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YOKOSUKA　Cruise Report

YK09-08

Mariana Trough

Jun. 29, 2009 - Jul. 17, 2009

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

Acknowledgements
We would like to express our sincere thanks to the officers and crew of R/V YOKOSUKA and the operation team of AUV URASHIMA for their professional skills and full cooperation during the cruise. We also thank the administrative and technical staff of JASTEC and NME for their support.
The cruise was partly supported by by *KAKENHI* Grant-in-Aid for Scientific Research on Innovative Areas, Project TAIGA: Trans-crustal Advection and In-situ biogeochemical processes of Global sub-seafloor Aquifer.

2009.7.31

Contents

1. Cruise Summary

1.1 Cruise Information

Cruise Number	YK09-08
Ship Name	R/V YOKOSUKA and AUV URASHIMA
Cruise Name	URASHIMA survey dives
Proposal 1	High-resolution, 3-dimensional and multi-sensor mapping of three hydrothermal sites in the southern Mariana Trough (P.I., Kyoko OKINO)
Proposal 2	Exploration of deep subsurface environment by metagenomic analysis (P.I., Taishi TSUBOUCHI)
Date	29 June 2009 - 17 July 2009
Ports of call	Yokosuka(JAMSTEC) - Wakayama
Area	Mariana Trough (see Fig.1-1)

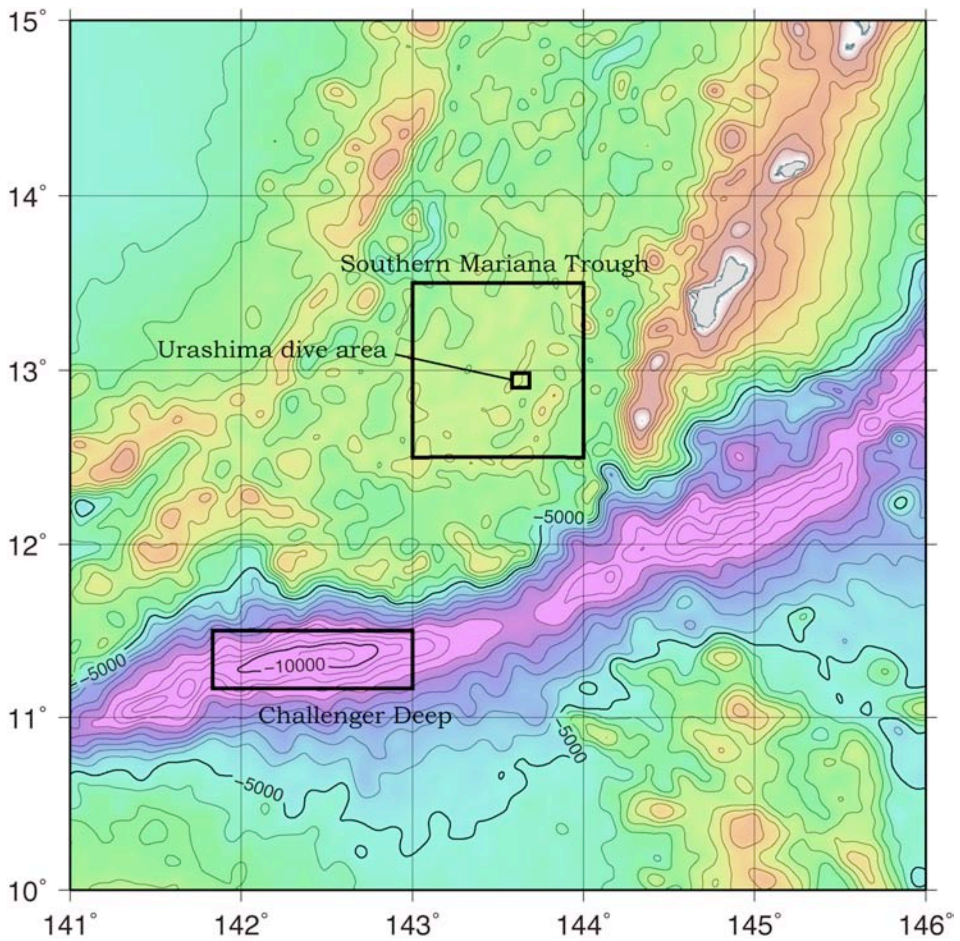

Fig.1-1 YK09-08 survey areas. Five Urashima dives and the geophysical mapping were done in the southern Mariana Trough and two 10K free fall camera maneuvers were done in the Challenger Deep.

1.2 Overview

1.2.1 High-resolution, 3-dimensional and multi-sensor mapping of three hydrothermal sites in the southern Mariana Trough

Background and Objectives

Three hydrothermal sites (Snai, Archean, Pika, Fig.2) have been known in the southern Mariana Trough. These sites are located just on the active backarc spreading axis, the eastern foot of the axial high and the top of an off-axis seamount about 5 km from the axis, respectively. Geochemical characteristics of the hydrothermal fluids and underneath volcanic rocks are different among these closely located three sites, where signature of arc magmatism is strong in the backarc spreading axis and is weak in off-axis seamount closer to the active arc. The purpose of this study is to reveal the detailed geological structure around these hydrothermal vent sites and the temporal and spatial distribution of hydrothermal plume originated from these sites in higher resolution than ever. Three-dimensional, high resolution, physical, chemical and microbiological mapping both in water column and seafloor can lead us to understand the tectonic setting that controls the type of hydrothermal activity, and to evaluate the effect of hydrothermal circulation on ocean via hydrothermal plume.

AUV URASHIMA survey

We conducted the three-dimensional, multi-sensor mapping of three hydrothermal sites using AUV *URASHIMA*. The survey items were as follows:

- detailed geological and structural mapping of hydrothermal sites by multi-beam echo sounder and side scan sonar
- hi-resolution magnetic anomaly mapping by newly equipped fluxgate magnetometers and Overhauser magnetometer
- three-dimensional plume mapping by CTD, H_2S, pH and ORP sensors
- Geochemical and microbiological analysis of sea water sampled by newly equipped Niskin water sampler

Additional underway geophysical survey by R/V Yokosuka was also done.

Preliminary results

Total five dives of AUV *URASHIMA* were successfully done in the hydrothermal area of the southren Mariana Trough. Dive#90 was planned for detecting the upper limit of the hydrothermal plume at water depth of 2600m. Three dives, Dive#91-93, were done at the constant altitude of 80 m, designed for detailed geological and magnetic mapping for each site. Last dive, Dive #94, was for detecting plume anomalies at the center depth of the plume, roughly at 150 m above seafloor. The dive tracks are shown in Fig.2, where the navigation is based on SSBL.

Dive#90 : Two survey lines across the backarc spreading axis at the depth of 2600 m were done and all equipments and sensors were tested. Unfortunately, any plume signal was not observed.

Dive#91 : The Snail site located on the backarc spreading aixs was explored at the constant altitude of 80m. The plume signal was detected by the physical and chemical sensors, and large negative magnetic anomaly was observed at SSW of the Snail site, the area known as the Yamanaka site, though the detailed investigation of tectonic setting has not been done. Swath bathymetry by SEABAT and side scan image by EdgeTech sonar were successfully collected.

Dive#92: The Archean site located at the foot of spreading axis was explored at the constant altitude of 80m. The plume signal was occasionally detected in wide area. Swath bathymetry by SEABAT and side scan image by EdgeTech sonar were successfully collected.

Dive#93: The Pika site located on a seamount at 5km off axis was explored at the constant altitude of 80m. The strong plume signal and distinctive magnetic anomaly were observed at the southwestern slope of the seamount. Swath bathymetry by SEABAT and side scan image by EdgeTech sonar were successfully collected.

Dive#94: Dive#94 visited three hydrothermal sites roughly at 150m above seafloor. The plume signal was slightly detected. The total magnetic force was successfully recorded by the Overhauser magnetometer along a part of the track.

This cruise is first proposal-based *URASHIMA* dive survey and is generally considered a success. It is particularly worth noting that we succeeded at world's first water sampling by AUV and at collecting high quality near bottom magnetic data.

The program was supported by *KAKENHI* Grant-in-Aid for Scientific Research on Innovative Areas, Project TAIGA: Trans-crustal Advection and In-situ biogeochemical processes of Global sub-seafloor Aquifer.

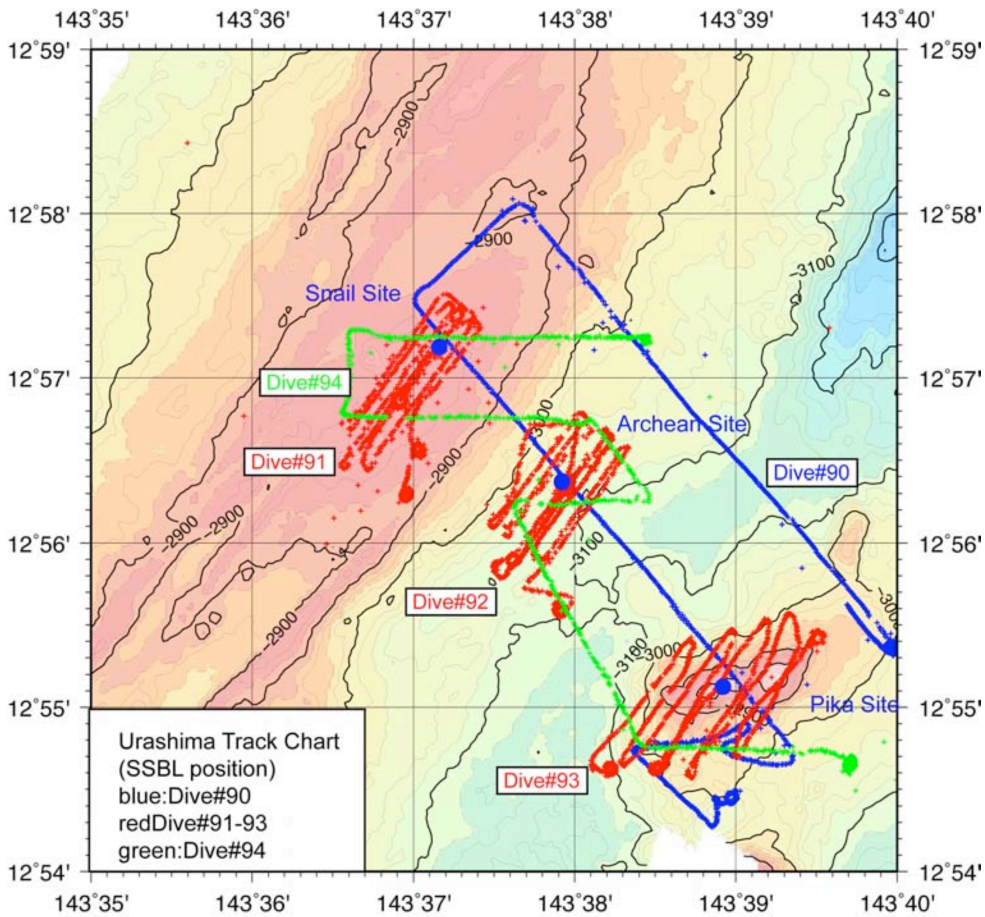

Fig.1-2 Track chart of URASHIMA dives, Dive#90-94. Navigation was based on SSBL.

1.2.2 Exploration of deep subsurface environment by metagenomic analysis

Background and Objectives

The destination of this study is understanding of the earth which has a large biosphere called "abyssal floor and crust" in a comprehensive manner. The abyssal environments are classified roughly into two groups that is dynamic circumstance like hydrothermal vent or static environment has no special event. Almost all of the deep sea seems to be the static environment, so that we focus the static hadal sea floor and try to analysis the relationship between microbes and its surroundings. During YK09-08 cruise, we try to collect the sea sediments for studying the below three items.1) meta-genomic data that are gained by analyzing nucleic acids, like DNA/RNA are essential for life activities. 2) geobiochemical data which are from high-molecule chemical substances affects these surroundings. 3) physical data which from conductivity and particle density in the hadal sea sediments.

10K free fall camera

We collected the saline mud samples from the world's deepest Challenger Deep at ~10,920 m, in order to analyze the community of deep sea microbes. The 10K free fall camera system was used for recording video images of hadal environment. The CTD meter and bait traps were also equipped on the free fall system to study the physical environment and to capture some benthos samples.

Preliminary Results

Two 10K free fall camera dives were successfully conducted at the Challenger Deep (Fig. 3). The sediment cores and some hadal sea floor lives were collected by bottom sampler 'Ashura' and bait traps equipped on 10K free fall camera system.

2. Participants List

Scientists

Kyoko OKINO* (Chief)	Ocean Research Institute,University of Tokyo
Taishi TSUBOUCHI*	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Yoshifumi NOGI	National Institute of Polar Research
Nobutatsu MOCHIZUKI	Ocean Research Institute,University of Tokyo
Miho ASADA	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Mitsunari SUNAMURA	University of Tokyo
Takuroh NOGUCHI	University of Kochi
Hiroyuki YAMAMOTO	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Hideki KOBAYASHI	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Takaaki KUBOTA	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Takeshi MIURA	University of Toyo
Hiromi UCHIDA	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Eriko TAKAHASHI	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

* Principal investigators of accepted research proposals

Marine Technician

Satoshi OKADA	Nippon Marine Enterprises

Specialist in Marine Technology

Minoru TAKATSUTO	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

AUV URASHIMA operation team

Kazuhiro CHIBA	Sub-Chief Submersible Staff
Satoshi OGURA	Sub-Chief Submersible Staff
Atsumori MIURA	1st Submersible Staff
Keigo SUZUKI	2nd Submersible Staff
Akihisa ISHIKAWA	2nd Submersible Staff
Seiji SHIGETAKE	2nd Submersible Staff
Takuma ONISHI	3rd Submersible Staff
Yuta SAKAKIBARA	3rd Submersible Staff
Yudai TAYAMA	3rd Submersible Staff

R/V YOKOSUKA Officers and Crew

Eiko UKEKURA	Captain
Shinichi KUSAKA	Chief Officer
Shintaro HASHIMOTO	2nd Officer
Syunsuke FUJII	3rd Officer
Toshihiro KIMURA	Chief Engineer
Takashi OTA	1st Engineer
Saburo SAKAEMURA	2nd Enginner
Ichiro DEGUCHI	3rd Enginner
SatoshiWATASE	Chief Radio Operator
Yoichi INOUE	2nd Radio OPerator
Yohei YAMAMOTO	Junior 2nd Radio Operator
Yasuyoshi KYUKI	Boat Swain
Shuji TAKUNO	Able Seaman
Osamu TOKUNAGA	Able Seaman
Nobuyuki ICHIKAWA	Able Seaman
Kaito MURATA	Able Seaman
Shinya ISHIZUKA	Sailor
Daisuke YANAGITANI	Sailor
Hirotaka SHIGETA	Sailor
Kiyoshi YAHATA	No.1 Oiler
Hiroyuki OISHI	Oiler
Tomoyuki HASHIMOTO	Oiler
Chihaya SANO	Oiler
Takeshi WATANABE	Oiler
Tomihisa MORITA	Chief Steward
Yoshinobu HAZATANI	Steward
Isao MATSUMOTO	Steward
Hidetoshi KAMATA	Steward
Kiyotaka KOSUJI	teward

