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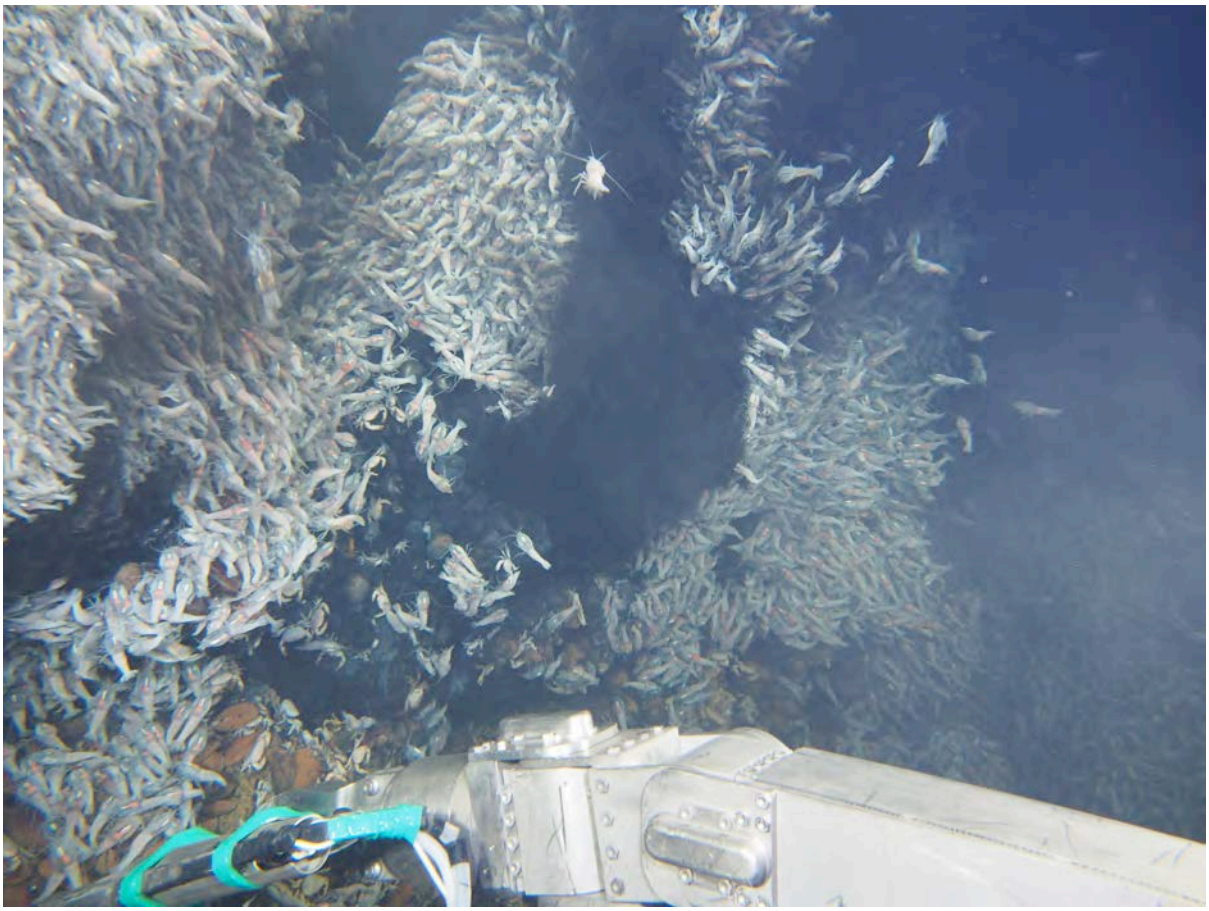
R/V Yokosuka & DSV Shinkai 6500 Cruise Report YK16-E02

Geochemical, Geomicrobiological and Biogeographical Investigation of DeepS Sea Hydrothermal Activities in the Central and Southwestern Indian Ridges

February 4, 2016 from Port Louis, Mauritius-March 2, 2016 to Port Louis, Mauritius



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

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We are grateful to Captain Mr. Y. Nakamura, Chief Officer Mr. Y. Mimori and Chief Engineer Mr. T. Abe for their safe navigation and their skillful handling of "R/V Yokosuka". Great thanks are due to Submersible Operation Manager Mr. T. Sakurai and "Shinkai 6500" operation team for their operations in sampling. We also thank Mr. Y. Fuwa, Nippon Marine Enterprise, Ltd., for his attentive supports. We thank all the JAMSTEC personnels who have supported us and this cruise. Finally, we would like to appreciate all the persons who have encouraged directly or indirectly this cruise.

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Cruise information

Cruise ID: YK16-02E

Vessel: YOKOSUKA

Title of the cruise: Geochemical, Geomicrobiological and Biogeographical Investigation of Deep-Sea Hydrothermal Activities in the Central and Southwestern Indian Ridges

Title of proposal: Geochemical, Geomicrobiological and Biogeographical Investigation of Deep-Sea Hydrothermal Activities
in the Central and Southwestern Indian Ridge

Cruise period: February 4 - March 2, 2016

Ports of call: Port Louis, Mauritius - Port Louis, Mauritius

Research area: Central and Southwestern Indian Ridges

Research map:

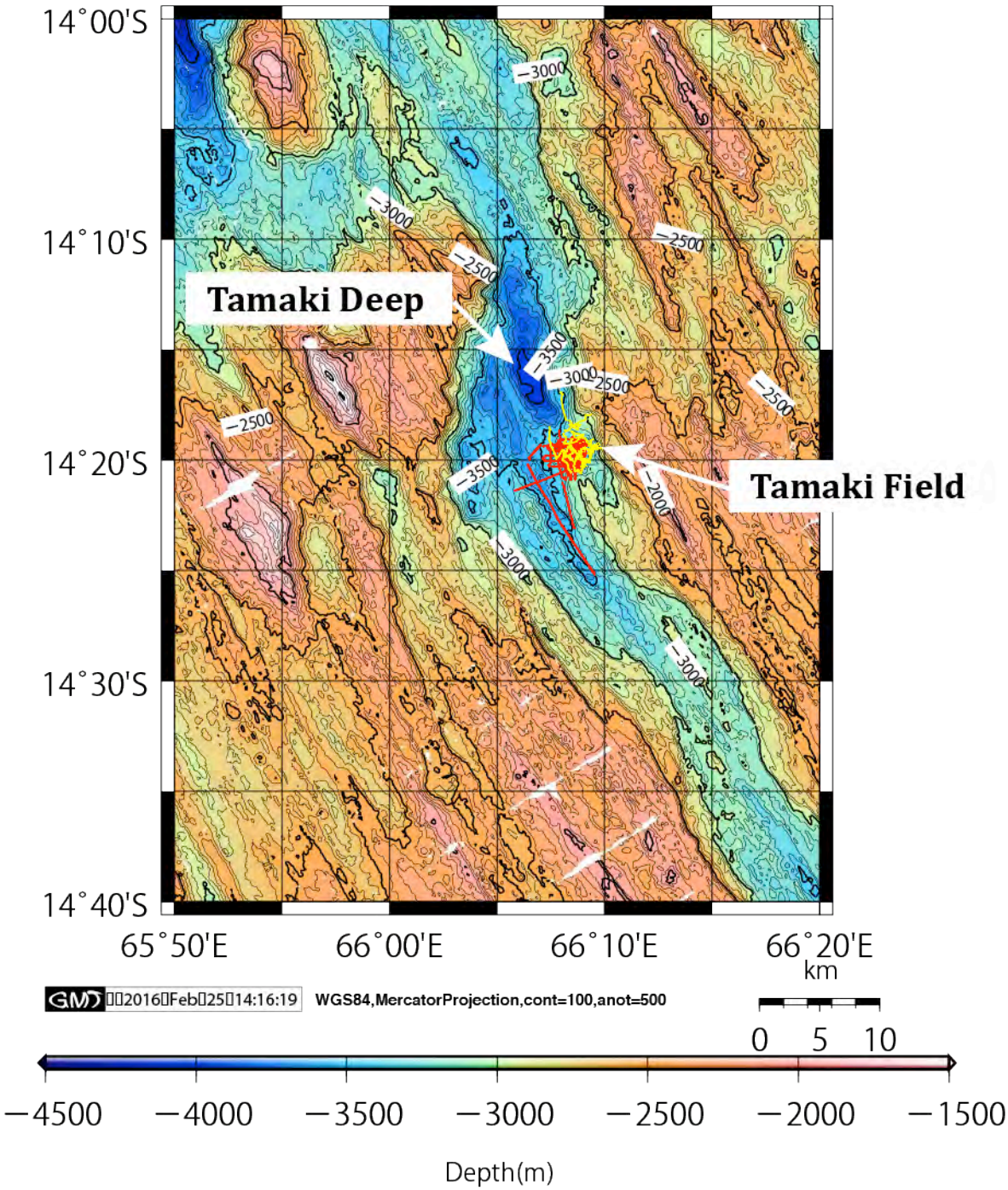

Figure Location of potential Tamaki Deep and potential Tamaki field that we surveyed in detail in this cruise.

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Quarter Master	**D. Yanagitani**
Quarter Master	**T. Miyashita**
Quarter Master	**H. Shigeta**
Quarter Master	**K. Kawamura**
Sailor	**F. Ohmachi**
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“Shinkai 6500” Operation Team

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1st Submersible Staff	**Keita Matsumoto**
1st Submersible Staff	**Tetsuya Komuku**
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2nd Submersible Staff	**Yokosuka Chida**
2rd Submersible Staff	**Keigo Suzuki**
2rd Submersible Staff	**Fumitaka Saito**
3rd Submersible Staff	**Naoto Minamino**

I. CRUISE SUMMARY

In YK16-02E cruise, we totally conducted 12 dives of Shinkai6500 and 2 dives of DeepTow in three specific locations in the Cnetral Indian Rdige (CIR). One of the cruise foci was the exploration of potential Tamaki hydrothermal field, which had been predicted originally from the data of hydrocast surveys by a Korean research vessel and currently from the results of AUV Urashima surveys in YK16-01E (previous cruise of YK16-02E). With 6 dives of Shinkai6500 and 2 dives of DeepTow, we thoroughly surveyed the hydrothermal activities in the potential Tamaki field area. Unfortunately, we did not successfully find a presently active seafloor hydrothermal activity there.

The potential Tamaki field area is located in so-called "inside corner high" of non-transform offset (NTO), in which many ultramafic rock-associated H_2-enriched hydrothermal fields (e.g., Kairei field) have been discovered. The potential Tamaki field area is characterized by a geologic setting such as the sequence of ridge axis valley, relatively young basaltic ridge, sedimentsp buried inter-ridges depression and steep ridge cliff from the ridge axis to the eastern ridge slope. AUV Urashima surveys detected faint turbidity, temperature and methane concentration anomalies at 200 m above the seafloor of the inter-ridges depression. Thus, we needed to survey all the slopes around the inter-ridges depression. At a depth zone of about 3300m, we found the hydrothermal alteration areas and dead chimneys and sulfide deposits at the eastern and northern cliffs of the inter-ridges depression. These are apparent signature of previous hydrothermal activities there. In addition, northern parts of the inter-ridges depression was characterized by many, large or small landslides, and the fresh outcrop of the cliff showed the excellent crustal formation. At the northern part of the interp ridges depression, the crustal formation and the bottom water chemistry were examined at a depth zone from 3500m to 3000m. From the deepest zone, a basalt breccia and a plutonic igneous rock were recovered but the former rock fell from the shallower parts and the latter one was a constitutional rock. From 3300 m to 3100m, enormous hydrothermal alteration area was found. At 3300m, we found a serpentinized peridotite and serpentinite mud and at 3100m, a plutonic igneous rock was recovered. These are very preliminary but quite important for understanding the geologic setting of the potential Tamaki filed area and the fluid source of the physicop chemical anomaly detected by the Hydrocast and AUV Urashima surveys. The nonp transform offset (NTO) around the potential Tamaki field is characterized by the large detachment fault and the deep depression at the center of NTO (Tamaki Deep) seems to represent the sequence from the upper mantle, the gabbroic layer and the overlying volcanic lava. Probably after the exposure of small ocean core complex (OCC) structure to the seafloor, hydrothermal circulation took place at the zone from peridotite to gabbro. The old hydrothermal circulation may be still active somewhere around the Tamaki Deep or may be submerged at the subseafloor environments. The physicop chemical anomaly detected by the Korean hydrocast and our AUV Urashima surveys would detect the steady-state but faint discharges of such serpentinization-driven fluids or –affected hydrothermal fluids or the episodic diffusion of the submerged fluids at the time of landslides. This is one of the most likely explanation based on our seafloor observation and sampling rocks and waters.

We have obtained lots of samples from two of the CIR deep-sea hydrothermal systems, Edmond and Kairei fields. From both fields, *Alviniconcha* gastropods were collected and

living individuals and tissues were used for the onboard experiments such as H_2 and DO consumptions. These experiments will provide important information to understand the physiological and metabolic differentiation of different ecotypes of *Alviniconcha* species dwelling at different chemical environments of different hydrothermal fields. At first, it looked that the Kairei-morphotype of scaly foot gastropod (*Chrysomallon squamiferum*) highly decreased their population, we found widespread and dense colonies at the Monju chimney site and successfully collected lots of individuals. In addition we conducted the in situ biomineralization experiments of scaly foot gastropods. The scale tissues and shells of the Soltairep morphotype of *C. squamiferum* and the surface-polished or -scratched scales and shells of the Kairei-morphotype of *C. squamiferum* were incubated at the previous *C. squamiferum*'s colony for 13 days. After the 13 days incubation, black minerals covered the new surface. The newly created minerals on the body surface of different morphotypes of *C. squamiferum* will be investigated onshore. These investigations will provide significant clues for clarifying how the fine iron-sulfide mineral crystals are created on the surface of scale and shell only of the Kairei-morphotype of *C. squamiferum* but not of the Solitairep and Longqi-morphotypes of *C. squamiferum.*

Many of the hydrothermal vent-endemic animal species in two hydrothermal fields were sampled. In tight collaboration between JAMSTEC and British universities, species composition of chemosynthetic animal communities will be completely characterized and the biogeographic, genetic connectivity and dispersal characteristics of animal components will be pursued based on population genetics, and evolutionary and developmental research.

The new findings and knowledge from the CIR hydrothermal systems and ecosystems will provide great new aspects to understand the deep-sea hydrothermal systems and associating microbial and biological interactions in this planet.

II. INTRODUCTION

General backgrounds & Scientific objectives

There have been only five high-temperature hydrothermal vent fields so far discovered in the Indian Ocean (Hashimoto et al. 2001; Gamo et al., 2001; Van Dover et al., 2001; Nakamura et al., 2012; Tao et al., 2012; Nakamura & Takai, 2015). In addition to an increasing interest in diversity and magnitude of hydrothermal activity for the evaluation of hydrothermal fluxes on a global scale, Indian Ocean hydrothermal systems are of great microbiological and biological 00nterest. For instance, the Kairei, Solitaire and Longqi hydrothermal fields are known to host a novel hydrothermal vent-endemic gastropod species, a scaly foot (*Chrysomallon squamiferum*), of which different morphotypes have sclerites on the foot and have different bio-mineralizations on scales and shells such as biologically controlled iron-sulfide coat, non-coat and chemically accreted coat, respectively (Waren et al., 2003; Suzuki et al., 2006; Chen et al., 2015). This gastropod is only the deep-sea animal capable of biomineralization of iron and sulfur. However, the details about biological and chemical mechanisms of iron-sulfide mineralization on the outermost body are still uncertain. However, based on the mineralogical, biochemical and genomic researches of different morphotypes and ecotypes of scaly foot gastropods, we have proposed that the iron-sulfide mineralization is highly associated with the physic-chemical interaction between the chemical features of their habitats and their structural proteins in the sclerite and shell. Namely, the kinetic control of adsorption and nucleation of soluble iron ions and sulfides on the surface proteins of sclerite and shell makes different mineralogical results of different morphotypes and ecotypes of scaly foot gastropods. Thus, one of the primary scientific objectives in this cruise is to justify our hypothesis by in situ experiments of dead scaly foot tissues and shells, particularly in the Kairei field.

Another predominant gastropod specie in three of the CIR hydrothermal fields is *Alviniconcha hessleri.* The *Alviniconcha* gastropods are distributed in the western Pacific hydrothermal fields and in the Indian ocean as well. This chemosynthetic animal was previously known to have a monophyletic gammaproteobacterial endosymbiont in the gill tissue, however all the Indian *Alviniconcha hessleri* are known to host the Sulfurovum-like epsilon-proteobacteria for their symbionts. This symbiont is very different from the gammaproteobacterial and even from epsilon-proteobacterial symbionts found in the Pacific *Alviniconcha hessleri*. The outstanding feature in the endosymbiosis of Indian *Alviniconcha* gastropods is its chemosynthetic metabolisms. The symbionts of Indian *Alviniconcha* gastropods represent the highest metabolic activity of H_2 and the great contribution of H_2-oxidation for biomass production of host. In the long history of deep-sea chemosynthetic animals, it has been believed that sulfide and methane are two primary energy sources for biomass production of chemosynthetic fauna. However, in the deep-sea hydrothermal vent-endemic microbial ecosystems, H_2 is the most important energy source for the primary production. Microorganisms like the best to have H_2 but why not animals like? Recently several genomic and transcriptomic approaches suggest that some mussels and gastropods utilize H_2 as supplements for their energy sources and biomass production. However, these researches have only suggested the additional use of H_2. Our previous investigations of Indian *Alviniconcha* gastropods showed that they have a homogeneous

symbiont genotype (*Sulfurovum*-like epsilonproteobacterium) but have dual energy metabolisms H_2-and S-oxidations and H_2-oxidation should be competitive or greater than S-oxidation. What we have to do for justification of this fact is mRNA-FISH analysis using the *Alviniconcha* individuals from different fields including the Kairei field. Thus, another primary scientific objective in this cruise is to coordinate the physical and chemical conditions of different *Alviniconcha* ecotypes and symbiotypes with the mRNA for hydrogenases and Sox systems expression levels using the in situ fixed samples.

