Inhomogeneous structure of the uppermost part of the Philippine Sea plate subducted beneath the Kii Peninsula, SW Japan

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The Nankai trough region, off SW Japan, is a famous seismogenic zone of M8 class interplate earthquakes associated with the northwestward subduction of the Philippine Sea (PHS) plate. For the full understanding on physical mechanism of the occurrence of such an interplate earthquake, it is inevitably important to clarify the mechanical properties of the subducted oceanic lithosphere and overlying island arc crust and upper mantle. Considering the spatial variation of frictional property on the plate boundary, the uppermost part of the subducted plate is expected to show strong structural heterogeneity in the down-dip direction. In 2006, an intensive onshore-offshore seismic refraction/wide-angle reflection survey was conducted in the eastern part of the Nankai trough area. This experiment, funded by JAMSTEC, was aimed to elucidate the geometry of the subducted PHS plate and inhomogeneous structure of in and around the recent rupture area of the Tonankai earthquake (M7.9) occurring in 1944. Our offshore line was set to cross the western margin of the asperity area of this event with NW-SE direction.

The onshore seismic line, 87.8 km in length, was laid out in the eastern part of the Kii Peninsula, almost on the northwest extension of the offshore profile line. The geology of the eastern Kii Peninsula is divided to two parts by the Median Tectonic Line (MTL), one of the major tectonic boundaries in SW Japan. It is also noted that surveyed region involves an active area of very low frequency (VLF) earthquakes. Our profile line was crossing this area in its middle part. On this profile, 519 receivers were set to record 5 dynamite shots with 100-400 kg charge. The obtained records were of good quality, and, other than clear first arrivals, several wide-angle reflections were identified as later phases. The most prominent features in the records are very clear and strong reflections which could be traced in almost the entire profile, probably coming from the subducted oceanic crust and its surrounding regions.

The entire structure including the subducted plate was modeled by the forward analyses of the travel times and amplitude based on asymptotic ray theory. The PHS plate in the southernmost part of the onshore line is mapped as a slightly northward dipping reflector at a depth of about 22 km. This depth is almost consistent with the position of the subducted oceanic crust in the northern edge of the offshore profile of our experiment (Nakanishi et al., 2008). The reflection from the PHS is so strong even in the pre-critical region. In order to explain the reflection, a thin (-0.5 km) layer with a relatively low velocity of 3.5-4 km/s is required at the top of the PHS. Our seismic data as well as natural earthquake distribution indicate that the PHS plate change in the subduction angle from 5 to 20 degrees at a distance of 15-20 km from the southern edge of the profile, The reflected waves further north of this bending point are extremely strong and characterized by 0.5-0.7 sec reverberation. Such waveform feature is not modeled by a single low velocity layer as under the southernmost part of the profile, but by a several kilometer thick reflective zone. The top of this reflective zone show flat configration as compared with the northward dipping geometry of the subducted plate. It is interesting that the VLF events are distributed within this reflective zone. The remarkable spatial correspondence between the cluster of VLF events and the reflective zone strongly indicates that dehydrated fluids ascending from the oceanic lithosphere are trapped in the vicinity of the top of the oceanic crust to form strong reflective zone. This fluid movement is considered to be a responsible factor for generating VLF events.