Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SCG67-01 Room:106 Time:May 22 14:15-14:30

Seismic structure and seismicity at the southern Mariana Trough with hydrothermal activities

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1. Introduction

The Southern Mariana Trough back-arc spreading system shows asymmetry spreading, and has high relief at spreading axes, which infers abundant melt supply. Furthermore, five hydrothermal vents that extrude different water contents, exist within 5 km near the spreading axis. To investigate upper mantle structure, crustal structure and hypocenter distribution provide important constraint on following four main points to understand the back-arc spreading system; 1) imaging melt delivery to the spreading axis and off axis seamount including volcanic arc, 2) production and character of the crust, 3) relationship between melt supply and crustal formation, and 4) pathway and heat source for hydrothermal circulation with related to its formation.

2. Observation and analysis method

We conducted a seismic reflection/refraction survey and seismicity observation at the hydrothermal area in the Southern Mariana Trough from August to November in 2010. We used 9 ocean bottom seismometers, an air gun (GI gun) and a single channel streamer cable. We took 7 parallel lines and 7 perpendicular lines to the spreading center. Line length was 15 km each, and line interval was 2.5 km.

In analysis of refraction data, we firstly made 2D cross sections of survey lines A1, A4, A7, B1,B4 and B7 using the progressive model developing method (Sato and Kennett, GJI, 2000). Then we made 3D initial models and conducted 3D inversion using FAST (Zelt and Barton, JGR, 1998).

3. Results

In refraction analysis, we used more than 9000 P-wave arrivals (hand picked). In 3D inversion, RMS was reduced from 120 ms (initial model) to 30 ms (after 10 iterations). The result of 3D inversion shows low velocity at the central part of the spreading ridge and high velocity under the off axis seamount. The high velocity under the off axis seamount suggests thick layer 3 and past magma intrusion from the mantle. The reflection survey shows that some reflectors exist under the hydrothermal area. From seismicity observation, we obtained very low seismicity at the hydrothermal area in the 3 month's observation. This suggests that hydrothermal activities are not related to tectonic stresses.

Acknowledgements

We thank the captain and the crew of R/V Yokosuka of Jamstec for their support. This work was supported by JSPS KAKENHI Grant Number 20109002.

Keywords: TAIGA, hydrothermal area, crustal structure, Mariana trough

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SCG67-02 Room:106 Time:May 22 14:30-14:45

Magnetic Structure of Back-arc Spreading Axis with Hydrothermal Vents; the Southern Mariana Trough

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Geological and geophysical characterization of seafloor hydrothermal system is important in investigating the mineral deposits, habitat of microbial communities and heat and chemical fluxes, and especially near-bottom geophysical mapping is an useful technique for the investigatioin. To reveal the high-resolution magnetic structure of oceanic crust with hydrothermal alteration zones, I constructed a new technique of three-dimensional forward modeling using three component of magnetic anomaly. I applied this technique to the near-bottom data acquired by submersible Shinkai 6500 at an altitude of 1 -100 m above seafloor in five hydrothermal vent sites near the Southern Mariana Trough (SMT), backarc spreading axis. In addition, I compared the results with NRM measurements of basalt samples and with magnetic signatures obserbed by AUV with higher altitude. Important results are detailed below.

The distribution of esitimated absolute magnetization well corresponds to the seafloor geological characters such as hydrothermal deposits and fresh pillow lava. The value of absolute magnetization is almost equal to measured NRM of collected samples, demonstrationg the reliability of new processing technique. The result is also consistent with the equivalent magnetization deduced from the previous AUV survey and shows more detailed structure.

My results reveal that hydrothermal alteration zones are accompanied with distinct low magnetization as some previous studies reported in mid-ocean ridges. It is considered that this low magenetization is caused by demagnetization of high temperature hydrothermal circularion exceending Curie temperature or alteration of magnetic minerals in stockwork pipe.

The horizontal scale of low magnetization zones around the off-axis vent sites is almost 10 times larger than those around the on-axis sites. I consider that the longer duration time of hydrothermal circulation in off-axis sites makes the alteration zone larger.

We obtain extremely high magnetization just on neo volcanic zone (NVZ) and relatively low magnetization away from the NVZ, suggesting a very rapid decrease of magnetization by low-temperature oxidization. My results shows higher decay rate than suggested by previous study.

Keywords: vector magnetic anomaly, Southern Mariana Trough, oceanic crust, hydrothermal system, back-arc spreading center, magnetization

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SCG67-03 Room:106 Time:May 22 14:45-15:00

Volcanic features and volcanic massive sulfide deposit of Myojinnsyo caldera, Izu-Ogasawara Arc.

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There are some submarine calderas on the volcanic front of Northern Izu-Ogasawara Arc. Volcanic massive sulfide deposits were reported from some of this caldera. Geological and geophysical investigations were carried out around the Myojinsho caldera. Caldera wall consists altered volcaniclastic deposits on the lower part, massive dacitic volcanic body on the middle part, and fresh pumiceous fragments on the upper part. There are some fossils with coral debris and shells, which show the shallow environments, on the caldera slops. Massive andesite to rhyolite were sampled from the central cone and middle part of caldera slop. These volcanic rocks are quite similar on geochemical composition. Many pumice samples were also collected from the caldera area. These samples are slightly different by trace element from back-arc samples.

Keywords: submarine caldera, volcanic massive sulfide deposit, Myoujin-sho

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SCG67-04 Room:106 Time:May 22 15:00-15:15

Across-arc geochemical variation of felsic rocks dredged from the Myojin Seamount and the Myojin Rift, Izu-Bonin arc

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The Myojin Seamount, located in the volcanic front of the north Izu-Bonin arc, is a submarine composite volcano with a large caldera. The Myojin Rift, western back arc side of the Myojin Seamount, exhibits graben structure rifting at present. The volcanic rocks from the Myojin Seamount are comprised of basalt, andesite, dacite and rhyolite, whereas the Myojin Rift is characterized by basalt and rhyolite assemblage. The felsic rocks from the Myojin Seamount and Rift consist mostly of pumices with variable vesicularity and lesser amount of massive lava and plutonic rocks, which are divided into three suites on the basis of incompatible element and isotopic characteristics: type 1 rocks with low Na_2O, Zr, LREE, and high Ba, $^{87}Sr/^{86}Sr$, type 2 rocks with low K_2, Rb, Ba, and high $^{87}Sr/^{86}Sr$, type 3 rocks with high Na_2O, K_2O, Rb, Zr, Nb, LREE, and low Ba, $^{87}Sr/^{86}Sr$.

The type 1 felsic rocks occur in the Myojin Seamount of the volcanic front, the type 3 felsic rocks in the Myojin Rift side, and the type 2 felsic rocks overall from volcanic front to back arc. Isotopic compositions of basalts from the volcanic front are similar to the type 1 and 2 felsic rocks, whereas those of basalts from the Myojin Rift are similar to the type 3 felsic rocks. Geochemical signatures and occurrences of the felsic and basaltic rocks suggest that the type 1 felsic magma may be derived from the basaltic sources beneath the volcanic front, and the type 3 felsic magma from the basaltic sources beneath the back arc. Isotopic compositions of the type 2 felsic rocks are similar to the type 1 felsic rocks, however, the differences of major and trace elements between the type 1 and the type 2 felsic rocks can not be explained by different conditions from the common basaltic sources, such as variable fO_2 (e. g. Sission et al., 2005; Tatsumi and Suzuki, 2009). An alternative model of the type 2 felsic rocks is partial melting of another source material, such as pre-rifting stage basaltic crust (e.g. the Oligocene middle crust of Tamura et al., 2009). The dispersed distribution of the type 2 felsic rocks from the volcanic front to the back arc is consistent with the old pre-rifting stage lower crust model.

Keywords: Izu-Bonin Arc, Myojin Rift, Myojin Seamount, Middle Crust, Igneous Rock, Felsic

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SCG67-05 Room:106 Time:May 22 15:15-15:30

Mapping hydrothermal sites in the Bayonnaise knoll caldera using acoustic sonars with an autonomous underwater vehicle

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The Bayonnaise knoll caldera is one of a number of submarine calderas in the Izu-Ogasawara island arc. Since a large active hydrothermal field associated with sulfide deposit, the Hakurei site or deposit, was discovered on the southeastern margin of the caldera floor in 2003, the caldera has attracted much attention because of its potential importance as submarine resources. We conducted autonomous underwater vehicle (AUV) surveys during the YK11-11 research cruise of the R/V Yokosuka in December 2011. Two dives of the AUV Urashima, a vehicle developed by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), were devoted for mapping the southern half of the caldera using a multi-narrow beam echo sounder and a side scan sonar.

The multibeam bathymetric data were first examined each ping to remove obvious outliers, and then combined with the vehicle's position and attitude data to determine their precise locations. Because some of the track lines over the Hakurei site were arranged densely, data from adjacent tracks commonly overlapped. Data misfits in these overlapped areas were dissolved by correcting the position data as required. All the located bathymetric data were finally compiled to produce a fine bathymetric map, the resolution of which is several tens of centimeters. It was confirmed that the Hakurei hydrothermal site is associated with the rugged seafloor surface, which probably represents sulfide mounds and chimneys.

