Seismic structure around the asperity area of off-Miyagi earthquake, NE Japan using OBSs, land stations and explosives

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In the region off Miyagi, it is suggested that a large earthquake will occur in the near future. Therefore a long-term ocean bottom seismic observation has been performed since 2002. In addition, many seismic surveys using ocean bottom seismometers(OBSs) and controlled sources were carried out. In August 2005, a large thrust-type earthquake (M=7.2) occurred in the estimated source area of future off-Miyagi earthquake. However, a detailed seismic structure around the source area is not still obtained due to its depth. In summer 2004, we conducted an intensive seismic refraction/reflection survey using OBSs, land stations and controlled sources such as airguns and explosives in sea and land. The purposes of this experiment are to obtain detailed P wave velocity structures around the plate boundary including asperities of large earthquakes, and to study amplitude variation of reflected waves from the plate boundary. Two profiles, one is perpendicular to the trench and another is parallel with the trench, pass across the apserities of past and future Off-Miyagi earthquakes. The EW profile, which is 200 km long in the marine area, was extended to the land to obtain a deep structure. The EW line had 22 OBSs at an average interval between 3.5km and 3.8km, and 7 land stations. The NS profile is 300km long, and 21 OBSs were deployed on the trench parallel profile at an interval of 15km. In the marine area, explosives whose charge size was 40 kg were used as seismic sources on the EW line and the trench parallel profile. On the land area, 300kg charge size explosive was used.

After positions of the OBSs, explosives and shot times of explosives were determined, record sections of each OBS and land station were obtained. Two dimensional velocity models beneath two profiles were estimated by a 2-D ray tracing method. We also calculated synthetic record sections using the ray tracing method to estimate detailed velocity structures. After constructing the model, the models were confirmed by calculating resolutions of velocity using an inversion method which used the first arrivals.

Beneath the trench parallel profile, an island arc Moho exists at 22-24 km depth and P-wave velocity of the uppermost mantle is estimated to be 7.9-8.1 km/s. The uppermost mantle of the island arc has lateral heterogeneity of P-wave velocity above the asperities of past large earthquakes. Furthermore, the depth to the plate boundary was estimated to be about 34 km by using travel times of reflected waves. The refracted waves penetrated to a depth of 25 km below the EW line. The structure deeper than 25 km was determined by reflected waves. The dip angles of the subducting plate are 10 degree and 27 degree at distances from the trench axis of 80 - 140 km and 140 -170 km, respectively. The subducting plate is estimated to bend at depths of 25-30 km.

The Pn velocity of mantle wedge beneath island arc in the survey area is comparable to that in the region off Sanriku, and is faster than those in the regions off Fukushima and beneath Tohoku Japan island arc. The dip angle of the subducting plate estimated from this study is consistent with that of a focal solution of the 2005 Off-Miyagi earthquake. Urgent aftershock observation of the 2005 Off-Miyagi earthquake using OBS were carried out. The obtained velocity structure can be compared with the hypocenter distribution of aftershocks determined by the OBSs, and the determined hypocenters are distributed around the plate boundary obtained by this study. The asperity areas of 1981 earthquake and 1978, 2005 earthquakes correspond to the plate boundaries with gentle and steep dip angles, respectively. In addition, boundary of asperities between 1981 and 1978 earthquakes is positioned at the bending point of the subduction plate. A shape of the plate boundary between the landward plate and the subducting oceanic plate may influence rupture of the interplate earthquakes.