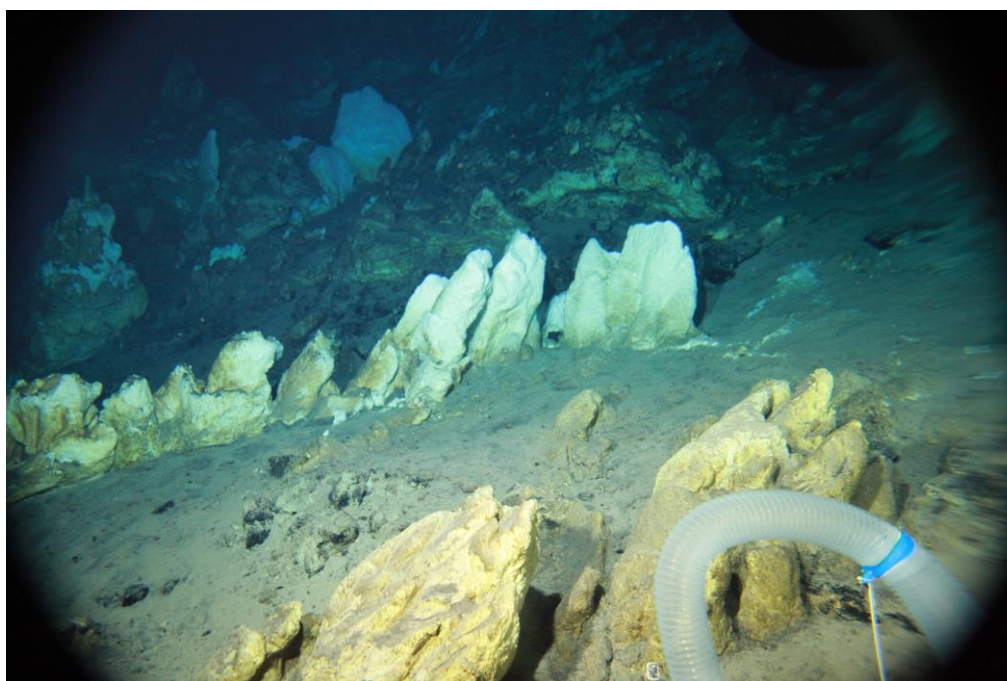




R/V Yokosuka & DSV Shinaki6500 Cruise Report

YK23-13

**Investigation of geochemical and microbial processes associated
with serpentinization-driven fluids in the Mariana Forearc and
Outer-rise regions**



July 23, 2023 from JAMSTEC Yokosuka - August 16, 2023 to

JAMSTEC Yokosuka

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

Acknowledgements

We are grateful to Captain Mr. Y. Nakamura, Chief Officer Mr. T. Shirayama, Chief Engineer Mr. T. Mori and all the other crews for their safe navigation and their skillful handling of “R/V Yokosuka”. Great thanks are due to Shinkai6500 Operation Manager Mr. K. Chiba and Shinkai6500 operation team for their operations in sampling. We thank all the JAMSTEC persons who have supported us and this cruise. Finally, we would like to appreciate all the persons who have encouraged directly or indirectly this cruise.

CONTENTS

Acknowledgements	2
Contents	3
Cruise information	4
List of participants	5
Captain and crew of the R/V YOKOSUKA	7
“Shinkai 6500” Operation Team	8
 I. Cruise summary	 9
 II. Introduction	 11
 III. Explanatory note	 13
1. Manned Research Submersible “Shinkai 6500”	13
2. Research Vessel “Yokosuka”	14
 IV. Dive report	 15
Shinkai6500#1708 (K. Takai)	16
Shinkai6500#1709 (J. Miyazaki & K. Taguchi)	19
Shinkai6500#1710 (D. Pan)	22
Shinkai6500#1711 (L. Deng)	25
Shinkai6500#1712 (J. Li)	28
Shinkai6500#1713 (F. Wang)	31
Shinkai6500#1713 (L. Dong)	34
Shinkai6500#1713 (J. Miyazaki & K. Takai)	37

Cruise information

Cruise ID: YK23-13

Vessel: Yokosuka

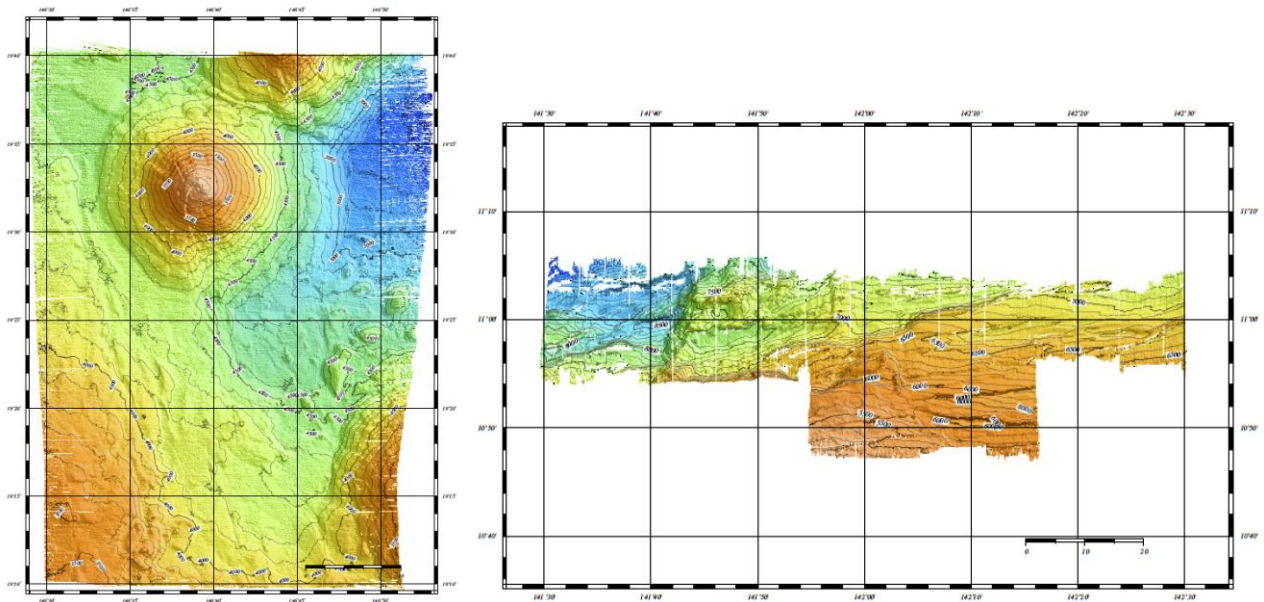
Title of the cruise: Investigation of geochemical and microbial processes associated with serpentinization-driven fluids in the Mariana Forearc and Outer-rise regions

Cruise period: July 23 – August 16, 2023

Ports of call: JAMSTEC Yokosuka – JAMSTEC Yokosuka, Japan

Research area: Conical Seamount, and Trench Outer-rise

Research map:



General topographic map of Conical SMt (left) and Mariana Trench outer-rise region (right)

List of Participants

Scientific party

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Director General (Geomicrobiology)

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

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Mr. Yoshi Horiuchi

Marine Technical Staff
MARINE WORKS JAPAN Ltd.

Captain and crew of the R/V YOKOSUKA

Captain	NAKAMURA, Y.
Chief Officer	SHIRAYAMA, T.
2nd Officer	ASAJI, K.
Jr. 2nd Officer	KAJISA, T.
3rd Officer	SAKAMOTO, R.
Jr. 3rd Officer	ITO, S.
Chief Engineer	MORI, T.
1st Engineer	FUJII, K.
2nd Engineer	INOMOTO, T.
3rd Engineer	SHIMUZU, K.
Jr. 3rd Engineer	TERAKAWA, A.
Chief Electric Operator	MABARA, T.
2nd Electric Operator	ONIKUBO, R.
3rd Radio Officer	OI, K.
Boatswain	ISOBE, H.
Quarter Master	CHIMOTO, T.
Quarter Master	NASU, K.
Quarter Master	KOJIMA, S.
Sailor	NAKANISHI, R.
Sailor	MATSUDA, T.
Sailor	INOUE, S.
No.1 Oiler	MOURI, J.
Oiler	FUJIWARA, M.
Oiler	SUZUKI, R.
Assistant Oiler	FUJISHIMA, T.
Assistant Oiler	DANTSUKA, A.
Chief Steward	HONDA, S.
Steward	NAGATOMO, T.
Steward	KASHIWAGI, K.
Steward	NAKANO, M.
Steward	FUJIMOTO, Y.