The side scan sonar data were first processed by forcing a flat bottom assumption. However, the resulting mosaic suffers from significant geometric distortion because of the large relief observed at small altitudes. Moreover, the backscattering intensities are rather influenced by the actual slopes in spite of radiometric corrections. We then tried to take advantage of the multibeam bathymetric data to determine actual footprints of each ping and to correct these geometric distortions and intensities. The mosaic was greatly enhanced by this processing: it well agrees to the topography and the effect of the incident angle was adequately removed. The image around the Hakurei site is characterized by the short-wavelength alternation of strong and weak backscattering, which probably represents reflections and acoustic shadows due to sulfide mounds and chimneys. We made a seabed classification of the mosaic, and four categories were chosen as representing major features. The Hakurei site is adequately classified to one of the categories.

The intensity data from the multibeam sonar were processed to create another backscatter mosaic. The Hakurei site is characterized by a distinctive spotty pattern unlike the side scan image that shows many acoustic shades due to topographic relief. One of the reasons for the different expressions of the hydrothermal site by the multibeam and side scan sonars might be the difference in the sound frequency. Another reason could be the geometric distortion in the side scan image signals from soaring chimneys. The spots of strong backscattering are from several to ten meters in diameter, and they were recognized to be actually associated with topographic highs in the multibeam bathymetric map. This conspicuous pattern was utilized to delineate areas that have similar characteristics, and several areas other than the Hakurei site were found to have similar patterns. The distribution is generally in good agreement with that of the classification from the side scan image to which the Hakurei site belongs. We suggest that hydrothermal activity at various scales would occur in several places in the caldera.

It was inferred from this study that hydrothermal sites are distinguishable by their acoustic characteristics. We suggest that deep-sea acoustic surveys with AUVs are effective means to seek unknown hydrothermal sites efficiently in a wide area.

Keywords: hydrothermal sites, AUV, side scan sonar, multibeam sonar

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SCG67-06 Room:106 Time:May 22 15:30-15:45

The structure of chimney at iron-silica rich hydrothermal environment in shallow marine, Satsuma Iwo-Jima, Kikai caldera

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Satsuma Iwo-Jima Island is a volcanic island in the northwestern rim of Kikai caldera. There are two post-caldera volcanoes in this island: the rhyolitic Iwo-dake and basaltic cone Inamura-dake. Iwo-dake has volcanic and hydrothermal activities at the present. Because of hydrothermal activity, seawater around the island is discolored to brownish and white color. Ferrous-rich hot spring (pH=5.5, 55-60 degree Celsius) discharges from the sea-floor at the Nagahama bay in the southwestern island. Brownish-color ferric particles that were produced by mixing of the hot spring water with seawater, discolor the seawater to brownish color (Shikaura and Tazaki, 2001). The bay is half-closed environment topography. There is a breakwater for a fishing port into two parts: East site and West site. Kiyokawa et al, (2012) indicated that the deposition rate of iron-rich sediments at West site is about 1 m per ten years. The deposition of sediment was influenced by tide, rain and wind. At East-site, the iron-rich chimney-complex mounds were found. The growth process of the chimney-complex mound is not studied so far. In order to understand the growth process of the chimney mounds, we observed structure of chimneys sampled from the chimney complex mounds at East-site.

Samples used in this study were massive chimneys (20-30cm). We observed the structure of chimneys with X-ray CT scan and FE-SEM and from the thin section samples, and analyzed the chemical composition with EDS. The massive chimney is classified into two parts seen with the naked eye: black high density-hard layer and brownish low-density soft layer. Additionally, we analyzed floating particles collected from seawater by a centrifugal separator.

The results of X-ray CT scan observation shows that the inside of chimney is constructed from the aggregation of convex structures (3-4cm). Low-density layers of the chimney have many pipe-like structures (typical radius: 1mm). Petrographic observations indicate that both high- and low-density layers have a filament-like form, however the form at the low-density layer are vertical to high-density layer. In the low -density layer, the number of particles attaching to the filament-like form increases toward the high-density layer. FE-SEM observation shows that filament-like form at the high-density layer consists of aggregation of bacillus-like form that is observed as the chain of particles (about 2um). At low-density layer, on the other hand, there is bacteria-like form with particles (<1um). Bacteria-like form could be classed into 3 types (helix, ribbon-like, twisted).

The floating particles were observed as an aggregation of fine particles (<0.5um). The particles show no bacteria-related form. EDS analysis shows that all particles are consist of Fe, Si and O, and are chemically homogeneous.

According to the observation results above, we present a hypothesis of growth process of a chimney-complex mound in Nagahama bay. The chimney was constructed form aggregation of convex structure with many pipes that probably work as the hydrothermal vent. All particles are consist of Fe, Si, and O. This suggests that the particles are silica rich iron-hydroxides. Bacteria-like structure may be Gallionella spp. known as iron-oxidizing bacteria because of those forms. This bacterium is known as neutrophilic bacteria that prefer an environment of redox interface (Weber et al., 2012). The increasing of the number of particles on filament-like form and the character of bacteria support that the activity of bacterium around hard rim makes high-density layer. The growth of chimney is likely to be influenced by microbes' activity.

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Keywords: hydrothermal activity, chimney, bacteria, iron-hydroxide

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SCG67-07 Room:106 Time:May 22 16:15-16:30

The subducting effect and characteristics of crustal structure in the east side of Shikoku Basin obtained by seismic ref

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The Shikoku Basin which locates the north part of Philippine Sea Plate between the Kyushu-Palau ridge and Izu-Bonin (Ogasawara) ridge is an important area to understand the evolution of the backarc basin. The Shikoku Basin is also subducting to Nankai Trough at the north region. The Shikoku Basin was in backarc rifting and spreading stage during 30-15Ma (Okino et al., 1994). Many seismic reflection surveys have been conducted in the Shikoku Basin. There were rarely reflectors of Moho discontinuity and internal crust. Nankai Trough is important region to understand large disaster earthquake.

Japan Agency for Marine-Earth Science and Technology has been carried out the multi-channel seismic reflection (MCS) surveys in 2011 and 2012 using new MCS system in order to understand the linkage mechanism of large disaster earthquake along the Nankai Trough. Total length of survey line is over 1800 km in these surveys. From obtained results, we recognized clear Moho reflector which obtained by newest seismic reflection survey in 2011 and 2012. We discuss about the spatial characteristics of Moho and crustal reflectors using the mapping results along the Nankai Trough.

Keywords: MCS survey, paleo-arc, backarc basin

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SCG67-08 Room:106 Time:May 22 16:30-16:45

Seismic structure of the Kita-Daito Basin and Minami-Daito Basin in the northwestern Philippine Sea plate

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Several large topographic features characterize the northwestern Philippine Sea plate. They are, for example, three large bathymetric highs, the Amami Plateau, Daito Ridge and Oki-Daito Ridge with thicker crust over 15 km, which indicates they are paleo-island arc. There are also large basins between them, the Kita-Daito Basin and Minami-Daito Basin.

The Kita-Daito Basin exists between the Amami Plateau and Daito Ridge and the Minami-Daito Basin between Daito Ridge and Oki-Daito Ridge. The average depth of the Kita-Daito Basin is 5300 m and that of the Minami-Daito Basin is slightly shallower, 5000 m. However, the difference of gravity anomalies between these basins is significantly large compared with the difference in water depth, which give us crucial information of the evolution of the Daito Ridge Group.

We could carry out several seismic refraction and multi-channel seismic reflection explorations across these basins under the Japanese Continental Shelf Project in 2004-2008. The P-wave velocity structure of the Kita-Daito Basin is normal oceanic with rather thinner crust of 4-6 km and is same as those of the Shikoku Basin and Parece Vela Basin on the Philippine Sea plate. The Pn velocity beneath the Kita-Daito Basin ranges 7.9-8.1 km/s generally, but is 8.3 km/s at the boundary with the northern end of the Daito Ridge. The crust beneath the Minami-Daito Basin is thicker than that of the Kita-Daito Basin and reaches to 10 km in the transition area to the Kyushu-Palau Ridge. The velocity at the bottom of the curst is slightly high, around 7.2 km/s, and Pn velocity is 8.0-8.2 km/s. There is not thick middle crust with Vp=6.3-6.8 km/s characterizing island arc crusts. The crustal structure for the Minami-Daito Basin rather resembles those of the Kyushu-Palau Ridge.

