Boron in deep subduction zone inferred from boron isotopic compositions of microdiamond-bearing tourmaline

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Potassium (K)-tourmaline with microdiamond inclusions has recently discovered in tourmaline (up to 25 volume percent) + K-feldspar + quartz rock at Kumdy-kol in the Kokchetav ultrahigh-pressure metamorphic belt, northern Kazakhstan (Shimizu and Ogasawara, 2005, Mitt.Oterr.Miner.Ges., 150, 141). Microdiamonds are included in the K-rich core of the tourmaline, and euhedral graphite occurs in the rim, suggesting that the core of the tourmaline formed under high-pressure conditions in the diamond stability (i.e., over 4 GPa at 900 deg.C), and overgrew under lower-pressure conditions of the graphite stability. In order to understand formation process of the K-tourmaline and behavior of boron (B) in deep subduction zone, we examined varieties in major-element (by EPMA) and B-isotope compositions (by SIMS) of the K-tourmaline. Analytical errors of the B isotopic ratios were estimated as 0.8-1.6 per mil (2-sigma mean) on the basis of the reproducibility for repeat analysis of a tourmaline standard; here, the isotopic ratios are expressed as a per mil deviation (delta-^{11}B value) relative to NIST SRM951 standard. Analytical results are summarized as follows; the K-rich cores of the tourmaline are more enriched in Al, and are higher in Fe/(Fe+Mg) ratio than the rims. As a whole, the B-isotopic ratios range in delta-^{11}B value from -1.2 to +7.7, and tend to be high at the K-rich cores; such a correlation between the major-element and B-isotopic compositions are observed within individual grains.

Petrography of the K-tourmaline + K-feldspar + quartz rock, and the major-element and B-isotope compositions of the K-tourmaline suggest that formation of such an unique lithology requires to extract large amounts of B, K, Al and Si from the surroundings, subsequently to crystallize under high-pressure conditions in the diamond stability. In general, high-pressure metamorphic tourmalines are characterized by low delta-^{11}B values from -15 to -10 (e.g., Bebout and Nakamura, 2003, Geology, 31, 407-410), because B-isotopic ratios in tourmaline and coexisting fluids become lower and higher, respectively, with the dehydration reactions during subduction by B-isotope fractionation between them. However, the K-tourmaline, especially its cores including microdiamonds, has positive delta-^{11}B values up to + 7.7; it is unlikely to produce such positive delta-^{11}B values by the fluid-related B-isotope fractionation during subduction metamorphism. Our results imply that (1) partial melting of deeply subducted sediments (Korsakov et al., 2004, Terra Nova, 16, 146-151) is the most probable formation process of the K-tourmaline-bearing rock, and that (2) subducted sediments could have retained a significant amount of B, even under high-pressure conditions of the diamond stability.