3. Ship Log

Date	Local time	Universal time	Note	Weather	wind direction/force
29/06/2009			**Transit**	Cloud	ENE/2
	10:00	1:00	Departure from Yokosuka (JAMSTEC)		
	13:00	4:00	Briefing and safty training by C/O		
	13:30	4:30	Briefing with Urashima team		
	15:23-15:31	6:23-6:31	Plankton net #1		
	16:40	7:40	KOMPIRA-SAN		
	18:30	9:30	Science meeting /Keynote lecture by Okino and Tsubouchi		
30/06/2009			**Transit**	Fair	SW/3
	8:30	23:30	Fire dril		
	15:30	6:30	28-00'0N,141-30'0E		
	17:30	8:30	Briefing with Urashima team		
	18:30	9:30	Science meeting /Lecture by Sunamura		
01/07/2009			**Transit**	Fair	East/2
	17:35	8:35	21-36.0N,142-22.4E		
	18:30	9:30	Science meeting / Lecture by Miura		
02/07/2009			**Transit**	Fair	ENE/3
	18:30	9:30	Science meeting		
03/07/2009			**Mariana Area**	Fair	East/2
	7:30	22:30	Arrived at research area		
	7:44-8:01	22:44-23:01	Plankton net #2 surface watere sampling		
	7:50	22:50	Deployed XBT#1 at 12-52.9655N,143-50.7978E		
	8:45	23:45	Urashima on surface (sea trial)		
	9:50	0:50	Urashima on deck		
	10:07	1:07	Deployed proton magnetometer		
	10:21	1:21	Started geophysical mapping		
	13:32-13:43	4:32-4:43	Carried out figure eight turn #1 for magnetometer calibration		
	18:30	9:30	Science meeting		
04/07/2009			**Mariana Area**	Cloud	SE/2
	5:48	20:48	Finished geophysical mapping		
	7:25	22:25	Recovered proton magnetometer		
	7:25	22:25	Arrived at dive point		
	8:35	23:35	Urashima Dive #90 started (surface)		
	10:38	1:38	Survey started		
	15:13	6:13	Urashima off bottom		
	16:22	7:22	Urashima on surface		
	17:10	8:10	Deployed proton magnetometer		
	18:20	9:20	Started geophysical mapping		
	19:00	10:00	Science meeting		
	20:32-20:43	11:32-11:43	Carried out figure eight turn #2 for magnetometer calibration		
05/07/2009			**Mariana Area and Guam**	Rain	SE/6
	3:21	18:21	Finished geophysical mapping		
	7:23	22:23	Recovered proton magnetometer		
	7:30	22:30	Arrived at dive point		
	9:30	0:30	Canceled Urashima dive (radio communication trouble)		
	11:00	2:00	Left Mariana Area for Apra(Guam) (transportation of injured person)		
	14:50	3:50	Arrived at 3 miles off of Apra port		
	15:00	4:00	Left Apra for Challenger Area		
	18:30	9:30	Science meeting		
06/07/2009			**Challenger Area**	Cloud	ESE/3
	4:00	19:00	Arrived at research area		
	4:18	19:18	Deployed XBT#2 at 11-22.1N,142-28.9E		
	4:54	19:54	Started site survey (MBES)		
	5:26	20:26	Finished site survey		
	7:00	22:00	10K free fall camera -Ashura Dive #1 started		
	8:25	23:25	Surface water sampling		
	10:19	1:19	Ashura on bottom		
	10:26-11:24	1:26-2:24	Carried out caibration for SSBL		
	11:36	2:36	Ashura off bottom		
	15:13	4:13	Ashura on surface		
	15:51	4:51	Recovered Ashura		
	15:57	4:57	Started moving to Mariana Area		
	1830	9:30	Science meeting		
07/07/2009			**Mariana Area**		East/2
	7:30	22:30	Arrived at dive point	Rain	
	8:22	23:20	Urashima dive started (surface)		
	8:50	23:50	Urashima emergency blast (System trouble)		
	8:56	23:56	Urashima on surface		
	11:30	2:30	Deployed proton magnetometer		
	11:55	2:55	Started geophysical mapping		
	18:30	9:30	Science meeting		

08/07/2009			**Mariana Area**	Cloud	ESE/4
	5:12	20:12	Finished geophysical mapping		
	7:39	22:39	Recovered proton magnetometer		
	8:00	23:00	Arrived at dive point		
	9:41	24:41	Urashima Dive #91 started (surface)		
	12:23	3:23	Survey started		
	15:48	6:48	Urashima off bottom		
	16:39	4:39	Urashima on surface		
	17:30	5:30	Deployed proton magnetometer		
	19:00	10:00	Science meeting		
09/07/2009			**Mariana Area**	Cloud	ESE/4
	3:44	18:44	Finished geophysical mapping		
	7:24	22:24	Recovered proton magnetometer		
	10:00	1:00	Arrived at dive point		
	10:35	1:35	Urashima dive started (surface)		
	10:37	1:37	Urashima emergency blast (optical cable trouble)		
	10:37	1:37	Urashima on surface		
	11:50	2:50	Started moving to Challenger Area		
	18:30	9:30	Science meeting		
	20:15	11:15	Arrived at Challenger Area		
10/07/2009			**Challenger Area**	Fair	East/4
	7:02	22:02	10K free fall camera -Ashura Dive #2 started(surface)		
	10:26	1:26	Ashura on bottom		
	10:30	1:30	Carried out caibration for SSBL		
	13:02	4:02	Ashura off bottom		
	16:44	7:44	Ashura on surface		
	17:20	8:20	Recovered Ashura		
	17:30	8:30	Started moving to Mariana Area		
	18:30	9:30	Science meeting		
11/07/2009			**Mariana Area**	Cloud	East/4
	8:10	23:10	Arrived at dive point		
	9:00	24:00	Urashima Dive #92 started (surface)		
	11:41	2:41	Survey started		
	15:54	6:54	Urashima off bottom		
	16:41	7:41	Urashima on surface		
	19:00	10:00	Science meeting		
12/07/2009			**Mariana Area**	Cloud	East/4
	7:30	22:30	Arrived at dive point		
	8:07	23:07	Urashima Dive #93 started (surface)		
	11:14	2:14	Survey started		
	15:50	6:50	Urashima off bottom		
	16:39	7:39	Urashima on surface		
	19:00	10:00	Science meeting		
13/07/2009			**Mariana Area**	Rain	ESE/4
	7:30	22:30	Arrived at dive point		
	8:42	23:42	Urashima Dive #94 started (surface)		
	10:38	1:38	Survey started		
	13:46	4:46	Urashima off bottom		
	15:01	6:01	Urashima on surface		
	15:30	16:30	Transit for Wakayama		
	19:00	10:00	Science meeting		
14/07/2009			**Transit**	Fair	East/3
	18:30	9:30	Science meeting / preliminary results by Tsubouchi, Kobayashi, Miura and Kubota		
	22:55-23:00	13:55-14:00	Carried out figure eight turn #3 for magnetometer calibration		
15/07/2009			**Transit**	Fair	ESE/4
	9:00	24:00	Lecture for ship crews by Okino, Tsubouchi and Ishikawa		
	18:00	9:00	Science meeting /preliminary results by Okino, Asada and Mochizuki		
	19:30	10:30	Farewell party with captains, officers and Urashima team		
16/07/2009			**Transit**	Fair	SW/2
	5:50-6:22	20:50-21:22	Plankton net #3 / surface water sampling		
	15:25-15:37	6:25-6:37	Carried out figure eight turn #4 for magnetmeter calibration		
	15:37-16:15	6:37-7:15	Plankton ne t#4 / surface water sampling		
	18:00	9:00	Science meeting / preliminary results by Yamamoto, Sunamura and Noguchi		
17/07/2009			**Transit**	Rain	WEW/1
	13:00	4:00	Arrived at Wakayama Shimotsu port		

4. Objectives and background

4.1 Mariana Area

Kyoko OKINO

Objectives

About 300 hydrothermal sites have been detected along world mid-ocean ridges, backarc spreading centers, and arc volcanic chains since the first discovery of undersea hydrothermal activity in 1970's [e.g, *Baker and German*, 2004]. Hydrothermal circulations play an important role in heat and mass flux from earth's interior to surface, and the hydrothermal ecosystem based on chemosynthesis is a key to understand the origin and the evolution of life on earth. Recent studies revealed that the world hydrothermal system shows the wide variety in its fluid geochemistry and depending ecosystem. We, however, have not yet reached the systematic understanding of these diverse hydrothermal activities.

We here propose a hypothesis that the tectonic background of hydrothermal sites, in other words the style of heat source, host rock, fracturing etc., controls the characteristics of the hydrothermal system and then the ecosystem around there. During this cruise, we aim to explore three hydrothermal sites in the southern Mariana Trough backarc basin (Fig. 4.1) using *AUV Urashima* and try to validate the hypothesis. These sites are located just on the active backarc spreading axis, the eastern foot of the axial high and the top of an off-axis seamount about 5 km from the axis, respectively. Geochemical characteristics of the hydrothermal fluids and underneath volcanic rocks are different among these closely located three sites, where signature of arc magmatism is strong in the backarc spreading axis and is weak in off-axis seamount closer to the active arc. The purpose of this study is to reveal the detailed geological structure around these hydrothermal vent sites and the temporal and spatial distribution of hydrothermal plume originated from these sites in higher resolution than ever. Three-dimensional, high resolution, physical, chemical and microbiological mapping both in water column and seafloor can lead us to understand the tectonic setting that controls the type of hydrothermal activity, and to evaluate the effect of hydrothermal circulation on ocean via hydrothermal plume.

Regional background

The Mariana Trough is an active backarc basin and has opened since 6 Ma [*Fryer*, 1996]. The spreading axis is located eastern part of the basin close to the volcanic arc, showing highly asymmetric spreading [e.g., *Asada et al.*, 2007; *Deschamps and Fujiwara*, 2003]. In southern part of the basin, the Mariana arc-trench system curves westerly and the distance between the backarc spreading axis and active volcanic arc becomes minimum, approximately 20 km [*Martinez et al.*, 2000]. The ridge axis shows fast-spreading type morphology in spite of its intermediate to slow spreading rate (half spreading rate is 35 mm/yr in western flank of the basin).

Three hydrothermal sites were reported in the survey area, near 12°57'N, 143°37'E (see YK03-09, YK05-09 cruise reports). Three sites are aligned roughly perpendicular to the spreading axis, from the axial high to 5 km eastern off-axis. The Snail (Fryer) site was discovered in 2003 and is located at the top of axial high. Active white smoker (~230°C) was observed when it was first discovered, but the decreased activity and lower fluid temperature were reported in the following cruises. The barite

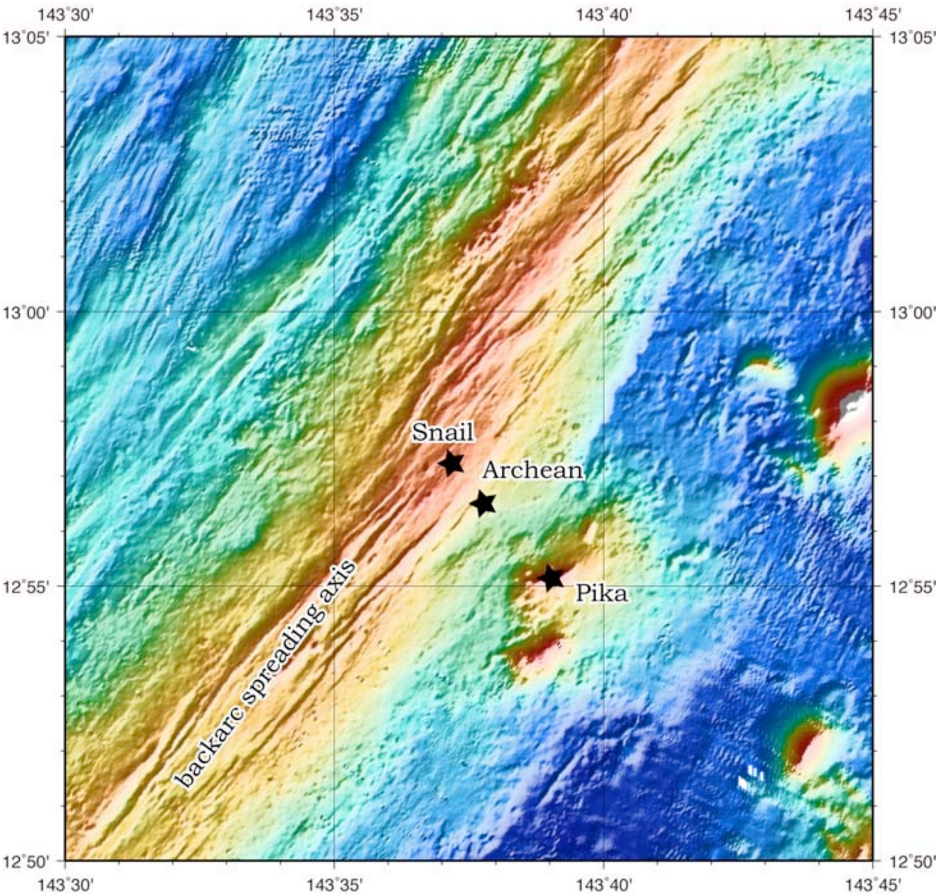

Fig.4.1 Three hydrothermal sites in the southern Mariana Trough. They aligns approximately parallel to the spreading direction within 5 km.

and zinc blend crust is formed around the vent. The Archean site is located 2 km southeast of the Snail site, at the foot of axial high. The site was discovered in 2003, and vigorous high temperature activity was reported. Several chimneys are found there and a 50 m high sulfide mound exists. The Pika site is located at the top of off-axis seamount, 5 km southeast of ridge axis. A 400m x 100m mound is formed and some black smokers blasting 300°C fluid were reported. Many dead chimneys were also found east of the currently active vent area.

The previous tow-yow survey detected the hydrothermal plumes near the Snail and the Archean sites, where the temperature and turbidity anomaly peaks were observed at 2700m and 2800m levels [*Baker et al.*, 2005]. The fluids from these three sites show extremely low pH, indicating the effect of magma-origin materials. High concentration of incompatible elements in fluids and heavy $\delta^{34}S$ in sulfide minerals were observed at Snail and Archean sites, that is in general interpreted as subduction component. The fluids from the Pika site shows typical mid-ocean ridge signature. This observation appears to be countertrend of tectonic location of these sites, the Pika site is the closest to the arc, and the Snail site corresponds to ridge axis. Host rock geochemistry also shows similar pattern, that the signature of arc magmatism is high in the Snail site. Why these three closely located sites show such a diversity and why the geochemical trend is opposite to tectonic setting are still unknown.

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4.2 Challenger Area

Taishi TSUBOUCHI

The destination of this study is understanding of the earth which has a large biosphere called “abyssal floor and crust” in a comprehensive manner. The land territory we land dwelling creature live on are only 30 % of earth surface area, the remaining 70% are marine. Moreover, the area of abyssal ocean is 95 % of that, and occupied extensively area. This area shows high pressure, low temperature, dark and poor nutrient, nevertheless so many lives there are. It reported that the half of biomass are remaining in exist in there compared with the land. 40 billion years have passed since the earth and primitive lives are born, the lives were at the mercy of the alteration of circumstances, repeating historical fact between glory and extirpation. The early phase of life mode really look like microbes. Studying the microbes which exist in hadal sea floor and make up a huge biomass leads to understanding of global ecosystem, and moreover is essential for ecological correctness through searching novel microbes and functional molecules.

