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Probing magma-mush reactions in primitive arc/backarc lavas using stable Fe isotopes

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Mantle-derived melts in subduction zones are predominantly basaltic in composition, yet erupting arc and backarc lavas display a compositional diversity from basaltic to rhyolitic. The key factor driving this diversity is magmatic differentiation *en route* to the surface. The understanding of this process has evolved from a simple fractional crystallisation model to complex magma-mush interactions involving dynamic fractionation. In this process, incongruent melting reactions in mush reservoirs act as a filter for ascending melts, which evolve towards elevated Si content by melt-mineral reactions and associated magma mixing between fresh melt and magma-in-residence [1].

Here we present stable Fe isotope data for a suite of rocks from the Pual Ridge in the Manus arc/backarc basin, Papua New Guinea, to test whether primitive lavas also interact with mush or bypass the mush reservoir. The Pual Ridge rocks define SiO_2-MgO trends that resemble a liquid line of descent until MgO ~1wt.%, despite sampling individual magmatic centers. A similar trend is observed for a range of trace elements, including chalcophile elements previously used to define the so-called magnetite crisis [2].

The Fe isotope compositions of the Pual Ridge rocks show a ‘zig-zag’ trend with decreasing MgO, similar to other arc lavas [3,4], towards heavier isotopic compositions until magnetite saturation at ca. 4 wt.% MgO, and then first lighter Fe isotopes followed by a reversal towards very heavy signatures in samples <1 wt.% MgO. Crucially, Kilauea Iki lavas, often treated as examples for perfect fractional crystallisation, do not show the magnetite reversal [5]. We interpret the zig-zag trend as melt-mush interaction and conclude that primitive arc/backarc lavas have passed through mush reservoirs. Accordingly, mineral-melt mush reactions in arc/backarc systems are a common process during their genesis. Magma mixing, however, based on Fe isotopes, does not occur in lavas >1 wt. MgO and appears to be absent in primitive arc lavas.

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