Heavy δ^{57}Fe in ocean island basalts: Is pyroxenite the solution?

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Lithological heterogeneity is a widely accepted feature of Earth's mantle. A variety of geochemical tools tell us that ocean island basalts (OIB) sample a spectrum of mantle components, with recycled crustal material accounting for a significant part of this heterogeneity compared to mid-ocean ridge basalts (MORB). In recent years, Fe isotopes have been used to link geochemical heterogeneity in OIB sources to distinct mineralogies due to mineral-specific fractionation effects. For example, heavy isotopic compositions of δ^{57}Fe > 0.25‰ in Pitcairn and rejuvenated Samoan lavas have been linked to recycled pyroxenite lithologies. However, with partial melting fractionations known to be small it remains unclear whether melting of a recycled crustal component derived from oceanic crust can generate the heavy Fe isotopic data in the existing global OIB dataset.

Here we present Fe isotope data for the Samoan shield, Galapagos and Azores volcanoes together with a quantitative combined phase-equilibria and melt isotope fractionation model to show that single-stage melting of a MORB-like eclogite, or of a hybridised pyroxenite commonly thought to form part of the OIB source, cannot generate the heavy Fe isotope values seen in Pitcairn, Azores, and Samoa rejuvenated lavas. Mixed melts of a MORB-like eclogite and peridotite source will likely be isotopically indistinguishable from MORB, perhaps consistent with Galapagos showing no Fe isotopic variability from MORB despite evidence for pyroxenite associated with the Galapagos plume. Solutions to the generation of isotopically heavy liquids in OIB may involve plume specific processes, meaning pyroxenite cannot be assumed to be the origin of heavy Fe isotopic compositions in OIB, and that 'normal' MORB-like Fe isotopic compositions do not necessarily indicate a pyroxenite-free mantle source.