According to a proposition proposed by Takai & Nakamura (2011) and Nakamura & Takai (2014), the H_2-enriched hydrothermal fluid vents would host HyperSLiME-like microbial communities in the proximity of the hydrothermal fluid discharges. Prior to this YK16-02 cruise, we identified that the Kairei and Dodo hydrothermal fields in the CIR, the Rainbow field in the MAR and the Beebe and Von Damm fields in the MCR harbored extraordinary populations of (hyper)thermophilic H_2-trophic methanogens and chemolithotrophic primary production by diverse H_2-trophs. However, other H_2-dominated hydrothermal fields in the ultraslow-spreading ridges such as the Longqi hydrothermal field in the SWIR and in the intermediate-spreading ridges such as the CIR have been never examined. Thus, another primary scientific objective in this cruise is to explore the seafloor and the potentially subseafloor microbial communities in the H_2-dominated hydrothermal fields in the Indian Ocean such as the Longqi hydrothermal field in the SWIR and the new fields in the CIR.

During YK16-01E, the scientific team led by the chief scientist Dr. Shinsuke Kawagucci have surveyed the seafloor along the segments 17, 18, 19, 20 of CIR for searching new hydrothermal fields using AUV Urashima. Fortunately, they have found multiple lines of signatures for hydrothermal activity on the eastern slope of ridge of the segment 18 at 14˚20'S (tentatively named as Tamaki field after Prof. Tamaki's (passed through in 2011) contribution to Indian Ocean seafloor geology, geophysics and hydrothermal activities. If this hydrothermal field is verified and is explored by Shinkai6500 during our cruise (YK16-02E), the data and samples will be very precious to pursue the above mentioned scientific objectives and the general cruise purpose "geochemical, geomicrobiological and biogeographical Investigation of deep-sea hydrothermal activities in the Central and Southwestern Indian Ridges". Thus, the seafloor observation and exploration of the Tamaki field by Shinkai6500 currently emerge but are also an important scientific objective of this cruise.

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communities in seafloor hydrothermal systems. Prog. Earth Planet. Sci. 1, 5.
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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" cannot 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. Geochemistry

WHATS-III fluid sampler

WHATS-III (Water Hydrothermal Atsuryoku Tight Sampler III) has been 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 is composed of inlet tubing, 4 sample bottle sets consisting of serially concatenated 2 types of pressure-resistant bottles (bottle 1; 19.5 ml, bottle 2; 56.5 ml) with ball valves at the both end, rolling bars to open and shut the valve and a deep-sea compatible pump. We will extract gases from fluids in 19.5 ml bottle1 and will analyze liquid chemical properties (pH, H_2S, NH_3 and so on) from fluids in bottle2. Usually WHATS is installed just at the ceter shell of Shinkai6500 and a sample inlet is located in a specific case in the sample baskets. Operation is controlled from the cockpit. At the time of each sampling, fluid temperature can be monitored using a thermometer attached to the top of the inlet tube.

Description	
Dimension of frame:	375 mm × 325 mm x 700mm
Weight:	32.95 kg in air
	18.65 kg in seawater
Depth range:	4000 m
Sample volume:	76 ml x 4 (19.5 ml x 4 + 56.5ml x 4)
Sampling rate:	97-390 ml / min
Electricity:	DC24 V / 1.0 A

MiyaJun-shiki 4 tubes samplers

Junshiki 4 tubes sampler is a gas-tight fluid sampler by Junichi Miyazaki, which much less cost than WHATS-III. The whole sampling scheme is very similar with that of WHATS-III but the manipulation of valve open/close is not operated by electric motor but by the submersible's manipulator. Gas-tight fluid is separately collected by 4 tubes and then are applied to the gas extraction and measurement. 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. Junshiki 4 tubes sampler is optimized to reduce valve operation and space occupation.

Treatment and onboard analyses of fluid samples for gas chemistry

In general, for vent fluid sampling, the WHATS-III sample bottles were used in pairs, one bottle for sample for soluble compoenents chemistry and the other for sample 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. Then, the valve on the bottle is opened and the fluid plus gas are allowed to drop into an evacuated flask. Sulfamic acid and mercury chloride have been put in the flask prior to the extraction, which acidify the fluid to extract dissolved CO_2 (carbon dioxide) and H_2S (hydrogen sulfide). The water in the extraction flask is then agitated by stirring bar. The H_2S gas and dissolved sulfide in the fluid are precipitated as HgS, which is provided for subsequent sulfur isotope analysis. The extracted gas phase was transferred to a total of 250 cm^3 evacuated stainless steel and glass container (for 34 compositional and isotope measurements of gas components). After the gas phase was obtained, the liquid phase was drawn 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 divided into a few bottles for each specific study. After samples for onboard analysis (pH, NH_4 and so on) and isotope determination were drawn, the rest of the fluid was filtered with a 0.45 μm disk filter. The filtrate was provided for chemical analysis of cations, anions and nutrients (NH_4). The rinse water was drawn into a bottle zinc acetate solution has been placed, to fix sulfide as zinc sulfide precipitation provided for sulfur isotope analysis. For a few samples, the fluid for isotope determination of specific organic matters was drawn in a small glass bottle and frozen immediately. The filtrate aliquot for cation (and trace metals) analysis was acidified with nitric acid to avoid hydroxide precipitation during storage. The filtrate aliquot for anion was storage in a refrigerator, and that for nutrients was frozen.

Because some chemical species (pH, alkalinity and some nutrients) are difficult to be conserved during storage, we therefore analyzed these species onboard, following Gieskes et al. (1991). Measurement of pH was conducted using an electrode (Radiometer, pHC2401-8) after calibration using JCSS standard solutions (pH = 6.86 and 4.01). Alkalinity was measured by 0.1N HCl titration, which end point was determined by gran's plot. Concentrations of ammonium ion (NH_4), and hydrogen sulfide (H_2S) were analyzed following classical methods; indo-phenol method (λ=640nm) for NH_4 and methylene blue method (λ=670nm) for H_2S, using a colorimeter (Shimazu, UV mini 1240). 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 (H_2S) and interference by specific species (NH_4).

4. 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.

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IV. DIVE REPORTS

YKDT#174 DIVE (Tamaki Field)	**Dr. Tomoo Watsuji**
YKDT#175 DIVE (Tamaki Field)	**Dr. Tomoo Watsuji**
#1447 DIVE (Tamaki Field)	**Mr. Masayuki Miyazaki**
#1448 DIVE (Tamaki Field)	**Dr. Alex Rogers**
#1449 DIVE (Kairei Field)	**Dr. Junichi Miyazaki**
#1450 DIVE (Kairei Field)	**Dr. Tomoo Watsuji**
#1451 DIVE (Edmond Field)	**Dr. Ken Takai**
#1452 DIVE (Tamaki Field)	**Dr. Christpher N. Roterman**
#1453 DIVE (Tamaki Field)	**Dr. Leigh Marsh**
#1454 DIVE (Tamaki Field)	**Dr. Julia Sigwart**
#1455 DIVE (Tamaki Field)	**Dr. Akiko Makabe**
#1456 DIVE (Tamaki Field)	**Mr. Masayuki Miyazaki**
#1457 DIVE (Edmond Field)	**Dr. Chong Chen**
#1458 DIVE (Kairei Field)	**Dr. Ken Takai**

Dive Report: 6K-DT Dive# 174
Date: February 7, 2016
Site: Tamaki Hydrothermal Field (CIR)
Landing: 9:44; 14˚19.0542S, 66˚08.4690E, D= 3363m
Leaving: 15:40; 14˚19.0804S, 66˚09.3522E, D=3233m
Observer: Tomoo Watsuji (JAMSTEC)

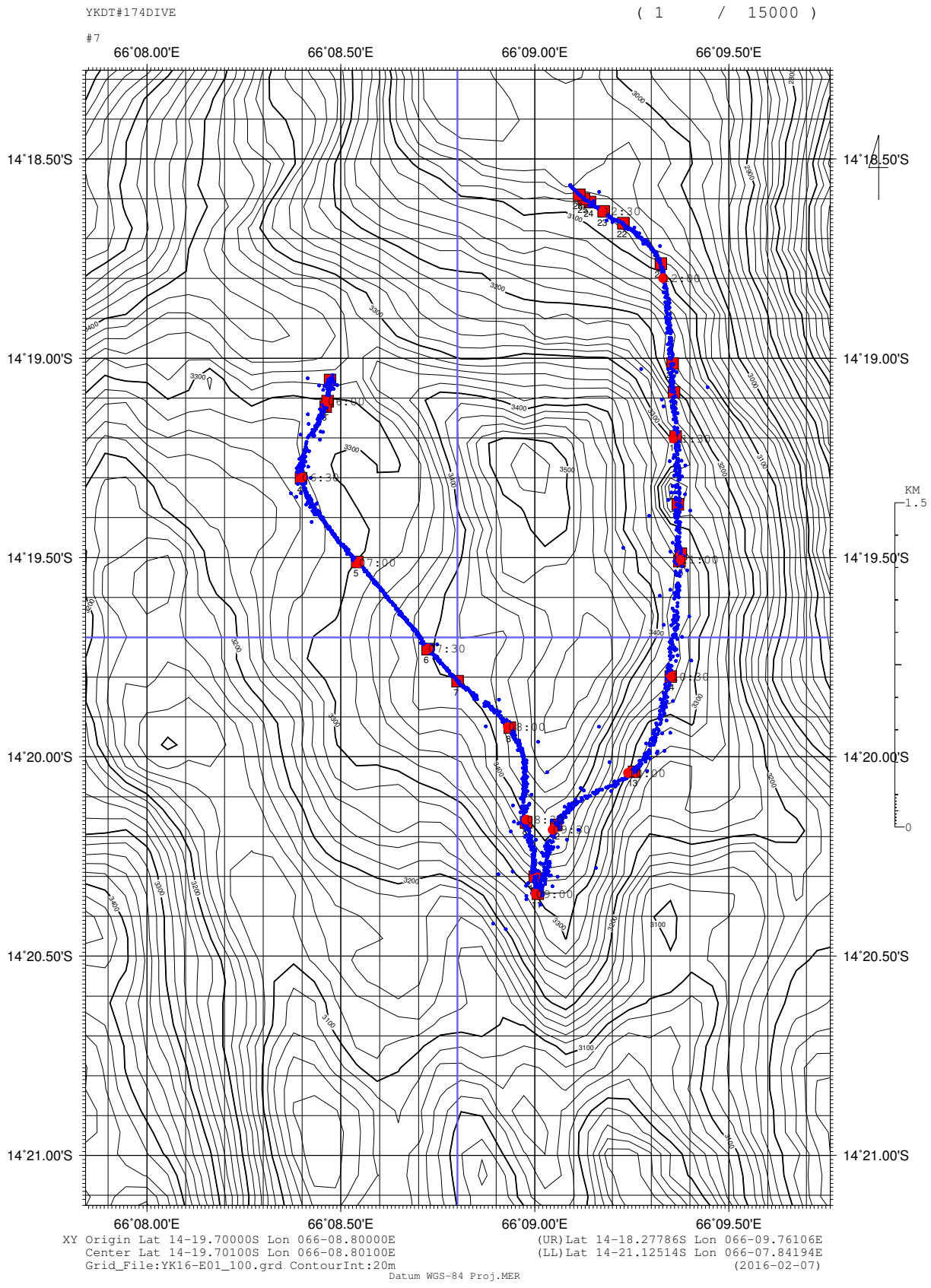
Objectives:
Main objective of the DT dive #174 is to find locations of hydrothermal activities in the Tamaki field.

Payloads:
- 8 bottles of Niskin water sampler
- DO sensor
- ORP sensor
- Methane sensor
- Turbidity sensor
- Marker x 1

Event list:

Time	Depth	Latitude&Longtitude	Description
9: 44	3363m	14˚19.0542S, 66˚08.4690E	Landing at sediment
9: 58	3320m	14˚19.0972S, 66˚08.4669E	We headed to the #1.
10:02	3298m	14˚19.1156S, 66˚08.4609E	We climbed the edge of basalt.
10:10	3269m	14˚19.1640S, 66˚08.4446E	We arrived at the #1. We couldn't see animal.
10:20	3282m	14˚19.2458S, 66˚08.4021E	We headed to the #2. Sediment and basalt were observed.
10:45	3273m	14˚19.4132S, 66˚08.4587E	We climbed the edge of basalt.
10:54	3279m	14˚19.4803S, 66˚08.5196E	We passed near the edge of basalt. A fish was observed.
11:41	3387m	14˚19.8047S, 66˚08.7969E	We arrived at the #2. Sediment and basalt were observed.
11:57	3443m	14˚19.9117S, 66˚08.9255E	Wareme was observed.
12:50	3332m	14˚20.3024S, 66˚09.0045E	We arrived at the #3. Sediment and basalt were observed.
13:45	3377m	14˚20.099S, 66˚09.1371E	Sediment and basalt were observed.
13:56	3278m	14˚20.0581S, 66˚09.2271E	We climbed the edge of basalt covered with sediment.
14:04	3227m	14˚20.01S, 66˚09.2699E	Sediment and basalt were observed.
14:32	3320m	14˚19.7766S, 66˚09.3415E	Sediment and basalt were observed.
14:50	3359m	14˚19.7303S, 66˚09.3648E	We arrived at the east of the #5.
14:57	3330m	14˚19.5321S, 66˚09.3926E	Sulfidic sediment might be observed.
15:14	3314m	14˚19.3500S, 66˚09.3718E	We arrived at the #7. Surface sediment was white, but underground was black.
15:17	3322m	14˚19.3172S, 66˚09.3677E	Oxidized basalt was observed.
15:40	3233m	14˚19.0804S, 66˚09.3522E	We left the bottom near the #6.

Dive Track of YKDT#174



Dive Report: 6K-DT Dive# 175
Date: February 8, 2016
Site: Tamaki Hydrothermal Field (CIR)
Landing: 9:44; 14˚19.9009S, 66˚08.7024E, D= 3388m
Leaving: 13:32; 14˚19.3761S, 66˚09.4099E, D=3280m
Observer: Tomoo Watsuji (JAMSTEC)

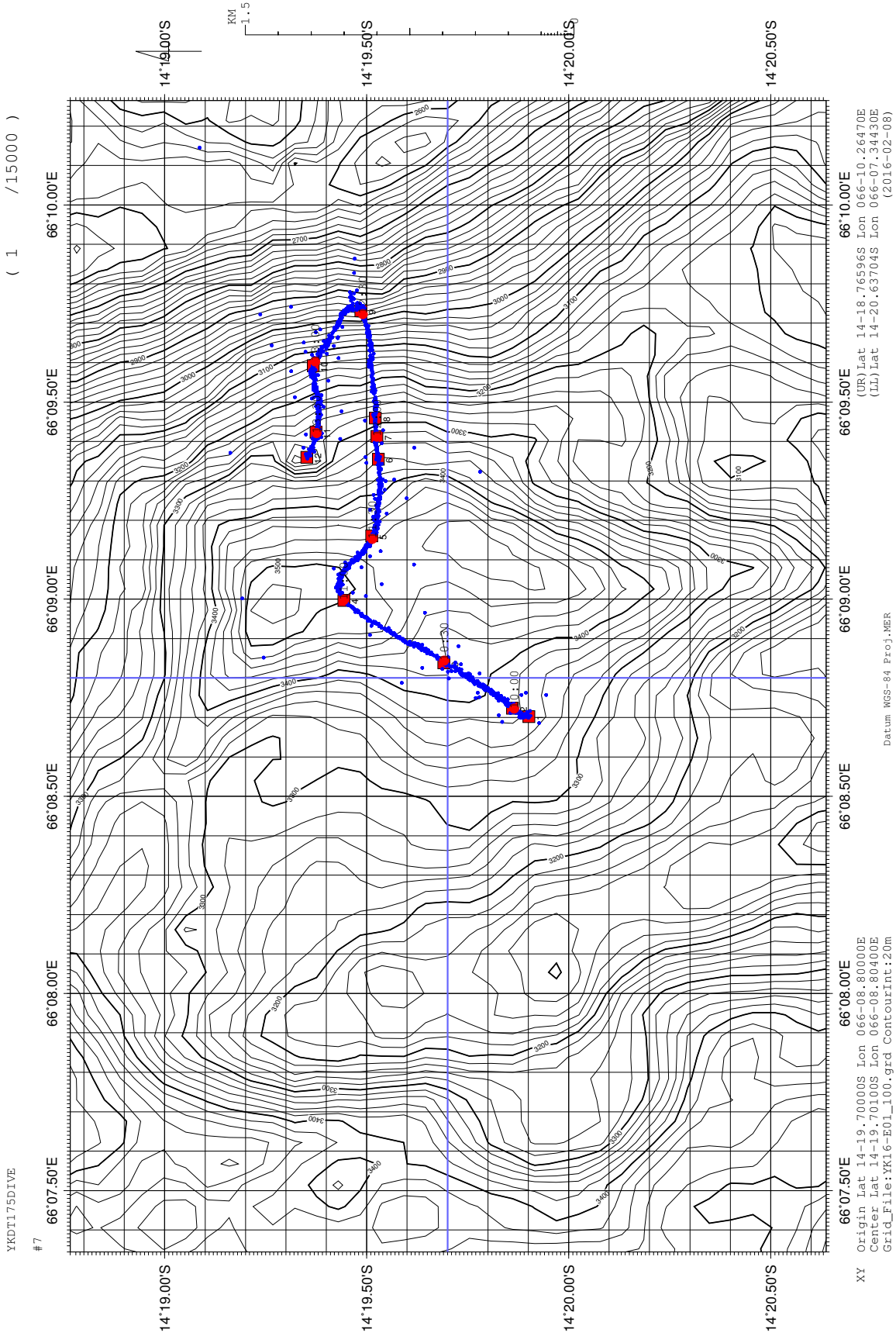
Objectives:
Main objective of the DT dive #175 is to find locations of hydrothermal activities in the Tamaki field.

