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

SCG64-P01 Room:Convention Hall Time:May 23 13:45-15:15

Resistivity structure around the Ishikari-teichi-toen fault zone, Hokkaido, Japan (3)

YAMAYA, Yusuke[1*], MOGI, Toru[2], HONDA, Ryo[2], HASE, Hideaki[1], Atsuo Suzuki[2], HASHIMOTO, Takeshi[2], UYESHIMA, Makoto[1]

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In order to understand source processes of inland earthquake, it is important to reveal a crustal structure and distribution of fluids beneath the fault zone. Resistivity sounding using magnetotelluric (MT) method can detect resistivity structure down to a few dozen km, depending on a frequency band, and resistivity is a sensitive quantity to the presence of fluids. The Ishikari-teichi-toen active fault zone is located on the eastern edge of Ishikari lowland. This region corresponds to the geological and tectonic boundary between the central and southwestern Hokkaido, and is realized as a strain concentration zone compressed in the E-W direction. In order to image a resistivity structure including the lower crust, the MT survey was carried out in this region.

Prior to a 2-D analysis, we calculated MT responses by 3D resistivity model assuming the ocean and conductive sediments, in order to estimate the effect due to low resistivity of the ocean. As a result, a significant effect was clarified in TE mode at a frequency band below 0.03 Hz. Therefore, 2-D analysis treated the TM mode of a whole frequency band and TE mode above 0.03 Hz. The 2-D resistivity inversion code developed by Ogawa and Uchida (1996) estimated resistivity sections along four survey lines that were perpendicular to the fault zone.

The four inverted resistivity sections indicated a similar tendency, which consisted of three layers; resistive (0-2 km), conductive (2-7 km) and resistive (>7 km). The structure shallower than 7 km was consisted with seismic velocity structure, showing characteristics of the detachment and fold due to the thrusting activity. The conductive layers are significant (<10 ohm-m) below the middle part of the lowland but they do not extend to the east beyond the fault zone. This boundary can correspond to the extension of the main fault and be interpreted as a detachment of thrusting structure. The deeper part was almost uniform resistivity of a few ohm-m, except the conductor at the southwestern part, which was probably related to the activity of the Shikotsu caldera. On the other hand, the conductor implying fluids in the crust was not found beneath the fault zone. However, the MT response including such structure (i.e. deep conductor) could be removed during the 2-D analysis, because we reduced the MT data to prevent the sea effect, which was caused by the conductive seawater surrounding the study area. A full 3-D inversion analysis can resolve this problem effectively.

Keywords: high strain rate zone, Ishikari-teichi-toen fault zone, resistivity structure, magnetotelluric

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Resistivity structure in southern Tohoku region inferred from Wide-band MT surveys (2)

HASE, Hideaki[1*], SAKANAKA, Shin'ya[1], KOYAMA, Takao[1], UYESHIMA, Makoto[1], WATANABE, Atsushi[1], Koji Miyakawa[1], Masato Serizawa[1], Shigeru Koyama[1], YAMAYA, Yusuke[1]

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In the tectonic zone, dehydrated fluid from a subducted oceanic plate is estimated to be localized in the crust and the upper mantle. It is considered that identifying the localized fluid is the critical key to clarify the mechanism of tectonic zone. Therefore, measuring of electrical resistivity structure which is highly sensitive to fluid, is thought to be contributing to clarify the mechanism of the tectonic zone. We started wideband magnetotelluric (MT) surveys in the northeastern margin of Japan sea tectonic zone since 2008. In 2010, we performed 27 MT surveys on YNZ line (Murakami, Niigata <-> Soma, Fukushima) from east to west in the southern part of Tohoku region.The surveys have been continued about 20 days at each site by using 12 measurement devices(11 of ADU07[Metronix Geophysics] and a MTU[Phoenix Geophysics]). We obtained impedance responses by using the robust code of BIRRP (Chase and Thomson, 2004), and estimated 2D resistivity structure by using a 2D inversion code (Ogawa and Uchida, 1996). 2D models from TE and TM modes show a conductive part (C1) between two resistive parts(R1, R2) in the middle of the survey line. The C1 is located at the volcanic front, which can image that the C1 is partial melts or hydrothermal area.

