

Chemical characteristics of arc magma and seafloor sulfide deposits on back-arc spreading center and off-ridge volcanoes

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The arc basalt of Mariana Trough is characterized by fluid-dominated chemistry. Stolper and Newman (1994) suggested that the H₂O-enriched arc magma of the Mariana Trough could be formed as melting mixture between MORB-type mantle source and H₂O-rich component.

Backarc Spreading Center and the off-ridge volcanoes in Southern Mariana Trough are selected as one of the main targets of TAIGA Project, due mainly to four known active hydrothermal fields; Snail site (120°57.19'N, 143°37.16'E, depth:2861m) and Yamanaka site (120°56.64'N, 143°36.80'E, depth: 2823m) on the spreading-axis, Archean site (120°56.35'N, 143°37.89'E, depth: 2986m), and Pika site (120°55.13'N, 143°38.92'E, depth: 2773m) on the off-axis seamount. Nine BMS (Benthic Multi-coring System) drillings were conducted during the Hakurei-Maru No.2 cruise in June 2010.

Both basalt glasses and associated seafloor massive sulfide ores from these sites are analyzed for their major/minor element contents using ICP-MS. Multi-element plot of basalt glass indicates that both on-axis and off-axis basalts have similar pattern and are categorized as arc basalt and/or arc basaltic andesite. As, Ba, Pb and other elements in sulfide ores show systematic variation across the axis and reflect the influence of subduction zone fluids.

Keywords: Mariana Trough, backarc spreading, hydrothermal deposit, TAIGA project, minor element, incompatible element

Geomorphological and geological characteristics of hydrothermal system in the southern Mariana Trough

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To examine the relationship between geomorphological characteristics and hydrothermal activity, and relation of tectonic and volcanic control to hydrothermal system in the southern Mariana Trough, we investigated the five hydrothermal sites using near-bottom swath mapping data collected by SEABAT7125AUV on the AUV Urashima during the cruise YK09-08, and dive observation data acquired by the submersible Shinkai6500 during the cruise YK10-11. The principal findings are as follows. 1) The two on-axis hydrothermal sites (Snail and Yamanaka sites) are possibly locally developed on a 4th order spreading segment, in association with diking events. The three off-axis sites (Archean, Urashima, and Pika sites) appear to represent locations of sustained hydrothermal activity, which has created relatively large-scale hydrothermal features as compared with those observed in the on-axis area. The formation of off-axis hydrothermal sites likely closely related to an off-axis magma upwelling system, as evidenced by the absence of fault systems and the undeformed morphology of the mound and the knoll. 2) The three off-axis hydrothermal sites are mainly composed of breccias assemblages probably originated in hydrothermal activity with black smoker venting. In those areas, numerous ridge lines (height, mainly 1-6 m), conically-shaped mound (height, 50-100; diameter, 250-300m), and bumpy seabed texture are found, in contrast, the on-axis sites are characterized by no ridge lines, and white smoker and shimmering observed on dome-shaped pillow mound (height, 5-30 m; diameter, 250-320 m). Hence, distribution of the ridge lines, mound morphology, and bumpy seabed textures likely to correlate with hydrothermal activity.

Electromagnetic constraints on a melting region beneath the central Mariana back-arc spreading ridge

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An electrical resistivity profile across the central Mariana subduction system shows high resistivities in the region of upper mantle beneath the back-arc spreading ridge where melt is supposed to exist. The question arises as to why the 2D magnetotelluric (MT) experiment failed to image the melt at the place where seismic attenuation structures showed a signature of the melt but seismic velocity structures did not strongly show it. We have run forward models that test possible melt geometries that are consistent with other observations from the region, and that we use to place upper bounds on the possible extent of melt beneath the spreading center. The tests are carried out by examining the differences in MT response between a starting 2D model which is essentially the result of inversion of data from the region and models with 3D melt bodies superimposed on this background starting model. If differences in the predicted MT responses are above a threshold level determined by the uncertainties in the field data, then we argue that such a feature should be resolvable and therefore is not compatible with our data. Features which do not greatly perturb the MT responses, within the error, could be considered acceptable. The tests with the across-strike real data profile and an along-strike hypothetical data profile show that perturbations in the off-diagonal elements of the MT response behave similarly in both profiles, and that weak signals from melt bodies in diagonal elements of the MT response may not be detected within the observational error. Taking into accounting melting regions suggested by other geophysical studies, as well as the likely effects of melt focusing, the most likely melt region has a pyramid shape and a resistivity of 100 Ohm-m, whose value is close to a dry olivine on mantle adiabat and could indicate the interconnected silicate melt of ~1%-0.1%. In contrast to the superfast spreading southern East Pacific Rise, the 3D melt region with a modest detectable melt supply suggests that buoyant mantle upwelling is the dominant process beneath the slow-spreading central Mariana back-arc spreading ridge.

Appearance of iron-dependent chemosynthetic ecosystem at the Southern Mariana Trough

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Microbial community structures in deep-sea hydrothermal vent fields may be constrained by available energy yields provided by inorganic redox reactions. Variability of fluid geochemistry of deep-sea hydrothermal vents in three geographically different areas of the Southern Mariana Trough (SMT) have been reported, and an unparalleled microbiological dataset of various samples (i.e., sulfide structures of active vents, iron-rich mats, borehole fluids and ambient seawater) collected in these areas are available for comparative analyses. Here, we summarize the microbiological and geochemical characteristics in the SMT and assess the relationship between the microbial community structures and the fluid geochemistry in the SMT by thermodynamic modeling. In particular, aerobic sulfide-oxidation has the potential to yield large amounts of bioavailable energy in the vent fluids, which is consistent with the detection of species related to sulfide-oxidizing bacteria (such as *Thiomicrospira* in the Gammaproteobacteria and *Sulfurimonas* in the Epsilonproteobacteria). Notably, the bioavailable energy yield from aerobic iron-oxidation reactions in the fluids collected from man-made boreholes and several natural vents were comparable to or higher than those from sulfide-oxidation. This is also consistent with the detection of species related to iron-oxidizing bacteria (*Mariprofundus* in the Zetaproteobacteria) in such samples. The combination of microbiological, geochemical and thermodynamic analyses in the SMT will provide novel insights into the presence and significance of iron-based microbial ecosystems in deep-sea hydrothermal fields.

