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

SSS34-01 Room:104 Time:May 21 09:00-09:15

Wide-angle OBS velocity structure along the SAHKE transect, lower North Island, New Zealand

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As part of the Seismic Array HiKurangi Experiment (SAHKE), we acquired wide-angle reflection / refraction seismic data using ocean bottom seismometers (OBSs) along a transect across the southern North Island of New Zealand, where the Hikurangi Plateau subducts westward beneath Wellington. The SAHKE project was designed to investigate the physical parameters controlling locking at the plate interface beneath the southern North Island and characterize slip processes in a major segment of the Hikurangi system. We deployed 16 OBSs with 5 km spacing off the east coast and 4 OBSs with 10 km spacing off the west coast. Controlled airgun sources were shot at every 100 m along a 350 km onshore-offshore transect. Although data from OBSs at shallow depths (~100 m) contain large amplitude ambient noise, first arrivals from the airgun sources can be traced up to over 100 km offset on record sections of most OBSs. We applied first-arrival travel-time inversion in order to obtain P-wave velocity structure along the 80 km-long OBS profile off the east coast. The velocity structure to ~20 km depth was resolved, and the down going slab was clearly imaged. The final RMS travel time residual is 31.7 ms from 6104 first-arrival travel-time picks. We, then, picked travel times of reflected waves, and projected reflection points by applying a travel-time migration method using the first arrival velocity model. Reflection interfaces including the plate interface, the Moho of the Hikurangi Plateau and a possible interface between the upper and lower crusts are imaged. The thickness of the subducting Hikurangi Plateau crust is 12 km. Very fast P-wave arrivals with apparent velocities of >8 km/s from near the Chatham Rise were observed on OBSs in the east of the profile. Travel times of shallow refractions can be well explained by the velocity structure of the Hikurangi Plateau. Such fast P-arrivals may be considered as either PnP, and represent the velocity of the upper most mantle beneath the Hikurangi Plateau or a deeper eclogite layer of the Hikurangi Plateau itself (Reyners et al 2011).

Keywords: Active seismic survey, Subduction zone, Hikurangi, Ocean Bottom Seismometer, New Zealand

SSS34-02 Room:104 Time:May 21 09:15-09:30

Seismic scatterer distribution beneath the Wellington region, southernmost part of New Zealand's North Island

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The wellington region is sited at the southern end of the Kermadec-Hikuragi subduction zone where the Pacific plate subducts beneath the Australian plate. A detailed crustal and upper mantle structure of the subducting Pacific plate and the overlying Australian plate is inevitably important to constrain the physical process of earthquake occurrence. In May of 2011, the second phase of the Seismic Array Hikurangi Experiment (SAHKE) was conducted to obtain the detailed subduction structure beneath the southern North Island. The transect line was extended from the Wairarapa coast to the Kapiti coast. Data collected from on the survey line have high signal-to-noise ratios, from which we can easily recognize not only the first arrival phases but also latter phages. The seismic coda waves are interpreted as scattered waves from inhomogeneities in the Earth [e.g., Aki, 1969]. Array recordings of seismic events are useful to locate scatterers. In this study, array analysis is applied to the waveform data for imaging seismic scatterer distribution, using semblance analysis [Neidell and Tarner, 1971]. In this study we assumed an isotropic scattering model. To locate scatterers, we established 3-D imaginary grid points beneath the survey area. The velocity structure beneath the survey area was derived by refraction tomography method [Zelt and Barton, 1998]. This velocity structure is used to calculate travel times between a source/receiver to a grid point. If a scatterer exists near the grid point, a semblance coefficient value is expected to be high. The distribution of scatterer was obtained down to a depth of about 30 km. The high westward dipping value zone is visible at the depth of about 25 km. A high value zone can be also recognized beneath Kaitoke.

Keywords: Seismic scatterer, New Zealand, subduction zone

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SSS34-03 Room:104 Time:May 21 09:30-09:45

Spatial variation of plate interface reflectivity at the source area of 1952 Tokachi-oki earthquake

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At the Tokachi-oki region, one of big question for recurrent large thrust events is why the source area of the 2003 Tokachi-oki (M 8.0) was smaller than the 1952 event (M 8.2). Although these hypocenters are almost similar position, these slip amounts significantly differ, especially at the eastern patch of the Tokachi-oki segment [Yamanaka and Kikuchi, 2003]. Hereafter we call this patch as the segmentation area. At the segmentation area the largest amount of coseismic slip of 7 m took place among the previous event [Hirata et al., 2003] However, the corresponding area didn't slip among the latest one. We focused on the difference in slip amount of them at the segmentation area even though they are recurrent events each other, and expected that it comes from an especial physical condition on the plate interface at the corresponding area. One of approaches to confirm it is to research the spatial variation of the plate interface reflectiveness which reflects a physical property on the interface such as the interplate coupling strength.

