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R/V Shinsei Maru Cruise Report

KS-21-20

Unraveling an abnormal gold enrichment mechanism at the Higashi-Aogashima Knoll Caldera hydrothermal filed

30th Aug. 2021 – 8th Sep. 2021

Joint Usage/Research Center for Atmosphere and Ocean Science (JURCAOS)
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Contents

1. Cruise Information

● Cruise ID: KS-21-20

● Name of vessel: R/V Shinsei Maru

● Title of the cruise: Unraveling an abnormal gold enrichment mechanism at the Higashi-Aogashima Knoll Caldera hydrothermal filed

● Title of proposal: (S21-8) Unraveling an abnormal gold enrichment mechanism at the Higashi-Aogashima Knoll Caldera hydrothermal filed

● Cruise period: 30th August 2021 to 8th September 2021

● Ports of departure and arrival: Yokosuka HQ to Kochi

● Research area: Higashi-Aogashima Knoll Caldera in the Izu-Ogasawara area

● Research Map:

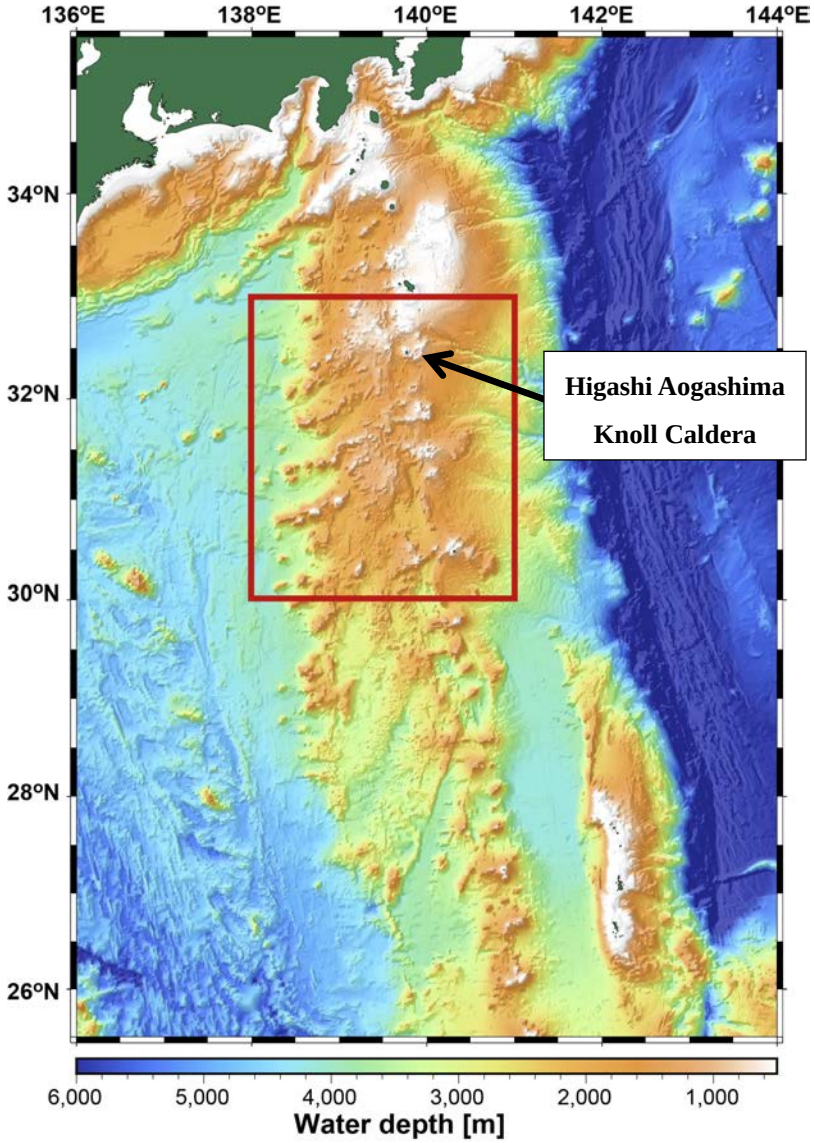

Fig. 1-1 Investigation area map of the cruise KS-21-20.

2. Researchers and Crews

● Chief scientist

Tatsuo Nozaki (JAMSTEC)

● Representative of the scientific party

Tatsuo Nozaki (JAMSTEC)

● Scientific party

Junji Torimoto	(JAMSTEC)
Man-Yin Tsang	(Kobe Univ.)
Jun-ichiro Ishibashi	(Kobe Univ.)
Pierre, E. B.-H. Methou	(JAMSTEC)
Satoshi Wakai	(JAMSTEC)
Kazuya Kitada	(JAMSTEC)

● Shinsei Maru Crew Members:

Captain	Yoshiyuki Nakamura
Chief Officer	Yuki Furukawa
2nd Officer	Keisuke Kusumi
3rd Officer	Kota Mori
Chief Engineer	Shinichi Ikuta
1st Engineer	Kenta Ikeguchi
2nd Engineer	Takaatsu Inomoto
3rd Engineer	Yoichi Yasue
Chief Electronic Op.	Yosuke Komaki
2nd Electronic Op.	Ryosuke Matsui
3rd Electronic Op.	Kohei Ikeda
Boat Swain	Hiroaki Nagai
Quarter Master	Satoshi Shimpo
Quarter Master	Toshiya Saga
Sailor	Masashi Ando
Sailor	Takumi Miura
Sailor	Taisei Matsuda
Sailor	Shin Ito
No.1 Oiler	Junji Mori
Oiler	Katsuyuki Miyazaki

Oiler	Makoto Kozaki
Assistant Oiler	Keishiro Kai
Assistant Oiler	Yutaro Ono
Chief Steward	Kiyotaka Kosuji
Steward	Hiroyuki Ohba
Steward	Toshiyuki Takama
Marine Technician	Taro Shirai

● Hyper-Dolphin Operation Team

Submersible Op. Manager	Teppei Kido
2nd Submersible Tec. Officer	Atsushi Takenouchi
2nd Submersible Tec. Officer	Yudai Tayama
2nd Submersible Tec. Officer	Yudai Sakakibara
2nd Submersible Tec. Officer	Taiken Yamaguchi
3rd Submersible Tec. Officer	Wataru Asano

3. Observation

3.1 Objectives & Background

Higashi Aogashima Knoll Caldera (hereafter called HAKC) hydrothermal filed is a relatively new one discovered in 2015 by the research group of The University of Tokyo (The University of Tokyo, 2015, 2016; Japan Oil, Gas and Metals National Corporation (JOGMEC), 2018). There have been known three hydrothermal sites within the HAKC hydrothermal filed; (1) Central Cone Site, (2) Southeast Site and (3) East Site (Katase et al., 2016; Iizasa et al., 2019). Out of these three hydrothermal sites, an abnormal gold enrichment (average Au concentration = 102 ppm, n =15) was observed only at the Central Cone Site (Iizasa et al., 2019). In particular, the gold concentration of the mound samples at the Central Cone Site is abnormally high, up to 275 ppm (Iizasa et al., 2019). The abnormal gold enrichment at the Central Cone Site is considered to be closely associated with the boiling process of hydrothermal fluid and its concomitant transportation of nano Au particles from the subseafloor (Iizasa et al., 2019). However, researches on the HAKC hydrothermal filed are at a beginning stage and only basic petrographic observations about chimney and mound rock samples and a bathymetric map by multibeam echosounder (MBES) were reported so far.

The cruise KS-21-20 by R/V Shinsei Maru with remotely operated vehicle (ROV) Hyper Dolphin (HPD) is the first multi-disciplinary research cruise from the aspect of economic geology, (fluid) geochemistry, geochronology, macro-/micro-biology and geophysics. Our purpose is to obtain the samples of rock, seawater, hydrothermal fluid, benthic animals and microorganisms as well as geophysical data such as bathymetry, gravity and magnetic intensity to unravel the reason/cause/phenomenon of abnormal gold enrichment in a multi-disciplinary manner at the HAKC hydrothermal field.

References

Iizasa, K., Asada, A., Mizuno, K., Katase, F., Lee, S., Kojima, M. and Ogawa, N. (2019) Native gold and gold-rich sulfide deposits in a submarine basaltic caldera, Higashi-Aogashima hydrothermal field, Izu-Ogasawara frontal arc, Japan. *Mineralium Deposita*, **54**, 117–132.

Japan Oil, Gas and Metals National Corporation (JOGMEC) (2018) Verification of the occurrence of new seafloor hydrothermal deposit at the Aogashima Island offshore, Izu-Ogasawara area. News Release on 27th December 2018.

Iizasa, K., Mizuno, K., Asada, A., Matsuda, T. and Saito, Y. (2016) Seafloor hydrothermal deposits exploration by bathymetry and backscattering data using multibeam echo-sounder in the Higashi-Aogashima Caldera. *The Journal of the Marine Acoustics Society of Japan*, **43**, 208–218.

The University of Tokyo (2015) Discovery of the seafloor hydrothermal deposit at the eastern offshore of Aogashima Island, Izu area; Development of a tool that can discover seafloor

hydrothermal deposit in a short span of time. Press Release on 7th August 2015.

The University of Tokyo (2016) Accomplishment of the practical and highest accurate exploration tool during the exploration at seafloor hydrothermal deposit in Higashi Aogashima Caldera, Izu Islands. Press Release on 2nd June 2016.

3.2 Dive Information & Preliminary Results

3.2.1 Dive HPD#2132 (31st August 2021 at the Central Cone Site, Higashi-Aogashima Knoll Caldera)

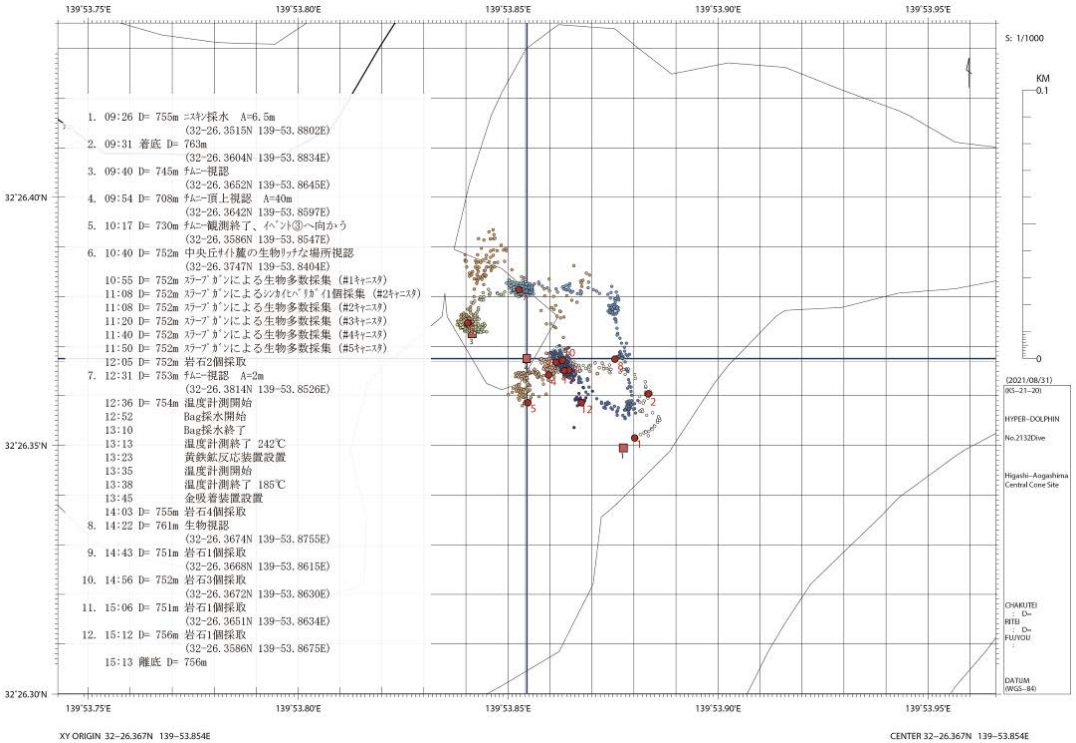

Fig. 3-1 Dive track and operation list of the dive HPD#2132 on a bathymetric map.

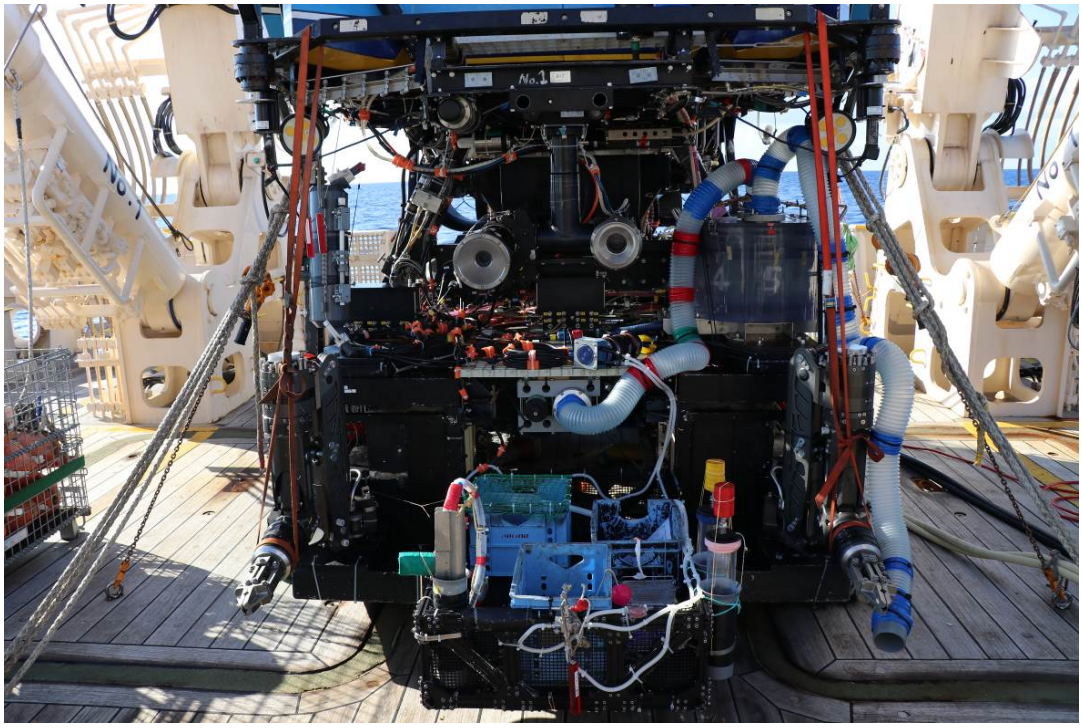

Fig. 3-2 Payload of the dive HPD#2132 in the sample basket.

