

Precise determination of olivine-wadsleyite transition in $(\text{Mg,Fe})_2\text{SiO}_4$

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We determined phase relations of olivine-wadsleyite transition in $(\text{Mg,Fe})_2\text{SiO}_4$ by combination of pressure determination by in situ X-ray diffractometry and compositional analysis by electron microprobe.

Experiments were conducted using Kawai-type multi-anvil apparatus 'SPEED-1500' at synchrotron radiation facility 'SPring-8'. Starting materials were 1/4 columns of sintered olivine solid solutions with composition of $(\text{Mg}_x\text{Fe}_{1-x})_2\text{SiO}_4$ ($x=0.95, 0.90, 0.85, 0.80$). Experimental temperatures were 1600 and 1900 K, which are measured using a W-Re thermocouple. Generated pressures were calculated from unit cell volume of MgO pressure standard and temperature indicated by the thermocouple.

If we compress the sample at ambient temperature and heat it to desired temperature simply, pressure drops while keeping press load and temperature by 0.5~2 GPa. In order to eliminate pressure drop, we conduct compression and heating as follows. First, the sample was compressed at ambient temperature to a press load that is 100~200 tonf smaller than the final press load. Then we heated the sample to 1000 K at constant press load, and kept the temperature for 10 min. and cooled to ambient temperature. After that, the sample was compressed again to target press load at ambient temperature, and heated to the target temperature. While keeping temperature, we gradually increased press load by 50~200 tonf. By this treatment, we were able to eliminate the pressure drop to 0.2 GPa. Temperature was kept for 20~30 min at 1900 K and for 60~80 min at 1600 K.

We adopted two recent EOS's for MgO to calculate pressure, that is, Matsui scale (Matsui, 2001) and Speziale scale (Speziale et al., 2001). We obtained fairly different pressure values from these two scales. In the following part, we mainly write pressure values obtained using Matsui scale and put values obtained using Speziale scale in brackets.

Center of olivine-wadsleyite loop at 1900 K is located at 13.6 (14.2) GPa at Fo89 composition. The pressure dependence of the loop is 4.6 (4.8) MPa/K. If we assume that olivine-wadsleyite transition occurred at 410 km depth in the mantle, that is, at pressure of 13.8 GPa, the temperature at this depth is found to be 1940 (1810) K. In this case, the thickness of the loop is found to be 12 (14) km. The partition coefficient of Fe and Mg between olivine and wadsleyite is found to be 0.6.

Neele (1996) suggested that the effective thickness of the 410-km discontinuity is 4 km. If we estimate that the effective thickness is half of real thickness of the loop, the observation by Neele (1996) is difficult to explain in view of olivine-wadsleyite transition in $(\text{Mg}_{0.89}\text{Fe}_{0.11})_2\text{SiO}_4$.