Crystal size distribution and microstructures of garnet in the highest-grade zone of the Ryoke metamorphic complex in the Yanai area, SW Japan

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Metamorphic minerals nucleate and grow during the change of physical conditions such as temperature and pressure. This change can be inferred based on microstructural features including grain size of minerals and their spatial distribution. These features together with information on chemical composition can constrain the crystal growth process. This study describes the microstructural features of garnet in pelitic gneisses from the highest-grade zone, garnet-cordierite zone, of the Ryoke metamorphic complex in Yanai area, SW Japan.

Four pelitic gneisses examined in this study can be classified into two according to mean size of garnet grain. A quantitative analysis reveals that the gneisses containing garnet of large mean size show higher number density and lower modal abundance than those of small mean size. Both types represent similar 2-D crystal size distributions that have a single peak and a tail on the coarse grain side. The gneisses with large and small mean size occur in the east and west, respectively, where the metamorphic pressure increases eastward.

The phase diagram predicts that the values of Mg/(Mg+Fe) (hereafter #Mg) of the three phases, biotite, garnet, and cordierite, increase with increasing pressure. This suggests that the modal abundance of garnet is higher at higher pressures for a bulk composition. At lower temperatures than dehydration melting reaction, Sil+Bt+Qtz=Grt+Crd+Kfs+L, the three-phase assemblage is unstable, and garnet is present at high pressures and undergoes a continuous reaction, Sil+Bt+Qtz=Grt+Kfs+L. In the east of garnet-cordierite zone, i.e. at high pressures, the modal abundance of garnet would increase continuously with increasing temperature. It further increases discontinuously when the discontinuous reaction of the dehydration melting takes place. This garnet would grow on the pre-existing garnet grains. This overgrowth of garnet explains the small number density and coarse grains. In contrast, in the west, at low pressures, garnet does not exist before the discontinuous reaction, and this reaction nucleates significant amount of garnet. The first appearance of garnet by the discontinuous reaction expects the grain number density to be large.

The crystal size distribution (CSD) estimated from 2-D histogram has a tail on the coarse-grained side in all four samples. This suggests that modification of CSD by Ostwald ripening is not dominant. In other words, the garnet preserves information during the nucleation-and-growth period. This may be due to the short duration of high temperatures or lack of intergranular fluids.

The #Mg of garnet in a gneiss from east area decreases from core to rim whereas the Mn content increases. The maximum value of #Mg in the melanocratic part is larger than that in the leucocratic part. The biotite in contact with garnet is poorer in Ti than that in matrix.

It can be inferred that the garnet grains in the garnet-cordierite zone in this area were formed by several reactions, which will be detected from microstructural point of view.