Payload:

Thermometer x 1, Bag water sampler x 1, Niskin water sampler x1, Slurp gun x 1, 7 multiple canister x 1, MBARI corer x 2, Gold adsorption apparatus x 1, Pyrite reaction apparatus x1, Three component small magnetometer x 1.

Operation:

Before approaching the seafloor, seawater was sampled (HPD#2132N) by the Niskin water sampler at ca. 10 m above the seafloor. After seawater sampling, HPD went to the largest mound and chimney structure at the dead center of the Central Cone Site (Fig. 3-3). We observed the southern side of this mound and chimney structure as well as the top part of the large chimney with ca. 40 m high. Then, we tried to measure the temperature of hydrothermal fluid discharging from this large chimney. However, it was impossible to approach this chimney because the side of the chimney that HPD facing was too steep. HPD then went to ca. 30 m WNW from the dead center of the Central Cone Site, where a biological colony, hydrothermal shimmering and bubbling was observed (Fig. 3-4) during the cruise KM17-13C by R/V Kaimei and KM-ROV in 2017. We collected biological samples by slurp gun into the five canister bottles (HPD#2132-BC1 to BC5) as well as two rock samples (HPD#2132R01 and R02) by manipulator. Then, HPD moved to ca. 15 m NE from this biological colony and a small chimney/mound of 2 m high with hydrothermal fluid effluence was observed. After breaking down the chimney, hydrothermal fluid was sampled by bag water sampler (HPD#2132B). The maximum temperature of the hydrothermal fluid was measured to be 242.3 ^{o}C (Fig. 3-5). The pyrite reaction apparatus was installed at exact position where hydrothermal fluid was sampled (Fig. 3-6). Another chimney was broken down by manipulator and the temperature of hydrothermal fluid was measured (T_{max} = 188.5 ^{o}C), followed by installation of the gold adsorption apparatus (Fig. 3-7) and four rock sampling (HPD#2132R03 to R06). Finally, HPD moved to the ESE and S side of the dead center of the Central Cone site with six rock sampling (HPD#2132R07 to R12) and this dive survey was finished. During this final rock sampling, deep-sea sediment sampling by MBARI corer was also conducted, but no samples were obtained due to the sandy property around the Central Cone Site (Fig. 3-8).

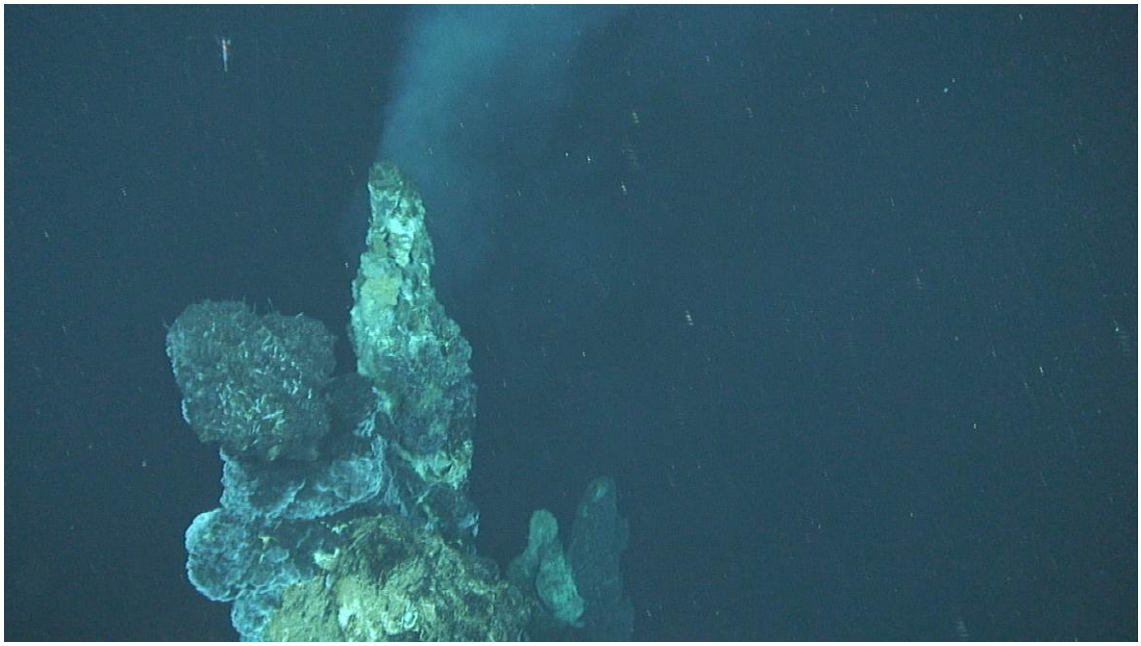

Fig. 3-3 Top of the large chimney (ca. 40 m high) at the Central Cone Site.

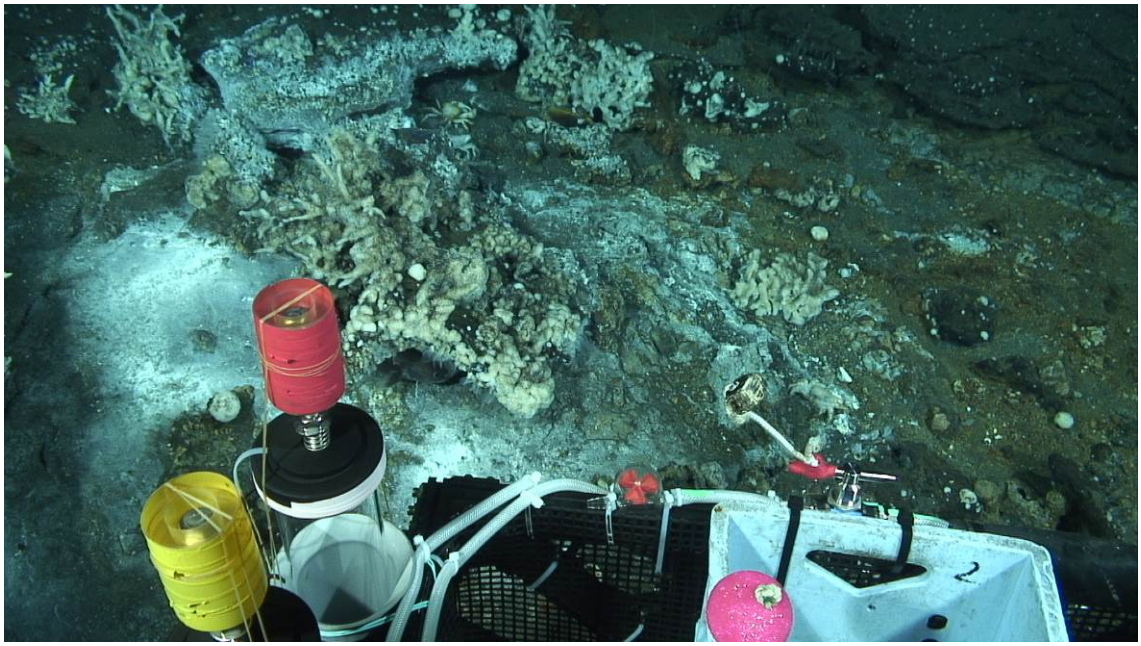

Fig. 3-4 Biological colony with hydrothermal shimmering/bubbling at 30 m WNW from the dead center of the Central Cone Site.

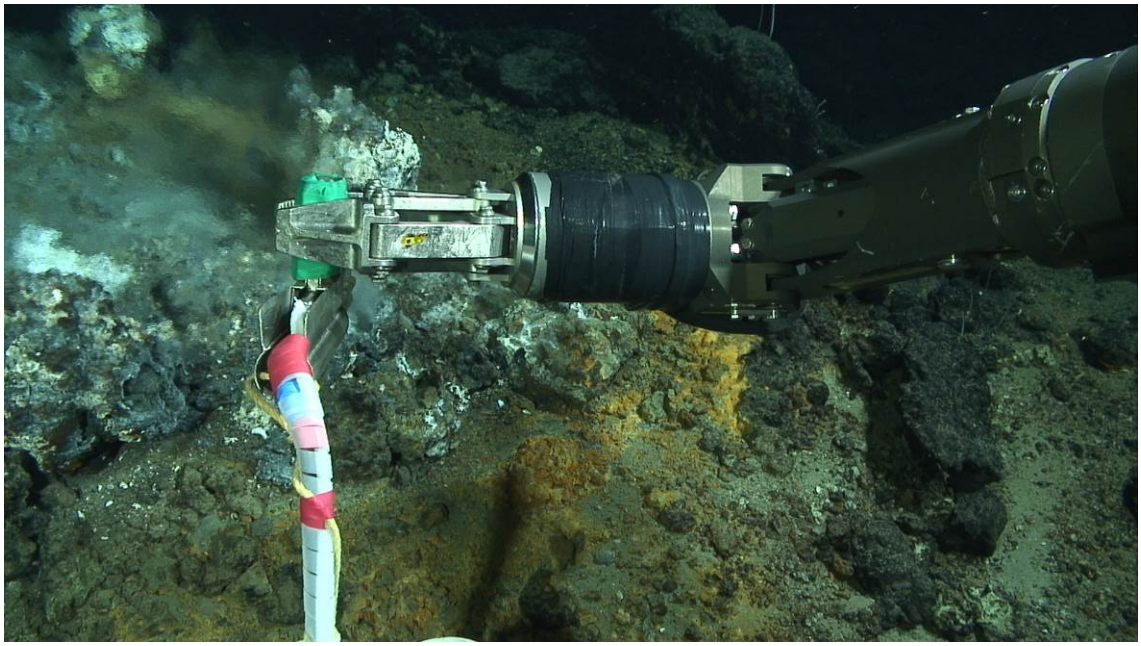

Fig. 3-5 Temperature measurement and fluid sampling at the active chimney ca. 15 m NE from the biological colony.

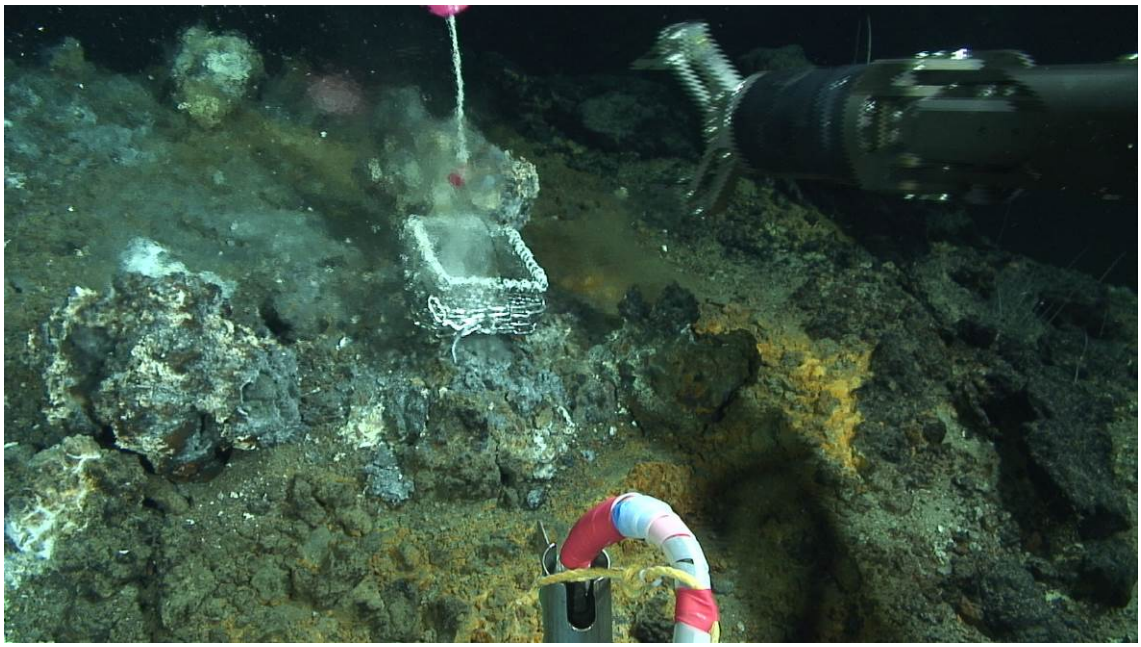

Fig. 3-6 Installation of the pyrite reaction apparatus on the exact same vent where fluid was sampled.

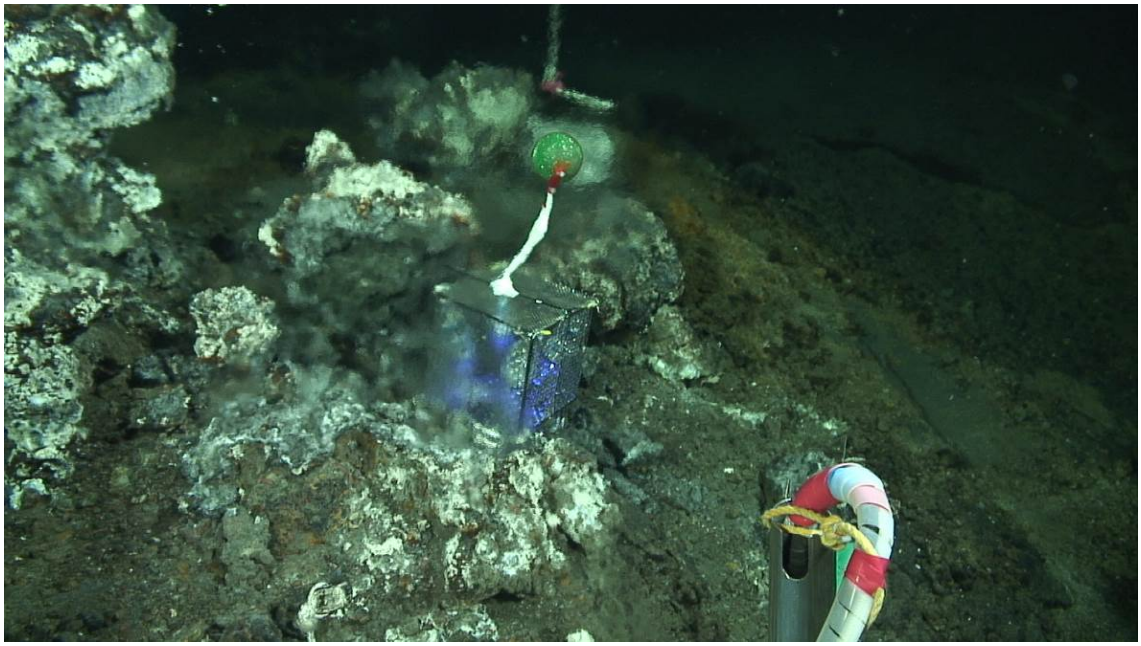

Fig. 3-7 Installation of the gold adsorption apparatus on the active hydrothermal vent.

