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

SSS31-P01 Room:Convention Hall Time:May 22 17:15-18:30

Seismic changes beneath the Nikkou-Ashio area associated with the 2011 Tohoku-Oki earthquake

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The 11 March 2011 Mw9.0 Tohoku-Oki megathrust earthquake induced many in-land earthquakes in Japan. Obvious changes in seismic activity are observed in the Nikkou-Ashio area located in the southern Tohoku. The seismicity rate was three to four times more active than usual. I have investigated the behavior of seismicity before and after the megathrust from 2000 to 2012, observed by Earthquake Research institute, University of Tokyo and report its changes, the relationship between hypocenters and the velocity structures and the b-value changes.

1) Seismicity.

After three hours later from the Tohoku-Oki earthquake, shallow micro earthquakes began to occur in the region. The induced earthquakes are characterized by locating very shallow depths of 1-2 km. They located at two different places in character. The one is near and around volcanic bodies such as Mt. Nantai-san and Mt. Shirane-san, where usual earthquakes seldom occur. The other is along the Uchinokomori faults. The place is the most seismically active zone in Ashio, where the local earthquakes always occur at depths of 7-8 km. The seismic activity around volcanoes is rapidly decreasing from June 2011, while the shallow earthquakes along the Uchinokomori faults still continue with usual activity.

2) Relationship between the seismicity and the velocity structure

Beneath the volcanoes, anomalous low velocity zones at depths of 5-8 km widely spread, which indicates the existence of magma or fluid. The induced shallow earthquakes are locating just above the low velocity zones. The shakes and the stress changes due to the significant earthquakes and fluid derived from under low velocity zones result in shallow earthquakes. The decreasing of normal stress for the Uchinokomori faults and the upwelling flow of fluid also may result in very shallow earthquakes along the faults.

3) Change in b-value

B-value in the Nikkou-Ashio region changed immediately concerned to the 2011 Tohoku-Oki earthquake. Before eight months b-value was 0.8, then gradually it increased up to 0.98 until just before the earthquake and after the Tohoku-Oki earthquake, it decreased down to 0.75. Until now the fluctuation of the b-value is related to the occurrence of low-frequency earthquakes. Low-frequency earthquakes in the Ashio region have occurred with a recurrence interval of about three years at the point of b-value reversal. When the b-value is relatively low, low-frequency earthquakes occur and after that b-value become high with promoted seismic activity. In this time, low-frequency earthquakes occur almost the same period associated with the reversal of b-value. The change of b-value is also caused by the 2011 Tohoku-Oki earthquake. We need a more study to understand the relation between them.

Keywords: seismicity change, b-value, low velocity zone, Nikkou-Ashio

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Index for simultaneous rupture assessment of active faults based on seismic velocity structure

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Tomographic inversion was carried out in the northern source region of the 1891 Nobi earthquake, the largest inland earthquake (M8.0) in Japan to detect subsurface structure which controls simultaneous rupture of active fault system. In the step-over between the two ruptured fault segments in 1891, a remarkable low velocity zone is found between the Nukumi and Ibigawa faults at the depth shallower than 3-5 km. The low velocity zone forms a prism-like body narrowing down in the deeper. Hypocenters below the low velocity zone connecting the two ruptured segments indicate the possibility of their convergence in the seismogenic zone. Northern tip of the Neodani fault locates in the low velocity zone. The results show that fault rupture is easy to propagate in the low velocity zone between two parallel faults. In contrast an E-W cross-structure is found in the seismogenic depth between the Nobi earthquake and the 1948 Fukui earthquake (M7.1) source regions. It runs parallel to the Hida gaien belt, a major geologic structure in the district at the northern margin. P-wave velocity is lower and the hypocenter depths are obviously shallower in the northern part. Since a few faults lie in E-W direction just above it, a cross-structure zone including the Hida gaien belt might terminate the fault rupture. The results indicate fault rupture is difficult to propagate beyond major cross-structure. The length ratio of cross-structure to fault segment (PL/FL) is proposed to use for simultaneous rupture assessment. Some examples show that fault ruptures never (PL/FL>3-4), sometimes (~1), and always (<1) cut through such cross-structures.

