

Spatially inhomogeneous stress field in the source area of the 2011 Fukushima Hamadori earthquake sequence

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After the 2011 great Tohoku-Oki earthquake, many earthquakes occurred near Iwaki, Fukushima Prefecture, including Mw6.8 event of April 11. This 2011 Fukushima Hamadori earthquake sequence is characterized by normal faulting, with T-axis oriented in the NW-SE, E-W and NE-SW directions for events in the northern, central and southern parts of the source area, respectively.

In order to understand the cause of such a remarkable spatial variation of focal mechanisms, we investigated the stress field in the source area of this earthquake sequence. First, we relocated hypocenters of events that occurred during the period from 1997 to 2012 by the double-difference location method. Relocated hypocenters show that events near the 3/19 Mw 5.8 earthquake in the southern area, those near the 3/23 Mw 5.7 earthquake in northern area and those near the 4/11 Mw 5.9 earthquake in central area are aligned along planes dipping westwards corresponding to one of nodal planes, respectively.

Then, we estimated the stress field in the source area of the sequence by a stress tensor inversion of focal mechanisms reported by the National Research Institute for Earth Science and Disaster Prevention and Japan Meteorological Agency. Results show that the stress field is very heterogeneous in space with normal fault stress regime after the occurrences of the main-shock of each part of the source area. In the northern, central, southern and east parts of the source area, the minimum principal stress (σ_3) axes are oriented in the NW-SE, E-W, NE-SW and NNE-SSW directions, respectively. As a whole, σ_3 axis shows the concentric circle-like distribution. In contrast, before the occurrence of the main-shock of each part, σ_3 axis is oriented homogeneously in space in the E-W direction.

This observation suggests the possibility that the remarkable heterogeneity in stress field is caused by the static stress change of large earthquakes. We estimated the static stress changes caused by the 2011 Fukushima Hamadori earthquake sequence. A slip model estimated by Hikima (2012) using strong motion waveforms was used for the Mw6.8 earthquake. Furthermore, we made fault models of the 3/19 Mw 5.7, 3/23 Mw 5.8 and 4/12 Mw 5.7 events using hypocenter locations and the scaling relation between moment magnitude, fault length, width and slip amount for estimating their static stress changes.

Spatial distribution of σ_3 axis direction of the static stress change is approximately the same as that of the observed stress field after the occurrences of the main-shock of each part of the source area. This strongly suggests that σ_3 axis rotated after the 2011 Fukushima Hamadori sequence and the stress magnitude in the focal area before the sequence was smaller than the static stress change (<~several MPa). We estimated the differential stress magnitude assuming that the difference in the stress tensor before and after the earthquakes is equal to the static stress change associated with the large earthquakes. Estimated magnitude of the differential stress was <20 MPa.

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