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Crustal movement analyzed from GPS geodetic data and tectonic provinces in the Shin'etsu region, central Japan

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The Shin'etsu region in central Japan is located in the Niigata-Kobe tectonic zone (Sagiya et al., 2000) and some moderate-sized inland crustal earthquakes, such as the Niigata Prefecture Chuetsu Earthquake in 2004 (M6.8), the Niigataken Chuetsu-oki Earthquake in 2007 (M6.8) and the Naganoken Hokubu Earthquake in 2011 (M6.7), occurred lately on end in this region. The concentration zone of crustal strain corresponds to the higher seismicity in the upper crust, and it is significant to understand the nature of crustal strain for discussing the generation mechanism of such crustal earthquakes in the back-arc belt. However, it is unclear how the geodetic strain-rate distribution relates geologically to the tectonic provinces. The purpose of this paper is to clarify the characteristics of crustal strain-rate distribution and mechanical relationship between the strain field and the tectonic provinces in the Shin'etsu region. Analyzing the GEONET geodetic data obtained in the last four and a half years, we evaluated the distribution of strain-rate in order to clarify crustal movement in the Shin'etsu region.

Contraction in a direction of WNW-ESE had substantially changed into large E-W extension at the moment of the 2011 off the Pacific coast of Tohoku Earthquake (M9.0). The distribution of strain-rate before and after the Tohoku earthquake is regionally heterogeneous. Before the Tohoku earthquake, the strain concentration zone revealed from GPS data extends in a NE-SW direction from Niigata to Matsumoto. This zone approximately corresponds to the late Cenozoic Niigata sedimentary basin and Minochi belt that have extremely thick sedimentary covers and the deep basement rocks. Moreover the distribution of strain-rate corresponds to the regional difference in thickness of the sedimentary veneers, it is likely that the crustal movement in the Shin'etsu region before the Tohoku earthquake was controlled by the differential movement of unit blocks in the tectonic provinces. The thick covers of sedimentary basins are more mobile than the rigid basement of the Echigo mountain range and the Central upheaval zone of Fossa Magna region. Thus it is possible that such a difference in mechanical property of the uppermost crust makes the regional heterogeneity of strain-rare. However, there is a mechanical model that a narrow zone of weakness in the lower crust accounts for the concentration zone of strain above (Iio, 2009). Thus the factors that affect the distribution of strain-rate on the surface are not only the regional difference in thickness of the veneer rocks but also the multiple controls included the behavior of the basements. In contrast, distribution of strain-rate after the Tohoku earthquake has no correspondence to the tectonic provinces. Because of large post-seismic displacement since the Tohoku earthquake, no characteristic pattern of strain-rate field corresponded to the tectonic provinces was recognizable. This suggests that the moderate signals as small as analyzed for the pre-seismic period might be hidden by such a large post-seismic deformation.

In order to understand the mechanism of strain concentration peculiar to the Shin'etsu region, it is necessary to continue our GPS geodetic observation for post-seismic deformation in order to investigate the behavior of lower crust of each tectonic province.

Keywords: the 2011 off the Pacific coast of Tohoku Earthquake, crustal movement, strain concentration zone, tectonic province