Heterogeneous rheological structures of the northeastern Japan illuminated by post-seismic deformation of the 2011 Tohoku-oki earthquake

*武藤 潤[1]、芝崎 文一郎[2]、飯沼 卓史[3]、太田 雄策[4]、岩森 光[3]、堀内 俊介[3]
*Jun Muto[1], Bunichiro Shibazaki[2], Takeshi Iinuma[3], Yusaku Ohta[4], Hikaru Iwamori[3], Shunsuke Horiuchi[3]

1. 東北大学大学院理学研究科地学専攻、2. 建築研究所国際地震工学センター、3. 海洋研究開発機構、4. 東北大学大学院理学研究科　地震・噴火予知研究観測センター
1. Department of Earth Sciences, Tohoku University, 2. International Institute of Seismology and Earthquake Engineering, Building Research Institute, 3. Japan Agency for Marine-Earth Science and Technology, 4. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Tohoku University

Viscoelastic properties of rocks play an important role in the long-term evolution of convergent margins. Especially, Billen and Gurnis (2001) proposed the presence of low viscosity mantle wedge to explain observable signals in topography and gravity for the Tonga-Kermadec trench. Furthermore, recent geodetic observations after the 2011 Tohoku-Oki earthquake also show transient viscoelastic flow plays dominant role even in the very early stage of the post-seismic deformation (e.g., Sun et al., 2014). Therefore, the nation-wide network of geodetic observations for the post-seismic deformation of the Tohoku-Oki earthquake can illuminate rheological properties and their heterogeneity in the northeastern (NE) Japan. In order to evaluate rheological heterogeneity reflecting thermal and petrological structures of the NE Japan, a model of two-dimensional viscosity structures of the NE Japan island arc-trench system were proposed (Muto et al., 2013). The model covers the source area of the 2011 Tohoku-Oki earthquake and can be applied to the analysis of the post-seismic deformation. From seismologically determined structures of the lithosphere, experimentally derived constitutive laws of various minerals, and densely measured geothermal gradient data for the NE Japan, we have proposed a model of steady state viscosity structures across the island arc. The profile shows strong lateral viscosity gradients both parallel and normal to the trench axis. Especially, the variation in viscosity structures across the arc is characterized by strong forearc and weak volcanic front. Using two-dimensional finite element modeling taking into account of the viscosity heterogeneity, we reproduced the observed post-seismic deformation of the 2011 Tohoku-Oki earthquake (Muto et al., 2016). We used terrestrial and seafloor geodetic data compiled by Iinuma et al. (2015) and modeled both horizontal and vertical displacement fields in two different time periods (1 and 5 years after the earthquake). From the analysis, we have succeeded in reproducing the local subsidence around Quaternary volcano (Mt. Naruko) by introducing the narrow low viscosity body beneath the volcano. The inferred low viscosity body is consistent with the low velocity anomaly in seismic tomography (Okada et al., 2015) and low resistivity anomaly in magnetotelluric observations (Ogawa et al., 2015). The presence of very localized rheological heterogeneity (low viscosity body) is inconsistent with Billen and Gurnis (2001)’s model of the wide low viscosity wedge in Tonga-Kermadec trench. However, the similar localized low viscosity zones are also predicted in the thermal-flow model of the NE Japan subduction zone (Horiuchi and Iwamori, 2016) which takes into account of temperature- and water-dependent flow properties of mantle wedge. The localized weakening by water infiltration, partial melting and serpentinization cause such localized low viscosity region in the mantle wedge. Combination of numerical modeling with rheological heterogeneity and detailed geodetic observation can contribute to illuminate small-scale (<20 km) heterogeneities and their rheological properties of NE Japan.

©2017. Japan Geoscience Union. All Right Reserved.

References:
Billen M. I. and M. Gurnis (2001) *EPSL*, **193**, 227-236, doi: 10.1016/S0012-821X(01)00482-4.
Horiuchi, S., and H. Iwamori (2016) *JGR*, **121**, doi:10.1002/2015JB012384.
Iinuma, T. et al. (2015) *Int. Assn. Geodesy Symp.*, **143**, doi:10.1007/ 1345_2015_162.
Muto, J. et al. (2013) *GRL*, **40**, doi:10.1002/grl.50906
Muto, J. et al. (2016) *GRL*, **43**, doi:10.1002/2016GL068113.
Ogawa, Y. et al. (2014) *EPS*, **66**, 158, doi:10.1186/s40623-014-0158-y.
Okada, T. et al. (2014) *EPS*, **66**, 114, doi:10.1186/1880-5981-66-114.
Sun, T. et al. (2014) *Nature*, **514**, 84–87, doi:10.1038/nature13778.

キーワード：レオロジー、余効変動、東北沖地震、粘弾性緩和
Keywords: Rheology, Post-sesimic deformaiton, Tohoku-Oki Earthquake, Viscoelastic relaxation

©2017. Japan Geoscience Union. All Right Reserved.