Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SCG062-01 Room:IC Time:May 27 10:45-11:00

Crustal deformation of the strain concentration zone along the eastern Japan Sea margin based on dense GPS observation

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We have been conducing dense GPS observation in the Joetsu-Chuetsu region, Niigata Prefecture, to investigate deformation and tectonic loading process in the strain concentration zone along the eastern Japan Sea margin. As our GPS campaign, we occupy about 50 GPS sites for 1-2 months every year. We have three campaign measurements since 2008 and obtained an initial result of horizontal displacement rate field.

Our GPS network covers a 90 km-long area extending E-W direction between Itoigawa and Minami-Uonuma cities. We detected about 15mm/year contraction over the whole area. Precision of each velocity estimate is about 2mm/year, but the estimate velocity pattern is consistent with that from the continuous GPS measurement using GEONET.

In the western half of the network, from Itoigawa to Takada plain, there is no significant contraction. Although the Western Takada Plain Fault is considered to be the source fault of a M7 earthquake in 1751, we do not see any deformation signal associated with this fault. On the other hand, a large amount of shortening (10mm/year contraction over 30km-wide area) is accommodated within the Eastern Kubiki Hills east of the Takada Plain. Average E-W strain rate is as large as 0.3 ppm/year. The deformation pattern in the Eastern Kubiki Hills is not a simple 2-dimensional one. We find a step-wise offset around the city border between Joestu and Tokamachi cities, and lateral variation may exist in the N-S direction. Also the crustal deformation may have short wavelength features.

In addition to the presentation of the observed result, we also present a preliminary deformation model based on it to discuss deformation process of the strain concentration zone.

Keywords: Strain concentration zone, GPS, crustal deformation, active faults, active folding

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SCG062-02 Room:IC Time:May 27 11:00-11:15

P and S wave tomography in the eastern margin of the Japan Sea

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We determined high-resolution images of P and S wave velocity and Poisson's ratio under the Japan Sea off NE Honshu using a large number of arrival-time data from local earthquakes in the crust and the subducting Pacific slab. The data were recorded by the dense seismic networks of JMA, Hi-net and Japanese national universities. Our new data collected from 360 crustal earthquakes under the Japan Sea which are relocated precisely with sP depth-phase data are crucial to make this work possible. Our results show that strong lateral heterogeneities exist in the crust and upper mantle under the eastern margin of the Japan Sea, which may have affected the seismotectonics in the region. The crustal velocity variations under the Japan Sea may reflect the complicated geologic structures which were produced during the opening of the Japan Sea and the present compressional stage of the Honshu arc associated with the collision of the Amur plate with the Okhotsk plate. Low-velocity zones in the mantle wedge are found to extend westward under the Japan Sea, rather than just confined under Honshu Island as suggested by the previous studies. This feature indicates that the back-arc magmatism and tectonics are part of the complex geodynamic system under the broad region including the western Pacific island arcs and the East Asian continental margin. The present study also indicates that high-resolution seismic imaging is feasible for the oceanic regions surrounding a seismic network if we can fully exploit the high-quality waveform data recorded by the seismic network, thus the structure and tectonics under the less-instrumental oceanic regions can be investigated well.

Keywords: Eastern margin of Japan Sea, P-wave velocity, S-wave velocity, tomography, slab

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SCG062-03 Room:IC Time:May 27 11:15-11:30

Inhomogeneous structure and seismicity in and around the high strain rate zones in the central part of NE Japan

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In the central part of Japan, the inhomogeneous distribution of strain rate distribution was reported (e.g. Miura et al., 2004). High strain rate is observed along the backbone range, the forearc region of Miyagi prefecture, and near coast line of the Japan Sea. To understand the origin of these high strain rate zones, we estimate seismic velocity structure of the crust in the central part of Tohoku, NE Japan, and discuss on its relation with seismic activity.

We determined three- dimensional seismic velocity structure and relocated hypocenters simultaneously using the tomography method (Zhao et al., 1991; Zhang and Thurber, 2003). Travel time data used are obtained from the dense seismic network by the temporary seismic stations installed for ”Multidisciplinary research project for high strain rate zone” promoted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan. and the Group for the aftershock observations of the Iwate-Miyagi Nairiku Earthquake in 2008 (GIMNE) and the Japan Nuclear Energy Safety Organization (JNES). We also used P- and S-wave data from networks of Tohoku University, JMA, Hi-net and other temporary stations during the period from 1997 to 2010.

In the upper crust, distinct low-velocity regions are distributed in the Osaki-plain, Kitakami low-land, Shinjo basin and Shonai plain. In some areas (e.g., in the source region of the 2003 northern Miyagi earthquake), these low-velocity zone are seems to be distributed in the hanging wall of the fault. We also found some low-velocity regions near the active volcanoes (e.g., Kurikoma, Chokai). High seismicity area in the upper crust corresponds with higher velocity areas.

In the lower crust, we found some distinct low velocity areas. These low velocity zones are located just beneath the volcanoes and these high strain rate zones. High seismicity includes the moderate-sized and large earthquakes (e.g., the 2003 northern Miyagi earthquake (M6.4), the 2008 M7.2 Iwate Miyagi Nairiku earthquake, the 1894 M7.0 Shonai earthquake) in the upper crust is just above these low velocity zones. These low-velocity zones in the lower crust are imaged to continuously distributed from the uppermost mantle.

We used data from temporary seismic stations installed for ”Multidisciplinary research project for high strain rate zone” promoted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan. We also used data from the Japan Nuclear Energy Safety Organization (JNES), JMA, Hi-net.

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SCG062-04 Room:IC Time:May 27 11:30-11:45

Seismic velocity image off Awa-shima island, Niigata, deduced from the seismic refraction/wide-angle reflection survey

Takeshi Sato[1*], Tetsuo No[1], Narumi Takahashi[1], Shuichi Kodaira[1], Yoshiyuki Kaneda[1]

[1]JAMSTEC

In the eastern margin of the Japan Sea, some destructive earthquakes occurred and the fault-fold belts developed by the deformation of the extension by the opening of the Japan Sea during the early Miocene and the shortening since the late Pliocene (e.g., Sato, 1994). However, it is unknown to the relation between the mechanism of the deformation including the concentration of this shortening and the occurrence of these earthquakes in fault-fold belts in this margin. To understand this mechanism and this relation, it is need to clarify the crust and uppermost mantle structure from the area without this shortening to the fault-fold belts in this margin. For this study, we present the seismic velocity image in the crust and uppermost mantle from the Yamato basin off Awa-shima island, Niigata, to the south of this island including the source area of the 1964 Niigata Earthquake in this margin deduced from the offshore seismic data.

