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

SCG67-P01 Room:Poster Time:May 2 16:15-17:30

GPS/acoustic measurement using a multi-purpose moored buoy system

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For monitoring crustal deformation and tsunami occurrence in the source region of the upcoming Nankai and Tonankai earthquake, JAMSTEC, JAXA, and Tohoku University have jointly developed a realtime continuous observation system using a moored buoy, called m-TRITON, and have started its sea-trial. The system consists of a seafloor pressure sensor for monitoring tsunamis and vertical crustal deformation, a GPS system for monitoring sea-level and position/attitude of the buoy, and a GPS/acoustic system for monitoring horizontal crustal deformation. Measuresd data are transmited to onshore station via satellite communication so that they can be monitored in realtime. The first sea-trial was carried out in Kumano-nada in 2013, and the second trial has been started in 2014 after improvement of the system. In this presentation, we focus on the issues particular to acoustic ranging of GPS/acoustic measurement for the purpose to remedy the system based on the data acquired in 2013, and report new data being acquired in the ongoing second trial in 2014.

The GPS/acoustic system measures horizontal movement of a seafloor banchmark, which consists of six transponders by combining GPS analysis of the buoy and acoustic ranging between the buoy and seafloor transponders. Considering bit-rate of the satellite communication, it is not realistic to send full acoustic waveform. So, it is required to send only the result processed on the buoy. In order to proceed acoustic wave with a low-powered device on the buoy, it is necessary (1) to cut out recorded waveform to the minimum requirement and (2) to send the processed data containing minimum but sufficient information. As for (1), in the current system recorded acoustic waveform is cut out by a window of $\pm$ 20 ms centered at synthetic traveltime calculated from provisional position of the buoy and each seafloor transponder. After that, cross-correlation waveform between the transmitted signal and the received signal is calculated to obtain an accurate observed traveltime. Then (2) send the correlogram only a 1 ms window centered at the maximum correlation peak, which is sufficient to include the sidelobe. Since correlation wave is represented in 8 bit and the sampling rate is in 100 kHz, the size-per-signle wave to be transmitted can be reduced only to 101 byte.

As a result of considering the fluctuating range for the uncertainty of provisional position obtained by the NMEA output of the GPS (˜10 m at most) and the average sound speed variation (˜2 m/s) that affect the synthetic traveltime, the window width of $\pm$ 20ms employed in (1) is a minimum requirement. In order to certainly cut out maximum correlation peak for all acoustic ranging, it is desirable to set the width to $\pm$ 30 ms. As for correlogram to be sent to onshore station, since the envelope of the correlation peak is within the 1 ms, current width is reasonable. However, apparent maximum correlation peak often known to appears due to multiples at sea surface. In that case, it is not possible to achieve proper adjustment only by the width. Therefore the development of an algorithm to detect the true correlation peak is required. We verified based on actual data about the condition that the multiple occurs, and found that it is explained by the incident angle of the sound wave and the directivity of transducer. We are developping an algorithm that automatically detects the true correlation peak based on this hypothesis.

Keywords: crustal deformation, moored buoy

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Inversion analysis for slip deficit rate along the Nankai Trough using on- and offshore crustal velocities

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Along the Nankai Trough, megathrust earthquakes occur every 100-150 years. A nationwide continuous GPS observation network in Japan has measured precise crustal deformation in this area for the past decade. However, the sources of these earthquakes are located offshore where slip resolution is generally poor. Since the early 2000s, seafloor geodetic observations using GPS/Acoustic techniques have been conducted against such a background in Japan. Today, seafloor geodetic observations are recognized as an effective and essential procedure for understanding the source process of earthquakes that occur in offshore areas. In this study, we show the result of seafloor geodetic observations using GPS/Acoustic techniques from 2004 to 2012 and estimate slip deficit rates along the Nankai Trough using both onshore GPS velocities and offshore crustal velocities derived from seafloor geodetic observations. We conducted inversion analysis with a priori information, and then, a high slip deficit rate of more than 50 mm/yr was detected off the Shikoku district. This decreases to approximately 30-50 mm/yr off the Kii Peninsula, and then it falls to approximately 10-30 mm/yr around the Suruga Trough relative to the Amurian plate, except for slip deficit rate of nearly 40 mm/yr which was detected at a fault segment beside the seafloor benchmark at the Suruga Bay. In addition, we investigated slip resolution by adding new established seafloor benchmarks off Shikoku district. As a result, we found that slip resolution was still poorer in offshore areas such as off the Ashizuri Cape, the Muroto Cape, and the Kii Peninsula near the trench axis than in onshore areas. Thus, it is important to conduct seafloor geodetic observations in areas with poor slip resolution.

Keywords: GPS/Acoustic, Nankai Trough, crustal deformation, slip deficit rate, slip resolution

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SCG67-P03 Room:Poster Time:May 2 16:15-17:30

Development and examination of new methods for traveltime detection in GPS/A geodetic data to high-precise and automatic

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The development of a technique for GPS-acoustic (GPS/A) geodetic observations has enabled us to understand the slip distribution of the 2011 Tohoku-oki earthquake. However, there remains an issue with the precision of GPS/A measurement is still lower by two orders of magnitude than that of on-land GPS measurement due to problems in observations and data processing methods. In this study, we focus on the problem for determination of traveltimes of acoustic signals obtained from GPS/A measurement.

The conventional approach for determining the two-way traveltime of observed acoustic signals is to determine the maximum peak of the cross-correlation waveforms between the transmitted and returned signals. However, the maximum peak often differs from the true peak due to the distortion in the correlation waveform which depends on the relative spatial geometry of the ship and station. These misread traveltimes have been re-read manually so far. Such procedure is no longer applicable for processing vast array of data obtained at newly installed over 20 GPS/A stations after the 2011 Tohoku-oki earthquake. The aim of this study is to develop fully automated algorithms for analyzing GPS/A data with high precision. We introduce here two algorithms.

