# A detailed hypocenter distribution along the upper boundary of the Philippine Sea plate beneath Kanto and its implications for the cause of repeating earthquakes

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The asperity model explains the diversity of source process and seismic coupling along the plate boundary (Lay & Kanamori, 1981). Although the word ‘‘asperity’’ originally meant a bump on an otherwise smooth surface, seismic studies have inferred asperities from slip and slip-deficit distributions (Sagy & Brodsky, 2009). Recent studies demonstrated the heterogeneity of seismic coupling along the plate boundary (e.g. Hashimoto et al., 2009).

Subducting seamounts play an important role in controlling the seismic coupling along the subducting plate boundary (e.g. Cloos, 1992). One idea is that a subducting seamount widely increases the normal stress and causes large earthquakes (e.g. Scholz, 1997). On the other hand, global or regional syntheses generally argue for a negative correlation between very large earthquakes and subducting seafloors with large topographic reliefs (Kelleher and McCann, 1976; Kopp, 2013; Loveless et al., 2010; Morgan et al., 2008; Sparkes et al., 2010). The complex structure and heterogeneous stresses of such seafloors provide a favorable condition for aseismic creep and small earthquakes but an unfavorable condition for the generation and propagation of large ruptures (Wang & Bilek, 2011).

Information of the detailed geometry of the plate interface provides an important clue to understand the generation mechanism of interplate earthquakes. In this study, we obtained a detailed hypocenter distribution along the upper plate interface of the Philippine Sea plate beneath Kanto, central Japan, and investigated the effects of geometry of the plate boundary on the generation of interplate earthquakes.

We relocated hypocenters of 6,465 earthquakes which occurred near the upper boundary of the Philippine Sea plate beneath Kanto. We computed cross correlations of P- and S-waves of event pairs with their horizontal inter-event distances less than 5 km. We used 1.5s and 2.5s windows for P- and S-waves, respectively, starting at 0.1s before arrival time. We obtained normalized cross correlation coefficients and the differential times when the normalized cross correlation coefficient higher than 0.85. By adding the 2,286,034 differential time data thus obtained to the 603,274 manually picked arrival time data, we relocated hypocenters by the Double-Difference method (Waldhauser & Ellswoth 2002). To remove the effects of errors of manually picked arrival times, we weighted correlation data strongly in the later iterations. The residuals of differential time reduced from ~113 ms to ~11 ms after 30 times iteration.

Clusters of repeating earthquakes became evident after the hypocenter relocations. The upper boundary of the Philippine Sea plate is sharply defined by those relocated hypocenters. Their distribution is generally consistent with the regional plate model obtained by Hirose et al. (2008) based on hypocenter distribution, focal mechanisms and three-dimensional seismic velocity structure. By examining the distribution of the relocated hypocenters repeating earthquakes in more detail, we noticed that their maximum dip direction and the dip angle significantly differs from those of the regional plate model. For example, the largest cluster (~ 20 km) including many repeating earthquakes beneath southwestern Ibaraki Prefecture has the maximum dip direction of NNE-SSW despite it is NW-SE in the regional plate model. Moreover, the dip angle of the cluster is 10 degrees larger than the plate model. The present observations suggest that this largest cluster as well as other repeating earthquakes are located on the bump of the plate boundary. The cluster of plate boundary earthquakes, which contains many repeating earthquakes, might be caused by the increasing normal stresses due to subducting seamounts.

Keywords: asperity, repeating earthquake, interplate earthquake

 