Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SCG67-01 Room:414 Time:May 1 14:15-14:30

The Ocean Floor was Expanded by Increasing Seawater

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Introduction

I wrote this paper in order to present the negation of a hypothesis which supports the plate tectonics. The hypothesis is 'Spreading Oceanic Floor Hypothesis'. This negation is based upon a new fact that has been revealed recently. I concluded the negation by such facts and my original reasoning. I already presented another fact negating the hypothesis of 'Spreading Oceanic Floor'. The abstract titled 'it was not switching global geo-magnetic fields that created the alternating anomalies over oceanic ridges' was presented at the Japan Geoscience Union Meeting 2013. Therefore, one of reasons that support the hypothesis of spreading oceanic floor was already denied. In this paper I will deny another reason of the hypothesis, which says that the plates of the oceanic floors are spreading.

What is the question

The Hypothesis of Plate tectonics was evolved from Wegener's 'Continental Drift Hypothesis' and based upon 'The Hypothesis of Spreading Oceanic Floor'. However, the hypothesis of spreading oceanic floor is denied as far as it means the spreading plate of oceanic floor. It is denied by the fact that the oceanic floors spread not because the oceanic plates themselves spread but merely because the seawater increased. Therefore, the hypothesis of plate tectonics lost one of its evidences.

The Expanding Oceanic Floor

The hypothesis of plate tectonics is supported by the hypothesis of spreading oceanic floor. The rapidity of the movement of the plate was estimated by the switching pattern of geo-magnetic anomaly near the ridges. The farer and farer it comes from the ridges, the older and older the dates of the basalts and fossils become. The estimated dates fit well the dates estimated from the pattern of geo-magnetic anomalies. It was proved that the rapidity was estimated 2cm par one year for the Pacific Ocean[1],[2].

Rising Sea Level Caused by Increasing Seawater

However, the hypothesis of spreading oceanic floor neglected the fact that the sea level increased greatly. The sea level increased more than 6000m after the creation of oceanic plates. That fact was revealed by the remaining river valleys on the oceanic floors. For instance the Kushiro River reaches more than 6000m in depth$^{[Fig1-B]}$. The Itoi River reaches about 3500m in depth$^{[Fig1-A]}$.

These facts revealed that the seawater increased greatly after the creation of the oceanic plates. It takes very long time to raise sea level to recent level. Gradually the amount of seawater is increasing even now.

Provably the increase of seawater is caused by crustal movements squeezing water from the rocks of the crust. The squeezed water becomes hot springs.

The date of the fossils near the ridges are newer because those places are higher and newly became under the sea level.

Conclusion

The oceanic floors spread not because the oceanic plates spread but because the seawater increased largely after the creation of the oceanic floor plates.

Therefore, it has no relation between the dates of the oceanic plates and the date of fossils contained in upper layers. Therefore, one of evidences of plate tectonics was lost.

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Keywords: Dating the Ocean Floor, Rise in the Sea Lebel, Increase of Seawater, Expansion of the Ocean Floor

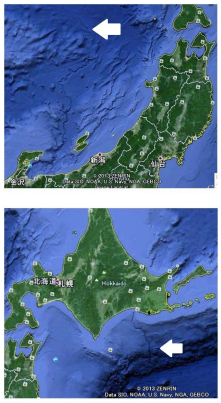

Fig 1

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SCG67-02 Room:414 Time:May 1 14:30-14:45

Noble gas evidence of deep plume origin of the Louisville hotspot

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Louisville seamount chain has been considered to be one of the long-lived hotspot tracks on the Pacific plate, but its magmatic source has not been well understood. I report noble gas compositions of the drill cores from four of the five seamounts drilled during IODP Expedition 330. Because the samples are aged (50-74 Ma), a stepwise crushing test for noble gas extraction from olivine phenocrysts and submarine glasses was made to assess contamination of post-eruption radiogenic nuclides. This test confirmed extraction of magmatic noble gases with minimal release of post-eruption radiogenic nuclides from the olivine samples; however, this was not always the case for the glass samples. The 3He/4He ratios in the olivine phenocrysts range from a value similar to those of mid-ocean ridge basalts (MORB) to slightly elevated ratios up to 10.6 Ra. Although these ratios are not as high as those observed in other ocean island basalts, two Louisville seamount basalts exhibit a primordial Ne isotopic signature that can be clearly discriminated from MORB Ne. The He and Ne isotopic compositions of the Louisville seamount basalts can be explained by the mixing of less degassed mantle and depleted upper mantle with different He/Ne ratios. The presence of the less degassed mantle component in the source of the Louisville seamounts documents the deep origin of the mantle plume.

One of the major objectives of the IODP Expedition 330 was to test the geodynamic model that predicts lateral advection of mantle plumes in the convecting mantle [Koppers et al., G-cubed, 2004; Steinberger and Antretter, G-cubed, 2006]. This model assumes a primary mantle plume that is rooted deep in the mantle, and the trajectory of a plume conduit is influenced by the overall mantle flow, which can be monitored by the hotspot drift on the Earth's surface [Tarduno et al., Science, 2009]. The paleomagnetic and dating results from IODP Expedition 330 verified the geodynamic modeling predictions for the Louisville seamount chain together with the Hawaiian-Emperor seamount chain [Koppers et al., Nat. Geosci., 2012]. The present noble gas data gives a guarantee for the deep-rooted Louisville plume assumed in the geodynamic model.

Keywords: Louisville seamount, mantle plume, deep mantle, noble gases, IODP

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SCG67-03 Room:414 Time:May 1 14:45-15:00

Preliminary result of the oceanic mantle structure revealed by ”Normal Oceanic Mantle Project”

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The oceanic mantle is an important region to understand the Earth system, because more than 2/3 of the surface is covered by oceanic area. Since 1990s, we have operated several seafloor observations by using newly developed long-term broadband ocean bottom seismometers (BBOBSs) in the northwest and central part of the Pacific Ocean. These observations have revealed the structures in and around the subduction zone in the Pacific Ocean and in the Pacific superswells, respectively. However, we have no observation and result in the normal oceanic regions. To reveal the normal oceanic mantle structure from observational approach, we conduct a long-term observation called “ Normal Oceanic Mantle Project ” (NOMan project) from 2010, deploying ocean bottom geophysical (seismic and electromagnetic) instruments in the northwestern Pacific Ocean. We conduct two arrays in that region. One is northwest side of the Shatsky Rise (Area A) and the other is southeast side of the Shatsky Rise (Area B). Sea floor age of Area A is 125 - 135 Ma, that of Area B is 135 - 145 Ma, so that the shear wave structures of those area should be similar.

