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Potassium isotope fractionation during granitic magmatic differentiation: mineral-pair perspectives

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Potassium (K) is a major constituent of planetary crusts, and its stable isotopes are emerging as a tracer of planetary accretion and differentiation. Before the applications of K isotopes, it is necessary to evaluate K isotope fractionation behavior during magmatic differentiation. Previous studies have found no K isotope fractionation during the differentiation of basaltic magma mainly reflecting the absence of crystallization of K-rich minerals. In more evolved magmas, K-rich minerals likely join the crystallization assemblage, which may lead to measurable K isotope fractionation.

We measured K isotopic compositions of granitoids and coexisting K-bearing minerals from the Dabie Orogen and Himalayan Orogen in China to investigate the behaviors of K isotopes at advanced stages of magmatic differentiation. The Dabie granitoids are I-type granitoids derived from the ancient lower continental crust. The Himalayan leucogranites are highly differentiated granites, which were derived from a metasedimentary protolith. We found large K isotopic variations in minerals and the enrichment of heavy K isotopes occurs in the order of plagioclase >> hornblende > biotite ≈ K-feldspar ≥ muscovite. $\delta^{41}K$ values of the granitoids also display significant variations. The influence from source heterogeneity can be excluded as $\delta^{41}K$ values are not correlated with $^{87}Sr/^{86}Sr$ and $\varepsilon_{Nd}(t)$ values. Considering the inter-mineral K isotope fractionation, K isotopes may be significantly fractionated during fractional crystallization, which is further supported by the modeling calculations. Overall, our study suggests that measurable K isotope fractionation may occur at advanced stages of magmatic differentiation.