Keywords: Active fault system, Simultaneous rupture, The 1891 Nobi Earthquake, Seismic velocity structure, Cross-structure

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Focal Mechanisms and Regional Stress Field in the Northern Kinki District using the Dense Seismic Array

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In the northern Kinki district, we have done seismic observations using the dense seismic array stations since 2008. Total 150 temporal and permanent stations are used, and the average interval between the stations is about 5km. We get numerous mechanism data in a short time period, and the space and time resolution of the focal mechanism analyses are improved. Based on these data, we'll discuss about the feature of focal mechanisms, space and time variation of the regional stress field, and the detail mechanism distribution within aftershock sequence following the M4 class earthquakes.

Keywords: Focal mechanism, Stress field, Micro-earthquake, Dense Array Observation, Tamba plateau

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Focal mechanisms of the small earthquakes in and around the Atotsugawa fault and stress accumulation process

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To understand the stress accumulation process in and around the Atotsugawa fault system with higher spatial resolution than previous reports (Katsumata et al., 2010; Imanishi et al., 2011), we examined the focal mechanisms for very small earthquakes in this region using the data observed from January 2005 to December 2008 with temporary deployed seismometers and permanent stations. We determined the focal mechanisms from P-wave first-motion polarities by the method of Maeda (1992). The P and S-wave arrival times, and P-wave polarities were automatically determined by the algorithm recently developed by Horiuchi et al. (2011). In most depth ranges, the obtained focal mechanisms correspond to various types of faulting (normal, reverse, and right-lateral strike slip). At the deepest part, on the other hand, the right-lateral strike slip seems to be dominant, which is consistent with Imanishi et al. (2011). We have checked the automatically picked P-wave arrivals by WIN system (Urabe and Tsukada, 1991) just in case. Finally, we estimated the stress field in and around the Atotsugawa fault system from the focal mechanisms by a conventional stress inversion technique (Gephart and Forsyth, 1984). The earthquakes less than 15 focal solutions were adopted as input data for the stress inversion.

Keywords: Atotsugawa Fault, focal mechanism, small earthquake, crustal heterogeneity, stress accumulation process

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Stress field in the western part of Tottori Prefecture inferred from focal mechanisms inversion

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Stress tensor inversions using focal mechanisms data are important in understanding the stress fields in the seismogenic region. In this study, we performed a stress tensor inversion using the data from the Joint Group for the Dense Aftershock Observations of the 2000 Western Tottori Prefecture earthquake. Kawanishi et al., (2009) could not estimate the stress field in the region where the main shock slip was large since the stress fields in the region is not homogeneous. Thus, in this study we divided the region into smaller subregions where stress fields can be regarded to be homogenuous. Furthermore we tried to improve the standard stress inversion method using focal mechanisms (ex. Gephart and Forsyth (1984)) to accurately estimate stress fields using less data.

If the shear stress on the fault plane is relatively low, theoretical slip vectors can change significantly by small changes of a strike and/or dip of the fault plane, therefore in such a case, misfit angles on the fault plane can inherently include large error. Since we could not accurately estimate stress fields in such a case, we tried to improve the accuracy of stress field analysis by reducing a weight for misfit angles when the shear stress normalized by S1-S3 is small. Simulations using test data show that the improved method estimates stress tensor more accurately than standard methods.

In this study, we used high-quality 1536 earthquake focal mechanisms data. We divided the aftershock area into 9 subregions along the axis of the aftershock distribution and 3 subregions along depth. In addition, to estimate stress fields in large sip area estimated by Iwata and Sekiguchi (2002), we further divided the subregions based on the spatial distribution of the static stress changes generated by the main shock and estimated stress field in each region. We inferred that the strength of fault planes in the large slip area is strong because directions of the maximum principal stress axis obtained by the stress inversion do not coincide with those of the static stress changes. On the other hand, we inferred that the strength of fault planes at either end of the large slip area is weak since directions of the maximum principal stress coincide with those of the static stress changes. From these results, we inferred that stress relaxation occurred prior to the main shock in the area where strength of fault planes is weak, but that stress concentration occurred prior to the main shock in the area where strength of fault planes is strong. This may be the reason why the large slip by the main shock occurred in this area.