By using seismograms of the NOMan project, other BBOBS observations, and permanent broadband seismic stations on land, we have determined the three-dimensional shear wave velocity structure of the upper mantle in the northwestern Pacific Ocean to reveal this area to be really normal. We used a surface wave tomography technique in which multimode phase speed of the surface wave are measured and inverted for a 3-D shear wave velocity structure by incorporating the effects of finite frequency and ray bending.

Our obtained model shows that lateral heterogeneity of each area is not strong and that average structures are different in two areas. Area A is consistent with previous models, whereas Area B is faster than previous models. We think for the present that Area A seems to be normal oceanic mantle, though Area B is not. We will recover all BBOBSs in this year. These BBOBS’s data enable us to obtain more reliable mantle structures.

Keywords: upper mantle, BBOBS, surface wave, tomography

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SCG67-04 Room:414 Time:May 1 15:00-15:15

Seismic anisotropy in the oceanic lithosphere/asthenosphere system estimated by the broadband ocean bottom seismology

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The uppermost mantle structure beneath the oceanic basins is essential to discuss the oceanic lithosphere/asthenosphere system, the most simple and representative system of the theory of plate tectonics. Seismic anisotropy within the oceanic lithosphere and asthenosphere is especially important, as it reflects the flow and deformation in the uppermost mantle. Previous structural studies have been, however, limited in terms of the depth range: the top of lithosphere at depths of ˜10-20 km by refraction surveys, and the structure deeper than ˜30 km by surface-wave tomography studies. There has been no discussion from the top of the lithosphere continuously to the asthenosphere, which needs the broadband analysis of surface waves at periods of 3-100 s. In addition, there has been limited discussion about the intensity of seismic anisotropy because of the difficulty of estimating the absolute value of seismic anisotropy by surface-wave tomography studies.

We have developed a new multi-band method to analyze surface waves in broadband array records of ocean bottom seismometers for determining seismic anisotropy structure at depths of ˜10-100 km quantitatively (Takeo et al 2013 JGR, submitted to GJI). The method uses the ambient noise cross-correlation method for analyzing surface waves at periods of 3-30 s and to determine structure at depths shallower than ˜50 km, as well as the array analysis method of teleseismic waveforms at longer periods for determining deeper structures.

In previous studies, we have applied the multi-band method to records obtained in three oceanic regions: the Shikoku Basin region (Takeo et al. 2013 JGR), the southwestern region of the Shatsky Rise (Takeo et al. submitted to GJI) and the French Polynesia region (Takeo et al. 2012 SSJ Fall Meeting). In this study, we applied the same method to the records of broadband ocean bottom seismometers obtained by the normal oceanic mantle (NOMan) project at two oceanic regions (northwestern and southeastern regions of the Shatsky Rise) from 2010 to 2013. By combining the results for five oceanic regions with different seafloor ages between 20 and 155 Ma, we can discuss the seismic structure and its anisotropy in the oceanic lithosphere and asthenosphere, and the deformation of mantle related to plate motions.

The results for five oceanic regions can be summarized into five points: (i) the high-velocity lid and the low velocity zone corresponds to the oceanic lithosphere and asthenosphere, (ii) the transition from the lithosphere to the asthenosphere occurs at depths of 40-90 km, (iii) the average intensity of S-wave radial anisotropy is 3-6 % at depths of 10-150 km with the velocity of horizontally propagating and vertically polarized S-wave slower than the horizontally polarized S-wave, (iv) the intensity of S-wave azimuthal anisotropy at depths of 10-100 km is weaker than that of S-wave radial anisotropy and weakens with depths, and (v) the azimuth of maximum S-wave velocity is not perpendicular to ancient spreading axis in general. These results indicate complex deformation system in the present and ancient oceanic asthenosphere related to the presence of partial melting, the unusual fabric of olivine and so on. We will summarize these results and discussions, and will also present the potential of the broadband ocean bottom seismology to elucidate structure and deformation in the oceanic lithosphere/asthenosphere system and in other oceanic systems such as hotspots, mid-ocean ridges and subduction zones.

Keywords: surface wave, ambient noise, anisotropy, plate tectonics

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SCG67-05 Room:414 Time:May 1 15:15-15:30

Locality and cause of the characteristics of high-frequency Po/So wave propagating in heterogeneous oceanic lithosphere

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In our previous study (Kennett & Furumura 2013; Geophys. J. Int.) we described the characteristics of the propagation of the high-frequency mantle phases Po and So. These oceanic Pn and Sn phases can be observed after propagation over many thousands of kilometres from the source, retaining high frequencies but acquiring a long and complex coda. This study concentrated on the way in which these characteristics can be sustained by fine-scale heterogeneity in the oceanic lithosphere that reinforces the influence of multiple P reverberations in the ocean and sediments as recognized by Sereno & Orcutt (1985; 1987). A form of quasi-laminar heterogeneity with horizontal correlation lengths around 10 km and vertical correlation lengths of about 0.5 km provides a good representation of the Po and So wavefield as also noted by Shito et al. (2013). This class of heterogeneity creates a strong scattering environment within the lithosphere that helps to sustain the Po and So phases over long distances. Propagation of So is most effective in thick old lithosphere, e.g., in the northwest Pacific Plate. Amplitudes of So are reduced significantly by propagation through thinner lithosphere in the Philippine Plate.

In this study we look at the entire Pacific basin and map out the propagation patterns for Po and So, which have the general characteristic of much more efficient propagation in the western sector than in the east that is much less well sampled. There are stronger changes in the nature of So than Po. For the same frequency S waves have a shorter wavelength than P waves, and so the So phase is more sensitive to the effects of both lateral variations in lithospheric structure and seismic attenuation.