“Shinkai6500” Operation Team

Operation Manager	CHIBA, K.
Deputy Op. Manager	MATSUMOTO, K.
1st Submersible Staff	KONDO, T.
1st Submersible Staff	UEKI, M.
1st Submersible Staff	ISHIKAWA, A.
2nd Submersible Staff	SUZUKI, K.
2nd Submersible Staff	SAIGO, R.
2nd Submersible Staff	ONISHI, T.
2nd Submersible Staff	IJIMA, S.
2nd Submersible Staff	MINAMINO, N
3rd Submersible Staff	SATO, K.
3rd Submersible Staff	ICHINOSE, D.

I. CRUISE SUMMARY

In YK23-13 cruise, we totally conducted 8 dives of Shinkai6500 in the Conical Seamount of the Mariana Forearc region and in the Southern Mariana Trench Outer-rise region. One of the cruise foci was whether a true active seafloor microbial ecosystem is present in the extreme alkaline and reductive seafloor environments of the Mariana Forearc serpentinite seamounts or not. It is not a scientific objective only during this cruise and a big objective of a series of cruises such as IODP Exp. 366, KM23-05 and YK23-13. The other one was to justify that newly discovered low-temperature hydrothermal fluid flows in the outer-rise regions host a diversity of microbial (or macrofaunal) communities that are different from previously known microbial ecosystems associated with high-temperature hydrothermal systems in the mid ocean ridges, volcanic arcs and backarc basins and even serpentinization-driven fluid flow systems in off mid ocean ridges and forearc regions.

During 4 dives in the Conical Seamount, we successfully found very active chimneys that host relatively fresh serpentinization-driven fluid flows. Previous dive surveys by Alvin and Shinkai6500 found only old and inactive chimneys in the Conical Seamount. Thus, the newly discovered chimneys represent the best samples for the future microbiological characterization of active seafloor microbial ecosystem in the extreme alkaline and reductive seafloor environments of the Mariana Forearc serpentinite seamounts. Particularly, we successfully obtained the relatively pristine porewater samples of chimneys. The porewater was depleted by H_2 and CH_4 but enriched by C_2H_6 . The significant amount of C_2H_6 is very useful for the onshore investigation whether the simple abundant organic compounds found in the Mariana Forearc serpentinite seamounts are derived from abiogenic or biogenic processes, or thermogenic sources. The pH values of porewater reached up to pH 11.9, which is also suitable for the detection of indigenous microbial community dwelling in the serpentinization-driven alkaline and reductive fluids, as compared to the pore-waters with pH12.5 in both the South Chamorro and Asut Tesoru Seamounts.

During 4 dives in the Southern Mariana Trench Outer-rise region, we focused on two sites (M and N sites) that was previously discovered by Chinese cruise using HOV/JyaoLong. The N site was located at about 6300 m and was surveyed by 6K#1712. We found one bottomless hole that was different from the pockmarks discovered by JyaoLong dive, and took core samples at the hole. However, onboard chemical analysis suggests that the hole does not host the relatively fresh and reductive fluid flow. On the other hand, 6K#1713 conducted at M site at 5500 m found the big pockmark and the core samples suggest that the deeper sediments are significantly affected by fresh and reductive fluid flow. Finally two more dives were conducted at M site, and we found lots of new pockmarks and iron-(hydr)oxide chimneys in the broad area of M site. These will be excellent samples to justify that new types of low-temperature

hydrothermal fluid flows in the outer-rise regions host a diversity of microbial (or macrofaunal) communities.

II. INTRODUCTION

General backgrounds & Scientific objectives

One of the scientific objectives of this cruise is to clarify the microbial communities and their biogeochemical processes under the extreme conditions of the Mariana Forearc serpentinite seamounts (herein after called SMts). The target seamount is Conical SMt in the Mariana Forearc. The primary objective is to find out whether a true active subseafloor microbial ecosystem is present in the extreme alkaline and reductive subseafloor environments or not.

In 1989, Ocean Drilling Program (ODP) Leg 125 was conducted to obtain the samples of serpentinization-derived fluids, rocks and mud in several Mariana Forearc serpentinite SMts (Fryer et al., 1990). The geochemistry characterization of the pore-water samples demonstrated that the subseafloor environment of the Conical SMt is an extreme environment of which pH reaches to pH12.5, the strongest hyperalkaline in this planet (Fryer et al., 1990). Meanwhile, the microbiological exploration was not conducted. Based on the microbial activity surveys of other Mariana Forearc Serpentinite SMts, we found a tiny but a certain signal of active microbial function but the other molecular and cultivation techniques found no apparent evidence of active microbial populations (Kawagucci et al., 2018; Aoyama et al., 2018). The subseafloor environment under pH12.5 is marginal for the microbial habitability (the highest pH limit for microbial growth is known as pH12.4). If the active microbial communities are present in the habitats, the communities might represent the novel microbial populations and functions beyond the presently known limits of life. However, the core samples obtained and distributed from previous ODP (Ocean Drilling Program) and IODP (International Ocean Discovery Program) Expeditions were not enough for further detail molecular and cultivation analyses in quantity to clarify whether a true active subseafloor microbial ecosystem is present in the extreme alkaline and reductive subseafloor environments or not. to clarify various chemical and biological processes in the subseafloor environment of serpentinite SMts with different geological backgrounds and genesis processes by conducting a submarine survey of the Conical SMt summit of the Mariana Trench forearc region by SHINKAI 6500.

The other scientific objective of this cruise is to clarify the chemical and biological processes of low-temperature hydrothermal fluid flow discharges in the outer-rise regions of Mariana Trench (Southern Mariana area) (Du et al., 2019), and to find other discharge sites in the similar regions. We plan to survey the seafloor observations at previously discovered discharge sites and collect the sediments, rocks, fluids and organisms samples related with the low-temperature hydrothermal fluid, using a Manned Research Submersible "SHINKAI 6500". The detail chemical and microbiological characterizations of the samples will address the driving force and

mechanisms of such low-temperature hydrothermal fluid flow, e.g., relatively shallow crustal iron-containing rock-water reaction or deep serpentinization reaction in the upper mantle peridotite. We would also like to know which geological processes (seismicity or deep faulting to the mantle) can sustain the seafloor microbial communities associated with the geo-fuels such as H₂ and CH₄. In addition, we will survey new discharge sites in the similar regions and will take a diversity of geochemical and microbiological characteristics. These surveys are also directly involved in the seafloor observation and preliminary observations of scientific drilling sites, which have been proposed in IODP (International Ocean Discovery Program) for the future expedition.

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- Du, M., Peng, X., Seyfried Jr., W. E., Ta, K., Guo, Z., Chen, S., Chou, I. M., Li, J., Xu, H. (2019) Fluid discharge linked to bending of the incoming plate at the Mariana subduction zone. *Geochem. Pers. Lett.*, II, 1-5.

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 digital video image.

Specifications

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

IV. DIVE REPORTS

6K#1708 DIVE (Conical SMt)	Dr. TAKAI, K
6K#1709 DIVE (Conical SMt)	Dr. MIYAZAKI, J., and Mr. TAGUCHI, K.
6K#1710 DIVE (Conical SMt)	Dr. PAN, D.
6K#1711 DIVE (Conical SMt)	Dr. DENG, L.
6K#1712 DIVE (South Mariana Trench OR)	Dr. LI, J.
6K#1713 DIVE (South Mariana Trench OR)	Dr. WANG, F.
6K#1714 DIVE (South Mariana Trench OR)	Dr. DONG, L.
6K#1715 DIVE (South Mariana Trench OR)	Dr. MIYAZAKI, J., and Dr. TAKAI, K.