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SSS31-P06 Room:Convention Hall Time:May 22 17:15-18:30

Distribution of crustal deformation around the Echigo plain, the Niigata-Kobe Tectonic Zone

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We examined the GEONET GPS data to clarify the contemporary deformation in and around the Echigo plain, Niigata prefecture where located in the Niigata-Kobe tectonic zone and the deformation zone of the eastern margin of the Japan Sea. Compressional strain in a direction of ESE-WNW is concentrated in a narrow zone where strain rate is about 0.2 ppm/yr along the coast of the Japan Sea. This strain concentration zone which is about 25 km wide accommodates more than 5 mm/yr of compression and geographically corresponds to the Echigo plain. The zone significantly subsided whereas surrounding regions was uplifted. These characteristics of the deformation are concordant with that measured by conventional geodetic surveys spanned more than several decades. The strain rate observed by GPS does not change significantly during more than a decade in the strain concentration zone, which is contrast with a large temporal change of a strain rate in the eastern region affected by a subduction of the Pacific plate. We proposed a simple model to explain the characteristics of the deformation. The model consists of aseismic slip on reverse faults which are extended to the east and west rims of the Echigo plain. Modeling with gravitational viscoelastic medium is essential to reproduce the observed subsidence in the strain concentration zone.

We started campaign GPS measurements across the Echigo plain in 2010. The distribution of the observed crustal deformation suggests a broad extension caused by the 2011 Tohoku-oki earthquake in a direction of east-west. The extension in the Echigo plain is larger than that of the surrounding region. The area where the larger extension was observed approximately corresponds to the strain concentration zone before the earthquake.

Keywords: crustal deformation, GPS, geodetic survey, deep slip, strain concentration zone

SSS31-P07 Room:Convention Hall Time:May 22 17:15-18:30

Strain concentration zone in quaternary caldera, eastern Hokkaido, detected by GPS data

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We estimated spatiotemporal strain field using GPS data in eastern Hokkaido. There is a high shallow seismicity around Kussharo caldera. In addition, according to JMA hypocenter catalogue, there are four middle size earthquakes in the last 100 years (e.g., M6.1 Kussharo earthquake in 1938, Mj 6.5 Teshikaga earthquake in 1967). Therefore, it is important to understand the strain accumulation and release processes in this area.

In this study, we used GEONET daily coordinates (F3 solutions), which has been organized by GSI. In order to figure out steady state strain field, we treated two periods, November 1998 to October 2001 and July 2007 to November 2009, and estimated site velocities by fitting linear trend and seasonal variation (annual and semi-annual trend) to the daily coordinates. Strain rate was calculated from these site velocities using method of Shen et al. (1996). For comparison, we also estimated strain field at the coseismic period of two large earthquakes (Mj 8.0 Tokachi-oki earthquake in 2003 and Mj 9.0 Tohoku-oki earthquake in 2011) and their early postseismic period (a half-year after those earthquakes) from each displacement field.

In the steady state period, large contractional dilatation strain rate (~0.2ppm/yr) and NW-SE shortening were detected around Kussharo caldera in both periods. Although the maximum shear strain rate (0.1-0.2ppm/yr) was not remarkable with respect to dilatation strain rate, relatively large area was recognized around this area. The extent of large strain rate region is slightly different between these two periods. However, their both centers are located near Kussharo caldera. This distribution pattern is probably not explained by possible shallow magmatic contraction of active volcanoes.

