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YK09-13_Leg2 Cruise Report

November 2, Port Louis, Mauritius – November 18, Port Louis, Mauritius, 2009

Japan Agency for Marine-Earth Science & Technology

Contents

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We thank all the JAMSTEC personnel who have supported us. Finally, we would like to appreciate all the persons who supported directly or indirectly this cruise.

Cruise Log of YK09-13 Leg 2

Shipboard Log & Ship Track (YK09-13Leg2)				Position/Weather/
Date	Time	Description	Remarks	Wind/Sea condition (Noon)
02Nov09	9:00	Departure from Port Louis	Shifting	11/02(UTC+4)
	10:00	Living seminar		19-44.5S 057-41.0E
	19:00	Sci meeting		Cloudy
				East-5(Fresh breeze)
				Sea Slight
03Nov09	9:00	Safety exercise	Shifting	11/03(UTC+5)
	10:00	Shinkai6500 meeting		22-05.0S 062-57.0E
	15:00	SCS meeting		Fine but Cloudy
				East-3(Gentle breeze)
				Sea Slight
04Nov09	16:59	XBT	Kairei Field	11/04 12:00(UTC+5)
	18:06	MBES		24-43.0S,1068-40.5-17.0E
				Fine but Cloudy
				East-3(Gentle breeze)
				Sea Slight
05Nov09	11:13	start of SCS Survey	Kairei Field	11/05 12:00(UTC+5)
				25-25.0S, 069-47.0E
				Fine but Cloudy
				East-4(Moderate breeze)
				Sea Slight
06Nov09	6:00	End of SCS survey	Kairei Field	11/06 12:00(UTC+5)
	09:49-17:36	Dive#1169		25-19.3S, 070-02.4E
				Fine but Cloudy
				NE-4(Moderate breeze)
				Sea Slight
07Nov09	09:51-16:52	Dive#1170	Kairei Field	11/07 12:00(UTC+5)
	20:19	Start of SCS survey		25-14.9S, 070-06.2E
				Fine but Cloudy
				NNE-5(Fresh breeze)
				Sea Slight
08Nov09	6:18	End of SCS survey	Kairei Field	11/08 12:00(UTC+5)
	09:49-17:05	Dive#1171		25-18.4S, 070-06.9E
				Fine but Cloudy
				NE-4(Moderate breeze)
				Sea Slight
09Nov09	5:52	XBT	Edmond Field	11/09 12:00(UTC+5)
	6:03	MBES		23-52.7S, 069-35.8E
	09:48-17:24	Dive#1172		Fine but Cloudy
				ENE-4(Fresh breeze)
				Sea Slight
10Nov09	09:50-17:32	Dive#1173	Kairei Field	11/10 12:00(UTC+5)
	20:54	Start of SCS Survey		25-16.5S, 070-07.3E
				Fine but Cloudy
				East-4(Moderate breeze)
				Sea Slight
11Nov09		SCS Survey	Kairei Field	11/11 12:00(UTC+5)
				25-21.0S, 070-01.0E
				Fine but Cloudy
				ENE-4(Moderate breeze)
				Sea Slight

12Nov09	5:45	End of SCS Survey	Kairei Field	11/12 12:00(UTC+5)
	09:46-17:23	Dive#1174		25-19.2S, 070-02.4E
				Fine but Cloudy
				East-4(Moderate breeze)
				Sea Smooth
13Nov09	09:45-17:34	Dive#1175	Kairei Field	11/13 12:00(UTC+5)
				25-19.3S, 070-02.4E
				Fine but Cloudy
				East-5(Fresh breeze)
				Sea Moderate
14Nov09	09:51-17:27	Dive#1176	Kairei Field	11/14 12:00(UTC+5)
				25-16.5S, 070-05.5E
				Fine but Cloudy
				ESE-4(Moderate breeze)
				Sea Smooth
15Nov09			Shifting	11/15 12:00(UTC+5)
				24-23.0S, 065-37.0E
				Fine but Cloudy
				East-4(Moderate breeze)
				Sea Slight
16Nov09	14:00	Scientist meeting	Shifting	11/16 12:00(UTC+5)
				22-59.0S, 058-59.5E
				Fine but Cloudy
				East-4(Moderate breeze)
				Sea Slight
17Nov09	9:00	Accomprishment briefing	Shifting	11/17 12:00(UTC+4)
				20-36.5S, 056-55.0E
				Fine but Cloudy
				East-4(Moderate breeze)
				Sea Smooth
18Nov09	10:00	Arrive at Port Louis	Shifting	

Ship Track


YK09−13 Leg2 Nav Track
56˚
58˚
60˚
62˚
64˚
66˚
68˚
70˚
72˚
−18˚
−20˚
−22˚
−24˚
−26˚
−28˚
2009 Nov 19 14:24:24
R/V YOKOSUKA, Mercator Projection,Data_source=SOJ

I. CRUISE SUMMARY

In this cruise, we have successfully conducted 8 *Shinkai 6500* dives; 3 dives at Kairei hydrothermal field, 1 dive at the Edmond hydrothermal field, and 4 dives at the area among the URANIWA-Hills, Hakuho-knoll, and inside corner high of the CIR Segment 1 (this area here after designates the Hakuho-garden). We also performed SCS survey at the Hakuho-garden as well as 25ºS OCC (Ocean Core Complex). The main results of these observations are as follows;

1. Dives#1170 and #1176 confirm that mantle peridotite is extensively exposed at the inside corner high of the CIR Segment 1, northern part of the Hakuho-knoll. This clearly indicates that this area is one of the possible source regions for hydrogen in the Kairei hydrothermal fluids, in addition to the URANIWA-Hills that was discovered in a previous cruise.

2. Dive#1171 shows that the eastern slope of the Hakuho-knoll is composed of pillowed basalt, as in the western slope, and no exposure of gabbroic and/or peridotitic rocks is observable. This confirms that the Hakuho-knoll, hosting the Kairei hydrothermal field, is completely composed of basaltic rocks.

3. We also discovered hydrothermally altered gabbroic and doleritic rocks in a small ridge located between the URANIWA-Hills and Hakuho-knoll at Dive#1173. This suggests that exposure of deep-seated rocks, constituting the URANIWA-Hills, continues toward western part, near the Hakuho-knoll.

4. We obtained single-channel seismic reflection data for 7 survey lines. We classified lithological units using several seismic attributes along the seafloor (e.g., reflection strength, smoothness, and frequency components). The lithology variation estimated by seafloor seismic response is well consistent with Shinkai observations. We further estimated subsurface structures; fault distribution and magmatic intrusions.

5. We successfully collected various hydrothermal vent animals, and performed a variety of onboard experiments.

II. INTRODUCTION

1. General background

Since the first discovery of hydrothermal vent site at the Galapagos Spreading Centre in 1977 (Corliss et al., 1979), submarine hydrothermal systems have attracted the particular interest not only of geoscientists (concerning mantle dynamics, magmaism, tectonics), but also of chemists and biologists (e.g., Humphris et al., 1995; Van Dover, 2000; Wilcock et al., 2004). It is well accepted that hydrothermal systems operating at mid-ocean ridges (MOR) play a major role in elemental exchange between ocean and crust through the interactions of circulating seawater with the oceanic crust at various temperatures. The MOR hydrothermal fluxes are now considered to affect significantly to the ocean chemistry for many elements such as Li, Sr, Si, Mg, S (e.g., Elderfield and Schultz, 1996). Besides the chemical fluxes, it has also been revealed that the diverse populations of the hydrothermal vent-endemic animal communities are generally dependent on the primary production of symbiotic and free-living, chemolithoautotrophic microorganisms which obtain energy from inorganic substances (e.g., H_2S, CO_2, H_2, and CH_4) derived from hydrothermal vent fluids (e.g., Jannasch and Mottl, 1985). Because this type of hydrothermal ecosystems is essentially independent from photosynthesis, the sea-floor hydrothermal systems are frequently cited as possible analogues for habitable environments on early Earth as well as other planets and moons, and have also been suggested as a possible site for the origin and early evolution of life on Earth (e.g., Takai et al., 2006).

Over the past 30 years, number of hydrothermal vent sites have been discovered and investigated in the Pacific and Atlantic Oceans (e.g., German and Von Damm, 2004). In striking contrast, there are only two hydrothermal vent sites recently discovered in the Indian Ocean (Gamo et al., 2001; Van Dover et al., 2001). In order to obtain better understanding of geological, geophysical, and geochemical diversities of the MOR hydrothermal systems on a global scale, it is clear that detailed investigations (as well as additional exploration and discovery) on the Indian Ocean hydrothermal systems are required. Moreover, the Indian Ocean ridge system is known to serve as a conduit for exchange of vent-endemic taxa between the Pacific and the Atlantic Oceans and to foster indigenous chemosynthetic animal taxa, too (Van Dover et al., 2001). Detailed biological investigations on hydrothermal vent sites in the Indian Ocean could, thus, also provide important insights into the biogeography of the Indian Ocean vent fauna and its relation to Pacific and Atlantic provinces.

To date, two active hydrothermal vent sites of the Kairei and Edmond hydrothermal fields are known to exist along the Central Indian Ridge (CIR) that is a typical MOR spreading at intermediate speed of 47.5 mm/year (DeMets et al., 1990). These two hydrothermal fields are located in close to each other, only 160 km apart. However, chemical characteristics of their vent fluids are quite different. The Kairei hydrothermal field at the CIR Segment 1 near the Rodriguez Triple Junction was discovered in August 2000 as the first directly observed hydrothermal vent site in the Indian Ocean (Gamo et al., 2001). The chemical composition of the vent fluids, including major dissolved species (e.g., Si, Ca, Mg, K, SO_4) and gases (CH_4, CO_2, H_2S), was first reported by Gamo et al. (2001), showing that the Kairei fluids are generally similar to the hydrothermal fluids from typical MORs in the Pacific and the Atlantic oceans. Subsequent investigations, however, revealed that the Kairei fluids have unusually high concentrations of H_2 (up to 8.5 mM) compared to typical MOR hydrothermal fluids (Van Dover et al., 2001; Takai et al., 2004; Gallant and Von Damm, 2006; Kumagai et al., 2008). In 2004, it was suggested that a hydrogen-based hyperthermophilic subsurface lithoautotrophic microbial ecosystem (HyperSLiME) existed in the subseafloor environments of the KHF (Takai et al., 2004). This microbial ecosystem is sustained by the primary production of hydrogenotrophic, hyperthermophilic methanogens, utilizing H_2 and CO_2 as the primary energy and carbon sources. Because both H_2 and CO_2 are completely photosynthesis-independent substances, provided only by hydrothermal (geological) processes, the HyperSLiME is considered as a likely modern analogue for the early Earth ecosystems prior to photosynthesis (Takai et al., 2006). In addition to subseafloor microbes, various hydrothermal vent macrofauna were found in the Kairei field. Although *Rimicaris* shrimp was widely distributed, gastropods, i.e. *Crysomallon squamiferum* and *Alviniconcha* sp., were found only in the lower part of Monju chimney. *Alviniconcha* from the Kairei field is unique in that they harbor epsilonproteobacterial endosymbionts (Suzuki et al., 2005).

The Edmond hydrothermal field at the CIR Segment 3, 160 km north of the Kairei hydrothermal field, was discovered in April 2001 (Van Dover et al., 2001). Hydrothermal fluids collected from the Edmond filed are characterized by high-chlorinities about 70% greater than ambient seawater and high iron concentrations of 14 mmol/kg. The iron enrichment at Edmond can be considered as a result of the higher chlorinity and temperature of Edmond fluids (Gallant and Von Damm, 2006; Kumagai et al., 2008). The most obvious difference in the composition of the Kairei and Edmond fluids is H_2 concentration. As mentioned above, the Kairei fluids contain high H_2 concentrations up to 8.5 mmol/kg. In contrast, the Edmond H_2 concentrations are more typical of MOR hydrothermal vent fluids (up to 0.25 mmol/kg), indicating that the Edmond is a typical MORB-hosted hydrothermal system. Biological activity in the Edmond field seems to be lower than that in the Kairei filed. Little microbial component was recovered from chimney structures, and less diverse hydrothermal vent animals were observed in the Edmond field. Especially population of *Alviniconcha* gastropods was quite small, and no *Crysomallon squamiferum* was observed in the Edmond field.

2. Objectives of the cruise

Geological and geophysical objectives

The Kairei hydrothermal fluids are characterized by unusually high concentrations of H_2 compared to typical MOR hydrothermal fluids, whereas its geological background was previously uncertain (Van Dover et al., 2001; Gallant and Von Damm, 2006). In January 2006, we discovered serpentinized troctolitic rocks from the URANIWA-Hills near the Kairei hydrothermal field (Kumagai et al., 2008). Petrological investigations and geochemical modeling for hydrothermal alteration of the URANIWA troctorites revealed that serpentinization of the troctolitic rocks can produce enough H_2 into the Kairei hydrothermal fluids (Nakamura et al., 2009).

However, there is still another possible source region of H_2 in the Kairei hydrothermal fluids, which have not been investigated yet. On bathymetric image, an approximately 10 x 10 km size gentle hill is observable in an inside corner of the CIR Segment 1, northern part of the Hakho-knoll (where the Kairei hydrothermal field is located). This kind of inside corner high is well known to be the place where lower crustal and upper mantle rocks are uplifted and emplaced near seafloor. In addition, the fluid circulation path of the Kairei hydrothermal fluids is also still uncertain. It is obvious that clarifying the fluid circulating path and the occurrence and distribution of certain rock types in the Kairei hydrothermal systems are the important keys to understanding generation process of the unusual chemistry of the Kairei fluids and its geological background. In the YK09-13 cruise, therefore, the major geological and geophysical objectives are:

1. Elucidating the occurrence of rocks in the inside corner high of the northern-end of the CIR Segment1, northern part of the Hakuho-knoll hosting the Kairei hydrothermal field.
2. Obtaining the crustal structure (especially faults) in the shallow part of the oceanic crust at the region between the Hakuho-knoll and URANIWA Hills

using Single Channel Seismic (SCS).

3. Measuring heat flow by the Stand-Alone Heat Flow meter (SAHF) at the URANIWA Hills.

Biological and microbiological objectives

Deep-sea vents are the light-independent, highly productive ecosystems fueled primarily by chemoautotrophic microorganisms. Most of the invertebrates thrive in the ever-changing physical and chemical gradients through their relationship with proteobacterial symbionts. Deep-sea vent invertebrates inhabiting near the vent emission, e.g. shrimps and gastropods, are hypothesized to acquire their endo- or epi-symbiotic bacteria from the environment each generation. However, little is known about the molecular mechanism through which host-microbe interact with each other.

Recently, glycoconjugates have been recognized as legislators of host-microbial interactions including symbiosis and pathogenicity. For example, the attachment of *Helicobacter pylori*, a member of Epsilonproteobacteria, to fucosylated or sialylated glycans produced by various gastric epithelial lineages and their progenitors skews the destiny of colonization toward pathogenicity. Our previous work indicated symbiotic deep-sea vent Epsilonproteobacteria have characteristic N-linked glycans. These lend support to the hypothesis that the capacity to synthesize diverse carbohydrate structures may have arisen in part from the need of both host and symbionts to co-evolve symbiotic relationships with non-pathogenic resident microorganisms. The major objectives of the YK09-13 leg 2 cruise are:

1. Obtaining glycan profiles from both host animals and their symbiotic bacteria.
2. Performing wide array of "-omics" analyses, such as community genomic, proteomic, transcriptomic analyses, on both host animals and their symbiotic bacteria.
3. Cultivating and isolating epi- or endo-symbiotic bacteria and free-living counterparts.
4. Characterizing larvae of hydrothermal vent animals.
5. Keeping hydrothermal animals alive and transporting them to Japan.

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III. EXPLANATORY NOTE

1. Manned Research Submersible “Shinkai 6500”

Mission of “Shinkai 6500”

“Shinkai 6500” is able to operate surveys and observations down to the depth 6500 meters with one scientist and two pilots. During the operation, “Shinkai 6500” finds her position by two ways; Long Base Line system (LBL) and Super Short Base Line system (SSBL). The LBL system needs three bottom-mounted transponders to be deployed in the survey area. “Shinkai 6500” locates her own position by herself in real time and the mother ship determines the position of “Shinkai 6500” based on the position of transponders. The SSBL system does not require any transponder but the accuracy of the position is inferior to LBL system and “Shinkai 6500” can not determine her own position.

Specifications

Length:	9.5m
Width:	2.7m
Height:	3.2m
Weight in air:	25.8t
Maximum operation depth:	6500m
Complement:	3 (2 pilots and 1 researcher)
Inner radius of pressure vessel:	2.0m
Normal dive time:	8 hours
Life support duration:	129 hours
Payload:	150kg (weight in air)
Under water speed:	0-2.0 knots (Emergency: 2.5 knots)
Observation instruments:	Pan-tilt-zoom color video camera
	Fixed-view color video camera
	35mm still camera
	CTD sensors
	Gamma ray spectrometer
	CTFM sonar
	Video-image transmission system
Operating devices:	2 manipulators
	2 retractable baskets

2. Research Vessel “Yokosuka”

Mission of “Yokosuka”

1) Operate submersible “Shinkai 6500”

2) Operate underway-geophysical equipments;

Multi Narrow Beam Echo Sounder (Sea Beam 2112.04)

Gravity meter (Type S-63)

Ship-borne three-components magnetometer (Type SFG-1212)

Proton magnetometer (Typ STC10)

Research Facilities

In wet laboratory, a fumigation chamber, Milli-Q water purification system, -80°C and -20°C freezer, incubator and rock saw are equipped. In addition, “Yokosuka” has on-board video editing system for DVCAM, S-VHS and VHS.

Specifications

Length:	105.22m
Breadth:	16.0m
Height:	7.3m
Draft:	4.5m
Gross tonnage:	4439t
Cruising speed:	about 16kts
Cruising range:	about 9000mile

3. **Geophysics**

Single Channel Seismic Survey (SCS)

We conducted seismic reflection experiment in the Kairei hydrothermal field for the purpose of studying hydrothermal fluid path and distribution of gabbro and serpentinized peridotite identified by submersible observations. We acquired single-channel seismic (SCS) reflection data around the Kairei hydrothermal field (Fig. 3-1). We determined the location of survey lines by considering seafloor topography, because survey area has rough seafloor (Fig. 3-1). Especially because 2D seismic data usually cannot consider 3D geometrical effects in seismic processing (French, 1974), we chose the topologic high for the survey line. Furthermore, we try to conduct seismic survey along the Shinkai dive tracks (Fig. 3-2).