Keywords: Chemosynthetic ecosystem, Deep-sea hydrothermal vent field, Iron-oxidizing chemolithoautotrophic bacteria, Thermodynamic modeling, Crustal fluid

History of hydrothermal activity in the Mariana Trough estimated by population structure of vent-endemic snails

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A hairy snail *Alviniconcha hessleri* is endemic to hydrothermal vent fields in the Mariana Trough and the dominant species of chemosynthesis-based communities in this sea area. We analyzed the genetic population structure of this species using specimens collected at five vent sites in the Mariana Trough, namely, the Alice Springs Field in the central Mariana Trough, the Forecast Vent Field in the southern Mariana Trough, and the Snail, Archaean, and Urashima sites in the southernmost part of the trough. A local population of the Forecast Vent Field showed the highest genetic diversity among five local populations. Individuals of *A. hessleri* were divided into two genetically deviated groups. The first group contained more individuals and showed higher genetic diversity than the second group. Although individuals of both groups were collected at all five vent sites, frequency of the second group were very low in the Alice Springs Field. Both groups were shown to have experienced rapid expansion of population size and estimated ages of the expansion is older for the first group than the second one. Within the trough, the southward gene flow (larval dispersal) was estimated to be much larger than the northward one. Based on these results, we reconstruct the population history of this species, namely, the reduction of population size and the isolation between the local populations of the central and southern regions, genetic deviation between them, the expansion of the central population, and the expansion of the southern population. In this presentation, we discuss about the correspondence between the ages of these events estimated on the basis of the molecular phylogenetic analysis of provannids, which contains *A. hessleri*, and the history of hydrothermal activities estimated by geochemical studies.

Keywords: Marina Trough, *Alviniconcha hessleri*, population structure, history of hydrothermal activity

Population genetic structure of deep-sea vent chemolithoautotrophs

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Deep-sea hydrothermal fields are areas on the seafloor of high biological productivity fueled primarily by microbial chemosynthesis. Chemolithoautotrophic *Epsilonproteobacteria* with an ability to utilize inorganic substrates such as H₂S and H₂ are dominant in deep-sea hydrothermal vents around the world. Beside the non-pathogenic deep-sea chemolithoautotrophs, the class *Epsilonproteobacteria* contains important human pathogens, i.e. *Helicobacter pylori* and *Campylobacter jejuni*. These pathogenic *Epsilonproteobacteria* have extremely high frequencies of genetic mutation and horizontal gene transfer. Little is known, however, about deep-sea epsilonproteobacterial population genetic structure. In our previous study, we clarified that *Epsilonproteobacteria* Group B population were geographically separated, and that they had high mutation rates. However, there are still many questions to resolve, e.g. whether these trends are common to all epsilonproteobacterial subgroups and non-epsilonproteobacterial chemolithoautotrophs. In this study, we performed multi-locus sequence analysis (MLSA) on deep-sea vent chemolithoautotrophs of *Epsilonproteobacteria* Group A, B, F and the genus *Persephonella* to clarify their population genetic structures.

Chemolithoautotrophic strains used in this study were isolated from chimney structures, vent fluids, and hydrothermal sediments. The hydrothermal samples were collected from geographically separated hydrothermal areas of the South Mariana Trough, Okinawa Trough and Central Indian ridge. We carried out various population genetic analyses including the construction of phylogenetic trees, estimation of mutation and recombination rates based on sequences of various housekeeping genes.

The MLSA revealed that the deep-sea chemolithoautotrophs commonly had extensive genetic diversity and their population genetic structure were influenced by geographic location. In addition, we found that their genetic diversity were controlled by mutation rather than recombination.

In our presentation, we will discuss the biogeography and evolution of deep-sea chemolithoautotrophs.

Diversity of seafloor massive sulfide ores in the Okinawa Trough

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The Okinawa Trough is one of exploration target areas for seafloor mineral resources around Japan, where eight active hydrothermal fields have been discovered. Since the Okinawa Trough is located in the continental margin, these hydrothermal systems develop within sediment layer. Subseafloor hydrothermal fluid flow within sediment layer may enhance accumulation of hydrothermal precipitates and preservation of hydrothermal ores, therefore large size sulfide ore deposits are expected to be discovered in the Okinawa Trough.

In 2011, two dive expeditions were conducted under framework of Taiga project, focusing on studies of seafloor hydrothermal ore deposits in the Okinawa Trough. NT11-15 expedition conducted in August investigated Jade and Hakurei sites in the Izena Cauldron, and active sites in the Iheya North Knoll. NT11-20 expedition conducted from September to October visited Minami-Ensei Knoll, Yoron Knoll, Izena Cauldron, Irabu Knoll and Hatoma Knoll. In this presentation, we will discuss diversity and commonality of mineralogy and geochemistry among hydrothermal ores collected from these active hydrothermal fields.

In some active hydrothermal fields in the Okinawa Trough, occurrence of sulfide and sulfate deposits is separately observed. Only sulfate precipitates were observed in chimney structures above the seafloor, while sulfide deposits were observed in mound structures buried in the seafloor. This signature could be attributed to phase separation of hydrothermal fluid just beneath the seafloor. Phase separation generates two different types of (vapor-rich and brine-rich) hydrothermal fluid, which could be related with sulfate and sulfide mineralization.

Hydrothermal ore deposits in the Okinawa Trough are characterized as enrichment in Zn and Pb, which corresponds to dominant occurrence of sphalerite, wurtzite and galena. Among trace elements, enrichment in Ag is notable. Ag is mainly included in tetrahedrite being associated with replacement of As by Sb. These chemical signatures could be attributed to formation of hydrothermal ores at rather low temperature.

Keywords: hydrothermal activity, volcanic massive sulfide, seafloor hydrothermal ore, back-arc basin

Microbial community and activity beneath the hydrothermal vent at the Iheya North field of the Mid-Okinawa Trough

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Deep-sea hydrothermal fluid harbors peculiar microbial community apparently different from that in the ambient seawater. These distinctive microbes are regarded as messengers transported along hydrothermal vein from subvent biosphere. We have explored scientific drilling at the hydrothermal vent on the Iheya North field of the Mid-Okinawa Trough in Sept. 2010 (IODP Expedition 331) and collected core sample of subseafloor biosphere beneath the hydrothermal field.

IODP Site C0014 was located 450 m east off the main hydrothermal vent. Temperature exceeded the limit of life at the depth of approximately 40 m below the seafloor. Both microscopic and molecular-based analysis successfully detected microbial populations in the shallower zone at 20 mbsf. Microbial community definitely shifted according to physicochemical conditions of their habitat. Additionally, microbial activities of methanogenesis, anaerobic methane oxidation, and acetogenesis were consistent with the geochemical interpretations. These results represented the direct evidence of active subvent biosphere on the edge of uninhabitable zone beneath the hydrothermal vent.

Site C0017 located 1.6 km east off the hydrothermal vent is a potential seawater recharge zone of the hydrothermal system, where seawater penetrates into the oceanic crust. The lithostratigraphy consists of characteristic coarse angular pumiceous gravel, lying above and below hemipelagic mud, suggesting that this layer is probable main pathway of entrained seawater. As is the case with deep sedimentary environment, uncultivated archaeal groups were dominantly detected in the hemipelagic sediment above and below pumice layer. In contrast, ammonia oxidizing archaea of order Nitrosopumilales were outstandingly dominant at pumice layer of around 20 mbsf, possible because of oxidative seawater transport. Though hydrothermal components were not observed from the entire core of Site C0017, deeper layer at around 150 mbsf showed high temperature up to 90°C. There, microbial community structure was similar to that from limit of habitable zone of Site C0014. Our data suggests that high temperature gradient due to hydrothermal activity might be one of the control factors of gradual change of microbial community structure in the subvent biosphere.

