

Experimental study on tourmaline in a pelitic system: Breakdown reactions and their implications for behavior of crustal boron

Tsutomu Ota[1]; Tomoo Katsura[1]; Eizo Nakamura[2]

[1] ISEI, Okayama Univ.; [2] ISEI(Misasa), Okayama Univ.

<http://ultra3.misasa.okayama-u.ac.jp/home.shtml>

High-pressure experiments were carried out in order to determine pressure-temperature stabilities and breakdown reactions of tourmaline in a pelitic system. A starting material was prepared by mixing a low-grade metapelite of the Sambagawa high-pressure metamorphic belt, with dravitic (NaMg-) tourmaline separated from an eclogitic metapelite of the Kokchetav ultrahigh-pressure metamorphic belt. Adding the tourmaline, the starting material contains c. 2000 ppm B, and c. 3.7 vol.% tourmaline. High-pressure experiments were conducted with a multi-anvil apparatus (700-900 deg.C at 3-6 GPa for 4-51 hours), and two piston cylinder apparatuses (700-850 deg.C at 1-2 GPa for 106-168 hours) at ISEI, Okayama University at Misasa. Phases in experimental products were observed and identified by using EPMA (with X-ray mapping), XRD and Micro-Raman spectrometer at ISEI.

At pressure of 3-6 GPa, most experiments produced garnet, jadeitic clinopyroxene, phengite, kyanite and coesite. At pressure of 1-2 GPa, plagioclase and quartz appeared instead of clinopyroxene and coesite; biotite occurred with Si-poor phengite. At pressure of 1 GPa, no garnet was observed. A significant amount of glass (a quenched melt with K-rich and granitic composition) was observed at pressure of 1-3 GPa; a trace amount of the glass at 4 GPa and 900 deg.C. With temperatures, a modal proportion of the glass increases while that of phengite decreases with appearance of alkali-feldspar. No tourmaline was confirmed in run products at pressure of 5-6 GPa or temperature of 900 deg.C. Abundant tourmaline crystals survived at pressure of 1-4.5 GPa and temperature of 700-850 deg.C. However, the tourmaline proportion clearly decreases between 700 and 750 deg.C at 4.5 GPa, between 800 and 850 deg.C at 4-2 GPa, and between 700 and 750 deg.C at 1 GPa. Tourmalines, survived the higher temperature conditions, have irregular outlines and seem to be corroded, suggestive of being metastable. In addition, the decreases of tourmaline proportion are accompanied with decreasing proportions of SiO₂ phases, and with increasing those of clinopyroxene or plagioclase, kyanite, garnet (pyrope component also), and the glass.

Experimental results in this study indicate that a stability field of dravitic tourmaline in a pelitic system is considerably restricted at lower pressure and temperature conditions, compared with that in a mono-phase (dravite) system previously reported. The tourmaline breakdown examined in this study always consumes a certain amount of the SiO₂ phase, although the tourmaline melts out at pressures of 1-3 GPa. It implies that the tourmaline is stable at higher pressure and temperature conditions in a SiO₂-undersaturated system (e.g., in ultramafic rocks). The tourmaline stability in the present pelitic system suggests that hot slab subduction would result in its partial melting with phengite-breakdown; most of the B in crustal materials would be incorporated to the granitic melt, and ascend back to the surface. Even in cold subduction zone, subducting crust would release B-rich fluids derived from the tourmaline breakdown with dehydration upon reaching 150-km depth. At the relevant depths, a trace amount of B could be partitioned through the fluids into phengite. However, most of the released B, with the fluids from the subducting crust, would ascend to the mantle wedge. In the hydrated mantle wedge of subduction-zone, serpentine and clinohumite are possible B-hosting phases. Some of the B released could be partitioned into serpentine and clinohumite, and transported by counter-flow in the mantle wedge to depths near the transition zone. Consequently, the B derived from the crustal materials would geochemically influence source materials of oceanic island basalts.