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メージャライトガーネット中の Si-Al 相互拡散
Si-Al interdiffusion in majoritic garnet

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It has been suggested that the mineral transformations in subducting plates are kinetically inhibited and therefore low-pressure phases could metastably survive without transforming to its high-pressure phases (e.g., Sung and Burns, 1976). Kinetic studies on the high-pressure transformations have suggested that olivine, pyroxene, and garnet metastably survive without transforming their high-pressure phases in cold subducting plates. Especially, the formation of majoritic garnet from pyropic garnet and pyroxene (the pyroxene-garnet trasnfomration) is very slow and phase relation of subducting plates is possibly different from the equilibrium phase relation. However, quantitative kinetic data for the pyroxene-garnet transformation have not been obtained yet. Here we report Si^{4+} + M^{2+} <=> $2Al^{3+}$ (M = Mg + Fe + Ca) interdiffusion rate in majoritic garnet, which controls kinetics of the pyroxene-garnet transformation. Based on the experimental results, we discuss the density of subducting plate.

We carried out four experiments at 17 GPa and temperatures of 1550-1700C (every 50C) for 5-50 hours using a multi-anvil apparatus. Pressure was generated by the double-stage system and the truncated edge length of the second-stage anvils was 8.0 mm. Garnet diffusion couples having different chemical compositions were used as starting material. One is natural single-crystalline pyropic garnet, and the other is polycrystalline majoritic garnet synthesized from pyrolite-minus olivine glass at 17 GPa and 1600C. The diffusion couples were contacted each other and surrounded by $MgSiO_3$ enstatite powder and Ni capsule. The sample assembly is composed of sintered (Mg,Co)O and ZrO_2 pressure mediums, a cylindrical $LaCrO_3$ heater, and a Mo electrode. Temperature was monitored with a W3%Re-W25%Re thermocouple. The diffusion profiles of run products were obtained using an analytical transmission electron microscope (ATEM, JEOL JEM-2010) with an EDS detector (Thermo-NORAN Vantage-ES). Thin foils perpendicular to the diffusion interface for ATEM analyses were prepared by a focused ion beam (FIB) apparatus (JEOL JEM-9310FIB). Water content of the majoritic garnet polycrystalline before and after diffusion experiments were determined by FT-IR spectroscopy on the basis of the Paterson calibration [1982], which yielded 20-40 wt.ppm H_2O.

The pyroxene-garnet transformation requires long-distance Si^{4+} + M^{2+} <=> $2Al^{3+}$ diffusion comparable to the grain size of original garnet. The results indicated that, if we consider the grain size of 1 mm for the original garnet, the transformation requires high temperatures of more than 1500C comparable to a normal mantle geotherm. This suggests that the pyroxene-garnet transformation would be kinetically inhibited in cold subducting plates and large amount of metastable regions exist in the subducting plate around the mantle transition zone.

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