Keywords: hydrothermal vent, subvent biosphere, methanogenesis, anaerobic oxidation of methane

Decrease of arsenate adsorption onto bacteriogenic iron oxides (BIOS) by the presence of organic material

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The adsorption behavior of trace elements onto iron (Fe) oxides has been well demonstrated for their importance in water chemistry. Especially, bacterial-induced Fe oxides (Bacteriogenic iron oxides: BIOS) are of common interest because of their ubiquity and characteristics of adsorption of various ions. Indeed, it is previously reported that the adsorption of heavy metal ions onto BIOS exhibited adsorption trend different from synthetic iron oxides [1]. In this study, arsenate adsorption behavior onto (A) synthetic ferrihydrite, (B) natural BIOS collected from Okinawa hydrothermal vent, and (C) synthetic BIOS obtained by incubation of iron-oxidizing bacterium (*Mariprofundus ferroxydans*) were compared. BIOS synthesis was performed using a set of diffusion cells by which we can obtain pure BIOS free from other inorganic and organic materials which are abundant in natural BIOS (e.g., silica, clay minerals, and other ions adsorbed on BIOS). Adsorption experiments were performed under sea water condition (I: 0.70 M; initial arsenate concentration: 70 mg/L; adsorbent: approx. 0.5 mg) as a function of pH 4-10. Iron mineral species of iron oxides were specified by Fe K-edge X-ray absorption fine structure (XAFS) [2] and adsorption structure of arsenate was examined by As K-edge XAFS analysis.

Iron K-edge XAFS analysis revealed that both natural and synthetic BIOS consisted mainly of ferrihydrite with 45-55 % of highly amorphous Fe hydroxides that is characterized by the primitive Fe hydrolysis stages. The crystal size was nano-scale which was smaller than the synthetic ferrihydrite. Thus, it was expected that BIOS should have more arsenate adsorption capacity than synthetic ferrihydrite. However, the amount of arsenate adsorbed onto each iron oxides decreased in the order of synthetic ferrihydrite > natural BIOS = synthetic BIOS with a same adsorption trend as a function of pH. XAFS and micro-XRF analysis indicated that arsenate was mainly adsorbed onto Fe phase within natural and synthetic BIOS forming inner-sphere complexation to the Fe oxides. These results were consistent with previous results on As adsorbed onto synthetic ferrihydrite. Contrary to their reduced crystal particle size, specific surface areas of synthetic BIOS was decreased by 25% from synthetic ferrihydrite, which is possibly caused by the coprecipitation of Fe oxides with organic materials [3]. Thus, it is suggested that strong aggregation of Fe particles by the presence of organic materials reduces (i) the surface area and/or (ii) the active adsorption site within BIOS, which may ultimately result in the decrease of the arsenate adsorption onto BIOS. These results also suggest that direct and indirect effects of organic materials should be taken into account to evaluate the anion adsorption onto BIOS.

[1] Katsoyiannis et al. (2006) *Water Research* 40, 3646.

[2] S. Kikuchi et al. (2011) *Chem. Lett.* 40, 680-681.

[3] Mikkuta et al. (2008) *Geochim. Cosmochim. Acta.* 72, 1111.

Keywords: iron oxides, arsenate, ferrihydrite, iron-oxidizing bacteria, XAFS, adsorption

Solid-water distributions of Mo and W in water-sediment system under various redox condition

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The concentration of W dissolved in the modern ocean is considerably lower than that of Mo, although Mo and W have similar chemical characteristics, since both elements belong to Group 6. It is considered that W is adsorbed significantly onto iron-manganese oxides, while in contrast Mo is difficult to adsorb on the iron-manganese oxide due to the difference in the surface complexes formed at the oxide surface (Kashiwabara et al., 2011). On the other hand, under the reductive ocean such as in the early earth, the concentration of these trace elements might be controlled by adsorption onto sulfides. In this system, it is assumed that Mo is adsorbed significantly onto the sulfide and is removed from seawater, while in contrast W is difficult to adsorb on the sulfide and dissolved in seawater. In other words, by the changes of redox condition due to the evolution of the atmosphere from low oxygen to high oxygen concentrations, the water solubilities of Mo and W in the primordial ocean are expected to be contrastive to the modern ocean. However, water solubilities of Mo and W under reductive ocean are not well known in particular from chemical process within the phenomena. Thus, purpose of this study is to clarify the solid-water distributions of Mo and W under reductive condition by adsorption experiments and analysis of marine sediments with their interstitial waters.

Based on the adsorption experiments, adsorption of Mo and W onto pyrite was larger at lower pH, possibly due to the larger positive charges induced at lower pH. However, it was found that adsorption distribution coefficient of Mo was about 8 times larger than that of W. XANES spectra showed that adsorption forms, or chemical species, of the both elements were also sulfide. However, the formation of Mo sulfide was not affected by pH, whereas formation of W sulfide did not proceed under high pH condition where W sulfide was not observed. Thus, the water solubility of W is most likely greater than that of Mo in the sediment under reductive condition.

The preference of formation of sulfur-bound species for Mo than W and larger affinity of Mo to the sulfide than W were the opposite result to what we found for their solid-water distributions under oxic condition. In the latter system, W forms more stable surface complex to iron-manganese oxides, which results in the larger solubility of Mo in water compared with W.

To confirm the suggestions from laboratory studies, abundances and speciation analyses were conducted for the hydrothermal water-sediment system in the mid-Okinawa Trough, especially for Mo. For the sediment samples, variation of chemical species of Fe and S estimated by their K-edge XANES indicates that redox condition became reductive at greater depth in the sediment. As a result of the distribution between sediment and interstitial water, a larger K_d values were obtained at deeper layer for Mo. In addition, XANES spectra indicated that dominant species of Mo was oxygen-bound species in oxidative shallow layer, while tetravalent sulfide was dominant in reductive deep layer.

Keywords: Molybdenum, Tungsten, Redox condition, Solubility, XAFS, Sediment

Experimental constraints on hydrogen generation and their linkage to the eco-system in ridge system

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Deep-sea hydrothermal vents were discovered in the late 1970s (Corliss et al., 1979; Edmond et al., 1979). Since then, they have been considered as a possible environment for the origin and early evolution of life on Earth (e.g., Yanagawa and Kojima, 1985; Russell and Hall, 1997). In addition, some researchers proposed that microbial ecosystems in the hydrothermal vents are primary producers which sustain most of the lives in the ocean (Jannasch et al., 1985 and our TAIGA project [<http://www-gbs.eps.s.u-tokyo.ac.jp/~taiga/en/index.html>]). It is important, therefore, to figure out the hydrothermal reactions in the ocean floor for better understanding of the ecosystems in the ocean. Especially hydrogen generation is one of the most crucial processes in the hydrothermal systems, because multidisciplinary studies suggest that the most ancient microbial ecosystems were originated and maintained in the vicinity of H₂-rich hydrothermal fluids (Russell and Hall, 1997; Sleep et al., 2004; Kelley et al., 2005; Canfield et al., 2006). Such communities are possibly composed of hyperthermophilic subsurface lithoautotroph methanogens (Takai et al., 2006).

