Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SCG059-01 Room:105 Time:May 26 10:45-11:00

GPS/acoustic seafloor geodetic observation by Japan Coast Guard - summary of fiscal 2010 and plan of fiscal 2011 -

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

In March, 2008, we installed an acoustic transducer on the hull of the middle-sized survey vessel and started sailing observations. This improvement enabled us to get more stable observation results. In addition, we installed an observation system in the large-sized survey vessel ”Takuyo” in December 2010.

In this presentation, we summarize seafloor geodetic observation results in fiscal 2010 and observation plans of fiscal 2010.

1. Summary of the observation results

(1) Seafloor reference points along the Japan Trench

Two seafloor reference points have been installed off Miyagi Prefecture. From the past observations, seafloor movements toward west-northwest indicating that the crustal strain restarted to reaccumulation at around 2007 were detected. The observation results of fiscal 2010 show the same trend. The velocities of 5.4-5.6 cm/year relative to the stable part of the Eurasian plate have been estimated from the observations from December 2006 to November 2010.

On the other hand, a westward movement of about 2cm/year has been detected at the seafloor reference point off Fukushima Prefecture. This result suggests that the interplate coupling is very weak in this area.

(2) Seafloor reference points along Nankai Trough

Six seafloor reference points have been installed along the Nankai Trough at intervals of about 100 km. From the past observations, the seafloor movements of 2-5 cm/year toward west/west-northwest have been detected at each reference point from the observations after 2006.

2. Plan of fiscal 2011

We are scheduled to conduct seafloor geodetic observations three times each. In addition, we will compare the observation results obtained by the large-sized S/V ”Takuyo” with those obtained by the middle-sized S/V ”Meiyo”, aiming to full-scale operation by Takuyo. Furthermore, in order to complement the blank area off Shikoku, we plan to install a seafloor reference point off Cape Muroto.

Acknowledgements

The installment of the seafloor reference point MYGW was financially supported by Ministry of Education, Culture, Sports, Science and Technology, Japan under the project ’Pilot survey focused on off-shore Miyagi Prefecture’. We thank Dr. Oscar L. Colombo of NASA/GSFC for providing us with the kinematic GPS software ’IT’. We thank the Geographical Survey Institute of Japan for providing us with the GEONET GPS data at 1 sec sampling for our kinematic GPS analyses.

Keywords: seafloor geodetic observation, off Miyagi, Nankai trough, crustal deformation

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SCG059-02 Room:105 Time:May 26 11:00-11:15

Study of efficiency improvement of seafloor geodetic observation

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We have been developing a system for precise seafloor geodetic observation with the GPS/Acoustic combination technique and deploying seafloor reference points on the land-ward slope of the major trenches around Japan, such as the Japan Trench and the Nankai Trough. The primary purpose of our observation is to detect and to monitor the crustal deformation caused by the subduction of the oceanic plate near the plate boundary.

We succeeded in detecting notable seafloor movements associated with, and subsequent to this event. However, the precision of observation and number of observation points are insufficient comparing with terrestrial GPS observation. To detect crustal deformation more precisely, it is necessary to improve precision and densities of observation network.

A precision of estimated position of seafloor reference point are improved using long-time series of observation data. There is trade-off between time length of observation and precision of result. Therefore, to increase a observation points, it is necessary to improve observation method more efficient.

In 2010, we carried out examination to study more efficient observation method at seafloor reference point installed at Sagami bay. In this presentation, we will report the result of these observations.

Keywords: seafloor geodetic observation

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SCG059-03 Room:105 Time:May 26 11:15-11:30

Observation of sea-bottom crustal deformation at Kumano Bay

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Our research group has performed the observation of sea-floor crustal deformation with the system composed of the kinematic GPS positioning and the acoustic ranging at the three stations (KMN, KMS, and KME sites) beneath the Kumano Bay where the large subduction earthquake, Tonankai Earthquake, is anticipated to occur. We measured 13, 18, and 6 times at KMN, KMS, and KME sites, respectively.

The observation shows the steady horizontal displacements of (1.1+/-0.4, -2.4+/-1.0), (1.6+/-0.3, -5.5+/-0.4), (5.4+/-2.2, -6.1+/-3.1) cm/yr at KMN, KMS, and KME sites, respectively. The directions of displacement vector almost coincide with that of plate conversion at the Nankai Trough. The estimated horizontal displacements at some sites are, however, obviously larger than that of relative motion between the Philippine Sea Plate and the Amurian Plate. The error ellipsoid is extremely large at The KME site because of a lack of both observation period and the number of measurement. It is necessary to estimate more precisely based on a continued measurement.

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SCG059-04 Room:105 Time:May 26 11:30-11:45

Application of inclined sound velocity structure to the measurement of ocean bottom crustal deformation

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We are developing a geodetic method of monitoring crustal deformation under the ocean using kinematic GPS and acoustic ranging. The goal of our research is to achieve sub-centimeter accuracy in measuring oceanic crustal deformation by a very short-time measurement like 10 hours. In this study, we focused on lateral variation of acoustic velocity structure in seawater and applied an inclined acoustic velocity structure model to the data analysis.

We have a few measurement sites along Nankai trough. In each site, we deployed a trio of transponders on ocean floor (seafloor benchmark units) within distance comparable with the depth.

An ultrasonic signal is generated from a surface vessel drifting over the benchmark unit, which is received and replied by the benchmark unit. In this system, both acoustic velocity structure and the benchmark unit positions were determined simultaneously for the each measurement using a tomographic technique. This tomographic technique has been adopted on an assumption that the acoustic velocity structure is horizontally layered and changes only in time, not in space. Ikuta et al., (JPGU 2010) reported an approach to improve accuracy of benchmark positioning using a new additional assumption. The additional assumption was that the configuration of the transponders trio constituting one benchmark unit does not change. They determined the time evolution of weight center for the fixed transponder triangle between different measurements using all repetitively obtained data sets at once. This is contrasting to the previous method in which each data set for different measurement was solved independently. This assumption worked well in reducing number of unknown parameters. As a result, repeatability of benchmark positioning improved from 5 cm to 3 cm.

In the new model in this study, we arrowed the velocity structure to be changed horizontally also. The accuracy of the positioning improved to be much better than that by old approach. We adopted this new model and the approach to solve the real data sets. As a result, the repeatability of the benchmark positioning improved from 3.1 cm to 2.5 cm in horizontal component. Although the improvement is not significant, this is of great significance in strategy of analysis. We can adjust freedom of the model or adopt some constraint to make new model to be more robust.

Acknowledgement: This research was promoted by a project of the Japanese Ministry of Education, Culture, Sports, Science, and Technology.

Keywords: Ocean floor, GPS, Acoustic Ranging, Crustal deformation, Transducer

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SCG059-05 Room:105 Time:May 26 11:45-12:00

Inversion of acoustic velocity structure models to develop observing seafloor crustal deformation.

