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SCG68-01 Room:303 Time:May 23 14:15-14:30

Difference of the seismic crustal structure between the northern Yamato Basin and the southern Japan Basin, Japan Sea

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The Japan Sea is one of very well studied back-arc basins in the northwestern Pacific. In the eastern margin of the Japan Sea, the fault-fold belts developed by the deformation of the extension by the opening of the Japan Sea during the late Oligocene and the shortening since the late Pliocene (e.g., Sato, 1994). The seismic crustal model, however, has been inadequate to elucidate the crustal evolution process including the deformation in fault-fold belts in this margin and the detailed opening model of the Japan Sea. To understand this process in this margin of the Japan Sea, it is necessary to clarify the crustal structure model, not only in the Japan and Yamato Basins without this shortening, but also in its marginal area, which presumed to show the transition of the structure from the basin toward the island arc. From 2009 to 2012, the seismic survey using ocean bottom seismographs (OBSs), an air-gun array, and a multi-channel hydrophone streamer were undertaken in this margin. For this study, we will present the crustal structure models from the northern Yamato Basin to the coastal of the northeastern Japan Island Arc and from the southern Japan Basin to the coastal area.

The crustal thickness of the northern Yamato Basin is about 16 km and is less than that of a typical continental crust (Christensen and Mooney, 1995) and greater than that of a typical oceanic crust (White et al., 1992). From the velocity gradient, the crust of the northern Yamato Basin is divided to two parts; one is upper part having the steep gentle velocity gradient and the other is the lower part having the gentle gradient. These upper and lower parts have about 5 and 8 km thick, respectively. In this Basin, there is a little in the part of 5.5-6.4 km/s of the P-wave which corresponds to the island arc upper crust. Moreover, the lowermost lower crust in the central part of this Basin has the high velocity as compared to the surrounding area. This high velocity may show that the mantle temperature was slight high during the formation of the Yamato Basin. On the other hand, the crustal thickness of the Sado Ridge where it locates between the northern Yamato Basin and the coastal area is about 23 km. From the distribution of the P-wave velocity, the shallow and deep parts of the crust beneath this Ridge correspond to the island arc upper and lower crusts (Iwasaki et al., 2001).

The crustal thickness of the southern Japan Basin is about 10 km. This crust is thinner than those of the northern Yamato Basin. This crustal structure beneath the southern Japan Basin is similar to a typical oceanic crust (White et al., 1992), except for the lowermost lower crust having the high velocity. Therefore, the difference of the crustal structure between the southern Japan and northern Yamato Basins including those marginal areas may show that of the crustal evolution process during the formation of the Japan Sea.

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SCG68-02 Room:303 Time:May 23 14:30-14:45

Configuration of Moho discontinuity beneath Japanese Islands estimated with seismic tomography

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1. Introduction

P-wave seismic velocity is up to 7.0 km/s in the lower crust, however, that in the mantle is over 7.5 km/s. There is a large velocity gradient at the Moho discontinuity between the crust and mantle. Zhao et al. (1992) estimated the Moho discontinuity based on the seismic velocity model. Ryoki (1999) gathered the Moho models obtained by reflection and refraction seismology. Katsumata (2010) estimated the Moho discontinuity with tomographic method.

Fine-scale three-dimensional seismic velocity structure beneath Japanese Islands is estimated using data obtained by dense seismic network (Matsubara and Obara, 2011). I can calculate the velocity gradient between the grid nodes. I estimate the configuration of Moho discontinuity with the isovelocity plane with large velocity gradient.

2. Data and method

I calculate the P-wave velocity gradients between the vertical grid nodes between a P-wave velocity from 6.5 to 8.0 km/s with interval of 0.1 km/s. The largest velocity gradient is 0.078 (km/s)/km at velocities of 7.2 and 7.3 km/s. In this study, I define the isovelocity plane of 7.2 km/s as the Moho discontinuity.

3. Result

The Moho discontinuity deepens over 35 km beneath Tohoku backbone range, Kitakami mountains, Eastern Chubu district, northern Kinki district, Chugoku mountains, northern Kyushu district, and eastern Kyushu district. The shallower Moho discontinuity shallower than 30 km depth is distributed beneath the southeastern Hokkaido district, northern and southern Kanto district except Tokyo district, Noto peninsula, southern Tokai, Kinki, and Shikoku district, and southwestern Kyushu district.

