Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SCG64-01 Room:A05 Time:May 27 12:00-12:15

A kick-off drilling expedition at Iheya-North Knoll in Ore Genesis study of Ocean Resources in SIP

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A R&D project, led by Prof. Emer. Tetsuro Urabe of Univ. Tokyo, "Next-generation Technology for Ocean Resources Survey" started in FY2014, as a part of the Cross-ministerial Strategic Innovation Promotion Program (SIP). In the project, three types of ocean resources are targeted: seafloor hydrothermal deposit, Co-rich Mn-Fe Crust, and REY mud. The study on Genesis of Ocean Resources in this project aims to develop a screening technique for area having high potential of ocean resources as well as air-borne and/or satellite remote sensing technique for on-land resource exploration. Especially in the study on hydrothermal ore-deposits, higher level of achievement is required than those for other two types of ocean resources as the SIP program because of the recent advancement of the knowledge on this type of resource. The project goals not only include the establishment of a genetic model but also aim to propose an exploration technique for concealed ore bodies.

In July 2014, a non-riser drilling expedition was conducted at and around an active hydrothermal field on the Iheya-North Knoll by D/V Chikyu. Three active hydrothermal sites are known so far at this location. One has been known since late 1990s and is referred as the Iheya-North "Original" site to distinguish it from other two. At this site, more than 20 holes were drilled in IODP Exp.331, successfully obtaining a wide-range of lithology including polymetallic massive sulfide ores (Takai et al., 2011). Some of the holes showed apparent fluid discharge at the pulling out of the drill pipe. Numerous biological and geological observations have also been performed by the manned submersibles (Shinkai 2000 and 6500) and ROVs. Contrastingly, other two sites were recently located in early 2014, called the (Iheya-North) Natsu and Aki sites.

In Exp. 907 (CK14-04 Cruise), systematic LWD observations of six holes down to 340 mbsf were conducted to constrain the area of the fluid reservoir beneath seafloor followed by three coring holes down to 150 mbsf. Detailed results of LWD and coring were reported in this meeting (Saito et al. and Nozaki et al.). To protect the sensors from the anticipated high temperature of hydrothermal fluids, exceeding 300^{o}C, a back-up pumping system was attached to maintain fluid-flow as coolant continuously even during pipe connection. The back-up circulation system, i.e. Non-Stop Driller (NSD), supplied the drill-fluid of approx. 500GPM (1.9kL/min) during the operation. This flow rate was determined to protect the sensors of logging tool under a range of reasonable flow-rate into borehole; however, the rate was overestimated. Recorded maximum temperature throughout the expedition was 84^{o}C. In addition, no apparent discharges of the fluid forming black smoker was observed. Regardless of these observations, profiles of annular temperature and comparison between structural cross-section of seismic reflection survey, provides us the area of fluid reservoir beneath the Iheya-North Knoll was tabulated (Figure).

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Figure; Estiamted area of sub-seafloor Hydrothermal reservoir (Red-colored area). Open star: LWD site. Red-color-filled star: LWD and coring site. Broken circles indicated the areas of hydrothermal sites.

Keywords: SIP, Iheya-North Knoll, Hydrothermal fluid reservoir, LWD

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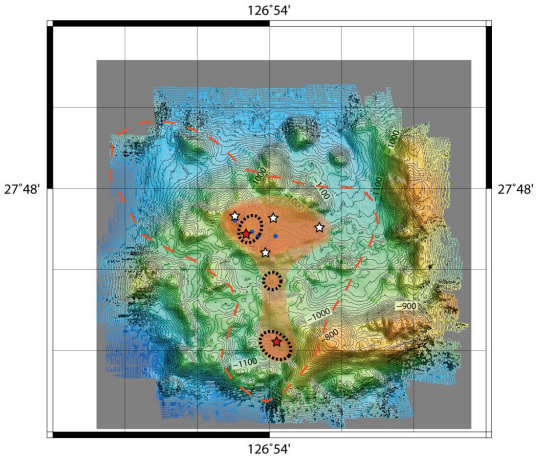

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SCG64-02 Room:A05 Time:May 27 12:15-12:30

Estimation of under-seafloor fluid on temperature and volume from the logging-while-drilling data

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In July of 2014, offshore drillings on Iheya-North Knoll, Okinawa Trough, was executed as part of Next-generation technology for ocean resources survey, which is a research program in Cross-ministerial Strategic Innovation Promotion Program (SIP). In this expedition, logging-while- drilling (LWD) and measuring-while-drilling (MWD) were inserted into 5 holes around Iheya-North (original) site (C9011 ? C9015) and in Iheya-North Aki site (C9016) to investigate spatial distribution of hydrothermal deposit and geothermal fluid reservoir. LWD tools are supplemented by a measurement-while-drilling tool that is located above the LWD tools in the bottom-hole-assembly. In this expedition, arcVISION and TeleScope were integrated as LWD and MWD respectively. The arcVISION obtained physical properties along borehole (resistivity, natural gamma-ray), and the TeleScope collected drilling mechanics data and transferred them to the surface by mud pulse telemetry. Both of these tools included annular pressure-while-drilling (APWD). Annular pressure and temperature were monitored by the APWD to detect possible exceedingly-high-temperature geofluid. In addition, drilling fluid was continuously circulated at sufficient flow rate to protect LWD tools against high temperature (non-stop driller system).

At C9012 and C9016, the arcVISION clearly detected temperature anomaly at 234 meter below the seafloor (mbsf) and 80 mbsf, respectively. Temperature quickly increases at that depth and it would reflect the existence of high-temperature heat source. During the drilling, however, drilling water was continuously circulated at high flow-rate (2600L/min) as stated above. Thus the measured temperature is not exactly in-situ temperature, but the profile of the temperature reflects the temperature variation of each stratigraphic layer of the bore hole.

To investigate the detail of the heat source, such as in-situ temperature and quantity of heat, we performed numerical analyses of thermal fluid and energy-balance, assuming two types of the heat source: A) hot fluid shifting with circulated water, and B) immobile layer like hot rock-bed. First, thermal fluid-flow analyses were conducted for estimation on how much the circulating water disturbed temperature of heat source. We combined equation of continuity, Navier-Stokes equation, and temperature equation. These equations were solved simultaneously with simplified Marker and Cell method. The fluid flow and its temperature between borehole wall and drilling pipe were simulated. The heat source temperature was also calculated by time. As the results, heat source A (fluid) could raise temperature of the circulation water as hot fluid injected and mixed with the cold water. On the other hand, heat source B was cooled by the circulation water immediately after the hot rock-bed was drilled. It should be required to have over 1000C of source temperature to make sure to keep the circulation water as warm as the thermometer measured at 234 mbsf in C9012A. APWD also recorded the abrupt rise in fluid pressure with the temperature anomaly for several minutes. Considering this synchronism between temperature and pressure, we assessed the high temperature fluid, such as geothermal fluid, is plausible as the heat source. Second, we estimated in-situ temperature and volume of the fluid heat source. From increase in temperature and flow rate of the circulation water, the quantity of heat supplied to the water was calculated as 3.5 GJ. This abundant heat would be brought by injection and mixing of geothermal fluid. The relationship between the temperature and injected volume of thermal fluid are constrained by the quantity of heat as: $Vf = 1.33 \times 10^5/Tf^2 - 257/Tf + 2.73$, where Vf is fluid volume injected to the borehole (m3) and Tf is fluid temperature (C). Thus, we estimated that the in-situ temperature and volume of the geothermal fluid are $>$150C and $<$6.3 respectively, causing the temperature anomaly in C9012A.

Keywords: hydrothermal deposit, geothermal fluid, Logging while drilling

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SCG64-03 Room:A05 Time:May 27 12:30-12:45

Lithology, constituent mineral, geochemical composition of the drilled core obtained by CK14-04 Cruise, Okinawa Trough

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CK14-04 Cruise by D/V Chikyu was performed in the Iheya-North Knoll, Okinawa Trough from 8 to 26th, June 2014 to investigate the subseafloor hydraulic structure and geology. Six holes (C9011B, C9012A, C9013A, C9014A, C9015A and C9016A) were drilled for logging while drilling (LWD) as well as coring of three holes (C9015B, C9015C, C9016B). Holes C9015B and C9015C locate the flank of HRV (high radioactivity vent) mound in the Iheya-North Original site, whereas Hole C9016B is ca. 150 m north from the central part of hydrothermal activity in the Iheya-North Aki site where has been discovered in January 2014. Total coring lengths of Holes C9015B, C9015C and C9016B were 31, 30 and 150 m, respectively. In this presentation, we report the lithology and constituent minerals determined by visual core observation and XRD analysis together with downhole variations of the geochemical composition determined by ICP-QMS analysis. Based on these data, we discuss the geology, hydrothermal alteration, geochemical features and sulfide mineralization in the Iheya-North Knoll, Okinawa Trough.

Keywords: Okinawa Trough, Iheya-North Knoll, seafloor hydrothermal deposit, kuroko-type deposit, CK14-04 Cruise, Expedition 907

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SCG64-04 Room:A05 Time:May 27 14:15-14:30

P-wave velocity structure in the southern Okinawa Trough

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[1]Japan Coast Guard

The Okinawa Trough is a backarc basin under continental rifting tectonics by subduction of the Philippine Sea plate beneath the Eurasian plate at the Nansei-Shoto (Ryukyu) Trench. The rifting stage varies from north to south along the trough and the southern region is in most evolved stage. We carried out around ten seismic experiments in the southern Okinawa Trough to obtain detailed images of crustal thinning in this region. We shot six lines along several en echelon rifts that characterize the seafloor feature in the southern trough. Each seismic experiment consists of multichannel reflection seismic (MCS) profiling using 240 ch. and 3000 m long hydrophone streamer and wide-angle seismic refraction profiling using ocean bottom seismographs (OBSs) as receivers.

The crusts in the Okinawa Trough roughly have three layers of the upper, middle and lower crust, which is same as an island arc crust. P-wave velocity model beneath the Yaeyama Rift, the deepest rift in the Okinawa Trough, also consists of the three crustal layers. The crustal thickness is more than 10 km and significantly thicker than a standard oceanic crust. Many intrusion signals in MCS records characterize the crust below the rift.

Keywords: Okinawa Trough, rifting, marine seismics

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SCG64-05 Room:A05 Time:May 27 14:30-14:45

MCS profiles of knolls scattered in the southern Okinawa trough

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In the Okinawa trough, reacently new hydro-thermal sites has been reported by several organizations. Especially, relatively large hydrothermal sites (e.g. the Iheya north site, the Noho site, and the Gondou site) were found in the middle part of the Okinawa trough.

The Iheya north site is known as one of the most active hydrothermal field. In the field, Tsuji et al.(2012) pointed out that there is the strong reflector which has opposite polarity to that of the seafloor reflector, and this indicates the seismic velocity below the negative-polarity reflector is lower than that of the overlying sequence. On the other hand, in the southern part of the trough not so many large scale hydrothermal sites have been found.

The Japan Coast Guard (JCG) conducted high density topographic surveys using a multibeam echo sounder and seismic surveys using a multi-channel streamer cable. As a sample of the result of our seismic experiments, we choosed the MCS time section of the Tarama knoll. The tarama knoll is 3 km in diameter and 500 m in hight. It has a hydrothemal field on the east flank.

On the seismic profile, several signals which imply the volcanic activity were imaged, such as:

volcanic sediments layer is located on the top of the land-derived sediment layer;

a strong reflector which has oposite polarity is detected between the volcanic sediments and the land originated sediments; and

strong reflectors which seems from dykes and sills by penetration of magma was observed.

some of these characteristics are consistent with the Iheya north site. This opposite polarity layer, therefore, may indicate the water supply source of the Tarama knoll’s hydrothemal system.

Keywords: MCS, knoll, hydrothermal, fault

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SCG64-06 Room:A05 Time:May 27 14:45-15:00

Sub-seafloor structure of hydrothermal deposits in Hakurei site, Izena Hole, the Mid-Okinawa Trough by VCS survey

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Seafloor hydrothermal deposits are formed in the deep sea around hydrothermal venting sites, where abundant metals precipitate. The seafloor locations of hydrothermal deposits are revealed by the exploration of geophysical, geochemical and submersible investigations. Hydrothermal deposits are known to form chimneys or mounds. Scale of hydrothermal mound is thought to be a hundred meters square by recent surveys. The sub-seafloor distribution of hydrothermal deposits are identified partially by drilling core data, however, a continuous structure has not been fully understood yet. To improve the quality of the sub-seafloor imaging of hydrothermal deposits, high-resolution geophysical data acquisition is required. We conducted two Vertical Cable Seismic (VCS) surveys at Hakurei site, Izena Hole in the Mid-Okinawa Trough to reveal sub-seafloor structure of hydrothermal deposits. In September 2011, we carried out 28 survey lines around the hydrothermal mound in the Hakurei site using an air-gun source during KY11-E04 cruise. In August 2013, we carried out 28 survey lines around the southern part of KY11E-04 survey area in the Hakurei site using a sparker source during KY13-E02 cruise. VCS surveys successfully imaged the shallow sub-seafloor structures of the hydrothermal field. We identified a mound shape reflector at the sub-seafloor. In addition, we estimated the seismic velocity at the sub-seafloor by the common reflection point (CRP) gathers. Some of the reflectors of the CRP gather show high velocity zone at the sub-seafloor. Previous drilling survey reported that hydrothermal deposits are buried by volcanic sediment in the Hakurei site. These results suggested that high velocity zone between reflectors at sub-seafloor is sediment-buried hydrothermal deposit.

Keywords: Hydrothermal deposits, VCS survey, Mid-Okinawa Trough, Sub-seafloor structure

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SCG64-07 Room:A05 Time:May 27 15:00-15:15

Hydrothermal sulfide/sulfate and alteration minerals obtained by drilling below the Iheya North Knoll hydrothermal field

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Seafloor drilling through active hydrothermal fields at the Iheya North Knoll in the middle Okinawa Trough provided a unique opportunity to directly access the subseafloor structure. Following IODP (Integrated Ocean Drilling Program) Expedition 331 conducted in 2010, CK14-04 cruise was performed by D/V Chikyu in 2014. We will report occurrence and mineralogical characteristics of sulfide minerals and alteration minerals in obtained sediment core samples by these drilling expeditions.

Drilled sites have been laid out from the NBC mound associated with active venting of 311 C hydrothermal fluid (27 47.4'N, 126 53.86'E, depth=1000m). Among them, occurrence of ore forming sulfide minerals were identified in sediment collected from Site C0016 just beside the NBC mound, from Site C0013 (100 m east from the NBC mound), from Site C0014 (450 m east from the NBC mound), Site C9015 (another mound in the west side of the NBC mound), and Site C9016 (150 m apart from Aki hydrothermal field which is located about 3 km south of the NBC mound).

From Site C0016B beside the mound, massive sulfide ore of ˜60 cm length was recovered from the first core (0-9 mbsf=meters below the seafloor). The ore looked like "black ore" in appearance and was composed of euhedral sphalerite, galena, chalcopyrite and pyrite which grain size up to a few 100 m. It is notable to that the ore include significant amount of clay minerals in the matrix. At the same drilled site, silicified sediment associated with vein sulfide consisted mainly of pyrite and chalcopyrite was abundant in the third core (27-45 mbsf). Dominant clay minerals in sediment at this depth were chlorite and illite.

From Site C0013 located at 100 m east from the NBC mound, intensely altered sediment including sphalerite, galena and pyrite was obtained from 0-16 mbsf. In the same sediment layer, occurrence of copper sulfides showed variation from covellite and tetrahedrite at a few meters below the seafloor to chalcopyrite at ˜10 mbsf. These sulfides are euhedral which grain size increased toward deeper depth and usually surrounded by clay minerals and/or sulfate minerals. Dominant clay minerals showed change along depth from smectite at a few meters below the seafloor to chlorite and/or chlorite-smectite mixed layer minerals at a deeper depth.

From Site C9015 at another hydrothermal mound, sulfide mineral enriched veins were recognized in sediment from 18-23.5 mbsf. These portions included sulfide minerals such as sphalerite, chalcopyrite, pyrite and galena, sulfate minerals such an s anhydrite and/or barite, clay minerals and quartz.

From Site C9016 a few km away from the NBC mound, occurrence of sphalerite, galena and barite within altered sediment obtained from 9-11 mbsf was notable. Dominant clay minerals in the sediment were kaolin minerals, which variation along depth is discussed in Tsutsumi et al. (poster presentation in this meeting).

In summary, occurrence of sphalerite and/or galena was limited in rather shallow depth (0-24 mbsf), but ubiquitous for drilled sites located with intervals of a few hundred meters to a few kilometer. This distribution should be interpreted as related to hydrothermal structure below active hydrothermal fields. Mineralogical texture of these sulfides was characterized as surrounded by clay and/or sulfate minerals, which is quite distinctive from that recognized in typical "black ore". This difference would be one of important problems if we consider seafloor sulfide deposits are a modern analogue of kuroko-type ore deposits. Whether the mineralization center has not been drilled yet or the hydrothermal activity at the Iheya North Knoll has not reached yet to the main mineralization stage?

Keywords: Seafloor massive sulfide mineral deposits, seafloor drilling, kuroko-type ore deposits, hydrothermal clay mineral

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ESR dating of barite in sea-floor hydrothermal sulfide deposits in comparison with disequilibrium dating

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The evolution of the hydrothermal fields is one of the important issues. Dating methods using disequilibrium between radioisotopes such as U-Th method (e.g. You and Bickle, 1998), ^{226}Ra-^{210}Pb and ^{228}Ra-^{228}Th method (Noguchi et al., 2011) have been employed for such studies.