The abyssal environments are classified roughly into two groups that is dynamic circumstance like hydrothermal vent or static environment has no special event. Almost all of the deep sea seems to be the static environment, so that we focus the static hadal sea floor and try to analysis the relationship between microbes and its surroundings.

In 1996, JAMSTEC was the first to succeed in sampling the saline mud using remotely operated vehicle called “*KAIKO*” at Challenger Deep, Mariana Trench, which is the deepest portion in the world. Then they tried screening microbes using the mud sample, and surprisingly approximately three thousands of microbes were picked up from the soils. It was amazing that so many microbes existed in the harsh environment like this, and in the phylogenetic species they were so variously, for instance, *firmicutes* is known as bacterium produce “*Natto*” or useful enzymes, aerobic photosynthetic bacterium which needs light and carbon dioxide and thermophilic bacterium. Why and how they could exist there, which shows dark, cold, high hydrostatic pressure and poor nutrient? How do they get energy source? It remained a mystery. To reveal this mystery, we have to formulate effective strategy of investigation, and that is environmental omics analysis, that is composite of investigation, biology, geochemistry, physics and bioinformatics. Integrating these special fields of study, it seems to reveal the microbial community and relationship life and earth.

More recently, we got some opportunities to go and take sample at Challenger Deep where is 10,920m depth therefore is the complete icy and shadowy world. In 2007, we took on a challenge for sampling of soil at the deepest sea floor using 10K Free fall camera system, but unfortunately in the act of withdrawing it, the wire was broken away and lost the system. So JAMSTEC needed to produce a near duplicate of the system, and test it in practice. In 2008, the new 10K Free fall camera system was tried out in field at Challenger Deep and was succeeded in sampling the saline mud. So we scientists tried to cryptanalyze the gene information of microbes in the mud as biological data using metagenomics technique. The phylogenetic analysis of 16S rRNA gene was finished and a certain number of gene sequential data were output little by little. Now then, we are analyzing what kind of genes or microbes exist and what types of metabolic systems are workable in the mud by deciphering the base arrangement data. To certify whether the putative genes or metabolic system are workable, geochemical analysis will need to perform.

In this YK09-08 cruise, hence we require the analysis of the geochemical parameter and physical data in saline mud at Challenger Deep.

5. Explanatory Notes

5.1 Research Vessel Yokosuka

Satoshi OKADA

R/V Yokosuka is designed serve as the mother vessel for *Shinkai 6500* and *Autonomous Underwater Vehicle URASHIMA*. It has silent engine, an advanced acoustic navigation systems and an underwater telephone for its state of the art operations.

There are 4 laboratories on *Yokosuka*, No.1-No.3 laboratories and No.1 Study room. No. 1 Lab. has dry space. The permanent installations are an video editing system, a PC and a printer. No.2 Lab. has semi-dry and wet space. There are two freezers (-40 & -80 deg.C), a incubator, a Milli-Q, and a fumigation chamber at dry one, and wet one has a rock saw. No.3 Lab. has dry space with storage. No.1 Study room has dry space, there are a gravity meter, a data acquisition system of gravity meter, a 3 axis fluxgate magnet meter and also a proton magnet meter, a work station for data processing, and a A0 size plotter.

Table 5.1 The principal specifications of R/V Yokosuka

Length overall	105.2 m
Beam overall	16.0 m
Depth	7.3 m
Draft	4.5 m
Gross tonnage	4,439 tons
Service speed	16knot
Complement	
Crew	27 persons
Submersible operation staff	18 persons
Researchers	15 persons
Total	60persons
Main propulsion system	Diesel engines: 2,206kW x 2
Main propulsion method	Controllable pitch propeller x 2

5.2 Yokosuka Sea Beam/magnetometers/gravity meter

Satoshi OKADA

Yokosuka is equipped with various kinds of underway geophysical equipment, a multi narrow beam echo sounder (Sea Beam 2112.004, Sea Beam Instruments, Inc.), a gravity meter (Type S-63, LaCoste & Romberg Gravity Meters Inc.), a ship borne 3 axis magnet meter (Type SFG-1212, Tierra Technica Inc.), and a proton magnet meter (Type STC 10, Kawasaki Geological Engineering Co., Ltd.). The specifications of these instruments are listed below.

Table 5.2 The specifications of MBES

measurement depth (m)	100～11,000
measurement range (deg.)	90～150
measurement frequency(kHz)	12
measurement method	cross fan beam style
accuracy	0.2%(center)～0.5%(outer)
beam width(deg.)	2
beam interval(deg.)	1
swath width(deg.)	150(～300m) 120(～4500m) 100(～8,000m) 90(～11,000m)
sampling rate(m sec.)	1.33 or 2.67
roll(deg.)	±20
pitch(deg.)	±7.5

Table 5.3 The specifications of Gravity meter

measurement range (m Gal)	12,000
drift	3mGal per month or less
stabilized platform	
platform pitch(deg.)	±22
platform roll(deg.)	±25
platform period(min.)	4 to 4.5
beam interval(deg.)	1
control system	
recording rate(Hz)	1
serial out put	RS-232
system performance	
resolution(mGal)	0.01
static repeatability(mGal)	0.05
50,000m Gal horizontal acceleration(mGal)	0.25
100,000m Gal horizontal acceleration(mGal)	0.50
100,000m Gal vertical acceleration(mGal)	0.25
dimension(cm)	71×56×84
weight(kg)	Meter:86, UPS:30

Table 5.4 The specifications of 3 axis magnet meter

system	ring core fluxgate
number of component	directly 3 axis
cable length(m)	50
sensor dimension(mm)	φ280×130H
measurement range (nT)	±100000
resolution (nT)	1

Table 5.5 The specifications of Proton magnet meter

measurement range (nT)	$3 \sim 7\times10^4$
resolution (nT)	0.01
sampling rate	10sec,20sec,1min,manual,external
time of applying field(sec.)	3 to 10
sensor dimension(mm)	φ200×1050
weight(kg)	28.6(in the air), 6.2(in the sea)

5.3 URASHIMA

Satoshi OKADA

Autonomous Underwater Vehicle (AUV) *URASHIMA* is cruised by oneself for built in control system. It is not connected by the cable with the mother vessel, therefore it can survey the sea floor widely and clearly. There are acoustic sonar equipments and sensors, side scan sonar, sub-bottom profiler, multi narrow beam echo sounder, and CTDO sensor.

Table 5.6 The specifications of AUV *URASHIMA*

Dimensions	Length(m) Width(m) Height(m) Weight(t)	10 1.3 1.5 10
Cruising Range(km)	Li-ion Fuel Cell(km)	100 300
Max Depth	3500m	
Cruising Speed	3kn	
Positioning	Inertial Navigation System Doppler Sonar SSBL Sonar	
Operation Mode	Autonomous Remote(Acoustic, Optical)	
Payload	300kg in air	

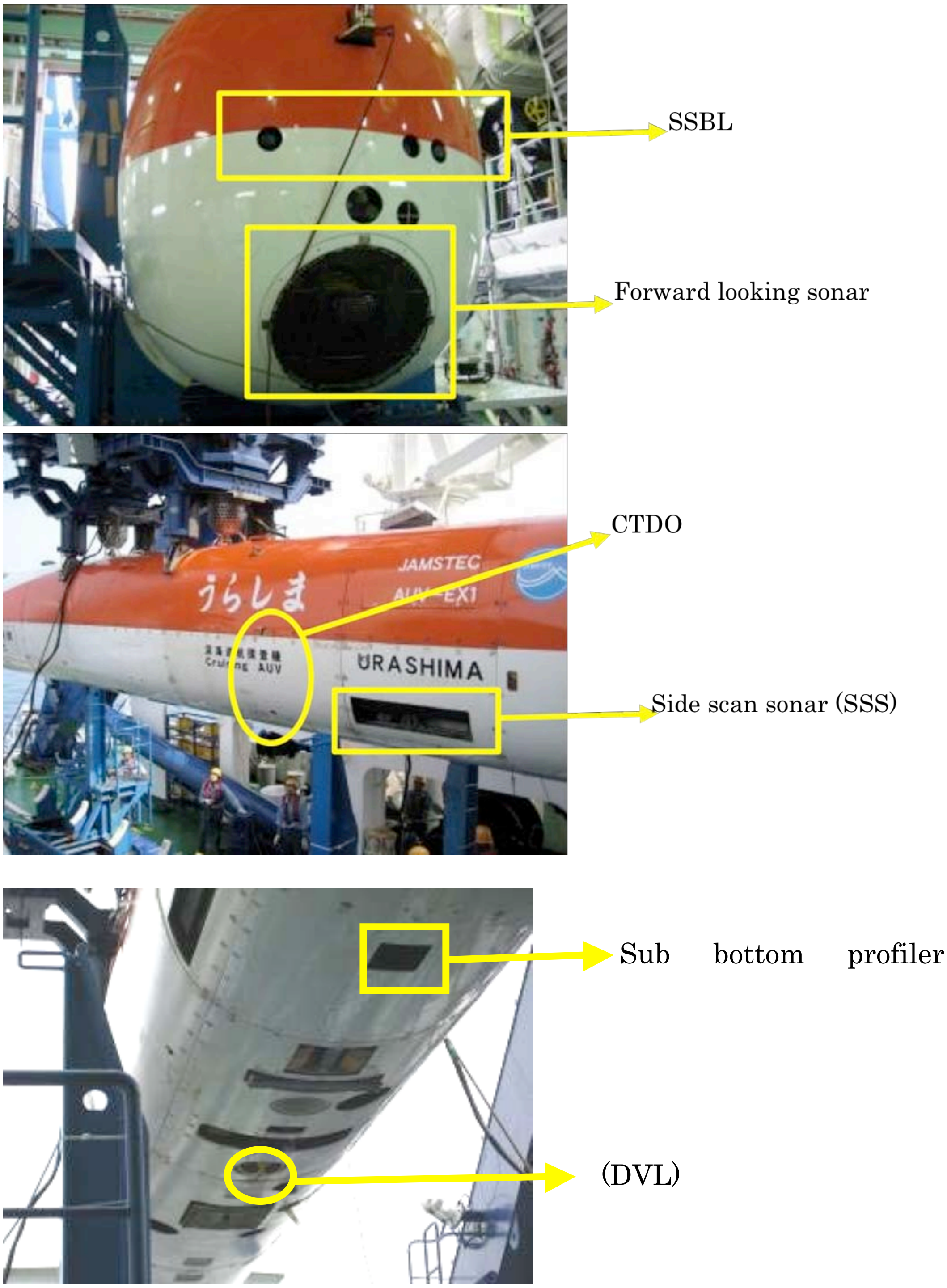


Fig.5.1 standard payloads of *URASHIMA*

5.4 URASHIMA payloads

5.4.1 Multibeam echo sounder

Kyoko OKINO

Bathymetric data were collected by Reson SEABAT7125AUV on *URASHIMA*. SEABAT7125 is a multibeam survey system that generates data for wide-swat h bathymetry maps and backscattering images. The system consists of two main subsystems, transmitter and receiver. The 400 kHz projector array is positioned fore and aft along the ship's keel. The along-track transmit beam width is 1°. The receiver array detects and processes the returning echoes through stabilized multiple athwart ship beams in a fan shape. The across-track receive beam width is 0.54°. The equi-distance mode is selected in beam forming. The ping rate is 2 Hz. The system swath angle is 120° and maximum number of beams is 512, but actual swath coverage is less during the survey. The swath width was about 3 times of center depth until 120 m of altitude, and decreased to 250-300 m at 120-160 m of altitude, and then 50% of center depth at 160-180m of altitude. Above 200 m from seafloor no effective data was logged. Data were logged in .s7k format and preliminary onboard processing was done using CARIS ver 6.1.

5.4.2 Side scan sonar

Asada Miho

Acoustic wave is the best and often only means to investigate the water column and seafloor efficiently and accurately. Side scan sonar system is one of the acoustic mapping systems. *AUV URASHIMA* emits a pulse of sound energy that radiates away from the source transducer and detects backscattering strength. When the sound energy impinges on objects harder than water, the energy is scattered in a new directions. Some of the energy is scattered back toward the source of the sound (= echo). The source transducer detects the returning energy for a fixed period of arrival time. The side scan sonar system assumes that observation of flat floor with constant altitude to a seafloor, and uniform propagation velocity of acoustic wave in seawater. The first returning echo is considered that come from just below the AUV (nadir) and is able to determine the altitude. Once the first echo was detected, they catch the magnitude of the pixels. Detected sounds after the first echo are aligned along arrival time from below the fish to side. Backscattering strength shows information of seafloor materials (sand or rock), seafloor roughness (fine grains or cobbles, for example), and inclination of seafloor (facing or opposite slope to the vehicle), in jumble magnitude.

A series of processing, including gain control, slant range collection, altitude correction, noise reduction, bottom tracking, radiometric correction, and positioning correction, is needed for analyzing the side scan sonar data.

Specifications of side scan sonar (Edge-Tech 2200C) installed in AUV *URASHIMA* are shown below. *URASHIMA* enables to use 120 kHz and 410 kHz acoustic wave but only 120 kHz wave was worked during the YK09-08 cruise.

Table 5.7 Specification of side scan sonar

Specificartion of EdgeTech 2200C side scan sonar in YK09-08	
Frequency	120 k Hz
Beam width	0.9 degree
Range	300 m each, fix (including altitude)
Pulse length	8.3 msec fix
Ping interval	Twice per second

5.4.3 Sub bottom profiler

Miho ASADA

Sub bottom profiler (Edge-Tech DW106) is installed near the head part of the AUV URASHIMA. The sub bottom profiler transmits chirp signals of 1-6 kHz, and detects sub-seafloor objects when the seafloor is covered by thick sediments. In case of YK09-08 cruise, we could not obtained sub-seafloor image from the sub bottom profiler, because of thin or almost no sediments.

Specification of the EdgeTech sub bottom profiler is shown below.

Table 5.8 Specification of sub-bottom profiler

Specificartion of EdgeTech DW106 sub bottom profiler	
Frequency	1-6 kHz, chirp
Beam width	28-36 degree
Resolution	15-25 cm
Ping interval	Twice per second

5.4.4 Magnetometer

Yoshifumi NOGI and Nobutatsu MOCHIZUKI

Magnetic anomalies observed in the ocean are basically originated from the variation of the magnetization of oceanic crusts mainly formed by basaltic rocks. Hydrothermal vent activities are possible cause of reduction of rock magnetization, namely demagnetization, in the small scale. Anomalous magnetic signals have been observed around past and present hydrothermal vent sites. However, anomalous magnetic signatures of hydrothermal vent sites are usually difficult to elucidate from sea-surface surveys. Near-bottom magnetic survey by using an AUV is an effective method to reveal the detailed magnetic anomaly signatures of ocean floor such as those around hydrothermal vent sites.

