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Development of heterogeneous rheological model of the Tohoku Island arc-trench system

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Subduction zone earthquake cycles can be characterized by various deformation processes taking place around the plate boundary and surrounding area. For example, after slip, viscoelastic relaxation and locking of the plate boundary are three primary processes among them. In order to illuminate the recovery of plate coupling after the Mw 9.0 Tohoku-Oki earthquake and strain budgets of island arc during cycles, the detailed viscoelastic structure of the Tohoku region is developed using seismologically determined subsurface structures and densely measured geothermal gradient data. The model is oriented perpendicular to the Japan Trench and also transects an area of large coseismic slip of the 2011 Tohoku Oki earthquake. Petrological model proposed by the laboratory measurement of seismic velocity of various rocks [Nishimoto et al., 2005] was utilized to infer rheologically major minerals from seismic velocity structures. We used geothermal gradient data from the inland Hi-net borehole [Matsumoto, 2007], as well as geothermal gradient data compiled from around Japan [Tanaka et al., 2004]. The strain-rate-dependent, steady state effective viscosity was calculated using constitutive laws of various rocks under the assumption of homogeneous geologic shortening rate [Sato, 1989]. The calculated viscosity structures show lateral viscosity gradients both parallel and normal to the trench axis. Moreover, the minimum viscosities are predicted to be 10^{19} Pa s in the mantle wedge and 10^{20} Pa s in the oceanic mantle. The values are consistent with previous estimates obtained by postseismic deformation analysis of subduction zone earthquakes with similar magnitudes (Mw ˜9). However those minimum values only appear in depths of 30-100 km in the upper mantle and the viscosity increases further with depths because of the pressure hardening effect. Taking the high values of viscosities in shallower part of the lithosphere, the thickness of high viscous layers found to have lateral variations implying the heterogeneous elastic layer thickness. Model viscosity structures of the Tohoku region utilizing realistic temperature and rheological properties of rocks can be used to evaluate the effect of rheological heterogeneity in the postseismic deformation field of the Tohoku-Oki earthquake observed by dense network of geodetic observations. In the presentation, we will mention the detailed information on the choice of the flaw law parameters, and physical and ambient conditions for NE Japan to calculate the viscosity structures. We also show how these heterogeneities affect the crustal deformation of the NE Japan during subduction zone earthquake cycles.

Keywords: rhology, Tohoku, viscoelastic relaxation, earthquake cycle, Tohoku oki earthquake