We explore the relation of the nature of the observations of Po and So and the age of the lithosphere, based on 2-D FDM simulation seismic wave propagation for examining the influence of changes in lithospheric structure across fracture zones and similar features. The strong diffuse scattering field created in the oceanic lithosphere is hard to destroy and it is quite difficult to explain situations where So is very much weaker than Po, except by introducing enhanced seismic attenuation for younger lithosphere and the warmer asthenosphere in the neighborhood of spreading centers.

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SCG67-06 Room:414 Time:May 1 15:30-15:45

Distribution of petit-spot volcanoes in relation to deformation and structures on a subducting plate

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Tiny submarine volcanoes, known as petit-spots, occur in regions of plate flexure prior to subduction and seamount-loading (Hirano *et al.*, 2006, 2013). The surface morphology and distribution of petit-spot monogenetic volcanoes are influenced by the stress field in the lithosphere. The magmas produced by the accumulation of melt originating from asthenosphere just below the site of plate-flexure, are able to rapidly ascend to the surface from the base of the lithosphere (Hirano *et al.*, 2006; 2011; Valentine & Hirano, 2011). As monogenetic petit-spot volcanoes are too small to be detected by satellite altimetry, their study requires a research vessel equipped for shipboard acoustic multibeam surveys. Although previously surveyed areas are limited to the regions off the Japan Trench, the eruption ages of petit-spot volcanoes in this region represent monogenetic eruptions over a period of >9 Myr over a large area, and the eruptions are related to the outer rise bathymetry. Such tiny volcanoes are ubiquitous in regions of plate flexure worldwide, and have been recently reported from the Tonga Trench (Hirano *et al.*, 2008), the Basin and Range province (Valentine & Hirano, 2010), south of Greenland (Uenzelmann-Neben *et al.*, 2012), the Chile Trench (Hirano *et al.*, 2013), an accretionary complex in Costa Rica (Buchs *et al.*, 2013), and submarine French Polynesia (Hirano *et al.*, submitted).

The spatial distribution of submarine petit-spot volcanoes remains poorly constrained because shipboard bathymetry has not covered the entire northwestern Pacific Plate. If petit-spot volcanoes occur only in regions of plate flexure, then tiny submarine volcanoes should appear homogeneously on the submarine surface of outer rises. However, areas devoid of volcanoes and lava have been found surrounding areas of petit-spot volcanoes (i.e., sites A?C in Hirano *et al.*, 2006), indicating that the local characteristics of the lithosphere, in addition to plate flexure, control the occurrence of petit-spot volcanoes. Here we report that the distribution of petit-spot volcanoes is controlled by the tectonic structure of the seafloor. We conducted submersible dives along the linearly distributed petit-spot knolls by JAMSTEC *Shinkai6500* in April 2014. Areas with tectonic fabrics appear on the subducting Pacific Plate off the Japan Trench, including a ridge-perpendicular fabric zone (RPPFZ), ridge-parallel abyssal hills (RPRAH), and subducting 'horst and graven' structures (HAGS) (Nakanishi *et al.*, 2011). At Site C, which is a trench-oceanward slope offshore from Soma City, Fukushima Prefecture, the trend of the Japan Trench changes from N?S in the north to NE?SW in the south, where two areas of trench-parallel HAGSs are intersecting in a complex manner (Nakanishi *et al.*, 2011). The distribution of young volcanic cones of more than 80 petit-spots, reported from Site C by Hirano *et al.* (2008), seems to be controlled by the fabrics of RPPFZ and RPRAH, the trends of which are continuous with the HAGS to the north and south along the trench-oceanward slope, respectively. Although the RPPFZ is not recognized as a fracture zone, its trend is sub-parallel to that of the neighboring Nosappu and Kashima fracture zones (Nakanishi, 1993). As the RPPFZ and RPRAH that control the petit-spot distribution are clearly original structures of the lithosphere (in contrast to HAGS), the occurrence of petit-spot eruptions is possibly related to lithospheric structures.

Keywords: petit-spot, alkali-basalt, Pacific plate, outer rise, lithosphere

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SCG67-07 Room:414 Time:May 1 15:45-16:00

Magnetic Anomalies in the Southern Indian Ocean Revisited

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Magnetic anomalies in the Southern Indian Ocean are vital to understanding initial breakup process of Gondwana. However, seafloor age estimated from magnetic anomalies still remain less well-defined because of the sparse observations in this area. To understand the seafloor spreading history related to the initial breakup process of Gondwana, vector magnetic anomaly data as well as total intensity magnetic anomaly data obtained in the Enderby Basin, Southern Indian Ocean, are used. The strikes of magnetic structures are deduced from the vector magnetic anomalies.

Magnetic anomaly signals, most likely indicating Mesozoic magnetic anomaly sequence, are obtained almost parallel to WNW-ESE trending lineaments just to the south of Conrad Rise inferred from satellite gravity anomalies. Most of the strikes of magnetic structures indicate NNE-SSW trends, and are almost perpendicular to the WNW-ESE trending lineaments. Mesozoic sequence magnetic anomalies with mostly WNW-ESE strikes are also observed along the NNE-SSW trending lineaments between the south of the Conrad Rise and Gunnerus Ridge. Magnetic anomalies originated from Cretaceous normal polarity superchron are found in these profiles, although magnetic anomaly C34 has been identified just to the north of the Conrad Rise. However, Mesozoic sequence magnetic anomalies are only observed in the west side of theWNW-ESE trending lineaments just to the south of Conrad Rise and not detected to the east of Cretaceous normal superchron signals. These results show that counter part of Mesozoic sequence magnetic anomalies in the south of Conrad Rise would be found in the East Enderby Basin, off East Antarctica. NNE-SSW trending magnetic structures, which are similar to those obtained just to the south of Conrad Rise, are found off East Antarctica in the East Enderby Basin. However, some of the strikes show almost E-W orientations.

Moreover, the thickness of the crust increase just to the north of the Conrad Rise and clear magnetic anomaly signals considered to be magnetic anomaly C34 in this region may indicate continental-ocean boundaries while taking dredged continental origin rock samples at the Ob seamount into account. Therefore, magnetic anomaly C34 identified in the Indian Ocean must be reconsidered. These suggest complicated ridge reorganization occurred during initial breakup of Gondwana in the Indian Ocean.