In order to detect signals of hydrothermally altered rocks in the southern Mariana Trough, the measurements of total intensity and three-components of the geomagnetic field are conducted by using AUV *URASHIMA*. Four three-axis fluxgate type magnetometers and an Overhauser type magnetometer are attached on AUV *URASHIMA* during the cruise. In addition, four three-axis fluxgate magnetometers were used in this survey in order to figure out the magnetic noises derived from AUV *URASHIMA* itself and other equipments on it, and those noise data are used to obtain the real geomagnetic anomaly signals.

Specifications of magnetometers are listed in Table 5.9. System configuration including the circuit is shown in Fig.5.2. The sampling interval of the Overhauser magnetometer was set as 5 sec for the Dive #90, 92, 93, 94 and as 1 sec for the Dive #91. The value for initialing tuning of the Overhauser magnetometer was set as 37,000 nT.

Table 5.9 Specifications of the fluxgate and Overhauser magnetometers

	Fluxgate	Overhauser
Model	Bartington MAG-03H	Marine Magnetics Exploror
Dynamic Range	+/- 70,000 nT	20,000-70,000 nT
Resolution	0.01 nT	0.001 nT
Accuracy	0.4 nTp-p@10Hz	
Period (Sampling interval)	0.1 sec (10Hz)	0.25, 0.5, 1, 3, 5, 10 sec

The circuit case and four three-axis fluxgate magnetometer sensors were fixed inside of the AUV. The positions of those sensors and three axis (X-Y-Z) coordinates of fluxgate type magnetometer are shown in Fig. 5.3.

During this cruise, the Overhauser magnetometer is tentatively set on the top of the AUV (see Fig. 5.3), though magnetic noises from the AUV and other equipments may affect the measurement of total intensity by the Overhauser magnetometer. This is the very first dive of AUV *URASHIMA* using Overhauser magnetometer and the risk for any troubles in AUV operation, such as towing behind the sensors, are minimized.

During the cruise, three components of the geomagnetic field are successfully obtained by the four fluxgate type magnetometers along the all dive tracks of AUV *URASHIMA*. Total intensities of the geomagnetic field measured by the Overhauser magnetometer are collected along almost E-W oriented observation lines during the Dive #94.

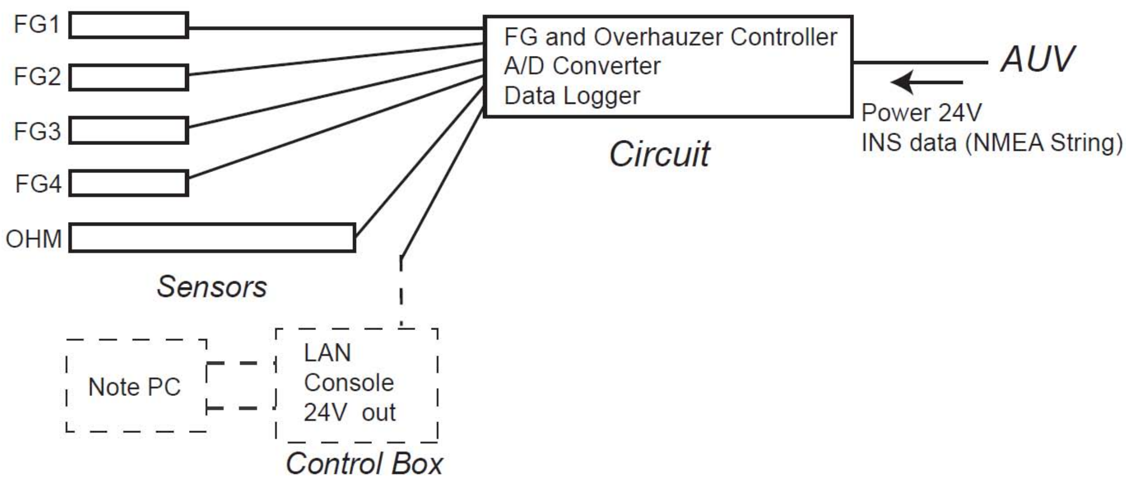


Fig. 5.2. System configuration. Note PC and Control Box are connected for transferring data from data logger to Note PC. FG denotes fluxgate magnetometer sensor and OHM indicates Overhauser magnetometer sensor.

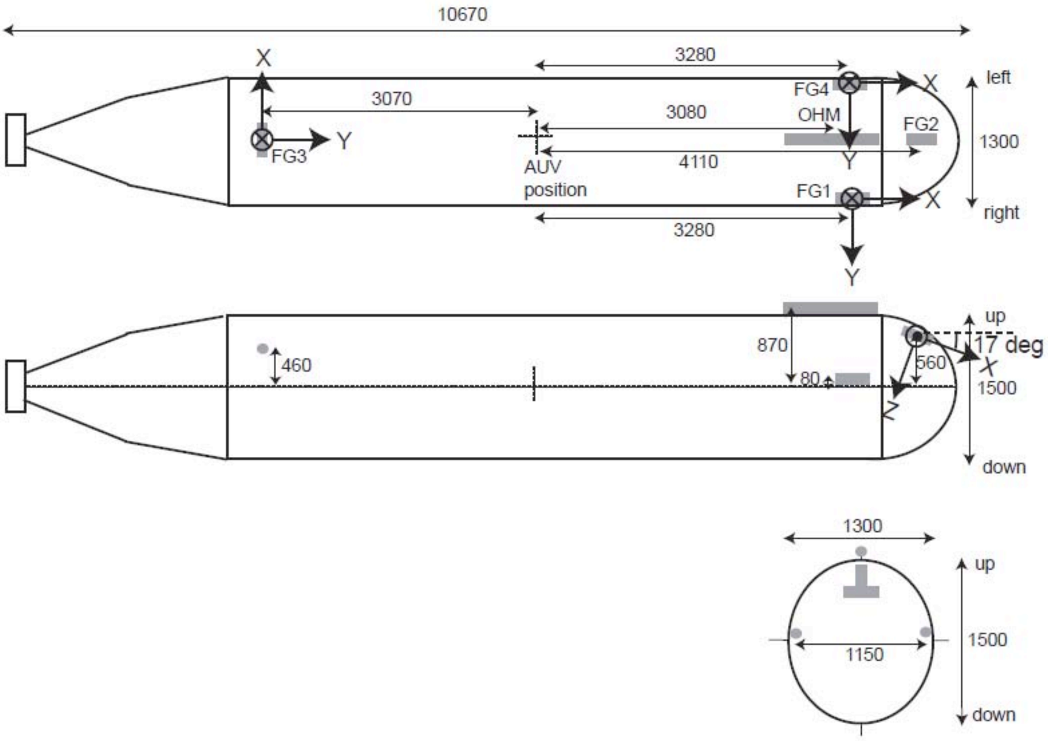


Fig. 5.3 The positions of magnetic sensors and three axis (X-Y-Z) coordinates of fluxgate type magnetometer. Scale unit is in mm.

5.4.5. ISFET type pH sensor

Michinari SUNAMURA

This sensor system used an ion-sensitive field-effect transistor (ISFET) as a pH electrode. The sensor has a quick response within a several second with an accuracy of 0.005 pH value. It can be used up to 6000m in water depth. The pressure housing contains pH sensor devices, data logger, RS-232C interface, and Li ion battery pack. This sensor system is a product of the Fukuba laboratory, University of Tokyo. The sensor measure pH of seawater and hydrothermal plume water every 10 seconds.

The pressure housing is deployed at the head of AUV *URASHIMA* (behind the orange square area in Fig. 5.4). The sensor electrode is deployed at the window of the head of the Urashima. The sensor face open onto the window (mazenta circle). The sensor was calibrated with both AMP and Tris buffer for 15 minutes before and after a dive.

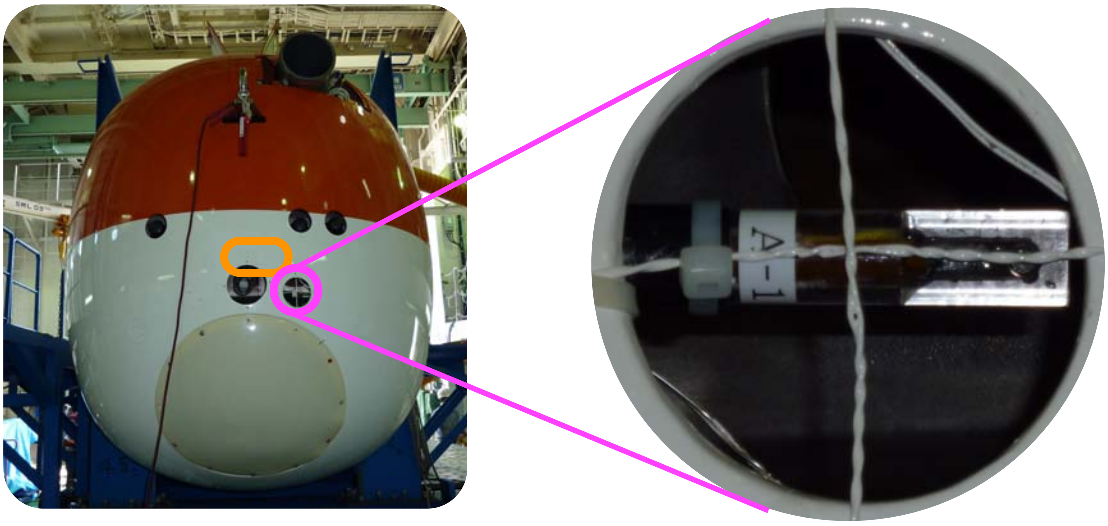


Fig.5.4 ISFET pH sensor equipped on AUV *URASHIMA*

5.4.6 ORP/pH sensor

Takuroh NOGUCHI

ORP/pH sensors (Fig. 5.5) are deployed for the plume mapping to detect the ORP and pH anomaly in the hydrothermal plume. ORP sensor (ORP-08) is consisted to the platinum electrode and reference electrode. Calibration was conducted by the two kinds of standard solution (HORIBA: 160-22 and 160-52). These solution are prepared just before deployment. The pH sensor (pH-08) is composed with the glass electrode and reference electrode. These electrodes were covered by the vinyl chloride for the pressure control. The pH sensor was calibrated daily with the phosphate buffer (pH: 6.85, 25 ºC) and borate buffer (pH: 4.00, 25 ºC) just before deployment. Both of the ORP and pH data were stored into the other CTD system (RBR, XR-620; Fig.5.6).

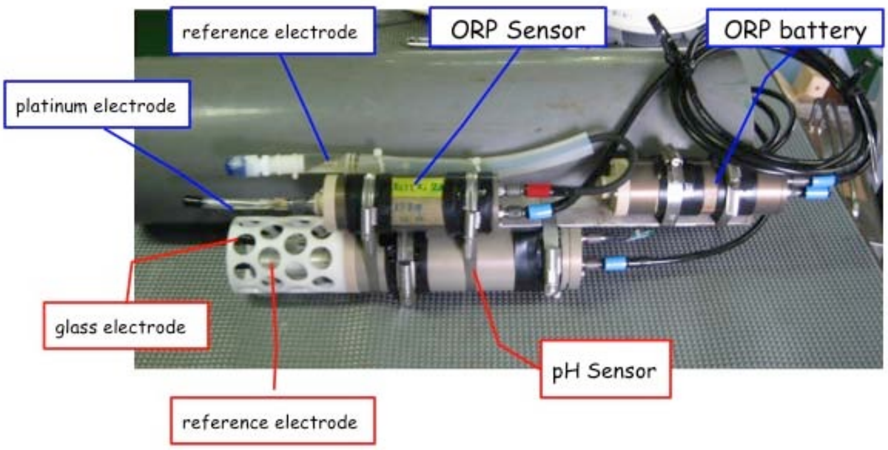


Fig. 5.5 ORP and pH sensor (ORP-08 and pH-08)

Fig. 5.6 CTD (RBR XR-620)

5.4.7 H_2S sensor

Takuroh NOGUCHI

Hydrogen sulfide is an anoxic volatile derived from the hydrothermal vent, which is useful for the chemosynthetic ecosystem. This hydrogen sulfide sensor (H_2S07) was developed using an electrochemical technique (cyclic voltametry) for the in situ hydrogen sulfide concentration. This sensor is composed with two pressure housings such as data logger with electrodes and battery unit (Fig. 5.7).

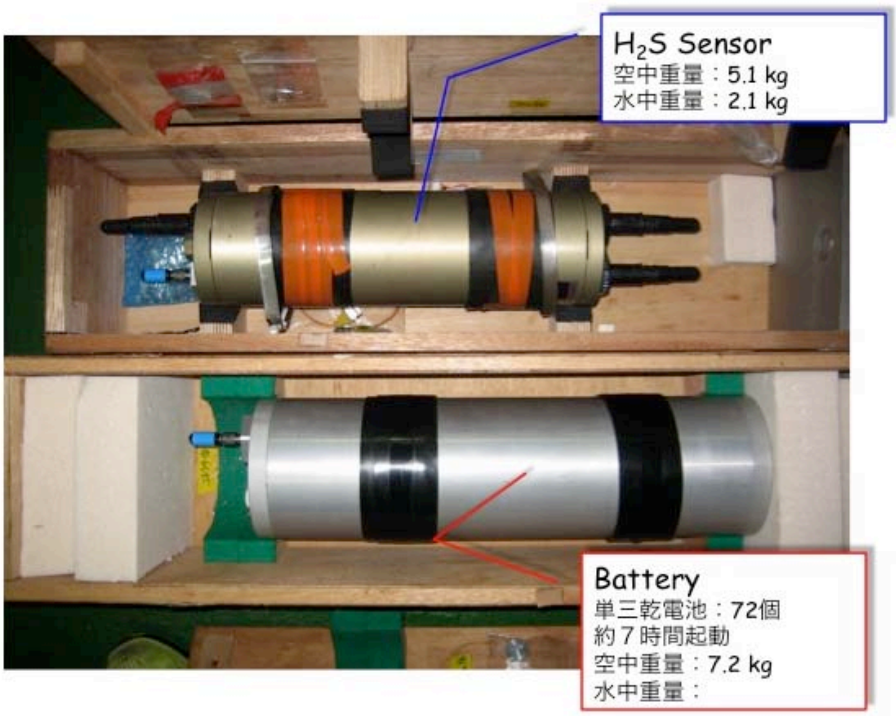


Fig. 5.7 Hydrogen sulfide sensor (H2S07) and battery unit.

5.4.8 Water Sampler

Hiroyuki YAMAMOTO

Autonomous underwater vehicle (AUV) is anticipated that a potential of broad area survey, especially cruising type AUV *URASHIMA*, has a capacity combined with vertical casting and ROV survey. In YK09-08 cruise, an examination of water sampling system and in situ chemical sensors equipped in AUV payload space has been examined, to establish a protocol for onboard measurement system on microbial abundance and physiological activities.

Intelligent Rosette Sampling System with twenty-four submersible arrays (Model 1018, General Oceanics Inc.) was modified to install in the payload space of AUV Urashima. Water samples can be collected in Niskin bottle (0.5L) under autonomous operation controlled by clock or depth sensor of the system.

Water-inlet was installed using 125 mm diameter pipe at the front, and the discharge hole was made at bottom of the AUV. Water flow into the payload space was monitored by a digital flowmeter (Model 2030R, General Oceanics Inc.). Counts of the screw rotation of flowmeter can convert to distance (meters), speed (cm/sec, water velocity), and volume (cubic centimeters) using the following equations.

