Title: Seismic evidence of localized distribution of dehydration-induced fluids or melts associated with stagnant slabs

Abstract:

I report on seismic evidence of low velocity anomaly (LVA) zones at the bottom of the mantle transition zone (MTZ) associated with stagnant slabs in the northwestern Pacific subduction zones. The LVA zones which are found to be highly localized based on the analysis of regional body waveform data, may represent melts or fluids dehydrated from subducted hydrous mantle minerals. The phase diagram of hydrous mantle minerals indicates dehydration-induced melts or fluids through the phase transformation (Ohtani et al., 2004). Because of the lateral temperature gradient associated with the slab geotherm, such a localized LVA may exist.

First I summarize how the region of large-scale flattened high velocity anomalies (HVAs), i.e., stagnant slab images in tomography models, can be delineated by layered models M3.11, M2.0, or a model with slight modification to these. Here, model M3.11 has HVA in the deeper part of the MTZ and depression of the discontinuity to 690 km. This structure is suitable for the ringwoodite phase transformation with cold temperature anomaly. Model M2.0 has HVA like M3.11 but does not have a depression of the discontinuity. The regions represented by M3.11 adjoin the zones of the M2.0 data. A hypothesis is proposed for the structural variation which may represent the contrast between a hydrous garnet-rich layer (subducted crust) and bulk peridotite at the bottom of the MTZ. This hypothesis is supported by the results of recent laboratory experiments. The garnet-rich layer can flow and descend faster than bulk peridotite as hydrous garnet is weaker and denser than peridotite in the MTZ (Katayama and Karato, 2008). Given that the Clapeyron slope for the hydrous majorite-perovskite transformation is positive (Sano et al., 2006), two zones of HVA with, and without a depression in the discontinuity depth may exist next to each other (Tajima et al., 2009).

Then, I would like to draw your attentions to some anomalous broadened P waves which propagated in the vicinity of the M3.11 or M2.0 data but could not be modeled by any of layered models (note that the source processes of the events are short and simple, and the corresponding SH waveforms did not show such anomaly). Our waveform modeling of up to 1 Hz in 2D and 3D space indicates a highly localized LVA zone (of about -10% anomaly, ~ 300 km long, 5 to 10 km thick) around the turning depths of the seismic rays, which is responsible for broadening the P waveforms due to SV to P conversion. The variation of the discontinuity depths coincides with the segmentation identified at deeper depths (> 629 km) in a P-wave travel-time tomography model although the resolution of the tomography inversion is limited to elaborate the discontinuity structure.