Dive Report: Shinaki6500#1708

Date: July 27, 2023

Site: Conical Seamount

Landing: 11:39; 19°31.8830'N, 146°38.4739'E, D=3224 m

Leaving: 15:38; 19°32.1995'N, 146°38.9218'E, D=3129 m

Observers: Ken Takai (JAMSTEC)

Pilots: Ryo Saigo, Naoto Minamino

Objectives:

The objectives of *Shinkai6500* Dive # 1708 was to 1) find serpentinite fluid discharges, carbonate/brucite chimneys and chemosynthetic animals, and 2) collect the fluid, chimney, animal samples in the Conical Seamount.

Dive summary:

We landed the southern slope of the Conical Seamount at a depth of 3220 m. Before the landing, we collected the seawater by Niskin sampler (blue) 100 m above the landing site. Immediately after the landing, we tested the multichemical sensors and methane (METS) sensor with H₂ and CH₄ standard samples in the bags and collected the standard fluids by MJ sampler. In addition, we obtained a swimming holoturian individual near the landing site.

Then we headed to northeast to arrive at chimney sites which were found in the previous Alvin and Shinkai6500 dives. During the navigation, we encountered many times the landslide flow from the summit to the foot. The landslide flow had at least three steps (cliffs) with the width of 20-50 m. At the cliff top and bottom, heavily serpentinized rocks exposed to seawater. We passed through such landslide flow traces during the survey from west to east and round trip from east to west.

Finally, we arrived at the main chimney site that was discovered by the previous Shinkai6500 dive in 2003. Many chimneys were observed but all the chimneys seemed to be inactive and old. The most fresh-looking chimney was obtained and the potential fluid seepage was measured by multichemical sensors and METS sensor. However, no signal was obtained. After collecting chimneys, we obtained seawater by Niskin sampler (Green). Then, we observed around chimney site and landed in front of dead chimney. We found a barnacle on the chimney. We did not successfully sample it.

Then, we landed 20 m south from the chimney site and obtained three MBARI corers for reference and obtained a holoturian individual. After running 40 m south from chimney site, we left bottom.

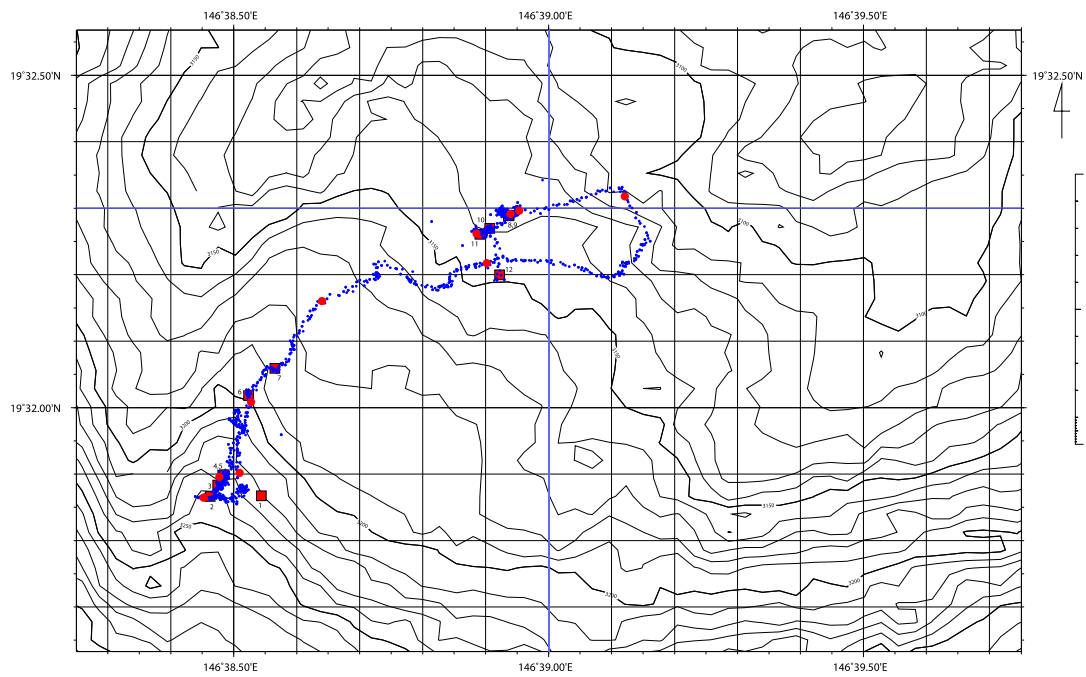
Payloads:

- MBARI corers (35 cm x 6)
- Suction sampler with a single canister
- DO meter
- Temperature sensor
- MJ water sampler (Green and Red)
- H₂ and H₂S sensors {Multi sensor}
- METS sensor
- *In situ* fixation box
- Sample box (Black)
- Markers (x3)

Event list:

11:27	19°31.8660'N,146°38.4620'E	D=3122	Niskin sample (Blue)
11:39	19°31.8830'N,146°38.4739'E	D=3224	Landing, and collect gas standard fluids
12:32	19°32.0175'N,146°38.5231'E	D=3192	Obtained a swimming holoturian
14:45	19°32.2887'N,146°38.9367'E	D=3124	Found and collected chimneys, sensoring potential fluids, deployed a marker 6K#254, and collected a Niskin sample (Green)
15:16	19°32.2883'N,146°38.9356'E	D=3128	deployed a marker 6K#255
15:31	19°32.2602'N,146°38.8905'E	D=3130	Obtained a swimming holoturian
15:38	19°32.1995'N,146°38.9218'E	D=3129	Left the bottom

Dive track of 6K#1708



Dive Report: Shinaki6500#1709

Date: July 28, 2023

Site: Conical seamount

Landing: 12:03; 19°32.2462'N, 146°38.8319'E, D=3137 m

Leaving: 15:52; 19°32.3866'N, 146°39.2010'E, D=3077 m

Observer: Junichi Miyazaki (JAMSTEC), Kodai Taguchi (Tokyo Institute and Technology)

Objectives:

The objective of this dive was geological survey of the Conical seamount. If we find the specific feature including flesh chimneys, colored sediments, chemosynthetic animal colonies and so on, we try to sample these samples.

Dive summary:

Before landing we started pump flow to measure H_2 , H_2S , and CH_4 .

At 12:03, we landed on the rocky seafloor covered with sand or serpentine mud. The temperature of ambient seawater at the bottom was 1.5 °C. As hearing from the observer in the previous dive (6k#1708), step wise structure and many old chimneys covered with manganese were observed. We headed to the northeast, and we found the marker 6k#255 set on carbonate (silicate) cluster in the previous dive was found after a moment. We passed through it then headed to the marker 6k#254 which was also set on silicate chimney in previous dive. For a while, we easily found 6k#254 and passed through. We headed to the top of small hill near ODP#780 site. After passing the marker 6k#254, the number of old chimneys became fewer. We arrived at the top of small hill, but there were no specific features. Therefore, we headed to east to go to ODP#780 site. The surface was also covered with mud.

When we moved to east and then we arrived at probable ODP#780 site, we found colony of chimney including white chimney structures. It seemed flesh and the color and size were quite different from chimneys around the marker 6k#254 and 6k#255. Therefore, we decided to approach to the chimney and then we observed. Venting or shimmering fluids from the any chimneys were not observed. But tiny gastropods and barnacles existed at the surface of white chimneys. Before we sampled the top of the flesh and white chimney structures, we tried to sample the lower chimney which seemed old, to know the hardness. The chimney structure was relatively soft but was enough tough to sample. After sampling the old chimney, we observed that the cross section was black indicating anoxic methane oxidation was occurred. Therefore, we recovered the old chimney structure. Next we sampled the top of flesh chimney structures. 5 to 6 pieces were sampled. After sampling chimney structures, we tried to measure H_2 , H_2S , and CH_4 concentration. As a results, since H_2 and CH_4 was detected (H_2S sensors were broken), we sampled water into the No. 1 and No. 2 bottle of D-WAHTS. After sampling water, we rose 1 m

and sampled water into Niskin bottle (Green) above the chimneys. Finally we set 6k marker #256 onto one of the old chimney in the chimney colony which was named Tagu chimney.

Next, we went around the Tagu chimney to grasp the whole image. The white flesh chimneys were only in the sampling place, the west side of the Tagu chimney.