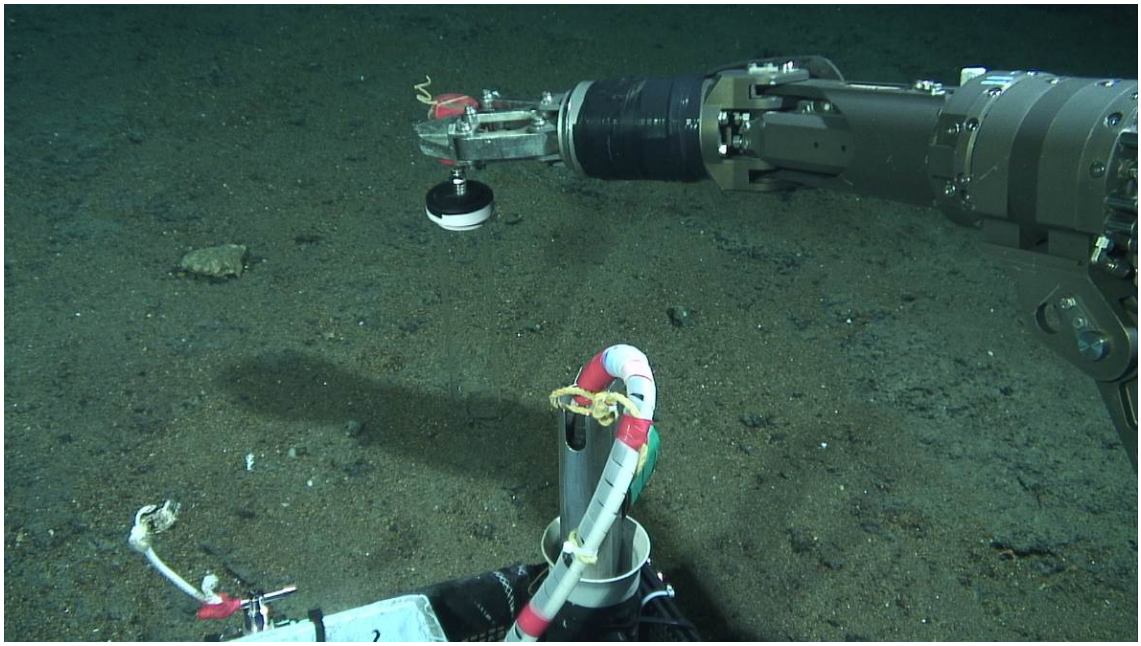

Fig. 3-8 Trial of the deep-sea sediment sampling by MBARI corer. No sediment sample was obtained due to its sandy property of the seafloor.

3.2.2 Dive HPD#2133 (1st September 2021 at the Southeast Site, Higashi-Aogashima Knoll Caldera)

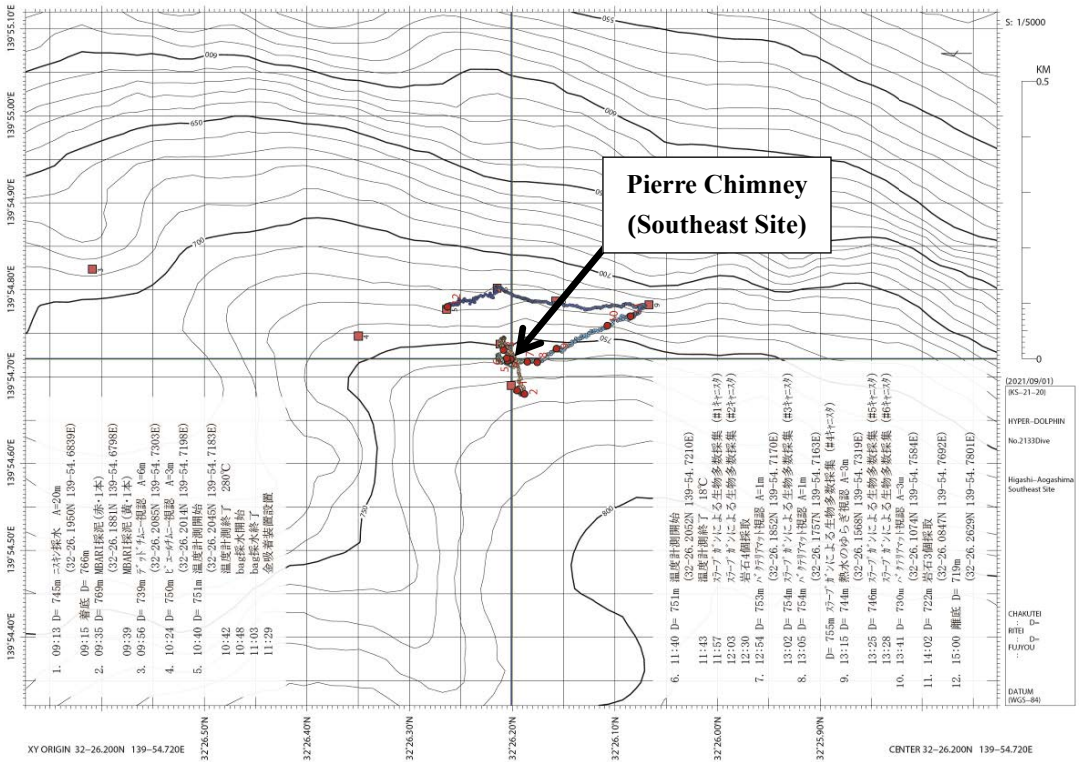

Fig. 3-8 Dive track and operation list of the dive HPD#2133 on a bathymetric map.

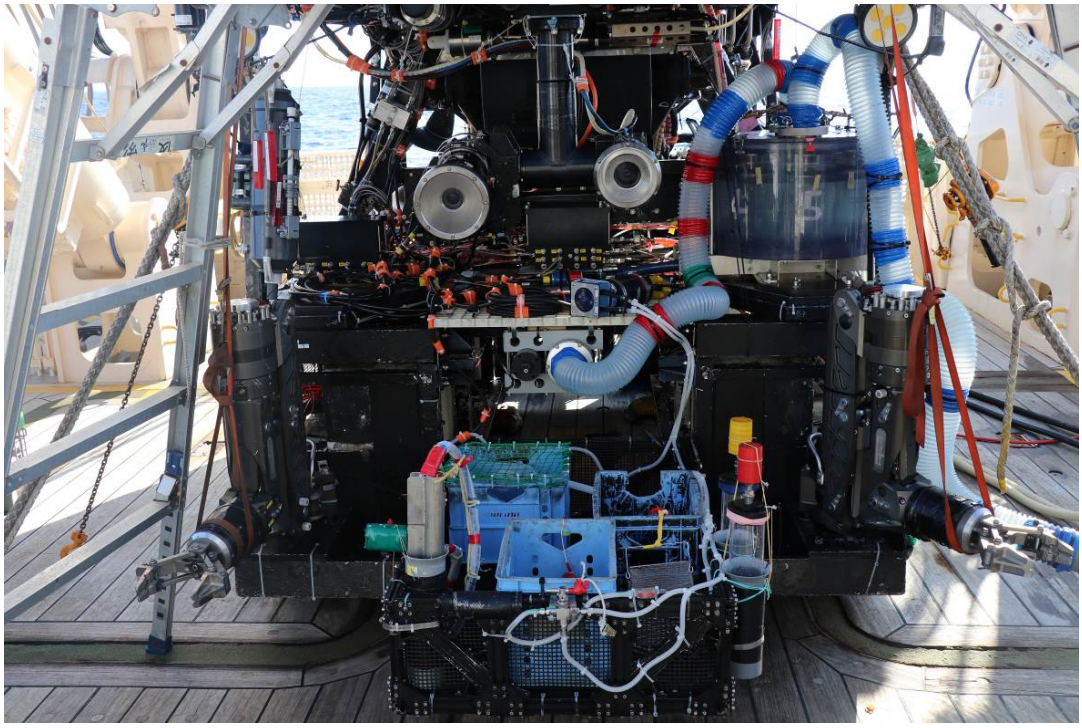

Fig. 3-9 Payload of the dive HPD#2133 in the sample basket.

Payload:

Thermometer x 1, Bag water sampler x 1, Niskin water sampler x1, Slurp gun x 1, 7 multiple canister x 1, MBARI corer x 2, Gold adsorption apparatus x 1, Pyrite reaction apparatus x 1, Three component small magnetometer x 1.

Operation:

Before approaching the seafloor, seawater was sampled (HPD#2133N) by the Niskin water sampler at ca. 20 m above the seafloor. Then, HPD approached the seafloor ca. 70 m west from the Southeast Site and conducted deep-sea sediment sampling by two MBARI corers (Fig. 3-10) (HPD#2133MR and MY). After sediment sampling, HPD moved to the eastward to find the exact place of the Southeast Site. Dead and active (Pierre) chimneys were found (Figs. 3-11 and 3-12) and, at first, the temperature of hydrothermal fluid was measured (T_{max} = 280.4 ºC) (Fig. 3-13), followed by hydrothermal-fluid sampling with a bag water sampler (HPD#2133B) and installation of the gold adsorption apparatus at the exact same vent where fluid sampling took place (Fig. 3-14). Benthic animals were also sampled by the slurp gun into two canister bottles (HPD#2133-BC1 and BC-2). Four rock samples were collected with the manipulator (HPD#2133R01 to R04). Then, HPD went to the topographically unique points of nos. 9, 8, 6 and 5 in turn determined by the detailed bathymetric data obtained by AUV Urashima during the cruise YK21-10 in June 2021. Between the Pierre chimney and unique point no. 9, there are several white/orange bacterial mats and biological colony (Figs. 3-15 and 3-16) where benthic animals were sampled into four canister bottles (HPD#2133-BC3 to BC6). Topographical unique points of nos. 9, 8, 6 and 5 were all inactive small mound (ca. 10 m high) and this mound seemed to be composed of altered volcanic rock (Fig. 3-17). Three altered volcanic rocks were sampled at the unique point no. 9. Topographically unique points (nos. 3 and 4) could not be observed because the planned dive operation time was finished at the unique point no. 5. During this dive survey, the pyrite reaction apparatus could not be installed.

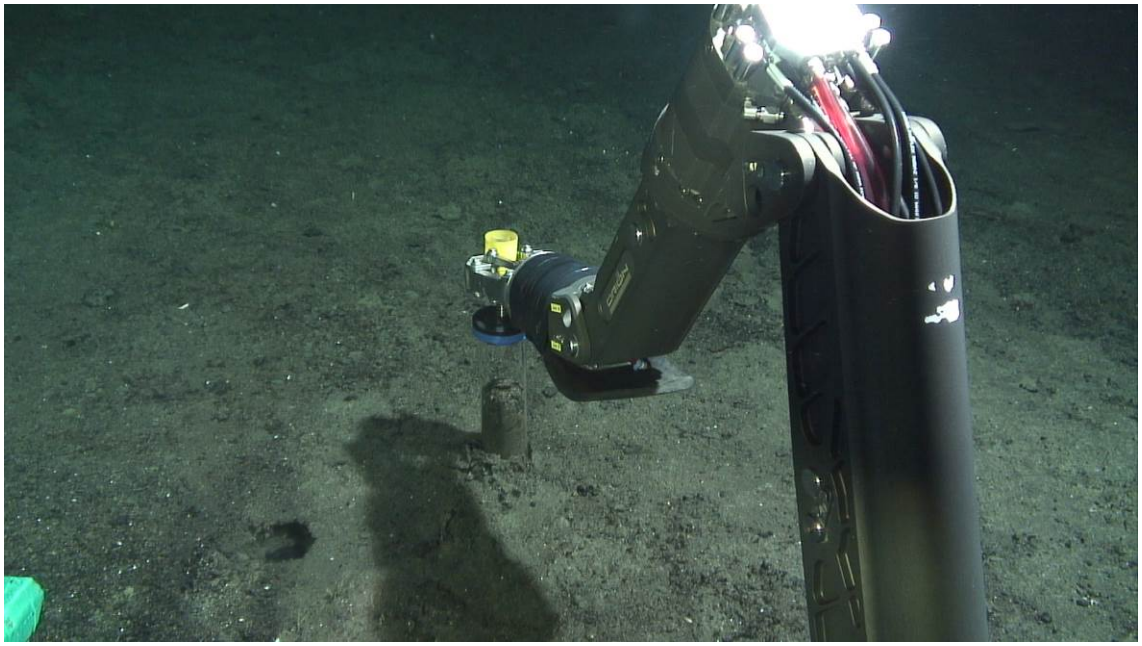

Fig. 3-10 Deep-sea sediment sampling by MBARI cores at the westside of the Southeast Site.