Okumura et al., (2010) made the first practical application of ESR (electron spin resonance) dating technique to a sample of submarine hydrothermal barite to obtain preliminary ages, while Kasuya et al., (1991) pointed out the possibility ESR dating. Toyoda et al., (2011) determined the optimum condition for ESR measurement while Sato et al., (2011) confirmed that the signal is thermally stable enough for an age range of several thousand years. Recently it was shown that this method is also practically applicable to barite, especially those in sea-floor hydrothermal sulfide deposits (Takamasa et al., 2013).

ESR, ^{226}Ra-^{210}Pb, and ^{228}Ra-^{228}Th ages were determined for barite crystals extracted from hydrothermal sulfide deposits taken at hydrothermal fields taken from Okinawa Trough. The ESR ages range 4.1 to 16000 years where the ages obtained by the three methods coincide in the samples up to 15 years while, for the other older samples, the ^{228}Ra-^{228}Th ages are the youngest and ESR ages, the oldest and the ^{226}Ra-^{210}Pb ages in between. The samples with younger ESR ages show younger ^{226}Ra-^{210}Pb ages and those with older ESR ages show older ^{226}Ra-^{210}Pb ages with no detection of ^{228}Ra. This tendency of the ages is explained by more than two hydrothermal events that formed the sulfide deposits where barite crystals with different ages are mixed together in the examined portions of the samples. While ESR method gives the averaged ages, ^{226}Ra-^{210}Pb and ^{228}Ra-^{228}Th ages are underestimated because of decay of the parent nuclides.

Based on the results of ESR measurements, for which the applicability of wide age range is shown in the present study, the order of ages of the 6 hydrothermal fields would be arranged, from young to old as follows; Yoron Hole field, Irabu Knoll field, Daiyon-Yonaguni Knoll field, Hatoma Knoll field, being nearly equal to Iheya North Knoll field. ESR is a practical dating method of hydrothermal barite, however, calibration for the absolute age determination would be still an issue.

Keywords: barite, hydrothermal activities, electron spin resonance, radioactive disequilibrium, dating

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SCG64-09 Room:A05 Time:May 27 15:30-15:45

Preliminary report of AUV URASHIMA dives at Tarama and Irabu hydrothermal fields

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We conducted four AUV URASHIMA dives at Tarama and Irabu Knolls in the Okinawa Trough to reveal the origin and extent of these hydrothermal systems and their geological and geophysical background. The structure, fluid geochemistry and associated ecosystem of hydrothermal systems are highly diverse and the diversity is constrained by the surrounding geological setting. The Okinawa Trough is located at back arc area of the Ryukyu arc-trench system and is considered to be in transitional stage from continental rifting to oceanic crust formation. Many hydrothermal fields have been recently discovered in the area and they are characterized by the influence of rich sediment supply both from arc and continent. In August 2014, we carried out two dives at Tarama Knoll and other two dives at Irabu Knoll during YK14-16 cruise. The survey objectives are 1) to conduct high-resolution, three dimensional mapping of two sites using multiple sensors equipped on the AUV, 2) to compare two sites of different host rocks and tectonic settings, and 3) to identify an unknown high-temperature vent site at the Tarama Knoll. The AUV was generally operated at constant altitude mode (alt.=100m). We succeeded to cover whole area of these two knolls, using multi beam echo-sounder, side-scan sonar, sub-bottom profiler, three-component magnetometer, CTD, ADCP, pH/ORP/turbidity sensors, and water sampling using 24-channel MINIMONE sampler. The Irabu Knoll is located within the back arc rift axis and consists of three topographic highs. Three hydrothermal vents were reported on the knoll in previous surveys and all hydrothermal systems are hosted by basaltic basement. In dive 181 and 184, we confirmed three known hydrothermal vents and revealed the surrounding detailed geology. Magnetic anomaly is extremely high in general, supporting the idea that the hydrothermal fields are hosted by fresh basalt and maybe by active magmatism.?The Tarama Knoll is located about 20 miles west of the Irabu Knoll, at the arc-side terrace of the back arc rift. Previous ROV survey reported a low temperature shimmering hosted by rhyolitic rocks at the top of the knoll and the extent of turbid seawater at the southern slope of the knoll that may indicate an existence of unknown high temperature hydrothermal vent site. We covered the whole knoll in Dive 182 and 183. We detected strong plume anomaly at the eastern slope of the knoll by geochemical sensors. We also detected the plume ejection form the seafloor in water column records of multi beam echo sounder and side-scan sonar, leading the identification of exact point of new vent site.

Keywords: hydrothermalism, AUV, Okinawa Trough, seafloor morphology, magneti anomaly, hydrothermal plume

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SCG64-10 Room:A05 Time:May 27 15:45-16:00

Deepsea Magnetics on Tarama and Irabu Hydrothermal Fields

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Magnetic signatures of oceanic lithosphere is changed by hydrothermal alteration, therefore magnetization contrast derived from magnetic anomaly provide us information about spatial extent of hydrothermal alteration zones. Previous studies reported both reduced and enhanced magnetization at different hydrothermal fields, suggesting the destruction and production of magnetic minerals are controlled by geological and tectonic background. In order to characterize magnetic response of arc/backarc hydrothermal systems, we investigated two hydrothermal fields of the southern Okinawa Trough. The Irabu knoll is located on the axial area of backarc rift and consists of basaltic lavas. The Tarama knoll is located between backarc and arc sides along with dacite to rhyolite. Previous surveys reported hydrothermal venting on both knolls. During the cruise YK14-16, we conducted near-seafloor magnetic measurements using autonomous underwater vehicle (AUV) URASHIMA. The vector geomagnetic field was measured by fluxgate-type magnetometer at an altitude of ˜100 m with the whole area of the Irabu and Tarama knolls. The correction of vehicle magnetization was successfully done using data obtained during 8-figure rotation loops. The amplitude variation of observed magnetic anomaly is up to 12000 nT at the Irabu knoll and 1000 nT at the Tarama knoll. Sea-surface anomaly also shows larger amplitude variation at the Irabu knoll (760 nT) than Tarama knoll (460 nT). These observations suggest the difference of hosted rock type, i.e. the Tarama knoll is hosted by basaltic rock with large amount of titanomagnetites. In addition to the magnetic signature of the Tarama and Irabu knolls, we will discuss relationship between magnetization distribution and locations of confirmed hydrothermal vent fields.

Keywords: near-seafloor magnetic anomaly, seafloor hydrothermal system, Okinawa Trough, AUV URASHIMA

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SCG64-11 Room:A05 Time:May 27 16:15-16:30

Underwater gravity survey using autonomous underwater vehicle in Izena caldera, the middle Okinawa Trough

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It is known that there are seafloor mineral deposits around Japan islands. Gravity survey is one of powerful methods to obtain density structure in crust, especially for exploration of underground deposits. In marine area, surface ship gravimeter and ocean bottom gravimeters are often used. Recently the system which can survey a wide area quickly with a higher resolution is required to obtain a high-resolution structure below seafloor. In addition, recent technology of autonomous underwater vehicle (AUV) enables us measure gravity in underwater environment. To estimate structure, measurement of both gravity and gravity gradient has an advantage for precise estimation. A required accuracy of the measurement was estimated by using model calculation. From an expected model of seafloor deposits, it is found that a resolution of gravity measurement should be approximately 0.1 mgal, and 10 eotvos for gradient to estimate deposit below seafloor.

From these objectives and specification, we have developed an underwater gravity measurement system for exploration below a seafloor using an AUV. Our system consists of an underwater gravimeter and an underwater gravity gradiometer. For gravimeter system, the sensor is mounted on a gimbal mechanism to keep vertical. The system is controlled and monitored via acoustic link of the AUV. The gradiometer has two gravimeter aligned vertical at a distances of 50 cm. For practical observation in the sea, we choose AUV Urashima belonging to Japan Agency for Marine-Earth Science and Technology. Because the Urashima is large AUV, Urashima has enough space for installation of the underwater gravity measurement system and stable navigation is possible. All the power is supplied from the Urashima and acoustic communication system on the Urashima enable real-time monitoring during observation. The first observation was carried out in September 2012 in Sagami-Bay, Japan. For the observation, the Urashima was navigated at the constant speed and constant depth on the profiles. We succeeded in obtaining gravity data and other data for compensation of the gravity data along both tracks with good quality. The obtained gravity data were low passed to reduce noise first. Our system has a high-precision water depth meter with resolution of less than 1 cm. Effect of vertical acceleration, which was calculated from these data, was removed from the gravity data. In addition, we made tilt correction using horizontal accelerometers. Finally ordinary data processing for onboard gravimeter were applied. After the data processing, the data from each track show good agreement, and standard deviation of the data are 0.1 mgal. In other words, our system is estimated to have accuracy or repeatability of 0.1 mgal. From comparison with the data between underwater gravimeter and onboard gravimeter, it is found that the underwater gravimeter system recorded more detailed changes of gravity, which seems to correspond to topography mainly.

In August 2014, we carried second gravity survey using our underwater gravity measurement system in the southern region of Izena caldera, the middle Okinawa Trough, where seafloor deposits were found. The survey area is approximately 2 x 2 km. The Urashima was navigated on 15 profiles in the survey area at constant speed and depth. We obtained the data from both gravimeter and gradiometer with good quality for all the profiles. From the obtained gravity data, we estimate gravity anomaly map in the Izena caldera through the processing for noise reduction, which is described above. After the processing, we obtained a free-water gravity anomaly, which corresponds to the seafloor topography. Because the AUV Urashima also has multi-narrow beam echo sounder, detailed seafloor topography was obtained. We also estimate Bouguer anomaly using the detailed topography and assuming density.

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SCG64-12 Room:A05 Time:May 27 16:30-16:45

Deep-sea magnetic and acoustic surveys using AUVs in the Bayonnaise knoll and Myojin knoll calderas

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The Bayonnaise knoll and Myojin knoll calderas in the Izu-Ogasawara arc have been noted for large sulfide ore deposits called the Hakurei and Sunrise deposits. We conducted deep-sea magnetic and acoustic surveys in the two calderas on board the AUV Urashima during the cruises YK14-10 and 11 by the R/V Yokosuka (JAMSTEC) in June 2014. Two dive surveys were carried out in the Bayonnaise knoll caldera (travel distance of 46 km in total) to complete mapping the magnetic anomalies inside the caldera together with results of previous surveys. Other two dive surveys were conducted in the Myojin knoll caldera (52 km in total), which were the first AUV surveys in the caldera, and data were successfully obtained in the Sunrise deposit, the central cone, and a part of the northern caldera wall.

A high-resolution bathymetric map of the Bayonnaise knoll caldera created from the multi-beam data shows many tectonic landforms which are probably associated with the back-arc rifting. A large north-south fault cutting the caldera rim in the southeast, a landslide landform in the central cone, a tabular, north-south trending scarp of the central depression, and an explosive fault north of the central depression seem to link in a north-south direction. In addition to the crater row in the western caldera floor, many northwest-southeast striking faults have been found in the caldera rim in the northwest of the crater row. These features indicate the existence of an extensional field in a northeast-southwest direction, which is different from the nearly east-west direction of the rifting. Results of magnetic analyses show that a small hill in the northern caldera floor is strongly magnetized, in contrast to dacitic central cones which possess low magnetization. The hill is considered to belong to a basaltic knoll chain going through the caldera. It appears that the topography of the caldera has been rapidly changing due to tectonic and volcanic activities associated with the rifting. The magnetic structure is generally characterized by a north-south trending high-magnetization belt associated with the knoll chain going through the caldera. Local low-magnetization zones appear in the southeastern caldera wall including the Hakurei hydrothermal field, around the central depression, and in the northeastern caldera wall. The topography near the top of the eastern wall of the central depression is characterized by rough and uneven surface, and some constructions are clearly cone-shaped. Considering that the area is associated with low magnetizations, they are possibly hydrothermal constructions.

Bathymetric survey in the Sunrise field of the Myojin knoll caldera has revealed that several ridges with chimneys on top grow in a direction perpendicular to bathymetric contours in the caldera wall. Hydrothermal plumes were clearly captured in side-scan sonar images. On the other hand, magnetic anomalies are generally small in this area and show no particular features in the hydrothermal field. The central cone is covered with several lava flows going down 500-800 m distance from the top. There are many corrugations and small projections on the surface of the lava flows, which contrasts to smooth surfaces of the caldera floor. High magnetization is localized on the top of the central cone, and zones of relatively high magnetization continue almost along the lava flows.

A common feature among the Hakurei and Sunrise deposits is that sulfide mounds tend to grow in a direction perpendicular to local bathymetric contours. The Hakurei site is clearly associated with low magnetizations, while no particular magnetic feature is recognized in the Sunrise deposit. It may because silicic host rocks originally have low magnetization, and therefore, the effect of demagnetization due to hydrothermal alteration is not significant. However, data in a wider area over the Sunrise deposit is required to come to a conclusion on the magnetic structure of the Sunrise deposit.

Keywords: hydrothermal deposits, AUV

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SCG64-13 Room:A05 Time:May 27 16:45-17:00

Electrical resistivity structure of the oceanic crust around hydrothermal vent sites on East Pacific Rise at N9 50'

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We report results of a Magnetometric Resistivity (MMR) survey around hydrothermal vent sites on East Pacific Rise (EPR) at N9 50'. The MMR method is one of the controlled methods, which is used to estimate electrical resistivity structure of the oceanic crust. The magnetic fields induced by 200 vertical bipole electric current source transmission points were recorded by 10 OBMs (Ocean Bottom Magnetometer) which were deployed in the on-axis, and further off-axis to a distance of approximately 4km. We estimated one-dimensional resistivity structure from all the data, and it indicates the three layers with different resistivity, presenting an average resistivity structure in the study area. The most upper layer has low resistivity, impling high porosity layer, the middle layer has high resistivity representing dike, and the bottommost layer has low resistivity, which is probably in association with the magma chamber or mashed melt zone. We introduce the magnetic field anomaly in order to determine the distribution of anomalous resistivity bodies in the oceanic crust. The magnetic field anomaly was calculated from the observed magnetic field data by subtracting magnetic field induced by the vertical bipole electric current source transmission in the average resistivity structure. Magnetic field anomaly map for the each OBM was obtained by plotting the magnetic field anomaly at each source transmission point. The magnetic field anomaly maps present the location of local anomalous resistivity bodies, which are possible due to hydrothermal vent actives and small-scale ridge tectonics.

Keywords: EPR, Magnetometric Resistivity method, controlled source method, hydrothermal vent

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SCG64-14 Room:A05 Time:May 27 17:00-17:15

Chemical composition and stratigraphy of sea floor sediments in Kikai Caldera and Nagahama Bay, Satsuma Iwo-jima Island

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Satsuma Iwo-Jima Island, with volcanic activities, is located about 40km south of Kyushu Island, Japan. This island is one of the best places to observe a shallow water hydrothermal system. Nagahama Bay, in the south of Satsuma Iwo-Jima Island, is partly separated from open sea. The seawater appears dark reddish brown due to suspended ferric hydroxide produced by the mixing of volcanic fluids and seawater (Ninomiya & kiyokawa, 2009; Kiyokawa et al., 2012; Ueshiba & kiyokawa, 2012). Reddish brown seawater sometimes flows out of Nagahama bay. However, movement of ferric hydroxide out of the bay has not been clarified. In this study, we report the results of scientific analysis of caldera bottom core samples at 10km south of Satsuma Iwo-Jima Island.

We observed reddish brown suspended particles and sediments in Nagahama bay with FE-SEM. We collected cores in two survey cruises (KT10-18 and KS14-10) in 2010 and 2014 using a research ship Tansei-maru and Shinsei-maru of JAMSTEC (Japan Agency for Marine-Earth Science and Technology) at 10km south of Satsuma Iwo-Jima Island. We observed the cores with X-ray CT scan and the thin-sectioned samples with a microscope. In addition, we conducted the chemical analysis with XRF to find out scientific behavior of sediments. Moreover, we analyzed the core at 70km south of Yakushima (TSK1PC) for comparison.

FE-SEM observation shows that the suspended particles consist of globular ferric hydroxide (about 0.2μm), on the other hand, the iron-rich sediments are composed of bigger one ($>$1μm). This indicates the ferric hydroxide is precipitated by flocculation. X-ray CT scan observation shows that the cores don't include foreign origins, such as volcanic ash. Characteristic change was observed in the 4 elements out of 10 elements. We found a strong negative correlation between concentration of Ca and that of Si. We can confirm a negative peak of the Ca at 30cm from the surface in the core (KS14-10), which probably results from clastic particles in this depth. It is thought that the high concentration of Mn in the core (TSK1PC) can be caused by high oxidative environment. In the surface of the core (KS14-10), high concentration of Fe can result from leaching iron by burial of sediments. Furthermore, concentration of Fe in the caldera bottom cores (KT10-18 and KS14-10) is smaller than the core (TSK1PC) at 70km south of Yakushima. The former cores are shallower and include more organic matter than the latter core. This suggests that the former has deposited in the more reductive environment, which probably caused the difference of Fe. It is conceivable that redox status affects concentration of iron in sediments more strongly than concentration of iron hydroxide in seawater does.

We discovered the change in color of the caldera bottom core (KT10-18 and KS14-10). Nevertheless, We didn't find foreign origins in the cores. This appears to be the strongest proof that we couldn't find the significant material changes in thin-sections. We conclude that the change in color in the caldera bottom cores (KT10-18 and KS14-10) is due to leaching ferric hydroxide by burial of sediments.

