An integrated study of prograde-zoned garnets in low-temperature eclogites: Reappraisal of omphacite antiphase domain geospeedometry and new insights in fluid-induced metamorphic crystal growths

*Ryo Fukushima[1], Tatsuki Tsujimori[1], Nobuyoshi Miyajima[2], Kazumasa Aoki[3]

1. Tohoku University, 2. Bayerisches Geoinstitut, University of Bayreuth, 3. Okayama University of Science

Omphacite with compositions close to $Ca_{0.5}Na_{0.5}(Mg, Fe^{2+})_{0.5}Al_{0.5}Si_2O_6$ and garnet occur ubiquitously in high-pressure and ultrahigh-pressure (H*P*–UH*P*) eclogites. In order to understand growth kinetics of garnets in progressive eclogitization of subducting oceanic crust, we zeroed in on antiphase domains (APDs) of omphacite inclusions in prograde-zoned garnets in glaucophane-bearing L*T* eclogites. Two garnet crystals, which were extracted from Syros (Greece) and the South Motagua Mélange (SMM) eclogites, show a rhombic dodecahedral crystal habit. The center-cut garnets exhibit concentric zoning, in which Mg/(Mg+Fe) atomic ratio increases rimward, and contains abundant mineral inclusions. TEM observations on the omphacite inclusions found a few pristine APDs, which are devoid of significant deformation; but also various types of APDs, which had undergone subtle deformation. The average sizes of equiaxed APDs were: ~54 nm (from the core of the SMM garnet); ~26 nm (from the rim of the SMM garnet); and ~32 nm (from the rim of the Syros garnet). Rim-to-rim trace-element zoning in the SMM garnets are characterized by both 'A'-shaped (Tb, Dy, Ho, Y, Er, Tm, Yb, Lu) and 'M'-shaped (Sm, Eu, Gd) profiles. In contrast, the Syros garnet showed only 'M'-shaped REE profiles, which was attributed to change of REE partitioning due to transition from titanite to rutile during the prograde metamorphism. Application of Carpenter (1981)'s APD geospeedometry for 'non-deformed' omphacite inclusions suggests that the Syros garnet had grown ~1–2 orders of magnitude faster than the SMM garnet. Moreover, our new diffusion-limited REE-uptake modeling scheme (Fukushima and Tsujimori, in this conference) for the analysed trace-element line profile infers that the Syros garnet had grown ~2–3 orders of magnitude faster than the SMM garnet.

Our TEM study of omphacite inclusions also confirmed: (1) the presence of elongated APDs near the boundary between omphacite and host garnet in the SMM sample; and (2) the presence of nano-size fracture-like pore between omphacite and host garnet in the Syros sample. Assuming that the pore was filled with aqueous fluid, we postulate a hypothesis that growth of such elongated APDs or cation ordering in omphacite near such boundaries was controlled by fluid transportation. Petrographic observations on two eclogite samples suggest different metamorphic fluid compositions between Syros and the SMM. Probably they led to difference in physical mechanisms of fluid transportation, consequently the shape diversity of APDs near such grain boundaries.

Keywords: omphacite, antiphase domain, garnet, diffusion-limited REE-uptake model, eclogite