Payloads:
- 8 bottles of Niskin water sampler
- DO sensor
- ORP sensor
- Methane sensor
- Turbidity sensor
- Marker x 1

Event list:

Time	Depth	Latitude&Longtitude	Description
9: 44	3388m	14˚19.9009S, 66˚08.7024E	Landing at sediment. We took the route of the line 1.
9: 58	3395m	14˚19.8714S, 66˚08.7150E	We headed toward northeast. White sediment was observed.
10:44	3477m	14˚19.5713S, 66˚08.9075E	We changed the direction of the route to southeast. The scenery was unchanged.
11:30	3459m	14˚19.5179S, 66˚09.1613E	We changed the direction of the route to east. The scenery was unchanged.
11:36	3434m	14˚19.5264S, 66˚09.2055E	We started to climb the edge of basalt and sediment.
11:50	3357m	14˚19.5304S, 66˚09.3208E	Black colored area was observed
11:53	3321m	14˚19.6168S, 66˚09.0879E	Oxidized basalt was observed.
11:57	3328m	14˚19.5256S, 66˚09.3851E	Black colored area was observed.
12:05	3278m	14˚19.5207S, 66˚09.4629E	Black colored area was observed.
12:18	3136m	14˚19.5054S, 66˚09.6054E	We arrived at the #5
12:30	2952m	14˚19.4872S, 66˚09.7314E	We headed to the #6 and started going down the slope.
13:32	3280m	14˚19.3761S, 66˚09.4099E	The electric system was down (No image and no CTD data came out). Dive was cancelled.

Dive Track of YKDT#175



Dive Report: Shinkai 6500 Dive# 1447
Date: February 9, 2016
Site: Area 7 in Indian Ocean
Landing: 12:59; 14º19.6962'S, 66º09.2243E, D=3486 m
Leaving: 15:46; 14º19.0019'S, 66º08.9550E, D=3295 m
Pilot: Tetsuya Komuku, **Co-pilot:** Keigo Suzuki
Observer: Masayuki Miyazaki (JAMSTEC)

Objectives:

The main objective of the dive #1447 is to explore the new hydrothermal vent in the area 7 field in Indian ocean. We will take samples of reference water, fluids, chimneys, animals and others.

Dive summary:

Shinkai 6500 landed the bottom, after reference seawater on 15 m from the bottom was collected in WHATS (#1). We navigated with observing the seafloor toward the event #2. We found dead chimney and observed it. We measured two standard solutions at the event #3 and #4. Finally, we collected a rock in sample box by manipulator.

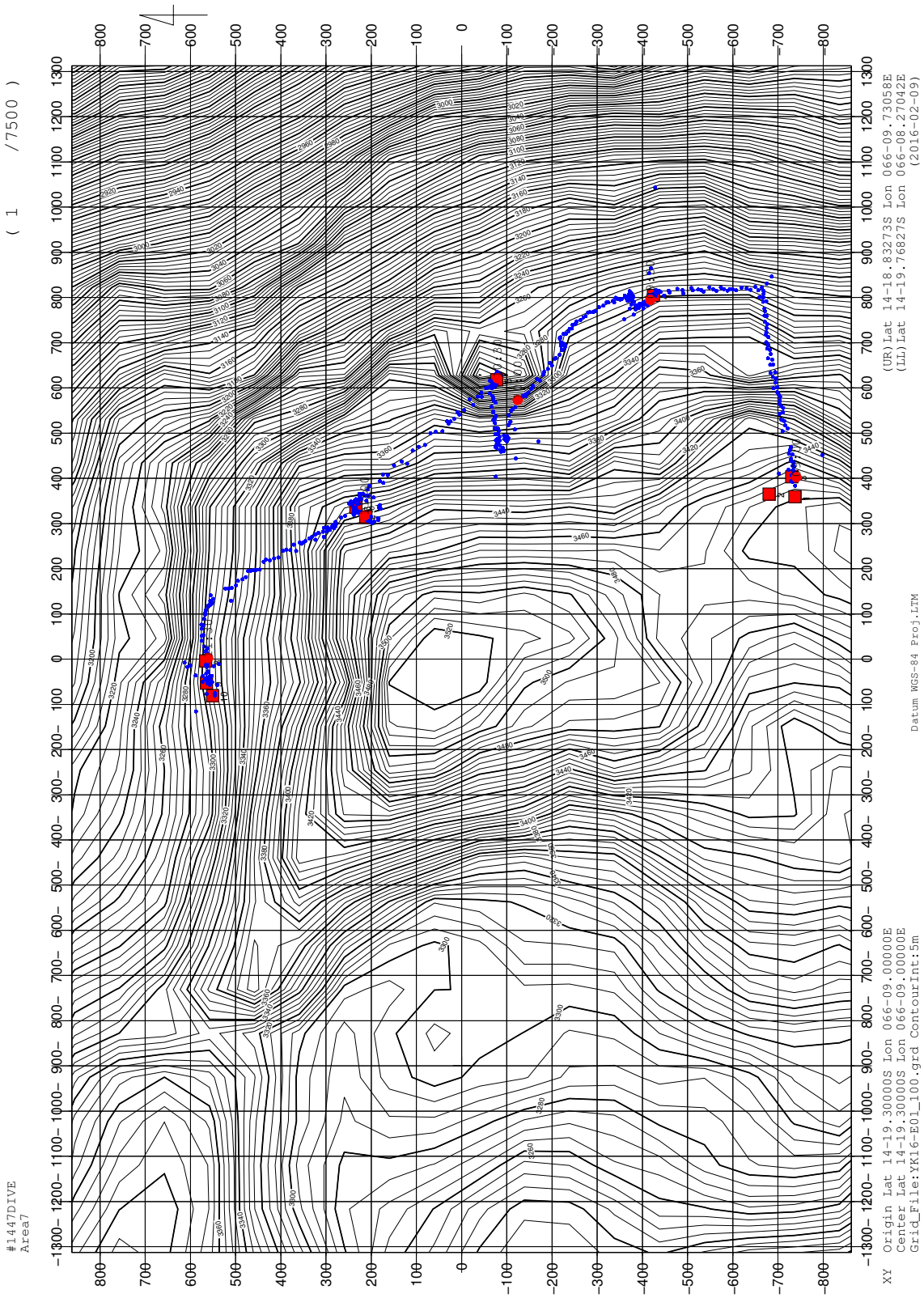
Payloads:

- 7 bottles canister x 1
- Slurp gun pomp x 1
- WHATS-III water sampler
- MJ water sampler x 2
- Thermometer with inlet x 1
- Methane sensor x 1
- Multi sensor x 1
- Standard solution (H_2 and H_2S) x 1
- Standard solution (CH_4) x 1
- Sample box x 2
- Marker x 2

Event list:

2. 12:55 Sampling #1 WHATS (reference water). (14º19.6691'S, 66º09.2031'E, D=3407 m)
3. 12:59 Landing at mud. (14º19.6962'S, 66º09.2243'E, D=3486 m)
4. 13:28 Finding Dead chimney. (14º19.5301'S, 66º09.4474'E, D=3296 m)
5. 14:20 Start measurement reference water of methane. (14º19.3428'S, 66º09.3437'E, D=3326 m)
6. 14:56 Finish measurement reference water of methane. (14º19.1731'S, 66º09.1869'E, D=3416 m)
7. 15:01 Start measurement reference water of hydrogen and hydrogen sulfide. (14º19.1856'S, 66º09.1754'E, D=3416 m)
8. 15:27 Finish measurement reference water of hydrogen and hydrogen sulfide. (14º19.1856'S, 66º09.1754'E, D=3416 m)
9. 15:41 Sampling Rock. (14º18.9948'S, 66º08.9702'E, D=3296 m)
10. 15:46 Leaving at mud. (14º19.0019'S, 66º08.9550'E, D=3295 m)

Dive Track of 6K#1447



Dive Report: Shinkai 6500 Dive# 1448
Date: February 10, 2016
Site: Area 7 in Indian Ocean
Landing: 12:12; 14º18.7827'S, 66º08.0807E, D=3382 m
Leaving: 15:46; 14º18.8367'S, 66º08.9294E, D=3175 m
Pilot: Akihisa Ishikawa, **co-pilot:** Hirofumi Ueki
Observer: Alex David Rogers (University of Oxford)

Objectives:

The main objective of dive #1448 was to locate a suspected new hydrothermal vent field in Area 7 of the Central Indian Ridge. In addition the dive was to include operation of the Methane Sensor and, should a vent be located, the WHATS-III water sampler. The canister was also to be tested or used in sampling vent fauna should a vent be located.

Dive summary:

The methane sensor package was started up at 10.40 at XX depth. The first ballast load was dropped at a depth of 3298m. Shinkai 6500 landed on the seabed at 12.12 just to the west of Waypoint 1 at a depth of 3382m. The seabed comprised fine grey sediment with bioturbation with pillow basalts lying to the starboard of the submersible. Shinkai 6500 then proceded up the slope of the knoll lying to the south towards Waypoint 2. As the vehicle proceeded we crossed several sediment ridges, presumably slumped from the slope of the knoll. Between these were troughs or gulleys formed of pillow basalts and fractured basalt rocks lying across the path of travel (east to west/ northeast to southwest). At 3260m (12.54) depth a particularly large fracture comprising fratured basalt was crossed and again at 3244m (12.58) with abundant pillow lavas, more or less on Waypoint 2. There may have been a slight blue haze in this fracture but it was difficult to tell with sediment falling off the front tray of the submersible. Shinkai 6500 continued up the slope following a ridge of broken basalts and encountering pillow lavas and fractured basalt rock with sediment between. Just after this the submersible changed heading to cross the slope of a ridge trending east to west. Again gulleys with pillow lavas and fractured basalt were crossed probably parallel with the contours. We moved downslope passing areas of sediment and fractures / gulleys of broken basalt finishing with a broken basalt pavement at 3280m (13.45). The then jumped over to the northern side of the depression in the ridge arriving in an area of shattered basalt and sediment at 3286m depth. Shinkai 6500 then moved up a sedimented slope where basalt boulders had rolled down. At 14.14 a small amount of sulphide was encountered with a small dead chimney at 3186m depth close to Waypoint 4. Traversing approximately east most of the slope comprised sediment with areas of basalt rubble. A low relief sulphide ridge was encountered at 14.44 at 3230m. Reaching the final waypoint it was decided to aim for the western side of the low-relief saddle between the two knolls bordering the northern and eastern side of the

depression. However, it was realized insufficient time was left to reach this so Shinkai 6500 diverted at 15.08 to move up the slope from a depth of 3287m. The slope comprised of basalt blocks and sediment. Shinkai 6500 stopped at 15.30 to take the methane standard. A small amount of sulphide was discovered at the end point of the dive, possibly in the same area as the previous (12.45). The canister was tried and found to be working erratically.

Fauna

On the sediment fauna was encountered fairly frequently mainly comprising holothurians (cf *Benthodytes*; cf *Pelopadytes*; cf *Peniagone*), cerianthid anemones, small dark anemones and decapod shrimps with one sighting of a *Bathynomus*. Sediment was bioturbated with lebenspurren including faecal trails of holothurians and various burrows including spoke burrows of echiura (patchy and quite rare). Fish were most often encountered over basalt areas and mainly comprised ophidioids (cusk eels) although a large halosaur was also observed. Over sediment *Ipnops* were occasionally observed. There were few animals on the basalt areas. These included the odd brisingid seastar, a few whip corals (octocorals) and some large dark red anemones.

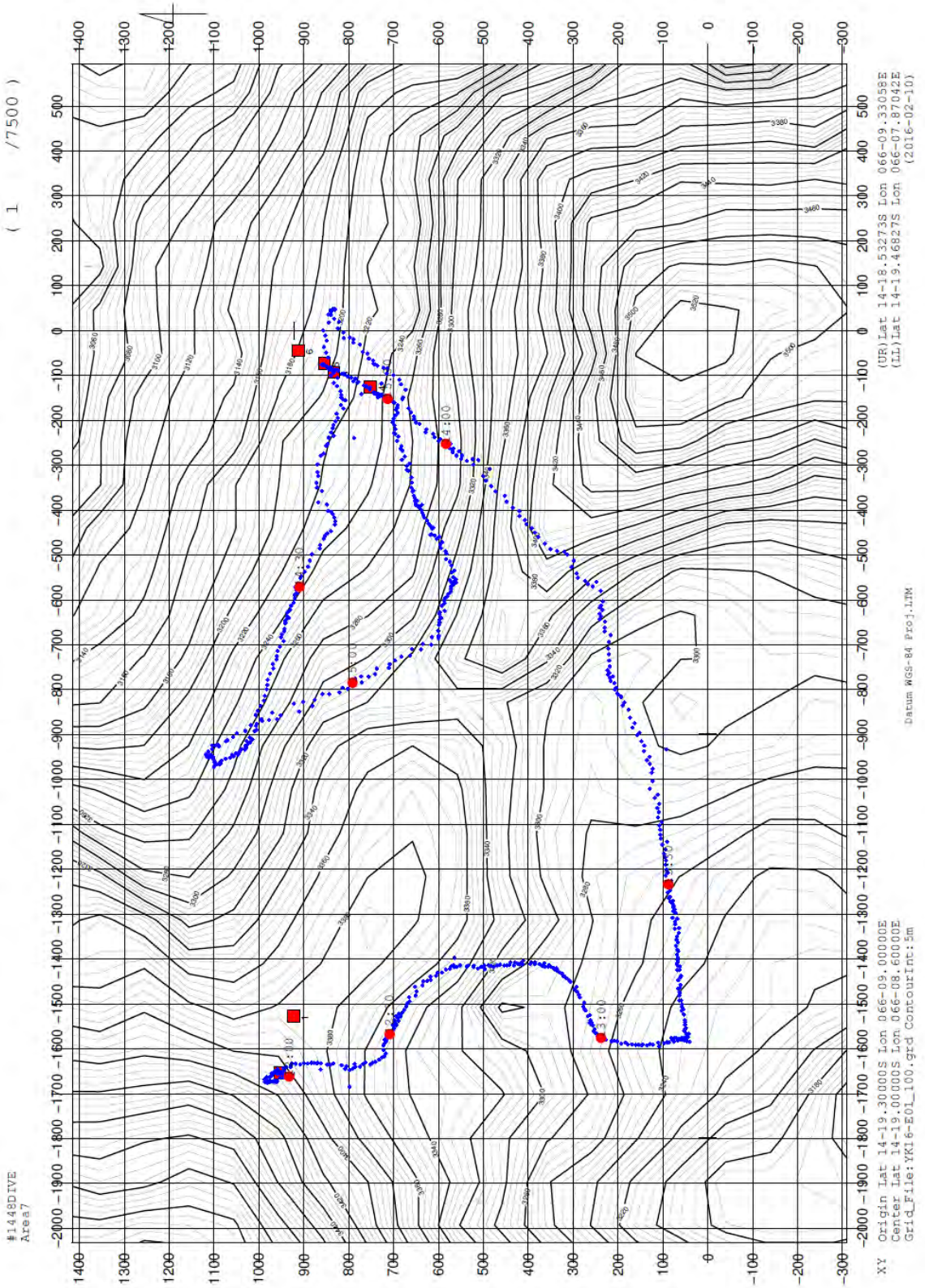
Payloads:

- 7 bottles canister x 1
- Slurp gun pomp x 1
- WHATS-III water sampler
- MJ water sampler x 2
- Thermometer with inlet x 1
- Methane sensor x 1
- Multi sensor x 1
- Standard solution (H_2 and H_2S) x 1
- Standard solution (CH_4) x 1
- Sample box x 2
- Marker x 2

Event list:

001 09.21 14°18.8000'S, 66°8.1500'E Depth 3380.00m Landing Target
002 12.12 14°18.7827'S, 66°8.0807'E Depth 3382.33m Landing
003 14.16 14°18.8482'S, 66°8.9482'E Depth 3186.00m Finding Dead Chimney
004 15.38 14°18.8923'S, 66°8.9294'E Depth 3217.00m Started transfering standard solution
005 15.46 14°18.8367'S, 66°8.9589'E, Depth 3175.00m Left Bottom
006 15.54 14°18.8051'S, 66°8.9747'E, Depth 2817.00m Finished transfering standard solution

Dive Track of 6K#1448



Shinkai 6500 Dive#1449

Date: February 13, 2016
Site: Kairei hydrothermal field in CIR segment 1
Landing: 11:13; 25°19.2838'S, 70°2.3911'E, 2473 m
Leaving: 16:04; 25°19.2294'S, 70°2.4626'E, 2401 m
Observer: Junichi Miyazaki (JAMSTEC)
Pilot: K. Matsumoto **Co-Pilot:** F. Saito

Objectives:

To know mechanism of forming iron-sulfide-coating sclerites of scaly-foot gastropods in Kairei field, the primary objects of this dive were setting new *in situ* coating system including shells and sclerites of white scaly-foot gastropods at the Monju chimney in Kairei field, and recovering the old system deployed in previous 2013 dive. The second objects was collecting chemical sensor data and water into both *Alviniconcha* and scaly-foot gastropods colonies to know what factors decide these habitat segregations at the Monju chimney in Kairei field. Moreover, to carry out on-board and on-shore experiment and to know the physiological properties of these gastropods, we collected a lot of these gastropods.

The third objects of this dive were carrying out sampling chimney structure, collecting hydrothermal fluids and recovering *in situ* colonization system of microbes set into Kali vent in previous 2013 dive for physiological and molecular microbiological analyses.

Dive Summary:

At 11:13, we landed on steep slope of the south of Kali vents. In this landing position, we could observe many sea anemones at the slope. We headed to Kissho vent chimney that was the best marker for deciding positions of Kali vents and other vent chimneys. But we climbed slope for about 15 min and then we found Kali vent chimney erupting black smoker. Compared with the chimney observed in last dive in 2013 (6k#1330), the chimney had 2 m height indicating that the chimney grew 1 m for 3 years. The number of attached Rimicaris shirimps also clearly increased. Moreover we confirmed that *in situ* colonization system (ISCS) which was deployed into the top of the vent was still remained but was pierced the middle of the chimney because of growing for 3 years. Therefore we sampled chimney structure from the middle of the chimney and recovered the ISCS. From the hole that was formed by removing ISCS from the chimney, black smoker hydrothermal fluid was erupted. We sampled hydrothermal fluid from the hole to a bottle set of WHATS III sampler for 5 min. 361.4°C was recorded as a highest temperature during the fluid sampling. The works at Kali vent site were finished at 12:40 P.M. and were perfectly succeeded.

