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Characteristic focal mechanisms of the double-planed shallow seismic zone in the northeast Japan forearc region

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Double-planed deep seismic zone is clearly observed within the Pacific slab beneath the NE Japan arc. Predominant focal mechanisms of the upper and lower plane earthquakes are down-dip compressional and down-dip extensional fault types, respectively. Recently, the double-planed shallow seismic zone has been found in the NE Japan forearc region by precise focal depth distribution constrained by arrival times of sP depth phase appearing in local seismograms. Focal mechanisms determined from P?wave initial motions recorded by onshore seismic networks are classified as normal faulting type in the upper, and as thrust faulting type in the lower plane, respectively; however, characterization of the focal mechanisms of the lower plane earthquakes are not enough due to two reasons: 1) Less seismicity in the lower plane than in the upper plane; 2) Poor station coverage on the focal sphere of the onshore P-wave polarities data. In this study, we investigate the focal mechanisms of the lower-plane events in the shallow seismic zone using both on- and offshore seismic observations.

We tried to determine the focal mechanisms of earthquakes whose focal depths were determined by the sP depth phase but no focal mechanisms were given by the previous study. The focal mechanisms were determined by P?wave initial motions observed by not only the onshore seismic networks operated by universities, JMA, and NEID but also by the ocean bottom cabled seismic stations and temporary ocean bottom seismic networks off Miyagi prefecture. The most suitable focal mechanisms for the observed polarities of P?wave initial motion data were determined by using a grid search algorithm.

As a result, focal mechanism solutions of four lower-plane events were precisely determined. The offshore observations helped a lot in constraining the focal mechanisms of these far-offshore earthquakes, especially in their rake angles. All the determined solutions were of thrust faulting type, consistent with the previous study based on the onshore data only (Gamage et al., 2009). Using the classification based on the dip angles of T, B and P axes (Frohlich, 1992), we classified less constrained focal mechanisms of other events having large misfit or poor station coverage . As a result, it was found that the focal mechanisms of the upper plane events are more likely to be normal faulting type whereas the lower plane events are thrust faulting type. We found that the focal mechanisms turn from normal faulting to reverse faulting at 30 km depth, possibly defining the depth of neutral plane. The western edge of normal faulting events along the upper plane is located about 60 km inward from the trench axis. These results suggest that the earthquake-generating stress field in the double-planed shallow and deep seismic zone in the NE Japan arc can be explained by the bending-unbending model of the subducting Pacific plate.