Keywords: MT survey, resistivity structure

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SCG64-P03 Room:Convention Hall Time:May 23 13:45-15:15

Spatial distribution of stress field around Niigata prefecture inferred from a marine and land seismic network

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The Niigata-Kobe Tectonic Zone (NKTZ) (Sagiya et al., 2000) is placed in the eastern margin of the Japan Sea, many large earthquakes occurred within NKTZ. To understand the generation mechanism of these earthquakes and a formation of the NKTZ, it is important to obtain detailed hypocenter distribution around the NKTZ and to estimate stress field around the region. From focal mechanisms of aftershocks of the 2004 Chuetsu earthquake and the 2007 Chuetsu-oki earthquake, the stress fields around the source regions were estimated (Kato et al., 2006; Imanishi et al., 2006; Imanishi and Kuwahara, 2009). It is difficult to estimate stress fields in the marine region around Niigata prefecture precisely, because it is difficult to locate precise hypocenters in offshore regions only land seismic stations. Precise hypocenter locations determined by using oceanic bottom seismometers enable us to estimate precise stress fields in marine area. Shinbo et al. (2010) determined hypocenters by using 10 long-term ocean bottom seismometers off Joetsu, Niigata prefecture and land seismic stations from Dec., 2008 to Oct., 2009 and estimated focal mechanism solutions. In this study, we examine stress tensor inversion using these focal mechanism solutions and investigate spatial distribution of stress field from source region of 2004 Chuetsu earthquake to the marine region around Niigata prefecture.

We calculated the stress field by applying method of Hardebeck and Michael (2006) and estimated the principal axes. As the result, azimuth of maximum principal stress is from NW-SE to WNW-ESE and its dip is close to be horizontal. Dip of minimum principal stress is close to be horizontal near the mainshock of 2007 Chuetsu-oki earthquake and is close to be vertical near the mainshock of 2004 Chuetsu earthquake and in the marine region around Niigata prefecture. This result show the stress field becomes the strike-slip type near the mainshock of 2007 Chuetsu-oki earthquake and becomes the reverse fault type in other regions. We suggest the local variation in stress field.

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SCG64-P04 Room:Convention Hall Time:May 23 13:45-15:15

P-wave velocity structure model in a shallow part around the source area of the 1964 Niigata earthquake

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At the eastern margin of the Japan Sea, large earthquakes have been occurred (e.g., 1964 Niigata earthquake, the 1983 Japan Sea earthquake, the 2004 Chuetsu earthquake and the 2007 Chuetsu-oki earthquake) along the Niigata-Kobe Tectonic Zone (NKTZ). The NKTZ is recognized as a region of large strain rate along the Japan Sea coast and in the northern Chubu and Kinki distinct. Among these events, the 2004 Chuetsu earthquake and the 2007 Chuetsu-oki earthquake is triggered by reactivation of pre-existing faults within ancient rift systems by stress loading through a ductile creeping of the weak lower crust (Kato et al., 2008). Because the tectonic zone is thought to be spread in offshore region, it is difficult to understand a precise activity of the tectonic zone from only land-base observations. To compare the seismic activity with the crustal structure in the region is indispensable to understand the stress field in the tectonic zone and the tectonics in the eastern margin of the Japan Sea. In order to understand precise seismic activities in the NKTZ, especially in offshore region, we installed Ocean Bottom Cabled Seismometers (OBCSs) in the source region of the 1964 Niigata earthquake in 2010 (Shinohara et al., 2010). The OBCS system has a length of 25 km and 4 OBCSs were developed with 5 km interval. The OBCSs have three accelerometers as seismic sensor. In 2011, a seismic survey using airguna and OBCSs was carried out to obtain a seismic velocity model. To understand a precise crustal structure is necessary for precise earthquake locations. The precise seismic activities may contribute to understand a current state of the source region of the 1964 Niigata earthquake. In this study, we construct a P-wave velocity model below each OBCS using the tau-p mapping and the tau-sum inversion method (Stoffa et al., 1981; Shinohara et al., 1994). Then we estimate proper station corrections each OBCS for earthquake location.