The data were recorded at 2 ms sampling interval. We employed two different single airgun configurations as seismic sources: (1) a 5.8 L (355 inch^3) generator-injector (GI) airgun and (2) a 3.4 L (210 inch^3) GI airgun (Fig. 3-3). At R/V Yokosuka's shooting speed of ~6.4 km/hr (~3.5 knot), shot intervals of 25 s for the 5.8 L GI airgun and 13 s for the 3.4 L GI airgun corresponded to approximately 44 m and 23 m, respectively. When we used 5.8 L GI airgun, we shoot generator and injector simultaneously to image deep structure. To image the shallow serpentinized rock, furthermore, we used 3.4 L GI airgun for two seismic lines (Fig. 3-1). The streamer cable was towed at ~18 m depth for 5.8 L airgun survey and ~10 m for 3.4 L airgun survey. Seismic data processing included band-pass filtering, deconvolution and migration (Yilmaz, 2001). Since it is difficult to extract the weak reflections at hard-rock exposed environments, we calculated several seismic attributes (e.g., instantaneous phase) and determine horizons (Taner et al., 1979; Tsuji et al., 2005).

Acquisition parameters

Airgun volume: 355 cuin
Shutting interval: 25 s (13 s for high-resolution survey)
Depth of airgun: 15 m (8 m for high-resolution survey)

Streamer length including lead-cable: 119 m
Sensor number: 1 channel with 48 grouping
Depth of streamer: 18 m (10 m for high-resolution survey)

Data format: SEGD

Recording length: 10,000 ms
Sampling interval: 2 ms

References:

French, W.S., 1974. Two-dimensional and three-dimensional migration of model-experiment reflection profiles. *Geophysics* **39,** 265-277.

Taner, M., Koehler, T., F., and Sheriff, R. E., 1979. Complex seismic traces analysis. *Geophysics* **44,** 1041- 1063.

Tsuji, T., Matsuoka, T., Yamada, Y., Nakamura, Y., Ashi, J., Tokuyama, H., Kuramoto, S., and Bangs, N., 2005. Initiation of plate boundary slip in the Nankai Trough off the Muroto peninsula, southwest Japan, *Geophys. Res. Lett.* **32,** L12306, doi:10.1029/2004GL021861.

Yilmaz, O., 2001. Seismic Data Processing: Processing, Inversion, and Interpretation of Seismic Data, Invest. Geophys. Ser., vol. 10, 2nd ed., edited by S. M. Doherty, Soc. of Explor. Geophys., Tulsa, Okla.

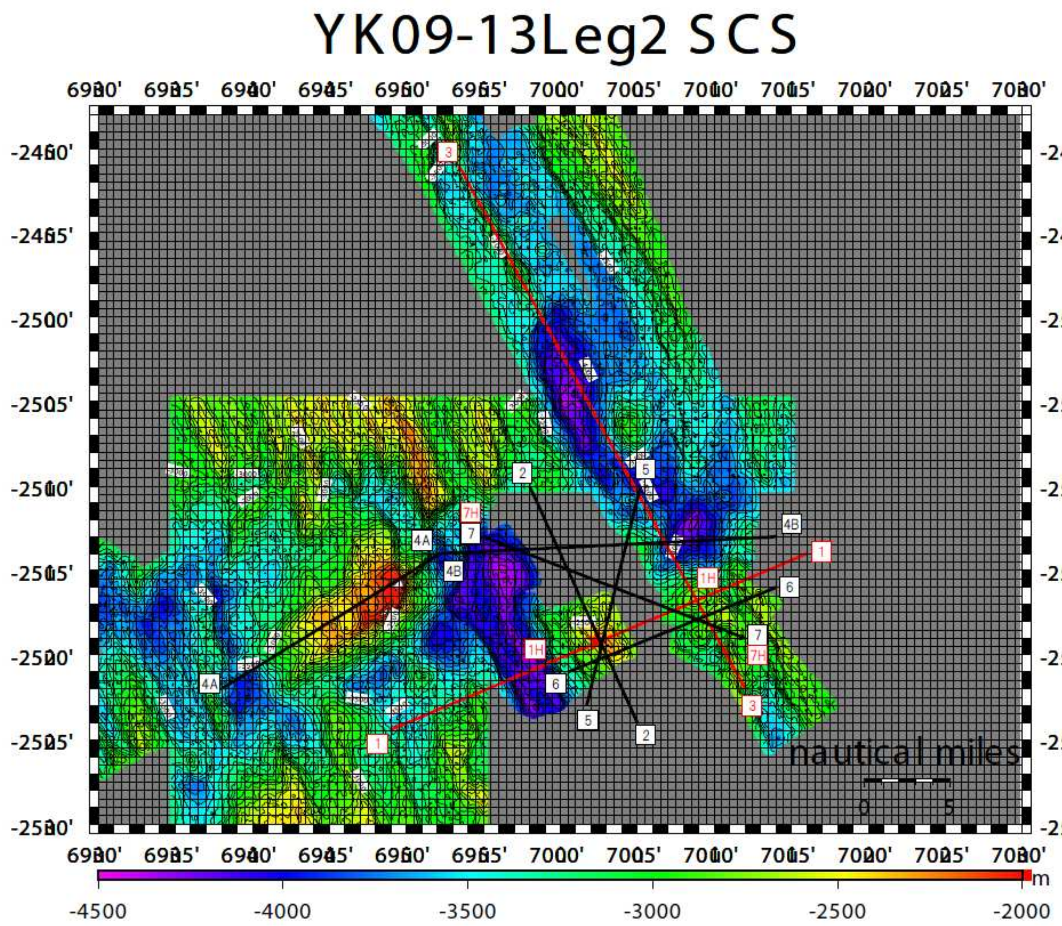


Fig. 3-1. Seismic survey lines on the bathymetric map around the Kairei hydrothermal field. The location of high-resolution seismic survey lines are shown as red lines. We conducted seismic survey for 7 lines.

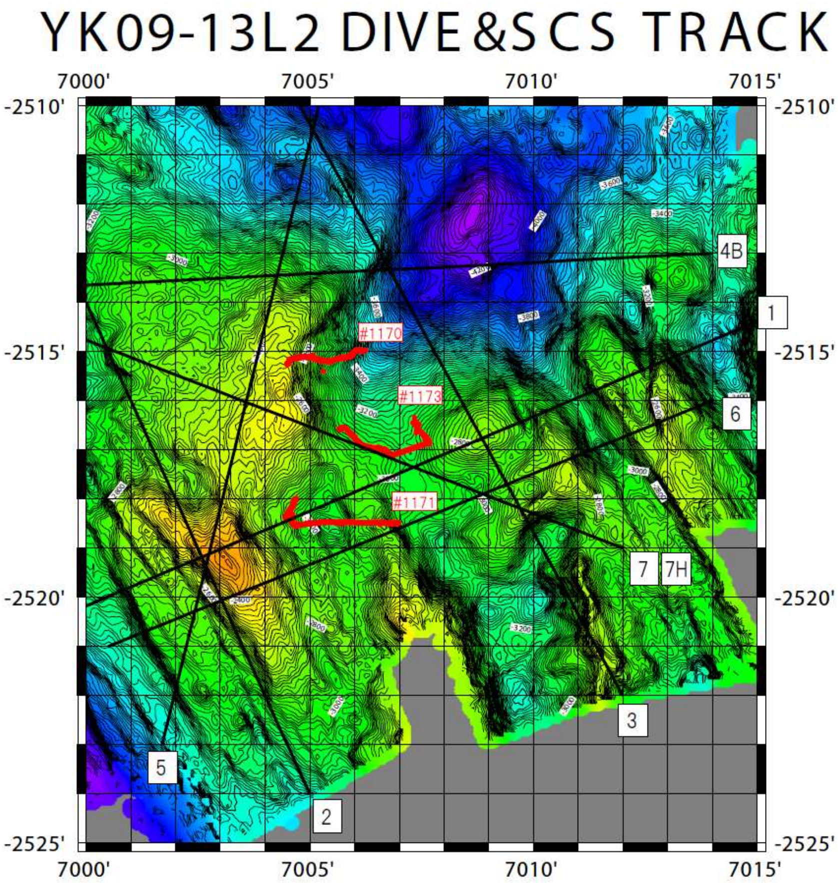


Fig. 3-2 Relative location of seismic lines (black lines) and Shinkai dive tracks (red lines).

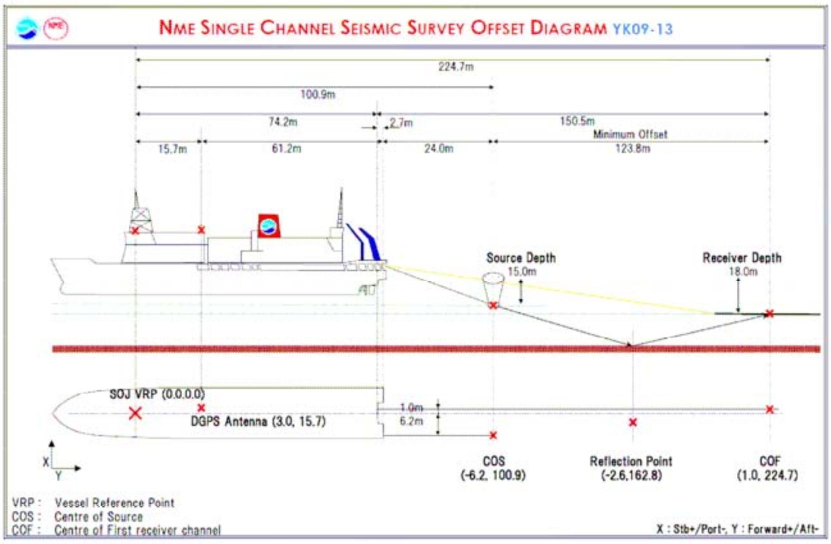


Fig. 3-3 Schematic image of single-channel seismic reflection survey.

SAHF Heat flow probe

Stand-Alone Heat Flow meter (SAHF) is designed to measure heat flow by manned submersibles or ROVs. Five thermistors situated within the probe at 11 cm intervals. Since SAHF takes measurements as "OFF LINE" system, heat flow can be measured while observer is conducting something else at that position or elsewhere. SAHF can also be used for long-term monitoring of sub-bottom temperature. We prepared two SAHFs, designated as SAHF#8 and #9, which are equipped with LED flashing during operation.

While Shinkai 6500 is descending or ascending, SAHF is set in a case inside a sample basket prepared by Shinkai 6500 operational team. After Shinkai 6500 lands on the seafloor, SAHF is grabbed by Shinkai's left manipulator and takes the reference temperature for 2-5 minutes (if SAHF locates enough at same position, temperature measurement for reference can be canceled). SAHF is then put vertically into sediment and measure temperature gradient for at 10-20 minutes. Thermal conductivity is necessary to obtain a heat flow value, which is not available on current SAHF. The description of SAHF is as follows (Fig. 3-4).

Description

Material	Alloy of titanium
Weight	3.1 kg in air, 1.5 kg in seawater
Length of pressure case	525 mm
Diameter of pressure case	85 mm
Length of probe	600 mm
Diameter of probe	13.8 mm (filled by silicon oil inside)
Number of thermistors	5
Intervals of thermistors	110 mm
Accuracy	0.01 °C
Resolution	0.001 °C
External Interface	RS232C (9600bps, 8 bit, Non-parity, 2 stop-bit)

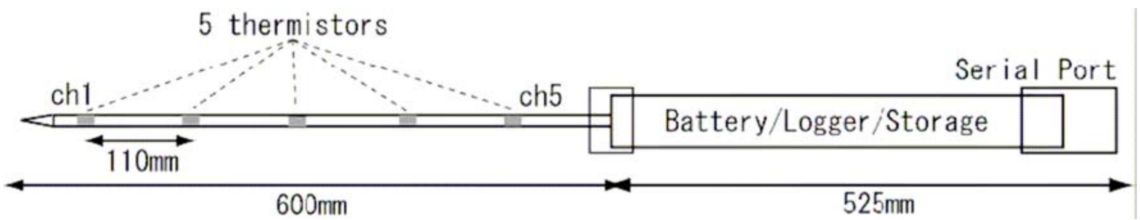


Fig. 3-4 Graphical description of SAHF

Deep-sea sub-bottom profiler

This system is a compact sub-bottom profiler for deep water, attached to Shinkai 6500. The source frequency is 10kHz, and strata (vertical) resolution is 6 cm with up to 40 m of sub-bottom penetration (depends on the sediments condition). Lower the frequency is, you get more penetration to sub-bottom layers but you lose resolution and compactness of the system. Fig. 3-5 shows sub-bottom transducer installed on Shinkai 6500. The following table represents the specifications of the deep-sea sub-bottom profiler components.

Basic specifications of Deep-sea sub-bottom profiler

Depth range	0-5, 0-10, 0-20, 0-40, 0-80, 0-150m
Strata resolution	6cm
Bottom penetration	40m (bottom type dependant)
Depth accuracy	0.5%
Transmit rate	up to 10Hz, depth and operator mode dependant
Data output	Digital ODC format and SEG-Y format
Transducer	ITC-3483
Frequency output	10kHz
Transmit output power	300W (pulsed)
Power supply	12VDC, 8W

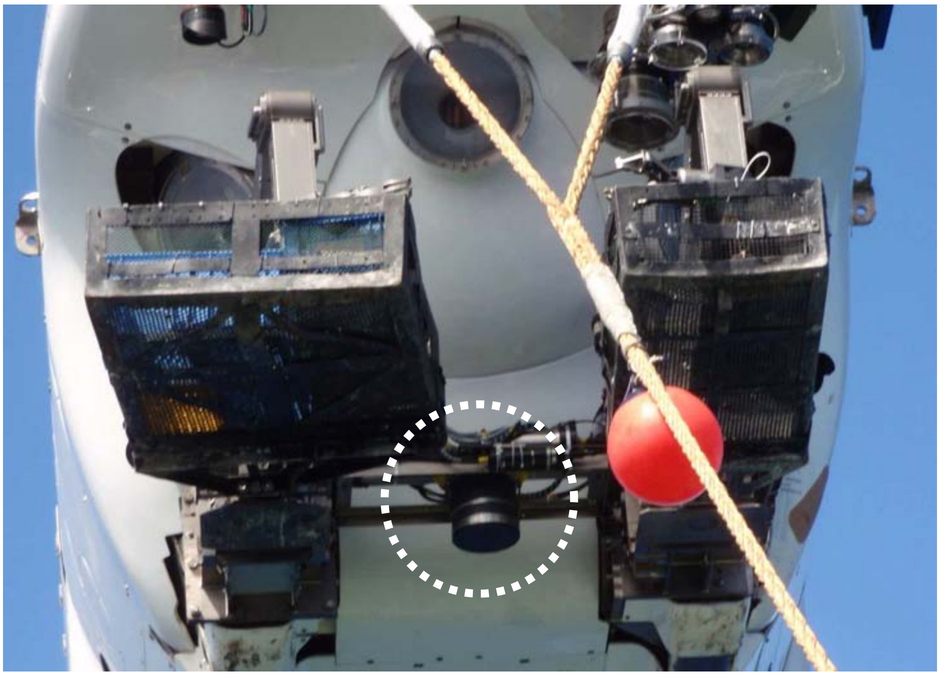


Fig. 3-5 Sub-bottom transducer installed on Shinkai 6500

Deep-sea three-component magnetometer

Vector magnetic field data were collected using a deep sea magnetometer attached on the submersible. The deep-sea three-component magnetometer "Shinkai-Miniko" (Clover tech Inc. / Ocean Research Inst. Univ. Tokyo) consists of a three-axis fluxgate-type sensor, a A/D conversion unit, a data controller/logger. The sensor and the A/D conversion unit are stored within a pressure case and the case is attached on the outer shell of the *Shinkai 6500*. The controller/logger unit is installed in the submersible. The main specification is as follows:

Specifications

Sensor and A/D unit

measurement range	± 70000 nT
orthogonality	± 20 min.
accuracy	± 200 nT
temperature stability	0.5nT/°C
resolution	1 nT
temperature range	-30~60°C
sampling rate	10 Hz
operating voltage	DC10~30V
power consumption	80 mA @ DC24V
size (pressure case)	φ70mm × 600m,
weight in air (in water)	4.2 kg (1.9 kg)
cable weight	1.2 kg (0.5 kg)

Controller / logger

recording media	compact flash memory
maximum data size	2GB
port type	RS232C (3 data port and 1 monitor port)

Installation

The sensor case is installed on fore side of the *Shinkai 6500* (Fig. 3-6), slightly biased toward starboard side. The sensor was installed at the center of the submersible during the previous cruises and the data were suffered from the noise from No.2 Camera on port side which was freely moved by observers. We tested the noise level caused by the movement of No.2 Camera and manipulators before YK09-13 and the more suitable position was selected.

The three axes of magnetometer were set to be X-positive: port side, Y-positive:

forward, and Z-positive: downward.