Keywords: magnetic anomaly, Indian Ocean, Gondwana, continental crust

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SCG67-08 Room:414 Time:May 1 16:15-16:30

Origin of the Palau Basin and a revised spreading model of the West Philippine Basin deduced from three-component magnet

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The western part of the Philippine Sea (PHS) plate was occupied by the West Philippine Basin (WPB) in the north and the Palau Basin (PB) in the south. The WPB is generally considered to have opened from about 50 to 30 Ma, but the details are still unclear; in particular the origin and age of the PB was unknown. Studying the history of the WPB is important for understanding better the initiation and evolution of the IBM Arc. Here we discuss the spreading history of the WPB using new data on three-component magnetic anomaly and swath bathymetry acquired in the PB as well as those obtained previously by JAMSTEC fleets in the southern WPB. NS-trending magnetic boundaries and seafloor fabrics occur in the PB, indicating the formation by EW seafloor spreading. With a constraint from a 40Ar/39Ar age of 40.4 Ma obtained from the northernmost part of the PB, we interpret that the observed magnetic anomalies correspond to polarity reversals from C16n1r to C18n/C18r (35.6 to 38/39 Ma). Previous models of WPB spreading incorporated a spreading-rate decrease around 40 Ma from about 4.4 to 1.8 cm/year. Our study in the southern WPB, however, suggests that the decrease is unnecessary for correlating observed three-component anomalies to the GPTS. A typical profile along 130E corresponds to C16r to C21 (36.3 to 45.3 Ma). The cessation age of the spreading in our interpretation, about 35 to 37 Ma, is older than the previous estimation (about 30 to 33 Ma). It was difficult to constrain rotation of the PHS plate from the magnetic anomaly skewness.

Keywords: Philippine Sea plate, West Philippine Basin, Palau Basin, magnetic anomaly, seafloor spreading

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SCG67-09 Room:414 Time:May 1 16:30-16:45

The composition of back-arc basin basalts in the West Philippine Basin and association with mantle dynamics

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The Philippine Sea Plate was expanded by multiple extensions of backarc basins. Ishizuka et al. (2011) and Haraguchi et al. (2012) pointed out that the enriched mantle was flowed from backarc side during the spreading of the Shikoku Basin from 25 to 15 Ma (Okino et al., 1994, 1999). Haraguchi et al. (Meeting of the Volcanological Society of Japan, 2013) considered that the process of flowing of the enriched mantle estimated by the composition of the backarc basin basalts (BABB) recovered by the drilling of the Deep Sea Drilling Project (DSDP), Ocean Drilling Program (ODP) and Integrated Ocean Drilling Program (IODP). In this study, we attend the BABB of the West Philippine Basin, precede backarc spreading of the Shikoku Basin, and consider mantle dynamics by geochemical characteristics of BABB.

The first drillings in the West Philippine Basin by the Deep Sea Drilling Project are the Leg 31 same as the Shikoku Basin, and following operations are Leg 59 and the Ocean Drilling Program (ODP) Leg 195. And the diving of the R/V *Shinkai 6500* during the Y9611 cruise by R/V *Yokosuka* and dredges during the KR9801 cruise by R/V *Kairei* at the spreading axis (e.g. Fujioka et al., 1999). In this study, we discuss the new analyzed data of the basements of DSDP Leg 58 Site 446 and ODP Leg 195 Site 1201, and compare the data of the former studies.

Site 1201 is located in the west of the West Philippine basin, about 500km north from the Central Basin fault, axis of the spreading center. The main purpose of this site is the set up of the borehole site WP-1. Thickness of covered sediments at this site is more than 500m. The chemical characteristics of basements at this site are the typical BABB, not find the island arc characteristics. SiO_2 and MgO contents of these basalts are 49-53 and 5-8 wt%, respectively, and are similar to the basalts from the DSDP Leg 58 Site 442˜444 in the Shikoku Basin. The TiO_2 contents of these basalts are 0.9˜1.0 wt%, lower than those of the Shikoku Basin. The alkali elements are 1.5-2.8 wt% of Na_2O and 0.1-1.6 wt% of K_2O, similar K_2O and lower Na_2O contents to Shikoku Basin BABB. The trace elements are 320-420 ppm of Cr, higher than Shikoku Basin BABB, and lower Sr, Y and Zr. The Zr/Y and Nb/Zr ratio are also lower than Shikoku Basin BABB. We consider that these characteristics are the existence of the depleted parent mantle before the spreading of the Shikoku Basin pointed by Ishizuka et al. (2011) and Haraguchi et al. (2012).

Site 446 ate located in the Minami Daito Basin between the Daito and the Oki Daito Ridges. Thickness of covered sediments is about 350m. These volcanic rocks are considered to the intrusion in the sediment layer, different from the basement. The chemical characteristics of this volcanics are classified into alkali basalts, and prominent enrichment of TiO_2, more than 4 to 5 wt%. This extremely enrichment of TiO_2 is not found from other inner plate volcanism in the Philippine Sea Plate. Therefore, we assume that the different inner plate volcanism from the mantle plume in the West Philippine Basin about 40 Ma (Deschamps and Lallemand 2002) were more active in the other Philippine Sea region.

We discuss these analyzed data and former data of the basements in the Philippine Sea Region, and consider parental material composition and magma dynamics before 30 Ma.

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

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Long-distance magma transport from oceanic island arc volcanoes

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Long-distance lateral magma transport away from volcanic centers is emerging as a common phenomenon where the regional stress regime is favorable. It should also be recognized as an important factor in the construction and growth of island arcs, and a potential trigger for devastating eruptions. In this contribution, we report on recent investigations into the magma dynamics of Izu-Oshima volcano: an active basaltic volcano with an extensive fissure system.

