doi : 10.17596/0003488

# NATSUSHIMA Cruise Report

NT09-17

Leg. 1

Okinawa Trough

September 26, 2009-October 3, 2009

Japan Agency for Marine-Earth Science & Technology
(JAMSTEC)

Contents

1. Cruise Information

1.1 Cruise number:

NT09-17, Leg 1

1.2 Name of Vessel

R/V Natsushima

ROV Hyper-Dolphin

1.3 Title of the cruise

Okinawa Trough

1.4 Titles of the proposals

(1) Analysis of invertebrates including sponges inhabiting on the sea knoll around Tokara Archepelago as the cell-biological and biochemical resources

(2) Ultra-high resolution bathymetric and volcanic-activity mapping on gigantic seafloor caldera

(3) Marine geology and tectonics in the area between the Okinawa and Miyako Islands

1.5 Cruise period

September 26, 2009-October 3, 2009

1.6 Ports of call

Hakata (departure) - Naha (arrival)

1.7 Research area

Central part of Tokara Archipelago: surrounded by the following lines of longitudes and latitudes: 28°50.0’N, 128°50.0’E, 29°30.0’N, 129°35.0’E.

Miyako Sea-knoll: surrounded by the following lines of longitudes and latitudes: 25°10.0’N, 125°35.0’E, 25°35.0’N, 126°00.0’E.

1.8 Research map

See Figures 1 and 2 as well as Figures 1.1-1.4 and 2-3 for the research map.

2. Researchers

2.1 Chief Scientist:

Shigeki Matsunaga (The University of Tokyo)

2.2 Representatives of the science party

Hidenori Kumagai (JAMSTEC), who could not attend the cruise.

Kousaku Arai (National Institute of Advanced Industrial Science and Technology, AIST)

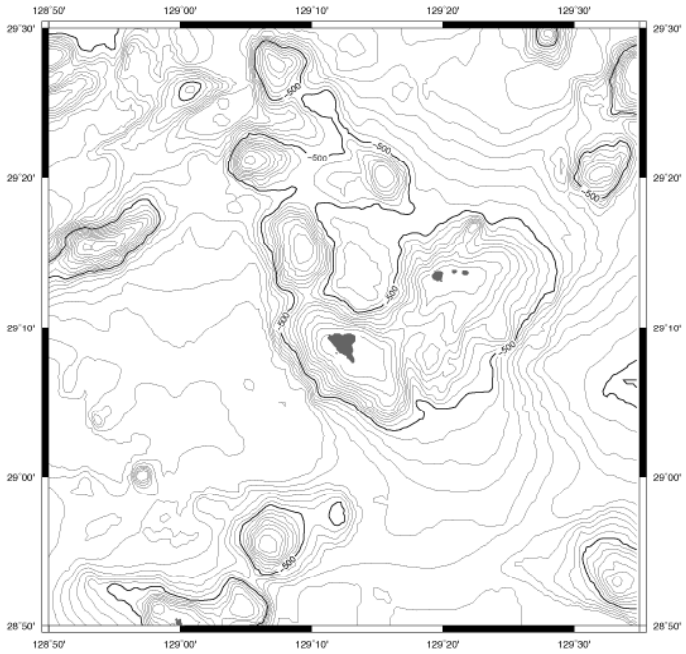



Figure 1. Central part of Tokara Archipelago

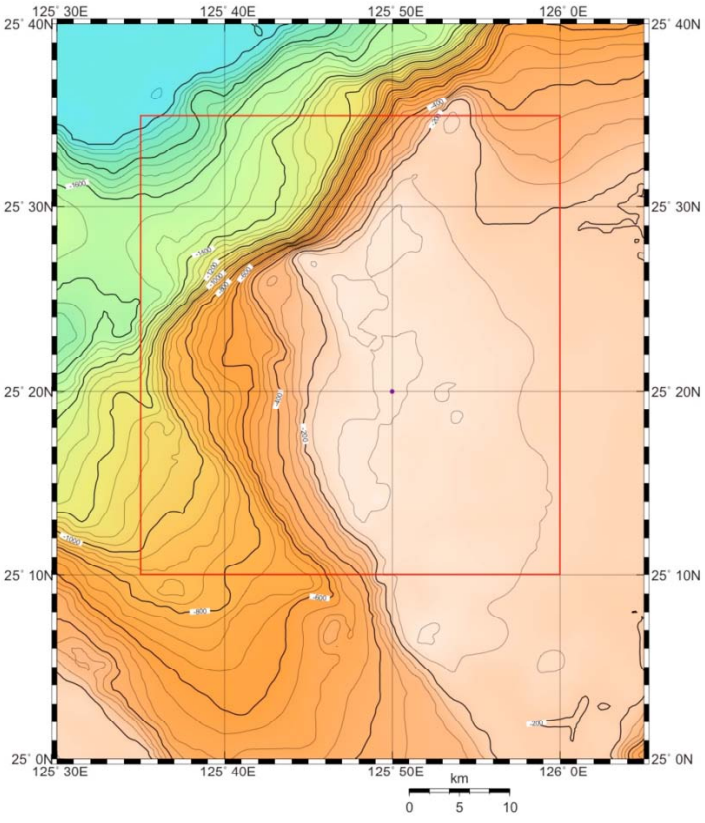



Figure 2. Miyako Sea-knoll

2.3 Science party

| Name | Affiliation |
|---|---|
| Shigeki Matsunaga | The University of Tokyo |
| Tetsuya Miwa | JAMSTEC |
| Mitsugu Kitada | Enoshima Aquarium |
| Yoshiteru Kume | JAMSTEC |
| Yuichi Nogi | JAMSTEC |
| Hitoshi Ouki | JAMSTEC |
| Takeshi Terahara | Waseda University |
| Yousuke Kamiya | OP Bio Factory |
| Yuji Ise | The University of Tokyo |
| Kanto Suzuki | The University of Tokyo |
| Tukasa Takeda | The University of Tokyo |
| Kiminori Shitashima | CRIEPI |
| Tatsuhiro Fukuba | The University of Tokyo |
| Kousaku Arai | AIST |
| Hideaki Machiyama | JAMSTEC |
| Tsuyoshi Kurashima | Nagoya University |

3. Observation

This section consists of three independent researches, whose results are presented in three parts in the following sections.

Part 1.

# Analysis of invertebrates including sponges inhabiting on the sea knoll around Tokara Archepelago as the cell-biological and biochemical resources

Shigeki Matsunaga (The University of Tokyo)

## Purpose, objectives, and background

Marine invertebrates, especially sponges, tunicates, and corals, frequently contain secondary metabolites whose architectures are totally different from those from terrestrial organisms. Some members of such compounds exhibit extraordinary biological activities, which is the basis of their utilization as medicinal agents and agrochemicals. More than 15,000 natural products have been discovered from marine organisms, most of which have been isolated as the major constituents of those inhabiting in shallow waters. On the other hand, microorganisms isolated in marine environment attract attention of natural product chemists as sources of novel secondary metabolites. Many invertebrates are in symbiotic relationship with diverse sets of microbes, whose constitution differs from species to species. These symbionts are known to be involved in the production of marine natural products.

Both macroorganisms and microbes in Japanese waters have been intensively studied for the past 30 years. Therefore, it is hard to discover untouched organism around Japanese shallow waters. In deep waters, the organisms are thinly populated and it appears to be difficult to collect materials sufficient for isolating secondary metabolites.

In our previous experience the top of sea knolls are shown to be densely populated by sponges as shown by dredging these areas. The populations of sponges are totally different from those in shallower waters. One of the most prominent sea knolls is Oshima-shinsone located in the Tokara Archepelago, where huge amounts of sponges are invariably collected by each dredging operation. We have isolated interesting compounds from the sponges collected there. It is also expected that such sponges contain unique symbionts.

The depths of the top of the sea knolls range between 200-400 m which are too deep for scuba diving. It is impossible to study the organisms inhabiting there in detail, because it is not possible to recollect the same organisms by dredging. Therefore, we propose to observe the top of sea knoll and collect rare organisms using ROV. There are many sea knolls in the Tokara Archipelago which become the collection sites for this

cruise.

Methods

Observations were conducted by high-vision camera and collection by Hyper-dolphin: Operation dates and sites: 29 Sep. 2009 (#1058 and #1059) at Oshima-shinsone 1 Oct. and 2 Oct. at Miyakosone (#1060 and #1061, respectively). Collected sponges were preserved or processed for metagenomic analysis (Terahara), culturing symbionts (Nogi and Kamiya), taxonomical study (Ise), and isolation of secondary metabolites (Matsunaga). Invertebrates were continuously observed by high vision camera throughout the paths of Hyper-dolphin, collected, and kept alive for cell culture study (Miwa).

Research results

The following biological specimens were collected.
Dive #1058: 32 sponges and one okinaebisu.
Dive#1059: 12 sponges and one okinaebisu.
Dive #1060: 17 sponges.
Dive #1061: 21 sponges.

Future plan

Biologically active compounds especially those with antitumor activity will be isolated from the sponges by Matsunaga. Metagenomes of sponges will be disclosed by Terahara and his co-workers. Associated microorganisms will be isolated and subjected to further study by Nogi and Kamiya and his co-workers. Cell lines of marine invertebrates will be established by Miwa.

Research area

For the details of research areas in dives #1058-1061, see Figures 1.1-1.4.

