Postspinel transition in Mg2SiO4

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We have determined the reaction boundary between Mg2SiO4 spinel and MgSiO3 perovskite + MgO periclase using 6-8 type high-pressure apparatus by in situ X-ray diffractometry in the temperature range of 1600-2050 K. it is shown that the boundary is located at ca. 22 GPa. Although this pressure is ca. 1 GPa lower than that of 660-km discontinuity, this discrepancy could be explained by the inaccuracy of the EOS of Au pressure maker. The dP/dT of the boundary is –0.6~1.2 MPa/K, which is significantly lower than those obtained by the previous studies. The topology of 660-km discontinuity associated with the tectonic setting cannot be explained by the temperature effect.

The 660-km seismic discontinuity is usually attributed to the dissociation reaction of (Mg.Fe)2SiO4 spinel to (Mg,Fe)SiO3 perovskite + (Mg.Fe)O periclase (post-spinel transition), and therefore, this reaction is studied by many workers. In this study, we have determined the phase boundary of the post-spinel transition in Mg2SiO4 by high-pressure in situ X-ray diffractometry.

The starting material is a mixture of forsterite and gold. The high-pressure and temperature experiment is carried out using the 6-8 type multi-anvil press SPEED-1500 installed in the beam line BL04B1 at SPring-8. The energy dispersive type of X-ray diffractometry is conducted by white X-ray and a solid state detector with diffraction angle of 4.9º. Temperatures are monitored using W3Re-W25Re thermocouple, and pressures are estimated from the volume of the gold pressure maker using the EOS proposed by Anderson et al. [1989]. The temperature and pressure ranges are 1300-2050 K and 20-25 GPa, respectively.

We have determined the reaction boundary in the temperature range of 1600-2050 K. The boundary is located at ca. 22 GPa. Its gradient is dP/dT = –0.6~1.2 MPa/K. The transition pressure obtained here is ca. 1 GPa lower than that of the 660-km discontinuity. However, the accuracy of the EOS of gold has some uncertainty at present. By choosing the value of pressure derivative of the bulk modulus, the pressure of the post-spinel transition could be reconciled with the depth of 660-km discontinuity.

The dP/dT obtained in this study is much smaller than those by the previous studies. Ito & Takahashi [1989] have determined the boundary by means of the quench method. They could have obtained the large negative dP/dT due to the kinetic effect. However, Irifune et al. [1998] determined the boundary with almost the same method as ours, and therefore, the discrepancy between results in our and their studies is difficult to explain.

Some seismological study shows that the 660-km discontinuity below subduction zones is depressed by ~30 km. In previous explanations, temperatures of such regions are lower than those of the surrounding mantle due to the cold slabs, and the discontinuity is depressed because of the negative dP/dT slope of the post-spinel transition. Such explanation is, however, invalid from our new results. Our preliminary study implies that the presence of water could elevate the post-spinel transition pressure, and therefore, the depression could be explained by the water carried by the subducted slabs into the deep mantle.

Some seismological study also shows that some subducted slab cannot enter the lower mantle and stays near the 660-km dicontinuity. Such observation is also explained by the temperature effect, which is also not valid from our results. This phenomena could be explained by the kinetic effect of the phase transition.

Numerical studies suggests that the post spinel transition could be a barrier of the mantle convection if its dP/dT is larger than -2~-3 MPa/K. The present study demonstrates that the dP/dT of the post spinel transition is too small that the post spinel transition would work as a barrier of the mantle convection.