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Strain concentration zone in quaternary caldera, eastern Hokkaido, detected by GPS data

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We estimated spatiotemporal strain field using GPS data in eastern Hokkaido. There is a high shallow seismicity around Kussharo caldera. In addition, according to JMA hypocenter catalogue, there are four middle size earthquakes in the last 100 years (e.g., M6.1 Kussharo earthquake in 1938, Mj 6.5 Teshikaga earthquake in 1967). Therefore, it is important to understand the strain accumulation and release processes in this area.

In this study, we used GEONET daily coordinates (F3 solutions), which has been organized by GSI. In order to figure out steady state strain field, we treated two periods, November 1998 to October 2001 and July 2007 to November 2009, and estimated site velocities by fitting linear trend and seasonal variation (annual and semi-annual trend) to the daily coordinates. Strain rate was calculated from these site velocities using method of Shen et al. (1996). For comparison, we also estimated strain field at the coseismic period of two large earthquakes (Mj 8.0 Tokachi-oki earthquake in 2003 and Mj 9.0 Tohoku-oki earthquake in 2011) and their early postseismic period (a half-year after those earthquakes) from each displacement field.

In the steady state period, large contractional dilatation strain rate (~0.2ppm/yr) and NW-SE shortening were detected around Kussharo caldera in both periods. Although the maximum shear strain rate (0.1-0.2ppm/yr) was not remarkable with respect to dilatation strain rate, relatively large area was recognized around this area. The extent of large strain rate region is slightly different between these two periods. However, their both centers are located near Kussharo caldera. This distribution pattern is probably not explained by possible shallow magmatic contraction of active volcanoes.

There was no large difference in strain rate between two periods. The strain rate was almost constant even the 2003 Tokachi-oki earthquake occurred between two periods. At the postseismic period after the 2011 Tohoku-oki earthquake, we also recognized large strain field around Kussharo caldera. On the other hand, we did not detect those strain anomalies at the coseismic period of two large earthquakes and the postseismic period after the 2003 Tokachi-oki earthquake. This strain concentration area probably has a viscoelastic characteristic feature, which gradually deforms following the instant stress change such as earthquake. Meanwhile, this area is deformable with respect to the long-term stress change. The case of early postseismic period of 2003 Tokachi-oki earthquake, it is possibly buried the strain anomaly in the large postseismic deformation signal due to the closeness from the focal area.

It is thought that the origin of strain concentration zone in Japan, such as Niigata-Kobe tectonic zone (Sagiya et al., 2000) and Ou-backbone range (Miura et al., 2004), is weakening of the lower crust due to the upwelling flow from subducting plate or mantle wedge. This phenomenon induces inelastic behavior in the lower crust (e.g., Iio et al., 2004). As well as those strain concentration zones, several studies suggest the possibility of the lower crust weakening beneath Kussharo caldera region. For example, low seismic velocity (e.g., Wang and Zhao, 2009), and low electric resistivity (Satoh et al., 2001) is detected in the lower crust. High geothermal gradient (Geological Survey of Hokkaido, 1995) is also reported.

To specify detailed extent and amount of this strain concentration area, it is necessary to reveal detailed crustal deformation from denser GPS network, and to compare several solutions from different estimation methods. Based on these results, we have to consider the strain accumulation and release process in this area.