We continued analyzing an airgun-OBS experiment data obtained along the trench parallel profile, including the segmentation area in August 2010 [Azuma et al., 2011]. We applied a travel time inversion for first arrivals [Fujie et al., 2006] and, subsequently, a travel time mapping method was used for travel time of reflected waves [Fujie et al., 2006].

The result reveals that the plate interface is more reflective at both the Tokachi-oki and the segmentation areas than at the Nemuro-oki area. This clear reflectiveness implies the presence of a low seismic velocity layer at the corresponding areas, which is possibly the water contained sediment layer on the plate interface. On the other hand, we found that the weaker reflective section at the Nemuro-oki is included in the predictive Nemuro-oki source area. These features agree with the previous seismic research at the Tokachi-oki [Azuma et al., 2007] and the Nemuro-oki [Nakanishi et al., 2004]. The segmentation area is probably an area not similar to a place ruptured by the thrust events with 50 years recurrence interval, such as the 2003 Tokachi-oki and the 1973 Nemuro-oki thrust events, so-called "regular" earthquake. We interpret that the segmentation area probably slips quasi-statically or ruptures as a more long-term asperity that can excite great tsunami, such as the 2011 Tohoku giant thrust. We infer that the 1952 Tokachi-oki thrust was an especial event which has the characteristic slip of "tsunami" earthquake in addition to that of regular earthquake.

Keywords: Kuril Trench subduction zone, plate interface reflectivity, tsunami earthquake

SSS34-04 Room:104 Time:May 21 09:45-10:00

The plate boundary fault in the northwestern margin of Izu-collision zone: 2011 Hakone-Fujiyoshida seismic survey

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The boundary between the Philippine Sea (PHS) and Eurasia (EUR) plates is uncertain due to the widely spread young debris flow and avalanche deposits (ca. 2900 yr: eg. Miyachi et al., 2004). Deep seismic profiling revealed the existence of aseismic slab beneath the Misaka range, NW of Izu collision zone, suggesting the probable blind active thrust beneath Mt. Fuji.

To reveal the crustal structure of the eastern flank of Mt. Fuji, we carried out the deep seismic profiling along the 34-km-long seismic line. Seismic signals were recorded by fixed 773 channel recorders. We used four vibroseis trucks as a seismic source. For wide-angle survey, we produced high energy shots at 2.5 km interval by stationary sweeps of vibroseis trucks and dynamite (100 kg). Obtained seismic data were processed by CMP reflection analysis and Multi dip CRS method. Velocity profile was obtained by turning ray refraction tomography analysis.

Obtained migrated, depth-converted seismic section and velocity profile portray the high velocity part, which corresponds to the Miocene Tanzawa Group in the western part of the seismic section. The depth of the top of high-velocity (Vp >5.4 km/s) part rapid increases from 2.5 km to 5 km beneath Gotemba. Based on the pattern of reflection, this velocity changes is marked by estimated fault, dipping to north with 30 degrees dip angle. This fault is the southwestern extension of the Kannawa fault. According to the high resolution survey at Oyama by Ishiyama et al (2012, JpGU), two splay faults is estimated in the east of the Kanawa fault at Gotemba. The volcanic products of the Hakone volcano were marked by west-dipping reflectors can be traced beneath the Gotemba. Beneath the Hakone volcanic products, 3-km-thick sedimentary package is estimated by velocity profile. Based on the surface geology, beneath the Hakone volcanic products 5 to 6-km-thick steeply dipping, trough fill sediments (Ashigara Group) are cropping out. This sedimentary layer corresponds to the Ashigara Group. Since 1 Ma after the increase of NW compression, shortening deformation of the Ashigara Group prevailed beneath the present Hakone volcano forming stacking thrust sheets at the toe of the subduction megathrust. Since 0.6 Ma after covered by the Hakone volcanic products, main displacement was progress near the Kannawa fault as an out-of-sequence thrust. The whole thrust system was covered by the Gotemba debris avalanche and debris flow. To understand the length of this blind active thrust and paleoseismic activity, detailed study is needed to estimate potential seismic and also volcanic hazards.

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SSS34-05 Room:104 Time:May 21 10:00-10:15

Interpretation of the seismic reflection survey at Kawajima, Saitama

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We conducted seismic reflection survey at Kawajima, Saitama in December 2010, and reported preliminary results with time profiles in the last meeting.