Keywords: marine seismics, Kita-Daito Basin, Minami-Daito Basin

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Aseismic deep subduction of the Philippine Sea plate

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The fundamental cause of the seismic and volcanic activities in the Japan Islands is the active subduction of the Pacific and Philippine Sea (PHS) plates. It has been well known that the Pacific plate has subducted deeply to the mantle transition zone and lower mantle, finally reaching the core-mantle boundary. In contrast, it is still not very clear whether the PHS plate has subducted deeply beyond the depth limit of the intraslab seismicity and how deep the tip of the slab has reached in the mantle. We attempt to address this issue in the present study. The PHS plate is one of the marginal sea complexes in the western Pacific and it started to subduct northwestwards ˜40 Ma ago when the Pacific plate changed its direction of motion from NNW to WNW. Along the Nankai Trough off Southwest Japan, the PHS plate is composed of several blocks with ages increasing from the east to west, which are the Izu-Bonin arc and back-arc (0-2 Ma), Shikoku Basin (15-30 Ma), Kyushu-Palau Ridge, and Amami Plateau (40-49 Ma). Within the PHS slab, earthquakes occur actively down to ˜80 km depth under western Honshu and down to ˜180 km depth under Kyushu. Recently we have made great efforts to collect and combine a large number of high-quality local and teleseismic arrival-time data recorded by the dense seismic networks in both South Korea and Western Japan. As far as we know, this is the first time that a large number of Korean and Japanese seismic data sets are analyzed jointly. As a result, a high-resolution 3-D P-wave velocity model down to 700-km depth under South Korea and Western Japan is determined, which clearly shows that the PHS slab has subducted aseismically down to 460-km depth under the Japan Sea, Tsushima Strait and the East China Sea. The aseismic PHS slab is visible in two areas: one is under the Japan Sea off western Honshu (Shimane Prefecture), and the other is under the East China Sea off western Kyushu. However, the aseismic PHS slab is not visible between the two areas, where a slab window may be formed. The slab window is located beneath the center of the present study region where many teleseismic rays crisscross very well. Detailed synthetic tests were conducted, which indicate that both the aseismic PHS slab and the slab window are robust features. Using the teleseismic data recorded by the Japanese stations alone, the aseismic PHS slab and the slab window were also revealed (Zhao et al., 2012), but the ray paths in the Japanese data set do not crisscross well offshore. The local and teleseismic data recorded by the dense seismic networks in both South Korea and Japan lead to very good ray-path coverage under the Tsushima Strait area, hence our new results on the aseismic PHS slab and the slab window are much more robust and convincing. These new findings are considered to be important for improving our understanding of the subduction history of the PHS plate and the dynamic evolution of the Japan subduction zone.

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Keywords: Philippine Sea plate, subduction zone, aseismic slab, Pacific slab, mantle transition zone, slab dehydration

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SCG67-10 Room:106 Time:May 22 17:00-17:15

Precise visualization of global plate motions

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GPlates (http://www.gplates.org/) is the one of the best free tools for visualizing global plate motions. However, it is still developing and has some problems for visualizing such as precise and smooth hotspot track formations on both sides between past oceanic ridges.

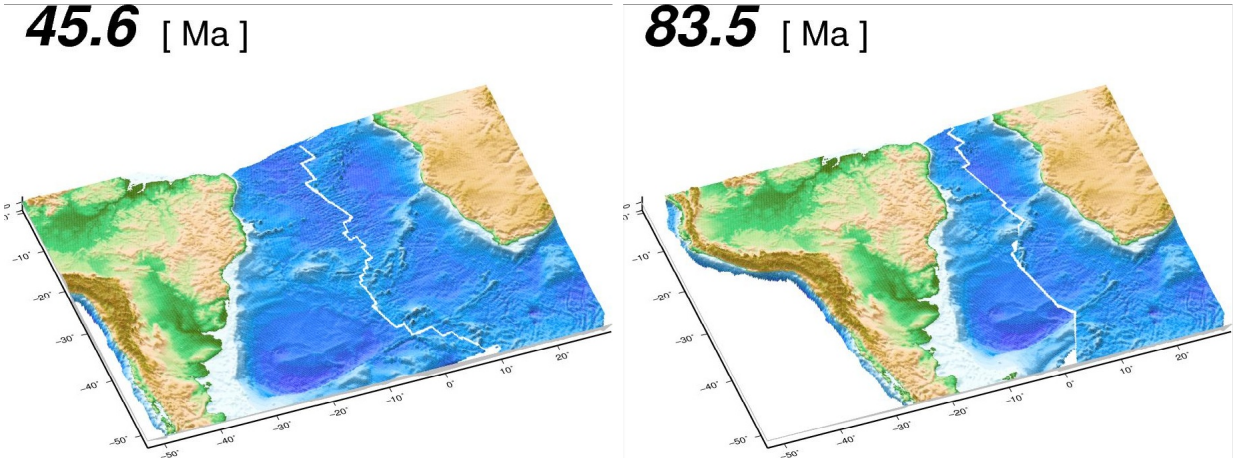
We developed a method to solve this problems by utilizing global data (gravity anomaly, Isochron positions), modifying the Euler rotation data sets, and by interpolating more data for precise positions and shapes of past plates. We needed to modify some Euler rotation angles of Muller et al., 1999 for consistency between the Euler rotations and Isochron data positions on two plates.

One of the merits on this study is that there are no limitations for types of data, time intervals, area, and types of visualization methods to visualize plate motions. We can also change vertical values of gravity anomaly or geoid data as a function of time for consistency of values of both sides of past spreading centers. This may be the most important part for future studies. Another thing we would like to emphasize is that these animations will be great materials for Earth science education.

Figure below is an example of reconstructed past positions of the South American plate relative to the African plate(45.6Ma, 83.5Ma).

All animations created in this study are downloadable at
http://kutty.og.u-tokai.ac.jp/~harada/

Keywords: Plate Motion, Visualization, Magnetic Anomaly, Gravity Anomaly, Reconstruction of plates



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Exploring submarine lava fields in the French Polynesian region

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The initial phases of a hotspot volcano and/or submarine tiny volcano must be complemented by sampling of present-day submarine volcanic activity. The large number of small and active volcanoes suggests that many volcanic systems are initiated prior to large or subaerial volcanoes at hotspots, which has been carried out at the Loihi Seamount of the Hawaiian chain (e.g. Moore et al., 1979), the Macdonald Seamount of the Austral chain (e.g. Johnson, 1970), the Adams Seamount of the Pitcairn chain (Devey et al., 2003), and on the Vailulu'u Seamount of the Samoan chain (e.g. Hart et al., 2000). Although the submarine samplings and their dating have often complicated the simple hotspot model, the distribution of submarine volcano is critical to recognize the hotspot and seamount chain. It is not only about hotspot, but unexpected submarine volcanoes, petit-spot volcanoes and arch lavas were newly found by the shipboard acoustic surveys off the NE Japan on the subducting Pacific Plate and at the flexural Hawaiian arch 300?500 km off the Hawaiian Islands, respectively (Hirano et al., 2006; Holcomb et al., 1988). The shipboard multibeam surveys, therefore, are necessary to find the submarine volcanisms and to know submarine portion around a volcanic island, expecting their future sampling.

The shipboard multibeam data for the French Polynesian region were obtained by two research cruises. The R/V Mirai cruise, MR08?06 Leg1, transited from south of the Tuamotsu Islands to the eastern Austral Islands in the southern Pacific Ocean by JAMSTEC (http://www.jamstec.go.jp/e/database/). The data near the Marquesas Islands, northern French Plynesia, from R/V Melville's PANR06MV and WEST13MV cruises, are supplied from the Geological Data Center, Scripps Institution of Oceanography (http://gdc.ucsd.edu/).

Some potential young volcanoes and lavas are newly found on the southern/eastern offshore of Marquesas hotspot, the north of western tip of Pukapuka Islands, and the southeastern offshore of Macdonald seamount. The sidescan imagery of some volcanic edifices shows high reflectivity because these young lavas are covered with only a thin layer of soft pelagic sediment, much thinner than the surrounding pelagic layer on the Pacific Plate. These data show more than three times as high as the reflective values of surrounding abyssal plain excluding the portions of steep slope (Hirano et al., 2008). Some of them do not build apparent edifices in spite of showing a high acoustic reflectivity, which the high reflective portion sparsely distribute to avoid the terraces and knolls. Some of volcanic clusters are found as young volcanic cones. Newly found potential young lavas might correspond to the portion above low velocity part of the shallow mantle (Suetsugu et al., 2009). Otherwise, they may be the submarine tiny volcano related to a stress field on the moving plate (i.e. petit-spot volcano) (Hirano et al., 2006). Understanding of volcanic distribution and future rock samplings will provide us the information about the stress field of the "hot" Pacific Plate on the plume, and the geochemical structure of Southern Pacific Superplume, awaiting future discovery.

Keywords: submarine volcano, polynesia, mantle plume, Pacific plate, petit-spot

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Experimental constraint on magma genesis for petit-spot in the northwestern Pacific: the first step

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A comprehensive investigation for petit-spot in the northwestern Pacific had been conducted using geological, petrological, electromagnetic, and seismological approaches. During the investigation, we faced some critical problems for petit-spot genesis as follows. (1) Although the ”plate flexure model” (Hirano et al., 2006, Science) is trying to explain the eruption mechanism by magma exuding where the Pacific plate flexes and fractures before subducting, it does not explain the melting mechanism. (2) Supposing that the ”plate flexure model” accompanying outer rise formation only constrains petit-spot genesis, volcanoes should be continuously distributed along with outer rise. However, distribution of the petit-spot in the northwestern Pacific, as an example, is limited to three regions, and is not continuous at least. This observation suggests that the restriction by melting mechanisms is the key to understanding the petit-spot genesis. (3) The ”small-scale recycled plate material melting model”, proposed on the basis of Sr, Nd, and Pb isotopic composition of lavas (Machida et al., 2009, GCA), is strong constraint on melting mechanism. However, the nature of source material is still not clarified, because the model is absolutely qualitative. Furthermore, (4) we could not detect heat anomaly, as well as melting region, by electromagnetic and seismological observations. In order to solve these problems, independent-determination of temperature and pressure for magma production on each volcanic edifice will be the breakthrough, thereby addressing construction of a comprehensive model for petit-spot genesis. We thus consider that multiple saturation experiment is the best way to determination of melting conditions. And, as the first target, we select a youngest knoll situated in flexed region of the northwestern Pacific plate.