1) We read the maximum peak in the observed correlogram and then deconvolve it by the synthetic correlogram. Then, we apply the same operation to the deconvolved waveform. This procedure is iterated until the correlation coefficient decreases lower than a pre-defined threshold. A true traveltime is defined as the fastest traveltime during the iterations.

2) We classify the observed correlograms into several groups based on their similarity through cluster analyses and choose a master waveform in each group. Then evaluate the traveltime residual between the maximum peak and the true peak in the observed correlogram. Thus obtained residual is applied as the correction value of each clustered group.

We also use a seismic data analysis tool to visually inspect whether above algorithms work properly. We confirmed that the both new methods properly correct for misreadings in the current method, which sometimes amount to several hundred micro seconds. This corresponds roughly to a 0.3-m difference in the slant range. Therefore, with the new algorithms, significant improvement in the estimation of the station location is expected. However, both methods have to be assigned an arbitrary value as a threshold. Further analyses are needed to determine arbitrary threshold values and to construct fully automated algorithms.

Keywords: ocean bottom geodetic observation

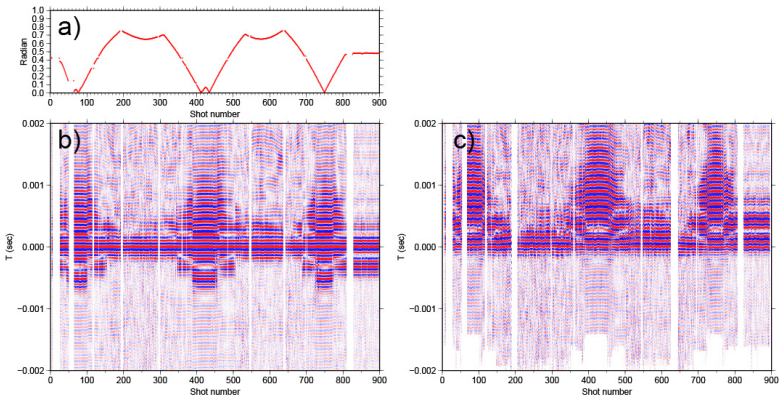

Fig. Incident angle of transmitted signals (a). Pasted corelation waveforms analyzed by reading maximum peak (b) and reading iteratively-deconvolved peak (c). Each trace was moved out by the observed traveltime.

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A NaI spectrometer for long-term radon measurement at the sea floor

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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 belt and the mechanism of earthquakes near the oceanic trench for damage mitigation of human lives and social basis. Increases of the radon concentration in atmosphere and in groundwater before earthquake are reported in the Southern Hyogo Prefecture Earthquake in 1995. In this research, gamma rays from radon daughter radionuclides at the sea floor will be continuously measured on the Kumanonada offing, where is the epicentral area of the expected Tonankai earthquake. The correlation between micro earthquakes and radon concentrations is also investigated to contribute the fundamental research on the response of the fluid in the crust corresponding to change of the crust.

Investigation on the gamma ray at the sea floor has been made only in a certain limited duration up to several hours while the submersible stays at the site for measurement. This time, a time variation of the gamma ray for several months is planned in order to investigate correlation between earthquakes and radon concentration. A battery drive type NaI spectrometer, which will be set on sea floor and can automatically record gamma ray, was designed. In this January it is almost constructed. A preliminary measurement is scheduled in February. After improvements of software and hardware, it will be set on spring water area of the Kumanonada offing from April to September, and will measure for more than about 4.6 months.

Specification of the NaI spectrometer for long-term radon measurement at the sea floor is as follows;
Name: Low consumed power type gamma-ray spectrometer for deep sea
PMT High-voltage : programmable (+1000V max)
Amplifier: Charge sensitive Memory Capacity: 1Gbit (NOR Flash)
Connection: RS-232C 921,600 bps Current: 110mA (on), 10mA (off)
Operation:
1. After initial setting with PC, measurement starts automatically, and records gamma-ray spectra.
2. It has the intermittent mode for electric power saving.
3. Battery Power Supply 30 AA alkaline batteries, 6 series, 9V
4. When the battery power supply voltage falls to 6V or spectral data is over memory capacity, measurement is suspended automatically and the battery power supply is disconnected.
5. It can connect with PC after measurement, and transfer the recorded spectra to PC.

Keywords: Radon, sea floor, long-term measurement, NaI

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Time stamp experiment of MEMS-gyro for the observation of seafloor crustal deformation using multi-buoy system

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We are developing a new method for the observation of seafloor crustal deformation using multi-buoy system. The system measures seafloor crustal deformation by determining position of benchmarks on the seafloor using multi-buoy which link-up GPS and acoustic signals. Acoustic ranging is used to measure distance between the buoys and seafloor benchmarks. And kinematic GPS is used to locate the multi-buoy every 0.2 seconds. Now we have deployed 4 seafloor benchmark units at Suruga Bay and 4 units at Kumano Basin. At each survey site, three seafloor transponders are settled to define a benchmark unit. In November 2012, first observation of seafloor crustal deformation using the buoys was held in Suruga Bay. Analyzing observed data, errors of traveltime ' s residual were about 0.2ms(Mukaiyama et al 2012JPGU). These errors were too large. From approximate calculation, it is predicted that these errors of 0.16ms at maximum can be removed by introduction of a gyro compass. So, we introduced MEMS-gyro to multi-buoy observation to monitor the attitude of the buoys at Suruga Bay at November 2013. The MEMS-gyro was NAV440CA by Crossbow Co.. For the attitude monitoring of the observation of seafloor crustal deformation, time stamp is important. Although the gyro introduces time stamp provided by its GPS processor, its accuracy was not evaluated. In this study, we conducted rotation experiments to evaluate the accuracy of its time stamp. In the experiment, we used another GPS antenna system as a time reference. The GPS antenna and the gyro were deployed on a rotation table to synchronize their motions and the time stamp of the rotated gyro was checked with reference to the GPS time. Timing between their motions was evaluated by cross correlation between GPS circular trajectory and the rotation angle of the gyro. Specifically, we rotated the table for 3 min every 1 hour. This subset was repeated 3 times. As a result, delay times in first two sets were about -38ms. But third set was -58ms. The delay became lager. Offset of the average angle between GPS and gyro was also deferent from first two sets to third set. This deference might be caused by that of rotation speed between three subsets. We tried additional experiment with different parameter settings of MEMS-gyro under controlled rotation speed. We will also report the result of this additional experiment.

