Seismic velocity structure and depth variation of the plate boundary around the focal area of the off-Miyagi earthquake

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In the off-Miyagi region, the large earthquakes with thrust mechanisms (M ˜7.5) have occurred at an interval of about 40 years. It is important for studying the occurrence mechanisms of large earthquakes to know the detail structure around the focal area of them. For this purpose, both active and passive source survey were performed in the off-Miyagi forearc region. The results of 3-D seismic tomography using microearthquake observation data in the off-Miyagi forearc region (Yamamoto et al., 2008, GRL) showed that there is structural heterogeneity in the mantle wedge overlying the plate boundary: the Vp of mantle wedge just above the asperities of 1978 and 2005 off-Miyagi earthquakes (Yamanaka and Kikuchi, 2004, JGR; Yaginuma et al., 2006, EPS) is large (˜8.0 km/s), while the Vp in the mantle wedge tend to have smaller value (˜7.5 km/s) around the asperities. On the contrary to this, the result of the active-source experiment made in the same area shows that the Pn velocity, which is the Vp of the uppermost mantle wedge, is almost homogeneous (˜8.0 km/s) with perturbations of ˜0.1 km/s (Watanabe et al., 2005, AGU). Shinohara et al. (2008, JPGU) supposed that vertical heterogeneity of the mantle could be the cause of the inconsistency between the results obtained passive and active seismic studies. Moreover, the shape of the plate boundary estimated from the passive source study does not agree with that from active source study. From the tomographic study using both active and passive source data, it becomes clear that the low velocity zone in the continental lower crust is needed to explain both active and passive source data (Yamamoto et al., 2008 ASC). We think that the existence of such as low velocity layer in the lower crust is unrealistic.

Since hypocenter parameters of the active source data were known, we inferred that there were some problems in the passive source data. Reviewing the passive source data, it cleared that the initial hypocenters were already deeper than the plate boundary estimated from active source study. Relocated hypocenters moved to deeper part in the process of tomographic inversion. From these features, it is suggested that there is a possibility that the initial hypocenter location and initial velocity structure are unsuitable.

In this study, we assumed that almost all earthquakes in the forearc region occurred around the plate boundary estimated by active source study. We found that the initial velocity model, which has higher Vp and higher Vp/Vs in the forearc region than previous study, is efficient to relocate the hypocenters around the plate boundary. Using this velocity model, we obtained the new initial hypocenters. The occurrence time of earthquakes delayed 1.0 sec on average compared with JMA catalogue. Next, we performed the seismic tomography using new initial hypocenters, but only passive source data. Relocated hypocenters were slightly deeper than initial hypocenters, but located relatively closer to the plate boundary. The structural feature around the plate boundary is similar with the previous passive source study. Now we are performing further examinations about modeling the initial velocity structure. To clarify whether vertical heterogeneity in the mantle wedge exists or not, we will perform a tomographic study by using both active and passive source data with suitable initial velocity model.