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R/V Natsushima Cruise Report

NT16-02

Drawn by
Y. Tomimatsu

Strategic Innovation Program (SIP), New-generation Technology for Ocean Resources Survey (ZIPANG in ocean), Metallogenic study on seafloor resources, in-situ test for the recovery of the Kuroko-ore cultivation apparatus

Iheya-North Knoll, Middle Okinawa Trough

Jan.11,2016 - Jan.18,2016

Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

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1. Cruise Information

● Cruise ID: NT16-02

● Name of vessel: R/V Natsushima

● Title of the cruise: Strategic Innovation Program (SIP), New-generation Technology for Ocean Resources Survey (ZIPANG in ocean), Metallogenic study on seafloor resources, *in-situ* test for the recovery of the Kuroko-ore cultivation apparatus

● Title of proposal: Recovery of the Kuroko-ore cultivation apparatus

● Cruise period: 11th, January 2016 to 18th, January 2016tel

● Ports of departure and arrival: Naha to Shimonoseki

● Research area: Iheya-North Knoll, Middle Okinawa Trough

● Research Map:

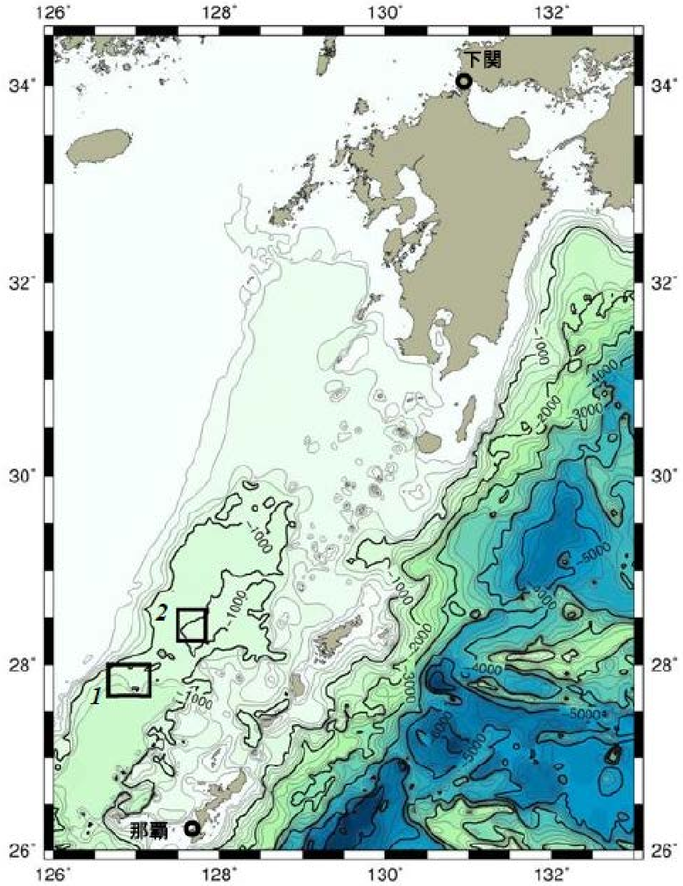

Fig. 1 Investigation area map of the NT16-02 Cruise. 1. Iheya-North Knoll, 2. Minami-Ensei Knoll (alternative investigation area).

2. Researchers and Crews

● Chief scientist

Tatsuo Nozaki [JAMSTEC]

● Representative of the science party

Tatsuo Nozaki [JAMSTEC]

● Science party

Masayuki Watanabe (JAMSTEC)
Yuka Masaki (JAMSTEC)
Yohei Matsui (JAMSTEC)
Yuki Tomimatsu (JAMSTEC / Kumamoto Univ.)
Takahiro Yokoyama (JAMSTEC)
Keita Akiyama (JAMSTEC)
Suehiro Nitta (JAMSTEC)
Masaharu Kiyosawa (USJ)
Shusuke Machida (NME)

● Natsushima Crew Members:

Captain:	Shinya Ryono
Chief Officer:	Masato Chiba
2nd Officer:	Hidehiko Konno
3rd Officer:	Yumihiko Kobayashi
Chief Engineer:	Kazunori Noguchi
1st Engineer:	Yoshinobu Hiratsuka
2nd Engineer:	Hiroki Tanaka
3rd Engineer:	Kazuki Ono
Chief Electronics Operator:	Hiroyasu Saitake
2nd Electronics Operator:	Tatsuhiro Takakuwa
3rd Electronics Operator:	Takayuki Mabara
Boat Swain:	Hideo Isobe
Able Seaman:	Shuichi Yamamoto
Able Seaman:	Tsuyoshi Chimoto
Able Seaman:	Shun Abe
Able Seaman:	Toru Nakanishi