In 2010, the offshore seismic refraction/wide-angle reflection survey using 58 ocean bottom seismographs (OBSs) and a tuned air-gun array (7,800 cu. inch) was conducted in off Awa-shima island, Niigata, ranging from the Yamato basin, Sado ridge to the Awa-shima uplift zone in the south of this island. The survey line has about 300 km length and runs across the source area of the 1964 Niigata Earthquake. In record sections of several OBSs and land stations, not only the first arrived phases but also later phases reflected from interfaces in the crust and uppermost mantle are visible. In this study, to obtain seismic velocity image and reflection image in the crust including sediments and uppermost mantle, we used a seismic refraction tomography using first-arrival phases (Zhang et al., 1998) and a diffraction stack migration approach using picked reflection travel times (Fujie et al., 2006).

The crustal thickness of the Yamato basin off Awa-shima is about 18 km. This thickness is similar to that off the northwest Sado-ga-shima island. In these areas in this basin, the character that the upper and middle crust is thinner than the lower crust also resembles. In the Sado ridge, the crust is estimated as having about 24 km. The upper and middle crust of the Sado ridge is thicker than that of the Yamato Basin. The P-wave velocity in the lower crust beneath the Sado ridge shows slightly higher than that in the surrounding area of this ridge. In the south of Awa-shima island, the P-wave velocity in the sedimentary layer and the upper part of the upper crust has a large lateral variation. This variation may correspond to the geologic structure in the Awa-shima uplift zone.

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SCG062-05 Room:IC Time:May 27 11:45-12:00

Preliminary report on multi channel seismic reflection survey around the strain concentration area off Niigata

Tetsuo No[1*], Narumi Takahashi[1], Takeshi Sato[1], Shuichi Kodaira[1], Yoshiyuki Kaneda[1]

[1]JAMSTEC

Recently, damaging earthquakes have occurred along the strain concentration areas located at Niigata prefecture (e.g. the 2004 Mid-Niigata Prefecture earthquake, and the 2007 Niigata-ken Chuetsu-oki earthquake). The 1964 Niigata earthquake (M 7.5) was the earthquake of largest magnitude in the Niigata prefecture in the last 50 years. These caused great damage along the strain concentration areas. However, this area has not been identified as one of the priority areas to be investigated. Therefore, we have joined as a member of the strain concentration areas study in collaboration with other Japanese research institutions using part of the Special Coordination Funds for Promoting Science and Technology, ”priority investigations of strain concentration areas”, and performed seismic surveys using R/V KAIREI at the eastern margin of the Japan Sea since 2008. Objectives of this cruise are to reveal structural characteristics of the strain concentration areas, which are active faults and fold structures. In particular, one of the main targets is to clarify crustal structure showing mechanism of the 1964 Niigata earthquake and understand the tectonics as the geologic background.

In August-September 2010, we conducted a MCS survey around the area near Sado Island and off Sakata in the eastern margin of the Japan Sea using the R/V KAIREI. MCS data was acquired along 11 lines with a total length of approximately 2,680 km. Survey lines were crooked to avoid the many fishing operations and equipment in the survey area. We shot a tuned airgun array with a spacing of 50 m. This array has a total capacity of 7,800 cubic inches (about 130 liters). The standard air pressure was 2,000 psi (about 14 MPa). During the shooting, we towed a 444-channel hydrophone streamer cable with a 5600-m maximum offset, and the group interval was 12.5 m. The towing depth of the streamer cable was maintained at 12 m below the sea surface using depth controllers. The sampling rate was 2 ms, and the recording length was 15 s.

We present an outline of the data acquisition and preliminary results of data processing and interpretations in this study.

Keywords: Eastern margin of the Japan Sea, Strain concentration areas, Seismic reflection survey, 1964 Niigata earthquake, Mogami Trough, Sado Ridge

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SCG062-06 Room:IC Time:May 27 12:00-12:15

Estimation of a feasible initial velocity model and earthquake locations for seismic tomography in the Niigata region

Bogdan Enescu[1*], Tetsuya Takeda[1], Youichi Asano[1], Kazushige Obara[2], Shoji Sekiguchi[1]

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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 about 300 seismic stations. In a previous study (Enescu et al., 2010) we have obtained a detailed tomographic image of the crustal structure in the region, using the earthquake data recorded during intense observations, as well as previous data recorded by the permanent Hi-net network. The study revealed the undulated surface of the basement rock, hidden under a thick low-velocity layer consisting of thick sediments and volcanic rocks of the Niigata basin. The earthquake locations, inverted together with the velocity structure, became systematically shallower (by more than about 3km), in agreement with results reported in other studies (e.g., Kato et al., 2009). However some earthquakes, especially those that occurred in the off-shore areas, persistently remained located deeper.

In this study we focus on the reliable determination of earthquake locations since they may play a critical role for an accurate imaging of the velocity structure in this complex tectonic region. We use the Joint Hypocenter Determination (JHD) algorithm (Kissling et al., 1994; Shibutani et al., 2005) to invert for the precise earthquake locations, improved 1D velocity model and station corrections. We select only data obtained during intense earthquake observations, from December 2008 to September 2009. We use as a starting 1D model the velocity structure obtained for the region by Shibutani et al. (2005), using the same JHD technique.

The most prominent features of the JHD relocated earthquakes are: a) a shift of the depth location by about 3km in the on-shore Niigata basin region, which includes the aftershock area of the 2004 Mid-Niigata earthquake; b) a shift of up to 10km upwards for the hypocenters that occur in the off-shore regions, in particular those located in the aftershock area of the 2007 Chuetsu-oki earthquake and c) a horizontal shift of up to 3 to 5km in the N65degW average direction for the epicenters in the on-shore Niigata basin region. These results are in agreement with those obtained in several previous studies (e.g., Shibutani et al., 2005; Yukutake et al., 2008; Kato et al., 2009). Although the earthquakes used in this study occurred after December 2008, the fault-like structures in the areas of the 2004 and 2007 Niigata earthquakes can still be recognized from the earthquake hypocenter distribution.

