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.

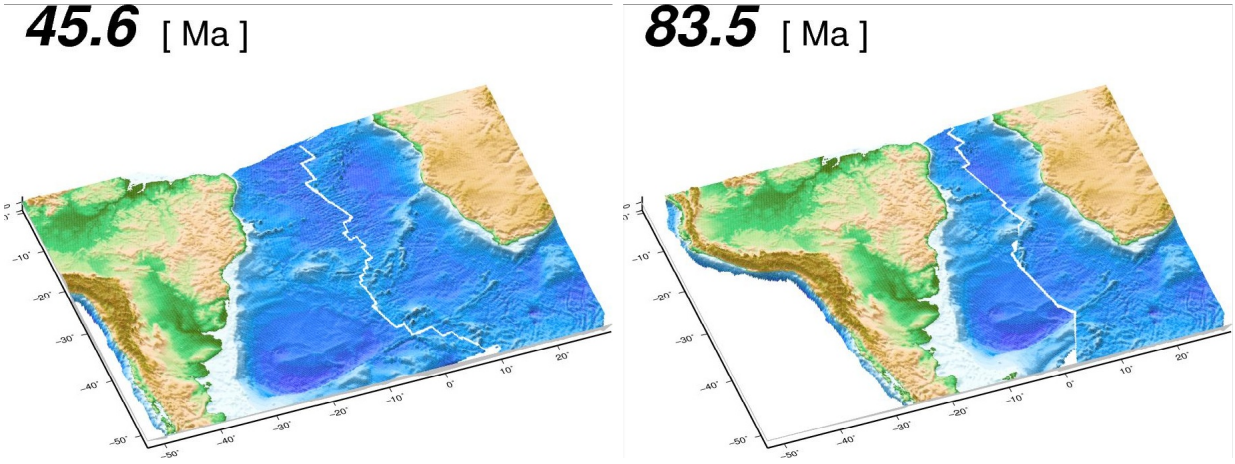
We developed a method to solve this problems by utilizing global data (gravity anomaly, Isochron positions), modifying the Euler rotation data sets, and by interpolating more data for precise positions and shapes of past plates. We needed to modify some Euler rotation angles of Muller et al., 1999 for 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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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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Current status and future prospect of GPS/acoustic seafloor geodetic observation by Japan Coast Guard

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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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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.