Reconciling the iron isotope composition of mid-ocean ridge basalts with their mantle source

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The heavy iron (Fe) isotope composition of Mid-Ocean Ridge Basalts (MORB) relative to mantle peridotites is difficult to explain by partial melting and differentiation, or redox and polymerization in magmas [e.g. 1-3]. An alternative possibility is that this mismatch is simply controlled by compositional heterogeneity in Earth's upper mantle.

This study presents Fe stable isotope data for MORB glass and oceanic crustal gabbros, and their consitutent phases, from a range of global localities. Incompatible element 'depleted' MORB from the Pacific Ocean yield δ^{56}Fe compositions that range from -0.06‰ to +0.04‰, significantly lighter than most MORB measured thus far, and indistinguishable from the range observed for abyssal peridotites. The question then is whether there is any evidence for MORB with a peridotite-like composition elsewhere. Coexisting phases (silicate and sulfide) in enriched MORB from the FAMOUS ridge segment in the N Atlantic Ocean yield δ^{56}Fe compositions of ~+0.29‰. In contrast, sulfide and melt inclusions in primitive olivine crystals from the same samples preserve light δ^{56}Fe isotope compositions, indicating that the melts from which these olivines crystallised also have a composition akin to peridotite. These primitive phases in MORB may have originated in the lower part of the oceanic crust, and preliminary data for oceanic gabbros, and consitituent clinopyroxene, indicates that they also possess light δ^{56}Fe compositions.

Overall, these new stable Fe isotope data considerably extend the range of compositions observed in MORB, indicating that at least some MORB may be sourced by mantle peridotite, and suggesting that the heavy compositions seen in many others may simply be due to preferential melting of a more 'enriched' source, such as pyroxenite [e.g. 4]. Whether the light δ^{56}Fe compositions of gabbros are a local phenomena or reflect a stratified oceanic crust remains to be seen.

[1] Teng, F.-Z. et al., GCA (2013) 107, 12-26. [2] Craddock, P.R. et al., EPSL (2013) 365, 63-76. [3] Dauphas, N. et al., EPSL (2014) 398, 127-140. [4] Williams, H.M. & Bizmis, M. EPSL (2014) 404, 396-407.