Japan Geoscience Union Meeting 2012
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SSS34-P01 Room:Convention Hall Time:May 21 13:45-15:15

Low-Q related to partially saturated pores within the reservoir beneath The Geysers area in the northern California

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A large reservoir is located beneath The Geysers geothermal area, northern California. Previous studies revealed high-velocity (high-V) and low-Vp/Vs zones in the reservoir (Julian et al., 1996) and a decrease of Vp/Vs from 1991 to 1998 (Guasekera et al., 2003) owing to withdrawal of steam from the reservoir by seismic tomography. I perform attenuation tomography in this region in order to investigate the state of vapor and liquid within the reservoir.

The target region, 38.5-39.0N and 122.5-123W, covers The Geysers geothermal area. The Northern California Earthquake Data Center recorded 65,810 events from 2002 to 2008 in the target region. I use seismograms of 1,231 events whose focal mechanism are determined among them. The band-pass filtered seismograms are analyzed for collecting the maximum amplitude data. There are 26 stations that have a three-component seismometer among 47 seismic stations. I use the P- and S-wave maximum amplitudes during the two seconds after the arrival of those waves in order to avoid coda effects. A total of 8,545 P- and 1,168 S-wave amplitude data for 949 earthquakes recorded at 47 stations are available for the analysis using the attenuation tomography derived from the velocity tomography (Matsubara et al., 2005, 2008) in which spatial velocity correlation and station corrections are introduced to the original code of Zhao et al. (1992). I use 3-D velocity structure obtained by Thurber et al. (2009). The initial Q value is set to 150, corresponding to the average Q of the northern California (Ford et al., 2010).

The Geysers geothermal area is bounded by Collayomi fault zone to the northeast and the Mercuryville fault zone to the southwest. The Geysers Peak fault runs from northwest to southeast about 3 km southwest of the Mercuryville fault. The Mercuryville fault dips to northeast and the Geysers Peak fault dips to southwest. High-Q zone is located between these faults and the width of this zone broadens as the depth increases corresponding to the fault geometry.

At sea level, low-Q zones are found extending from the middle of the steam reservoir within the main greywacke to the south part of the reservoir. At a depth of 1 km below sea level, a low-Q zone is located solely in the southern part of the reservoir. However, at a depth of 2 km a low-Q zone is located beneath the northern part of the reservoir. At depths of 1 to 3 km a felsite batholith in the deeper portions of the reservoir, and it corresponds with a high-Q zone. The low-Q zone is consistent with the reservoir as it extends through the main greywacke and into the uppermost part of the felsite. Most of the felsite has high-Q, however, the portion of the reservoir that extends into the felsite has low-Q.

The presence of liquid water introduces high-Vp/Vs, however, steam rich zones become low-Vp/Vs. Near the transition zone between the water and steam, laboratory experiments indicate that the amplitude becomes extremely small (Ito et al., 1979). A partially saturated zone has lower Q than a fully saturated zone, and a dry zone has high-Q. A low-Q zone with low-Vp/Vs corresponding to the reservoir indicates that the reservoir is partially saturated with steam and water near transition zone.

Keywords: Geothermal area, Attenuation tomography, Transition zone, Low Q, Low Vp/Vs

SSS34-P02 Room:Convention Hall Time:May 21 13:45-15:15

P-wave velocity structure and deep crustal reflections in the central Ontong Java Plateau

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The Ontong Java Plateau (OJP) is an elevated expanse of seafloor in the western equatorial Pacific outlined by 4000-m depth contour, and encompasses an area of 1.86 x 10^6 km^2 area (Mahoney et al., 2001), five times the size of Japan. Although thick crust has been inferred from OJP's shallow water depths and size, the feature's crustal thickness and structure have not been accurately determined. The OJP is the largest oceanic plateau on earth and is a typical large igneous province (LIPs) (Coffin and Eldholm, 1994). The formation mechanism of LIPs does not fit plate tectonic theory. No current alternative formation models can explain all of the observations. Understanding LIP formation is important not only for solid earth investigations, but also for environmental studies, because evidence suggests that LIPs may have had major environmental impacts (e.g. Tejada et al., 2009). The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) conducted an active source seismic survey using R/V *Kairei* to constrain the structure in the central OJP (Miura et al., 2011). The new multi-channel seismic (MCS) data show a clear reflection boundary about 1 s below seafloor, which is thought to represent the contact between sediment and igneous basement (Mahoney et al., 2001). We observe several deep reflections below igneous basement. Two deep and strong reflections at 11-13 s and 14-15 s (two-way travel time) are thought to be significant reflections with respect to OJP's structure. Ocean bottom seismographic (OBS) data show clear first arrival refraction phases at $>$300 km offset distances and large amplitude later reflection phases. Refraction phases with an apparent velocity of 7 km/s are widely observed, indicating a thick layer. First arrival tomographic analysis reveals the velocity structure down to 40 km below sea level. We also employed a travel time mapping method that reveals deep interfaces using later reflection phases. From our analyses, we observe a continuous boundary at about 15 km depth where the P-wave velocity is 6.8-6.9 km/s, i.e., less than 7 km/s. Two continuous boundaries at about 33-35 km and 42-45 km depths are clearly imaged. Depth converted MCS data using OBS tomographic velocities show good agreement in distribution of the two deep reflections. Interpretation of the deep reflections is a subject for the future. According to Coffin et al. (2006), the crustal structure of oceanic plateaus may be divided in two types according to tectonic setting at the time of formation: off-spreading axis and on-spreading axis. The former case incorporates original oceanic crustal structure. From our data, we cannot identify original oceanic crustal structure in the central OJP; therefore, it may have formed on-axis. In this presentation, we will show further data analyses and interpretations of OJP structure including formation mechanisms.