The station corrections pattern shows consistency with the shallow subsurface velocity structure: relatively large positive travel-time residuals in the Niigata basin and negative residuals in the Echigo Mountains to the east.

The obtained 1D velocity model has lower velocities in the upper 7km, compared with the 1D model of Shibutani et al. (2005) and is similar in the deeper part. To further check the reliability of our results, we have considered a different starting 1D velocity model that has significantly lower velocities in the upper layers and performed the JHD inversion. The relocated earthquakes had a similar hypocentral distribution to those obtained by using Shibutani et al. (2005) crustal structure as starting 1D velocity model. Thus, we consider the relocated earthquakes to be robust enough for obtaining a reliable 1D velocity structure.

The relocated earthquakes and the improved 1D velocity model obtained in this study will be used to update our previous tomography results and discuss in more detail the relation between the earthquake activity and velocity structure in the Niigata region.

Keywords: Niigata region, earthquake relocations, velocity structure

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SCG062-07 Room:IC Time:May 27 12:15-12:30

Integrated seismic imaging of crustal structure for multi-scale, multi-mode deep reflection data

Susumu Abe[1*], Hiroshi Sato[2], Hideo Saito[1], Kazuya Shiraishi[1], Takaya Iwasaki[2], Naoko Kato[2], Tatsuya Ishiyama[2]

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Deep seismic reflection profiling across the area of land-marine transition zones in Japan has been imposed serious restrictions and compromises on both data processing and acquisition. In addition to complex subsurface structure, rugged acquisition topography, crookedness of seismic lines, irregular distribution of shot points, and large noise level often result in deterioration of the data quality and poor reflection image in seismic profile. The combination of telemetry and independent recording system provides the deployment of 100-200km long survey line across the area of land-marine transition zones with dense seismic array. Multi-scale and multi-mode survey layout has been realized by the simultaneous data acquisition of regional refraction, low-fold wide-angle reflection and standard reflection survey for the several targets on the same seismic line optimized by the integration of different seismic sources and supplementary three-component digital accelerometers with broader frequency responses. In our study, multilateral approach beyond the conventional CMP stack is applied to the multi-scale, multi-mode seismic data for the extraction of deep crustal reflection patterns. The high-resolution velocity structure can be estimated by the hybrid profiling of wide-angle reflection and refraction data. The uncertainty of the tomography solutions is estimated using a nonlinear Monte Carlo approach with randomized initial models, and the velocity structure of upper crust is constrained by subsequent forward reflection and refraction modeling. In recent years, many case studies have demonstrated that the Common-Reflection-Surface (CRS) stack based on paraxial ray theory produces an efficient alternative profile to conventional CMP stack with a pronounced signal-to-noise ratio. The CRS-driven velocity attribute with the short-wavelength structural heterogeneity has the potential imaging capabilities including velocity model for improved prestack depth migration. In our study, multi-dip reflection surfaces method is adopted for the imaging of wide-angle deep reflections. In order to build the detailed basin-scale geophysical model, we developed a processing workflow based on the combined tomographic analysis of refraction, P-P and P-S reflection profile. Multi-component seismic reflection data using ocean-bottom cable with 4C MEMS sensors has presented imaging capabilities in P-S wave reflection profiling and Vp/Vs estimation for the delineation of volcanic stratigraphy in our study. In 2008, the Headquarters for Earthquake Research Promotion Japan started a program of deep seismic profiling to reveal regional characterization of the Niigata basin, central Japan. We refer two deep seismic profiles in this program to review the recent advances and multilateral approaches in reflection seismology.

Keywords: reflection seismology, deep seismic profiling, 4C OBC, refraction tomography, P-S converted wave, common reflection surface method

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SCG062-08 Room:IC Time:May 27 12:30-12:45

Crustal structure of the fold-and-thrust belt, Chuetsu, central Japan: result of 2010 Higashiyama-Mishima 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 along the three seismic lines in 2008, 2009 and 2010. The 2010 Higashiyama-Mishima seismic line cut through the northern part of the epicentral area of the 2007 Chuetsu-oki earthquake. The seismic sources were air-gun (3020 cu. inch), four vibroseis trucks and explosives ($<$ 200 kg) and seismic signals were recorded by by ocean bottom cables, cable-connected-recording system and offline recorders, forming a maximum 2040 channels receiver array. The basin fill consists of early to middle Miocene volcaniclastic rocks and overlying Neogene sedimentary rocks showing upward coarsening sedimentary facies deposited under bathyal to fluvial environment. Main features of basin development, such as early Miocene normal faulting, associated with the formation of Japan Sea, and shortening deformation since the Pliocene, are well demonstrated on the seismic sections. Particularly, boundary between pre-Tertiary meta-sedimentary rocks and Miocene felsic volcanics were identified by velocity profiles deduced by diving wave tomography and they enabled us to identify the geometry of extensional rift-basin. Fault reactivation of Miocene normal faulting to subsequent reverse faulting is common style of deformation. The 2007 Chuets-oki earthquake was produced by thrusting of the Miocene low-angle normal fault, which contributed the formation of rift basin by simple shear extension. During the extensional deformation associated with Japan Sea, due to progressive "double-door" opening of SW and NE Honshu arcs, transfer zones and commonly developed in the Niigata sedimentary basin. Present day the rift parallel Miocene normal faults reactivated as reverse faults, and their segmentation is strongly controlled by transverse faults formed during the extensional deformation. For better estimation of seismogenic source faults and its segmentation in an inverted rift-basin, the information of basin development plays a significant role.

