Shear stress and earthquake mechanism of a shallow subduction zone as inferred from elastic plate models

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Shear stress characteristics of a shallow subduction zone are investigated based on elastic plate models. One of the basic models examined is the plate model UMB-Plate (Yoshida, 2015; 2016). Young’s moduli and Poisson’s ratios for the oceanic (Plate 1) and continental (Plate 2) plates and the upper mantle (LMS) are adopted from those used in the study of earthquake cycle simulation in southwest Japan (Hori et al., 2004). Two transitional layers at the plate boundary (PB) between Pate 1 and Plate 2 and the upper mantle boundary (UMB) between Plate 1 and LMS are assumed in the model, which correspond to low viscosity layers (Seno, 2001). Young’s modulus of mild steel of rubber-like-elasticity and Poisson’s ratio of elastic rubber are used for the PB and UMB.
The shear stress is calculated using the finite element method in the case of plane strain. The plate model with the thickness of 30 km and the length of 60 km is rather close to the vertical cross section of the crust and upper mantle in the Tokai district, southwest Japan. The shear stresses calculated show that they are mostly negative for Plate 1 and positive for Plate 2 and PB. A positive shear stress zone exists in a deeper part beneath the trough at depths of 10-25 km. Comparing these shear stress pattern with several earthquake mechanisms near the Suruga trough (JMA, 2009), normal fault earthquakes are located inside the subduction zone of the negative shear stress area. On the other hand, reverse fault earthquakes are located at the land side of the positive shear stress area.
Shearing force is a couple of forces acting on two sides of a minute particle of matter. If the mechanical property of shearing force is taken into consideration, the shear stress pattern obtained in the present coordinates system suggests that the shearing force acts counterclockwise toward the oceanic side in the subduction zone while it acts clockwise toward the land side in the continental plate. The shear stress calculated depends on the elastic plate model. It is necessary for us to improve the subducting oceanic plate model so that we can appropriately represent the shear stress field near the Suruga trough.
References
Yoshida, M., 2015, Sher stress distributions of a subduction zone as inferred from elastic plate models, Japan Geoscience Union Meeting, SSS30-01.
Yoshida, M., 2016, Slab pull force and shear stress of a subduction zone as inferred from elastic plate models, Proceedings of the 35th Japan Simulation Conference, Japan Society of Simulation and Technology, 165-168.
Hori, T., M. Hyodo, K. Hirahara, 2004, Toward large scale numerical simulations of earthquake cycles on faults in a three-dimensional inhomogeneous viscoelastic medium, BUTSURI-TANSA, 57, 639-649.
Seno, T., 2001, Part 2 Fundamentals of plate tectonics (in Japanese), Asakura Publishing Co. Ltd., Tokyo, 124-142.
JMA, 2009, Saigaiji Shizen Gensho Houkokusho (Disaster Natural Phenomena Report), Tokyo Regional Headquarters, Japan Meteorological Agency, No. 1, 25-27.
Yamanaka, Y. and T. Seno, 1993, A unified model of the stress state in subducting slabs, EOS, Trans. Am. Geophys. Union, 74, 91.

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