Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SIT38-16 会場:304 時間:5 月 23 日 16:30-16:45

二次元単色 X 線回折を用いたカンラン石の粒成長実験
Grain-growth experiments of olivine using 2D monochromatic X-ray diffraction pattern.

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Rheology is one of the most important mineral properties which plays a major role in controlling dynamic processes in the Earth's mantle. Olivine is the most abundant mineral in the upper mantle (60vol% in pyrolite mantle). Rheology in the upper mantle is dominated by this mineral. If diffusion creep is the most dominant deformation mechanism, the rheology of an aggregate is a function of the grain size of the constituent minerals. Thus, knowledge of grain size of olivine is important for understanding the rheology of the upper mantle.

The grain size of rock is controlled by several mechanisms (e.g. grain-growth, dynamic recrystallization and recrystallization by phase transformation). Grain-growth is one of the most important processes in controlling the grain size of the rock by which grain size is enlarged. Grain-growth experiments of olivine were conducted by some workers (e.g.Karato 1989, Ohuchi and Nakamura 2006). However grain-growth exponent, which is a parameter of time dependence, is controversial between previous studies.

Thus, in this study, we have investigated grain-growth kinetics in the olivine single phase system at high pressure and temperature (1373 - 1573 K, 2.3 - 10.5 GPa) using a in situ monochromatic X-ray diffraction and Kawai-type multi-anvil apparatus (SPEED-1500) installed at the synchrotron beam line, BL04B1, in the SPring-8 at the Japan Synchrotron Radiation Research Institute. The San Carlos olivine powder was used as starting material. The grain size was estimated by the relationship between the number of diffraction spot and the number of grains per radiated volume reported by Hirsch (1955).

The grain-growth kinetics of olivine is described by $G^n - G_0^n = k_0 \exp(-(E+PV)/RT)t$ where G is the average grain size at annealing time t; G_0, the initial average grain size; k_0 is the pre-exponential constant, E is activation energy, P is pressure, V is activation volume, R is the gas constant and T is absolute temperature, with n = 2.5 +- 0.2, $\log_{10} k_0$ = -9.2 +- 2.6 $m^{2.5}/s$, E = 184 +- 10 kJ/mol, V = 0.4 +- 0.2 cm^3/mol. The activation energy of grain-growth is similar to that of grain boundary migration (Toriumi, 1982). Thus, in terms activation energy and grain-growth exponent, in this study, grain-growth could be caused by grain boundary migration in the single phase system.

キーワード: カンラン石, 粒成長, その場観察実験, 上部マントル
Keywords: olivine, grain-growth, in-situ experiments, upper mantle