Keywords: Seafloor crustal deformation, buoy, GPS, MEMS-gyro, Time stamp, Rotation experiment

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Three year observations of ocean infragravity waves by broadband seismometers and pressure gauges of Japanese seafloor n

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Ocean infragravity (IG) waves are sea-surface gravity waves with periods of several minutes and wavelengths up to tens of kilometers. We used a slant-stack technique to detect IG waves from the three-year period records (2011-2013) of the vertical component broadband seismograms and pressure gauges of the seafloor network deployed in the Nankai Trough region (DONET). IG signals show good match in waveform between the seafloor displacement and pressure with propagation speeds consistent with the seafloor depths of 2000 m. The signal intensities are strongly azimuth-dependent. Except for the days with extreme weather, waves incoming from the SE direction (from the deep ocean to the coast across the Nankai Trough) are by far dominant. The incoming direction sharply splits into two, SSE and ESE. Waves from the deeper ocean in the SSE direction are more dominated in longer-period components than those from the shallower ocean in the ESE direction. Amplitudes of these waves clearly show a seasonal variation, high in winter and low in summer. The effect of typhoon is to generate IG waves incoming from the source direction and those incoming from the NE-ENE direction through the corridor between the coast and the Nankai trough. The latter is often stronger than the former.

Keywords: Infragravity wave, Nankai Trough, DONET

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Evaluation of resolution and estimation error of vessel-based seafloor displacement observation using AUV bathymetry

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Bathymetry is basic information for any kind of seafloor observation, and therefore vessel-based multi-narrow beam bathymetric surveys are conducted quite often. In recent years, previous bathymetric data exist in most scientifically-important areas. A repeated bathymetric survey reveals seafloor displacement related to geodynamics [e.g. Fujiwara et al., Science 2011]. However, the spatial resolution and estimation error of the seafloor displacement observation from the vessel-based bathymetric survey are not exactly known. Because the observation compares a pair of limited-resolution bathymetric data. Water depth (distance from the vessel's echo sounder to the seafloor) degrades the spatial resolution and precision of depth measurement from the vessel-based survey. While on the other hand, a near-seafloor Autonomous Underwater Vehicle (AUV)-based survey enables us to obtain high-resolution bathymetric data. In this paper, we evaluated the spatial resolution and estimation error of the seafloor displacement observation from vessel-based bathymetric survey. In this evaluation, bathymetric data from vessel-based and AUV-based surveys in the Iheya-North knoll of the Okinawa Trough were used.

AUV Urashima bathymetric survey was conducted in YK07-07 cruise aboard the R/V Yokosuka in May 2007 [Yamamoto et al., 21st Mtg, Japan Society for Marine Surveys and Technology 2009]. The applied multi-narrow beam echo sounder was a SEABAT 7125. R/V Yokosuka bathymetric survey was performed using a SeaBeam 2112 echo sounder in YK06-09 cruise from 18 to 24 July 2006 [Masaki et al., JAMSTEC R&D 2011]. The vessel passed over the survey area six times with each constant speeds and obtained bathymetric data. One survey track was treated as one's independent survey in this evaluation. The beam angle (angle formed by the vertical line and a narrow sounding beam) was within 40^o in the survey area.

AUV bathymetry shows hills (the shallowest depth ∼870 m) in the western side and basins (the deepest ∼1070 m) in the eastern side. The average/median depth is 1010 m. Hydrothermal chimney mounds ∼30 m in diameter and ∼10-20 m in height were found on the hillside in the high-resolution bathymetry. Vessel-based bathymetry is spatially-smoothed as a function of the footprint (area of the narrow sounding beam projected onto the seafloor) size. The footprint size of the Yokosuka survey at a depth of 1000 m is ∼35×35 m-43×55 m (∼5% of water depth). In the vessel bathymetry, geographical features smaller than the footprint size, such as the hydrothermal chimney mounds, cannot be recognized. And seafloor morphology is slightly different from each other track surveys due to distribution of sounding points and measuring error. Standard deviations of depth differences between the AUV- and the vessel-based data were 2.67-3.08 m. The AUV bathymetry are assumed to be the "true" bathymetry, and therefore the precision of the vessel-based depth measurement (standard deviation of measuring error) is considered to be ∼0.2-0.3 % of water depth.

Simulated vessel-based bathymetric data "before and after" the seafloor displacement were made using AUV-based bathymetric data. The displacement was verified by comparing these simulated data using the analysis conditions that neither depth accuracy variation within the area nor locational errors of beam sounding points are allowed. We used the method of Fujiwara et al. [2011] to estimate horizontal displacement. As a result, we found that estimation error of the seafloor horizontal displacement depends on the precision of the depth measurement and is ∼0.2-0.3 % of water depth. As for the seafloor vertical displacement, the smallest displacement that can be detected occurs when the horizontal extent of the deformation is larger than several times the size of the footprint, and in the situation that the amplitude of the depth difference is greater than the precision of depth measurement.