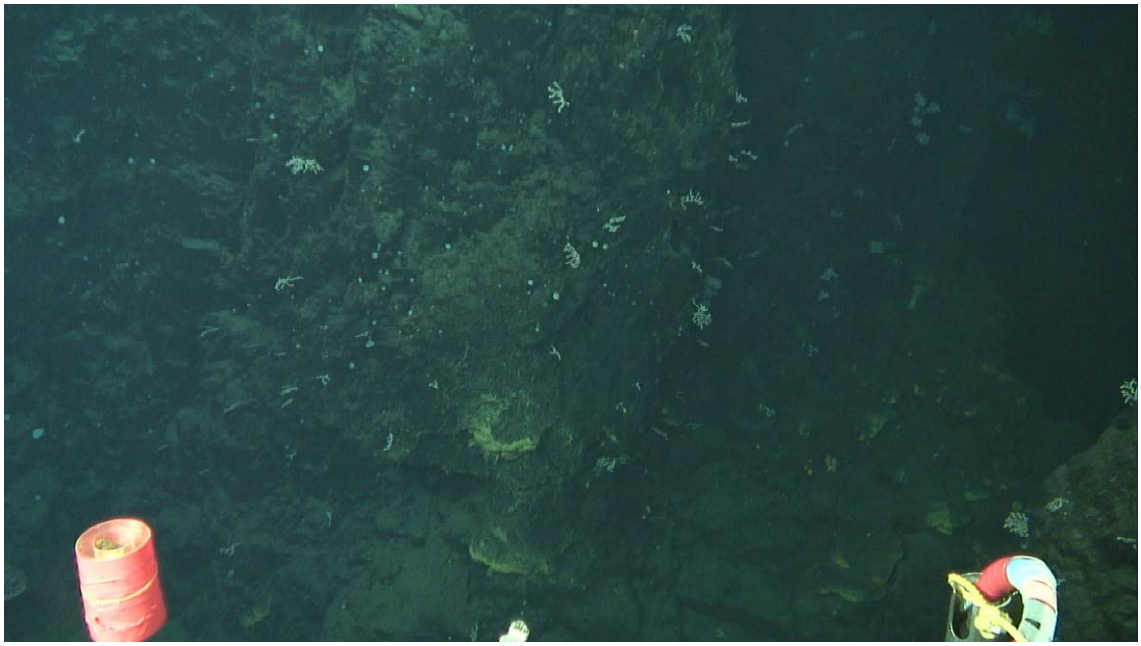

Fig. 3-11 Dead chimney cluster at the Southeast Site.

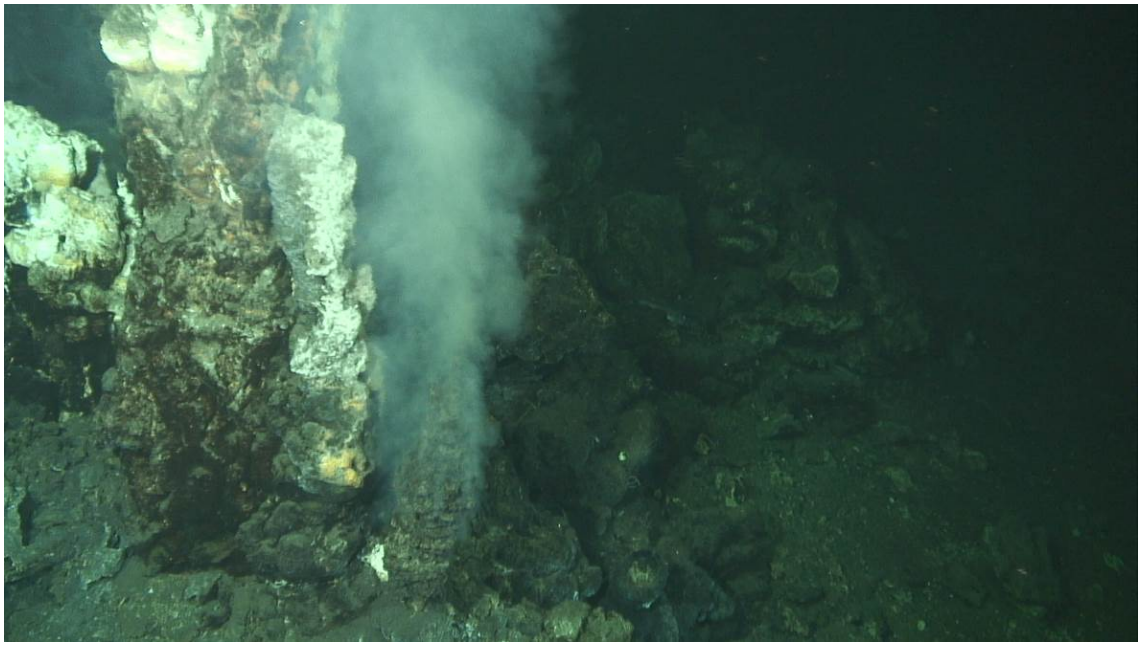

Fig. 3-12 Active (Pierre) chimney at the Southeast Site.

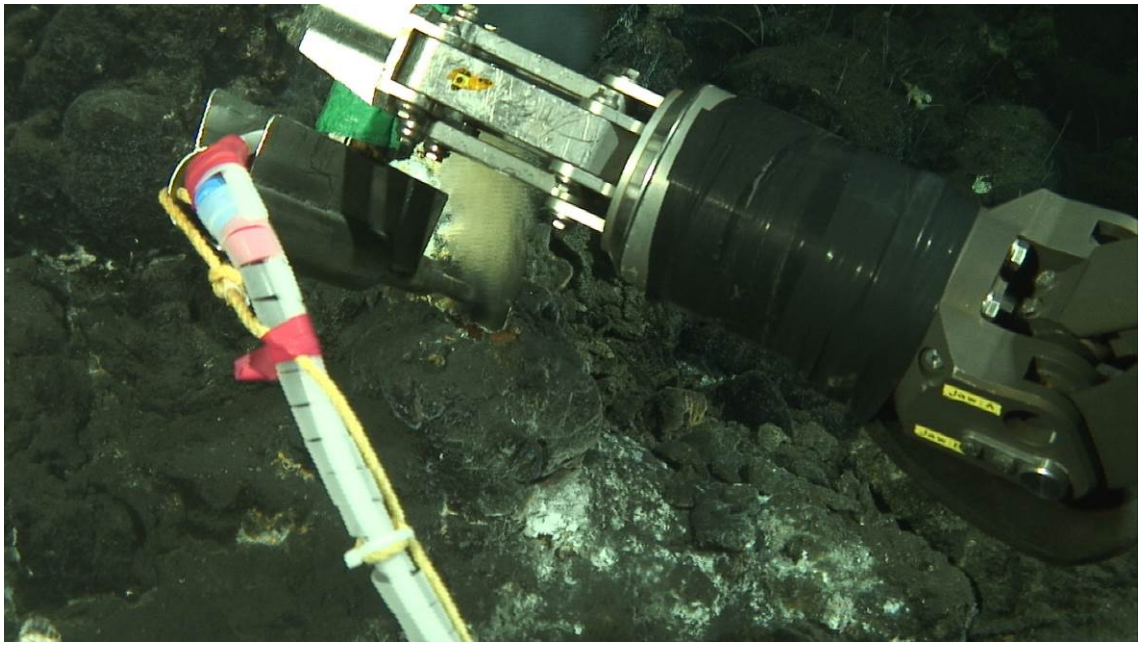

Fig. 3-13 Temperature measurement and fluid sampling at the active (Pierre) chimney at the Southeast Site.

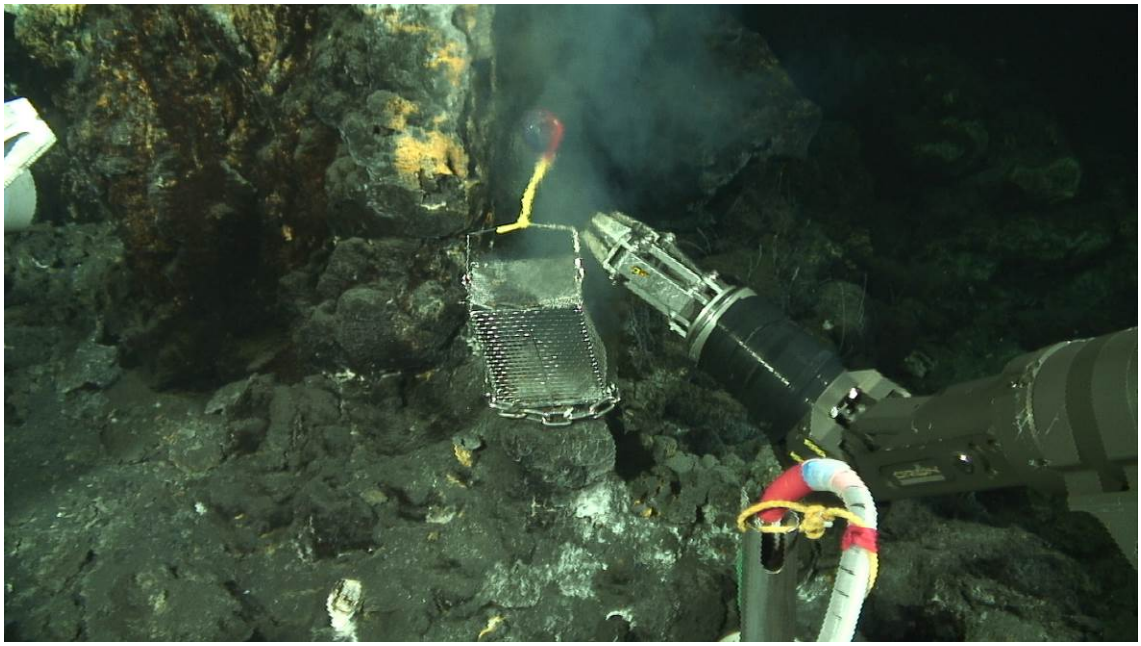

Fig. 3-14 Installation of the gold adsorption apparatus on the active hydrothermal vent (Pierre chimney).

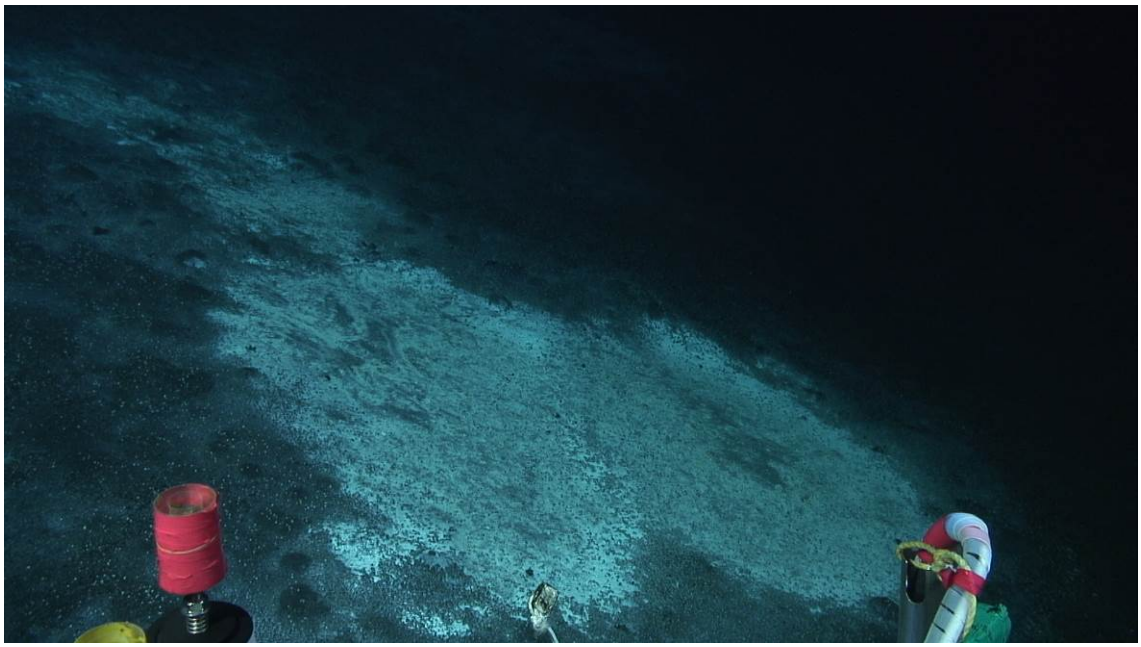

Fig. 3-15 White bacterial mat between the topographically unique points of nos. 7 and 9.

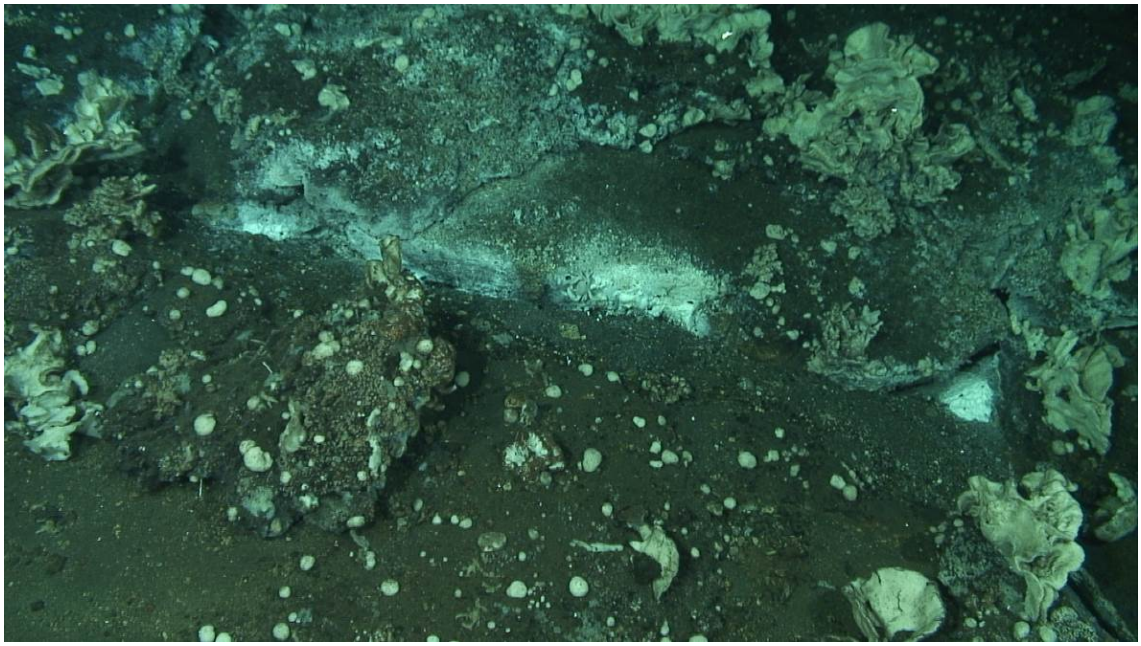

Fig. 3-16 Biological colony with hydrothermal shimmering between the topographically unique points of nos. 7 and 9.