After looking around, we headed to the Southern top of the Conical seamount. We observed the stepwise structure during the moving. However during this moving, we could not find any specific features. We next headed to the valley which was formed between the Northern and Southern top of the Conical seamount. But there was no specific feature. We headed to the Tagu chimney along the valley. During moving, we found a long wire but we could not find any specific features.

Since the time we left bottom had come, we left the bottom at 15:52.

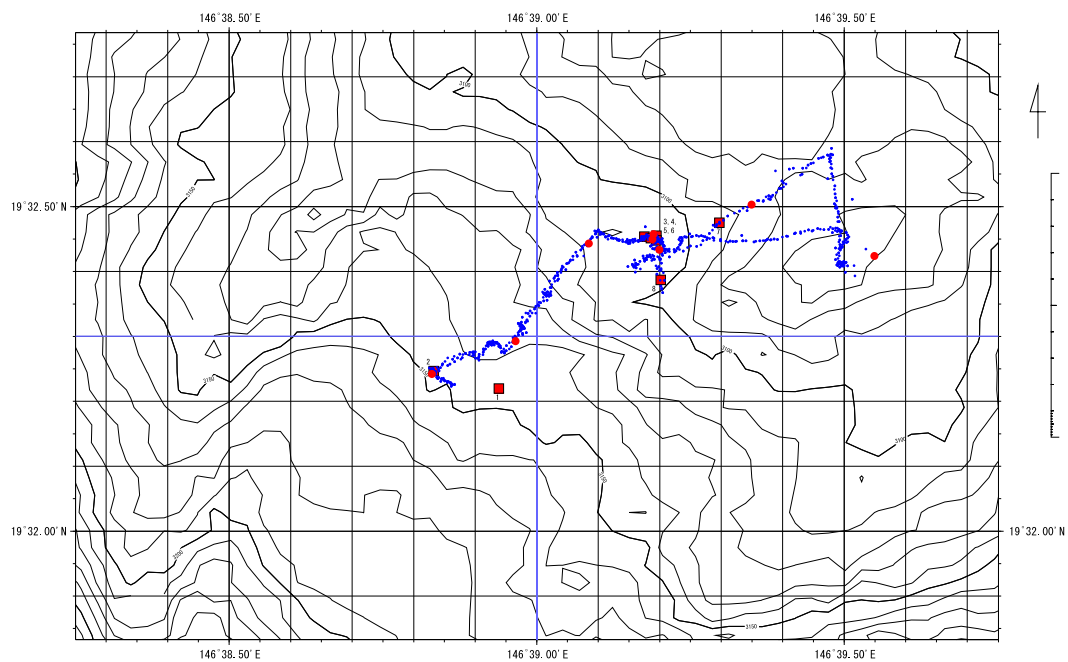
Payloads:

- D-WHATS
- Suction sampler with single canister
- DO meter
- Temperature sensor
- H₂ and H₂S sensors {Multi sensor}
- METS methane sensor
- Sample box (Black)
- Kumade sampler
- 6k markers (#256, #257, #258)
- MBARI sampler [3xRed, 3xYellow]

Event list:

12:03	19°32.2462'N, 146°38.8319'E, D=3137m	Landing
13:17	19°32.4534'N, 146°39.1748'E, D=3098m	Finding Artificial things
13:51	19°32.4511'N, 146°39.1852'E, D=3099m	Sampling Chimney, Measurement Temperature, Sampling WHATS(Red#1,#2)
14:08	19°32.4548'N, 146°39.1944'E, D=3098m	Sampling Niskin(Green)
14:20	19°32.4475'N, 146°39.1941'E, D=3094m	Set #256Marker
15:32	19°32.4749'N, 146°39.2968'E, D=3084m	Finding Wire
15:52	19°32.3866'N, 146°39.2010'E, D=3077m	Left Bottom

Dive track of 6K#1709



Dive Report: Shinaki6500#1710

Date: July 30, 2023

Site: Conical Seamount

Landing: 11:40; 19°32.5004'N, 146°39.0349'E, D=3100 m

Leaving: 15:58; 19°32.3941'N, 146°39.1793'E, D=3024 m

Observers: Donald Pan (Shanghai Jiao Tong University)

Pilots: Keigo Suzuki, Tomoe Kondo

Objectives:

The objectives of *Shinkai6500* Dive # 1708 were to 1) collect chimney samples identified during dive #1709, 2) deploy and test a new serpentinite fluid discharge collection cap tool, and 3) collect animals from the surfaces of chimneys.

Dive summary:

A Niskin sample (blue) was taken approximately 100 m above the landing site at a depth of 2992 m (19°32.4301'N, 146°39.0535'E). *Shinkai 6500* landed northwest of the targeted landing site. Nearby the landing site, a round depression with a white tubeworm-like structure was observed. It was noted and photo was taken. We proceeded eastward toward the planned site previously visited during Dive #1709.

We approached the round chimney ("Beehive") and took a Niskin sample (green) above it (19°32.4472'N, 146°39.1950'E). The co-pilot estimated that the distance was approximately 2 m above the chimney. Then, we moved toward the other proposed chimney ("Takenoko"). The left-most chimney was sampled. The chimney was very fragile and easily crushed by the manipulator. The observer noted that black cloudy material was seen escaping from the subsurface or interior of the chimney during sampling.

The pilots then moved to the chimney "Beehive" for sampling. A white crab-like crustacean was noted on the chimney and a photo was taken. Due to the size of the chimney and its location near many obstacles such as tall, old chimneys, a large portion of the chimney was out of reach of the manipulators. Only a small part of the upper portion of the chimney was sampled. D.O. was measured after sampling. An M-BARI core sample (#4) was attempted, but only a chimney piece remained stuck inside. The rest of the core did not remain. A cap (yellow) was placed on top of the chimney. It only covered a small portion of the chimney.

We proceeded to return to the chimney "Takenoko". The chimney area was cleared. DO was measured at the cleared chimney site and an MBARI core was taken (#5). A cap (blue) was placed on top of the hole created by the MBARI core. Because of a lack of time, fluid inside the cap was soon sampled (WHATS – red). There was difficulty in getting the sampler to be detached from the basket due to a zip-tie. An MBARI core was attempted nearby the cap, but it was not

possible due to the hardness of the material.

Before leaving the bottom, organisms on the surface of a nearby older chimney were sampled.

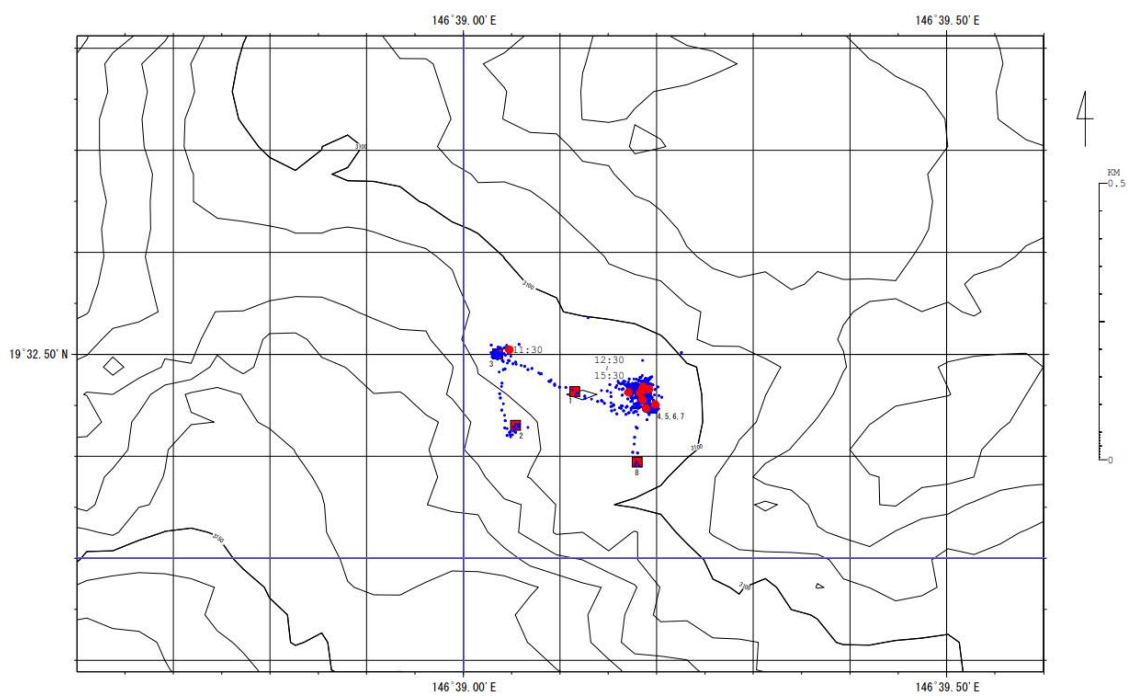
Payloads:

