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Fe-Isotopes Evidence for Recycled Crustal lithology in Southwest Indian Ridge Basalts

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We investigate the influence of magmatic and source processes on the Fe isotope (δ^{56}Fe) compositions of 27 basalts from the Southwest Indian Ridge (SWIR), dredged on- axis between 49°E and 69°E longitude. Our results reveal significant δ^{56}Fe variability, ranging from +0.06‰ to +0.16‰ (relative to the IRMM-014 standard), with an average value of +0.10 ± 0.03‰. Although a broad correlation between δ^{56}Fe and MgO suggests that some of this variability may be attributed to fractional crystallization, the heterogeneity persists even after correcting the data to primitive melt compositions (average $\delta^{56}Fe_{prim}$ of +0.08 ± 0.03‰, *prim* stands for recalculated primitive compositions). In the easternmost samples, between the Rodriguez Triple Junction and the Melville Fracture Zone, the $\delta^{56}Fe_{prim}$ variations correlate with enrichments in incompatible elements, namely Na and REEs, but not with Sr-Nd or Hf isotope compositions. While Na_{prim} content in MORB typically reflects variations in the degree of partial melting (F), the lack of correlation between $\delta^{56}Fe_{prim}$ and other melting proxies suggests that $\delta^{56}Fe_{prim}$ fractionations are driven by lithological heterogeneities in the mantle source rather than melting processes. This interpretation is further supported by a negative correlation observed between $\delta^{56}Fe_{prim}$ and Pb isotopes compositions in this ridge section.

A melting-induced mixing model involving a lithologically heterogeneous mantle source—comprising pyroxenitic bodies or veins dispersed within a peridotitic matrix [1] —successfully reproduces the $\delta^{56}Fe_{prim}$ variations and incompatible element enrichments observed in the SWIR basalts. The inferred Sr-Nd-Hf-Pb isotopic compositions of this enriched pyroxenitic source display particularly unradiogenic Pb isotopes. This not only excludes a metasomatic origin involving low-F melts [2] but also differ from the local DUPAL isotopic anomaly, which is more likely attributed to the recycling of lower continental crust lithologies [3]. Notably, the pyroxenitic source identified in the SWIR basalts shares striking Sr-Nd-Hf-Pb isotopic similarities with the "Unradiogenic Lead Component" described in Pacific MORB [4], which potentially originates from the recycling of sulfide-bearing mafic cumulates from arc roots [4].

[1] Guo ,et al. (2023) GRL ; [2] Guo, et al. (2023) EPSL ; [3] Escrig, et al. (2004) Nature ; [4] Mougel, et al. (2014) Nat Comm.