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

SCG64-01 Room:302 Time:May 23 09:00-09:15

Crustal structure imaging around the rupture zone of the 1983 Nihonkai-Chubu earthquake by seismic reflection survey

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Large earthquakes have frequently occurred on the eastern margins of the Japan Sea (e.g., the 1983 Nihonkai-Chubu earthquake (M_J 7.7), the 1993 Hokkaido-Nansei-Oki earthquake (M_J 7.8)) causing very strong vibrations, large tsunamis, and serious damage across the coastline of the Japan Sea. The 1983 Nihonkai-Chubu Earthquake was triggered by an east-dipping reverse fault, according to the analyses of aftershock distribution and the focal mechanism of the epicentral area across the western margin of the Okushiri Ridge and Sado Ridge (e.g., Urabe et al., 1985; Sato, 1985). The fracture zone was divided into three regions. The starting point of the fracture is located near the southern end of the epicentral region, which is likely where the crustal structure changes abruptly (Ohtake et al., 2002). In August 2011, we conducted a marine seismic survey around the rupture zone of the 1983 Nihonkai-Chubu earthquake using the *R/V Kairei* of the Japan Agency for Marine-Earth Science and Technology. Within the aftershock area of this earthquake, there was an earthquake of M_J 6.4 in March 2011 following the 2011 off the Pacific Coast of Tohoku Earthquake. The western part of the survey area covered the transition zone of the Yamato Basin and Japan Basin. The seismic exploration data of this survey is important to help us understand the crustal structure of the Japan Sea, particularly its eastern margins. In addition, we carried out seismotectonic and growth structure studies off the coast of Akita and Yamagata.

The multichannel seismic reflection data was acquired along 11 lines with a total length of approximately 1,924 km. The survey lines were curved to avoid the many fishing operations and equipment in the survey area. We shot a tuned air gun array with a spacing of 50 m. This array has a total capacity of 7,800 cubic inches (about 130 l). The standard air pressure was 2,000 psi (approximately 14 MPa). During the shooting, we towed a 444-channel hydrophone streamer cable with a 5700-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 16 s.

We present an outline of the data acquisition and preliminary results of the data processing and interpretations in this study. Asymmetrical anticlines with east-dipping reverse faults are well developed near the rupture zone of the 1983 Nihonkai-Chubu earthquake. Imaging of the crust on the western side of the anticline showed low-frequency reflectors. Though the basement around the source region shows larger deformation in the seismic line on the southern side than the northern side, there is more deformation in the sedimentary layers on the northern side than on the southern side. In the continental shelf off the Oga Peninsula, the basement of the continental shelf off the southern coast of the peninsula becomes rapidly deeper near the eastern end of the survey line and forms a basin with a thickness of more than 4 s. Anticlines have developed in this basin, and the basement of the basin is unclear in the low-frequency image. In the continental shelf of the northern part from the Oga Peninsula, thickness of the deposited layer is about maximum 2 s, and deformation structures has been clearly grown as compared to the southern part, and is formed asymmetrical anticline related with west-dipping reverse fault. In the Japan Basin and Yamato Basin, reflectors of the Moho and the crust below the basement were identified more clearly in the Japan Basin than in the Yamato Basin.

Keywords: the eastern margin of the Japan Sea, strain concentration areas, seismic reflection survey, 1983 Nihonkai-Chubu Earthquake

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SCG64-02 Room:302 Time:May 23 09:15-09:30

Seismic velocity image off the northern Oga Peninsula in the Japan Sea, deduced from the offshore seismic survey

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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 late Oligocene and the shortening since the late Pliocene (e.g., Sato, 1994). However, it is unknown to the relation between the occurrence of these earthquakes and the crustal structures including active faults and folds developed by these deformations in fault-fold belts in this margin. To understand this relation, it is need to clarify the crustal structure from basin areas without this shortening in the Japan Sea (Japan and Yamato Basins) to the fault-fold belts in this margin. For this study, we present the seismic velocity image in the crust from the southern tip of the Japan Basin to off the northern Oga Peninsula across the source area of the 1983 Nihonkai-Chubu Earthquake in this margin deduced from the offshore seismic data using ocean bottom seismographs (OBSs).