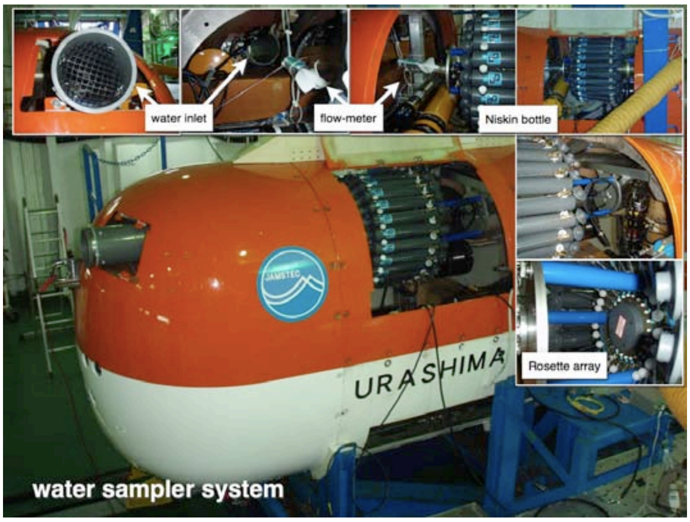


Fig. 5.8 water sampler

Distance = (difference in counts x rotor constant) / 999999
Speed = (distance x 100) / sampling time in seconds
Volume = distance x (inlet diameter)^2 / 4
* Rotor constant of the standard flowmeter (model 2030) is 26873.

These parameters were used to examine the water flow condition in the payload space, and to estimate a quality of water samples, for example contamination with circulation water in the payload due to low water flow rate, etc. The results shown in Table 5.10 proved that enough water flow to change the water mass of payload has been kept in the *URASHIMA* dives.

Table5.10 Results of flowmeter measurements in YK09-08 cruise

	Dive #90	Dive #91	Dive #92	Dive #93	Dive #94
Distance (m)	19155.36	10111.62	13278.02	12849.42	12400.48
Speed (cm/sec)	68.36	40.41	48.11	41.91	58.22
Volume (cubic cm)	2349524.91	1240253.55	1628631.69	1576061.48	1520996.08

5.5 Free Fall 10K Camera

Taishi TSUBOUCHI

11,000m class Free Fall Mooring System

The 11,000-meter class remotely operated vehicle (ROV) *KAIKO* (Kyo, Miyazaki, Tsukioka and Ochi, 1995) which was owned by Japan Agency for Marine-earth Science and Technology (JAMSTEC), had shown successful results on scientific research of the deepest sea. However in 2003, the vehicle of *KAIKO* was lost by the break of the secondary cable that connected the launcher and the vehicle. JAMSTEC have developed the alternate ROV *KAIKO7000*. Later, *KAIKO7000* was re-constructed to *KAIKO7000II*.

The other side there is strong demand for exploring of the deepest parts of the ocean. Especially the old *KAIKO* showed excellent result on the field of the bacteria. Many bacteria had been found in the mud sampled from the Challenger Deep of the Mariana Trench by the old *KAIKO*. So JAMSTEC has developed another deep sea observing system which is 11,000m class free fall mooring system. It aims to observe the environment under the hadal sea easily. This system is made up with some instruments, which mean that 10,000 m-class transponder which is proven in *KAIKO7000* operation, and observation equipments, i.e. HDTV camera, underwater light system, battery case, CTD meter, bait traps and three bottom samplers whose name are "*Ashura*". This 10,000 m-class free fall camera system is connected 16 mm thick nylon rope with nineteen floats and argos-beacon.

Weight of this camera system is about 270 kg in aerial regions or about 190 kg underwater regions. HDTV camera is able to record for 8 hours, and the switch is able to control by recording- timer basement. Two illuminating device are equipped with this system, which have lighting intensity enough to observe the hadal sea floor.

The three bottom samplers "*Ashura*" are 60 cm length acrylic tubes and can take a saline mud sample maximum volume of 7.7 l. The mud samples are used for several studies, for example microbial screening, metagenomic analysis biogeochemical analyses, and so on.

The CTD meter equipped with this system works up to 11,000 m depth and measures some parameters, conductivity (S/m), temperature (degree) and depth (m).

The bait trap aims to capture some hadal sea floor lives, for instance, amphipoda which called "*Hyrondellea gigas*". We tried collecting hadal sea lives with 5 bate traps. The bait trap is a small polypropylene box (100x80x200-300 mm) containing small fish fillet. One bait trap has a fish filet in metal cage to avoid eating bait (Oazuke-trap). The bait traps were equipped to the leg of 10K camera system "Ashura".

5.6 Plankton net

Takeshi MIURA

0.05 liters of seawater (plankton) collected from surface of the ocean by the plankton net. The plankton net tied with a 20 m long rope and a 0.05 liter polybottle were prepared. The net is conical shaped, 0.6 meters long, the inlet opening is 0.3 meters in diameter and the end hole has a diameter of 0.03 meters. The mesh size is 100 micro meters.

5.7 Surface water sampling

Takaaki KUBOTA

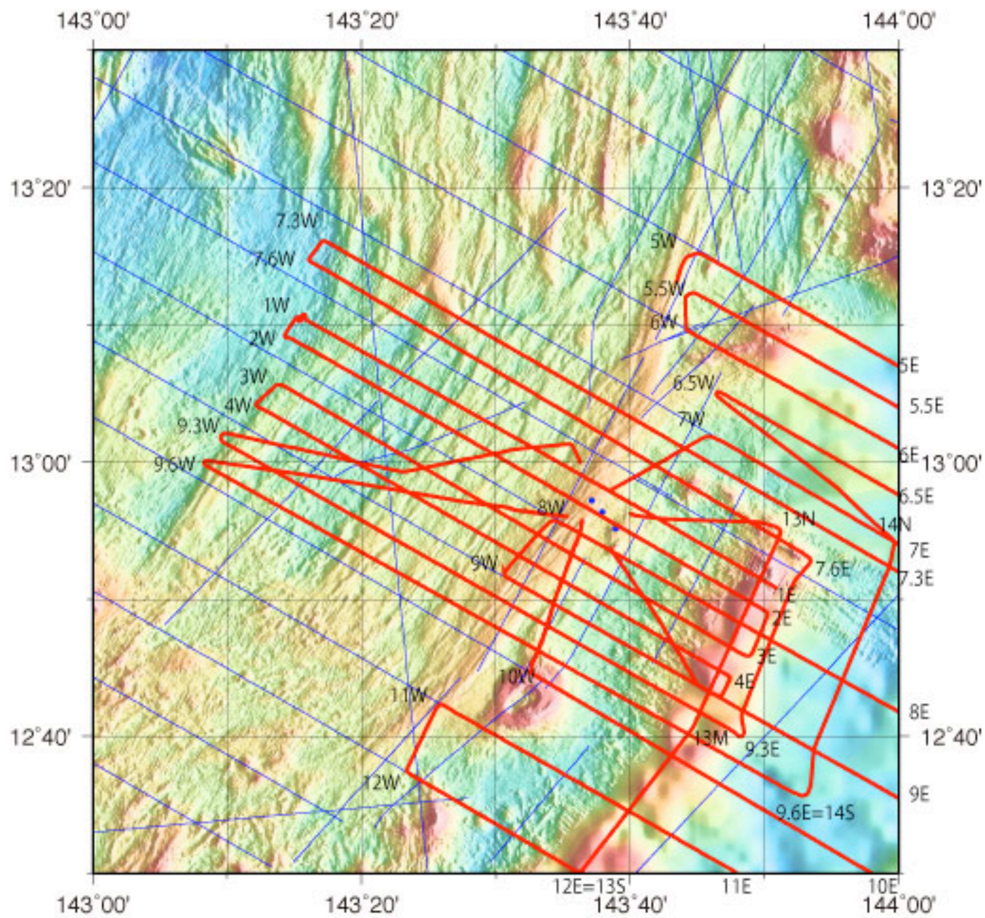
A 7.5-liter metallic bucket tied with a 20-m long rope and two 18-liter plastic buckets were prepared. The metallic bucket was washed with seawater before using. Following the rope work, the seawater sample was transferred into the 18-liter plastic bucket after rinsing the inside.

6. Operation Notes

6.1 Underway Geophysics

Kyoko OKINO

During YK09-08, total 672 miles of underway geophysical survey wad conducted with average ship speed of 13 knot. The Mariana Trough backarc area was mostly covered by multibeam echo sounders in previous cruises, so we planned two sets of survey lines, 1) eastern extension of previous survey lines from active arc to fore arc area (line interval is about 7 n.m.), and 2) densely located lines (line interval is 1.8 to 2 n.m) over the Urashima dive site. The latter is mainly for collecting dense magnetic and gravity data sets.Tracks and



waypoints are shown in Fig.6.1. All lines are perpendicular to the backarc ridge except for two lines parallel to the arc. Sea state was well through the survey. Navigation data were imported from ship's GPS.

Fig.6.1 YK09-08 geophysical survey lines (red) and existed surveys (blue).

Bathymetry

Bathymetric data were collected by SeaBeam2112. The swath width is 120° for almost all survey lines, but 45° for lines 5 and 6 due to miss operation. We conducted two XTD measurements for collecting sound velocity data for calculating depths on 2009/7/2(UT) and 2009/7/5(UT). Data were logged in mb41 format and edited by using MB System [Caress and

Chayes, 1996]. After data cleaning, two sets of bathymetric grids were created using GMT4.4 [Wessel and Smith, 1998] , a fine grid (0.025 arcmin =~ 46m) for Urashima survey area and a coarse grid (0.05 arcmin =~92m) covering all survey lines.

Magnetics

The proton magnetometer was first deployed on 2009/7/3 1:07 (UT) and recovered on 2009/7/3 22:25 (UT). Second deployment was done from 2009/7/4 8:10 (UT) to 2009/7/4 22:23 (UT). Third and fourth deployment were done from 2009/7/7 2:30 (UT) to 2009/7/7 22:39 (UT), from 2009/7/8 8:30 (UT) to 2009/7/8 22:24 (UT), respectively. The sensor was towed 300m behind the ship on starboard side. After 6 sec excitation, total magnetic force was measured every 20 sec. Frequency count was done in 500 msec. Although the area is rather close to magnetic equator and the IGRF value in the survey area is around 36000 nT, the data quality was very good and no special tuning was needed. Data were logged in two types files, one only includes proton magnetometer file and another records both proton magnetometer and three component magnetometer data. The total magnetic intensity data were corrected for cable length, and subtracted IGRF version 10.0 to calculate magnetic anomaly onboard.

Three component magnetometer data were also logged from 2009/6/29 01:07 (UT). We conducted four figure eight turns at 13°11’N on 2009/7/3 4:32 (UT), 12°30’N on 2009/7/4 11:32 , 20°46’N on 2009/7/15 13;56 and XXX on 2009/7/16 . Each turn includes both clockwise and anticlockwise 360°turns, and the average ship speed and operation time were 10 knot and 15 minutes, respectively. No onboard data processing was done.

Gravity

The measurement of gravity was made continuously during the cruise. The data were logged every 10 sec and the filter length is 180 sec. The calibration ties were done at JAMSTEC pier (absolute gravity = 979758.3 mGal) on 2009/6/28 23:11 (UT) and at Wakayama port (absolute gravity = 979683.22 mGal) on 2009/7/18 0:40 (UT) using portable Lacoste&Lomberg G-1039 gravity meter. See calibration data sheet for details. No onboard data processing was done.

6.2 *URASHIIMA* Dives

Dive#90		4 July 2009
Area	:	Southern Mariana Trough
Site	:	Fryer-Archean-Pika hydrothermal vent area
Main Target	:	plume detection, magnetic survey, and checking sensors
Control	:	constant depth, 2600 m, manual operation
Payloads	:	SEABAT multibeam echo sounder (almost no data)
		water sampling bottle x 24
		Fluxgate magnetometer x 4
		Overhauser magnetometer x 1 (almost no data)
		pH sensor x 1
		H2S sensor x 1
		ORP sensor & pH sensor x 1 each (no data)
Average speed of vehicle:		1~3knots
Depth range	:	2570~2781m
Altitude range	:	-

Events

JST (UT)	Descriptions
08:35 (23:35, 3 Jul.)	AUV on surface
11:05 (02:05)	pass the first WP, start survey
14:40 (05:40)	pass the last WP, end of survey
16:22 (07:22)	AUV on surface
16:45 (07:45)	AUV on deck

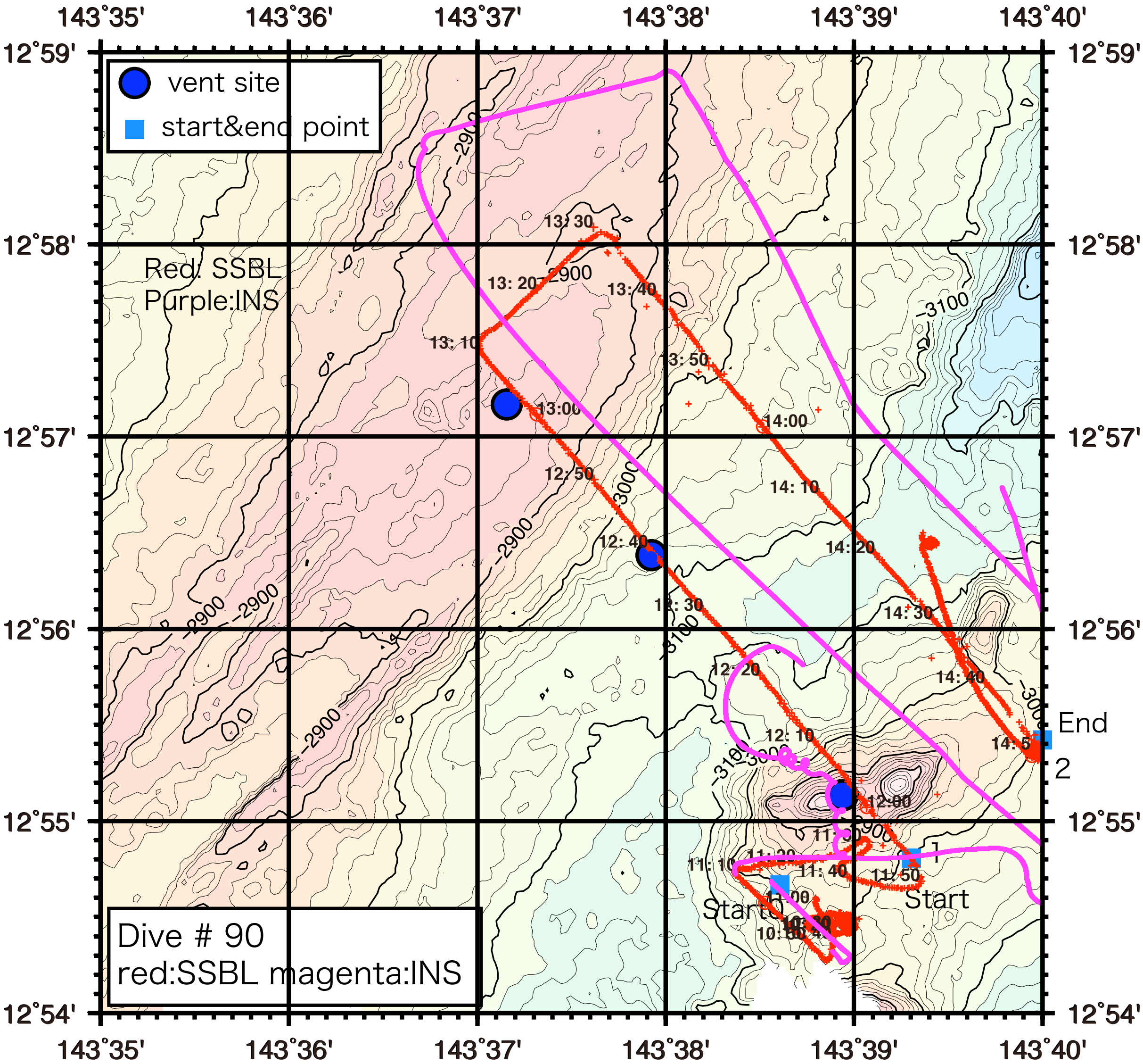


Fig. 6.2 URASHIMA Dive#90 track chart on bathymetry map

Dive#91		8 July 2009
Area	:	Southern Mariana Trough
Site	:	Snail Site
Main Target	:	High-resolution morphology and geology
Control	:	constant altitude, 80 m
Payloads	:	SEABAT multibeam echo sounder
		EdgeTech sidescan sonar
		Sub bottom profiler
		water sampling bottle x 24
		Fluxgate magnetometer x 4
		Overhauser magnetometer x 1
		pH sensor x 1
		H_2S sensor x 1
Average speed of vehicle:		2.7 knot (northbound)
		2.5 knot (southbound)
Depth range	:	2710~2765 m
Altitude range	:	79~94 m