The characteristic shallow Moho discontinuity beneath the southeastern Hokkaido district and deep Moho discontinuity beneath the Tohoku backbone range, eastern Chubu district, and eastern Kyushu district are also estimated by Zhao et al. (1992), Ryoki (1999), and Katsumata (2010). The shallow Moho discontinuity beneath the northern and southern Kanto district and deep Moho discontinuity beneath Tokyo is one of the characteristic Moho configuration of this study and is consistent with the model by Katsumata (2010). I can estimate the complex configuration of Moho discontinuity not only along the isodepth line not parallel to the coastal line as well as that parallel to the coastal line same as Katsumata (2010), however, Ryoki (1999) and Zhao et al. (2010) estimated that only parallel to the coastal line. The Moho discontinuity beneath the Chugoku district deeper than 35 km is also one of the characteristic structures of this study, however, that by Katsumata (2010) is shallower than 30 km. My model is consistent with that by Ryoki (1999) and Shiomi et al. (2006). Ryoki (1999) estimated the deep Moho discontinuity beneath the central Chugoku and Shikoku district and Shiomi et al (2006) estimated the Moho configuration deeper than 35 km beneath the Chugoku mountains using receiver function method.

It is difficult to identify the Moho discontinuity of the Eurasian plate where the lower crust of the Eurasian plate contacting the oceanic crust of the Philippine Sea plate using seismic velocity structure since there is no mantle high-velocity material. However, I can detect the Moho discontinuity if there is a mantle material since there is a high-velocity zone. Deep low-frequency tremors are observed beneath the southwestern japan (e.g. Obara, 2002). They occur at the boundary of the partly serpentinized mantle wedge in the Eurasian plate and the oceanic crust at the uppermost part of the subducting Philippine Sea plate (Matsubara et al., 2009). It is possible that the Moho discontinuity on the south side of the tremor zone is the Moho discontinuity within the subducting Philippine Sea plate. The shallow Moho discontinuity shallower than 30 km beneath the southern Tokai and Kinki district is consistent with Shiomi et al. (2008).

Keywords: Moho discontinuity, tomography, Japanese Islands, seismic velocity, 7.2 km/s

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SCG68-03 Room:303 Time:May 23 14:45-15:00

Deep seismic reflection profiling across the northern Fossa Magna, central Japan

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The northern Fossa Magna (NFM) is a back-arc rift basin produced in the final stages of the opening of the Sea of Japan. It divides the major structure of Japan into two regions, NE and SW Japan. The Itoigawa-Shizuoka Tectonic Line (ISTL) bounds the western part of the northern Fossa Magna and forms an active fault system that displays one of the largest slip rates in the Japanese islands. The eastern rim is bounded by the Shinanogawa fault system, which produced the Zenkoji earthquake of 1847 (M7.4). We carried out deep seismic reflection and refraction/wide-angle reflection profiling across the northern part of NFM in order to delineate structures in the crust, and the deep geometry of the active fault systems. The seismic data were acquired using four viboseis trucks, explosives (4 locations, 100 kg). We further applied refraction tomography analysis to distinguish between previously undifferentiated syn-rift volcanics and pre-rift Mesozoic rock based on P-wave velocity. The 60-km-long velocity profile suggests 5-km-thick Miocene basin fill beneath in the NFM basin. The thick argillaceous basin fill was strongly deformed by compression since the Pliocene. The shortening deformation is marked by fault-related folds and detachment folds. The middle Miocene over pressured mudstone forms detachments within a basin fill. Geologic reconstruction based on the seismic section suggests that the NFM basin was formed by east dipping normal fault systems. Western edge of the NFM basin is formed by the ISTL and Otari-Nakayama fault. The vertical offset of the Otari-Nakayama fault is several times larger than that of ISTL. Thus, the Otari-Nakayama fault and its northeastern extension, played an important role for the formation of NFM basin. Due to reactivation of normal faults as reverse faults, Miocene major normal faults forms seismogenic source fault. The Shinanogawa fault system, which bounds the eastern rim of NFM basin, is estimated to form a wedge thrust with deep-sited eastward-dipping fault. The distribution of strong seismic intensity area accords well to such wedge thrust geometry.

