

Constraining oceanic lithosphere depletion: a stable Fe isotope perspective

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Archaean cratonic harzburgites record significant depletion of incompatible elements, driven by major melt extraction. Since the Archaean, such extreme depletion is rare. However, peridotites of the Cretaceous Papua New Guinea (PNG) ophiolites are some of the most depleted rocks in incompatible major and trace element concentrations [1]. We examine depletion processes in these Phanerozoic rocks via trace elements and stable Fe isotopes, which are a powerful tool to characterize partial melting processes, as well as tracing mineralogical variability in the source of the melt region [2,3].

We present the first bulk-rock Fe isotope data from two PNG ophiolite suites: the Marum Ophiolite (upper mantle unit + cumulates) and the Papuan Ultramafic Belt (PUB; upper mantle unit + cumulates + basalt). We analysed bulk rock powders of 12 peridotites and 8 cumulates from Marum and 11 peridotites, 8 cumulates, and 7 basalts from PUB. PUB basalts record an average $\delta^{56}\text{Fe}$ of $-0.09 \pm 0.01\text{‰}$, whereas peridotites yield an average of 0.00‰ (with a large range of -0.12 to $+0.14\text{‰}$). We observe a trend of lighter Fe isotope compositions with increasing Mg# in the peridotites, generally consistent with partial melt extraction. Thermodynamic modelling of single-stage equilibrium batch melting using MAGEMin [4] cannot reproduce the observed $\delta^{56}\text{Fe}$ and Mg# values and require a heavy initial $\delta^{56}\text{Fe}$ of 0.15‰ , much heavier than typical fertile upper mantle [2]. The data could be explained by a multi-stage melting process and with later melt in-flux with basalts/boninites carrying heavier Fe isotope signatures. Hence, extreme incompatible-element depletion can be achieved in the Phanerozoic in more complex tectonic settings of supra-subduction zones and require multi-stage processes.

[1] Barrett et al. (2022), *Journal of Petrology* 63(3), p.egac014.

[2] Weyer & Ionov (2007), *Earth and Planetary Science Letters* 259(1-2), pp.119-133.

[3] Williams et al. (2018), *Geochimica et Cosmochimica Acta* 226, pp.224-243.

[4] Riel et al. (2022). *Geochemistry, Geophysics, Geosystems*, 23(7), p.e2022GC010427.