Seismic velocity structure and seismic activity around the rupture area of the 1994 Sanriku-Oki earthquake

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Seismic activity is extremely active around the plate boundary in the northeastern Japan subduction zone. Around the rupture area of the 1994 Sanriku-Oki earthquake, recent seismological and geodetic researches have shown that the locations of asperities are persistent in the earthquake cycle, and that distributions of aseismic slips and coseismic ruptures are mutually exclusive. These observations suggest that the spatial variation of the interplate coupling is prescribed by heterogeneities of the structure on the plate boundary and spatial correlations between the seismic structure and the seismicity have become to be sought. However, the knowledge of the seismological structure, especially in 3D view, is not enough to discuss the cause of the asperity or the aseismic slip because of a dearth of offshore observations.

We estimated the three dimensional seismic velocity structure and precise hypocenter distribution around the rupture area of the 1994 Sanriku-Oki earthquake by combining arrival time data obtained by three OBS observation experiments conducted in this area and the land seismic network operated by Tohoku University. Hypocenters were relocated along a landward dipping slope, suggesting that the seismic activity is concentrated along the plate boundary. Upper 20 km of the focal distribution is in very good agreement with the plate boundary interface revealed by a previous seismic refraction experiment. Below the concentration of hypocenters there exists a low Vp zone, which is interpreted as the subducting oceanic crust. The Moho of the overriding island arc crust shows a considerable undulation trending in NW-SE, oblique to the dip of the subduction interface. Thus obtained seismic structure shows remarkable correspondences with the interplate seismic activity as follows: (1) Around the up-dip limit of the seismogenic zone, where pre- and post-seismic slips prevail, the upper crustal layer of the island arc is underlain by the subducting oceanic crust. (2) The rupture of the main shock of the 1994 earthquake started at the forefront of the lower crustal layer of the overriding plate. (3) The extent of one of the asperities corresponds well to the contact between the lower crustal layer and subducting oceanic crust. (4) The area of the significant post seismic slip is overlaid by the wedge mantle with Vp of over 8 km/s.