We conducted melting experiments using 1/2-in.-diameter piston cylinder type high-temperature and high-pressure apparatus at Kyoto university. A starting material was prepared from mixture of oxide and carbonate reagents, representing the major element compositions of a primary magma equilibrated with Fo=90 olivine (obtained by the olivine maximum fractionation model) and including 10% CO_2 (estimated on the basis of vesicularity of lavas (Okumura and Hirano, in prep.)). All experiments were configured by complete melting of starting material under a target pressure and 1400^{o}C in graphite capsule within outer sealed platinum capsule for 2 hours, followed by equilibrating of melt and solid phases under a target temperature with constant pressure for 2 hours. As a result, the primary magma is saturated with olivine and orthopyroxene or clinepyroxene at 1280^{o}C and 2.1-2.2 GPa. Therefore, it is revealed that petit-spot magmas were equilibrated with depleted peridotite (harzburgite) at the lower part of lithosphere, in consideration of 82 km deep for lithosphere-asthenosphere boundary beneath WP2 (Kawakatsu et al., 2009, Science) in the northern Pacific.

Keywords: petit-spot, multiple saturation experiment

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SCG67-13 Room:106 Time:May 23 09:00-09:15

Development of an ultra-deep seafloor acoustic ranging system

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The 11 March 2011 Tohoku-Oki earthquake ruptured the interplate boundary off the eastern shore Honshu, generated a devastating tsunami that swept the coastal area along the northeastern Japan. The seafloor geodesy brought important results that show that the large slip was near the Japan Trench and suggested the heterogeneity of the coseismic slip distribution in the plate interface. The maximum displacement region for interplate earthquake is mainly located offshore region. Therefore it is important to monitor the postseismic displacement and the stress accumulation process using seafloor geodesy. And if we can observe the postseismic displacement near the Japan Trench, we contribute to understand the coupling condition of plate boundary. There is a seafloor acoustic ranging system for direct observation of horizontal displacement on seafloor. The system is designed to measure distances of up to 1-2 km with a precision of less than centimeter. We plan to use these instruments to make time-series distance measurements across the faults to detect and quantify seafloor crustal movements. But this system doesn't use the axis of Japan Trench because this system does not adapt a deep-sea area. Therefore we improve this system that adapted for the axis of Japan Trench. We carried out the experiment toward the observation of Japan Trench on Feb. 2013 using RV Kairei. We reported the results of this experiment.

Keywords: seafloor geodesy, acoustic ranging, Japan Trench

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Postseismic seafloor movements associated with the 2011 Tohoku Earthquake detected by GPS/acoustic geodetic observation

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The Hydrographic and Oceanographic Department, Japan Coast Guard, have been developing precise seafloor positioning systems using the GPS/acoustic combination technique and carrying out campaign observations along the major trenches in the Pacific Ocean, such as the Japan Trench and the Nankai Trough. For example, after the 2011 off the Pacific coast of Tohoku Earthquake (Mw = 9.0), we detected a huge coseismic displacement of 24 m toward ESE at the MYGI site. The geodetic observations along the Japan Trench continue in order to detect postseismic deformation.

As the results of observations (the latest results are in the end of 2012), the decreasing motions toward ESE have been detected at the CHOS site and the FUKU site, which seem to be caused by the after-slip of the earthquake.
On the other hand, the motions toward WNW have been detected at the MYGI site, the KAMS site and the KAMN site, and the motion toward S has been detected at the MYGW site. Especially, at the MYGI site where the largest coseismic displacement among JCG's sites had been detected, 22 cm displacement was detected during 30th August 2011 to 12th December 2012 (in this period, a notable aftershock had not occurred near the MYGI site).

Besides, using these crustal motion results on the seafloor and on the land, we have estimated the slip inversion model after the mainshock in the same method as in Yabuki and Matsu'ura (1992). The slip model shows that the slip in the seaward region is to be the landward slip in spite of the seaward slip in the other region.

In this presentation, we will report the newest results of the seafloor geodetic observation along the Japan Trench, and also will show the slip inversion model using the newest geodetic data.

Keywords: seafloor geodetic observation, the 2011 Tohoku Earthquake

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SCG67-15 Room:106 Time:May 23 09:30-09:45

Development of GPS/acoustic survey sites along Japan Trench and getting started on their first measurement

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After the occurrence of the devastating M9.0 earthquake, MEXT, Japan promoted the development of seafloor geodetic stations, such as cabled pressure gauge and seafloor transponders for GPS/acoustic survey in order to monitor the crustal movement associated with the earthquake. Our group of Tohoku University and Nagoya University have constructed up 20 GPS/acoustic stations. Each station consists of at least three and at most six transponders, which results in 86 transponders in total. Most of them were installed near trench over 4000m depth, where is found to play an important role on the occurrence of low-frequent giant earthquake.

Transponders were installed on September 2012, using chartered vessel, Shinkai-maru, Shin-Nihon-Kaiji and the first observation including initial positioning has started this and subsequent cruises, using Tubasa, Dokai-Marine on November. We employ shipboard transducer system rather than towing buoy system. For the noise-level, S/N ratio of replied acoustic signal from seafloor over the ship-noise is still in good condition even in thrusting mode for shallow survey sites (<3000m), but S/N ratio getting worse for deeper sites, in where we have to declutch and keep drifting. Improving the software algorithm to handle acoustic waveform will reduce this problem. For the survey style, these cruises were good opportunity to compare the stationary and moving survey styles, because we sufficiently took both types of data. We consider new analytical algorithm to integrate or involve any kind data is needed to efficiently use all the data taken in various opportunity of ship-time. In this talk, as well as technical report addressed above, the result of these initial observation and expectation of precision are presented by introducing an example data.

Keywords: Tohoku-oki Eq., Japan Trench, seafloor geodesy

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SCG67-16 Room:106 Time:May 23 09:45-10:00

Current status and future prospect of GPS/acoustic seafloor geodetic observation by Japan Coast Guard

Mariko Sato[1*], Naoto Ujihara[1], Shun-ichi Watanabe[1], Tadashi Ishikawa[2], Masayuki Fujita[1], Masashi Mochizuki[3], Akira Asada[3]

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We have been developing a system for precise seafloor geodetic positioning with the GPS/acoustic combination technique and deploying seafloor reference points on the landward slope of the major trenches around Japan, such as the Japan Trench and the Nankai Trough.

In March, 2008, we permanently installed an acoustic transducer on the hull of the middle-sized survey vessel ”Meiyo” and started sailing observations. This improvement enabled us to obtain more stable observation results. In addition, we have started the replacement of seafloor stations since 2009 to ensure the long-term observation.

For the 2011 Tohoku-oki earthquake, we have succeeded in detecting a huge co-seismic displacement of about 24 m toward ESE and about 3 m upward at the seafloor reference point just above the hypocenter. After that, we have been carrying out observations to monitor crustal movements above the focal region.

Furthermore, to monitor seafloor movement spatially in the focal regions of Tokai, Tonankai and Nankai earthquake, we deployed nine new seafloor reference points on the landward slope of the Nankai Trough in addition to the existing six points from off-Omaezaki to off-Muroto in January 2012. We have so far carried out campaign observations about three times at each site.

In the hardware aspect, subsequent to the S/V ”Meiyo” in March 2008, the S/V ”Takuyo” in December 2010 and the S/V ”Kaiyo” in February 2012, we installed observation equipment to the large-sized S/V ”Shoyo” in December 2012.

We plan to conduct campaign observations at the seafloor reference points along the Japan Trench to monitor the crustal movement after the 2011 event. In addition, we are also going to carry out campaign observations about three times at each new seafloor reference point along the Nankai Trough.

In this presentation, we report the current status and the future prospect of GPS/acoustic seafloor geodetic observation by Japan Coast Guard.

Keywords: seafloor geodetic observation, off Miyagi Prefecture, Nankai Trough

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SCG67-17 Room:106 Time:May 23 10:00-10:15

New buoy observation system for tsunami and crustal deformation for strong ocean current

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The off Tohoku earthquake did severe tsunami damage to coastal residents around the Tohoku region. In particular, Japan surrounded by subduction zones has high risk of the tsunami. The tsunami early warning system using a buoy has developed by many countries, which are US, German, Indonesia and Malaysia. These are similar system of the buoys named by DART system, which was developed by NOAA, and it is working in several seas. However, it is not useful under a condition of the strong ocean current. There are many ocean currents around Japan, and the most famous one is the Kuroshio with the maximum speed of over 5 knots. To realize the earliest report of tsunami, we have to observe them near trench axis with deep sea water and the strong ocean current. The most convenient tool is ocean bottom cables with pressure sensors like dense ocean floor network system for earthquake and tsunami (DONET). However, the cost is very expensive and it takes long time to complete the installation. Therefore, we developed new buoy system for the tsunami observation and detection of crustal deformation under the strong ocean current and adopted the TRITON buoy system developed by Japan Agency for Marine-Earth Science and Technology (JAMSTEC) using slack mooring. Pressure data collected on the seafloor is sent to the buoy using acoustic transmission. Tuning of directivity and sound pressure level of transponders used for the transmission is needed for the observation point due to the slack mooring. In addition, we decided to use time difference of the double pulses to express the observed pressure value to save battery, and the transducer to hear the acoustic signals from the seafloor was set on the end of 1000 m-wire rope to minimize error of the data transmission brought by strong heterogeneity of the shallow water structure. We observe water pressure with a sampling interval of 15 seconds and the collected data is sent to the buoy with an interval of one minute in normal mode or 15 seconds in tsunami mode. At the seafloor, not only pressure sensor but six transponders to detect crustal deformation were deployed. We installed four antennas on the buoy to determine attitude of the buoy precisely and estimates the position of transducer on the buoy to communicate with seafloor transponders. The distance between the buoy and six transponders is measured with an interval of one week. The collected data of tsunami and distance between buoy and the transponders are transmitted to our land station via iridium satellite transmission. And a test satellite 'KIKU No.8' is also used for the data transmission to it in realtime to keep the redundancy. In addition, we have a plan to observe of sea surface height in realtime using a quasi-zenith satellite 'Michibiki'. The observation using a technique of a precise point positioning (PPP) estimates the position with an accuracy of approximately 10 cm. Now we are in a stage of sea trial in the rupture area of the Tonankai earthquake with a magnitude of 8. Because we selected a location near the trough axis with a depth of approximately 3000 m and it is expected future large crustal deformation. We introduce the specification of the new buoy system, report a preliminary result of the sea trial and future issues to be fixed and resolved.

