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An experimental approach to quantify the effect of tetrahedral boron in tourmaline on the boron isotope fractionation between tourmaline and fluid

Martin Kutzschbach[1,*], Bernd Wunder[2], Robert B. Trumbull[2], Alexander Rocholl[2], Anette Meixner[3], and Wilhelm Heinrich[2]

[1]Fachgebiet Mineralogie-Petrologie, Technische Universität Berlin, 13355 Berlin, Germany
[2]GFZ German Research Centre for Geosciences, 14473 Potsdam, Germany
[3]Faculty of Geosciences & MARUM-Center for Marine Environmental Sciences, University of Bremen, 28359 Bremen, Germany

Abstract

This study investigates the effect of tetrahedral B ($^{[4]}$B) in synthetic tourmaline on the B-isotope fractionation between tourmaline and fluid. This is important for the correct interpretation of B-isotope variations in natural tourmalines containing "excess" B (greater than three atoms per formula unit), which substitutes for Si at tetrahedral sites. Such tourmalines commonly occur in Li, Al-rich pegmatites and have been reported from glaucophane schists that formed at high pressures during subduction.

Tourmaline synthesis experiments were performed in a piston-cylinder apparatus in the system SiO_2-Al_2O_3-B_2O_3-NaCl-H_2O at 4 GPa and 700 °C using different run durations, starting from quartz-γ-Al_2O_3-H_3BO_3 solid mixtures and NaCl-solutions. We were able to produce "olenitic" tourmaline with excess B between 1.2 and 2.5 $^{[4]}$B per formula unit. The B-isotope compositions of the olenitic tourmaline and coexisting fluids were determined by secondary ion mass spectrometry and multi-collector plasma source mass spectrometry to derive isotope fractionation coefficients. The results indicate that for every 10 mol% of total B in tourmaline in tetrahedral coordination, the value of $\Delta^{11}B_{tur\text{-}fluid}$ is shifted to more negative values by about 1‰ at 700 °C. This is in good agreement with published ab initio calculations and corresponds to an intracrystalline fractionation of B-isotopes between the trigonal B and tetrahedral T sites of tourmaline on the order of 8 ± 5‰, whereby ^{10}B partitions to the T site.

Keywords: SIMS, experimental geochemistry, fluid, matrix effect, mass spectrometry