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Boron isotopic fractionation in subducted oceanic crust

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Subducted oceanic crust plays an important role in controlling the chemical budget of the crust, mantle and arc lavas. Boron isotopes (^{10}B and ^{11}B) are fractionated during oceanic-crust dehydration in subduction zones. This fractionation is temperature dependent and governed by boron coordination in minerals and fluids. Two approaches can be employed to quantify boron isotopic fractionation in subducted oceanic crust: modeling based on boron coordination or direct measurement of the isotope budget of samples derived from the devolatilized slab. To address this, we conducted simultaneous measurements of major and trace elements, and boron isotope ratios using a split-stream LA-SF-ICPMS setup at FIERCE.

We investigated in-situ boron isotope compositions of minerals from reaction zone rocks from the high-pressure (HP) mélange on the island of Syros, formed at ~ 0.7 Gpa, 415 ±15 °C. The paragenesis of tourmaline, phengite, omphacite and glaucophane offer the opportunity to determine equilibrium B isotope fractionation among these minerals. The proportions of trigonally and tetrahedrally coordinated B in omphacite and glaucophane can be then estimated from the respective boron isotope fractionation against tourmaline and phengite. In clinopyroxene (omphacite), 88 ± 9% of boron is incorporated in tetrahedral coordination, whereas, B in glaucophane is exclusively incorporated in the tetrahedrally coordinated sites.

We have analyzed elemental abundances and boron isotopic compositions of oceanic metamorphic rocks, from the Zambezi Belt, the Cabo Ortegal complex, the Raspas Complex, from Syros Island, and from the Tian Shan. Whole-rock B/Pr ratios were used to quantify the progress of B loss during dehydration. The boron isotopic composition of almost all samples (approximately -10 to +5 ‰) ranges from $\delta^{11}B$ values close to that of fresh MORB to that of typical altered oceanic crust. Also, the sample set shows no correlation between $\delta^{11}B$ values and B/Pr, as would be expected from current B isotope fractionation models.

Our results, thus, demonstrate that B isotopic fractionation in subducted oceanic crust is much smaller than current models predict. We suggest that this discrepancy can be resolved by accepting high pH values in high-pressure hydrous fluids, which show a much smaller boron isotope fractionation in equilibrium with B-bearing silicates.