Keywords: Multi-narrow beam bathymetry, seafloor displacement, Iheya-North knoll, AUV Urashima, R/V Yokosuka

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Bathymetric survey and discovery of hydrothermal plume in the Daiichi-Amami Knoll using autonomous underwater vehicle

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Many submarine volcanoes exist along the volcanic front in the Ryuku Arc. The Daiichi-Amami Knoll, which is located about 70 km off Amami Oshima Island, is one of those submarine volcanoes. Detailed bathymetric survey of this knoll has not been done before, therefore its shape and size have not been known. Japan Coast Guard conducted a high resolution bathymetric mapping of the knoll using survey vessel and autonomous underwater vehicle (AUV) and discovered hydrothermal plumes which are rising from the seafloor, indicating that the presence of hydrothermal activities in the Daiichi-Amami Knoll.

1. Method

The survey was conducted in August and September, 2013 using survey vessel Takuyo and AUV Gondo. The knoll was surveyed with multibeam echo sounder (MBES) installed on S/V Takuyo. Then the detailed survey was done with MBES on AUV Gondo.

2. Bathymetry

The bathymetry of the Daiichi-Amami Knoll indicates that the knoll is a volcanic high. The knoll has flat areas, a caldera with a diameter of 1.6 km and some volcanic cones at its summit. The knoll also has two small depressions near to the volcanic cones and they are deeper about 40 m than the surrounding areas. The relative high of the knoll is about 500 to 700 m and the shallowest depth of the knoll is 245 m.

3. Hydrothermal plume

Water column data acquired by MBES on S/V Takuyo detected the clear hydrothermal plumes in the two depressions. The plumes were especially clear at the rim of the depression. Some plumes were observed to rise from the seafloor of 350 m depth to near sea surface (although no discolored water was visually observed on the sea surface). Plumes were also detected at the slope areas of the volcanic cones. AUV Gondo dived to the depressions at the altitude 40-50 m above seafloor and conducted a detailed survey. The high resolution bathymetric map shows a presence of a numerous small depressions near the plume points. The side scan image by AUV Gondo also shows the plumes acoustically at its nadir.

4. Water temperature

AUV Gondo observed the water temperature at the altitude 40-50 m in the depresions, but distinguished temperature increases were not observed. Temperature profile observation, which was conducted using expendable bathythermograph launched from S/V Takuyo, showed over 2 degrees temperature increase near the seafloor in the depression. This observation along with the presence of plumes indicate the presence of hydrothermal activity in the Daiichi-Amami Knoll.

5. Importance of this survey result

The detailed bathymetry and the presence of plumes in the Daiichi-Amami Knoll were revealed by the survey using survey vessel and AUV. The discovery of plumes suggests the presence of hydrothermal deposits and chemosyhthetic community, therefore being important in terms of seafloor resources. The high resolution bathymetric map acquired by AUV is fundamental information which is useful for scientific research and mineral exploration. This result is a first step for further survey to understand the geological history of the knoll and to secure new seafloor resources.

Keywords: Daiichi-Amami Knoll, submarine volcano, plume, AUV, bathymetry

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Topography, geology, tectonics and ore deposit of the Bayonnaise knoll caldera, Izu-Ogasawara arc

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Several hydrothermal sites have been discovered in the volcanic front of the Izu-Ogasawara arc: Myojin knoll caldera, Myojinsho caldera, Smith caldera, Suiyo seamount, and Kaikata seamount. The Hakurei hydrothermal site in the Bayonnaise knoll caldera is the only hydrothermal site discovered in the rift zone of the arc. We analyzed deep-sea multibeam and side scan sonar data obtained using autonomous underwater vehicle Urashima in the caldera and discussed the topography, geology, tectonics, and ore deposit of the caldera.

The survey area ∼3 km x ∼2 km wide covers the southern half circle of the caldera. Major geomorphic elements are, from the outside to the inside, the knoll slope, the steep caldera wall, the flat caldera floor, the central cone with three peaks, and the central depression surrounded by the peaks. The high-resolution bathymetric map shows that large slope failures occurred in the southeastern caldera wall and that the Hakurei deposit is distributed over the failure area. Slope failure is also going on in the southwestern wall and a large collapse may shortly occur. The eastern hill, the main part of the central cone, seems to be a lava dome: it has a small flat surface on the top, convex slopes in the upper part, and rectilinear to concave slopes near the base. The northeastern slope of the dome is relatively flat from top to bottom, indicating that a slope failure occurred there. A series of depressions lying in a NW-SE direction in the western caldera floor would be a crater row, seeing that the terrain gently slopes down from the rim of the depressions. The direction of the crater row suggests that the caldera is under the extension stress in a NE-SW direction.

Morphological and textural characteristics of the Hakurei site were determined by three kinds of analyses. The gray-level co-occurrence matrix was used to describe the texture of the side scan sonar image and to classify the seafloor using cluster analysis. The Hakurei area was distinctly classified to a group that was characterized by high entropy and low homogeneity, and a broad area from the top to the northeast slope of the eastern lava dome was also classified to the group. Some areas belonging to the group were distributed around the top of the southern central cone, in the eastern caldera wall northeast of the Hakurei site, in the southwestern caldera wall, and around the crater row. A band-pass filtered topography was used to determine areas where short-wavelength topographic features like chimneys and mounds observed in the Hakurei site dominate. The band-pass filtering was also performed on the multibeam backscattering intensity data to detect similar patterns to numerous spots of strong backscattering from chimneys observed in the Hakurei area. These results commonly show that areas of similar characteristics to the Hakurei site are distributed in a zone crossing the caldera in a NW-SE direction, from the Hakurei site to the crater row through the central cone.

The Izu-Ogasawara rift zone is separated to many segments ranging in a N-S direction. The Bayonnaise knoll caldera is located on the northeastern margin of an oval depression called the North Myojin rift, which has a longer N-S axis of ∼20 km. It appears that the direction of the crater row, the distributions of hydrothermal or volcanic features, and the distribution of slope failures are along the rim of the North Myojin rift going through the caldera. The North Myojin rift is surrounded by seven knolls including the Bayonnaise knoll. Although hydrothermal activity has been discovered only in the Bayonnaise knoll so far, the geological settings that volcanoes of acidic rocks lying along a circular fault of a depression host ore deposits closely resembles that of the Hokuroku Kuroko region in northern Akita. It is suggested that the Hakurei site is the present field of the Kuroko ore formation.