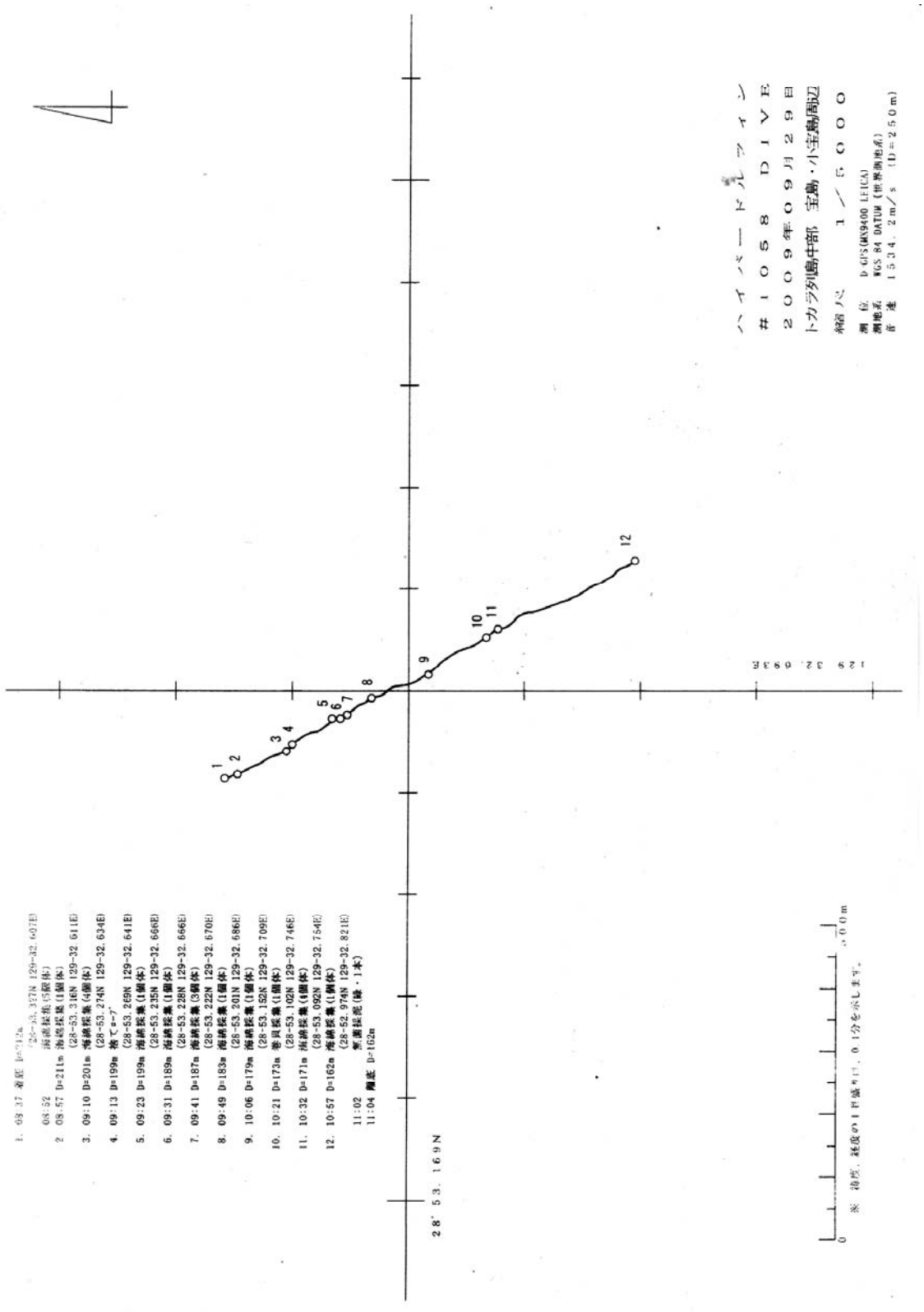



Figure 1.1 Dive #1058.

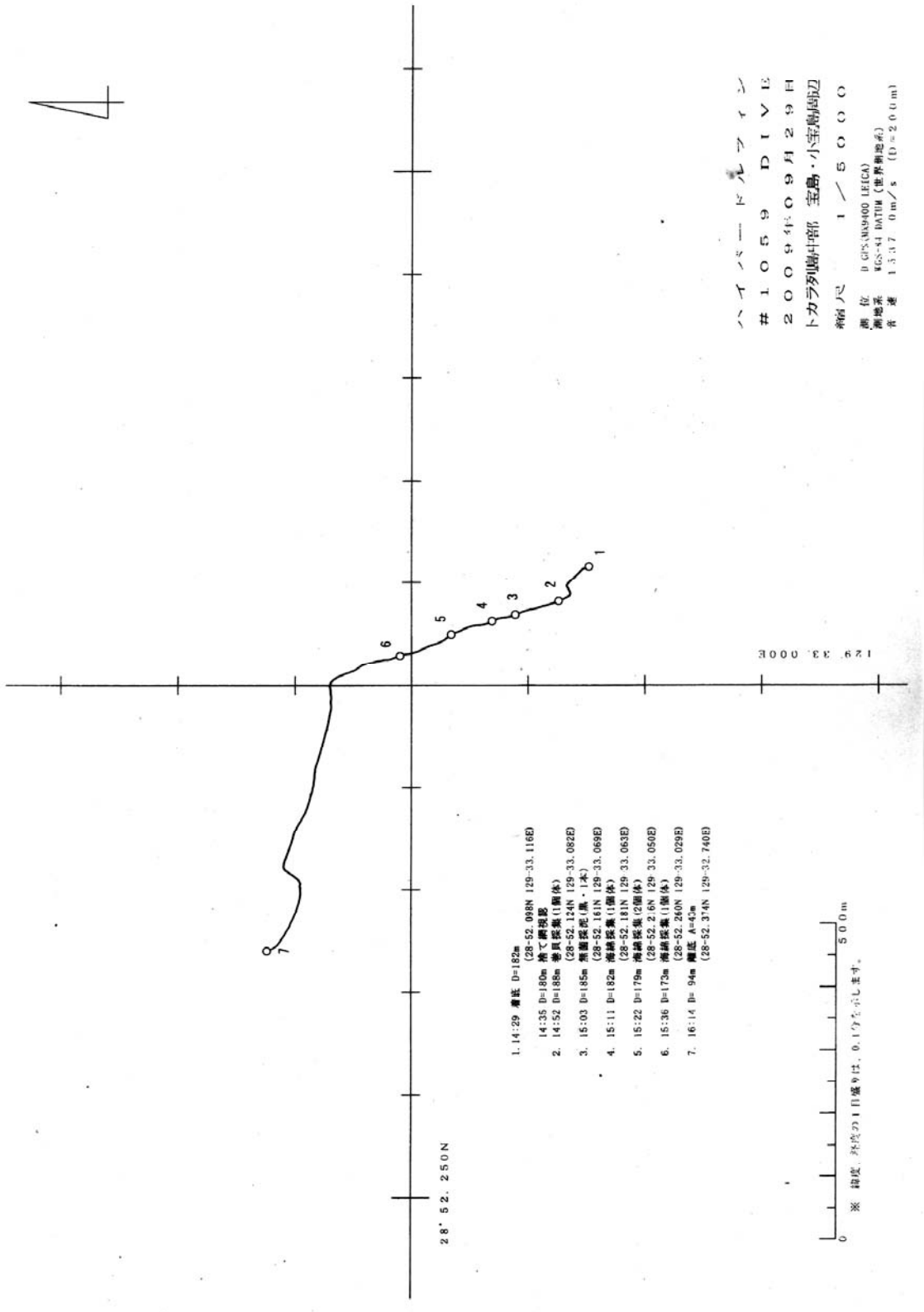



Figure 1.2 Dive #1059.

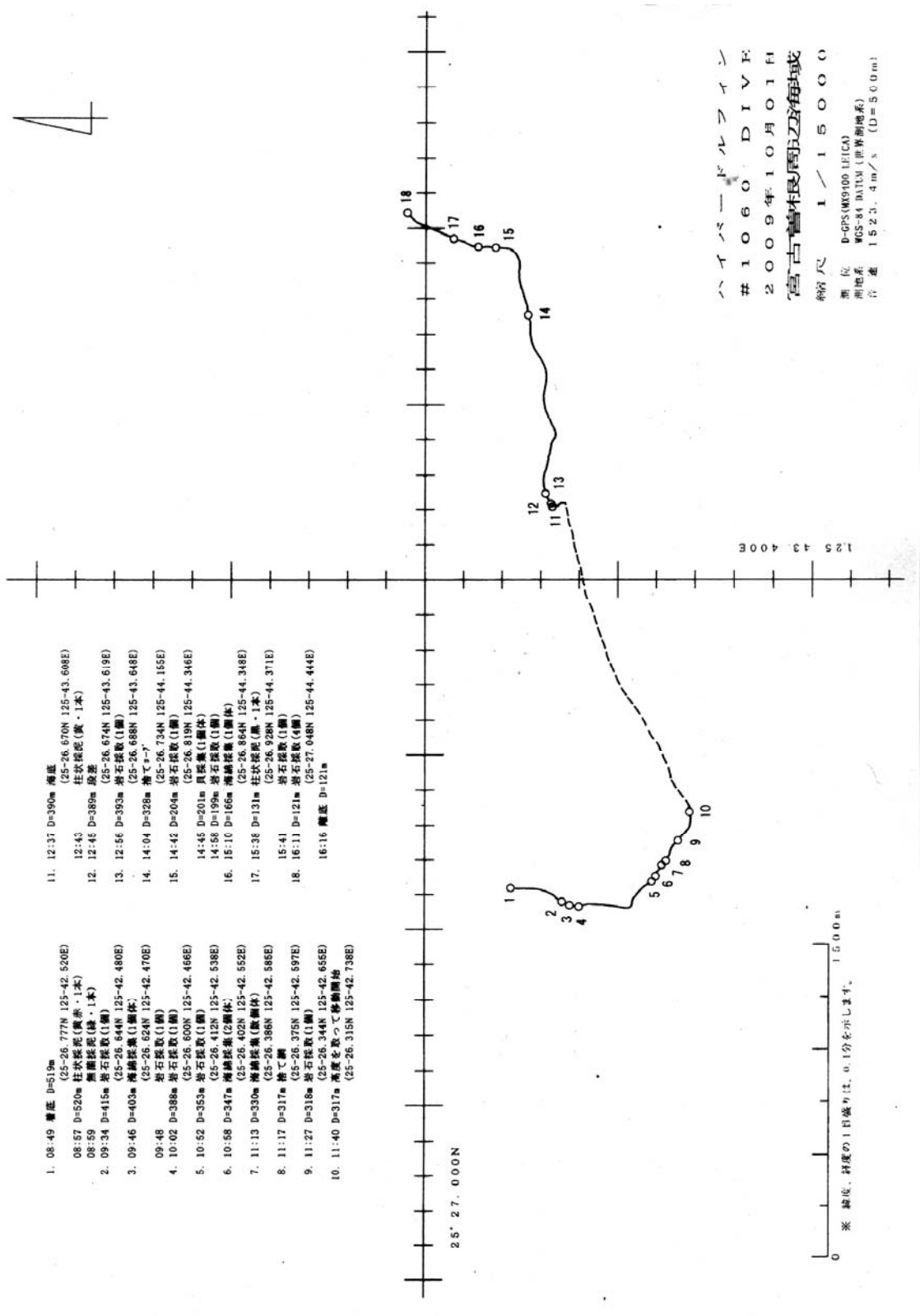



Figure 1.3 Dive #1060.

