Calcium isotope fractionation during mantle melting and Ca isotope composition of Earth's upper mantle

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Significant Ca isotope fractionation has been observed in terrestrial basalts. However, Ca isotope composition of the upper mantle is currently under controversial, with $\delta^{44/42}Ca$ ranging from 0.42±0.06 to 0.51±0.02 (2SD) [1-3], and the effect of mantle melting on Ca isotope fractionation remains obscure. To better constrain the scale and mechanism of Ca isotope fractionation during mantle melting, here we report high-precision (0.03‰ on $\delta^{44/42}Ca$) Ca isotope composition for 39 terrestrial samples including 24 peridotites and 15 basalts (MORBs and OIBs). $\delta^{44/42}Ca$ of 13 non-metasomatized peridotites range from 0.41±0.04 to 0.56±0.03, positively correlating with MgO and Mg#. These correlations indicate that the upper mantle tend to enrich heavy Ca isotopes with increasing melt extraction. Accordingly, $\delta^{44/42}Ca$ of the upper mantle is estimated to be 0.43±0.03 based on the Mg# and MgO of it, which is consistent with Kang et al. (2017) (0.43±0.02). Our modelling suggests that $\Delta^{44/42}Ca$ between peridotite and melt can be 0.05 at 3 GPa, within the estimate in Kang et al. (2017) (0.05–0.12). In addition, $\delta^{44/42}Ca$ of a glimmerite sample from Northern Tanzania, as an endmember that represents metasomatic melt, is 0.33±0.02, indicating that the Ca isotope composition of mantle peridotites can also be siginificantly modified by metasomatic progresses. $\delta^{44/42}Ca$ of 14 basalts range from 0.37±0.05 to 0.46±0.04 with an average of 0.41±0.04 (2SD), which is consistent with the average of previously reported values [4]. We note that the OIBs in this study seems to have slightly lighter Ca isotope compositions than MORBs by ~0.03. The lighter isotope compositions of OIBs could be resulted from their lower melting degrees or the heterogeneities inherited from the source.

[1] Huang et al., EPSL, 2010, 292(3-4): 337-344. [2] Kang et al., EPSL, 2017, 474: 128-137. [3] Simon and Depaolo, EPSL, 2010, 289(3-4): 457-466. [4] He et al., GGR, 2017, 41(2): 283-302. # This work is supported by the National Nature Science Foundation of China (41673012).