

Direct Observation of Mg/Si Ratios of H₂O Fluids Coexisting with Mantle Minerals Under High Temperature and Pressure Conditions

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H₂O affects almost all physico-chemical characteristics of the earth forming materials. H₂O can dissolve some degrees of silicate components in high pressure and temperature conditions. Stalder et al., (2001 Contrib Mineral Petrol) and Mibe et al. (2001, submitted to Geochim Cosmochim Acta) performed quench experiments in the MgO-SiO₂-H₂O system with Kawai type multi anvil apparatus. They suggested H₂O fluids coexisting with enstatite (MgSiO₃) and forsterite (Mg₂SiO₄) become more Mg/Si ratios as pressure increases in a pressure range from 1 GPa to 10 GPa.

We conducted a series of X-ray diffraction experiments at BL04B2 in SPring 8 in a pressure range from 0.5 GPa to 5 GPa and a temperature range from 800 to 1000C, using a Bassett type externally heated diamond anvil cell (Bassett et al., 1993, Rev. Sci. Inst.). The following three systems were investigated: de-ionized water with synthesized MgSiO₃ crystals, Mg₂SiO₄ crystals, and glass of MgSiO₃ compositions. A collimated synchrotron beam with a diameter from 40 to 100 μ m was exposed for three minutes and the X-ray diffraction was recorded on the imaging plate at a given temperature. The temperature was monitored using thermocouples that were calibrated using melting temperatures of NaNO₃, CsCl, and NaCl. The temperature gradient in the sample was believed to be within several degrees.

We identified crystalline phases coexisting with H₂O fluids and estimate possible Mg/Si ratios of H₂O fluids in the high temperature and pressure conditions. At a pressure range from 0.5 to 1 GPa, Mg₂SiO₄ was observed at the system of MgSiO₃ and H₂O. This indicates that chemical compositions of H₂O fluids coexisting with MgSiO₃ are enriched in SiO₂ component. At around from 1 to 5 GPa, MgSiO₃ and Mg₂SiO₄ are found to dissolve into the H₂O fluid congruently. This suggests that the H₂O fluids have silicate components with 1 - 2 Mg/Si atomic ratios in these conditions. It is likely to conclude that H₂O fluids become more Mg/Si ratios with increasing pressure in the investigated PT conditions, which is consistent with the results based on the quench experiments by the previous workers. The present method using in-situ determination of crystalline phases coexisting with fluid phases can put constraints on the H₂O chemistry in the earth's mantle.