Boron isotopes as a tracer of subduction zone processes

J.C.M. DE HOOG[1*] AND I.P. SAVOV[2]

[1]School of GeoSciences, The University of Edinburgh EH9 3FE, UK (correspondence: ceesjan.dehoog@ed.ac.uk)
[2]School of Earth & Environment, University of Leeds, Leeds LS2 9JT, UK (I.Savov@leeds.ac.uk)

Boron and its isotopes provide some of the most powerful tools for investigating fluid-mediated processes at subduction zones, as B is extremely depleted in the mantle but strongly enriched and isotopically fractionated (by up to 40 ‰) in subducted sediments, altered oceanic crust (AOC) and serpentinized mantle (subducted lithospheric section and forearc wedge). Upon subduction, much of the slab volatile inventory is lost in the forearc region due to diagenesis and compaction, giving rise to vast fore-arc serpentinite reservoirs, which may still enter magma source regions through subduction erosion. The remaining fraction of B hosted in AOC and sediments is isotopically light as a result of isotope fractionation that occurs during shallow B loss. In contrast, serpentinized oceanic mantle retains a heavy seawater-derived isotopic signature until its dehydration beneath or beyond the volcanic arc front. Thus, B can track the origin of fluid sources to subduction zone magmatism.

This complex interplay of fluid sources and their range in B isotopic compositions is reflected in arc volcanics. Boron isotope variations in arc rocks show a dramatically large range ($\delta^{11}B$= -9 to +16 ‰) with an average $\delta^{11}B$ value of +4.1 ‰ for rocks with MgO >4 wt.% [1] compared to -7.4±2.6 ‰ for ocean floor basalts [2]. Although the thermal structure of a subduction zone determines where dehydration reactions take place and thus where fluids and B are released into the overlying mantle wedge, there is no clear correlation between the global arc dataset and the thermal parameter Φ of the subduction system. However, B isotopes are negatively correlated with widely used subduction zone tracers like Sr, Zr and Nb, as well as with Nb/B and Zr/B ratios. Commonly used sediment and/or crust tracers in subduction zones, the radiogenic isotope ratios of Sr, Nd, Hf and Pb, do not co-vary with the global $\delta^{11}B$ arc dataset. This suggests a significant contribution of serpentinites, either as subducted forearc material, mélanges overlaying subducting slabs, or hydrated oceanic mantle in the subducting slab.

[1] De Hoog and Savov (2018) In: Boron Isotopes The Fifth Element, Adv. Isotope Geochem. pp. 217-247. [2] Marschall (2018). In: Boron Isotopes The Fifth Element, Adv. Isotope Geochem. pp. 189-215.