Keywords: LIPs, OJP, MCS, OBS

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Uppermost mantle velocity distribution just beneath the Moho discontinuity of Japanese islands

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Katsumata (2010) estimated Moho depth distribution beneath Japanese islands. Velocity distributions in layers were also estimated in the study. Velocity distribution just beneath the Moho discontinuity estimated by Katsumata (2010) is viewed here.

One of major features of the uppermost mantle velocity pointed out in previous studies is low velocity beneath the volcanic front. Estimated uppermost mantle also indicates low velocity beneath the volcanic front. However the low velocity beneath the volcanic front shows spotted distribution rather than continuous one. Low velocity is distributed in the eastern, central and western areas in Hokkaido. If the low velocity is distributed along the volcanic front, distribution along ENE-SWS is expected. Low velocity in the central Hokkaido is distributed in the N-S direction.

In Tohoku district, low velocity regions beneath Shimokita Peninsula, Lake Towada, Mt. Iwate and Mt. Kurikoma are not continuous and are separated by relatively high velocity regions. Low velocity region is recognized also beneath the eastern Kitakami mountains.

Low velocity regions are seen beneath the area from Fukushima Prefecture to northern Nagano Prefecture, and they are not continuously distributed. Major feature beneath Kanto area are low velocity beneath south Kanto and high velocity beneath central Kanto. Low velocity beneath Kanto district is considered to be related to the Philippine Sea plate (Matsubara et al., 2005).

Major features beneath western Japan is low velocity beneath Chugoku district. It is considered that this would be related to reflective layer beneath the Moho discontinuity (Ito et al., 2009). P-wave and S-wave velocities seems to be relatively high and low beneath the region along the volcanic front in Chugoku district, respectively. In Kyushu district, velocity beneath NW and eastern parts seems to be low.

Similar features are seen in results in the previous studies (ex., Matsubara et al., 2008; Nakamura et al., 2008). These features would be related to tectonic history.

Keywords: uppermost mantle, velocity distribution, volcanic front

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SSS34-P04 Room:Convention Hall Time:May 21 13:45-15:15

Re-analysis of Gravity Anomaly aound the Kitakami district based on Conrad-Moho-Slab-residual gravity anomaly

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As a pasrt of the study of active faults in and around the Kitakami area, we performed the re-analysis of extisting gravity anomay data. A key point of this re-analysis was to extract the gravity anomaly component without the influence of the relief of conrad/moho discontinuities and the subduction of Pacific plate in order to realize more clearly the shallow-depth tectonic strucrures. This was done using the method proposed by Gennai and Kono (1999), who referred this componet as Conrad-Moho-Slab-residual gravity anomaly (CMSRG). Here, the method and results of this re-analysis were reported.

Method

Re-analysis of garvity data was intended for an area of 38.0-39.7N/139.8-141.5E, which included the almost whole are of the Tohoku district. Gravity data used was 1km-mesh gridded data of Bouguer anomaly (2.67g/cmˆ(3)) compiled in 'Gravity CD-ROM of Japan, Ver.2' (GSJ, 2004). Using this dataset, CMSRG was calculated by the following procedure.

1. Based on the published data concerning the depth distribution of Conrad and Moho discontinuities (Zhao et al.,1992), and that of upper surface of subducting Pacific plate (Nakajima and Hasegawa, 2006), 3D model was constructed, which was constituted by four layers, upper crust, lower crust, slab, and asenosphere. The thickness of slab was assumed to be 90km.

2. Assuming that each of these four layers area homogeneous with respect to density, average densities were assigned to these layers, so 3D density structure model was constructed. Average densities of upper crust, lower crust, asenosphere and slab were set to be 2.67, 2.90, 3.30 and 3.42 g/cmˆ(3)) respectively, which were determined with reference to the seismic tomography results.

3. Gravity anomaly due to above 3D density structure model was calculated, and was subtracted from observed Bouguer anomaly.

As pointed out by Gennai and Kono (1999), CMSRG calculated in this way, was considered to reflect the structure (density heterogeneity) in the upper crust.

In the step 2, the density contrast (0.12g/cmˆ(3)) between asenosphere and slab was determined to remove the monotonically westward-decreasing trend observed in the Bouguer anomay. This value was larger than that reported by Furuse and Kono (2003) (0.065g/cmˆ(3)). This difference may be attributed to the density increase during subduction due to mineral-phase transition, however, further study is needed about this point.

Result

CMSRG obtained was separated to several components based on wavelengths by means of FFT fitering, and then was compared with the geological information, eearthquake distributions, results of seismic reflection survey, and so on. These studies reveals the following characteristics.

1. CMSRG represents more clearly, the tectonic structures in the shallow-depth part of upper crust, such as caldera and active fault.

2. The Kitakami lowland is divided to several blocks by EW- or NNW-SSE-trending structures shown by high gravity anomalies, which patterns are consistent with seismic and geodetic observations.

3. The patterns and extents of low gravity anomalies within the Kitakami lowland well reflect rift structures.

4. Forward calculation based on the seismic reflection profiles (Kato et al., 2006) reproduced well the observed gravity profiles, and shows that almost of gravity anomaly at the lowland is responsible for the depth change of basements.

