Sharpness of the post-perovskite phase transition boundary in natural pyrolitic mantle

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Large anomalies in seismic velocities are observed in the deepest several hundred kilometers of the mantle called D" layer. Since the origins of these anomalies were difficult to explain with the known properties of MgSiO3 perovskite, the D" layer has long been the most enigmatic region inside the Earth. The recent discovery of MgSiO3 post-perovskite phase transition at P-T conditions expected near the core-mantle boundary (CMB) has very important implications for the nature and dynamics of this mysterious hidden layer.

Seismological observations frequently show a sharp positive velocity jump, especially for S-wave, between 100 to 300-km above the CMB (D" discontinuity). The first publication on the post-perovskite phase transition by Murakami et al. [2004] suggested that the cause of the D" discontinuity is likely to be this phase transformation, because the transition pressure nearly corresponds to the depth of velocity increase. However, some features remain unexplained. For example, the seismically inferred velocity jump is too large in comparison to the mineral physics predictions. Moreover, the velocity jump occurs in a width ranging from 50 to 70-km [Young and Lay, 1987], which corresponds to the pressure interval of 3 to 4 GPa. Both experiments and theory showed that both perovskite and post-perovskite coexist in much wider pressure interval in the presence of FeO or Al2O3 [Mao et al., 2004; Akber-Knutson et al., 2005]. The sharp discontinuity may require chemical boundary. The sharpness of the post-perovskite phase transition in natural pyrolitic mantle composition needs to be determined.

We examined the post-perovskite phase transition boundary in a natural pyrolitic mantle (KLB-1 peridotite) composition by a combination of in-situ x-ray diffraction measurements and laser-heated diamond-anvil cell (LHDAC) techniques. Present results together with earlier similar work by Murakami et al. [2005] show that phase transition from MgSiO3-rich perovskite to post-perovskite occurs in a narrow pressure range from 108 to 111 GPa at 2000 K, based on the Au pressure scale [Tsuchiya, 2003]. The sharpness of the post-perovskite phase transition boundary in the natural peridotite composition is consistent with the width of D" seismic discontinuity. It supports the phase transformation origin of velocity jump at the top of D" layer.