Shuhei Eto[1*], Satoru Nagai[2], Keiichi Tadokoro[2], Tsuyoshi Watanabe[2], Ryoya Ikuta[3]

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Along the Suruga-Nankai trough, major earthquakes have occurred repeatedly. Therefore we should construct a system for monitoring the behavior on plate boundary zones. Although very dense routine geodetic GPS network (GEONET) has been developed, we cannot observe beneath ocean with enough resolution. So our group has tried to develop a system for observing seafloor crustal deformation.

The system becomes possible to observe seafloor benchmarks by combining two techniques; acoustic ranging and kinematic GPS. Using this system, we have achieved an accuracy of about 1-5 cm of horizontal positioning in each observation, but it is not enough to discuss behavior on plate boundary zones. We need to develop our system and consider variations of acoustic velocity structure.

Acoustic velocity structure in ocean varies largely in shallower parts. In present analysis, we assume homogeneous acoustic velocity model with temporal change. To obtain high-resoluted crustal deformation, we estimate with considering the variation of acoustic velocity structure.

Although ray paths of our acoustic ranging are not good to invert full 3-dimensional acoustic velocity structure with temporal variation, we can invert 1-dimension velocity variation with depth for a given short time through some prior information, like a snapshot in some time.

We apply the simple Joint Hypocenter Determination method in seismology [Kissling et al., 1994]. This method allows acoustic velocity structure to exist low-velocity layer such as thermocline. Acoustic ranging data observed by Nagoya University group both in Suruga Bay and Kumano Basin. This paper focused on results and related remarks to Suruga Bay. Another is presented by Nagai et al. [This meeting].

Keywords: acouctic velocity structure, 1-dimensional structure, Variation of space and temporal

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SCG059-06 Room:105 Time:May 26 12:00-12:15

Simultaneous inversion of 1-D sound velocity and positions of benchmarks to develop ocean-floor geodetic observation

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To clarify the behavior on plate boundary zones, especially related with mega-thrust earthquakes, we have needed high-resoluted crustal observation both in space and time. Around Japan, those plate boundaries are located beneath ocean, so our group has tried to develop an observation system for sea-floor crustal deformation.

As a part of these sea-floor crustal deformation measurements, we use an accurate acoustic ranging technique. However, due to variations of acoustic velocity structure, sometimes, estimated position error of seafloor benchmark units becomes larger than ~ 1 cm, which is not useful to identify relative plate motions. For our objectives, we try to invert variations of acoustic velocity structure in ocean to make stable estimation of bench marker positions. Although ray paths of our acoustic ranging are not good to invert full 3-dimesional acoustic velocity structure with temporal variation, we can invert 1-dimension velocity variation with depth for a given short time through some prior information, like a snapshot in some time. We apply the simple Joint Hypocenter Determination method in seismology [Kissling et al., 1994] to acoustic ranging data observed by Nagoya University group both in Suruga Bay and Kumano Basin. This paper focused on results and related remarks on Kumano Basin. Another is presented by Eto et al. [This meeting].

We report our strategy for observation systems and some results from observation data and synthetic data test.

Keywords: sea-bottom crustal deformation measurement, acoustic ranging, sound speed structure in ocean, joint hypocenter determination

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SCG059-07 Room:105 Time:May 26 12:15-12:30

Seafloor geodesy-derived sound speed structure in ocean

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Much efforts have been made for improving accuracy and spatio-temporal frequency of seafloor geodetic observation by means of GPS/acoustic technique, which now provides significant data to the earth science field. Actually, GPS/acoustic surveys have detected some important tectonic events, such as coseismic displacement associated with the 2004 off Kii peninsula earthquake, secular movement at off Miyagi, and co- and post-seismic deformation after the 2005 off Miyagi earthquake. However, comparing with current state of the land-based GPS network, GEONET, improvement in its quality and quantity is required in providing more general scientific purpose.

There three factors that affect the accuracy of GPS/acoustic measurement; kinematic GPS analysis to monitor surface platform, acoustic signal processing in identifying traveltimes, and uncertainty in sound speed in ocean for traveltime-range conversion. Among the three, it is getting obvious through the past survey that sound speed variation is most significant.

Sound speed structure is known to be well approximated by time dependent stratified structure, i.e., depth profile. Furthermore, its effect on seafloor positioning can be expressed time-dependent single scholar quantity that in a depth integral of the profile, called vertical delay. We have succeeded in monitor the variation of the vertical delay with time from a GPS/acoustic measurement, and confirmed that it is well coincided with concurrent physical oceanographic in situ measurement. However, apparent fluctuation in horizontal seafloor position up to 20-30cm is remained even after removal of the vertical delay. To achieve 2-3cm accuracy we need more than one-day survey time to average out the fluctuation. As mentioned above, improvement inefficiency of the survey is required, we have to estimate the factor and evaluate its quantity to correct the positioning. The fluctuation is thought to be spatio-temporal variation of sound speed structure, which must be modeled by a simple assumption that can be estimated by sparse and limited traveltime data. When the spatial scale in the variation is large enough, its can be simply approximated as gradient at our survey point, which can be estimated by adding some extra seafloor transponders to increase traveltime data. However our observed data indicate that this assumption may be wrong and variation sometimes has much smaller scale.

In the decade, the resolution in numerical simulations of ocean variability have been greatly improved, the scale of which is getting closer to our scale of interested. For example, vertical delay mentioned above is found to often have a semi-diurnal time-scale. It is also supported by up to 20m semi-diurnal oscillation in the sound speed profile obtained by concurrent in situ measurements. This has been well modeled by numerical simulation of internal wave that modulated by M2 tidal current by Niwa and Hibiya (2001). In addition, long-timescale spatial variation is related to large scale ocean current and/or middle-scale eddy. We are now compared our observation with data-assimilated reanalysis product of ocean variability, JCOPE2 (Miyazaki et al., 2009), that is opened in public. There still remain a gap in scale between our observation and the numerical simulation, some temporal tendency can be highly expected in the comparison. In this talk, we introduce several example of our observation with comparison of above simulations, and address how do the simulations provide significant information to our side.

