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An integrated EPMA-EBSD study of metamorphic histories recorded in garnet

Masaki Enami[1,*], Takayoshi Nagaya[2,†], and Maw Maw Win[2,‡]

[1]Center for Chronological Research, Nagoya University, Nagoya 464-8602, Japan
[2]Department of Earth and Planetary Sciences, Graduate School of Environmental Studies, Nagoya University, Nagoya 464-8601, Japan

Abstract

Growth histories recorded in garnet grains in metasedimentary rocks from the Sanbagawa belt in Japan and the Mogok belt in Myanmar were analyzed using an effective combination of electron backscatter diffraction (EBSD) and electron probe microanalysis (EPMA) data. Garnet in the Sanbagawa metapelite has inner and outer zones that formed in the eclogite and epidote-amphibolite facies stages, respectively. Based on EPMA element mapping, this garnet appears to have grown as a single crystal with a temporal break in growth between the inner and outer zones that occurred during exhumation. The EBSD data, however, document that the garnet grain is composed of four domains. The misorientation angles of crystallographic orientations between the domains are as large as 59°, and domain boundaries crosscut the growth zoning and the compositional boundary between the inner and outer zones. Sets of quartz grains included in the garnets on either side of the domain boundaries sometimes share the same crystallographic orientation with misorientation angles less than 4°. The garnet grains formed via a three-step process of prograde crystallization of polycrystalline garnet during the eclogite facies stage (inner zone) → resorption around garnet rims and along domain boundaries during exhumation → crystallization of the outer zone and in the domain boundaries during the prograde epidote-amphibolite facies stage.

The garnet porphyroblasts in the Mogok pelitic gneisses, which formed during prograde metamorphism to the upper amphibolite-granulite facies (0.6–1.0 GPa/780–850 °C), are now separated into segments of various sizes by mosaic or symplectite aggregates of biotite, plagioclase, and quartz or monomineralic biotite veins. The segment texture formed at about 0.3–0.4 GPa/610–650 °C or lower-grade conditions. The EBSD analysis shows that most of the segments share the same crystallographic orientation with misorientation angles less than 4° and show no evidence of deformation and/or rotation processes after segmentation. These data suggest that the Mogok sample did not experience dynamic deformation of the garnet grains after the resorption and segmentation stage and may have been exhumed under static conditions from depths of 9–12 km.

Keywords: EBSD, EPMA, garnet, polycrystals, growth process, metamorphism