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Plate Coupling and Deformation of Forearc Sliver in Southwest Japan

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The Philippine Sea plate has subducted beneath southwest Japan at the Nankai Trough. Oblique subduction of the plate and strong coupling on the plate interface have deformed the overriding plate in two different modes: crustal shortening in the direction of plate convergence and long-term lateral movement of the forearc sliver along the Median Tectonic Line (MTL). In this study, we decompose crustal deformation field into these two modes using three-component GPS displacement rates (velocities) from nationwide continuous GEONET and supplementary campaign networks across the MTL.

Horizontal and vertical velocities are obtained from final coordinate (F3) time series at 333 sites of GEONET from Kinki to Kyushu regions during 2004-2009. The original velocity data contain both of the elastic compressional deformation and lateral forearc movement. At first we correct the original velocity data to remove the latter. We assume that the forearc slides at a constant rate along the MTL but its fault plane is fully locked from surface to a depth of 15 km. Next, using the corrected velocity data, we estimate interseismic slip deficit distribution on the plate interface reproduced by more than 500 triangular elements. Then site velocities calculated from the above plate coupling distribution are compared with the original GEONET and campaign velocities. Residuals between the original and calculated velocities illustrate forearc lateral motion and locking effect of the MTL fault plane. Now we can use the residual velocity field to estimate slip-locking distribution on the MTL fault plane. At last we check the first-assumed constant rate of the forearc block motion by comparing it with the estimated slip deficit rate on the MTL. Since no clear evidence of creep motion has been obtained from the surface observation across the MTL, the two rates should agree with one another. In this analysis the optimal rate of the forearc block motion is 5 mm/yr. In the eastern Shikoku the slip pattern is nearly pure strike-slip at a rate of 2-4 mm/yr. In contrast significant normal component is recognized together with strike-slip component of about 5 mm/yr in the western Shikoku.

In the above modeling we assume a constant block rate of the forearc sliver. To investigate internal deformation of the sliver we calculate strain distribution after removing the effect of the plate convergence. We recognize small E-W compression in the eastern Shikoku but the compression is altered by E-W extension in the western Shikoku and the principal axis of the extension rotates counter-clockwise gradually toward a N-S trending in the central Kyushu. This means that the forearc sliver is not absolutely rigid and its driving force is not only the oblique subduction of the plate. Further detailed modeling is needed to better understand deformation mechanism of the forearc sliver.

Keywords: Philippine Sea plate, the Median Tectonic Line, GPS, Nankai Trough