Keywords: hydrothermal deposit, Izu-Ogasawara rift, multibeam sonar, side scan sonar, GLCM, Kuroko deposit

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Electrical resistivity structure of the Snail site at the Southern Mariana Trough spreading center

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The electrical resistivity of the oceanic crust is sensitive to the porosity of the crust and the fluid temperature within crustal fractures and pores. The spatial variation of the crustal porosity and the fluid temperature that is related to a hydrothermal circulation can be deduced by revealing an electrical resistivity structure of the oceanic crust involving a hydrothermal site. We carried out a magnetometric resistivity experiment using an active source to reveal an electrical resistivity structure of the oceanic crust at the Snail site on the ridge crest of the Southern Mariana Trough. Active source electric currents were transmitted along and across the ridge axis in a 4000 m^2 area including the Snail site. Five ocean bottom magnetometers were deployed around the Snail site as receivers to measure the magnetic field induced by the transmission of the active source electric currents. The amplitude of the induced magnetic field was calculated by maximizing data density and the signal to error ratio in the data, and locations of the transmissions were determined using several types of calibration data. An optimal 1-D resistivity structure of the oceanic crust, averaged over the experimental area, was deduced by least squares from the data of the amplitude of the magnetic field and the location of the transmission. After calculating magnetic field anomalies, which are deviations of the observed amplitude from the prediction of the optimal 1-D resistivity model, an optimal 3-D resistivity structure was deduced from the magnetic field anomalies through trial and error 3-D forward modeling. The optimal 1-D resistivity structure is a two-layer model, which consists of a 5.6 Ω-m upper layer having a 1500 m thickness and a 0.1 Ω-m underlying half-space. Using Archie's law and porosity profiles of the oceanic crust, the resistivity of 5.6 Ω-m at depths ranging from 800 to 1500 m suggests the presence of high-temperature fluid related to the hydrothermal circulation. The resistivity of 0.1 Ω-m below 1500 m depth may represent a magma mush that is a heat source for the hydrothermal circulation. The optimal 3-D resistivity structure includes a conductive anomaly (0.56 Ω-m in approximately 300 m^2 area down to 400 m depth) just below the Snail site, two resistive anomalies (56 Ω-m with slightly larger volumes than the conductive anomaly) adjacent to the conductive anomaly on the across-ridge side, and three conductive anomalies away from the Snail site. The conductive anomaly just below the Snail site suggests hydrothermal fluid, and the adjacent resistive anomalies suggest areas of low porosity. The size and distribution of the conductive and resistive anomalies near the Snail site constrains the size and style of the hydrothermal circulation.

Keywords: electrical resistivity structure, temperature and porosity, oceanic crust, hydrothermal circulation, magnetometric resistivity method

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SCG67-P11 Room:Poster Time:May 2 16:15-17:30

Crustal Imaging of initial structure in Izu-Ogasawara forearc region obtained by seismic reflection survey

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The Izu-Bonin (Ogasawara)-Mariana (IBM) arc is known to the typical oceanic island arc, and it is the most suitable area to understand the growth process of island arc. The existence of two paleo arc which consists of Oligocene and Eocene paleo age is known in IBM forearc region by geological and geophysical studies. The Ogasawara ridge is also known to locate the initial structure of arc evolution from geologic sampling of research submersible. In this region, IODP drilling site: IBM-2 is proposed in order to understand the temporal and spatial change in arc crust composition from 50 to 40Ma magmatism. Site IBM-2 consists of two offset drilling holes (BON-1, BON-2). BON-1 designed to first encounter forearc basalt and will reach the sheeted dykes. BON-2 will start in boninites and finish in fore arc basalts. The purpose of these drilling is sampling the full volcanic stratigraphy from gabbro to boninite. This drilling project is already scheduled in 2014. The survey lines along the proposed sites, however, there are no crossing seismic data around BON-1 and BON-2. Therefore, it is need to conduct the MCS survey until 2013 for the evaluation of proposed site.

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) newly carried out multi-channel seismic reflection (MCS) survey using 7,800 cu.in. air gun, 5 km streamer with 444 ch hydrophones in April, 2013. We obtained two seismic reflection profiles of lines IBr11n and IBr11 across from Shikoku Basin and current volcanic front to the paleo arc. The preliminary results show the distribution of volcanic sediments and basement.We also identified the block type structure associated with the uplift in northern side of Kinyo seamout. We will discuss about the characteristics between backarc and forearc from north to south.

Keywords: MCS survey, IBM forearc, initial arc structure

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Across-arc geochemical variation of Quaternary Basalts dredged from central part of Izu-arc