Keywords: seafloor geodesy, data assimilatio reanalysis, internal wave, sound speed

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SCG059-08 Room:105 Time:May 26 12:30-12:45

Accuracy evaluation of Kinematic GPS analysis based on the difference of the IGS products (follow-up report)

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The Philippine Sea plate subducts beneath the southwest Japan from the Nankai Trough with a rate of about 4-6 cm/year, where great interplate earthquakes have repeatedly occurred every 100-150 years. To clarify the mechanism of earthquake occurrence at such subduction zones, we require the geodetic data obtained from not only onshore area but also offshore area. However it is difficult to estimate the plate interaction in offshore areas, due to the poverty of those data. For this issue, we have conducted seafloor geodetic observation using GPS/Acoustic techniques around the Nankai Trough since 2004. In this system, we estimate the position of a surveying vessel by Kinematic GPS analysis and measure the distance between the vessel and the benchmark on the seafloor by Acoustic measurements. Next, we determine the location of the benchmark and detected crustal movement on the seafloor. Recently, a number of research institute have conducted seafloor geodetic observation after earthquake occurred in offshore area (Tadokoro et al., 2006), and then speedy solution is desired from a viewpoint of not only scientific research but also disaster mitigation. Although we use the IGS final product for its accuracy, the latency of that is longer, about 13 days or more. On the other hand, the IGS ultra-rapid product is updated every 6 hours with the delay of 3 hours. In the previous study, we compared the kinematic GPS solutions using the IGS final and ultra-rapid products. The rover GPS site was located on the roof of a building at Nagoya University and 5 fixed GPS sites were located on the roof of other buildings whose baseline lengths were 30-150 km. Though the standard deviation of the difference between final and ultra-rapid solutions increases with increasing baseline length, which is about 1.6 mm in 150 km baseline. This result showed that the difference was not significant for seafloor geodetic observations. In this study, we investigate the kinematic GPS solutions based on the difference of the IGS products using GPS data obtained from seafloor geodetic observations, and assess the accuracy and effectivity of the IGS ultra-rapid product.

Keywords: Kinematic GPS, Seafloor geodetic observation, IGS products

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Receiver function for ocean bottom seismograms

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We introduce a receiver function which is appropriate for ocean bottom seismograms to image the seismic structures below the stations. It is an application of the receiver function proposed by Takenaka and Murakoshi (2010, AGU) for deep borehole records, which is an extension of ”S-wavevector receiver function” (SWV-RF), originally introduced for ground surface records by Reading et al. (2003, GRL). Standard receiver function obtained by deconvolving a horizontal record with the vertical record of a teleseismic P wave and its coda, includes the contribution of the sea surface (free surface). The sea surface reflection phases mask the original signals from the subsurface interfaces. The free surface contribution is contained much larger in the down-going components of the seismic wavefields than the up-going ones. The SWV-RF uses only the up-going components, which is defined as the deconvolution of the up-going S-wave component with the up-going P-wave one. In this study we propose a method for extracting up-going P and S waves from the observed seismograms at the ocean bottom stations to calculate the SWV-RFs for borehole and ocean bottom stations based on the structure models from the top to the receiver level. If we have a structure model below the receiver level, we can also calculate the SWV- RFs at any levels (virtual receivers) below the ocean floor. In the presentation we apply this method to synthetic waveform data for a 3D trench-junction model to illustrate the effectiveness of the SWV- RF.

Keywords: receiver function, ocean bottom station, teleseismic body wave

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SCG059-10 Room:105 Time:May 26 14:30-14:45

Crust and uppermost mantle structure of transition between the Oki-Daito Rise and West Philippine Basin

Azusa Nishizawa[1*], Kentaro Kaneda[1], Mitsuhiro Oikawa[1], Yasuhiko Ohara[1], Taisei Morishita[1]

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The broadly-defined Oki-Daito Ridge, one of the bathymetric highs at the northwestern Philippine Sea plate, is divided into three parts, the narrowly-defined Oki-Daito Ridge in the southeast, Oki-Daito Plateau in the northwest and Oki-Daito Rise in the southwest. We conducted seismic exploration to elucidate transitional structure between the Oki-Daito Rise and West Philippine Basin.

The P-wave velocity structure shows that the crustal thickness decreases from 14 km beneath the rise to 6 km at the northwestern end of the West Philippine Basin. The thinning is mainly due to the lower crust. The velocity of the lower crust is reliably deduced from clear later phases propagating in the entire crust and estimated to be 7.2-7.3 km/s at the bottom of the crust, which is rather higher than a typical oceanic crust produced at a mid ocean ridge. Pn velocity is 7.9 km/s beneath the Oki-Daito Rise and increases to over 8.4 km/s below the West Philippine Basin. Such abnormally high Pn velocities of 8.4-8.6 km/s were widely found beneath the West Philippine Basin to the north of the Oki-Daito Escarpment.

A difference in the basin structure from a typical oceanic crust is existence of a constant velocity of about 5 km/s layer with a thickness of 1-2 km in the upper crust. Large reflection signals from 5-10 km below the Moho were identified in many records obtained by ocean bottom seismographs. Similar large reflection signals from about 30 km under the Moho were also detected in the region between the Oki-Daito Rise and Oki-Daito Plateau. Such deep reflection signals may characterize the upper mantle structure in this region.

Keywords: Oki-Daito Ridge, Oki-Daito Rise, West Philippine Basin

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SCG059-11 Room:105 Time:May 26 14:45-15:00

Extremely high crustal production rate of the Izu-Ogasawara-Mariana intra-oceanic arc

Narumi Takahashi[1*], Yoshiyuki Tatsumi[1], Shuichi Kodaira[1], Seiichi Miura[1], Takeshi Sato[1], Mikiya Yamashita[1], Tetsuo No[1], Kaoru Takizawa[1], Naoto Noguchi[1], Yuka Kaiho[1], Yoshiyuki Kaneda[1]

[1]JAMSTEC

The crustal structures across the Izu-Ogasawara-Mariana arc, obtained by Japan Agency for Earth-Marine Science and Technology (JAMSTEC), provides an estimate of the average crustal production rate since 50 Ma. It has been well established that continental crusts have been created as the middle crust of the Izu-Ogasawara-Mariana arc with P-wave velocity of 6.0-6.5 km/s (Suyehiro et al., 1996; Takahashi et al., 2007); however, the production rate of this 'continent' has been still unknown yet. The crustal volume can be calculated by crustal structures obtained by seismic surveys, however, a part of the crustal materials are transformed into mantle through differentiation of crustal materials (Takahashi et al., 2007). Based on a model of Tatsumi et al. (2008), we estimated volumes of transformed crustal materials and calculated the total volumes of arc materials. As shown by distribution of high velocity lower crust beneath the eastern half of the Shikoku Basin, the arc volcanisms also occurred on oceanic crusts produced by backarc opening in the past and the crust has been overprinted by the arc activities after stop of the backarc opening. We, therefore, identified the eastern end of the original oceanic crust using magnetic lineation pattern (Okino et al., 1994) and removed volumes of the oceanic crust from total ones of arc crustal materials. It is then suggested that the total volume of crustal materials across the Izu-Ogasawara-Mariana arc is over 16,000 cubic kilometers per one kilometer. The total volume is higher in the northern Izu-Ogasawara arc and smaller in the southern part. We assumed the volumes of the Kyusyu Paleo Ridge as the remnant arc, and found that the crustal production rate of the oceanic arc is unexpected high value. In this presentation, we introduce crustal image across the arc and the detailed scenario derived the result.

