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Light Fe isotope ratios reveal the contribution of carbon-rich melts to magma generation in Iceland

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We present a new Fe stable isotope dataset (n=38) generated from well characterised primitive basaltic glasses from Iceland's active rift zones. We report δ^{57}Fe values that are among the lowest seen in primitive ocean-island and mid-ocean-ridge basalts. Using new self-consistent thermodynamic models for fractional crystallisation, fractional mantle melting, and reactive melt transport we demonstrate that such low values of δ^{57}Fe cannot be generated by silicate melting, melt transport, or crustal processing. Instead, we propose that this signature derives from low degree carbonated silicate melts generated at the redox-melting front deep below the volatile-free and hydrous peridotite solidus [1]. The large isotopic fractionations between carbonate-coordinated Fe and silicate-coordinated Fe [2] mean that such melts are likely to have very low δ^{57}Fe. In regions of buoyancy-driven active mantle upwelling (i.e., mantle plumes) such as Iceland we expect the aggregate melt to contain a disproportionate contribution of melts from the base of the melting region [3,4], thereby providing a mechanism for shifting magmas to lower δ^{57}Fe than expected.

While contributions from carbonatite melts have been identified at ocean islands on relatively thick oceanic lithosphere, direct evidence of the generation of these melts beneath Iceland has not been seen, despite evidence that the Icelandic mantle is carbon rich [5,6]. Understanding the contribution of deep volatile-rich melts to melting is important for building models of Icelandic magmatism and inferring properties of the Icelandic mantle. In particular, the addition of low fraction melts will tend to increase trace element enrichment, potentially biasing our models towards lower melt fractions or greater source enrichments. This work is an important step towards better constraining basalt petrogenesis in Iceland and linking the composition of lavas to their mantle source.

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