

Phase equilibrium in the system of MgO-FeO-SiO₂ to 50 GPa

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Mantle is the largest part in the solid Earth and compartmented to upper and lower part by the 660 km seismic discontinuity. In the Earth's lower mantle, it is widely accepted that (Mg,Fe)SiO₃-magnesian silicate perovskite (Pv) and (Mg,Fe)O-magnesiowustite (Mw) are dominant minerals. Therefore MgO-FeO-SiO₂ system is the most fundamental system to understand the mantle dynamics and evolution history. Previously, high-pressure and high-temperature phase equilibrium in that system was studied a number of times using various experimental device. Those results were well summarized in Mao et al. (1997). In experiments performed using Kawai-type multi anvil apparatus, which has advantage to produce stable high-pressure and high-temperature conditions, experimental pressure was limited to 27 GPa, corresponding to the uppermost lower mantle, by the mechanical strength of tungsten carbide second stage anvils. For that reason, in high-pressure and high-temperature study under deep lower mantle conditions, almost all experiments were performed by laser-heated diamond anvil-cell. We used the sintered diamond (SD) as second stage anvils and have established the experimental method to reproduce deeper conditions in lower mantle using Kawai-type multi anvil apparatus.

High-pressure and high-temperature experiments were performed using Kawai-type multi anvil apparatus of SPEED Mk.II installed in BL04B1, SPring-8 and Sakura-2500 installed in Magma Factory, Tokyo Institute of Technology. 14 mm SD cubes with truncated edge length of 2.0 mm were used as second stage anvils and enabled to generate higher pressure than 30 GPa. Starting material of clino-pyroxene has the composition of (Mg_{0.53},Fe_{0.47})SiO₃ was synthesized in the controlled fugacity to eliminate the ferric iron. After heating duration, samples were quenched and recovered to the ambient condition. Present phases in the recovered products were confirmed by X-ray diffraction measurement and chemical compositions were measured using EPMA. A total of 8 experiments were performed at 1500 and 2000 C on broad pressures up to 48 GPa. In the every recovered sample, it was confirmed that Pv, Mw and stishovite were coexisting from X-ray diffraction measurement. In the result, maximum solubility limit of iron content in perovskite expands above 30 mol% as pressure and temperature increase. In addition, FeO content of coexisting Mw has large pressure dependence under uppermost lower mantle conditions and dramatically increasing up to 90 mol% at each temperature. In the consequence of that, partition coefficient of Mg-Fe between Pv and Mw significantly decreased to 0.05 at 2000 C, as pressure increase. This result implies that ferrous iron would concentrate in Mw, and Pv would have little ferrous iron content in the mid lower mantle.