Spatial distribution of seismic activity and stress field in the source region after the 2011 Tohoku-Oki earthquake

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The 2011 Tohoku-Oki earthquake changed the stress field around its source region. Significant coseismic rotation of the principal stress axes was observed and it was suggested that almost all the accumulated shear stress was released on the ruptured plate boundary (e.g. Hasegawa et al. 2011). Therefore, it is important to study the spatial variation of the stress state after the Tohoku-Oki earthquake in detail to understand not only the coseismic stress change but also the stress state before the occurrence of the earthquake. Since previous studies used the focal mechanism solutions to estimate stress field inversion are based on the data of the onshore seismic networks, it has been difficult to discuss detailed features of the spatial variation of the stress state, especially of the depth variation, because accuracies of focal depths (centroid depths) of offshore earthquakes are not sufficient. In this study, we relocated the hypocenters by using arrival time data of ocean bottom seismic stations deployed in the central part of the Japan trench where the coseismic slip was large to improve three-dimensional distribution of the focal mechanism solutions of the earthquakes in the area occurred before and after the Tohoku-Oki earthquake. As a result of stress field estimation based on the improved focal mechanism catalogue, it was shown that the stress field after the Tohoku-Oki earthquake shows clear difference between the overring and the subducting plates in the west side of the coseismic slip region. This sharp change in the stress field across the plate boundary suggests that the shear stress along the plate interface is extremely small. The area corresponds to the region with extensive afterslip estimated from the postseismic deformation data. A remarkable intraplate seismicity extending upward from the plate interface by ~ 25 km was identified after the Tohoku-Oki earthquake at the western rim of the large coseismic slip area. By applying a moment tensor inversion to these earthquakes, we investigated the depth variation of the stress field in the upper plate above the large coseismic slip zone. As a result, the minimum principal stress axis was found to orient almost in the direction of the coseismic slip just above the plate boundary, whereas its direction changed to the along-strike direction in the shallow depth range. The change can be interpreted by the decrease of the tensional stress associated with the coseismic slip with the increasing distance from the rupture plane.

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