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The Izu-Bonin arc located western margin of the Philippine sea plate extend to ca. 1200 km south from central Honshu of Japan with ca. 400 km width. The Izu-Bonin arc is a match for NE Honshu arc (Nishimura and Yuasa, 1991). Although volcano lying on the volcanic front (VF) of northern part of this arc expose above the sea level (e.g. Izu Oshima, Miyakejima), almost this arc sink down to sea surface. Active rifts (AR) exist just behind VF with 20-30 km width. These are parallel to the VF and Izu-Bonin Trench and enclosed with escarpment. Ishizuka et al. (2003b) reported Ar-Ar age of igneous rocks dredged from central part of Izu-Bonin arc. According to these age data, recent volcanism (<1Ma) occurred only VF and AR. In this study, we report geochemical data of basalt dredged from Myojin volcano, Myojin rift and Aogashima rift. Basalts exhibit evident across-arc variations. Ba/La ratio, Sr, Nd and Hf isotopic ratios decrease correspondingly distance from Izu-Bonin trench toward rear-arc. Whereas (La/Sm)N increase correspondingly distance from Izu-Bonin trench. Based on ratios of trace elements and each isotopic feature, we conclude that VF basalts generated from flux melting of mantle due to adding aqueous fluid to wedge mantle from subducting slab. On the other hand, genesis of AR basalt is to supply supercritical melt (e.g. Kessel et al. 2005) of slab to wedge mantle. Chromian spinel composition, Cr# of inferred chromian spine equilibrated with mantle is 0.75, held in olivine of VF basalt suggest that residual mantle equilibrated with VF primary magma is dunite. Degree of partial melt of AR basalt decrease correspondingly distance from Izu-Bonin trench toward rear-arc. Tollstrup et al. (2010) interpreted magma genesis of basalt after cessation of Shikoku back-arc basin. They proposed that basalts of western seamount chain (WS) and back-arc knolls (BAK) derived from partial melting of mantle due to adding supercritical melt to mantle wedge from subducting slab, whereas aqueous fluid contributed to partial melting of mantle beneath AR and VF. In their discussion, activity age and activity region are not considered. According to their conclusions, supercritical melt related to genesis of basalts from WS and BAK is not contribute to partial melting of mantle wedge recent volcanism (<1Ma). Bryant et al. (2003) revealed that VF basalt volcanism has continued since 15Ma. Moreover, Ishizuka et al. (2003b) reported volcanism has traveled eastward with time in the central Izu-Bonin arc. It means Izu-Bonin arc volcanism has become narrow range with time. Distinct slab flux between VF and AR in this study suggest that occurrence of supercritical melt is traveling with time toward VF side due to change subducting angle of slab into more steep angle since 15Ma to 3Ma (Honda et al., 2007). Therefore supercritical melt related to genesis of basalt from WS and BAK at predate volcanism contribute to AR recent volcanism.

Keywords: basalt, Izu-Bonin arc, geochemical across-arc variation, Myojin seamount, Aogasima rift, Myojin rift

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The variety of silisic rocks around the Myojin volcano, central Izu-Bonin arc

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The Izu-Bonin arc located western margin of the Philippine sea plate (PSP) extend to ca. 1200 km south from central Honshu of Japan with ca. 400 km width. The Izu-Bonin arc is a match for NE Honshu arc (Nishimura and Yuasa, 1991). Active rifts (AR) exist just behind volcanic front (VF) with 20-30 km width. These are parallel to the VF and Izu-Bonin Trench and enclosed with escarpment. Generally primitive basalts possibly erupted at oceanic arc volcano without any process in the oceanic crust due to be thinner than continental crust. Although it is well known that Izu-Oshima and Miyakejima, located on VF, erupted basalts, Kouzushima, Niijima and Myojin reef are represented volcanoes which provide mostly felsic products exist on the Izu-Bonin arc VF (Tamura et al., 2009). Nowadays extensive seismic experiments in the Izu-Bonin arc have documented the occurrence of middle crust with P-wave velocity of 6.0-7.0km/s (e.g. Suyehiro et al., 1996). Because of the rock, with P-wave velocity of 6.0-7.0km/s, correspond to tonalite exposed Tanzawa complex Izu collision zone and tonalitic xenoliths in the volcanic rocks sampled VF, inferred middle crust of Izu-Bonin arc composed of tonalitic igneous rocks (Suyehiro et al., 1996). In this study, our aim is to understand mechanism of felsic volcanism contribute to making continental crust. Therefore we consider about felsic rocks dredged from Myojin volcano, Myojin rift and Aogashima rift.

Felsic rocks in this study are divided into three suites (type 1, type 2, type 3) on the basis of Zr/Y versus Zr diagram. Type 1 is lowest Zr/Y ratio trend, type 3 exhibit highest Zr/Y ratio and type 2 have intermediate Zr/Y ratio. Type 1 occur mainly VF, and small amount of type 1 appear AR. Type 2 collected overall from VF to AR. Type 3 occurs only AR.

Although Sr and Nd isotopic compositions of type 1 is similer to the basalt from the VF, Hf isotopic compositions of type 1 differ from VF basalt, and Hf isotopic compositions of type 1 is same as mafic xenoliths in VF lava rather than VF basalt. Isotopic features of type 2 are distinguished from lavas erupted normal-arc magmatism after cessation of Shikoku basin. And Isotopic features of type 2 dredged from more AR-side have higher Nd, Hf isotope ratios. Although Sr and Nd isotopic compositions of type 3 is similer to the basalt from the AR, Hf isotopic compositions of type 3 differ from AR basalt, and isotopic compositions of type 3 is different from lavas erupted normal-arc magmatism after cessation of Shikoku basin and tephra data from ODP boring (Straub et al., 2010).

On the basis of Na2O vs ASI diagram, three type felsic rocks in this study agree with compositions of experimental liquids which derived from basaltic source materials (e.g. Sission et al., 2005). There is possibility that felsic rocks derived from associated basalt. But because of Hf isotope ratio, all felsic rocks are not derived from associated basalt. Therefore all felsic rocks, provided by recent volcanism, are rejuvenated products of old arc crust.

Because of isotopic compositions of type 1 are similer to mafic xenoliths in VF lava, type 1 derived from remelting of arc crust which have postdate VF basalt composition (Bryant et al., 2003). Altough There is possibility that type 2 derived from remelting of Oligocene mafic arc crust, type 2 dredged from more AR-side have higher Nd, Hf isotope ratios. It suggests that AR-side type 2 is possibly affected by PSP. Geochemical data which is similer to type 3 have been found out in previous ODP boring data, and it is possible exist crustal material which is peculiar to AR. We long for IODP projects which start at this year to accumulate new AR crustal material data to consider source of type 3. We propose heterogeneous crust model. It have made by underplating or intrusion of mafic magma derived from mantle into PSP for 50Ma.