The supply of abundant hydrogen to power such primary producers is the most likely coupled to hydrothermal serpentinization of ultramafic rocks. In the modern ocean, H₂-enriched hydrothermal fluids are commonly associated with slow-spreading mid-ocean ridge (MOR) setting dominated by peridotite (Kelley et al., 2001; Fruh-Green et al., 2004). The serpentinization of abyssal peridotite has been well investigated both experimentally and theoretically. The investigations indicate that the peridotite-water reaction provides an extraordinarily high concentration of H₂ in the fluids (e.g., Seyfried et al., 1979; Allen and Seyfried, 2003; McCollom, 2007; McCollom and Bach, 2009). In the Hadean and early Archean ocean, however, it is believed that peridotite would be scarce in the ocean floor, and komatiite - hydrothermal reactions are the possible mechanism of hydrogen generation in the ocean floor. Yoshizaki et al. (2009) experimentally revealed that abundant H₂, equivalent to H₂ abundance in the peridotite-hosted hydrothermal solutions, was produced in komatiite alteration. On the other hand, the fault-related H₂ generation has been found by the gas monitoring along surface trace of the active Yamasaki fault (Wakita et al., 1980) and more from the drilling cores near hypocenters of micro-earthquakes along the San Andreas Fault (Erzinger & Wiersberg, 2008). Recently, we showed using our friction experiment system that abundant H₂ generation in the fault systems readily occurs (Hirose et al., 2011).

In this contribution, I will briefly introduce the results obtained in our laboratory experimental systems, both hydrothermal and simulated fault types.

Keywords: experiment, hydrogen generation, hydrothermal system, ecosystem, ridge

Electrical resistivity structure of the upper mantle beneath the southern Mariana Trough

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In the Southern Mariana Trough, the seafloor spreading rate is 45km/Myr at present (Kato et al., 2003) that is relatively slow, but there are characteristics of the fast spreading ridge. Specifically, the southern Mariana region has an axial topographic high (Martinez et al., 2000) and a low-gravity region under the spreading axis associated with high magmatic activity as well as a sheet-like mantle upwelling (Kitada et al., 2006). In this study, we carried out an electromagnetic experiment along a profile across the spreading axis to estimate an electrical resistivity structure and hence the physical property like temperature, water and melt content in the upper mantle beneath the Southern Mariana Trough. The experiment was carried out with 11 Ocean Bottom Electro-Magnetometers (OBEM), which were deployed on a 126km length survey line across the spreading axis. Time-variation of electric and magnetic fields are obtained from recovered 10 OBEMs. The observation period is from August 2010 to November 2010, the data was recorded for ~85 days in two OBEMs and for ~60 days in the rest of the OBEMs. In this presentation, we show a result of an investigation of a 2-D electrical resistivity structure using OBEM data with good quality at 8 sites. The magnetotelluric (MT) method is a base for the data analysis. We performed an inversion analysis of the electrical resistivity structure by using an upper boundary of the subducted slab inferred from a seismic research (Gudmundsson and Sambridge, 1998) as a prior constraint. This structure shows that the resistivity gradually decreases with distance from the Mariana Trough. Especially, at depths less than 40km the trenchward region has higher resistivity (300 Ohm-m) than the opposite side (30 Ohm-m). The less resistive region prevails below the spreading center.

Keywords: resistivity structure, the southern Mariana, upper mantle, subduction zone

Decay of natural remanent magnetization of oceanic basalt on the back-arc spreading axis in the southern Mariana

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Magnetic anomaly high on a spreading axis has been a well-known character of the magnetic anomalies in the ocean, which is mainly related to magnetization intensity reduction of oceanic basalt due to alteration (low-temperature oxidation of titanomagnetite). For a better understanding of natural remanent magnetization (NRM) of oceanic basalt, we studied NRMs of basaltic rocks in the back-arc spreading axis in the southern Mariana. One to four meter cores were drilled from the seafloor by using a BMS in the cruise of TAIGA project (Taiga10M). Block samples were also collected during the dives of SHINKAI6500 in the cruise YK10-11. NRM intensities of these samples show a clear decrease within 2 km from the ridge axis. This value is consistent with a reported value in East Pacific Rise. These data suggest that the alteration has completed within 2 km distance from the ridge axis. Consistent scales from different ridges suggest that the NRM intensity reduction, which can be also observed as magnetic anomaly variation, may be related to the structure of ridge axis, for example, active hydrothermal circulation zone. Discussions of previous studies assume that the alteration process of ocean basalt is associated with age.

Keywords: oceanic basalt, natural remanent magnetization, magnetic anomaly, Mariana, hydrothermal circulation, TAIGA project

Crustal magnetic structure around the hydrothermal fields in the Southern Mariana Trough

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Seafloor hydrothermal systems are important in relation to global heat and chemical fluxes as well as habitat of microbial communities. Circulation of fluids within oceanic crust depends on the geometry of heat source, the composition of rock as permeable medium and seawater. The substantial variation of hydrothermal systems active in various tectonic setting has important implications for the magnetic structure of oceanic crust.

It has been very difficult to detect the geophysical signature of hydrothermal systems based on crustal properties because the small scale of hydrothermal systems compared to distance between surface and bottom imposes limitation of resolution on the sea surface observation. The advance of near-bottom survey methods using a submersible, deep-tow, ROV and AUV has made possible high resolution geophysical mapping around hydrothermal areas. Near-bottom magnetic survey can provide direct information on the magnetization of shallow part of oceanic crust, implying the hydrothermal alteration both in active and fossil vent sites.

Near-bottom three component magnetic measurements on submersible Shinkai 6500 were carried out at three hydrothermal fields in the Southern Mariana Trough, the slow spreading backarc basin. We investigated the magnetic structure of three hydrothermal systems (Pica, Snail and Archean) to clarify how the geophysical and geological setting controls the fluid circulation in the small scale here.

The 14 dive surveys were conducted successfully during R/V Yokosuka YK11-10 and YK10-11 cruise. A fluxgate magnetometer was attached to Shinkai 6500. Four dives (dives 1218, 1220, 1227 and 1228) were devoted to the Snail site located in nearest to the backarc spreading axis. Among those dives, dive 1227 crossed the axial volcanic zone, providing a ~2km long NW-SE transect. The other five dives (dives 1216, 1217, 1221, 1223 and 1224) were conducted around the Archean site, forming a ~60m high mound at the foot of ridge crest. The remaining four dives (dives 1214, 1219, 1222, 1225 and 1226) were done at an off-axis seamount where the Pica site was located. Dives 1214 and 1219 mainly cover the northern slope of this seamount and lead to the discovery of a new vent site (Urashima Site).

The observed data were first corrected for the effects of induced and permanent magnetizations of the submersible, based on Isezaki [1986]. To find plausible correction coefficients, we adopted the dumped least-square method (Honsho et al., 2009). The International Geomagnetic Reference Field (IGRF) is subtracted from the corrected data to obtain the geomagnetic anomalies. The crustal magnetization will be estimated using the AUV-collected high resolution bathymetry.

