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沈み込むプレートにおけるポストガーネット相転移の粒内核生成
Intracrystalline nucleation of post-garnet transformation in deep subducting plate

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Untransformed metastable garnet possibly exists in the plates subducted into the lower mantle because the kinetics of the post-garnet transformation is very slow. Although the post-garnet transformation may affect the density profiles and rheological structure of subducting slab, the realistic depths of the transformation considering the kinetic effects has not been discussed well. Here we report experimental results on the mechanisms of the post-garnet transformation under the large overpressure conditions using single crystalline garnet and sintered diamond anvils. Based on the experimental results, the post-garnet transformation kinetics in the deep subducted plate was discussed.

Natural pyropic garnet single crystals cut to the 0.250 mm cubes were used as the starting material. The material was surrounded by a fine powder of MgO and enclosed in an graphite capsule. All experiments were carried out using a Kawai-type high-pressure apparatus (MADONNA-II, Ehime University). The sintered diamond anvils with the truncated edge length of 1.5 mm were used as the second stage anvils in order to generate high pressure over ˜30 GPa. The sample assembly is composed of sintered (Mg,Co)O pressure mediums, a cylindrical LaCrO3 heater, and a Mo electrode. Temperature was monitored with a W3%Re-W25%Re thermocouple. Transformation microstructures of recovered samples were examined using a field emission-scanning electron microscope (FE-SEM, JSM-7000F) and transmission electron microscopy (TEM, JEOL JEM-2010). Thin foils for TEM analyses (ideally 100 nm) were prepared using a focused ion beam (FIB) system (JEOL JEM-9310FIB).

We found that the intracrystalline nucleation occur above ˜ 35-38 GPa although only grain boundary nucleation occurs at the lower pressure conditions. Also, growth rate of the transformed phases increased with increasing pressure due to the change of the mineral assemblages. Both of the nucleation and growth process at large overpressure conditions would strongly enhance the transformation kinetics, and therefore the post-garnet transformation may proceed rapidly in the subducted plate at around the depth of 900-1000 km. The seismic discontinuities are observed at depth of 900-1080 km beneath subduction zone (the mid-mantle discontinuity). This may be caused by the metastable post-garnet transformation at the large overpressure state.