Post-Perovskite Phase Transition in Silicate and Mineralogy in the Lowermost Mantle

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A recent discovery of post-perovskite phase (MgPP) in pure $MgSiO_3$ composition suggests that a primary lower mantle mineral of $MgSiO_3$-rich perovskite (MgPv) undergoes structural phase transition near the base of the mantle. However, the effects of other major elements in the mantle such as iron and aluminum on the stability of MgPP are not known yet. In addition, knowledge of the element partitioning between MgPP and coexisting phases is also of great importance because it strongly affects the geophysical and geochemical properties of the lowermost mantle. Here we report the post-perovskite phase transition in a natural primitive mantle composition and the phase chemistry of the lowermost mantle by a combination of in-situ x-ray diffraction measurements in a laser-heated diamond anvil cell and chemical analyses on recovered samples using transmission electron microscope (TEM). Nine separate experiments were conducted at pressures from 38 to 126 GPa and temperatures form 1950 to 2550 K along the typical temperature profile in the lower mantle. Starting material was a gel with a chemical composition of KLB-1 peridotite, which has a primitive mantle composition. The sample was covered with a thin film of gold for both sides that served as an internal pressure standard and a laser absorber. It was loaded into a rhenium gasket, together with insulation layers of NaCl except one experiment at 126 GPa in which the sample was sandwiched by pure KLB-1 gel layers. Heating was achieved by a focused multimode continuous wave Nd:YAG laser using the double-sided heating technique.

We confirmed three-phase assemblage of MgPv + (Mg,Fe)O magnesiowüstite (Mw) + $CaSiO_3$-rich perovskite (CaPv) up to 92 GPa. At higher pressures above 115 GPa, the mineral assemblage changed to MgPP + Mw + CaPv, and MgPv was not observed. Minor modification of perovskite structure in MgPv proposed by Shim et al., (2001) was not found. Mw retains a rocksalt structure throughout the P-T conditions in the present study. CaPv adopts cubic structure at high temperatures and a distortion to tetragonal structure of CaPv at room temperature was clearly recognized above 114 GPa. Chemical analyses of these coexisting phases show that distribution of iron significantly changes at the post-perovskite phase transition. The Fe-Mg partition coefficient between MgPP and Mw shows that iron partitions predominantly into Mw, implying MgPP contains small amount of iron much less than MgPv. These results demonstrates that post-perovskite phase transition occurs at about 2500-km depth in the mantle (~400-km above the core-mantle boundary) and that the primitive lowermost mantle consists of 72% iron-poor MgPP, 21% iron-rich Mw, and 7% CaPv. A strong partitioning of iron into Mw causes unique geophysical and

geochemical properties such as viscosity, electrical conductivity or melting reaction in the lowermost mantle.