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Analysis of metamorphic history recorded in garnet: A combined EBSD and EPMA study

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Pressure-temperature and deformation histories recorded in garnet grains in metapelites were analyzed with an effective combination of EBSD (Electron Backscatter Diffraction) and EPMA (electron-probe microanalyzer) data.

Sanbagawa metapelite (UKE04N07b):
This sample was collected from the eclogite-unit in the Besshi region, central Shikoku, which experienced the following successive metamorphic pressure-temperature path: prograde eclogite facies stage (1.7-1.9GPa/470-530 ℃) → decompression and hydration reaction stage → prograde epidote-amphibolite facies stage (up to 1.0-1.1GPa/600-630 ℃) (e.g., Kouketsu et al., 2014, IAR, 263-280). The main matrix phases are garnet, biotite, phengite, epidote, albite, quartz, and graphite. The analyzed garnet grain is composed of inner and outer segments formed in the eclogite and epidote-amphibolite facies stages, respectively. The inner segment ($Alm_{67-73}Sps_{3-10}Prp_{4-10}Grs_{16-21}$) contains paragonite and quartz with high residual pressure (up to 0.8-0.9GPa). The outer segment, which has Mn-poorer and Ca-richer composition ($Alm_{56-66}Sps_{0-10}Prp_{4-9}Grs_{26-36}$), mantles the inner segment in a compositional discontinuous change. The analyzed garnet grain seems to have grown as a single crystal, although it records a break in the growth period between the inner and outer segments. The EBSD data, however, implies that the garnet grain is composed of four domains with different crystallographic orientations, respectively, and misfits between these domains are 40-59 degrees. Sets of quartz grains included in garnet on both sides of the domain boundaries sometimes share the same crystallographic orientation (misfits are less than1-6 degrees). The four domains are all composed of inner and outer segments. Thus, the EPMA and EBSD data suggest that the garnet grain studied was formed through the following process: prograde formation of polycrystalline garnet during the eclogite facies stage → resorption around the garnet grain and along the domain boundaries during exhumation → recrystallization of the outer segment and domain boundaries during the prograde epidote-amphibolite facies stage.

Mogok metapelite (S22b):
This sample was collected from an upper-amphibolite and granulite facies region in the Mogok metamorphic belt, northwest of Mandalay, Myanmar. The main matrix phases are garnet, biotite, plagioclase ($An_{43+/-4}$), K-feldspar, quartz, ilmenite, and graphite. Sillimanite occurs as inclusions in garnet. The peak metamorphic conditions are estimated at about 0.8GPa/800 ℃ (Maw Maw Win, personal communication, 2014). The garnet grain is separated into sub-grains of various sizes by resorption during the exhumation and cooling stages. Each sub-grain is mostly homogeneous, and shows a gradual increase of Mn and Fe and a decrease of Mg in the outermost margin ($Alm_{60-70}Sps_{1-3}Prp_{20-33}Grs_{5-7}$). Aggregates of biotite, plagioclase, and quartz fill the sub-grain boundaries, suggesting that the resorption stage progressed under the relatively high-temperature conditions of 0.2-0.4GPa/500-600 ℃. The EBSD analysis shows that the sub-grains share the same crystallographic orientation (misfits are less than 1-4 degrees) and show no rotation or deformation. These data suggest that the sample has not experienced any dynamic deformation causing revolution of garnet grains after the resorption stage, and may have been exhumed under stationary conditions from at least 6-12 km of depths.

Keywords: EBSD, EPMA, garnet, metamorphic history