Keywords: acidic rock, Izu-Bonin arc, Myojin volcano, Myojin rift, Aogashima rift

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General remarks of velocity structures of the Ogasawara Plateau, revealed by the Contineltal Shelf Survey of Japan

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Japan Coast Guard conducted seismic refraction surveys with OBSs and multi-channel seismic surveys over more than 10 survey lines on the Ogasawara Plateau which is located on the Pacific Plate, close to a plate boundary to the Philippine Sea Plate. Analysis of these seismic data in 2006-2007 revealed that 1)the Ogasawara Plateau collide and partly accreted with the Philippine Sea Plate, 2)crustal thickness of the Ogasawara Plateau is approximately 25 km, close to that of the Izu-Ogasawara Arc, and 3)low velocity structure in lower crust extends below flat seafloor to the south-east to the plateau.

Recently, re-analyzing of the data by utilizing various later phases and MCS profiles revealed more detailed velocity structure of 1')plate boundary between the Pacific Plate and the Philippine Sea Plate, 2')under plating below the Ogasawara Plateau and 3')low velocity structure distributing around the plateau.

Keywords: velocity structure, Ogasawara Plateau, seismic experiment

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Acoustic characterization of abyssal plain, northwestern Pacific region

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The old seafloor covered by pelagic sediment has not attracted large scientific attention and remained untouched for many years, however, the recent studies on intra-plate volcanism as well as the increasing interest in deep-sea natural resources focus spotlight on the abyssal plains. We analyzed the multi-beam bathymetry, beam intensity, and side-scan images of abyssal plain in the northwestern Pacific, around the Minami-Torishima (Marcus) Island. The data were collected by Japan Coast Guard as part of Japanese EEZ survey and by R/V Yokosuka for decades. The beam intensity data from multi-beam echo sounder were processed to create a backscatter mosaic without geometric distortion. The mosaic shows a large variation of acoustic characteristics in whole study area. The high backscattering areas at the foot of large seamounts likely reflect the distribution of volcaniclastic sediments and debris. We can also recognize another type of high backscattering areas in flat seafloor, where neither remarkable seamounts nor knolls exist. The latter type partly corresponds to the area where the high concentration of rare-earth elements were reported and may suggest a thin cover of uppermost soft sediment layer. We try to integrate the backscattering mosaics and the statistic analysis of bathymetry and to establish a new method of acoustic characterization of abyssal plain. We also plan to compare our results with piston core samples as ground references and to discuss the sedimentation process and the relationship with intra-plate volcanism on old seafloor.

Keywords: marine acoustics, muti-beam echo sounder, backscattering intensity, abyssal plain

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Spreading stability at the mid-ocean ridges derived from 3D magnetic survey

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The Shipboard Three Component Magnetometer (STCM) has provided vector data of the geomagnetic filed provided detailed information more than total magnetic force measurement. Previous study shows the results about relationship with ocean floor topography and standard deviation of magnetic boundary strike (MBS) calculated from Intensity of the Differential Vectors (ISDV) in Southeast Indian Ridge (SEIR) classified intermediate spreading rate. In this study, the standard deviation of MBS and half spreading rate were analyzed from STCM data in East Pacific Rise (EPR) of fast spreading ridge, Explorer Ridge (ER) and Southeast Indian Ridge (SEIR) classified intermediate spreading ridge and Mid Atlantic Ridge (MAR) categorized as slow spreading ridge. In EPR existing axial high, the results shows that standard deviation and half spreading rate are stable in west of EPR whereas standard deviation and half spreading rate are variability in east of EPR. However standard deviation is low and spreading rate is stable on both sides in MAR developed axial valley. Thus there is no relationship with topographic features and spreading of stability. Additionally, standard deviation of MBS is the low although half spreading rate has variability in ER. The results show differential MBS at the same position in SEIR. As a result, dispersion of MBS is caused by inaccurate measurements of magnetic anomaly. In addition, there is no clear relationship though the simulation was run about plate reconstruction. Therefore spreading stability is controlled by the balance among plate reconstruction, slab pull and magma provided from mantle.

Keywords: mid-ocean ridge, spreading rate, 3D magnetometry

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Detailed bathymetry and magnetic anomaly in Central Ryukyu: Implications on westward shift of volcanic front after 2.1Ma

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Detailed bathymetry and magnetic anomaly were obtained by GH12 cruise in 2012 using R/V Hakurei, in the southern part of Central Ryukyu. Volcanic structures such as caldera were observed on the southwestward extension of the present-day volcanic front, implying recent volcanic front of the Ryukyu arc. Furthermore, bathymetric highs which are sub-parallel to the recent volcanic front were observed and is located ~20 km east. These are accompanied by spotted magnetic anomalies, which continue to Kume-jima via Aguni-jima Islands to the south, suggesting an existence of an ancient volcanic front. The ages of volcanic rocks from these Islands suggest that the magmatic activity along the ancient volcanic front had been active at least until ~2.1 Ma. The magmatic anomalies connecting two volcanic fronts suggest that a volcanic front have moved gradually westward. This shift would be explained by the termination of asthenospheric upwelling and/or rapid retreat of Ryukyu Trench.

Keywords: Ryukyu arc, Volcanic front, Okinawa Trough, magnetic anomaly, seafloor bathymetry

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Evolution of depositional basin accompanied by recurring caldera collapses in Kikai caldera, southern-off Kyushu, Japan

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Kikai caldera (Matsumoto, 1943) is a mostly submerged highly active caldera volcano located in 40 km off Kyushu Island. The caldera is recognized as the product of 7300 cal. BP super-colossal eruption with Akahoya tephra (Machida and Arai, 1978; Fukuzawa, 1995) which is widely distributed along the western part of Japan. Previous studies for near-vent onshore geology strongly suggests such a large eruption was not occurred only once, but multiple times in the Kikai caldera (Ono et al., 1982).

