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Crustal movement of the Nagano-ken Hokubu earthquake and seismotectonics of the Sakae-Tsunan-Matsunoyama district

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Just after the Mw9.0 off the Pacific coast of Tohoku Earthquake (Tohoku Earthquake), the Mw6.7 Nagano-ken Hokubu Earthquake (Sakae Earthquake, hereafter) occurred on the boundary between Nagano and Niigata prefectures, on March 12th in 2011. This area is located within the Shinanogawa Seismic Belt (Ohmori, 1907) and Niigata-Kobe Tectonic zone (Sagiya et al., 2000), where the maximum shortening occurs in an E-W trend.

By analyzing the GEONET GPS data, Geospatial Information Authority of Japan (GSI) announced that, the Matsuno-yama site (0244) in Niigata Prefecture was displaced northeastward by 39.3 cm, and that the Nagano-sakae site (0982) was displaced northward by 4.2 cm.

In order to reveal and understand temporal change in displacement field at and around the time of those earthquakes, and also to examine the characteristics of the source fault of the Sakae Earthquake, this study analyzed the GEONET GPS data by utilizing both GAMIT software (ver.10.42) and RTD software (ver.3.5).

As a result, this study revealed that at the moment when the Sakae earthquake occurred, the Matsuno-yama (0244) was displaced by 35.6 cm northward and 20.2 cm eastward while the Nagano-sakae (0982) was displaced by 7.7 cm northward and no displacement was recorded both eastward and westward. The Sakae Earthquake did cause a large displacement to around the epicenter area, while the post-seismic crustal movement of the Tohoku Earthquake has progressed remarkably after the Sakae Earthquake.

The ground surface deformation due to shear and tensile faults were also analyzed with DCSTN software (Okada, 1992). The result showed that, a reverse faulting with an upward dip-slip in a northwest direction could account for the coseismic displacement field of the Sakae Earthquake. However, such a fault slip is not enough to account for all the displacement at the GEONET sites.

This implies that any other movements than the faulting might affect the displacements of GPS permanent stations. One of such possibilities is tilting of sedimentary layers due to dome-like upheaval. The dome structure around this area is an anticline with a short axis, which is characterized by the intersection of the eastern margin of Northern Fossa Magna and the western margin of central uplift belt. So this study presents a 2-dimensional fault model for the main shock, which can explain displacements at Matsuno-yama and Nagano-sakae sites and geological structure in the study area. Coseismic growth of the fold structure might imply that the basement faulting made the sedimentary cover to be deformed.

After analyzing an after-slip deformation of the Sakae Earthquake, this study is able to present the following two possibilities. The first is that the source fault of the main shock was also reactivated to slip also after the main shock. The second is that, to the south of the Sakae source fault, another strike-slip fault was also activated to generate Mw5.6 event on April 12, 2011.

Keywords: Nagano-ken Hokubu earthquake, Niigata-Kobe Tectonic zone, Northern Fossa Magna, GEONET, faults, dome