Keywords: fold-and-thrust belt, source fault, crustal structure, seismic reflection profiling, Niigata basin, 2007 Chuetsu-oki earthquake

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SCG062-09 Room:IC Time:May 27 14:15-14:30

Seismic reflection profiling across the Yukyuzan fault in the eastern margin of Niigata basin, central Japan

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Inverted rift-basins form a fold-and-thrust belt along the backarc side of Honshu. The Niigata basin is one of the inverted rift-basin and frequently attacked by devastative earthquakes. To reveal seismogenic source faults beneath thick-sediments, deep seismic reflection profiling was undertaken across the northern part of epicentral area of the 2007 Chuetsu-oki earthquake (Sato et al., 2011: 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 and refraction profiling across the Yukyuzan fault in the eastern margin of the Niigata basin for 5.7-km-long seismic line. Seismic data were acquired using a vibrator truck (IVI, EnviroVib). The sweep signals (8-100Hz; reflection profiling, 8-60Hz; refraction profiling) were recorded with 10 Hz geophones deployed at 10 m intervals, off-line recorder (JGI MS2000) and digital telemetry system (JGI G-DAPS4). The seismic data were processed using conventional CMP-reflection methods and refraction tomography (Zelt & Barton, 1998). The obtained seismic section portrays the seismic image and velocity structure down to 1 km. The seismic section demonstrates an asymmetric fold with steeper western limb and gentle eastern limb. It western limb shows rotation with growth strata. Based on the image of deep seismic section, the fold is a fault-related-fold, the growth strata has been produced by a deep sited, eastward dipping thrust. On the high-resolution seismic section, an eastward dipping thrust is interpreted at the crest of the anticline, based on the discontinuity of reflectors and velocity structure. The thrust is not emerged to the surface and 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 the development of the Higashiyama hills.

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SCG062-10 Room:IC Time:May 27 14:30-14:45

Active faults along the southeastern margin of the Echigo Plain based on tectonic geomorphology and borehole data

Hiroyuki Tsutsumi[1*], Tatsuya Ishiyama[2], Takehiko Suzuki[3], Daisuke Hirouchi[4], Toshifumi Imaizumi[5], Takanobu Kamataki[6], Abe Kohei[7]

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We studied active faults/folds along the southeastern margin of the Echigo Plain based on analysis of tectonic geomorphology and borehole data. The margin east of Nagaoka City is marked by west-facing fold scarps on fluvial terraces for a distance of 10 km that are probably related to an east-dipping reverse fault. Boreholes revealed that the erosional boundaries between the Plio-Pleistocene Uonuma Formation and late Quaternary terrace gravels are higher to the east across the fold scarps. We plan to calculate the slip rate of the east-dipping reverse fault by estimating the ages of the fluvial terraces based on tephrochronology.

Keywords: Echigo Plain, Nagaoka City, tectonic landform, fault slip rate, borehole survey

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SCG062-11 Room:IC Time:May 27 14:45-15:00

Active tectonics of the southern Northeast Japan

Tatsuya Ishiyama[1*], Daisuke Hirouchi[2], Hiroyuki Tsutsumi[3], Takehiko Suzuki[5], Naofumi Marushima[4], Tomoo Echigo[6], Toshifumi Imaizumi[4], Hiroshi Sato[1], Naoko Kato[1]

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We review recent advances on an understanding of active tectonics across the southern Northeast Japan, focusing on newly obtained, late Pleistocene to Holocene stratigraphic data on basin and terrace deposits, and shallow to deep seismic profiles, and geomorphic signatures of active structures. In particular, we emphasize that meso-scale topography of the southern NE Japan arc can be subdivided by domains based on tectonic activity and intracontinental deformation, comprised by backarc fold-and-thrust belt, backarc regional subsidence and uplift bounded by active fold and thrust belts, Ou backbone ranges, and forearc uplift.

Keywords: Active tectonics, Tectonic Geomorphology, Active fault, Quaternary, Seismic reflection profiling, Southern Northeast Japan

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SCG062-12 Room:IC Time:May 27 15:00-15:15

Integrated velocity model of shallow and deep subsurface structure in Niigata region for strong-motion evaluation

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1. Introduction
The deep (between seismic bedrock and engineering bedrock) and shallow subsurface structures are individually modeled in the most of strong-motion evaluation. Now we are studying the method integrating shallow subsurface structure with deep structure in Niigata region to improve the accuracy of the strong-motion evaluation.

2. Initial model
We use the "Subsurface Structure for Deep Sedimentary Layers of Japan for Strong-motion Evaluation" for "National Seismic Hazard Maps for Japan" as the deep subsurface structure. In this model, the improvement by the H/V spectrum ratio of the observed records at the strong-motion station had been applied for the ground motions in period of 1 second or more. In addition, improvements based on ground motion simulations for aftershocks of the 2004 Mid Niigata prefecture earthquake had been also applied for Niigata region in this model.
For modeling the shallow subsurface structure, we collected the borehole data as much as possible. We modeled the shallow subsurface structure in every 250m mesh based on geological features by using about 10,000 borehole data in the Niigata region. Here the physical properties necessary for the strong-motion evaluation are given from empirical relations with N value. Therefore, the validity is not verified at this stage.

3. Upgrade of the model
The upgrade of the subsurface structure model by integrating shallow structure with deep structure so that ground motion can be duplicated in broad period range (0.1-10 seconds) is necessary to improve the accuracy of strong-motion evaluation. In order to overcome the above problem, we executed high-density microtremor measurements in and around the sedimentary basins. And we are studying the upgrade of the integrated subsurface structure model by using the phase velocities of the Rayleigh waves and H/V spectrum ratio obtained from the microtremor measurements together with the establishment of the technique itself.

Keywords: Integrated structure model, strong-motion, borehole data, microtremor measurements

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SCG062-13 Room:IC Time:May 27 15:15-15:30

Re-examination of the damage distribution and the source area of the 1751 Takada Earthquake

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The Takada earthquake (M7.0-7.4) that occurred in the western Niigata Prefecture at 1-3 a.m., 26th day of 4th month, Kan'en 4th (Gregorian calendar: 26 May, 1751) caused serious damage especially along the western edge of the Takada plain, in the western mountain regions, and along the coastal area of the Sea of Japan. The epicenter is estimated in the northwestern part of Takada plain (Usami, 2003).

In this study, we investigate damage distribution and focal region of the Takada earthquake. At first, we select reliable and contemporary historical documents, because historical documents written in later ages sometimes include a wrong or exaggerate description. Next, we calculate the collapse ratio of houses (hereafter referred as CR) using only historical records that describe both the number of houses before the mainshock and that of collapsed houses. Finally, we convert CR at each village or town to seismic intensity scale (SI) based on Usami (1986)'s table as described below, and examine the focal region of the Takada earthquake.

SI 7: 81 - 100 % CR.
SI 6: 71 - 80 % CR.
SI 5+: 1 - 70 % CR.
SI 5-: 0 % CR.