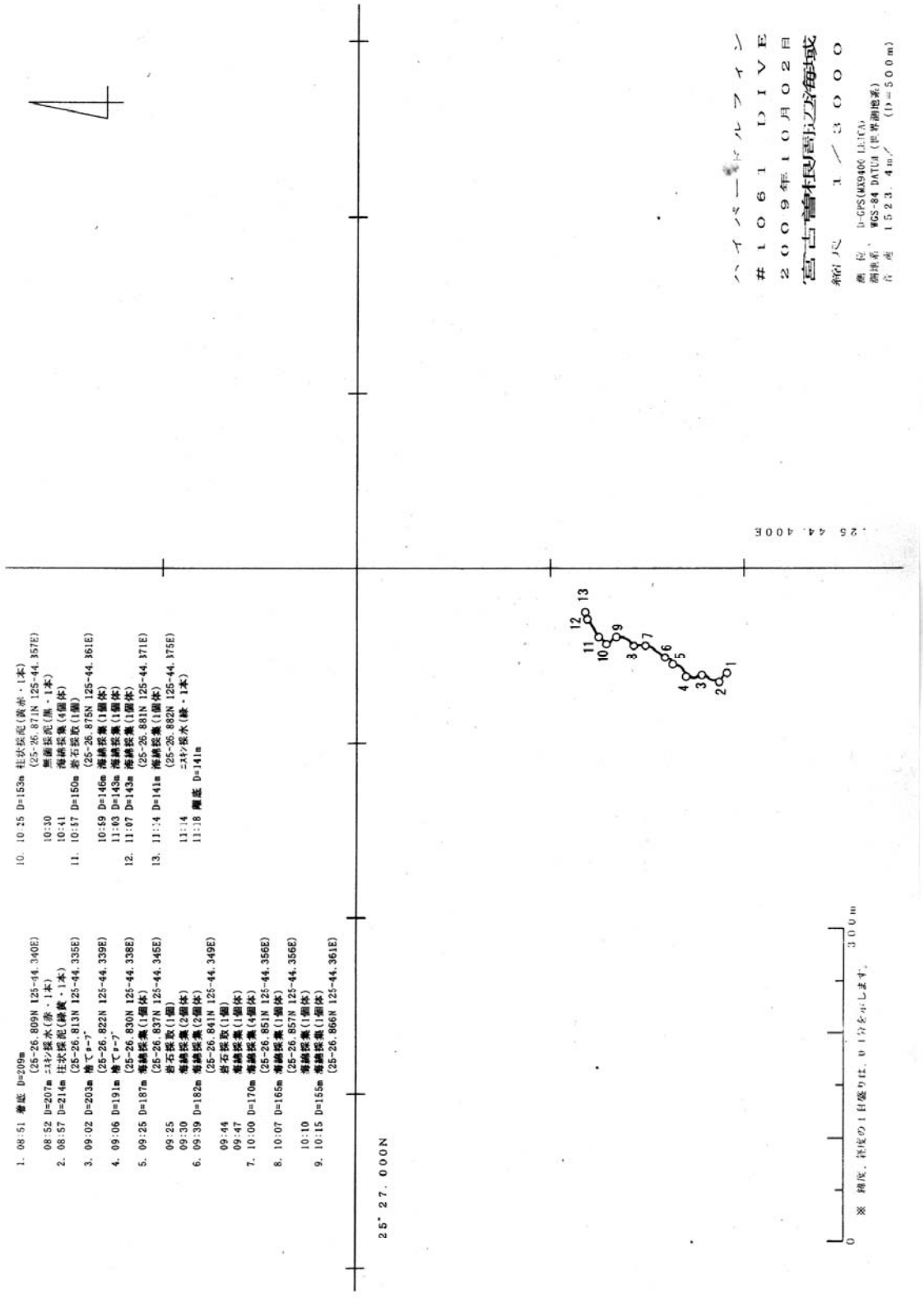



Figure 1.4 Dive #1061.

Associated research activities by collaborators are described below.

1. Isolation of sponge-associated microorganisms by Yuichi Nogi

1.1. Purpose of the research.

Isolate the useful microorganism on the deep water, deep-sea organism and sediment. Isolate the new microorganism such as actinomycete and fungi.

The chitin and cellulose, etc. are natural resources that exist most abundantly on the earth. However, these resources are not used too much effectively. To use these unused resources effectively, a good enzyme is needed. We are searching for the new, useful enzyme production bacterium for that. Moreover, quite new actinomycete and fungi are isolated, and they are used as a biotechnology resource.

1.2. Execution item

Isolation of useful microorganism that resolves chitin, cellulose, etc. are tried from deep water, deep-sea organism and sediment. In addition new microorganism such as actinomycete, fungi, and the difficult culture microorganisms are isolated. In addition, we try the isolation of the new microorganism such as actinomycete, fungi, and the difficult culture microorganisms.

1.3. Technique and observation equipment

Sampling by sterilizing mud sampler and collection of sponge by manipulator.

1.4. Observational result and execution result

All gathered samples were described to the meta data sheet. Each sample was homogenized and spread on the chitin and cellulose, etc. plate, medium for actinomycete and fungi. These are cultured at each temperature now.

1.5. The future plan

The isolated microorganism is identified. A detailed identification experiment is conducted to novel strain. The production enzymes of each strains are examined. When a useful enzyme and a new material are found, a more detailed analysis is done with the co researcher.

* List of instrument used

Sterilizing mud sampler

When searching for microorganism lives to a specific place in the deep-sea, it is

necessary to prevent the microorganism being mixed other than the field setting. It is necessary to use the sterilized apparatus for that. It is necessary to prevent the microorganism from the outside being mixed during the round trip to the point. The device developed for that is a sterilizing mud sampler. This sampler uses the centrifuging tube of 50ml on the market. The part where the centrifuging tube was installed is sealed up, the pressure adjustment with the outside is done through the filter of 0.22 $\mu$ m, it is possible to gather it without mixing of the microorganism of other points.

2. Metagenomic analysis of Deep-Sea Marine Sponge-associated Bacteria by Takeshi Terahara

2.1 Objective

Marine invertebrates especially sponges are noteworthy for their unmatched diversity of secondary metabolites. During this process, many microorganisms are taken up and digested by phagocytosis or harbored as symbiontic consortia. However, standard culturing techniques support the growth of less than 1% of the bacterial found in the environment. Metagenomic analysis is proven to be a powerful tool for mining the diverse environmental microorganism resources. Thus the present study is an attempt to analyze metagenomics of deep-sea marine sponge-associated bacteria.

2.2 Material and Methods

Marine sponges were collected at 100-200 m depth from Ohshima Shinsone (28°53′N, 129°32′E) and from Miyakosone (25°26′N, 125°44′E). Sponges were diced into small

pieces and mechanically homogenized into cell suspension by a juicer in a TNE buffer (10 mM Tris, 3.5% NaCl, 50 mM EDTA-2Na, pH 7.5). The cell suspension was first filtered by nylon mesh (100 μm pore size) and centrifuged at 700 g for 5 min to get rid of the sponge debris and dirt. The suspension was then centrifuged at 3,500 g for 5 min to concentrate the bacteria. The bacterial pellets were stored at 4°C and -20°C.

2.3 Future plan

Much of the interest in metagenomics comes from the discovery that the vast majority of microorganisms had previously gone unnoticed. We have an attempt to analyze metagenomics of deep-sea marine sponge-associated bacteria using DNA sequencing based on 16S rRNA genes.

3. Isolation of sponge-associated Actinomycetes by Yousuke Kamiya

3.1 Introduction

Recently, the actinomycetes living in marine sponges (Porifera) attract our attention as a new source of various bioactive compounds. We have been investigated the actinomycetes living in sponges and other marine invertebrates that inhabit shallow sea area around Okinawa (Okinawa's Main Island and Yaeyama Islands). In this survey, we aimed to isolate actinomycetes from deep-sea sponges and evaluate them as an isolation source for actinomycetes.

3.2 Purpose of the research

Isolation of actinomycetes from deep-sea sponges, and the evaluation of deep-sea sponges as an isolation source for actinomycetes

3.3 Materials and methods

Twelve deep-sea sponges collected by a deep submergence search vehicle "Hyper-Dolphin", Japan Agency for Marine-Earth Science and Technology (JAMSTEC) were provided by favor of JAMSTEC. Approximately 10 g of the sponge was grinded by a mixer with 10 ml of sterilized sea water. The suspension was diluted with sterilized sea water to make 10% diluted solution. The diluted solution was applied onto agar medium plates with a sterilized cotton swab. The plates were incubated at 27℃ for 2 weeks. The plates were observed under a microscope, and actinomycetes were isolated by transferring a small piece of colonies with a sterilized needle.

3.4 Results and discussion

Only an isolate of actinomycetes was isolated from the 12 deep-sea sponges treated in this study. This suggests that deep-sea sponges might be inadequate for isolating a number of actinomycetes isolates. However, because the number of actinomycete isolates from sponge often changes drastically depend on the samples, further studies are needed before reaching a final conclusion.

3.5 Future plan

We should isolate actinomycetes from more deep-sea sponges.

3.6 Equipment list

Mixer: Tescom Corporation "Mill & Mixer"

Microscope: Olympus BX41N-32-PH

4. Taxonomy of deep-sea sponges collected from Tokara Islands by Yuji Ise

4.1 Purpose, objectives, and background

Sponges (Phylum Porifera) are an ecologically important and highly diverse component of marine benthic communities, ranging from the intertidal to the deep-sea. Aside from their importance to reconstruct metazoan phylogenetics, and their enormous commercial, pharmaceutical and biotechnological potentials increasingly recognized, yet many aspects of their basic biology remain enigmatic. Taxonomy of sponges offers an important basement for these applied sciences however Japanese sponge fauna has not been proceeded for 20 years since Tanita & Hoshino (1989). Moreover, sponge fauna around Tokara islands are totally unknown. Unveiling biodiversity of sponges in this area will greatly contribute to related field dealing with sponges (e.g. ecology, symbiotic bacteria, secondary metabolites).

4.2 Materials and Methods

The sponges were collected during the NT-09-17, Leg2 cruise of the RV Natsushima of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) carried out 26 September –3 October 2009. This cruise was organized as part of the research program “Analysis of invertebrates including sponges inhabiting on the sea knoll around Tokara Archepelago as the cell-biological and biochemical resources.” The sponges were collected by remotely operated vehicle ROV Hyper-Dolphin (Dives#1058–1061). Under water pictures were taken by high vision camera of ROV. The specimens were

preserved in 90% ethanol soon after landing of ROV on the deck and taking picture of the specimen. Subsequent morphological description and molecular phylogeny will be conducted in the laboratory.

4.3 Results

The following sponge specimens were obtained. Dive #1058: 32 samples. Dive#1059: 12 samples. Dive #1060: 17 samples. Dive #1061: 21 samples. Most sponges are probable undescribed species or new records from Japan because this cruise was the first survey in this area. Blue color sponges never found from Japanese waters were collected during Dive #1058. Preliminary study revealed these blue sponges contained number of unknown species such as *Plakina* sp. Blue color *Plakina* species has never been found from the world, thus is considered as possible undescribed species.