Keywords: Kitakami, gravity anomaly, upper crust, rift

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Basement structure based on gravity anomaly in the northwestern Noto peninsula

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The northern Noto Peninsula is divided into four geological block structures from tectonic geomorphological perspectives (Ota and Hirakawa, 1979). The 2007 Noto Hanto earthquake caused the coseismic uplift in the Kuwatsuka block and active faults on the seafloor was played a major role for the formation of the block structures (Hiramatsu et al., 2008).

We compiled the data measured and published previously (Gravity Database of Southwest Japan, 2001; Geological survey of Japan, 2004; Geographical survey institute of Japan, 2006; The Gravity Research Group in Southwest Japan, 2001; Komazawa and Okuma, 2010; Hokuriku electric power Co. Ltd., undisclosed) and calculated Bouguer anomaly in the northwestern Noto Peninsula. Based on this Bouguer anomaly, we analyzed subsurface density structures along eleven northeastern-southwestern profiles and seventeen northwestern-southeastern profiles using the two dimensional Talwani's method (Talwani et al., 1959).

The boundary between the Kuwatsuka block and the Saruyama block corresponds to a transition zone where the basement depth becomes deeper toward north. The boundary between the Saruyama block and the Hachibuse block also corresponds to another transition zone where the basement depth becomes deeper toward east. In addition, boundary between active fault segments, Monzenoki segment and Saruyamaoki segment, on the seafloor reported by Inoue and Okamura (2009) corresponds to a transition zone of basement depth. The distribution of the basement depth obtained by the analysis of Bouguer anomaly, thus, suggests that the block movement in the northwestern Noto peninsula relates to the movement of active faults on the seafloor.

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Estimation of quality factor of auto correlation function obtained by seismic interferometry around the Noubi fault zone

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Based on the seismic interferometry, it is expected that the autocorrelation function of ambient noises at a single station gives the signal equivalent to the scattered seismic waves whose hypocenter and the station are at an identical location (Claerbout,1968). Sens-Shoenfelder and Wegler(2006) reported the quality factor of auto correlation function (QACF) obtained by seismic interferometry is coincident with Qc reported by Jin and Aki(2005). However, there are some reports that show different results from those of Sens-Shoenfelder and Wegler (2006)(e.g.Mouri et al.,2010; Tsuji et al., Seismological Society of Japan 2011,Fall Meeting).In this study, we examine the relationship between seismicity and the quality factor of both QACF and QC using a dense seismic network data.

For QC analysis, we use event data recorded at stations around the Noubi fault zone. The period is from 2009/06 to 2011/06. We use 5 frequency bands, 1-2, 2-4, 4-8, 8-16 and 16-32Hz to estimate the quality factor. We use the model of Aki and Chouet(1975) represented by the following formula that is able to apply to both surface wave (n = 1/2) and body wave (n = 1),

Ac (f|t)=A/t^n * exp((-pai*ft)/(Q_C (f))) ,

where , AC(f|t) is the RMS amplitude of the band-pass filterd auto correlation function, f is the central frequency, t is the lapse time.

For QACF analysis, we use continuous seismic waveform data recorded at stations around the Noubi fault zone. The period is from 20010/02 to 2010/05. We use the same frequency bands and the model with n = 1 as the QC analysis.

We, here, estimate the n value assuming QACF = QC. As a result, the average n values are 0.87+-0.47(1-2Hz),0.50+-0.38(2-4Hz), 0.57+-0.44(4-8Hz), 0.38+-0.36(8-16Hz), 0.44+-0.38(16-32Hz), respectively. If QACF is a parameter that indicate the same heterogeneity as QC, n value should be 1.0. Therefore QACF is considered to reflect different heterogeneity from QC. Moreover, the body wave assumption (n = 1) provides no positive values of QACF, showing that QACF obtained by seismic interferometry may be the quality factor of surface wave.

The obtained QC is roughly the same as QC reported by Jin and Aki(2005).On the other hand, the value of QACF is roughly a half value of QC. We examine the relationship between both the quality factors and the number of the earthquakes occurred in small areas that are separated by 6min*6min in the analyzed area. For the source depth of 4.0-9.0km, QACF shows a slightly negative correlation(R=-0.22) and QC a no correlation (R=0.06) with the number of the earthquakes. On the other hand, For the source depth of 9-14km, QACF shows no correlation (R=0.09) and QC a negative correlation(R=-0.56) with the number of the earthquakes. This supports that QACF reflects different crustal heterogeneity from Qc.

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Shear-wave Splitting Analysis in the Focal Area of Earthquake Swarm at the Hakone Volcano from 1995 to 2010

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Many intense earthquake swarms have been reported in the Hakone caldera. The relation between the occurrence of earthquake swarms and crustal fluid has been discussed in the previous studies: it is considered that hydrothermal activity from deep underground causes the earthquake swarms. We performed the shear wave splitting analysis for the seismograms recorded at the station located just above the focal area of earthquake swarm occurred at Hakone Volcano to depict crack distribution and discuss the relation between the crack structure and the occurrence of earthquake swarm.

