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Experimental determination of boron isotope fractionation between silicate melts and hydrous fluids, with application to understanding magmatic-hydrothermal ore genesis

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The magmatic-hydrothermal transition is an important but poorly-understood process in the formation of Sn-W, Nb-Ta and Li deposits associated with evolved granites and pegmatites. Theory predicts that boron isotopes will fractionate between magma and fluid, so the magmatic-hydrothermal transition may be recorded in the borosilicate mineral tourmaline, which is widespread and common in these kinds of deposits. The key information needed to interpret the tourmaline record is the B-isotope fractionation between granitic melts and the fluids derived from them but former experimental studies on B-isotope fractionation between the relevant phases are not in agreement (e.g. [1] Kowalski and Wunder, 2018, [2] Maner and London, 2018).

This study fills this gap by an experimental, multivariant approach. We synthesized a glass of haplogranitic composition ($Ab_{40}Or_{25}Qtz_{35}$) and produced variants of water content (0, 4 and 6 wt%), aluminum saturation (ASI 0.7, 1, 1.3) and boron concentration (2 and 5 wt%). For each composition we determined the coordination environment of B in the glass and the fractionation of B isotopes between the respective melt and aqueous fluid at near-solidus temperature. The first part of the study was the chemical characterization and analysis of B coordination in the glasses. The NMR analysis of ^{11}B (Figure 1) indicates that the coordination of ^{11}B is dominantly trigonal in all glasses, but there is an increase of tetrahedral coordination with increasing boron concentration and water content. Fluid-melt fractionation experiments are ongoing and first results will be presented.

References:

[1] Kowalski, P., Wunder, B. (2018). Boron isotope fractionation among vapor–liquids–solids–melts: Experiments and atomistic modeling. In: Marschall, H., Foster, G. (eds) Boron Isotopes. Advances in Isotope Geochemistry. Springer-Verlag, Berlin-Heidelberg, volume 7, pages 33–69

[2] Maner, J. L., London, D. (2018) Fractionation of the isotopes of boron between granitic melt and aqueous solution at 700 °C and 800 °C (200 MPa), Chemical Geology, Volume 489, Pages 16-27

Figure 1: Coordination of ^{11}B in experimental glasses (measured by NRM, in percentage of tetrahedral/(tetrahedral+trigonal)) in dependence to the nominal water [wt%] and boron [wt%] content.