4.4 Future work

Taxonomic study including morphological description and molecular phylogenetics about sponges collected in this cruise is in progress. In this cruise, we mainly collected large sponges however more number of small sponges was observed during the Dives. Next project aiming for collecting these small sponges will be inevitable for comprehensive understanding of sponge fauna in the area. Combined dataset of sample image *in situ*, sample itself, morphological description and molecular data of the sponge will be very useful for related study dealing with sponges.

Part 2

# Ultra-high resolution bathymetric and volcanic-activity mapping on gigantic seafloor caldera

Hidenori KUMAGAI, Inst. For Research on Earth Evolution (IFREE), JAMSTEC
Hisayoshi YOKOSE, Kumamoto Univ.
Kiminori SHITASHIMA, CRIEPI
Tatsuhiro FUKUBA, IIS, Univ. Tokyo

## Introduction and Background

Distribution of gigantic calderas on the Japan Arc is limited in its both ends; from western Hokkaido toward Kuril Islands and from Aso volcano to Kikai submarine caldera. Recently, Yokose (2007) pointed it out that distribution of such calderas possibly extends to the area western off Amami-Oshima centered as 28°30’N, 128°38’E, using gridded bathymetry compiled by JCG or by Kisimoto (2000). Here after, this potential caldera western off Amami-Oshima is referred as “Amami Caldera.” Geochemical composition of magma, observed at such caldera forming volcanoes, generally shows evolved silicic compositions. Durations of volcanic activity of such silicic caldera is anticipated to fairly long, up to a few tens of million years both observations or by modelings (e.g. Kaneko and Koyaguchi, 1996). This infers that the hydrothermal activity has also long lives in such volcanoes.

In terms of the hunting of hydrothermal activities, to locate the sources of hydrothermal plumes do so far require huge effort composed by the several tens of submersible/ROV dives. Recently, acoustic detections of methane bubbling or hydrothermal plumes are reported (Schneider von Deimling et al. 2007; Gardner, 2009), which could be applied to such mappings.

*Research Area*

Takarajima and associating islet are on the quarternaly volcanic front of the Tokara Islands, northern part of Nansei-Shoto island arc. Study area of Hyper-dolphin dives consists of the two parts: post caldera cones inside of Takarajima caldera, and a no-name small cone on the southwestern flank of Takarajima volcano. Bathymetric survey was also carried out along the estimated quarternaly volcanic front.

## Survey contents

Bathymetric surveys were carried out in and around Takarajima caldera, and present days’ volcanic front from north of Takarajima via Yokoatejima to inferred Amami caldera (Figure 2-1). Hyper-dolphin observations were carried out to clarify the detailed volcanology and hydrothermal activity of Takarajima caldera.

## Summary of Principal Survey Results

### Bathymetry

Using ship-equipped multi narrow beam echo sounder, Seabat8160 of R/V Natsushima, totally approx. 10 hours bathymetric survey was carried out as four survey lines (Table x_1). Although limited swath of single or double track of the survey lines, some of volcanic features were observed. In addition, two box surveys were carried out as the pre-dive surveys: one includes two post-caldera cones in the Takarajima caldera, the other does Nigori-Sone (28°56'N, 129°6.5’E). Detailed analysis of the bathymetric data will be done at Kumamoto Univ. and JAMSTEC on the aspect of the submarine volcanology and disaster mitigation.

## Hyper Dolphin Surveys

**Dive Report of Hyper Dolphin**

Dive Number: HPD#1056
Date: September 28, 2009
Place: Inside of Takarajima-caldera
Landing: 29°12.947'N, 129°13.535E, WD = 400m
Leaving: 29°13.155'N, 129°13.727E, WD = 384m
Samples: 1 core (MBARI-type), HPD#1056-S01
Payloads: Seabat7125, Geochemical Sensors (pH, pCO2, ORP, Gamma Ray).

According to the 500m-grided digital bathymetric data provided from JCC, Takarajima, Kodakarajima and associated islet are on the rim of the Takarajima caldera having 80km$^3$ of volume. In this dive, sea bottom observation of post-caldera cone within the Takarajima caldera was carried out. During the traverse, acoustic, chemical and biological plume detection was also tried; assemblages of payloads are shown in Plates 2-1 and 2-2. For the acoustic mapping, Seabat7125 was used as its side-scan mode. The dive started from one of the peaks on the post-caldera cone of 1.5-km in the diameter. Around the landing point, sea floor was covered by the light-colored, less-sorted gravels (Plate 2-3). They were firmly cemented and hardly sampled. After the observation, acoustic recording of SeaBat7125 side-scan mode were started. The course of the acoustic survey was set as firstly northward, then, turned to eastward on the peak at northwestern corner. Finally, the vehicle approached another peak located on the northeastern corner of the cone, and landed again. Length of acoustic survey was 76 min. Very weak reflection was recorded in the survey, of which analysis is still on-going (Figure 2-2). Seafloor of the second landing point was also covered by cemented gravels (Plate 2-4). Such gravels were sampled using MBARI-type sampler (HPD#1056-S01). On the post caldera cone, no apparent hydrothermal activity was found on visual observation. Detailed analysis of geochemical sensors is still on-going.

Dive Number: HPD#1057
Date: September 28, 2009
Place: Small Cone on Southwestern flank of Takarajima-caldera
Acoustic survey commencement: 29°05.357'N, 129°10.637E, Depth = 284m, Alt = 22m
Landing: 29°05.384'N, 129°10.668E, WD = 306m
Leaving: 29°05.390N, 129°10.524E, Depth = 256m, Alt = 46m
Samples: water in Niskin bottle
Payloads: Seabat7125, Geochemical Sensors (pH, pCO2, ORP, Gamma Ray), Biological Sensor (ISSA-Gene)

In this dive, acoustic plume mapping coupled w/chemical and biological sensors was carried out on the small no-name cone on the southern flank of Takarajima-caldera. The dive intended to gridded mapping of hydrothermal plumes, however, the strong bottom current flowing inverse to the surface current prohibited such systematic survey (Figure 2-3). Only 1-hour survey forming separated two parallel lines of 200m and 300m in length was allowed with 20-50m of altitude from the sea bottom. During the survey, any significant anomalies were not recorded either acoustic sonar or chemical sensors although the equipments worked well (Figure 2-4). Poorly sorted light colored gravels were also observed at the landing point. Sea water was also sampled near the landing point.

**Future Works**

Bathymetric data will be analyzed at Kumamoto Univ. and JAMSTEC on the the

submarine volcanology and disaster mitigation. Feasibility study of advanced plume mapping will be done at CRIEPI, IIS of Univ. Tokyo and JAMSTEC. Water sample will be analyzed at IIS, Univ. Tokyo, coupled with the data obtained in Leg2.

**Summary**

No active hydrothermal activities were found in and around Takarajima caldera. Poorly sorted and fairly cemented gravels indicates inactive features of the volcano at least near the landing points.

References

Gardner (2009) EOS Trans, 90, 275.
Kaneko and Koyaguchi (2006) Memoires of Geological Society of Japan, 46, 29-41.
Kisimoto (2000) GSJ open files 353.
Schneider von Deimling et al. (2007) Geochem. Geophys. Geosyst., 8, Q06004.
Yokose (2007) Monthly Chikyu (Gekkan Chikyu), 29(9), 561-569.

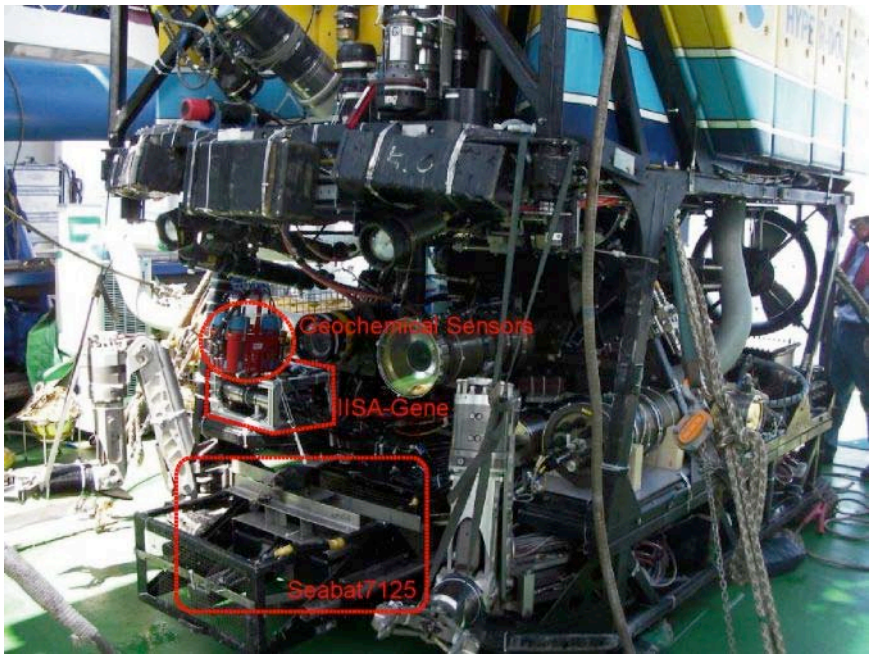



Plate 2-1: Front view of payloads for HPD#1057 dive.