Keywords: fold-and-thrust belt, source fault, Northern Fossa magna, deep seismic profiling, active fault, 1847 Zenkoji earthquake

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SCG68-04 Room:303 Time:May 23 15:00-15:15

High-resolution seismic reflection profiling across the Tsukioka fault, central Japan

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To understand the relationship between an active and seismogenic source fault is crucial for estimating seismic hazards. Along the western margin of the Echigo mountains, basin-ward dipping active faults are distributed. To obtain complete image of the active-seismogenic source fault system, we carried out the high-resolution seismic reflection profiling across the eastern margin of the Echigo plain for 8-km-long seismic line. Seismic data were acquired using a vibroseis truck (IVI, Y2400). The sweep signals (8-100Hz; reflection profiling) were recorded with fixed 812 channels deployed at 10 m intervals, off-line recorder (GSR, JGI MS2000). The seismic data were processed using conventional CMP-reflection methods. The obtained seismic section portrays the seismic image down to 2.5 km. The seismic section demonstrates a wedge-thrust system and the deeper extension of the Tsukioka fault merges to the deep-sited east-dipping thrust.

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SCG68-05 Room:303 Time:May 23 15:15-15:30

Detailed characteristics of the March 12, 2011 Nagano-Niigata earthquake sequence and its seismo-tectonic backgaround

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The Tohoku-oki earthquake (Mw9.0) occurred on March 11, 2011, involving a large number of aftershocks and widespread induced seismicity all over Japan. About 13 hours later, the March 12, 2011 Nagano-Niigata earthquake (M6.7) occurred within the high-strain-rate zone of Japan. Both the Hi-net and F-net focal mechanism solutions of this earthquake revealed a reverse fault mechanism, with a P-axis trending NNW-SSE. The largest Nagano-Niigata aftershock (M5.9) occurred 30 minutes after the mainshock and was characterized by a NNW-SSE compressional reverse fault mechanism, similar to the one of the mainshock. The Tohoku-oki earthquake caused crustal deformation in a widespread area of Tohoku district (e.g. Ozawa et al., 2011). In such changed stress field, the Nagano-Niigata earthquake occurred. It is important to study in detail this earthquake sequence and the underlying tectonic background to understand the physical mechanism of its occurrence. In this work we analyze the Nagano-Niigata aftershocks and obtain a detailed aftershock distribution. Finally, based on these results, we are able to describe the detailed features of the Nagano-Niigata sequence and suggest a physical model for its occurrence.

We describe the features of this earthquake from the obtained aftershock distribution and the detailed 3-D velocity structure (Enescu et al., 2012). The aftershock region consists of two basement-rock blocks, which divide the area into NE and SW parts. The NE block hosts the source fault of the mainshock, with a SE dipping plane. The source fault of its largest aftershock, with a NW dipping fault plane (different from the one of the mainshock) lies within the SW block. The velocity structure of the two blocks is different; the SW block has a higher velocity than the NE block. Such difference indicates a different rock composition, likely related to the tectonic processes that lead to the formation of the two blocks.

These blocks were formed by normal and transform faulting accompanying the opening of the Sea of Japan in the Miocene. The faulting processes are at the origin of the many tectonic blocks that exist below the high-strain-rate zone. Similar with the sequence analyzed in this study, the mainshock and/or aftershock source faults of the 2004 Niigata Chuetsu earthquake and the 2007 Niigata Chuetsu-oki earthquake are divided into multiple areas (e.g. Kato et al., 2005, Yukutake et al., 2008). Therefore, earthquakes occurring within the high-strain-rate zone may break multiple blocks either at the same time or during a short time period. In most cases distinct ”block-dependent” behavior could be noticed.

Finally, we discuss why the Nagano-Niigata earthquake was induced by the M9.0 Tohoku-oki earthquake. After the occurrence of the Tohoku-oki earthquake, the seismicity in many volcanic regions all over Japan became active. The activated areas include a volcanic region in Kyushu, very far from the Tohoku-oki source region. This indicates that the triggering is likely caused by dynamic rather than static stress changes (that is, stress change induced by the passage of the surface waves from the megathrust event). The tomography result showed the existence of a high Vp/Vs ratio below the mainshock hypocenter, which suggests fluid existence, same as in volcanic areas. The Nagano-Niigata earthquake may have been induced by a stress transfer due to the very large amplitude surface waves from the Tohoku-oki earthquake, similar with the seismicity activation process in volcanic regions.

