Seismic structure of the seismogenic subduction plate interface in the northeastern Japan arc

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Active interplate seismicity along the plate boundary between the subducting Pacific plate and the overriding the northeastern Japan arc characterize the landward slope area of the Japan Trench. The spatial distribution of rupture areas of large earthquakes and the background microseismicity is considerably heterogeneous, suggesting that the state of the plate coupling is quite different from place to place along the trench. Recent results of offshore seismic explorations and seismic tomographic studies using OBS data conducted along the Japan trench have shown that there are many correspondences between the seismic velocity structure and the patterns of the interplate seismicity.

The seismogenic part of the plate boundary does not extend to the trench axis (TA) of the Japan Trench, as well as in most of the subduction zones in the world. The width of the aseismic part of the inner side of the trench is significantly different along the arc; about 30 km in the northern part while nearly 100 km in the southern part. The extent of the aseismic zone usually corresponds to that of the low velocity sedimentary materials accumulated along the inner trench wall (Tsuru et al., 2002). In the middle part of the Japan Trench, there is an evident area of low seismicity. Fujie et al., (2002) pointed out that the reflection intensity of the plate boundary is much larger in the low seismicity zone than the surroundings. They explain the variation of the strength of the seismic reflection signals are due to the heterogeneous distribution of the low velocity materials along the plate boundary. The existence of the low velocity material may increase the reflectivity but may decrease the interplate seismicity, and therefore, the correlation between the reflection intensity and the seismicity arises.

The dip angle of the subducting Pacific plate has come to be considered as another important factor controlling the plate coupling. The dip angle is very gentle near TA, suddenly increases to more than 20 degrees at ˜100 km landward from TA. It is noteworthy that the location of the asperities of large interplate earthquakes, zones of large coseismic slip (Yamanaka and Kikuchi, 2004) tend to be located along the location of change in the slab dip angle. Ito et al. (2004, 2005), who investigated the shape of the plate boundary in the rupture areas of the 1994 Sariku and 1978 earthquakes, reported that the increase of the dip angle is not gradual but discontinuous. They further pointed out that the extent of the asperities seems to be delimited by the bending points.

On the other hand, recent results from seismic tomographic studies have shown the correlation between the heterogeneity of the overriding plate and the spatial variation of the interplate seismic coupling, in the spatial scale of 20 km or more. In the landward half of the seismogenic part of the plate boundary in the northern part, no large interplate earthquakes has ever recorded although there is very active microseismicity. Recent studies (Mishra et al., 2003; Kuwano et al., 2005; Yamamoto et al., 2005) indicate that the mantle wedge of this part is characterized by significant low velocity anomaly.

Although it is still difficult to present a comprehensive model to explain how the seismic structure relate to the coupling behavior at this moment, it is certain that the combination of the heterogeneities of the intervening materials along the plate boundary, the slab geometry and the overriding materials makes up the complicated pattern of the interplate seismic activity in the Japan trench subduction zone.