Plate 2-2: Rn-sensor (CRIEPI) and back view of HyperDolphin where the sensor was attached

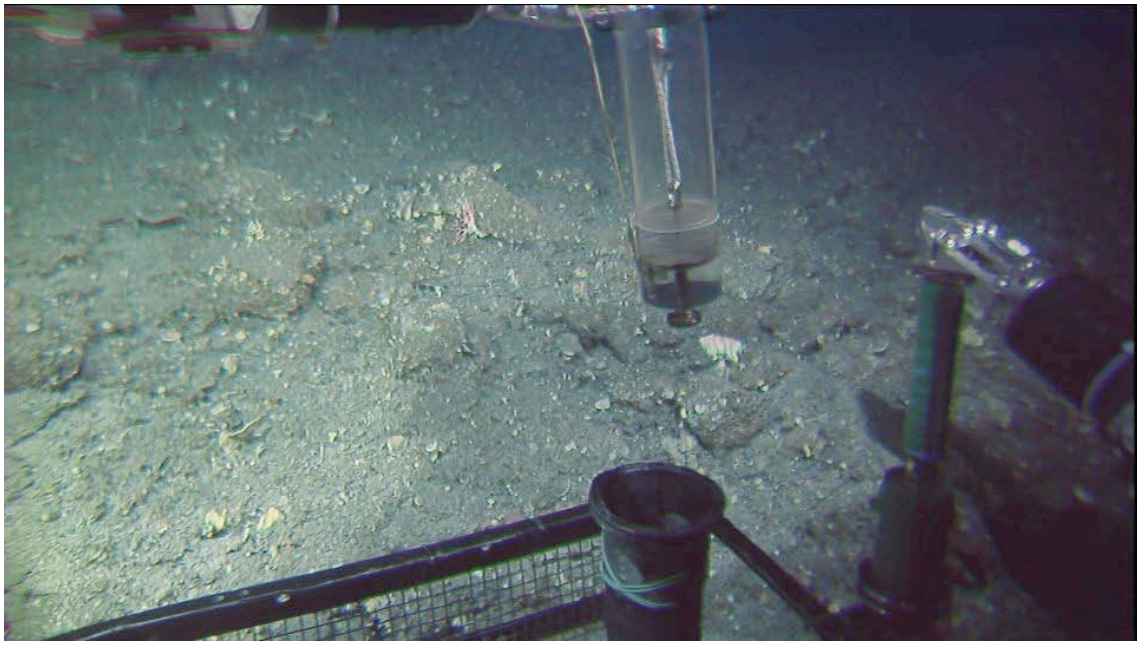


Plate 2-3: Sea floor image at the first landing point of HPD#1056. At this point, the coring was failed.

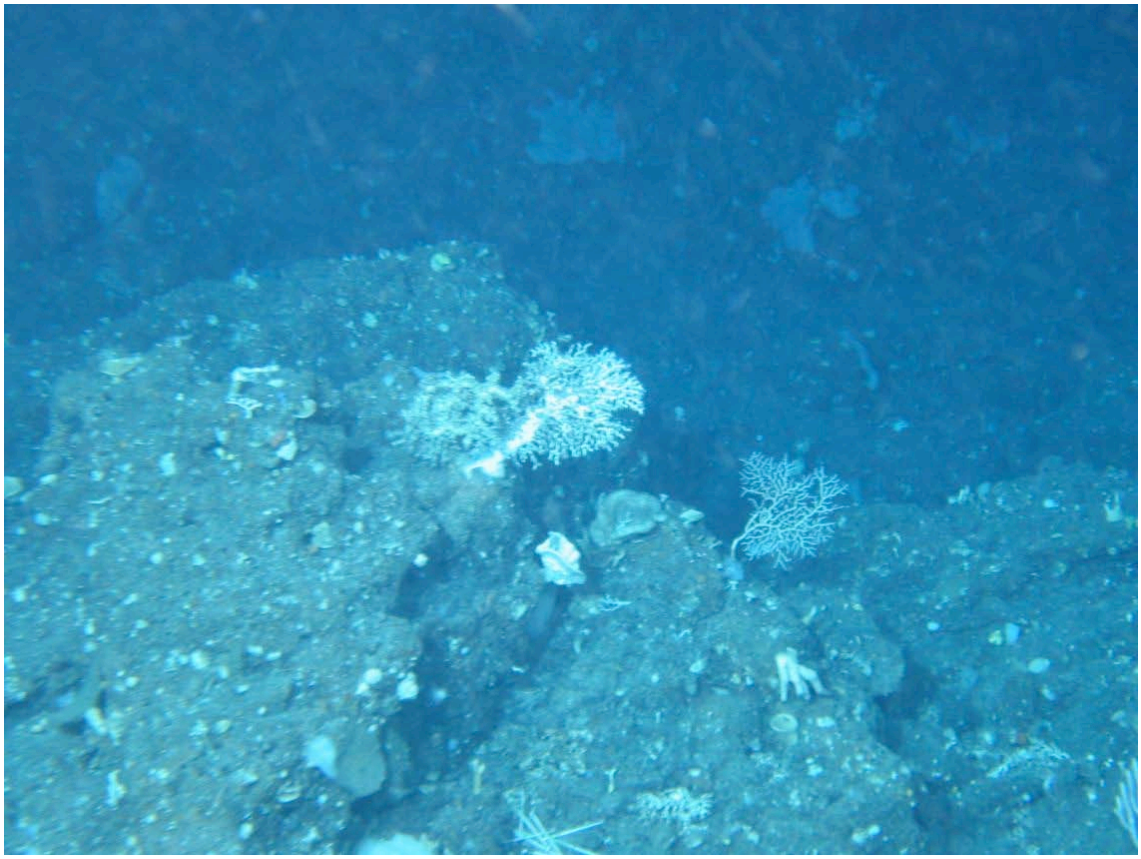


Plate 2-4: Sea floor image at the second landing point of HPD#1056.

Fugure 2-1: Bathymetry obtained in the cruise.

Figure 2-2: Acoustic image recorded by the side-scan mode of Seabat7125 equipped on Hyper-dolphin. The yellow colored saturated reflection is those from seafloor. Within the water column, weak reflection is occasionally recorded (red circle).

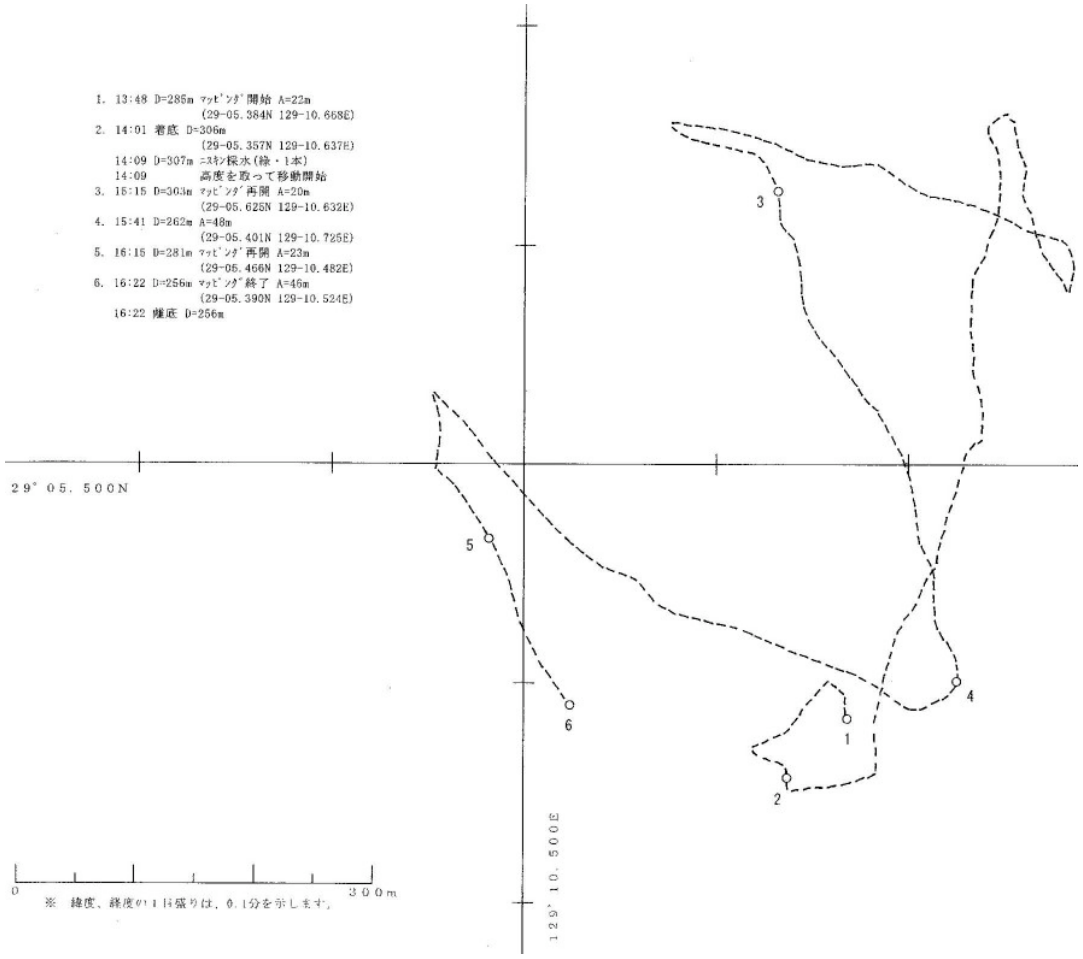



Figure 2-3: Acoustic, geochemical and biological survey track in the HPD#1057 dive.

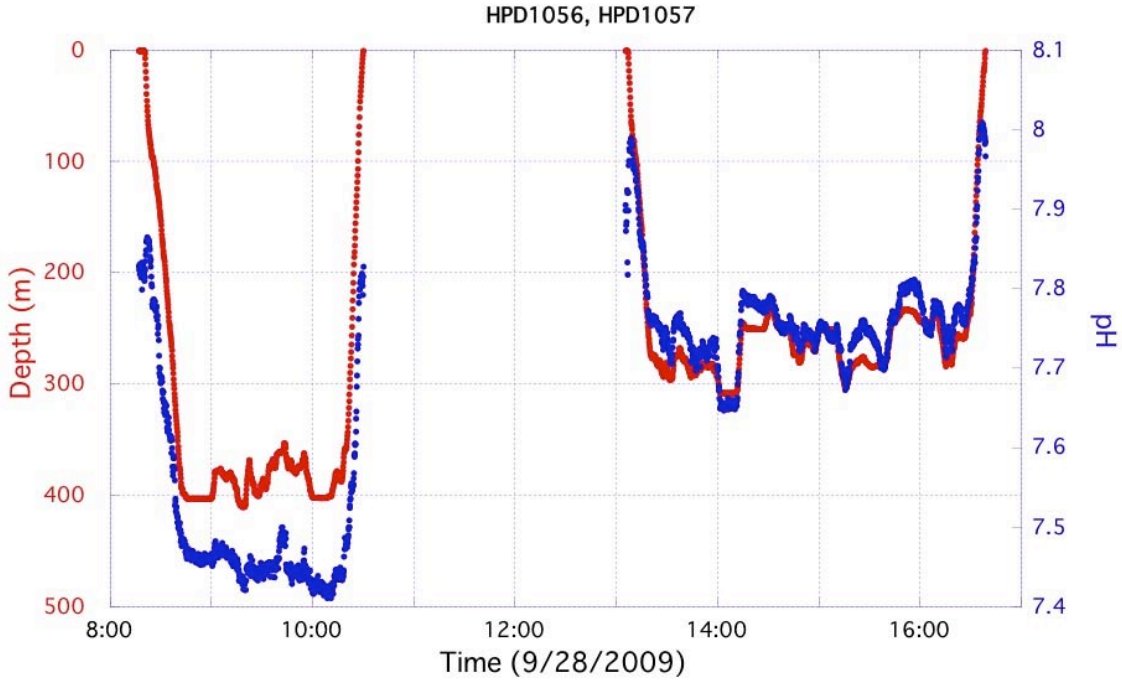



Figure 2-4: Raw data plot of pH sensor at the dives HPD#1056 and 1057.