We used the seismograms of the earthquakes recorded at the station KZR located just above the focal area of earthquake swarms occurred in 2001 and 2009 for the period between April 1995 and June 2010. We used the events where incident angles less than 35 degrees to avoid the effect of S-P conversion wave. We selected also the seismograms with clear S wave first motion. We applied the method that computes the cross-correlation with rotating the coordinate axes (e.g., Shih and Meyer, 1990) with steps of 5 degrees and shifting the time of one component waveform by steps of 5 ms for the two horizontal component waveforms with low-pass filtered at 10 Hz. We adopted the rotated axis and the lag time as the direction of faster split shear waves polarization (PHI) and the time lag between the two split shear waves (DT), respectively, when the cross-correlation coefficient attains the maximum value. We quantified the error of the solution on the basis of the reliability estimation for the correlation coefficient with Fisher's z-transformation. We determined the 95 % confidence interval of z and transformed back to define the confidence interval of correlation coefficient. We omitted the events which confidence interval is wider than 20 ms (about 1/4 of wavelength) from the result as unreliable data.

We divide the events used for the analysis into the following two groups: 1) the events of earthquake swarms occurred in 2001 and 2009 (Group-I), and 2) the other events (Group-II). The numbers of events used are 51 for Group-I and 115 for Group-II. The averages and the standard errors of PHI and DT are 140+/-2 degrees and 86+/-2 ms for Group-I and 125+/-2 degrees and 55+/-2 ms for Group-II. The angle of PHI is measured clockwise from the north. The values of PHI and DT for Groups-I and II are significantly different. The difference of PHI reflects the difference of anisotropy in the paths. The depths of events are shallower than 2.5 km for Group-I and 30 km for Group-II. The result of Group-I suggests that the orientation of cracks is parallel to the orientation of focal alignment of earthquake swarm in 2009. Moreover, the cracks with relatively higher density are distributed in the focal areas of earthquake swarm when the earthquake swarms occurred. The facts suggest that the observed crack structure is related to the occurrence of earthquake swarm. The result of Group-II suggests that cracks whose orientation is different from that in the focal area of earthquake swarm are widely distributed around the station KZR. The value of DT for Group-I is higher than that for Group-II. The result suggests that the density of cracks in the focal area of earthquake swarm become relatively higher only during the period of earthquake swarm if the paths from the event of Group-II pass through the crack structure in the focal area of earthquake swarm.

In conclusion, we found that the cracks oriented in the different direction from that of widely-distributed cracks are distributed in the focal area of earthquake swarm and its density may become higher during the period of earthquake swarm. It is presumed that the crustal fluid selectively inject into the crack structure in the shallow region and causes the earthquake swarms at the Hakone Volcano.

Keywords: Shear-wave splitting, Hakone Volcano, earthquake swarm, crustal fluid, crack

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Stripping analysis of S and Ps waves traveling through a dipping anisotropic layer structure

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The seismic anisotropy in a horizontal layer structure can be determined as a function of depth by the stripping analysis of the Ps waves converted at velocity discontinuities (Oda, 2011). Stripping analysis of a Ps converted wave that originates at velocity discontinuity located at a deep portion in the earth tells us about the seismic anisotropy in the deep layer, but the Ps wave can be sometimes difficult to identify on the receiver functions. In such a case, a direct S wave that travels into the deep layer should be analyzed instead of the Ps phase. So we try to determine anisotropic structure by the stripping analysis of S and Ps converted waves. Synthetic seismograms were produced for the case where P and S waves were incident on the subduction zone structure that consists of upper and lower crust, mantle wedge, a dipping oceanic crust and the oceanic plate. We gave direction and dip angle of hexagonal symmetry axis and anisotropy intensity to each layer. The Ps converted waves were identified on the P-wave receiver functions constructed from the synthetic seismograms. Polarization anisotropies in the upper and lower crust were determined by the stripping analysis of the Ps converted waves at the Conrad and Moho discontinuities. As a result, they were in agreement with those given to the upper and lower crust. Similarly, seismic anisotropy in the mantle wedge was estimated from the direct S wave which was corrected for the polarization anisotropy in the crust by the stripping analysis. The estimated S-wave polarization anisotropy was consistent with that given to the mantle wedge. This result shows that the stripping analysis of Ps and S waves is applicable to estimation of the anisotropic structure in the subduction zone consisting of dipping layers.

Next we investigate the polarization anisotropy of S wave traveling through a horizontal three-layer structure which consists of two anisotropic layers and a semi-infinite bottom layer of isotropic elastic body. The top layer is assumed to be thinner than the middle layer. The S-wave polarization anisotropy is measured as a function of period from S-wave splitting which is observed on synthetic seismograms calculated for the anisotropic layer structure. The synthetic S wave shows polarization anisotropy predicted for the seismic anisotropy of the top layer when the period of S wave is shorter, and that of the middle layer when it is longer. Thus the S wave polarization anisotropy changes with changing the period of S wave.

Keywords: Stripping analysis, S-wave polarization anisotropy, dipping anisotropic layer structure, Ps converted wave

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Crustal resistivity structure at the western extension of Kannawa Fault

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Kannawa, Kozu-Matsuda Fault System is located at the boundary between the Izu block and the Honshu block. The western potential extension of the Kannawa fault remains unknown because the surface is covered by volcanics from Mt. Fuji and Mt. Ashitaka. The objective of the present study is to image the crustal resistivity structure under the volcanic cover using wideband magnetotelluric method. The 45km profile extends from Hakone volcano to Lake Kawaguchi with 40 magnetotelluric stations. The data quality was fair from 300Hz to 0.3 Hz after remote referencing to the Eshashi station, in Iwate prefecture operated by Geographical Survey Institute. We chose NE-SW direction as the regional strike and inverted the data in TM mode using two-dimensional inversion code(Ogawa & Uchida, 1996). The initial model was a 100 ohmm uniform earth plus ocean at the southeastern end. The final model had 1.55 as rms and major features of the dataset were explained.