Sailor:	Shinya Mogi
Sailor:	Kyohei Murai
No.1 Oiler:	Yukihiro Yamaguchi
Oiler:	Katsuyuki Miyazaki
Oiler:	Takuya Watanabe
Oiler:	Toru Hidaka
Oiler:	Shogo Isobe
Chief Steward:	Kazuhiro Hirayama
Steward:	Hideo Fukumura
Steward:	Akio Suzuki
Steward:	Katsuyuki Omiya
Steward:	Mizuki Nakano

● Hyper-Dolphin Operation Team

Operation Manager:	Tomoe Kondo
2nd ROV Operator:	Hirofumi Ueki
2nd ROV Operator:	Yosuke Chida
2nd ROV Operator:	Atsushi Takenouchi
2nd ROV Operator:	Teppei Kido
2nd ROV Operator:	Yudai Sakakibara
3rd ROV Operator:	Shuya Sugiura

3. Observation

3.1 Objectives & Background

There are several active hydrothermal sites in the Okinawa Trough within the Japanese EEZ. Cu-Pb-Zn-rich sulfide deposits occurring at these hydrothermal sites are considered to be a modern analogue of the Kuroko-type volcanogenic massive sulfide (VMS) deposits on land (e.g., Halbach et al., 1989). In 2010, the drilling research cruise of the IODP Exp. 331 was conducted at the Iheya-North Knoll, middle Okinawa Trough (Takai et al., 2011), whose main purpose of this expedition was unravelling the deep-hot biosphere. The massive sulfide core sample was successfully obtained and four artificial hydrothermal vents were formed during this expedition. Semi-annual ROV dive expeditions were performed to observe and collect fluid/rock samples from these artificial hydrothermal vents (Kawagucci et al., 2013). On the bare hole artificial hydrothermal vent formed at the NBC (North Big Chimney) mound, Iheya-North Knoll (Hole C0016A), rapid growth of chimney which became a 15 m height in 25 months was observed (Kawagucci et al., 2013; Nozaki et al., *in press*). The sulfide-rich part of this rapidly grown chimney on the artificial hydrothermal vent has a similar compositions to that of high-grade Kuroko VMS ore on land (Nozaki et al., *in press*). These observations inspired us “cultivation of seafloor mineral deposits” by controlling mix and quench processes of hydrothermal fluid with ambient cold seawater by Kuroko-ore cultivation apparatus which is now collaboratively developing by the Research and Development Center for Submarine Resources and CDEX. This unique apparatus will be installed at two hydrothermal sites in the Okinawa Trough during the next D/V Chikyu’s cruise.

Thus, we aimed to do *in-situ* test of the various hydraulic pressure tools for the future recovery operation of the Kuroko-ore cultivation apparatus using a ROV. Moreover, we planned to install the simplified flow meter having pressure and temperature gauges after removing scale within the steel pipe to do monitoring while drilling (MWD) during the next Chikyu’s cruise by using an artificial hydrothermal vent (Hole C0014G) at the Iheya-North Knoll. Finally, we have planned to do tests of free fall and movement/recovery of a mooring cable bearing a large buoyant material together with an acoustic releaser, which enables to recover the Kuroko-ore cultivation apparatus of several hundred kg by ROV.

Halbach, P., Nakamura, K., Wahsner, M., Lange, J., Sakai, H., Kaselitz, L., Hansen, R.-D., Yamano, M., Post, J., Prause, B., Seifert, R., Michaelis, W., Teichmann, F., Kinoshita, M., Marten, A., Ishibashi, J., Czerwinski, S. and Blum, N. (1989) Probable modern analogue of Kuroko-type massive sulphide deposits in the Okinawa Trough back-arc basin. *Nature*, **338**, 496-499.

Kawagucci, S., Miyazaki, J., Nakajima, R., Nozaki, T., Takaya, Y., Kato, Y., Shibuya, T., Konno, U., Nakaguchi, Y., Hatada, K., Hirayama. H., Fujikura, K., Furushima, Y., Yamamoto, H., Watsuji, T., Ishibashi, J. and Takai, K. (2013) Post-drilling changes in fluid discharge, mineral deposition patterns and fluid chemistry for the seafloor hydrothermal activity in the Iheya-North hydrothermal field, Okinawa Trough. *Geochemistry Geophysics Geosystems*, **14,** 4774-4990, doi:10.1002/ggge.20283.

Nozaki, T., Ishibashi, J.-I., Shimada, K., Nagase, T., Takaya, Y., Kato, Y., Kawagucci, S., Watsuji, T., Shibuya, T., Yamada, R., Saruhashi, T., Kyo, M. and Takai, K. (*in press*) Rapid growth of mineral deposits at artificial seafloor hydrothermal vents. *Scientific Reports*, **xx,** xxx-xxx.

