

P-wave velocity structure in the subducting crust of the Pacific plate beneath northeast Japan

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It is considered that the low-velocity oceanic crust exists at the uppermost part of the oceanic lithosphere. Water produced by dehydration reactions of hydrous minerals is considered to weaken the strength of faults by increasing pore-fluid pressure and facilitate seismic activity in the oceanic crust. Therefore, it is important to reveal the spatial variation in seismic velocity to understand where fluids are trapped and where dehydration reactions occur in the oceanic crust. However, it is generally difficult to obtain the detailed velocity variation in the oceanic crust, because the direct P- and S-waves from intraslab earthquakes tend to propagate in a short distance in the crust.

It is known that P-to-S converted phases at the plate interface are often observed in seismograms of intraslab earthquakes. Matsuzawa et al. (1986) examined arrival times and amplitudes of PS-converted phases, and suggested the existence of a low-velocity layer at the top of the slab down to a depth of at least 150 km. Here, we follow the strategy of Matsuzawa et al. (1986), and estimate the spatial variation in P-wave velocity in the oceanic crust beneath northeastern (NE) Japan using arrival times of PS-converted waves.

At first, we identified PS-converted waves in seismograms of intraslab earthquakes and obtained 2,798 arrival times of PS converted waves from 305 earthquakes. Before estimating P-wave velocity structure in the oceanic crust, we applied tomographic inversion method of Zhao et al. (1992) to arrival-time data of the direct P and S waves, and estimated 3D seismic velocity structures beneath the entire region of NE Japan. We then relocated earthquakes with the obtained 3D velocity model and determined P-wave velocity in the oceanic crust using arrival-time data of PS-converted waves.

The obtained results show that P-wave velocity in the oceanic crust varies across the arc, with V_p of 6.5-7.5 km/s in the fore arc and 7.5-8.5 km/s in the back arc. P-wave velocity at depths of < 100 km is much lower than the values derived from MORB model beneath NE Japan (Hacker et al., 2003), suggesting the existence of aqueous fluids in the oceanic crust. High seismic activity at depths of 70-90 km (Kita et al., 2006) is located in areas of abundant aqueous fluids. The enhanced pore-fluid pressures and the resultant reduced effective normal stress weaken the strength of the faults sufficiently to bring the system into the brittle regime. Fluid-related embrittlement is probably working for the genesis of crustal earthquakes. Another important observation to be noticed here is that the observed P-wave velocity is almost consistent with the prediction of MORB model at depths of >100 km. This suggests that aqueous fluids in the crust should be released to surroundings at depth of ~100 km, and the fluids thus liberated may contribute to metamorphic reactions in the overlying mantle wedge.

Keywords: PS converted wave, oceanic crust, Pacific slab