- MBARI corers (35 cm x 3)
- Suction sampler with a single canister
- Chimney cap (Blue and Yellow)
- DO meter
- Water sampler and Temperature probe
- MJ water sampler (Green and Red)
- H₂ and H₂S sensors {Multi sensor}
- METS sensor
- *In situ* fixation box
- Sample box (Black)
- Markers (x2)

Event list:

11:23	19°32.4301'N,146°39.0535'E	D=2992	Sampling Niskin(Blue)
11:40	19°32.5004'N,146°39.0349'E	D=3100	Landing
12:08	19°32.4472'N,146°39.1950'E	D=3093	Sampling Niskin(Green) above the round chimney "Beehive"
13:52	19°32.4660'N,146°39.1886'E	D=3097	Sampling Chimney, MBARI(#4), Measurement DO, Set Chimney Cap(Yellow) for the chimney "Beehive"
14:49	19°32.4660'N,146°39.1856'E	D=3098	Measurement DO, Sampling MBARI(#5), Water, WHATS(Red), Set Chimney Cap(Blue) for the chimney "Takenoko"
15:49	19°32.4667'N,146°39.1749'E	D=3096	Sampling animals from chimney surface
15:58	19°32.3941'N,146°39.1793'E	D=3024	Left Bottom

Dive track of 6K#1710



Dive Report: Shinkai6500#1711

Date: August 2, 2023

Site: Conical Seamount

Landing: 11:36, 19°32.5025'N, 146°39.0565'E, D=3099m

Leaving: 15:14, 19°32.3734'N, 146°39.2009'E, D=3095m

Observers: Longhui Deng (Shanghai Jiao Tong University)

Pilots: Ryo Saigo, Naoto Minanino

Objectives:

The objectives of *Shinkai6500* Dive # 1711 were to 1) sample the possible serpentinite fluids collected by the cap tool at the two chimney sites investigated during Dive1710, 2) take chimney materials in large pieces, and 3) collect animals from the surfaces of chimneys, 4) optional: sample sediments from a round depression hole-like structure observed during Dive1710.

Dive summary:

Shinkai 6500 landed close to the targeted landing site (19°32.5025'N,146°39.0565'E). The previously observed round depression with a white tubeworm-like structure was not found, so we proceeded eastward toward the planned site previously visited during Dive #1710.

We first approached the "Takenoko" chimney (19°32.4328'N,146°39.2058'E), took a Niskin sample (green) above it (19°32.4527'N,146°39.1888'E). At the same location we first sampled a big piece of chimney rock, then sampled fluids from inside the cap (WHATS – red) and retrieved the cap (blue).

We then moved to the round chimney ("Beehive", 19°32.4491'N,146°39.1805'E), sampled fluids from inside the cap (WHATS – green) and retrieved the cap (yellow). No chimney rock samples were taken, as it was difficult to perform sampling at this site and the battery of Shinkai was low.

Since the battery of Shinkai was low, we had to leave the bottom soon. Before leaving the bottom, at a location close to the Takenoko chimney, we quickly sampled a brittle star (19°32.4242'N,146°39.2004'E), sea anemone (19°32.4499'N,146°39.2057'E) attached to a chimney, and two sediment cores next to the chimney.

Payloads:

- MBARI corers (30 cm x 3)
- Suction sampler with a single canister
- Chimney cap (Blue and Yellow)
- DO meter
- Water sampler and Temperature probe
- MJ water sampler (Green and Red)
- H₂ and H₂S sensors {Multi sensor}
- METS sensor
- *In situ* fixation box
- Sample box (Black)

Event list:

20230802,11:36, 19°32.5025'N,146°39.0565'E,3099m,"Landing"

20230802,11:56, 19°32.4328'N,146°39.2058'E,3096m,"Finding Chimney"

20230802,13:34, 19°32.4527'N,146°39.1888'E,3098m,"Sampling Niskin(Green), Chimney, WHATS(Red), Retrieve Chimney Cap(Blue)"

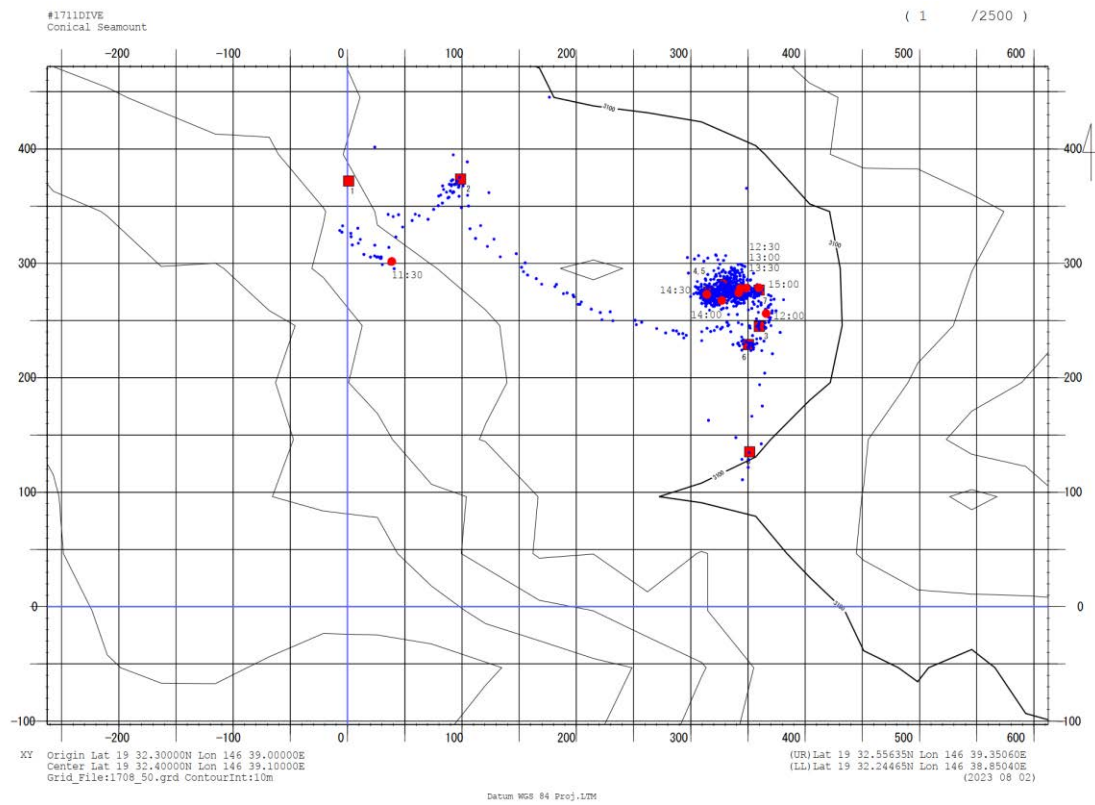
20230802,14:29,19°32.4491'N,146°39.1805'E,3096m,"Sampling WHATS(Green), Retrieve Chimney Cap(Yellow)"

20230802,14:46, 19°32.4242'N,146°39.2004'E,3097m,"Sampling Starfish"

20230802,15:04,19°32.4499'N,146°39.2057'E,3100m,"Sampling Sea anemone, Core(2)"

20230802,15:14,19°32.3734'N,146°39.2009'E,3095m,"Left Bottom Alt=5m"

Dive track of 6K#1711



Dive Report: Shinkai6500#1712

Date: August 5, 2023

Site: Southern Mariana outer rise

Landing: 12:00, 10°53.2971'N, 142 ° 14.5063'E, D=6310m

Leaving: 14:54, 10°53.1676'N, 142°14.2256'E, D=6249m

Observers: Jiwei Li (Institute of Deep Sea Science and Engineering, CAS)

Pilots: Takuma Onishi, Tomoe Kondo

Objectives:

The objectives of *Shinkai6500* Dive # 1712 were to 1) observe the geological and ecological features at the Southern Mariana Outer Rise region; 2) find the Pockmark N discovered previously by Chinese HOV JiaoLong at this region, 3) take samples (water, hydrothermal fluids if possible, sediment cores) from the target site, 4) survey around N site to find potential other pockmarks; 5) observe and sample (if possible) benthic animals around the target site.