Keywords: Kikai caldera, ferric hydroxide, redox status

Japan Geoscience Union Meeting 2015
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SCG64-15 Room:A05 Time:May 27 17:15-17:30

Abiotic formation of methane by oxidation of sulfur species under hudrythermal conditions

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In recent years, abiotic reactions have been considered as one of the potential mechanisms for the formation of reduced carbon species (i.e., CH_4, ..) in hydrothermal systems at seafloor. Because the fluid flux through deep-sea hot-springs represents a potentially significant source of carbon and energy to support microbial activities in surface and sub-surface habitats, the possibility that abiotic processes may influence the speciation of carbon in vent fluids has direct implications for the maintenance of life in present-day hydrothermal environments. Although aqueous carbon compounds have significant role in broad spectrum of geochemical and biological processes, reactions to produce abundant aqueous hydrocarbons at seafloor hydrothermal environment are poorly understood.

Abiotic synthesis of hydrocarbons in hydrothermal environments is attributed to Fischer-Tropsch type processes, which are characterized by the reduction of CO_2 or CO by H_2 on catalytic mineral surfaces including magnetite (Anderson, 1984). These reactions are also thought to occur in association with serpentinization of mantle peridotites, which produces H_2 and Fe_3O_4. Previous experimental studies under hydrothermal conditions (e.g., Foustoukos et al. 2004) succeeded in production of H_2 and abiotic CH_4. For example, Foustoukos et al. (2004) reported the production of 208 mmol/kg of H_2 and 39 μmol/kg of CH_4 by the olivine hydration over 1000 hours; however, the concentration of CH_4 gas was quite low than those observed in natural ultra mafic ?hosted hydrothermal vent fluid, for example, 0.13 ˜2.2 mmol/kg of CH_4 from the hydrothermal vent at the Lost City.

In this study, we focused on sulfur species as reducing agent, based on Putri et al. (2011), which reported high H_2 generation rate (64.3 mmol/kg in an hour) in the system of H_2S and H_2O. We conducted a series of hydrothermal experiments with H_2S to generate H_2 by reduction of H_2O. We used $Na_2S \bullet 9H_2O$ for H_2S species, $NaHCO_3$ for CO_2 species, and Fe_3O_4 for catalyst of Fischer-Tropsch type CH_4 synthesis. The initial concentration of H_2S and CO_2 species were set to be 10 mmol/kg and 40 mmol/kg, as analogue of hydrothermal vent fluids. The experiments were conducted at 300 degree C , and initial pH was controlled at 9.9˜10.0 with NaOH. After 168 hours experiment, the concentration of H_2 gas was 39.7 mmol/kg, which means almost H_2S species was consumed by the reduction of H_2O. The generated H_2 gas was used for the second reaction CH_4 gas. The CH_4 gas concentration was 30.3 μmol/kg in 168 hours, 6.3 times higher than that from serpentinization experiment (Foustoukos et al., 2004). In the same condition except for absence of Fe_3O_4, the gas concentration of H_2 were 40.14 mmol/kg and 4.91 μmol/kg, respectively. The experiment without Fe_3O_4 generated CH_4 gas and the concentration of CH_4 was quite lower than the experiment using Fe_3O_4, that indicates Fe_3O_4 takes the role of catalyst in the formation of CH_4, while other catalytic effect should be considered in the system.

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Putri S., Javier V., Watanabe N., Kishita A., Tsuchiya N., International Journal of Hydrogen Energy, 2011, 36, 10674.

Keywords: hydrothermal fluid vent, abiotic methane, CO2 reduction

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SCG64-16 Room:A05 Time:May 28 09:00-09:15

Paleoshape of Antarctica and Australia

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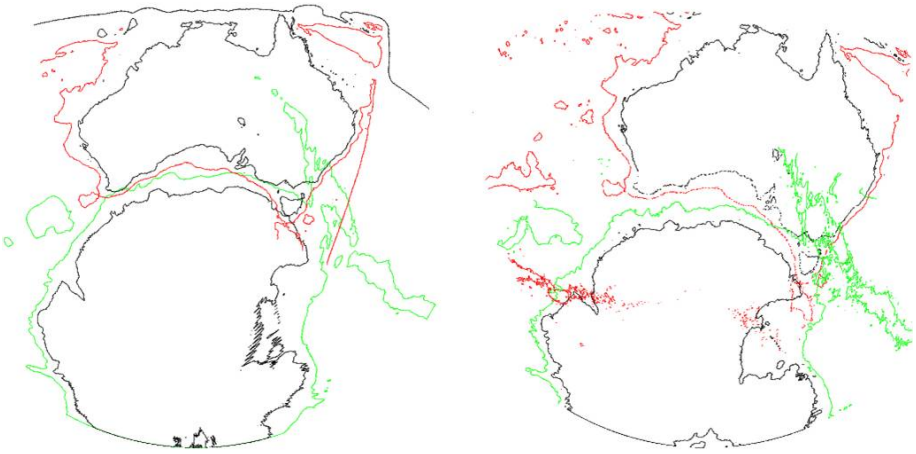
Using 20 years GPS data, we reconstructed the paleo shapes of Antarctica and Australia continents by extrapolating smooth-surfaced vector field of the GPS data to check how far we can extrapolate the GPS data toward the past.

Figure below shows that about 90Ma shapes of the two continents (left) fit better each oher than current shapes of the continents (right). black lines are coast lines, green and red lines are 3000m depth contours of Antarctica and Australia respectively. This result implies that 20 years of GPS data include deformation of continents for the time scale of tens of million years.

Keywords: GPS, Antarctica, Australia, deformation



Japan Geoscience Union Meeting 2015
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SCG64-17 Room:A05 Time:May 28 09:15-09:30

Seismic structure at the Kairei Hydrothermal vent field near the Rodriguez Triple Junction in the Indian Ocean

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1. Introduction

The Central Indian Ridge is located at the north of the Rodriguez Triple Junction and shows slow˜intermediate spreading rate. The Kairei Hydrothermal Field (KHF) was discovered in the first segment of the Central Indian Ridge. The vent fluid has higher H_2 content compared to other hydrothermal vent fluids in the world.

Although the KHF itself exists above a basaltic rock massif named the Hakuho Knoll, gabbro and peridotites were discovered on the seafloor around the KHF. The Yokoniwa Rise is located at the north of the KHF and shows peridotites exposure on the seafloor. The Uraniwa Hills are small core complexes which exist just east of the KHF and olivine-rich gabbroic rocks are exposed on the seafloor. The serpentinization of these deep-seated rocks exposed around the KHF may contribute to the high H_2 concentration of the vent fluid. To understand the sub-seafloor of the KHF, we conducted a seismic reflection/refraction survey with ocean bottom seismometers (OBSs).

2. Observation and Analysis

We conducted a seismic reflection/refraction survey from January 27 to January 29 in 2013 and from March 5 to March 6 in 2013 using S/V Yokosuka of JAMSTEC. In the experiment, we used 19 OBSs, an air gun (G.I.gun) and a single channel steamer cable. We obtained 5 survey lines NNW-SSE direction parallel to the ridge axis, 5 lines E-W direction and 5 lines NE-SW direction. In addition to these lines, we acquired other 5 lines passing through the point above the KHF or the Yokoniwa Rise.

In analysis of refraction data, we estimated 2-D velocity model under survey lines using the progressive model development method (Sato and Kennett, 2000). Then, we constructed a 3-D initial model and conducted 3-D inversion using FAST (Zelt and Barton, 1998).

3. Results

Seismic velocities under the Yokoniwa Rise and the Hakuho Knoll exceed about 6 km/s at depth of 1-2 km below seafloor. The high velocity area extends horizontally beneath the Yokoniwa Rise, suggesting that deep-seated rocks are uplifted when the Yokoniwa Rise was formed. The high velocity area beneath the Hakuho Knoll extends vertically, indicating that the knoll is a volcanic seamount.

A 1-D velocity profile of this study area generally seems to be similar to that of mid ocean ridges such as Mid-Atlantic Ridge, East Pacific Rise until depth of 3 km below the seafloor. However, the velocity of this study area at the seafloor shows about 1 km/s faster than that of other ridges except Juan de Fuca Ridge and the Southern Ridge. The Southern Ridge is the south part of the Atlantis Massif core complex on the Mid-Atlantic Ridge, and serpentines were sampled on the seafloor. The 1-D velocity structure of this study area is similar with that of the Southern Ridge, suggesting that deep-seated rocks are uplifted and serpentinized at shallow depth in this study area.

Acknowledgment

We thank the captain and crews of S/V Yokosuka of JAMSTEC for their support. This work was supported by Grant-in-Aid for Scientific Research on Innovative Areas of the Ministry of Education, Culture, Sports, Science and Technology (Grant Number 20109002, TAIGA project).

Keywords: TAIGA Project, hydrothermal field, crustal structure, triple junction of the Indian Ocean

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SCG64-18 Room:A05 Time:May 28 09:30-09:45

Distributions of mantle heterogeneity across segment at southern segment of Central Indian Ridge

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Recent petrological and geochemical investigations of MORB at the southern segments of Central Indian Ridge (CIR) reveal the heterogeneous distributions of MORB-source mantle (Sato et al., 2015). Sato et al. (2015) concluded that MORB from CIR-S2 segment and off-ridge area at the CIR-S1 segment are depleted compositions than typical MORB. Furthermore, depletions based on trace element geochemistry of off-ridge MORB from CIR-S1 segment decrease toward present spreading ridge. Because off-ridge MORB was recovered from several dredge sites parallel to the flow line, these distributions might indicate spatial distributions of mantle heterogeneity beneath CIR-S1 segment.

Keywords: mid-ocean ridge basalt, Central Indian Ridge, mantle heterogeneity, geochemistry

Japan Geoscience Union Meeting 2015
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SCG64-19 Room:A05 Time:May 28 09:45-10:00

On the origin of seafloor flattening

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The subsidence of an aging seafloor starts to slow down at ∼70 Ma old with respect to the prediction of simple half-space cooling, and this phenomenon has long been known as seafloor flattening. The flattening signal remains even after removing the influence of the emplacement of hotspot islands and oceanic plateaus. The combination of small-scale convection and radiogenic heating has been suggested as a mechanism to explain seafloor flattening, and this study explores a possibility of using the magnitude of seafloor flattening to constrain the amount of radiogenic heating in the convecting mantle. By comparing properly scaled geodynamic predictions with the observed age-depth relation of the normal seafloor, the mantle heat production is estimated to be ∼12±3 TW, which supports geochemistry-based estimates. A widely-held notion that small-scale convection enhances cooling thus being unable to explain seafloor flattening is suggested to be incorrect. The ability to predict the age-depth relation of seafloor based on the thermal budget of Earth has an important bearing on the future theoretical study of early Earth evolution.

Keywords: seafloor flattening, mantle convection, internal heating, early Earth, surface environment

Japan Geoscience Union Meeting 2015
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SCG64-20 Room:A05 Time:May 28 10:00-10:15

Pacific Array

KAWAKATSU, Hitoshi[1*] ; TAKEO, Akiko[2] ; ISSE, Takehi[1] ; NISHIDA, Kiwamu[1] ; SHIOBARA, Hajime[1] ; SUETSUGU, Daisuke[3] ; SUGIOKA, Hiroko[3]

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Based on our recent results on broadband ocean bottom seismometry, we propose a next generation large-scale array experiment in the ocean. Recent advances in ocean bottom broadband seismometry (e.g., Suetsugu & Shiobara, 2014, Annual Review EPS), together with advances in the seismic analysis methodology, have now enabled us to resolve the regional 1-D structure of the entire lithosphere/asthenosphere system, including seismic anisotropy (both radial and azimuthal), with deployments of ˜10-15 broadband ocean bottom seismometers (BBOBSs) (namely ”ocean-bottom broadband dispersion survey”; Takeo et al., 2013, JGR; Kawakatsu et al., 2013, AGU; Takeo, 2014, Ph.D. Thesis; Takeo et al., 2014, JpGU). Having ˜15 BBOBSs as an array unit for 2-year deployment, and repeating such deployments in a leap-frog way (an array of arrays) for a decade or so would enable us to cover a large portion of the Pacific basin. Such efforts, not only by giving regional constraints on the 1-D structure, but also by sharing waveform data for global scale waveform tomography, would drastically increase our knowledge of how plate tectonics works on this planet, as well as how it worked for the past 150 million years. International collaborations might be essential, as if three countries/institutions participate this endeavor together, Pacific Array may be completed within five or so years.

Keywords: OBS, seismic array, lithosphere, asthenospher

Japan Geoscience Union Meeting 2015
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SCG64-21 Room:A05 Time:May 28 10:15-10:30

Oceanic plate structure beneath the northwestern Pacific Ocean revealed by explosion experiments

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Plate tectonics is based on a concept that a rigid lithosphere moves over a weaker asthenosphere. Understanding of the plate tectonics is important to understand the Earth's system. However, the nature of the lithosphere and asthenosphere boundary (LAB) is not yet well determined. To understand the physical condition for the LAB, we have conduct a seafloor observation called " Normal Oceanic Mantle (NOMan) Project". We focused on the oceanic plate because the nature and evolution history of the oceanic plate is simpler than the continental plate so that it is easier to investigate its nature.

To analyze the upper mantle structures around the LAB, we conducted a seismic explosion experiments as a part of NOMan project.

Seismic explosion experiments were conducted at four shot sites with ten broadband ocean bottom seismometers and the size of explosions is 400 kg at two sites, and 200 kg at other sites. The profile lengths are about 700 and 400 km, respectively.

Previous studies in this area revealed the azimuthal anisotropy in the uppermost lithosphere (Shinohara et al., 2008), a sharp LAB at a depth of ˜80 km (Kawakatsu et al. 2009), and small-scale heterogeneities in the lithosphere (Shito et al., 2013).

We have detected first arrivals from all data whose epicentral distance is between 100 and 670 km. At these distant ranges, first arrival is passing though the mantle, that is, Pn wave is first arrival. The apparent velocities of longer shots are about 8.0 km/s. However, at a shorter shot, first arrival times with nearly same distance is apart about 3 seconds. It suggests that the uppermost mantle structure in this region is very heterogeneous or has azimuthal anisotropy. After analyzing, we found the azimuthal anisotropy in the uppermost mantle whose amplitude is about 4% and whose fast axis is nearly perpendicular to the magnetic lineations, which is consistent with Shinohara et al. (2008).

We also found that some Pn waveforms at ˜300 km is complicated although some others are simple, which may suggest the existence of the heterogeneities in the lithosphere.

Keywords: oceanic plate, explosion experiment, northwestern Pacific Ocean

Japan Geoscience Union Meeting 2015
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SCG64-22 Room:A05 Time:May 28 10:30-10:45

Geographical distribution of shear wave anisotropy within marine sediments in the northwestern Pacific

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Elastic properties of marine sediments, including P and S wave velocities, have been recently investigated well by active seismic surveys. However, information on S anisotropy associated with alignments of fractures and fabric remains elusive. To obtain such information, we used ambient noise records observed by ocean bottom seismometers at ~250 sites in the northwestern Pacific to calculate auto-correlation functions for retrieving S reflections coming from a sedimentary basement. We measured differential travel times and polarized directions of these S reflections to see, if any, geographical systematic distribution of S anisotropy. Consequently, the observed differential times were at most 0.05 s. The fast polarization axes tend to align in trench-parallel direction in the outer rise region. In particular, their directions systematically change in accordance with the direction of trench axis that changes sharply across the junction of the Kuril and Japan Trenches. We suggest two contributors for the obtained S anisotropy within marine sediments in the outer rise region, cracks induced by stresses due to bending of the plate and fractures associated with the basement deformation below the sediments. Which effect is dominant depends on the degree of plate bending. In the northwestern Pacific, both stress-induced cracks and fractures due to the basement deformation cause S anisotropy in a region where a large bending of the plate is observed, while fractures due to the basement deformation only create S anisotropy in other region of small bending of the plate. Moreover, we carried out numerical simulations with three-dimensional finite difference method taking into account anisotropy to simple, two-layered structure. Our results indicate that successful extraction of S anisotropy from the retrieved S reflection attributes near-vertically propagating S reverberations associated with extremely low Vs within marine sediments. Another numerical simulation with a realistic velocity model underneath the seafloor was conducted on the Earth Simulator in order to confirm whether S reflections from interfaces below the basement could be extracted or not. As a result, it is considered that such S reflections would be hindered by S reverberations with large amplitudes within marine sediments.

Keywords: marine sediment, S anisotropy, ambient noise, northwestern Pacific

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SCG64-23 Room:A05 Time:May 28 11:00-11:15

Crustal thickness of the Ontong Java Plateau revealed from traveltime inversion analysis

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The Ontong Java Plateau (OJP) is the largest oceanic plateau on Earth, located in the western equatorial Pacific and delineated by the 4000-m bathymetric contour. It is five times as large as the Japanese islands. From the results of sampling and drilling, the OJP is a representative example of large igneous provinces (LIPs) (e.g. Coffin and Eldholm, 1994), which do not fit plate tectonic theory, and no formation model explains all existing observations from the OJP. Environmental impacts of OJP formation had the potential to be large scale as suggested by a geologically short interval of emplacement and the feature's large area and volume. To understand its formation and environmental impacts, investigation of the crustal structure of the OJP is important. Structural studies of the OJP began in the 1960s. Since then, the few studies have determined the Moho depth beneath the OJP, which have varied according to survey method. For example, the Moho depths of seismic (Furumoto et al., 1976) and gravity (Sandwell and Renkin, 1988) studies are 35-42 km and 25 km, respectively. The Moho depth beneath the southernmost OJP is 35 km, as determined by a forward modeling approach (Miura et al., 2004), and an inversion analysis shows similar results (Korenaga, 2011). However, until recently the Moho depth at the center of the OJP has not been clearly determined and modern survey techniques were required. A seismic survey with 100 ocean bottom seismometers (OBS) across the center of the OJP was conducted in 2010 (Miura et al., 2011). First arrival traveltime tomography and forward modeling have been applied to the OBS data (Miura et al., 2013). Recently we have initiated traveltime inversion analysis of the OBS data using first arrivals and the largest amplitude later reflection phases (PmP), following noise reduction processing of reverberations from previous shots (Miura et al., 2014). Our analyses with initial models using various Moho depths show crustal thicknesses greater than those resulting from previous studies. Uncertainty analysis (Korenaga, 2011) will be applied to verify reliability of Moho depths.