Keywords: the high-strain-rate zone of Japan, Nagano-Niigata earthquake, Tohoku-oki earthquake

SCG68-06 Room:303 Time:May 23 15:30-15:45

Seismic anisotropy at the northern part of Kanto and Tohoku regions

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1) Introduction

Beneath Japan, the Pacific and Philippine Sea plates are descending toward west and north, respectively. The stress distribution of inland of Japan is expected to be complex. The seismicity around Japan is related to the stress field caused by the plate subduction. It is very important to understand the stress field of Japan. The stress field in the shallow crust in Japan has been studied previously, with Kaneshima (1990) reporting that the maximum stress axis in northeastern Japan had a WNW?ESE orientation, parallel to, and potentially controlled by, the subduction direction of the Pacific Plate.

Shear-wave splitting is an ideal tool for determining the orientation and form of the stress field in an area. Shear-wave splitting in the crust is related to the orientation of faults or cracks, and it is thought that propagating cracks are preferentially aligned parallel to the orientation of the maximum stress axis, in turn meaning that the polarization direction should also be parallel to the maximum stress axis [Crampin, 1981]. Then, the shear-wave splitting method was used to understand the stress field in the northern Kanto and Tohoku regions.

2) Data

We analyzed crustal earthquakes at depths of $<$30 km during this study. Those earthquakes are from Jan. 1, 2000 to Mar. 10, 2011. The dataset consists of earthquakes that occurred before the 2011 Tohoku earthquake. The seismic stations operated by the National Research Institute of Earth Science and Disaster Prevention (NIED), the Japan Meteorological Agency, and the University of Tokyo are used.

3) Results

The shear-wave splitting results for earthquakes prior to the 2011 Tohoku earthquake are laterally variable. However, some interesting characteristics were found of the map of the polarization directions. The polarization directions which were observed at the seismic stations located in the western part of Japan suggested that the polarization direction with WNW-ESE. The direction is consistent with that of regional stress field which are caused by the subduction of the Pacific plate. However, the polarization direction with the north-south direction was found at the easternmost seismic stations of the northern part of Kanto and Tohoku regions. The direction is clearly inconsistent with the direction of the regional stress field. But, the characteristic, that the E-W and N-S polarization directions were observed at the western and eastern parts of the region, respectively, was as same as the result of Iidaka and Obara (2013), which was observed in the southern part of the Tohoku region. The cause of the lateral variation was researched considering the mechanism of subduction.

Keywords: Shear-wave splitting, crust, subduction

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Quaternary strain rates distribution and crust-upper mantle structure of the southern Northeast Japan

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We estimated spatial distributions of intraplate permanent strain rates accommodated by active faults and fault-related folds in southern Northeast Japan during the late Cenozoic time, based on combinations of recently obtained deep to shallow seismic re?ection data, and rates of fault slip determined by offsets of geomorphic features or stratigraphic horizons identified of drilled shallow boreholes across fault and/or fold scarps. Tectonic setting of the northeastern Japan in late Cenozoic times, underlain by westward subducting old and cold Pacific plate, is characterized by north to northeast trending active thrust sheets that deform Neogene deposits. Although previous studies indicated that active reverse faults are predominant in this region, revised active fault mapping after the 2011 Tohoku-oki earthquake (M9.0) and its normal-fault aftershock sequence indicate that active normal faults are widely distributed on the southeastern flank of the coastal mountains along the Pacific coast and continental shelf off the southern Northeast Japan. Estimated strain rates accommodated by active faults and folds are an order of 10-8/yr for each structures, that are in general 10 to 100 times higher than previous estimates only from surficial Quaternary active fault data and historical seismicity. Contrastingly, geodetic strain rates observed before the 2011 Tohoku-oki earthquake shows 10 times higher than those estimates in this study. Most of these active thrusts are reactivated normal faults originally formed during Miocene in extensional stress regimes. Trench-normal, spatial distributions of the longer-term permanent strain rates is characterized by a distinctive trend that strain rates in back-arc are apparently 10 times higher than in fore-arc region, quite similar to those estimated based on late Cenozoic folded/faulted strata. Most of these active thrusts are reactivated normal faults originally formed during Miocene in extensional stress regimes. Longer-wavelength, late Quaternary uplift and subsidence overprinting these short wave-length strains, estimated by fluvial incision rates based on tephrostratigraphy, and borehole stratigraphy in alluvial plains, indicate relatively uniform, moderate uplift rates in fore-arc and west of the volcanic front, and very fast subsidence rates in back-arc. Late Cenozoic major tectonic records in southern Northeastern Japan after Miocene Japan Sea opening are, in summary, mainly characterized by Quaternary strong compression and coeval fast subsidence in back-arc region. Crust-upper mantle structures of the southern Northeast Japan based on seismic tomography, seismic reflection and refraction profiles indicates crustal thickening beneath the Ou backbone Range probably associated with magmatic underplating during late Cenozoic volcanisms. Back-arc subsidence is underlain by thinned crust and low P-wave velocity anomaly in the upper mantle imaged by seismic tomography, suggesting that downwelling of the mantle lithosphere may be driving present-day surface fast subsidence.

