Origin of carbonatites from Ca stable isotopes

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Carbonatites are rare igneous rocks that have a high content of carbonate minerals and nearly no silica. Carbonatitic magmas are derived from carbonated mantle sources but the origin of the carbonates (recycling of surface material or primary mantle source) is still debated. While mafic igneous rocks present a $\delta^{44/40}$Ca around 0.8-1.2‰ normalised to SRM, surface carbonates have $\delta^{44/40}$Ca ~ 0‰. Ca isotopes are therefore well suited to study the origin of Ca in carbonatites.

We analysed the Ca isotopic composition of 25 carbonatites from continental and oceanic locations and from different ages (from 2 Ga to present day). The large majority of the carbonatites are isotopically light ($\delta^{44/40}$Ca down to 0.07‰) compared to mantle derived rocks. On the other hand, the natrocarbonatite from Oldoinyo Lengai is isotopically heavier ($\delta^{44/40}$Ca =0.82‰), similarly to basalts.

Three mechanisms can explain the very light isotopic composition of the calciocarbonatites i) A very low degree of partial melting of the mantle may enrich the melt in light isotopes, yet there is no evidence of such large isotopic fractionation during partial melting. ii) The mantle source for the calciocarbonatites is enriched in light Ca likely due to recycling of surface material. iii) aqueous alteration has enriched the calciocarbonatites in the lighter isotopes.

On the other hand, the natrocarbonatite from Oldoinyo Lengai have a MORB-like Ca isotopic composition. The difference of $\delta^{44/40}$Ca between natro- and calcio-carbonatite would then suggest that they either have different mantle sources, were formed from different degree of partial melting and/or that aqueous alteration has modified the Ca isotopic composition of calciocarbonatites.