Boron depletion controlled by the breakdown of tourmaline in the Yanai area, Ryoke metamorphic belt, SW Japan

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Pelitic metamorphic rocks up to granulite facies grade are continuously exposed in the Yanai area, Ryoke metamorphic belt, southwestern Japan. It is possible, therefore, to observe the progressive change of boron-bearing mineral assemblages and whole-rock boron contents in this area alone. Detailed observations are made in following points: (i) The relationship between breakdown of muscovite, which is the important sink of boron in the pelitic rocks lower than the lower-amphibolite facies grade (Sperlich et al., 1996), and change of chemical composition and grain size of tourmaline. (ii) Breakdown phenomena of tourmaline by attaining the high-temperature stability limit. (iii) Depletion of whole-rock boron through the breakdown of tourmaline in the tourmaline-out region.

Progressive changes in composition and chemical zoning of tourmaline in pelitic metamorphic rocks are studied in detail. The rim composition of tourmaline progressively becomes aluminous as the metamorphic grade increases from the biotite zone to the sillimanite-K-feldspar zone. Chemical zoning of tourmaline in the biotite and muscovite-cordierite zones are both controlled by the [X]AlNa-1Mg-1 and MgTiY[Al]-2 exchange vectors whereas that in the K-feldspar-cordierite (Kfs-Crd) zone is controlled by the CaMgO[X]-1Y[Al]-1(OH)-1, Mg(OH)Y[Al]-1O-1 and MgTiY[Al]-2 exchange vectors, where [X] and Y[Al] denotes the vacancy in the X-site and Al in the Y-site of crystalline structure in tourmaline, respectively.

The size of tourmaline crystals increases drastically at the boundary between the Ms-Crd and Kfs-Crd zones where breakdown of muscovite and quartz took place. This feature, together with the presence of newly nucleated tourmaline occurring as inclusions in the northern part of the Kfs-Crd zone, suggests that the rim of tourmaline crystals in this zone has formed through the muscovite-consuming reaction.

A breakdown front of tourmaline (a tourmaline-out isograd) can be defined in the southern part of the Kfs-Crd zone, and depletion of whole-rock boron contents controlled by the breakdown of tourmaline is observed on the high-temperature side of the tourmaline-out isograd.

Tourmaline that is surrounded by the fine-grained muscovite aggregates, originally cordierite, in the Grt-Crd zone may be the relic of the breakdown reaction of tourmaline. Dumortierite in the Grt-Crd zone occurs exclusively at the grain boundaries in the matrix and may have precipitated from the boron-bearing fluid that emanated from the boron-bearing melt formed by the breakdown of tourmaline.

The retrograde tourmaline shows irregular shape and occurs at the grain boundaries in the matrix, commonly replacing biotite. Some of them have distinctly different composition from that of prograde tourmaline and is rich in Al and Fe, poor in Mg and Ti compared with other prograde tourmaline.

Local presence of these retrograde borosilicates implies that boron-bearing melt was not completely removed from the rocks of the high-temperature side of the tourmaline-out isograd in the Yanai area, which differs from the case of the Aoyama area, Ryoke metamorphic belt, southwestern Japan (Kawakami, 2001a; b).