The CR and SI in the western Niigata Prefecture are summarized as below.

(a) The CR in Takenao village situated on terraces with hard ground condition is 2 % [SI 5+]. However, the CR in other villages situated on the alluvial plain with soft ground condition is 13-58 % [SI 5+]. The Iwadegumi area (present Joetsu City Kakizaki-ku area) is not the focal region because the CR is low in village with hard ground condition.

(b) The CR in Ima-machi town situated on sand dune of hard ground condition is 5 % [SI 5+]. The CR in Yoko-machi situated on inclined sand dune is 45% [SI 5+]. The CR in Naka-machi situated on flood plain with soft ground condition is 83% [SI 7]. The Ima-machi area is not the focal region because the CR is low in village with hard ground condition.

(c) The Nagahama village is situated on coastal lowland with hard ground condition and damage due to landslides accompanied with the Takada earthquake was not severe. The CR is 43% [SI 5+]. Coastal area along the Sea of Japan is not the focal region because the CR is not high in villages with hard ground condition although most villages in beachfront such as Nadachi-kodomari village are severely damaged by landslides.

(d) The CR in the downstream of the Kuwadori River, which flows in the western part of Joetsu City from south to north, is low (0 % [SI 5-] for the Hanatate, Nakakuwadori, and Shimo-Tsunago villages; 5 % [SI 5+] for Yamadera village). This region is not the focal region because of low CR.

(e) The villages in midstream of the Kuwadori River locate on landslide deposits with soft ground condition, and the CR is significantly high (100 % for Koike and Higashi-Yoshio villages, 91 % for the Nishi-Yoshio village, and 58 % for the Yokoyama village). However, these CRs include numerous houses due to landslides and hence, this area is not the focal region.

(f) The upper stream of the Kuwadori River is situated on hard ground condition. However, the CR is relatively high (26% [SI 5+] for the Doguchi village; 40 % [SI 5+] for the Minakuchi and Yokobatake villages). The CRs of villages in the upper stream of the Kuwadori River are significantly higher than those of downstream. In addition, the CR is high (20 % [SI 5+] for the Nakanomata village; 53 % [SI 5+] for the Kami-Tsunago village) in the mountains between the Kuwatori River and Takada plain in spite of hard ground condition. Therefore, this area is close to the focal region because of high CR with hard ground condition.

(g) Machiya area, the western part of the Takada plain, locates on river terraces with hard ground condition. However, the CR is as high as 71 % [SI 6].

The focal region of the 1751 Takada earthquake probably locates near (f) and (g).

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

Keywords: Takada Earthquake, historical records of earthquake, collapse ratio of houses, ground condition

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SCG062-14 Room:IC Time:May 27 15:30-15:45

The midterm report of the systematic historical earthquake study along the west coast of the Sea of Japan.

Ritsuko S. Matsu'ura[1*], Mitsuko Furumura[1], Mayumi Sekine[1], Koji Iwasa[1], Yasunori Suzuki[1]

[1]ADEP

We have been systematically examining Japanese destructive earthquakes since early modern. For the concentrated deformation zone, we have analyzed more than half of known destructive earthquakes in it. For Oga area, we compared two close events of 1810 and 1939's. Under the Oga Peninsula, plural faults of length about a dozen kilometers exist in the Vp=6km/s layer, and overall displacement of earthquakes in the breadth catches up with the concentrated deformation observed on the surface. Although we cannot tell the dip direction conclusively, our compiled result will be utilized to set source regions of future events in the eastern margin of the Sea of Japan.

This research is supported by funds from MEXT including the project "Intensive Surveys and Study on the Concentrated Strain Zone".

Keywords: the concentrated deformation zone, historical earthquake, Oga earthqauke

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Tectonic structure and siesmogenic faults in Kyushu

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Most of in-land seismogenic faults in Japan are re-activated ones originated as older faults or some mechanically weak planes such as axial planes of kink folds. Seismogenic faults in Kyushu also can be interpreted in this concept. Here I discuss the relationship between tectonic structures and seismogenic faults in Kyushu.

NNW-trending faults in northern Kyushu

There are some NNW-trending seismogenic faults in northern Kyushu. Their strikes coincide with those of Chikuho-type faults forming half-graben-like structure of Paleogene strata. Chikuho-type faults are considered to have been formed in an ENE-extensional setting in the outer arc of the bends between the SW Japan Arc and the Ryukyu Arc in middle Miocene age when the SW Japan Arc clockwise rotated and the Japan Sea opened. The current faults are reactivated ones of these Chikuho-type faults in a different tectonic setting.

Southern marginal fault of the Beppu - Shimabara graben

The Southern marginal fault of the Beppu - Shimabara graben (Oita - Kumamoto Tectonic Line) is the western extension of the current Median Tectonic Line (MTL). The original MTL separating the Inner and Outer Zones in Kyushu is the Usuki - Yatsushiro Tectonic Line and differs from this current MTL. The original MTL, which had been dipping northward, was folded by the uplift of the Sambagawa Metamorphic Rocks and formed an antiform and a synform. The current MTL consists of the northward dipping part of the folded original MTL in the northern limb of the antiform and a short-cut fault to the surface. The current MTL was formed as the southern margin of the *Nagasaki Dreieche*, which was depressed in the middle Miocene extensional setting same as the Chikuho-type faults mentioned above.

Hinagu Fault

The Hinagu Fault counterclockwise diagonally intersects the Kurosegawa and Southern Chichibu Belts. Faults with similar strikes are recognized in the Kurosegawa and Southern Chichibu Belts from Kyushu to Kanto Mountains at intervals of several tens to a hundred kilometer. These faults show northwestern-side-down and left-lateral separations. They are considered to have been formed in a transtensional setting with Early Cretaceous left-lateral strike-slip movement along the northern margin of the Kurosegawa Belt. Some of these faults were reactivated later. The Gokasho-Arashima-Kamishima Fault in eastern Kii Peninsula was in activity in the middle Miocene as a left-lateral strike-slip fault, which extended the Outer Zone in NE-direction as a result, in the outer arc of the bends of the eastern terminal part of the SW Japan Arc caused by the collision against the Izu-Bonin Arc. The Hinagu fault may also have been reactivated in the middle Miocene between the clockwise rotated northern and central Kyushu and Amakusa area that still keeps the trend of the Ryukyu Arc. The current Hinagu Fault is reactivated again as a right-lateral strike slip fault with some northwestern-side-down component.

