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Novel stable isotope constraints on mantle mineralogical heterogeneity and melting processes

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Many studies of transition metal stable isotope systems such as Fe have exploited variations in mineral- and redox-specific equilibrium fractionation effects to link observed variations to source mineralogy and melting processes [e.g., 1-6]. However, our interpretation of these variations is hampered by a lack of understanding of equilibrium partitioning of stable isotopes during the processes of partial melting and melt transport through the mantle and crust. These concepts have recently been developed further by combining self-consistent thermodynamic models with predictions of stable isotope partitioning between ubiquitous mantle mineral phases and melt [5-6]. These new models in conjunction with high-precision stable isotope data allow us to quantify the extent to which different novel stable isotope systems may record the upper mantle melting of enriched and depleted lithologies.

Here we review how stable isotope systems such as Fe can be used to place constraints on the mineralogy and chemistry of the mantle source regions of ocean island basalts (OIB), and the nature of the magma generation processes at mantle plumes. We will discuss a range of different case studies, including new Fe isotope results from the Galapagos mantle plume [7], which has cooled from a mantle potential temperature of 1800 to 1400°C [1] over ~ 90 Ma and is inferred to sample pyroxenite and peridotite mantle lithologies [8-9]. We will also present new Fe isotope data from characterised basalts from Iceland's active rift zones, which demonstrate a contribution from carbonated-silicate melts at the centre of the Iceland plume [10].

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