Keywords: High strain rate zone in Japan, The 1964 Niigata earthquake, Ocean Bottom Cabled Seismometer (OBCS), Crustal structure

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Crustal structure of the fold-and-thrust belt, Chuetsu, central Japan: result of 2012 Muikamachi-Naoetsu seismic survey

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Associated with the opening of the Japan Sea, volcanic rift-basins have been developed along the Japan Sea coast of northern Honshu. The Niigata basin, central Japan, is one of such basins and filled by thick ($<$ 8 km) Neogene sediments. By subsequent convergence since the Pliocene, an arc-parallel fold-and-thrust-belt has been developed along the Miocene rift-basins. In this belt devastative earthquakes, such as 1964 Niigata (M7.5), 2004 Chuetsu (M6.8) and 2007 Chuetsu-oki (M6.8) earthquakes, occurred by reverse faulting. Due to thick Neogene sediments, relationship between active faults/folds at near the surface and deep-sited seismogenic source faults is poorly understood. To reveal the crustal architecture, in particular geometry of source faults, onshore-offshore integrated deep seismic profiling was undertaken since 2008 for five-years-project. The 2011 Muikamachi-Naoetsu seismic line cut through the south of the epicentral area of the 2007 Chuetsu-oki earthquake.The seismic sources were air-gun (3020 cu. inch), four vibroseis trucks and explosives (100 kg) and seismic signals were recorded by ocean bottom cables, cable-connected-recording system and offline recorders, forming a maximum 2040 channels receiver array. The velocity profile obtained by P-wave refraction tomography portrays the depth of the top of Mesozoic metasedimentary rocks (Vp$>$5.4 km/s). Pre-Neogene rocks cropping out at near surface in the Echigo Mountain area and increasing its depth on the hanging wall of the Muikamachi fault.As the Muikamachi fault is a reverse active fault, the vertical offset of the top of pre-Neogene suggests that the fault reactivation since the Pliocene. The base of Neogene fill under the Higashikubiki hills ranges from 5 to 7 km below the sea level and shows swell beneath the western part of the hills.Based on the velocity profile and pattern of reflectors, the relationship between deep-sited source faults and active faults and folds, are clearly identified. Shallow detachment commonly developed in the lower Teradomari Formation.Due to this detachment, a source fault in the thick-skinned part does not connect straight to a fault in the thin-skinned part.

SCG64-P06 Room:Convention Hall Time:May 23 13:45-15:15

High-resolution seismic reflection profiling in the eastern margin of Takada plain, central Japan

KATO, Naoko[1*], SATO, Hiroshi[1], ISHIYAMA, Tatsuya[1], KURASHIMO, Eiji[1], KOSHIYA, Shin[2], TODA, Shigeru[3], TOYOSHIMA, Tsuyoshi[4], SAITO, Hideo[5], SHIRAISHI, Kazuya[5], ABE, Susumu[5], KITAMURA, Shigehiro[6], NAKAYAMA, Yoshitaka[6], Kakeru Wakita[3], Kouya Shinada[4]

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Mapping of seismogenic source fault beneath a fold-and-thrust belt is significant for the estimation of seismic hazard. To reveal seismogenic source faults, deep seismic reflection profiling was undertaken along the Muikamachi-Naoetsu seismic line (Sato et al., 2012: JPGU). The deep seismic profiling aims crustal scale image and for the imaging of shallow fine-scale structure its resolution is not enough. To obtain complete image of the active-seismogenic source fault system, we carried out the high-resolution seismic reflection profiling in the eastern margin of the Takada basin for 7-km-long seismic line. Seismic data were acquired using two vibrator trucks (IVI, EnviroVib). The sweep signals (8-80Hz; reflection profiling) were recorded with 4.5 & 10 Hz geophones deployed at 12.5 m intervals, off-line recorder (ERI LS8200SD, JGI MS2000). The seismic data were processed using conventional CMP-reflection methods. The obtained seismic section portrays the seismic image and velocity structure down to 2 km. The seismic section demonstrates an asymmetric fold with steeper eastern limb and gentle western limb. The thrust forms a small-scale wedge-thrust. As the main anticline was formed by the deep-sited thrust, this shallow thrust played a secondary role for this anticline.