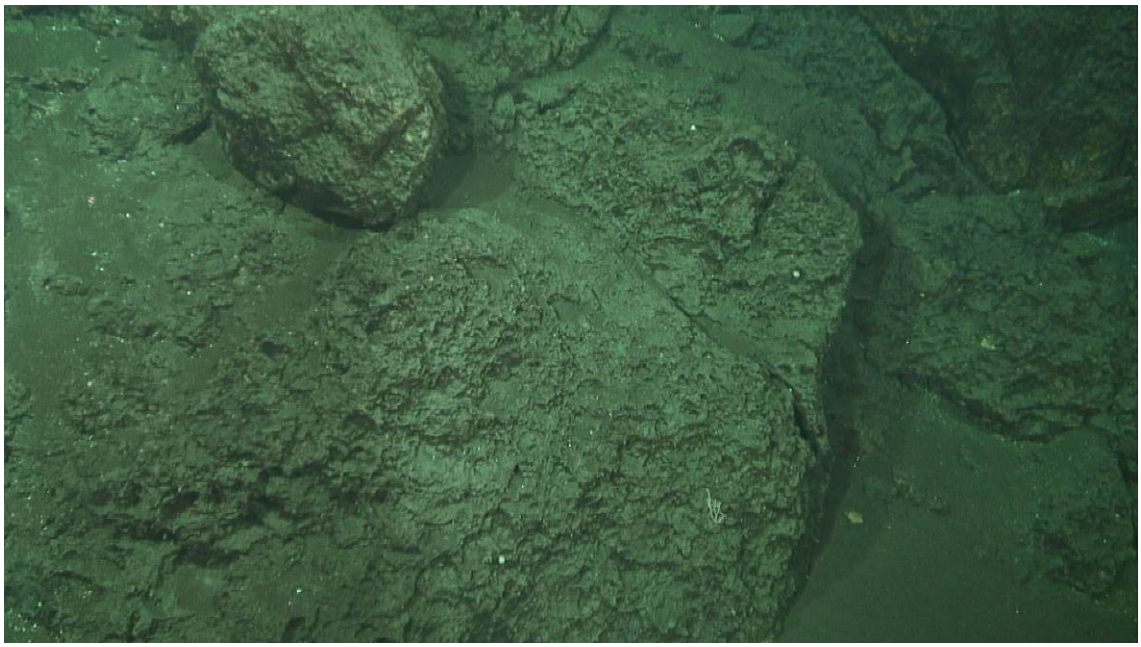

Fig. 3-17 Outcrop of the altered volcanic rock at the small mound of topographically unique point of no. 9.

3.2.3 Dive HPD#2134 (2nd September 2021 at the East Site, Higashi-Aogashima Knoll Caldera)

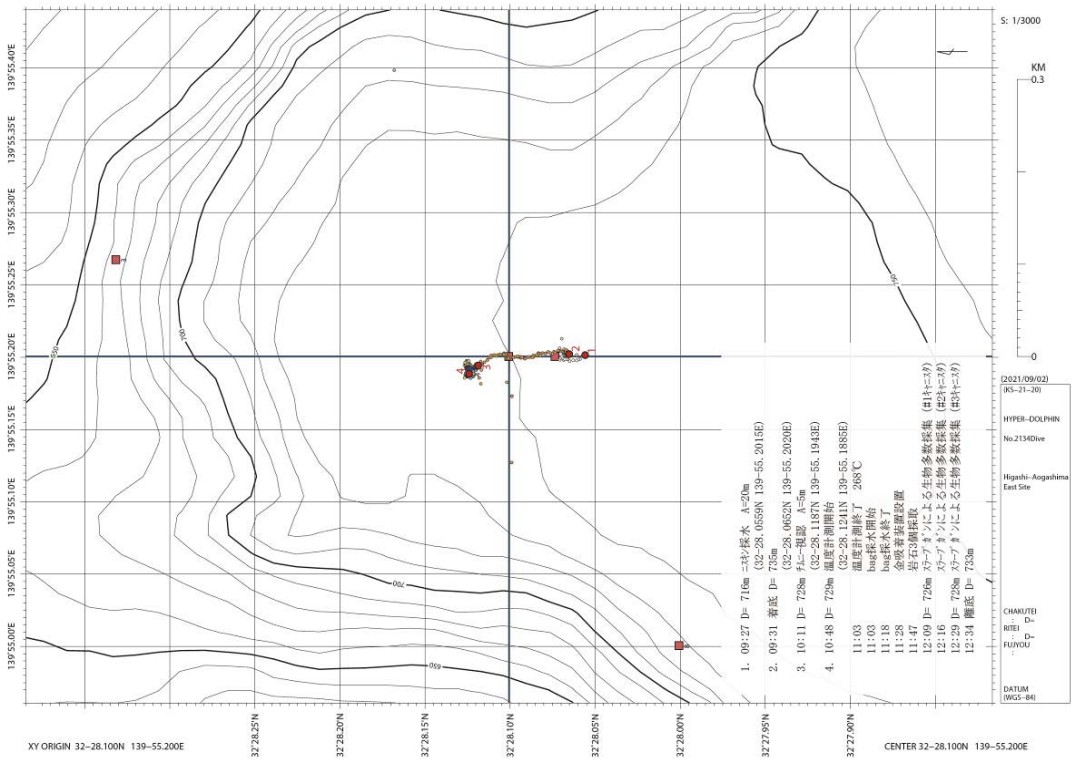

Fig. 3-18 Dive track and operation list of the dive HPD#2134 on a bathymetric map.

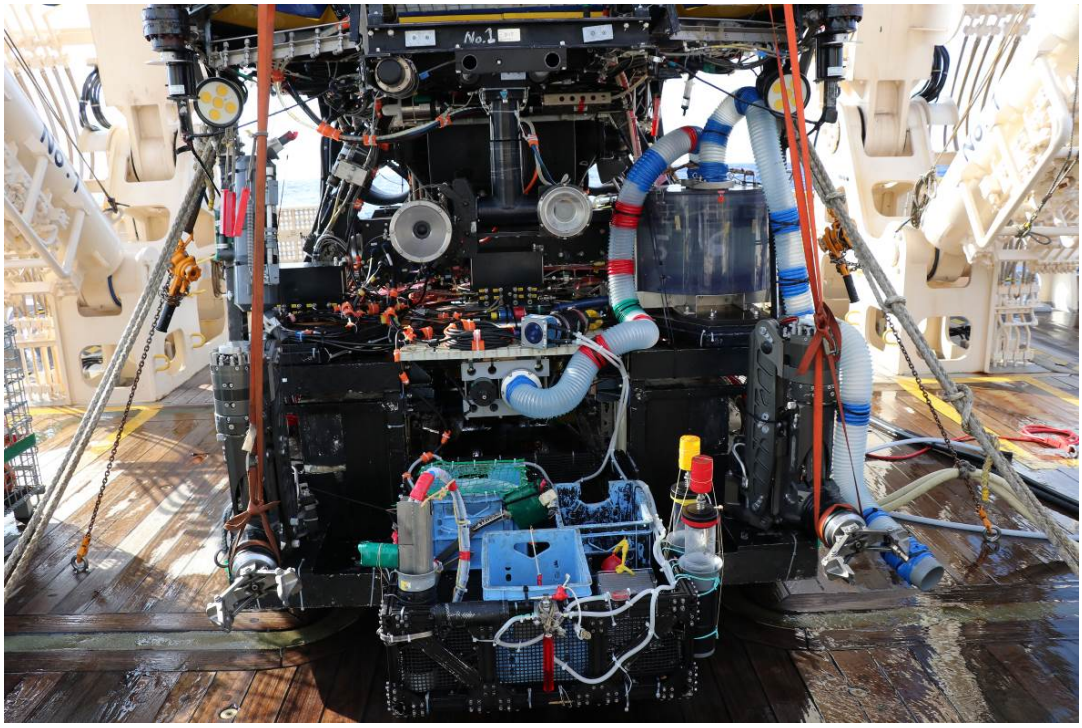

Fig. 3-19 Payload of the dive HPD#2134 in the sample basket.

Payload:

Thermometer x 1, Bag water sampler x 1, Niskin water sampler x1, Slurp gun x 1, 7 multiple canister x 1, MBARI corer x 2, Gold adsorption apparatus x 1, Pyrite reaction apparatus x 1, Three component small magnetometer x 1.

Operation:

Before approaching the seafloor, seawater was sampled (HPD#2134N) by the Niskin water sampler at ca. 20 m above the seafloor. Then, HPD approached the seafloor ca. 120 m south from the East Site and conducted deep-sea sediment sampling by MBARI corers (Fig. 3-20). However, we could not successfully obtain sediment sample due to the sandy property of the sediment. After the operation of sediment sampling, HPD moved northward to find the exact position of the East Site. Topographically unique point no. 4 determined by the detailed bathymetric map obtained by AUV Urashima during the cruise YK21-10 corresponds to the exact position of the East Site. We found the active chimney cluster at the East Site (Figs. 3-21 and 3-22) and, at first, started to measure the temperature of hydrothermal fluid (T_{max} = 271.6 ºC) (Fig. 3-23), followed by hydrothermal fluid sampling with a bag water sampler (HPD#2134B) (Fig. 3-24), installation of the gold adsorption apparatus at the exact position for fluid sampling (Fig. 3-25), three rock-sampling operations (HPD#2134R01 to R03) and benthic animal sampling with the slurp gun into three canister bottles (HPD#2134-BC1 to BC3). Based on the weather forecast, the sea state will be rough in the afternoon and this dive survey was finished at 12:30 (JST; Japan Standard Time), about 2.5 hours earlier than planned. During this dive survey, the pyrite reaction apparatus could not be installed.

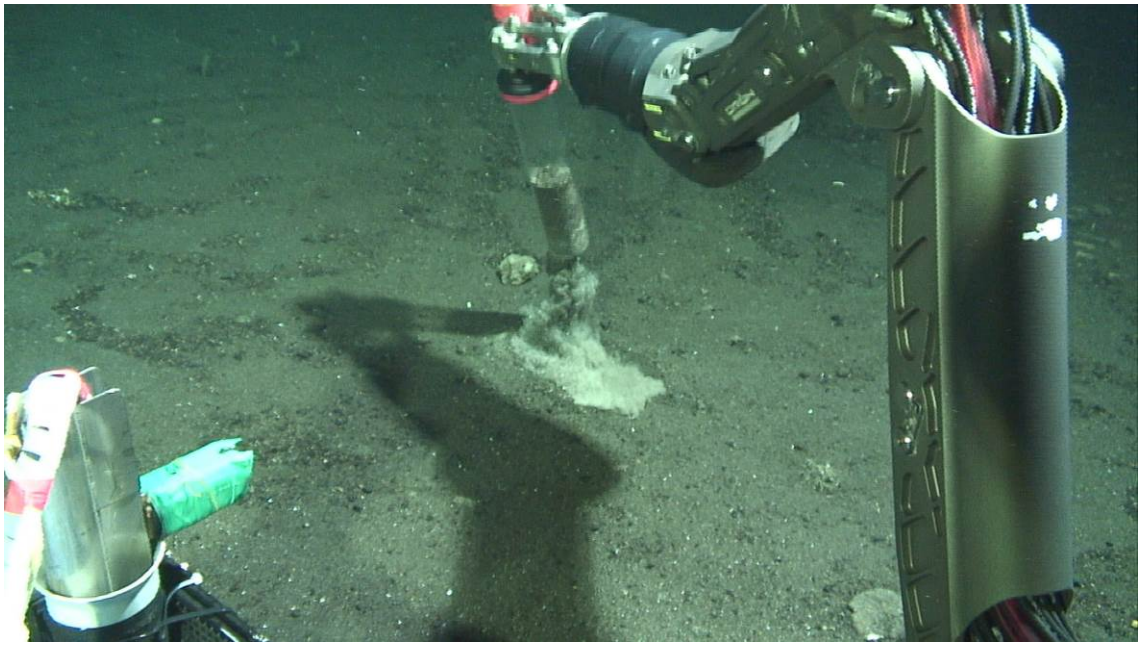

Fig. 3-20 Deep-sea sediment sampling by MBARI corer at the southside of the East Site. All sediments fell out due to its sandy property.

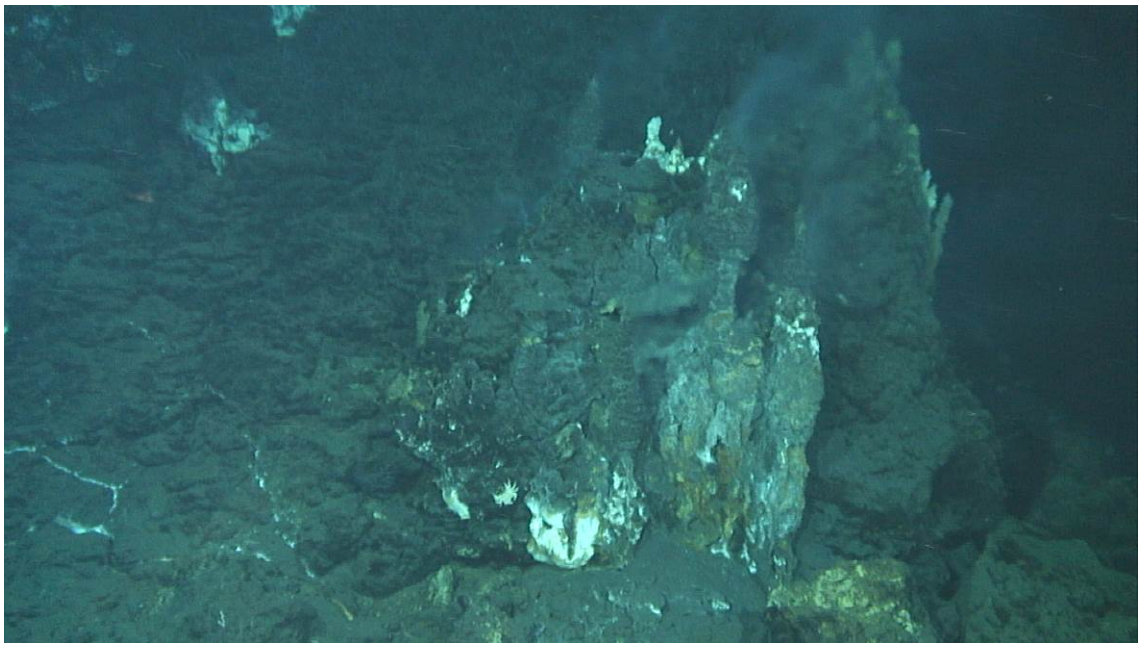

Fig. 3-21 Active chimney cluster at the southern flank of the East Site.