Keywords: Southern Mariana Trough, backarc basin, hydrothermal system, near-bottom magnetic measurement, crustal magnetization

U-Th radioactive disequilibrium dating of hydrothermal sulfide minerals from Okinawa and South Mariana Trough

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The time scale for a hydrothermal activity is an important factor controlling the size of hydrothermal ore deposits (Tivey, 2007) and the evolution of chemosynthesis-based communities in a submarine hydrothermal system (Watanabe et al., 2005). Many dating techniques using radioactive disequilibria of ²³⁵U, ²³⁸U, and ²³²Th decay series have been applied for hydrothermal submarine ore deposits (Lalou et al., 1993, Kadko, 1996). As one of several possible decay systems, ²³⁰Th-²³⁴U disequilibrium dating uses the increase of (²³⁰Th/²³⁴U) (parentheses denote activity ratios), which starts from zero in hydrothermal deposits. The maximum dating range of this method is up to 450 kiloyears (kyr). The system has been applied for massive sulfide mounds from Transatlantic Geotraverse (TAG) deposit on the mid-Atlantic Ridge using a thermal ionization mass spectrometer (TIMS), which yields a wide range of ²³⁰Th-²³⁴U ages: 2.6-38 kyr. Results show that episodic activities lasting more than 30 kyr in the TAG area which is positioned on a slow spreading ridge.

We will analyze several fractions of a sulfide crust collected from the South Mariana Trough and Okinawa Trough using ²³⁰Th-²³⁴U method by MC-ICP-MS.

The samples used in this study contain high amounts of sulfide and barite. Pb and Ba causes analytical interferences for U and Th isotope analyses, thus a good separation of the two elements is necessary. A two stage column chromatography was therefore used for the separation process.

The sulfide mineral from Izena hole of Okinawa Trough yielded ages ranging from 700 to 1000 years. Archean site of Mariana Trough yielded ages ranging from 0 to 2450 years with high U/Th ratio. Pika, Urashima and Snail site yielded ages ranging from 250 to 5000 year.

Keywords: hydrothermal vent, U-Th radioactive disequilibrium dating, Okinawa Trough, South Mariana Trough

Distribution of hydrothermal clay minerals in cores obtained by TAIGA 11 cruise from the Middle Okinawa Trough

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Intense hydrothermal fluid-sediment interactions are expected to occur below seafloor of active hydrothermal fields in the Middle Okinawa Trough, since these fields are covered with thick volcanic sediment which consists mainly of hemipelagic mud and pumiceous sediment. We investigate distribution of hydrothermal clay minerals in the sediment layer at these areas, in order to discuss physical and chemical environment below the seafloor.

In June 2011, the TAIGA 11 cruise was conducted using the R/V Hakurei-maru No.2 (Japan Oil, Gas and Metals National Corporation (JOGMEC)). We drilled 7 holes using the Benthic Multicoring System (BMS) and collected 2 cores using a large-diameter gravity corer (LC) in the Iheya North Knoll and the Izena Cauldron. Sub-samples were collected from the obtained cores at 5 to 10 cm intervals. Mineralogy of the samples was studied by analyses using XRD (X-ray diffraction) and EPMA (Electron Probe Micro Analyzer). Clay fractions (< 2 micrometer) were obtained from suspending bulk samples in distilled water and analyzed in detail. Oxygen and hydrogen isotope composition of the clay minerals was determined for some samples.

At the Iheya North Knoll, we drilled one hole using BMS (BMS-I-4. Drilling depth was 453 cmbsf). BMS-I-4 core comprised grayish white hydrothermal altered mud below 10 cmbsf. XRD and EPMA analysis indicated that the core was mainly composed of kaolin mineral. In addition to kaolin mineral, sphalerite and galena were found below 240 cmbsf, and sphalerite and dolomite were found in sediment plugged in a core catcher.

Occurrence of kaolin mineral has not been common in other seafloor hydrothermal active area and reported only at the Jade hydrothermal field in the Izena Cauldron by Marumo and Hattori (1999). However recently, kaolin mineral was dominantly found in a shallow depth at the Iheya North Knoll by drilling during the Integrated Ocean Drilling Program (IODP) Expedition 331 (Miyoshi et al., Clay Science Forum, 2011). These results suggest that kaolin mineral distributes laterally in a shallow depth below the seafloor at the Iheya North Knoll. Occurrence of kaolin mineral is rather common in onland geothermal areas, especially around acid springs caused by steam heating that is considered to be related with boiling of the deep hydrothermal fluid. In the Iheya North Knoll, venting fluid chemistry was explained by boiling of deep hydrothermal fluid beneath the seafloor (Kawagucci et al., 2011). Based on this analogy, occurrence of kaolin mineral at the Iheya North Knoll would be attributed to acid condition caused by vapor-rich component deriving from boiling of deep hydrothermal fluid below the seafloor.

At the Izena Cauldron, we drilled one hole using BMS (BMS-J-2. Drilling depth was 530 cmbsf) and collected one core using LC (LC-J-2. 330 cmbsf) near the Biwako Vent site (BV site), which is located in the lower part of the slope in the Jade hydrothermal field. BMS-J-2 core comprised grayish white or gray hydrothermal altered mud below 380 cmbsf and XRD analysis found chlorite and sericite. LC-J-2 core comprised grayish gray hydrothermal altered mud below 280 cmbsf and was mainly composed of K-feldspar and chlorite below 300 cmbsf.

Chlorite and/or sericite were found in the BMS-J-2 and LC-J-2 cores collected near the BV site. This clay mineral assemblage near the BV site is different from that in the Black Smoker Chimney site (BSC site) which is located in the higher part of the slope in the Jade field. In the BSC site, kaolin mineral, smectite and sericite were found in surface sediment (Miyoshi et al., the Blue Earth Symposium, 2011). This different assemblage of clay minerals may reflect different physical and chemical environment below the seafloor of these two sites; for example low temperature and acid environment in BSC site and high temperature and alkaline environment in the area around BV site.

Keywords: Seafloor hydrothermal system, Iheya North Knoll, Izena Cauldron, Benthic Multicoring System (BMS), Hydrothermal alteration, Kaolin mineral

Growth rate determination of ferromanganese crusts from the Takuyo Daigo Seamount using an osmium isotope stratigraphy

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A ferromanganese crust (Fe-Mn crust) is widely distributed on the seamount slopes and is recognized on the ocean floor at various depths throughout the world. Since a Fe-Mn crust precipitates from ambient seawater at an extremely slow rate, one thick Fe-Mn crust sample solely records paleocean environmental changes through the Cenozoic period. In order to unravel paleocean environmental changes using a Fe-Mn crust, the sedimentary age of a Fe-Mn crust is required. Previous studies proposed that the Os isotope stratigraphy is a reliable dating method for a Fe-Mn crust throughout the Cenozoic period (e.g., Klemm et al., 2005, 2008). In this study, we determined the Os isotope profile of Fe-Mn crusts from the Takuyo Daigo Seamount (#5 Takuyo Smt) to estimate its growth rate. Our samples were systematically collected from the seamount outcrops using ROV Hyper Dolphin / RV Natsushima during the NT09-02 Leg.2 Cruise.