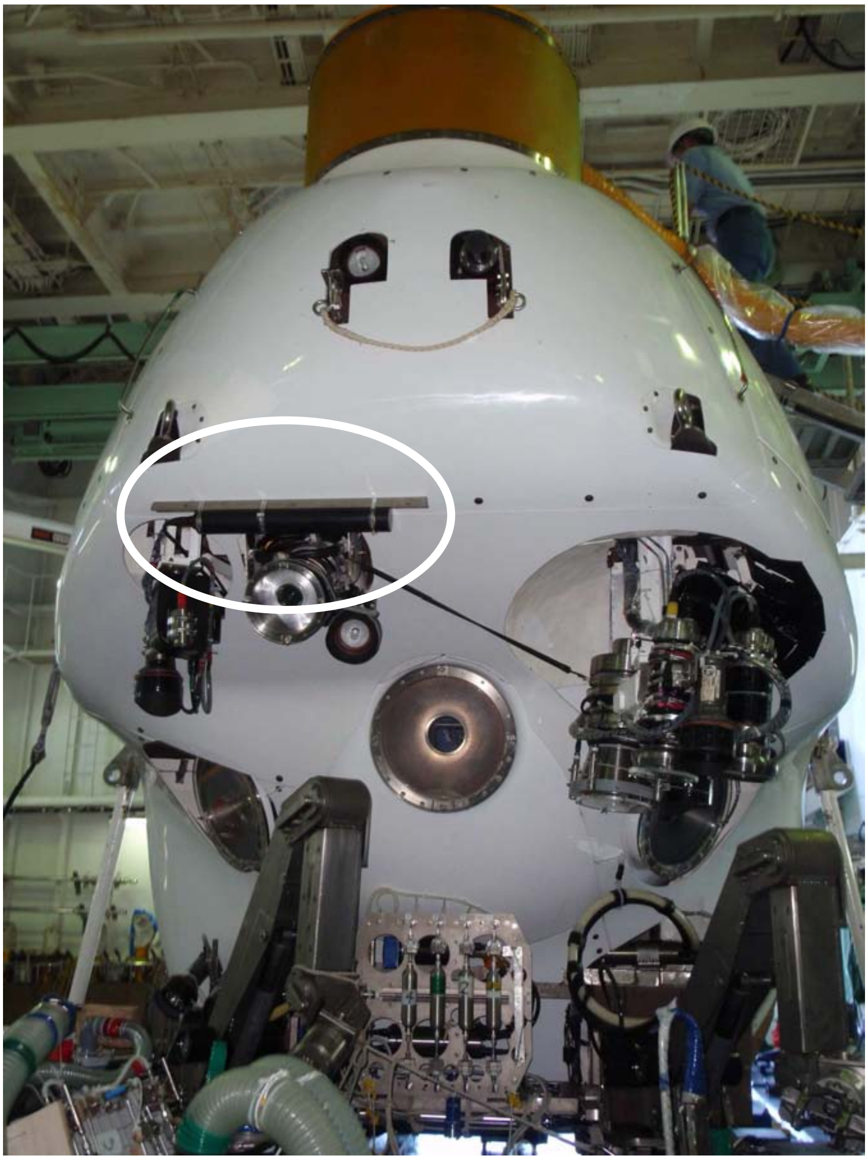


Fig. 3-6 “Shinkai-Miniko” installed on the *Shinkai 6500*.

Observation

During YK09-13 Leg2, total 8 dives were conducted and the magnetometer data were collected along Dives #1170, #1171, #1173, and #1176. The dive tracks are shown in Fig. 3-7.

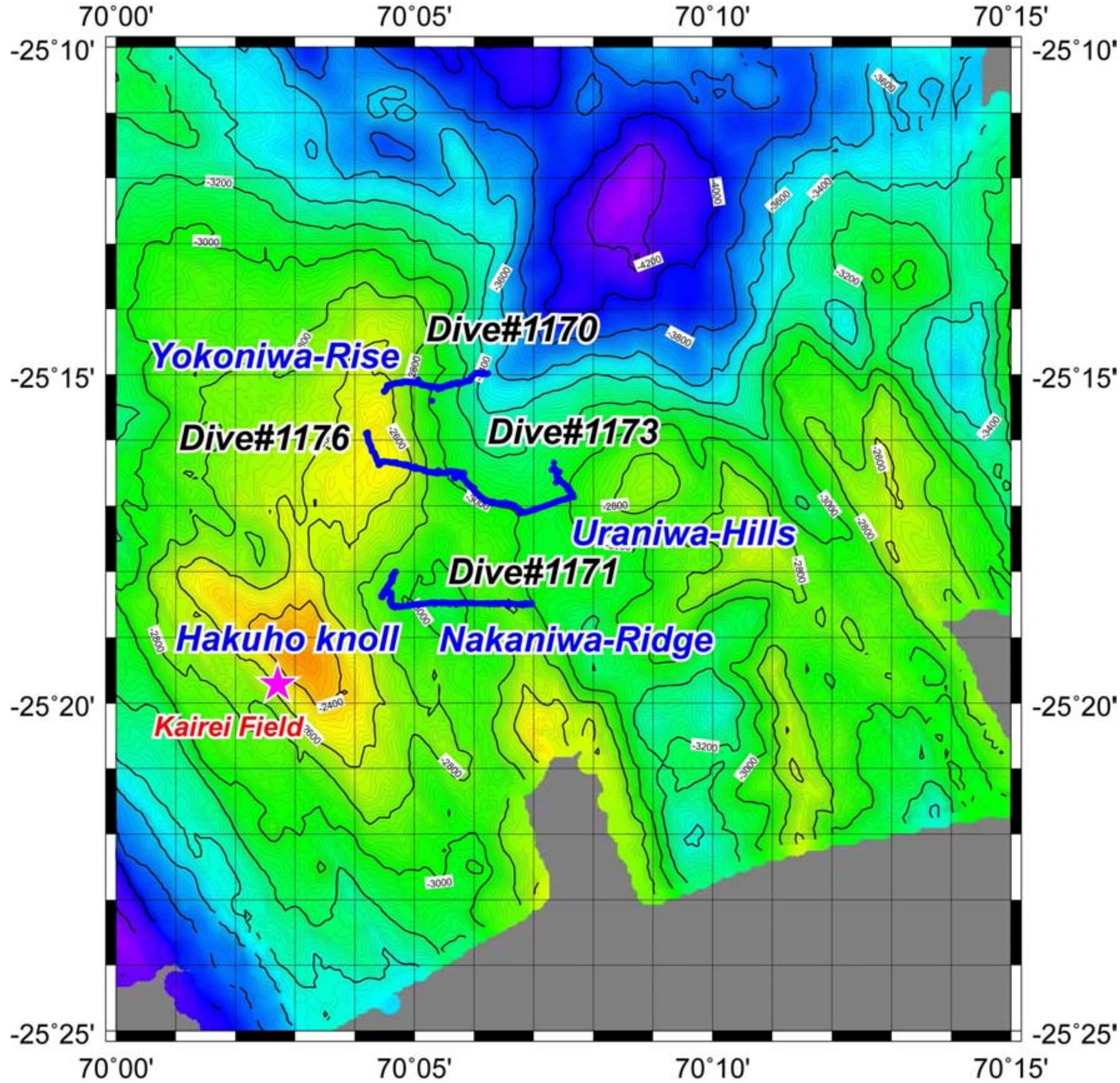


Fig. 3-7 Bathymetric map showing the dive tracks obtaining the magnetometer data.

Data processing

The relation between a vector magnetic filed observed on submersible, Hobs, (in the submersible fixed coordinate system) and the earth's geomagnetic filed, F, (in the earth's fixed coordinate system) is expressed as:

$$H_{obs}=RPYF+ARPYF+H_p \qquad (1)$$

where R, P, and Y are roll, pitch and yaw of submersible. A is a matrix which represents magnetic susceptibility of the submersible. H_p is the magnetic field produced by a permanent magnetic moment of the submersible body. The equation (1) can be rearranged as:

$$BH_{obs}-H'_p=RPYF \qquad (2)$$

where B=(A+I)-1 and H'_p=BH_p. For the submersible rotates itself during descending and ascending paths, the constants in matrix B and Hp can be estimated assuming that F is equal to the IGRF value of the area. Then the magnetic vector field along the dive tracks can be calculated by removing the effect of submersible magnetization using these constants.

No onboard processing was done during the cruise.

4. Geochemistry

WHATS fluid sampler

WHATS-II (Water Hydrothermal *Atsuryoku* Tight Sampler II) was developed for collecting hydrothermal fluid samples without any loss and atmospheric contamination of gas species. Since it overflows its sample bottle with sampling fluids, it is rather easy to collect fluids close to the endmember.

This sampling system consists of inlet tubing, 4 pressure-resistant sample bottles with ball valves at both ends (volume of one bottle: 150 ml), an arm to open and shut the valve and a deep-sea compatible pump. Usually WHATS is installed just below the shell of *Shinkai 6500* and a sample inlet is handled with a manipulator (Fig. 3-8). Operation is controlled from inside the shell. At the time of each sampling, fluid temperature can be monitored using a thermometer attached to the top of the inlet tube. It takes about 7 minutes to fill up one sample bottle of 150 ml capacity. Detailed description of the system is shown bellow.

Description

Dimension of frame:	600 mm × 660 mm
Weight:	35.2 kg in air
	28.0 kg in seawater
Depth range:	4000 m
Sample volume:	150 ml × 4
Sampling rate:	75-300 ml / min.
Electricity:	DC24 V / 1.0 A

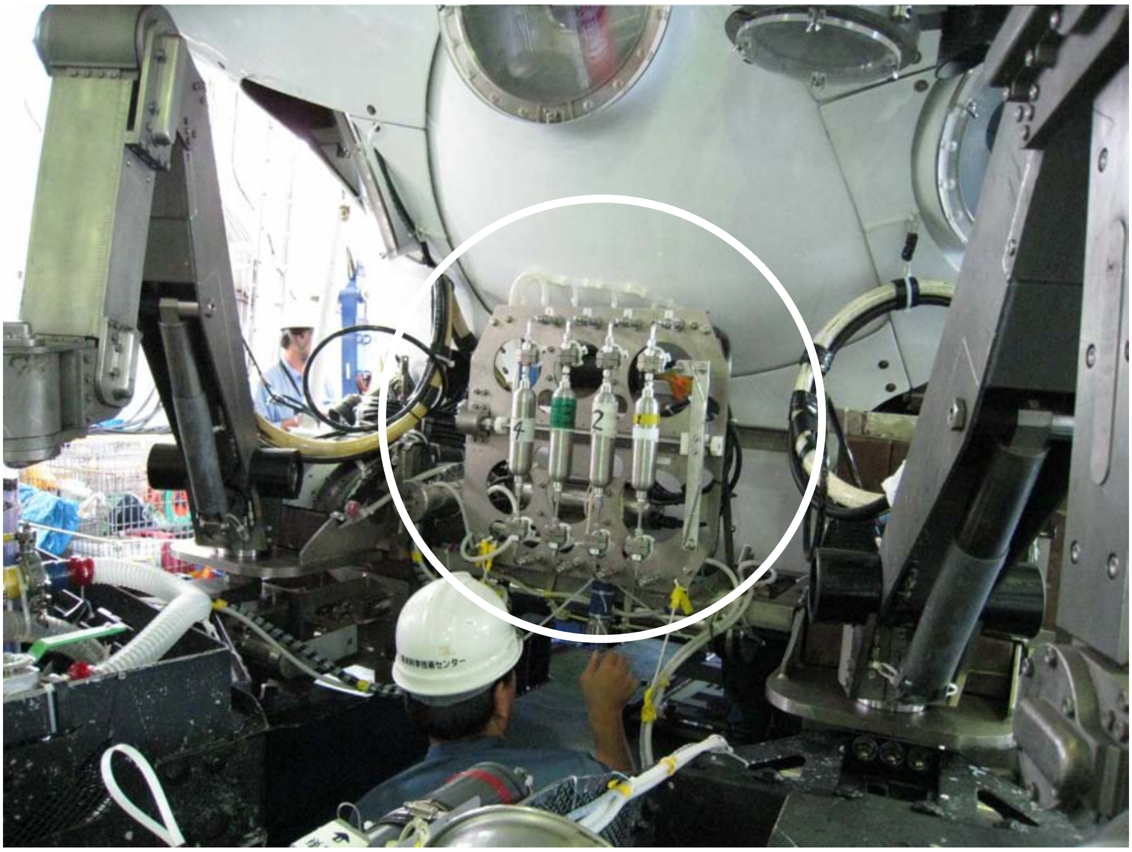


Fig. 3-8 WHATS II fluid sampling system attached to Shinkai 6500.

Cheap WHATS sampler

Cheap WHATS is a newly developed gas-tight fluid sampler (Fig.3-9) by Ken Takai, after several modification of WHATS-II, which much less cost than WHATS-II. The whole sampling scheme is very similar with that of WHATS-II but the manipulation of valve open/close is not operated by electric motor but by the submersible's or the ROV's manipulator. This improvement ensures the successful valve operation. However, in some cases, the successful valve operation is inhibited by messy payload and is affected by the unexpected physical misuse.

Description

Dimension of frame:	Flexible
Weight:	Flexible (>4 kg in air, 2 kg in water)
Depth range:	3500 m
Sample volume:	Flexible
Sampling rate:	150 ml / min.
Electricity:	DC24 V / 1.0 A

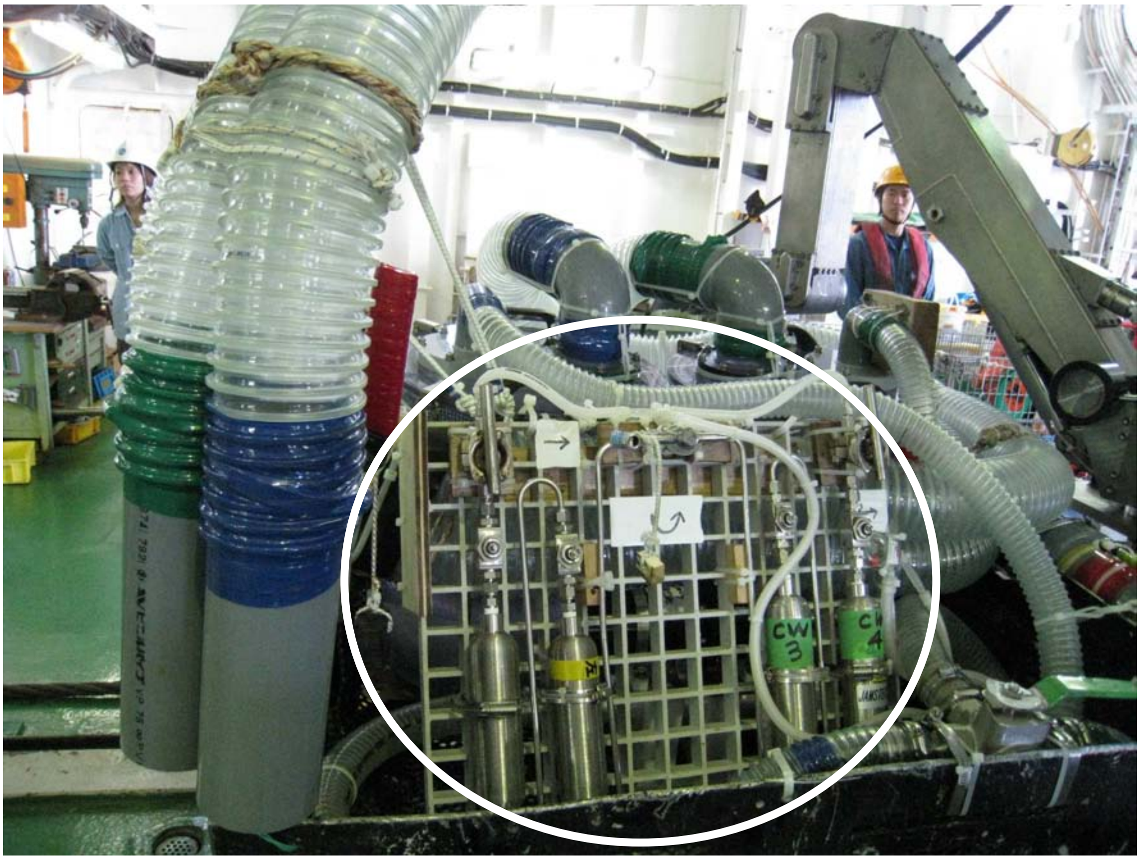


Fig. 3-9 Cheep WHATS sampler installed on Shinkai 6500.

Treatment and onboard analyses of WHATS-II & Cheap WHATS samples for gas chemistry

In general, for vent fluid sampling, the WHATS-II sample bottles were in pairs, with one of the bottles used for the analysis of soluble compoenents chemistry and the other for gas chemistry. The bottle devoted to gas chemistry was processed on board using a high vacuum line specifically designed for this purpose using the following procedure.

After the WHATS bottle is connected to the vacuum line, all of the connecting lines are evacuated to high vacuum using an oil diffusion pump. When sufficient vacuum is achieved, the vacuum line is closed in a static condition, and the valve on the bottle is opened and the water plus gas is allowed to drop into an evacuated flask. Sulfamic acid or cadmium chloride is added to the flask prior to the extraction in order to acidify the sample and aid in the extraction of carbon dioxide or to precipitate H2S gas and dissolved sulfide in the hydrothermal fluid as CdS for the subsequent sulfur isotope analysis. The water in the extraction flask is then agitated by stirring bar. The gas phase was transferred to a total of 150 cm^3 evacuated stainless steel and glass container (for compositional and isotope measurements of gas components). After the gas phase was obtained, the liquid phase was taken into a 50 cm^3 polypropylene bottle (for major cation and anion measurements).

The obtained gas sample in the glass container with a butyl rubber stopper was balanced with ultrapure He gas and the gas pressure was monitored by a manometer. Then, gas components were quantified by GC-PID system on board.

Onboard analyses for dissolved species

The bottle devoted to fluid chemistry was shared with microbiological study. After sample for pH, Alkalinity, and H_2S determination was drawn, the rest of the fluid was filtered with a 0.2μm disk filter. The filtrate was provided for chemical analysis of major elements, nutrients (NH_4, SiO_2), and trace metals. The filtrate aliquot for trace metals was acidified with nitric acid to avoid hydroxide precipitation during storage.

Because some chemical species such as nutrients and pH are difficult to be conserved during storage, we therefore analyzed these species onboard. In this cruise, colorimetric methods and titration were employed for onboard analyses as described below. Using the same apparatus, some conservative species were also analyzed. Most of these analytical methods are conventional ones and summarized in Gieskes et al. (1991).

pH and alkalinity

Determination of pH at room temperature was conducted with a pH meter with a combined glass electrode (Metrohm, 794 Basic Titrino). Measurements were done within an hour after sample distribution from the WHATS bottle. Calibration was conducted daily using JIS standard buffer solutions (pH=6.865 and 4.010). Alkalinity was determined by titration with hydrochloric acid. For calculation of the endpoint, Gran plot is employed using the pH/ion meter (Metrohm, 794 Basic Titrino).

Colorimetric method

Using a colorimeter (Shimazu, UV mini 1240), concentrations of dissolved silica (SiO_2), ammonium ion (NH_4), and hydrogen sulfide (H_2S) were analyzed following classical methods; molybdenum blue method (λ=812nm) for SiO_2 and indo-phenol method (λ=640nm) for NH_4 and methylene blue method (λ=670nm) for H_2S. Analytical precision is usually better than 3% for seawater analysis, although sometimes the precision is somewhat worse for the case of hydrothermal fluids due to wide range of concentrations (SiO_2 and H_2S) and interference by specific species (NH_4).

5. Microbiology and macrobiology

Sample preparation

For cultivation, water samples collected by the Niskin bottle and WHATS were immediately poured into sterilized glass vials under the atmosphere of nitrogen gas.