Keywords: oceanic crust, crustal structure, arc growth, OBS, seismic survey

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SCG059-12 Room:105 Time:May 26 15:00-15:15

Tectonic reconstruction of initial stage of Philippine Sea Plate formation

Osamu Ishizuka[1*], Toshitsugu Yamazaki[1], Ogitsu Itaru[1], Yoshihiko Tamura[2], Kenichiro Tani[2], Yumiko Harigane[3], Izumi Sakamoto[4], tomohiro sasaki[5], Youhei Katayama[4], Junki Sumizawa[4], Ryuichi Shitahaku[4]

[1]GSJ/AIST, [2]JAMSTEC, [3]Kanazawa University, [4]Tokai University, [5]Tsukuba University

Recent research in the Izu-Bonin-Mariana (IBM) forearc revealed volcanic section representing earliest record of IBM arc magmatism (e.g., Ishizuka et al., 2006; Reagan et al., 2010). The obtained stratigraphy combined with petrological, geochemical and geochronological study led us to propose a model for subduction initiation along this arc (Ishizuka et al., 2006). This model assumes spontaneous subduction of old and cold, thus, with higher density plate begins to sink beneath younger and hotter plate with lower density (Stern, 2004). This model for subduction initiation, however, has not been tested from a tectonic point of view. To do this, it is necessary to reconstruct tectonic environment at c. 50 Ma and before of Philippine Sea region.

R/V Yokosuka YK10-14 cruise investigated Palau Basin and southern part of West Philippine Basin (WPB) to obtain crucial geological and geophysical data for reconstruction of one of the oldest parts of the Philippine Sea Plate.

Bathymetric and geomagnetic survey in the Palau Basin and southern WPB revealed: 1) Topographic fabric associated with the seafloor spreading can be recognized in the southern WPB. The strike of the topographic fabric in the northern part near the Central Basin Fault is close to E-W, whereas that of the southernmost part is nearly NW-SE, which suggests that the spreading direction of WPB changed clockwise with time. 2) The topographic fabric and magnetic lineations near N-S strike can be recognized in the Palau Basin, suggesting seafloor spreading of E-W direction. This fabric in the Palau Basin curves eastward in the vicinity of the Mindanao Fracture Zone (MFZ). 3) A trough of unknown origin runs WNW-ESE near 5^{o}N, 130^{o}E. 4) Southern and eastern part of the Palau Basin is occupied by numerous seamounts.

Main targets of dredge sampling were: 1) oceanic crust of the oldest part of WPB. 2) oceanic crust of Palau Basin exposed along the fracture zones. 3) volcanic structure within the Palau Basin. 4) basement of Southern Kyushu-Palau Ridge (KPR) which corresponds to the eastern margin of the Palau Basin.

Sampling of the Palau Basin crust along the MFZ, which separates the Palau Basin from WPB, was conducted in 2 regions. One is at c. 130^{o}E, where seafloor in the Palau Basin is relatively deep (generally deeper than 6000m) and shows series of abyssal hills trending N-S to NE-SW. The other region, east of the first one, has much shallower basin floor of 4500 - 4000 m deep. Dredge hauls in these region successfully recovered pillow lava blocks of mainly aphyric basalt with remaining fresh glass rind and olivine-rich dolerite. Sampling of crustal materials in the Palau Basin was also conducted at WNW-ESE trending trough in the middle part of the Basin near 5^{o}N, and recovered olivine basalt with some fresh glass.

Southern part of the Palau Basin is characterized by abundant NE-SW-trending ridges crosscutting N-S-trending abyssal hills. Clinopyroxene-olivine basalts were mainly recovered from these ridges. They are distinct in petrography from basalts from the Palau Basin along the MFZ, but similar to those from near 5^{o}N.

The oldest part of ocean crust of WPB was sampled at the NW-SE-trending scarp at c. 8^{o}26'N. Pillow lava blocks of aphyric basalt were recovered. These samples will provide first reliable age constraint in the southern WPB which can be linked with magnetic anomaly data obtained during this cruise.

In southernmost part of the KPR, eastern escarpment of a ridge between main KPR crest and the Palau Trench was dredged to recover basement of the KPR. This dredge recovered the metamorphic rocks including amphibolites, amphibole schist and siliceous schist, which implies occurrence of non-oceanic crust.

Preliminary geochemical data indicate that basalts from the Palau Basin and the WPB have characteristics of MORB-like backarc basin basalt. Details of geochemical data and $^{40}Ar/^{39}Ar$ ages will be reported in this presentation.

Keywords: Palau Basin, subduction initiation, West Philippine Basin, tectonic reconstruction, ArAr age, magnetic anomaly

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SCG059-13 Room:105 Time:May 26 15:15-15:30

Landslide-related decoupled anomalies of heat flow and pore water chemistry: Nankai Trough off Muroto

yoshifumi kawada[1*], Masataka Kinoshita[1], Tomohiro Toki[2], Ryosaku Higa[2], Takafumi Kasaya[1]

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We observed surface heat flow and biological activity, and sampled push cores near the deformation front of the Nankai Trough accretionary prism off Muroto, in order to obtain relationships between the distribution of fluid discharge and the topography. Fine scale topography near the deformation thrust is characterized by a regularly-spaced stairway-like structure with a period of 1 km across the subduction axis. Each step consists of a flat area of 600-800 m long with a gentle landward down-dipping, and a steep wall of 400-200 m long and 100 m high. Near the foot of each steep wall, the exits of the sequentially thrusts cutting through the decollement are expected. We took an observation line, which crosses the hypothetical exit of the secondary frontal thrust perpendicularly to its strike. We found that the anomalies of pore water chemistry and biological activity were correlated in location, and that the anomalies of heat flow were not always correlated to the former anomalies in location. (1) On a flat place near the ODP hole 808I, regional mean heat flow value of 150 mW/m2 was observed, and neither chemical anomalies nor biological activities was detected. (2) Near the foot of a slope structure where the exit of sequential thrust is expected, high heat flow anomaly as high as 250 mW/m2 was observed, but no other anomalies were detected. (3) On the slope just above the foot, low heat flow anomaly around 120 mW/m2 was observed, and no other anomalies were found. (4) At a flat terrace-like place 40 m above the foot of the slope, where landslide structures were visible, moderately high heat flow anomalies around 200 mW/m2 were observed and both of biological activities (calyptogenas and tubeworms) and chemical anomalies (methane and ammonium) were found. The present observation basically agrees with a commonly accepted qualitative model, in which conduit-like fluid flow upwells through the thrusts and is restricted by near-surface geological structures such as landslides. However, the origin of the high heat flow anomaly observed near the foot of the slope is remained to be solved.

