High temperature anomalies around the 410-km discontinuity oceanward of the subducting Pacific slab

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We showed the seismic evidences of slow anomalies oceanward of the subducting Pacific slab [Obayashi et al., JEPS, 2002]. The existence of the low velocity anomalies was indicated by the P-wave records of J-array and Hi-net as well as by our P-wave tomographic model. For Bonin earthquakes, the P waveforms at stations in northeast Japan (distance ~ 15 degree) are strongly triplicated because of the 410-km seismic discontinuity. The first arrivals along the prograde branch of the triplication are anomalously fast, the later arrivals along the retrograde branch are anomalously slow. The ray paths indicate that the first arrivals are refractions through the subducted slabs, while the later arrivals are reflections at the 410-km discontinuity oceanward of the subducted slab, consisting with the slow anomalies near the 410-km discontinuity indicated by the tomographic image.

We investigated what a one dimensional P wave velocity model is able to explain the travel time anomalies observed in northeastern Japan. We made synthetic seismograms for the models modified from the IASP91 using propagator matrix method [Wang, 1999] and compare with the observed seismograms. As a result, we conclude that the observed anomalies are explained sufficiently by the existence of fast anomalies around 100 km depth, slow anomalies near the 410-km discontinuity and a depression of the 410-km discontinuity.

The model includes the 30 km depression of the 410-km discontinuity and the 2.6% slow anomaly at 410 km depth compared with the IASP91. The amount of the depression and low velocity are consistent with high temperature anomalies provided that the 410-km discontinuity attributes to the phase transition from olivine to modified spinel. Adopting the coefficient values of dVp/dT= -5.3E-04 km/s/K [Ita and Stixrude, 1992], dh/dT = 0.08 km/K [Katsura and Ito, 1989] (where Vp: P-wave velocity, h: depth of the discontinuity, T: temperature), the high temperature anomaly is estimated at 440 degree C and 375 degree C from the velocity anomaly and the discontinuity depth anomaly, respectively. Allowing for uncertainty in the estimated seismic anomalies, the temperature anomalies estimated from the velocity anomaly and the depression of the discontinuity agree well and are consistently evaluated to be about 400 degree C higher than the surrounding mantle.