Chimney samples were subsampled into several portions (e.g. vent orifice surface, inside structure, middle-inside structure). Each piece of chimney structure was slurried with filter-sterilized seawater under N_2 for cultivation. For molecular analysis, the rest of pieces was kept under -80 °C.

Hydrothermal vent animals were dissected, incubated, or fixed once onboard ship. Individuals or their tissues were applied to various onboard experiments (e.g. enzyme activity measurement and incubation under the H_2-containing atmosphere), or kept under -80 °C. Some individuals of hydrothermal vent animals were frozen under -80 °C or fixed with ethanol or formalin.

Larval and reproductive characteristics of vent animals

Planktonic larval stage is important for benthic animals to disperse and settle on the new population, as well as maintain their source population. In addition, some vent animals acquire their symbionts during the metamorphosis from planktonic larvae to juvenile (e.g., Nussbaumer et al. 2006). To figure out the ecological characteristics of the larvae and juvenile, we developed the larval sampler named Yousei Hoihoi to collect larva and juveniles at vent fields. The collected larva and juveniles were observed under compound microscope on board for brief identification. The details of the morphology of the larva and juveniles will be observed with SEM. The relationships between symbiont and larvae or juveniles will be studied with FISH and stable isotopic analyses.

References:

Nussbaumer, A.D., Fisher, C.R., Bright, M., 2006. Horizontal endosymbiont transmission in hydrothermal vent tubeworms. *Nature* **441,** 7091.

IV. DIVE REPORTS

#1169 Dive (Kairei Field) Dr. S. Nakagawa
#1170 Dive (Yokoniwa Rise) Dr. T. Morishita
#1171 Dive (Edmond Field) Dr. T. Shibuya
#1172 Dive (Nakaniwa Ridge) Dr. K. Takai
#1173 Dive (Uraniwa Hills-Nakaniwa Ridge) Dr. T. Morishita
#1174 Dive (Kairei Field) Dr. H. Watanabe
#1175 Dive (Kairei Field) Dr. G. Beedessee
#1176 Dive (Yokoniwa Rise) Dr. K. Nakamura

Dive Report: Shinkai 6500 Dive#1169

Date: November 6, 2009
Site: Kairei field
Landing: 11:08; 25°19.3302'S, 70°02.3623'E, 2540 m
Leaving: 16:18; 25°19.2334'S, 70°02.3368'E, 2435 m
Observer: Satoshi Nakagawa (Hokkaido University)
Pilot: H. Ueki **Co-Pilot:** Y. Chida

Objectives:

Objectives of this dive is collecting hydrothermal vent animals, chimney structures, and vent fluids from Kali and Monju chimneys.

Dive Summary:

We landed at approximately 250 m south of the Kali vent and then headed to north. After going over two small ridges, we successfully found the Kali vent. Although we set #22 marker at the site in 2006, we could not find any markers. Nevertheless, considering the landscape and depth, the vent was clearly Kali vent. Hydrothermal activity at the Kali vent seemed to become more vigorous, and a relatively smaller vent was found at 1-2 m lower part of the main vent.

We started to collect chimney structure from the Kali main vent. However, it was too soft to be collected by the manipulator of Shinkai 6500. Additionally, the smaller vent prevented us to land just in front of the main vent. Therefore, we started to collect vent fluids from the main vent. We successfully collected the vent fluids with two bottles of WHATS sampler. Since the temperature probe was broken, we could not clarify the temperature of the vent fluid samples.

Then, we found the hose of suction sampler was broken. This is probably because of the ultra-hot hydrothermal fluids. One hose was completely broken, and another one seems to be still available. Therefore, we decided to move to the Monju vent and collect hydrothermal vent animals there before collecting the Kali vent fluids with the Cheap-WHATS sampler. When we left the Kali vent, we set the #103 marker and collected hydrothermal plume with a Niskin bottle.

Since markers settled in 1996 were gone or covered by anemones, it was quite hard to get to the Monju chimney. About 1 hour later, we finally found the Monju chimney. The landscape and macrofauna in Monju seemed to be changed. What was most surprising was the number of Alviniconcha was drastically decreased. In 1996, we could see lots of brownish Alviniconcha in the immediately lower part of Rimicaris colony. However, we could identify only several blackish Alviniconcha individuals. In contrast, the number of Bathymodiolus, Rimicaris and scaly foot in the Monju chimney seemed to be increased. We successfully collected a portion of chimney structure and hydrothermal vent animals (Alviniconcha, Rimicaris, scaly foot, Bathymodiolus and Yunohanagani). Then, we conducted the DO measurement immediately above the Alviniconcha habitat. Additionally, we collected fluids surrounding the Alviniconcha colony with WHATS (2 bottles). After these operations, we went back to the Kali vent.

At the Kali vent, we collected hydrothermal fluids from the main vent with Cheap WHATS (2 bottles). After taking a rock, we left the bottom.

Payloads:

1) Suction sampler with two cylinders
2) WHATS
3) Cheap WHATS
4) Sample box with lid
5) Niskin bottle
6) DO sensor
7) Turbidity sensor
8) Alviniconcha-sweeper
9) Marker

Location of Events:

As in the section, “Event List”.

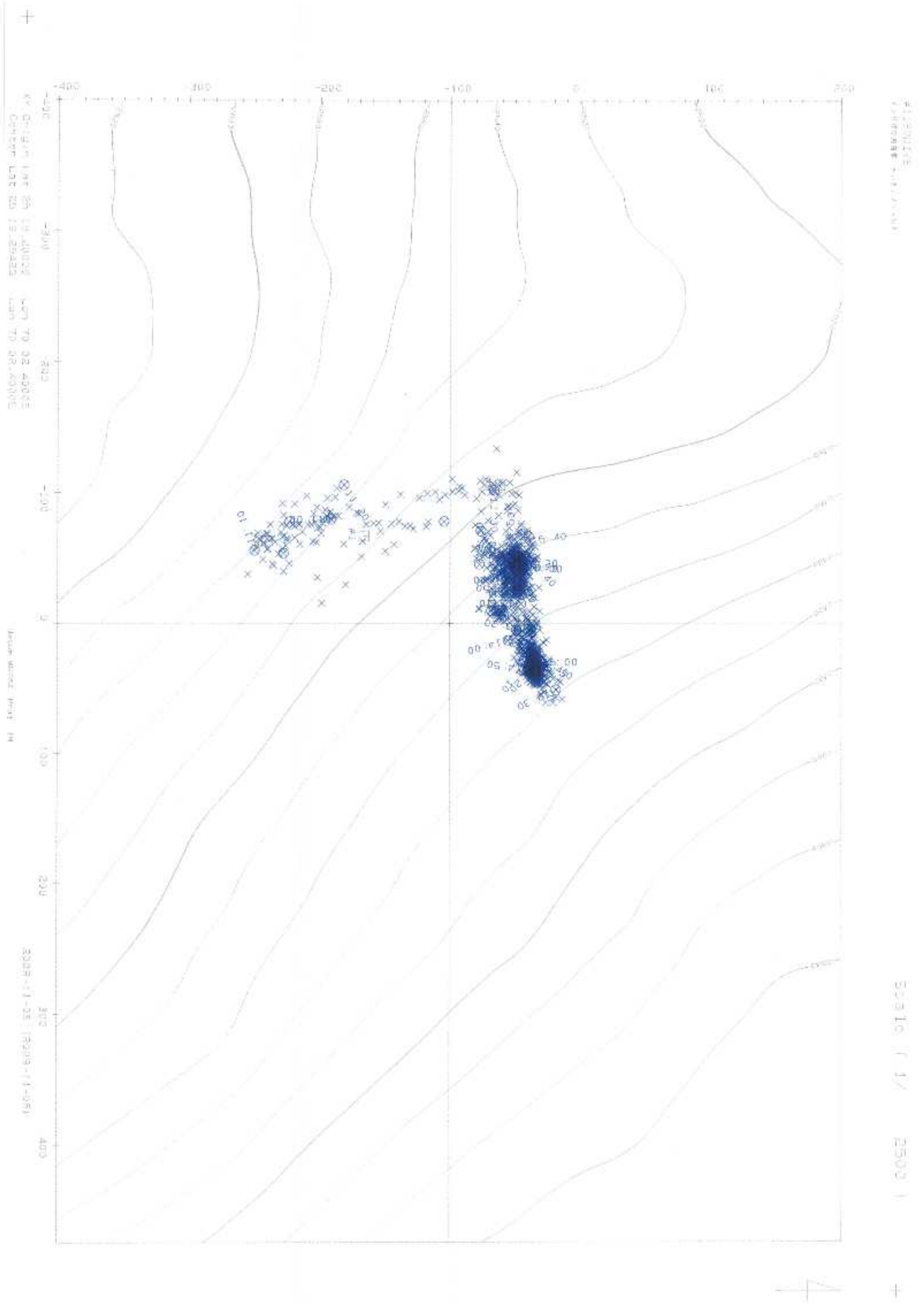
Event List:

1) 10:00, 25°19.2900'S, 70°2.3600'E, Landing Target
2) 11:08, 25°19.3302'S, 70°2.3623'E, Landing, D=2540 m
3) 13:04, 25°19.2274'S, 70°2.3698'E, Sampling WHATS (2), Niskin, Deployment #103 marker, D=2456 m
4) 13:14, 25°19.2213'S, 70°2.4006'E, Finding marker, D=2433 m
5) 13:50, 25°19.2334'S, 70°2.23944'E, Finding #20 marker, D=2430 m
6) 15:26, 25°19.2186'S, 70°2.24219'E, Sampling chimney, animals, WHATS (2), D=2422 m
7) 15:26, 25°19.2186'S, 70°2.24218'E, Finding #23 marker, Measurement DO, D=2422 m

8) 16:07, 25°19.2256'S, 70°2.23817'E, Sampling Cheap WHATS (2), D=2454 m

9) 16:18, 25°19.2334'S, 70°2.3368'E, Left bottom, D=2435 m

Dive Track:



Dive Report: Shinkai 6500 Dive#1170

Date: November 7, 2009
Site: An oceanic rise (Yokoniwa Rise) located at northeast of the Hokuho knoll where the Kairei hydrothermal filed exists
Landing: 11:25; 25°14.9825'S, 70° 6.1222'E, 3420 m
Leaving: 16:03; 18°20.1156'S, 65°17.9302'E, 2743 m
Observer: Tomoaki MORISHITA (FSO, Kanazawa Univ.)
Pilot: S. Ogura **Co-Pilot:** M. Yanagitani

Objectives:

Objective of this dive is to understanding of geological background to supply for hydrogen-rich hydrothermal fluids at the Kairei hydrothermal filed along the Central Indian Ridge.

Dive Summary:

We observed and recovered rock samples from 3420 m water depth to the ridge (2600 m water depth) of the eastern facing slope of an oceanic rise (Yokoniwa Rise, hereafter) located at northeast from the Hakuho knoll, then went for the top of the rise in the south direction. Outcrops are very few along the track. We observed and recovered samples from an outcrop of pyroxene-rich peridotites or gabbros with carbonate vein networks at 3298 m water depth. Most of the samples were thus recovered from talus and/or float on mud. We only found a few small aggregates of floats on mud from 3200 m to 3000 m water depth. Instead of these conditions, most of the recovered samples were serpentinized and/or weathered peridotites with small amount of gabbros which were derived from deeper part of the oceanic lithosphere. It is interesting to note that two of three samples along the ridge of the rise (2539 m water depth) were basalts and the other was serpentinized peridotites, indicating that both basalts and serpentinized peridotites are distributed along the ridge of the rise. In conclusion, the rise body is mainly consisting of peridotites with small amounts of gabbros, and fresh basalts. The latter probably covers the top of the rise after these peridotites (and gabbros) were exposed on the ocean floor.

Payloads:

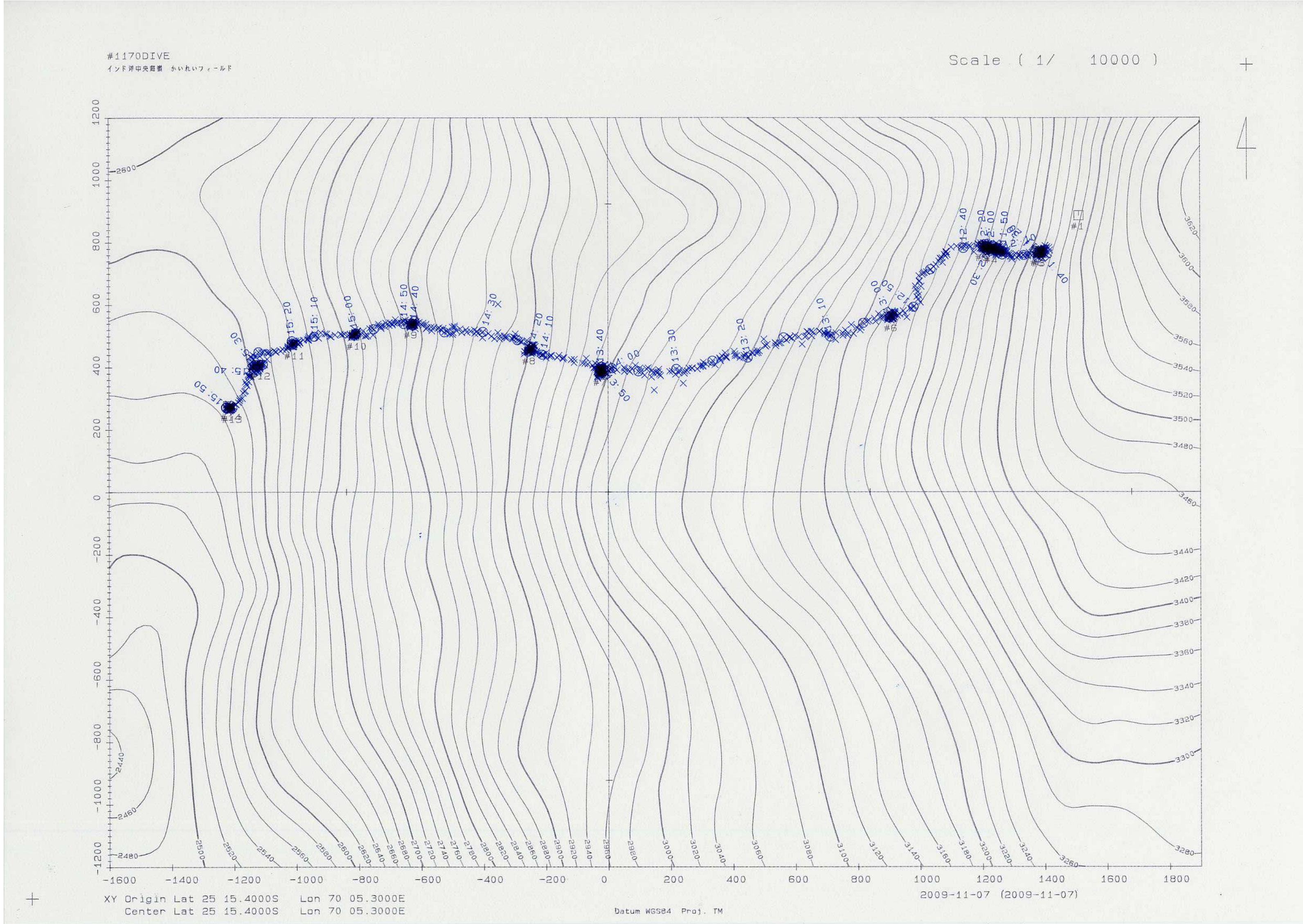
1) Sample baskets w/separation and lids
2) Core-type M

3) JAMSTEC-SBP

Location of Events:
As in the section, “Event List”.

Event List:
1) 10:00, 25°14.9200'S, 70° 6.2000'E, Landing Target
2) 11:25, 25°14.9825'S, 70° 6.1222'E, Landing, D=3420 m
3) 11:39, 25°14.9842'S, 70° 6.1248'E, Sampling rocks (3), D=3420 m
4) 12:14, 25°14.9782'S, 70° 6.0338'E, Sampling rocks (2), D=3315 m
5) 12:32, 25°14.9739'S, 70° 6.0172'E, Core type-M, Sampling rocks (3), D=3298 m
6) 12:59, 25°15.0963'S, 70° 5.8442'E, Sampling rocks (3), D=3216 m
7) 13:59, 25°15.1905'S, 70° 5.2863'E, Sampling rocks (3), D=2987 m
8) 14:20, 25°15.1534'S, 70° 5.1509'E, Sampling rocks (3), D=2885 m
9) 14:46, 25°15.1079'S, 70° 4.9245'E, Sampling rocks (3), D=2783 m
10) 15:03, 25°15.1277'S, 70° 4.8153'E, Sampling rocks (3), D=2700 m
11) 15:17, 25°15.1443'S, 70° 4.6966'E, Sampling rocks (3), D=2635 m
12) 15:37, 25°15.1790'S, 70° 4.6311'E, Sampling rocks (3), D=2569 m
13) 15:52, 25°15.2545'S, 70° 4.5771'E, Sampling rocks (3), D=2539 m
14) 15:55, 25°15.2505'S, 70° 4.5743'E, Left Bottom, D=2539 m

Dive Track:



#1170DIVE
インド洋中央海嶺 かいれいフィールド
Scale (1/ 10000)
XY Origin Lat 25 15.4000S Lon 70 05.3000E
Center Lat 25 15.4000S Lon 70 05.3000E
Datum WGS84 Proj. TM
2009-11-07 (2009-11-07)

Dive Report: Shinkai 6500 Dive#1171

Date: November 8, 2009
Site: Hakuho Knoll, Nakaniwa Ridge and Yokoniwa Rise in the CIR-S1
Landing: 11:14; 25°18.4827'S, 70°5.8461'E, 2913 m
Leaving: 16:02; 25°18.0002'S, 70°4.7863’E, 2892 m
Observer: Takazo Shibuya (Precambrian Lab., JAMSTEC)
Pilot: K. Matsumoto **Co-Pilot:** T. Ohnishi

Objectives:

Objective of this dive is to clarify the geological relationship between Hakuho Knoll and Inside Corner High (Yokoniwa Rise). In addition, we collect rock samples at a small hill (Nakaniwa Ridge) situated between the Hakuho Knoll and the Uraniwa Hills.

Dive Summary:

We landed at the eastern cliffside of the small hill at 11:14. Angular rolling stones derived from earthfall were scattered on this steep slope, while we could not find outcrops. The Shinkai 6500 ascended along the slope, collecting rock samples. When we got at the top of the hill, massive outcrops was shown up from the white sediments. Thus, the rock samples from the outcrop were sampled at 12:29. Then, we made a flight to the eastern bottom of the Hakuho Knoll.

