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Strain rate field in Kyushu district estimated from GPS velocity data

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Kyushu district is one of the areas where unique crustal deformation is detected in Japan. For major tectonic characteristics, the Philippine Sea plate subducts and repeatedly generates M7 class earthquakes with a recurrence interval of about 20-30 years at the Hyuga-nada area (Yoshioka, 2007). In the Bungo Channel, slow slip events have occurred at intervals of about 6-7 years (Ozawa et al., 2013). These differences of tectonic process may be responsible for the frictional property of the plate interface (Hirose and Maeda, 2013). Moreover, back-arc spreading at the Okinawa Trough (Nishimura and Hashimoto, 2006) also brings about complicated tectonics. Takayama and Yoshida (2007) investigated some tectonic factors using GPS velocities obtained from 1998 to 2002. Then, they suggested that there was a velocity gap of about 5 mm/yr in the EW component along N32^o where subsequent M5-6 class earthquakes occurred. However, clear active faults are not distributed there and the process of stain budget is unrevealed, indicating that the present-day crustal deformation began to develop in the recent geological age. Additionally, inelastic deformation (Noda and Matsu'ura, 2010) with high temperature is also expected, since many active volcanoes exist in this region. Therefore, it is important to estimate the influence of the inelastic behavior attributed to heterogeneity in the crust and upper mantle on the deformation field quantitatively. It is thought that the quantitative understanding of strain rates leads to the assessment of seismic potential such as locking depth of faults and estimating the future crustal deformation. In this study, we estimated the strain rate field in Kyushu district using GPS velocities.

We estimated site velocities using GEONET F3 solution, daily coordinates of continuous GNSS sites, derived from the Geospatial Information Authority of Japan (Nakagawa et al., 2009). According to a conventional method of processing for GPS time series, we removed annual and semiannual variations, and offsets caused by earthquakes and GPS antenna replacement. Next, using the method proposed by Shen et al. (1996), we calculated strain rates by forming crossover area within a 50 km diameter every one GPS observation site, assuming uniform deformation in each crossover area. Finally, we determined a rigid motion and strain rates in the whole area simultaneously by the method of least squares, and then, we obtained strain rate distribution interpolated every 20 km. We set the same period as shown in Takayama and Yoshida (2007), when few unsteady events occurred. From estimated strain rate field, following characteristics were derived.

(1) A high strain rate region with the maximum shear strain rate of about 120 nanostrain/yr was recognized along N32^o, whose width was about 50 km.

(2) The crustal shortening of about 30-210 nanostrain/yr in the northern part and the central part of Kyushu district indicated the direction of ESE-WNW on the Pacific side. On the back-arc side, the magnitude of those shortening decreased and those directions were rotating counterclockwise.

(3) The crustal shortening in the southern part of Kyushu district indicated the direction of ENE-WSW and the highest shortening rate was 130 nanostrain/yr on the back-arc side.

The result (1) suggests that the fault locking ranges from 0 to 5 km in depth, assuming the fault slip (5 mm/yr) of infinitely long fault in the EW direction under high strain rate region. As for results (2) and (3), it is necessary to consider the effects of plate subduction and back-arc spreading into the analysis. For the future, we will calculate strain or strain rate released by earthquakes (moment release) and conduct the quantification of inelastic behavior ongoing in Kyushu district by comparing strain budget.

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Keywords: crustal deformation, strain rate, high strain rate region, inelastic deformation, Kyushu district, Philippine Sea plate