Table 2-1. Survey lines for bathymetry

| | Lat.(deg) | Latm (min) | Long.(deg) | Long.m (min) |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Line 1 Start | 29 | 30 | 129 | 16 |
| Line 1 End | 29 | 17.5 | 129 | 12 |
| Line 2 Start | 29 | 6 | 129 | 10.5 |
| Line 2 End | 28 | 51 | 129 | 1 |
| Line 3 Start | 28 | 51.2 | 129 | 2 |
| Line 3 End | 29 | 6 | 129 | 11.1 |
| Line 4 Start | 28 | 47 | 128 | 59 |
| Line 4 End | 28 | 30 | 128 | 38 |

Part 3

Marine geology and tectonics in the area between the Okinawa and Miyako islands

Geological Survey of Japan (GSJ), National Institute of Advanced Industrial Science and Technology (AIST)

Kohsaku ARAI

Kochi Institute for Core Sample Research, JAMSTEC

Hideaki MACHIYAMA

## Introduction and Background

The Ryukyu Island Arc extends from Kyushu to Taiwan, a distance of 1200 km, along the Ryukyu Trench where the Philippine Sea Plate is subducting beneath the Eurasian Plate (Fig. 1). The Okinawa Trough, a back arc basin (Shinjo et al., 1999), formed behind the Ryukyu Island Arc in the late Pliocene to early Pleistocene (Sibuet et al., 1998 and Park et al, 1998). The formation of the Okinawa Trough is strongly related with tectonics of the Ryukyu Island Arc and assigns to the complicate uplift and/or subsidence on the Islands. Previous onland surveys of the coral reef terrace such as Kikai Island led to the detailed sea-level study of inter-glacial ages (Omura, 1988). If the study of the subsidence offshore areas should recorded the detailed glacial ages sea level changes. The surveys between Okinawa and Miyako islands aim to reveal geology and tectonic setting of the Miyako-Sone that infer subsidence terrace.

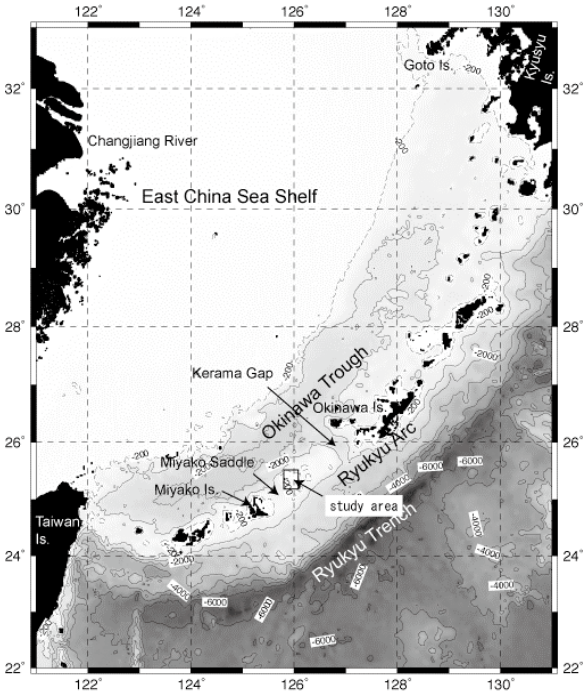



Figure 1: Bathymetric map of the Ryukyu Island Arc. Note the study area of Miyako-Sone located on the part of the Ryukyu Island Arc.

Research area:

Study area of the northwestern Zyuho-Sone located on the part of the Ryukyu Island Arc (50-60 km northeastern from Miyako Island). The area of shallower than couple hundred meters in water depth is widely developed between Miyako and Okinawa Islands including the Zyuho-Sone. In this report, the “Miyako-Sone” are used widely means of this shallower area including the Zyuho-Sone. The Miyako-Sone is approximately 130 km long and 60 km wide in the northeast to southwest direction that bounded by the steep slope to the Kerama Gap and to the Miyako Saddle.

**Survey contents**

Bathymetric surveys and Hyper-dolphin submersible observation studies were carried out on NT09-17 cruise to clarify the detailed geology and tectonics of the Miyako-Sone area.

**Summary of principal cruise results**

**Bathymetric surveys**

Bathymetric surveys are concentrated on the Zyuho-Sone area (Fig. 2). Bathymetric data were collected using a SeaBat 8160 multi-narrow beam echo-sounder system, which has frequency of 50 kHz beams and a swath width of 150˚.

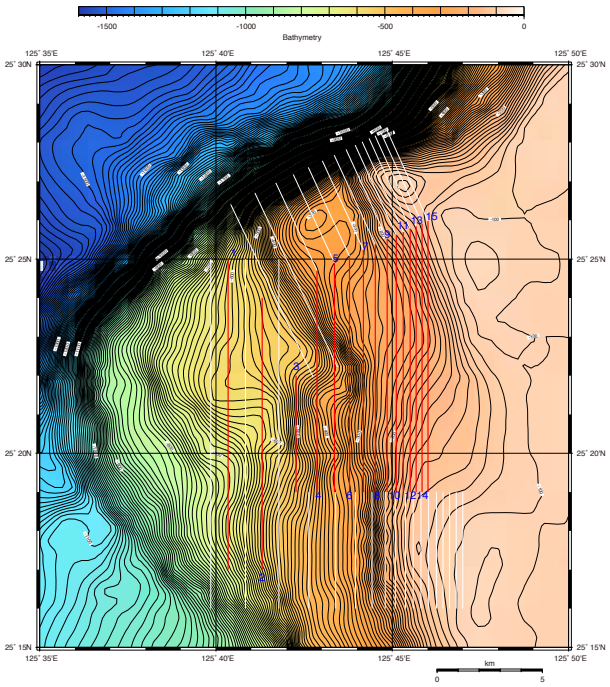



Figure 2: Bathymetric survey lines of the Miyako-Sone area (survey plan).

Hyper-dolphin submersible observation is detailed in below.

**Future studies**

1. We will make detailed study on rock samples, which were corrected Dive # 1060 and 1061 (GSJ-AIST, JAMSTEC, Nagoya Univ. and Univ. Kumamoto).
2. Bathymetric data will analyze at GSJ-AIST. This result will be use for future seismic reflection and ROV surveys.
3. This results will use for IODP proposal (COREF project).
Title: Coral-reef Front Migration in the Ryukyu Arc: Responses of high latitude coral reefs to Quaternary climatic changes in North Western Pacific (H. Matsuda et al.)

**Hyper-dolphin Surveys**

Dine Report of Dive # 1060
Date: October 1, 2009
Place: Miyako-Sone
Landing: 25-26.777N, 125-42.520E, 519 m in water depth
Leaving: 25-27.048N, 125-44.444E, 121 m in water depth
Samples: 3 cores, 10 rocks and sponges (detailed in Table)
Extra 2 cores and 3 rocks are also corrected Dive #1061

The ROV sea bottom observation was carried out using “Hyper Dolphin” dive #1060 to clarify the geology on cliff of Miyako Saddle (Fig. 3). The dive #1061 was also carried out part of the same location of #1060. The track starting from cliff of Miyako Saddle 520 m in water depth and up to the flat floor of Miyako-Sone about 121 m in water depth. The dive traverse based on the detailed bathymetric mapping on this cruise (Fig. 3).

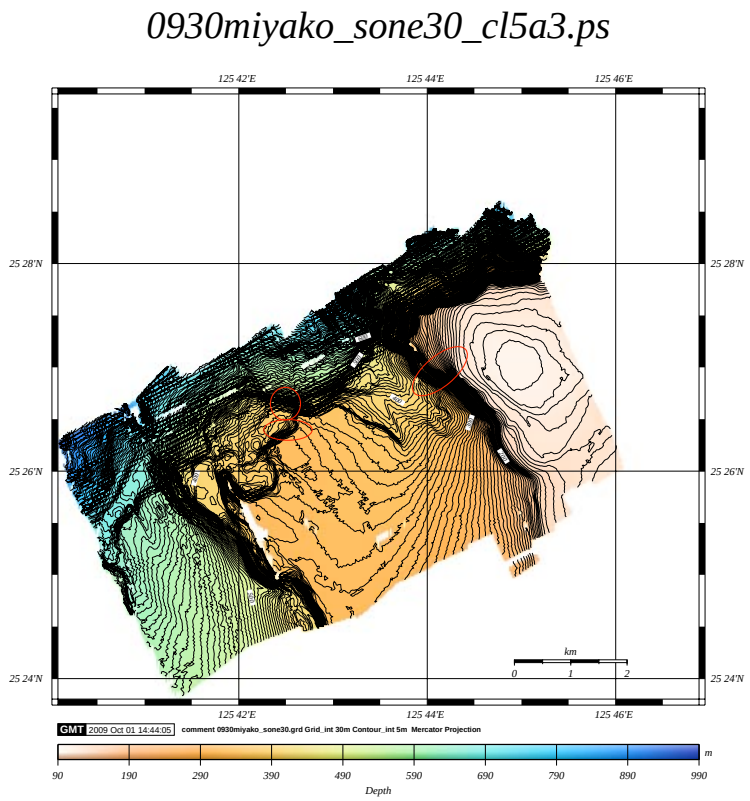



Figure 3: Bathymetric map around dive area. Red circles show the location of interested cliffs.

A sandy flat seafloor (Fig. 4) shows sand ripples and extends around landing area. Core samples (C-1 and C-2) were corrected at 25-26.777N, 125-42.520E (519 m).