Akune Fault (tentatively named)

Akune Fault with WNW-strike caused the Northwestern Kagoshima Earthquake in 1997. Its position coincides with that of an axial plane of a Megakink formed in a compressional setting in the inner arc of the bending area between the SW Japan Arc and the Ryukyu Arc in the middle Miocene age. This fault is considered to have been formed along this mechanically weak plane.

Although the faults discussed here have various origins, each of them or their original structures played a role in the deformation of the SW Japan Arc crust in the middle Miocene age. This feature is also recognized in seismogenic faults in other areas in Japan. Faults activated or originated in the middle Miocene events may be reactivated in current settings.

Keywords: Kyushu, seismogenic fault, tectonic structure

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Stress field in seismogenic zone of Kyushu, Japan inferred from seismic activity 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. However, it is not always confirmed whether this region behave as a graben formation or not from other evidence. 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.

Recently, Nakao et al. (2005) estimated spatial distribution of strain rate field in Kyushu area from GPS data. The area in which higher strain rate dominates not in extension but share is found in Beppu-Shimabara graben. This can explain high seismic activity in this region. They also revealed notable contraction in east-west appear around Aso volcano. High strain rate can be seen around Aso volcano.

On the other hand, information about stress field is also important to understand deformation of the crust. Elastic and anelastic 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 40 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. At each grid point, we collected polarity data of events occurred nearer than 10 km apart from grid point and carried out the stress tensor inversion. 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, implying the maximum stress is close to the moderate principal value. The maximum stresses in Beppu-Shimabara graben incline toward vertical direction while those have direction in east-west at most of points. It implies normal faulting would dominantly occur in Beppu-Shimabara graben. 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. Strain rate field by GPS observation also show the similar pattern and support the existence of the relaxing mechanism. This could be interpreted by existence a 'weak body' in the crust. The area would be contracted by regional stress field. This could explain the strain rate distribution. And stress in east-west could be relaxed so that second principal stress in vertical direction would be maximum one. On the other hand, this stress relaxation implies another important suggestion about strength of medium in B-S area. Only a medium with weak shear strength leads seismic activity into high under the condition of the low horizontal stress. Therefore, the crustal material in the B-S area would be easily fractured due to weak strength.

Keywords: Beppu Shimabara, Stress field, Focal mechanism

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Miocene extensional and contractional tectonics in the northern part of Kyushu

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The NW-SE trending faults have been developed in the northern part of Kyushu, especially Fukuoka Prefecture. As the thing which characterized in this area, it is said to block-tilting half graben structures by normal faulting, regulated the distribution of Paleogene system, have been developed. It is called Chikuho-type structure (Matsushita, 1949). However, in fact, there are many N-S to NW-SE trending left-lateral and reverse faults in the district, and the part of Chikuho-type structure are considered as left-lateral or reverse faults. Rather north Kyushu is an area characterized by complicated structure caused by the changes from extensional to contractional tectonics. In considering the active tectonics in this area, it is important to clarify history of formation of these geological structure in this area that strongly takes influence of its structures. About two structures that are main geological structure in this area, their characteristics and examination result about the formation time are shown as follows.

(1) Half graben structure of NW-SE trend

The half graben structures formed by the normal faults develop in Fukuoka and western Yamaguchi Prefecture, as represented by the Fukuchi-yama, Futajima and Takakura Faults. The vertical shift of the structure reaches up to 1,000-3,000m, showing the biggest displacement in these areas. Many of these structures are called Chikuho type structure. The dips of master faults are around 80-60 degrees, however, a few faults are identified as a listric normal fault by the data of the coalfield. Those structures are complicatedly deformed by the later compression stress as described later. It has been thought that so-called the Chikuho-type structure is syn-sedimentary deformation of Paleogene coal-bearing formations (Matsushita, 1971). However, there is no sedimentary evidence indicative of syn-depositional half graben development in the Paleogene starta. Moreover, NW-SE trending half grabens cut the E-W trending half graben and earlist Middle Miocene Kawajiri Foramation in the back arc basin of the Sea of Japan in Yamaguchi Prefecture (Ozaki et al, 2006). Furthermore, the extensively distribution of Paleogene system along the Pacific side of the inner zone of Southwest Japan Arc that became clear recently, indicate that the Paleogene system of the northern part of Kyushu is a part of Paleogene forearc basin fills of in the continental margin arc of southwest Japan and it is not necessary to relate the special structure that is not recognized in the other areas to peculiar distribution. Therefore, the half-grabens seem to have been formed in NW-SE extensional stress in the earliest Middle Miocene time. This timing would be important in understanding of not only tectonic status of northern Kyushu but also the timing and mechanism of the opening of southern Japan Sea.

(2) Left-lateral strike-slip and revers faults of N-S and NW-SE trends

Left-lateral strike-slip and revers faults trending N-S and NW-SE direction are well distributed in north Kyushu, caused by NW-SE directed compressional stress from Middle to Late Miocene time. The Kokura-Tagaw and Kumagahata Faults which are representative of the faults, are estimated that strike-slip and dip-slip displacements reach a few km and several 100 m respectively. The NW-SE trending half graben structures have strongly been deformed and bent by above compressional fault-related movements. Some planes of strike-slip and revers faults overlap partly master fault plane of half grabens such as the Fukuciyama Fault and so on. Therefore, the normal fault of the NW direction derived from the main strike-slip fault and the secondary reverse and strike-slip faults fault of the NW direction by shortening of the half graben structure have been developed in half graben fills. The active faults in this area are considered to be reactivated faults of the left-lateral strike-slip and reverse fault mentioned above.

