Elemental Partitioning and Zoning in Tourmaline: An Experimental Investigation

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Elemental partitioning between the a and c axes and the c+ and c- axial directions of tourmaline has been assessed using cold-seal experimental techniques. Experiments began with the synthesis of a nearly crystal free and hydrous melt (glass) from a mixture of powdered minerals and reagents at 800°C, 200 MPa, and $f(O_2)$ near NNO-0.5 log units. The 800°C pre-conditioned step was quenched to room temperature and then reran to a synthesis step of 700°C. The chemical composition of glass and crystal products, including Sps-rich garnet, were determined using an electron microprobe analyzer.

Tourmaline products are predomintanly a solid solution of schorl-dravite with minor amounts of uvite, olenite, and alkali-free tourmaline (AFT). All tourmaline crystals display compositional zoning between the c and a axes. Because determination of the c+ and c- axial directions is impossible for crystals with two equally geometrical pyramidal terminations, such as the crystals in this study, the c+ direction was chosen to be the direction with the longest growth zone. The composition of the a and c- axes are similar for all elements within a 1σ standard deviation except Ti (a axis: TiO_2=0.03 wt.%, 1σ=0.02 and c- axis: TiO_2=0.08 wt.%, 1σ=0.01). The c+ axis is enriched in Mg (~1 wt.% MgO) and depleted in Ca (~0.15 wt.% CaO), Al (~1 wt.% Al_2O_3), and Ti (~0.04 wt.% TiO_2) relative to the c- and a axes. The ratio of $c+^{Ti}/c-^{Ti}$ is 0.52 (1σ=0.14) and the ratio of $c+^{Ca/Na}/c-^{Ca/Na}$ is 0.65 (1σ=0.06). The a axis exhibits no compositional heterogeneity within and between crystals (1σ standard deviation).

At 700°C, the partitioning of elements between the a and c axes and the c+ and c- axial directions is small. The small degree of partitioning might be caused by high temperature conditions, trace concentrations of TiO_2 and CaO in the starting melt composition, or other variables such as crystallographic and surface charge effects. Further experiments are being performed at different temperatures and melt compositions to determine the extent of elemental partitioning between the axes of tourmaline.