Dive summary:

Shinkai 6500 landed at the seafloor around 12:00am at site 2 with a water depth of 6310m. The land site (10°53.2971'N, 142°14.5063'E) is on the east side of the targeting N pockmark, at approximately 800 meters distance. We moved westward along the planned course surveying for potential pockmarks. This area is a gently slope which tilts towards the south. And it is a vast sedimentary area mainly covered with yellowish muds, and a small part can observe few altered rocks and manganese crusts scattering around. Occasionally, we can observe some benthic organisms, such as sea cucumbers, polychaete, fish and shrimp along our moving track.

Around 13:20pm, we arrived at site N, and finally found a pockmark (10°53.1676'N, 142°14.2256'E) with a diameter of about 1.5m. However, it is difficult to observe its bottom by naked eyes due to its depth exceed 5 m. We observed some black crust covered parts of the pockmark's rim. Based on visual comparison, we believe it is a new pockmark rather than the one Jialing had discovered previously in this area.

We first took potential fluids by WHATS and attempted to place the sample tubes as deep as possible into the center of this pockmark. Next, we used the slurp gun to collect the black crust samples at its rim. Then, we take seven sediment push cores one by one at its rim. After that, we set the #257Marker. Lastly, we drove Shinkai 6500 forward slowly and floated just about one meter above the pockmark center, then took two Niskin bottled water samples. We left the seafloor at 14:54 pm.

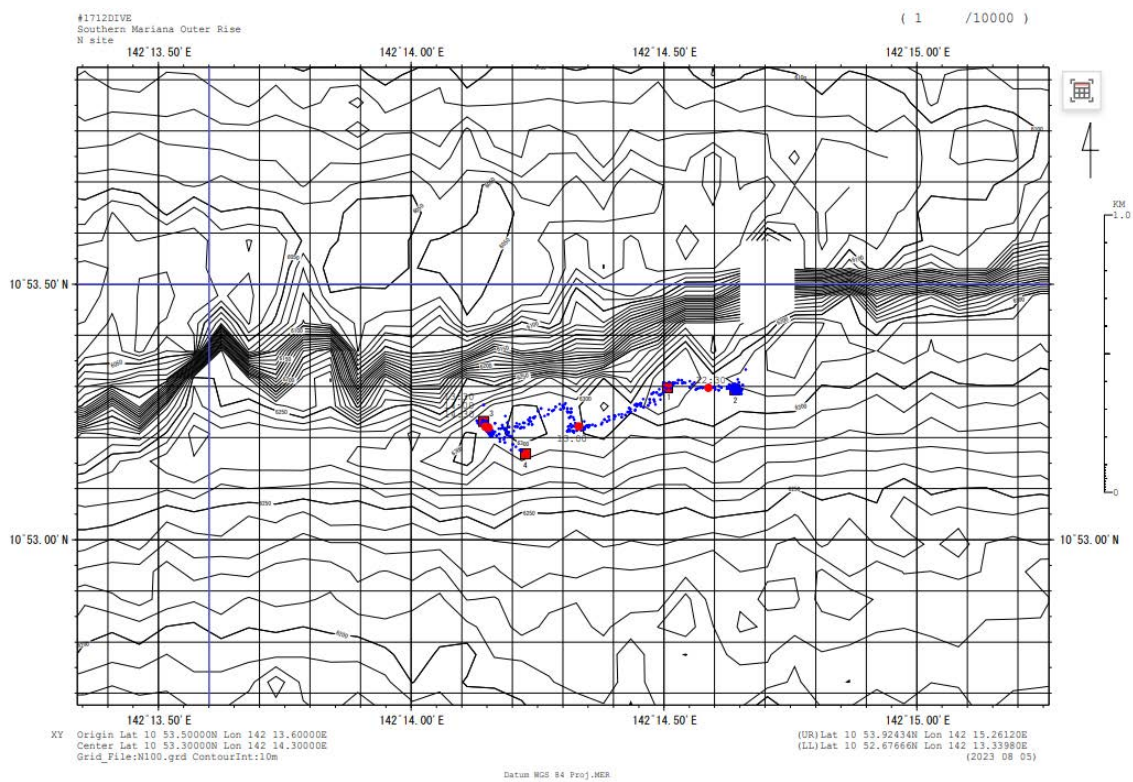
Payloads:

- MBARI corers (50 cm x 7)
- Suction sampler with a single canister
- D-WHAT water sampler (Green and Red)
- Niskin (2,5L)
- H₂ and H₂S sensors {Multi sensor}
- METS sensor
- Sample box (Black)

Event list:

001,20230805,000000,-374.02,1651.41,10-53.2971N,142-14.5063E,6310.00,"Landing Target"
002,20230805,121400,-381.56,1894.30,10-53.2930N,142-14.6396E,6292.00,"Landing"
003,20230805,144800,-495.54,988.88,10-53.2312N,142-14.1427E,6298.00,"Sampling
WHATS(Red), MBARI(7), Niskin(Blue, Green), Mud, Clasts, Measurement Diameter of Pock
Mark, Set #257Marker"
004,20230805,145400,-612.78,1139.94,10-53.1676N,142-14.2256E,6249.00,"Left Bottom
A=22"

Dive track of 6K#1712



Dive Report: Shinkai6500#1713

Date: August 6, 2023

Site: Southern Mariana outer rise

Landing: 11:30, 10°51.3316'N, 141 ° 56.6904'E, D=5543m

Leaving: 15:03, 10°51.0803'N, 141°57.0037'E, D=5473m

Observers: Fengping Wang (Shanghai Jiao Tong University)

Pilots: Iijima Satsuki, Matsumoto Keita

Objectives:

The objectives of *Shinkai6500* Dive # 1713 were to 1) find the Pockmark M discovered previously by Chinese HOV JiaoLong at the Southern Mariana Outer Rise region, 2) take samples (water, fluids if possible, sediment cores) from the target site, 3) survey around M site to find potential other pockmarks; 4) observe and sample (if possible) animals around the site.

Dive summary:

Shinkai 6500 landed at 11:38am western to the site 2 which is north of the targeting M pockmark (site 3). We drove eastern-ward zigzagged surveying for potential pockmarks. The area is a vast sedimentary area covered with dense manganese nodules. The manganese nodules at these areas change with sizes, which are large (~10cm in diameter) around the landing area, change to small sizes (~1-3cm in diameter) while moving east. The area holds a colorful benthic animal community with sea anemone most abundant (small sizes), other animals such as sea cucumber, starfish, small shrimp, unknown fishes frequently observed. But we didn't find any pockmarks, we decided to go straight southern to search for the M pockmark.

The landscape changed when we drove from site 2 to site 3, from manganese nodule inserted sediment seafloor to largely rock covered. During moving, we attempted to sample a few rocks, but too hard to get. Then we focused on searching for the pockmark, and we did find the targeting pockmark at round 13:00pm. The pockmark is ~3m in diameter, ~1m depth. Then we first took a Niskin sample above 1m of the center of the pockmark, took potential fluids ~2cm above the center (WHATS – red). Next we pulled out the number 4 corer to take sediment core from the center, around half of the core could be filled. We attempted to take more cores from the center, but all failed. Then we decided to move a bit outside of the pockmark to sample sediments, but we couldn't find a good place as the surrounding area is almost fully covered by rocks. We then decided to go back to the rim of the pockmark to suck in the gravels and the fragile rock crust. After the rock sampling, we have to go surface at 15:03pm.