Keywords: north Kyushu, Miocene, extensional tectonics, contractional tectonics, half graben, Chikuho-type structure

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Quaternary tectonics of Miyazaki Plain and Kyushu Mountain, southern Japan

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The tectonics of the Miyazaki Plain during the past 2 Ma are estimated from landforms and geological structures. During 2-1 Ma, the forearc basin beneath the sea was uplifted slowly and the Miyazaki Plain emerged. Then the left-lateral movement of Wanitsuka Mts block bordering the plain on the north formed the two pull-apart basins of the Kariya and Nojiri formations at the southern part of the plain during 1-0.3 Ma. The left-lateral movement was caused by the opening of the Okinawa Trough in the back arc of Ryukyu Arc. At 0.3 Ma, the Miyazaki plain suddenly began uplifting rapidly due to E-W trend compression. During 0.8-0.6 Ma, the movement direction of the Philippine Sea Plate changed from NW to WNW, and then the plate subducted obliquely along the Nankai trough. Consequently, the Southwest Japan fore arc including the Miyazaki Plain decoupled from the inner arc, moving westward, and finally caused the E-W trend compression and uplifting around Miyazaki Plain. The uplift rate of the southern part of the plain accelerated from 0.1 m/ka to 1 m/ka during the last 0.3 Ma at the southern part of the plain. In detail, the tectonical mode is domical uplifting the center, which is several kilometers off Miyazaki City in the Pacific Ocean. The domical uplifting and the increasing uplift rate relate to the isostasy of the subducting Kyushu-Palau Ridge on the Philippine Sea plate under the Miyazaki Plain or a rising serpentinite diapir in the crust of the Eurasia plate.

Keywords: Quaternary, tectonics, uplift, Miyazaki

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SCG062-19 Room:IC Time:May 27 17:00-17:15

Formative process of the Beppu-Simabara Graben and its active tectonics

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The basic tectonics of the Beppu-Shimabara Graben (BSG) is roughly characterized by the right-lateral motion along the main fault with releasing bends based on the interpretations of seismic profiles at both ends of the BSG. However, following three problems on the formative and growing process are still unsolved.

1.The main fault corresponds to the Median Tectonic Line (MTL) from Beppu, the eastern end to Kumamoto, and extends straightly to the west separately from the MTL. Thus the westernmost part of the main fault does not correspond to the MTL from Kumamoto to the Shimabara Bay, western end of the graben. What significance does the westernmost part have in the Inner zone in Kyushu?

2.As roll-over structures are found in sedimentary basins at both ends, a listric structure surely exists in the main fault down to a certain depth. However what structural style does the main fault have as a whole?

3.The releasing bend seems to connect with E-trending Matsuyama-Imari Tectonic Line corresponding to the northern side of the Nagasaki Triangle.

If so, what structural relationship does the BSG to the Nagasaki Triangle?

Generally speaking, active tectonics concerning a certain structure is the present stage of the formative and growing process of the structure. This means to understand the formative and growing process of the structure is essentially important to make clear active tectonics. Fortunately the huge amount of geological, geomorphologic, seismological, geodetic, gravitational data sets have been accumulated in northern Kyushu, which gives us the great advantage to challenge the more understandings of the formative and growing process of the BSG. In this talk, at first, we will discuss the formative and growing process of the BSG using the newly accumulated data sets, and then, analyze the active tectonics.

Keywords: Beppu-Shimabara Graben, half graben, extension tectonics, Median Tectonics Line, Kyushu

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SCG062-20 Room:IC Time:May 27 17:15-17:30

Detailed seismological structure of eastern Kyushu - Structural inference on left-lateral motion in southernmost Kyushu-

Hiromu Otsu[1*], Takaya Iwasaki[1], Aitaro Kato[1], Hiroki Miyamachi[2]

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Kyushu Island is located at the westernmost part of the subduction zone of the Philippine sea plate. This island is under a complex tectonic environment. Northern Kyushu has been dominated under the extensional stress regime. In the Beppu-Shimabara graben, a number of normal faults were formed with E-W strike diretion. Central Kyushu is characterized by zonal structure of accretionary prisms with a NE ? SW strike. Southern Kyushu has been affected by the subducted Kyushu-Palau ridge and Okinawa trough which is back arc basin behind the Kyushu island and Ryukyu Island chains. Paleomagnetic analysis by Kodama et al. (1995) indicated the existence of left lateral shear zone in the southeastern part of Kyushu. This shear zone was confirmed by the recent GPS research by Wallece et al. (2009).

The crustal and uppermantle structure of the Kyushu Island, however, remains enigmatic. In 1994 and 1996, refraction and wide-angle reflection survey using dynamite shots were carried out in eastern Kyushu. The about 230 km-long seismic line was laid out in NS direction, crossing major tectonic lines of OKTL, Usuki-Yatsuchiro tectonic line, BTL and NTL. To obtain new knowledge of deep structure of the individual geological blocks, We reanalyzed these refraction/wide-angle reflection data. Then, to obtain deeper structure of crust and upper mantle, an integrated seismic tomography method was undertaken using combined data set of active and passive sources.

The seismic tomography and ray-tracing for first arrivals reveals lateral structural variation of upper crustal model. The results include volcanic sedimentary packages (Vp = 3.3-4.9 km/s) with a thickness of 2 ~ 3 km north of the OKTL in Northern Kyushu. The seismic velocity south of the OKTL increases to 5.4 km/s, which corresponds to the Sanbagawa belt. Shallow geometry in OKTL is high-angle northward dip. The Chichibu belt has a velocity of Vp = 5.4 km/s. Further south, a low velocity body of the Hyuga complex (Vp=3.9 ~ 5.8 km/s) shows a northward dip of 15 degrees with a thickness of 6.5 km. The northern boundary of this body is interpreted to be the Nobeoka Tectonic Line (NTL). In the southernmost part of Central Kyushu, high velocity layer (Vp =5.3 ~ 5.8 km/s) with thickness of 3.7 km correspond to intruding granodiorite close to Mt.Osuzu. This area is characterized by small Vp/Vs value. In Southern Kyushu, low velocity packages (3.3~5.8 km/s) exists with thickness of 12km.

The travel-time and amplitude calculations for the wide-angle reflection data provides deep crustal structure. In Northern Kyushu, a northward dipping reflector with a low angle was imaged at a depth of 10 ~ 15km beneath OKTL, probably representing the deeper extension of OKTL. This geometry of OKTL is in good agreement with the reflection image of MTL in Beppu Bay (Yuasa, 1992), providing a strong indication that the OKTL is interpreted to eastward continuation of MTL.

