High strain rate zone resulting from viscosity heterogeneities in the uppermost mantle

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The high strain rate zone in central Honshu (NKTZ: the Niigata - Kobe tectonic zone) has been revealed by the dense GPS array (GEONET, Geographical Survey Institute of Japan) (e.g., Sagiya et al., 2000). Iio et al. (2002) and Hyodo and Hirahara (2003) emphasized the importance of the crustal heterogeneity to produce NKTZ. In this study, we investigate effects of rheological structures within the uppermost mantle on the interseismic deformation field associated with the subduction of the Philippine Sea plate, based on a two-dimensional finite element model. We then try to reveal the origin of NKTZ.

A vertical section from the Tokai district to the Japan Sea is constructed using the finite element code TEKTON (e.g., Melosh and Raefsky, 1980). The earthquake cycles in the Tokai district associated with the subduction of the Philippine Sea plate are described by the back-slip model, the fault slip at the thrust zone is included by means of the split node technique in the code (Melosh and Raefsky, 1981). The size of the model is 200 km (depth) 5400 km (horizontal distance), and the total numbers of elements and nodes are 6180 and 6417, respectively. The mechanical boundary condition at the left is fixed or free, at the right side the horizontal displacement is zero, and the vertical displacement at the bottom is zero. The surface of the model is stress-free. The convergence velocity of the Philippine Sea plate is assigned to be 4 cm/yr, and the coupling depths on the plate boundary is from 0 to 35 km. The period of the earthquake cycle is assumed to be 150 years in this study.

Based on the numerical experiments, we show that the high strain rate zone can be reproduced by the model with the effective elastic thickness of 30 km and with the presence of the localized low-viscosity zone (~1018Pas) in the uppermost mantle beneath and seaward of the high strain rate zone. The localized reduction in viscosity could be partly caused by the serpentinization in the wedge mantle (Kamiya and Kobayashi, 2004). We suggest that the viscosity heterogeneity in the uppermost mantle as the origin of NKTZ.