Geophysical observations in the Izu-Bonin intra-oceanic island arc indicate that magma periodically is moved away from the main basaltic composite volcanoes. When Miyakejima erupted in 2000, seismic activity migrated about 30km northwestward from the volcanic centre (Geshi et al., 2002). This event is interpreted to reflect magma injection and dike propagation at a depth range between 12 and 20km (Kodaira et al., 2002). Long-distance lateral magma transport has also been identified at the Nishiyama volcano on Hachijojima Island using petrological, geochemical and structural studies of satellite vents (Ishizuka et al., 2008). Nishiyama has provided evidence for two types of magma transport: Primitive magma moving laterally for $>$20km in the middle to lower crust (10-20km deep) and short distance transport ($<$5km) from shallow, differentiated magma reservoirs. Of these the long-distance transport seems to be controlled by a regional extensional stress regime, while short distance transport may be controlled by the local stress regime resulting from the load of the main volcanic edifice.

Izu-Oshima is flanked by numerous, subparallel NW-SE trending submarine ridges extending up to 22 km to the NW and SE from the center of the volcano. During a recent diving survey we have identified that these ridges are fissures which erupted basaltic spatter and lava flows. Furthermore, lavas are petrographically similar along each ridge, while there are noticeable differences between ridges. The subparallel ridges are observed to transect a series of knolls, the Izu-Tobu monogenetic volcanoes (ITMV), which are dispersed across this area of the rear-arc. However, there is a consistent petrographic difference between these seamounts and the ridges.

We have found similar, and in some cases a matching, geochemistry between the submarine ridges and subaerial ridges of eruptions found ascending the flanks of Izu-Oshima. This implies that the subaerial ridges and submarine ridges together represent the track of a magma transport episode away from the storage system beneath the central volcano.

ITMV and the transecting ridges are found to have quite distinct geochemical characteristics, indicative of different magma sources. Yet, they are essentially found interspersed in outcrop. The most appropriate scenario for their development is one where ITMV are fed by an ”in-situ” underlying source, while the NW-SE ridges are fed by lateral magma transport from Izu-Oshima. Unlike Nishiyama volcano, Izu-Oshima does not show a compositional variation along the length of the ridges, and has no evidence of primitive magmas. Hence, the magma transport is likely to be derived from a crustal chamber where crystal fractionation and plagioclase accumulation has taken place.

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Seafloor geodetic observation along the Nankai Trough - Progress report after the 2011 Tohoku-oki earthquake -

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We have been carrying out GPS/acoustic seafloor geodetic observation on the landward slope of the major trenches around Japan, such as the Japan Trench and the Nankai Trough. From the past observations, we detected intraplate deformation caused by the subduction of oceanic plates and coseismic displacements associated with large earthquakes.

Along the Nankai Trough, we deployed six seafloor reference points in the sea area from off-Omae-zaki through off-Muroto in 2002-2004 and had been carrying out campaign observations. From the observations conducted before the 2011 Tohoku-oki earthquake, we obtained the intraplate velocities of 2-5 cm/year toward WNW, which were generally consistent with those detected by on-land GPS measurements. A closer look gives us the differences of the velocities by sea areas.

Furthermore, to monitor seafloor movement spatially in the whole expected focal regions along the Nankai Trough, we deployed nine new seafloor reference points mainly off Shikoku in January 2012. If we obtain crustal velocities at all the site, it is expected that a spatial variation of interplate coupling will be revealed in the sea area along the Nankai Trough. It has been two years after the expansion of seafloor reference points and seafloor movements westward and northward are being observed at most of the sites.

In this report, we present a progress report on seafloor geodetic observation along the Nankai Trough after the 2011 Tohoku-oki earthquake.

Keywords: Seafloor geodetic observation, Seafloor geodesy, Nankai Trough

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Postseismic seafloor movements following the 2011 Tohoku-oki earthquake detected by GPS/acoustic positioning

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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 Tohoku-oki earthquake (Mw = 9.0), we detected a huge coseismic displacement of 24 m toward ESE at MYGI which is located above the epicenter. We have been continued the geodetic observations along the Japan Trench in order to detect postseismic deformation.

The results of the observations show that the displacements vary with the sites even in the directions. MYGI and KAMS had moved toward west-northwest at constant rate. MYGW had moved toward south-southeast. KAMN had moved toward northwest. FUKU and CHOS had moved toward east-southeast. In addition, the displacements at FUKU and CHOS decay with time. For vertical component, significant subsidence was detected at all sites except CHOS where no vertical displacement was detected within the accuracy range.

In this presentation, we will report and discuss the latest results of the seafloor geodetic observation along the Japan Trench.

Keywords: seafloor geodetic observation, the 2011 Tohoku Earthquake

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A summary of the achievement in the project for advanced GPS/acoustic survey

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GPS/acoustic survey is known as a most probable way to measure the crustal deformation of seafloor far from the coasts, where dense GPS network is not available. We, Tohoku University, together with Nagoya University and Japan Coast Guard dedicated in GPS/acoustic survey for more than decade. MEXT has been strongly promotes our activities though financially support as governmental project. We summarize individual topics in the project.

For the moored buoy, collaborating with JAMSTEC and JAXA, we have started long-term continuous and realtime seafloor geodetic survey at Kumano-nada. At the early stage of the project, we employed a small buoy, which can be also used as towing survey, at off-Miyagi site. Because the size of battery is limited, sea-trials was lasting only for two days. However, using this platform, we developed an automatic ranging system and simple on-demand operation technique via UHF communication. In 2012, we have started developing a automatic ranging system in a realistic working condition using a time-proven platform, m-TRITON buoy, operated by JAMSTEC. Together with JAMSTEC and JAXA, satellite communication part and GPS positioning part have been shared for multi-purpose. Tohoku University group concentrate acoustic ranging part and onsite data processing to compute precise traveltimes. Using a limited onsite resource in the buoy, we have eliminated unnecessary and redundant procedure and data as possible. The first sea-trial took place in 2013 for four months and the ongoing second trial has started in 2014 for six months. In the second trial, acoustic ranging data has been successfully transmitted to onshore station every week and we can monitor it from our laboratory.

For the Autonomous Surface Vehicle (ASV) system, we aimed to develop an automatic survey system, which can also be used simultaneous measurements from other platform, such as a research vessel, for improve the ranging accuracy with multi-acoustic-paths. In our system, vehicle is like an unmanned boat (2.4m long and 400kg in weight), whose propulsion system is driven by electric power from onboard diesel generator lasting for a week. As the ASV system demonstrates sufficient performance for our use in GPS/acoustic survey, it can be a candidate of multi surface platform for simultaneous ranging to achieve high accuracy GPS/acoustic measurement taking the spatial sound speed variation into account.

