The roles of source and process in generating Fe-isotope variability in basaltic suites: a combined empirical and theoretical approach

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The extreme mineralogical heterogeneity present in Earth's mantle records the history of our planet's differentiation and the evolution of plate tectonics. Mapping the mantle's mineralogical variability allows us to interrogate how these processes have shaped our planet.

As a major constituent of the mantle and basaltic magmas, Fe and its stable isotopes are expected to be robust tracers of major planetary processes and the mineralogical changes they effect. Primitive basalts offer the most direct window into the Earth's deep interior, yet the chemical processes operating during melt genesis, transport and storage obscure their primary chemical signals. To exploit the full potential of Fe isotopes as a proxy for mantle mineralogy the influence of these variables on basaltic magmas must be quantified.

We present new Fe-isotope analyses made on a suite of well characterised primitive basalts from Iceland's neo-volcanic zones and flank-zones. The observed geographic structure in δ^{57}Fe, and its co-variance properties with radiogenic isotope ratios, trace and major element concentrations, requires the primary mantle Fe-isotope signal to have been extensively modified during magmatic processing.

By novel integration of Fe-isotope fractionation calculations into phase equilibria modelling, we provide a new quantitative basis for assessing the simultaneous effects of mantle melting, magma transport and crystal fractionation on the δ^{57}Fe in basaltic suites. Applying these models to the Icelandic suite allows us to assess the fidelity with which basaltic magmatism records the mineralogical heterogeneity of the mantle from which it derives.

This combined empirical and theoretical approach affords us an improved understanding of how Fe-isotope observations can constrain the processes operating in the Earth's mantle throughout its life.