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Late Pleistocene uplift rate across the eastern margin fault zone of the Takada-heiya based on borehole drillings

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Keywords: the eastern margin fault zone of the Takada-heiya, sliprate, active fault, Takada-plain, borehole drillings

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SCG64-P08 Room:Convention Hall Time:May 23 13:45-15:15

High resolution seismic reflection profiling across the Torigoe fault, central Japan

ISHIYAMA, Tatsuya[1*], KATO, Naoko[1], SATO, Hiroshi[1], KOSHIYA, Shin[2], TOYOSHIMA, Tsuyoshi[3], ECHIGO, Tomoo[4], KOBAYASHI, Kenta[3], TODA, Shigeru[5], IMAIZUMI, Toshifumi[6], OKAMOTO, Takahiro[7], IRITANI, Masato[7], TANAKA, Mai[7], Tomoya Onodera[2], Takuya Hatakeyama[2], Tadako Terui[2], KOIKE, Taro[8]

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We collected and processed shallow high-resolution seismic reflection data across the Torigoe fault in Niigata sedimenrary basin, in order to resolve shallow structures and to understand structural linkage between active faults and folds recognized at ground surface and deeper, complicated fold and thrust structures. We deployed 200 seismic channels, 10-Hz geophones, and mini-vibrator as a seismic source along about 7-km-long seismic line. Common midpoint stacking by use of initial velocity analysis successfully illuminates subsurface geometries of active fault-related fold to 1-1.5 two-way time. Detailed seismic reflection analyses including refraction and residual statics, migration, deconvolution, and time-space variant bandpass filters, and depth-conversion by use of stacking velocities enable to obtain subsurface depth section of these active structures. The high-resolution depth section shows that upward extension of the west-dipping thrust imaged in the deeper section is consistent with emergent thrust fault defined by middle Pleistocene conglomerates, sand- and mudstone are thrust over younger fluvial sediments. It is of interest that several active fault/fold scarps on the footwall side of the emergent thrust are underlain by west dipping thrusts marked by fault cutoffs recognized by discontinuities of reflectors. These west-dipping thrusts are interpreted to merge into sedimentary layers shallower than 1 km. Gently upward geometries of the footwall strata show that they are upward folded at northward propagation of a right stepping en echelon active anticline to the south. These observations suggest that interactions between adjacent en echelon, lateral propagating active folds strongly controls styles of faulting at structural highest levels, manifested by topographic fault or fold scarps.

Keywords: Torigoe fault, active fault, active fold, seismic reflection profile, Niigata

SCG64-P09 Room:Convention Hall Time:May 23 13:45-15:15

Improved, high-resolution underground velocity structure in the Niigata region and its relation with seismicity

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Niigata area is part of a broader region, located in the central and north-eastern part of Japan, known for its high strain rates (Sagiya et al., 2000). To have a detailed understanding of the seismotectonic characteristics in the Niigata region, we have installed a dense temporary network of 300 seismic stations, which started functioning from 2008. In a previous tomography analysis (Enescu et al., 2011) we have revealed the undulated surface of the basement rock, hidden under a thick low-velocity layer of Neogene sediments and volcanic extrusions that form the Niigata basin. The earthquake locations, inverted together with the velocity structure, became systematically shallower, in agreement with results reported before (e.g., Kato et al., 2009).

In this study, we have used additional very deep earthquakes to better constrain the basement structure. The data consists of 1805 crustal events that have 151,780 P-wave and 169,696 S-wave arrivals, recorded at 434 temporary and permanent seismic stations. We have also manually picked deep earthquakes, with magnitudes larger than 3.5, which occurred within the subducting Pacific plate and have depths between 80 and 280 km. We have given ten times additional weight to the deeper events. The tomography inversion is conducted using the tomoDD software (Zhang and Thurber, 2003). The horizontal and vertical grid spacing were of 5 ~ 10 km and 2 ~ 10 km, respectively.