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SCG68-08 Room:303 Time:May 23 16:15-16:30

How elastic is the island arc crust?

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The earth's crust is usually treated as elastic in the many studies. The term elasticity refers to a physical property of materials that recover their original shape after they are deformed. The elastic theory is very useful in data analysis and interpretation in seismology and geodesy. On the other hand, elasticity of the crust is nothing but a first order approximation. It has not been thoroughly tested in which time scale, in which spatial scale, and to what extent the crust is elastic. These issues have important implications associated with tectonic loading of crustal faults, evaluation of seismic potential, and topographical as well as geological structure development. As an example, we have found that there is significant inconsistency between geodetic and geologic deformation rates around active fault zones in central Japan such as the Atotsugawa Fault and the Itoigawa-Shizuoka Tectonic Line. Geodetically estimated fault slip rate is larger than geologic estimates by a factor of 2 to 3 there. Such an observation strongly suggests that there exists significant amount of inelastic deformation, and a large part of the inelastic deformation should be accommodated within the crustal blocks. Currently available geologic data about crustal strain rate are mostly related to fault offset and do not take deformation of the whole block into account. Thus it is important to develop appropriate methods to estimate long-term deformation rate of crustal blocks. One possibility is to examine cumulative deformation of strata based on seismic exploration and boring. Another possibility is to translate seismological properties such as attenuation and/or scattering coefficient into inelasticity. These possibilities should be investigated and derived results should be integrated into comprehensive modeling of deformation process of the Japanese island arc.

Keywords: island arc crust, elastic deformation, plastic deformation, strain rate, seismic potential

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SCG68-09 Room:303 Time:May 23 16:30-16:45

Simulation for coseismic and postseismic deformation in the Japan region due to the 2011 Tohoku earthquake with finite e

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The 2011 Tohoku earthquake, Japan (M9) remarkably characterizes earthquake generation system in the northeastern Japan arc and greatly affects the plate subduction system in the Japan region. For the rational prediction of earthquake activities and crustal deformations in these situations, we have to quickly construct a realistic model for the physical property structure under the Japan region and simulation model of crustal deformation based on the structure. In this region, two plate subduction system is formed due to the Pacific and Philippine sea plates. Thus, the deformation problem in this region is essentially three-dimensional. To solve a problem of this kind, it is necessary to model with finite element methods with which we can incorporate realistic structures. Currently, it is very important to reveal how the Tohoku earthquake generated the stress field change and how the stress field will change with time. Therefore, for the purpose of realistic prediction of earthquake activity in the Japan region after the Tohoku earthquake, we simulated the coseismic and postseismic deformation of the Tohoku earthquake with a three-dimensional crustal structure using the finite element method.

The most basic structure for simulation of time-dependent deformation in the Japan region is the geometry of the plate boundaries and elastic/viscoelastic material structure. First, we take a modeling space of 4500 km x 4900 km x 600 km. This space corresponds to the region from Kuril islands to Mariana islands and Ryukyu islands. So far, studies on earthquake activity have proposed a plate boundary model under Japan (e.g., Nakajima & Hasegawa, 2006; Nakajima et al., 2009; Kita et al., 2010; Hirose et al., 2008). For the Kuril, Izu-Bonin and Ryukyu arc, Hayes et al. (2012) made Slab1.0 plate boundary model. We constructed geometry of plate boundary structure for the whole region by interpolating these two models. Detailed seismic velocity structure under the Japan region has already been obtained by observation of densely aligned Hi-net seismograph network (Matsubara et al., 2011). At this stage, however, we simply assume uniform thickness of 30 km in the continental side, and 70 km in the oceanic plate and the slabs as the first version structure.

