Symmetry of iridescent garnets from Tenkawa, Nara Prefecture, Japan

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Grossular (Ca3Al2Si3O12) - andradite (Ca3Fe3+2Si3O12) garnet solid solutions (space group, Ia-3d), termed grandite series, often exhibit optical birefringence and iridescence. Iridescent garnets (rainbow garnet) is a variety name for the iridescent Fe3+-rich grandite. Shimobayashi et. al (2005) examined the iridescent garnets from Tenkawa, Nara Prefecture, Japan and they reported the presence of fine lamellar texture (ca. 100-300 nm in thickness) with small differences in chemical composition (Al/Fe3+ ratio) by transmission electron microscope (TEM). They also suggested that Al-rich fine lamella should be reduced in symmetry from cubic system, but they did not show the direct evidence of the symmetry reduction. Our previous study (Chang et al., 2016) reported that extra reflections, 110, 200, 411 and so on, to break the symmetry of Ia-3d were detected, in selected area electron diffraction (SAD) patterns from Al-rich fine lamellae. In this study, we examine convergent-beam electron diffraction (CBED) method in addition to SAD method by TEM to investigate the symmetry of same iridescent garnet from Tenkawa.
A thin section (100 μm thickness) cut parallel to the (001) face through the center of the crystal was prepared from an euhedral single crystal of iridescent garnet with well-developed rhombic dodecahedral {110} facets. TEM specimens with various crystal planes, (001), (1-10), and (111) were prepared from the thin section by using a focused ion beam technique (FIB, FEI: Quanta 200 3DS) and then TEM (JEOL JEM-2100F) observation was carried out to investigate the symmetry.
SAD patterns obtained from Fe-rich fine lamellae reveals that the Ia-3d symmetry retains as the usual garnet and extra reflections did not appear, although 200 and 020 reflections appear for multiple (double) diffraction. On the other hand, in SAD patterns from Al-rich fine lamellae, extra reflections, 110, 200, 411 and so on, to break the symmetry of space group (Ia-3d) were detected, indicating that a-glide and d-glide planes should be lost. However, all reflections satisfy the reflection condition of body centered lattice (I-lattice, hkl; h+k+l=even). Furthermore, the each intensities of 110, -110, -1-10 and 1-10 have different counts and this indicate that symmetry in this area does not have fourfold rotation axis. CBED pattern in (111) TEM sample indicates no threefold rotation axis and CBED in (001) sample shows no mirror planes perpendicular to a- and b-axes and no twofold rotation angle parallel to a-, b- and c-axes. Moreover, CBED in (1-10) also shows no mirror planes perpendicular to c-axis. These results indicate crystal family of this Al-rich fine lamella is triclinic and lattice type is I-lattice and suggest the space group is I-1 or I1.

Reference

Shimobayashi et al. (2005) Abstracts of Annual Meeting of the Mineralogical Society of Japan ,p80.
Chang et al. (2016) Japan Geoscience Union MEETING 2016, SCG56-P04

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