Keywords: tsunami, crustal deformation, observation buoy, realtime data transmission

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SCG67-18 Room:106 Time:May 23 10:15-10:30

The first observation of a newly developed underwater gravimeter by using autonomous underwater vehicle

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We developed an underwater gravimeter for exploration of a seafloor hydrothermal deposit. Our hybrid gravimeter system consists of an underwater gravimeter and an underwater gravity gradiometer, and we present the system of the underwater gravimeter and first observation by using autonomous underwater vehicle. Gravity survey is one of powerful method to obtain density structure in crust. In marine area, surface ship gravimeter and ocean bottom gravimeters are often used. For survey of a seafloor hydrothermal deposit, they are required to survey a wide area quickly and to have a higher resolution than that obtained by the surface survey. On the other hand, because technology of autonomous underwater vehicle (AUV) is been developing, there is a possibility to measure the gravity by using AUV's.

To obtain a position and amount of seafloor hydrothermal deposit that has a diamond shape with a diameter of 400m, 20m thick at the center and density difference of 1 g/cm3, a resolution of gravity measurement should be less than 0.1 mgal. In addition, measurement must be carried out 50m above a seafloor. AUV is suitable for such measurement near seafloor.

We adopted Micro-g LaCoste S-174 as a gravity sensor. The sensor is mounted on a gimbal mechanism with a fiber gyroscope (IXSEA PHINS). A titanium sphere contains the sensor system. For acquisition of high resolution gravity data, the gravity sensor must keep a constant temperature (60.4C) and avoid effect of magnetism. The sensor is heated and is totally covered with thermal insulation and sheet of permalloy. Maximum depth rating is 4,200 m. The data are sent to a recording system housed in another cylinder-shape capsule. The whole system is controlled and monitored via acoustic link of the AUV. During test measurement on land, the resolution was estimated to be 0.02 mgal after compensation of tilt, acceleration and low-pass filtering.

In September 2012, the first practical measurement in marine area was carried out by using JAMSTEC's AUV Urashima to evaluate performance of the system. The gravimeter and gravity gradiometer were simultaneously mounted on the Urashima. The first measurement was performed in Sagami-Bay. One profile was laid on smooth seafloor and another has rough seafloor topography. From these surveys, we obtained the gravity data and supplemental data for compensation of the gravity data with good quality. From preliminary analyses, the resolution of the gravity data from the first practical measurement is estimated to reach 0.1 mgal.

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SCG67-P01 Room:Convention Hall Time:May 22 18:15-19:30

Acoustically transparent deposits possibly originated from 7300 BP Kikai Koya PDC

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Kikai caldera (Matsumoto, 1943) is a mostly submerged highly active caldera complex located in 40 km off Kyushu Island. The caldera is considered to be the source of Akahoya tephra (Machida and Arai, 1978) which date was determined as 7300 cal. BP (Fukusawa, 1995). The climactic ignimbrite of the eruption was Koya-Takeshima PDC (pyroclastic density current), which extent was reached the deep inland of Kyushu (Ono et al., 1982). Recent work by Maeno and Taniguchi (2007) provided much detailed insights for the escalating evolution of magma-water interaction in the eruption, however present mostly subaqueous setting prevents further understanding of its geographical distribution and morphology. Here we report with the observation of seismic reflection, relatively thick (100˜ m) and acoustically transparent layer that can be compared to Koya-Takeshima PDC because of its substantiality.

The seismic reflection observations were held in two survey cruises (KT-10-18 and KT-11-11) in 2010 and 2011 using a research vessel Tansei-maru of JAMSTEC (Japan Agency for Marine-Earth Science and Technology). The sound source was a 150 cubic inches G-I gun with 10 seconds of shot interval, and a 48-channled 1.2 km-length streamer cable was used for acquisition. Totally 24 profiles were obtained with the speed of 4 knots.

The caldera has 20 km wide rim and 10 km wide inner ring fracture. They were previously speculated as two different calderas of outer-older one and inner-newer one (e.g. Yokoyama et al., 1966), however it is unlikely according to our interpretation because both of their structure is fresh. At the southeastern end of the caldera, the rim is appeared as a major fault for caldera basin subsidence, which the latest displacement can be expected for 400 m in maximum. The inner fracture is the deepest structure in the caldera (˜600 m), which is characterized as poorly deposited subcircular valleys surrounding the central rise of the caldera.

The distinctive transparent layer is named A3 in our interpretation. We assume that because of its wide distribution (most areas in Kikai except the central rise) and voluminosity (40˜ cubic km), A3 is the submarine counterpart of the climactic Koya-Takeshima PDC. The morphology of A3 is highly constrained by its bottom uncomformitive terrain therefore A3 is possibly some kind of flow deposits at least. It shows the maximum thickness at the southwestern caldera rim (˜150 m) while it quickly loses its transparency and turned into chaotic facies at the caldera outskirts. The chaotic counterpart extends every direction from Kikai caldera with the constant thickness of about 100 m. Absence of A3 equivalent facies at the central peaks of the caldera supposes the area was a topographical high at the A3 outbreak.

Keywords: Kikai caldera, Seismic reflection observation, Submarine volcano, Marine geology, Caldera formation

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SCG67-P02 Room:Convention Hall Time:May 22 18:15-19:30

Geochemical variation of backarc basin basalts and magma genesis in the Shikoku Basin

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The Shikoku Basin is a back arc basin located Westside of the Izu-Ogasawara (Bonin) arc, spreading was from 25Ma to 15Ma (Okino et al., 1994, 1999). The drilling of the Deep Sea Drilling Project (DSDP), Ocean Drilling Program (ODP) and Integrated Ocean Drilling Program (IODP) recovered the backarc basin basalt (BABB) of the Shikoku Basin. Sites 442, 443 and 444, located at the central Shikoku Basin, was operated during the DSDP Leg58 and recovered BABB and post-spreading volcanism basalts. Site 808, southeast of the Kyushu Island, was operated during the ODP Legs 131 and 196. Site C0012, south of the Kii Peninsula, was operated during the IODP Leg ex-333. Sites 808 and C0012 is located near the Nankai Trough, and BABB was recovered from under thick sediment. In this study, we compare Petrographical and geochemical characteristics of these BABBs, arc volcanics of the Kyushu-Palau Ridge and those of Izu-Ogasawara active arc, and consider the origin of difference of these characteristics and environment of BABB volcanism.

The example of the Shikoku Basin BABB, the Site C0012 BABB was recovered under the more than 500m thickness of sediment and drilled 100m thickness of basement. These BABB are aphyric pillow (upper) and massive flow (lower part), and show variable degree of alteration, gel-paragonite, fibro-paragonite to zeolite deposition. SiO_2 and MgO contents of these basalts are 47-55 and 5-8 wt%. The many basalts have 1.5-1.8 wt% of TiO_2, higher than island arc volcanics from the recent Izu arc and the Kyushu-Palau Ridge. These basalts show enrichment of alkali elements. The Alkali basalts are recovered from the Site 444 and the Kinan Seamount chain near the spreading axis of the Shikoku Basin. However, the element ratios associated with enrichment of parent material of these basalts are different from these alkali basalts, similar to BABB from the Sites 442-444. We considered that the enrichment of alkali element in these basalts is the effect of albitization and paragonitization. The enrichments of Na and K are different strata, assumed to different alteration temperature; Na and K were enriched under higher and lower temperature.

Ishizuka et al. (2011) and Haraguchi et al. (2012) pointed out that the across-arc variation of bulk chemical characteristics of arc volcanics in the Izu arc is described by replacement of mantle under the Izu arc from depleted to enriched composition at the beginning of spreading of the Shikoku Basin. The BABB in the Shikoku Basin is assumed to produce from this enriched mantle. However, the element ratios associated with mantle enrichment show regional differences. Therefore, we consider that the mantle enrichment in the Shikoku Basin show regional differences.

