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

SSS31-01 Room:104 Time:May 22 15:30-15:45

Thin- skinned tectonics holds in the back-arc region of Northeast Japan?

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In the back-arc region of Northeast Japan, large contractive deformation occurred since Pliocene time (e.g., Sato, 1989). Recently, Okada and Ikeda (2011) compiled seismic reflection, gravity, and surface geologic data and estimate the mechanism of this contractive deformation. They claim that the thin-skinned tectonics holds for the back-arc region of Northeast Japan, but several observations appear to be inconsistent with this model.

Keywords: thin-skinned, intraplate earthquake, detachment fault, tectonic inversion, lower crust, NKTZ

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SSS31-02 Room:104 Time:May 22 15:45-16:00

Fault slip around the initiation point of the 2005 Fukukoka earthquake inferred from focal mechanism data

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Fault slip was found at deeper part of the earthquake fault of the 2005 Fukuoka earthquake by Matsumoto et al. (2012). The slip was estimated by the focal mechanism data of the aftershock, implying post-seismic stress field still has strong heterogeneity at the deeper part. According to studies that estimated fault slip based of GPS data, the co- and post-seismic fault slip only occurred at the shallow part of the fault. These results suggest a possibility that the fault at the deeper part slipped prior to the main shock occurrence and stress accumulated at the initiation point of the earthquake. Based on the GPS data around the area before the earthquake occurrence, No large slip within short term variation less than a day are found, suggesting very slow slip occurred at the deeper part of the fault.

Keywords: Inland earthquake, focal mechanism, fault slip, GPS, 2005 Fukuoka earthquake, stress field

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Relationship between crustal stress field and fault slickenlines due to the 2011 Iwaki earthquake

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After the occurrence of the 2011 Mw 9.0 off the Pacific coast of Tohoku Earthquake (March 11, 2011), a Mw 6.8 (Mj 7.0) aftershock occurred on April 11, 2011 in Iwaki-city, Fukushima Prefecture, NE Honshu, Japan. The earthquake on April 11, 2011 (hereafter, 2011 Iwaki earthquake) occurred in temporal seismicity gaps and it was one of the major aftershocks after the 2011 Tohoku earthquake. To investigate the stress field before the 2011 Iwaki earthquake, we applied the multiple inverse method to the focal mechanisms during one month before the earthquake. Using 12 focal mechanisms during the one month, the multiple inverse method (Otsubo et al., 2008) revealed normal-faulting stress state with the NE-SW trending Sigma3-axis. The small angular misfits (7 degrees) between the slip direction predicted from the stress and that observed for fault plane of the 2011 Iwaki earthquake shows that the NW-SE trending extension is concordant with the slip motion of the 2011 Iwaki earthquake (Otsubo et al., 2011). We then succeeded measured co-seismic slip directions during the rupture of the 2011 Iwaki earthquake. Slickelines caused by the 2011 Iwaki earthquake are observed extensively over a wide range of the fault ruptures along the Itozawa Fault (Active Fault and Earthquake Research Center, 2011; Ishiyama et al., 2011; Otsubo et al., in press). Especially, the curved or cross-cutting fault slickenslins are observed at 8 localities along the Itozawa fault. The co-seismic slip have the curved slickenlines that the direction of fault motion during the rupture of the 2011 Iwaki earthquake shifted from a normal faulting with a left-lateral component to that with a right-lateral component. The angular misfits between the slip direction predicted from the NW-SE trending extensional stress and that predicted from the each component of the curved slickenlines on the fault scarps are ~33 to 65 degrees and ~2 to 17 degrees, respectively. Misfit changes show that the co-seismic slip direction shifted to normal faulting explained by the regional stress in the process of the faulting. These results suggest that co-seismic rupture processes near surface is a key to understand the gradual stress accumulations in the overlying plate associated with the huge trench type earthquake.

Acknowledgements:
Thanks are also due to the National Research Institute for Earth Science and Disaster Prevention (NIED) for making available the focal mechanism data in the study area.

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Keywords: Stress, Surface rupture, Fault striation, 2011 off the Pacific coast of Tohoku Earthquake, Fore arc, NE Japan

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SSS31-04 Room:104 Time:May 22 16:15-16:30

Stress change due to the great 2011 Tohoku earthquake (Mw 9.0) and induced earthquake activity in the inland areas of

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The 2011 Tohoku earthquake (Mw 9.0) triggered very high seismicity not only in the source region but also in the inland of eastern Japan (e.g. Hirose et al., 2011). Hasegawa et al. (2011, SSJ) and Yoshida et al. (2011, SSJ) estimated the stress field using these focal mechanisms, and suggested that the 2011 Tohoku earthquake changed the stress-field in the wide range from the source region to the inland area. This means that the stress magnitude (the important but unknown parameter) in Japan has been very small. In this study, to know the general value of the stress-magnitude in Japan, we examined in detail the boundary line between the two regions where the stress-fields have changed and unchanged due to the 2011 Tohoku earthquake. Thus, we analyzed the earthquakes near the Iwaki city and the northern part of the Ibaraki prefecture where the change in the stress-direction is reported by Yoshida et al. (2011).

