Fe-isotopes as a powerful tracer of lithological heterogeneity in OIB and MORB source regions

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The extent of lithological heterogeneity in the Earth's convecting mantle is highly debated. While inferences of peridotite and pyroxenite in the mantle source regions of Ocean Island Basalts (OIBs) have been largely based on the minor-element chemistry of olivine phenocrysts, recent studies have shown that Ni and Mn contents of olivine may be influenced by temperature [1], as well as magma chamber recharge and re-equilibration [2]. Nevertheless, constraining the lithological properties of the mantle is important due to it's influence on the P-T path followed by solid mantle material during adiabatic ascent, as well as the density (and therefore buoyancy flux) of upwelling plumes. We have therefore explored the use of Fe-isotopes as a novel method of tracing lithological heterogeneity in the mantle source regions of OIBs [3] and plume-influenced regions of the global Mid-Ocean Ridge system.

We analysed the Fe-isotope and trace-element composition of 28 samples from the plume-influenced Galapagos Spreading Centre (GSC). Our results reveal systematic along-axis geochemical variations, which can be related to the well-constrained variations in delivery of compositionally enriched material to the GSC. Our results are investigated using a series of mantle melting models, coupled to a Monte Carlo algorithm. These models, in which the enriched mantle component may be represented by either a peridotite or pyroxenite component, are used to evaluate whether the heterogeneity observed in the Fe-isotope composition of the GSC basalts is consistent with: (i) melting in the garnet-stability field and fractionation of isotopically light Fe into residual garnet; (ii) melting of a highly oxidised component in the Galapagos mantle plume; or (iii) melting of a lithologically distinct component beneath the GSC.

Our results indicate that, when other factors that may cause Fe-isotope fractionation are carefully considered, Fe-isotopes provide a powerful method for constraining the lithological properties of OIB mantle source regions.

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