Just after the arrival at the Hakuho Knoll, we fortunately found many rolling stones; rock samples were collected at 14:10. After that, we ascended the eastern slope of the Hakuho Knoll. During ascending, we found beautiful outcrop of pillowed basalts, which was collected at 14:19. Then, we changed course to the north along the counter line, to find the boundary between basalt and peridotite. Along this route, the slope was covered with white sediments but outcrops are rarely exposed. At these points, we collected rock samples of pillow and sheeted lavas at 15:02 and 15:39, respectively. In the north of the sampling point at 15:39, NW-SE trending depression was developed due to normal fault, where pillow-sheet lavas were exposed between the depressions. At last, we took a sample from the outcrop at 16:02. Shinkai 6500 left the seafloor at 16:03.

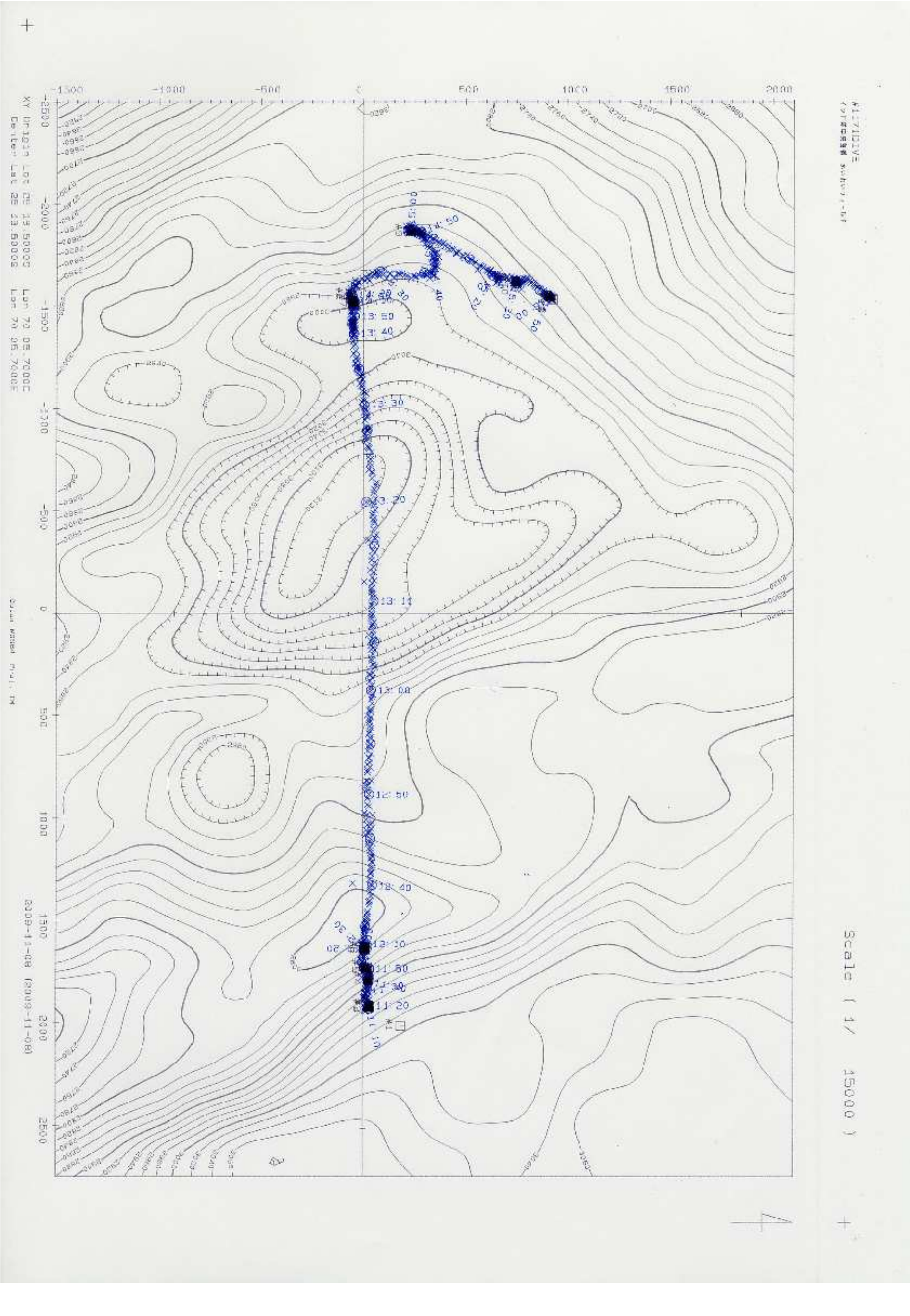
Payloads:

1) Deep-sea sub-bottom profiler

Location of Events:
As in the section, “Event List”.

Event List:
1) 10:00, 25°18.4000'S, 70°6.9000'E, Landing Target
2) 11:14, 25°18.4827'S, 70°5.8461'E, Landing, D=2913 m
3) 11:19, 25°18.4856'S, 70°6.8433'E, Sampling Rocks (3), D=2913 m
4) 11:42, 25°18.4848'S, 70°6.7647'E, Sampling Rocks (3), D=2840 m
5) 11:58, 25°18.4892'S, 70°6.7305'E, Sampling Rocks (3), D=2802 m
6) 12:29, 25°18.4946'S, 70°6.6749'E, Sampling Rock, D=2775 m
7) 14:10, 25°18.5260'S, 70°4.7930'E, Sampling Rocks (3), D=2978 m
8) 14:19, 25°18.5358'S, 70°4.7720'E, Sampling Rock, D=2944 m
9) 15:02, 25°18.3790'S, 70°4.5873'E, Sampling Rock, D=2908 m
10) 15:39, 25°18.0977'S, 70°4.7374'E, Sampling Rock, D=2906 m
11) 16:02, 25°18.0002'S, 70°4.7839'E, Sampling Rock, D=2892 m
12) 16:03, 25°18.0002'S, 70°4.7863'E, Left Bottom, D=2892 m

Dive Track:



Dive Report: Shinkai 6500 Dive#1172

Date: November 9, 2009
Site: Edmond field
Landing: 11:26; 23°52.6989'S, 69°35.7949'E, 3300 m
Leaving: 15:53; 23°52.7466'S, 69°35.7156'E, 3235 m
Observer: Ken Takai (JAMSTEC)
Pilot: Y. Ogura **Co-Pilot:** Y. Yoshiume

Objectives:

Objectives of this dive are collecting hydrothermal vent animals, chimney structures, and vent fluids from Edmond hydrothermal field.

Dive Summary:

We landed at approximately 60 m south of the hydrothermal activity center of the Edmond hydrothermal field. Unexpectedly, the landing point was a huge dead chimney site, at which several spire-like chimneys host clear diffusing fluids and black smokers. After landing, we went to the north and we found a very steep slope down from east to west. We went on along the slope and found many sea anemone on the slope. Actually we pass through a slightly eastern and above the Edmond hydrothermal activity center at the time. At a 100 m north from the landing point, the hydrothermal activity signatures were completely absent. Thus, we rightly turned around and went to the west. Then we passed through the north edge of the hydrothermal activity center, where we found many, huge sulfides blocks in the slope. They were likely collapsed chimneys that relatively currently occurred. When we turned to the south at the collapsed chimney blocks, we found numerous clear and black hydrothermal fluid flows with Rimicaris. In addition, lots of Alviniconcha colonies were observed. Although no marker was found, the site were very close to the previous marker #24 site. However, above the Alviniconcha site, no hydrothermal mound was observed. It was a big difference between the observations this time and 3 years ago. After landing the Alviniconcha site, we tried to take chimneys first. However, the position was not good, and finally we failed to take any of the chimney samples. Next, the black hydrothermal fluid from a chimney was sampled (C-WHATS #3&4; Tmax = 245 ˚C). After sampling a black smoker fluid, two separate Alviniconcha colony waters were collected (right colony water was in WHATS #1&2, left colony water was in WHATS #3&4, both water was ~3-4 ˚C higher than the ambient seawater). Then, the DO was measured at the two

Alviniconcha colonies and the adjacent Rimikaris colonies) for 3 min each. Before sampling the Alviniconcha individuals, the seawater at a 10-20 cm distant from the colonies were sampled by Infant HoiHoi. Finally, many Alviniconcha and other animals individuals were collected by the Suction sampler. To the end, we observed the 3 huge chimney structures on the hydrothermal activity center and moved to southwest, left the bottom.

Payloads:

1) Suction sampler with two cylinders
2) WHATS
3) Cheap WHATS
4) Sample box with lid
5) DO sensor
6) Marker
7) Chimney Pan

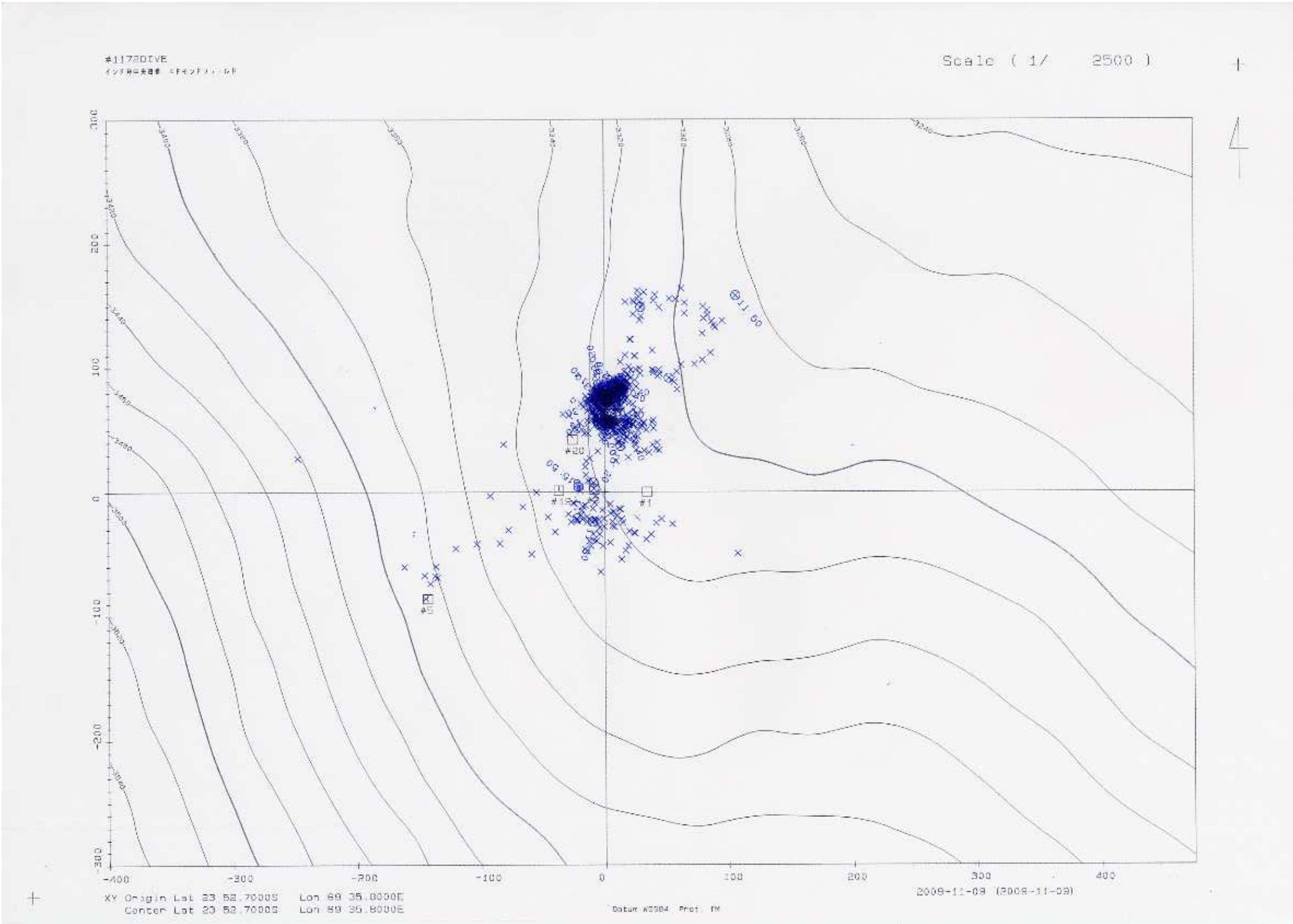
Location of Events:

As in the section, "Event List".

Event List:

1) 11:26, 23-52.6989S, 69-35.7949E, Landing, D=3300m
2) 12:15, 23-52.6563S, 69-35.8055E, Sampling Cheap WHATS(2),WHATS(2), D=3278m
3) 15:37, 23-52.6601S, 69-35.8029E, Samp.WHATS(2), Measur.DO,Samp.Larvae, Animals, D=3277m
4) 15:53, 23-52.7466S, 69-35.7156E, Left Bottom, D=3235m

Dive Track:



#1172DIVE
Scale (1/ 2500)
XY Origin Lat 23 52.7000S Lon 69 35.8000E
Center Lat 23 52.7000S Lon 69 35.8000E
2009-11-09 (2009-11-09)

Dive Report: Shinkai 6500 Dive#1173

Date: November 10, 2009
Site: From the western slope of the north Uraniwa-hill to the eastern slope of an oceanic rise (Yokoniwa Rise) located at northeast of the Hokuho knoll where the Kairei hydrothermal filed exists through the northern slope of a small hill (Nakaniwa Ridge) between the Uraniwa-hills and the Hokuho knoll along the same water depth around 3000m
Landing: 11:20; 25°16.4277'S, 70° 7.2646'E, 3420 m
Leaving: 16:02; 25°16.5783'S, 70° 5.7537'E, 2743 m
Observer: Tomoaki MORISHITA (FSO, Kanazawa Univ.)
Pilot: K. Chiba **Co-Pilot:** A. Ishikawa

Objectives:

Objective of this dive is to understanding of geological background to supply for hydrogen-rich hydrothermal fluids at the Kairei hydrothermal filed along the Central Indian Ridge.

Dive Summary:

We landed at 3000 m water depth of the northwestern slope of the north Uraniwa-hill and recovered basalt samples from a small hill consisting of basaltic fragments. We faced to the south to go the place where normal fault-like structure is expected from SCS observations. On the way to the south, we crossed small hills of basaltic fragments. We sometimes observed a fragment of pillow structures. We measured heat flow using SAHF at a point of the western slope of the north Uraniwa-hill. Then we moved to the west to go to the eastern slope of a small rise (named Nakaniwa Ridge, hereafter) between the Uraniwa-hills and the Hakuho knoll. We also measured heat flow using SAHF again. We slowly observed the eastern slope to the northern slope of the Nakaniwa Ridge to keep the water depth about 3000 m. We did not find any outcrops along the track, but recovered samples from float on mud in several points. It should be emphasized that some samples were altered gabbros and dolerites. Then we finally moved to go to the eastern slope of the northern oceanic rise (Yokoniwa Rise). We recovered float on mud. Samples were all basalts.

Payloads:

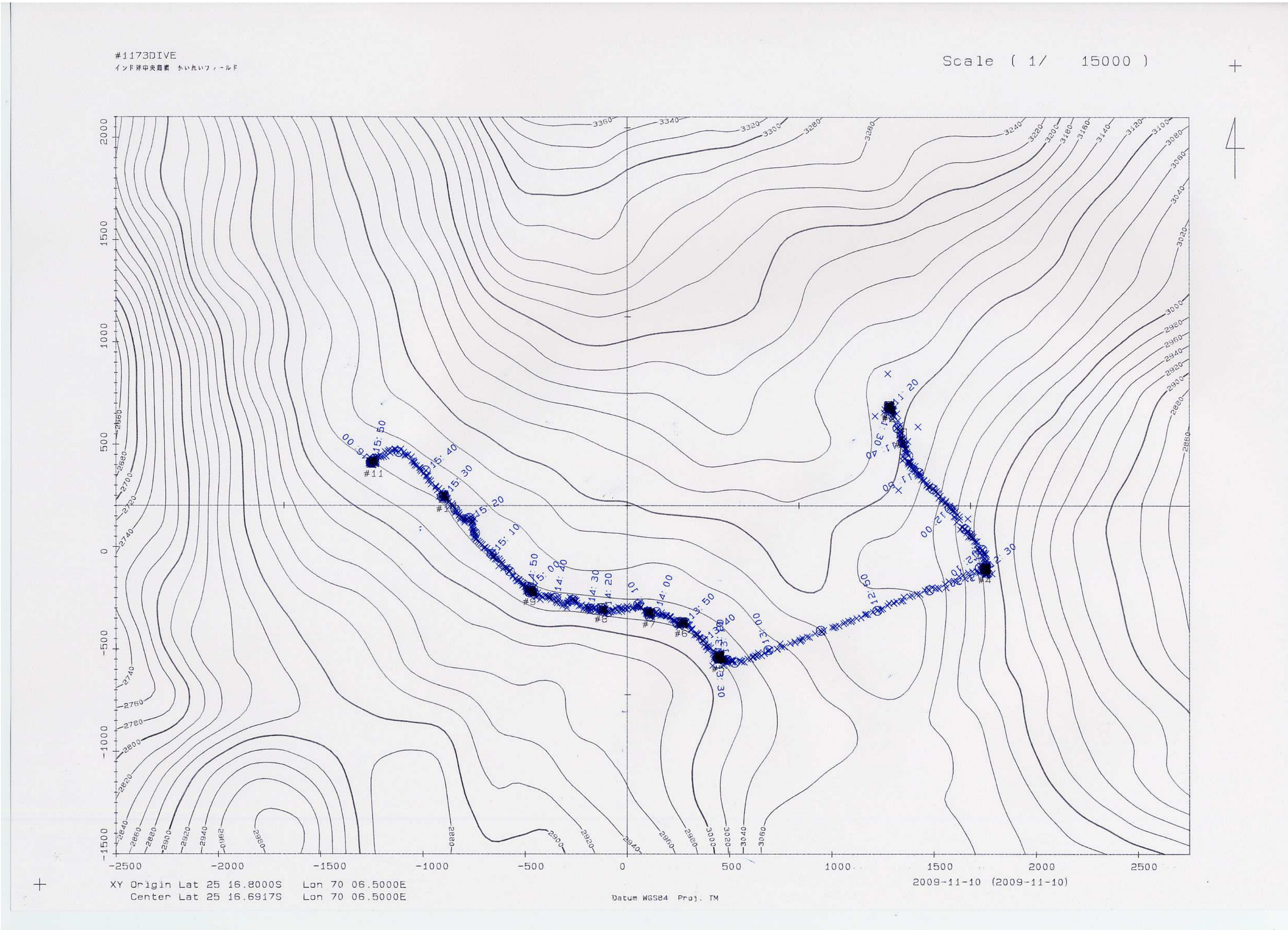
4) Sample baskets w/separation and lids

5) JAMSTEC-SBP
6) SAHF

Location of Events:
As in the section, “Event List”.

