A low-velocity layer atop the mantle transition zone beneath Mexican gulf inferred from triplicated P and S waves

*XIN LONG[1], Hitoshi Kawakatsu[1], Nozomu Takeuchi[1]

1. ERI, Univ. of Tokyo

The knowledge to the mantle transition zone (MTZ) is crucial for us to understand the mantle dynamics, especially in the subduction zone where it interacts with a subducting slab. In such a region, a low-velocity layer (LVL) just atop the 410-km discontinuity is often reported (Revenaugh & Sipkin 1994, Song et al. 2004); previous studies, however, suffer large uncertainty due to poor station coverage, and only S waves were analyzed. The origin of the LVL is still unclear, as it seems to be found globally (Tauzin 2010, Wei & Shearer 2017) but does not necessarily correlate with tectonic settings. Volatiles such as water released from MTZ is often invoked to explain the LVL; however, no evidence that there is a relation between the MTZ water content and the LVL atop 410km has been reported, probably due to the lack of the Vp/Vs ratio information.

In this study, we utilize triplicated P and S waves recorded by dense temporary and permanent seismic networks in the US to investigate the MTZ structure beneath the Mexican gulf. For analyzed earthquakes (depth from 75 to 200km) in Central America, B-cusp of triplicated P and/or S wave predicted by ak135 (Kennett et al. 1995) model should be around a distance of 20°, however, AB phase extending beyond 26° is observed. Such extended AB phases do not decay quickly as a general diffracted phase and are dominated by a large negative trough. Only a LVL atop the MTZ could explain this feature because it acts as a waveguide and permits the AB phase to propagate to larger distances. The extended AB phase is only observed for waves that sample the MTZ beneath the central and eastern Mexican gulf and disappears as the ray begins to sample the western margin of the gulf. In addition to the extended AB phase, we also observed anomalously strong P410P and S410S phases that are reflected at the underside of the 410km-discontinuity. For P410P, its ratio to the EF phase is usually 2 times larger than the prediction of the 1D model, and this could be partly attributed to an LVL that increases the velocity contrast across the 410km-discontinuity.

Another possibly related prominent observation is the opposite differential residuals of CD and EF phases (relative to ak135) for P and S waves. Residuals for P wave are almost negative, and for S wave residuals are positive and gradually increase with distance. Because the differential arrival time between CD and EF phase is only sensitive to the velocity around the 660km-discontinutiy, an opposite residual for P and S may suggest a distinctive Vp and Vs relative ak135 (e.g., high Vp and low Vs within MTZ, which suggest a high Vp/Vs ratio). It could be noted that there is an abrupt change for Scd-ef residuals around a longitude of 90°W, which corresponds to the location where the extended AB phase begins to disappear.

2D waveform modeling is conducted for P and S waveforms using AXISEM (Nissen-Meyer et al. 2014), and preliminary results suggest the existence of a 40km thick LVL with generally -4% Vp and -6% Vs relative to ak135 atop MTZ beneath the central Mexican gulf. A MTZ with Vs reduction of 3% and Vp increase of 2% could explain the observed CD-EF differential travel time residuals, which suggests a Vp/Vs ratio of over 1.9. This may indicate a water-rich MTZ beneath the Mexican gulf that is related to the LVL atop the 410km-discontinuity.