Takai, K., Mottl, M. J., Nielsen, S. H. and the Expedition 331 Scientists (2011) Proceedings of Integrated Ocean Drilling Program 331, Tokyo (Integrated Ocean Drilling Program Management International, Inc.), doi:10.2204/iodp.proc.331.2011.

3.2 Methods & Instruments

3.2.1 Independent Hydraulic Power Unit (IHPU)

IHPU is a supply unit of hydraulic pressure to various tools equipped with a ROV. The IHPU is independent with the hydraulic power system of the ROV. So, if the IHPU was damaged and seawater invaded into this tool, the hydraulic power system of the ROV will be protected.

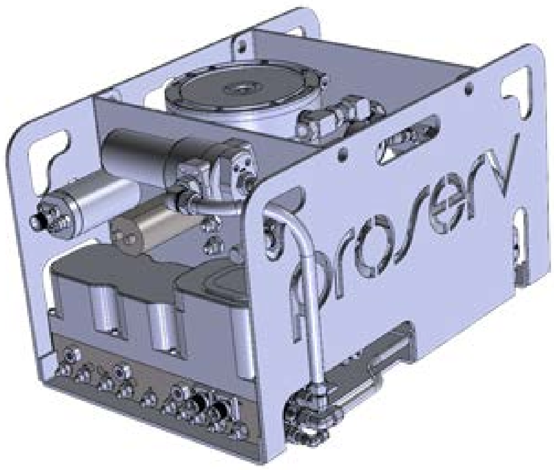

Fig. 3-1 Independent Hydraulic Power Unit (IHPU).

3.2.2 Hydraulic Power Drill

Hydraulic power drill was developed to remove scale within the pipe of the corrosion cap. The hydraulic power of this drill is supplied from the IHPU and its stroke length is 5 inch (ca. 12.5 cm). This drill is fixed on the steel pipe of the corrosion cap by anchor clasp during the operation.

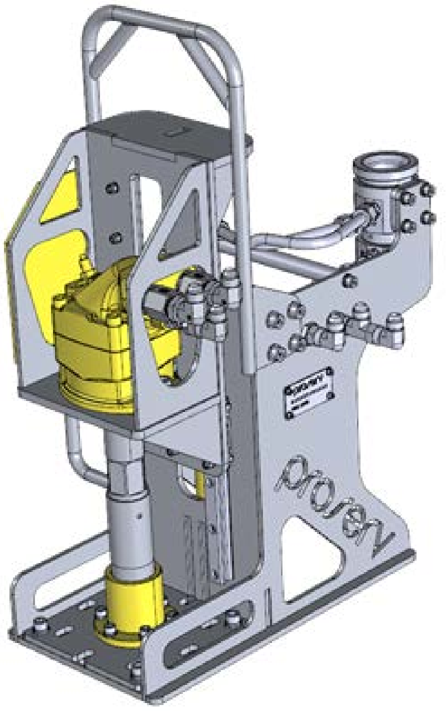

Fig. 3-2 Hydraulic power drill.

3.2.3 Hydraulic Power Chisel

Hydraulic power chisel was originally developed to effectively collect Fe-Mn crust from the seamount basalt. We used this chisel to remove scale within the steel pipe of the corrosion cap. The hydraulic power of the chisel is supplied from a ROV directly.

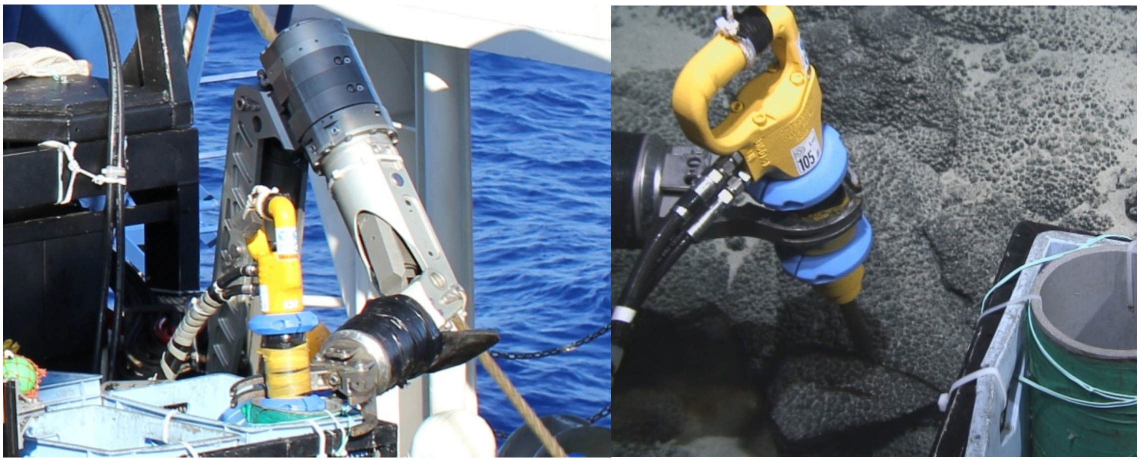

Fig. 3-3 Hydraulic Power Chisel.