Keywords: Nankai Trough, heat flow, accretionary prism, landslide, pore water, off Muroto

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SCG059-14 Room:105 Time:May 26 15:30-15:45

Topography and structures of Nagahama bay of Satsuma Iwo-Jima island and Kikai Caldera

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The Kikai Caldera is located 50 km south of the Satsuma peninsula of Kagoshima Prefecture in South Japan. The Kikai Caldera produced Akahoya tephra at 7300 years ago by Caldera forming big eruptions. Along the Kikai Caldera, Satsuma Iwo-Jima and Takeshima were identified as outer rim of caldera crater. In Satsuma Iwo-Jima, volcanic activity still well preserved at the Iwo-Dake volcano.

To understand of modern oceanic caldera structure and sedimentation is important to understand Archean greenstone forming environment. Many Archean greenstone belt was reported to understand by caldera models. Sedimentation of iron material is also very important to understand the iron formation at Archean time (eg. Banded Iron Formation).

Here we will report 1) Seismic exploration in Kikai Caldera by KT 1?18 cruse at 2010 August. 2) Shallow ocean topography to use Dual-Frequency Identification Sonar (DIDSON) and malti-narrow beam (SeaBat) at 2010 September. Windynetwork corporation and Toyo Corporation helped to use these sonars.

In Kikai Caldera, there are well preserved listric normal fault and tilted sedimentary sequences in the outer Caldera margin. There is very small sediments within deepest Caldera valley. Based on the multiple core works, the bottom of valley mostly sand rich sequence. Some portion contains hemi-pelagic greenish gray sediments.

At Nagahama bay, there are many conical iron hydrate rich mound system identified. After 2009 dredging result, these iron rich mounds grow up more than few cm pare years. Top of the shallow portion of the mound is formed flat head because erosion by boat floor during low tide.

Keywords: Satsuma Iwo Jima, Kikai Caldera, iron deposit, listric normal fault, sliding

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Relation between sediment and meteorological event for 10 years in Nagahama Bay, Satsuma Iwo-Jima Island, Kagoshima

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Satsuma Iwo-Jima Island, with active rhyolite volcano (Iwo-Dake), is located about 40 km south of Kyushu Island, Japan. Nagahama Bay, which is partly isolated from pelagic sea, is located in the south of Satsuma Iwo-Jima. The seawater is red color attributing to the presence of suspended ferric hydroxide produced by the mixing of volcanic fluids and seawater (Ninomiya and Kiyokawa, 2009).

In this study, the Fishermans port of Nagahama Bay was divided into two areas as E-site and W-site by the T-shaped breakwaters. The breakwaters were extended at W-site in 2000 and 2004. Big breakwater at the entrance of Nagahama Bay was built in December 2006. In March 1998, W-site experienced wide and deep dredging construction. Since then, the thick sediments at W-site have accumulated during the last 10 years. To understand mechanisms of sedimentation in the Bay, we observed stratigraphy of core sample from the Fishermans port in detail and investigated a relation of the stratigraphy of core samples to meteorological and volcanic activity records for the past 10 years.

I) Stratigraphy: 12 cores are collected from E-site (1 core) and W-site (11 cores). These cores consist of ferric hydroxide, sand and tuff bed. Four units are identified from these cores. 1) The Basement unit contains coarse sand bed. 2) The Lower unit contains ferric hydroxide beds and a 1 to 7 cm-thick pink-tuff bed (T1). 3) The Middle unit mainly contains ferric hydroxide bed with a 2 to 8 cm-thick gray-tuff bed (T2) and a 1 to 9 cm-thick gray-tuff bed (T3). Within ferric hydroxide bed, we observed a few sheets of thin tuff beds. 4) The Upper unit contains thick sand and ferric hydroxide beds. Smear slides and SEM observation shows that 1) ferric hydroxide bed contains very fine ferric material, 2) sand bed is composed of terrigenous clastics, volcanic glass and very fine ferric material, and 3) tuff bed contains volcanic glass.

II) Volcanic activity: At Iwo-Jima Island, volcanic ash has fallen intermittently from September 1997 (Shinohara, 2002) to October 2004 (The Meteorological Agency, 2010). The thickness of the tuffs deposited in the Iwo-Jima village near Nagahama Bay was only a few millimeters. After October 2004, volcanic Mt. Iwo-Dake dropped down, and volcanic ash has not been reported at the village.

III) Meteorological records: We compiled record of rainfall, air pressure, wind velocity, wind direction and typhoon date from March 2000 to March 2010, and found the following events. A) Rainfall: Three heavy rain events were identified in the rainy season of 2000 (precipitation 189 mm/day), 2001 (124.5 mm/day) and 2002 (122 mm/day). B) Typhoon: Three strong typhoon events, with maximum wind velocity over 20 m/s, came in 2004 (40.3 m/s, 54.3 m/s and 44.6 m/s), 2005 (43.3 m/s) and 2007 (50.2 m/s). C) Other notable events: Typhoon did not come in 2006 and there is no rainy day, which is precipitation of more than 40 mm/day, in 2003 and 2007.

Conclusions: We identified events in the ferric hydroxide-rich sediment in Nagahama Bay. 1) Based on the record of dredging in Nagahama Bay, we identified that the sediment just above the Basement unit was accumulated in 1998. 2) Three thick tuff beds (T1, T2 and T3) may be correlated to heavy rain events in 2000, 2001 and 2002. 3) Sand bed in the Upper unit may have formed by strong typhoon event during 2004.

Keywords: Iwo-Jima Island, hydrothermal water, ferric sediment, weather, Kikai caldera

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HYDROTHERMAL ACTIVITY AND IRON SEDIMENTATION IN NAGAHAMA BAY, SATSUMA IWO-JIMA ISLAND, KAGOSHIMA

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Satsuma Iwo-jima Island is active volcanic island and 6 x 3 km in size, located 38km south of Kyushu Island, Japan. The reddish brown water along the coast of the Iwo-dake volcano at the center of the island is formed by neutralization through mixing of shallow hydrothermal fluid and seawater. The reddish brown water contains reddish ferrihydrite (Fe3+) that is derived from oxidation of Fe2+ from acidic hot spring (Shikaura and Tazaki, 2001). In Nagahama Bay with its opening to the south, red-colored Fe-rich water is affected by tidal current. Sedimentation of the ferric hydroxide is confirmed to occur in the ocean bottom (Ninomiya and Kiyokawa, 2009). Here we focus other lines of evidence from long term observations and meteorological records as important factor to form thick iron rich sediments.

