# On the temporal decay of the localized strain rate in the Tohoku region after the Tohoku-Oki earthquake

*Youichiro Takada[1], Tomomi Inamatsu[2]

1. Faculty of Science, Hokkaido University, 2. Dept. Natural History Sciences, Hokkaido University

The 2011 Tohoku-Oki earthquake (Mw9.0) provides us the first opportunity to examine the responses of strain concentration zones and active faults to megathrust earthquakes with dense permanent GNSS network. Along the Backbone range in the Tohoku region, strain rate localization has been found before and after the Tohoku-Oki earthquake (e.g., Miura et al., 2004; Takada and Inamatsu, 2018). In this study, we focused on the post-seismic strain rate localization along the Backbone range, and examined its driving mechanism with GNSS data and simple FEM simulation.
We used daily coordinates obtained at GEONET stations operated by GSI. We estimated surface velocity field before and after the earthquake by removing annual and semi-annual perturbations. For post-seismic period, we estimated the velocity field for every two years to use linear approximation. From the velocities thus obtained, we calculated the strain rates following the method of Shen et al (1996). Next, we approximated the long wavelength components, which reflects the afterslip and/or the viscoelastic relaxation of Asthenosphere following the Tohoku-Oki earthquake, by polynomial function for each component, and removed it to extract the short wavelength component. Then, we found patchy distribution of localized contraction (negative dilatation rate) areas along the Backbone range with these amplitudes rapidly decreasing with time.
To examine the mechanism of rapidly decreasing strain rate, we conducted a simple numerical simulation with a finite element software COMSOL Multiphysics. There are thermally active regions with many calderas along the Backbone range (e.g., Yoshida, 2001; Takada and Fukushima, 2013). On the other hand, the thermal activity of surrounding area is not very high. Considering these points, we set a rectangular elastic body and located several ellipsoids in north-south direction that consist of low viscosity Maxwell viscoelastic medium. Then we applied gravitational body force to all the model region, and supported it from a lateral boundary. In addition, we also applied a step-wise 1 MPa stress change which represents coseismic stress perturbation due to the Tohoku-Oki earthquake. From the calculated results, we removed the long wave-length component. Then, we successfully extracted the short wave-length dilatation rate around the viscoelastic ellipsoids. Just after the step-wise stress change, whole medium responded as an elastic body. Soon after that, viscous flow starts in the ellipsoids. As differential stress decreases with time in the ellipsoids due to viscous relaxation, the surrounding elastic region becomes important to support the differential stress. Thus, the localized strain rates can be large only during the viscous relaxation in the ellipsoid. After the completion of viscous relaxation, all the differential stress is supported solely by elastic region, and the localized strain rates vanish. Thus, three dimensional connectivity of low viscosity regions play an important role when considering crustal response to an externally applied stress change.

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