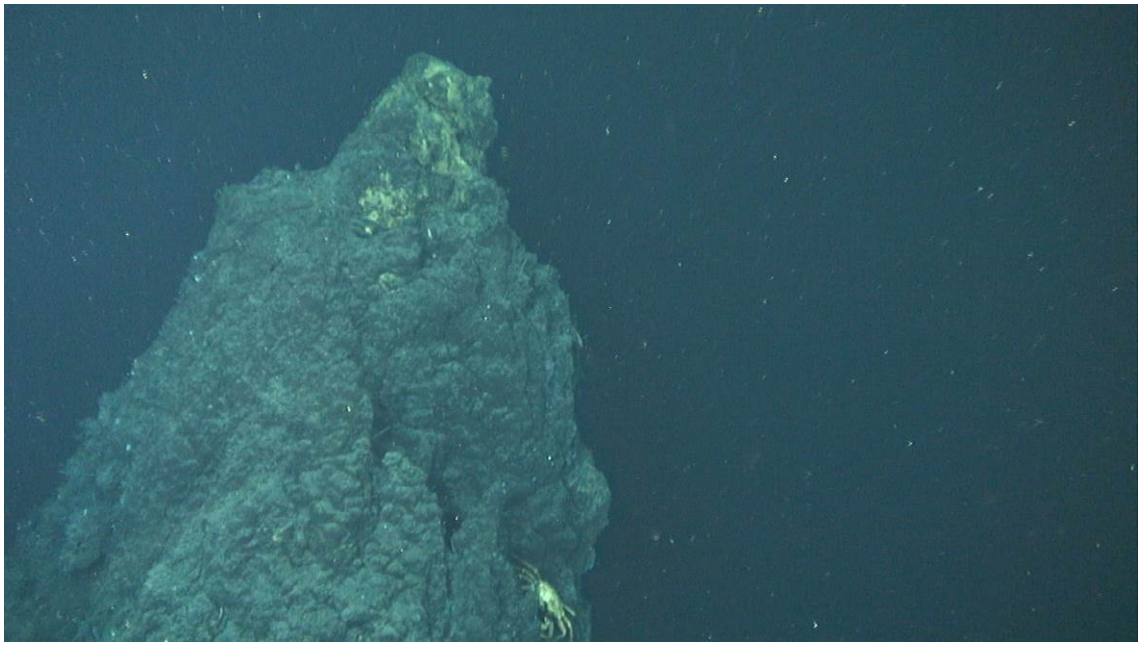

Fig. 3-22 Summit of the chimney and mound structure at the East Site.

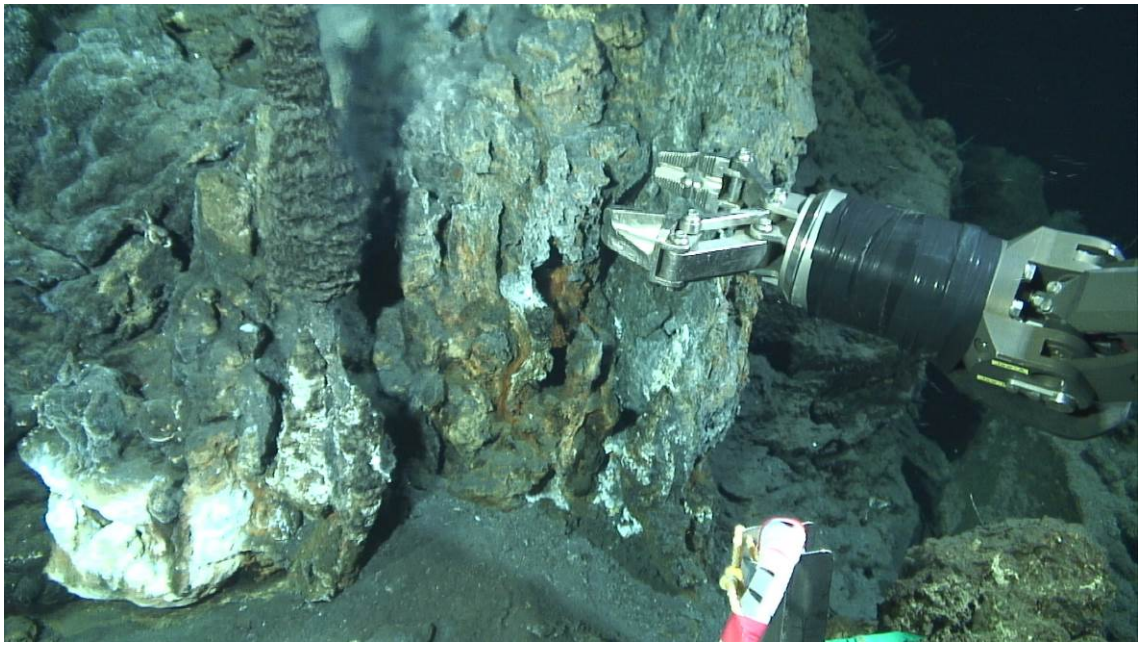

Fig. 3-23 Active chimney that was broken by the manipulator for hydrothermal fluid sampling.

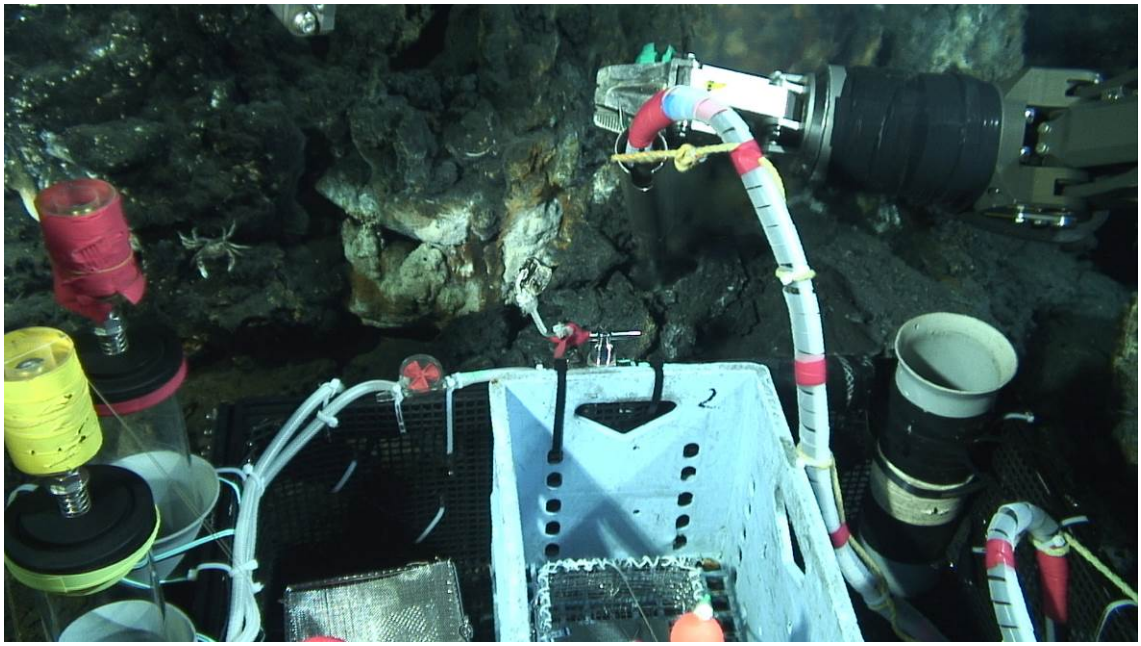

Fig. 3-24 Temperature measurement and fluid sampling at the active chimney at the East Site.

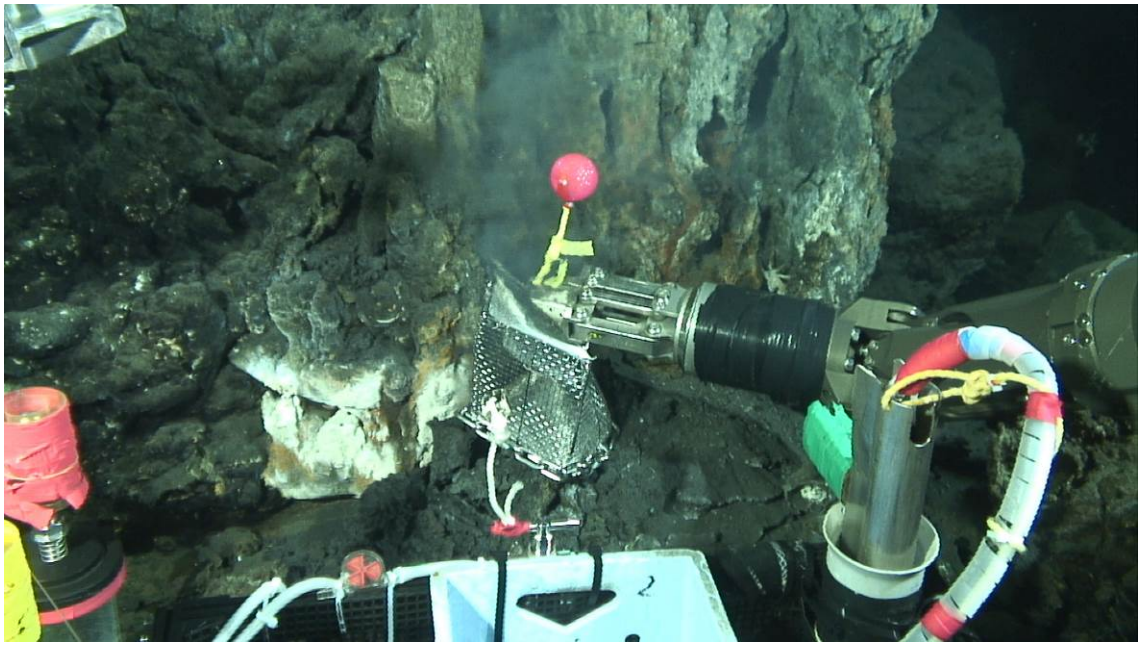

Fig. 3-25 Installation of the gold adsorption apparatus on the active hydrothermal vent.

3.2.4 Dive HPD#2135 (4th September 2021 at the Central Cone Site, Higashi-Aogashima Knoll Caldera)

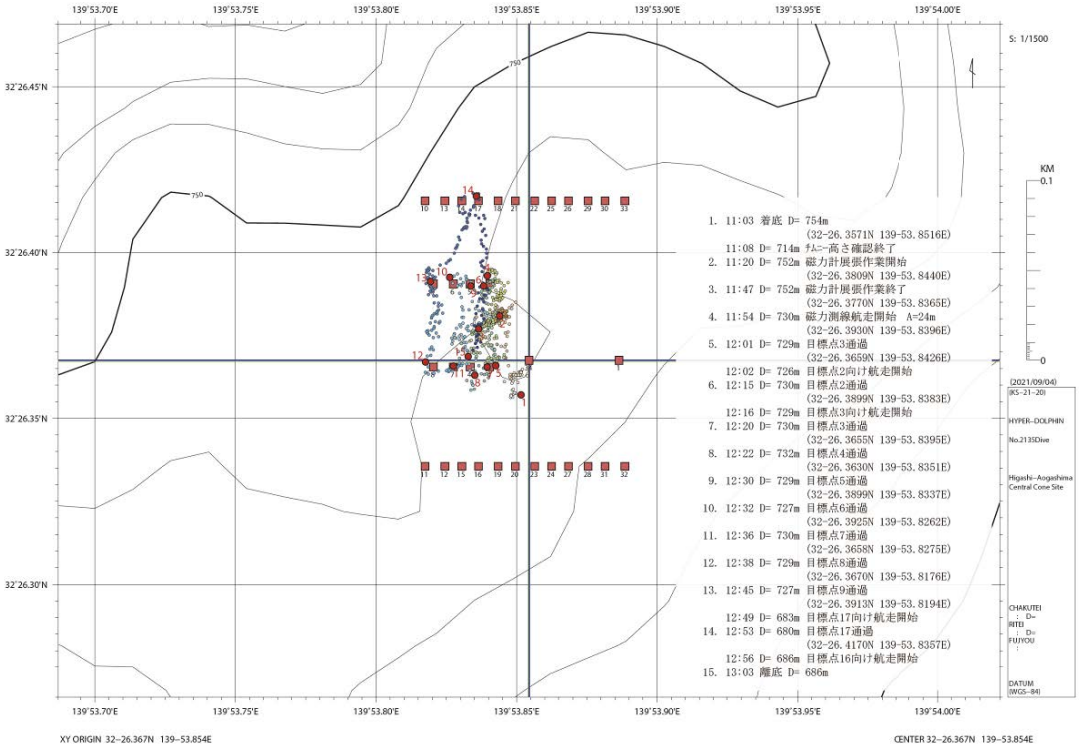

Fig. 3-26 Dive track and operation list of the dive HPD#2135 on a bathymetric map.

