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Mixing of melts during OIB petrogenesis constrained by Ca isotopes

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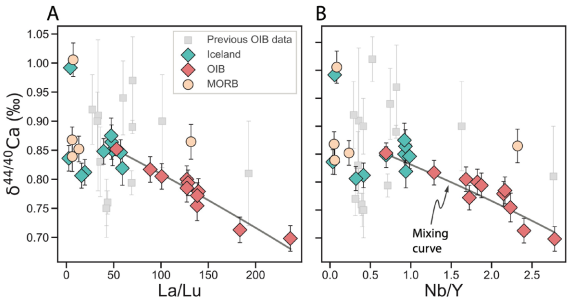

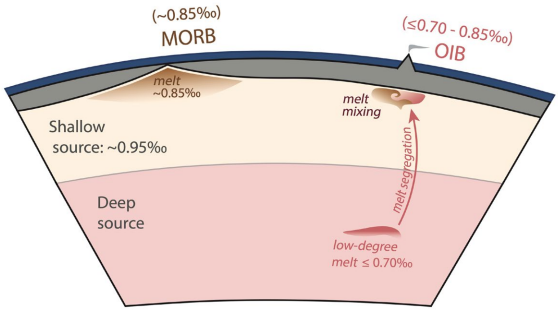

Lithological and isotopic heterogeneity in the mantle archive the mantle's melting history and fingerprint crustal recycling processes coupling the deep Earth with the terrestrial biosphere. Oceanic basalts, consisting of ocean island basalts (OIB) and mid-ocean ridge basalts (MORB), are invaluable tools for studying the chemical evolution of the mantle because they sample mantle heterogeneity at a variety of depths and length scales [1, 2]. In this study, we probe mantle heterogeneity by exploring the systematics of stable Ca isotopes in OIB and MORB. We find that OIB from Iceland have $\delta^{44/40}$Ca values (~0.85‰) that are indistinguishable from MORB, while OIB from Mangaia, the Azores, the Canary Islands and Hawaii have an average $\delta^{44/40}$Ca value ~0.08‰ lighter than the MORB-Iceland group. Moreover, MORB and Iceland $\delta^{44/40}$Ca values are relatively invariable, while OIB ranges from 0.70‰ to 0.85‰ and correlates negatively with La/Lu and Nb/Y. The Ca-isotope signature of the MORB-Iceland group is consistent with equilibrium fractionation during high-degree melting of average spinel/garnet peridotite with bulk silicate Earth (BSE) $\delta^{44/40}$Ca. Calcium-isotope variability in OIB requires two-component mixing of melts with distinct $\delta^{44/40}$Ca values, one of which is a high-degree melt consistent with derivation from average peridotite with BSE $\delta^{44/40}$Ca. The melt-mixing endmember with isotopically light Ca (≤0.70‰) must be a deep, low-degree melt. This low-degree melt cannot be derived from a peridotite source with BSE $\delta^{44/40}$Ca, but instead requires either a peridotite source with a lighter-than-BSE $\delta^{44/40}$Ca or a different source mineralogy (e.g., mixture of garnet peridotite and pyroxenite, possibly carbonate bearing). This deep endmember melt is consistent with derivation from an orthopyroxene-rich (or possibly majorite-rich) source. Recycled materials (e.g., seafloor carbonates) may also play an important role, but their effects must be further evaluated. Regardless, mixing of melts from a shallow peridotite source and a deep source appears to be a ubiquitous part of OIB petrogenesis.

References: [1] Langmuir, C. H., Klein, E.M., & Plank, T. (1992). *Mantle flow and melt generation at mid-ocean ridges*, 183-280. [2] Hofmann, A. W. (1997). *Nature*, *385*(6613), 219-229.