Keywords: Backarc basin basalts, Incompatible element ratio, Parent material of magma

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SCG67-P03 Room:Convention Hall Time:May 22 18:15-19:30

New GANSEKI: Major System Revision and Improved Usability

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[1]JAMSTEC

Every year, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) collects hundreds of rock samples from deep seafloor using its research vessels and submersibles. Deep seafloor is one of the fields which are not easily accessible for individual researchers. Seafloor rock samples are precious materials because they are rare, costly, and technically difficult to obtain. Recent researches related to seafloor mineral resource exploring and its industrial development attract broad public attention. People from various fields other than natural history sciences are getting interested in seafloor rock samples.

For the better use of JAMSTEC rock samples and associated data, it is important that they are utilized for not only specific research plans of individual cruses but also other general scientific and educational purposes. JAMSTEC has been maintaining rock sample collection and associated databases, and publicizing them to domestic/foreign activities of research, education, and public relation. Users can access these rock samples and associated data through the rock sample database ”GANSEKI [1]”. GANSEKI was established on the Internet in 2006 and its contents and functions have been continuously enriched and upgraded since then.

JAMSTEC also maintains various samples and data other than rock samples, including such as sediment core samples, biological samples, cruise and dive information, visual images and movies. Close relationship among these databases is important for better usability and wider application. In 2012, the whole cruise information database ”DARWIN [2]” was released on the Internet, replacing the previous data site for research cruises. The major revision of GANSEKI in 2013 was planed to deal with the various improvements in JAMSTEC data management.

The previous GANSEKI already had functions to exhibit meta-data of sample recovery, inventory data of rock sample collection and associated data such as geochemical data and photo images. Samples in the previous GANSEKI were also searchable from the international geochemical portal site ”EarthChem [3]”. In spite of these advantages, there were some points to be improved in the previous GANSEKI, such as absence of linkage to cruise and dive information databases, inflexibility of available geochemistry data types, and awkward procedures for image browsing. The major revision of GANSEKI includes replacement of database core system. The newly designed interface provides much improved searchability and visibility for both users and curatorial staffs. Multiple references to other databases such as DARWIN, numerical search of geochemical data, and thumbnail browsing of thin-section images and sample photos are comfortably available in the new GANSEKI.

References: [1] ”GANSEKI (Geochemistry and Archives of Ocean Floor Rocks on Networks for Solid Earth Knowledge Information)” http://www.godac.jamstec.go.jp/ganseki/. [2] ”DARWIN (Data Research System for Whole Cruise Information in JAMSTEC)” http://www.godac.jamstec.go.jp/darwin/e. [3] ”EarthChem” http://www.earthchem.org/.

Keywords: rock sample, curation, database, seafloor

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Development of observation method for seafloor hydrothermal flow based on acoustic image

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We have been developing a method of observation for seafloor hydrothermal flow. The system is based on acoustic video camera 'DIDON'. DIDSON (Dual-Frequency IDentification SONar) is acoustic lens-based sonar. It has sufficiently high resolution and rapid refresh rate that it can substitute for optical system in turbid or dark water where optical systems fail.

DIDSON equipped on the submersible Shinkai6500 could capture sliced images of the seafloor hydrothermal flows at the Rodriguez segment of the Central Indian ridge, in YK09-13 Leg.1 cruise. We could identify shadings inside the acoustic movie images of the hydrothermal flows. Silhouettes of the hydrothermal flows varied from second to second, and the shadings inside them also varied. These variations were thought to be corresponded to internal structures and flows of the plumes. These are only a few acoustic video images of the hydrothermal plumes. Results from this observation show that DIDSON has a potential of equipment for hydrothermal flow observation.

We performed a tank experiment so that we will have acoustic images of water flow under the control of flow rate. The purposes of the tank experiment were to delineate water flow images in the tank and to get clue to estimate the volume of the water flow.

Water was heated in the hot tub and pumped to the water tank through the silicon tube. We observed water flows discharging from the tip of the tube with DIDSON. Flow rate had been controlled and temperatures of the discharging water and background water had been measured. The proposed method to observe and measure hydrothermal flow is the one to utilize a sheet-like acoustic beam. Scanning with concentrated acoustic beam gives distances to the edges of the hydrothermal flows. And then, the shapes of the flows can be identified even in low and zero visibility conditions.

Preliminary result of the tank experiment showed that 3D images of water flows in the tank could be reconstructed with the proposed method. We have been trying to estimate the volumes of water flows based on the reconstructed images, on the assumption that the water flows were in a constant state of movement.

We will report the overview of the tank experiment and proposed observation method in this presentation.

Keywords: seafloor hydrothermal flow, acoustic video camera

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Availability to the ocean floor geoscience of the deep-sea videos

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The deep-sea videos are important to assess geological, topographical, temporal variation in deep-sea environments and to understand the diversity of deep-sea organisms and their ecology. For example, video observations are essential to elucidate behavior of deep-sea animals, and the georeferences can be used to construct distribution maps of those organism as shown on the marine biodiversity database of JAMSTEC, Biological information system for marine life (BISMaL).

In Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is holding a vast amount of deep-sea videos taken by manned/unmanned submersibles. The videos are given annotation (ex. living organism, geological phenomena and topographical characteristic) and opened to public via the Internet. We are holding the optimization of quality with the trend and introduce Panorama technique using the deep-sea videos. We are aiming at utility value of the deep-sea videos.

In this presentation, we introduce our works and discuss about availability to the ocean floor geoscience of the deep-sea videos.

Keywords: deep-sea video, research data, utilization promotion

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SCG67-P06 Room:Convention Hall Time:May 22 18:15-19:30

The three-dimensional conductivity structure beneath the Philippine Sea and the western Pacific Ocean

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The electrical conductivity of the upper mantle beneath the Philippine Sea and the western edge of the Pacific Ocean was imaged in three-dimension (3-D) for the first time from marine magnetotelluric (MT) data.

We performed 3-D inversion analysis for the MT responses at 25 sites, which were obtained by a previous study (Baba et al., 2010) as a part of the Stagnant Slab Project (Shiobara et al., 2009). 21 sites of all sites were located on the Philippine Sea plate, while 4 sites were on the Pacific plate. The inversion scheme that we applied in this study was newly developed for this study to treat the effect for both regional large-scale and local small-scale topographic changes on MT responses (Tata et al., 2012; Baba et al., submitted) because the bathymetry and land/ocean distribution are known to significantly affect seafloor MT responses because of high contrast in the conductivity between seawater and crustal rocks..

The area imaged in this study is more than 3,000 x 3,000 square kilometers. The resolution of the electrical conductivity structure is at least 500 km x 500 km. This is small enough to discuss differences or similarities among basins in the Philippine Sea plate. And also we can discuss differences/similarities between the Philippine Sea mantle and the Pacific mantle from the electrical conductivity structure.

The best electrical conductivity model shows four features. (1) The conductivity of the Philippine Sea mantle is higher than that of Pacific mantle for the depths shallower than 200 km, and become almost equal to that of Pacific mantle in deeper parts, suggesting thinner young Philippine Sea Plate and thicker old Pacific Plate. (2) A conductive anomaly is located below 125 km depth beneath the Sikoku and Parece-Vera Basins. (3) A resistive anomaly is located at shallower than 40 km depth beneath the Daito and Oki Daito ridges. It might reflect complex tectonic history such as paleo Daito Ridge island arc-trench system (Tokuyama, 1995). (4) A resistive anomaly is located at shallower than 240 km at the northern part of the Shikoku Basin, which indicates the subducted Pacific Plate.

The next step will combine our result with other parameters such as seismic velocity structures in order to understand an evolution of the Philippine Sea plate in detail.

Keywords: 3-D conductivity structure, Philippine Sea, Marine MT method, Inversion

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Origin of the petit-spot melt suggested from electrical conductivity structure

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Petit-spot is young volcanic activity on very old (about 130 Ma) oceanic plate characterized as a clump of small knolls which erupted strong to moderate alkaline basalt. This volcanic field is associated with neither any plate boundaries nor hot spots. To elucidate the magma generation process of this new-type volcanic activity, marine magnetotelluric (MT) surveys were carried out using ocean bottom electromagnetometers (OBEMs) in May - August, 2005 and in May, 2007 - August, 2008. Total nine OBEMs were deployed and seven of those were successfully recovered with good quality data. We compiled data at two other sites collected in July, 2003 - November, 2004 and analyzed the nine sites data in total in this study. We first estimated a one-dimensional (1-D) electrical conductivity structure model which explains the data of all sites averagely correcting topographic effect on the observed MT responses. Then, we carried out 3-D inversion analysis using the 1-D model as the initial and prior model. The 3-D inversion program that we used is WSINV3DMT (Siripunvaraporn et al., 2005) but modified for seafloor MT data by Tada et al. (2012).

The obtained 3-D model shows two distinct features. 1) The lithospheric mantle beneath the petit-spot field at 37.5N, 149.8E (Yukawa Knolls) is relatively more conductive than surrounding area. The conductivity is about 0.003 S/m at about 70 km depth. This feature is depicted as thinned resistive layer in the vertical section. 2) High conductivity (~0.1 S/m) layer at around 200 km depth is not isolated beneath the petit-spot field but rather distribute widely beneath the survey area except for the area to the northwestern area of the Yukawa Knolls. Checker board inversion and forward modeling tests support that these features are reasonably resolved by the data.