We decided that we headed to west to go to Monju chimney site. Since we passed through the Kissho chimney site in the journey of Monju chimney site, we tried to drop the marker #202 at Kissho chimney site. But we could not pick up the marker from the right side basket of HOV Shinkai 6500 because the marker #202 was tightly bound with the basket. Therefore our available marker had been only a marker #203 during this dive. I thought that deploying marker at the Monju chimney was more important than deploying at the Kissho chimney site considering of the purposes of this cruise. Thus we gave up setting marker at the Kissho chimney site.

We left the Kali vent site and went to Monju chimney site via Kissho, Fudo, and

Daikoku vent chimneys. The number of swimming Rimicaris shirimps was increased when we passed through the Fudo chimney. From the Fudo chimneys we proceeded along the chimneys and kept the water depth 2422 m and we arrived at Monju chimney site by visual confirmation of marker #23. It seemed that there was no obvious change with 2013 dive on the route from Kali vents site to Monju chimneys.

We landed in front of Monju chimney (right side of Merker #23). I confirmed that this point was same with the point in which I found scaly-foot gastropods in 2013 dive. However we could not find *in situ* coating system deployed in 2013 dive. The shape of Monju chimney was almost same with observed in 2013 dive but the boundary between oxidative and reductive rocks was clearly recognized. The reductive black chimney zone was covered with a lot of Rimicaris shrimps. On the other hand, in oxidative brown zone, a lot of mussels and 30-40 individuals of *Alviniconcha* were observed. We could not identify scaly-foot gastropod. In camparison of 2013 dive, the number of mussels remarkably increased and the number of *Alviniconcha* was slightly decrease. However scaly-foot was unknown in this time. Therefore to look for scaly-foot gastropod, we first swept Rimicaris shrimps by broom for the black chimney zone. However we could not find scaly gastropod. We tried to sweep everywhere but we could not identify the gastropods. Therefore we stopped sweeping, and then started sampling water inside the *Alviniconcha* colony with measurement by chemical sensors for 10 min. During sampling water, thermometer demonstrated 10 to 15°C. Next we measured DO of the colony. Finally we sampled *Alviniconcha* gastropods from the colony. I hoped that scaly-foot gastropod colony existed under the *Alvinconcha* as observed in 2006 cruise. We could find only a few scaly-foot gastropods there. We sampled 2 individuals of scaly-foot gastropods. We gave up looking for scaly-foot gastropod colony in this point and then we carried out little movement to west (about 4 m). We swept Rimicaris shrimps but the color of the swept chimney is right brown. Since I thought scaly-foot gastropods were attached to black chimney, we gave up seeking the scaly-foot gastropods in this point. We moved to east and landed in front of the chimney at the left side of Marker#23. We also swept Rimicaris shrimps but there were no scaly-foot gastropod. We continued to look for scaly-foot gastropod by our eyes and No.2 camera. We could not find scaly-foot gastropod but we found *Alviniconcha* colony. Since I had image of 2006 cruise as described above, we expected there were scaly-foot gastropods, however we could not access the colony whose location was out of range of manipulators. We tried to move closer position but we could not access the colony because shimmering of hydrothermal fluid lost our visibility. We also tried to move the south side of the Monju chimney, but we failed.

Since the time leaving the bottom had come, therefore we gave up looking for scaly-foot gastropods and deploying *in situ* coating system. We returned to the first landing point of the Monju chimney and sampled vent-endemic faunas including Rimicaris shirimps, mussels and planaria-like animals. At 16:04 we went east and left the bottom.

Payloads:

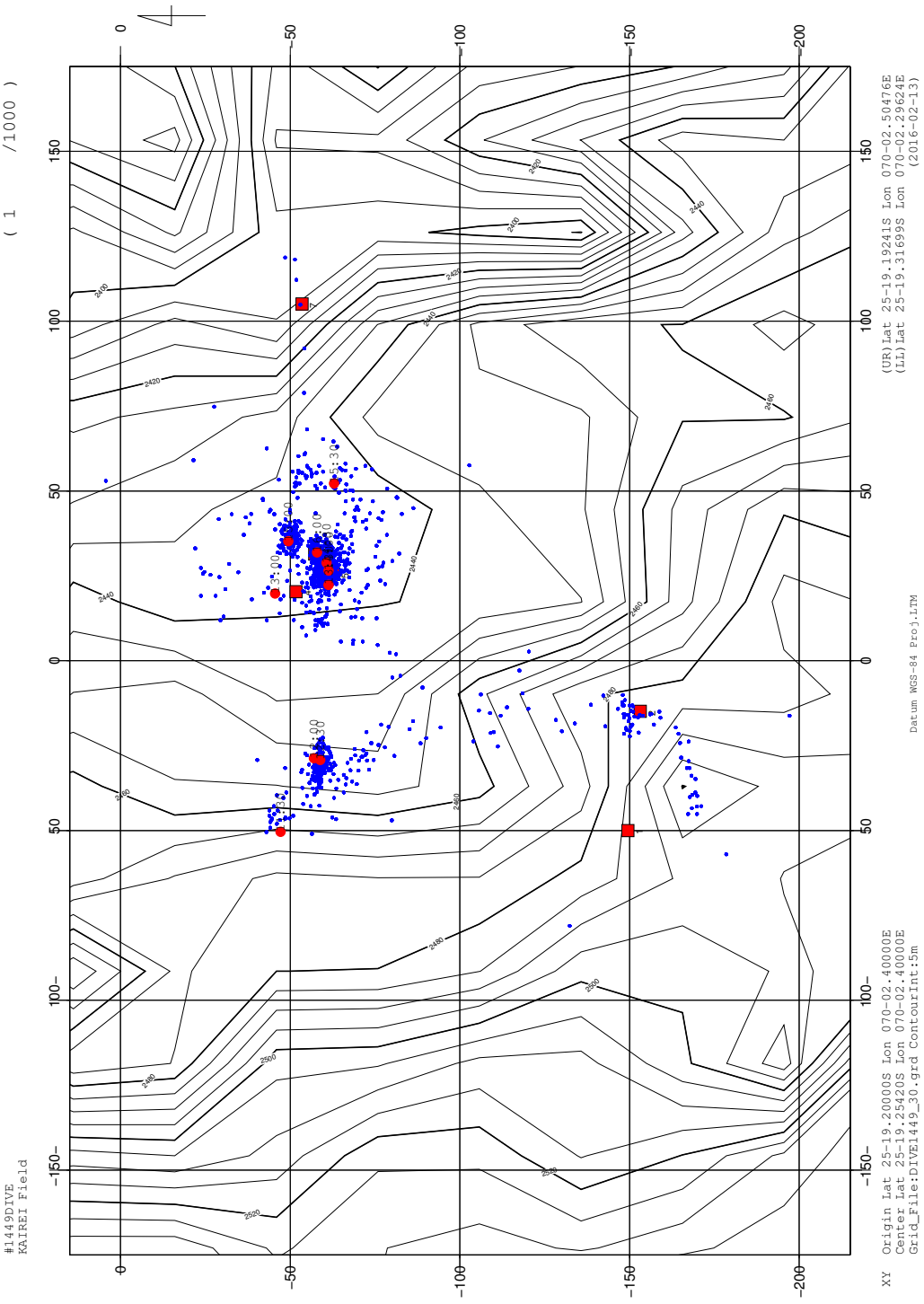
1) Suction sampler (Single canister and fixation canister)
2) WHATS III with 4 sets of 2 bottles (19.5mL and 55 mL)
3) Thermometer into the fluid sampling nozzle.
4) MJ type water sampler x 2
5) 2 x Sample box (empty and enclosing *in situ* coating system)
6) METS sensor

7) Unisense multi sensor
8) DO sensor
9) Broom
10) 2 x Marker (#202, #203)

Event List:

(1) 11:13, 25°19.2838'S, 70°2.3911'E, D=2473 m, Landing
(2) 12:30, 25°19.2325'S, 70°2.3821'E, D=2452 m, Sampling Chimney. Retrieve ISCS. Sampling Water in Kali vent site
(3) 12:44, 25°19.2286'S, 70°2.4121'E, D=2419 m, Finding Marker at Fudo Chimney
(4) 14:02, 25°19.2345'S, 70°2.4152'E, D=2423 m, Sampling water. Measuring DO sensor. Sampling Animals in Monju chimney
(5) 16:00, 25°19.2315'S, 70°2.4187'E, D=2424 m, Sampling Animals. Set Marker#203 in Monju Chimney
(6) 16:04, 25°19.2294'S, 70°2.4626'E, D=2401 m, Left Bottom

Dive Track: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(1 /1000)
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Center Lat 25-19.25420S Lon 070-02.40000E
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(UR)Lat 25-19.19241S Lon 070-02.50476E
(LL)Lat 25-19.31699S Lon 070-02.29624E
(2016-02-13)
Datum WGS-84 Proj.LTM

Dive Report: Shinkai 6500 Dive# 1450
Date: February 14, 2016
Site: Kairei field in Indian Ocean
Landing: 11:07; 25°19.1891S, 70°2.3736E, D= 2474 m
Leaving: 16:07; 25°19.2459S, 70°2.4642E, D= 2425 m
Pilot: Yoshitaka Sasaki, **co-pilot:** Keigo Suzuki
Observer: Tomo-o Watsuji (Jamstec)

Objectives:

The main objective of dive #1450 was to sence and collect colony water of Scaly foot and *Alviniconcha* of Monjyu chimney. In addition, the dive was to place *in situ* incubation shell box on the colony.

Dive summary:

We landed on the North of Kairei field. We headed to the Daikoku chimney. *Archinome* and sea anemones were collected in No. 1 bottle. Although we looked for scaly foot, we could not find it in the Daikoku chimney.

Next, we went to the Monjyu chimney through the Bisyamon chimney. *Phymorhynchus* and *Bathymodiolus* were collected in No. 2 bottle. *Nematean* was collected in No. 3 bottle. We found small a colony of *Alviniconcha* and Scaly foot near the #23 marker. Although we went around the Monjyu chimney to find big colony of Scaly foot, Scaly foot was not found. Thus, we came back to the small colony where the dive #1449 took sampling of *Alviniconcha* and Scaly foot. And then, we conducted DO measurement, sampling of *Alviniconcha* colony water by MJ water sampler (green), collection of *Alviniconcha* in No. 4 bottle. Additionally, a box containing shells and scales of Scaly foot was placed in the small colony. Near the *Alviniconcha* colony, stalkecl Barnacles were collected in No. 5 bottle. We left the bottom and collected reference water by MJ water sampler (red).

Payloads:

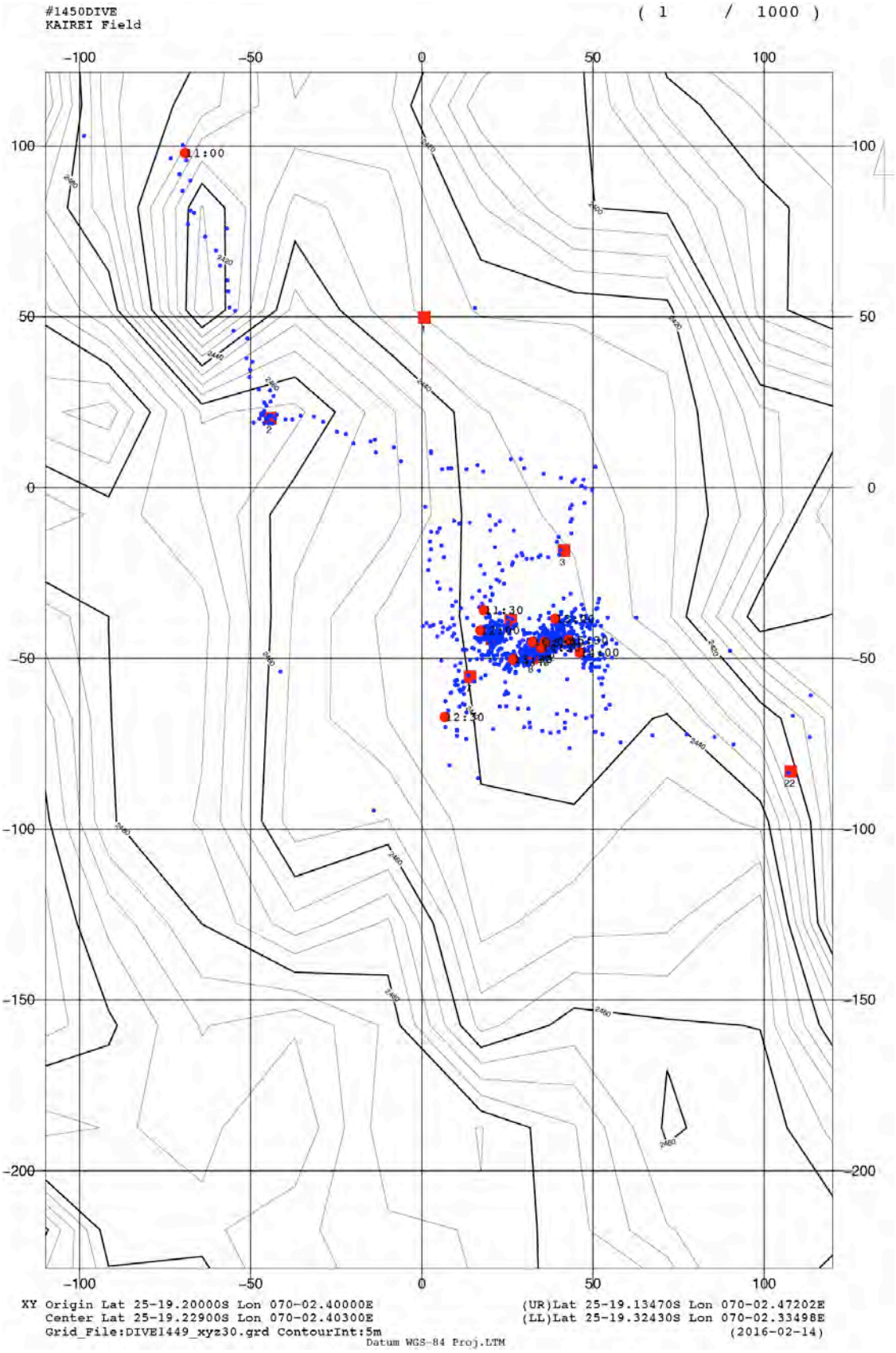
- 7 bottles canister x 1
- Slurp gun pomp x 1
- WHATS-III water sampler
- MJ water sampler x 2
- Thermometer with inlet x 1
- Methane sensor x 1
- Multi sensor x 1
- Sample box x 2
- *In situ* incubation shell box x 1
- Marker x 2

Event list:

001	11:07	25°19.1891S, 70°2.3736E	Landing
002	11:23	25°19.2106S, 70°2.4247E	Finding Chimney
003	11:34	25°19.2219S, 70°2.4155E	Finding Marker

004	11:46	25°19.2249S, 70°2.4123E	Sampling Animals in No. 1 bottle
005	12:06	25°19.2249S, 70°2.4123E	Sampling Animals in No. 1 bottle
006	12:23	25°19.2308S, 70°2.4084E	Finding Marker
007	13:19	25°19.2271S, 70°2.4192E	Finding #23 Marker
008	13:47	25°19.2250S, 70°2.4212E	Sampling Animals in No. 2 bottle
009	14:12	25°19.2250S, 70°2.4212E	Sampling Animals in No. 3 bottle
010	14:32	25°19.2249S, 70°2.4228E	Sampling Rock of *Alviniconcha* colony
011	14:38	25°19.2249S, 70°2.4228E	Measuring DO sensor of *Alviniconcha* colony
012	14:45	25°19.2249S, 70°2.4228E	Measuring DO sensor of *Alviniconcha* colony
013	14:51	25°19.2249S, 70°2.4228E	Measuring DO sensor of *Alviniconcha* colony
014	15:07	25°19.2267S, 70°2.4214E	Sampling colony water of *Alviniconcha*
015	15:42	25°19.2253S, 70°2.4217E	Sampling *Alviniconcha* in No. 4 bottle
016	15:45	25°19.2263S, 70°2.4190E	Set #202 Marker
017	15:51	25°19.2263S, 70°2.4190E	Set *in situ* incubation shell box
018	16:00	25°19.2250S, 70°2.4211E	Sampling barnacles in No. 5 bottle.
019	16:07	25°19.2459S, 70°2.4642E	Left Bottom and reference water sampling

Dive Track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(1 / 1000)
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-50
0
50
100
100
50
0
-50
-100
-150
-200
11:00
11:30
12:30
22
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(LL)Lat 25-19.32430S Lon 070-02.33498E
(2016-02-14)
Datum WGS-84 Proj.LTM

Dive Report: Shinkai6500 Dive# 1451
Date: February 15, 2016
Site: Edmond Field
Landing: 11:39; 23˚52.7776S, 69˚35.7821E, D=3338 m
Leaving: 15:48; 23˚52.7159S, 69˚35.8692E D=3175 m
Observer: Ken Takai (JAMSTEC)
Pilot: Tetsuya Komuku
Copilot: Akihisa Ishikawa

Objectives:

The main objective of the dive #1451 is to obtain the physical and chemical conditions of Alviniconcha gastropods and their individuals in the Edmond field as the comparative controls of Alviniconcha gastropods in the Kairei field. In addition, we will try to take samples of hydrothermal fluids, chimneys, animals and Kairei-morphotype of scaly foot gastropods.

Dive summary:

Shinkai6500 landed on the basalt breccia with sediments at about 40 m south of Edmond field. (Methane sensor was crashed at a depth of 1000 m). A pair of big fishes (a kind of Sokodara) were along the Shinkai6500. We headed north to the Mosquit chimney site. Passing through the Mosquito chimney site, we arrived at the western flank of the Great Shrimp Castle (Main hydrothermal mound at the Edmond field). So many vent sites and chimneys came up from the wall of enormous hydrothermal mound, of which surface is red by iron (hydr)oxides. At high-temperature zones of chimneys and crack vents, Rimikaris shrimps covered the surface while at around diffusing fluid flows, several individuals of Alviniconcha gastropods formed small colonies. Thus, we found several good (easy-to-sampling) colonies and landed near the colonies.

