

## Offshore double-planed shallow seismicity in the NE Japan forearc region revealed by seismic waveform characteristics

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Precise locations of earthquakes and their focal mechanisms in subduction zones promote better understanding of the subduction process of the oceanic plate beneath the overriding plate. A deficiency of seismic network detectability and inadequate distribution of seismic stations will cause some of difficulties in focal depth determination for small offshore shallow earthquakes. Therefore it is difficult to determine precisely focal depths of offshore small shallow earthquakes in the forearc region of subduction zones by the conventional methods using only land-based seismic network data. Gamage et al. (2004) detected sP depth phase at small epicentral distances of about 150 km or more in seismograms of shallow earthquakes in the NE Japan forearc region, and precisely determined their focal depths by using the sP phase. Relocated hypocenter distribution clearly shows the configuration of a double-planed shallow seismic zone beneath the Pacific Ocean. The upper plane has a low dip angle near the Japan Trench, and then its dip angle increases abruptly up to ~30 degree at about 90 km away from the Japan Trench. The lower plane of the double-planed shallow seismic zone is apparently the near-trench counterpart of the lower plane of the double-planed deep seismic zone beneath the NE Japan land area (Umino and Hasegawa, 1975; Hasegawa et al., 1978). The separation between the upper and lower planes is 25-30 km, which is approximately the same as or slightly narrower than that of the double-planed deep seismic zone beneath the land area. Although P wave initial motion data from offshore events are not ideally distributed on the focal sphere, we found that upper plane events occurring near the Japan Trench are characterized by a normal fault and lower plane events by a thrust fault. Characteristics of this focal mechanism distribution are quite opposite to that of the double-planed deep seismic zone beneath the land area.

Seismograms of the lower plane events recorded at seismic stations near the coast of NE Japan appear to be considerably simple; they show distinct direct P- and S-waves, and have occasionally sP depth phase. On the other hand, seismograms of the upper plane events appear to be relatively complicated; they have obscure first P- and S-waves, and have relatively large P and S coda waves after P- and S-waves, respectively. These characteristics of seismic waveforms recorded at land-based seismic stations seem to be related to focal depths of the events. Consequently we will be able to classify those offshore events into the upper and lower plane events by evaluating their seismic waveforms, although sP depth phase can not be detected in the seismograms. Seismograms of offshore shallow earthquakes with magnitude greater than 3 occurring in the period from 2000 to 2004 are systematically analyzed. High-pass-filtered seismograms and those envelopes of the offshore shallow events are used for the analysis. A large number of seismograms show obscure P- and S-waves and many later phases after P- and S-waves: the upper plane seismicity is very active in the subduction zone of NE Japan. Several seismograms have distinct P- and S-waves and only a few later phases: the seismicity of the lower plane of offshore double-planed shallow seismic zone is relatively low in NE Japan.

Those characteristics of seismic waveforms may be explained by considering geometry of seismic ray paths from hypocenters to stations in the subduction zones. In the case of the upper plane events, seismic ray paths go through highly heterogeneous upper portion of the subducting oceanic slab, and it is likely that many later phases are generated by scatterings and/or reflections within the oceanic slab. Seismic ray paths from lower plane events can go through relatively homogeneous middle or lower portion of the oceanic slab, and distinct direct P- and S-waves and very rare later phases may be detected at seismic stations near the coast of NE Japan.