The final model is characterized by the resistive block corresponding to Tanzawa mountains. To the south east of the Tanzawa block, conductors exist down to 4km depth and they dip to northwest. These conductors imply sedimentary layers of Ashigara formation, which deposited in the trough until the collision of the Izu block (Amano, 1991). One of the NW dipping structures corresponds to the western extension of Kannawa fault.

Keywords: Kannawa fault, collision, resistivity, magnetotellurics

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Velocity profile along the Boso peninsula: result of Boso 2002

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Due to the buoyant subduction at the Izu collision zone, the shallow subduction of the Philippine Sea plate (PHS) occurs in the sourthern part of Kanto area (Sato et al., 2005). At the Boso peninsula, fore-arc structure (accretionary prism, trench slope break, fore-arc basin), which is commonly found in the sea bottom, is exposed on land area (Saito, 1992: Kawakami and Shishikura, 2006) and it produces exceptional opportunity to investigate the geological process near the subduction zone on land.

In 2002, seismic reflection and refraction survey was conducted in Boso peninsula as part of special project for earthquake disaster mitigation in urban areas (Boso 2002). Boso 2002 was laid out 150km-long seismic line in NNE-SSW direction. This seismic line extends from southern edge of Boso to Kashima city in Ibaraki prefecture through central region of Boso. On this line 12 shots with dynamite (maximum weight 300 kg) were recorded at 2473 stations. In addition 11 shots with air-gun and with vibroseis and 496 shots with vibroseis were conducted in the southern part of this line. The receiver interval is 50- m in southern part and 100-m in northern part.

Based on near vertical seismic section, Sato et al. (2005) revealed the geometry of PHS, and main features of reflection image. However, detailed seismic velocity structure is not well understood. In particular, In order to understand the tectonic evolution of accretionary prism, constructing seismic velocity structure is very important. Therefore, we performed velocity analysis of this section using ray tracing method (Iwasaki 1988) and refraction tomography analysis to construct P-wave velocity model. By ray tracing method, the following results were obtained.

(1)P-wave velocity of Neogene sedimentary layers are from 1.7km/s to 3.2km/s.

(2)The maximum thickness of the Neogene fore-arc sediments is about 4 km in North of the Mineoka belt, central part of seismic line.

(3)The Neogene basement shallows toward north (1 km$<$). P-wave velocity of upper part of basement is from 4.8km/s to 5.4km/s . Northern Mineoka zone shows low P-wave velocity.

(4)The depth of Neogene basement is consistent with existing seismic reflection profiles and borehole data.

(5) The Mineoka zone, is marked by thick moderate velocity zone (Vp=4km/s, 5 km in depth), suggesting the thick development of accreationary complex.

Keywords: Boso peninsula, fore arc structure, seismic velocity structure, seismic refraction method, Kanto Plain, Philippine sea plate

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Estimation of velocity discontinuities in and around the swarm seismicity region beneath the Kii Peninsula (Part 2)

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There is a non-volcanic swarm seismicity beneath the Wakayama region, southwest Japan (Mizoue, 1971; Matsunami and Nakamura, 2004). Recent studies such as reflection analysis (Mizoue, 1971) and receiver function one (e.g. Yamauchi et al., 2003; Shiomi et al., 2008; Ueno et al., 2008; Shibutani et al, 2009) have revealed the distributions of the Moho and the Conrad discontinuities in this region. Kato et al. (2010) conducted the dense seismic observation in the southern region of the swarm activity and detected the low Vp/Vs region at depth of 25 km through travel time tomography. Though crustal structure has been studied in this region, the mechanism of the swarm activity is not still completely understood.

In this study, we investigated lateral velocity discontinuity distribution in and around the swarm region, using Sp converted waves from earthquakes which occurred in Philippines Sea Plate. We used waveforms recorded at seven Hi-net stations in the Wakayama region from 94 events at depths of 40-70 km. First, two horizontal components were rotated into radial and transverse ones and picked P and S times by eyes. Then, the travel time of the Sp converted wave is connected to the converted point, assuming Vp 6.0 km/s and Vp/Vs ratio 1.73. Dividing the analysis area into blocks with the horizontal and vertical length 5 km and 2 km, respectively, we stacked the amplitudes in the blocks which the converted point corresponding to the travel time of the Sp converted wave lies in.

As a result, we found velocity discontinuities at depths of 5 km and 10 km beneath the swarm region and 20 km beneath all over the analysis area. Amplitudes corrected in terms of radiation pattern are used to calculate the conversion coefficient at each velocity discontinuity. This information will be useful to discuss the relationship between velocity discontinuities and the generation process of the swarm activity.