Keywords: LIPs, OJP, MCS, OBS, traveltime, inversion

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SCG64-24 Room:A05 Time:May 28 11:15-11:30

New insights into the oceanic lithosphere from petit-spot around the Marcus Island

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Petit-spot volcanoes on the subducting NW Pacific Plate off the Japan Trench formed from melt that originated in the asthenosphere and ascended within a zone of concave flexure in the outer rise. Such tiny volcanoes are likely to be ubiquitous in such zones of plate flexure and have recently been reported from the oceanward slope of the Tonga, Chile, and Java trenches. They may also commonly occur in other settings, as similar volcanoes have been reported from the extensional Basin and Range province in North America, and from south of Greenland. It is therefore important to search for other examples of petit-spot volcanoes because they help us to address some important first-order questions about zones of lithospheric flexure.

Clusters of small conical volcanoes occur in the area southeast of Marcus Island, as inferred from precise bathymetric data acquired by the Japan Coast Guard. Most of the cones in the clusters are $\sim$100 m high and $\langle$10 km across. Their morphologies are similar to those of petit-spot volcanoes. A search for petit-spot volcanoes around Marcus Island was conducted in May 2010 by the R/V *Yokosuka* of JAMSTEC (cruise YK10-05), carrying the submersible *Shinkai6500*. A young volcano was observed southeast of Marcus Island, contradicting the assumption that Cretaceous seamounts only occur on the Jurassic Pacific plate. The occurrence of highly vesicular alkaline lavas indicates that petit-spot volcanic activity is ubiquitous on the oldest oceanic plate as well. The morphologies of the lava flows in the area southeast of Marcus Island are different to those of flows in the NW Pacific, indicating a low-viscosity magma. The eruption setting in the area southeast of Marcus Island is unusual because the site is located far from any trench. An as-yet unknown origin of petit-spot melt ascending through the lithosphere might be identified via studies of the oldest oceanic crust in the world ′ s oceans.

Keywords: alkali-basalt, petit-spot, Pacific, lithosphere, Marcus Island

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SCG64-25 Room:A05 Time:May 28 11:30-11:45

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

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Plate deformation owing to the outer-rise induces eruption of magma forming diminutive volcanoes compared to hotspots and large igneous provinces, so called petit-spot volcanism. Even if unique geochemistry of alkaline basalts suggest that they are originated from partial melts in the heterogeneous asthenosphere, detailed melt production process for petit-spot volcanism is still not constrained. We thus conduct melting experiments to define phase relations for the petit-spot primary magmas. Our first experiment (Machida et al., 2013, JpGU) for the youngest knoll situated in flexed region of the northwestern Pacific plate (sample KR04-08 D08-002) showed that the primary magma is saturated with olivine and orthopyroxene or clinopyroxene at about 2.1 GPa and about 1280 ℃. Therefore, when we consider that the depth of the lithosphere-asthenosphere boundary (LAB) for the northwest Pacific (WP2) is 82 km (Kawakatsu et al., 2009, Sicence), equilibrated pressure corresponds to the lower lithosphere. This result looks like resisting a conventional hypothesis that the petit-spot volcano was formed by exuding of magma existing in the upper asthenosphere, place deeper than approximately 90 km, through the lithosphere (Hirano et al., 2006, Science). To verify the universality of the result, we further select two samples as the second targets. Sample 6K 879-R3A was collected from a knoll in flexed region of the northwestern Pacific plate (approximately 2 km north of youngest knoll for the first experiment) during cruise YK05-06 of *R/V Yokosuka*. Sample 10K 56-R001 was collected from a knoll distributed at the Japan Trench ocean-ward slope during cruise KR97-09 of *R/V Kairei*. Based on the $^{40}Ar/^{39}Ar$ age of sample 10K 56-R001 and the present absolute plate motion, the erupting location corresponds to flexed region of the northwestern Pacific plate, same as the other two samples.

We conducted melting experiments using 1/2-in.-diameter piston cylinder type high-temperature and high-pressure apparatus at Kyoto university. Starting materials were prepared from mixture of pre-dried reagents of oxide, hydroxide, and carbonate representing major element compositions of primary magmas equilibrated with Fo=90 olivine (obtained by the olivine maximum fractionation model), and including 10% CO_2 and 1% H_2O (Okumura and Hirano, 2013, Geology). The other experimental procedures are same as those of Machida et al. (2013, JpGU). As results of our experiments, sample 6K 879-R3A is multiply saturated with olivine, orthopyroxene, and clinopyroxene at about 1.8 GPa and about 1280 ℃, and sample 10K 56-R001 is multiply saturated with olivine and orthopyroxene at about 1.4 GPa and about 1275 ℃. Therefore, it is a common condition, regardless of the difference of eruption position and age, that petit-spot magmas were equilibrated with depleted peridotite at the lower part of lithosphere.

Keywords: petit-spot, multiple saturation experiment

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SCG64-26 Room:A05 Time:May 28 11:45-12:00

Dense heat flow measurements on the outer rise of the Japan Trench: Fracturing and pore fluid flow in the oceanic crust

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Anomalous heat flow values, higher than that expected for the seafloor age, are observed on the seaward side of the Japan Trench. Previous surveys revealed that the high heat flow is widely distributed on the seaward trench slope and outer rise along the northern half of the Japan Trench but does not extend beyond about 150 km from the trench axis (Yamano et al., 2014), indicating that the anomaly is related to deformation of the incoming Pacific plate associated with subduction. The seismic velocity structure of the oceanic crust also shows anomaly on the seaward side of the trench, attributable to fracturing and seawater percolation (Fujie et al., 2013). Based on these observations, Kawada et al. (2014) proposed that thickening of the permeable layer in the oceanic crust due to fracturing leads to development of pore fluid circulation, which efficiently pumps up heat from the underlying impermeable basement. They showed through numerical modeling that this process may yield a broad high heat flow anomaly at a scale of 100 km, as observed on the seaward side of the Japan Trench.

Overlapping the broad high anomaly, large local variations at a scale of a few kilometers were found at some sites where concentrated measurements were made. Such local anomalies may arise from heterogeneity of the oceanic crust, e.g., topography of the permeable basement in which fluid circulation occurs and high-permeability faults produced by plate bending. The existing heat flow data are, however, not dense enough to be compared with the detailed crustal structure.

For investigation of the origin of the local anomalies, we conducted closely-spaced heat flow measurements on the outer rise of the Japan Trench around 39^{o}N on KS-14-17 cruise of the R/V Shinsei-maru in 2014. Measurements were made at intervals of several hundred meters along an E-W pre-existing multi-channel seismic survey line (JAMSTEC SR101), in an area 60 to 80 km from the trench axis, where immature horst and graben structures are observed. The obtained 20-km detailed heat flow profile perpendicular to the trench shows prominent sawtooth-like variations (60 to 110 mW/m^2) at a scale of 3 to 5 km. This characteristic heat flow distribution has no apparent correlation with the basement topography and faults and might result from heterogeneity in deeper part of the oceanic crust. Possible causes of the observed small-scale anomalies, including local variations in the permeability structure, are discussed in another paper in this session (Kawada and Yamano). We should conduct measurements along lines parallel to the trench as well for further investigation of the relation between the heat flow distribution and the crustal structure.

Keywords: Japan Trench, Pacific plate, heat flow, oceanic crust, subduction zone, pore fluid

Japan Geoscience Union Meeting 2015
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SCG64-27 Room:A05 Time:May 28 12:00-12:15

Fluid flow in a partially-thickening aquifer: A model for km-scale high heat flow on the outer rise of the Japan Trench

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Anomalous high heat flow is observed broadly on the seaward side of the Japan Trench offshore of Sanriku (*Yamano et al.*, 2008, 2014). Average heat flow within 150 km seaward of the trench axis is ca. 70 mW/m^2, which is substantially higher than that predicted by thermal models with the plate age 135 Ma, 50 mW/m^2. Individual heat flow values scatter between 50 and 120 mW/m^2. Dense measurements (at intervals of several 100 meters) conducted along 39^{o}N have revealed that the scatter has a spatial scale of 3-5 km (*Yamano et al.*, JPGU2015). The origin of such fine scale anomaly must be just below the seafloor; however, seismic surveys cannot detect any structure within the sediment below the heat flow anomaly.

A high V_p/V_s layer is imaged at the uppermost part of the subducting oceanic plate where the heat flow anomaly is observed (*Fujie et al.*, 2013a, 2013b). The layer is imaged to be thickened toward the trench axis. The uppermost part of the oceanic plate is porous and works as an aquifer, and the observation could be interpreted as thickening of the aquifer toward the trench axis.

Previously, we constructed a model to explain the high average heat flow (*Kawada et al.*, 2014). Being inspired from the observation of the high V_p/V_s layer, we modeled a 500-m-thick aquifer 150 km seaward the trench axis that is linearly thickened to 3000 m toward the trench axis. Numerical modeling of heat and fluid transport results in anomalous high heat flow that is comparable to the observation, +20 mW/m^2. According to this model, the origin of the observed anomalous high heat flow is vertical heat mining from the underlying plate below the thickening aquifer.

In this presentation, we investigate the role of partial thickening of the aquifer on the resulting heat flow anomaly, in order to explain the observed fine-scale heat flow anomaly. Although *Kawada et al.* (2014) assumed that the aquifer is thickened smoothly, thickening of the aquifer should occur as discrete events because it is physically propagation of fissures. We consider two situations:

1. A part (1-2 km width) of an aquifer is abruptly thickened to 3000 m. In this case, we conducted numerical calculations of heat and fluid transport across the trench axis.
2. A permeable fault of $\sim$100 m width, 3000 m deep, and infinite length along the strike is abruptly formed. In this case, we conducted calculations of conductive heat transport with enhanced thermal conductivity that mimics hydrothermal circulation.

In both cases, high heat flow peaks are formed above the permeable zone (thickened aquifer or fault) immediately after the calculation begins. High heat flow anomaly that is comparable to the observation $\sim$100 mW/m^2 persists over several hundreds of thousand years. Heat is transported from the surrounding areas of the permeable zone, where no hydrothermal convection occurs. That is, heat in the surrounding area is mainly transported horizontally toward the permeable zone by thermal conduction and then is transported vertically due to hydrothermal circulation within the permeable zone. Because the area of the surrounding area is larger than the permeable zone, high heat flow anomaly can continue for a long time.

Keywords: heat flow, hydrothermal circulation, Japan Trench, subduction zone

Japan Geoscience Union Meeting 2015
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SCG64-28 Room:A05 Time:May 28 12:15-12:30

Large tsunamis along a weakly coupled interface in the western Ryukyu trench

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A large tsunami struck the coasts of Ishigaki and surrounding islands along the western Ryukyu Trench on 24 April 1771. Several different earthquake phenomena were recently found along the western Ryukyu Trench: slow slips on the plate interface, very low frequency earthquakes, a tsunami earthquake and splay faults near the trench, which were similarly found in the Nankai trough. Moreover, it is pointed out based on GPS data on Taiwan that the westernmost Ryukyu subduction zone is fully coupled (Hsu et al., 2012). For all of these reasons, we purpose to investigate a plate coupling condition along the western Ryukyu subduction zone, based on tsunami deposits and GPS velocity data.

We analyze the data from the baseline of Iriomote and hateruma islands from 1997 to 2015. We exclude the data between Dec. 2001 and Mar. 2002 when Mw6.8 and Mw7.1 earthquakes occurred near the baseline during the time interval. This baseline is aligned perpendicular to the general trend of the western Ryukyu trench. The baseline length of 40 km between the two islands shows an extension of 1 mm/yr and strain rate (+2.5 10E-8) over the period. The absolute strain rate along the western Ryukyu trench is smaller by one order of magnitude than those along the Nankai trough and Japan trench. As a matter of fact, the strain rate along the Nankai trough and Japan trench is negative (shortening). The long-term and constant rate extension of the baseline suggests that rifting of the Okinawa trough is caused by the retreat of the Ryukyu trench. This retreat is produced by a rollback of the Philippine Sea plate in the western Ryukyu trench.

Keywords: large earthquakes, Ryukyu trench, Interplate coupling, 1771 Yaeyama tsunami, tsunami deposits, GPS velocity

Japan Geoscience Union Meeting 2015
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SCG64-29 Room:A05 Time:May 28 12:30-12:45

Digital terrain analysis of sea-land combined data on the Outer Zone of Southwest Japan

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Geomorphological studies have been done in predominantly land areas, and usually have been treated separately: divided into either land or seafloor. The authors have been studying land topography, however, many parts of the Japanese archipelago were formed by lifting of the seafloor associated with plate sinking in trenches. The Outer Zone of Southwest Japan, which is the object of this study, is on plate boundaries.

Recently spatial resolutions of seafloor DEMs have become enlarged, and a few subsurface structure data have been published. Therefore the authors thought that we should visualize and analyze the sea-land combined data.

In this study, we analyzed drainage networks, profiles, and terrain types of Southwest Japan using a 500-m DEM which was a mosaic of land elevation by GSI and seafloor elevation by the Japan Coast Guard. Moreover, we visualized land topography and other data, i. e., seismic tomography data (Matsubara and Obara, 2011), distribution of seismic intensity, and plate boundary data that were published on the Internet. The visualization shows inhomogeneous structure of velocity below Japanese islands and a clear hot section leading out from deep underground to Osaka Bay.

Land and shelf edges are quantitatively similar to each other in topography. However, there are almost no steep slopes with high valley density on the seafloor in contrast to land surfaces. Instead of high valley density slopes, long large steep slopes as in Quaternary volcanos, such as Mt. Fuji, are widely distributed on the deeper seafloor. In addition, steeper parts of long large slopes are distributed around active faults in land, inner trench areas and outer ridges on the seafloor, in addition to tops of volcanos.

This study was carried out within a framework of ”Mapping of large landslides based on the sea-land combined terrain classification: case study of the overall Outer Zone of Southwest Japan including the Nankai Trough” which was a theme in ’2014 Collaborative Research with the Disaster Prevention Research Institute, Kyoto University’. We would also like to thank the Japan Coast Guard who provided the 150-m and 450-m Geographical Feature Meshes Data of Southwest Japan.

References

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Keywords: Fundamental Geospatial Data, seafloor topography, DEM, digital terrain analysis

Japan Geoscience Union Meeting 2015
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SCG64-30 Room:A05 Time:May 28 14:15-14:30

Seismic velocity structure beneath the Philippine Sea plate descending under the Kumano basin

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[1]JAMSTEC

In order to monitor seismic activity in the Kumano basin, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) developed the Dense Oceanfloor Network System for Earthquakes and Tsunami (DONET) above the Tonankai earthquake source region off the Kii Peninsula (Kaneda et al., 2009, Kawaguchi et al., 2010). DONET ocean-bottom seismic and water-pressure observation stations are connected with an optical fiber cable, and data from the sensors are transferred in real time to our laboratory at JAMSTEC. The seismic and water-pressure observations made by the DONET stations immediately above the source region of megathrust earthquakes improve our ability to detect earthquakes and tsunamis.

Kamiya et al.(2012) selected seismic events occurred in and around the Kumano basin and the Kii peninsula in the period from January 2011 to June 2012 and estimated seismic P and S velocity structures in this region using arrival time data picked from the seismic waveform recorded by the DONET system and the JMA catalog. Owing to adopting DONET data, the resolution of seismic tomography was improved beneath the Kumano basin off the Kii peninsula and the low velocity region beneath the Kumano basin above the descending Philippine Sea plate and the upper boundary of the plate beneath the DONET network were depicted clearly.

In the present study, we adopt data in the period from January 2011 to December 2014. We pick arrival times from the events occurred not only in this region but also outside of this region. We use these data and estimate seismic P and S velocity structures by the use of seismic tomography technique. For the model space, we take the latitude range of 30N-37.5N, the longitude range of 129E-141E. We use a grid interval of 0.2 degree x 0.2 degree. The new data improve the resolution of seismic tomography, in particular, the data from the events occurred outside of this region make it better in and below the lower boundary of the descending Philippine Sea plate. We are able to estimate the thickness of the descending plate and the seismic velocity structure beneath the plate in this region.

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SCG64-31 Room:A05 Time:May 28 14:30-14:45

Deformation structure obtained by high resolution multi-channel seismic reflection survey around Nankai Trough axis

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[1]JAMSTEC

The big disaster earthquakes had often occurred in the Nankai Trough with a great Tsunami event. In order to reduce a great deal of damage to coastal area from both strong ground motion and tsunami generation, it is necessary to understand rupture synchronization and segmentation of the Nankai megathrust earthquake. We focus on the deformation structure around the Nankai Trough. However, there are few seismic survey lines in the trough axis in the Nankai Trough. Therefore, we planned new survey around the trough axis in the Nankai Trough in order to obtain the high resolution structure.