Payloads:

- MBARI corers (50 cm x 7)
- Suction sampler with a single canister
- D-WHAT water sampler (Green and Red)
- Niskin (2,5L)
- H₂ and H₂S sensors {Multi sensor}
- METS sensor
- Sample box (Black)

Event list:

001,20230806,000000,351.02,-649.30,10-51.2904N,141-56.6437E,5553.00,"Landing Target"

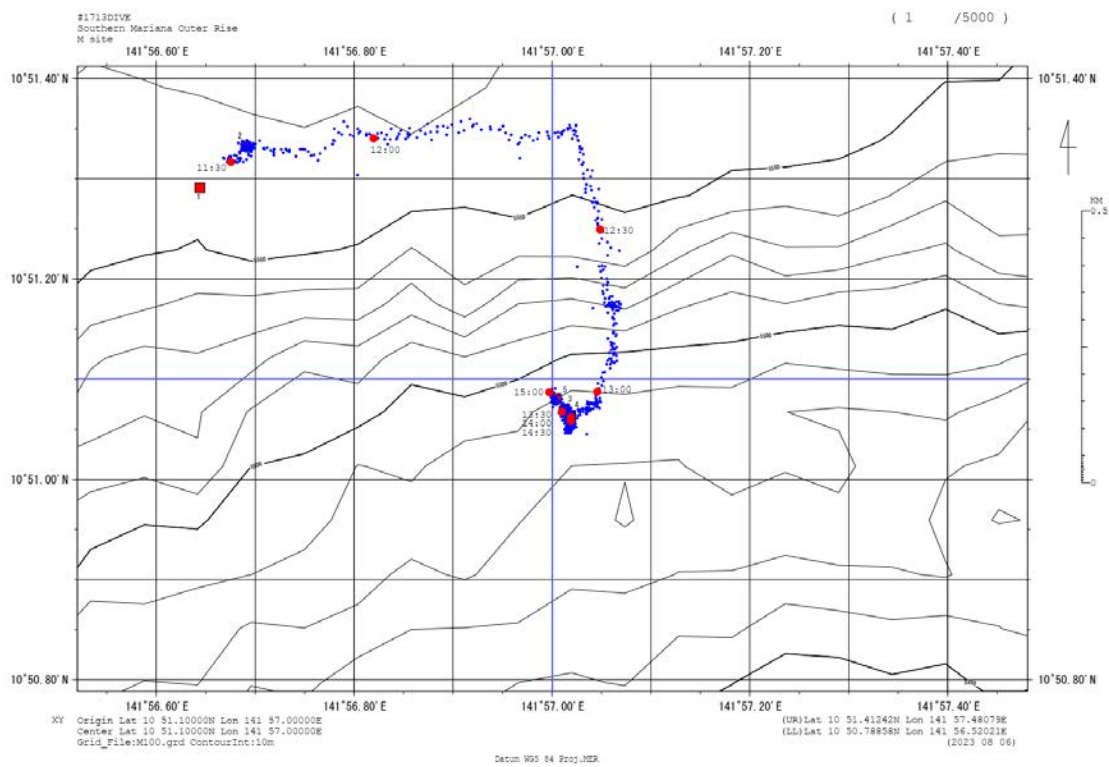
002,20230806,113800,426.97,-564.20,10-51.3316N,141-56.6904E,5543.00,"Landing"

003,20230806,140000,-56.78,23.14,10-51.0692N,141-57.0127E,5472.00,"Sampling Niskin(Green), WHATS(Red), Core"

004,20230806,145400,-67.47,34.08,10-51.0634N,141-57.0187E,5472.00,"Sampling Core(2), Sediments, Set #258Marker"

005,20230806,150300,-36.32,6.74,10-51.0803N,141-57.0037E,5473.00,"Left Bottom"

Dive track of 6K#1713



Dive Report: Shinkai6500#1714

Date: August 7, 2023

Site: Southern Mariana outer rise

Landing: 11:30, 10°50.9106'N, 141°58.0434'E, D=5553m

Leaving: 15:03, 10°51.0748'N, 141°57.7678'E, D=5417m

Observers: Liang Dong (Shanghai Jiao Tong University)

Pilots: Keigo Suzuki, Nanto Minamino

Objectives:

The objectives of *Shinkai6500* Dive # 1714 were to 1) find new Pockmarks around Pockmark M discovered previously by Chinese HOV JiaoLong at the Southern Mariana Outer Rise region, 2) take samples (water, fluids if possible, sediment cores) from the target site, 3) observe and sample (if possible) animals around the site.

Dive summary:

The dive onboard the Shinkai 6500 submersible commenced at 11:38 at the designated dive site. The initial descent revealed a substantial accumulation of sediments at site 1. As the submersible moved towards site 2, a distinct pokmark was encountered around 12:06. Subsequent exploration unveiled yet another significant pokmark, though regrettably, both these two pockmarks were lost. Large amounts of suspected iron and manganese oxides, possibly generated by fluid overflow, have been observed at site 2.

Continuing the expedition, we circled back to the original pokmark initially encountered and conducted a revisitation at 14:18. At this point, our scientific activities included retrieving water samples using the Niskin bottle. Unfortunately, this process led to increased turbidity, making visibility increasingly challenging.

To facilitate future reference and data collection, we established a marker labeled as "#259" and securely positioned it within the vicinity of the dive site. The decision to leave the bottom was made after careful consideration of the conditions and operational requirements.

Overall, the dive yielded valuable insights into the geological and topographical characteristics of the underwater environment. Despite encountering challenges with visibility, the expedition provided essential data for further analysis and research.

Payloads:

- MBARI corers (50 cm x9)
- Suction sampler with a single canister
- D-WHAT water sampler (Green and Red)
- Niskin (2,5L)
- H₂ and H₂S sensors {Multi sensor}
- METS sensor
- Sample box (Black)

Event list:

001,20230807, 000000, -349.12,1901.47, 10-50.9106N, 141-58.0434E, 5553.00," Landing Target"

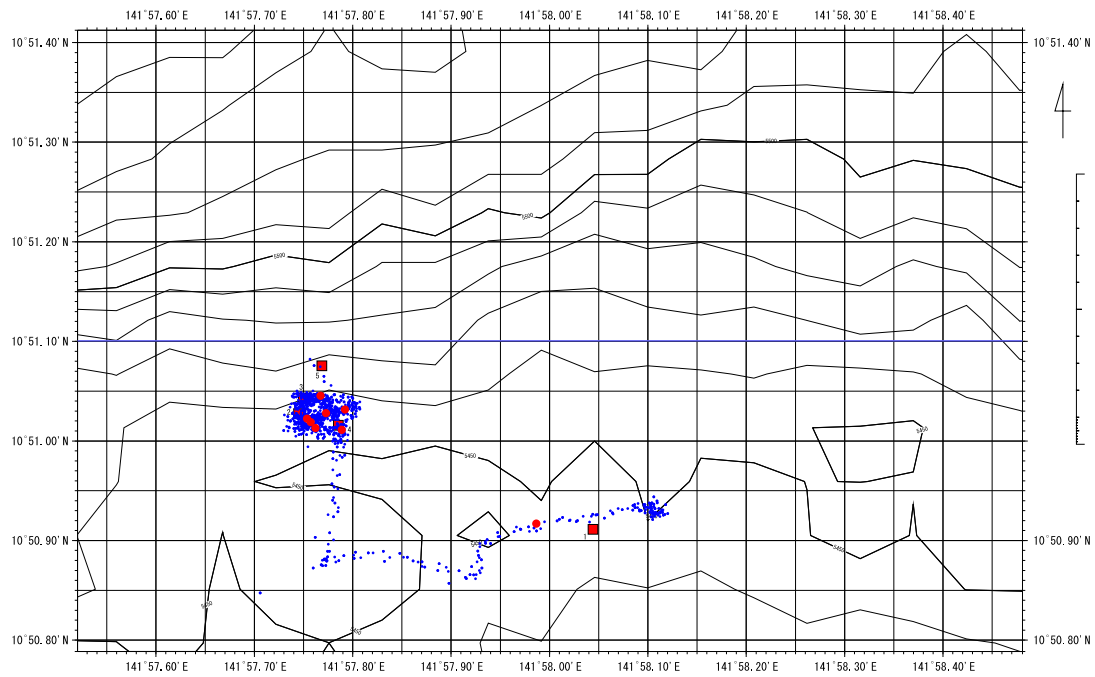
002,20230807, 120600, -134.74,1356.03,10-51.0269N,141-57.7441E,5438.00," Finding Pock Mark"

003, 20230807, 141800, -105.79, 1365.14, 10-51.0426N, 141-57.7491E, 5444.00," Sampling Niskin(Green)"

004, 20230807, 150500, -156.30, 1430.02, 10-51.0152N, 141-57.7847E, 5444.00," Set #259Marker"

005, 20230807, 151200, -46.43,1399.21, 10-51.0748N, 141-57.7678E, 5417.00," Left Bottom Alt=50m"

Dive track of 6K#1714



Dive Report: Shinakai6500#1715

Date: August 8, 2023

Site: M site in the Outer Rise region of Mariana Trench

Landing: 11:29; 10°51.0467'N, 141°57.8165'E, D=5449 m

Leaving: 15:18; 10°50.9885'N, 141°57.6024'E, D=5449 m

Observer: Ken Takai, Junichi Miyazaki (JAMSTEC)

Objectives:

The objectives of this dive were sampling sediments, fluid, animals, and rocks from pockmarks in M site.

