# フォルステライト＋ペリクレース多結晶体のクリープ速度と粒成長速度の関係

# The relationship between creep and grain growth rates in forsterite+periclase polycrystals

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Absence of seismic anisotropy in the earth's lower mantle suggests deformation by diffusion creep mechanism (Karato et al., 1995). The mantle is considered to consist mainly of perovskite and ferropericlase. Thus, it is required to understand a mechanism of diffusion creep of a two-phase material. The diffusion creep is significantly sensitive to grain size such that the flow in the lower mantle is likely to be controlled by grain growth (Solomatov, 1996). Both creep and grain growth require diffusion of atoms with a long-distance, which is almost the size of grains. Thus, it is likely that rate-controlling processes for creep and grain growth are identical. To examine this prediction, we conducted creep and grain growth experiments on an analogue material of the lower mantle, which consists of elements similar to the lower mantle minerals, at high-temperature and atmospheric pressure.

We synthesized highly-dense forsterite + periclase (10vol%) polycrystals from a mixture of fine powders of $Mg(OH)_2$ and $SiO_2$ (Koizumi et al., 2010). Grain sizes of forsterite and periclase are 0.3 and 0.2 μm, respectively. We performed uni-axial compressional creep experiments on these materials at atmospheric pressure. Prior to the deformation, the sample was annealed at 1420℃ for 12h to avoid grain growth during the experiment. We changed loads ranging from 50 to 200 MPa under constant temperatures of 1180℃~1400℃ during the experiments. At each stress level, we measured a strain rate where we could assume steady-state creep. We also performed grain growth experiments at different temperatures ranging from 1280℃ to 1400℃ for 500h using temperature gradient formed outside the central heat zone in the furnace. We observed microstructures of the aggregates after the experiments using scanning electron microscope (SEM).

Based on creep data, we obtained a relationship of $d\varepsilon/dt \propto \sigma^{n}$ ($n$ = 1.3~1.6). We observed monotonic increment of grain sizes of both forsterite and periclase grains with increasing temperature. We calculated grain boundary diffusivities from rates of creep and grain growth using theoretical models for grain growth and for diffusion creep (Coble creep), finding both diffusivities are essentially identical. The diffusivities are compared with previously measured grain boundary diffusivity of $Si^{4+}$ (Fei et al., 2016) and MgO (Gardes & Heinrich, 2011) finding our values are comparable to the diffusivity of $Si^{4+}$. We will discuss the flow mechanism of the lower mantle based on these results.

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