First, DO measurement was completed and then in situ chemical sensing and sampling with MJ sampler (Green) were finished. Tmax was found to be around 38 ˚C. Next, we tried to collect the Alvoniconcha individuals by the suction sampler. About 10 individuals were collected into No.1 bottle but the samples for in situ fixation were not successfully recovered because the hose of suction sampler was broken (only several animals there but successfully fixed later). Then we moved a little bit forward and then tried to collect more Alviniconcha individuals from a different colony. We obtained the Alviniconcha gastropods and other proximal animals into No.2 bottle. However, it took almost 2 hours to complete these operations.

During a little bit climbing up from these Alviniconcha's colonies, we found another blackish gastropods' colonies and wished that they contained Kairei-morphotype of scaly foot gastropods. Approaching the colony, we were disappointed to know they were Alviniconcha gastropods. However, it looked a high density of colony and we tried

to collect them. It was impossible.

Finally, we had very short time left and thus we tried to observe the whole landscape of the Great Shrimp Castle. We tried to climb the mound but the newly created vigorous black smoker vent made us blind with highly turbid black smoke. We flied east and then escaped from the plumes. Finally, we left the bottom at the position fully distant from the mound.

Payloads:

- 7 bottles canister x 1
- Slurp gun pomp x 1
- WHATS-III water sampler
- Methane sensor
- Multiple chemical sensor
- MJ water sampler (Green)
- MJ water sampler (Red)
- Perister pomp x 1
- Sample box x 2
- Blass x 1
- DO meter
- In situ RNA fixing box
- In situ RNA fixing solution bag

Event list:

11:33 23˚52.7776S, 69˚35.7821E, Depth = 3338m, Landing

11:38 23˚52.7593S, 69˚35.7835E Depth = 3330m, Finding Chimney

11:49 23˚52.7148S, 69˚35.7737E, Depth = 3302m, Finding Dead Chimney

11:53 23˚52.7092S, 69˚35.7777E, Depth = 3297m Finding Great Shrimp Castle

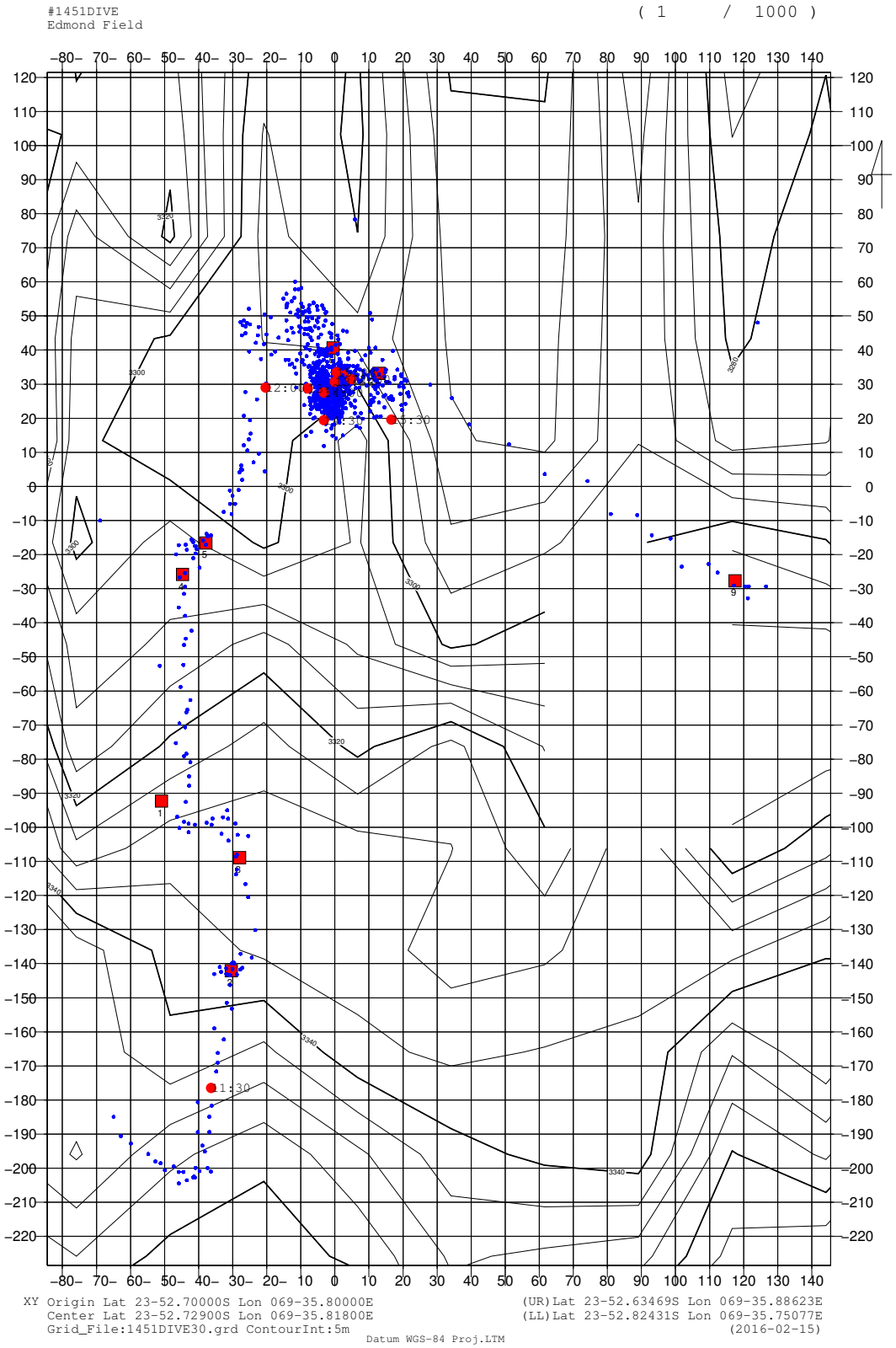
12:17 23˚52.6785S, 69˚35.7997E, Depth = 3276m Finding Alviniconcha gastropods

14:39 23˚52.6823S, 69˚35.8013E, Depth = 3277m DO measurement, Water(MJ) Sampling, Animals sampling

15:28 23˚52.6828S, 69˚35.8076E, Depth = 3273m Deployed #204 Marker at Alviniconcha colonies and Black smoker vent

15:48 23˚52.7159S, 69˚35.8692E, Depth = 3175m Left Bottom A=58m

Dive Track of Shinkai6500



Dive Report: Shinkai 6500 Dive# 1452
Date: February 20, 2016
Site: Area 7 in Indian Ocean
Landing: 11:36; 14º19.9000'S, 66º09.1000E, D=3473 m
Leaving: 15:43; 14º20.1214'S, 66º09.3039E, D=3211 m
Pilot: Keita Matsumoto, **co-pilot:** Hirofumi Ueki
Observer: Christopher Nicolai Roterman (University of Oxford)

Objectives:

The main objective of dive #1452 was to locate a suspected new hydrothermal vent field in Area 7 of the Central Indian Ridge. In addition the dive was to include operation of the Methane Sensor and, should a vent be located, the WHATS-III water sampler. An MBARI push core was to be deployed in a sedimented area.

Dive summary:

In water at 0952, with diving commencing at 1000. At 150m depth the background temperature sensors switched on. The first ballast load was dropped at a depth of 3392 m at 1123. Shinkai 6500 landed on the seabed at 1136 at waypoint 1 at a depth of 3473 m. The seabed comprised broken basalt rubble and a layer of fine grey sediment. The backround methane sensor was switched on at 1143 after confirmation with the surface. Shinkai 6500 then proceded up a gentle slope westwards towards Waypoint 2 comprising fine sediment and patches of broken basalt. A steep rocky escarpment was encountered at 1158, before reaching waypoint 2 at 1200. From there, we headed north to waypoint 3 across mostly fine sediment with evidence of bioturbation. At 1219 a munidopsis squat lobster was sampled with the slurp gun into chamber 1 at 3417 m depth amongst old pillow basalt. Waypoint 3 was reached at 1227 (at 3380 m) and more slopes with rubble and drifts of sediment were encountered southwards enroute to Waypoint 4, which was reached at 1240.T A steep slope with pillow basalt outcrops amongst the sediment was encountered at 1244, before reaching Waypoint 5 at 1249. At 1250, there was a momentary contact with the sedimented seafloor. From 1254 to 1307 (waypoint 6) Shinkaii 6500 ascended a steep, rubbly slope, and proceeded to encounter small topographical ridges whilst generally ascending to waypoint 7, which was reached at 1322 at 3175 m depth. Waypoint 8 (3157 m) encountered at 1336 was a terrace feature and more sedimented than the previous basalt slopes. From waypoint 8 we headed northeastwards. At 1346 a holothurian was spotted for sampling. The holothurian was collected with the slurp gun into chamber 2 at 1353 after having to wait for the fine sedment to settle. At 1356 a nearly vertical escarpment was encountered consisting of basalt rock with a light dusting of sediment. At 1400 an intermediate waypoint between 8 and 9 was reached on the ridged slope of a terrace, which consisted of basalt rubble and sediment. We then headed southeastwards towards waypoint 9. At 1413 the basalt ribble slope gave way to a more flat sedimented

area. Waypoint 9 was reached at 1416 at 3069 m depth. Originally the plan was to head north back to waypoint 1 and to take a sediment push core sample before continuing, but owing to time constraints, the decision was taken (at 1440) to head directly to waypoint 10 in an easterly direction, which was on another terrace feature, in the hope that the sediment core sample could be taken there and new terrain could be covered before the end of the dive. At 1457, seafloor was visualized again after a ~ 400 m descent. From 3456 m depth, Shinkai 6500 began moving eastwards up a scree/rubble slope with large boulders. At 1507 the scree rubble slope gave way to a sheer vertical cliff at around 3400 m depth. The top of the cliff, at 3222 m depth was reached at 1522. At 1528 the MBARI pushcore sampling was completed in the fine sediment at the top of the cliff near waypoint 10. The 'standard' water transfer began at 1531. At 1537 the waypoint 10 terrace was reached – which consisted of fine sediment. At 1543 weight was jettisoned and the final ascent began. The 'standard' was completed at 1558 at 2518 m depth. We surfaced at 1659.

Fauna

On the sediment fauna was encountered fairly frequently mainly comprising large holothurians (cf *Benthodytes*; cf *Pelopadytes*; cf *Peniagone*), cerianthid anemones, an Umbellula sp., small dark anemones and decapod shrimps, including a large Plesiopenenaus sp.two Munidopsis sp. squat lobsters were seen and one sampled. Sediment was bioturbated with lebenspurren including faecal trails of holothurians and various burrows including spoke burrows of echiura. Fish mainly comprised ophidioids, although halosaurs, a synaphobranchid eel, tripod fish a possible zoarcid and a species of Coryphaenoides was also observed. One ipnops was observed. On the rocky outcrops, brisingid seastars and a few whip corals (octocorals) were observed – as well as a large dark anemone. In addition, curious patches of low-density clumps of 'balls' were seen which may either be decayed jellyfish carcasses, or foraminifera.

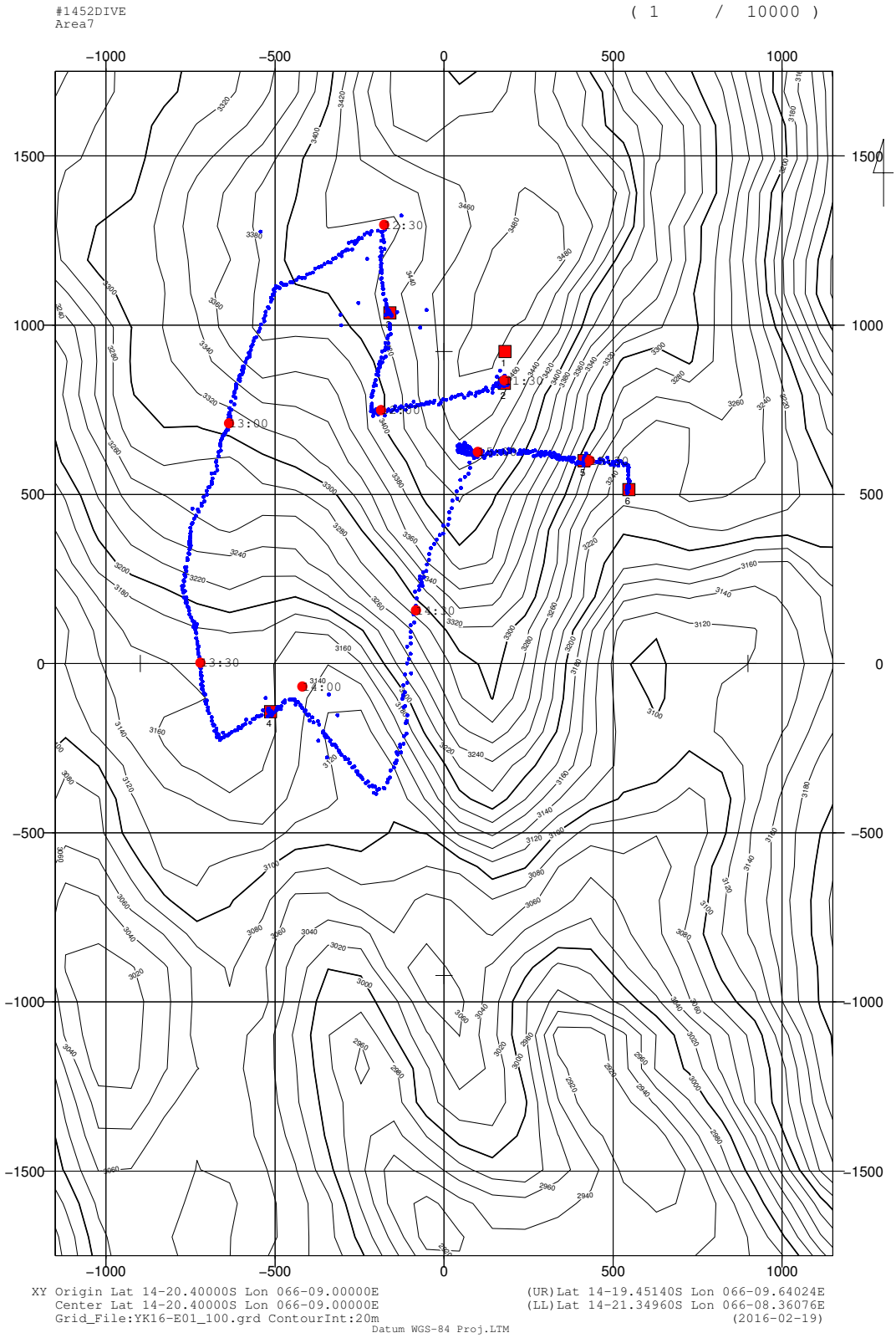
Payloads:

- 7 bottles canister x 1
- Slurp gun x 1
- MBARI push core sampler
- WHATS-III water sampler
- MJ water sampler x 2
- Thermometer with inlet x 1
- Methane sensor x 1
- Multi sensor x 1
- Standard solution (H_2 and H_2S) x 1
- Standard solution (CH_4) x 1
- Sample box x 2
- Marker x 2

Event list:

001	1000	14°19.9000'S, 66°9.1000'E	Depth 3480.00m Landing Target
002	1136	14°19.9514'S, 66°9.0994'E	Depth 3373.00m Landing
003	1219	14°19.8389'S, 66°8.9110'E	Depth 3420.00m Sampling Munidopsis
004	1353	14°20.4770'S, 66°8.7146'E	Depth 3161.00m Sampling holothurian
005	1528	14°20.0758'S, 66°9.2301'E,	Depth 3222.00m Sampling MBARI core
006	1543	14°20.1214'S, 66°9.3039'E,	Depth 3211.00m Left bottom

Dive Track



Dive Report: Shinkai 6500 Dive# 1453
Date: February 21, 2016

Site: Area 7 in Indian Ocean
Landing: 11:34; 14º18.5219'S, 66º07.4463E, D=3523.00 m
Leaving: 15:44; 14º20.5693'S, 66º08.4317E, D=3080.00 m
Pilot: F. Saito, **co-pilot:** K. Suzuki
Observer: Leigh Marsh (University of Southampton)

Objectives:

In order to constrain areas of possible hydrothermal activity, the primary objective of dive #1453 was to investigate local topographic highs identified from the Urashima AUV bathymetry and sidescan sonar anomalies detected from cruise YK16-E01.

Dive summary:

On descent (approx. 150m) the multi-sensor pump was switched on. Shinkai 6K arrived at the seafloor at 11:34 at a depth of 3523m at waypoint 1. We arrived on a steep slope of lava tubes and some collapsed domes, all partially covered in a thin veneer of sediment. We began our first move and started to transit upslope (Shinkai heading 162) to waypoint 2. Camera No. 2 (science) experienced some interference - as a result we were not able to use (or record) this camera at this time.

At 11:42, at a depth of 3500m, we reached the summit of a local topographic high. Here, the seafloor levelled out and was covered in a thick layer of sediment. As we continued on heading 186, the seafloor dropped away rapidly and was replaced by fractured pillow basalts. A target was seen in the forward scanning sonar and on approach, we were confronted with a vertical lava wall with an E-W orientation. No notable fauna were observed. The foot of the wall was at 3487m. Shinkai 6K ascended to a depth of 3413m where we reached the summit (39m elevation). As we approached waypoint 2 (11:59), the seabed levelled off and constituted a similar seafloor type as previous; pillow lavas with thin sediment cover. Heading altered to 176, and we began our transit to waypoint 3. We followed a similar terrain of sediment covered pillow basalts. The seafloor dropped away from us and we descended to 3449m. At 12:07 we encountered another sheer slope of pillow basalts and lava tubes. In-between the pillows, there was evidence of folded sheet flows. At 12:17 we reached our target at waypoint 3. As with waypoint 1, the summit of waypoint 3 was characterized by a flat summit covered in a thick layer of sediment.