The Os isotope compositions of three Fe-Mn crusts collected from different depths (1424, 1440 and 2987 mbsl) show a similar trend and coincide very well with that of marine Os isotope record from present ($^{187}\text{Os}/^{188}\text{Os} \sim 1.02$) to 12 Ma ($^{187}\text{Os}/^{188}\text{Os} \sim 0.77$). These results indicate that the growth rates of Fe-Mn crusts in the #5 Takuyo Smt are uniform (ca. 3 mm/My) regardless of water depths which is consistent with the age constraints of the Be-10 dating method. However, in the older part (bottom part near the basement rock) of the two Fe-Mn crusts collected from 1424 and 1440 mbsl, the Os isotope compositions have large deviations from the seawater Os isotope record reconstructed from metalliferous sediment cores (Ravizza & Peucker-Ehrenbrink 2003). Moreover, the Fe-Mn crust collected from 2987 mbsl totally lacks the section older than 12 Ma. These large deviations can be explained either by the occurrence of growth hiatus or secondary geochemical modifications by phosphatization.

It is turned out that Fe-Mn crusts of the #5 Takuyo Smt. are appropriate material to reconstruct the paleocean environmental changes continuously from present to 12 Ma. In this presentation, we also discuss the secular and temporal variations in the major and trace element geochemical compositions of the Fe-Mn crusts together with the Os isotope compositions.

Keywords: ferromanganese crust, growth rate, osmium isotope, Takuyo Daigo Seamount, geochemistry, paleoceanography

Reactivity of chromate, molybdate, and tungstate on ferrihydrite by XAFS and molecular orbital calculation

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Hexavalent Chromium (Cr(VI)) has serious toxicity and carcinogenicity with high mobility in aquatic system. Therefore, fundamental understanding of the adsorption mechanism of chromate to ferrihydrite, an important adsorbent in natural systems, is essential to discuss their scavenging behavior. Although molybdenum (Mo) and tungsten (W) are congeners with Cr, the adsorption mechanisms (inner- or outer-sphere complexation) on ferrihydrite are different: molybdate forms outer-sphere complex, but tungstate forms inner-sphere complex (1). However, adsorption mechanisms of Cr(VI) on ferrihydrite is unknown. In this study, we performed extended X-ray absorption fine structure (EXAFS) analysis and *ab initio* molecular orbital (MO) calculations to reveal adsorption mechanisms of chromate and the results were compared with those for molybdate and tungstate.

Based on the adsorption experiments, adsorption amount of chromate was determined using inductively coupled plasma mass spectrometry (ICP-MS). EXAFS analysis was used to clarify coordination environment of chromate on ferrihydrite measured at BL-12C in Photon Factory (Tsukuba, Japan). In addition, *ab initio* MO calculations were performed for the oxyanions (chromate, molybdate, tungstate) with Fe-(oxyhydr) oxide cluster model to obtain adsorption energy of outer-sphere complex and hydration energy of these oxyanions.

From the EXAFS analysis, Cr-Fe shell was observed for chromate on ferrihydrite in pH 4 and pH 6 spectra, while the spectrum at pH 8 was almost identical to that of chromate solution. However, the contribution of Cr-Fe shells at pH 4 and pH 6 are considered small degree because of low coordination number (CN) value. Hence, it is suggested that chromate mainly forms outer-sphere complex on ferrihydrite. Adsorption amount of chromate decreased as the ionic strength increased, which can be regarded as another evidence of the formation of outer-sphere complex. From *ab initio* MO calculations, stabilities of hydration complex in water and outer-sphere complex on ferrihydrite decreased in the order of chromate > molybdate > tungstate. Based on these results, it is suggested that it is relatively less stable for tungstate to form hydration and outer-sphere complexes, which allows us to conclude that chromate and molybdate prefer to form outer-sphere complexes, whereas tungstate to inner-sphere complex.

(1) Kashiwabara et al (2011) *Geochim. Cosmochim. Acta* **75**, 5762-5784.

Keywords: Chromium, Ferrihydrite, Adsorption, XAFS, Molecular orbital calculation

Mineralogy and geochemistry of hydrothermal ores collected from active hydrothermal fields in shallow water depth

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Since boiling is inhibited by hydrostatic pressure, hydrothermal fluid circulates below the seafloor in a liquid phase that can dissolve much amount of elemental species. Metal elements transported by the hydrothermal fluid precipitates near the seafloor due to cooling, which results in formation of seafloor massive sulfide ore deposits. If hydrothermal activity develops at shallower water depth, the boiling point is limited to lower temperature. Since solubility of metal elements is strongly controlled by fluid temperature, the limitation of fluid temperature would affect mineralogy of hydrothermal ores precipitated at rather shallow water depth. In order to find this influence in natural systems, we studied mineralogy and geochemistry of hydrothermal ores collected from two active hydrothermal field in the Okinawa Trough, both are located at water depth shallower than 1000 m.

Hydrothermal ore samples were collected during NT11-20 expedition using ROV Hyper-Dolphin (JAMSTEC), from Minami-Ensei Knoll at water depth around 700 m, and from Yoron Knoll at water depth around 600 m. Dominant minerals in the ores were determined by XRD (X-ray diffraction) analysis. To identify minor minerals and to determine chemical composition of the representative minerals, EPMA (Electron Probe Micro Analyzer) analysis was conducted. Neutron activation analysis was conducted to determine bulk content of some trace elements.

Major sulfide and sulfate minerals commonly found in the hydrothermal ores were barite, sphalerite, galena, pyrite, chalcopyrite, stibnite, orpiment, tetrahedrite and Pb-Ag-Sb sulfide mineral. A few ores included covellite and Ag-S sulfide mineral as trace mineral. The tetrahedrites showed diversity in chemical composition. Ag content of the tetrahedrites was 0 to 2.8 atm% for the ores from Minami-Ensei Knoll and 2.6 to 9.5 atm% for those from Yoron Knoll. It is well known that higher Ag content in a tetrahedrite is related with replacement of As by Sb in higher proportion. This tendency was confirmed among the ores we studied. FeS content in ZnS is known as an indicator for oxidation-reduction environment during ore formation. FeS/ZnS ratio was 0 to 3.2 mol% for the ores from Minami-Ensei Knoll and 0 to 2.7 mol% for those from Yoron Knoll. The low FeS content would reflect formation under rather oxidative circumstances.