Dive summary:

Before landing we started pump flow to measure H_2 , H_2S , and CH_4 .

At 11: xx, we landed on the seafloor covered with sediments. The temperature of ambient seawater at the bottom was 1.4 °C. We immediately moved to 6k marker#259 with very slow speed. We found 6k marker#259 but there is no pockmark, and therefore we passed through. We continued to look for pockmarks with 230° heading. After a while, we found the pockmark which was discovered previous #1714 dive. After landing in front of the pockmark, we also confirmed another pockmark ahead of this pockmark.

We set marker#261 and then sampled water into Niskin (Green). Next we inserted the long nozzle pipe into the #261 pockmark. Since full length of the long nozzle did not reach to the bottom of the #261 pockmark, it was estimated that the depth of the #261 pockmark was more than 2 m. Then, we sampled water via the long nozzle into D-WHATS (Red). During the water sampling, the change of neither temperature nor Methane concentration was observed. When 1000 mL of water was sampled, we finished water sampling. Finally, we carried out sediment sampling using 4 sets of MBARI (No. 1, 3, 4, 5) from the rim of pockmark vertically. After sampling sediments, we headed to another pockmark and moved ahead.

This pockmark was existed adjacent to cliff, and it seems that the depth was relatively shallow. We landed on the pockmark as front half of submersible was just above the pockmark. We sampled water into Niskin bottle (Blue). Next, we inserted the long nozzle pipe into the pockmark. Since half of length of the nozzle pipe was reached to the bottom, it was the depth of pockmark was estimated that the depth of the pockmark was less than 1 m. Then, we sampled water via the long nozzle into D-WHATS (Green). During the water sampling, the change of neither temperature nor Methane concentration was observed. When 1000 mL of water was sampled, we finished water sampling. Finally, we carried out sediment sampling using 4 sets of MBARI (No. 2, 6, 8, 9) from the cliff of pockmark horizontally. After sampling sediments, we found rocks at the side of the pockmark. We pick up several pieces of rock into black box. Then, we

headed to east with keeping the depth of 5440 m at which these pockmarks existed.

After moving about 20 m, we found 4 small and shallow pockmarks. In one of these, the specific features (Marimo-like structures) were observed. But when we found the structures, the submersible had already passed through the pockmark. Therefore we gave up sampling the structures and we tried to other pockmarks (but we could not find the structures). We continued to head east with keeping the depth of 5440 m at which these pockmarks existed.

After moving about 30 m, we found orange colored chimney structures. On the chimney, tubeworm-like animals and microbial mats were existed. We tried to sample by manipulator but failed. Therefore we sampled the structures by suction sampler and Kumade sampler.

After sampling we headed to the east with keeping the depth of 5440 m. But the landing time had come. We left the bottom at 15:18.

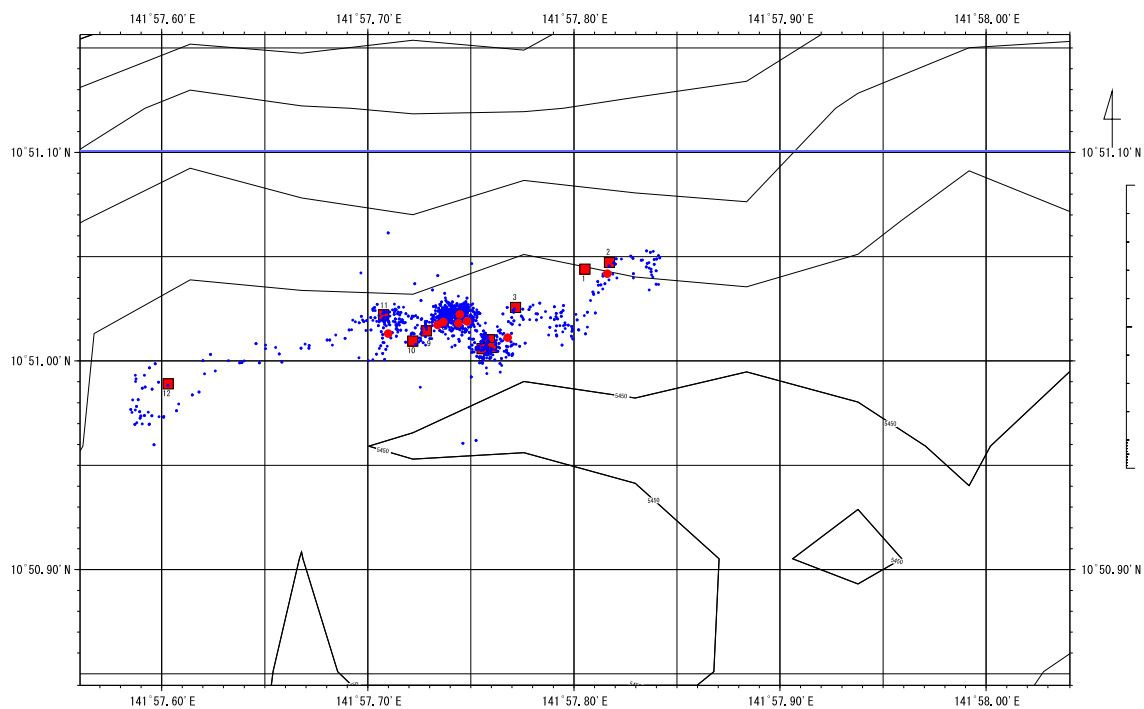
Payloads:

- D-WHATS
- Suction sampler with single canister
- DO meter
- Temperature sensor
- 2 m Long nozzle pipe
- H₂ and H₂S sensors {Multi sensor}
- METS methane sensor
- Sample box (2, Black and Chibax2 box)
- Kumade sampler
- 6k markers (#260, #261)
- MBARI sampler [9]

Event list:

11:29	10°51.0467'N, 141°57.8165'E, D=5449m	Landing
11:45	10°51.0251'N, 141°57.7709'E, D=5449m	Finding 6k#259 marker
12:03	10°51.0096'N, 141°57.7583'E, D=5445m	Finding Pockmark
12:05	10°51.0054'N, 141°57.7547'E, D=5445m	Set #261Marker
12:07	10°51.0060'N, 141°57.7594'E, D=5444m	Sampling Niskin (Green)
13:14	10°51.0223'N, 141°57.7438'E, D=5446m	Sampling D-WHATS (Red), 4xMBARI
14:14	10°51.0202'N, 141°57.7368'E, D=5447m	Sampling Niskin (Blue), D-WHATS (Green), 4xMBARI,
Rocks		
14:20	10°51.0139'N, 141°57.7276'E, D=5441m	Finding Pockmark
14:27	10°51.0091'N, 141°57.7221'E, D=5441m	Finding Pockmark
14:55	10°51.0216'N, 141°57.7070'E, D=5440m	Sampling chimney structure
15:18	10°50.9885'N, 141°57.6024'E, D=5449 m	Left Bottom

Dive track of 6K#1715



● Notice on Using

This cruise report is a preliminary documentation as of the end of cruise.

This report is not necessarily corrected even if there is any inaccurate description (i.e. taxonomic classifications).

This report is subject to be revised without notice. Some data on this report may be raw or unprocessed. If you are going to use or refer the data on this report, it is recommended to ask the Chief Scientist for latest status.

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E-mail: submit-rv-cruise@jamstec.go.jp