Then, we set boundary conditions. In this type of problem we have to give not only boundary conditions for the outer surface of the model space but also we have to give relative displacement on the two sides of the fault surface (fault slip) of the source region of the Tohoku earthquake. Under these conditions, we ran numerical computation and solve the deformation problem. In this study, we show results for the deformation in the above first-order structure.

From the computational results, we can identify the structural parameters that mainly constrain the behavior of the model, which make us to construct a rational plan for observation of these parameters. Then, we can update the deformation model with the new results and construct more effective observation plans. Establishing such a cycle of observation and modeling is required for studies of prediction of the earthquake activity and crustal deformation.

Keywords: Japan islands, Community model, 2011 Tohoku earthquake, Stress field, Crustal structure, Finite element modeling

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SCG68-10 Room:303 Time:May 23 16:45-17:00

Change in the stress field in the inland area of NE Japan after the 2011 Tohoku-Oki earthquake

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We have reported that the principal stress orientations changed after the 2011 Tohoku-Oki earthquake even in the inland areas far from the source area (Yoshida et al., 2012). A typical example of such areas with changed stress orientations is central Akita Prefecture. We investigated amply the stress field in the inland area of Tohoku to further confirm the above results and to know in detail the areas where the principal stress orientations changed after the 2011 Tohoku-Oki earthquake. In order to considerably increase focal mechanism data, we picked P-wave initial-motion polarity data from original seismic waveform records observed at many temporary seismic stations that are deployed in this area both before and after the Tohoku-Oki earthquake. Then we determined focal mechanisms of those events. The number of well-determined focal mechanisms is 2835 and 4291 before and after the 2011 Tohoku-oki earthquake, respectively. These numbers almost doubled the previous dataset. First, we estimated the spatial variation of the stress fields in NE Japan before and after the Tohoku-Oki earthquake in each 50 km spaced grid by applying the stress tensor inversion method. The results show that the estimated principal stress orientations significantly changed after the earthquake in three regions; northeast Miyagi Prefecture, central Akita Prefecture and southeast Tohoku near Iwaki city. The estimated orientations correspond to those of the static stress change caused by the coseismic slip of the Tohoku-Oki earthquake.

Then, we estimated again the stress fields in those regions before and after the Tohoku-Oki earthquake in more detail. We relocated hypocenters using the double-difference location method in the three regions, and applied the stress tensor inversion method to those data by subdividing the regions. Although the change in the stress fields near Iwaki city was not significant due to the existence of the depth variations of stress fields, the stress fields changed significantly in NE Miyagi Prefecture and central Akita Prefecture. This suggests that the stress magnitudes in NE Japan are very low because the static stress changes are only about 1-3 MPa of differential stress. Another possibility is that the stress fields in NE Japan are spatially very heterogeneous with the scale < 10 km.

To confirm whether the stress magnitude has such a low value, we investigated the effect of the tidal stress on earthquake rate. Tidal stresses were calculated including both the solid earth and ocean loading to focal mechanisms estimated above. The phase distribution exhibits a strong influence of tidal shear stress increments in NE Japan both before and after the Tohoku-Oki earthquake. Statistical test shows that it is significant (Schuster, 1897). Using the formula by Dieterich (1987), which was obtained through numerical simulations based on rate- and state-dependent friction law, we estimated the effective normal stress from the phase distribution. Assuming $a = 0.004$-0.01, the effective normal stress is estimated as 1.0-2.5 MPa. This value is roughly consistent with the value estimated using the change of the stress field after the 2011 Tohoku-oki earthquake.

Keywords: stress field, static stress change, focal mechanisim, tidal triggering, stress magnitude, frictional strength

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SCG68-11 Room:303 Time:May 23 17:00-17:15

IBM arc petrology, arc evolution and andesite problem

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Modern magmatism at the intra-oceanic Izu-Bonin-Mariana (IBM) arc is bimodal, with basalt and rhyolite predominating (Tamura & Tatsumi, 2002); and turbidites sampled during Ocean Drilling Program (ODP) Leg 126 in the Izu-Bonin arc, which range in age from 0.1 to 31 Ma, are similarly bimodal (Gill et al., 1994), suggesting that the bimodal volcanism has persisted throughout much of the arc's history. Moreover, such bimodal magmatism is not unique to the Izu-Bonin arc, with the 30-36.5 degrees S sector of the Kermadec arc, another example of an intra-oceanic arc, also exhibiting it (Smith et al., 2003; 2006; Wright et al., 2006).