Core sample: >1m thick Fe-rich sediments have the following lithological characteristics; the upper part, 10-20cm thick is composed of unconsolidated Fe-rich materials and the lower part shows alternation of weakly consolidated Fe-rich orange-colored mud, the organic-rich black mud and volcanic ash layers. The basal part has a distinctive pink ash layer that represents 1997 volcanic activity. Three-dimensional analysis of the sediments suggests that they are alternating sediments during quite weather periods (Iron mud) and reworked sediments (Tuff and Sand). Layer of fine-grained volcanic ash have the feature of fining-upward. All Iron mud samples show high FeO contents about 20˜25wt.%. The depth profiles of FeO and Al2O3 contents show parallel changes. SEM images and XRF results indicate very small (>1 micron) grains of amorphous Fe-bearing minerals such as ferrihydrite and/or feroxyhite. XRD results indicate that Iron mud contains Si-bearing minerals such as quartz, cristobalite and tridymite. Triangular Fe-Al-Zr diagram may indicate multiple origins for each layer in the examined sediment core: e.g. Iron mud is derived from hot spring water because Fe content rate in hot spring water is high, and elevated abundance of Al and Zr indicates that Sand and Tuff are reworked sediments.

Long term temperature monitoring: Measured seawater temperature seems to have fluctuated synchronically with the air temperature. But the temperature of the hot spring water remained rather constant regardless of the seasonal change. We observed that seawater temperature in Nagahama Bay is relatively lower during high tide and higher during low tide, and the difference between high and low peaks in temperature reaches maximum in the period of spring tide and minimum in the period of the neap tide. These observations suggest that an amount of discharged hot spring inversely correlated with that of seawater flowing into Nagahama Bay.

Meteorological and stationary observations: We used meteorological records in the Satsuma Iwo-jima Island and cross-checked with stationary observations, which enabled us to observe color changes of the surface water of Nagahama Bay. It was made clear that prevailing north wind in Nagahama Bay resulted in changes of the color from red to green, most likely by intrusion of open ocean water to the bay.

In Nagahama Bay, ”Iron mud” formed during quite periods of quiet weather and ”Tuff and Sand” formed as reworked sediments by storm and flood event. Neap tide would have induced enough supply of hot spring into seawater and prevailing south wind would have worked as a cap of underlying seawater. The fine-grained Fe-hydroxide formed and deposited during neap tide with prevailing south wind.

Keywords: Hydrothermal activity, Iron sedimentation

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Hydrothermal exploration along the Central Indian Ridge - background and impacts of a hydrogen-rich hydrothermal system

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The Kairei Hydrothermal Field (KHF) is located at the southern end of the Central Indian Ridge (CIR), near the Rodriguez ridge triple junction. The KHF was discovered by ROV Kaiko in 2000, based on the preceding report of hydrothermal plume anomaly detected in Hakuho-maru KH-93-3 cruise in 1993 . The fluids venting from the KHFare characterized by its high concentration of hydrogen, and a hydrogen-based hyperthermophilic subsurface lithoautotrophic microbial ecosystem was confirmed by Takai et al. [2004]. The hydrothermal vent lies on basaltic lava area on the shoulder of ridge axial wall, on the other hand, gabbro and ultramafic rocks are discovered around the KHF [e.g., Kumagai et al., 2008; Nakamura et al., 2009]. The recent submersible dive discovered a group of dead chimneys on the hill north of the KHF, where peridotite is widely exposed. Previous studies on other hydrogen-rich hydrothermal systems inferred that they may be related to the serpentinization of lower crust and/or mantle rocks and be controlled by detachment faulting, however the integrated study based on detailed field observations have not been done. The microbiological production and its impact on deep-sea ecosystem of hydrogen-rice hydrothermal plumes are unknown. The objectives of KH-10-6 cruise (23 Nov. 2010 - 13 Dec. 2010) are, 1) to verify the hypothesis that hydrogen-rich KHF is controlled by the ambient crustal structure and the chemical composition of lithosphere, 2) to estimate the chemical and microbiological fluxes from KHF to seawater through hydrothermal plumes, and 3) to quest an unknown hydrothermal field on the rise, tentatively called Yokoniwa Rise, north of the KHF. During 21 days operation, we conducted one successful AUV dive, 22 dredge hauls, 10 CTD tow-yo surveys, 3 CTD vertical casts, 4 VMPS and 1 MTD plankton net. Total 800 miles of surface geophysical mapping was also done and a 80 miles of deep-tow magnetic profile was obtained. The preliminary results are, 1) A r2D4 #68 dive was done successfully above the Yokoniwa Rise north of the KHF, where the dead chimneys on ultramafic exposure were discovered in 2009. High-resolution side scan image and interferometric bathymetry was obtained with data of chemical and physical sensors. The attached magnetometer could detect the positive anomaly on the dead chimney area. 2) Surface geophysical mapping revealed the detailed feature of CIR-4 segment, where no previous data existed. The result will improve our understanding of spreading history and structural segmentation of the CIR, and will provide a key to consider the tectonic setting of the EHF. 3) Total 80 mile of deep-tow magnetic profile was obtained across CIR-1 segment. The detailed spreading history since 2 Ma was revealed, that will constrain the evolution of detachment faults around the KHF. 4) A number of lower crust / mantle materials were collected around the KHF. Focused dredge hauls on the Yokoniwa Rise will lead us a reliable model of Yokoniwa formation. 5) Systematic sampling of mid-ocean ridge basalts with fresh glass along the ridge axis will provide a good opportunity to study the mantle heterogeneity beneath the southern CIR. 6) Total ten CTD tow-yo surveys and three vertical casts could reveal the spread of hydrothermal plumes and their chemical and physical properties around the Kairei and Edmond Hydrothermal Fields. The anomalies of pH, turbidity, alkalinity, Mn, CO2 and DO were detected around the KHF. Very high concentration of hydrogen was also confirmed. 7) Newly developed pH sensor and turbidity meter were attached to the wire during most of dredge hauls and plankton net operations. Distinct turbidity anomalies were detected at some sites, that could prove the effectiveness of 'dredge-attached' sensors. 8) Approximately double-dense microbial cell density was detected within the hydrothermal plume above the KHF. The detailed distribution will provide a new insight into microbiological flux through the plume.

Keywords: hydrothermalism, Central Indian Ridge, tectonics, petrology, hydrothermal plume

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MORB and mantle peridotite along southern Central Indian Ridge: Preliminary results of dredge during KH-10-6 cruise

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Two active hydrothermal systems, Kairei and Edmond, are found along the Central Indian Ridge (CIR) with intermediate spreading rate (~ 48 mm/year). These hydrothermal system show distinct geochemical signature in their vent fluids. The former, Kairei Hydrothermal field (KHF), is characterized by hydrogen-rich hydrothermal activity (Gamo et al., 2001, EPSL), and it is located at the first segment of CIR. The latter, on the other hand, Edmond Hydrothermal field, show normal or lower hydrogen concentrations (Gallant & Von Damm, 2006, G3), and it is located at the 3rd segment of the CIR.

Recent investigations revealed that the origin of high hydrogen concentrations of the KHF is related to the serpentinization of olivine-bearing mafic to ultramafic rocks, which are exposed around the KHF (Kumagai et al., 2008, Geofluids; Nakamura et al., 2009, EPSL). However, these rocks are collected only from eastern side of the KHF, and detail distributions of olivine-bearing mafic to ultramafic rocks around the KHF was still uncertain.