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Seismic structure of the locked-sliding transition on the plate boundary beneath the southern part of Kii Peninsula

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The Nankai trough region, where the Philippine Sea Plate (PHS) subducts beneath the SW Japan arc, is a well-known seismogenic zone of interplate earthquakes. The most recent great earthquakes occurred in 1944 (Tonankai Earthquake, M=7.9) and 1946 (Nankai Earthquake, M=8.0). Detailed crustal and upper mantle structure of the subducting Philippine Sea Plate and the overlying SW Japan arc are important to constrain the process of earthquake occurrence. Active and passive seismic experiments were conducted to obtain a structural image beneath the southern part of Kii Peninsula, southwestern Japan (e.g., Kurashimo et al., 2011). Sixty 3-component portable seismographs, approximately 1 km apart, were installed on a survey line between Shimokitayama and Minabe in the east-west direction. To improve accuracy of hypocenter locations, we additionally deployed six 3-component seismic stations around the survey line. Waveforms were continuously recorded during a five-month period from December, 2009. The continuously recorded data were divided into event files, starting from an origin time determined by the Japan Meteorological Agency. In October of 2010, a deep seismic profiling was conducted in the southern part of Kii Peninsula. In this experiment, 290 seismometers were deployed on a 60-km-long line between Shimokitayama and Minabe in the east-west direction with about 200 m spacing, on which five explosives shots were fired as controlled seismic sources. In order to obtain a high-resolution velocity model, a well-controlled hypocenter is essential. Due to this, we combined the seismic array data with permanent seismic station data. We used 41 permanent seismic stations in the present study. Permanent seismic stations observed the controlled seismic signals as well as natural earthquakes. We picked P- and S-wave arrivals of 677 events, including 671 local earthquakes and 6 explosive shots. The arrival times for the first P- and S- waves obtained from local earthquakes and explosive shots were used in a joint inversion for earthquake locations and three-dimensional Vp and Vp/Vs structures, using the iterative damped least-squares algorithm, simul2000 (Thurber and Eberhart-Phillips, 1999). The depth section of Vp/Vs structure shows the lateral variation of the Vp/Vs values along the top of the PHS. Clustered low-frequency earthquakes are located in and around the high Vp/Vs zone.

Keywords: philippine sea plate, seismic tomography, transition zone, Nonvolcanic deep low frequency tremor

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Upper surface of Philippine Sea plate and asperity in the south Ryukyu arc

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We determined the focal depths of hypocenters of earthquakes near the Ryukyu Trench using the arrival time of the depth phase, and estimated the position of the upper interface of subducted Philippine Sea plate beneath the south Ryukyu arc. The Ryukyu trench is a convergent plate boundary extending about 1200km from Kyusyu to Taiwan. The Philippine Sea plate is subducting at a rate of 5- 7 cm/yr northwestward. The seismic coupling is assumed to be weak. However, recent observations showed that the plate interface is regionally coupled along the Ryukyu Trench. The occurrence of very low frequency earthquakes and slow slip events are implicated as the locked plate interface. Fine structure of the subducted plate interface is important to estimate the pressure and temperature condition of the coupled and decoupled zone, which inform us what is the essential parameter for the formation of interplate coupling in the Ryukyu trench. However, depths of the hypocenters have large errors for the hypocenter determination near the Ryukyu Trench region because the seismic stations are limited to the islands and far from the trench. We relocated the hypocenters of earthquakes using the arrival times of the sP phases. The sP phase is the S-to-P converted phase at the seafloor. The phase velocity of the sP phase is the same as that of the P phase. The particle motion of the sP phase is dominant with vertical component. Using the sP-P delay time, we can estimate the accurate focal depths. The waveforms at the JMA stations are used for the analysis. We used the earthquakes whose magnitudes were over 3.5. We selected two areas, southern Iriomote area and southern Miyako area. For the southern Iriomote area, we selected the earthquakes which occurred in the range of 123.4E to 124E, and 23.2N to 23.5N. The epicentral distances of earthquakes range from 87km to 120km from Iriomote Island, and sP-P times are at the range of 0.64- 5.98s. The other is the southern Miyako region ranging from 125E to 125.4E, and 23.7N to 24.4N. The epicentral distances of the earthquakes range from 35- 113km from Miyako Island. First we picked the arrival times of the sP phases from the waveforms. sP-P times in the events which occurred in the south Iriomote area and south Miyako area are 0.64- 5.98s and 0.72- 4.11s, respectively. Second we computed the focal depth of earthquake using sP-P time delays. The 2D velocity structure was employed for the calculation of the sP travel times. And sP-P times of the events in the southern Miyako region 0.72- 4.11s. Then we estimated focal depths using sP-P time delays. The results show that the focal depths are 7.1- 26km in the Iriomote area, and 6- 20.3km in the Miyako area. Next, we relocated the hypocenters using P, S, and sP arrival times. The relocated hypocenters are distributed at the depth range from 5- 20km in the southern Iriomote region near the trench, while the hypocenters are at the depth range of 35- 50 km by the JMA catalogue. in this area. In the southern Miyako region, The hypocenters are distributed at the depth from 5- 20km, while the hypocenters are at the depth range of 10- 50km by the JMA catalogue in this area. The strike-slip faulting type earthquakes are dominant at the south of the Iriomote Island. Since the relocated depth of the earthquakes are 5- 20km and these are in the subducted Philippine Sea plate, the earthquakes occurred in the Philippine Sea plate. Thus, the estimated depth of the plate interface is shallower than that estimated using the usual hypocenter catalogue. And, if the estimated depth is shallower, we consider that temperature and pressure are higher than before.