Closer inspection of the IBM arc remarkably reveals the presence of a significant volume of middle crust with seismic velocities of 6.0-6.8 km/s throughout the entire arc (Calvert et al., 2008; Kodaira et al., 2007a,b; Kodaira et al., 2008; Kodaira et al., 2010; Takahashi et al., 2007; Takahashi et al., 2008; Takahashi et al., 2009). This is remarkable because these velocities are characteristic of a wide range of intermediate-felsic plutonic/metamorphic rocks (Christensen & Mooney, 1995; Behn & Kelemen, 2003, Behn & Kelemen, 2006) and are similar to the mean velocity of andesitic continental crust, such material would not be expected to be present on the basis of the bimodal volcanism.

One possible way to understand this phenomenon is to investigate arc crustal sections exposed on land, but in the IBM arc, remnants of this old crust have never been found at the northern end of the arc, where it is colliding with the Honshu arc (Izu collision zone) (e.g. Tani et al., 2010; Tamura et al., 2010). Tamura et al. (2010) suggest that IBM arc middle crust in the collision zone was partially melted during the collision and then intruded into the overlying upper crust of the Honshu and IBM arcs. This resulted in the complete loss of chronological information, original mineralogy and possibly their original composition, and thus any information related to their original source. 'Ultra-Deep Drilling into Arc Crust' is the best way to sample unprocessed juvenile continental-type crust in order to observe the active processes that produce the nuclei of new continental crust, and to examine the nature of juvenile continental crust being generated at intra-oceanic arcs.

Keywords: IBM arc, andesite, oceanic arc

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SCG68-12 Room:303 Time:May 23 17:15-17:30

Report on the Fujikawa kako fault system˜ Itoigawa-Shizuoka Tectonic Line seismic profiling, FIST. (2) Deep structure

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It is difficult to interpret the deeper part of the FIST profiles processed by the conventional method, although the profiles contain many events. Therefore we try to visualize both the velocity heterogeneities and the dominant event patterns by the following techniques.

1. To overlay the velocity structure obtained by tomographic analyses on the profiles.
2. To distinguish and classify the dominant event patterns in the MDRS (Multi-dip reflection surface) profile as follows:

1) Skeltonization of the events.

2) Classification in average dips of events and degrees of average event-lengths in skeltonization attributes.

Thus we successfully recognize the following five subsurface domains of A to E.

A: Foreland of the Fujikawa kako fault system.

Horizontal or subhorizontal events are dominant down to about 4000 m deep.

B: Fujikawa kako fault system (in a broad sense)

W-dipping reverse faults, the Omiya, the Agoyama, the Shibakawa, and the Noshita faults are arranged from east to west. W-dipping events are dominant down to about 6000 m deep parallel to the faults. The velocity structure suggests that the main activity in the four faults have been migrated eastward from the Noshita to the Omiya faults.

C: Between the Noshita and the Neguma faults

W-dipping events are dominant down to about 5000 m deep between the Noshita and the Neguma faults. Although both the Noshita and the Neguma faults are dipping west at about 45 degrees, the former is a reverse fault and the latter is a normal one.

D: Between the Neguma and the Tashirotoge-Otoshita faults

An open syncline is inferred from the velocity structure between the Neguma and the Tashirotoge-Otoshita faults.The W-dipping Neguma fault is cut at about 3000 m deep by the high angle W-dipping Tashirotoge-Otoshita fault which displaces the 5000-m/s-strata reversely at about 2500 m..

E: From the Tashirotoge-Otoshita fault, across the Itoigawa-Shizuoka Tectonic Line, to the Jumaiyama Tectonic Line

This domain is characterized by the left lateral with reverse faults, all of which are W-dipping at high angle.

A relatively dense event zone (DEZ) of about 2 km thick is dipping westward at about 20 to 25 degrees from about 5 km deep (beneath the Omiya fault at surface) to about 10 km deep (beneath the Neguma fault at surface). The lower boundary is considerably prominent due to the contrast with the wide poor-event domain beneath it. Although there are not any continuous reflectors along the lower boundary, it is reasonable that the boundary corresponds to the upper surface of the Philippine Sea plate judging from the seismicities obtained by Hi-net of NIED. The reason why typical reflectors are not seen along the upper surface is that there is no strong impedance contrast between the Philippine Sea plate and the overlying strata of the Honshu arc. In reality both are originally the same materials derived from the Izu volcanic arc.

