Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG68-01 Room:201A Time:May 20 15:30-15:45

Proper estimation of stress fields in the source region of the 2011 Off the Pacific Coast of Tohoku earthquake

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A various observation data revealed that coseismic slip of the 2011 Off the Pacific Coast of Tohoku earthquake exceeded a few tens of meters near the Japan Trench. This suggests that a prominent spatial variation in stress fields may be found there. In this study, we report that the spatial variation in stress fields can be identified on the basis of proper data-set selection in the stress tensor inversion.

A single earthquake as well as a set of nearly identical focal mechanisms cannot constrain the stress tensor, so that we need an adequately diverse set of focal mechanisms in the stress tensor inversion. Using synthetic focal mechanism dataset, Hardebeck and Hauksson (2001) showed that when the mechanism diversity is low, the stress tensor inversion returns an incorrect solution in which a direction of the maximum principal stress (S_1) is about 45 degree from the strike of the reference fault. The same situation may occur in the present study area, because most of earthquakes are low-angle reverse-faulting types occurring along the plate interface.

In order to overcome the problem, we try to divide the dataset into earthquakes along the plate boundary (On-fault earthquake) and other events (Off-fault earthquake). Here we defined the on-fault earthquake that satisfies all the following three criteria: (1) Thrust mechanism categorized in the triangle diagrams of Frohlich (1992), (2) Kagan's angle (Kagan, 1991) relative to a reference mechanism (strike=195, dip=15, rake=90) is less than 35 degree, (3) focal depth is within +-10 km of the inferred plate interface. We applied these criteria to F-net moment tenser solutions during the period from February 1997 to the occurrence of the 2011 Tohoku-oki earthquake. The strike and dip angles of on-fault earthquakes are consistent with the geometry of subducted Pacific slab, suggesting that the above criteria work well. Off-fault earthquakes show a diversity of focal mechanisms.

We divided the study region into several small subareas and applied the stress tensor inversion method (Michael. 1984) using off-fault earthquakes. The inversion results show that the plunge of S_1 is subhorizontal within a subarea where a large coseismic slip occurred. Considering the 95% confidence regions, the angle between S_1 axis and the plate interface (A) is about 10-40 degree. In contrast, the dip angle of S_1 becomes higher in other subareas and the angle A in Ibaraki-oki is nearly perpendicular. This suggests that the shear stress was relatively high around the large coseismic slip area, while those in other areas were very low.

Acknowledgements: We are grateful to NIED for F-net moment tensor solutions.

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Keywords: stress tensor inversion, 2011 Off the Pacific Coast of Tohoku earthquake, data-set selection criteria

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Stress field of normal-faulting seismic sequences in Ibaraki and Fukushima Prefectures triggered by the Mw9.0 Tohoku-oki

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The 2011 M9.0 Tohoku-Oki Earthquake triggered widespread seismicity throughout the Japanese island arc including Hokkaido and Kyushu regions. In particular, a significant increase in the shallow seismicity was observed in the minutes following the main-shock along the Pacific coast of NE Japan, notably the northern part of Ibaraki Prefecture and the southern part of Fukushima Prefecture. The most striking feature of the induced seismicity is that the focal mechanisms reveal normal faulting with a T-axis orientated in a roughly E-W direction. Several large magnitude events including the maximum 7.0 earthquake have occurred during the sequence. It is very important to understand the stress field of driving such intensive seismic swarm activities.

We have, therefore, conducted a series of temporary seismic observations through a dense deployment of about 60 portable stations after outbreak of the intensive seismic swarm. We manually picked polarity of first motion of P-wave observed at each seismic station. Then, we have determined focal mechanism of earthquakes applying the method developed by Hardebeck and Shearer [2002] to the first motion data.

Most of the determined focal mechanisms at depths shallower than 10 km show normal faulting with a vertical P-axis. It interesting that the orientation of T-axis shows spatial variation. The T-axis at the northern part of the Ibaraki is roughly oriented ENE-WSW. The T-axis at the southeast part of the Fukushima is roughly oriented NEN-SWS. In contrast, focal mechanisms at depths greater than 15 km are complex. They consist of normal-, reverse- and strike-slip faulting.