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) carried out new high resolution multi-channel seismic reflection (MCS) surveys using portable system over 1,500 km of line length from off Kochi to Kii Peninsula during 2013-2014. The seismic source used was an G-gun cluster array of 4 air guns with total volume of 380 cubic inches (5.24 L). The hydrophone cable is ca. 1200 m long, having 192 channels at an interval of 6.25 m. The MCS data were processed through a standard seismic processing flow, which consists of noisy-trace editing, 20?200 Hz band-pass filtering, velocity analysis with every ca.313 m intervals picking, normal moveout, Common Depth Point (CDP) stacking, and poststack time migration.

We obtained 23 MCS profiles around the Nankai Trough. Clear frontal thrusts are imaged in the margin of Nankai Trough axis. We recognized distinct proto thrust zone in the south part of the frontal thrust. This results yield the possibility of extended rupture area in the Nankai Trough.

This study is part of ”Research project for compound disaster mitigation on the great earthquakes and tsunamis around the Nankai Trough region” funded by MEXT, Japan.

Keywords: MCS survey, Nankai Trough, proto thrust

Japan Geoscience Union Meeting 2015
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SCG64-32 Room:A05 Time:May 28 14:45-15:00

Improvement of gas hydrate response in marine controlled-source electromagnetic exploration using fictitious wave domain

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While most of gas hydrate deposits is found clearly on seismic sections as cross-bedding events of the Bottom Simulating Reflector (BSR), the detailed structure of gas hydrate concentrated zones is not well estimated. We focus on marine controlled-source electromagnetic (CSEM) exploration considered as a technique in practice for the exploration of hydrocarbon reservoirs including resistive gas hydrate.

Recently, transforming the Maxwell equation from the diffusive domain to the fictitious wave domain has been developed to reduce computational time (Mittet, 2010). Although the diffusive Maxwell equations require a large number of time steps in finite-difference time-domain (FDTD) method to satisfy the stability condition, the number of iterations could be greatly reduced in the fictitious wave domain. However, the characteristic of the propagation in the fictitious wave domain has not been well exploited, and has potential for a new imaging technology of subsurface structures. In this study, we suggest a new data analysis approach to transform the data from the diffusive domain to the fictitious wave domain. Since the application of the transformation has a potential for improving the response of gas hydrate in the subsurface, we conduct some numerical experiments and discuss the applicability of our approach to the gas hydrate detection and evaluation.

We assumed a 3D resistivity model as a sub-seafloor structure including anisotropic resistive gas hydrate for simulating the inline CSEM exploration. By employing the singular value decomposition (SVD) method, we transformed the received data from the diffusive domain to the fictitious wave domain. Since the stability and accuracy of the transformation depend on the threshold of singular value, we adopt the appropriate value with considering the noise floor. Finally, our results indicate that the separated gas hydrate response becomes about twice as much than the case in diffusive domain.

Keywords: marine CSEM exploration, fictitious wave domain, gas hydrate, anisotropy

Japan Geoscience Union Meeting 2015
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SCG64-33 Room:A05 Time:May 28 15:00-15:15

Pie-shaped and dome-shaped submarine mud volcanoes

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Mud volcanoes can be viewed as natural tectonic conduits that bring up deep substances and fluids motivated by overpressuring at deep depths. Thus, mud volcanoes are useful tools to explore processes in fluid migration and material cycling. Large number of studies of the mud volcanism on Earth has been conducted, and about 300 offshore mud volcanoes had been confirmed and the double had been inferred around a decade ago. Nevertheless, so far, quantitative and statistical studies of mud volcano morphology have been mostly restricted to onshore mud volcanoes on Earth and mud volcano-like structure imaged on Mars. Herein we globally compile heights and radii of offshore mud volcanoes using bathymetric data and literatures. The compilation is forwarded to estimate a mean volume of episodic mud eruptions from the mud volcano based on authoritative studies into granular flows. The volumes are estimated in the function of the ratio of height over basal radius of mud volcano's body. Nearly all found offshore mud volcanoes are definitely proved to be polygenic. Moreover, an individual erupted volume from the pie-shaped mud volcano has a couple of orders of magnitude larger than the one from the dome-shaped one. A frequent occurrence of pie-shaped mud volcanoes, discovered in the accretionary margins characterized by high sediment influxes, is likely resulted from being efficient players for escaping large amount of fluidized sediments to reach the seafloor.

Keywords: Submarine mud volcanoes, catalog, granular flows, aspect ratio, subduction zones, material cycling

Japan Geoscience Union Meeting 2015
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SCG64-34 Room:A05 Time:May 28 15:15-15:30

Distribution of boron in slope sediment of Nankai accretionary prism off Kumano using B isotope as a tracer

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[1]University of the Ryukyus

1. Introduction

In oceanic mass balance, boron is taken up into clay minerals, thus seafloor sediment plays a role as an important sink of boron (Spivack et al., 1987). But a mechanism of the uptake has not been clarified yet in a detail. Isotopic fractionation has a specific value for each reaction, thus to investigate isotopic fractionation enables to infer in-situ reaction mechanisms. But the isotopic fractionation in the previous study through laboratory experiments cannot exactly explain reaction mechanisms in natural environments, especially at a low-temperature condition. In this study, isotopic fractionation of boron in surface sediment at a lower temperature than 25 ℃ was investigated to discuss a behavior of boron in natural environments at a low-temperature condition.

2. Materials and analytical methods

Samples of pore water were extracted from surface sediment recovered from Nankai accretionary prism off Kumano during IODP Expedition 338. The boron concentrations in the pore waters were measured on board by the inductively coupled plasma atomic emission spectroscopy (Strasser et al., 2014). The precision was within ±2.5%. The boron isotope ratios in the pore waters were measured by the multi-collector inductively coupled plasma mass spectrometry after its isolation (Wang et al., 2010). The analytical results were normalized by the standard material, NBS SRM 951, and denoted as a δ^{11}B value. The precision was within ±0.7 ‰.

3. Results and discussion

The boron concentration in the pore water was higher than that of seawater at the surface, and decreased with increasing a depth. The δ^{11}B value in the pore water was lower than that of seawater at the surface, and higher with an increasing depth. Isotopic fractionation, α, between solid and aqueous phases for each layer ranged from 0.950 to 0.970, lower than the reported values through a laboratory experiment between 0.975 and 0.980 (Palmer et al., 1987). In a laboratory experiment, there would be factors that could not imitate enough to natural environments; in-situ pressure, porosity, mineral compositions, ion strength of aqueous phases, and so on.

The relationship was verified between isotopic fractionation and several factors; in-situ temperature, pH, plagioclase abundance, and total organic carbon content. The relationship with pH showed a slightly negative, and the similar relationship was observed in surface sediment all around the world (You et al., 1993; Kopf et al., 2000; Teichert et al., 2005). This relationship would present uptake of $B(OH)_4^-$ enriched in ^{10}B, because $B(OH)_4^-$ is dominant in a solution when pH is higher.

4. Conclusions

Isotopic fractionation of boron in surface sediment of Nankai accretionary prism would be moderately controlled by pH, suggesting a reaction mechanism at a low-temperature condition has never been precisely imitated in laboratory experiments.

Keywords: Nankai Trough, Accretionary prism, slope sediment, Boron isotope

Japan Geoscience Union Meeting 2015
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SCG64-35 Room:A05 Time:May 28 15:30-15:45

Development of a stand-alone gamma-ray measuring system for long-term change at the sea floor, and first measurement

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In the Japanese Islands, the Tokai, Tonankai and Nankai earthquakes are expected within a few decades. It is a very important scientific issue to understand the physicochemical process occurring in the earthquake occurrence zone and the mechanism of earthquakes near the subduction zone for mitigation of casualties and social infrastructures. Increases of the radon concentration in atmosphere and in groundwater before earthquake are reported in the Southern Hyogo Prefecture Earthquake in 1995. The correlation between micro earthquakes and concentrations of radionuclides is expected to contribute the fundamental research on the response of the fluid in the crust corresponding to change of the crustal stress. Then this time, environmental gamma ray measurement derived from natural radionuclides at the deep-sea floor in the Kumano-basin, where the epicenter of the coming Tonankai earthquake has been inferred.

To date, submarine environmental radiometry around Japan has been mainly performed by diving of a manned submersible ”Shinkai 6500/2000” or a remotely operated vehicles, e.g. ”hyper-dolphin” At such measurement, the NaI gamma-ray instrument was connected by cable to power supply and data transfer (cable-tethered NaI). Thus, the spatial distribution of environmental radioactivity has limitedly been measured around diving points. On the other hand, it was impossible to measure radiation at a fixed point for a long period. Subsequently, an automatic recording gamma- ray measurement system (GRAMS [Gamma RAy Monitoring System]) was developed, and it made possible to measure submarine gamma-ray at a fixed point. But gamma ray measurement has been performed only for short period of 12 days so far.

This time we developed a new stand-alone NaI gamma-ray measuring system (stand-alone NaI) for long-term monitoring of radiation at the deep-sea floor. This system has following features; 1. It has intermittent operation mode to save power consumption. 2. An automatic shut-down function to suspend the measurement when a battery voltage falls below the threshold (for example, 6V). 3. Low power consumption: the requirement of cable-tethered NaI is 12V 170mA (2W) regardless of that of stand-alone NaI is 6V 110mA (0.66W). Thus, the power consumption decreases in 1/3 even in measurement. It enables gamma-ray measurement for long-term temporal change of submarine environmental radiation at a fixed point. Its power is supplied by 180 AA alkaline batteries, then running cost becomes dramatically inexpensive.

As first measurement, we measured secular fluctuation of radiation from 24th April to 3rd August (about 3.5 months) at a cold seepage on Kumano-Basin. Respective U, Th and K contents was calculated as almost constant of 0.19+-0.07 ppm, 0.07+-0.07 ppm and 0.05+-0.01wt.% in surrounding seawater. There was no large fluctuation. However, after Fourier analysis, a feeble peak of 25 hours, which corresponded to tidal fluctuation, has come out.

Keywords: radiation, sea floor, long-term temporal change, NaI, gamma-ray

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(May 24th - 28th at Makuhari, Chiba, Japan)

SCG64-36 Room:A05 Time:May 28 15:45-16:00

The changes of past sea-bottom environment deduced from the recent benthic foraminifera Southern off Costa Rica

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IODP Exp.344 (Costa Rica Seismogenesis Project: CRISP 2) is designed to understand the processes that control nucleation and seismic rupture of large earthquakes at erosional subduction zones and drilled five sites off the western coast of Costa Rica around the southern end of the Middle America Trench, where the oceanic Cocos Plate is subsiding beneath the Carribbean Plate. In this cruse, the benthic foraminiferal data were strongly needed because the distribution of recent living benthic foraminifera is essential tool to estimate the past bottom-ocean environment and paleobathymetory. However, there are few data about the distribution of the recent foraminifera southern off Middle America.

In this study, we have recognized six assemblages out of samples of southern off Costa Rica.

And we identified the the shallower-water environment assemblages of U1413 using these recent data.

Keywords: the recent benthic foraminifera, Paleobathymetory, the erosional subduction zone, southern off Costa Rica

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GPS-Acoustic seafloor geodetic observation by Japan Coast Guard - results and future plan -

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The Hydrographic and Oceanographic Department of Japan Coast Guard has been developing a system for precise seafloor geodetic positioning with the GPS-Acoustic combination technique and deploying seafloor observation sites on the landward slope of the major trenches around Japan, such as the Japan Trench and the Nankai Trough.

In this presentation, we summarize seafloor geodetic observation results and future observation plans.

Summary of the observation results:

(1) Seafloor sites along the Japan Trench

We have been carried out seafloor geodetic observations along the Japan Trench in order to detect post-seismic deformation of the Tohoku-oki earthquake. 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.

(2) Seafloor sites along Nankai Trough

Along the Nankai Trough, we deployed six seafloor reference points in the sea area from off-Omae-zaki through off-Muroto in early 2000s and had been carrying out campaign observations. From the observation data obtained before the 2011 Tohoku-oki earthquake, we detected the intraplate velocities of 2-5 cm/year toward WNW, which were generally consistent with those detected by on-land GPS measurements.

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. It’s been 3 years since we installed new sites, we obtain provisional results which suggests the velocities are different among some regions. It is expected that a spatial variation of interplate coupling will be revealed in the sea area along the Nankai Trough.

Keywords: GPS-Acoustic combination technique, seafloor geodetic observation, Japan Trench, Nankai Trough

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SCG64-38 Room:A05 Time:May 28 16:30-16:45

Postseismic deformation following the 2011 Tohoku-oki earthquake measured by seafloor geodetic observation

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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-shore geodetic observation. Watanabe *et al.* (2014, GRL) indicate significant contribution of viscoelastic relaxation to the postseismic deformation based on the fact that off-shore GPS/A sites just above the source region of the 2011 Tohoku-oki earthquake show significant landward movement while on-shore GPS sites show trenchward movement. Furthermore, Sun *et al.* (2014, Nature) show the viscoelastic relaxation is a dominant postseismic mechanism based on their numerical simulation explaining both off-shore and on-shore geodetic data. However, since GPS/A sites used in these studies are limited in the Miyagi-oki region and not above the shallow portion of the plate interface which caused large coseismic slip, it is not sufficient to reveal the spatial extent of the postseismic deformation. Hence, we aim to constrain the spatial extent and distribution of postseismic deformation using 23 GPS/A sites deployed along the Japan trench from Aomori-oki to Ibaraki-oki. Twenty out of these sites were newly deployed in Sep. 2012 in order to observe postseismic deformation following the Tohoku-oki earthquake.

So far, we conducted six campaign surveys from Sept. 2012 to Sept. 2014 (9-10/2012, 11/2012, 7-8/2013, 10-11/2013, 2-3/2014, 9/2014) completing three surveys at most of the sites. Based on the method derived by Kido *et al.* (2006, EPS), we estimate the seafloor transponder array positions for each survey and calculate the postseismic displacement rate at each site by applying linear regression to the time-series of the array positions.

Since errors in the postseismic displacement rates are estimated to be about 5-10 cm/yr, it is difficult to discuss the postseismic deformation at individual sites. However, sites above the heavily ruptured area in Miyagi-oki show a tendency of landward movement as previous studies indicate, and sites to the north and south of the heavily ruptured area show slight northward and southward movements, respectively. Moreover, these observed postseismic deformation patterns are consistent with the result of the viscoelastic model constructed by Sun *et al.* (2014). Consequently, the viscoelastic relaxation is likely a dominant postseismic deformation process during the observation period.

Next campaign survey is planned in Feb. – Mar. 2015 and will expand the time-series of seafloor array positions improving the estimation accuracy of postseismic displacement rates at individual sites. In this talk, we report these observation results including the data to be obtained in the next campaign survey and discuss detailed postseismic deformation following the Tohoku-oki earthquake.

Keywords: Tohoku-oki Earthquake, postseismic deformation, GPS/Acoustic observation, seafloor geodesy

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SCG64-39 Room:A05 Time:May 28 16:45-17:00

Seafloor movements on the northern part of the Philippine Sea plate detected by GPS-acoustic observation

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Along the Sagami Trough, where the Philippine Sea plate subducts beneath the North American plate, the megathrust earthquakes such as the 1923 Taisho Kanto earthquake (M7.9) and the 1703 Genroku earthquake (M7.9-8.2) had occurred repeatedly. On the west side, the west edge of Sagami Bay is considered as a boundary of the Izu Micro plate (IM) and the Philippine Sea plate [e.g. Sagiya, 1999]. Moreover, Taylor et al. [1991] suggested the back-arc rift zone along Izu-Ogasawara trench where the Pacific plate subducts beneath the Philippine Sea plate. Nishimura [2011] quantitatively estimated the motion of the Philippine Sea plate as the rigid rotations of several blocks and the slip deficits on the boundary faults. Because the most part of the Philippine Sea plate is covered with the ocean, however, few geodetic observations have been performed near the boundary faults. Thus, we, the group of Japan Coast Guard, have repeatedly performed seafloor geodetic observation with the GPS-acoustic technique (GPS-A) in order to detect the motion of the northern part of the Philippine Sea plate, especially near the boundaries.

We installed the GPS-A sites BOSS and SAGA on the seafloor southeastern off the Boso Peninsula and in the west part of the Sagami Bay, respectively. We set BOSS on the Izu-Arc block (IA) near the Sagami Trough, to detect the speed of the subducting Philippine Sea plate. On the other hand, we set SAGA on the IA near the northern part of the IM-IA boundary, where the Izu-Hanto-Toho-Oki earthquake (M6.7) had occurred in 1980. SAGA should be affected by the coupling of the IM-IA boundary faults.

We obtained the displacements relative to the rigid IA [Nishimura, 2011] on which the sites are located. Before the 2011 Tohoku-Oki earthquake (M9.0), no significant displacement was detected at BOSS (Sep. 2007 - Oct. 2010), which suggests that the seafloor around BOSS was considered to be rigid. Displacements detected at BOSS after the Tohoku-Oki earthquake (Apr. 2011 - Nov. 2013) were not significant either, though eastward coseismic displacement of 4-5 cm was detected. On the other hand, displacements at a rate of 1-2 cm/y toward south-southeast were detected at SAGA before the Tohoku-Oki earthquake (Jan. 2003 - Mar. 2011). We also detected eastward coseismic displacement of about 10 cm due to the Tohoku-Oki earthquake at SAGA. After the earthquake, eastward component of the displacement rate at SAGA was increased (May 2011 - Jun. 2014), which is considered to be caused by the postseismic deformation. Our results at SAGA obtained before the Tohoku-Oki earthquake are consistent with the quantitative model estimated by Nishimura [2011], which indicated the coupling on the IM-IA boundary faults. Therefore, the results at both BOSS and SAGA support the validity of the block-motion model by Nishimura [2011] on the seafloor near the boundary.

In this presentation, we report and discuss the results at BOSS and SAGA as well as other sites on and around the northern part of the Philippine Sea plate.