The electrical conductivity can be converted into temperature or melt fraction under some assumptions, using results of conductivity measurement of minerals in laboratories. We take the partition of H_2O and CO_2 in minerals and melt and the condition of partial melting into account for the conversion based on Hirschmann (2010). Then, the electrical conductivity at 200 km depth can be explained by small fraction (0.004-0.033%) of hydrous silicate melt but the temperature is unrealistically high (1600-1700 C) but explained by 0.25% of carbonated melt on realistic temperature (1400 C) above the solidus of peridotite including H_2O and CO_2. The sampled petit-spot lavas are very vesicular, indicating that significant amount of H_2O and CO_2 were dissolved in the incipient melt. From the above discussion, we speculate that the asthenospheric mantle is partially molten and the melt is extracted to the lithosphere (and partly to the seafloor) by the petit-spot activity.

Keywords: petit-spot, northwestern Pacific, electrical conductivity, ocean bottom electromagnetometer, magnetotellurics

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Using STCM data, relationship between spreading rate and magnetic boundary strike in mid ocean ridge

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Previous study using STCM data which were obtained Icebreaker SHIRASE and R/V MIRAI at 2003 and 2004 have suggested the results about spreading rate and stability of spreading in the Southeast Indian Ridge(SEIR) classified intermediate spreading ridge.

The results shows that the standard deviation of the MBS (Magnetic Boundary Strike) calculated from ISDV (Intensity of the Differential Vectors) is the low in 90E area characterized East Pacific Rise(EPR) type axial high, and the high in the 110E area showed the feature of Mid Atlantic Ridge(MAR) type axial valley at JpGU2012 meeting.

In this study, the standard deviation of MBS and half spreading rate were analyzed STCM data obtained by R/V MIRAI in East Pacific Rise of fast spreading ridge and Mid Atlantic Ridge classified slow spreading ridge.

The results were standard deviation of MBS is low and half spreading rate is stable in east of MAR, whereas standard deviation of MBS is the high and half spreading rate is unstable in west of MAR. Although, standard deviation of MBS is the low in west and the high in east of EPR, half spreading rate is variability in both areas. Therefore, there was no clear relationship about stable of MBS and half spreading rate. Moreover, the results in this study were different topographic compared to previous study in SEIR.

Keywords: Mid ocean ridge, Magnetic anomaly

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Active topographic features on the oceanward plate of the Japan Trench near the hypocenter region of the 2011 Tohoku Ear

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The trench-outer rise earthquake near the Japan Trench occurred after the 2011 Tohoku Earthquake. Several studies pointed out high occurrence probability of trench-outer rise earthquake after the 2011 Tohoku Earthquake in near future. Trench-outer rise earthquakes occur by reactivation or creation of normal faults caused as the oceanic lithosphere approaches a subduction zone and bends into the deep-sea trench. Bending-related faults in the oceanward trench slope are ubiquitous structures of oceanic plates incoming to trenches. In general, the faults are formed parallel or subparallel to the bending axis of the incoming plate, namely the trench axis. Oceanward slopes of several trenches have bending-related structure with a strike different from the trench axes (e.g. Kobayashi et al., 1998). In these areas, abyssal hill fabric was reactivated instead of the creation of new faulting parallel to the trench axis.

The Cretaceous Pacific Plate (132-138 Ma) is subducting along the Japan Trench (Nakanishi et al. 1992). The strike of the Japan Trench changes at around 38N from about N08E in the northern part to N30 E in the southern part. The outer swell of the Japan Trench is slightly less clear compared to that of the Kuril Trench. Its crest is deeper than 5,200 m and situated about 80 km east of the Japan Trench axis. The outer swell is distinctly identified north of 37N in the Japan Trench, north of the Joban Seamounts. The outer swell is obscure around the Joban Seamounts.

The bathymetric map around the Japan Trench by Nakanishi (2011) demonstrated that most of bending-related topographic structures exist in the oceanward trench slopes deeper than 5600 m. The map also revealed that bending-related topographic structures are developed parallel to the trench axis or inherited oceanic spreading fabric. Most of bending-related topographic structures in the northern segment of the Japan Trench are subparallel to the trench axis. The bending-related topographic structures are confined to areas less than 80 km away from the trench axis. Topographic expressions of these north of 39 40N are a half graben, an asymmetric graben and ridges, which is similar to that of the western Kuril Trench. The height of bending-related topographic structures does not show any gradual trenchward increase. Some of bending-related topographic structures north of 40 N have the same strike as those of Kuril Trench. In the middle region of the northern segment between 38 50N and 39 40N, bending-related escarpments form symmetric grabens subparallel to the trench axis Gradual growing of the bending-related topographic structures is observed in this area. Trench-subparallel escarpments decrease in relief southward and a dominant set of escarpments become roughly parallel to the seafloor spreading fabrics striking at large angles to the trench axis. Between 38 N and 39 15N, several elongated escarpments have a strike perpendicular to seafloor spreading fabrics.

The sidescan images exposes numerous knolls, petit-spot volcanoes, on the Pacific Plate around 38N (Hirano et al., 2008). The knolls are covered with thin or no pelagic sediments, implying that they were formed by recent volcanism, not related with any plate boundaries.

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Keywords: bending-related topographic features, petit-spot volcanoes, trench-outer rise earthquake, oceanic spreading fabric, Japan Trench

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Seafloor mapping of the 1998 Papua New Guinea earthquake and tsunami source area

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The 1998 Papua New Guinea earthquake and tsunami occurred on 17 July 1998 off the northern coast of the New Guinea Island. The maximum wave eight of 15m was recorded near Sissano Lagoon near the town of Aitape. After the hazardous tsunami JAMSTEC dispatched DOLPHIN-3K (ROV) and SHINKAI2000 (manned submersible) in 1999 and 2001 and total 13 dives were carried out to figure out the large-scale slump in the source area. Since an over-all seafloor geological route map of the source area has not been made so far, the author compiled all the visual observation through all the 13 dives together with other results of the offshore geophysical survey and made the final version of the seafloor geological survey route map. The result shows that a slump which might generate the hazardous tsunami is located 10km off the northern coast along the amphitheatre. The total volume of the collapsed area at the slump is estimated to be about 5.4km3.

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Study for observation and analysis method in urgent seafloor geodetic observation

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Japan Hydrographic and Oceanographic Department (JHOD) and the Institute of Industrial Science, University of Tokyo, have been developing a system for precise seafloor geodetic observation with the GPS/Acoustic combination technique and carrying out campaign observations on the landward slope of the major trenches around Japan, such as the Japan Trench and the Nankai Trough.

When a large earthquake occurs near a seafloor reference point, JHOD has carried out seafloor geodetic observations urgently and reported seafloor movements to the Headquarters for Earthquake Research Promotion of Japan as soon as possible. However, it is sometimes difficult to secure sufficient observation time because the survey vessels of Japan Coast Guard have to do other works for the disaster response. Therefore, to make the most of every opportunity, we have to know the observation precision for a shorter observation time. In addition, it is desirable to analyze observation data and obtain preliminary results onboard although in present, we analyze observation data after the survey ship comes back because on-land GPS data is required in KGPS analysis.

In this presentation, we report the way of urgent observation and analysis to report preliminary result as soon as possible, in case that a large earthquake occurs near a seafloor reference point in the future.

Keywords: Seafloor geodetic observation

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Development of a new method for GPS/Acoustic seafloor observation using multi-buoy system

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We are developing a method for observation of seafloor crustal deformation using kinematic GPS and acoustic ranging system. The system measures seafloor crustal deformation by determining position of benchmarks on the seafloor using a vessel which link-up GPS and acoustic signals. Acoustic ranging is used to measure distance between the vessel and seafloor benchmarks. And kinematic GPS is used to locate the moving vessel every 0.2 seconds. Now we have deployed 4 seafloor benchmark units at Suruga Bay and 4 units at Kumano Basin. At each survey site, three seafloor transponders are settled to define a benchmark unit. In this system, each measurement takes about ten hours and both sound speed structure and the benchmark unit positions were determined simultaneously for the each measurement using a tomographic technique. This tomographic technique was adopted on assumption that the sound speed structure is horizontally layered and changes only in time, not in space. However, when sound speed structure has a heterogenity, the assumption of a horizontally layer causes error in the determination of seafloor benchmarks. So we are developing a new system using multi-buoy. In this system, multi-buoy plays role of vessel. Doing observation by the buoys, we can estimate spatial variation of sound speed structures every moment. In November 2012, first observation of seafloor crustal deformation using the buoys was held in Suruga Bay. In this study, we estimate a spatial variation of sound speed structures and, at the same time, defined some problems in this system. From checking of the waveform data, we found that there are differences in the yield of data. These differences are caused by the observation system itself. We estimate that when the difference of acoustic path is less than 413m, the buoys do not make a record of the waveform data. We estimated a spatial variation of sound speed structures by evaluating residuals of one-way travel-time between the buoys and the seafloor benchmarks. As a result, we found large scale (between the different buoys) spatial variation of sound speed structure. But small scale (between the same buoys) spatial variation was not detected. To estimate a small scale spatial variation, attitude of the buoys should be monitored by motion sensors like gyrocompass. From approximate calculation, it is predicted that traveltime errors of 0.16ms at maximum can be removed by introduction of a good motion sensor.

