The effect of the steady plate subduction in the case of southwest Japan

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The deformation of the subduction zone expresses the superposition of the elastic coupling and the steady plate subduction. In the former, the elastic coupling on the plate interface corresponds to stress accumulation for the next earthquake. Thus, the earthquake releases the accumulated stress on the plate interface due to the elastic coupling. The accumulated stress due to elastic coupling is not accumulating over the earthquake cycle. In the latter, the steady plate subduction expresses the creeping on the plate interface. Hence, the shear stress on the plate interface does not accumulate within the earthquake cycle. However, the steady plate subduction effect the long-term deformation over the earthquake cycle. In order to understand the process of the subduction zone, the steady plate subduction is essential not only in seismology but also in geomorphology and geology.

In order to evaluate and understand the effect of steady plate subduction, we introduce a three-dimensional finite element (FE) method. Our target area is southwest Japan. We make a FE model that the size of a model region is 1460km×1400km×700km, where southwestern and northeastern corners of the FE model are corresponding to Amami Island and Tohoku region, respectively. The FE model considers the topography, the three-dimensional shape of the Philippine Sea plate and the complex underground structure that the Philippine Sea plate is subducting in the asthenosphere. The FE model consists of four blocks, such as the Philippine Sea plate, oceanic mantle, continental mantle, and crust. The material of mantle assumes a viscoelastic medium. The crust and the Philippine Sea plate assume an elastic medium. To realize the subducting Philippine sea plate, we set up the boundary condition. The kinematic expression of the Philippine Sea plate is the relative plate motion along the plate interfaces, which are both upper and bottom surfaces of the Philippine Sea plate. In this study, the relative plate motion at each point is expressed by the Euler pole.

As a result, the simulated long-term vertical deformation correlates with topography. The feature of large scale topography, such as the Seto Inland Sea, Kii mountain, Hyuganada and so on, are well reproduced. For the shear stress on the plate interface, The depth-dependent variation is available. There is small shear stress on the plate interface at deeper than Moho depth because of shear stress relaxed by a viscoelastic medium. At shallower than the Moho depth, although the shear stress is available, the direction of shear stress is different from the direction of the Philippine Sea plate because the three-dimensional shape of the Philippine sea plate produces the shear stress on the plate interface. For normal stress on the plate interface, the normal stress on the plate interface is more significant than shear stress. The normal stress produces long-term vertical deformation and tectonic stress distribution. Hence, the tectonic stress around subduction zone produced by dominantly normal stress. The normal stress on the plate interface does not relate with the curvature of the plate interface but is due to the curvature changing rate.

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