Keywords: GPS-acoustic seafloor geodetic observation, Philippine Sea plate, Sagami Trough, Block motion

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SCG64-40 Room:A05 Time:May 28 17:00-17:15

Numerical simulation of GPS-Acoustic seafloor geodetic observation for accuracy evaluation

YOKOTA, Yusuke[1*] ; ISHIKAWA, Tadashi[1] ; WATANABE, Shun-ichi[1]

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Hydrographic and Oceanographic Department of Japan, Japan Coast Guard (JHOD), has been preforming a seafloor geodetic observation with the GPS-Acoustic combination technique. In this observation, we first measure the absolute position of the acoustic transducer set at the bottom of the vessel using the GPS measurement. In addition, we measure the relative position of the seafloor acoustic transponder from the on-board transducer using the acoustic ranging and finally determine the absolute seafloor position. In the present system, the movements of the seafloor positions are measured with 2 - 3 centimeters precision (1-σ). We have determined the seafloor positions from seafloor geodetic observations 3 times a year for 4 - 5 years.

However, we should estimate the seafloor position with a high precision using a short-term data for determining a variable crustal movement due to the postseismic effect after the 2011 Tohoku-oki earthquake and the slow event along the Nankai Trough. This observation is also expected to be broadened to the Kuril Trench and Ryukyu subduction zones. Therefore, the improvement of observation and analytical approaches is required through the quantitative accuracy evaluation.

JHOD has discussed and estimated the accuracy of this technique by means of empirical approach using the practical data [e.g., Sato et al., 2013]. Because the final solution involves the effects from all error causes, we cannot discuss individual error causes quantitatively. This constitutes a barrier to develop for accuracy improvements. The past simulation studies from other research groups [e.g., Yamada et al., 2002] were not used for our system due to difference observation setting.

In this presentation, we numerically simulated the GPS-acoustic seafloor geodetic observation and evaluated the error causes in the observation and analytical processes. First, the error effects from the GPS positioning and the graded sound speed structure were derived in and investigated. The error effect from the GPS positioning was estimated smaller than the graded sound speed structure. The graded structure emerges the distortion of the array positioning of seafloor transponders and can be estimated on some level. We have plan to evaluate the error effects from the number of data, the coverage of observation lines, and time changes of sound speed structure, and so on, and compare with the practical observation data.

Keywords: seafloor geodetic observation, GPS-Acoustic combination technique, numerical simulation

Japan Geoscience Union Meeting 2015
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SCG64-41 Room:A05 Time:May 28 17:15-17:30

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

IKUTA, Ryoya[1*] ; HARUKA, Mukaiyama[1] ; TADOKORO, Keiichi[2] ; YASUDA, Kenji[2] ; CHIBA, Haruna[2] ; SAYANAGI, Keizo[3]

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We are developing a new method for GPS/Acoustic seafloor positioning using multi-buoy system. In this system, we combined GPS positioning and acoustic ranging to locate seafloor benchmarks. We usually use a vessel for this observation. In the single vessel measurement, we need to assume that seawater sound speed structure is horizontally layered and changes only in time because the measurement geometry by single vessel has a resolution for sound speed variation in space or time, not both. However, this assumption causes systematic error in the locations of seafloor benchmarks when sound speed structure has some lateral heterogeneity. Using the multi-buoy system, we can estimate both the spatial and temporal variation of sound speed structure because the system can obtain travel times for cross-passing ray paths at each moment. In November 2013, we conducted multi-buoy observation in Suruga Bay. In the analysis, we introduced an obliquely layered sound speed structure model (Ikuta et al., 2010). In this model, sound speed changes depending on positions of buoys and seafloor benchmarks as S(t,X,x) = S(t)+dS(X+ax), in which X and x are position of the buoys and benchmarks, respectively, S(t) and dSX are the temporally- and spatially-varying slowness, respectively, and dSx is contribution of the sloping structure. The coefficient (a) is implicated as the thickness of the laterally changing layer relative to the total depth, which is usually limited in the uppermost part of the seawater. Although the measurement time of about 2 hours was very short comparing to usual measurement time c.a. 10 hours, the benchmark was located within 19 cm from the expected position by previous study. The solution was improved 14 cm comparing to the same time-length single vessel measurement.

Keywords: Oceanbottom geodesy, GPS/Acoustic seafloor measurement, Buoy, Sound speed structure, Suruga Bay

Japan Geoscience Union Meeting 2015
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SCG64-42 Room:A05 Time:May 28 17:30-17:45

Development of on-demand buoy system for crustal displacement observation and future plan

TAKAHASHI, Narumi[1*] ; ISHIHARA, Yasuhisa[1] ; FUKUDA, Tatsuya[1] ; OCHI, Hiroshi[1] ; TAHARA, Jun'ichiro[1] ; MORI, Takami[1] ; DEGUCHI, Mitsuyasu[1] ; KIDO, Motoyuki[2] ; OHTA, Yusaku[2] ; HINO, Ryota[2] ; MIYOSHI, Motoyuki[3] ; HASHIMOTO, Gousei[3] ; MOTOHASHI, Osamu[3] ; KODAIRA, Shuichi[1]

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Tohoku University and Japan Aerospace Exploration Agency (JAXA) has developed real-time observation system for tsunami and crustal movement using a buoy through twice sea trials since 2011. We already succeeded in mooring under the high speed sea current with over 5 knots, observation using a pressure gauge with tsunami mode, acoustic data transmission using double pulses, and data transmission from the buoy to a land station using satellite. We entered in new stage of the buoy system development for on-demand crustal displacement observation since 2014 as a part of strategy innovation program using accumulated know-how. This system measures the vertical and horizontal crustal displacements using above pressure gauge and six acoustic transponders in realtime and also make possible to measure via satellite transmission in on-demand. At this moment, we have some issues to be improved to implement this system. One is acoustic data transmission using double pulse between the seafloor unit and the wire-end station. There are error cases for identification of the double pulse due to reflection signals from the sea surface and sea bottom. And we have an issue about the accuracy for the acoustic transmission, and faced accuracy of the double pulse detection with over 1 msec. We try to reduce the accuracy to keep broad dynamic range, too. Second is data transmission between the wire-end station and the buoy station. We experienced stop of the data transmission there. As a result, we concluded that the reason is torsion of the wire rope there based on profile of the buoy position data. Considering damages by fishery activities, we decided to keep redundancy for data transmission by two methods using an electric line and pairs of electromagnetic modem. In addition, we also prepare precise point positioning systems for real-time calculation of the crustal displacement on the buoy station, which are MADOCA system developed by JAXA and starfire of commercial base. In this presentation, we introduce current stage of the development and the future view.

Keywords: Crustal displacement observation, Buoy, On-demand, real-time, Nankai Trough

Japan Geoscience Union Meeting 2015
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SCG64-43 Room:A05 Time:May 28 17:45-18:00

Launching seafloor geodetic monitoring for the North Anatolian Fault in the Marmara Sea, Turkey

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The North Anatolian Fault (NAF) is known to be activated sequentially from east to west in the last century. NAF passes through entire Anatolian peninsula, Turkey, including the most populous city, Istanbul, where no significant earthquake has been occurred for long time. Unfortunately, NAF is submerged beneath the Marmara Sea near Istanbul, which prevent us to monitor the coupling state of the fault by land-based geodetic means, such as GNSS or triangulation. Under the SATREPS project between Japan and Turkey promoted by JICA, we have started seafloor geodetic monitoring of NAF in the Marmara Sea since 2014. We employed acoustic transponders, called extensometer, which can precisely measure ranges among instruments for short-baseline. Relative horizontal motion of the fault can be monitored as variation in baseline length across the fault. The system is designed as permanently installed for more than five years until their batteries run out. The recorded data can be obtained through acoustic modem communication without pop-up recovering of the instrument. In September 2014, we deployed four extensometers along the NAF at the Western High in the Marmara Sea, where no prominent branching faults are observed and the strain should be concentrated along the main fault. The beginning of the monitoring, we put high-frequent measurement (5 min) for 24 hours to check the accuracy of the ranging and recovered the data. Then measurement frequency has been turned into low-frequency (12 hours) for long-term monitoring. Examining the initial data, we confirmed the repeatability of the ranging is less than 5mm, which encouraged us to continue the monitoring to detect any signal in the next couple of years. In the presentation, we also show the first long-term data (6 months), which is to be recovered in the research cruise scheduled on March 2015.

Keywords: Marmara Sea, North Anatolian Fault, Turkey, earthquake, extensometer, seafloor geodesy

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SCG64-P01 Room:Convention Hall Time:May 27 18:15-19:30

Occurrence of hydrothermal kaolin minerals beneath the Iheya North Knoll hydrothermal field in the Okinawa Trough

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Introduction

Kaolin minerals is known as common alteration minerals observed in on land geothermal or fumarole area. On the other hand, only few studies reported occurrence of kaolin minerals in seafloor hydrothermal fields. As an example, occurrence of kaolin minerals was reported at the Jade site in the Izena Hole in the Okinawa Trough by Marumo and Hattori (1999). Recently, seafloor drillings conducted at the Iheya North Knoll in the Okinawa Trough revealed occurrence of kaolin minerals in sediment cores obtained from the vicinity of active hydrothermal fields. We conducted X-ray diffractometric analysis (XRD) and Scanning Electron Microscope (SEM) observation of the sediment samples. In this presentation, we report depth profiles of clay mineral assemblage in sediment below active hydrothermal fields, with interest in the relationship with a profile of metal elements content in the sediment.

Sampling and methods

Sediment cores were obtained by drilling at Hole C9016B (27 ^{o} 46.6' N,126 ^{o} 54.6' E, depth =1124m) in the vicinity of Aki site during CK-14 expedition in 2014, and by drilling at Site BMS-I-4 (27 ^{o} 47.4' N, 126 ^{o} 53.9' E, depth=1048m) located 200 m east from the Original site, during TAIGA11 cruises in 2011. Identification of clay minerals was conducted by X-ray diffraction technique (XRD) after separation of clay minerals and by scanning electron microscope (SEM) observation of bulk sediment.

Results and discussion

In the Aki site, change of dominant clay mineral assemblage along depth was recognized as below; smectite and illite in 0-9 mbsf, illite and kaolin mineral in 9-11 mbsf, and illite and Mg-chlorite below 11 mbsf (to 91 mbsf). Detailed investigation of the kaolin-rich layer revealed change of occurrence of kaolin minerals along depth as below; spherical kaolin minerals at 8.88 mbsf, plate-like kaolinite and tubular halloysite at 9.18 mbsf, and crystal kaolin minerals at 10.83 mbsf. It is interesting to note occurrence of sphalerite and barite were identified in the 9.18 mbsf sediment but not observed in 10.84 mbsf. Profile of trace elements content in bulk sediment (Nozaki et al., in this meeting) corresponded to the occurrence of sulfide/sulfate minerals in the sediment. High contents of Ba, Zn and Pb were notable in the 9.81 mbsf sediment, whereas high contents of Cu and Ag were recognized in the 10.28 mbsf sediment.

In the Original site, intense alteration represented by dominant occurrence of kaolin minerals was recognized in sediment from just a few 10 cmbsf to 3.5 mbsf. Also in the sediment from this site, occurrence of sphalerite, galena and barite was identified.

As mentioned above, occurrence of kaolin minerals associated with sphalerite and barite was recognized in relatively shallow depth below the seafloor located at a few hundred meters apart from the active venting in two hydrothermal sites in the Okinawa Trough.

Keywords: submarine hydrothermal deposit, clay minerals, submarine drilling

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SCG64-P02 Room:Convention Hall Time:May 27 18:15-19:30

The structure of iron oxidized mounds at shallow marine hydrothermal environment in Satsuma Iwo-jima Island, Kagoshima

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Satsuma Iwo-Jima, located 38km south of Kyusyu Island, Japan, is a volcanic island in the northwestern rim of Kikai caldera. Here is preserved and identified on occurring iron precipitation at shallow ocean where can be recorded modern analogy of iron precipitation and sedimentation. Iron oxidized mounds are developing at seafloor with hydrothermal activity (pH=5.5, 50-60 degree Celsius), and there is high deposition rate of iron-oxides (33 cm/year: Kiyokawa et al., 2012).

Result of sea sonar scan seismic images shows that the iron oxidized mounds in Nagahama bay are estimated about 7.8 m^3 in volume, which formed 2-3 thick mound at 32.68 m^2 area for 20 years. Each mound is formed two layers: blackish hard layer and brownish soft layer. The inside of samples is constructed from the aggregation of convex structure (3-4 cm) covered by hard layers as a rim. Petrographic observations indicate that both layers have filament-like forms, and the form in soft layer is perpendicular to that in the hard layer. The number of iron oxides particles observed on filament-like forms in soft layer increases toward hard layer. Hard layer consists of aggregation of bacillus-like form as the chain of particle (about 2 um). At soft layer, on the other hand, bacteria-like form with smaller particles ($<$0.5 um) is observed. Bacteria-like form could be classified into 3 types (helix, ribbon-like, twisted). Furthermore, hard layers consist of ferrihydrite and opal-A (Si: 26.8%, Fe: 56.0%) and soft one is composed by ferrihydrite, opal-A and silica mineral (Si: 36.5%, Fe: 43.5%). *Mariprofundus ferrooxydans* known as iron-oxidizing bacteria belonging to Zeta-proteobacteria identified in this matter, but they are nothing at floating iron oxide samples.

The process of forming iron oxidized mounds: 1. Soft layers were made by chemical and biological activity. The filament-like forms at soft layer is the stalks of iron oxidizing bacteria. 2. The hard layers were made by adsorption of iron oxyhydroxide around stalks. Iron oxidizing bacteria is prefer to the redox interface (Chan et al., 2011) such as the mixing zone located in hard layer between hydrothermal fluid and seawater. 3. Hydrothermal activity form the liner structure at hard layer. Iron oxidized mounds were formed by repeating of those process over ten times.

Based on the seismic data, the forming rate of iron oxidized mounds is about over 1.2 cm/yr. Formation of hard layers in these mound is the result of adsorption of iron oxyhydroxide around stalks made by the activity of iron oxidizing bacteria. The iron providing rate ($2.474*10^6$ kg(Fe)/m.y./m^2) from the Nagahama bay iron mounds is as about ten times as that of the Hamasley Group sediment ($2.51*10^5$ kg(Fe)/m.y./m^2). Furthermore, if there is the Nagahama bay iron oxidized mounds at Archean, $6.0*10^8$ times of these mounds need to form the Joffre Member volume (360 m/2m.y.). In this study, we strongly suggest that the combination of chemical and biological reaction is important system to form large amount of iron oxide deposit.

Keywords: iron oxidizing bacteria, hydrothermal fluid, iron oxide, satsuma iwo jima, biomineralization

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SCG64-P03 Room:Convention Hall Time:May 27 18:15-19:30

Geochemistry of trace alkali elements in the seafloor hydrothermal fluids

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Hydrothermal fluid contains many elements at high concentrations as a result of fluid interaction with rock/sediment and seawater dusring fluid circulation beneath the subseafloor. In particular, Rb and Cs are known as ”soluble elements” which is easily leached from the rock/sediment into the fluid because of their large ion radii. Thus, trace alkali element compositions of hydrothermal fluids would provide information about water/rock interactions.

We determined Rb and Cs concentrations of hydrothermal fluids collected from four fields in the Izu-Ogasawara arc (Myojin Knoll Caldera, Myojinsho Caldera, Bayonnaise Knoll Caldera and Suiyo Seamount), from six fields in the Mariana Trough (Alice Springs Field, Forecast Vent Field, Pika Site, Archean Site, Snail Site and Urashima Site), and from the Iheya North Knoll hydrothermal field in the Okinawa Trough, to discuss their diversity.

Analysis of Rb and Cs concentrations of each sample was conducted using ICP-QMS. To determine the endmember Rb and Cs compositions for each hydrothermal field, the analytical results of the samples were extrapolated to zero Mg concentration. The endmember concentrations of Rb and Cs are plotted in Figure 1. In addition to the results of this study, data from hydrothermal field in the EPR 21^{o}N[1] and MAR (TAG and MARK)[6] located in sediment-starved mid ocean ridge setting, in the Escanaba Trough and Guaymas Basin[2] located in a sediment-hosted setting, and in the Lau Basin[3] and Manus Basin[4] located in a back-arc basin setting are plotted in the same figure. Moreover, compiled data for volcanic rocks and sediment material around these hydrothermal field are overimposed as shaded region in Figure 1.

A range of Rb/Cs ratio of hydrothermal fluids from an arc setting (square symbols; Rb/Cs=12.8 to 26.7) can be distinctive that from a back-arc setting (circle symbols; Rb/Cs=18.6 to 100.1). Rb and Cs concentrations in hydrothermal fluids from a sediment-hosted hydrothermal field is characterized by their substantially high concentrations. Moreover, it is likely that the range of Rb/Cs ration of hydrothermal fluids are comparable for those of volcanic rocks/sediment surrounding these hydrothermal field. It would be suggest that the distribution of Cs from rocks to hydrothermal fluids in arc setting is higher than one in other tectonic setting.