Keywords: Seafloor massive sulfide, tetrahedrite, sphalerite, Okinawa Trough

Ecological effect of hydrothermal plume on deep sea environment

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Seafloor is one of the largest interface of the biosphere in the earth. Interfaces among the subsystem of the earth, e.g. atmosphere, land, sea, and subseafloor, produce energy potential that harbors life. Hydrothermal plume assume the major flux of heat and chemicals between sea and subseafloor. In the TAIGA project, we investigated ecology in the hydrothermal plumes. We found that 1.) the microbial population was closely correlated with the chemical composition of hydrothermal fluid and 2.) the major microbes in the plume were putative sulfur oxidizer SUP05 and methane oxidizer Methylococcus. On the other hand, hydrothermal plume of Hakurei site at Izena hall and Pika site at southern Mariana trough harbors fewer microbial populations, which expected by their chemicals in hydrothermal fluid. Based on these microbial information, we will discuss the variety of hydrothermal systems in subduction zone.

Electrical resistivity structure of a seafloor hydrothermal system at the southern Mariana Trough spreading axis

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The electrical resistivity structure of the shallow crust is sensitive to the porosity of the crust and seawater temperature within the crustal pore. Therefore, by revealing the electrical resistivity structure of the shallow crust around a hydrothermal system, we can reveal the horizontal and depth distribution of seawater associated the hydrothermal system. In this study, we estimated the electrical resistivity structure around the southern Mariana Trough spreading axis (Snail site; 12.57°N, 143.37.2°E) with the Magnetometric Resistivity (MMR) method which is effective to reveal the shallow (~1000m) electrical resistivity structure. The MMR survey was carried out during the KR03-13 cruise of R/V Kairei from Japan Agency for Marine-Earth Science and Technology (JAMSTEC). The vertical bipole source was applied between two electrodes near the sea-surface and just above the seafloor to generate an artificial electric current. Five Ocean bottom electro-magnetometers (OBEMs) were deployed as receivers around the active hydrothermal site to record variations of magnetic field induced by currents flowing into the crust. We determined the one-dimensional crustal electrical resistivity structure by the method of least square by comparing the observed amplitude of induced magnetic field with the analytical solution of Edwards et al. (1981, 1984). Also, we determined the three-dimensional crustal electrical resistivity structure by the trial-and-error method using three-dimensional forward modeling (Tada et al., in prep.) to reproduce the distribution of the magnetic field anomaly. Magnetic field anomaly was calculated from differences in the amplitude between the observation and the prediction from the one-dimensional model determined by the method of least square. We determined the one-dimensional crustal electrical resistivity of 5.6 Ohm-m to a depth of 1500m. We estimated the temperature of crustal pore fluid between 0 and 390 deg C, and increases with depth, from 5.6 Ohm-m uniform structure, a crustal porosity profile at the Hole 504B (Becker, 1989), and Archie's law (Archie, 1942). We also estimated the three-dimensional crustal electrical resistivity structure around the hydrothermal site based on the uniform one-dimensional model. We found that there are four low crustal electrical resistivity regions around the hydrothermal site. These regions have the resistivity of 0.6 Ohm-m, expose at the seafloor, and these maximum depth is 200m. One low resistivity region is located near the Snail site and the others are away to northwest by ~350m from the Snail site. The low resistivity regions of 0.6 Ohm-m correspond to the temperature of crustal pore fluid of between 109 and 148 deg C, is constant at a depth of 200m from the seafloor. If the temperature of pore fluid in the region with the resistivity of 0.6 Ohm-m is supposed to be 0 deg C, which was estimated to be the temperature of pore fluid in the uniform 5.6 Ohm-m resistivity region, the porosity of this region is required to be approximately 60%. However, the crustal porosity of approximately 60% is not realistic because crustal porosity at a young crust is observed to be 34% (Pruis and Johnson, 2002). Therefore, the low crustal electrical resistivity regions suggest the existence of hot pore fluid because the highest porosity region can not have low crustal electrical resistivity. We conclude that there are four low crustal electrical resistivity regions which suggest the existence of hot pore fluid around the Snail site, one is near the Snail site and the others are away to northwest by ~350m from the Snail site.

Keywords: Southern Mariana Trough, seafloor hydrothermal system, Magnetometric Resistivity method

Evaluation of redox condition by selenium speciation coprecipitated with barite

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Barite (BaSO₄) preserved in marine sediments can maintain its crystalline form at wide range of temperature, which can be present in hydrothermal vent. Barite crystals coprecipitated in seawater contain some elements that may reflect the physico-chemical condition of the seawater from which they are formed. Selenium dissolves mainly as selenite (SeO₃²⁻) or selenate (SeO₄²⁻) in seawater, where the valence of selenium depends on the redox condition. Sulfate ion is stable in wide range in the Eh-pH diagram of sulfur, and the range include the Eh-pH boundary of selenite-selenate in the Eh-pH diagram. Therefore, the oxidation state of selenium in barite can provide information on the redox condition in the depositional environment. The purpose of this study is to establish a method to estimate the redox condition in the environment where barite is precipitated.

Coprecipitation experiment of selenium with barite was conducted to clarify the relationship between selenate/selenite rates in synthetic seawater and in barite. After this experiment, the precipitates of barite and aqueous phase were separated by filtration with a 0.20 μm micro-meter filter (mixed cellulose ester, Advantec). Total concentrations of selenium in the remaining solution and precipitates were measured by ICP-MS to determine the apparent distribution coefficient (K_d) of selenium between barite and seawater. The selenate/selenite ratios in the solution and in the precipitates were measured by HPLC-ICP-MS and X-ray absorption near-edge structure (XANES) at the selenium K-edge, respectively. Micrometer scale distribution and oxidation state of selenium in barite formed in marine sediments in Okinawa hydrothermal vent was determined by μ-XRF- XAFS in natural samples.

The XANES results showed that selenite was preferentially incorporated into barite rather than selenate. Selenate can be incorporated only when the selenate/selenite ratio is over 0.9 in the aqueous phase. The apparent distribution coefficient of selenium was reduced by increasing selenate/selenite ratio in the aqueous phase. These results are caused by the preferential incorporation of selenite into barite due to the high stability of Ba-selenite complex compared with Ba-selenate complex.

Based on the relationship, the redox condition of the interstitial water in the sediment was estimated. The μ-XRF-XAFS result showed that selenate fraction was 60% for the barite in the sediment. The result suggests that the seawater from which barite was precipitated was under oxic condition. This result is consistent with the redox condition of the sediment suggested by iron and sulfur XANES results in the same sample, which showed that the environment was highly oxic.

Keywords: barite, selenite, selenate, redox condition

Geochemistry of pore fluids collected from active hydrothermal fields in the mid-Okinawa Trough

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TAIGA11 Expedition was conducted in June, 2011 to investigate seafloor environment below active hydrothermal fields by direct access using a shallow drilling system. Three active hydrothermal fields at Iheya North Knoll (27°47'N, 126°54'E), at Izena Cauldron Jade site (27°16'N, 127°05'E) and at Izena Cauldron Hakurei site (27°15'N, 127°04'E) were selected as exploration targets. The expedition focused on a seafloor hydrothermal fluid circulation system that develops in sediment consists of volcanoclastic and hemipelagic materials. In this presentation, we will report geochemistry of pore fluids extracted from the obtained core samples and discuss evidence for intrusion of the hydrothermal component and for hydrothermal interactions.