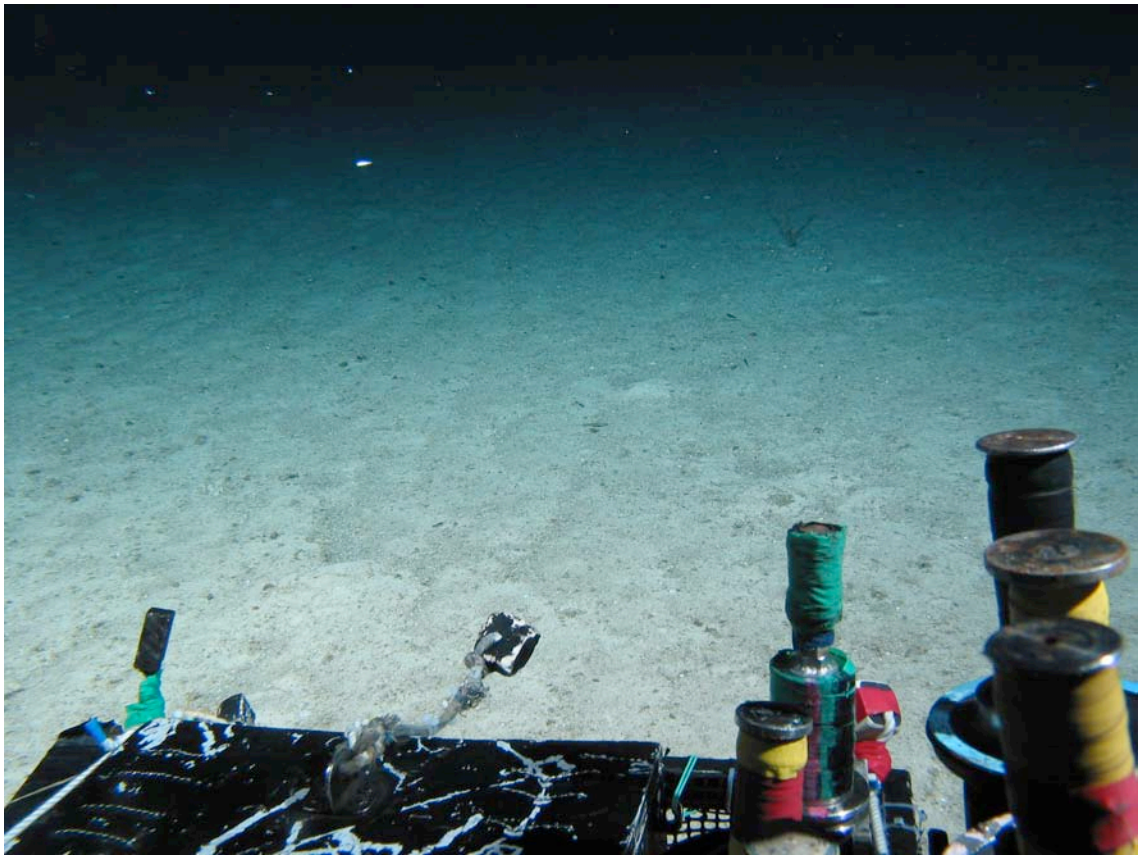


Figure 4 Image of seafloor of sandy area (2009/10/1 08:53 JST)

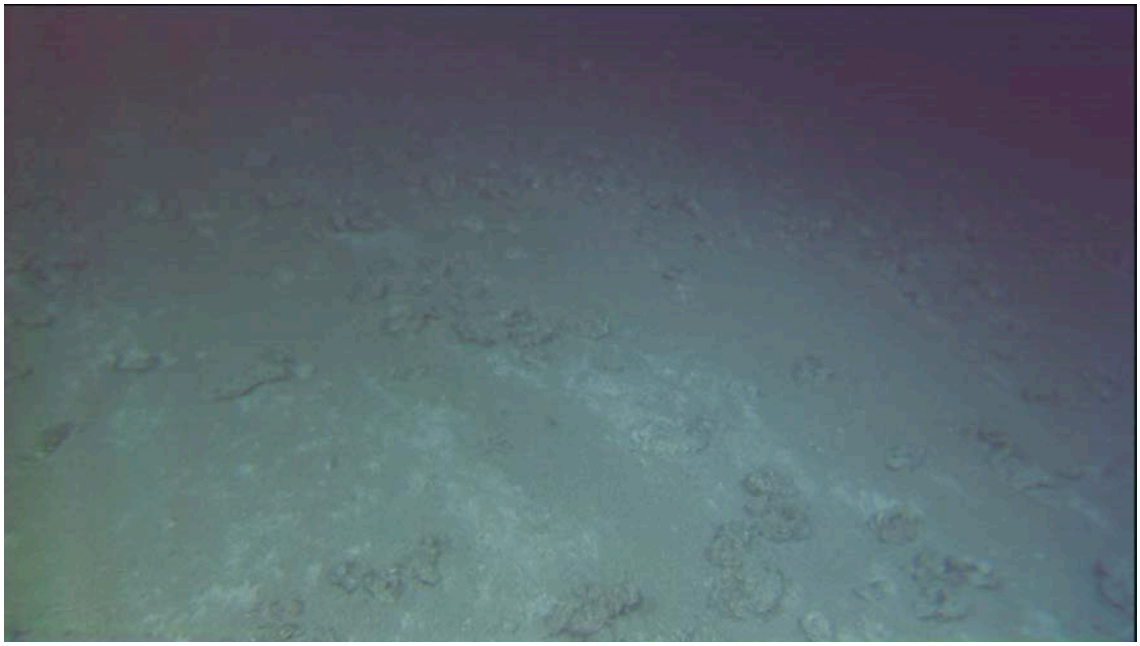


Figure 5 Image of sea floor of about 410 m in water depth. Many rocks observed on this area (2009/10/1 09:40 JST). Note the encrusted sponges and other biota is not so much in this area.

Rock sample (R-1) was corrected at 25-26.644N, 125-42.480E (415 m). Shallower than this area, many rocks are scatter on the sea floor (Fig. 5). The rocks may come from the outcrop of about 400 m in water depth (Fig. 6). Rock samples (R-2 R-3 and R-4) are corrected from the outcrop (R-2: 25-26.624N, 125-42470E 403 m, R-3: 25-26.600N, 125-42.466E 388 m, R-4: 25-26.412N, 125-42.538E 353 m). The cliff of the outcrop reaches more than 50 m high. After rock sample (R-5) was corrected at 25-26.315N, 125-42.738E (317 m) the ROV moves from 11:40 JST (location 25-26.315N and 125-42.738E 317 m) to 12:37 JST (location 25-26.670N and 125-43.608E 390 m).

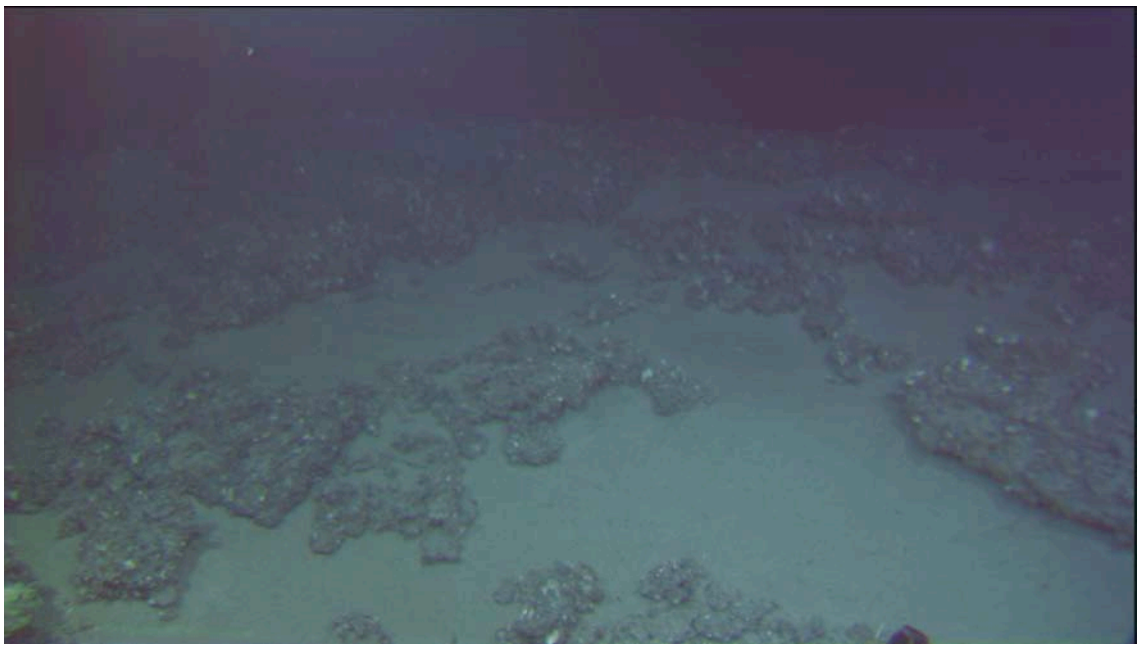


Figure 6 Image of sea floor of about 380 m in water depth. We found outcrops on this area (2009/10/1 10:10 JST).

Same sandy seafloor extends around second landing area. Core sample (C-3) was corrected at 25-26.670N, 125-43.608E (390 m). Sand ripple are well observed in this area and larger scaled sand wave (several ten meters scale) also observed. The directions of sand wave infer the ENE-WSW that direction cross to the Miyako Saddle. Rock sample (R-6) was corrected at 25-26.688N, 125-43.648E (393m) at sandy seafloor. Rocks increase around 350 m in water depth (13:56 JST), subsequently, the outcrops as Fig. 8 were found. Outcrop is covered by modern sediment. Rock samples (R-7 and R-8) ware corrected about 200 m in water depth (R-7: 25-26.819N, 125-44.346E 204 m and 199 m). The steep slope changes slightly flat at 140 m in water depth (Fig. 3). Core sample (C-4) and Rock sample were corrected at 25-26.928Nm 125-44.371E (131 m). Outcrop is covered by modern thin sediment same as the area below 140 m in water depth, however, the encrusted sponges and other biota decrease compare the previous outcrop.

