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Magnesium isotope fractionation during mantle partial melting

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Since Mg is both a dominant constituent of the mantle and a compatible element, its isotopic composition in primitive melts should provide a new perspective on long-debated lithological variability in the sources of oceanic magmas. Although previous research [1] suggested limited Mg isotope fractionation during partial melting, significant Mg isotope differences between mantle minerals has been theoretically predicted (e.g.,[2]) and empirically determined (e.g.,[3]), suggesting some scope for magmatic Mg isotope fractionation. Here, we measured the inter-mineral Mg isotope fractionation to higher precision than before, and importantly link this to melting via determining the Ol-melt fractionation factor using natural Ol-glass pairs.

We employed critical mixture double spiking [4] which enables high-precision (2se of 0.01 to 0.02‰) and comparable accuracy. Separated minerals from mantle peridotites show significant and consistent fractionations from olivine with lowest δ^{25}Mg (~ -0.13‰) to spinel with the heaviest values (~ 0.02 ‰). Our results are consistent with previous less precise measurements and theoretical calculations [2,3]. Meanwhile, natural Ol-glass pairs picked from MORB sample were measured to further constrain the melt-olivine fractionation factor. These reaffirm the ^{25}Mg $_{Ol/glass}$ value (0.999960±0.000013) of our previous work [5], validating this vital but previously poorly-constrained number.

By applying these newly determined fractionation factors, we modelled Mg isotope fractionation during partial melting of the mantle. Melts from peridotite are anticipated to have slightly elevated δ^{25}Mg values (about 0.01 to 0.02 ‰) as a result of olivine preferring lighter Mg isotopes than melt. The δ^{25}Mg of melt from olivine-free pyroxenite mainly depends on the melting modes of garnet and clinopyroxene. If garnet exists as a residual mineral, the melt is always isotopically heavier (~0.05‰) in its magnesium composition than its source. When at higher pressure clinopyroxene becomes the residual mineral, the melt is ~0.01‰ lighter than its source. Such predictions make δ^{25}Mg values of OIB samples a temping tracer of mantle heterogeneity.

[1] Teng *et al.* (2010) *GCA* **74**, 4150-4166. [2] Schauble *et al.* (2011). *GCA* **75**, 844-869. [3] Pogge van Strandmann et al. (2011). *GCA* **75**, 5247-5268. [4] Coath et al. (2017) *Chemical Geology* **451**, 78-89. [5] Liu *et al.* (2021) *GCA* **under review**