In KH-10-6 cruise, we performed 10 dredge operations around the KHF in order to reveal the geology of the north of the KHF. Further 12 dredge operations are performed from 1st to 4th segments of CIR. Descriptions of recovered samples during KH-10-6 cruise are as follows.

Yokoniwa-rise, north of the KHF
KH-10-6DR01: ol-phyric basalt with glassy surface; dolerite; gabbro; serpentinized peridotite
KH-10-6DR02: aphyric to sparsely pl-phyric basalt with glass rim
KH-10-6DR03: slightly to highly pl (-ol) phyric basalt. Large pl-phenocryst (up to 2cm in size)
KH-10-6DR04: aphyric to sparsely pl-phyric basalt
KH-10-6DR05: sparsely pl-phyric basalt with glass rim. Large pl-phenocryst (up to 2cm in size)
KH-10-6DR06: aphyric to pl-phyric basalt with glass rim in places
KH-10-6DR08: highly altered dolerite and breccia (green schist facies metamorphism)
KH-10-6DR09: fine- to coarse-grained altered gabbro with dolerite; altered oxide gabbro; serpentinite
KH-10-6DR10: ol-pl phyric basalt with glassy rim; gabbro; amphibolite; serpentinized peridotite
KH-10-6DR11: serpentinized peridotite with deformation (foliation)
KH-10-6DR12: ol-phyric basalt (ol phenocryst up to 2 mm in size); weathered massive sulfide with goethite rim; serpentinized (and weathered) peridotite

CIR-1, ridge axis and off-ridge
KH-10-6DR07: basaltic glass; aphyric basalt
KH-10-6DR20: serpentinized peridotite with serpentine vein
KH-10-6DR21: aphyric basalt with glassy rim; serpentinized peridotite; gabbro
KH-10-6DR22: Mn-coated serpentinite, aphyric basalt, and mud stone

CIR-2
KH-10-6DR17: altered basalt with chlorite vein; altered dolerite
KH-10-6DR18: basalt glass; pl-phyric basalt with glassy rim
KH-10-6DR19: serpentinized peridotite with serpentine vein; gabbro; pyroxenite

CIR-3
KH-10-6DR15: very fresh aphyric basalt with glass rind with pillow lava texture
KH-10-6DR16: very fresh aphyric basalt with glass rind

CIR-4

KH-10-6DR13: pl-phyric basalt with glass rind (pl phenocryst up to 5 mm in size); basaltic glass
KH-10-6DR14: sparsely ol-phyric basalt with glass rim

These observations clarify inter-segment scale petrological differences along southern CIR as well as geological features around the KHF. We present here the petrological preliminary features (petrography, petrology, mineralogy, and microstructures) observed in mafic to ultramafic rocks obtained from the north of KHF and the 1st to 4th segments of CIR.

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

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Observation of mid-oceanic ridge floor using acoustic video camera

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DIDSON (Dual-Frequency IDentification SONar) is acoustic lens-based sonar. It has sufficiently high resolution and rapid refresh rate that it can substitute for optical system in turbid or dark water where optical systems fail.

Institute of Industrial Science, University of Tokyo (IIS) has understood DIDSON's superior performance and tried to find new method for utilization of it. The observation systems that IIS has ever developed based on DIDSON are waterside surveillance system, automatic measurement system for fish length, automatic system for fish counting, diagnosis system for deterioration of underwater structure and so on. A next challenge is to develop an observation method based on DIDSON for hydrothermal discharging from seafloor vent. We expected DIDSON to reveal whole image of hydrothermal plume as well as detail inside the plume.

We had a chance to participate the cruise YK09-13 (JAMSTEC Shinkai6500 / RV Yokosuka) to Rodriguez segment of Central Indian Ridge, where hydrothermal plume signatures were previously perceived. Several experimental trials based on DIDSON in tank and sea had been done in order to confirm whether flows in water can be detected by acoustical method. These trials showed that DIDSON could detect flow of water even if there was no clear thermal difference between the flow and its surrounding. Observation system based on DIDSON was prepared and equipped on the top of Shinkai6500 in order to get acoustic video images of hydrothermal plumes. In YK09-13 Leg.1 cruise, seven dives of Shinkai6500 were conducted. The acoustic video images of the hydrothermal plumes had been captured in three of seven dives.

Low-quality wire connection between DIDSON and Shinkai6500 limited on data transmission. Only low frequency mode was available, and average frame rate was lower than 1 frame per second. Acoustic image data captured by DIDSON in YK09-13 indicate capability of tool for seafloor observation, even though the data was low-quality and low-quantity ones.

Contrasting density inside the acoustic image of the hydrothermal flow could be distinguished. DIDSON showed its possibility of observation tool that can delineate spatial and temporal change of internal structure of the hydrothermal flows. Mosaic acoustic images showed bottom features of ridge axis. This indicates that DIDSON has a possibility of bottom observation tool, especially on the occasions of turbid or dark water.

Keywords: acoustic video camera, seafloor hydrothermal flow, seafloor terrain observation

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Geological setting and hydrothermal system at southern Mariana Trough: approach from high-resolution bathymetric survey

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To investigate the complex seabed morphology created by volcanic and tectonic processes and hydrothermal venting, near-bottom high-resolution bathymetric mapping of deep-water environment started at fast and slow spreading ridges during the last twenty years. As more recent technological and scientific advance, detailed feature and distribution of vent, fissure, fault, and lava morphology etc. have been well understood. In general, a localized hydrothermal system is mainly organized by interaction between tectonic and volcanic control. The occurrence and/or existence of fault, fissure, and fracture play an important role as formation of hydrothermal conduit (e.g. Humphris et al., 2002; Glickson et al., 2007; Ondreas et al., 2009).

In the study area, southern Mariana Trough, near 12 57'N, 143 37'E, have several hydrothermal systems. Three hydrothermal sites (Snail, Archaean, Pika) are located just on the active backarc spreading axis, the eastern foot of the axial high, and the top of an off-axis seamount about 5 km from the axis, respectively (Ishibashi et al., 2004; Kakegawa et al., 2004, 2008; Urabe et al., 2004), and these are aligned roughly perpendicular to the spreading axis. According to observation of the hydrothermal fluid, the system of on-axis site (Snail) is ephemeral, on the other hand, the two off-axis sites (Archaean and Pika) seem to have longevity of life (Urabe et al., 2004). The topography of sulfide mound, lava morphology, occurrence of fault and fissure, and chemistry of volcanic rock and sulfide deposit at each site has unique characteristic respectively, despite these sites are closely located. Thus, we will discuss that "what is necessary to maintain or develop these system?". The high-resolution bathymetric data for the examination was collected by AUV (autonomous underwater vehicle) URASHIMA in 2009 during the YK09-08 cruise.