In 2011, the offshore seismic refraction/wide-angle reflection survey using 55 OBSs and a tuned air-gun array (7,800 cu. inch) was conducted from the southern tip of the Japan Basin to the continental shelf off the northern Oga Peninsula where Awashima-Oga fault belts locates (Okamura et al., 1998). This survey line has about 283 km length and runs across the source area of the 1983 Nihonkai-Chubu 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. To obtain seismic velocity image and reflection one in the crust including sediments and uppermost mantle below this line, 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 southern tip of the Japan Basin is about 9 km. This crust is thinner than those of the Yamato Basin off the northwest Sado-ga-shima island and Awa-shima island. The crust exhibits a quite uniform thickness in the basin area with water depths greater than 3000 m. However, this thickens gently to the land from the area at the water depth of 3000 m. This area where this crust is thickening may correspond to the active fault zone locate to the southwest part of the Okushiri Ridge (Okamura et al., 1998). In the source area of the 1983 Nihonkai-Chubu Earthquake, the crustal thickness is about 19 km and the Moho lies at the depth of about 21 km. Moreover, the P-wave velocity below this area has an anomaly compared to the surrounding area. The boundary of the south-eastern side of this anomaly area may correspond to the fault plane of the 1983 Nihonkai-Chubu Earthquake. In the continental shelf area where active faults and folds have developed, the sedimentary layer and the upper crust have large lateral variations.

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SCG64-03 Room:302 Time:May 23 09:30-09:45

Subsurface image inferred from receiver functions using a dense linear array in Niigata region: Preliminary results

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NIED installed a dense linear seismic array in Niigata and western Fukushima in 2008 and will continue its operation until fall of 2012. This linear array, which has about 165 km length, is composed of 31 velocity type three-component seismometers with eigenfrequency of 1Hz. This temporal observation is done as a part of the MEXT research project for high-strain rate zone. We can include two NIED Hi-net stations (N.TWAH / N.TSTH) to the linear array. In order to reveal subsurface structure around the high-strain rate zone, we apply the receiver function analysis to the data obtained by this linear array. As a reference, we also estimate the receiver functions at the F-net station N. ADMF in Sado Island.

For temporal stations, we select teleseismic waveforms with high signal-to-noise ratio observed from November 2008 to September 2011. For Hi-net and F-net stations, we choose earthquakes from October 2000 to November 2011. Magnitudes of the target teleseismic events are 5.5 or greater for all stations. Two kinds of low-pass filters (fc = 1 Hz / 2 Hz) are applied to estimate receiver function.

We got pretty good teleseismic records at the stations in the mountain area. In the radial receiver functions, we can find clear positive phase arrivals at 4 to 4.5 s in delay time at these stations. Since this time delay corresponds to 35 km-depth velocity discontinuity existence, these phases may be the converted phases generated at the Moho discontinuity. Seeing the backazimuth paste-ups of the transverse receiver functions, we can find polarity changes of later phases at 4 to 4.5 s in delay time. This polarity change occurs for direction of N0E (north), N180E (south), and N270E (west). Although we have no events in N90E (east) direction, this feature implies that anisotropic rocks may exist around the Moho and that its fast-axis (or slow-axis) directs to N-S or E-W direction. This characteristic is consistent with the fast-axis direction estimated by the S-wave splitting analysis [e.g., Sakakibara, 2004]. At the stations in the edge of Niigata plain, the first pulse, which corresponds to the direct P-wave arrival, delays from zero and its pulse width becomes broad. This feature is caused by the existence of thick sediments. In these cases, Shiomi & Obara (2005) pointed out that arrival time of the Moho converted phase may be contaminated by the multi-reflection phases by sediment layer. Thus, it is hard to discuss the structural feature using receiver function itself.

We will construct a crustal anisotropy model based on the receiver functions and compare it with the results of S-wave splitting analysis as the next step. We also try to construct the geometry of the Moho discontinuity.

Keywords: Receiver function, High strain rate zone, Moho discontinuity, Anisotropy

Japan Geoscience Union Meeting 2012
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SCG64-04 Room:302 Time:May 23 09:45-10:00

Some problems on the deformation of the back arc region of Northern Honshu arc, Japan

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Deformation of the overlying plate is mainly controlled by the coupling condition on the plate interface. Next factors are geometry of the lithosphere on the overlying plate, such as cold and strong mantle wedge, thin strong layer in volcanic arc and thick lithosphere in the backarc. However, actual structural data using seismic waves are still not available. If the above mentioned structure has certain reality in northern Honshu, the deformation does concentrate on the volcanic arc. Geological strain is concentrated along the Sea of Japan coast and subordinate along the volcanic front, suggesting the factor of effective thickness is so thin, due to the Miocene rifting and concentration of fault, which produced during rifting. Present shortening deformation has been performed by reactivation of normal faults. However, the zone of reactivation has a western limit. It was produced by the limit of volcano-plutonic influence to the backarc or the eastern limit of underplated mantle lithosphere beneath the Sea of Japan. To reveal this problem, new project of seismic observation in the Sea of Japan will be needed.