Due to the inclusion of deep earthquake picks, the velocity image of middle to lower crust was improved. The clearest feature of our velocity model is the undulated surface of the basement rock extending from SW to NE. Compared with the results we have reported previously, the undulated structure could be imaged further to the north-east, beneath the Niigata basin. The obtained results indicate that the majority of the earthquakes are located in regions where the P-wave velocity ranges from 5.5 to 6.5 km/sec. Most of the events occur on the flanks of the low-velocity region; in the basin area (of low-velocity) and the undulated basement underneath there is almost no seismicity. However, a few earthquakes do occur in the deeper region (at depths below 15 km). The earthquake activity from 2001 to present (Hi-net catalog) confirms these features. In particular, the aftershocks of the 2004, M6.8 and 2007, M6.8 Niigata earthquakes, as well as the more recent seismic activity following the M6.7 Nagano earthquake (April, 2011) are all located either on the flanks of the low-velocity region or slightly further apart. A high velocity body (i.e., P-wave velocity larger than about 6.5 km/s) is imaged below the central axis of the rift-like structure, similar with results reported by Kato et al. (2009). However, the high velocity body appears to be present only in the central part of our study region, in-between the aftershock distributions of the 2004 and 2007 Niigata aftershock sequences. Only a few earthquakes occur within the higher velocity region. The existence of the higher velocity body constrains the lower limit of the seismogenic region. The detailed mapping of the rift-like structure helps understanding where and why large earthquakes nucleate.

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Crustal movement of North Nagano earthquake and seismotectonics of the Sakae - Tsunan - Matsunoyama district

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On March 11th in 2011, off the Pacific coast of Tohoku Earthquake (M9.0) occurred off Miyagi. Next day, on March 12th in 2011, North Nagano earthquake (M6.7) occurred on the boundary between Nagano and Niigata prefecture. This area is located in Shinanogawa seismic belt (Ohmori, 1907) and Niigata-Kobe tectonic zone (Sagiya et al., 2000).

By GEONET GPS analysis, Matsunoyama (0244) displaced 39.3 cm toward the northeast and Naganosakae (0982) displaced 4.2 cm toward the north. But, on Niigata-Kobe tectonic zone maximum shortening occurs in an E-W trend.

In this study, in order to reveal temporal change in displacement field at and around the time of those earthquakes and to examine characteristics of the earthquake source fault, to elucidate a cause of displacement, I analyzed the GEONET GPS data by using GAMIT software (ver.10.42) and RTD software (ver.3.5). Also I presumed characteristics of the source fault inferred from aftershock distribution by utilizing Seis-PC software (Nakamura et al., 2005), and estimated ground surface deformation due to shear and tensile faults by using DCSTN software (Okada, 1992).

Concluding remarks resulted from the study are as follows.

At the moment when the North Nagano earthquake occurred, Matsunoyama (0244) performed 40.3 cm displacement northeastward, while Naganosakae (0982) displaced 11.8 cm northwestward. The North Nagano earthquake caused a large of displacement to epicenter surrounding area, but postseismic crustal movement due to the Tohoku -Pacific Earthquake progress remarkably after the North Nagano earthquake.

There is a possibility that an unknown fault was active by aftershock distribution. Displacement of GPS permanent stations have been not necessarily affected with faulting direct. Coseismic development of the fold structure is implied as the cause.

Keywords: North Nagano earthquake, GEONET, faults, Matsunoyama dome, geopressure

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GNSS continuous observation network in sourthern Niigata Prefecture

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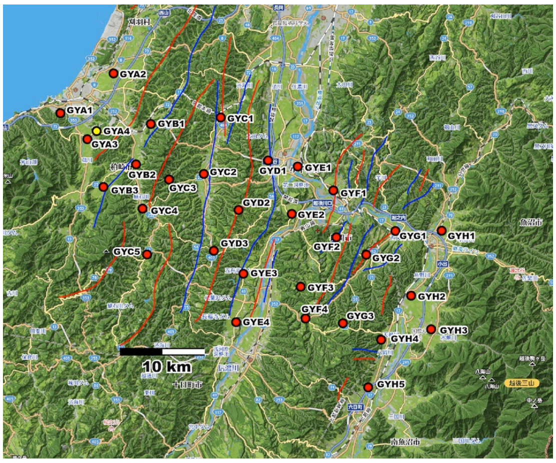
Continuous GNSS observation network is deployed in southern Niigata prefecture expanding an area of 50km to 15km. This is comprises of 30 GNSS stations (Leica GR10 with AR10 anntenna) attached on buildings or fixed on the ground.

GPS data of the network are analysed combined with 21 of the GEONET stations (GPS Earth Observation Network) and far stations of IGS (international GNSS service). GPS 24 hour data are analyzed everyday by means of Bernese GPS software (version 5.0) (Hugentobler et al., 2001), using the IGS precise ephemeredes and Earth orientation parameters. Troposphere delays are estimated at each station for every one-hour period. Also, GPS/GLONASS analysis is conducted.

