Diffusion of Fe^{2+} in MgO crystal at high-pressures and high-temperatures

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1. Introduction

(Mg, Fe)O magnesiowustite is one of the most major constituents in the Earth's lower mantle. Hence, in order to understand the properties of the lower mantle, we have to know the properties of magnesiowustite. Recently, diffusion in (Mg, Fe)O on high-pressures and high-temperatures has been reported by Holzapfel et al. (2003) and Yamazaki et al. (2003). These workers measured the inter-diffusion coefficient of Fe^{2+} and Mg^{2+} in (Mg, Fe)O magnesiowustite and determined the diffusion coefficient as a function of Mg/Fe ratio. In order to determine the diffusion coefficient in pure MgO, we have carried out a series of high-pressure experiments.

2. Experiments

We employed SPI-1000 multi-anvil apparatus at Tokyo Institute of Technology. Experiments were carried out at 5 to 12GPa and 1473 to 1874K up to 12h. two MgO single crystals were cut parallel to (100) and placed at the center of the $LaCrO_3$ heater (3.0 mm ID). Thin film of FeO was placed at the inter face of MgO which was originally decorated as Fe under vacuum and then oxidized to FeO in a furnace. The high-pressure run products were polished parallel to the length of the heater until the diffusion couple is exposed.

The polished run products were examined by X-ray mapping with EPMA for the uniformity of the Fe^{2+} distribution and then Fe^{2+} diffusion profiles vertical to the interface were measured. The diffusion profiles, consisting of 8 to 11 point analysis, were fitted by Gauss function and the diffusion coefficient was calculated using the thin film tracer diffusion approximation.

3. Results

Fig.1 shows the diffusion coefficients obtained from our experiments. Neglecting concentration dependence of the diffusion coefficients diffusion coefficients are determined as $D(Fe\text{-}Mg) = D_o \exp(-(E^*+PV^*)/RT)$; where Do is the coefficient, E* is the activation energy, and V* is the activation volume. From the data shown in Fig.1, following values were obtained; $D_o = 6.2(\pm 8.2)\times 10^{-9}$ m2/s, $E^* = 173(\pm 18)$ kJ/mol, and $V^* = 2.3(\pm 0.2)\times 10^{-6}$ m3/mol.

The diffusion coefficients in pure MgO at 1673K at various pressure were estimated by liner extrapolation from the results of Holzapfel et al. (2003) and Yamazaki et al. (2003)and the results are shown in Fig. 1. The results of our experiments correspond with that of Yamazaki et al. (2003), but are lower than that of Holzapfel et al. (2003) by about a half log unit.

Yamazaki, et al., Phys. Earth Planet. Interiors. 216 (2003) 301-311

Holzapfel, et al., Phys. Earth Planet. Interiors. 139 (2003) 21-34

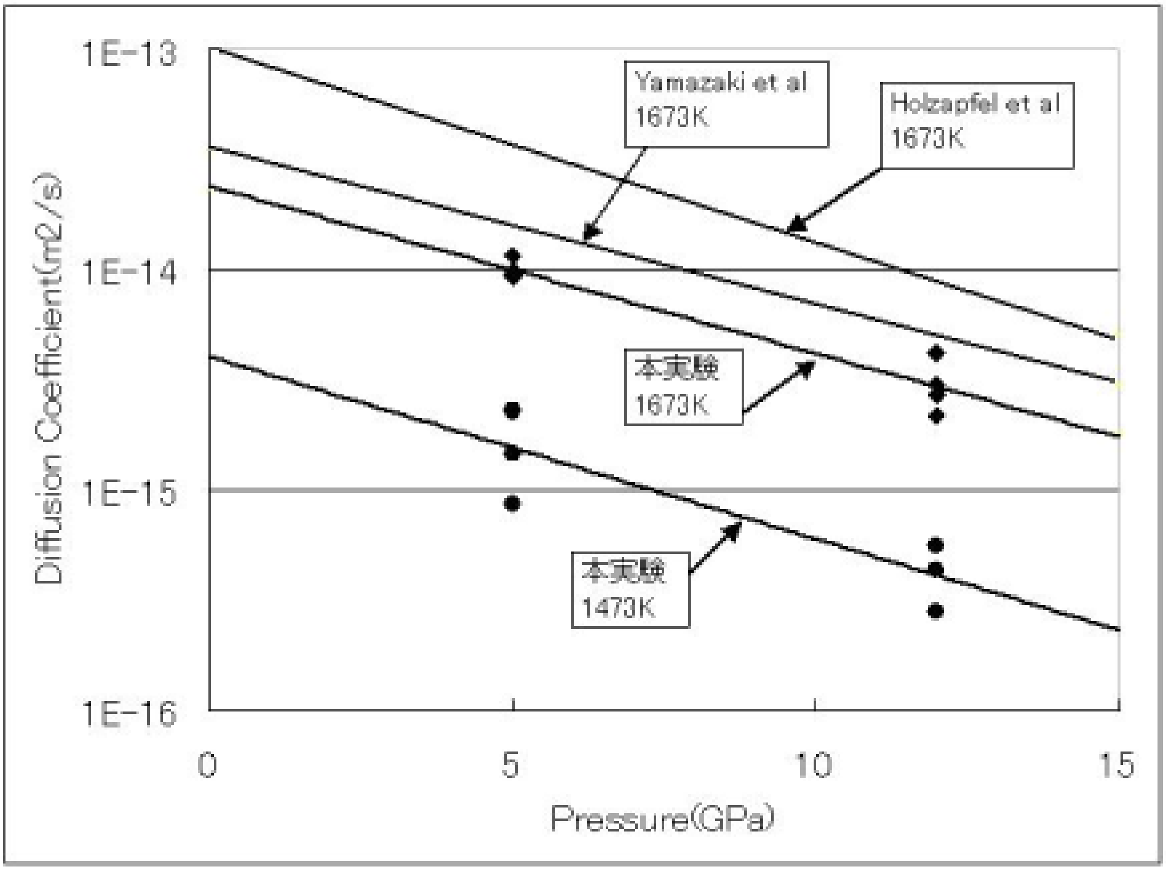

図1 拡散係数の温度圧力依存性