Stagnant Slab at the 660 km Phase Transformation: Variation of Seismic Discontinuity Depths and Mineral Physics Implications

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Recent tomography models provide stunning images of stagnant slab in the northwestern Pacific. However, structural variation is apparent within the zones of high velocity anomaly (HVA) in the mantle transition zone, for which triplicated regional broadband waveforms have ample information. Here we focus on the velocity models M3.11 and M2.0 (Tajima and Grand, 1995, 1998) which delineate the structure with stagnant slab, in particular, the variation of the discontinuity (phase transformation) depths at around 660 km that is distinguished among the models.

Model M3.11 is consistent with the structure predicted for a cold slab in the stable field of ringwoodite (Ringwood and Irifune, 1988). Model M2.0 is characterized by HVA which is similar to that in M3.11 indicating the existence of a flattened cold slab in the transition zone, but not accompanied by broad depression of the 660 km discontinuity. Taken the profile for the assemblage of ringwoodite, the lack of depression of the 660 km discontinuity may be interpreted with the temperature which is normal beneath the flattened slab. However, the observed change of structure from M3.11 to M2.0 in the northwestern Pacific is more rapid than what can be expected from the temperature gradient associated with cold slab. Instead, we suggest a possibility of change of geochemical properties associated with stagnant slab at the bottom of the upper mantle, in which the contrast of garnet-rich MORB and peridotite involves.

Results of recent experiments under high pressure and temperature conditions are supportive for this hypothesis. Sano et al. (2006) has shown that the Clapeyron slope of hydrous garnet at the phase transformation is positive, and there may be no depression of the phase transformation depth if T is lower than 1200^{o}C. Given this condition, if the region primarily consists of hydrous MORB (garnet) at the bottom of the upper mantle, the structure may be delineated by model M2.0. The distribution of the 660 km discontinuity depths and HVA from our waveform modeling is compared with the images of HVA in the tomography model (Fukao et al., 2001), which provides stable images of stagnant slab but does not have resolution of the discontinuity depths.