Si and O diffusion in wadsleyite and ringwoodite

Akira Shimojuku[1]; Tomoaki Kubo[2]; Eiji Ohtani[3]; Tomoki Nakamura[4]; Ryuji Okazaki[5]; Sumit Chakraborty[6]; Ralf Dohmen[6]

[1] Inst.Mineral. Petrol.& Econ. Geol., Faculty of Sci.,Tohoku Univ; [2] Kyushu Univ.; [3] Depart. Earth and Planetary Materials Science, Tohoku Univ; [4] Earth and Planetary Sci., Kyushu Univ.; [5] Dept. of Earth Planet. Sci., Kyushu Univ.; [6] Bochum Univ.

Wadsleyite and ringwoodite is thought to be major constituent minerals in the mantle transition zone. In order to understand rheological properties of the mantle transition zone, it is essential to determine the diffusion rates of the slowest diffusing species which may control plastic deformation. In this study, we conducted Si and O diffusion experiments of $(Mg,Fe)_2SiO_4$ wadsleyite and ringwoodite.

High-pressure experiments were performed using a Kawai-type multi-anvil high pressure apparatus. Starting material of polycrystalline wadsleyite and ringwoodite were synthesized from San Carols olivine single crystal at 16 GPa and 1773 K, and 22 GPa and 1673K, respectively. Surface of the polycrystalline wadsleyite and ringwoodite were polished and then deposited with thin film (200 nm) of $(Mg, Fe)_2SiO_4$ doped with ^{18}O and ^{29}Si using pulsed laser deposition installed at Bochum University (Dohmen et al. 2002). In wadsleyite, diffusion experiments were conducted at 16 GPa and 1673-1873 K. In ringwoodite, diffusion experiments were carried out at 22 GPa and 1673-1873 K. After the annealing, concentration profiles of ^{29}Si and ^{18}O were obtained by the depth profiling method using secondary ion mass spectrometry installed at Kyusyu University.

In both wadsleyite and ringwoodite, it was found that Si diffusion rates are about one order of magnitude slower than O diffusion. Si is the slowest diffusing element in both wadsleyite and ringwoodite compared with previously reported Mg-Fe interdiffusion rates (e.g., Kubo et al. 2004). Therefore, Si is likely to be rate-controlling species in high-temperature creep processes involving diffusion creep and climb-controlled dislocation creep.

References

R. Dohmen et al. (2002) Eur. J. Mineral., 14, 1151-1168

T. Kubo et al. (2004) Phys. Chem. Miner., 31, 456-464.