Crust structure of the surrounding oceanic regions determined by using sP depth phase data

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Seismologists have traditionally used the so-called depth phases (e.g., pP, sP, etc.) to locate teleseismic events, in particular, suboceanic earthquakes. Such phases are reflected waves from the surface (or the ocean bottom) with bounce points close to the epicenter, and so their travel times are very sensitive to the focal depth. Hence the hypocenter, in particular, the focal depth can be well constrained with the depth phase data. Umino et al. (1995) first detected sP depth phases from short-period seismograms of local earthquakes in the forearc region under Western Pacific recorded by the seismic stations on the land area of northeast (NE) Japan. They used the sP depth phase to locate accurately the suboceanic earthquakes in the NE Japan forearc. Zhao et al. (2002) first determined the 3-D P-wave velocity structure under the NE Japan forearc using the suboceanic earthquakes relocated with the sP depth phase, and suggested it was a way of tomographic imaging outside a seismic network. Later, several studies have been made to determine 3-D P and S wave velocity structures under the adjacent oceanic areas off Hokkaido, Tohoku, Kanto, and Kyushu (Mishra et al., 2003; Wang and Zhao, 2005, 2006; Zhao et al., 2006).

In this presentation, we summarize these studies using the sP depth phase data. The general procedure of conducting these studies is as follows. We first select a set of oceanic earthquakes which are distributed uniformly in the study area. For each of the selected oceanic events, we detect and pick up sP depth phases from three-component seismograms recorded by the Hi-net stations following the criteria established by Umino et al. (1995). On average, 3 to 4 sP depth phase data can be detected for each of the oceanic events, which are sufficient to locate the events accurately (hypocenter uncertainty smaller than 3 km). Then arrival times of first P and S waves and sP depth phase data from the well-located oceanic events recorded by the Hi-net stations are used jointly to determine the 3-D crust structure. Usually the data from the earthquakes under the land area are also added for conducting the tomographic imaging.

Strong lateral heterogeneities are revealed in the surrounding oceanic regions. An important finding of these studies is that there is a good correlation between the tomographic images along the upper boundary of the subducting Pacific and Philippine Sea slabs and the distribution of large interplate earthquakes (M greater than 7.0) in the forearc regions off Hokkaido, Tohoku and Kyushu. The large thrust earthquakes are located in areas with higher velocity and lower Poisson's ratio. No large earthquakes are found in areas with lower velocity and higher Poisson's ratio, which may represent weakly coupled patches on the slab boundary due to reasons such as the release of water from the slab dehydration. These results suggest that lateral heterogeneities on the slab boundary can affect the rupture nucleation of large thrust earthquakes and the degree of interplate seismic coupling. The approach to determining the 3-D structure outside a seismic network has important implications for the methodology of seismic tomography. It can be applied to many regions of the world where a seismic network exists and earthquakes occur in and around the network. Thus the costly seismic networks can be better exploited for studying seismotectonics and Earth structure.