At 12:20, both video cameras (No 1. And No.2) were restored by replacing a connector within Shinkai 6K. Lasers on No.2 were switched on.

At 12:28, we started our transit over sediment covered pillow basalts to waypoint 4 on heading 182. Fauna observed include ?Brisingidae seastar (12:33), whip octocoral (12:31) and occasional Aristidae shrimp. We reached the local topographic high of waypoint 4 at 12:36 and continued our transit to waypoint 5. There was a small depression between waypoint 4 and waypoint 5. Here, the basalts were characterized by shallower, possibly faster flows. We reached the summit of waypoint 5 at 12:54

(3395m). We continued to ascend upslope to waypoint 6 on a heading of 160. There was notably less sediment over the pillow basalts with the occasional stalked sponge (e.g. 13:05) and holothurian (e.g. 13:08). At 13:13 we altered our heading to 180 and continued to move towards waypoint 6. At 13:16 we encountered another vertical wall formed of basalt talus and rubble. We ascended from 3244-3219m (24m elevation) and reached the topographic high of waypoint 6 at 13:19. No notable fauna observed.

At 13:21, we changed our heading to 038 and began our transit to waypoint 7 where we observed a dumbo octopus (13:23). Here, the seafloor comprised a mix of both lobate flows and basalt talus. At 13:26, we altered our heading to 124 to ascend another vertical basalt wall. Within the wall, there was some evidence of hydrothermally altered basalts. At the top, we changed our heading to 027 to continue to waypoint 7. At 13:34 (3163m) we encountered an interface of lava flows and basalt talus with evidence of localized rock-falls and chute features. As we moved over the 3200m contour, there was notably more sediment cover and associated benthic fauna including ?cerianthid anemones and Aristidae shrimp (13:46). An enteropneust (13:48) was also observed. As we moved upslope to waypoint 7, the seafloor was replaced by basalt rubble and talus. The summit of waypoint 7 was reached at 13:50. We then transited south on a heading of 178 towards the next waypoint. The seafloor was predominantly characterized by undulating slopes of basalt rubble and talus with localized areas of fractured pillow lavas. Fauna included whip octocorals (e.g. 14:14; 14:19) and a large galatheid squat lobster (14:09) was observed from altitude. The topographic high of waypoint 8 (14:22, 3060m) was a an area of basalt rubble. On transit to waypoint 9 (heading 186) we descended downslope to 3133m and encountered a large expanse of thick sediment. Faunal observations include an Ipnops fish (14:35) and a branching coral ?Stylasterid (14:40) on a basalt outcrop. The seafloor then transitioned into basalts at the summit of waypoint 9 (14:45).

We followed the 'ridge' feature which comprised mainly basalt rubble to both waypoint 10 (15:07, 3012m) and waypoint 11 (15:16, 3088m). At 15:17 we continued south on a heading of 167 towards waypoint 12. At 15:24, the Shinkai prepared the manipulators for sampling. There was an attempt to sample a glass sponge (Hexactinellidae) and a Brisingid seastar. Unfortunately, problems with the suction chamber prevented successful sample collection.

In summary, no evidence of hydrothermal activity was observed. From the lava formations, the topographic highs at waypoints 1-6 represent more recent volcanic features than those associated with the 'spur' feature (waypoints 7-12) which appear to be from older geological events.

Shinkai 6K left the seafloor at 15:43 and at 15:51, the multi-sensor pump was switched off. We surfaced at 16:52.

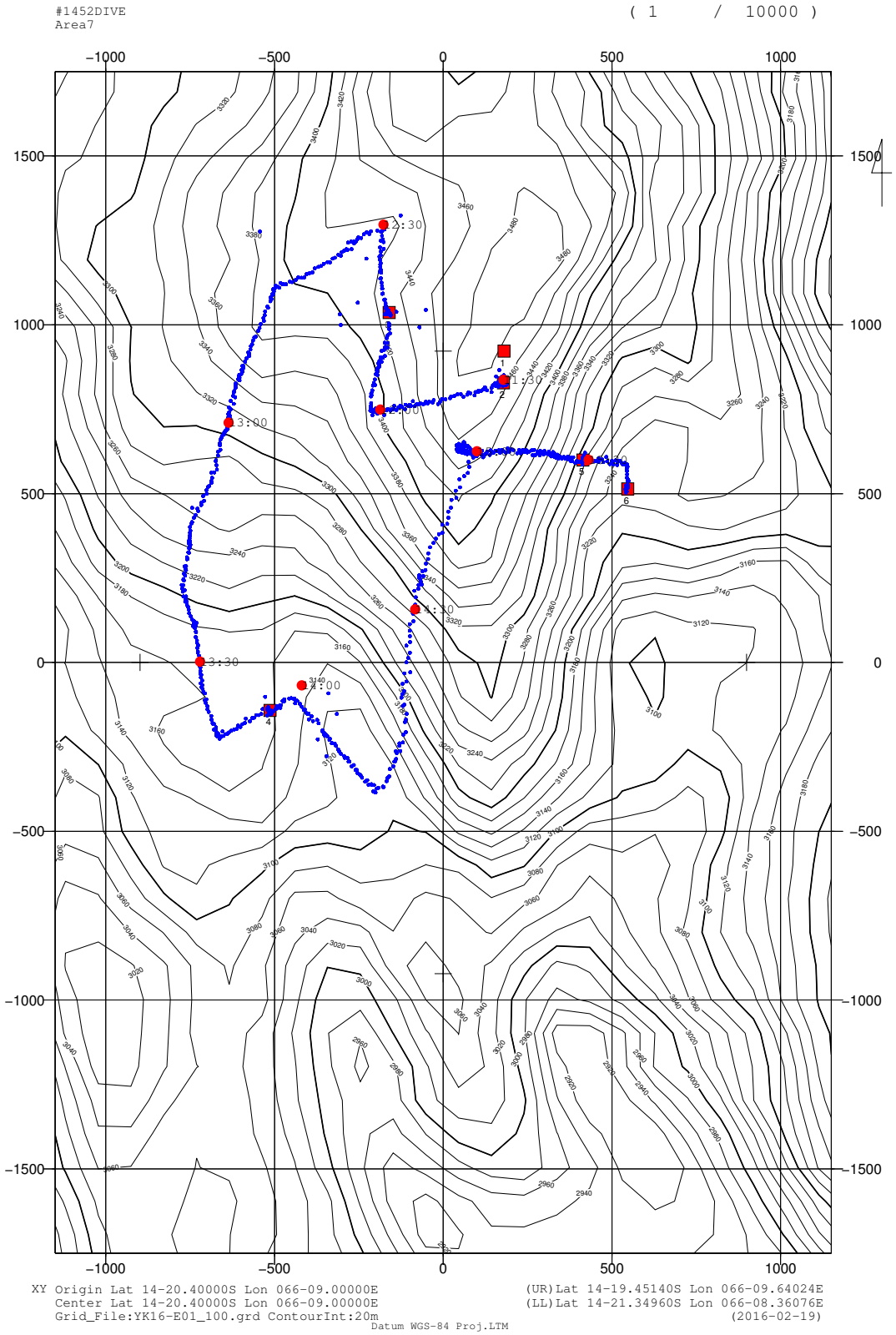
Payloads:

- 7 bottles canister x 1
- Slurp gun x 1
- WHATS-III water sampler
- MJ water sampler x 2
- Thermometer with inlet x 1
- Methane sensor x 1
- Multi sensor x 1
- Sample box x 2

Event list:

001 1000 14^{o}18.5000S, 66^{o}7.4000E Depth 3850.00m Landing Target
002 1134 14^{o}18.5219S, 66^{o}7.4463E Depth 3523.00m Landing
003 1542 14^{o}20.5693S, 66^{o}8.4317E Depth 3080.00m Sampling Animals
004 1544 14^{o}20.5693S, 66^{o}8.4317E Depth 3080.00m Left Bottom

Dive Track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Area7
(1 / 10000)
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Center Lat 14-20.40000S Lon 066-09.00000E
Grid_File:YK16-E01_100.grd ContourInt:20m
Datum WGS-84 Proj.LTM
(UR)Lat 14-19.45140S Lon 066-09.64024E
(LL)Lat 14-21.34960S Lon 066-08.36076E
(2016-02-19)

Dive Report: Shinkai 6500 Dive# 1454
Date: February 22, 2016
Site: Area 7 in Indian Ocean
Landing: 11:28; 14°18.3926S, 66° 8.3586E, D=3287.00 m
Leaving: 15:49; 14°17.9372S, 66° 9.3476E, D=2894.00 m
Pilot: H. Ueki, **co-pilot:** A. Ishikawa
Observer: Julia D. Sigwart (Queen's University Belfast)

Objectives:

In order to constrain areas of possible hydrothermal activity, the primary objective of dive #1454 was to investigate ridge and terrace structures for hydrothermal activity, in the region adjacent to the Urashima AUV bathymetry and sidescan sonar anomalies detected from cruise YK16-E01.

Dive summary:

On descent (approx. 200m) the multi-sensor pump was switched on. During the descent the altimeter was not functioning correctly. The underwater telephone was used to determine altitude above the seabed for navigation. Altitude measurements imprinted on some portions of the video records for dive 6K1454 are inconsistent or inaccurate.

Shinkai 6K arrived at the seafloor at 11:28 at a depth of 3287 m slightly NW of the planned landing side (dive plan waypoint 1; dive path event 2). The area was mud bottom with scattered basalt. We began our transit toward the next set waypoint (Shinkai heading 115). On the upward slope there was a basalt scree with some potential sulfides among the rocks (11:39; depth 3279 m). The scree gave way to steep cliffs with complex volcanic geology and evidence of past hydrothermal alteration (11:49; depth 3182 m) and patches of white sediment (11:52; depth 3161 m).

The uppermost stratum of the cliff face was partially covered over by sediment and the plateau at the top of the cliff was flat mud, with some lines of broken basalt (12:00, depth 31119 m). At 12:07 (depth 3126) we halted to sample a holothurian (suction chamber 1). After the sampling was complete (12:11 h) we continued toward the next dive plan waypoint (12:15, Shinkai heading 120, depth 3098 m). The terrain was mud and basalt. At 12:26 (depth 3128 m) we halted to attempt animal sampling (unsuccessful). Because the mud was uniform and appeared to continue homogeneously, we altered course to continue directly toward the next dive plan waypoint (12:30, depth 3133 m, Shinkai heading 020).

At 13:00 (depth 2987) we arrived at the waypoint (dive path event 4). This was also mud and with no evidence of geology relevant to hydrothermal activity. We therefore altered course to return to the area of waypoint 1 to conduct a more thorough examination of the cliff with evidence of hydrothermal alteration (waypoint 1). At 12:56 (depth 2990) and we sampled two holothurians (*Benthodytes*? sp., suction chamber 2; *Peniagone* sp., suction chamber 3) while awaiting confirmation from Shinkai operations team for course alteration. At 13:02 h we began transit to return to the area of waypoint

1 (Shinkai heading 090, depth 3180 m).

At 13:30 (depth 3237) we arrived at the lower part of the cliff face identified in the earlier part of the dive and climbed the cliff again, heading north-east to explore a second transect. The lower half of the cliff face (depths 3240 – 3170) represented strongest evidence for recent hydrothermal activity. We observed sulfides (13:35, depth 3210 m) and bacterial mats of white colour (13:39, 3207 m). There were some structures that appeared to be potentially formed from extinct chimneys or fractures from the main bedrock (13:40, 3205 m), in strata that had the appearance of a serpentinite system. Moving further north-east (Shinkai heading 070) there was a large fissure highlighted in potential microbial mats which may represent an area of low-level fluid flow (13:46, 3198 m). Beyond this place, the cliff gave way to sharp ridge formations (13:50, depth 3180 m), this was the end of the region with the strongest evidence of hydrothermal activity. At 14:00 (depth 3174 m) we sampled an anemone (this attempt failed and the specimen was destroyed in the chamber mesh) and polychaete tube worm, and surrounding rocks and sediment (suction chamber 4).

We continued northeast and upward along the cliff face (Shinkai heading 045), with large volcanic outcrops. There were further sulfides and small patches with evidence of hydrothermal alteration (14:17, depth 3132). Above this point, sediment covered the basalt scree (14:25, depth 3097 m), although with some dark-colour patches which may be related to sulfides. At 14:30 (depth 3056) we reached the top of the cliff and saw the mud plateau. We then proceeded to re-join the original planned navigation course for the dive (Shinkai heading 064).

The area across the terrace at 3020 m was mud and basalt. At the eastern extent of the terrace (14:53, depth 3032) we halted to attempt collection of a holothurian (failed attempt), and changed course to the north toward dive plan waypoint 7 (Shinkai heading 355). In this area there were some slightly different rock formations, with larger pillow-type basalt boulders (cf. 14:58 and 15:03, depth 3020). At 15:07 (depth 3010) we halted to attempt collection of *Enypniastes eximia* (failed attempt). The density of rock emergent on the mud plain increased from this point on. At 15:11 (depth 3010) we halted to sample rocks (two samples, sample box 2). At 15:16 we continued on the planned course (Shinkai heading 080). The terrain was mud, interspersed large basalt boulders, covered in a thin layer of sediment, giving way to smaller rocks and increasingly extensive mud (15:22, depth 3000 m).

At 15:35 (depth 2906) we saw less mud and more rocks, at the start of the rise ot the next cliff stucture. At 15:37 (depth 2902) we halted to sample a juvenile octopus (*Grimpoteuthis* sp., suction chamber 6), and at 15:43 we sampled polychaete tube worm at the same site (sample box 2).

When animal sampling was complete we left the bottom. On ascent we were able to

observe the lower part of the cliff below the next terrace structure to the east; the rise showed only broken basalt rocks and no evidence of any hydrothermal activity.
Shinkai 6K left the seafloor at 15:49 and the multi-sensor pump was switched off as we approached the surface.

In summary, the area in the western edge of dive 6K 1454 showed some evidence of hydrothermal activity, although it appears to represent an extinct vent field and/or serpentinite system. Weak activity in the formations observed on this dive, over an extensive cliff area, may be sufficient to explain anomalies detected by AUV Urashima during cruise YK16-E01.

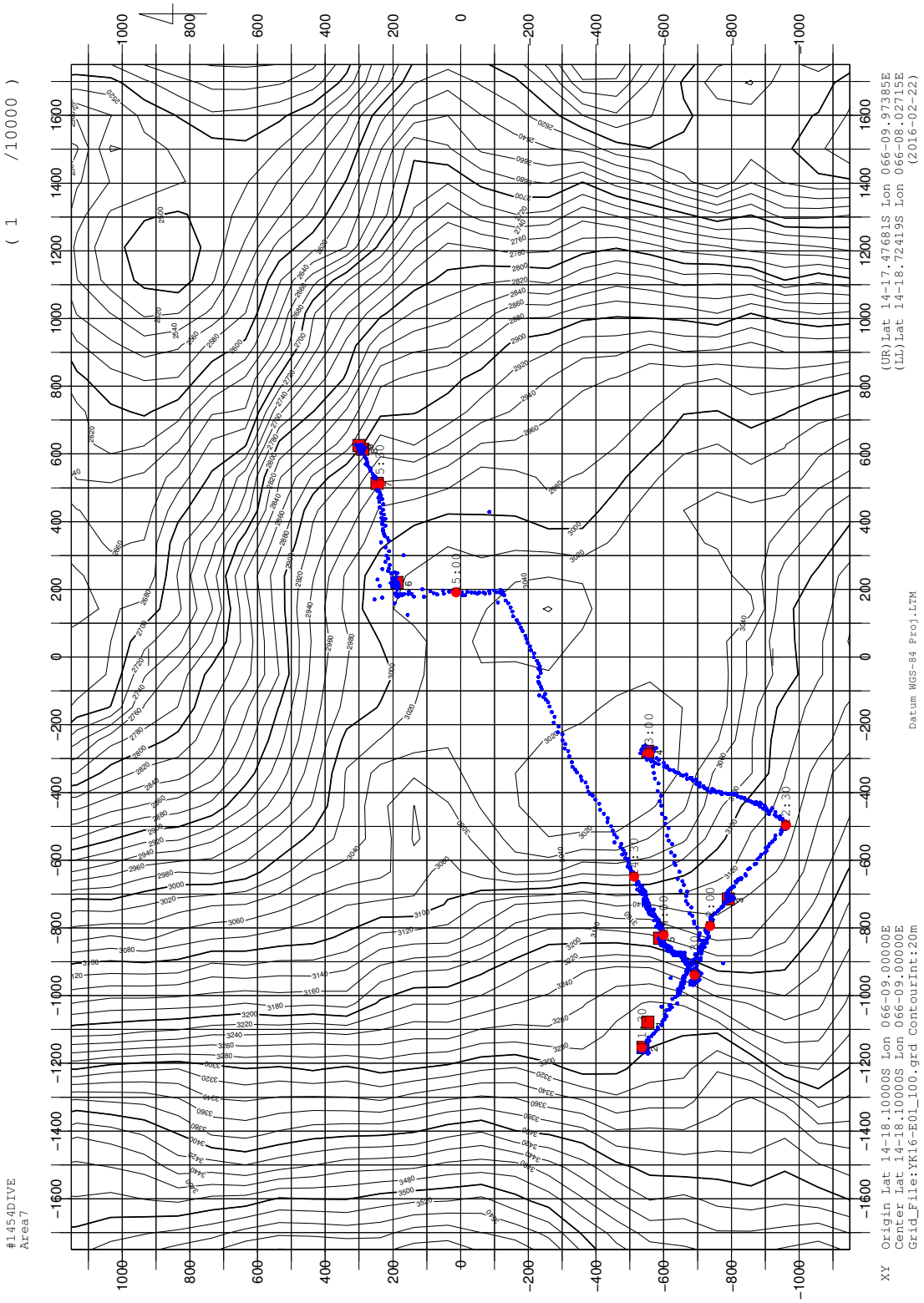
Payloads:

- 7 bottles canister x 1
- Slurp gun x 1
- WHATS-III water sampler
- MJ water sampler x 2
- Thermometer with inlet x 1
- Methane sensor x 1
- Multi sensor x 1
- Sample box x 2

Event list:

001	0000	14°18.4000S, 66° 8.4000E	depth 3290.00 m	Target WP1
002	1128	14°18.3926S, 66° 8.3586E	depth 3287.00 m	Landing
003	1211	14°18.5290S, 66° 8.6024E	depth 3126.00 m	Sampling Animal
004	1303	14°18.4000S, 66° 8.8449E	depth 2987.00 m	Sampling Animals
005	1403	14°18.4199S, 66° 8.5382E	depth 3174.00 m	Sampling Animals
006	1515	14°17.9981S, 66° 9.1224E	depth 3013.00 m	Sampling Rock
007	1530	14°17.9669S, 66° 9.2856E	depth 2941.00 m	Sampling Animal
008	1545	14°17.9430S, 66° 9.3415E	depth 2902.00 m	Sampling Animals
009	1549	14°17.9372S, 66° 9.3476E	depth 2894.00 m	Left Bottom

Dive Track


(1 /10000)
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Datum WGS-84 Proj.UTM
(UR)Lat 14-17.47681S Lon 066-09.97385E
(LL)Lat 14-18.72419S Lon 066-08.02715E
(2016-02-22)

Dive Report: Shinkai 6500 Dive# 1455
Date: February 23, 2016
Site: Area 7 in Indian Ocean
Landing: 10:29; 14°18.7002S, 66° 8.1558E, D=3394 m
Leaving: 13:45; 14°16.9414S, 66° 7.9630E, D=3408 m
Pilot: Keita Matsumoto, **co-pilot:** Yohsuke Chida
Observer: Akiko Makabe (JAMSTEC)

Objectives:

The main objective of dive #1455 is to collect altered rocks observed at dive #1454 in Area 7 of the Central Indian Ridge and ambient seawater around the rocks to verify methane anormarly detected by Son et al. (2014) and AUV Urashima survey on YK16-E01. In addition, we will try locating a suspected new hydrothermal vent on the terrace in the northern part of Area 7.