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Keywords: trace alkali elements, hydrothermal fluids, arc, back-arc basin, sediment

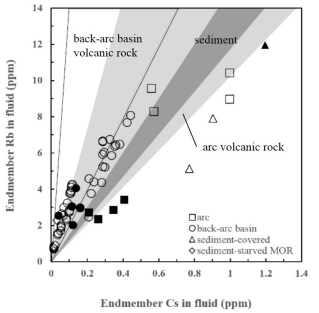

Fig. 1 Relationship between Rb and Cs end-member concentrations in hydrothermal fluids measured this study (solid symbols) and compiled data from submarine hydrothermal systems of various tectonic setting (open symbols). Symbols are; squares; Izu-Ogasawara and Kermadec arc[2] of arc hydrothermal systems, circles; mid/southern Mariana Trough, Lau Basin[3] and Manus Basin[4] of back-arc basin (BAB) hydrothermal systems, triangles; Iheya North Knoll at Mid Okinawa Trough, Guaymas Basin and Escanaba Trough[2] of sediment-hosted hydrothermal systems, and diamonds; EPR 21°N[1], TAG and MARK[6] in Mid Atlantic Ridge of sediment-starved mid-ocean ridge (MOR) hydrothermal systems. Moreover, the range of Rb/Cs in volcanic rock collected around each the hydrothermal site were compiled and were drawn meshing in Fig. 1. The meshing show; area surrounded solid line: BAB volcanic rock, dark gray; sediment, and light gray; arc volcanic rock, respectively.

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SCG64-P04 Room:Convention Hall Time:May 27 18:15-19:30

Seismicity at the Kairei Hydrothermal Vent Field Near the Rodriguez Triple Junction 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 circulate in subsurface, we conducted a seismic refraction/reflection survey and seismicity observation with ocean bottom seismometers (OBSs). This presentation will show seismicity of the survey area.

2. Observation and methods

We conducted a seismic survey around the Kairei hydrothermal field from January 27 to March 19 in 2013 using S/V Yokosuka of Jamstec (YK13-01, YK13-03). We used 21 OBSs. We determined hypocenter locations in a 3D velocity structure. The 3D structure is estimated by Takata et al. (2015, This Meeting). We used NonLinLoc software (Lomax, 2000), which can estimate earthquake locations in 3D media.

3. Results

From the 50 days seismicity observation, we found more than 5000 micro earthquakes in this area. A swarm of micro earthquakes exists at a location about 1-3 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). The focal mechanisms in the swarm are normal type. These indicate that this swarm shows normal fault activity parallel to the ridge axis. This swarm may be related 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 about 3-6 km from seafloor, and deeper than that of the swarm near the Kairei field. The focal mechanisms at the segment are normal type with the T axis parallel to the plate motion. At the non transform offset, there are no lineaments of earthquakes and left lateral strike slip mechanisms are dominant.

Acknowledgements

We thank the captain and the crew of S/V Yokosuka of Jamstec for their support. This work was supported by Grant-in-Aid for Scientific Research on Innovative Areas of the Ministry of Education, Culture, Sports, Science and Technology (Grant Number 20109002, TAIGA project).

Keywords: TAIGA Project, hydrothermal field, seismicity, Triple Junction in the Indian Ocean

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SCG64-P05 Room:Convention Hall Time:May 27 18:15-19:30

Petrographical and morphological charaeter or volcanicrocks dredgard around the Sumisu calderam, Izu-Ogasawara arc

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The Izu-Ogasawara arc is located the south of Izu peninsula. It opens for total extension approximately 1,500km, approximately 400km in width. In addition, it is an active oceanic island arc of the volcanic activity. A volcanic zone of the Quaternary period ranges to the Shititou-Ioushima ridge in the Izu-Ogasawara arc to the north and south and constitutes a volcanic front. There are many submarine volcano with caldera in the Izu-Ogashawara arc (Murakami,1997).

In this study, mention of the topography of Smith caldera gathered by Tokai University Bousheimaru from May 9, 2014 through May 15 and the rock analyzed it.

As a result, (1)the diameter of the Sumisu caldera is 9km (2)the depth of the water of the outer rim of a volcanic crater top is 30m (3)caldera wall is steep than the outer slope (4)stepped terrain development in the caldera outside slope (5)water depth of caldera bottom 900m (6)there exists a central cone of relative height 100m in the center. As a result of bottom sampling, fresh rhyolite volcanic rock and volcano-clastic rock were gathered from a caldera bottom and the central cone. Flesh rhyolite volcanic rock rhyolite was gathered in the lower caldera wall and central part. By the petrochemistry composition, a value of SiO2 was concentrated in two places of 49.6(wt.%)˜51.1(wt.%) and 67.5(wt.%)˜69.4(wt.%). Typical bimodal volcanic activity was confirmed from this caldera.

From the slope of the back arc side, flat basalt and a large quantity of pumice and acid plutonic rocks were collected. A large quantity of dacite quality pumice (quality of corner stone) was gathered at the same time, too. Therefore, bimodal volcanic activity was estimated in the back arc side than not including volcanic rock of the quality of andesite.

Keywords: Smith caldera, Bimodal volcanism, Spatter ejecta, Dacitic pumice

Japan Geoscience Union Meeting 2015
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SCG64-P06 Room:Convention Hall Time:May 27 18:15-19:30

Petrological study on Marcus Island

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Marcus-Wake seamount trail is located in West Pacific Seamount Province (WPSP), where the oceanic plate is oldest in the world, around 160 Ma Pacific plate. WPSP had occurred during Cretaceous and was reconciled with current active hotspots of French Polynesia in South Pacific. Marcus (Minami-tori) Island is located 50 km away from Marcus-Wake seamount trail to the north. Most of seamounts, particularly well-studied seamounts, are more voluminous than the edifice of Marcus Island, whereas no islands and atolls are found around the island within 500 km. In this study, mineralogical and whole rock analysis of lava samples, obtained in submarine survey of northwest flank of Marcus Island, are adopted in order to compare with volcanic samples from WPSP and South Pacific islands of active hotspot volcanism. High TiO_2 in relic of chrome spinel indicates the typical intra-plate volcanism to be similar characteristics with those of WPSP. Major element compositions reveal normal-alkali basalts. Nb/Zr and Nb/Y ratios can classify the origins of shallow mantle plume, not in superplume as old Polynesian hotspots, like the Marcus-Wake seamounts of WPSP. Therefore, Marcus Island was produced from intraplate volcanism which differs from hotspot activities forming the Marcus-Wake seamounts.

Keywords: Marcus-Wake seamount trails, seamount, WPSP, HFSE, superplume, alkali-basalt

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SCG64-P07 Room:Convention Hall Time:May 27 18:15-19:30

Olivine xenocrysts in lava of petit-spot volcano

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Petit-spot is a small volcano erupted on the seafloor. The magma comes from asthenosphere, just below oceanic lithosphere, through a crack in subducting plate. The petit-spot volcanoes appear globally on the seafloor where the plate is flexing (e.g., Japan and Chile Trenches). The petit-spot lavas and entrained mantle materials have been already reported from areas of Japan Trench oceanward slope (Sites A), and of NW Pacific (Site B). Although the discovery of the petit-spots has been anticipated from Site C (offshore of Fukushima, south of Site A), lava samples and entrained mantle materials have never been reported. To examine the activity of the petit-spot volcanoes, we conducted the nine submersible dives of the *SHINKAI 6500* submersible during cruise YK14-05 of *R/V Yokosuka* at Site C in April 2014.

Alkaline pillow lavas were collected from the Site C during cruise YK14-05. Eruption age is at the time between 0.31 and 2.1 Ma estimated on the basis of the thickness of paragonite on quenched glass rind. The lavas are classified into basanite, and include large amount of olivine (>10% normative olivine). Large (1-5 mm) olivines have anhedral morphology. The large olivines show forsterite numbers (Fo) of 88-90 and NiO contents of 0.3-0.5 wt. %, corresponding to the composition of the primitive mantle peridotite. On the other hand, the small olivines surrounding the large olivines have similar range of compositions (Fo of 84-87, CaO contents of >0.1 wt. %) to those of groundmass olivines. These observations imply that large olivines are fragments of mantle peridotites, that is, these are mantle xenocrysts. If these are xenocrystic olivines, it tells us the cryptic aspects of an old oceanic lithosphere. Fo values of the present olivine xenocrysts are slightly lower than those of the mantle xenoliths reported from Site A and B (90-93). The chemically heterogeneous mantle might be existed in the subducting NW Pacific plate.

Keywords: petit-spot, olivine, xenocryst

Japan Geoscience Union Meeting 2015
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SCG64-P08 Room:Convention Hall Time:May 27 18:15-19:30

Petrological analysis of Fe(III)-rich serpentine in the Central Indian Ridge serpentinites

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Aqueous fluids at serpentinite-hosted hydrothermal vent fields near mid-oceanic ridges are characterized by high concentrations of dissolved reducing chemical species, such as H_2, H_2S and hydrocarbons, and aid development of unusual chemosynthetic ecosystems. Petrological, geochemical and experimental works suggest that the cause of the H_2-rich fluids is oxidation of Fe during water-rock reactions in ultramafic lithosphere to form magnetite. However, a recent micro-XANES study of the Mid-Atlantic Ridge serpentinite indicates that serpentine can be a primary phase for Fe^{3+} prior to magnetite. In order to understand the role of Fe^{3+}-rich serpentine in the H_2 production, we made petrological analyses of serpenitinite exposed at the southern end of the Central Indian Ridge (CIR), very close to the Kairei Hydrothermal Field where high temperature, H_2- and Si-rich fluids are emitting. Serpentinite samples used in this study (dredged using Hakuho-maru from Yokoniwa Rise) include 11-13 modal % of bastite after Opx indicating that the protoliths are mantle peridotite with harzburgite compositions.

Base on microscopic observations and micro-Raman and EPMA analyses, we identified three types of serpentine after olivine. The most dominant one is characteristically brownish under microscope and optically isotropic. The Raman O-H bands are distinct from those of typical serpentine polymorphs but can be explained as composites of chrysotile and lizardite. Therefore, we call this type of occurrence as “brown serpentine aggregate” . It occupies about 70 vol % of the samples. Extensive replacement of olivine by brown serpentine (Stage I) was followed by formation of Fe-rich lizardite along pre-existing magnetite (Stage II), resulting in a mesh-like texture. During a later stage of hydrothermal alteration (Stage III), the mesh texture has been partly or fully overprinted by a vein-like texture consisting of Fe-poor well-crystalline lizardite and crack-filling chrysotile at its center. The microtextural evolution represents stepwise serpentinization probably during uplifting of the CIR mantle lithosphere.

Distribution and mineral chemistry of “brown serpentine” indicate that SiO_2 activity was a significant driving force of the formation. Total oxide compositions of “brown serpentine” are significantly lower than that of lizardite implying fine-grained aggregates with porous nature. They can be interpreted as a product of high reaction rate under high temperature conditions.

Preliminary micro-XANES analyses of “brown serpentine” at a mesh center revealed that about 70% of Fe in the serpentine is Fe^{3+}. Assuming that this value is applicable to the whole sample and that the bulk Fe content is constant during serpentinization, we estimate that the contribution of “brown serpentine” in H_2 generation was as large as that of magnetite. Total H_2 produced by complete hydration of olivine 1kg is estimated to be 9.6L (the contribution of “brown serpentine” is 4.5L), which is equivalent to the amount of H_2 dissolved in 54kg of the Kairei hydrothermal fluid (8 mM H_2). Conversion of Fe^{3+}-serpentine to Fe-poor serpentine + magnetite at shallower parts may cause a minor absorption of H_2 although we do not have sufficient data to quantify it. The maximum estimation of this study implies a high water/rock ratio in hydrothermal system beneath CIR.

Keywords: Mid-oceanic ridge, hydrothermal field, serpentinite, ferric iron, hydrogen

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SCG64-P09 Room:Convention Hall Time:May 27 18:15-19:30

Lithosphere-Asthenosphere boundary beneath NW Pacific Ocean detected with seismic waveform data

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We have conducted seismic observation around the Shatsky Rise in the northwest Pacific Ocean at 18 stations equipped with a broadband ocean bottom seismometer (BBOBS) for understanding the structure of the Earth's interior and the mechanism of plate motion (Normal Mantle Project). It is important to estimate the upper mantle structure beneath these stations, for revealing existence of partial melt and water in the oceanic upper mantle.

We calculated P-wave and S-wave receiver functions (PRF, SRF) with waveform data obtained from the BBOBSs. We analyzed teleseismic events occurring between June 2010 and September 2014, whose magnitudes are over 5.5. Epicentral distances of the events used for calculating PRF are between 30^o and 90^o, and those for calculating SRF are between 55^o and 90^o. Careful handling is required for the data obtained at stations northwest side of the Shatsky Rise because the data are largely affected by reverberations in the thick sediments (Abe and Kawakatsu, 2014, SSJ Fall Meeting). We eliminated frequency components higher than 0.1 Hz from SRF with a Gaussian filter because noise level of the observed waveforms in the frequency domain around 0.2 Hz is high. Frequency components higher than 0.05 Hz were eliminated from PRF for preventing contamination by reverberations in the sediments. We averaged PRFs and SRFs for each station, and obtained a broad negative peak on averaged PRFs and a broad positive peak on averaged SRFs, between 5 s and 10 s. Both these peaks correspond to velocity decrease with depth in the upper mantle. We synthesized PRF and SRF with a model, which contains a discontinuity at depths between 30 km and 150 km, where velocity decreases between 0% and 20% with depth, and searched a model that explains both PRF and SRF obtained at each station. From the search, a model with 8% drop in velocity at 85 km in depth and a model with 4% drop in velocity at 125 km in depth explain the data observed at the northwest and southeast side of the Shatsky Rise the best, respectively. Kawakatsu et al. (2009 Science) detected a discontinuity with downward decreasing velocity at 80 km in depth by an RF analysis of waveform data from borehole BBOBS on north side of Shatsky Rise, and they interpreted the discontinuity as the Lithosphere-Asthenosphere boundary (LAB). The discontinuity detected in this study may also correspond to LAB. The structure of the oceanic crust and sediments and water depth of a station may affect the waveform of RFs. Therefore, we now check how correctly we can constrain the depth and the drop in velocity with different assumptions of the shallower structure.

Keywords: oceanic plate, receiver function, Northwest Pacific Ocean, Lithosphere-Asthenosphere boundary

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SCG64-P10 Room:Convention Hall Time:May 27 18:15-19:30

Sharp gravity increase following an outer-rise earthquake: possibility of viscoelastic rebound by melt-rich channel

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We are going to talk about postseismic gravity increase by outer-rise earthquakes, and explain their geophysical mechanism through viscoelastic theory.

Keywords: outer-rise earthquake, melt-rich channel, viscoelastic rebound, GRACE, postseismic gravity change

Japan Geoscience Union Meeting 2015
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SCG64-P11 Room:Convention Hall Time:May 27 18:15-19:30

Earthquake induced deposits during the 2004 off Kii Peninsula earthquakes at a terminal basin

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Submarine paleoseismology has been advanced mainly by investigation of distribution and age of seismogenic turbidite deposits. However, we have to pay attention to the following issues for the usage of this method. 1) Turbidity currents are also triggered by flood, wave, rapid sedimentation and so on. 2) It is hard to determine a seismic source region by investigation of turbidites originated from more than one sediment-provenance. 3) Tuibidity current does not provide sedimentary record or remove the former sequence in some cases. In order to avoid these problems, a terminal basin with a limited small provenance area and without direct river input is an appropriate target. The term ”a terminal basin” is a sedimentary depression surrounded by topographic heights that capture all sediments supplied from outside.

The sedimentary basin located between the Kumano forarc basin and the outerarc high corresponds to a terminal basin 250 meter deeper than the surroundings. The core sample collected by R/V Shinsei-maru KS-14-08 from this basin includes thin very fine-grained sand at 17 cm below seafloor and mud with silty clay laminae above it. The surface 17 cm thick mud layer is interpreted to be younger than 1950 because Cesium-137 measurements show constant high value above 17 cm and lower value than detection limit below it. Moreover, excess Pb-210 values show constant high above 17 cm and rapid decrease downward below it. This indicates a sedimentation event for a short period of time. Because the sampling site is isolated from river flood sedimentation area, earthquake shaking is the most plausible trigger of sediment gravity flow. The 2004 off the Kii peninsula earthquakes is a potential candidate within the historical earthquakes in this area after 1950.

Sidescan sonar WADATSUMI survey was conducted in this area in December 2004 just after the Kii peninsula earthquakes. The sidescan sonar image at the terminal basin shows extremely low backscattering intensity suggesting surface veneer of very high water content mud derived from earthquake triggered turbidity flow.

Keywords: turbidite, turbidity current, sedimentary basin, accretionary prism, submarine landslide

Japan Geoscience Union Meeting 2015
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SCG64-P12 Room:Convention Hall Time:May 27 18:15-19:30

Microstructure analysis of earthquake-induced deposits associated with the 2004 off Kii Peninsula earthquakes

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An ENE-WSW elongated depression is located between the southern margin of the forearc basin and the outer ridge off Kumano and a terminal basin that captures all sediments supplied from outside is developed in it. No sediment is supplied from the rivers to this basin, so it is an adequate site to study paleoseismology using seismogenic turbidites.

The result of the Cs-137 and Pb-210 measurements indicates that the upper 17-cm mud layer was deposited immediately after the 2004 off Kii Peninsula earthquakes (Ashi and others, in this Session). We herein investigate the characteristics of the earthquake-induced deposits based on several measurements including their compositions, grain sizes, X-ray CT images, and anisotropy of magnetic susceptibility (AMS).