In this report, we show a depth profile with more accurate geometry, renewed velocity structure, and with static correction, post-stack migration, time to depth conversion.

Reflected event can be seen at around 300 to 600m depth of along whole survey line, and it can be the boundary between the Kazusa Group and the Miura Group. Kawajima 84KJ borehole locates at between CMP944 and CMP945. The top of the Miocene is at 578m at the borehole, and it is expected that an event is seen at the depth in the reflection profile. However, obvious event cannot be seen at around the depth in the profile. The reason why the event cannot be seen is unknown.

South dipped event can be seen at 50m depth around the north end, and at 150m depth around the south end of the survey line. It can be the boundary between the Shimosa Group and the Kazusa Group. South dipped event can be seen at 700m depth around the north end of the survey line, and at 1300m depth around the center of the line. South dipped event also can be seen at 700m depth around the north end of the survey line, and at 1300m depth around the center of the line. These events mentioned above is identified with the events seen in the previous survey along Kawagoe-1 Line by AIST.

Strong reflected events can be seen at around 1600m depth in the north of the survey line. Moreover, in the north of the survey line, clear events can be seen at around 1400m depth. These events can be clearly only in the north of the survey line, but can be barely traced to the south of the line.

Keywords: seismic reflection survey, seismic velocity structure, upper crust

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SSS34-06 Room:104 Time:May 21 10:15-10:30

Reconstruction of reflection data with dense spatial sampling by deconvolution interferometry using backscattered waves

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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. However, the layout of shot distribution has been constrained by irregular acquisition geometries and environmental disturbance.

In our study, acquisition footprint anomalies associated with irregular shot distribution were evaluated by the reconstruction of reflection data with dense spatial sampling. Comparing to model-based wavefield extrapolation, the fully data-driven deconvolution interferometry can kinematically predict pseudo-shot records extracted by the free-surface backscattered waves,. 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 can be utilized for the velocity model for improved prestack depth migration. In our study, multi-dip reflection surfaces method is adopted for the imaging of free-surface backscattered waves.

Synthetic seismograms simulated by the elastic pseudospectral method for a simple 2-D/3-D crustal model are given to extract multi-mode free-surface backscattered waves for active and passive data. The numerical modeling results demonstrate the potential imaging capabilities of detailed imaging for crustal structure using deconvolution interferometry.

Keywords: Crustal structure, Backscattered wave, Deconvolution interfeorometry

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SSS34-07 Room:104 Time:May 21 10:45-11:00

Improvement of S-wavevector Receiver Function Analysis for Deep Borehole Logging

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The S-wavevector receiver function (SWV-RF) is useful for deep borehole records to image the seismic structures below the stations (Takenaka and Murakoshi, 2010, AGU). The most significant difference between the SWV-RF from deep borehole records and standard receiver function from the ground surface ones is relatively robust to the structure model in the SWV-RF. The SWV-RF can eliminate the free surface response and the first P-pulse entirely and give the complete representation of the converted waveform in principle. Murakoshi and Takenaka (2011, AGU) applied the SWV-RF from the deep borehole records of the Hi-net (NIED) to obtain the seismic structures under the Kanto Plain, Japan. The resulting SWV-RF images can see the subducted Philippine Sea slab and Pacific slab surface. In this study, we improve the SWV-RF analyis for deep borehole logging.

Keywords: Kanto Plain, crustal structure, receiver function, deep borehole

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SSS34-08 Room:104 Time:May 21 11:00-11:15

Characteristics of the crustal structure in the occurrence areas of crustal earthquakes

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The 2011 off the Pacific coast of Tohoku earthquake occurred on 11 March 2011 in the subducting Pacific plate boundary in northeast Japan. This earthquake caused many induced earthquakes in land areas. The strain accumulation process due to interplate coupling should have a large effect on inland shallow earthquakes that occur in the overriding plate. Investigation on the crustal structure is the key to understanding the stress concentration and strain accumulation process. In this study, we estimated the seismic velocity structures of the crust beneath the Japanese Islands by using receiver function analysis, and compared them with seismic activities in land areas.

We searched for the best-correlated velocity structure model between an observed receiver function at each station and synthetic ones by using a grid search method. Synthetic receiver functions were calculated from many assumed one-dimensional velocity structures that consist of four layers with positive velocity steps. Observed receiver functions were stacked without considering backazimuth or epicentral distance. Telemetric seismographic network data covered on the Japanese Islands and several temporal dense seismographic stations are used. We selected events with magnitudes greater or equal to 5.0 and epicentral distances between 30 and 90 degrees based on USGS catalogues. Data analysis was performed separately before and after the 2011 mainshock occurred.