Events

JST (UT)	Descriptions
09:41 (24:14, 7 Jul.)	AUV on surface
12:23 (03:23)	pass the first WP, start survey
15:45 (04:45)	pass the last WP, end of survey
16:40 (07:40)	AUV on surface
17:02 (08:02)	AUV on deck

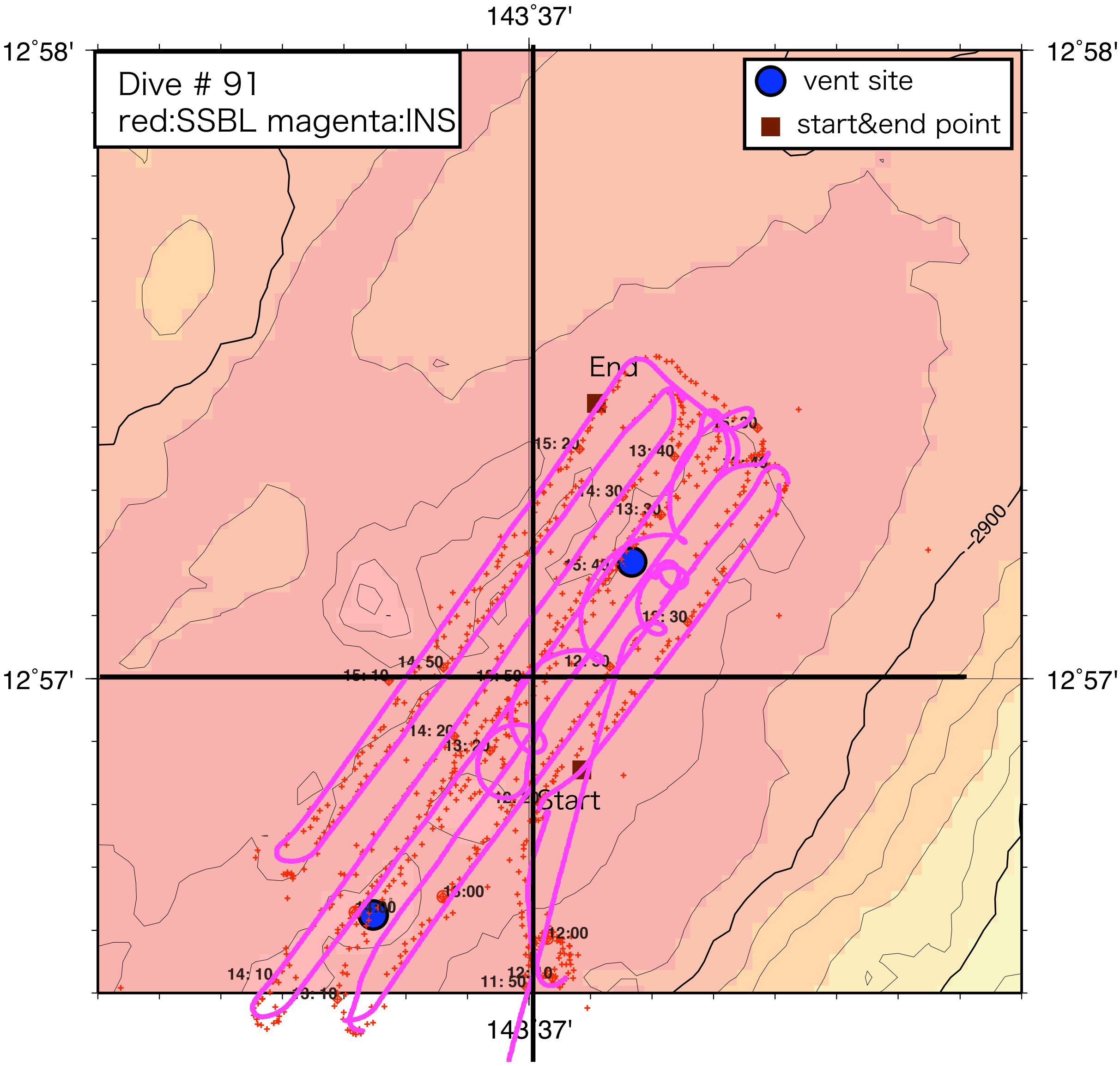


Fig. 6.3 URASHIMA Dive#91 track chart on bathymetry map

Dive#92		11 July 2009
Area	:	Southern Mariana Trough
Site	:	Archean Site
Main Target	:	High-resolution morphology and geology
Control	:	constant altitude, 80 m
Payloads	:	Seabat multibeam echo sounder
		EdgeTech sidescan sonar
		Sub bottom profiler
		water sampling bottle x 24... but 23 bottols are failed
		Fluxgate magnetometer x 4
		Overhauser magnetometer x 1 (almost no data)
		pH sensor x 1 (no data)
		H2S sensor x 1
Average speed of vehicle:		-
Depth range	:	2634~3006 m
Altitude range	:	51~168 m

Events

JST (UT)	Descriptions
09:00 (0:00)	AUV on surface
11:14 (02:14)	pass the first WP, start survey
15:43 (06:43)	pass the last WP, end of survey
16:40 (07:40)	AUV on surface
17:00 (08:00)	AUV on deck

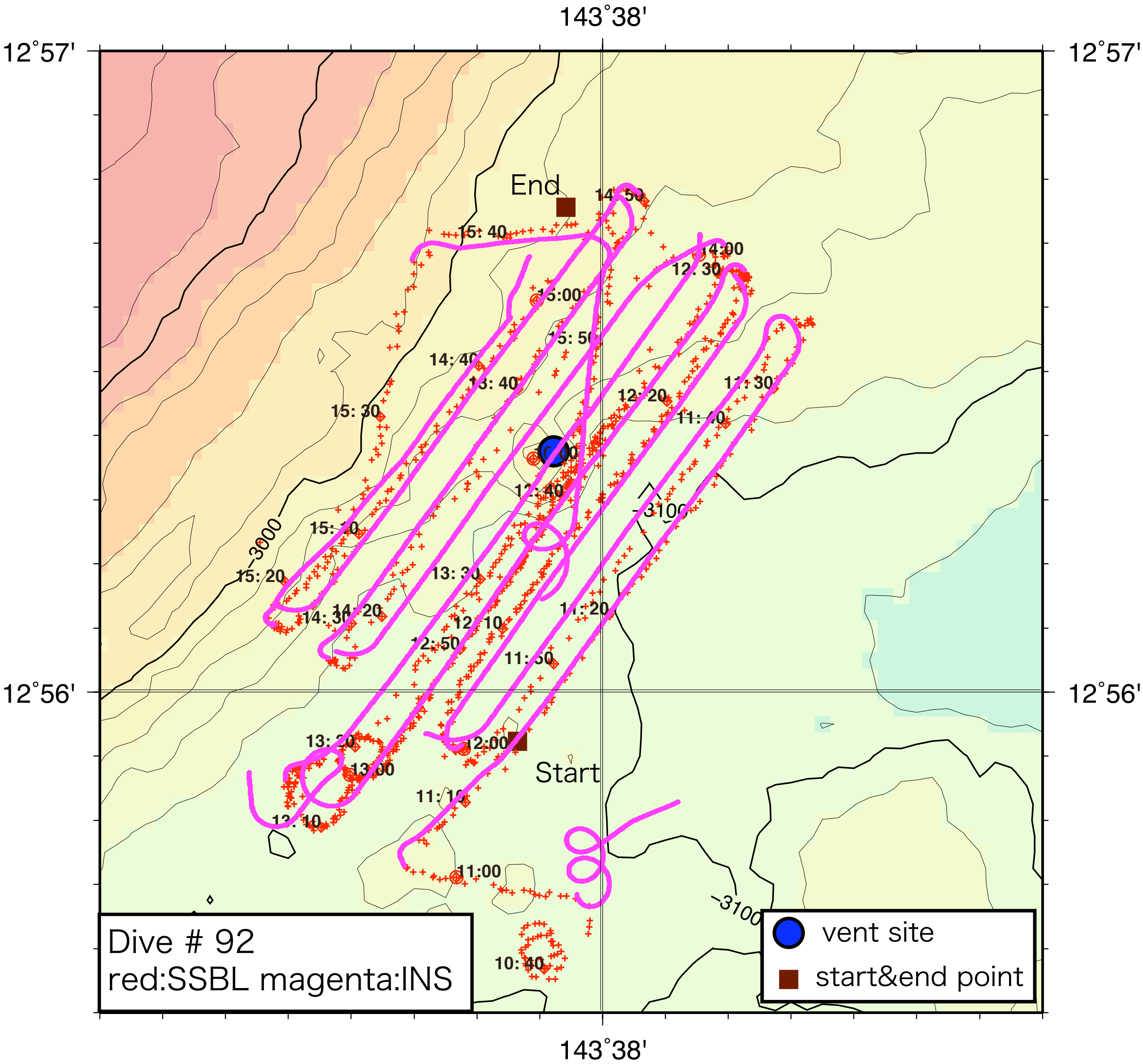


Fig. 6.4 URASHIMA Dive#92 track chart on bathymetry map

Dive#93		12 July 2009
Area	:	Southern Mariana Trough
Site	:	Pika Site
Main Target	:	High-resolution morphology and geology
Control	:	constant altitude, 80m
Payloads	:	SEABAT multibeam echo sounder
		EdgeTech sidescan sonar
		Sub bottom profiler
		water sampling bottle x 24
		Fluxgate magnetometer x 4
		Overhauser magnetometer x 1 (almost no data)
		pH sensor x 1
		H2S sensor x 1
Average speed of vehicle:		1.7 knot
Depth range	:	2368~2997 m
Altitude range	:	11~over 200 m

Events

JST (UT)	Descriptions
08:08 (23:08, 11 Jul.)	AUV on surface
10:35 (01:35)	pass the first WP, start survey
15:50 (06:50)	pass the last WP, end of survey
16:40 (07:40)	AUV on surface
17:23 (08:23)	AUV on deck

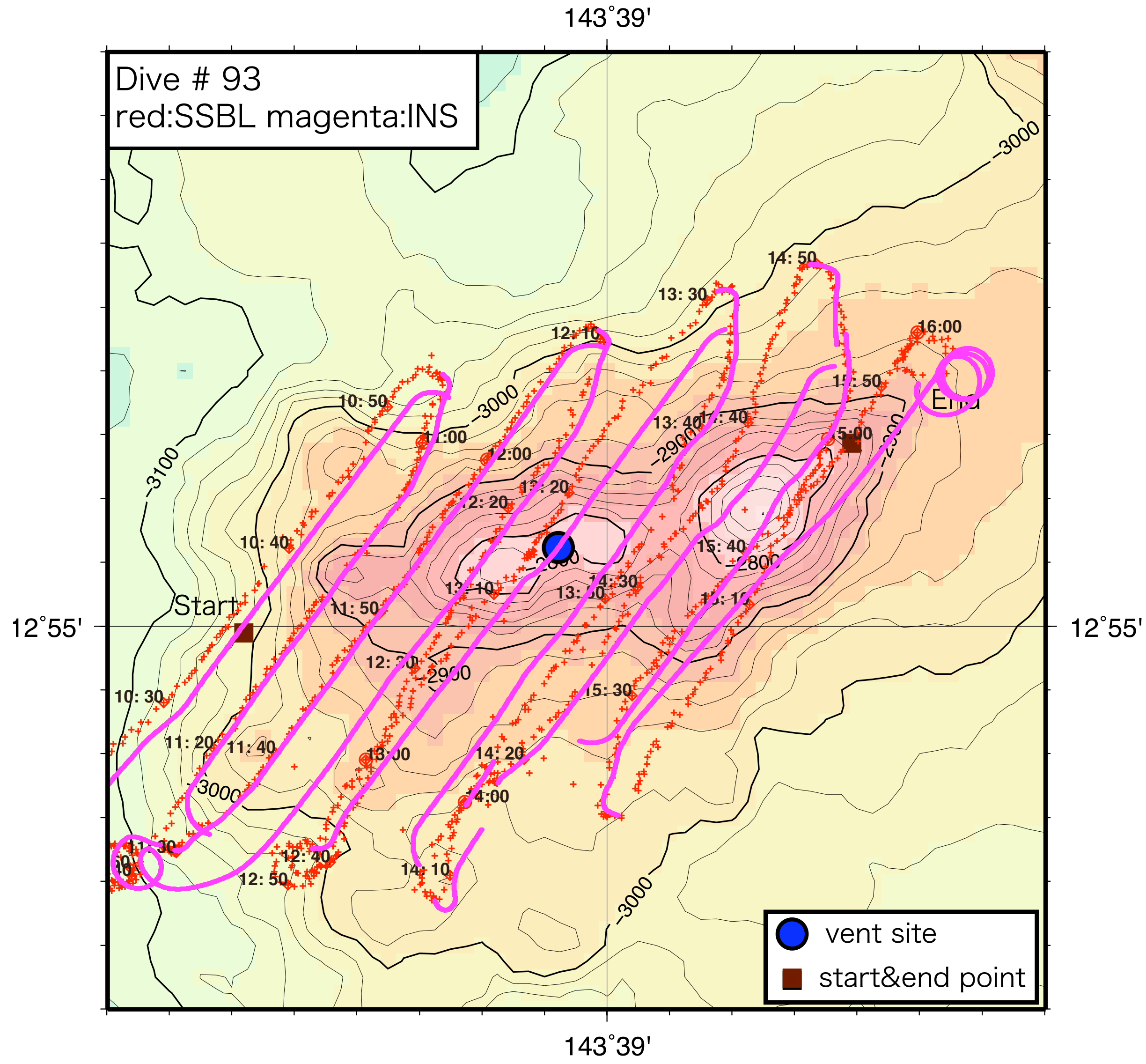


Fig. 6.5 URASHIMA Dive#93 track chart on bathymetry map

Dive#94		13 July 2009
Area	:	Southern Mariana Trough
Site	:	Fryer-Archean-Pika hydrothermal vent area
Main Target	:	plume mapping and side-scan sonar imaging
Control	:	alt=150~200m, manual operation (**no position up**)
Payloads	:	SEABAT multibeam echo sounder
		EdgeTech sidescan sonar
		Sub bottom profiler
		water sampling bottle x 24
		Fluxgate magnetometer x 4
		Overhauser magnetometer x 1
		pH sensor x 1
		H2S sensor x 1 (no data)
Average speed of viecle:		2.6 knot
Depth range	:	2663~2956 m
Altitude range	:	80~over 200 m

