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高圧下でのフォルステライト反応帯の組織と成長カイネティクス
Microstructure and growth-kinetics of forsterite reaction rim under high pressure

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Since many transport properties, such as rheology, highly depend on grain-size of the constituent materials, knowledge of grain-growth is important for accurate understanding of dynamics in the Earth's mantle. Tasaka and Hiraga (2013) showed that grain-growth in forsterite-enstatite two-phase system is rate-limited by growth of secondary phase through Mg-O grain-boundary diffusion in primary phase. In this study, we have experimentally studied growth-kinetics of forsterite (Mg_2SiO_4) reaction rim at deep upper mantle conditions which is controlled by Mg-O grain-boundary diffusion in forsterite. Based on the experimental results, depth dependence of grain-growth in the upper mantle is discussed.

Experiments were carried out using multi-anvil apparatus installed at GRC, Ehime University, Japan. The starting materials, MgO (single crystal) and $MgSiO_3$ (powder or aggregate), were packed in Pt capsule. The annealing experiments were conducted at pressure of 3.0-11.1 GPa and temperature of 1473-1873 K for duration of 0-780 min. Recovered samples were analyzed by SEM or FE-SEM for microstructural observation and by FT-IR to examine water content.

Water content in MgO single crystal in the recovered samples was relatively low and 6.9 wt ppm H_2O at the maximum. The Pt marker, which was originally placed at MgO-$MgSiO_3$ boundary, was always on MgO-Mg_2SiO_4 boundary indicating that Mg-O diffusion in Mg_2SiO_4 is the rate-limiting process in the rim growth. $MgSiO_3$ inclusions were found in Mg_2SiO_4 grains suggesting the grain-boundary diffusion is rate-limiting. Based on the analysis using equation for reaction-rim growth rate-limited by grain-boundary diffusion (Gardes and Heinrich, 2011), the activation energy and the activation volume were determined to be 375 kJ/mol and -2.1 cm^3/mol, respectively. Although reason for the small negative value of the activation volume is not quite clear, this may be due to successive structural change of grain-boundary. The results suggest that the grain-growth in the Earth's upper mantle is faster at deeper part.

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