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Evaluation of seismic tomography images: topography of the 660 km discontinuity and anomalous low velocity zones near the bottom of stagnant slabs

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Large-scale seismic tomography studies visualized the images of subducting plates as high velocity anomalies (HVA's), which gradually deflect and flatten to form stagnant slabs in the mantle transition zone (MTZ). The production of stagnant slabs was predicted by mineral physicists more than two decades ago, in that the phase transformation of olivine (ringwoodite) to higher pressure phases may be delayed under cold temperature anomaly, and thus the seismic discontinuity at ∼660 km be depressed. A number of succeeding studies found variation of the discontinuity depths and interpreted the depressed discontinuities as the evidence of stagnation of subducted cold slabs albeit there are normal discontinuity depths found in the region of HVA's. As part of the supplementary efforts to long-wavelength studies, we carried out waveform modeling of relatively short-wavelength regional body waves (∼1Hz, recorded at distances from ∼14 to 30 deg) to verify tomographic images focusing on the MTZ structure in the NW Pacific subduction zones. This waveform modeling has resolving power of the structure near the 660 km discontinuity that is contrasting to tomography modeling of travel-time anomalies alone. Our results show discontinuity depth variation and low velocity anomaly (LVA, ∼-10%) zones in the vicinity. The LVA zones which were modeled with SV-P conversion and scattering are highly localized with the lateral extent of a few hundred km length and several 10's km width. Recent laboratory experiments show clear difference in the measured properties for olivine and garnet under dry and wet conditions (Ohtani and Litasov, 2006), implying that the seismically observed depression of the discontinuity depth should represent cold ringwoodite (high pressure phase of olivine) under wet condition. As lower mantle minerals have much smaller capacity of water content than in the MTZ, dehydration should occur from further descending slabs at the base of the MTZ. The highly local LVA zones may represent the fluids thus created. Our seismic results have been interpreted with variable distribution of geochemical properties and dehydration induced fluids near the bottom of stagnant slabs. Regional tomography studies which usually represent longer-wavelength features and hardly capture the image of such local LVA's can be enhanced in the resolution with quantitative feedback from mineral physics.