Keywords: Philippine Sea Plate, depth phase, relocation, asperity

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Three-dimensional P-and S-wave velocity structures in the southwestern Ryukyu arc, and its relationship to repeating slo

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The three-dimensional crustal structure in the southwestern Ryukyu arc was computed to show the relation among the crustal structure, distribution of micro-earthquakes, and occurrence of slow slip events. The biannually repeating slow slip events occur in the southwestern Ryukyu arc. The average magnitude of the slow slip events is Mw 6.6. The slow slip events occur at the depth of 20-40 km on the upper interface of the subducted Philippine Sea plate.

A tomographic inversion was used to determine P and S wave structures in the southwestern Ryukyu region (Iriomote Island) for comparison with the locations of slow slip events. The double-difference tomography (Zhang and Thurber, 2003) was employed. The P- and S- wave arrival time data picked manually by Japan Meteorological Agency are used. The 5733 earthquakes from January 2000 to July 2011, which were observed at the seismic stations of the Japan Meteorological Agency, were used. The used events are distributed from 23.8N to 24.7N, from 123.0E to 124.5E, and from 0 km to 100 km in depth. The numbers of arrival time data analyzed are 32277 for the P-wave and 31193 for the S-wave as absolute travel times. The intervals of horizontal and vertical grid-nodes are set to 10?20 km. The distance between earthquake pairs was limited to 10 km. A total number of 13 seismic stations are used.

The result shows that the depths of the faults are 20 km shallower than those of the hypocenters in the slab. This is consistent with the analysis of S-wave reflectors. The depth of plate interface, which was estimated from travel time of S-to-S reflection at the plate interface, is 23?40 km at the 123.6E and 24.3N. This is about 20 km shallower than the depths of the earthquakes cluster in the slab (depth range of 50?60 km).

The fault-planes of the repeating slow slip events (Heki and Kataoka, 2008) are located in the low Vp zone. This zone is between the overlying high Vp/Vs zone and underlying low Vp/Vs zone. Assuming that the difference between high Vp/Vs and low Vp/Vs originates to the fluid contents, this may suggest that the fluids from the subducted oceanic crust cannot be transported upward and is trapped at the plate interface. The observed strong S-wave reflector in the upper interface of the subducted plate also supports the idea.

The tops of the faults of the repeating slow slip events connect to the cluster of micro-earthquakes in the lower crust. This suggests that the trapped fluids are transported upward along the faults, accumulates in the lower crust, and induce the swarm of micro-earthquakes in the lower crust.

Keywords: crustal structure, Philippine Sea plate, subduction, Ryukyu Trench, seismic tomography

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Seismic Exploration along a longitudinal profile in the central part of Kyushu, 2011 - The outline of the experiment -

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Seismic exploration using artificial sources was conducted in Kyushu, Japan in November, 2011, in order to clarify the detailed velocity structure in the crust beneath Kyushu. Our seismic profile runs longitudinally across the central part of Kyushu, and the Beppu-Shimabara graben and the Aso caldera are located in the middle part of the profile. Geologically the north and middle parts of the profile are widely covered by the volcanic rock group. On the other hand, the Chichibu Belt and the Shimanto Belt, which are composed of the sedimentary rocks, are distributed in the south part of the profile.

On the about 152 km long profile, we deployed 535 temporary seismic stations and 7 shot points with charges of 100 to 300 kg dynamite. The seismic stations, located mainly in the middle part of the profile, equipped a 4.5Hz vertical component seismometer and a portable data logger "LS-8200SD". The other stations located in the north and south parts have a 2Hz vertical component seismometer and a portable data logger "LS-8000SH" or "LS-8200SD". Seismic waves are digitally recorded by the loggers with a 250Hz or 200Hz sampling. The locations of the stations and shots are basically estimated by the handy GPS instrument.

The shots were fired on November 28, 2011. We can successfully observe the seismic signals generated from each shot. However, it is found that the signals from the shots S1, S2, S3, and S7 located in the north and middle part of the profile are greatly attenuated due to the thick surface layer of the volcanic rocks. And also no obvious reflection waves are observed. On the other hand, the refraction and reflection signals from S4, S5, and S6 in the south part, can be clearly observed. It is suggested that preliminary travel time curves obtained from all shots are well correlated with the surface geology.

We installed the 8 hours long recording time schedule to the potable logger, and aimed for detecting seismic waves derived from micro earthquakes. We can fortunately observe the seismic waves generated by some micro earthquakes occurred near the profile. These data may be available for validate the velocity model estimated from the travel time data.

Keywords: Kyushu, Velocity structure

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Relationship between half-graben and high-velocities area at depths of 10km 5

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The distribution of half-graben (ground-based V shaped Valley structure) (Takahashi 2005)seems to coincide with high-velocities area at depths of 10km in Kanto Area(Matsubara 2005)-(Oishi 2007)

[Kyusyu Area]

Similarly in Kyusyu Area the distribution of coalfield over half-graben seems to coincide with high-velocities area at depths of 10km in Kyusyu Area with some exceptions.

