Zr stable isotope variability in the silicate Earth: is zircon to blame?

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Recent studies have shown that Zr stable isotope compositions vary in terrestrial igneous systems, both at the mineral [1] and bulk-rock scales [2]. Nevertheless, the mechanism(s) driving this variability and thus the petrogenetic significance of fractionated compositions remain poorly understood. While detailed single-crystal observations have shown zircon to be isotopically 'heavy' relative to the melt from which they crystallize [1], the opposite has been suggested based on inferences made from bulk rock measurements [2]. Here, we test these competing hypotheses in two ways: 1) at the intra-mineral scale; and 2) at the intra-crustal scale, targetting a zircon-fertile system.

Fractionation of derivative melts by removal of a phase with contrasting isotopic composition predicts that the phase(s) driving fractionation should themselves be internally zoned. We sectioned a 5 cm-long megacryst from the Mud Tank carbonatite (Australia) and microsampled it along a rim-to-rim transect (n= 18) for measurement using a Zr double spike [3]. All micro-cores have undistinguishable $\mu^{94/90}Zr_{NIST}$ to within ± 30 ppm, indicating no resolvable zoning within this megacryst. Multiple random fragments from the 91500 megacryst (Ontario, CA) were also found to be reproducible at this level, also suggesting homogeneity. These results indicate that zircon crystallization is not a driver of Zr stable isotope fractionation in carbonatitic and syenitic magmatic systems.

To evaluate the integrated effects that intra-crustal distillation and zircon removal from mantle-derived melts have in the $^{94/90}Zr$ composition of Earth's continental crust, arc-related juvenile and evolved lavas, as well as zircon-bearing lower-crustal cumulates, are currently being analyzed. The composition of the depleted upper mantle was determined using 19 mid-ocean ridge basaltic glasses from the Smithsonian volcanic glass collection. All samples from ridges located >500 km away from plume centers are tightly distributed around a mean $\mu^{94/90}Zr_{NIST}$= -53 ± 40 ppm (2SD).

[1] Ibanez-Mejia & Tissot (2018) Goldschmidt abstract #1115; [2] Inglis et al. (2019) *GCA* **250**, 311; [3] Ibanez-Mejia & Tissot (2018) Goldschmidt pre-conference workshop.