Events

JST (UT)	Descriptions
08:42 (23:42, 12 Jul.)	AUV on surface
10:35 (01:35)	pass the first WP, start survey
13:43 (04:43)	pass the last WP, end of survey
14:35 (05:35)	AUV on surface
15:00 (08:00)	AUV on deck

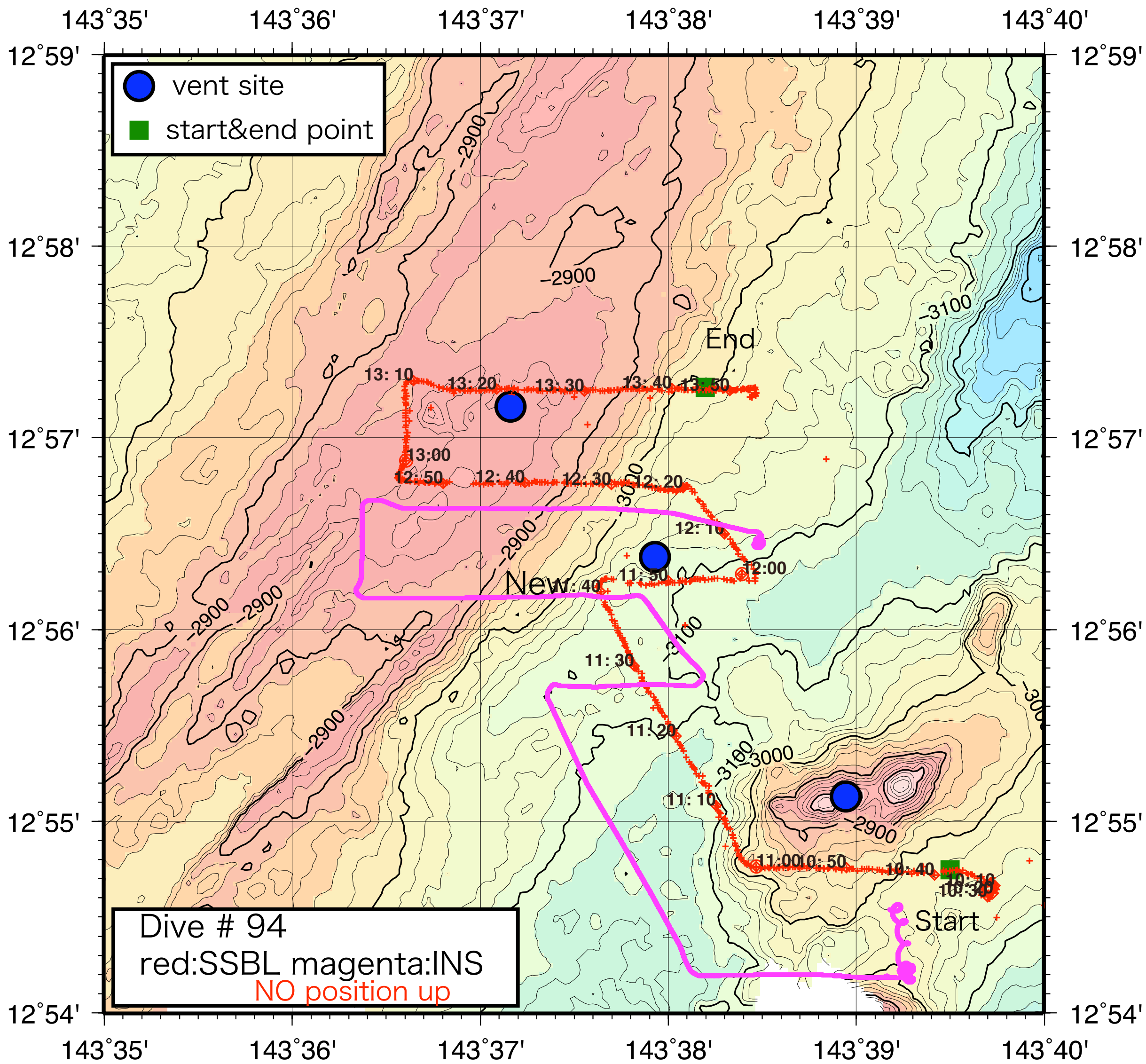


Fig. 6.6 URASHIMA Dive#94 track chart on bathymetry map

6.3 10K Free fall camera

6.3.1 General description and sediment cores

Taishi TSUBOUCHI

Dive#1

1. 10K Free fall camera system and saline mud sampling at Challenger Deep (Fig.6.7)

On July 6, 2009, we tried to get hadal sea floor mud sample with 10K Free fall camera system at Challenger Deep, Mariana Trench. The system was thrown in the surface sea at the point of 11^o 22’ 1803N – 142^o 26’ 0162E. It foundered at a velocity of 54.7 m per second and taking about 3 hours, arrived in the sea floor at the point of 11^o 22’ 3130N – 142^o 25’ 9412E, which depth is 10,8667 m. We set up to turn on the lighting device and the VDTV camera to record abyssal ocean image at 8,800 m depth and to turn off after 4 hours. It was necessary to calibrate the landing point information for 1 hour. After that we sent the ballast-delinking signal, the camera system started floating at a velocity of 50.1 m per second. We withdrew the system and checked the bottom sampler “*Ashura*” to certain the volume of saline mud yield. As a result, we got about 4.6 l of saline mud sample.

2. Genomic DNA and Total RNA of the microbes extraction from saline mud of sea floor sample

Microbial genomic DNA is extracted from mud sample for clone analysis and to use meta-genomic analyses. On the other hand, Total RNA extracted from the same saline mud is used for the verification whether the microbes are vegetative or not (or dormant). The genomic DNA and total RNA extracted are stored in -80°C freezer.

3. RT-PCR assay

Total RNA extracted from saline mud is used for reverse transcription reaction as a template. These primers used are Bac797R, Bac806R and Bac1200R for bacteria detection, Arch806R and Cren957R for archaea, Eyu1747R and Eyu539R for eukaryote and UNI806R for most microbes. The cDNA product are stored at -80°C.

4. Yeast/eukaryotes screening

The saline mud samples are spread on the appropriated medium to isolate yeast and eukaryotes. The medium consists of YPD medium diluted by tenth and 3% NaCl, and antibiotics.

5. Sample sore

The remaining saline mud sample (approximately 3.0 l) was repackaged into small sizes an stored in -80°C freezer.

Dive#2

1. *10K Free fall camera system and saline mud sampling at Challenger Deep* (Fig.6.7)

On July 10, 2009, we tried the 10K Free fall camera system to collect saline mud again at Challenger Deep. The system was thrown into the surface water at the point of 11^o 22’ 0443N – 142^o 26’ 1082E. It foundered at a velocity of 56.7m per second and arrived in the sea floor at the point of 11^o 22’ 1136N – 142^o 25’ 8547E, which depth is 10,897m. At this time, we set the HDTV camera record on to prevent improper operating signal of video-platform. After the calibration, the system was remained for 2.5 hours at the sea floor to capture more amphipoda than that of dive#1. Then, we sent the ballast-delinking signal, the camera system started floating at a velocity of 49.0 m per second. We withdrew the system and checked the bottom sampler “*Ashura*” to certain the volume of saline mud yield. As a result, we got about 4.0 l of saline mud sample.

2. Yeast/eukaryotes screening

About 0.5 ml of the saline mud samples are spread on the appropriated media to isolate yeast and eukaryotes. The media consists of YPD medium diluted by tenth and 3% NaCl, and antibiotics.

3. Sample store

The saline mud obtained was stored as mentioned below; each 0.8 l of saline mud was stored in the condition on aerobic or anaerobic, at 4°C; 2 l of mud was stored at -80°C; the water lied directly on the surface mud was stored at -80°C.

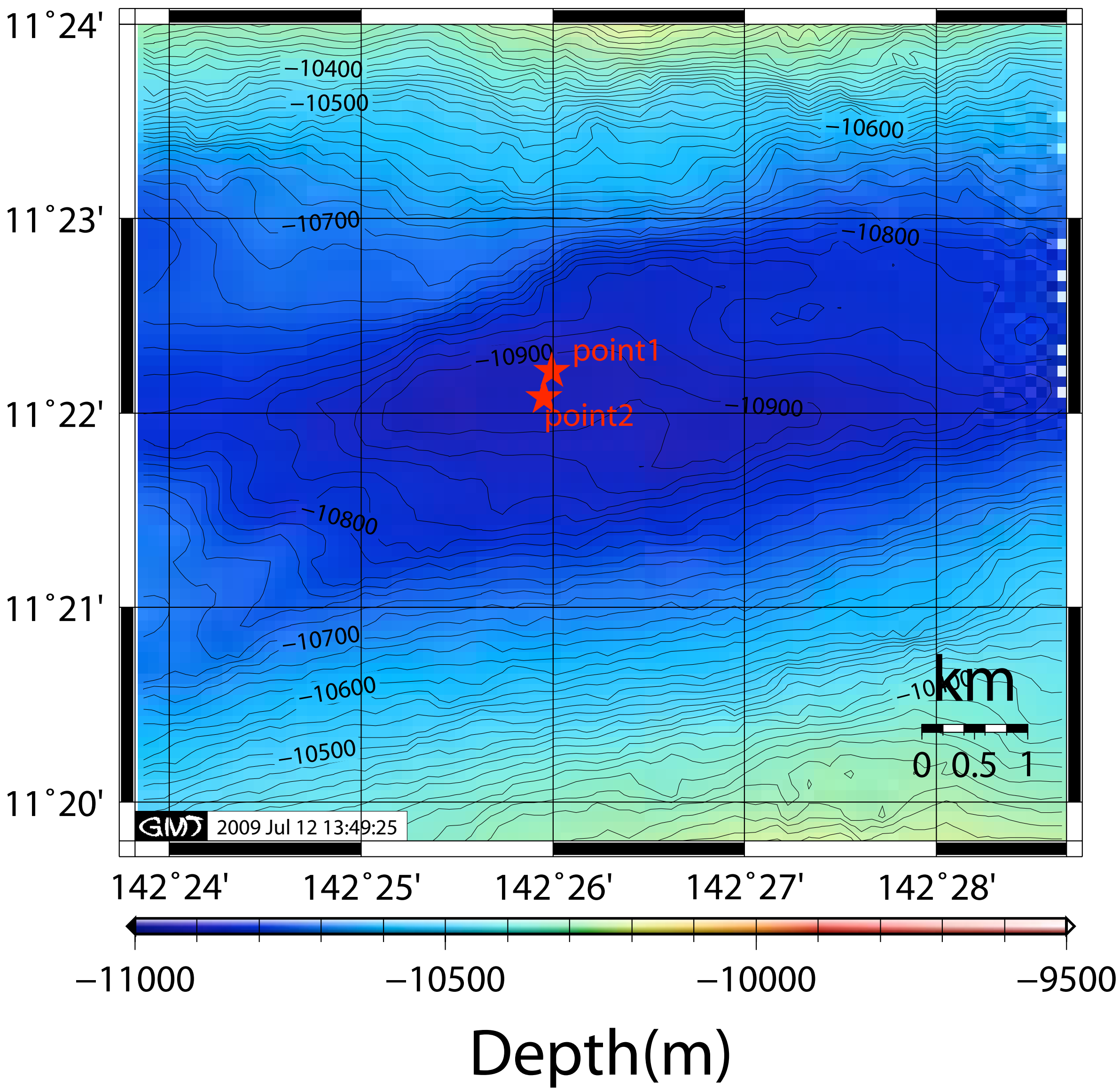


Fig. 6.7 Locations of 10K Free fall camera Dive #1 and #2 at the Challenger Deep

6.3.2 Bait trap

Hideki KOBAYASHI

Ecological study of hadal sea lives

Hadal sea is on of extreme environments for high hydrostatic pressure and oligotrophy. Indeed, there are a number of bacteria, which can grow under high hydrostatic pressure about 100 MPa. However, a large number of sea lives have been observed and collected from the Challenger Deep (Depth; 10,000m). The hadal sea lives of the Challenger Deep are mainly amphipoda and sea cucumbers. Why are they gathering in Challenger Deep? Why can they survive under the high hydrostatic pressure? What are they eating in poor sea floor? The biology of hadal sea lives is still unknown. In this cruise, we try collecting amphipoda as well as unknown hadal sea lives at the Challenger Deep with bait traps. In addition, soil microbes are also investigated to understand habitat of hadal sea lives.

Dive#1

1. Collection of hadal sea lives at Challenger Deep

We tried collecting hadal sea lives with 5 bate traps. The bait trap is a small polypropylene box (100x80x200-300 mm) containing small fish fillet. One bait trap has a fish filet in metal cage to avoid eating bait (Oazuke-trap). The bait traps were equipped to the leg of 10K camera system “Ashura”. As the result, two amphipoda are collected from bait trap. They are about 3x1.5 cm in size.

2. Analysis of hadal sea lives

One amphipoda is used for extraction of fatty acid with mixture of chloroform and methanol (1:1). The other amphipoda is used for somatic cell cultivation.

3. Analysis of microbes in the soil of sea floor

The soil samples are spread on the various media to isolate bacteria and eukaryotes. In addition, DNA in soil is extracted for clone analysis. DNA sample is stored in -80°C freezer.

Dive#2

1. Collection of hadal sea lives at Challenger Deep

Basically, the same bait traps as Dive #1 are set to Ashura. As the result, 120 amphipoda are collected from a bait trap, and 53 amphipoda are collected from a Oazuke-trap.

2. Analysis of hadal sea lives

32 individuals are used for fatty acid extraction, 8 individuals are stored in -80°C freezer, 10 individuals are used for microorganisms isolation, and 3 individuals are used for cell cultivation from 53 individuals in Oazuke-trap, respectively. 1 individual is used for enzyme assay, 25 individuals are transferred to MIURA, and 94 individuals are stored in -80°C from 120 individuals in normal bait trap, respectively.

3. Analysis of microbes in the soil of sea floor

The soil samples are spread on the various media to isolate bacteria and eukaryotes. In addition, DNA in soil samples of bottom and top core sampler is extracted for clone analysis. DNA samples are stored in -80°C freezer.