There was no large difference in strain rate between two periods. The strain rate was almost constant even the 2003 Tokachi-oki earthquake occurred between two periods. At the postseismic period after the 2011 Tohoku-oki earthquake, we also recognized large strain field around Kussharo caldera. On the other hand, we did not detect those strain anomalies at the coseismic period of two large earthquakes and the postseismic period after the 2003 Tokachi-oki earthquake. This strain concentration area probably has a viscoelastic characteristic feature, which gradually deforms following the instant stress change such as earthquake. Meanwhile, this area is deformable with respect to the long-term stress change. The case of early postseismic period of 2003 Tokachi-oki earthquake, it is possibly buried the strain anomaly in the large postseismic deformation signal due to the closeness from the focal area.

It is thought that the origin of strain concentration zone in Japan, such as Niigata-Kobe tectonic zone (Sagiya et al., 2000) and Ou-backbone range (Miura et al., 2004), is weakening of the lower crust due to the upwelling flow from subducting plate or mantle wedge. This phenomenon induces inelastic behavior in the lower crust (e.g., Iio et al., 2004). As well as those strain concentration zones, several studies suggest the possibility of the lower crust weakening beneath Kussharo caldera region. For example, low seismic velocity (e.g., Wang and Zhao, 2009), and low electric resistivity (Satoh et al., 2001) is detected in the lower crust. High geothermal gradient (Geological Survey of Hokkaido, 1995) is also reported.

To specify detailed extent and amount of this strain concentration area, it is necessary to reveal detailed crustal deformation from denser GPS network, and to compare several solutions from different estimation methods. Based on these results, we have to consider the strain accumulation and release process in this area.

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Earthquake and stress around the inland active faults - in-situ stress measurements at Gofukuji and Hagiwara fault -

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Earthquakes occur when the shear stress accumulated and exceeds the shear strength on the fault plane. We think the distribution of stress around the fault is important for the earthquake forecasting. We reports results of in-situ stress measurements at Gofukuji and Hagiwara fault. As for the Gofukuji fault, more the 1000 years have passed and the forthcoming earthquake is regarded to be impending. After The 2011 off the Pacific coast of Tohoku Earthquake, a large earthquake occurred near the Gofukuji fault. The Hagiwara fault also does not generate earthquake for more than 1000 years. In addition, due to effects of the 2011 off the Pacific coast of Tohoku Earthquake, the long term probability of earthquake occurrence on this fault might become to be higher than that before the earthquake (Headquarters for Earthquake Research Promotion 2012). It is considered the stress states around the inland active faults are significant to forecast the forthcoming earthquake.

Keywords: In-situ stress measurement, Earthquake occurrence, Inland active fault, Gofukuji fault, Hagiwara fault

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AMT observations over the remotely triggered seismicity in Hakone volcano

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Seismicity around the Hakone volcano was activated just after the arrival of surface waves caused by the 2011 off the Pacific coast of Tohoku Earthquake. Most of these triggered earthquakes had similar distribution to prior occasional swarm activities. In order to image electrical properties around such seismic events, we carried out audio-frequency magnetotelluric (AMT) measurements at 39 sites in December 2011. These AMT sites were arranged in an area of approximately 15km by 20km covering the caldera of Hakone volcano. On each site, electromagnetic data were recorded for up to 20 hours. As the result of remote-reference processing using local and far sites for shorter and longer periods, respectively, we obtained fair sounding curves at most sites for frequencies higher than 1Hz. In this presentation, we will show the outlines of our research project, an overview about the AMT data, and report preliminary results of three-dimensional inversions compared with seismicity.

Keywords: resistivity, magnetotellurics, Hakone volcano, triggered earthquake

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On the Network-MT survey in the vicinity of the 1891 Noubi Earthquake seismic fault

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Network-MT survey has started since Jun, 2011 in the western part of Chubu district, where one of the largest inland earthquakes in Japan, the 1891 Noubi Earthquake, took place. We aims at investigating static shift free fine structure in the vicinity of the fault, and at obtaining wide and deep resistivity structure beneath whole Chubu district to investigate dehydration process on the subducting Philippine Sea Plate and generation mechanism of the Niigata-Kobe Teconic Zone.

In this presentaton, we introduce the on-going Network-MT survey and results from its data processing and preliminary 3-D structural analysis.

Keywords: noubi earthquake seismic fault, resistivity structure, network-MT