This research is funded and supported by Japan Nuclear Energy Safety Organization (JNES).

Keywords: GPS, crust deformation



SCG64-P12 Room:Convention Hall Time:May 23 13:45-15:15

Construction of integrated velocity model of shallow and deep structure in the high strain rate zone

SENNA, Shigeki[1*], Takahiro Maeda[1], yoshiaki Inagaki[2], Norihiro Matsuyama[2], Nobuyuki Morikawa[1], Hiroyuki Fujiwara[1]

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In this study, the microtremor investigation was carried out in the Yamagata whole region and Shallow and deep integrated model (initial geological model) were created. Moreover, in the Niigata whole region, an initial geological model and S wave velocity structure were improved, and shallow and a deep integrated structure model were developed. In order to overcome the above problem, we executed a lot of microtremor measurements in and around the sedimentary basins. About the Niigata area, the initial structure model (shallow structure model J-SHIS model) which was being created until now deviated greatly with the phase velocity obtained by microtremor observation. The theoretical phase velocity by the added speed structural model is as harmonic as observation phase velocity, and the convergency of the joint inversion calculation which unites the periodic characteristic became very good. Moreover, results, such as the periodic characteristic calculated from a model, have checked that a harmonic result was obtained as compared with results, such as the periodic characteristic by seismic observation record.

Keywords: Integrated structure model, strong-motion, microtremor measurements, Geology stratigraphy, S-wave velocity

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SCG64-P13 Room:Convention Hall Time:May 23 13:45-15:15

Microtremor Measurement at Large Seismic Intensity Regions of the 1828 Sanjo Earthquake

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The 1828 Sanjo earthquake is considered to be a crustal event with around M6.9 (Usami, 2003). The source region seems to be located in the Niigata-Kobe tectonic zone. The numbers of fatalities and damaging houses were 1,681 and 13,149, respectively (Usami, 2003). The Sanjo earthquake is one of the well documented historical earthquakes to validate strong ground motions using the seismic intensities.

According to the historical seismic intensities by Yada and Urabe (2010), large seismic intensities were estimated inside and eastern edge of the Echigo basin. Senna et al. (2011) performed dense microtremor measurement and constructed deep and shallow velocity structure models inside the basin. Therefore, we set our objective to measure microtremor in large seismic intensity regions located at the basin edge near the Higashiyama hill in Mitsuke, along the eastern edge of the basin from Mitsuke to Sanjo, and western part of the basin near Yahiko.

We performed microtremor measurement during the daytime between 28 to 30 Novmeber 2011. The portable strong motion seismometer consists of three components of acceleration sensor SMAR-6A3P with data logger LS-7000XT. We surveyed 30 min for each station and recorded the data with 100 Hz sapling. From the preliminary analyses of H/V spectral ratios, there were several stations of seismic intensity 7 with a dominant frequency of 1 Hz. Other stations with less seismic intensity showed dominant frequencies of 3-5 Hz. Although most stations were located in the back marsh, variations were significantly seen in the amplification factors.

Keywords: Sanjo earthquake, historical earthquake, microtremor measurement, H/V spectral ratio

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

SCG64-P14 Room:Convention Hall Time:May 23 13:45-15:15

The trial edition of historical earthquake data base in high strain rate zone

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There are many historical documents in Japan and these are analyzed by historical researchers. The descriptions of the occurrence times and damage of historical earthquakes in and around Japan are included in these historical documents. However, the analyses of these historical documents require technical knowledge and therefore, it is not straightforward for unprofessional researchers to directly utilize these historical documents. A historical earthquake document data base was made by Ishibashi et al. for ancient and medieval ages (until around AD 1600). For early modern, or Edo, period, the amount of historical documents is significantly larger and quality of documents is variable, hence quality check is important.

We are making historical earthquake data base, which is composed of the historical earthquake document data base and seismic intensity data base, for a few earthquakes in Edo period. The 1751 Echigo-Takada and 1828 Echigo-Sanjo earthquakes, which occurred in Echigo (the present Niigata Prefecture) and caused extensive damage, were selected for the trial edition of historical earthquake data base. We selected historical documents with high reliability, formatted them as XML data, and created historical earthquake document data base. Incidentally, pictures which describe damage of these historical earthquakes are also contained in this data base, and the damage can be visually shown.