Keywords: seafloor crustal deformation, moored buoy, GPS/Acoustic, sound velocity, spatio-temporal variation

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Gamma-ray fluctuation observed on deep seafloor off Hatsushima Island in Sagami Bay after the 2011 Tohoku Earthquake

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Long-term gamma-ray observation with NaI(Tl) detector attached to the cabled observatory on deep seafloor at a depth of 1175 m off Hatsushima Island in Sagami Bay has been carried out since 2000. It has multi-channel (256 ch) pulse height analyzer and energy spectra of gamma-ray can be obtained.

Temporal fluctuation of net area of each peak in the energy spectra, which corresponds to radiation dose rate, of Bi-214 (U series), K-40 and Tl-208 (Th series) between January 2010 and December 2012 was studied this time. Although each peak shifts to lower channel as time passes because of the aging of the equipment, in order to prevent discontinuity, ROI (Range of Interest) for each peak was set constant and spectra were averaged for one day. Because of the trouble at the shore station caused by typhoon, the observation stopped from 21st September to 5th October in 2011.

Just after the off the Pacific coast of Tohoku Earthquake on March 11th in 2011, sudden increase of radiation does rate of Bi-214 occurred. It continued to increase until April in 2011. It began to decrease gradually in January until June in 2012. On the other hand, the fluctuations of those of Tl-208 and K-40 are not so significant except sudden decrease in February in 2012 which is probably caused by the work of ROV (Remotely Operated Vehicle) on seafloor near the observatory. The temporal fluctuation of Bi-214 might reflect crustal deformation, however, because of poor resolution in energy spectra, the Bi-214 peak might contain the dose rate of Cs-137 associated with atomic power plant accident to some extent. More detailed analysis would be necessary.

Keywords: Gamma-ray observation, deep seafloor off Hatsushima Island in Sagami Bay, Off the Pacific Coast of Tohoku Earthquake in 2011

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The phase velocity and arrival direction of infragravity waves observed by DONET

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The Infragravity wave (IG wave) creates periodic, horizontally propagating pressure fields at the deep seafloor. The displacement to pressure transfer function, called as the compliance, provides information about elastic wave velocity of ocean crust (Crawford et al., 1991). We have tried to detect the IG wave from DONET data and to measure the compliance continuously which aims to monitor the stress and the distortion beneath the Nankai Trough. In this study, we report the phase velocity and arrival direction of IG wave detected from DONET data.

We use the data of vertical component of broadband seismometer and those of quartz pressure gauge recorded from January, 2011 to December, 2012. The IG waves are detected by a slant stack method. We stack the waveforms in a frequency domain between 0.005 and 0.025 Hz. The slowness and direction which give the maximum rms amplitude, are considered as the phase velocity and arrival direction of IG wave.

Since the phase velocity of IG wave changes with water depth, the phase velocity with same wavelength changes at the depths of 2000 and 4000 m. We use the data observed at the stations which are installed at about 2000 m depth. Although the estimated phase velocity and arrival direction are unstable till Octorber, 2011, the stable results are shown after that. The 57% and 48% of results show the phase velocity of 123-127 m/s and arrival direction of 140 -160 deg from the north, respectively.

Although the origin of IG wave with stable arrival direction of 140-160 deg is one of the future subjects, we assume that the IG wave always comes from southeast with phase velocity of 125 m/s to the stations installed at about 2000 m depth. This stable IG wave would be detected by the stacked waveforms for a station or an array of 4 stations connected to each node and would provide us the localized compliance.

Keywords: Infragravity wave, DONET, compliance

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Bouguer gravity anomaly of Japan's adjacent seas

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The Japan Coast Guard (JCG) conducted bathymetric, marine gravity and magnetic, and seismic surveys for Continental Shelf Survey Project between 1983-2008. The survey area extends over 350 nautical miles from the coastline in the southern region of Japan. Since the project has been settled temporarily, we can now report the precise Bouguer gravity anomaly map of Japan's adjacent seas which has been newly compiled based on these survey results.

The drift correction, Eotvos correction and the up-to-date normal gravity formula were applied to the raw gravity data then the freeair gravity anomaly was obtained. Atmospheric correction was not applied. The gravity grid data was made in 1 km mesh. Bouguer gravity anomaly was calculated by applying a terrain correction under the assumption that the average density of oceanic crust was 2.67 g/cm3. For the terrain correction, the square pillar model of topography griddized 1 km x 1 km was made and the gravity effect of the model within 40 km radius was calculated by using half-infinite integral.

A topography model was made by using mainly bathymetric data which was collected by multibeam echo sounder on JCG's Continental Shelf Survey Project. Blank areas with no bathymetric data were complemented with ETOPO1. The effect of sediment layers was not entered into calculations. The new Bouguer gravity anomaly map took more exact terrain correction into account and covered wider areas; the southern part of Kyushu-Palau ridge, the surrounding of Minami-torishima island, the northern part of Izu-Ogasawara ridge, the surrounding of Amami Plateau, etc. compared to the previous map (Oikawa and Kaneda, 2007).

Seismic structure of oceanic crust such as its thickness is obtained by seismic survey and gives information on its creation process. However, it is not a practical way to conduct seismic surveys in all regions. The thickness of oceanic crust is generally one of the key factors in Bouguer gravity anomaly, and Bouguer gravity anomaly tends to increase when the thickness of oceanic crust gets thinner, if the density structure below the mantle is assumed to be constant. According to this relationship, it might be possible to estimate the thickness of oceanic crust for sea areas where seismic surveys have not been conducted. Therefore, we have reported the regional relationship between the thickness of oceanic crust and Bouguer gravity anomaly. We set conditions to choose areas: The effect of sediment layers is small and its structure is comparatively homogeneous, in order to make it easy to compare the relationships. As a result, the comparison was conducted in the areas constituted of oceanic crust.

The thickness of oceanic crust was extracted from the velocity structure model resulted from analysis of seismic refraction survey at sea areas where lineation of geomagnetism was observed. Sea areas were divided into three groups whose formation process of oceanic crust were different in order to compare them; the areas of Shikoku Basin and western part of Parece Vela Basin, the area of northern and eastern parts of West-Philippine basin, and the area of Minami torishima island's adjacent seas. Then datasets of the thickness of oceanic crust with Bouguer gravity anomaly were plotted. Each thickness of oceanic crust with Bouguer gravity anomaly shows the regional characteristic.

In the areas of Shikoku Basin and western part of Parece Vela Basin, the thickness of oceanic crust tends to decrease depending on the increase in Bouguer gravity anomaly. In the area of Minami torishima island's adjacent seas, on the other hand, Bouguer gravity anomaly changes between 340-440 mGal regardless of the thickness of oceanic crust is almost constant.

Keywords: Bouguer gravity anomaly

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Characteristics of Hf isotopic composition of basalts from northwestern part of the West Philippine Basin

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We report Hf isotope data of basalts from the West Philippine Basin (WPB). In the western part of WPB near to the Ryukyu trench, the Okinawa-Luzon Fracture Zone (OLFZ) exists, extending in the NE-SW direction. Shirahashi (2007, master's thesis of Univ. Ryukyus) reported that basaltic basement rock around the OLFZ have Sr-Nd-Pb isotopic composition similar to those of the isotopic Indian Ocean MORBs. In this study we analyzed the Hf isotope ratio of the same samples reported by Shirahashi (2007). All samples plot within the range of the Indian Ocean MORBs in eHf - eNd diagram, suggesting that they have Hf isotopic characteristic of the Indian Ocean MORB type. In addition, it has been suggested that Hf isotope ratios of other (and younger) back arc basin basalts in the Philippine Sea plate show Indian Ocean MORB type. This suggests that asthenosphere with the isotopic characteristic of Indian Ocean MORB type has involved since early stage of the the formation of the Philippine Sea plate.

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Nd and Hf isotopic compositions of the Oman ophiolite extrusive rocks

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The peri-Arabian ophiolite belt, from Cyprus in the west, eastward through Northwest Syria, Southeast Turkey, Northeast Iraq, Southwest Iran, and into Oman, marks a 3000 km-long convergent margin that formed during a Late Cretaceous (ca 100 Ma) episode of subduction initiation on the north side of Neotethys. The Oman ophiolite is the largest and best exposed ophiolite in the world that preserves the original structure of oceanic lithosphere formed at the Neotethys ridge system with fast spreading rate. The volcanic sequence in the Oman ophiolite are divided into three units from lower to upper: V1 (Geotimes Unit), V2 (Alley Unit) and V3 (Salahi Unit). There is a debate on the lava stratigraphy for the Lasail Unit.

This study reports new data on Hf?Nd isotope systematics for volcanic rocks from northern Oman ophiolite. On the trace element compositions, samples can be devided into three types; N-MORB type, ultra-depleted type, and U-shaped type. These broadly corresponds to V1, V2 and boninite, respectively. In a eHf(t) vs eNd(t) plot, all Oman lavas within the modern Indian ocean MORB-type mantle domain, suggesting that magma source region has Nd and Hf isotopic composition similar to those of Indian ocean MORBs. This is compatible with the previous suggestion based on Pb isotope systematics, that Neotethyan ocean domains share the Indian ocean MORB type mantle. Although most samples have eNd>8, few samples have low eNd(<6). Low eNd lavas include boninite-type and ultra-depleted type rocks; they have higher La/Sm values. It is likely that sediments as subduction components involved in petrogenesis of these low evalues.