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Compressional deformation of the Philippine Sea plate estimated from the seismic activity below the Nankai trough

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Off the Kii peninsula, Dense Observation Network for Earthquake and Tsunami (DONET) has been developed by Japan Agency for Marine-Earth Science and Technology (JAMSTEC). In this study, we determined hypocenters off the Kii Peninsula around the Nankai trough using data obtained from DONET, and discuss about the tectonic background of the seismic activity.

We assumed a layered velocity structure for the hypocenter determination. The velocity structure is based on the investigation by the Research concerning Interaction between the Tokai, Tonankai and Nankai Earthquakes, a project of JAMSTEC (Nakamura et al., 2011). We picked P and S onsets manually and determined the initial hypocenter locations by using the method of Hirata and Matsuura (1987, hypomh). We then used the double-difference method (Waldhauser and Ellsworth, 2000) to obtain detailed hypocenter distribution. We analyzed data between January 2011 and end of October 2012.

The hypocenters distributed below the Nankai trough extending about 100 km along the trough axis and 50 km width, which area well overlaps with the aftershock distribution of the 2004 Off the Kii Peninsula earthquakes. The seismic activity can be distinctly separated into those in the oceanic crust and uppermost mantle. A few earthquakes were found in the sedimentary wedge. The activity in the crust can also be divided into several clusters: Cluster A, located in the northeast of the active area, aligns in the ENE-WSW, parallel to the trough axis. About 20 km south of this activity is Cluster B, trending in the NNE-SSW almost parallel to the trough axis. Southwest of these clusters, intensive seismicity trending in the NS is found (Cluster C), perpendicular to the trough axis. The activity in the uppermost mantle is aligned on a plane striking parallel to the trough axis and dipping to the southeast. We also found an activity distributed on a plane dipping to the northwest.

Southeast of Cluster B, the Zenisu ridge is located along the oceanward slope of the Nankai trough. This ridge is considered to be formed by the compressional deformation in the lithosphere of the subducting Philippine Sea plate. The existence of a thrust dipping to the northwest is estimated below the ridge (e.g. Nakanishi et al., 1998; Mazzotti et al., 2002). Mazzotti et al. (2002) tried to explain the distribution of earthquakes around this ridge by the Coulomb stress change due to a slip on the estimated thrust in the mantle. Northwest of the Zenisu ridge, the Paleo-Zenisu ridge is estimated to be subducted below the sedimentary wedge (e.g. Le Pichon et al., 1995). This ridge is also considered to be formed by the compressional deformation of the oceanic plate (e.g. Park et al., 2003). The Paleo-Zenisu ridge is estimated to extend to below the Kumano fore-arc basin (Park et al., 2003), corresponding to the present seismic activity (clusters A and B). Assuming a thrust in the uppermost mantle, the earthquake clusters A and B may correspond to the region of the Coulomb stress increase estimated by Mazzotti et al. (2002).

The present seismic activity infers the existence of a thrust dipping to the southeast in the lithosphere of the subducting Philippine Sea plate below the Paleo-Zenisu ridge. The thrust estimated below the Zenisu ridge dips to the northwest, on the other hand. The location of uplift caused by the thrust does not correspond to the Paleo-Zenisu ridge. Accordingly, the estimated thrust may not be related to the formation of the Paleo-Zenisu ridge. However, we would conclude that the compressional deformation of the Philippine Sea plate still continues; the 2004 earthquakes ruptured the oceanic crust and the seismic activity in the crust and uppermost mantle have been activated afterwards.

Keywords: Nankai trough, Ocean-bottom seismic observations, Paleo-Zenisu ridge