

Crustal deformation before and after the Tohoku-oki earthquake in the central part of the Tohoku district by GPS data

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The Yamagata-bonchi fault zone runs along the western margin of the Yamagata basin. This fault zone is separated into northern and southern parts around Sagae city. The first objective of this study is to investigate the difference in the strain field between the Yamagata-bonchi fault zone and the surrounding area. The difference of strain distribution between the northern and southern parts of the Yamagata-bonchi fault zone was also investigated.

Ohzono et al. (2012) estimated the coseismic heterogeneous property of crustal response to stress disturbance of step function using GPS data from the Tohoku district. Their result showed that crustal deformation in the strain concentration zone along the backbone range was small compared to the theoretical coseismic crustal deformation associated with the 2011 Tohoku-oki earthquake. They indicated that the difference resulted from the structure of the lower crust in the strain concentration zone. The second objective of this study is to investigate the strain distribution character in the middle of the Tohoku district where Ohzono et al. (2012) indicated a heterogeneous crust.

We used 54 GEONET stations, 4 Yamagata University stations, and 11 Tohoku University stations. The number of total stations is 69. The analysis period was January, 2008 to December, 2012. Analysis softwares were GAMIT/GLOBK ver. 10.4 (Herring et al., 2011). We calculated each day coordinate value of 69 stations using ITRF2005 as a reference.

We calculated each site displacement rate during 1, July, 2008 to 1, March, 2011 to estimate the strain distribution before the Tohoku-oki earthquake. We considered the annual variation and half annual variation to estimate the strain displacement for this period. We estimated the strain distribution using the method of Shen et al. (1996). The result showed contraction in the east-west direction caused by subduction of the Pacific plate. The southern part of Yamagata Prefecture containing the Yamagata-bonchi fault zone was contracted in the northeast-southwest direction. This direction is the same as that of a compression axis of microearthquakes in the southern part of Yamagata bonchi fault zone obtained by Furusawa et al. (2008). There is a little strain concentration in the Yamagata-bonchi fault zone compared to the surrounding area, but no difference between the northern and southern parts of the fault zone. We obtained coseismic strain distribution using displacement from 3-9, May, 2011 to 18-20, April, 2011. The result showed 1.5×10^{-5} extension in the east-west direction in the Yamagata-bonchi fault zone. We also estimated the strain distribution after the Tohoku-oki earthquake. The prominent results were as follows. The back-arc area was the extensional strain field. A coastal area on the Pacific Ocean side was a contraction field, and there was an extensional field on the east side of the backbone range. The area along the backbone range was a contraction area. We calculated the strain distribution assuming a single rectangular after slip area on the plate boundary, referring to the Geospatial Information Authority of Japan (2012) and compared the calculation and observed strain distribution. We found that strain distribution could be explained by after slip except in the area along the backbone range that was an extensional field in the calculated result. Ohzono et al. (2012) suggested that backbone range is smaller contraction compared with surrounding region by coseismic displacement. Our result also show the characteristic strain anomaly distribution in postseismic stage. This anomaly may be caused by some elastic constant variation of upper crust and/or rheological heterogeneity of lower crust or upper mantle.

Keywords: Tohoku-oki earthquake, Crustal deformation, GPS, Yamagata-bonchi fault zone