Geophysical Research Abstracts
Vol. 13, EGU2011-1787-2, 2011
EGU General Assembly 2011

Seismic observation and numerical modeling for the mantle transition zone with stagnant slabs

Fumiko Tajima (1) and Eiji Ohtani (2)

(1) Ludwig-Maximilians-University (LMU) Munich, Geophysics Section, Earth and Environmental Science, Munich, Germany (tajima@geophysik.uni-muenchen.de), (2) Tohoku University, Graduate School of Science, Sendai, 980-8578, Japan

To supplement large-scale tomography studies, a number of studies examined the finer structure around the mantle transition zone (MTZ) with stagnant slabs using relatively short-wavelength body waveforms, determined structural variation near the discontinuity depths, and interpreted the results with variation of temperature and other properties. Tajima and her co-workers studied the structure associated with stagnant slabs in the northwestern Pacific subduction zones where the MTZ structure is largely represented by M2.0 or M3.11. Here the layered models are characterized by flattened high velocity anomaly (HVA) in MTZ with or without a depression of the 660 km discontinuity depth. Considering only temperature effects on the phase transformation of ringwoodite, the lack of discontinuity depth depression was interpreted with the normal temperature beneath the flattened slabs. However, there are also some anomalous broadened P waveform data which propagated in the vicinity of the layered model data but could not be synthesized with any layered model. The cause was attributed to possible local low velocity anomalies (LVAs) along the propagation paths (Tajima and Grand, 1995, 1998; Tajima and Nakagawa, 2006). The discontinuities in M3.11 and M2.0 are fairly sharp and the lateral gradient between the two structures could be within the extent of several tens of km or less. On the other hand recent high-pressure experiments examined the effects of water on the phase transformations of ringwoodite and majorite under dry and wet conditions, and suggested that the seismically observed depression of the discontinuity to $\sim$690 km could not be explained with slab geotherm alone under dry conditions, but wet conditions are plausible to make the Clapeyron slope of ringwoodite steeper. In contrast the Clapeyron slope of majorite is positive and the discontinuity depth may shift to a shallower depth ($\sim$660 km) under wet condition (see Ohtani and Litasov (2006)). Features observed in our seismic studies are remarkably supportive for the implications provided by the high pressure experiments. Based on these results, a hypothesis of deep water transport by subducted slabs and dehydration near the bottom of the MTZ has been postulated (Tajima et al, 2009, 2010). In this paper we present results of numerical simulation of wave propagation in a 3D model space that accounts for the lateral transition from M3.11 to M2.0 structure with inclusion of an LVA zone (about -10%) near the bottom of the MTZ. P waveform broadening has been produced with the structural transition, and the broadening has been emphasized with an LVA. The gradual lateral transition from M3.11 to M2.0 structure produces somewhat similar effects to the LVA zone on the waveforms. However, the lateral transition should be relatively sharp that is constrained by the observed layered model data located closely to the anomalous waveform data. High pressure experiments also suggest that the hydrogen diffusivities measured for wadsleyite and ringwoodite are small, and the dehydration induced fluids could be produced in a highly local extent of $\sim$10 km or so in a billion years (Hae et al., 2006; Ohtani and Zhao, 2009). In summary we suggest that the MTZ structure beneath the northwestern Pacific Rim supports the hypothesis of deep water transport with slab subduction. The 660 km discontinuity may be sharp or appear to be somewhat broader depending on the propagation paths of waveform data relative to the subduction geometry.