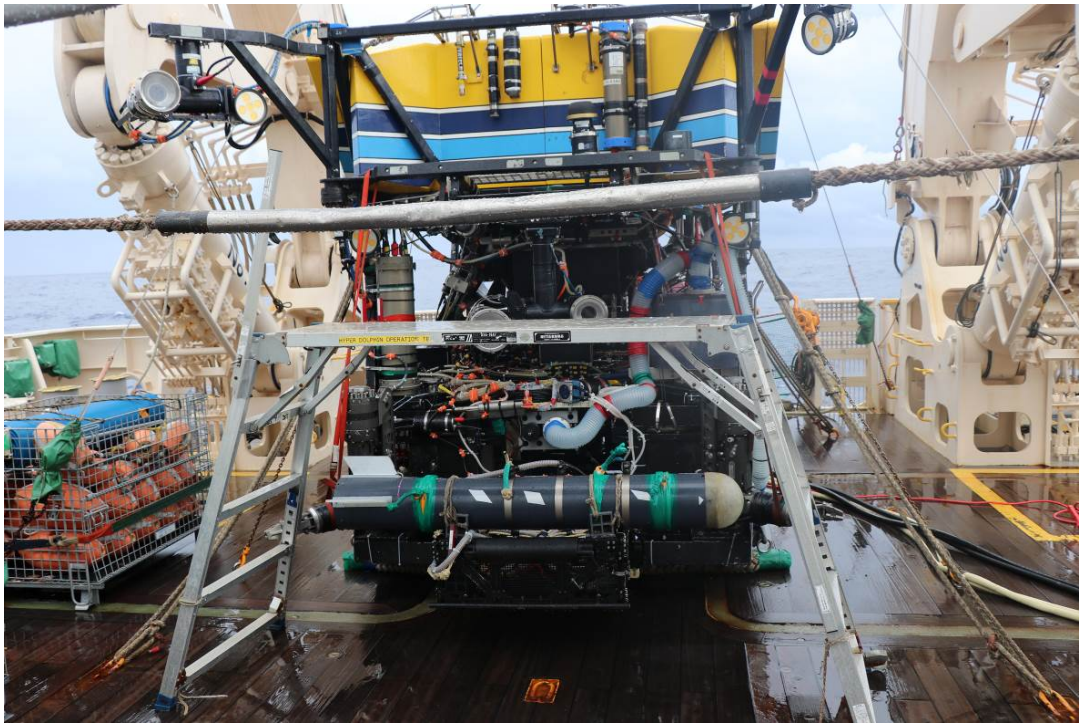

Fig. 3-27 Payload of the dive HPD#2135 in the sample basket.

Payload:

Three component small magnetometer x 1, Towing magnetometer x 1.

Operation:

HPD went to the largest chimney of the Central Cone Site to check the exact height and water depth of the uppermost part of the largest chimney (40 m high and 710 m water depth, respectively) (Fig. 3-28). Then, HPD approached the seafloor to release the towing magnetometer from the sample basket (Fig. 3-29). After releasing the towing magnetometer, HPD started the grid survey to conduct the high-resolution magnetic exploration. When HPD finished the survey of the fourth measurement line, oil leakage was observed from HPD and this dive was urgently finished at ca. 13:00 (JST).

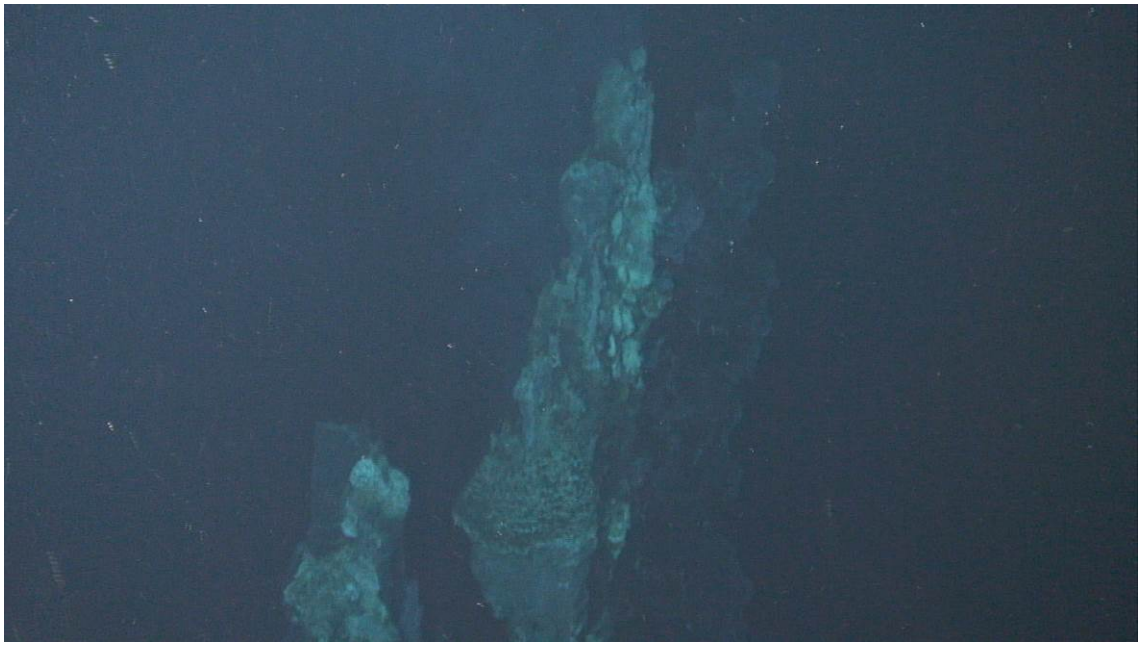

Fig. 3-28 Uppermost part of the largest chimney structure at the Central Cone Site.

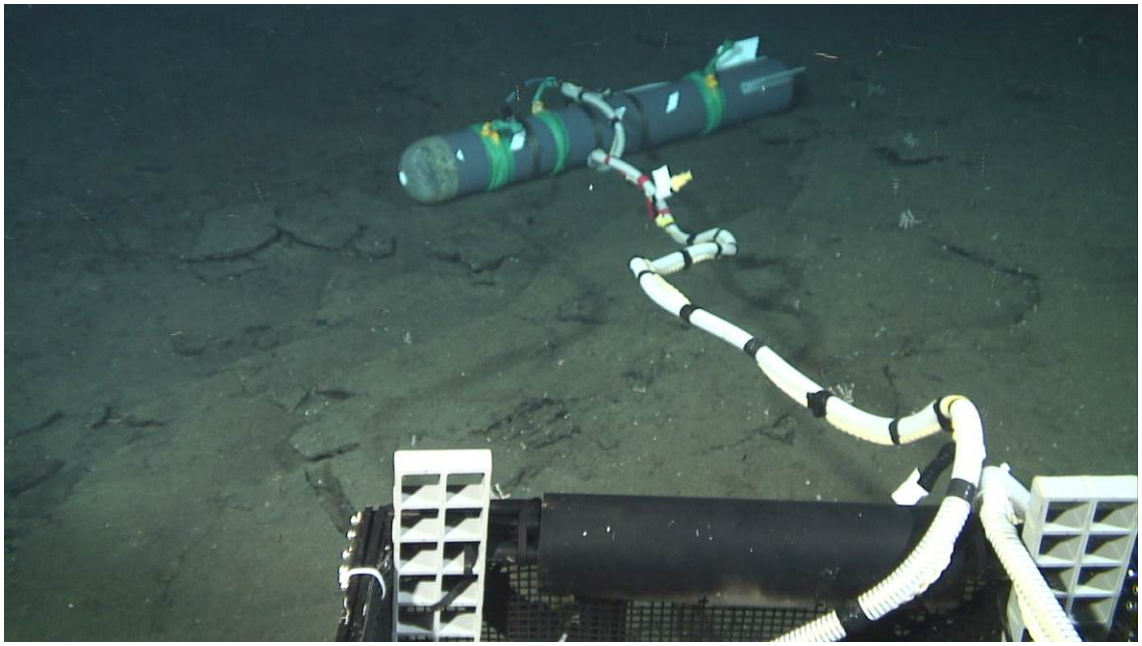

Fig. 3-29 Releasing the towing magnetometer from the sample basket of HPD.

3.2.5 Dive HPD#2136 (5th September 2021 at the Central Cone Site, Higashi-Aogashima Knoll Caldera)

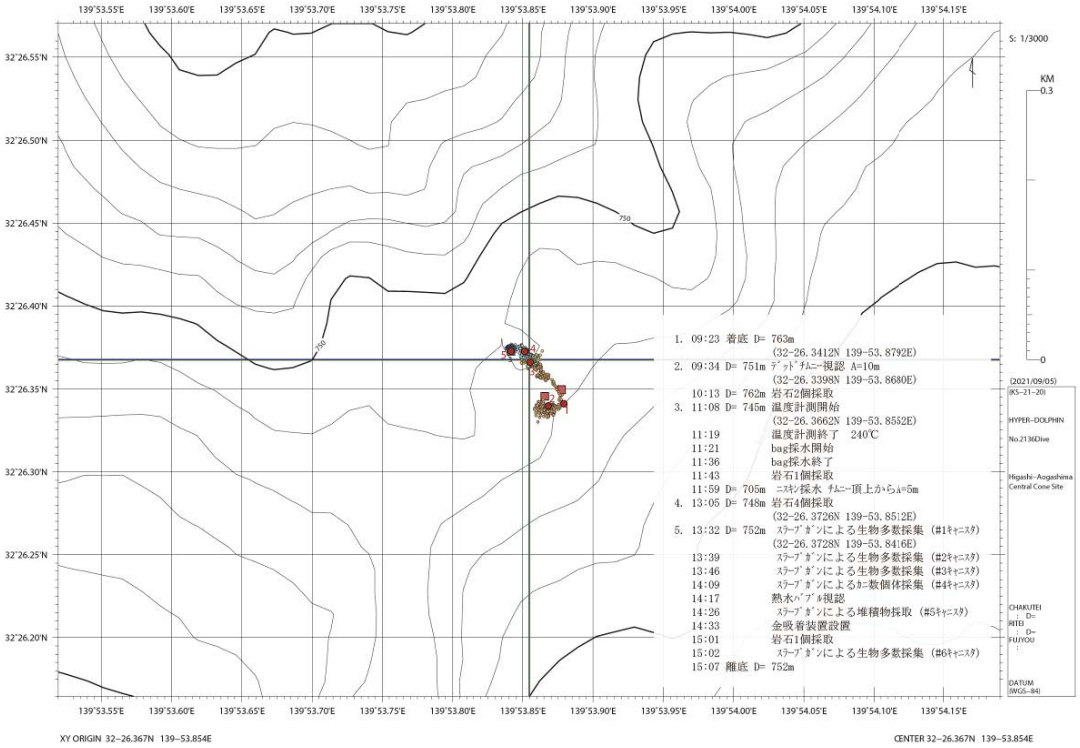

Fig. 3-30 Dive track and operation list of the dive HPD#2136 on a bathymetric map.

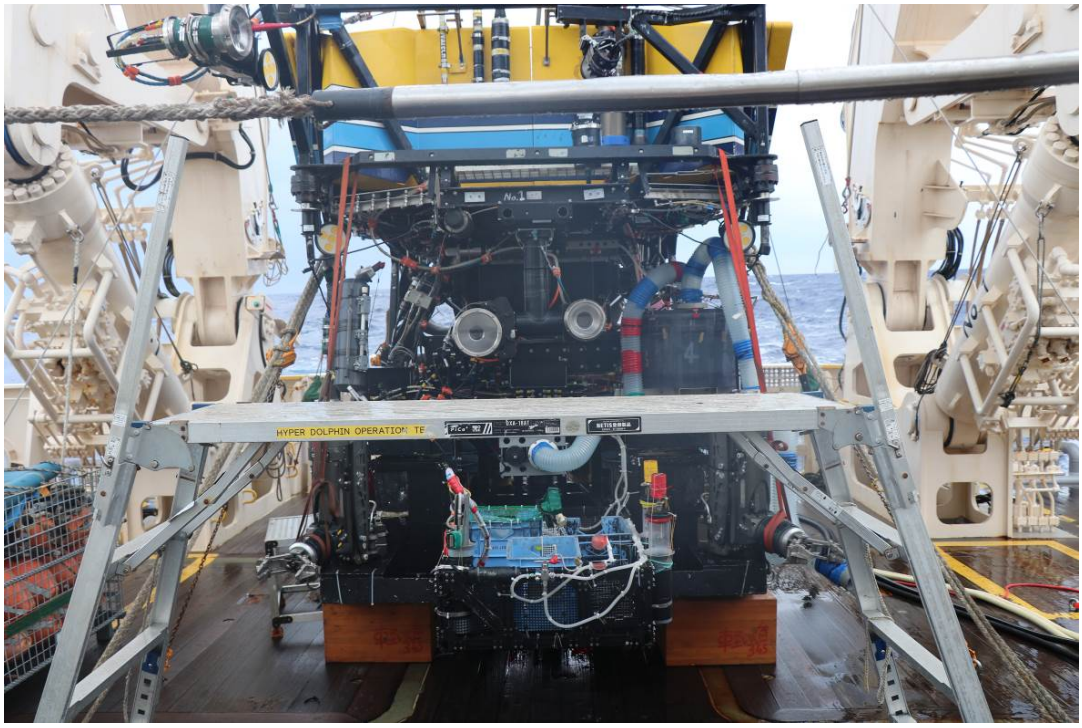

Fig. 3-31 Payload of the dive HPD#2136 in the sample basket.

Payload:

Thermometer x 1, Bag water sampler x 1, Niskin water sampler x1, Slurp gun x 1, 7 multiple canister x 1, MBARI corer x 2, Gold adsorption apparatus x 1, Pyrite reaction apparatus x1, Three component small magnetometer x 1.

