Anisotropy and temperature dependence of Fe-Mg interdiffusion in olivine at 1400-1600oC

Shinnosuke Tamada[1]; Haruka Kawasaki[2]; Shogo Tachibana[3]

[1] Department of Earth and Planetary Physics, The University of Tokyo; [2] none; [3] Earth and Planet. Sci., Univ. of Tokyo

Diffusivity of ions in minerals can be used to incorporate time into studies of various geological processes such as thermal and deformation histories of rocks and minerals. Numerous previous studies have determined Fe-Mg interdiffusion coefficients in olivine, one of the major rock-forming minerals, and have discussed diffusion mechanisms of Fe and Mg within a crystalline structure of olivine. In this study, we present new experimental data on Fe-Mg interdiffusion in olivine in the temperature range of 1400-1600oC, which is higher than that in previous studies, using the diffusion couple technique. Oriented single crystals of synthetic forsterite and San Carlos olivine (Fo91, Fo89) were prepared, and two crystals were aligned along the a-, b-, or c-axis and tied with platinum wire. The diffusion couples were annealed at a desired temperature for 26-73 hours in a one-atmosphere gas-mixing furnace at a controlled oxygen fugacity. The Fe-Mg diffusion profiles were obtained with EPMA, and the interdiffusion coefficients were determined by the Boltzman-Matano analysis.

We found little compositional dependence of the interdiffusion coefficient within the compositional range in this study (Fo100-Fo89). The obtained Fe-Mg interdiffusion coefficients show anisotropy within all the temperature range at fO2 of 10^-7.5 bar; diffusion is fastest and slowest along the c- and a-axis, respectively. The activation energy obtained for the composition of Fo95 was about 210, 290, and 290 kJ/mol along the a-, b- and c-axis, respectively, which is consistent with that obtained at lower temperatures (Misener, 1974; Chakraborty et al., 1997), indicating that Fe-Mg interdiffusion mechanisms at 1400-1600oC are the same as that at lower temperatures. If the Fe-Mg interdiffusion at temperatures lower than 1300oC is controlled by the presence of impurities in olivine (Chakraborty et al., 1997), the diffusion occurs in the extrinsic diffusion regime even at temperatures above 1400oC. We also note that the absolute values of interdiffusion coefficients are smaller than those extrapolated from data obtained at temperatures lower than 1300oC by Misener (1974), but closer to those extrapolated from from data by Chakraborty et al. (1997)

We obtained the Fe-Mg interdiffusion coefficients at fo2 = 10^-7.5, 10^-9.0 and 10^-10.5 bars at 1400oC. Our limited data sets show little dependence of diffusivity on oxygen fugacity, which is not consistent with that for Ni diffusion in olivine (Petry et al., 2004).