Calcium isotope fractionation during crustal melting and magma differentiation: A granite and mineral-pair perspective

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We report high-precision Ca isotopic data of 17 well-characterized granitoids from the Dabie orogen to investigate Ca isotope fractionation during crustal melting and magma differentiation. To facilitate explanation of the whole rock data, mineral pairs from representative granitoids and local eclogites and garnet peridotites have also been measured. Hornblende and plagioclase pairs yield consistent $\Delta^{44/42}Ca_{hbl-plg}$ of 0.10–0.12 that likely records isotopic equilibrium at 487°C–517°C [1]. Clinopyroxene and garnet pairs from Dabie eclogites and Sulu garnet peridotites yield variable $\Delta^{44/42}Ca_{grt-cpx}$ values, from 0.09 to 0.39. The slope between $\Delta^{44/42}Ca_{grt-cpx}$ and $1/T^2$ of each garnet-clinopyroxene pair ($A = \Delta^{44/42}Ca_{grt-cpx} * T^2$), representative of isotope fractionation with the temperature effect corrected, decreases with increasing of Ca/(Ca+Mg+Fe) (atomic ratio), indicating compositional control on equilibrium fractionation.

Eight non-adakitic granitoids with CaO contents variable from 1.56 wt.% to 6.80 wt.% yield homogeneous Ca isotopic compositions with an average $\delta^{44/42}Ca$ of 0.37 ± 0.03 (2SD), identical to the mean value of local basements [2], indicating insignificant Ca isotope fractionation during crustal melting and differentiation at low pressures (e.g., without a role of garnet). This observation is consistent with the limited $\Delta^{44/42}Ca_{hbl-plg}$ (~$0.0618 \times 10^6/T^2$) at the liquidus temperatures, e.g., ~0.04 at 900°C. $\delta^{44/42}Ca$ of nine low-Mg adakitic granitoids varies from 0.24 to 0.38. Given their low CIA (< 51%), narrow CaO range (1.86 wt.%–3.07 wt.%) and mineral assemblage similar to non-adakitic granitoids, $\delta^{44/42}Ca$ variation in low-Mg adakitic samples cannot be explained by either weathering, alteration, or fractional crystallization. Instead, a negative correlation with $(Dy/Yb)_N$ indicates a role of residual garnet.

[1] Wu et al. (2017) GCA 198, 208-217. [2] Lu et al. (2017) Goldschmidt Abstracts, 2467.