Seismicity along Japan Trench revealed by hybrid method for hypocenter determination using both travel time and waveform analyses

Yoshihiro Ito[1]; Takeshi Iinuma[1]; Makoto MATSUBARA[2]; Kazushige Obara[2]

[1] RCPEV, Graduate School of Sci., Tohoku Univ.; [2] NIED

http://www.aob.geophys.tohoku.ac.jp/˜yito/

The Pacific plate is subducting beneath Tohoku, northeastern Japan, along the Japan Trench. The seismicity along the plate boundary is the highest in the world. The regional seismicity varies from north to south along the Japan Trench. From off Sanriku to off Miyagi, the northern part of the subduction zone, there exist asperities of large earthquakes exceeding a magnitude of 7 and some clusters of small or intermediate earthquakes around the asperities. On the other side, a few large earthquakes occur off Fukushima, the southern part of the subduction zone. Small earthquakes occur actively along the plate boundary. Recently, we revealed the coupling ratio on the plate interface with the help of a geodetic study. In this study, the hypocenters and the moment tensor solutions of small or intermediate earthquakes were first calculated using the hybrid of a waveform analysis and a travel time inversion method. Next, the earthquakes were divided into three categories: (1) interplate earthquakes, (2) crustal earthquakes within the landward plate, and (3) slab earthquakes. Finally, comparing between the backslip distribution and the seismicity, the difference in the seismic activity from off Sanriku to off Fukushima was investigated.

In this method, we determined the hypocenters and focal mechanism by using both the observed waveform and the travel times of P and S waves; this method is henceforth referred to as the hybrid method. First, we calculated the focal depth and focal mechanism at an initial epicenter by the moment tensor inversion method using the waveforms observed at the National Research Institute for Earth Science and Disaster Prevention (NIED) F-net broadband and Hi-net tiltmeter networks. Next, we fixed the focal depth calculated by the moment tensor inversion method and determined the epicenter based on the travel times by using the least square method. The moment tensor inversion method and the least square method were used repeatedly in this hybrid method.

Appling the hybrid method to small or intermediate earthquakes with a moment magnitude ranging from 3.5 to 6.0, we calculated the hypocenters and the moment tensor solutions of the earthquakes occurring beneath the landward slope of the Japan Trench.

The earthquakes were classified into three categories on the basis of the focal depth and the characteristic feature of moment tensor solution. The interplate earthquakes whose focal depths were consistent with the depth of the upper plate boundary and whose moment tensor solutions exhibited a thrust faulting on the plate boundary were chosen from the results.

Comparing between the distributions of the coupling ratio on the plate interface and the interplate seismicity, we obtained the following two results: (1) Interplate earthquakes off Sanriku and off Miyagi occur in regions with a coupling ratio of 0.4 or 0.6 around the strong coupling region; (2) Off Fukushima, interplate earthquakes are distributed along regions with a coupling ratio of 0.6, although large coupling regions do not exist here. These results suggest that small or intermediate earthquakes commonly occur on plate boundaries with a coupling ratio of approximately 0.5. The difference in the seismic activity of small earthquakes may be attributed to the coupling ratio on the plate interface.