After the Tohoku-Oki earthquake in 2011, the project has an extra mission that significantly enhance the survey framework, especially in deep seafloor ($>$5000m) near the trench axis. In this extra mission, we have developed a new type of seafloor transponder that works at over 5000m depth and its acoustic communication range is greater than 15km. We made 86 transponders in total and constructed 20 new GPS/acoustic station along the Japan Trench in 2012. In addition, we chartered a research ship for about 50 days per year to construct and observe the new stations. At present we have carried out four times of campaign surveys during 2012-2013. At these new stations, we conducted both moving and stationary surveys, the former generally took several hours and the latter 12 hours for each station. We found a problem in acoustic property in the new transponders, which can be corrected with post-processing shown in Azuma et al. (2014, JpGU). Campaign surveys ranges only about one year, but we have observed post-seismic movement at selected stations. These results are reported in Tomita et al. (2014, JpGU). The new transponders are hybrid type so that Japan Coast Guard has started to make measurements with their own system at several stations above.

This work has been supported by MEXT project for advanced GPS/acoustic survey. Stuffs in RCPEV and IRIDeS, Tohoku University gave dedicated support and collaborative operation in the onboard and GPS surveys. The construction and surveys in the new stations were collaboration with Nagoya University.

Keywords: GPS/acoustic, moored buoy, autonomous surface vehicle, Japan trench

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Detection of post-seismic movement after Tohoku-oki Earthquake using GPS/Acoustic technique

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Using GPS/Acoustic seafloor geodetic observation (GPS/A observation), we can directly measure seafloor movements, which cannot be obtained from on-land geodetic observation. For example, Kido et al. (2011) and Sato et al. (2011) detected huge co-seismic displacements associated with 2011 off Pacific coast of Tohoku Earthquake near the Japan Trench, 150km distant from the coast.

After the occurrence of the Tohoku-oki Earthquake, we deployed new seafloor benchmarks at 20 sites along the Japan Trench from Ibaraki-oki to Sanriku-oki. Including three sites installed before 2011, we totally have 23 sites to monitor the post-seismic movement for the Tohoku-oki Earthquake. We have conducted four GPS/Acoustic surveys at present (09/2012, 11/2012, 07/2013, 10/2013) at these sites.

The surveys consists of two types of observations; they are moving survey to locate the position of individual seafloor transponders that make up each geodetic site and point survey to determine the precise location of the center of the transponder array. The displacement at each site is estimated from the temporal change of the array center position. However, we identified two dominant factors that influence the precision of the array center positioning in our observation.

The first factor is the instability in the waveforms of acoustic signals. In GPS/A analysis, we calculate cross-correlation waveform between received and transmitted signals, and determine the timing of maximum peak as round trip travel time. However, multiple peaks separated by 0.3-0.5ms each other are found in a cross correlation waveform, whose relative amplitudes are influenced by the relative position between the hydrophone on the research ship and the seafloor transponder. We have developed an algorithm that can automatically picks up the first peak from the multiples and reduces the error in determining round trip travel time. The detail of this problem and the algorithm will be reported by Azuma et al. (2014, JpGU).

The second factor is uncertainty in the position of the hydrophone equipped on the research ship with respect to three GPS antennas at the top of the ship for attitude determination. In our observations, it is difficult to directly measure the relative position of the three GPS antennas and the hydrophone attached at the end of the pole mounted on the ship's side; the provisional position based on the drawing has about 1m offset. The horizontal component of the offset causes systematic deviation in the apparent position of the transponders depend on ship's heading. Taking this behavior into account, we can correct for the horizontal offset with about 5cm in accuracy. The vertical offset is thought to have less influence on the estimation of the array center position because the sound speed correction intrinsically includes the vertical offset. However, accuracy of offset estimation is still insufficient, hence the estimation technique must be refined further.

After these correction, we have succeeded to obtain preliminary movements at 10 sites using the data in two of the four surveys (09/2012 and 07/2013) at present. These preliminary results generally indicate eastward seafloor movements at the northern Sanriku-oki sites and westward movements at off-Miyagi sites. In this talk, we introduce outline of the analysis and up-to-date results of evaluation of the post-seismic movement incorporating the data in 11/2012 and 10/2013.

Keywords: seafloor geodesy, Tohoku-oki Earthquake, Japan Trench, post-seismic movement

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Understanding recoupling process using a seafloor geodesy in megathrust earthquake zone

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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 showthat 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. We improve this system that adapted for the axis of Japan Trench. The system is designed to measure distances of up to 3 km and to adapt the pressure vesselof 9000m water-depth. We deployed the seafloor acoustic ranging system between 2013 May and 2013 Sep. We observed across the Tranch baseline (about 7km), baseline between the bottom of Tranch to the seaward side of Japan Trench (about 3.6km). We get data both baseline results for 4 month. We report this results on this presentation.

Keywords: seafloor crustal movement, Japan Trench

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Sea trial of tsunami and crustal movement observation buoy system in real-time under environment with high speed sea cur

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Tohoku University and Japan Aerospace Exploration Agency (JAXA) have developed real-time observation system for tsunami and crustal movement using a buoy since 2011. Although observation interval of crustal movement is generally sparse, because the timing depends on availability of observation ship, we aim to construct to observe tsunami in real-time and crustal movement when it is necessary. Because Japan is surrounded by seismogenic zones with large earthquakes and such large event brought huge damages on coastal region people, early detection is needed to reduce the severe damage. Although online cable system is best for it, the cost for the construction and implementation is huge. Therefore, we point use of the buoy as the removable temporal early detection system. The system is composed of a pressure seafloor unit with pressure sensor and acoustic transmission unit, six seafloor transponders and buoy station incorporating some loggers, transducers to communicate with seafloor systems and data transmission system to land. The seismogenic zones, however, are under the environment of high speed sea current like the Kuroshio. Therefore, we use the slack mooring on our system, but the some technical development is needed for adoption of the mooring. For example, low consumption electricity due to high power acoustic signals for the data transmission and We tried sea trial for three months in last year, and confirmed to fully resistance for high speed sea current over 5.3 knots. On the other hand, the issued to be resolved are clarified, which are on acoustic transmission between the pressure seafloor unit and the buoy, the resistance for the fishery activities and so on. We took measures for above issues and deploy the revised system at off the Kumano Basin. The observation period of the second sea trial is six months. In addition to the measures, we implement tsunami mode. In normal case, we obtain tsunami data with an interval of 15 minutes, but, it is switched to be 15 seconds in tsunami mode. The tsunami mode is triggered when a ratio of average for short period of time (STA) and that of long one (LTA) exceed the threshold level. And, we move the timing of the STA and LTA and try to detect the first arrivals of tsunami. Now, we obtain real-time tsunami and crustal movement data via iridium transmission and introduce it in this presentation.

