Estimation of inelastic strain rate in the lower crust based on GNSS and seismic data and its implication for dynamics in Kyushu, southwest Japan

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It is considered that localization of inelastic deformation due to viscous inhomogeneity in the lower crust results strain concentration zone in island arc, and estimation of the inelastic strain rate in the lower crust is being performed. On the other hand, while the inelastic strain rate and the deviatoric stress are related by the flow rule, the information on the estimated deviatoric stress field has not been taken much care in the previous studies. In this study, we proposed a new method for estimating the inelastic strain rate in the lower crust, which incorporates the information of deviatoric stress field. Furthermore, since the subduction of the plate is an important factor for the crustal deformation process in island arc, we also attempted simultaneously to estimate the distribution of locking at the interface of the subducting slab with the inelastic strain rate in the lower crust.

We adopted back slip model (Savage, 1983) for the coupling of the interface and the box-shaped source (Barbot et al., 2017) for inelastic deformation in the lower crust. Using the ground surface strain rate estimated from GNSS observations as data, the inelastic strain rate in the lower crust and the slip deficit rate at the plate boundary were estimated. We applied two constrains in the scheme: 1) the smoothing of the slip deficit rate distribution and 2) the direction of the inelastic strain rate followed the deviatoric stress (flow rule). The strength of these constraints is determined by minimizing the Akaike Bayesian information criterion (Akaike, 1980).

The results showed that high inelastic strain rate (~1×10^{-6} /yr) were obtained around Central and southwestern Kyushu. These areas correspond to the areas with high seismic activity. We found that the seismicity was induced by the inelastic deformation in the lower crust by calculating the stress change due to the inelastic deformation in the lower crust. In addition, these areas have high geothermal gradients in Kyushu (Tanaka et al., 2004), and the seismic velocity at depth 20 km is low velocity anomalies (Saiga et al., 2010). The results suggest that the lower crust in these region is in a high temperature / wet environment, and that the viscosity of the rocks is low. Therefore, the estimated high inelastic strain rate can be interpreted as an inelastic deformation concentration zone in the low viscosity lower crust. Also, the estimated the distribution of slip deficit rate is 10 - 25 mm/yr around the Bungo Channel, while the Hyuga-Nada is hardly locked. The stress change due to locking between plates are smaller than one due to inelastic deformation in the lower crust. Therefore, it is considered that the inelastic deformation in the lower crust plays an important role in seismic activity and crustal deformation in inland Kyushu.

Keywords: Kyushu, inelastic, Inland Earthquakes