We selected historical documents which describe both the total number of houses and the number of collapsed houses in each village or town at the occurrence time of these earthquakes because the number of houses varies in time. Then, we calculated the ratio of collapsed houses and estimated seismic intensities in the Japan Meteorological Agency (JMA) scale based on Usami (1986)'s table as described below.

JMA seismic intensity 7 (XII on Modified Mercalli (MM) intensity scale): 81-100% ratio of collapsed houses.
JMA seismic intensity 6 (X-XI on MM intensity scale): 71-80% ratio of collapsed houses.
JMA seismic intensity 5+ (IX on MM intensity scale): 1-70% ratio of collapsed houses.
JMA seismic intensity 5- (VIII on MM intensity scale): 0% ratio of collapsed houses.

We created the trial edition of seismic intensity data base by using Google Earth as a platform. We plan to make a similar data base in other area, and try to make seismic intensity data base by enriching historical documents for the other earthquakes.

Acknowledgment: This study is supported by "Multidisciplinary research project for high strain rate zone" of the MEXT, Japan.

Keywords: historical earthquakes, 1751 Echigo-Takada earthquake, 1828 Echigo-Sanjo earthquake, ratio of collapsed houses

Japan Geoscience Union Meeting 2012
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SCG64-P15 Room:Convention Hall Time:May 23 13:45-15:15

Seismic acitivity at southern part of Kusatsu-Shirane volcano

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We examined seismic activity at southern part of Kusatsu-Shirane volcano with our seismic network supported by temporary stations. We have observed seismic activity of the volcano since 2001. Currently six stations are concentrated within about 1 km from the main crater lake, Yugama. Based on past seismic network, Mori et al. (2006) pointed out two seismic clusters, one at Yugama and the other at Ainomine, an old volcanic cone 1.5 km to the south of Yugama. Mori et al. (2006) also pointed out that seismic activity at the latter zone is comparable to the former. There used to be a station at Ainomine till few years ago, and current capability of event detection is relatively low. In response to the crustal deformation event on May 27, 2011, we constructed a temporal seismic station to the south of Ainomine. The station is equipped with a L-4C three-component seismometer by Mark Products Corporation and LS-7000 data logger by Hakusan Corporation. Seismic data are stored on site and periodically collected. Collected data are then combined with our data of real time seismic network. Now seismic events are detected based on variation of seismic amplitude.

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

SCG64-P16 Room:Convention Hall Time:May 23 13:45-15:15

Spatial distribution of coda Q around the Atotsugawa fault zone

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We investigate a detailed spatial distribution of coda Q around the Atotsugawa fault zone in a high strain rate zone, central Japan, using waveform data from a dense seismic observation. Low coda Q at lower frequencies is localized along the fault zone, showing a good spatial correlation with the strain rate. On the other hand, we find no characteristic spatial distribution of coda Q at higher frequencies. The spatial distribution of coda Q at lower frequencies shows a good correlation with the S-wave velocity structure from the base of the upper crust to the lower crust reported by Nakajima and Hasegawa (2007). We, therefore, suggest that the coda Q at lower frequencies is the parameter that reflects the ductile deformations below the brittle-ductile transition zone of the crust. We estimate a spatial variation in stressing rate using those of coda Q in the analyzed region based on the procedure of Hiramatsu et al. (2010). The estimated variations of 15 kPa/year at the 1.5 Hz band and 18 kPa/year at the 2.0 Hz band are slightly larger than that estimated from the result of Jin and Aki (2005). This result suggests that the spatial variation in stressing rate around the Atotsugawa fault zone is possibly to be larger than the average one in the Niigata-Kobe high strain rate zone.

Keywords: the Atotsugawa fault zone, coda Q, stressing rate, high strain rate zone

Japan Geoscience Union Meeting 2012
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SCG64-P17 Room:Convention Hall Time:May 23 13:45-15:15

Stress field and pore-pressure distribution in seismogenic zone of Kyushu, Japan inferred from and focal mechanisms

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In the upper crust of Kyushu district, Japan, an area with high seismic activity is found in the middle part. This area is called Beppu-Shimabara graben (B-S area) because of existence many normal faults in this region. Many active volcanoes exist (i.e. Unzen, Aso, Kuju, Beppu), and historical large earthquakes occurred in this region. The major mechanism of earthquakes in the Kyushu district is strike slip type. Generally, extensional (minimum principal) stress is in north-south direction in Kyushu. On the other hand, microearthquakes normal faulting also occurs in B-S area. Basic question is why seismic activity is high and stress field changes in B-S area.

