Isotopically heavy boron in the source of ocean island basalts

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Basalts erupted at ocean islands (OIB) have isotope signatures that are distinct from those of MORB with implications for mixing and convection processes in the mantle. Yet, the genesis of these source heterogeneities is subject to a long-standing debate. Boron isotopes can provide insight into the origin of mantle heterogeneities: B is strongly enriched in the continental crust, sediments, seawater, altered oceanic crust (AOC) and abyssal serpentinites, but shows very low concentrations in the mantle. The B isotopic composition of MORB and the mantle is homogenous at $\delta^{11}B$ = -7.1 ±0.9 ‰ [10.1016/j.gca.2017.03.028], whereas subduction introduces isotopically heavy (seawater-derived) B into the mantle. However, much of this B may be expelled from the slab and returned to the overriding plate, combined with the potential of a preferential loss of heavy B. Boron isotopes in OIB from various global localities have been investigated in a relatively large number of studies, and extreme variations have been reported ranging from -17 to +17 ‰ [10.1007/978-3-319-64666_8]. However, much of this variation is due to assimilation of altered basement by the ascending magmas.

This study focuses on glasses and melt inclusions that show low Cl/K ratios and are thought to represent the uncontaminated mantle signal from the HIMU (Tuvalu and Mangaia), EM1 (Pitcairn) and EM2 (Samoa) sources. All samples are depleted in B (relative to the LREE) and range in $\delta^{11}B$ from MORB values up to -2.5 ±1.5‰ in Pitcairn and Tuvalu lavas. The total range is, thus, much smaller than reported previously, and it does not extend to values below that of MORB. Importantly, the samples show a clear excursion to heavy B that does not correlate with Cl/K, but instead correlates with signatures such as Zr/Nd and Pb isotopes characterisitc of the mantle source heterogeneity. The OIB samples support the hypothesis that surface materials are deeply recylced into the source region of OIB. The B depletion in all types of OIB shows that this element is efficiently (but not quantitatively) removed from subducted sediments and AOC. Preferential loss of heavy B during subduction may push these deeply subducted materials to lighter $\delta^{11}B$ values than the pre-subducted protoliths, but they do not extend below the $\delta^{11}B$ of ambient MORB mantle.