Cryptic chemical heterogeneity in omphacite: FIB-STEM analysis of antiphase domains in garnet-hosted omphacite from Syros, Greece

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Low-temperature (*T*) eclogite (a.k.a. Group-C eclogite), which occurs in Phanerozoic high-pressure/ultrahigh-pressure (H*P*–UH*P*) metamorphic complexes, can provide clues to understanding geochemical dynamics of progressive slab-dehydration in subduction zones. In particular, prograde-zoned (*i.e.,* Mg# increases rimward) garnet porphyroblasts have received considerable attention; their compositional zoning in major- and trace-elements is a useful indicator of the prograde *P*–*T*–time paths and slab-fluid infiltration.

However, compared to such chemical heterogeneity in garnet from Group-C eclogites, compositional zoning and/or cation ordering in omphacite are less debated. Among micro-to-nanoscale chemical heterogeneities in omphacite, morphology of antiphase domains (APDs), which are formed by cation ordering with the transformation from metastable C-lattice omphacite to low temperature P-lattice omphacite, should be a crucial tool to clarify metamorphic kinetics during progressive slab-eclogitization (*e.g.,* Carpenter, 1981).

In this study, we observed APD morphology within garnet-hosted omphacites from an eclogite from the Cycladic Blueschist Unit, Syros Island, by using a focused ion beam (FIB) apparatus and field-emission transmission electron microscope (FE-TEM). For a single omphacite inclusion (~50 μm in size) within the garnet-rim portion, we discovered peculiar, columnar antiphase domains (~130 nm in length) aligned perpendicular to the garnet–omphacite boundary. We comprehensively interpreted this thin omphacite-rim portion as a syngenetic part with the host garnet. This was because: (1) these columnar APDs were heterogeneously distributed depending on the spatial relationship to the host garnet; (2) similar APDs can be formed by rapid growths of partially ordered alloy; and (3) our additional scanning TEM (STEM) energy-dispersive X-ray analysis revealed that this thin omphacite-rim portion was characterized by a distinctly low Fe content relative to the inside (Fukushima *et al.* 2021). In addition, our simple Fe–Mg interdiffusion modeling within the investigated omphacite indicated that the peak-*T* residence time of the eclogite was quite shorter than the garnet-growth duration, possibly <~10^4 years. These novel results demonstrate that sophisticated analyses of eclogite-facies omphacites, especially those included within the host garnets, have potential to unravel short-span metamorphic events in subduction zones, as well as mineral-growth kinetics and/or nanoscale elemental transportations.

Carpenter, M.A., 1981. Omphacite microstructures as time-temperature indicators of blueschist- and eclogite-facies metamorphism. *Contributions to Mineralogy and Petrology* 78, 441-451.

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