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Comparison of postspinel transition boundaries in pyrolite and Mg2SiO4

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The mantle transition zone-lower mantle boundary (660 km discontinuity) is considered to be due to decomposition from spinel phase to perovskite phase and rocksalt phase (postspinel transition). Precise phase relations in $Mg_2SiO_4$and pyrolite which has a representative composition of the upper mantle have been examined with quench and in situ X-ray diffraction experiments. But it is still discussed whether this transition really corresponds to the 660 km discontinuity or not, because there are problems of uncertainty of pressure in pressure scales, and so on. Therefore, we compared postspinel transition in pyrolite and $Mg_2SiO_4$by examining the phase relations at P, T conditions of around 660 km discontinuity with a multicell technique. We also compared phase boundaries of formation of perovskite in $Mg_2SiO_4$and $MgSiO_3$.

Mg_2SiO_4forsterite was synthesized from a mixture of MgO and $SiO_2$with a 2:1 mole ratio by heating for 75 hours at 1500C. $MgSiO_3$enstatite was synthesized as follows. A mixture of MgO and $SiO_2$with a 1:1 mole ratio was heated for 1 hour at 1670C and quenched to form $MgSiO_3$glass. The glass was crystallized into enstatite by heating for 63 hour at 1300C. Pyrolite was prepared by mixing SiO_2(44.98), TiO_2(0.20), Al_2O_3(4.45), Cr_2O_3(0.38), FeO(8.05), NiO(0.25), MgO(37.78), CaO(3.55) and Na_2O(0.36), where numbers in parentheses are contents in wt%. High-pressure experiments were made at 21-25 GPa and 1400-1800C with a 6-8 type multianvil apparatus. Three samples were packed in three holes in a Re capsule, kept simultaneously at desired pressure -temperature conditions for 2-6 hours, quenched and recovered after the run. Phase identification of each sample was made with a microfocus X-ray diffraction apparatus, and compositional analyses of them were made with a SEM-EDS(Scanning electron microscope with Energy dispersive X-ray spectrometer).

The experimental results indicate that a part of garnet in pyrolite first transforms to ilmenite, and subsequently transforms to perovskite at temperatures lower than 1500C. A part of spinel in pyrolite is dissociated into garnet and magnesiowustite, and then garnet transforms to perovskite at temperatures higher than 1700C.When we compare postspinel transition boundaries in Mg_2SiO_4 and pyrolite, the postspinel transition in pyrolite occurs at lower pressure than that of Mg_2SiO_4 within about 0.5 GPa. The reason why pyrolite and Mg_2SiO_4have the different phase relations and transition pressures is that pyrolite contains minor components of Fe, Al, Ca, and so on. When we also compare phase boundaries of formation of perovskite in $Mg_2SiO_4$and $MgSiO_3$, the two boundaries have almost the same slopes.

Keywords: pyrolite, postspinel, 660 km discontinuity, Mg2SiO4, MgSiO3, High-pressure experiment