We observed a very thin fine-grained sand layer of 6 mm thick at 17 cm below seafloor and a massive mud below it on the core split section. On the other hand, the X-ray CT image shows seven silty clay laminations thinning upwards at 6 -15 cm below seafloor, and homogeneous clayey silt above it. The AMS parameters decrease upwards in the interval showing parallel/cross laminations and the lowest value is measured in the overlying silt layer, whereas grain sizes have no significant change. These results indicate that the upper 17 cm layer beginning from the very fine-grained sand can be interpreted to be formed by a low-density sediment gravity flow. Below the depth of 17 cm, the deposition is mainly composed of muddy sediments with a wood chip-enriched thin bed and a very fine-grained thin sand layer at the depth of 32 cm. Structural observations by X-ray CT scanner reveal characteristic structures yielding various orientation oblique to bedding plane at the mud layer 17 cm below seafloor, suggesting that the structure is likely formed by coseismic deformation accompanied by the earthquake in 2004 or earlier ones. Magnetic fabrics derived from AMS measurements and the structure observed by X-ray CT scanner also agree to this picture.

Keywords: turbidity current, anisotropy of magnetic susceptibility, X-ray CT, event deposit

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Application of C-14 dating on *Calyptogena* shells for historical fault activity analysis off Tokai, Nankai Trough

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Cold seeps are frequently found at tectonically active continental margins including areas such as the Nankai and Tokai regions. The fluid conduits created by the tectonic activities often form cold seeps, releasing hydrocarbon rich fluids such as methane. Substances such as this are essential for supporting *Calyptogena* bivalve communities to survive through a symbiotic process with the chemosynthetic bacteria. The lifespan of bivalves can be ephemeral due to the conduits altering from tectonic events of converging plate margins, or the source of the hydrocarbon depleting over time. These characteristics may suggest that the *Calyptogena* bivalve shells may hold important information on historical fault activities of the area.

Marine samples originating from the deep sea have often been difficult to radiocarbon date due to the complicated calibration processes involved. Deep circulating ocean currents and sub seafloor seepage of hydrocarbons are main factors responsible for the necessary complex calibration calculations, referred to as the dead carbon effect. DSV *Shinkai* 2000 discovered an unusually large *Calyptogena* bivalve colony in 1997, ranging approximately 200m^2 off the Daini Tenryu Knoll off Tokai in Japan. Bivalve colonies found are composed mainly of dead shells with few spots of living communities remaining. Past tectonic events may have influenced the methane hydrate layer below to destabilise, releasing significant amounts of methane fluid and gas to the seafloor, consequently allowing bivalves to flourish (Kuramoto, 2001; Ashi et al., 2002; Otsuka et al., 2010).

Amino acid racemisation dating technique was employed on the same shells by Misawa (2004) revealing two different age groups of 0∼500 years (white shells) and 1000∼2000 years (brown shells), yet the technique was prone to temperature and pH change. This study therefore proposes a novel application of radiocarbon dating of such bivalves to further understand the interaction between local active faults and the bivalve community. Current ^{14}C age measured range between 1868–1949 year cal AD, coinciding with the 1854 Ansei Tokai earthquake (M8.4). Seafloor mapping, seawater analysis and EPMA and SEM structural analysis of shells from ROV *HyperDolphin* Dives 1355 and 1377 during NT14-07 and NT02-08 respectively, will also be reported.

Keywords: Radiocarbon dating, Cold seep, Calyptogena shell, Active fault, Methane

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Distribution of methane hydrate BSRs and shallow thermal structure in the Nankai subduction zone

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Thermal structure in subduction zones influences pore pressure and diagenesis such as consolidation, dewatering, cementation, and constrains physical propertiies of fault-slip plane. Methane hydrate is a clathrate that consists of water and methane. Recently, it attracts attentions not only for marine resources but also for estimates of thermal information below the seafloor using the characteristics of its stabilization under low-temperature and high-pressure conditions. Precise two-dimensional thermal structure ranging from the seafloor to BSR depths is calculated taking topographic effect into account, because subsurface heat flow is affected by bathymetry features.

Geothermal gradients in rougher topography tend to be widely different from that in flat seabeds. To remove this effect, I evaluated the effect by conducting the simple two-dimensional thermal calculation of Blackwell et al. (1980). Additionally, I calculate the Base of Gas Hydrate Stability zone (BGHS) taking into consideration the thermal structure coupled with the topographic effect.

A deepening trend of BSR depths landward of trough floor is confirmed as suggested in previous studies. This observation yields countertrend because the BSR depth should be deepest in the trough floor as methane hydrate is stable under low-temperature and high-pressure conditions. Thus, observed BSR depths suggest that heat flow actually decreases landward of the trough floor.

The investigated BSR depths are constrained from deep heat flux, and vary basically landward of the trough floor. But, in this study, BSR depths are deeper around anticline parts and shallower around sycline. Theoretically, the convex-upward seabed is subject to cooling owing to cold bottom seawater, while the convex-downward one is less subject to the cooling. Evaluations of this kind of topographic effect suggest that sycline can be explained by only the topographic effect. Thus, thermal regime calculated from BSR depths does not change in sycline or slope areas.

In this study, the BSR was confirmed for the first time at the prism toe. The detailed BSR distribution map can contribute to disaster prevention because BSRs have potential to being fault-slip planes. In the Nankai area, geothermal gradient values scatter, but the values can be explained by considering subducting plate age, topographic effect, and sedimentation or erosion. In addition, while distances from seafloor to BSR depths are different even under the same water pressure, the calculation taking topographic effect into account revealed to be able to explain these depth changes. Moreover, the calculated thermal structure over BSR depths considering topographic effect seems to be accurate, because estimated BGHS depths and BSR depths fit well together. Understanding precise BSR depths enables to precisely estimate deposited amount of methane hydrate. This study provides thermal information essential for seismic simulations in subduction zones and for laboratory experiments as analogues to seismic ruptures in plate boundary faults.

Keywords: Nankai sucduction zone, methane hydrate BSRs, shallow thermal structure

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Physical property of sea bottom surface estimated from fin whale vocalization

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At the cabled observatory off Kushiro-Tokachi in Hokkaido, fin whale vocalizations, which have the frequency range of 15-20 Hz and the duration of about 1 second, were sometimes observed not only with hydrophones but also with ocean bottom seismometers (OBSs) mainly in winter seasons. By using the waveform data of both hydrophone and OBS at OBS1 at the observatory observed from 13:44 to 14:59 JST on December 10th in 2004, the location of the fin whale was estimated. The localization was done based on the incident orientation which was estimated from the horizontal particle motion observed with the OBS and the horizontal range between the OBS and the whale estimated from the time difference of multi-path arrival (TDOMA) in sound pressure data of a hydrophone which includes the reflection at both seafloor and sea surface. During the above observation period, 62 vocalizations were used, whose direct and multi-path arrivals were both identified. The waveforms were band-pass filtered between 10 and 25 Hz and the incident orientation of the particle motion was estimated by applying principal component analysis and by obtaining eigen vector of first main component. As a result it was found that the whale was moving south-south-east near the east of OBS1.

In the previous study carried out in the northeast Atlantic (Harris et al., 2013), the incident angle which was estimated from the apparent emergent angle in the sediments observed with the OBS was used instead of the TDOMA for the localization of the whale. However, the apparent emergent angle is affected by the density and P-wave (pressure wave) velocity of both sediments and water, and is also affected by SV-wave (share wave) velocity of the sediments, which are mostly unknown. This time, the author compared the apparent emergent angle in the sediments observed with the OBS with the incident angle estimated from the TDOMA in order to examine the consistency of those estimations. As a result, good correlation between the apparent emergent angle and the incident angle was confirmed, and the critical incident angle of pressure wave in seawater was estimated to be 60 degrees. Accordingly, the P-wave velocity in sediments was estimated to be about 1.7 km/s according to Snell’s law, assuming that sound velocity in water was 1.5 km/s and SV-wave velocity in sediments was very slow.

Keywords: fin whale vocalization, incident angle, apparent emergent angle, critical angle, seismometer, hydrophone

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Crustal density structure derived from gravity modelling using results of seismic crustal structure surveys

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The Japan Coast Guard (JCG) has conducted marine gravity surveys in Japan's adjacent seas as part of collecting marine-related information to the development and use of the oceans, and possesses enormous amount of marine gravity data. We calculated crustal thickness distribution in the Western Pacific area by applying the gravity inversion method (Ishihara and Koda, 2007) using these data.

Free air anomalies obtained from the satellite altimetry (Sandwell et. al., 2014) were used as a reference in order to correct deviations of marine gravity values of each surveys. In the long wavelength components, gravity data observed and these from the satellite altimetry match well. In the short wavelength components, maritime gravity data were used in preference because gravity data from the satellite altimetry include a few mGal of noises with wavelength of 20-30 km.

The initial density structure model consists of five layers; sea water, sediments, upper crust, lower crust and mantle. The depths of layers of the initial model reflect results of JCG's seismic crustal structure surveys: the depth of basement as boundary between sediments and upper crust is made by interpolation of the depth of the strong reflectors in the reflection cross section obtained from multichannel seismic reflection surveys, and the depths of the top of the lower crust and the Moho are made by interpolation of the depth of area whose velocity gradient of seismic velocity structure cross section obtained from seismic refraction surveys, respectively.

The differences of the observed free air anomalies from the gravity anomalies obtained by model calculation for the initial five layer model were divided into some components by their wavelengths because they include the effects due to the structure such as inhomogeneity in the mantle. The depths of the top of the lower crust and the Moho were obtained by inversion calculation using their anomaly contributions, then the crustal thickness distribution was estimated. According to the results, most of large seamounts are associated with the Moho convex downward, however, some of them have almost no Moho lows below them.

Keywords: gravity, inversion calculation

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Seafloor crustal deformation at the Kumano Basin and along the Nankai Trough

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Our research group performs monitoring of sea-floor crustal deformation with the GPS/acoustic system at four sites (KMN, KMC, KMS, and KME) on the Kumano Basin. We have already measured 16, 6, 20, and 10 times at KMN (from 2005), KMC (from 2012), KMS (from 2004), and KME (from 2008) sites, respectively. The battery at KME site ran out in the previous year, and we cannot continue to measure at the site. The research vessel we used is Asama of Mie Prefecture Fisheries Research Institute.

We carried out correction of travel-times of acoustic ranging wave and removal of incorrect results of KGPS positioning and ship's attitude measurement before the benchmark position analysis for improving data quality before deriving site velocities. We also fix a correction parameter, related to the relative position of GPS antenna and transducer, at an averaged value for the benchmark position (weight center) determination.

We obtained the horizontal site velocities from linear trends of the time series of benchmark position through the robust estimation method (Tukey's Biweight estimation), adopting REVEL model for the plate motion. The steady horizontal site velocities with relative to the Amurian Plate are: 45+/-2 mm/yr in N78+/-5W direction (KMN), 46+/-5 mm/yr in N75+/-4W (KMS), and 32+/-12 mm/yr in N69+/-21W (KME). These results show no significant difference in the site velocities at the three sites. We installed two different benchmarks on the same weight center position at KMS site. The horizontal site velocity of the other set of benchmark has no significant difference compared to the above-mentioned one at KMS site, which shows high precision of our system.

During the 2011 Tohoku earthquake, it is estimated that the large slip of 40-50 m on the plate interface immediately adjacent to the trench axis. It is, therefore, essential to measure the slip deficit also at the same region along the Nankai Trough. For this reason, we installed a new site, TCA and TOA, on the seafloor 15 and 35 km from the trough axis, respectively. We have already measured four times at the two new sites. A transducer is equipped at the bottom of the research vessels we used, Shinsei Maru and Kaiyo Maru No.3, and we can perform acoustic ranging for distances more than 6,000 m above 5 knot. Now we are carrying out the benchmark position analysis, with checking the effect on the benchmark positioning of sound speed structure in the sea, as well as the data quality of KGPS.

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Improvement in the accuracy of GPS/Acoustic measurement using a multi-purpose moored buoy

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In 2011 Tohoku-oki earthquake (Mw 9.0), seafloor geodetic observation using GPS/Acoustic measurement revealed that large co-seismic slip occurred along the Japan trench (Kido et al., 2011; Sato et al., 2011). For clarifying the mechanism of plate boundary earthquakes and forecasting Tsunami immediately, it is necessary to monitor seafloor crustal deformation and Tsunami in the source region. DONET and the GPS buoy system monitor Tsunamis in offshore. On the other hand, horizontal seafloor crustal deformation is measured by GPS/Acoustic surveys, which are mainly carried out by campaigns several times a year. Therefore, we cannot obtain information on co-seismic and post-seismic crustal deformations immediately. Considering the above, JAMSTEC, JAXA, Tohoku University have jointly developed a continuous observation system using a moored buoy and have started its sea-trial at Kumano-nada in 2013 and 2014 (Takahashi et al., 2014). In this study, we evaluate the accuracy of the estimate of horizontal seafloor crustal deformation using the data obtained by this system in the 2014 sea-trial. Moreover, we propose an analysis for improving positioning accuracy.

In general, GPS/A survey is carried out near the center of the transponder array, which cancel out the effect of the time?variation of layered sound speed structure. Due to violation in the assumption of layered structure, positioning accuracy of each shot is 20 ˜30 cm. By repeating this in a campaign observation half a day, we realize to measure crustal deformation in a few cm order (Spiess et al., 1998). On the other hand, the buoy is moored by slack cable for observation at strong tide and the acoustic ranging is carried out at a point away from the array center. A set of acoustic ranging consists of 11 pings an interval 65 seconds. This cycle repeated once a week. Therefore, it is not possible to cancel the time variation of the speed sound. Based on the above and the fact that our target is detecting of the co-seismic slip associated with massive earthquake just above the source region, we aim that positioning accuracy is 1m order.

In the acoustic ranging, each travel time is obtained by picking up the maximum peak in correlogram between transmitted and received waves. In the current system, only 1ms of correlograms (8bit, sampling frequency: 100 kHz) are sent to land station to save bandwidth in the satellite communication. However, by investigating the raw data recovering after sea-trial, it is revealed that the travel time of multi-path at sea surface is often sent to land station through the process mentioned above. Imano et al. (2014) proposed the new method to pick up the earliest peak of peaks in a correlogram for a single acoustic signal. We estimate the array center based on Kido et al. (2006) using the travel time obtained by the conventional method and the travel time obtained by Imano et al. (2014). The standard deviation of the estimated array center using the travel time obtained by the conventional method is 3.7 m (East-West component) and 2.6 m (North-South component) in the data in a week, 5.2 m (E-W) and 3.9 m (N-S) in the data in the entire period. On the other hand, the standard deviation using the travel time obtained by Imano et al. (2014) is 0.45 m (East-West component) and 0.34 m (North-South component) in the data in a week, 3.6 m (E-W) and 2.2 m (N-S) in the entire period. The apparent fluctuation of the estimated array center of the latter is smaller than that of the former, in the same week data in particular. However, the fluctuation of the array center is a few meter order in the entire observation period. Therefore, we should take measures such as re-analyzing after determining the position of each transponder in the accuracy about 10 cm in order to aim that the accuracy of GPS/A measurement using the buoy system is 1 m order in the future. In this presentation, we demonstrate and discuss how much the accuracy is improved after the measure.

Keywords: Seafloor crustal deformation, Moored buoy

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GANSEKI: Utilize fieldwork information for studying JAMSTEC rock samples

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC) carries out several tens to more than a hundred of observation cruises each year, using research vessels e.g. ”Mirai,” ”Kairei,” ”Kaiyo,” ”Yokosuka,” and ”Natsushima”. Activities during each cruise differ depending on individual research projects, and more than ten of these cruises involve rock collecting activities. Rock samples are recovered using deep-sea submersibles such as ”Shinkai 6500”, ”Hyper-Dolphin”, ”Kaiko 7000II” and ”Deep Tow”, and dredgers. These activities yield tens to more than a hundred of rock samples each year.

JAMSTEC considers its rock sample collection as a common property of human community [1], which can be a resource for research and education of earth-ocean sciences. After up to 2 years of moratorium period during which only on-board researchers can access to samples, JAMSTEC makes the rock samples accessible to second-hand users with research/educational purposes. The information of JAMSTEC rock samples is published through the ”GANSEKI” database [2]. Using GANSEKI, users can access to the various information such as basic information (metadata) of 20,663 sampling activities, archive information (inventory data) of 12,243 physical samples, geochemistry data of 19,508 analyses, thin-section photos, publication, and links for associated databases. JAMSTEC rock sample collection includes not only relatively new samples, which were collected after the establishment of curatorial handling in 2008, but also old samples from ’80s or ’90s, which were donated by researchers.

After the major update of GANSEKI in 2013, which improved the searchability and visibility of user interfaces, the curatorial team has been maintaining inter-database network around GANSEKI. In addition to the cruise and dive information in the DARWIN database[3], GANSEKI users can now access to the abundant field information such as sampling processes, geological and geometrical information, which can be recognized through watching dive photos/movies in the ”J-EDI” database [4] and tracing 3D dive tracks on the ”JDIVES” data viewer [5]. It is not easy even for experienced researchers to organize and utilize huge data obtained during individual cruises or dives. The inter-database networking among GANSEKI and associated databases are advantageous not only for second-hand users, but also for on-board researchers themselves.

References: [1] ”Basic Policies on the Handling of Data and Samples” http://www.jamstec.go.jp/e/database/data_policy.html. [2] ”Geochemistry and Archives of Ocean Floor Rocks on Networks for Solid Earth Knowledge Information (GANSEKI)” http://www.godac.jamstec.go.jp/ganseki/e. [3] ”Data Research System for Whole Cruise Information in JAMSTEC (DARWIN)” http://www.godac.jamstec.go.jp/darwin/e. [4] ”JAMSTEC E-library of Deep-sea Images (J-EDI)” http://www.godac.jamstec.go.jp/jedi/e. [5] ”JAMSTEC deep-sea Data-Image Virtual Exploration System (JDIVES)” http://www.godac.jamstec.go.jp/jdives/e.

Keywords: marine geology, rock sample, curation, database