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SCG68-03 Room:201A Time:May 20 16:00-16:15

Temporal change in stress field in the northern part of Tohoku district associated with the 2011 Tohoku-oki Earthquake

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We have investigated the stress field in the northern part of Tohoku district for the both periods before and after the 2011 off the Pacific coast of Tohoku (Tohoku-oki) Earthquake. We determined focal mechanisms using data of P-wave first motion, then estimated stress field by a stress tensor inversion method. After the Tohoku-oki earthquake, the seismicity is quite high in Akita prefecture, forming newly activated three major clusters and many minor ones. The location of major clusters is complementary for the periods before the Tohoku-oki earthquake. Seismicity in some clusters started almost immediately after the Tohoku-oki earthquake, however, beginning was delayed even for months in some clusters, and the duration of activity is highly variable among the clusters. Focal mechanisms of earthquakes in the new clusters show predominantly strike-slip or oblique-slip solutions with consistently NW-SE trending T-axis. The stress tensor inversion using focal mechanism data indicates clear temporal change in the stress field due to the Tohoku-oki earthquake, from reverse-faulting regime to strike-slip regime. Thus the new stress field brought the quiescence of seismicity in the former clusters with predominantly reverse faulting, which is consistent with the Coulomb stress calculation. This change is explained qualitatively by the static stress change due to the slip of megathrust of Tohoku-oki earthquake; compressional stress in WNW-ESE direction was reduced by the slip. However, the spatiotemporal variation in seismicity and focal mechanisms suggest the need of additional factors to bring temporal change. Possible factors are, for example, fluid migration in the crust following the static stress change, delayed response of crustal materials, and viscoelastic response in the lower crust and uppermost mantle.

Acknowledgments
We used hypocentral parameters of the JMA catalog that was prepared by the JMA and the Ministry of Education, Culture, Sports, Science and Technology in Japan. The hypocenters of the catalog were determined by the data of JMA, NIED, Hirosaki University, Tohoku University, Hokkaido University, University of Tokyo, and Aomori Prefecture. We thank these institutions for providing waveform data used for the determination of focal mechanisms.

Keywords: Off the Pacific coast of Tohoku Earthquake, induced seismicity, focal mechanisms, stress field, temporal variation

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SCG68-04 Room:201A Time:May 20 16:30-16:45

Introduction of neotectonics and crustal extension in the Wasatch active fault zone, Utah: Review

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The Basin and Range province (BRP) in the western USA extends north-south, occupying between the Coastal Range and Colorado Plateau, and is characterized by a wide range of east-west extension since the Miocene. The total tectonics from the Colorado Plateau to BRP is similar to Japan as the Cretaceous horizontal shortening and Miocene to the present stretching. The easternmost part of BRP is consistent with the Wasatch Mountains, where the Wasatch active fault zone demarcates in its western margin, eventually in the eastern boundary of the Salt Lake and Utah Valleys as well. The ten segments of the fault zone, each 30 to 70 km long, have 1200 to 1500 years recurrence time within the respective segments, and on average one segment moves at least once every 300 years. Because the last motion $>$ M7.0 moved in 17th century, this fault zone is one of the most dangerous seismic hazardous areas in the U.S. The GPS displacement velocity averages 2-3 mm/yr, relative to the easterly stable continent, suggesting the zone coincides with the strain concentration. The cause and effect between such stretching have been discussed either as the plume first or extension first, but there are no common understandings. The basis of the tectonics is the same of the origin of core complex, and the stretching stress and strain history, tectonics, after Cretaceous-Paleogene convergent tectonics for BRP has not yet reached the definite conclusion. One of the interesting figures is that the magma intrusion is complementary with the active fault movement as the area of intrusion has scarce active faulting, suggesting the strain of stretching is diverted by magma intrusion. There are at least four mechanisms for the stretching that likely all contribute at amounts that are debated. These consist of gravitational collapse of the Laramide orogenic plateau, roll back due to subduction of the Farallon-Pacific spreading ridge, hot spot weakening and doming and plate boundary reorganization associated with NW slip of the Pacific Plate along the San Andreas Fault.

Keywords: Wasatch active fault system, Utah, stretching tectonics, strain concentration, core complex, magma intrusion

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Latest methods for inferring stress conditions from dikes and mineral veins

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Paleostress analysis using parallel dike swarms has been popular since the 1970s. Methodological development has been made since the 1980s for the analysis. Now, stress conditions can be determined not only from the attitudes of parallel dikes but also from those of the dikes whose poles make a girdle. The stress axes and stress ratio optimal for a group of dikes can be determined with 95% confidence limits (Yamaji et al., 2010). And, if there are dikes formed by different stress conditions, the statistical inverse method of Yamaji and Sato (2011) distinguishes and infers the conditions, and evaluates the probability that a dike was formed under each of the conditions. The methodological development is reviewed in this paper.

Keywords: tectonic stress, magma pressure, clustering