Misorientations of garnet aggregate in a sealed vein

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How long it takes for cracks to be sealed is of special importance to constrain fluid flux during metamorphism. In this study, we investigated chemistry, microstructure, and texture of garnet aggregate in a sealed crack occurring in mafic schist of the Sanbagawa metamorphic belt. Garnet-bearing veins were colleted from the albite-biotite zone in the central Shikoku, Japan. They occur as a layer with thickness of 1-50 mm, subparallel to the foliation of the host mafic schist.

The analyzed vein is mainly composed of garnet, quartz, and pyrite rimed by ilmenite, amphibole, epidote, chlorite, phengitic mica. In the vein numerous fine-grained garnet (mean radius 0.01 mm) form aggregates. Although it is difficult to estimate P-T condition of garnet growth within the vein, the analyzed vein is considered to have formed during the prograde or near-peak stage (500C, 1.0 GPa) of the Sanbagawa metamorphism for the following reasons: (1) The garnet + quartz veins occur subparallel to the foliation of the mafic schist and are often folded in harmony with the host mafic schist. (2) The chemical zoning of the outer part of garnet grains in the vein are similar to that of garnet in the host mafic schists, which shows a bell-shaped zoning of Mn, and the monotonous increase of Mg. (3) Mafic schist was suffered from the retrograde reaction to produce actinolite and chlorite. However, no systematic change of the extent of the retrograde reaction with respect to the distance from vain is observed.

Misorientation, crystallographic preferred orientation (CPO) were analyzed by SEM-EBSD system at the Shizuoka University. Positions of grain boundaries within the aggregate detected in the EBSD mapping were compared with those observed in the back-scattered electron image and composition image by EPMA. The analyses revealed that (1) the misorientation distributions of garnet grains for both neighbor-pair and random-pair are completely consistent with theoretical curve of random distribution pattern, (2) there is no meaningful CPO pattern in each aggregate, and (3) there is no subgrain boundaries in each garnet crystal. Recently, several works have revealed that misorientation distribution of garnet grains in mica schists of the Palaeozoic western Scneeberg Complex of the Eastern Alps deviates from the random distribution pattern, and that the misorientation angle becomes small during the formation of garnet aggregates (Spiess et al. 2001; Wheeler et al. 2001; Prior et al. 2002). They have suggested that such garnet porphyroblasts developed by multiple nucleation, coalescence and boundary misorientation-driven rotations. While there are several similarities in grain size, microstructures between their and our samples, considerable difference is found in the distribution pattern of misorientations. Although temperatures of garnet growth are somewhat different between their sample (600C) and our sample (500C), the duration of porphyroblasts formation may have been responsible for misorientation distribution. Spiess et al. (2001) proposed a simple kinetic model, which describes misorientation-driven rotation of garnet grains, assisted by boundary diffusion of surrounding quartz. Application of their model to aggregates analyzed in this study with reasonable values for grain-boundary diffusion coefficient and interfacial energy reveals that upper-limit of the duration of garnet aggregate to be several tens thousand years. This timescale may be comparable to the timescale for sealing the vein.