Figure 7 Image of seafloor of sandy area (2009/10/1 13:09 JST)

Figure 8 Image of outcrops about 200 m in water depth (2009/10/1 14:46 JST)

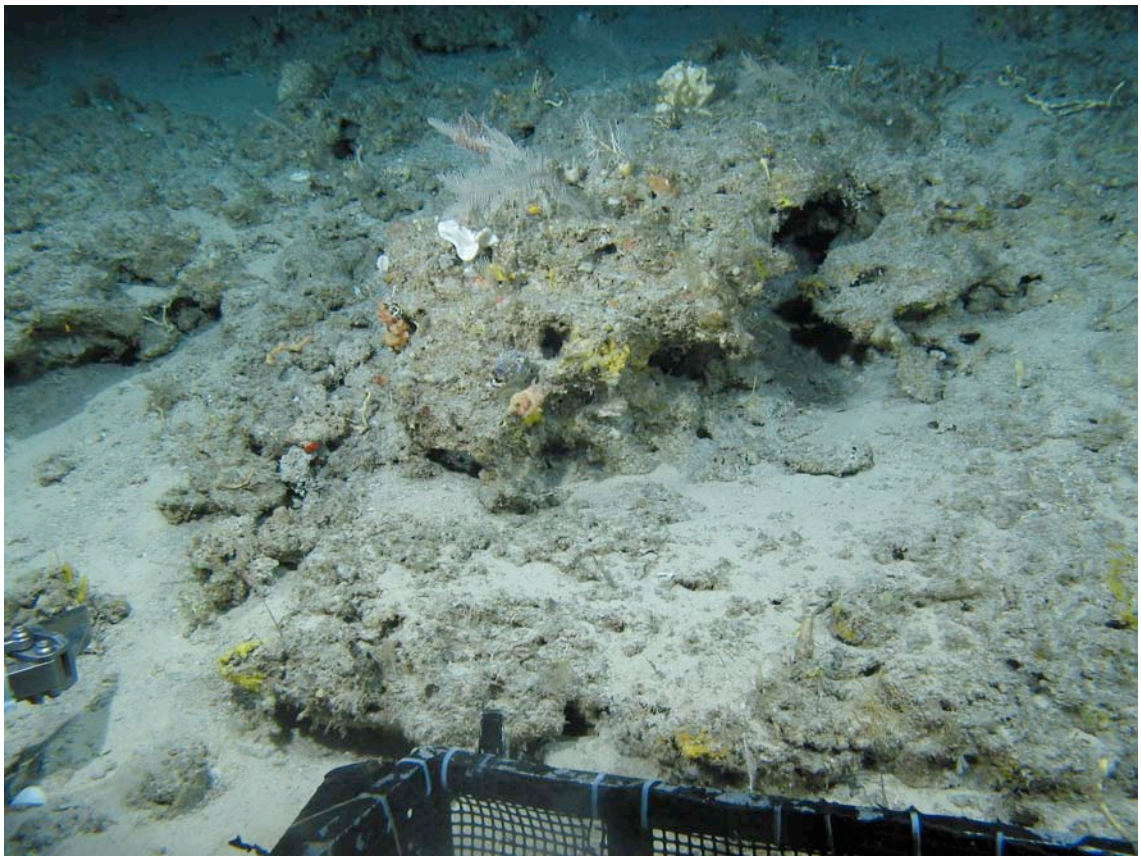


Figure 9 Image of outcrops about 190 m in water depth (2009/10/2 09:10 JST)

Finally, many Rodolith covered seafloor at area about 120 m in water depth (Fig. 10). Same modern distribution of Rodolith around Okinawa Island was reported by Iryu et al. (1995). 8 pieces of Rodolith (sample R-10) were corrected at 25-27.048N, 125-44.444E (121 m).

**Summary:**

We found the carbonate outcrops that have formed steep cliffs and relatively flat sea floor was covered by sandy sediment. The mudstone correlated with such as the Shimajiri Formation (and other oldest Formation) is not found in Dive #1060 (above 500 m in water depth). Top of the Miyako-Sone possibly shallower than140 m in water depth cropped out at inter-glacial stage and karstified the carbonate rocks should be occur in this stage. The results of submersible surveys show the possibility of subsidence on the study area. Detailed sample analyses include dating are let us know the geological subsidence history on the Miyako-Sone area.

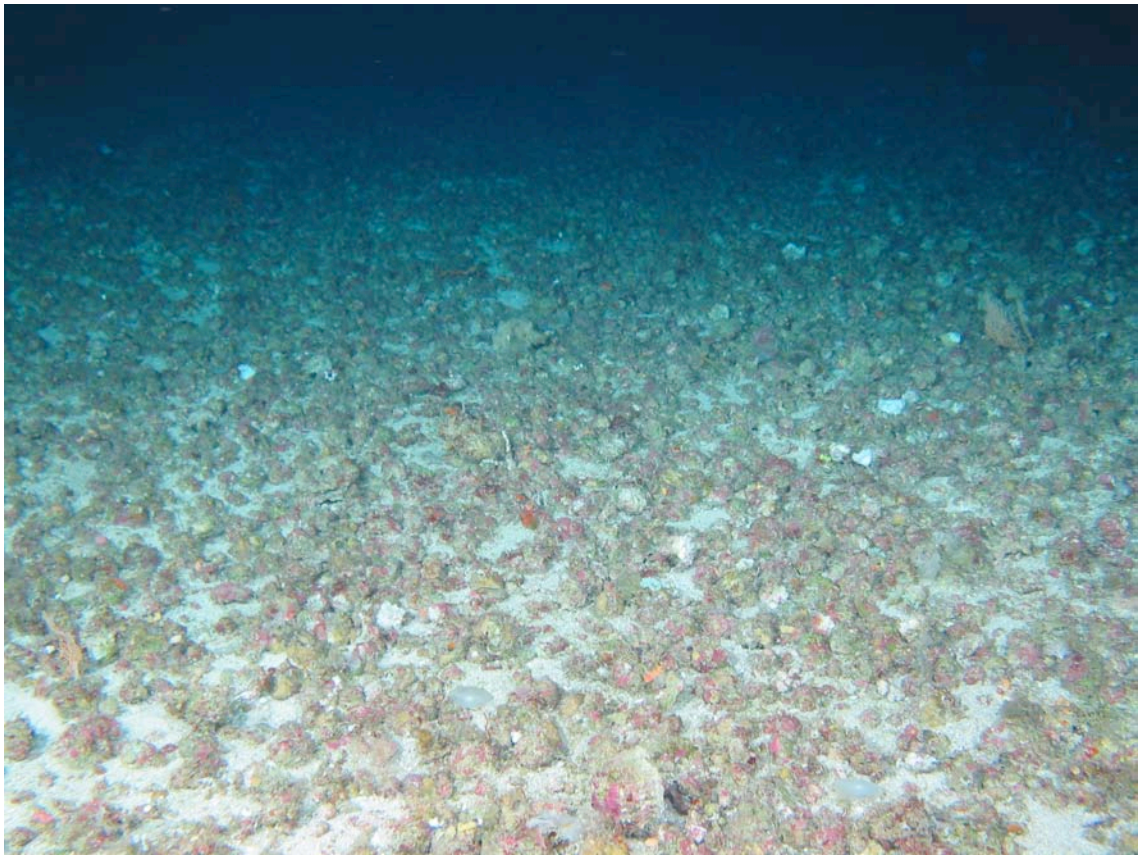


Figure 10 Image of Rodolith distributed area about 121 m in water depth (2009/10/1 16:05 JST)

References

Iryu, Y., Nakamori, T., Matsuda, S and Abe, O. (1995) Distribution of marine organisms and its geological significance in the modern reef complex of the Ryukyu Island. Sedimentary Geology, 99, 243-258.

Omura, A. (1988) Geological history of the Kikai Island, central Ryukyus, Japan: Summary of uranium-series dating of fossil corals from the Riukiu Limestone, Mem. Geol. Soc. Jap., 29, 253-268 (in Japanese with English abstract).

Park, J.O., Tokuyama, H., Shinohara, M., Suyehiro, K. and Taira, A. (1998) Seismic record of tectonic evolution and backarc rifting in the southern Ryukyu island arc system. Tectonophysics, 294, 21-42

Sibuet, J.C., Deffontaines, B., Hsu, S.K., Thareau, N., Le Formal, J.P., Liu, C.S. and ACT Party (1998)

Okinawa Trough backarc basin: Early tectonic and magnetic evolution. J. Geophys. Res. 103 (B12) 30245-30267

Shinjo, R (1999) Geochemistry of high Mg andesites and the tectonic evolution of the Okinawa Trough-Ryukyu arc system. Chemical Geology 157: 69-88

| Photo | Dive # | Samp | Data | Latitude | Longitude | Depth | Large | Description | Remark |
|---|---|---|---|---|---|---|---|---|---|
|  | 1060 | R-1 | 2009.10.1 9:34 | 25-26.644N | 125-42.480E | 415 m | 24X22X10 cm | gray limestone (lithified) skeletal packstone to grainstone | |
|  | 1060 | R-2 | 9:48 | 25-26.624N | 125-42.470E | 403 m | 22X16X12 cm | gray limestone (lithified) skeletal packstone to grainstone | |
|  | 1060 | R-3 | 10:02 | 25-26.600N | 125-42.466E | 388 m | 23X13X10 cm | calcified sedimentary rock (pebble, mudstone included) | |
|  | 1060 | R-4 | 10:52 | 25-26.412N | 125-42.538E | 353 m | 27X20X10 cm | brownish gray limestone (lithified) | |
|  | 1060 | R-5 | 11:27 | 25-26.344N | 125-42.655E | 318 m | 16X10X4 cm | brownish gray limestone (lithified) skeletal grainstone encrusted by biota | |
|  | 1060 | R-6 | 12:56 | 25-26.674N | 125-43.648E | 393 m | 9X5X2 cm | coral (white) encrusted by warm cube | |
|  | 1060 | R-7 | 14:42 | 25-26.819N | 125-44.346E | 204 m | 9X8X5 cm | gray limestone (lithified) skeletal packstone to grainstone encrusted by biota | |



Table Preliminary description of rock samples

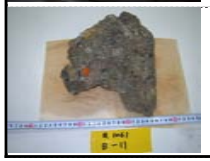
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
|  | 1060 | R-8 | 14:58 | 25-26.819N | 125-44.346E | 204 m | 8X5X3 cm | gray limestone (lithified) encrusted by biota | |
|  | 1060 | R-9 | 15:41 | 25-26.928N | 125-44.371E | 131 m | 24X18X9 cm | gray limestone (lithified) skeletal grainstone encrusted by biota | |
|  | 1060 | R-10 | 16:11 | 25-27.048N | 125-44.444E | 121 m | 8 pieces, 5X5X5, 4X4X4, ex | rodolith (red) | |
|  | 1060 | B-01 | 9:46 | 25-26.624N | 125-42.470E | 403 m | 9X7X7 cm | yellowish gray limestone (lithified) skeletal grainstone encrusted by biota | |
|  | 1061 | R-1 | 2009.10.2 9:25 | 25-26.837N | 125-44.345E | 187 m | 12X11X4 cm | yellowish gray limestone (lithified) skeletal grainstone encrusted by biota | |
|  | 1061 | R-2 | 9:44 | 25-26.841N | 125-44.349E | 182 m | 15X11X6 cm | brownish gray porous limestone (lithified) | |
|  | 1061 | R-3 | 10:57 | 25-26.875N | 125-44.361E | 150 m | 10X9X8 cm | gray limestone (lithified) skeletal grainstone | |
|  | 1061 | B-11 | 9:39 | 25-26.841N | 125-44.349E | 182 m | 20X20X12 cm | brownish gray limestone (lithified) skeletal grainstone encrusted by biota | |



Table Preliminary description of rock samples