

TEM observation of rainbow garnets from Tenkawa, Nara Prefecture, Japan

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Grossular ($\text{Ca}_3\text{Al}_2\text{Si}_3\text{O}_{12}$) - andradite ($\text{Ca}_3\text{Fe}^{3+}_2\text{Si}_3\text{O}_{12}$) garnet solid solutions, termed grandite series, generally occur in skarns. Grandites often exhibit optical birefringence, iridescence, and oscillatory zoning. "Rainbow garnet" is a variety name for the iridescent Fe^{3+} -rich grandite. Shimobayashi et al. (2005) examined the iridescent garnets (rainbow garnets) from Tenkawa, Nara Prefecture, Japan. They reported that they consist of $\{110\}$ growth sectors with banding textures parallel to $\{110\}$ faces that looks like the oscillatory zoning, and that wavy lamellae (ca. 10-20 μm in thickness) across the $\{110\}$ bandings were observed. In addition, their TEM observation revealed the presence of fine lamellar texture (ca. 100-300 nm in thickness) with small differences in chemical composition (Al/ Fe^{3+} ratio) within the wavy lamellar zone. Shimobayashi et al. (2005) demonstrated that the multilayer interference of light with these periodic fine lamellae originate the iridescence. They also suggested that the thinner lamella (ca. 20 nm in thickness) in the fine lamellar texture should be reduced in symmetry from cubic system, but they did not show the direct evidence of the symmetry reduction. Crystalline symmetry of the iridescent garnets is still uncertain. In this study, we analyzed the microstructures in iridescent garnets from Tenkawa. We used optical microscope, SEM (JEOL: 7001F, JXA-8105) and TEM (JEOL JEM-2100F) with EDS detector to investigate the symmetry reduction of the rainbow garnets. A thin section (100 μm in thickness) cut parallel to the (001) face through the center of the crystal was prepared from an euhedral single crystal of rainbow garnet with well-developed rhombic dodecahedral $\{110\}$ facets from Tenkawa, Nara Prefecture, Japan. A TEM specimen perpendicular to the $\{110\}$ growth bands was prepared from the thin section by using a focused ion beam technique (FIB, FEI: Quanta 200 3DS). The present (001) thin section consists of four $\{110\}$ growth sectors. We observed $\{110\}$ growth bands with wavy lamellae across them and $\{110\}$ fine lamellae in each sector, as well as reported by previous researchers (Shimobayashi et al., 2005). The wavy lamellae texture consist of thicker Al-rich lamellae (widths of approximately 10-20 μm) and thinner Al-poor lamellae (widths of approximately 1-2 μm). Part of fine lamellae parallel to the $\{110\}$ growth bands has been observed within in wavy lamellar zone. The fine lamellae texture also consists of thicker Al-rich lamellae (100-300 nm in thickness) and thinner Al-poor lamellae (ca. 20 nm in thickness). The fact that the fine lamellae cut across the interfaces of wavy lamellae and continuously elongate shows that the former should be formed after the latter, as pointed out by Shimobayashi et al. (2005). There is a clear zone (widths of approximately 3 μm) in which the fine lamellae could not be clearly observed in the present TEM specimen used. Electron diffraction patterns obtained from this lamellar-free zone reveals that the Ia-3d symmetry retains as the usual garnet and extra reflections did not appear. On the other hand, in the electron diffraction patterns from the area with the $\{110\}$ fine lamellar texture, extra reflections 110, 200, 411 and so on to break the symmetry of space group (Ia-3d) can be detected, indicating that a-glide and d-glide planes should be lost. The dark-field imaging using a 110 reflection shows that only Al-rich fine lamellae have the bright contrast. Therefore, thinner Al-rich fine lamellae should be changed to lower symmetry from Ia-3d. The symmetry inferred from the diffraction pattern with these extra reflections is considered as I23, Im3, I2₁3, I43m, I432, or Im3m under the condition of cubic and I-lattice.

Reference

Shimobayashi et al. (2005) Abstracts of Annual Meeting of the Mineralogical Society of Japan ,p80.