A northward dipping reflector with low angle is imaged from the wide-angle data in Southern Kyushu at a depth of 15 ~ 25 km beneath Miyazaki Group. This boundary was first found out by the present study. It is noted that this northward dipping structure is characterized by high seismicity. Focal mechanism solutions of these earthquakes are of left lateral shear, which is well consistent with the crustal movement deduced by the Paleomagnetic analysis (Kodama et al,1995) and GPS analysis (Wallace et al ,2009). So, it is quite plausible that the eastward motion of the southern tip of Kyushu occur along this structural boundary.

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Kinematic Modeling of Crustal Deformation in Kyushu Island Based on Inter-plate Coupling and Block Rotation

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Global positioning system (GPS) site velocities and earthquake focal mechanisms reveal an active left-lateral shear zone cutting across Kyushu in southwest Japan. Surprisingly, no active faults have been identified in association with this zone of rapid contemporary deformation. To explain the existence of this shear zone, we proposed a model comprising subduction of an aseismic ridge (Kyushu-Palau Ridge) at the southwest end of the Nankai Trough. Because of rapid (~40 mm/yr) along-strike migration of the ridge, we suggest that the ridge subduction point (and resulting left-lateral shear zone) is never in one place long enough to enable the development of a through-going fault zone that can be identified at the ground surface, reconciling the mismatch between the GPS, seismological, and geological data in this region. Our conceptual model is supported by numerical modeling results. We also suggest that the along-strike change in subducting plate buoyancy explains the recent counterclockwise rotation of the Kyushu forearc documented in paleomagnetic studies, as is found in many other western Pacific subduction margins.

Keywords: plate coupling, block rotation, Kyushu Island, GPS, crustal deformation

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Deep structure of active volcanoes in southern Kyushu

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I investigated the stratigraphic relations between the tephra sequence and geologic evidence of ground shaking events during the 7.3 cal ka BP eruption of the Kikai caldera. The important points for the caldera-forming eruption are: the long dormant period is not an essential factor for the eruption, and some magmas of different compositions existed prior to the eruption. On the bases of the magma plumbing model of the Kikai caldera, the magma reservoir of the Aira caldera is storing silicic magma, whereas andesitic magma is passing nearby the main magma reservoir without any mixing. Ground deformation data around the Aira caldera suggest that the silicic magma has been stored since the latest eruption of ca. 30 ka, and that several tens km3 of silicic magma has already accumulated in it.

Keywords: active volcano, caldera, crust

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Rifting crustal structure in the Okinawa Trough

Azusa Nishizawa[1*], Kentaro Kaneda[1], Daishi Horiuchi[1], Noriaki Izumi[1], Mitsuhiro Oikawa[1]

[1]Japan Coast Guard

We have conducted seismic exploration to elucidate the backarc basin-island arc-trench system in the Nansei Shoto (Ryukyu) Arc, southwestern part of Japan. This region is characterized by a rifting stage at the Okinawa Trough as a backarc basin. The exploration consists of several wide-angle seismic and multi-channel seismic reflection lines of which directions are perpendicular to and along the trough axis. In the experiments, we used a non-tuned airgun array with a total volume of 98.4 liter (6,000 inch^3) as a controlled seismic source at an interval of 200 m (90 s) for refraction lines and a 3-gun cluster airgun, 17.1 liter (1,050 inch^3) in a total volume, at an interval of 50 m for reflection lines. Ocean bottom seismographs (OBS) deployed at every 5 km interval and a 3000-m-long, 240-channel hydrophone streamer were used as receivers.

The P-wave velocity model along the trough axis shows very large variation. The crustal thickness generally decreases from 23 km in the north to around 10 km beneath the Miyako and Yaeyama Submarine Grabens in the southern end of the Okinawa Trough. The crust beneath the trough is composed of three layers, upper crust with a P velocity less than 6 km/s, middle crust with Vp = 6.0-6.5 km/s, and lower crust with Vp = 6.5-7 km/s. The decrease in the total crustal thickness may be due to the thinning of lower crusts.

The preliminary crustal models obtained in the lines across the trough axis also indicate the existence of the mid crust throughout the lines, which may characterize the island arc crustal structure of the Nansei Shoto Arc. The largest variation in the velocity models along the perpendicular lines is positioned around the transition zone between the Okinawa Trough and East China Sea rather than the center of the trough. The thinnest lower crusts along the lines do not necessarily correspond to the center position of the trough deduced from the seafloor topography.

Keywords: Okinawa Trough, crustal structure, rifting

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Seismic observation and survey for elucidating tectonics of the Hikurangi subduction zone

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The Hikurangi subduction zone is situated off to the east of the north island of New Zealand, where the Pacific Plate subducts beneath the Australia Plate at ~4.3 cm/year. Accordingly, M~7 earthquakes have occurred. The dip angle of the subducting plate is high in the north, and becomes low in the south. Recent GPS observations revealed the distribution of coupling strength along the Hikurangi Trough. The results show that the coupling region is narrow along downdip in a region of northern two-thirds, and abruptly becomes wide toward the back-arc region across the capital region of Wellington. Such abrupt along-arc change of coupling strength cannot be explained by variation of a single parameter, such as temperature along the plate interface. Slow-slip events are also observed along the downdip margin of the coupling region, where the coupling strength is considered to be in transition from strong to weak. As looking at inland tectonics, back-arc opening is occurring with its strike along the arc, and crustal rotation is observed. This tectonic setting resembles that of southwest Japan from Shikoku to Kyushu islands. Comparative studies among mutually resembling subduction zones are important for elucidating tectonics of these regions.

In 2001, a marine-land integrated seismic survey (NIGHT project) was conducted along ~350 km long transect in the middle of north island in order to reveal structure along the Hikurangi subduction zone. The result leads to discussion on relationship between elevated pore pressure and generation of reverse-fault earthquakes along the plate interface. We conducted a seismic observation from September, 2009 through April, 2010 in the lower north island deploying 50 3-component seismometers. In March, 2010, in addition to land stations, we deployed 20 ocean bottom seismometers from Earthquake Research Institute, Univ. of Tokyo, along a ~360 km long transect, and conducted a seismic survey (SAHKE project). Each station recorded data of good quality, and we are pursuing data analysis. Preliminary result includes crustal structure of the subducting plate from the trough axis to the region of strong coupling. By integrating land and marine data, we will reveal structure further downdip to the region of slow-slip events.

Keywords: Seismic survey, Hikurangi subduction zone, Back-arc opening, Plate interface