Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SCG65-05 Room:201A Time:May 19 12:00-12:15

Stress drops of induced earthquakes associated with the 2011 Tohoku-oki earthquake

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After the occurrence of the 2011 Mw 9.0 Off the Pacific Coast of Tohoku Earthquake (Tohoku-oki earthquake), induced earthquakes are actively occurring at several inland areas, including Fukushima Hamadori region and the middle part of the Akita prefecture. Focal mechanisms of these induced earthquakes are inconsistent with the present-day stress field in overall northeast Japan that is characterized by a reverse-faulting regime with E-W compression. One possible mechanism is that the stress field in those areas abruptly changed from horizontal compression to extension because trench-normal compressive stress within the overlying plate was reduced after the Tohoku-oki earthquake (Kato et al., 2011; Yoshida et al., 2011). If so, the differential stress magnitudes in those areas before the Tohoku-oki earthquake should be smaller than the static stress changes associated with the Tohoku-oki earthquake (1 MPa or less). Moreover, it is expected that stress drops of these induced earthquakes is less than 1 MPa. In this study, we determined stress drops of these induced earthquakes by using the Multi-Window Spectral Ratio method (Imanishi & Ellsworth, 2006). The estimated stress drop values are approximately 10 MPa, which is inconsistent with the hypothesis of a drastic change in stress state. The present result rather favors the conclusion of Imanishi et al. (2012) that the Tohoku-oki earthquake could trigger those earthquakes in a limited area combined with a locally formed pre-shock stress regime that is different from a reverse-faulting one with E-W compression. Terakawa et al. (2013) indicate that the increase in fault-confined fluid pressure would have played a critical rule in the occurrence of these induced earthquakes. This mechanism and the combination with the locally formed pre-shock stress heterogeneity are also enabled if the fault strength was still in excess of approximately 10 MPa (the stress drops of induced earthquakes).

Acknowledgements: The seismograph stations used in this study include permanent stations operated by NIED (Hi-net).

Keywords: induced earthquake, the 2011 Mw 9.0 Off the Pacific Coast of Tohoku Earthquake, stress drop, stress field, MWSR method