As a result, we clarified spatial distributions of the crustal S-wave velocities. Average one-dimensional S-wave velocity structure estimated from analyzed stations is approximately equal to the JMA2001 structural model although the velocity from the ground surface to 5 km in depth is slow. The low velocity distributions correspond to thick sediment layers in several plain and basin areas. The velocity perturbations in the crust are consistent with existing tomography models. There are low-velocity zones corresponding to volcanoes in the upper crust to the crust-mantle boundary. In contrast, non-volcanic mountain foothills are relatively high velocity zones.

Many crustal earthquakes have occurred around the edge of the high or low velocity region; Earthquakes which occurred before the 2011 mainshock were located mainly around low velocity zones whereas earthquakes induced by the 2011 mainshock tend to occur around high velocity areas. This suggests that there is a correspondence between the structure to generate earthquakes and stress state in the crust. Furthermore, a comparison of the upper crustal structure before and after the 2011 mainshock suggests that the forearc side and backarc side of northeastern Japan arc changed to higher and lower velocities in some areas, respectively. However, this kind of velocity changes might be due to other effects such as the difference of used seismic waveforms and/or changes of velocity polarizations. We will clarify the cause of changes in the estimated velocity structure in the further studies.

Keywords: Receiver function analysis, Crustal structure, Crustal earthquake, the 2011 off the Pacific coast of Tohoku earthquake

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SSS34-09 Room:104 Time:May 21 11:15-11:30

Seismic anisotropy in the southern part of Tohoku region

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Introduction

The 2011 off the Pacific coast of Tohoku earthquake (the 2011 Tohoku earthquake) is a huge earthquake with the magnitude of 9.0. The earthquake occurred on March 11, 2011, in off shore of Tohoku region. It was the largest earthquake after the modern seismic network systems was established. Several fault models of the 2011 Tohoku earthquake have been presented. The effect of the earthquake seems to be large. The seismicity pattern in the eastern part of Japan changed after the 2011 Tohoku earthquake.

The area, northern part of Ibaraki prefecture and southern part of Fukushima prefecture, is one of the places that the seismicity changed. In the region, background seismicity was very low before the 2011 Tohoku earthquake. It is very obvious the low seismicity region was activated by the great earthquake. Most of the focal mechanisms of the earthquakes are normal fault type after the 2011 Tohoku earthquake. The stress filed of the Japan has been reported (e.g., Kaneshima et al., 1990). The maximum stress direction of the area is E-W direction. It was parallel to the subduction direction of the Pacific plate. It has been considered that the stress field is caused by the subducting Pacific plate.

In the northern Ibaraki and southern Fukushima areas, the seismic activity increased abruptly after the 2011 Tohoku earthquake. The mechanisms of the earthquakes are normal fault type with the tension axis of N-W direction. It is inconsistent with the stress field in this area. It is expected that the stress field of Japan should be changed because of the large displacement caused by the huge earthquake.

The shear-wave splitting is one of the good tools to know the stress field. The cause of the shear-wave splitting in the crust is related to the alignment of crack opening. It is estimated that the direction of the alignment of opening cracks is parallel to the maximum stress axis. The polarization direction should parallel to the direction of maximum stress axis. This method is useful to know the stress field where the large earthquake cannot be observed. In this study, the polarization direction is researched between the before and after the 2011 Tohoku earthquake. The lateral variation of the pattern of the polarization direction was researched. The change of the stress field was estimated by the use of shear-wave splitting method.

DATA

We set up two data sets. One is the data of the earthquakes before the March 11 2011. The earthquakes with the period from January 1, 2001 to March 10, 2011 are used at the data set of before earthquakes (dataset 1). The other is the data with the earthquakes which occurred from June 1, 2011 to Sep. 30, 2011 (dataset 2).

Results

The shear-wave splitting results of the southern part of Tohoku region suggested clear lateral variation. The shear-wave splitting in the northern part of Ibaraki prefecture and southern part of Fukushima prefecture shows the N-S polarization direction. On the other hand, the seismic stations, which are located at the western part of the research area suggested the E-W polarization direction. The E-W polarization direction is consistent that the expected stress field in this area. However, the data at the area of the northern part of Ibaraki prefecture and southern part of Fukushima prefecture indicated that this area is characterized by the local stress field.

The shear-wave splitting of the data of after the 2011 Tohoku earthquake indicated that the polarization azimuths are almost N-S direction. The polarization direction was also consistent with that of before the earthquakes. It is suggested that the stress field in this research area was not changed by the 2011 Tohoku earthquake.

Keywords: Crust, Anisotropy, Tohoku