Dive summary:

The measurement of multiple sensors was started at a depth of approx. 2300 m in descending (9:53). Shinkai6500 landed on the breccia and sediment with white colored line at the southwestern foot of the terrace surveyed on dive #1454 (10:29, depth 3394 m). We moved a short distance toward northeast to find easy-to-sampling rocks near the landing point. We collected a basalt like rock in the box #1 (10:42) and reference seawater in the bottle #1 of WHATSⅢ sampler (10:50).

Then, we started climbing the terrace along the ridge toward the northeast. Firstly we saw the sedimented area with few rocks (10:57), and headed east to find rocks. Then we obsereved the area covered with basalt breccia (11:04). Through the basalt breccia area and after we went up a heigth of approx. 70 m, the white color altered mud were studded on the sediment (11:10). We landed on the place we could easily take rocks. We ripped away a rock from the wall and collected it in the box #2 (11:12). Just then, the white colored mud came appear from under the rock we had collected. We also collected the white colored mud with the rock. The rock surface looked right brown color in taking but was greenish gray with white lines after washed on board. It was likely to be a surpentinite as observed on borad.

After sampling the rock, we started climbing the terrace again toward the northeast to find the altered rocks observed on dive #1454. However, we went up a little bit northern part than expected. There were only the basalt breccia with sediment in the lower part (11:30) and the basalt bed rock with sediment in the upper part (11:36) of the northern slope of the ridge. It was supposed that altered rocks and sediment spreaded just south of the submersible track over at least 150 m length along the top of the ridge. After climbing a height of approx.. 60 m from the latest sampling point, we turned to the east and thus found altered rocks (11:51). We ripped away rocks from the wall including a white-colored altered line and collected them in the box #3-2

(11:57). The wall was easily crumbled and some pieces of the rocks were fell in the baskets. And then, we collected the ambient seawater of the rocks in the bottle #2 of WHATSⅢ sampler (12:05).

Finally, Shinkai6500 headed northwest and ran down to another terrace in the northern part of Area 7 for 1 hour. We couldn't see any feature of hydrothermal plume along the way. We landed on the southeastern foot (13:12, depth 3540 m) of the mound on the terrace and went up to the top of the mound. We observed small size of basalt like breccia in the lower part (13:16) and large size of basalt like breccia in the upper part (13:21) of the mound. At near the top of the mound (depth 3407 m), we collected basalt like rocks in the box #3-1 (13:33) and ambient seawater of the rocks in the bottle #3 of WHATSⅢ sampler (13:42). We left the bottom at the final sampling point (13:45, depth 3408 m). The pump of water for multiple sensors was stopped at a depth of 2000 m (14:15). We saw some shrimps, a crab, a few fishes, a few tubewarms, a starfish, and a sea cucumber, but not any kinds of hydrothermal macrofauna all the dive.

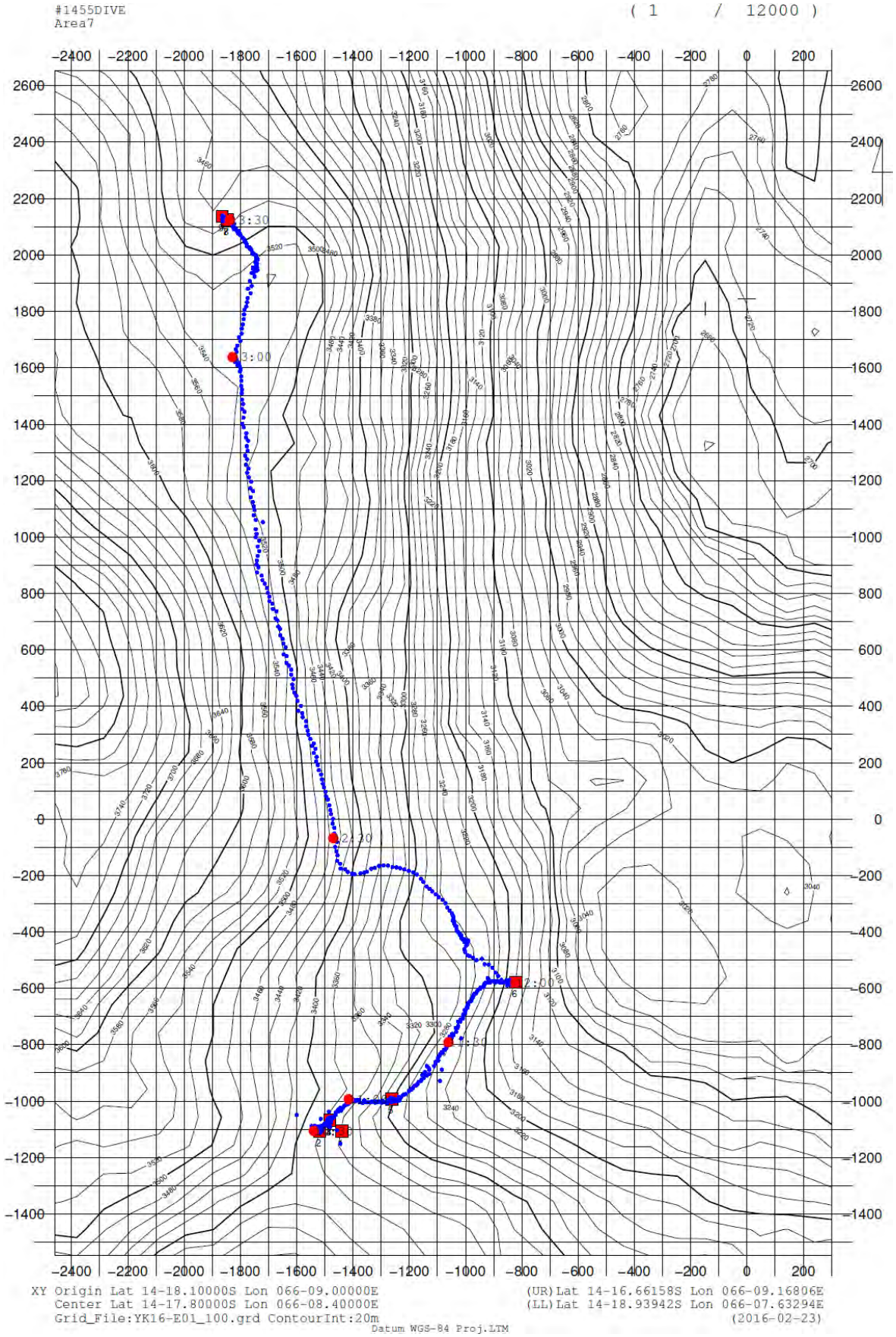
Payloads:

- Single canister x 1
- Slurp gun pump x 1
- WHATS-III water sampler
- MJ water sampler x 2
- Thermometer with inlet x 1
- DO sensor x 1
- Multiple sensor x 1
- Sample box x 3
- Marker x 2
- Cutter x 1

Event list:

001 00:00 14°18.7000S, 66° 8.2000E, Depth = 3360m, Landing Target WP1
002 10:29 14°18.7002S, 66° 8.1558E, Depth = 3394m, Landing
003 10:42 14°18.6797S, 66° 8.1754E, Depth = 3401m, Sampling Rock
004 10:50 14°18.6797S, 66° 8.1754E, Depth = 3401m, Sampling Water(WHATS)
005 11:12 14°18.6382S, 66° 8.2983E, Depth = 3322m, Sampling Rock
006 12:05 14°18.4141S, 66° 8.5429E, Depth = 3192m, Sampling Rocks, Sampling Water(WHATS)
007 13:36 14°16.9487S, 66° 7.9733E, Depth = 3407m, Sampling Rocks
008 13:42 14°16.9487S, 66° 7.9733E, Depth = 3407m, Sampling Water(WHATS)
009 13:45 14°16.9414S, 66° 7.9630E, Depth = 3408m, Left Botom

Dive Track


#1455DIVE
Area7
(1 / 12000)
13:30
13:00
12:30
12:00
11:30
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Center Lat 14-17.80000S Lon 066-08.40000E
Grid_File:YK16-E01_100.grd ContourInt:20m
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(LL)Lat 14-18.93942S Lon 066-07.63294E
(2016-02-23)
Datum WGS-84 Proj.LTM

Dive Report: Shinkai 6500 Dive# 1456
Date: February 24, 2016
Site: Area 7 in Indian Ocean
Landing: 10:24; 14º20.0800'S, 66º08.5573'E D=3,268 m
Leaving: 13:49; 14º19.5274'S, 66º08.0962'E, D=3,141m
Pilot: Yoshitaka Sasaki, **co-pilot:** Tetsuya Komuku
Observer: Masayuki Miyazaki (JAMSTEC)

Objectives:

The main objective of the dive #1456 is to explore the new hydrothermal vent in the area 7 field in Indian ocean. We will take samples of reference water, fluids, chimneys, animals, sediments and others.

Dive summary:

Shinkai 6500 landed the bottom at rocks (10:24), after reference seawater on 15 m from the bottom was collected in WHATS (#1) (10:15). We moved with observing the seafloor toward the point (11:00). The bottom material of this area was mud, basalt or pillow lava. We took the sample of a rock in event #4 (11:30). Hydrothermal vent activities were jumped to the next point (12:30) because it could not be observed though it was observed to the top of a ridge. We were observed with the point (13:00) and the point (13:30). We observed mud, basalt or pillow lava as well as the place of the anterior half. Finally, we collected a rock in sample box (3-1) by manipulator, and leaved (13:49).

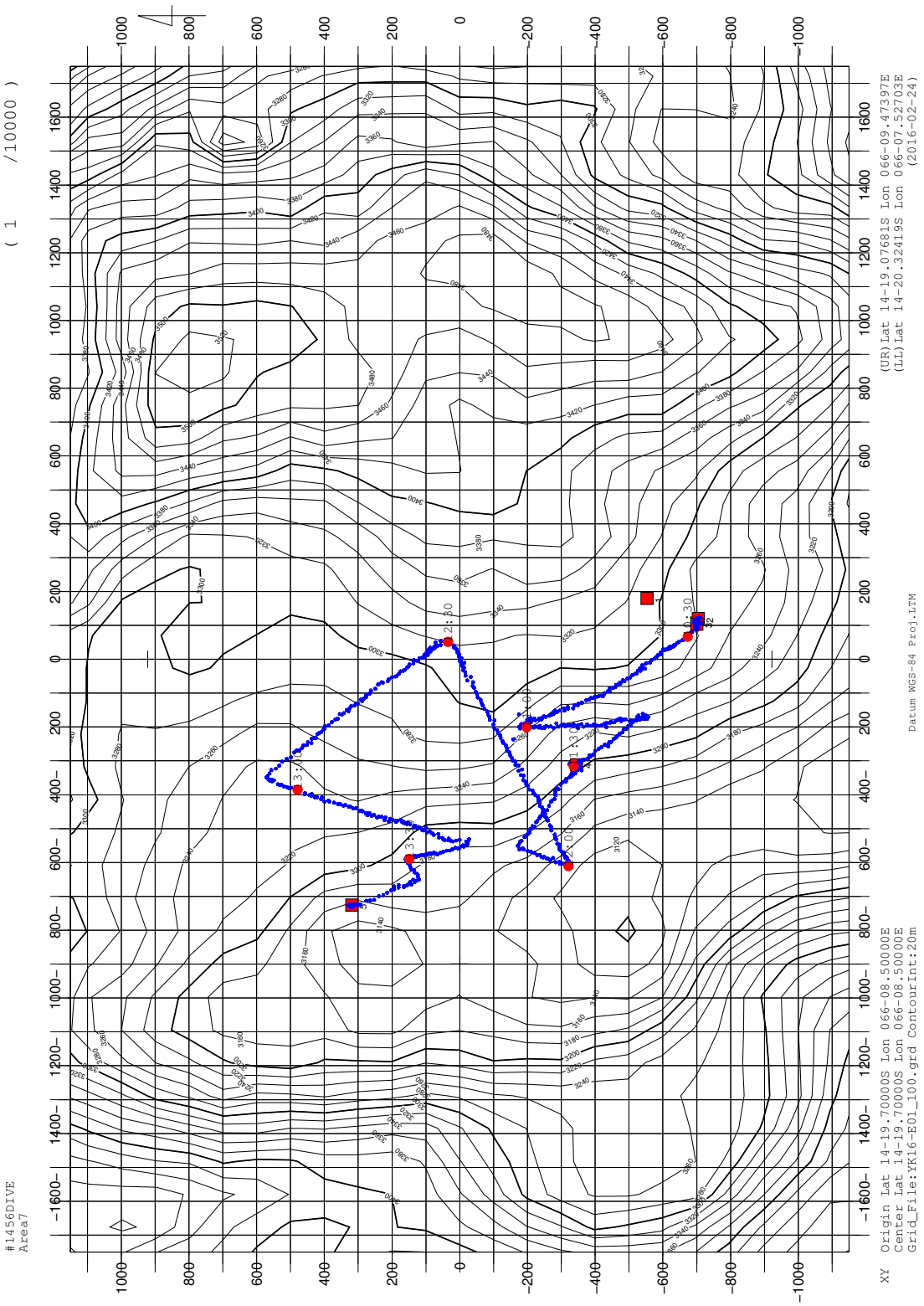
Payloads:

- Single canister x 1
- Slurp gun pomp x 1
- WHATS-III water sampler
- MJ water sampler x 2
- Thermometer with inlet x 1
- Multi sensor x 1
- MBARI Core x 2
- Sample box x 3
- Marker x 2

Event list:

2.	10:15	Sampling #1 WHATS (reference water). (14º20.0827'S, 66º8.5667'E, D=3,201 m)
3.	10:24	Landing at rock. (14º20.0801'S, 66º8.5573'E, D=3,268 m)
4.	11:40	Sampling Rock. (14º19.8873'S, 66º8.3265'E, D=3,179 m)
5.	13:49	Sampling rock and leaving at basalt and mud. (14º19.3428'S, 66º09.3437'E, D=3326 m)

Dive Track


(1 /10000)
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Area7
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Center Lat 14-19.70000S Lon 066-08.50000E
Grid_File:YK16-E01_100.grd ContourInt:20m
(UR)Lat 14-19.07681S Lon 066-09.47397E
(LL)Lat 14-20.32419S Lon 066-07.52703E
(2016-02-24)
Datum WGS-84 Proj.UTM

Dive Report: Shinkai6500 Dive# 1457
Date: February 26, 2016
Site: Edmond Field
Landing: 11:26; 23˚52.6815S, 69˚35.7401E, D=3320 m
Leaving: 15:50; 23˚52.6677S, 69˚35.8574E D=3221 m (A=95 m)
Observer: Chong Chen (JAMSTEC)
Pilot: Hirofumi Ueki
Copilot: Akihisa Ishikawa

Objectives:

The chief objective of the *Shinkai 6500* dive #1457 was to collect hydrothermal fluid and vent chimney from Edmond vent field. A second objective was to obtain a further replicate measurement of the physical and chemical environment conditions of one *Alviniconcha marisindica* colony, as well as sampling specimens for comparison with those taken from Kairei vent field. A third objective was to search for a potential new population of the 'scaly-foot gastropod' *Chrysomallon squamiferum*.

Dive summary:

Shinkai 6500 landed approximately 100 m west of the main mound of Edmond field, on rust-coloured rubble bottom (11:26). The substrate was sparsely colonized by sea anemone (*Marianactis*? sp.). A few swimming *Rimicaris kairei* was seen as well as one large fish, probably in Macrouridae. Notably, the altimeter gave erroneous readings on descent before landing (over 100 m) but it behaved fine afterwards. We were about 20 m south of the planned landing point but we decided to head straight east towards the main mound to 6K marker #204 as planned. This marker was placed by Ken Takai on the previous dive here (6K #1451) and indicate the location of a vigorously venting black smoker formed by breaking off a fraction of the main mound – a perfect location for fluid sampling.