The deeper part of the Omiya fault probably merges into the upper part of the DEZ at about 6000 to 7000 m deep. The deeper parts of the Shibakawa and the Noshita faults may reach a gently e-dipping event zone at about 5000 m deep. The zone corresponds to 5300 m/s contour. The relationships between the deeper parts of the faults in Domain E and the subducting PHS are not clarified.

Keywords: Fujikawa kako fault system, Itoigawa-Shizuoka Tectonic Line, Philippine Sea Plate, seismic survey, MDRS

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Reinterpretation of the lithospheric structure beneath the Hidaka collisionzone, Hokkaido, Japan 2 Biratori-Obihiro Line

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The Hidaka region in the central part of Hokkaido Island, Japan is known as an arc-arc collision zone where the Kuril Arc (southern part of eastern Hokkaido) has been collided against the NE Japan Arc (western Hokkaido) since the middle Miocene. This collision is a controlling factor for the formation of the Hidaka Mountains, the westward obduction of the middle/upper part of lower crustal rocks of the Kuril Arc (the Hidaka Metamorphic Belt) and the development of the foreland fold-and-thrust belt. A series of seismic reflection/refraction surveys from 1994 to 2000 revealed the collision and deformation processes occurring in this region (e.g. Arita et al., 1998; Tsumura et al., 1999; Ito et al., 2002). As indicated by Tsumura et al. (2013, this symposium), the high quality of these data sets has large potentiality to provide more clear collision image and new geological finding with the use of more advanced processing and interpretation techniques including CRS/MDRS method.

This paper focus on the reanalysis for the data sets from ”the Hokkaido Transect Project from 1998 to 2000”, which was multidisciplinary effort intended to clarify the structural deformation process associated with the arc-arc collision. The element of the active source experiment in this project was composed of a 227-km seismic refraction/wide-angle reflection profile running middle part of Hokkaido and three seismic reflection lines from the hinterland to the foreland (Biratori-Obihiro) crossing the Hidaka Mountains.

The previous study for these data sets, mainly based on the forward modelling by the ray-tracing technique, revealed the collision structure in the upper and middle crustal levels beneath the Hidaka Mountains, and a thick sedimentary package developed beneath the fold-and-thrust belt (Iwasaki et al., 2004).

Generally, refraction/wide-angle reflection method and near-vertical reflection profiling are complimentary to each other. Therefore, simultaneous evaluation for these two kinds of data set is expected to yield significant improvement for structural modelling and its geophysical/geological interpretation. In the present analysis, seismic tomography analysis was applied to a combined set of a large amount of near vertical reflection data and the refraction data. This analysis was mainly undertaken to confirm the validity of the upper 20-km crustal structure deduced from the previous result (Iwasaki et al. 2004) and quantitatively evaluate the resolving power of the data sets and the reliability of the structure model. The obtained image is well consistent with the previous result, showing a thick (4-5 km) undulated sediments in the hinterland, the outcrop of crystalline crust beneath the Hidaka Metamorphic Belt with higher Vp and Vp/Vs, probably expressing the obduction of the middle/lower crustal materials, and an enormously thick (>8 km) sedimentary package beneath the foreland. The CRS /MDRS processing for the reflection data provided clearer images of the base of the obducting lower crustal part of the Kuril Arc and shallow structural packages within the fold-and-thrust belt. Furthermore, it succeeded in imaging eastward dipping events around 25-35 km depth beneath the Hidaka Mountains. These reflectors, which were not imaged by the previous conventional CDP processing, are situated below the offscrapped and thrust-up part of the Kuril Arc crust, probably representing the lower crustal part and uppermantle of the NE Japan Arc. In several record sections of the wide-angle data, we can recognize weak later phases at a rather distant offsets (> 80-100 km). Their travel times are explained fairly well by the eastward dipping lower crust and Moho of the NE Japan Arc as indicated by the CRS/MDRS imaging.

Keywords: Hidaka Collision Zone, Kuril Arc, Delamination, NE Japan Arc