Keywords: hydrothermal system, geological setting, Southern Mariana Trough, high-resolution bathymetric survey, lava morphology, sulfide mound

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U-Th radioactive disequilibrium dating of hydrothermal sulfide minerals

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The time scale for a hydrothermal activity is an important factor which controls the evolutionary interaction of chemosynthetic-based communities in a submarine hydrothermal system and "Rock-Fluid -Ecosystem linkage".

Dating techniques involving radioactive disequilibria of ^{235}U, ^{238}U and ^{232}Th decay series have been applied for hydrothermal submarine ore deposits. Among previous studies, ^{230}Th-^{234}U disequilibrium dating applied for massive sulfide mounds from Transatlantic Geotraverse (TAG) deposit on the mid-Atlantic Ridge yielded a wide range of ^{230}Th-^{234}U ages from 2.6 to 38 kilo years. The results indicated episodic activities lasted which more than 30 kyr in the TAG area positioned on a slow spreading ridge. In this study, we have attempted ^{230}Th-^{234}U disequilibrium dating for younger hydrothermal deposits from Okinawa Trough and South Mariana Trough using a Multiple-Collector Inductively Coupled Plasma Mass Spectrometry (MC-ICP-MC) and examined its applicability for dating of younger hydrothermal activity. Before 1990, radioactive counting method was widely used to measure radioactivities of U and Th. But recently, mass spectrometry has made it possible to determine lesser amounts of uranium and thorium with higher precision.

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

The sulfide mineral from Izena hole of Okinawa Trough was separated by acidic decomposition from insoluble barite. The ^{230}Th-^{234}U disequilibrium age of three samples yielded 700 to 1000 years. It has thus been fairly possible to apply the ^{230}Th-^{234}U disequilibrium dating for young age hydrothermal deposits to about several hundred years. However, due to low U/Th ratios in these samples, the precision of this method deteriorates. In addition, it was found necessary to estimate the initial ^{230}Th /^{232}Th ratios to determine the age more accurately. The samples from Archean site of Mariana Trough have higher U/Th ratio and enables more precise dating. Samples from a big chimney form two isochrones yielding 700 to 1800 years.

The results show that we need analyze several samples to see if they form an isochron.

Keywords: U-Th radioactive disequilibrium dating, Hydrothermal vent

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Marine DC resistivity survey at deep-sea mine in the Izu-Bonin arc, Japan

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The recent growth of world-wide requirement of metals demands advanced explorations for finding metal mine and deposits. Here we propose a new way for exploration of buried submarine massive sulphides with marine controlled-source electromagnetic

technique, and magnetic survey. We demonstrated feasibility studies using various marine electromagnetic soundings: magnetometric resistivity (MMR) survey, CSEM survey and marine DC resistivity survey. As a result, we confirmed that the electromagnetic responses of each marine electromagnetic survey are very sensitive to the conductive layer simulating the submarine massive sulphide deposits, which is buried at the depth of several tens meters. We newly developed our own controlled-source EM survey system for AUV and ROV, and the real field test for the ROV-based marine DC resistivity survey system was conducted on Jan-Feb in 2011. The JAMSTEC R/V Kairei and ROV Kaiko 7000II gave us a chance to apply our system to a deep-sea mine at the Bayonnaise knoll, Izu-Bonin arc, off Japan. Our system stably obtained the resistivity information in the seawater at the middle depth of sea, which allows us the system calibration because the seawater electrical conductivity is known. Then, we obtain the apparent resistivity distribution on the seafloor. Although our sounding depth is limited (one system has a few meters and another has several tens of meters), the deep-sea mine zone shows relatively conductive feature compared to the surrounding area. We also found that the resistivity distribution seems to be complicated possibly reflecting heterogeneous geological structures. In addition, the magnetic survey using AUV, to which three-components and total-force magnetometers were attached, was carried out on the same area, and the magnetic anomaly around the knoll was successfully obtained. These results suggest us a possibility of our new CSEM survey with ROV and magnetic survey with AUV to imaging the distribution of exposed and buried deep-sea mine.

Keywords: deep-sea mine, controlled-source, EM survey, ROV, AUV

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Seafloor spreading history in the Natal Valley and Mozambique Ridge deduced from vector magnetic anomalies

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The break-up of Gondwana is the important geological event to have affected the southern hemisphere in the past 200 Myr. The seafloor spreading history revealed by the geophysical survey around the Southern Ocean is one of the vital key to understanding the timing and geometry of early Gondwana break-up. However, magnetic anomaly lineations are less well defined because the existing marine magnetic data are still poor resolution especially in South Indian Ocean.

To reveal more detailed seafloor spreading history in this region during the initial break-up of Gondwana, the shipboard three components magnetic survey were carried out for the first time in the Natal Valley and the Mozambique Ridge off South Africa, using the R/V Pelagia operated by the Nederlands Institute voor Onderzoek der Zee (NIOZ) from 9th April to 1st June 2009.

In northern Natal Valley, complicated strike patterns of magnetic structure are shown, and trends of magnetic anomalies are not consistent with trends of magnetic isochrons reported in previous study. Additionally, characteristic trends are observed between S28/E34.5 and S27/E35. We will present vector magnetic anomaly features in the Natal Valley and the Mozambique Ridge, and discuss the seafloor spreading process in this region.

Keywords: vector magnetic anomalies, magnetic lineation, Gondwana breakup, Natal Valley, Mozambique Ridge

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Preliminary report of the R/V Hakuho-Maru KH-10-7 cruise, Southern Ocean

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The Antarctic Ocean is a key area to understand global environmental changes. Role of Antarctic Ocean is considered to be very important in the Earth system, but data coverage is still poor and further observations are required. The research cruise KH-10-7 by the R/V Hakuho-Maru of Japan Agency for Marine-Earth Science and Technology was conducted in the Indian Sector of the Antarctic Ocean from 17 December, 2010, to 17 January, 2011. The main objectives of the cruise are as follows.

1) Antarctic Cryosphere evolution based on marine geological observations in Conrad Rise and off Lutzow-Holm Bay: Site survey for new drilling proposal.
2) Studies on tectonic history of the Conrad Rise.
3) Quantitative estimation of cyclonic gyre and Antarctic Bottom Water transport in the Australia-Antarctic Basin.
4) Changes of ecosystem due to global warming and/or acidification in the Southern Ocean and following responses of biogenic trace gases in surface seawater.

The R/V Hakuho-Maru left Port Louis, Mauritius, on 17 December, 2010, and arrived at Fremantle, Australia, on 17 January, 2011, after multi disciplinary observations in the Southern Ocean. CTDs, water samplings, sediments sampling, rock sampling and multi channel seismic observations as well as underway observations were carried out during the cruise to attain these objectives. We will present the outline of KH-10-7 cruise and the topics concerning tectonic history of the Conrad Rise briefly.

Keywords: Southern Ocean, Cryosphere, tectonics, sediment, Antarctic Bottom Water, global warming