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Study for improving efficiency in seafloor geodetic observation by means of multi acoustic ranging

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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. In this observation, the movements of the seafloor reference points are measured with 2 - 3 centimeters precision. JHOD has been carrying out seafloor geodetic observations 2 - 4 times a year for each station and reported the inter-seismic deformation before and after the 2005 Miyagi-oki earthquake and the co- and post-seismic deformations of the 2005 Miyagi-oki earthquake and the 2011 Tohoku-oki earthquake and so on.

After the 2011 Tohoku-oki earthquake, this observation is expected to be broadened and densely-arranged with the objective of large-scale earthquake disaster prevention. In order to expand further seafloor geodetic observation, shortening of observation time, which is about one day for one campaign, is required. Therefore, we are considering a new acoustic ranging method. In this new method, we conduct the acoustic ranging for multi seafloor transponders not individually but sequentially. We report the details of this new multi acoustic ranging method and discuss how much efficiency will be improved by the introduction of the new method.

Keywords: seafloor geodetic observation, acoustic ranging

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Hydrothermal heat mining due to the aquifer thickening toward the trench axis: A model for the Japan Trench

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Observation: At the Japan Trench, a 135-Myr-old Pacific plate is subducting beneath the Japan Island. Heat flow on such an old oceanic plate is expected to be 50m W/m^2 by a thermal model of the oceanic plate. However, observed heat flow values range from 50 to 120 mW/m^2 and the averaged value is 70 mW/m^2 (Yamano et al., 2008, Int. J. Earth Sci.). In the area of high heat-flow anomalies, a high V_p/V_s layer (highly porous, and probably highly permeable) is observed within the uppermost part of the oceanic plate (Fujie et al., 2013, JpGU Meeting). The layer thickness is observed to increase toward the trench axis.

Hypothesis: Permeability within the uppermost several hundred meters of oceanic plate is measured to be high for fluid to convect; this layer is called an aquifer. We assume that thickening of the observed high V_p/V_s layer is a consequence of thickening of this highly permeable layer. Accordingly, we construct a numerical model including hydrothermal circulation within an aquifer being thickened with time, and calculate the resulted heat flow anomalies.

Results: Calculations show that heat flow is increased as the aquifer thickness begins to increase. With typical parameter values for the Japan Trench, the result accounts for the observed high heat-flow anomaly of 20 mW/m^2. This high heat-flow arises due to the mining of heat from the base of the thickening aquifer. Downward thickening of the aquifer invades the high-temperature region, and incorporates the heat into convection. As a result, this heat is transported upwards through sediments above the aquifer, and heat flow is increased.

Keywords: hydrothermal circulation, heat flow, the Japan Trench, seismogenic zone

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Seismic structure and seismicity surevey at the Kairei hydrothermal vent field in the Indian Ocean

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1. Introduction

In the first segment of the central Indian Ridge from the Rodriguez triple junction, the Kairei hydrothermal vent field exists and extrudes hydrothermal fluid with richer hydrogen content compared to other hydrothermal vents in the world. Around the Kairei hydrothermal field, serpentinized peridotite and troctolites, and gabbroic rocks were discovered. These deep-seated rocks exposed around the Kairei field may cause the enrichment of H2 in the Kairei fluids. At the Kairei field, a hydrogen-based subsurface microbial ecosystem and various hydrothermal vent macrofauna were found. In the TAIGA Project (Trans-crustal Advection and In situ reaction of Global sub-seafloor Aquifer), this area is a representative field of TAIGA of hydrogen. To investigate how the deep-seated rocks (originally situated at several kilometers below seafloor) are uplifted and exposed onto seafloor, and the hydrothermal fluids circurate in subsureface, we conducted a seismic refraction/reflection survay and seismicity observation with ocean bottom seismometers (OBSs).

2. Observation

We conducted a seismic survey around the Kairei hydrothermal field from January 27 to March 19 in 2013 using S/V Yokosuka of Jamstec. We used 21 OBSs, an air gun (GI gun) and a single channel streamer cable. Deployed intervals of OBSs are about 7.5 km, and 2 km near the Kairei field. Survey lines are 5 lines NNW-SSE direction parallel to the ridge axis, 5 lines E-W direction, and 5 lines NNE-SSW direction. Line lengths are from 7 km to 30 km. In addition, we conducted other 5 lines pass around the point just above the Kairei hydrothermal field and the Yokoniwa Rise. The air gun was a GI gun with 355 cu. in. (5.5 l), and the shot interval was 40 s (about 100 m).

3. Results

From seismicity observation, we found many micro earthquakes in this area. A swarm of micro earthquakes exists at a location about 1 km northwest of the Kairei field. The swarm has a NNW-SSE strike, parallel to the ridge axis. The depth of the swarm is very shallow (˜4 km from seafloor). This swarm may be relateted to the hydrothermal activities of the Kairei field. At the first segment of the central Indian Ridge, many micro earthquakes occurred. The depth of these events is deeper than that of the swarm near the Kairei field.

Acknowledgements

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Keywords: TAIGA, hydrothermal area, seismicity, Triple junction in the Indian Ocean

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Origin of boron in Okinawa Trough hydrothermal fluids using B isotope as a tracer

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The Okinawa Trough is a back-arc basin located around the Ryukyu Arc, where several hydrothermal systems have been discovered. The Okinawa Trough has a very thick sedimentary cover, and the chemistry of the hydrothermal fluids appeared to be influenced by interaction with the sediment. However, the temperature environments below the seafloor have not been clarified yet in detail. In this study, we investigated B isotope ratios (δ^{11}B) in hydrothermal fluids from Okinawa Trough, and discussed the origin of the boron and the reaction temperature.