We used the focal mechanism data estimated by 1) Asano et al. (2011) based on centroid moment tensor inversions of F-net and Hi-net data of NIED, 2) NIED applying moment tensor inversions to F-net data of with variance reductions better than 70% and 3) JMA based on P-wave polarity. Because there are few mechanism solutions at the shallow ($<$ 30 km in depth) portion in Iwaki and the northern part of the Ibaraki prefecture, 4) we presently picked the P-wave polarities for the earthquakes with the magnitude $>$ 1.0 and estimated the focal mechanisms of them. We only used the focal mechanisms which occurred in the hanging-wall. The classifying method is similar to Asano et al. (2011).

We performed the damped stress tensor inversion (Hardebeck and Michael, 2006). The region is gridded with 0.25 degree spacing, and each focal mechanism is assigned to the nearest grid node. These focal mechanisms are also divided with depth in two by the different way in the inland and offshore. In the inland part, the focal mechanisms in the shallower part have the depth 0 - 12.5 km, and the focal mechanisms in the deeper part have the depth 12.5 - 30km. This threshold is determined by considering the earthquake distribution. In the offshore part, we divided the focal mechanisms using the distance from the plate-boundary. The focal mechanisms in the deeper part occurred with the distance 0 - 25 km from the plate-boundary, and those in the shallower part with the distance 25 km- 50 km.

We compared the stress results in the region where stress-tensor is estimated both before and after the earthquake. In the shallower part of the inland, normal-faulting stress regime were estimated both before and after the earthquake. The directions of the maximum extension are NNW-SSE before the mainshock but E-W after the earthquake (E-W extension consists with the static stress change by the dislocation model). However, the confidence regions are overlapped. In the deeper part of the inland, different stress-regime are estimated. Before the earthquake, the reverse-faulting regime with the E-W maximum compression is estimated. But, after the earthquake the normal-faulting regime with the E-W minimum compression is estimated.

In the shallower part of the offshore, stress-fields are estimated near the coast both before and after the earthquake. Stress-field there changed from the E-W compressive strike-slip faulting regime to E-W extensional normal-faulting. In the deeper part of the offshore, stress-fields are estimated in wide range both before and after the earthquake. Generally, before the earthquake, E-W compressive reverse-faulting and strike-slip faulting regimes are estimated. But after the earthquake, E-W extensional normal faulting regimes are estimated.

These directions after the earthquake are consistent with the directions of the static stress-change by the 2011 Tohoku earthquake. The regions where the stress field changed before and after the earthquake are found in the area where the differential stress change is larger than about 1 MPa.

Keywords: 2011 Tohoku earthquake, focal mechanisms, stress tensor inversion, static stress change, stress magnitude

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Diversity in Triggering Mechanism for Seismic Events Following the 2011 off the Pacific Coast of Tohoku Earthquake

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Extensive aftershocks and triggered seismic events are ubiquitous following large earthquakes, but the controlling mechanisms are not yet understood. Focal mechanisms of these events can provide insight into physical triggering mechanisms because they reflect friction coefficient and pore fluid pressure on the fault as well as the tectonic stress pattern. In the present study we examined physical processes triggering seismic events following the 2011 off the Pacific Coast of Tohoku earthquake (Mw = 9.0) by examining focal mechanisms through CMT data inversion and changes in the Coulomb failure function (DCFF). In the shallow part (< 20 km) of the source region the tectonic stress pattern drastically changed from reverse-type with east-west compression to normal-type with east-west tension, while it doesn't change in the remaining region. We evaluated DCFF in the direction of resolved shear traction on the maximum shear plane of the present tectonic stress field. The direct causes triggering aftershocks of the 2011 Tohoku earthquake are increase of the magnitude of deviatoric stresses and decrease of the fault strength, which directly correspond to the two factors of the Coulomb failure function. The increase of seismicity rate in the region east to the Japan trench and central Honshu was mainly controlled by the former, which is caused by the static stress change due to the mainshock. The latter is more complicated, but one of the plausible physical processes is fluid diffusion excited by the mainshock. The temporal (apparent) stress rotation observed in the northernmost part of Nagano prefecture reflected temporal changes of statistical characteristics of focal mechanisms, caused by decrease of fault strength through increase of pore fluid pressures. The local excitation of seismicity rate in the northern Honshu also indicates that aftershocks in the region with negative DCFF may have been triggered by the same process.

Keywords: Aftershock/triggered seismic events, Stress, Pore fluid pressure, Change in Coulomb failure function

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Temporal decays of induced inland earthquakes associated with the 2011 M=9.0 Tohoku-oki, Japan, earthquake

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To reveal the status of regional stress loading and frictional properties, we take advantage of seismic responses due to static Coulomb stress transfer associated with a large earthquake. Here we examine spatio-temporal changes of inland seismicity after the Tohoku-oki shock, and find that there are two distinct temporal behaviors of induced seismicity: One is a short-lived triggered activity within a few months, and the other shows continuous high seismicity lasting more than a year. Induced seismicity in the later type can be mostly fit by the Omori-Utsu law with a p-value lower than 0.8. Together with their lower background rate of seismicity, extremely longer aftershock durations can be estimated, which is consistent with the rate and state dependent friction of Dieterich (1994). In contrast, the Izu Peninsula and Izu islands, which locate highly strained northern edge of the Philippine Sea plate, is typical to the short-lived induced seismicity. Seismicity beneath Tokyo metropolitan area, underlying multiple plate interfaces, has been moderated by the acceleration of loading rate associated with post-seismic deformation, and is estimated to be lasting its higher rate about 4 years since the main shock.

Keywords: Tohoku-oki earthquake, induced earthquake, Coulomb stress change, aftershocks