Shallow drillings during TAIGA 11 Expedition was conducted using a BMS (Benthic Multi-coring System) that was loaded on R/V Hakurei-maru No.2. In addition to the BMS drilling, we also conducted coring using a large diameter gravity corer (abbreviated as LC) during bad sea condition. Pore fluid extraction from sub-sampled sediment was conducted onboard as soon as possible after core recovery. Three to eight sub-samples of 20 to 50 cm³ in volume were collected every one meter from the core samples. The extracted pore fluid were divided into sub fluid samples and provided for analysis of major elements, trace elements, organic species, and specific isotope measurements. Sub sediment samples for gas species analysis were collected directly from the obtained core, those were kept in a glass vial and provided for headspace gas analysis. Chemical analysis of major species was conducted in following methods; Onboard colorimetry (molybdene blue method) for Si, ICP-AES after 200 times dilution of an acidified sample for Na, Mg, Ca, atomic absorption spectrophotometry after 200 times dilution of an acidified sample for K, ion chromatography after 300 times dilution for SO₄, silver titration (Mohr method) for Cl, onboard electrode measurement for pH, onboard acid titration for alkalinity, and onboard colorimetry (indo phenol method) for NH₄.

In the Iheya North Knoll hydrothermal field, one BMS drilling and one LC coring were conducted. Core of BMS-I-4 (drilling depth: 453 cm) comprised grayish white hydrothermal altered mud that was identified as kaolin mineral, below 10 cmbsf (Miyoshi et al., this meeting). Pore fluid from the corresponding depth showed enrichment in major cations (Na, K, Ca and Mg), which may be explained by leaching during the hydrothermal alteration. Pore fluid chemistry also showed evidence for sulfate reduction in the sediment layer, such as high alkalinity and existence of hydrogen sulfide.

In the Jade site in the Izena Cauldron, three BMS drillings and one LC coring were conducted. Core of BMS-J-2 (drilling depth: 529 cm) comprised grayish white or gray hydrothermal altered mud below 370 cmbsf (Miyoshi et al., this meeting). Unfortunately, pore fluid could not be extracted from this alteration layer. Pore fluid collected from the shallower layer showed similar major element composition to that of seawater.

In the Hakurei site in the Izena Cauldron, two BMS drillings were conducted. Core of BMS-H-1 (drilling depth: 610 cm) showed evidence for sulfide/sulfate mineralization below 223 cmbsf. Pore fluid from corresponding depth show enrichment in Si, K, Ca and NH₄, which could be attributed to intrusion of the hydrothermal component. This result suggests the mineralization is related with fluid mixing between the hydrothermal component and seawater component within the sediment layer beneath the seafloor.

Keywords: Seafloor hydrothermal activity, hydrothermal component, hydrothermal fluid interaction, ocean floor drilling, pore fluid

Hydrothermalreaction between NaCl fluid and felsic rock collected from the Hatoma knoll, Japan

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Many active hydrothermal fields exist in the Okinawa trough, Japan, where the seafloor is spreading due to a rifting activity of back-arc basin. The trough is covered with both hemipleagic and volcanic sediments and hosts a number of hydrothermal sites that form black smoker type metal-rich sulfide chimneys.

To clarify the generation mechanism of high-temperature hydrothermal fluid in the felsic rock-hosted system, we are conducting a hydrothermal experiment simulating the water/rock reaction under an elevated temperature/pressure condition. As a starting material, we use a volcanic rock collected from the Hatoma knoll hydrothermal vent field during the NT11-20 cruise. The rock sample and a NaCl fluid are reacted at 325 degree C and 300 bars over 1,080 hours. Although the experiment is still continuing, we will present the preliminary results such as the time variation of the composition of the reacted hydrothermal fluid.

Keywords: Hydrothermal alteration experiment, Hatoma knoll, Felsic rock

Comparative analysis of microbial community on ferro-manganese crusts from Takuyo-Daigo seamount and Ryusei seamount

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Purpose

Ferro-manganese crusts (Mn crusts) are the rocks covered with iron and manganese oxides and are widely distributed on the seafloor. Due to rapidly depleting land-based mineral resources, oceanic mineral deposits gain greater significance. Mn crusts are known for enrichment of several transition metals like Cu, Ni, Fe, Co, Pt etc. They are abundant in the seafloor and it is expected that they contribute greatly to the material circulation between hydrosphere and lithosphere. The microbes inhabiting the surface of the crusts may have a major role in the material circulation, especially on carbon and nitrogen. Previous electron microscopic observations demonstrated the existence of microbes on Mn crusts. However, there is a lack of molecular studies on species diversity and abundance. Thus, a comparative study was undertaken to analyze the diversity and abundance of microbes on the Mn crusts from Takuyo-Daigo seamount and Ryusei seamount

Method

Mn crusts, ambient sediments and seawater were collected from four sampling points at Takuyo-Daigo Seamount NT09-02 cruise in Feb 2009. The water depth of each sampling point was 1200 m, 1419 m, 2209 m and 2991 m, respectively. Mn crusts, ambient sediments and seawater were collected from two sampling points at Ryusei seamount on KY11-02 cruise in Feb 2011. The water depth of each sampling point was 1194 m, 2079 m, respectively. DNA was extracted from each sample, followed by amplification of 16S rRNA gene and *amoA* (ammonia monooxygenase, subunit A) gene using universal primers and bacterial/archaeal *amoA* specific primers respectively. Clone libraries were constructed and nucleotide sequences were determined. The microbial community compositions and diversity were analyzed by phylogenetic and statistical analysis. Copy numbers of the 16S rRNA and *amoA* genes of bacteria and archaea were estimated by quantitative PCR.

Result and Discussion

Quantitative PCR estimated that both bacterial and archeal abundance in the ferro manganese crust from the Takuyo-Daigo were about 10^6 to 10^7 cells/g, respectively. Archaea was dominated in the three of four Mn crust samples (50~83 % of total cell numbers) analyzed.

Comparing the microbial community of Mn crusts, sediment and seawater it is evident that Mn crusts consist of a significantly different microbial composition from the others, suggesting the uniqueness of the ecosystem.

Phylotypes closely related to Marine crenarchaeota Group I (MGI) were detected from six Mn crust samples, collected from the two seamounts. MGI includes ammonia oxidizing archaean which is distributed ubiquitously in the ocean. Phylotypes closely related to *Nitrosospira*, an ammonia oxidizing bacteria were present in four Mn crusts sample collected from the Takuyo-Daigo seamount. Abundance of the ammonia oxidizers were confirmed by sequencing and quantitative PCR analysis of bacterial and archaeal *amoA* gene. The copy number of bacterial and archaeal *amoA* gene was estimated as 10^5 to 10^6 copy/g.

This study demonstrated a high abundance of ammonia oxidizers in ferro-manganese crusts, which signifies the possible role of ammonia oxidizers as the primary producers in ferro-manganese crusts.

Keywords: ferro-manganese crusts, microbial ecosystem, 16S rRNA gene