Fault tectonic analysis of aftershocks of the 2011 Tohoku, Japan, earthquake: interaction between three different tectonic domains and approximation of stress magnitude

Pom-yong Choi
Korean Institute of Geoscience and Mineral Resources, Geological Research Division, Daejeon, Korea, Republic of (choi_py@hanmail.net)

In order to elucidate the regional variation of stress field in the eastern part of Japan after the 2011 Tohoku earthquake of M=9.3, we tried to analyze focal mechanism data of earthquakes that occurred in 2011, presented by the Japan Meteorological Agency (JMA). Although earthquakes (aftershocks) occurred largely in the offshore area along the subduction zone of the Pacific plate under the North American and Eurasian plates, focal mechanism data presented by JMA are mainly those on land. For fault tectonic analysis, the suggested focal mechanism data are classified into appropriate populations on the basis of clusters and focal depths to reduce the bias and errors of stress tensors resulting from areal stress variation and varying vertical load. According to the results, the stress types of determined stress tensors consist of reverse, wrench and normal faulting ones. As for reverse faulting stresses in which the vertical load is the minimum principal stress axis, those of NW-SE compression prevail, which may be tightly related to northwestward movement of the Pacific plate. Those of E-W compression are determined in the continental crust deeper than about 9 km around Yamagata and in the lower part of subducting oceanic crust. In the Kanagawa and Chiba areas, determined stress tensors display NNW-SSE compression as well as NW-SE and E-W compressions. The NNW-SSE compression seems to be related to the movement of the Philippine Sea plate. Stress tensors of wrench faulting type are found in the continental crust far from the subduction zone of the Pacific plate, displaying NW-SE and E-W compressions in the shallower and deeper parts of crust, respectively. The E-W compression is presumably associated with the Himalayan tectonic domain. Determined stress tensors of normal faulting type show diverse extension directions: NW-SE extension in the coastal area, parallel to the Pacific compression, and E-W or NE-SW extension elsewhere. Especially, numerous focal mechanism data showing normal faulting stresses are present in the coastal area of Fukushima and Ibaraki, from which Poisson's ratio of shallow crust was determined to be 0.25 to 0.27 using friction lines on Mohr's circles and focal depths (or corresponding vertical loads). Additional horizontal stress related to the northwestward motion of the Pacific plate was estimated to be 46, 122 and 286 MPa in three groups of 0 to 1.5, 1.5 to 4.5 and 3.5 to 11.5 kilometers in depth, respectively.