Elastic and inelastic feature of crust could be inferred from both of stress and strain field. We performed stress tensor inversion by using polarity data of first motion at direct P wave arrival. The data were obtained at stations operated by NIED, JMA and Kyushu University. In addition, we deployed more than 35 temporal seismic stations around the graben in order to determine the stress field. Directions of principal stresses are obtained at spatially distributed grid points every 20 km interval. The minimum axes of the principal stress are generally oriented in NNW-SSE direction. The maximum axes are almost in WSW-ENE direction. The stress rates are greater than 0.75 at most of the point in B-S area, implying the maximum stress is close to the moderate principal value. In addition, the minimum axes in the graben rotate counterclockwise. This stress field change requires a mechanism either relaxing the stress in east west direction or vertically loading in this region.

Following Terakawa et al. (2010), we estimated average pore-pressure at each grid point

They estimated fluid pressure from variation of the fault plane under the uniform stress field. Assuming fault slip controlled by Coulomb failure criterion, we obtain the pore fluid pressure distribution and its average value at the each grid point. The high pressure area is found around the fault zones. On the other hands, B-S area is in the low pressure condition. Two major high seismicity regions in Kyushu district have different feature each other. The seismic activity in B-S area is under the high stress ratio and the low average pore-pressure. On the other hand, the fault zones have opposite feature to B-S area. This suggests the possibility that the high seismic activity in B-S area is caused by low strength of the medium

Keywords: stress field, pore-pressure, seismic activity, Kyushu

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

SCG64-P18 Room:Convention Hall Time:May 23 13:45-15:15

Comparisons of source characteristics among recent disastrous inland earthquake sequences in Japan (3)

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Toward strong motion prediction for earthquakes in high strain rate zone in Japan, Somei et al. (2010, 2011) have investigated seismic scaling relationship for M7-class inland earthquake sequences in Japan to discuss source characteristics between eight sequences occurring in the high strain rate zone and five sequences occurring in others. They showed that there was no obvious difference between stress drops of them.

After the great Tohoku earthquake (M_w9.0) occurred, several large inland crustal earthquakes occurred in the high strain rate zone (the 2011 North Nagano prefecture earthquake; M_w6.7 and the 2011 West off Aomori prefecture earthquake; M_w6.1) and outside of the zone (the 2011 East Shizuoka prefecture earthquake; M_w5.9 and the 2011 East Fukushima prefecture earthquake; M_w6.6). In this study, we continued to investigate source characteristics for these crustal earthquake sequences. Then, we obtained stress drops of events (M_w: 3.1-6.9) in sixteen earthquake sequences using S-wave coda spectra of strong motion network (K-NET and KiK-net) records. S-wave coda spectral ratio between large and small event records gives source spectral ratio. For a number of event pairs including large earthquakes such as mainshocks, we also used F-net (Full range seismograph network) records. As these records have high SN ratios in the lower frequency range, we can obtain the full-range source spectral ratios, whereas we could not obtain full-range spectral ratios when we used the strong motion records. Because the source spectra of large earthquakes have the lower corner frequencies, the full-range spectral ratios are available to estimate the corner frequencies of those earthquakes. Most of source spectra obey omega-square source spectra. Stress drops are estimated by the corner frequency f_c from observed source spectral ratio and the seismic moment M_0 given by the moment tensor solution of F-net. In results, there is also no obvious difference between stress drops of events in the high strain rate zone and others.

Acknowledgements

We would like to sincerely thank CEORKA, NIED (K-NET, KiK-net) for providing the strong motion data. The hypocenter information was providing by JMA and moment tensor by F-net of NIED. Prof. Kato permits us to use relocated hypocenter information of the 2007 Noto and the 2004 Chuetsu earthquakes.

Keywords: High strain rate zone, S-wave coda, Source spectral ratio, Corner frequency, Scaling