Influence of temperature- and depth-dependent viscosity structures on postseismic deformation for the 1946 Nankai earthquake

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In order to investigate the influence of spatial variation in viscosity in the mantle on postseismic deformation associated with the interplate 1946 Nankai earthquake (M 8.0) at the Nankai Trough, southwest Japan, we newly constructed a realistic viscoelastic structure model, taking into account temperature- and depth-dependent viscosity of materials and computed displacements.

For this purpose, we first compiled leveling and triangulation data during postseismic periods and clarified characteristics of the amount and spatial patterns of postseismic vertical displacement and principal strain fields. Then, we calculated the spatial distributions of viscosity from temperature and flow fields, which were obtained from 2D subduction models. By incorporating the obtained viscosity structure into 3D viscoelastic finite element models, we constructed a temperature- and depth-dependent viscosity structure model (MODEL P2). Based on MODEL P2, we constructed a viscoelastic structure model, taking into account Poisson's ratio for the oceanic plate and low-velocity regions and the existence of low-viscosity materials beneath the Shikoku and Chugoku districts (MODEL P3), which were revealed from seismic tomography. We also constructed a conventional layered viscoelastic structure model (MODEL L1) and plate subduction model (MODEL P1) with constant viscosity for each region to compare the effects of different viscoelastic structures on postseismic surface deformations. Using the coseismic slip distribution obtained by inversion analyses of geodetic data by Ito and Hashimoto (2004), we computed the calculated surface deformations for each model to compare them with the observed postseismic crustal deformations in and around Shikoku.

The results show that postseismic surface deformation fields for the newly constructed MODEL P2 are rather different from those for MODELs L1 and P1. Northwestward horizontal displacements for MODEL P2 are smaller than those for MODELs L1 and P1, southeastward horizontal displacements are negligible, and vertical displacement is characterized by small subsidence over Shikoku. The postseismic horizontal principal strain field for MODEL P2 is characterized by contractions in the N-S to NW-SE directions at amounts smaller than those for MODELs L1 and P1. Postseismic surface deformations for MODEL P3 are almost the same as those for MODEL P2. The observed postseismic vertical displacement and horizontal principal strain fields could not be explained by the viscoelastic response for the realistic viscoelastic structure models P2 and P3. This indicates that the effects of elastic and viscoelastic responses due to interplate coupling on the plate interface, afterslip on the extension of the coseismic slipped part of the plate interface, and poroelasticity should be taken into account to reproduce the observed postseismic surface deformation. This also suggests that, in order to evaluate postseismic crustal deformations derived from a large interplate subduction zone earthquake, it is essential to use realistic temperature- and depth-dependent viscoelastic structure.