Event List:
1) 10:00, 25°16.5000'S, 70° 7.3000'E, Landing Target
2) 11:20, 25°16.4320'S, 70° 7.2646'E, Landing, D=3084 m
3) 11:20, 25°16.4277'S, 70° 7.2634'E, Sampling rocks (3), D=3084 m
4) 12:35, 25°16.8589'S, 70° 7.5442'E, Measurement SAHF, D=3018 m
5) 13:32, 25°17.0940'S, 70° 6.7677'E, Measurement SAHF, D=3010 m
6) 13:51, 25°17.0940'S, 70° 6.7677'E, Sampling rocks (3), D=2997 m
7) 14:08, 25°16.9766'S, 70° 6.5659'E, Sampling rocks (3), D=3003 m
8) 14:24, 25°16.9632'S, 70° 6.4265'E, Sampling rocks (2), D=3021 m
9) 14:57, 25°16.9170'S, 70° 6.2176'E, Sampling rocks (4), D=3024 m
10) 15:32, 25°16.6711'S, 70° 5.9650'E, Sampling rocks (2), D=3020 m
11) 16:02, 25°16.5783'S, 70° 5.7537'E, Sampling rocks (3), Left bottom, D=3026 m

Dive Track:



#1173DIVE
Scale (1/ 15000)
XY Origin Lat 25 16.8000S Lon 70 06.5000E
Center Lat 25 16.6917S Lon 70 06.5000E
2009-11-10 (2009-11-10)
Datum WGS84 Proj. TM

Dive Report: Shinkai 6500 Dive#1174

Date: November 12, 2009
Site: Kairei field
Landing: 11:02; 25°19.2432'S, 70°02.3921'E, 2454 m
Leaving: 16:09; 25°19.2646'S, 70°02.4173'E, 2398 m
Observer: Hiromi Watanabe (JAMSTEC)
Pilot: Y. Chida, **Co-Pilot:** S. Ogura

Objectives:

Objectives of this dive are collecting *Alviniconcha* snails, planktonic larvae, chimney structures, and vent fluids at Kali and Monju chimneys.

Dive Summary:

We tried to land at the south of the Momju chimney. However, unexpectedly, the landed point was at approximately 30 m south of the Kali chimney. Therefore, we started sampling at Kali first. The animal assemblage around the Kali chimney was dominated by sea anemone, and we could observe some conger eel, macrourid fish, *Rimicaris* and *Mirocaris* shrimps, *Austinograea* crab, *Leucolepas* barnacle, *Phymorhynchus* whelk and *Branchinotogluma* polynoid. The chimney of the newly developed vent below the Kali vent (Shita-vent) was collected by the Chimney sampler, but only a piece of the chimney could be collected as the sampler was molten by the venting fluid. The WHATS water sampling (2 bottles) was failed as the valve trouble, while the Cheap WHATS (4 bottles) could collect venting fluid and the temperature of the venting fluid was measured as 359 °C in maximum.

After the left of the Kali chimney, we tried to get to the Monju chimney through the Fudo chimney. During the way, we found the Daikoku chimney and observed its animal assemblage briefly. The Daikoku chimney was covered with a swarm of *Rimicaris* shrimp, and *Bathymodiolus* mussels were distributed below the shrimp swarms.

At the Monju chimney, Shinkai landed just beside of the #23 marker (the south wall of the Monju chimney). Firstly, DO sensor was picked out from its case to measure *in situ* DO. We found some *Alviniconcha* colonies and started to sample the fluid on one of the colonies with WHATS (2 bottles), but it was failed as the former WHATS sampling. The temperature above the *Alviniconcha* colony was measured up to 9.2 °C. The DO above the *Alciniconcha* colony was measured from 14:18 to 14:24. Then the plankton above the *Alviniconcha* colony was collected with the larval sampler

(Yousei-Hoihoi) for five minutes, and many of adult *Alviniocncha* were also collected. We moved to collect some active chimneys but only a piece of a chimney could be collected. After that, we left the bottom.

Payloads:

1) Suction sampler with two cylinders and Larval sampler (Yousei-Hoihoi Kai)
2) WHATS
3) Cheap WHATS
4) Sample box with lid
5) DO sensor
6) Turbidity sensor
7) Chimney sampler
8) Marker

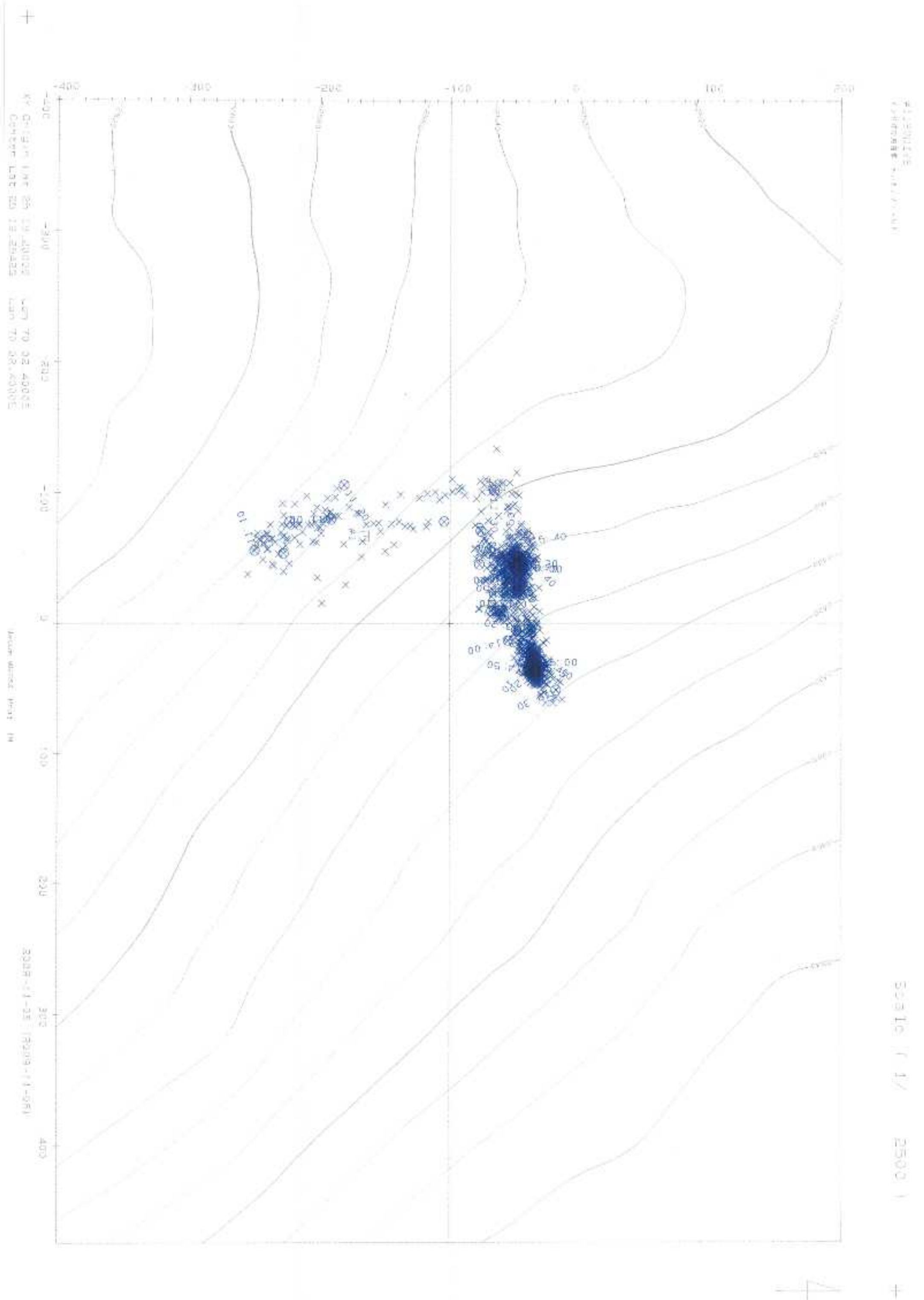
Location of Events:

As in the section, “Event List”.

Event List:

1) 10:00, 25°19.2542'S, 70°2.4000'E, Landing Target
2) 11:02, 25°19.2432'S, 70°2.3921'E, Landing, D=2454 m
3) 11:15, 25°19.2242'S, 70°2.3781'E, Finding #103 marker, D=2455 m
4) 12:52, 25°19.2238'S, 70°2.3827'E, Sampling chimney, WHATS (1), CheapWHATS (4), D=2453 m
5) 15:31, 25°19.2237'S, 70°2.4183'E, Sampling WHATS (2), Larvae, Alviniconcha, Measurment DO, D=2421 m
6) 16:03, 25°19.2260'S, 70°2.24270'E, Sampling chimney, D=2417 m
7) 16:09, 25°19.2646'S, 70°2.24173'E, Left Bottom, D=2398 m

Dive Track:



Dive Report: Shinkai 6500 Dive#1175

Date: November 13, 2009
Site: Kairei field
Landing: 11:05; 25°19.2054'S, 70°02.3207'E, 2540 m
Leaving: 16:16; 23°19.2500'S, 70°02.4032'E, 2395 m
Observer: Girish Beedessee (Mauritius Oceanography Institute)
Pilot: Y. Yoshiume **Co-Pilot:** T. Ohnishi

Objectives:

1. Collect vent fluid from Kali
2. Collect chimneys structures from Daikoku
3. Collect animals (Scaly Foot, Alviniconcha, mussels, crab and shrimps) and measure DO of fluids surrounding Alviniconcha colony from Monju
4. Collect any other organisms (sponges, anemones and fish) in and around Kairei Field

Dive Summary:

We landed south of Kali and explored the surrounding area for sampling of sponges but could not find any. We headed north and sampled a rock with sea anemones attached on its surface. Moving towards Kali, we could see several dead chimneys. After going over some small ridges, we finally reached Kali and proceeded to the chimney.

The pilot cleared the small chimney area and took chimney structure, followed by the temperature measurement and collection of vent fluid (Whats # 1).Surprisingly, the vent activity stopped and thus allowing us to move closer to the main chimney where there was vigorous activity. We collected vent fluids from the second chimney (Whats # 2)

We then proceeded towards Fodu where we found marker # 20 and collected some mussels and shrimps. We deployed marker # 104.We then continue to explore the area and reached Monju.We decided to move in front of the chimney site to take DO measurement, just above the Alviniconcha population. We also collected the fluids with Whats (# 3 and 4) around the neighboring alviniconcha habitat.

As planned, we wanted to use Blue suction sampler for collection of animals a Monju but then we noticed the sampler is not working because the tubing was broken. We ultimately collected alviniconcha, shrimps and crabs using the Green suction sampler .1-2 specimens were collected which appeared to be scaly foot. During this collection, a fish was collected. The submersible was moving away from Monju but upon request, returned to Monju .We approached the other side of Monju to collect the scaly foot. But on continuous search for the scaly foot, we could find any such colony.

We then proceeded towards Daikoku and finally found marker #30.Chimney samples were taken. During the preparation for vent fluid collection, the valve of the Cheap Whats got disconnected and this prevented us from any collection. We observed the chimneys and could notice the enormous population of rimicaris covering the chimney. We stopped the observation at 16:00.

Payloads:

1) Suction sampler with two cylinders
2) WHATS
3) Cheap WHATS
4) Sample box with lid
5) DO sensor
6) Marker
7) Plankton net

Location of Events:

As in the section, “Event List”.

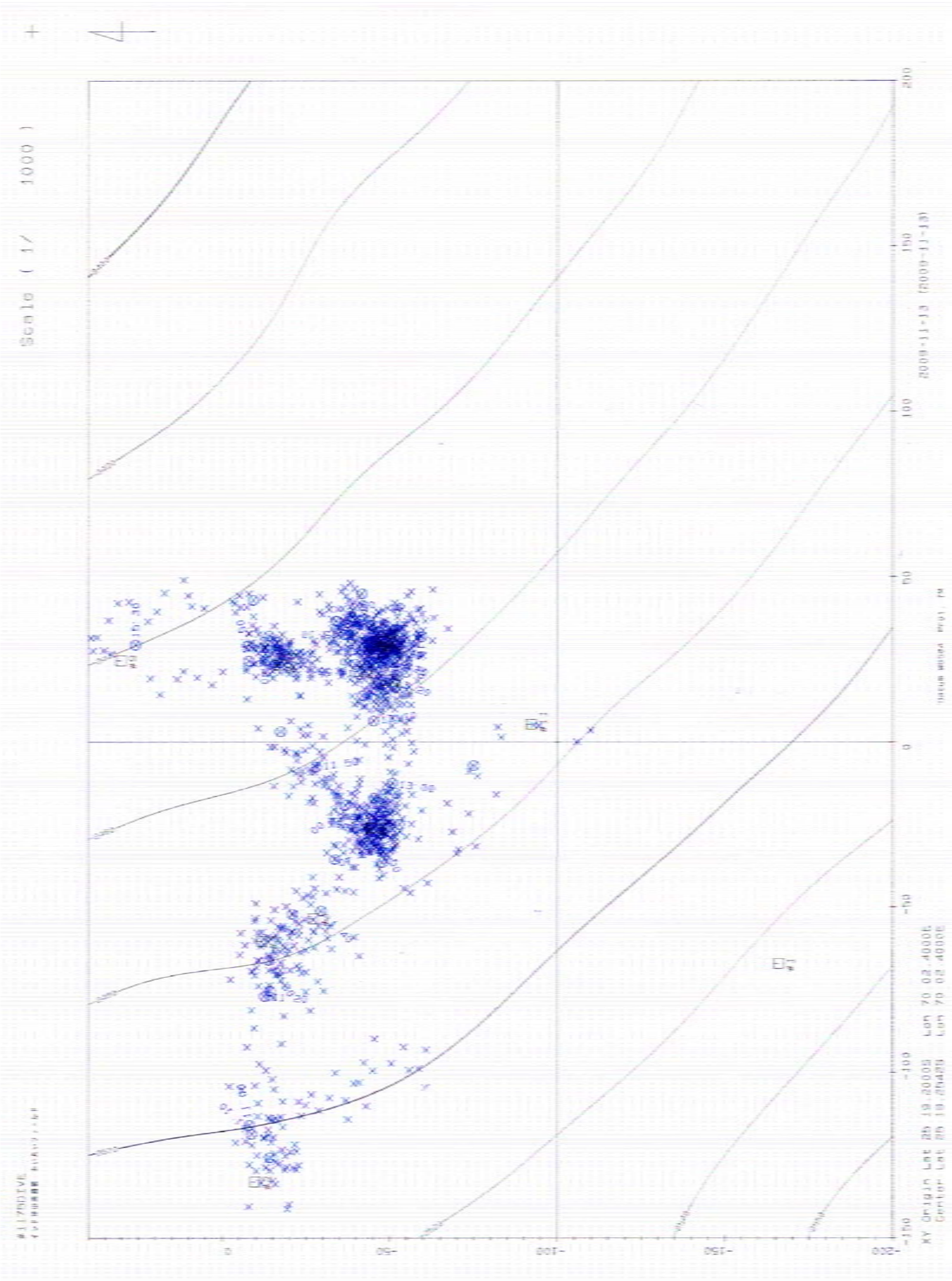
Event List:

1) 10:00, 25°19.2900’S, 70°02.3600’E, landing target
2) 11:05, 25°19.2054’S, 70°02.3207’E, landing 2507 m
3) 11:28, 25°19.2065’S, 70°02.3640’E, Sampling rocks (2) with sea anemone Depth=2472 m
4) 11:36, 25°19.2148’S, 70°02.3680’E, Finding dead chimneys, Depth=2465 m
5) 12:55, 25°19.2240’S, 70°02.3845’E, Sampling rocks (2), chimneys (2), Whats (2), Depth =2453 m
6) 13:20, 25°19.2265’S, 70°02.4111’E, Finding marker #20, Sampling of animals, Deploy marker # 104, Depth=2429m
7) 14:29, 25°19.2262’S, 70°02.4181’E, Measurement DO, Sampling Whats(2), animals, Depth=2422m
8) 14:47, 25°19.2220’S, 70°02.4127’E, Finding marker #28 Depth =2432m
9) 15:30, 25°19.1836’S, 70°02.4147’E, Finding barnacles, Depth=2444m

10) 15:42, 25°19.2094’S, 70°02.4139’E, Finding marker #30, Sampling chimney, Depth=2442m

11) 16:16, 25°19.2500’S, 70°02.4032’E, Left bottom, Depth =2395

Dive Track:


#1175DIVE
Scale (1/ 1000)
XY Origin Lat 25 19.2000S Lon 70 02.4000E
Center Lat 25 19.2542S Lon 70 02.4000E
2009-11-13 (2009-11-13)

Dive Report: Shinkai 6500 Dive#1176

Date: November 14, 2009
Site: Eastern slope of an inside corner high (Yokoniwa Rise), northeastern part of the Hokuho knoll.
Landing: 11:21; 25°16.5174'S, 70° 5.7518'E, 3048 m
Leaving: 16:12; 25°15.8945'S, 70° 4.2975'E, 2427 m
Observer: Kentaro NAKAMURA (PEL, JAMSTEC)
Pilot: K. Matsumoto **Co-Pilot:** H. Ueki

Objectives:

Objective of this dive is to check the extension of peridotite exposure at the Yokoniwa Rise, as well as to confirm whether or not basaltic rocks extensively covered with the top of the Rise.