Operation:

HPD went to the topographic high point ca. 50 m SSE from the center of the largest chimney and mound structure of the Central Cone Site. This topographic high point was composed of mound and dead chimney structure (Figs. 3-32 and 3-33). Two platy/fragile rocks were sampled at the flank of the topographic high point (HPD#2136R01 and R02). Then, HPD went to the largest mound and chimney structure to try to sample hydrothermal fluid from the active part of the dead center. It was difficult to approach the steep chimney structure, but finally HPD approached the middle point of the structure. HPD then measured the temperature of hydrothermal fluid (T_{max} = 240.7 ºC) and sampled the fluid with a bag water sampler (HPD#2136B) (Figs. 3-34 and 3-35). The active chimney was broken for fluid sampling with a manipulator (HPD#2136R03). After fluid and rock sampling, HPD went to 5 m above the uppermost part of the largest chimney for seawater sampling with Niskin water sampler (HPD#2136N) (Fig. 3-36). We tried to sample the benthic animals from the largest chimney, but it was unsuccessful due to the steepness of the structure. HPD went to the northern flank of the largest mound of the Central Cone Site, followed by four rock sampling (HPD#2136R04 to R07). Then, HPD went to the biological colony with hydrothermal shimmering/bubbling ca. 30 m WNW from the largest chimney again (Fig. 3-37) as in dive HPD#2132. Here, we sampled benthic animals with the slurp gun into all six canister bottles (HPD#2136-BC1 to BC6), installed the gold adsorption apparatus (Fig. 3-38) and sampled one rock (HPD#2136R08). During these operations at the biological colony, deep-sea sediment sampling by MBARI corer was attempted but no samples were obtained due to the hardness of the sampling point (Fig. 3-39). Moreover, the movie of the hydrothermal bubbling was captured here. During this dive survey, the pyrite reaction apparatus could not be installed.

This is the last dive of the cruise KS-21-20. After HPD was on deck, R/V Shinsei Maru started to go to the Kochi Port.

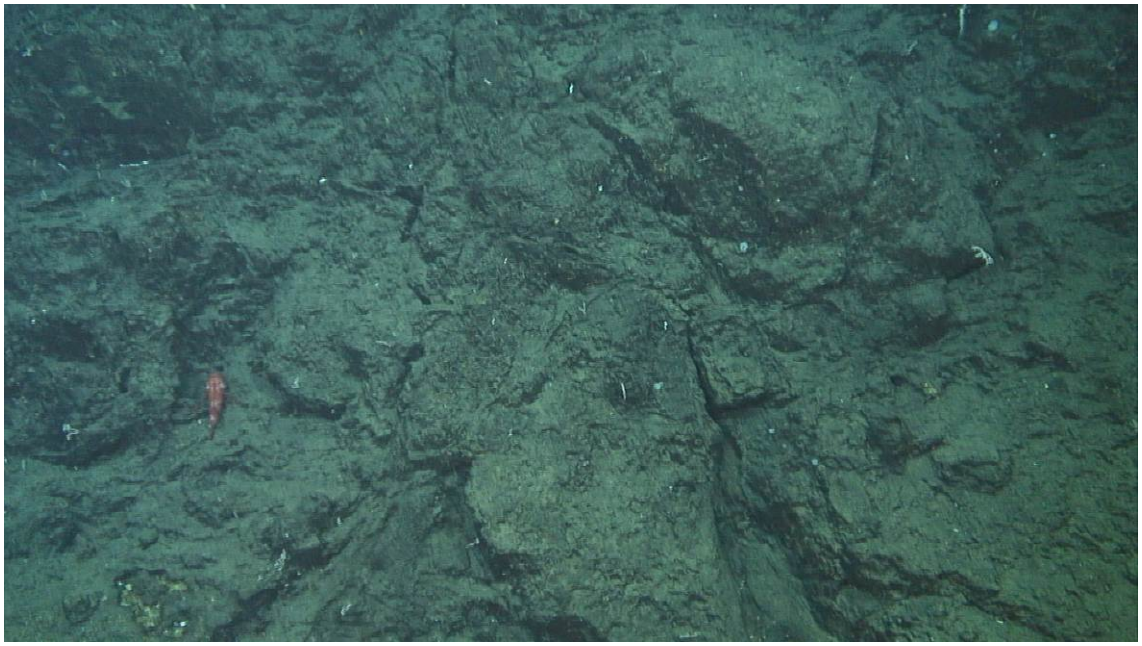

Fig. 3-32 Mound of the topographic high point ca. 50 m SSE from the largest chimney and mound structure of the Central Cone Site.

Fig. 3-33 Uppermost part of the dead chimney on the topographic high point ca. 50 m SSE from the largest chimney and mound structure of the Central Cone Site.

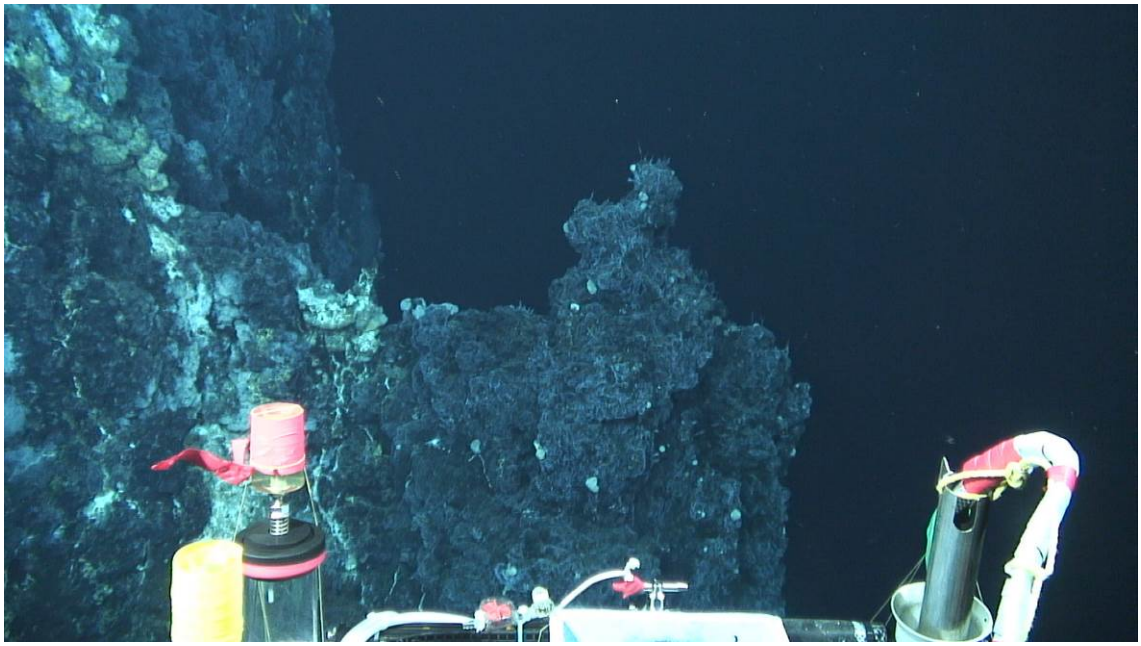

Fig. 3-34 Middle point of the largest chimney structure approached for hydrothermal fluid sampling.

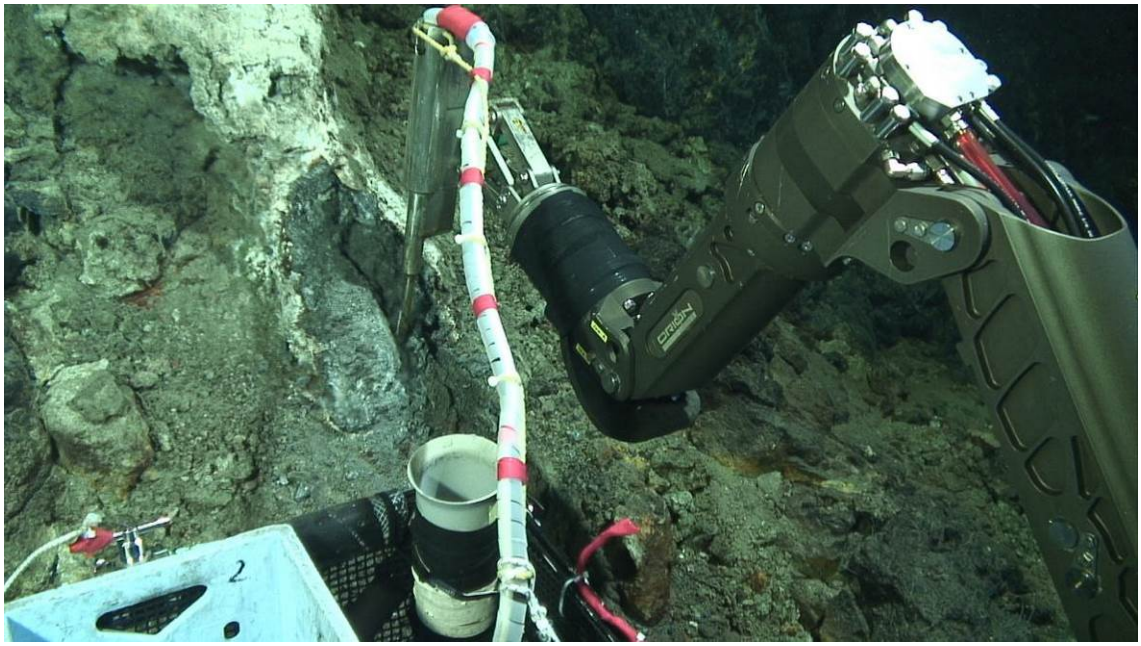

Fig. 3-35 Temperature measurement and fluid sampling at the active chimney at the Central Cone Site.

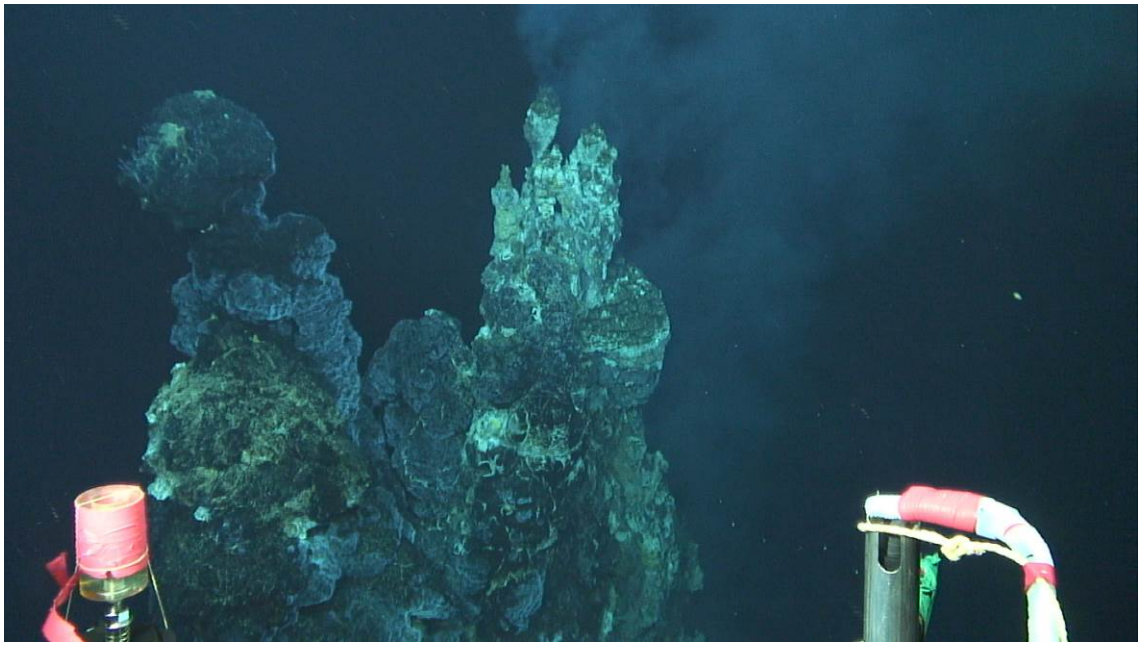

Fig. 3-36 The uppermost part of the largest active chimney at the Central Cone Site.

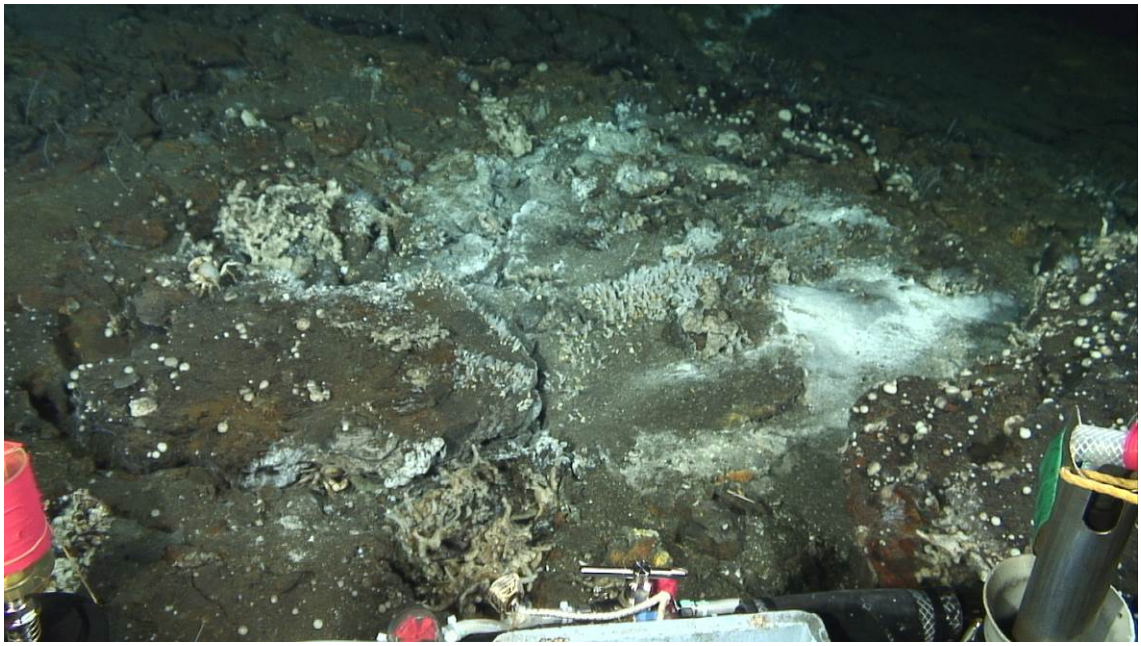

Fig. 3-37 Biological colony with hydrothermal shimmering/bubbling at 30 m WNW from the dead center of the Central Cone Site.

Fig. 3-38 Installation of the gold adsorption apparatus on the hydrothermal shimmering from cracks of seafloor rocks.

Fig. 3-39 Deep-sea sediment sampling by MBARI cores which could not penetrate the hard seafloor.

4. 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.
Users of information on this report are requested to submit Publication Report to Cooperative Research Cruise office.

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