There are high-velocities areas at 10km below Coalfield in Chikuho (Fukuoka prefecture),Karatsu(Saga prefecture),Sasebo(Nagasaki prefecture),Amakusa(Kumamoto prefecture)

There are high-velocities are at 10km below Coalfield in Chikuho (Fukuoka prefecture),Karatsu(Saga prefecture),Sasebo(Nagasaki prefecture),Amakusa(Kumamoto prefecture)

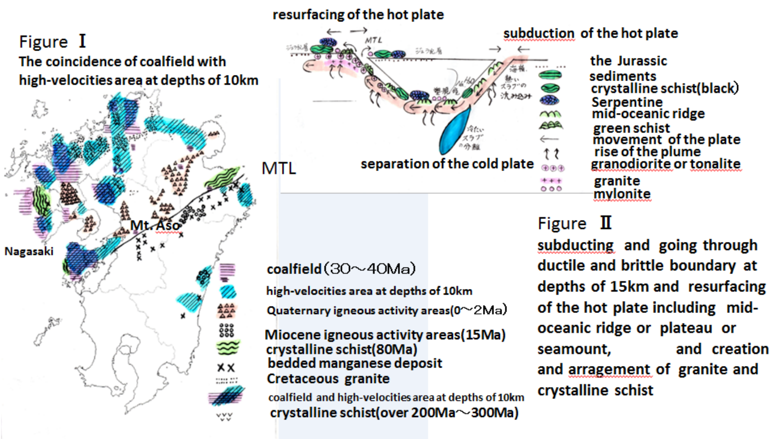
A coalfield is a place of spreading and sinking.

The Nishisonogi Peninsula has crystalline schist (which is as old as that of Sanbagawa metamorphic belt) and has mylonite and bedded manganese deposit.

Strangely enough, near M T L (U Y T-L) Kyusu has crystalline schist only in Saganoseki (Ohita prefecture).

Nagasaki prefecture and west part of Kumamoto prefecture are spreading areas (
Quaternary igneous activity areas)

Considering the distribution of spreading areas (Quaternary igneous activity area and
coalfield 40Ma)and that of mylonite and bedded manganese deposit ,The Nishisonogi Peninsula was once pilled under MTL(around Mt. Aso)at depths of 20km ,slipped out and went up by 40Ma,moved to west about 200 km.



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Reprocessing of 1988-90 Seismic Reflection Data of the Beppu Bay and the Bungo Strait : A new attempt

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A big project of geophysical explorations was conducted in the Beppu bay and along the Bungo strait from 1988FY to 1990FY in collaboration with all sections of Geophysical Department, Faculty of Science, Kyoto University. The project was originally planned as a succession of the paleoenvironmental research promoted by late Professor Horie in the Lake Biwa (Horie ed.,1987; 1991). The geophysical explorations of the project were organized by several techniques; marine seismic reflection with air-gun shots in the Beppu bay and along the Bungo strait, seismic reflection along the coastal road of the Beppu bay with vibroseises, gravitational survey at sea-bottom etc. Both data acquisition and processing of the explorations were made by JGI, a subsidiary of JAPEX. Their results were reported in Yusa et al. (1992). However a severe problem remained unsolved in the seismic reflection survey. Multiples were not suppressed satisfactorily in the seismic reflection profiles, because the length of a streamer cables was restricted to be within 664 m in the bay, and 1473m in the Bungo strait, in order to avoid disturbing coastal fishery and sea routes. More efforts were necessary for suppressing multiples and improving the profiles.

The first attempt was made by reprocessing the original data in 1998, then reported in "8th International Symposium on Deep Seismic Profiling" (Ikawa et al., 1998). As a new reprocessing has been done, its result is presented in this poster. These efforts will surely provide improved profiles that contribute not only to the research of crustal structures in the Beppu bay, but also to wide areas of earth science.

Keywords: Beppu bay, Bungo strait, marine seismic reflection, multiple, reproccessing

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Preliminary results of SAHKE II low fold seismic reflection profile across the Wairarapa fault, New Zealand

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Oblique plate subduction of the Pacific Plate at a rate of about 42 mm/yr along the Hikurangi margin in the southern North Island contains large amount of margin-parallel component of plate motion (Beavan et al., 2002). This margin-parallel component of plate convergence is partly accommodated by dextral-slip on the NNE-striking faults within the overriding plate including the Wellington and Wairarapa faults (Little et al., 2009; Rogers and Little, 2005; Van Dissen and Berryman, 1996). Unusually high displacement/length ratio for the 1855 earthquake along the Wairarapa fault (Mw˜>8.1) suggest that the rupture may extended downward to merge into the underlying subduction megathrust to comprise splay fault systems at depths of 20-30 km beneath the southernmost part of the North Island (Rogers and Little, 2006), also as inferred from seismicity. Aiming to understand structural characters and deeper crustal scale geometry of the Waireararapa fault, and ultimately its structural relations to subducting oceanic lithosphere beneath he southern segment of the Hikurangi Margin, we analysed seismic data obtained by the SAHKE II project seismic experiment to make a low fold stack section across the Wairarapa fault. At this point we carried out preliminary data processing, which includes common depth point stack of densely deployed area after NMO of CDP-sorted, all shots data using a single velocity (6.0 km/s) with a stretch mute, first arrival mute, elevation statics, bandpass filter, velocity filter to attenuate S waves. In the preliminary image several west-dipping reflectors can be seen beneath the Rimutaka Range from depth of about 20 km. Upward projection of a west dipping event among them is approximately coincident with surface location of the Wairarapa fault. Shallower, westerly dipping reflectors from 15 to 22 km depth underlie beneath the Wairarapa event is similar to geometry of subducting Pacific Plate. These seismic characters may imply splay fault signature of the Wairarapa fault extending from the underlying megathrust.

Keywords: Wairarapa fault, low fold seismic reflection profile, Hikurangi subduction margin, active fault, splay fault