Dive Summary:

We landed at 3050 m water depth of the eastern slope of the Yokoniwa Rise, close to the point where Dive#1173 was ended. At the landing point, thick white sediment extensively covered with basement and thus, no rock exposure was observable. We headed to west and stated to climb the eastern steep slope of the Yokoniwa Rise. Using sonar reflection image, we were searching rocks exposed onto the sediment. Then, we successfully found out rock exposures on the thick sediment, and sampled rocks at several points. Such rock exposures, however, cannot judge whether these are outcrop or not. Based on SBP images, thickness of the sediments significantly reduce toward the rock exposures, probably indicating that these are outcrops. At the nearly end of the steep slope, we found out highly altered rock zone with networking of white veins, regarded as carbonate veins. This occurrence is very similar to another alteration zone reported from T. Morishita in the Dive#1170. This leads me to consider that this alteration zone continues to north and connected to the area founded by T. Morishita. We corrected the highly altered rocks in this point. On the top of the Yokoniwa Rise, massive rocks were exposed continuously along the ridge of the Yokoniwa Rise, and we sampled several rocks in this point. I first expected that top of the Yokoniwa Rise is covered with basaltic lava flows, whereas the occurrence of the massive rocks implies that deep-seated rocks, such as gabbro and peridotite, are exposed on the top of the Yokoniwa Rise. Finally, we reached the crest of the Yokoniwa Rise. There are also large massive rocks exposed ubiquitously, and we took several samples here. This dive, together with the Dive#1170, demonstrates that the Yokoniwa Rise is completely composed of deep-seated rock, most of them are mantle peridotite, and there are essentially no basaltic rocks covering the top of the Yokoniwa Rise.

Payloads:

7) Sample baskets w/separation and lids
8) JAMSTEC-SBP

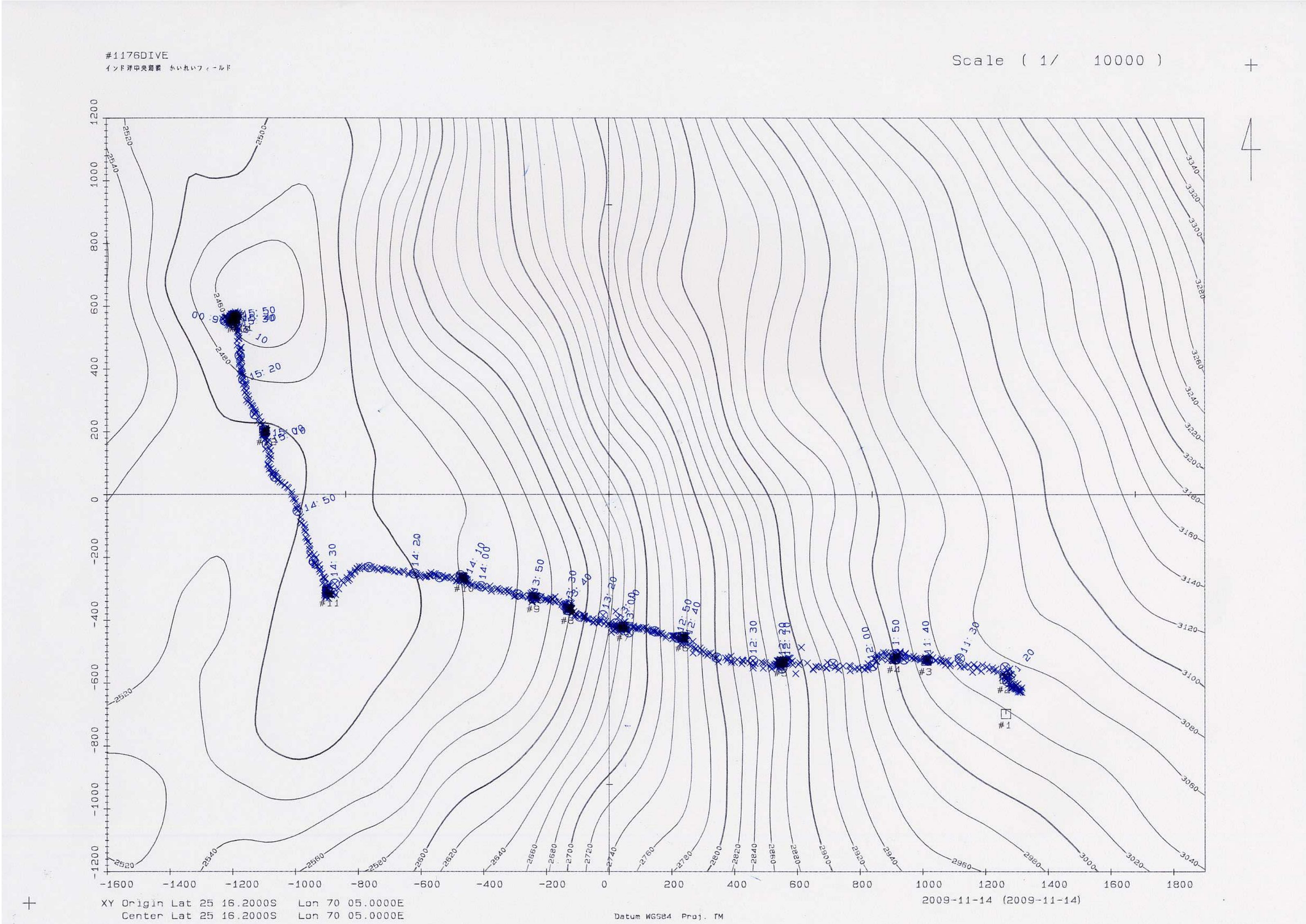
Location of Events:

As in the section, “Event List”.

Event List:

1) 10:00, 25°16.5783'S, 70° 5.7537'E, Landing Target
2) 11:21, 25°16.5174'S, 70° 5.7518'E, Landing, D=3048 m
3) 11:40, 25°16.4864'S, 70° 5.6029'E, Sampling rocks (2), D=3031 m
4) 11:52, 25°16.4828'S, 70° 5.5425'E, Sampling rocks (2), D=2998 m
5) 12:22, 25°16.4885'S, 70° 5.5328'E, Sampling rocks (3), D=2874 m
6) 12:44, 25°16.4456'S, 70° 5.1406'E, Sampling rocks (2), D=2763 m
7) 13:12, 25°16.4279'S, 70° 5.0286'E, Sampling rocks (2), D=2657 m
8) 13:35, 25°16.3983'S, 70° 4.9230'E, Sampling rocks (2), D=2562 m
9) 13:50, 25°16.3784'S, 70° 4.8578'E, Sampling rocks (2), D=2530 m
10) 14:06, 25°16.3430'S, 70° 4.7204'E, Sampling rocks (2), D=2513 m
11) 14:37, 25°16.3683'S, 70° 4.4647'E, Sampling rocks (2), D=2468 m
12) 15:10, 25°16.0902'S, 70° 4.3455'E, Sampling rocks (2), D=2491 m
13) 15:49, 25°15.8956'S, 70° 4.2875'E, Sampling rocks (4), D=2426 m
14) 16:12, 25°16.8945'S, 70° 4.2975'E, Left bottom, D=2427 m

Dive Track:


#1176DIVE
Scale (1/ 10000)
XY Origin Lat 25 16.2000S Lon 70 05.0000E
Center Lat 25 16.2000S Lon 70 05.0000E
Datum WGS84 Proj. TM
2009-11-14 (2009-11-14)
4

V. SHORE BASE STUDY

1. Geophysics

Takeshi TSUJI (Kyoto University)

We will analyze the seismic reflection data and try to improve the imaging quality. Especially we will apply migration to the data considering the subseafloor velocity variation. Since we cannot estimate seismic velocity from the single-channel seismic reflection data, we will measure the physical properties of various rock samples obtained by Shinkai dives. Furthermore we will apply seismic attribute analysis (using neural network) and classify the subseafloor properties as well as lithology. Finally we try to construct the geological and hydrological model around the Kairei-hydrothermal field from the estimated lithology distributions.

2. Geochemistry & Biogeochemistry

Ken TAKAI (SUGAR & PEL, JAMSTEC), Kentaro NAKAMURA (PEL, JAMSTEC), Shinsuke Kawagucci (PEL, JAMSTEC), Manabu Nishizawa (PEL, JAMSTEC), Yuichiro Ueno (TITEC), Tomonori Toki (Ryukyu Univ.), Takuro Noguchi (Kochi Univ.)

All the hydrothermal fluid and biogeochemical experiment samples will be conducted to the detail isotope characterization. The $\partial D(H_2)$, $\partial D(CH_4)$, $\partial D(>C2$ hydrocarbon), $\partial^{13}C(CO_2)$, $\partial^{13}C(CH_4)$, $\partial^{13}C(>C2$ hydrocarbon), $\partial^{15}N(N_2)$ and multiple sulfur isotopes. These data will be discussed with the following questions. How are the Kairei hydrothermal fluids enriched with H_2? How are the geochemical processes in the whole hydrothermal fluid circulation? How do the subseafloor microbial communities affect the Kairei hydrothermal fluids? Does truly the HyperSLiME affect the carbon isotopic fractionation in the Kairei hydrothermal field? Does truly the *Alviniconcha* endosymbiont eat H_2? What controls the energy metabolisms of free-living and symbiotic microbial components?

We will also conduct measurements of dissolved non-gas species including major elements (Mg, Ca, Na, Cl), minor elements (Sr, Ba, K, Li, B, Br, I, SO_4, NO_3), and trace metals (Mn, Fe, other heavy metals, rare-earth elements) for seawater, hydrothermal fluid, and shimmering water samples. For the dissolved elements, analyses will be performed in Kochi University using ICP-AES, flame spectrophotometry, and ion chromatography for major and minor elements, and ICP-MS for trace metal elements.

3. Microbiology and macrobiology

Toward understanding molecular mechanisms underlying deep-sea vent chemoautotrophs-macro fauna symbioses

Satoshi NAKAGAWA (Hokkaido University)

Shore-based study includes:

1. Obtaining glycan profiles from both host animals and their symbiotic bacteria.
2. Performing wide array of "-omics" analyses, such as community genomic, proteomic, transcriptomic analyses, on both host animals and their symbiotic bacteria.
3. Cultivating and characterizing free-living chemoautotrophs which have close phylogenetic relationship to symbionts.

Glycome analyses of deep-sea organisms

Takahiro Maeda, Kazuko Hirose, Ryuta Miakawa, Junko Kobayashi, Maho Amano and Shin-Ichiro Nishimura (Hokkaido University)

Glycoprotein is observed in all eukaryote and its carbohydrate moieties are predicted to play some essential roles in the bodies such as signal transduction, infection and cell recognitions. But their glycome analyses have not been proceeded compared with proteins and genomes because of the difficulty.

Recently, our group developed the "glycoblotting method", a large-scale and quantitative glycome analysis technique utilized by MALDI-TOF MS, and firstly, performed the birds and fish glycomics. From these results, we elucidated that glycome were different among not only species but also the same family members, and it is indicated that the evolutions of carbohydrate-related proteins including glycosyltransferases and glycosidases are possible to be clarified by comparison of their structures and functions.

And next, we focus on the deep sea organisms. We will analyze the carbohydrate diversity of deep sea organisms and their internal organ distributions (for example, serum, heart, brain, colon and gills) by glycoblotting method and compare to those of other animals like birds and fish to chase the foot print of molecular evolutions. In addition, the functional analyses of the glycoproteins will be performed based on the obtained results, and finally, the genome information which code proteins will be discovered by glycoform- focused reverse genomics.

Stereo selective catalyst search from deep sea materials

Takahiro Maeda, Shin-Ichiro Nishimura (Hokkaido University)

Natural compounds are still attractive as seeds of biologically active compounds like anti-cancer drugs and their organic synthesis is necessary to prepare enough amounts of target compounds to solve their function and structure. But, the complex structure is difficult to synthesize, especially stereo selective reactions are so hard that scientists have explored various catalyst and resolved using organ-metallic-complex.

Now, I focus the deep-sea materials to search new catalysis because first life is considered to be bone in deep sea and fist stereo selective reaction was performed at the time. In addition, various metals melt in chimney and stones around there.

I try the various symmetrical reactions under the complex materials from deep sea in classical organic solvent or high-pressure and high-temperature solvent like deep sea environment such as supercritical carbodioxide and subcritical water to discover new functional stereo selective catalysts.

Metabolic activity of deep-sea hydrothermal vent animals.

Tomoo Watsuji (SUGAR, JAMSTEC)

In this investigating cruise, I conducted the consumption experiments of hydrogen sulfide, thiosulfate, methane and hydrogen using Scaly foot, Alviniconcha sp., Rimicaris kairei and Bathymodiolus marisindicus. The deep-sea animals were added in the artificial seawater in which each substance was dissolved and were incubated at five degree. I collected a part of the seawater or gas including the beginning and the end during the incubation. I am planning to analyze the decrease of substrates using photometer, HPLC and gas chromatography. If hydrogen is consumed by endosymbiont and epibiotic microbial communities, it will be first finding in the any deep-sea invertebrates associated with bacteria. In the future, I want to indicate existence of autotrophic bacteria in the deep-sea animals from Kairei field and Edmond field to combine the consumption experiments with the enzymatic experiment.

In addition, I am planning to rear the caught deep-sea animals including Scaly foot. To the purpose, I will be back to Japan by ship with rearing of the animals.

Microbiological characterization of epi- and endo-symbiotic microorganism that live in the Kairei hydrothermal fired.

Hiroko Makita (SUGAR, JAMSTEC)

I carried out cultivation of symbiotic microorganisms using an animal's tissue with several media, and detected growth of several microorganisms, which must be concerned in the deep-sea hydrothermal animals. These cultures will be analyzed in detail at the shore laboratory. Results of the analyses will provide insights into contribution of microorganisms to symbiosis of deep-sea hydrothermal animals, and symbiotic microorganism's diversity.

Diversity of the animal communities associated with hydrothermal vent in the Indian Ocean

Hiromi Watanabe (IOB, JAMSTEC), Girish Beedessee (Mauritius Oecanography Institute), Suguru Nemoto (Enoshima Aquarium)

The first step to describe the animal community is listing up the abundance of animals consisting of the community to estimate species diversity. During YK09-13 Leg. 2 cruise, we listed and counted the animals collected from the Kairei and Edmond hydrothermal vent fields to estimate the species diversity of each communities.

In addition, genetic diversity and population connectivity between the Kairei and Edmond fields will be estimated using DNA sequence data sets of animals, such as *Alviniconcha* and scaly-foot gastropods and *Rimicaris* shrimp.

4. Petrology

Tomoaki MORISHITA (Kanazawa University) and Takazo SHIBUYA (JAMSTEC)

1. Major and trace element analyses for basaltic and doleritic rocks from Hakuho Knoll, Nakaniwa Ridge and Yokoniwa Rise will be performed in order to clarify the chemical characteristics of the rocks. We also plan to compare these results with previously obtained Uraniwa basalts data for the purpose of elucidating the genesis of and relationship among the Hakuho Knoll, Uraniwa Hills, Nakaniwa Ridge, and Uraniwa Rise. An XRF and solution-based ICP-MS at JAMSTEC will be used for the analyses. A laser ablation ICP-MS at Kanazawa University will also be used.

2. We examine petrology and mineralogy of peridotites and gabbros in order to reveal magmatic processes in the Central Indian Ridge. Isotopic compositions of clinopyroxene in peridotites should be applied to reveal genetic relationships between

isotopically unique CIR MORBs and their potential sources (peridotites we recovered). We also examine elemental and mineralogical changes on alteration and weathering of peridotites. An XRF and solution-based ICP-MS at JAMSTEC will be used for the analyses. A laser ablation ICP-MS at Kanazawa University will also be used.

3. Based on mineralogy and petrology of the all collected samples, we will reveal the hydrothermal alteration history of the Hakuho Garden. Secondary mineral assemblage and their composition will be analyzed in order to estimate the condition of hydrothermal alteration. Whole rock composition also provides chemical exchange between seawater/fluid and rock. Further, fluid inclusions in the hydrothermal deposit will be analyzed, using Laser Raman and PIXE, in order to estimate the composition of hydrothermal fluid below seafloor. For this purpose, the samples will be requested in the case that hydrothermal deposits are found by the microscopic observation in the laboratory. An EPMA, XRF and solution-based ICP-MS at JAMSTEC will be used for the analyses.

VI. APPENDIX

Sample lists for Micro- and Macro-biology, Geochemistry, and Petrology.