There is a big difference on the convergent rate determined by GPS and geological information. Later is much smaller. To understand this phenomena is important to understand the stress and strain build up on the hangingwall of the subduction megathrust. Before the 2011 Tohoku-oki earthquake, the occurrence of the devastative earthquakes were focused in the relation between the existence of high convergent rate zone measured by GPS. However, another high zone was developed just behind the maximum slip area of the 2011 Tohoku-oki earthquake and in this region 2008 Iwate-Miyagi inland earthquake and 2003 Northern Miyagi earthquakes occurred. These phenomena can be understand as stress concentrating processes caused by the 2011 Tohoku-oke earthquake.

For the understanding whole processes of strain and stress build up in the overlaying plate, the budget of the strain rate, including nonelastic deformation of the hangingwall, in the subduction system is very crusial. For this purpose, we need to start construct numerical model, which includes whole subduction system in different time duration.

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SCG64-05 Room:302 Time:May 23 10:00-10:15

Petrological crustal structure model of the northeast Honshu arc, Japan

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After the 2011 Tohoku-Oki M9 earthquake, numerous crustal earthquakes occurred beneath the northeast Honshu arc. However, crustal earthquakes following the 2011 Tohoku-Oki M9 earthquake is not homogeneously distributed throughout the northeast Honshu arc. For example, seismicity rate increase around Iwaki after the 2011 Tohoku-Oki M9 earthquake, and the 11 April 2011 Mj=7.0 Iwaki earthquake, which is one of the biggest crustal earthquakes, produced over 10km of normal faulting along Shionodaira fault in the Abukuma metamorphic belt. The 2011 Tohoku-Oki M9 earthquake induces large stress over a very broad region of northeast Honshu arc, and the relaxation of this stress causes prolonged crustal deformation far away from the rupture zone of the 2011 Tohoku-Oki M9 earthquake.

Because mineral chemistry and rock composition are important factors to control rheological strength of the arc crust, inhomogeneous distribution of the crustal earthquakes is expected to reflect deep crustal inhomogeneity, Our previous study of petrological crustal structure model of the northeast Honshu arc showed that; (1) the high-Vp and Vs regions beneath the Tobishima Basin consist of hornblende-pyroxene gabbro, (2) hornblende gabbro is a predominant rock type beneath the Dewa Hills and Ou Backbone Range, (3) the low-velocity anomalies beneath the active volcano areas may be caused by the existence of partial melts of hornblende gabbro, and (4) the low-Vp and high-Vs regions beneath the Kitakami Mountains consist of quartz-plagioclase-bearing rocks. The study demonstrated that the heterogeneity of seismic velocity in the lower crust of the northeast Japan arc reflects variations in rock composition and temperature that are related to the regional geological history. Thus, we propose to build a new petrological crustal structure model across the northeast Honshu arc from Japan trench to Japan Sea. In order to evaluate the postseismic crustal deformation of the arc in terms of stress relaxation of the arc crust and mantle, it is necessary to estimate the deep crustal viscosity of the northeast Honshu arc.

Keywords: crust, elastic wave velocity, seismic velocity, Tohoku, island arc

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SCG64-06 Room:302 Time:May 23 10:15-10:30

Basement structures and lower crustal rocks of the NE Japan arc

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NE Japan arc is one of the typical example of trench-arc-back arc basin system. Combined geological, petrological, and geophysical studies have become a valuable tool in revealing intra-crustral structures of the NE Japan. Sato et al. (2004) presented a crustal cross-section of NE Honshu arc based on the geology and the deep seismic profiling and recognized two rift systems, the Yamato basin rift system and the northern Honshu rift system. Nishimoto et al. (2005) interpreted that the lower crust of the NE Honshu arc are composed of hornblende bearing mafic rocks based on the laboratory measurements of Vp of the Ichino-megata xenoliths under high P-T conditions, to use these data in conjunction with the results of seismic tomography for evaluating the petrological characteristics of the heterogeneous lower crust of the NE Japan arc. Nakajima et al. (2008) have shown the detailed 3D seismic velocity structure estimated by travel-time tomography around Sendai, NE Honshu, and explained the complex velocity structure using its Vp, Vs and Poissons ratio as Cenozoic sedimentary pile, shallow fluid-rich plutonic rocks under cooling, H2O-filled vein fractures, mafic plutonic rocks, and partially molten lower crust. The resulted view of crustal structure of NE Honshu is closely related with the Cenozoic tectonic and magmatic evolution of the arc having three prominent stages of volcanic activity; continental margin, back-arc basin, and island-arc stages. Huang et al. (2010) determined a preliminary Vp structure and P-wave anisotropy in the eastern margin of the Japan Sea, and Zhao et al. (2011) have determined detailed 3-D Vp, Vs, and Poissons ratio structures beneath the Amur-Okhotsk plate boundary zone using a large number of arrival-time data from many earthquakes under the Japan Sea that are relocated with sP depth-phase data. Their results show that strong lateral heterogeneities exist in the crust and upper mantle under the Amur-Okhotsk plate boundary zone. We examined the compositions of the crustal rocks based the Vp, Vs values using mineral physics studies (Nishimoto et al., 2005, 2008), and the relationship between the geological basement structures and the resulted 3-D structures of the area.