In Kikai caldera, 24 lines of multi-channeled seismic reflection surveys were held in two survey cruises (KT-10-18 and KT-11-11) in 2010 and 2011 using R/V Tansei-maru of JAMSTEC (Japan Agency for Marine-Earth Science and Technology). The acquired seismic data for subseafloor structures spotted thick sedimentary basin at the eastern margin of the caldera. The basin covers 70 square km of the 20 km-wide caldera and is next to caldera rim fault. The infill of the basin is characterized by the group of onlapping stratified deposits named B which maximum thickness is more than 600 m. The B-sequence has two major depositional discontinuities in the middle and the top. The lower one is paraconformity and the upper one is disconformity though, the both of them are associated with similar deformation of the basin itself. The deformation is characterized by 1. Dragged-up reflectors along the caldera rim fault, and 2. Slight outward rotation of the deposits. Both characteristics intensify along the depth, which means lower deposits were experienced much more deformation.

The both two types of the deformation suggest the basin was experienced at least two major subsidence event. The former dragged-up structure is interpreted as the incomplete slip of the caldera rim fault for the relief of the subsidence, while the latter rotation shows the slippages were slightly listric. The displacements of the subsidence events could be estimated from the top and bottom of the dragged-up structures, as more than 100 m in the lower-older event and more than 50 m in the upper-newer event. The subsidence would be an abrupt event, as the paraconformity was formed in the lower-older event. The most likely candidate for such a significant subsidence is caldera collapse. As therefore, the basin might be the one of the pre-caldera structure, and it has been experienced multiple caldera collapse events in the past.

Keywords: caldera, seismic reflection survey, Kikai caldera, Akahoya

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Estimates on fluid migration and material recycling via offshore mud volcanoes

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About 300-400 offshore mud volcanoes are currently confirmed and the double is inferred. Mud volcanism can be viewed as a tectonic window to understand geological frameworks at much greater depth, since mud volcanoes bring up deep substances and fluids to seafloor and are consequently good tools to explore their migration mechanism. Herein we present a global catalog of offshore mud volcanoes and estimate their contributions to subsurface fluid migration and material recycling.

Keywords: Submarine mud volcanoes, fluid migration, material recycling, overpressure

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New Marine Sediment Core Database ”COEDO”

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC) established basic policies on the handling of data and samples (http://www.jamstec.go.jp/e/database/data_policy.html). On the basis of the policies, JAMSTEC provides data and samples in an easily accessible manner. Data and sample information of geological sediment core has been published at ”JAMSTEC Core Data Site” since 2008. In order to improve quality and usability, we reconstructed and released new database in January 2014.

Details of the new database are shown below:

<Name>

COre Electronic Database of Ocean floor (COEDO)

<URL>

http://www.godac.jamstec.go.jp/coedo/e/

<Search Method>

Multiple-filter search using interactive map and basic information filters (Cruise ID, date, location etc.)

In the previous version of the database, users have to take longer steps to reach sample information, because only one of two methods (map search for general users and Cruise ID list menu for science parties) were available. In COEDO, all users can search samples by multiple filters in a single step on a single window.

<On-line accessible data>

Basic information of sediment core (Cruise ID, date of collect, chief scientist, ship name, position, depth), core photo, scanned image, visual core description, X-ray photo, X-ray scanned image, physical property data, literature, link for geochemical data.

We are planning further updates to improve the usability, as follows:

1. Acquiring information of sedimentary ages of core, and making them easily accessible on the database as numerically searchable information.
2. Integration with sample inventory information of JAMSTEC core sample collection, which is currently available at the Kochi Institute for Core Sample Research.
3. Publishing other data, which have not been incorporated into the database yet.

We aim not only improving services to current users, but also making effort to propagate the user community. JpGU and Yokohama city government have a special geological training course for junior/senior high school students at Keio University High School in Yokohama city on April 13. JAMSTEC cooperates with the training course, and provides lecture and practices using actual database and real core samples. In the training course, trainers give lectures on how to obtain marine sediment core onboard and how to study core sample data in COEDO, then trainees observe the actual core samples for which they have just pick up the associated data on the database. The course stimulates trainees’ interest and curiosity on the geological study, and we can nurture the new generation. As a result of this cooperation, we can hopefully increase educational users of JAMSTEC core samples.

Keywords: JAMSTEC, marine sediment core, database, ocean floor, piston corer, geology

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Geological Annotation for the Deep-Sea Images

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The Global Oceanographic Data Center (GODAC) of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has been collecting, archiving and disseminating videos and photos acquired by deep-sea research programs using submersibles and remotely operated vehicles owned by JAMSTEC. We register those videos and photos to our database with annotations (keywords), which are names of geological features or organisms, and enable users to search for images of their interest. Those videos and photos with annotations are distributed from the data site called, ″ JAMSTEC E-library of Deep-sea Images (J-EDI)∗1 ″ on the Internet.

Researchers of deep-sea can use the videos and photos distributed by J-EDI as materials for their research or lecture, and also for planning of research cruises or dives, etc. Through the database for marine biodiversity, ″ Biological Information System for Marine Life (BISMaL)∗2 ″ , biological annotations are used to visualize the distribution of organisms or to accumulate the observation record of them, since those videos and photos of deep-sea organisms are not only valuable data, but also indicate the proof of existence of organisms at those points.

We put annotations which can be recognized from the images itself by clicking icons from the prefixed palette or selecting classification name from hierarchical tree. The videos and photos with annotations concerning to the ocean floor geoscience are 41,000 with 95 different kinds of terms out of approximately total 120,000 videos.

To promote the use of deep-sea videos and photos especially in the solid earth science we tried to register more detailed annotations by using scientific papers, reports or documents about research dives and we found that registration of precise annotations takes considerable time. In order to progress the annotating work efficiently we think it necessary to select contents of annotations that lead to an efficient expansion of its use.

In this presentation, we introduce the current status of annotating work for the geological features of the deep-sea and we also show our approach to expand its use.

∗1 http://www.godac.jamstec.go.jp/jedi/
∗2 http://www.godac.jamstec.go.jp/bismal/

Keywords: deep-sea video and photo, geological environments, annotation