Animal sample list

Sample code	Description	Site	Date	Latitude	Longitude	Depth (m)	Total	Distribution (amount)
6K#1169-B01	Alviniconcha sp.	Monju chimney, Kairei Field	Nov 6th	25°19.2186'S	70°02.4219'E	2422	117 individuals	Nakagawa (100), SUGAR (2), Watanabe (15)
6K#1169-B02	Scaly foot	Monju chimney, Kairei Field	Nov 6th	25°19.2186'S	70°02.4219'E	2422	152 individuals	Nakagawa (100), SUGAR (21), Watanabe (22), Maeda (7), MOI (2)
6K#1169-B03	Rimicaris kairei	Monju chimney, Kairei Field	Nov 6th	25°19.2186'S	70°02.4219'E	2422	263 individuals	Nakagawa (30), SUGAR (40), Maeda (8), Enosui (185)
6K#1169-B04	Bathymodiolus marisindicus	Monju chimney, Kairei Field	Nov 6th	25°19.2186'S	70°02.4219'E	2422	22 individuals	Nakagawa (15), Maeda (5), SUGAR (2)
6K#1169-B05	Yunohanagani	Monju chimney, Kairei Field	Nov 6th	25°19.2186'S	70°02.4219'E	2422	18 individuals	Nakagawa (10), Maeda (5), Enosui (3)
6K#1169-B07	Monju chimney	Monju chimney, Kairei Field	Nov 6th	25°19.2186'S	70°02.4219'E	2422	155 g	SUGAR (100), Nakagawa (50), Maeda (5), Enosui ()
6K#1169-B08	Kali dead chimney	Kali chimney, Kairei Field	Nov 6th	25°19.2256'S	70°02.3817'E	2454	100 g	SUGAR (100), Enosui ()
6K#1172-B01	Alviniconcha sp.	Edmond Field (20-30m north of #24)	Nov 9th	23°52.6601'S	69°35.8029'E	3277	90 individuals	Nakagawa (55), SUGAR (6), Watanabe (17), Enosui ()
6K#1172-B02	Rimicaris sp.	Edmond Field (20-30m north of #24)	Nov 9th	23°52.6601'S	69°35.8029'E	3277	1179 individuals	SUGAR (160), Enosui (1019)
6K#1172-B03	Mirocaris sp.	Edmond Field (20-30m north of #24)	Nov 9th	23°52.6601'S	69°35.8029'E	3277	44 individuals	Enosui (44)
6K#1172-B04	Yunohanagani	Edmond Field (20-30m north of #24)	Nov 9th	23°52.6601'S	69°35.8029'E	3277	2 individuals	Enosui (2)
6K#1174-B01	Alviniconcha sp.	Monju chimney, Kairei Field	Nov 12th	25°19.2237'S	70°02.4183'E	2421	57 individuals	Nakagawa (50), SUGAR (2), Watanabe (1), Enosui (4)
6K#1174-B02	Scaly foot	Monju chimney, Kairei Field	Nov 12th	25°19.2237'S	70°02.4183'E	2421	40 individuals	Nakagawa (35), SUGAR (3), Enosui (2)
6K#1174-B03	Rimicaris kairei	Monju chimney, Kairei Field	Nov 12th	25°19.2237'S	70°02.4183'E	2421	95 individuals	SUGAR (40), Enosui (55)
6K#1174-B04	Yunohanagani	Monju chimney, Kairei Field	Nov 12th	25°19.2237'S	70°02.4183'E	2421	1 individual	Enosui (1)
6K#1174-B06	Chimney	Monju chimney, Kairei Field	Nov 12th	25°19.2260'S	70°02.4270'E	2417	150g	Nakagawa (50), SUGAR (100)
6K#1175-B01	Alviniconcha sp.	Monju chimney, Kairei Field	Nov 13th	25°19.2262'S	70°02.4181'E	2422	57 individuals	Nakagawa (30), MOI (15), Watanabe (12)
6K#1175-B02	Rimicaris kairei	Monju chimney, Kairei Field	Nov 13th	25°19.2262'S	70°02.4181'E	2422	3479 individuals	MOI (30), SUGAR (128), Enosui (3321)
6K#1175-B03	Bathymodiolus marisindicus	Fudo chimney, Kairei Field	Nov 13th	25°19.2265'S	70°02.4111'E	2429	42 individuals	MOI (15), SUGAR (27)
6K#1175-B04	Yunohanagani	Monju chimney, Kairei Field	Nov 13th	25°19.2262'S	70°02.4181'E	2422	30 individuals	MOI (30)
6K#1175-B05	Mirocaris indica	Monju chimney, Kairei Field	Nov 13th	25°19.2262'S	70°02.4181'E	2422	1 individual	MOI (1)
6K#1175-B06	Fish (Ashiro)	Monju chimney, Kairei Field	Nov 13th	25°19.2262'S	70°02.4181'E	2422	1 individual	MOI (1/2), Maeda (1/2)
6K#1175-B07	Daikoku active chimney	Daikoku chimney, Kairei Field	Nov 13th	25°19.2094'S	70°02.4139'E	2442	250g	Nakagawa (50), SUGAR (200)
6K#1175-B08	Daikoku inactive chimney	Daikoku chimney, Kairei Field	Nov 13th	25°19.2094'S	70°02.4139'E	2442	250g	Nakagawa (50), SUGAR (200)

Fluid sample list

Dive	ID	Date DD/MM/YYYY	Time	Location Latitude	Location Longitude	temperature max (˚C)	temperature average (˚C)	Distribution	Objective	Note
#1169	W1	06/11/2009	13:04	25º19.2274 S	70º02.3698 E	320	247	KU, JAMSTEC	Fluid chemistry, M-bio (fixation)	Kali chimney
	W2		13:04	25º19.2274 S	70º02.3698 E	n.d.	n.d.	JAMSTEC	Gas analysis	Kali chimney
	W3		15:26	25º19.2186 S	70º02.4218 E	n.d.	n.d.	KU, JAMSTEC	Fluid chemistry, M-bio (fixation)	Monju scaly colony
	W4		15:26	25º19.2186 S	70º02.4218 E	n.d.	n.d.	JAMSTEC	Gas analysis	Monju scaly colony
	N		13:04	25º19.2274 S	70º02.3698 E	n.d.	n.d.	KU, JAMSTEC	M-bio (DNA, cultivation), Fluid chemistry	Kali chimney plume 5 m above
#1172	W1	09/11/2009	15:37	23˚52.6601 S	69˚35.8029 E	6.6	4.5	KU, JAMSTEC, Hokkaido Univ.	Fluid chemistry, M-bio (cultivation, fixation)	Alviniconcha colony water right
	W2		15:37	23˚52.6601 S	69˚35.8029 E	6.6	4.5	JAMSTEC	Gas analysis	Alviniconcha colony water right
	W3		15:37	23˚52.6601 S	69˚35.8029 E	8.5	5.3	KU, JAMSTEC, Hokkaido Univ.	Fluid chemistry, M-bio (cultivation, fixation)	Alviniconcha colony water left
	W4		15:37	23˚52.6601 S	69˚35.8029 E	8.5	5.3	JAMSTEC	Gas analysis	Alviniconcha colony water left
	CW3		13:08	23˚52.6563 S	69˚35.8055 E	245	243.5	KU, JAMSTEC	Fluid chemistry, M-bio (cultivation, fixation)	Alviniconcha sita black smoker
	CW4		13:08	23˚52.6563 S	69˚35.8055 E	245	243.5	JAMSTEC	Gas analysis	Alviniconcha sita black smoker
#1174	CW1&2	12/11/2009	12:27	25º19.2274 S	70º02.3698 E	352	350	JAMSTEC	M-bio (cultivation)	Kali chimney
	CW3&4		12:27	25º19.2274 S	70º02.3698 E	359.4	359.1	JAMSTEC	M-bio (cultivation)	Kali chimney
	CW1.5		12:27	25º19.2274 S	70º02.3698 E	352	350	KU, JAMSTEC	Fluid chemistry	Kali chimney
	CW2.5		12:27	25º19.2274 S	70º02.3698 E	352	350	KU, JAMSTEC	Fluid chemistry	Kali chimney
	CW3.5		12:27	25º19.2274 S	70º02.3698 E	359.4	359.1	KU, JAMSTEC	Fluid chemistry	Kali chimney
	CW4.5		12:27	25º19.2274 S	70º02.3698 E	359.4	359.1	KU, JAMSTEC	Fluid chemistry	Kali chimney
	W3&W4 no sample		14:15	25º19.2237 S	70º02.4183 E	20.2 (Min = 4.1)	10.5		Just temperature record	Monju Alviniconcha colony
#1175	W1	13/11/2009	12:55	25º19.2240 S	70º02.3845 E	356.7	349.6	KU, JAMSTEC	Fluid chemistry, M-bio (cultivation, fixation)	Kali chimney
	W2		12:55	25º19.2240 S	70º02.3845 E	359.1	358.8	JAMSTEC	Gas analysis	Kali chimney
	W3		14:29	25º19.2262 S	70º02.4181 E	18.8 (Min = 5.5)	12.4	KU, JAMSTEC	Fluid chemistry, M-bio (cultivation, fixation)	Monju Alviniconcha colony
	W4		14:29	25º19.2262 S	70º02.4181 E	18.8 (Min = 5.5)	12.4	JAMSTEC	Gas analysis	Monju Alviniconcha colony

Rock sample list

Dive	ID	Date DD/MM/YYYY	Time	Location Latitude	Location Longitude	Depth	Distribution	Archive	Note
#1170	R01	07/11/2009	11:39	25°14.9842'S	70° 6.1248'E	3420	Jamstec, Kanazawa, Kyoto	○	peridotite
	R02		11:39	25°14.9842'S	70° 6.1248'E	3420	Jamstec, Kanazawa	○	basalt
	R03		11:39	25°14.9842'S	70° 6.1248'E	3420	Jamstec, Kanazawa	○	peridotite
	R04		12:14	25°14.9782'S	70° 6.0338'E	3315	Jamstec, Kanazawa	○	peridotite
	R05		12:14	25°14.9782'S	70° 6.0338'E	3315	Jamstec, Kanazawa	○	peridotite
	R06		12:32	25°14.9739'S	70° 6.0172'E	3298	Kanazawa		gabbro?
	R07		12:32	25°14.9739'S	70° 6.0172'E	3298	Jamstec, Kanazawa	○	gabbro?
	R08		12:32	25°14.9739'S	70° 6.0172'E	3298	Jamstec, Kanazawa	○	gabbro?
	R09		12:59	25°15.0963'S	70° 5.8442'E	3216	Jamstec, Kanazawa	○	peridotite
	R10		12:59	25°15.0963'S	70° 5.8442'E	3216	Jamstec	○	basalt
	R11		12:59	25°15.0963'S	70° 5.8442'E	3216	Jamstec	○	basalt
	R12		13:59	25°15.1905'S	70° 5.2863'E	2987	Jamstec, Kanazawa	○	peridotite
	R13		13:59	25°15.1905'S	70° 5.2863'E	2987	Jamstec, Kanazawa	○	gabbro
	R14		13:59	25°15.1905'S	70° 5.2863'E	2987	Jamstec, Kanazawa	○	peridotite
	R15		14:20	25°15.1534'S	70° 5.1509'E	2885	Jamstec, Kanazawa	○	peridotite
	R16		14:20	25°15.1534'S	70° 5.1509'E	2885	Jamstec, Kanazawa	○	peridotite
	R17		14:20	25°15.1534'S	70° 5.1509'E	2885	Jamstec, Kanazawa		peridotite
	R18		14:46	25°15.1079'S	70° 4.9245'E	2783	Jamstec, Kanazawa, Kyoto	○	gabbro
	R19		14:46	25°15.1079'S	70° 4.9245'E	2783	Jamstec, Kanazawa	○	peridotite
	R20		14:46	25°15.1079'S	70° 4.9245'E	2783	Jamstec, Kanazawa	○	peridotite
	R21		15:03	25°15.1277'S	70° 4.8153'E	2700	Jamstec, Kanazawa	○	peridotite
	R22		15:03	25°15.1277'S	70° 4.8153'E	2700	Jamstec, Kanazawa	○	peridotite
	R23		15:03	25°15.1277'S	70° 4.8153'E	2700	Jamstec, Kanazawa	○	peridotite
	R24		15:17	25°15.1443'S	70° 4.6966'E	2635	Jamstec, Kanazawa	○	peridotite
	R25		15:17	25°15.1443'S	70° 4.6966'E	2635	Jamstec, Kanazawa	○	peridotite
	R26		15:17	25°15.1443'S	70° 4.6966'E	2635	Jamstec, Kanazawa	○	peridotite
	R27		15:37	25°15.1790'S	70° 4.6311'E	2569	Jamstec, Kanazawa	○	peridotite
	R28		15:37	25°15.1790'S	70° 4.6311'E	2569	Jamstec, Kanazawa		peridotite
	R29a		15:37	25°15.1790'S	70° 4.6311'E	2569	Jamstec, Kanazawa		gabbro or peridotite
	R29b		15:37	25°15.1790'S	70° 4.6311'E	2569	Jamstec, Kanazawa	○	peridotite
	R30		15:52	25°15.2545'S	70° 4.5771'E	2539	Jamstec	○	basalt
	R31		15:52	25°15.2545'S	70° 4.5771'E	2539	Jamstec, Kanazawa	○	gabbro
	R32		15:52	25°15.2545'S	70° 4.5771'E	2539	Jamstec, Kanazawa	○	basalt

Rock sample list

Dive	ID	Date DD/MM/YYYY	Time	Location		Depth	Distribution	Archive	Note
				Latitude	Longitude				
#1171	R01	8/11/2009	11:19	25°18.4827'S	70°6.8433'E	2913	Jamstec	○	Basalt
	R02		11:19	25°18.4827'S	70°6.8433'E	2913	Jamstec, Kanazawa (glass)	○	Basalt
	R03		11:19	25°18.4827'S	70°6.8433'E	2913	Jamstec	○	Basalt
	R04		11:42	25°18.4848'S	70°6.7647'E	2840	Jamstec, Kanazawa (glass)	○	Basalt
	R05		11:42	25°18.4848'S	70°6.7647'E	2840	Jamstec	○	Basalt
	R06		11:42	25°18.4848'S	70°6.7647'E	2840	Jamstec	○	Basalt
	R07		11:58	25°18.4892'S	70°6.7305'E	2802	Jamstec	○	Basalt
	R08		11:58	25°18.4892'S	70°6.7305'E	2802	Jamstec	○	Basalt
	R09		11:58	25°18.4892'S	70°6.7305'E	2802	Jamstec	○	Basalt
	R10		12:29	25°18.4946'S	70°6.6749'E	2775	Jamstec, Kyoto	○	Basalt, massive, on outcrop
	R11		14:10	25°18.5260'S	70°4.7930'E	2978	Jamstec	○	Basalt
	R12		14:10	25°18.5260'S	70°4.7930'E	2978	Jamstec	○	Basalt
	R13		14:10	25°18.5260'S	70°4.7930'E	2978	Jamstec	○	Basalt
	R14		14:19	25°18.5358'S	70°4.7720'E	2944	Jamstec, Kanazawa (glass)	○	Basalt, pillow, on outcrop
	R15		15:02	25°18.3790'S	70°4.5873'E	2908	Jamstec	○	Basalt, pillow, on outcrop
	R16		15:39	25°18.0977'S	70°4.7374'E	2906	Jamstec, Kanazawa (glass)	○	Basalt, lava flow, on outcrop
	R17		16:02	25°18.0002'S	70°4.7839'E	2892	Jamstec, Kanazawa (glass)	○	Basalt, lava flow, on outcrop

Rock sample list

Dive	ID	Date DD/MM/YYYY	Time	Location		Depth	Distribution	Archive	Note
				Latitude	Longitude				
#1173	R01	10/11/2009	11:20	25°16.4277'S	70° 7.2634'E	3084	Jamstec, Kanazawa	○	olivine-rich basalt
	R02		11:20	25°16.4277'S	70° 7.2634'E	3084	Jamstec, Kanazawa	○	olivine-rich basalt
	R03		11:20	25°16.4277'S	70° 7.2634'E	3084	Jamstec, Kanazawa	○	olivine-rich basalt
	R04		13:51	25°17.0940'S	70° 6.7677'E	2997	Jamstec, Kanazawa	○	dolerite
	R05		13:51	25°17.0940'S	70° 6.7677'E	2997	Jamstec	○	dolerite
	R06		13:51	25°17.0940'S	70° 6.7677'E	2997	Jamstec	○	basalt
	R07		14:08	25°16.9766'S	70° 6.5659'E	3003	Kanazawa	○	mudstone
	R08		14:08	25°16.9766'S	70° 6.5659'E	3003	Jamstec	○	dolerite
	R09		14:08	25°16.9766'S	70° 6.5659'E	3003	Jamstec, Kanazawa	○	gabbro
	R10		14:24	25°16.9632'S	70° 6.4265'E	3021	Jamstec, Kanazawa		ol-gabbro
	R11		14:24	25°16.9632'S	70° 6.4265'E	3021	Jamstec, Kanazawa		micro-gabbro
	R12		14:57	25°16.9170'S	70° 6.2176'E	3024	Jamstec, Kanazawa	○	basalt
	R13		14:57	25°16.9170'S	70° 6.2176'E	3024	Jamstec, Kanazawa	○	basalt
	R14		14:57	25°16.9170'S	70° 6.2176'E	3024	Kanazawa		Mn-coated
	R15		14:57	25°16.9170'S	70° 6.2176'E	3024	Jamstec, Kanazawa	○	micro-gabbro
	R16		15:32	25°16.6711'S	70° 5.9650'E	3020	Jamstec	○	basalt
	R17		15:32	25°16.6711'S	70° 5.9650'E	3020	Jamstec	○	basalt
	R18		16:02	25°16.5783'S	70° 5.7537'E	3026	Jamstec, Kanazawa	○	basalt
	R19		16:02	25°16.5783'S	70° 5.7537'E	3026	Jamstec	○	basalt
	R20		16:02	25°16.5783'S	70° 5.7537'E	3026	Jamstec, Kanazawa, Kyoto	○	basalt

Rock sample list

Dive	ID	Date DD/MM/YYYY	Time	Location Latitude	Location Longitude	Depth	Distribution	Archive	Note
#1176	R01	14/11/2009	11:40	25°16.4864'S	70° 5.6029'E	3031	Jamstec, Kanazawa	○	peridotite
	R02		11:40	25°16.4864'S	70° 5.6029'E	3031	Jamstec	○	dolerite
	R03		11:52	25°16.4828'S	70°5.5425'E	2998	Jamstec, Kanazawa	○	peridotite
	R04		11:52	25°16.4828'S	70°5.5425'E	2998	Jamstec, Kanazawa	○	peridotite
	R05		12:22	25°16.4885'S	70°5.3280'E	2874	Jamstec	○	dolerite
	R06		12:22	25°16.4885'S	70°5.3280'E	2874	Jamstec	○	dolerite
	R07		12:22	25°16.4885'S	70°5.3280'E	2874	Jamstec	○	dolerite
	R08		12:44	25°16.4456'S	70°5.1406'E	2763	Jamstec, Kanazawa	○	peridotite
	R09		12:44	25°16.4456'S	70°5.1406'E	2763	Jamstec, Kanazawa	○	peridotite
	R10		13:12	25°16.4279'S	70°5.0286'E	2657	Jamstec, Kanazawa	○	peridotite
	R11		13:12	25°16.4279'S	70°5.0286'E	2657	Jamstec, Kanazawa	○	peridotite
	R12		13:12	25°16.4279'S	70°5.0286'E	2657	Jamstec, Kanazawa		peridotite
	R13		13:35	25°16.3983'S	70°4.9230'E	2562		○	mud
	R14		13:35	25°16.3983'S	70°4.9230'E	2562	Jamstec, Kanazawa		mud
	R15		13:50	25°16.3784'S	70°4.8578'E	2530	Jamstec, Kanazawa	○	peridotite
	R16		13:50	25°16.3784'S	70°4.8578'E	2530	Jamstec, Kanazawa		peridotite
	R17		14:06	25°16.3430'S	70°4.7204'E	2513	Jamstec	○	dolerite
	R18		14:06	25°16.3430'S	70°4.7204'E	2513	Jamstec, Kanazawa	○	dolerite
	R19		14:37	25°16.3683'S	70°4.4647'E	2468	Jamstec	○	basalt
	R20		14:37	25°16.3683'S	70°4.4647'E	2468	Jamstec, Kanazawa, Kyoto		peridotite
	R21		15:10	25°16.0902'S	70°4.3455'E	2491	Jamstec, Kanazawa	○	peridotite
	R22		15:10	25°16.0902'S	70°4.3455'E	2491	Jamstec, Kanazawa		peridotite
	R23		15:49	25°15.8956'S	70°4.2895'E	2426	Jamstec	○	rock