Soon, we spotted the *Shinkai 6500* marker #29 which is indicative of the bottom of the Huge Monk Head chimney. Although we could only see a mound and not the actual chimney, we decided to prioritise fluid sampling so we gave up seeing the Huge Monk Head chimney and headed east. However, our course was severely influenced by a strong northeastern current, and we drifted to the north side of the main mound. On approach to the main mound, all viewports and cameras blacked out due to the extreme amount of black smoke. The pilots suggested to take altitude of over 5 m from seafloor to fly through to the southern part of vent field and re-approach from there, to which I agreed.

After arriving at the south, we turned *Shinkai 6500* and headed north. Soon we encountered the main mound again, but this time we could clearly see the shiny 6K marker #204. The target black smoker chimney was located with ease, and then we

sampled 1000 ml of high-temperature hydrothermal fluid (highest temp. = 370°C) into WHATS III (12:28). The pilots were instructed to then purge the high-temperature fluid remaining in the water line out through the void line, but there was a slight delay in adjusting the valve, causing some high-temperature fluid to go into the multi-sensor line. After that, we could easily sample a piece of this vigorous chimney into sample box 1. Interestingly, the chimney appears to have grown more than 20 cm since the last dive. At this point, we could see another small but active chimney lower on the mound, so we wanted to try and sample it. Unfortunately the current was not in favour of that, so we gave up and started to go around the main mound clockwise looking for *Alviniconcha marisindica* and *Chrysomallon squamiferum* colonies.

Not long after we started the search, a moderately large colony of *A. marisindica* consisting of around 20 individuals was located near a tiny chimney. Firstly, DO measurement with the DO sensor was taken for three minutes at two different locations (13:05). Secondly, 1000 ml of colony water was taken using the MJ-type water sampler (green), and then the green ball valve was closed (13:24). The measured temperature of the colony water was between 5 to 20°C. Unfortunately, we dropped the sheath of the water sampler during this operation and had to store the water sampler directly in the right sample basket. Thirdly, we sampled *A. marisindica* into chamber 1 (13:26), *Bathymodiolus* mussels and *Branchinoglutoma*? sp. scale worms into chamber 2 (13:30). Closer examination of the area revealed further *A. marisindica* below *Rimicaris kairei* shrimps, which were sampled into chambers 3-4 after attempting to eliminate *R. kairei* with movement of the slurp gun (13:36). We also saw some platyhelminthes, but they were not within the reach of slurp gun.

Next, we moved on from this *Alviniconcha marisindica* colony to look for other colonies. A small colony was soon found on a diffuse flow site, so we halted to sample (13:52). It became apparent with high magnification zoom on the science camera that two specimens of *Shinkailepas* sp. were present, so we sampled these into chamber 5 (14:00). Furthermore, a few individuals of *A. marisindica* were sampled together into chamber 5 before we left this site. At this point, chamber 5 was only half full.

At 14:20, we have completed a round-trip around the main mound and arrived at the back of marker #204 and saw the black smoker we took the WHATS III sample from earlier. Just north of that black smoker, and noticed a large colony of *Alviniconcha marisindica* there consisting of more than 50 individuals. We landed on the chimney wall to collect *A. marisindica* from this colony. As we were surrounded by three vigorously active black smokers, the pilots suggested we leave as soon as possible. Therefore, we just took one DO measurement for three minutes (14:31) before sampling many *A. marisindica* individuals into the remaining space of chamber 5 as well as the whole of chamber 6 (14:36). We then quickly left the spot.

Now that we have filled all slurp gun chambers, we decided to find a chimney with bacteria that we can easily sample. We reached the Grand Shrimp Valley at 14:50, and found some active and fresh black smoker chimneys covered in layers of *Rimicaris kairei.* The terrain appeared suitable for landing, and thus we landed to sample. The pilots noticed some platyhelminths nearby and attempted to sample them into chamber 6, although this unfortunately failed (15:02). Following that we successfully sampled a chimney, which we placed into sample box 2 (15:11).

By this point we have completed the two major objectives of this dive and still had about 30 minutes left. Therefore, we wanted to head to Nura Nura chimney to see its current condition, since it has not been visited since 2006. During the course, however, we had a black-out over the main mound (15:29) and thus had to escape towards southeast and try again. This cost us more than ten minutes of dive time, and regrettably we could not reach Nura Nura before end of dive. After observing the northern end of the main mound for one last time, we moved away from Edmond field in full speed towards east into the rubbly basalt area. Finally, we left the bottom at 15:50.

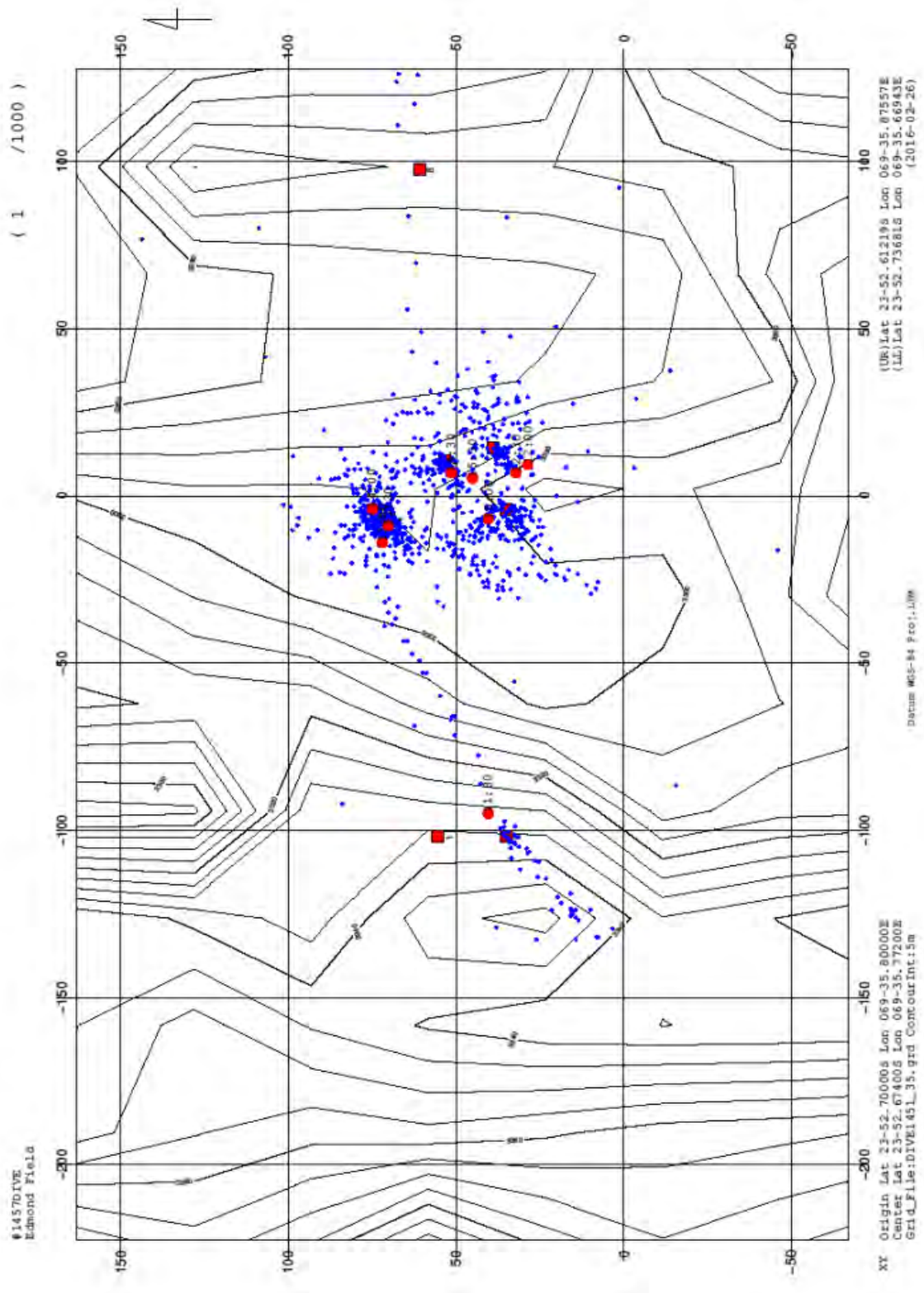
Payloads:

- 7 bottles canister x 1
- Slurp gun pump x 1
- WHATS-III water sampler
- Multiple chemical sensor
- MJ water sampler (Green)
- MJ water sampler (Red)
- Perister pump x 2
- Sample box x 2
- Broom x 1
- DO meter

Event list:

10:00	23°52.6700S	69°35.7400E	Depth = 3320	Landing Target
11:26	23°52.6815S	69°35.7401E	Depth = 3320	Landing
12:28	23°52.6799S	69°35.8085E	Depth = 3273	Sampling WHATS
13:37	23°52.6621S	69°35.7959E	Depth = 3279	Measurement DO Sampling
Water (MJ)				
14:03	23°52.6601S	69°35.7974E	Depth = 3280	Sampling Animals
14:31	23°52.6712S	69°35.8062E	Depth = 3275	Measurment DO Sampling
Alviniconcha				
15:15	23°52.6810S	69°35.7975E	Depth = 3281	Sampling Animals on Rock
15:50	23°52.6677S	69°35.8574E	Depth = 3221	Left Bottom Alt.=95m

Dive Track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(1 /1000)
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Datum WGS-84 Proj.UTM
(UR)Lat 23-52.612198 Lon 069-35.87557E
(LL)Lat 23-52.736818 Lon 069-35.66943E
(2016-02-26)

Dive Report: Shinkai6500 Dive# 1458
Date: February 27, 2016
Site: Kairei Field
Landing: 11:09; 25˚19.1945S, 70˚02.3962E, D=2467 m
Leaving: 16:01; 25˚19.2732S, 70˚02.3771E, D=2426 m
Observer: Ken Takai (JAMSTEC)
Pilot: Fumitaka Saito
Copilot: Keigo Suzuki

Objectives:

The main objective of the dive #1458 is to recover a 'Yudesuke', which is a incubation apparatus containing dead individuals and tissues of Solitaire- and Kairei-morphotypes of *Chrysomallon* and was deployed at Shinkai6500 dive#1450. In addition, one of the important missions is to find a large and dense colony of Kairei-morphotype *Chrysomallon* that was not successfully detected in the previous two dives. The physic-chemical measurement of 'true' *Alviniconcha* colonies is also an objective.

Dive summary:

Shinkai6500 landed on the northern depression of the Kairei field. Then we went directly to the Monju chimney, in which both *Chrysomallon*'s and *Alviniconcha*'s colonies are spread and a 'Yudesuke' was deployed. Going several tens meter to the south, we found two new 6K's markers and a 'Yudesuke' marker. After we landed in front of 'Yudesuke', we recovered it. The 'Yudesuke' was completely covered with *Rimikaris* shrimps and the cage was filled with small (young) *Rimikaris* shrimps. During the recovery operation, I found a piece of *Alviniconcha* colonies exposed from thick *Rimikaris* screen below a diffusing black smoke. The landscape reminded me of the previous *Chrysomallon*'s and *Alviniconcha*'s colonies that had been observed in the 2006 cruise. I was highly convinced that there should be large and dense colonies of *Chrysomallon* around the black smoker chimney.

We tried to access the black smoker at a depth of 2422 m. Below this depth, most of the diffusing flows and the proximal area are dwelled mainly by mussels. First, the DO measurement and sampling the colony water were done (temperature seemed to be 19-21 ˚C during the measurement), and then a longer time of multichemical sensor measurement was conducted. Subsequently, many *Alviniconcha* individuals were sampled by a suction sampler (Bottles 1, 2 & 3).

After the operation of *Alviniconcha* colonies, we swept the Rimikaris screen by blass. The outer zones were occupied with dense *Alviniconcha* individuals but after removal of overlying *Alviniconcha* individuals, many and dense black brilliant Kairei-morphotype *Chrysomallon* emerged. Thus, the DO measurement and sampling the colony water were

first done (temperature seemed to be 10 ˚C during the measurement), and a longer time of multichemical sensor measurement was next conducted. Subsequently, many *Chrysomallon* individuals were sampled by a suction sampler (Bottles 4, 5 & 6).
After the successful missions of this dive, we had lots of time left. So for the future visit, we also checked the widespread occurrence of *Chrysomallon* colonies. At around the black smoker, 1 m eastern chimney wall and more than 3 m western chimney wall (previously called as 'western annex'). During the monitoring the *Chrysomallon* colonies, we obtained a dead chimney colonized with *Chrysomallon* individuals.
After the environmental assessment, we found an active black smoker chimney on the meddle part of Monju chimney at a depth of 2425m. We collected the chimney pieces. Then, we went to the observation of whole landscape of the Kairei field. We checked the Fudo, Bishamon, Daikoku, Kissyo and Kali chimney and vent sites. Finally, at the Kali vent site, we found active black smokers several meters south of the main Kali vent. This 'Kali-Migi' chimney was sampled. Then, we went east and south, and finally left the bottom.

Payloads:
- 7 bottles canister x 1
- Slurp gun pomp x 1
- Multiple chemical sensor
- MJ water sampler (Green)
- MJ water sampler (Red)
- Perister pomp x 1
- Sample box x 2
- Blass x 1
- DO meter

Event list:
11:09 25˚19.1945S, 70˚02.3962E Depth=2467m, Landed on the seafloor

12:30 25˚19.2298S, 70˚02.4143E Depth=2423m, Recovery of Yudesuke, and completed DO measurement, colony water sampling, multichemical sensor measurement and individual sampling of at an *Alviniconcha* colony

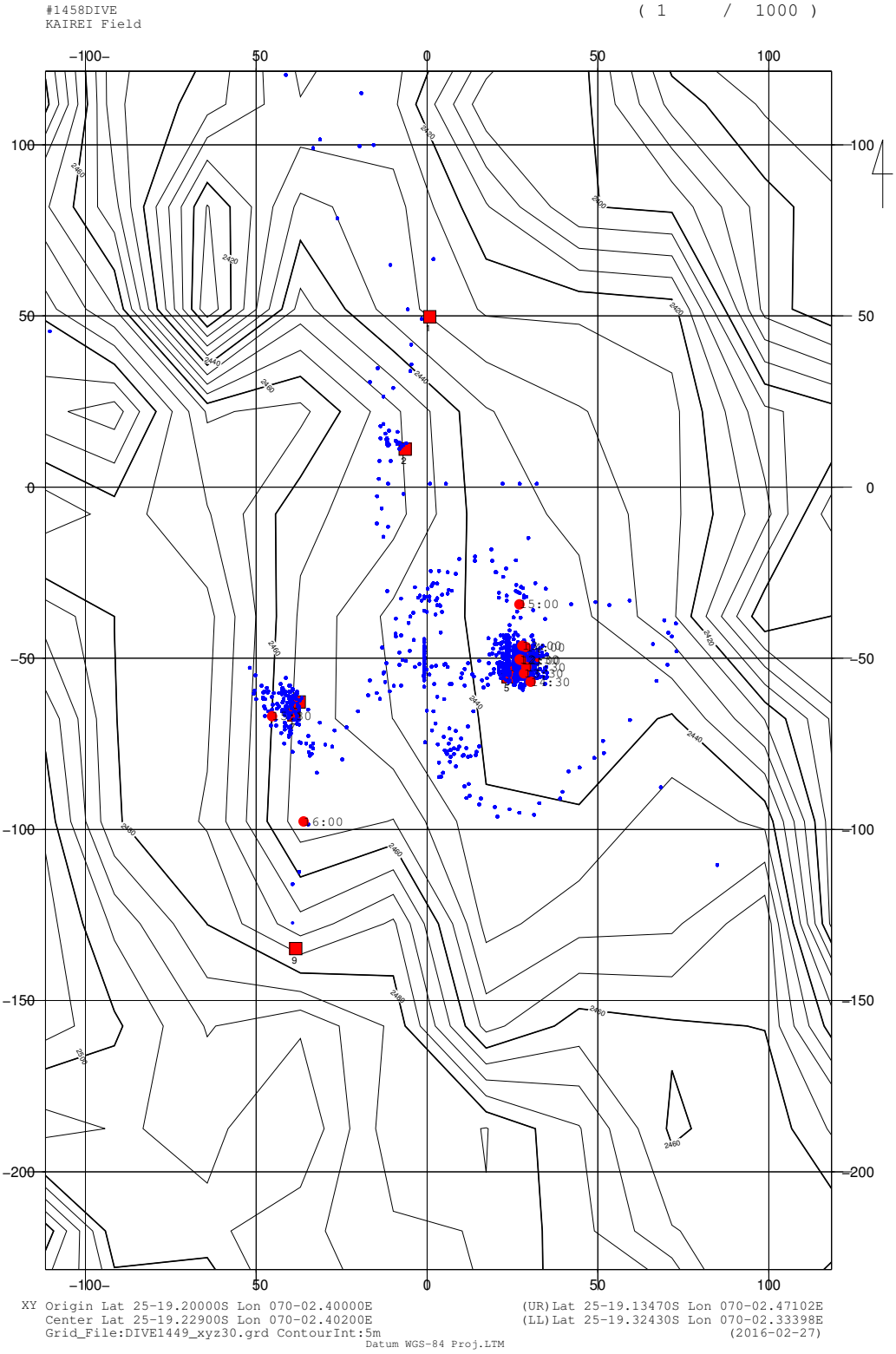
13:07 25˚19.2275S, 70˚02.4165E, Depth=2422m, completed DO measurement, colony water sampling, multichemical sensor measurement and individual sampling of at n *Chrysomallon* colony

13:52 25˚19.2301S, 70˚02.4141E, Depth=2422m collected a dead chimney with *Chrysomallon* individuals

14:25 25˚19.2275S, 70˚02.4184E, Depth=2424m collected an active chimney

15:35	25˚19.2362S, 70˚02.3768E,	Depth=2451m	Found Kali-Migi chimney and deployed a 6K#205 marker
15:50	25˚19.2349S, 70˚02.3777E,	Depth=2450m	collected an active chimney
16:01	25˚19.2732S, 70˚02.3771E,	Depth=2426m	Left Bottom

Dive Track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(2016-02-27)
Datum WGS-84 Proj.LTM