Keywords: Japan Sea, 3-D velocity structure, Tanakura tectonic line, Continental crust

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SCG64-07 Room:302 Time:May 23 10:45-11:00

Seismic structures below the Japan Sea complied from results of ocean bottom seismographic observations

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The Japan Sea is one of back-arc basins in the northwestern Pacific, and is believed to be formed in association with subduction of an oceanic plate below the Japan island arc. Because seismic structure below the Japan Sea is important for revealing the formation of the Japan Sea and the present tectonics of the Japan island arc system, numerous seismic survey using ocean bottom seismometers and controlled seismic sources have been carried out since 1980's. As a result, the Japan Sea becomes one of the most well studied back-arc basins in the world. The northeastern area of the Japan Sea (the Japan Basin) has an oceanic crust. The crustal structures which are neither a typical oceanic nor continental crust were found in the Yamato Basin and the Tsushima Basin in the central part of the Japan Sea. The crustal thicknesses of both the basins are approximately twice that of the oceanic crust. The Kita-Oki Bank which is a topographic high in the southern Japan Sea comprises. In eastern margins of the Japan Sea, it is found that the crusts become thicker toward the Japan island and a variation of thickness of the upper crust is larger than that of the lower crust. It is also essential to obtain the deep seismic structure beneath the Japan Sea. From 2001 to 2004, long-term seismic observations were performed in the Sea using OBSs including broadband type to estimate the deep structure. The broadband OBS data enable an analysis of surface waves, and the estimated S-wave model does not have a large low-velocity zone in the upper mantle. In addition, travel time tomography analysis shows a high velocity anomaly in the mantle wedge extends down to a depth of approximately 150 km beneath the Yamato Basin. To obtain a variation of thickness of the lithosphere of the Japan Sea is necessary to elucidate the formation of the Sea and the dynamics of the arc-trench system at the present. Therefore sea floor long-term seismic observations using broadband seismic sensor are needed.

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SCG64-08 Room:302 Time:May 23 11:00-11:15

Long-term permanent strain accumulation in southern Northeast Japan estimated from seismic reflection data and rates of

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We calculated amounts of permanent strain rates accommodated by active faults in southern Northeast Japan based on recently obtained deep to shallow seismic reflection data, and rates of slip determined by shallow borehole stratigraphy drilled across fault and /or fold scarps. Strain rates accommodated by active structures are an order of 10-8/yr for each. Their spatial distribution shows that strain rates in back arc region are apparently larger than in fore arc region by an order of ten. Margin-normal variation of permanent strain rates in hangingwall block in the Northeast Japan is similar to previous studies.

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The Research of Historical Earthquakes on the Eastern Margin of Japan Sea - 1762 Horeki Sado Earthquake etc.

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We have been systematically examining Japanese destructive earthquakes from early modern times to the present. For the concentrated deformation zone project, we analyzed 1762 Horeki Sado earthquake in 2011. We also added the analysis of newly printed historical materials for 15 earthquakes, which we had analyzed before the current research project started in 2008. The source area of 1762 Horeki Sado earthquake is the part of the area north off Sado island in the long term evaluation of the seismic hazard by HERP. For 1670 Western Kanbara earthquake, Ishibashi(2011) pointed out the diary of Nobumitsu Nakura mentioned the damage of Aizu-Wakamatsu instead of Edo. The change of that point reinforced our estimation of the focal area just north of 1828 Sanjo earthquake. Our compiled result will be utilized to set source regions of future events in the eastern margin of the Sea of Japan.

Keywords: the concentrated deformation zone, Eastern Margin of Japan Sea, historical earthquakes, 1762 Horeki Sado earthquake, 1670 Kanbun Nishi-Kanbara earthquake

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SCG64-10 Room:302 Time:May 23 11:30-11:45

Strong ground motion, ambient noise, and GPS continuous observation in southern Niigata prefecture, JAPAN

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We have developed seismic and GPS station arrays respectively composed of 15 velocimeters and 31 GPS receivers in southern Niigata prefecture. See detail in Japanese version.

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Keywords: ground motion, ambient noise, GPS, Niigata, continuous observation