6.4 Plankton net

Takeshi MIURA

During YK09-08 cruise, we towed the plankton net at four sites (Table 6.1, Fig. 6.8) . We went to the left side on the upper deck for 8~17minutes. The samples were observed under the microscope (×20). After the filtration (5 micro meters filter: ADVANTEC) of plankton samples, the filter was cultured in Marine broth 2216 (Difco) in 1/10 Marine broth containing 3% NaCl at room temperature on light. A part of filters were stored in 15% glycerol at 4°C for future works.

Sample No.	Sampling point	Water temperature (°C)	Day (JST)
YK09-08_PN01	34° 03.5810N 139°53.7122E	21	2009/6/29, 15:23～15:31
YK09-08_PN02	12° 52.1769N 143°50.7988E	29.9	2009/7/3, 7:44～8:01
YK09-08_PN03	27 ° 57.1N 137 ° 36E	28.6	2009/7/16, 5：50～6：22
YK09-08_PN04	30 ° 11N 136 ° 39.9E	28.4	2009/7/16 15：42～16：15

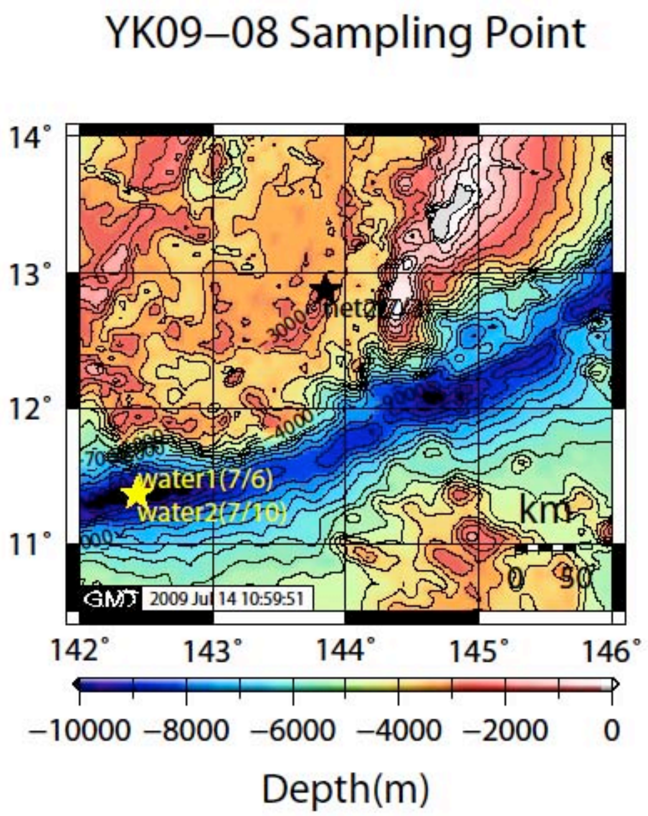


Fig. 6.8(a) Sampling points of plankton net PN01 and PN02.

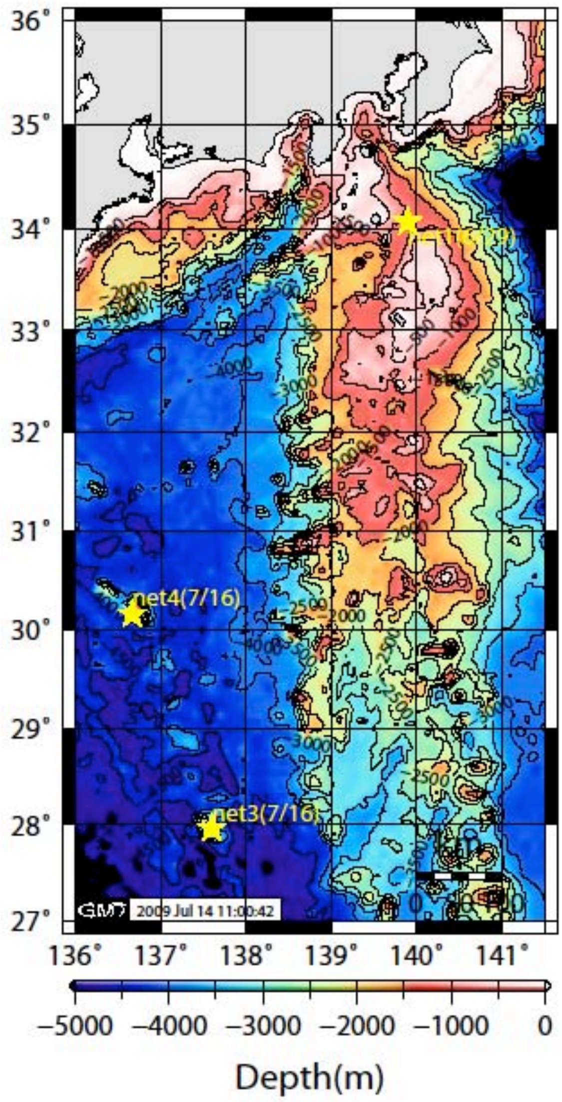


Fig. 6.8(b) Sampling points of plankton net PN03 and PN04

6.5 Surface water sampling

Takaaki KUBOTA and Takeshi MIURA

The 10, 15, 30, 15, and 15 liter of seawater samples were collected from surface of the ocean on June 29, July 03, July 10 and July 16 (Table 6.1, FIg. 6.8), respectively. A 7.5-liter metallic bucket tied with a 20-m long rope and two 18-liter plastic buckets were prepared. The metallic bucket was washed with seawater before using. Following the rope work, the seawater sample was transferred into the 18-liter plastic bucket after rinsing the inside. The almost seawater samples were filtered through both 5-micron filter and 0.22-micron filter, these filters were stored at 4˚C or -30˚C. The rest of the seawater samples were stored at 4˚C.

We have isolated a variety of microbes from surface water and deep sea sediment. They have potential values for industrial applications. We will investigate the following issues using surface water: (1) isolation of algae capable of applying for industrial uses (2) isolation of microorganisms capable of applying for industrial uses, e.g. production of useful enzymes; (3) evaluation of tolerance of microorganisms to harmful materials and environments, e.g. organic solvents, oxidative materials, heavy metals, alkaline pH, acidic pH, high salinity;

7. Future studies

Kyoko OKINO (Ocean Research Institute, University of Tokyo)

Estimation of AUV's position

Two navigation systems were worked, super short base line (SSBL) and inertial navigation (INS) during the URASHIMA dives. I will try to integrate these two datasets in order to estimate the AUV's position in higher reliability. Then final position data will be fixed by comparing micro topographic features recorded in different survey lines.

Analysis of microbathymetry

Data processing of SEABAT raw data using CARIS will be completed and 2m-grid 1m contour bathymetry maps will be created for three hydrothermal sites. I will then analyze the volcanic and tectonic features based on these maps and investigate the tectonic background of the hydrothermal circulation.

Miho ASADA (JAMSTEC)

First, I will perform processing and analysis on EdgeTech 120 kHz sidescan sonar data. Reliable mosaic image, which brings out the best performance of the *URASHIMA*'s high quality sidescan sonar imagery, will be output after the needed processing on the sidescan sonar data. Then, detail geological mapping on the mosaic will be done. An appropriate statistical analysis of geological feature will also be applied on the mosaic image.

To the second, unidentified backscattering patterns of EdgeTech 120 kHz sidescan sonar data in water column will be recognized. The detail position of unidentified patterns along 4 dive records will be drawn on the sidescan sonar mosaic image.

At the same time with processing of sidescan sonar data, I will deal SEABAT 400 kHz multibeam bathymetry data obtained by AUV *URASHIMA*. I will try to make compatible positions and geological interpretations between two data sets, 400 kHz bathymetry data and 120 kHz sidescan sonar data. After fixing position of multibeam bathymetry data, 400 kHz sidescan sonar data will be extracted. The 400 kHz sidescan sonar data will give us more detail geological features on seafloor. Comparison between two sets of sidescan sonar imageries will show us more reliable geological seafloor map. An appropriate statistical analysis of geological features will also be applied on the 400 kHz sidescan sonar imagery, too.

As a whole, I'll try to make a map of hydrothermal vents distribution over the YK09-08 survey area. Interpretations on high resolution mosaics and bathymetry maps including unidentified high backscatter patterns in water column will show us geological background which hosts hydrothermal vents.

Yoshifumi NOGI (National Institute of Polar Research)

Magnetic effect of AUV *URASHIMA* will be estimated using clockwise and counter clockwise turns during descending and ascending of the AUV. Variations of geomagnetic anomaly fileds will be determined along the all dive tracks after correcting the AUV's magnetic field and subtracting IGRF. Magnetic structures are speculated from those vector magnetic anomaly fields around hydrothermal vent sites, and depth of the magnetic source are also deduced from different depth level of the magnetic anomaly signals.

Nobutatsu MOCHIZUKI (Ocean Research Institute, University of Tokyo)

On the basis of the magnetic anomalies, we are going to calculate magnetization models of the oceanic floor by using forward and/or inversion methods. Next year we are going to sample basaltic rocks of oceanic floor using a drilling system (BMS) and plan to collect basaltic rocks from the areas which correspond to magnetization lows/highs in the models noted above. Remanent magnetization and magnetic property of the collected rocks will be measured. On the basis of the measured rock-magnetic data, we will give the constraints on the distribution of magnetization and can make a more reliable forward model of magnetization distribution. These magnetization models will clarify the horizontal (and approximate vertical) distribution of altered rocks of the hydrothermal vent fields, Snail (Flyer), Archean, and Pika sites, in the southern Mariana.

Takuroh NOGUCHI (Kochi University)

I will conduct the chemical analysis on the plume fluid samples collected during this YK09-08 cruise. Elements and/or chemical species to be measured are described as follows;

(1) heavy metal elements (manganese, iron, zinc, copper, etc.)
(2) major cation and anions (sodium, magnesium, calcium, potassium, chloride, and sulfate)
(3) nutrients (silicate, phosphate, ammonium, nitrate, and nitrite)

Based on these geochemical results, microbial results, and geological results, we will discuss the temporal and spatial variation of hydrothermal plume including the microbial activities and geochemical evolution.

Michinari SUNAMURA (University of Tokyo)

The distribution of plume was successfully detected at Snail, Archaean, and Pika site with temperature and pH anomaly. Together with the geographical data and AUV position, we are going to process the temperature and pH data for the three-dimensional mapping of the hydrothermal plume. onshore collaborator: Tatsuhiro Fukuba, IIS, Univ. Tokyo

In this cruise, we collected plume water samples using the water sampler (see 5.4.8 in detail). Microbial cells in water samples were stained with fluorescent dyes, e.g. SYBR Green 2 and CFDA, and the stained cells were counted using Flow-Cytometry system (CellLab Quanta, Backman) within 12 hours after sample retrieval. These data will be analyzed on land to determine the total microbial cell and the CFDA positive cell densities.

Other 100 mL of water sample was collected in plastic bottle and 9 mL of 38% formalin was added to the water sample to kill and fix the microbial cells in the water. The water samples were stored in refrigerator at 4°C for 12 hours. Microbial cells in the water sample was filtered on 0.2μm-pore-sized polycarbonate membrane. The microbial cells on the membrane filter will be stained and determined using the FISH method.

These microbial cell data will compare with geographical and geochemical data to study microbial ecology and microbial impact on the deep sea environment.

Hiroyuki YAMAMOTO (JAMSTEC)

Biodiversity of marine microbial community

Data base projects in JAMSTEC recently launched a biological information system for marine life (BISMaL). This system collects all data of the JAMSTEC research cruises, including applied proposals, but currently microbes and environmental data are out of scope. Thus, total information system directly connecting between research vessel and database should be developed.

The water sampler used in this cruise is a stand alone system, which also can accepts a signal of external instruments (CTD, computers), and cable communication. Advanced system combined with physicochemical sensor and in situ experiment tool should be needed to measure the microbial activity in pelagic water.

The distribution pattern of gene and species between terrestrial and marine is a issue on evolutionary history. This phenomenon is fundamental query even in the microbes. A part of the water samples will be served for the study of gene distribution pattern in marine environments, which collaborate with Dr Yoshikazu Ishii, Medical School, Toho University.

Taishi TSUBOUCHI (JAMSTEC)

10K Free fall Camera system and mud sampling

In this cruise, we succeeded in recording the environment of hadal sea floor at Challenger Deep, Mariana Trench, although there are still many problems remaining. One of the most important problems is how we'll get the video image more clearly and crispy. As it now stands, we set the camera system at higher position than past installation site. Otherwise, we buy in a set of camera system and have that one in place. In the point of recording extensively, the latter solution is favorable, at the same time suffering from lack of a funding.

As regards sampling saline mud, we could get enough volume of mud for investigating for microbial assays, probability of survival, screening of valuable microbes and substances, genomic DNA and total RNA extraction for meta-genomics and biogeochemical analyses. On board in ship, genomic DNA and total RNA were extracted, so we'll check the phylogenetic relationships of microbes at Challenger Deep, Mariana Trench after disembarkation. In addition, looking into how kinds of microbes are able to survive in the severe environment, how do they produce the community, what kinds of substances are there and utilizing, and so on are interesting topic on microbial ecology.

Hideki KOBAYASHI (JAMSTEC)

Amphipoda in bait trap

The chemical composition, genetics, symbiotes and any adherent microbes of hadal sea lives are important information to investigate adaptation mechanisms in hadal sea. We will study each component in the future, as well as fatty acid. A lot of amphipoda stored in -80°C freezer will be used for enzyme isolation or fatty acid purification. In addition, cultivation of somatic cell is also interesting trial to understand hadal sea lives. The relationship between amphipoda and soil microbes will be also investigated and explore the world of hadal sea habitat.

Takeshi MIURA (University of Toyo)

We will isolate a variety of microbes from the plankton net sample. Isolation of microbes will be examined and stocked in 15％ glycerol at -80^{o}C for a future works. Isolation of algae and microorganisms capable of applying for industrial uses e.g. production of useful enzymes.

Takaaki KUBOTA (JAMSTEC)

We will investigate the following issues using seawater samples and those filters: (1) isolation of microorganisms capable of applying for industrial uses, e.g. production of useful enzymes. (2) comparison with biodiversity of aerobic bacteria from sediments of Challenger Deep.

Hiromi UCHIDA (JAMSTEC)

Core sample

The comparison with previous studies is objective. Diversity of bacterial community in soil will be investigated with DNA sequences amplified by group specific primers. Bacteria grown from soil sample on agar plates will be on an advanced identification examination according to a result of 16S rRNA gene analysis after a single isolation.

Hirondellea gigas sample

The bacteria isolated from Hirondellea gigas will be a possibly related its life in the deepest sea. The 16S rRNA gene analysis and species identification will be done to isolated bacteria to understand relationship to H. gigas.

Eriko TAKAHASHI (JAMSTEC)

We will study the biodiversity of fungi by two methods as follows.

(A) We spread the core-soil and amphipoda on 7 kinds of agar plates for isolation of fungi. In addition, we used 4 kinds of liquid cultures for baiting deep-sea fungi. 28S rRNA gene analysis will be done for identification of species after isolation of each strain.

(B) We will try PCR cloning method for study of the diversity of fungi in the deepest sea. We directly extract DNA from the core-soil and amphipoda for amplification of 18S rRNA gene by specific primers. The amplified 18S rRNA genes will be analyzed about the fungi specific sequences by auto-sequencer.

The results of those analyses will help the study of biodiversity and ecology of deep-sea fungi.

YK09-08