The hydrothermal fluid samples were collected by WHATS with Hyper Dolphin and *Shinkai 6500* from Iheya North Knoll, Izena Caldron, Hatoma Knoll, and Yonaguni Knoll IV. The sample was filtered and acidified by HNO_3. B was isolated by microsublimation, and δ^{11}B measurement was carried out using a MC-ICP-MS (Neptune plus). The precision was within 0.3%. All values reported in this study are presented in delta notation relative to NBS SRM 951.

The concentrations of B in the hydrothermal fluids from Okinawa Trough were higher than those from sediment-starved MOR, and the δ^{11}B showed ^{10}B enrichments. A difference of δ^{11}B among Okinawa Trough hydrothermal fields was found; Yonaguni IV ‹ Izena Caldron ‹ Iheya North ‹ Hatoma Knoll. The δ^{11}B in the hydrothermal fluids showed the strong correlation with the carbon isotopic ratios of methane (δ^{13}C-CH_4) in the hydrothermal fluids, suggesting the factor controlling the variation of δ^{11}B in the hydrothermal fluids is identical with the one controlling the variation of δ^{13}C-CH_4 in the hydrothermal fluids. The controlling factor for the variation of δ^{13}C-CH_4 in the hydrothermal fluids is a mixing ratio between thermogenic methane and microbial methane, implying the controlling factor for the variation of δ^{11}B would be a mixing ratio between B derived from sediment at higher temperature and lower temperature.

We calculated the reaction temperature based on the correlated equation of reaction temperature with δ^{11}B fractionation between solid phase and aqueous phase. For δ^{11}B of the solid phase, reported δ^{11}B of surface sediment from Okinawa Trough (– 5.4 and – 2.2 ‰) was used. However, all observed δ^{11}B in the hydrothermal fluids could not be explained. Instead, δ^{11}B of solid phase was estimated between 50 and 400 ℃; the lowest temperature of leaching B from sediment is 50 ℃ and the highest temperature of sub-critical water is 400 ℃. δ^{11}B of sediment involved in B leaching was estimated to be from – 20 to – 10 ‰, which are lower than the δ^{11}B in surface sediment from Okinawa Trough. Hydrothermal alteration lowered δ^{11}B in sediment, suggesting the origin of the B in Okinawa Trough hydrothermal fluids would be altered sediment. For the reaction temperature, the lowest value among Okinawa Trough hydrothermal fluids was obtained in Hatoma hydrothermal fluids, following Iheya North, Izena, and Yonaguni IV, suggesting a large amount of sediment is distributed in recharge zone in Hatoma Knoll, and the B would be derived from the sediment at relatively low temperature. On the other hand, sediment is distributed in reaction zone beneath Yonaguni IV, and the B would be derived from the sediment at relatively high temperature.

Keywords: hydrothermal fluid, Okinawa Trough, boron isotope

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The structure of iron- and silica-rich mounds at hydrothermal environment in shallow marine, Satsuma Iwo-Jima

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Satsuma Iwo-Jima Island, located 38km south of Kyusyu, Japan, is a volcanic island in the northwestern rim of Kikai caldera. Iron- and silica-rich mounds develop with hydrothermal activity (pH=5.5, 50-60 degree Celsius) in Nagahama bay located southwestern part of the island. The brownish seawater at the bay is due to mixing of the hot spring water with seawater (Shikaura and Tazaki, 2001). Very high deposition rate (33 cm per year) of iron-rich sediments was observed in the bay (Kiyokawa et al., 2012). In this study, we analyzed samples (20-30 cm long) recovered from mounds at the seafloor of Nagahama bay by the observation with X-ray CT scan, FE-SEM, and the thin-sectioned sample, and the chemical analysis with EDS, XRF, XRD and DNA, and found that the structure of mounds has unique information.

Visual observation indicated that the samples were made from two layer: black high-density hard layer and brownish low-density soft layer. X-ray CT scan observation shows that the inside of samples is constructed from the aggregation of convex structure (3-4 cm). Soft layer is covered by a hard layer as a rim. The soft layer has many pipe-like structures (typical radius: 1 mm). Petrographic observations indicate that soft and hard layers have filament-like forms, and the form in soft layer is perpendicular to that in the hard layer. The number of small particles (about 20 μm) observed on filament-like forms in soft layer increases toward hard layer. FE-SEM observation shows that filament-like form in hard layer consists of aggregation of bacillus-like form as the chain of particle (about 2 μm). At soft layer, on the other hand, bacteria-like form with smaller particles ($<$0.5 μm) is observed. Bacteria-like form could be classified into 3 types (helix, ribbon-like, twisted). Furthermore, the result of XRD and XRF show that hard layer consists of ferrihydrite and opal-A (Si: 26.8%, Fe: 56.0%) and soft one is composed by ferrihydrite, opal-A, quartz, cristobalite and tridimite (Si: 36.5%, Fe: 43.5%). DNA analysis indicated predominance of *Mariprofundus ferrooxydans* that is known as iron-oxidizing bacteria belonging to Zeta-proteobacteria.

The forming process of the mounds at Nagahama bay is that firstly chemical and biological reaction made soft layer. During occurrence of the reaction, volcanic ash originating from Iwo-dake was contained as silica in the soft layer. Bacteria-like form in soft layer is considered to be the stalk made by iron-oxidizing bacteria according to the result of DNA analysis. Such neutrophilic iron-oxidizing bacteria prefers an environment of redox interface between hydrothermal water and seawater (Chan et al., 2011), and their activity made hard rim at outer soft layer. Inside of hard rim, the keeping of both reaction resulted in relative iron-rich layer and layering at hard rim. Because such process occurred repeatedly, the mounds at Nagahama bay had the aggregation of convex structure with many pipes as the hydrothermal vent. The high depositional rate of iron hydroxides is likely to be influenced by the activity of bacteria.

Keywords: hydrothermal activity, iron-hydroxide, iron-oxidizing bacteria, shallow marine