3.2.4 Hydraulic Power Torque tool

Hydraulic power torque tool was developed to rotate the flow adjuster valve of the Kuroko-ore cultivation apparatus and regulate flow rate of hydrothermal fluid. The hydraulic power of the torque tool is supplied from the IHPU.

Fig. 3-4 Hydraulic power torque tool.

3.2.5 Hydraulic Power Jack

Hydraulic power jack was developed to raise the Kuroko-ore cultivation cell which may be plugged and fixed with the manifold part. The hydraulic power of the torque tool is supplied from the IHPU.

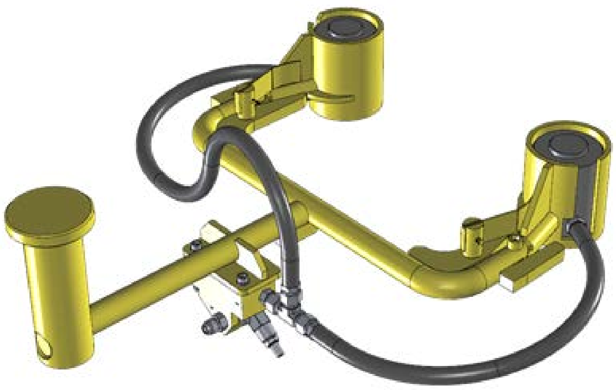

Fig. 3-5 Hydraulic power jack.

3.2.6 Simplified flow meter

Simplified flow meter has both analogue and digital flow meters together with pressure and temperature gauges and their sensor loggers. We tried to install this simplified flow meter after remove scale within the steel pipe of the corrosion cap at Hole C0014G to do monitoring while drilling (MWD) of the artificial hydrothermal vent in the next Chikyu's cruise.

Fig. 3-6 Simplified flow meter with pressure and temperature gauges with a sensor logger.

3.2.7 Thermometer

High-T thermometer was used for the measurement of hydrothermal fluid on Hole C0014G. We borrowed this thermometer from Dr. K. Okamura at Kochi University.

Fig. 3-7 Thermometer for hydrothermal fluid (borrowed from Kochi Univ.).

3.2.8 Mooring cable

A mooring cable was constructed to aim the future recovery operation of the Kuroko-ore cultivation apparatus of several hundred kg by ROV. We planned to do three operations of the mooring cable; (1) *in-situ* test of an acoustic releaser, (2) movement test of the mooring cable by ROV and (3) recovery test of the mooring cable by ROV.

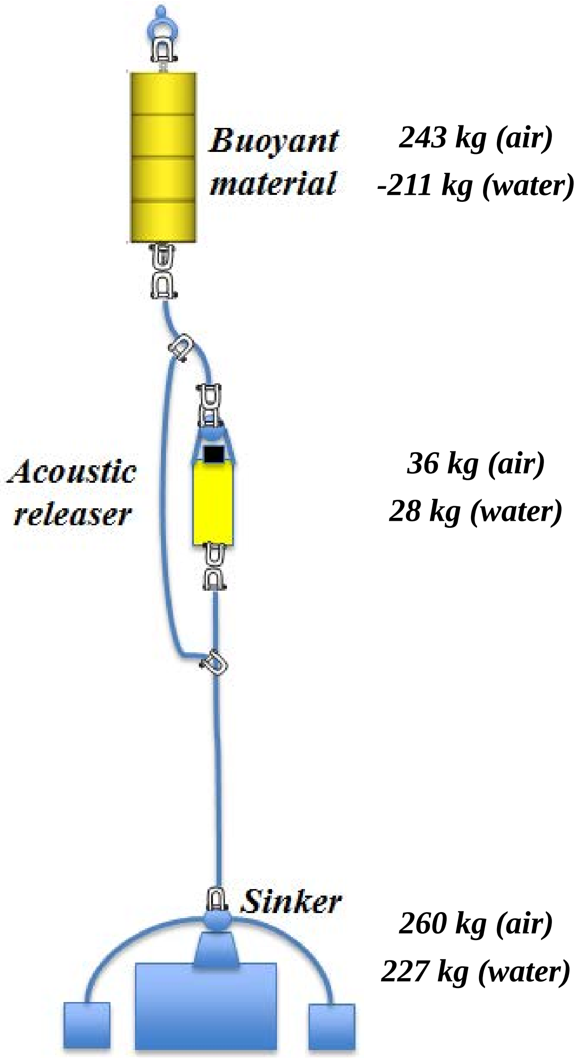

Fig. 3-8 Mooring cable.

3.3 Dive Information & Preliminary Results

3.3.1 Dive HPD#1931 (15th January, 2016)

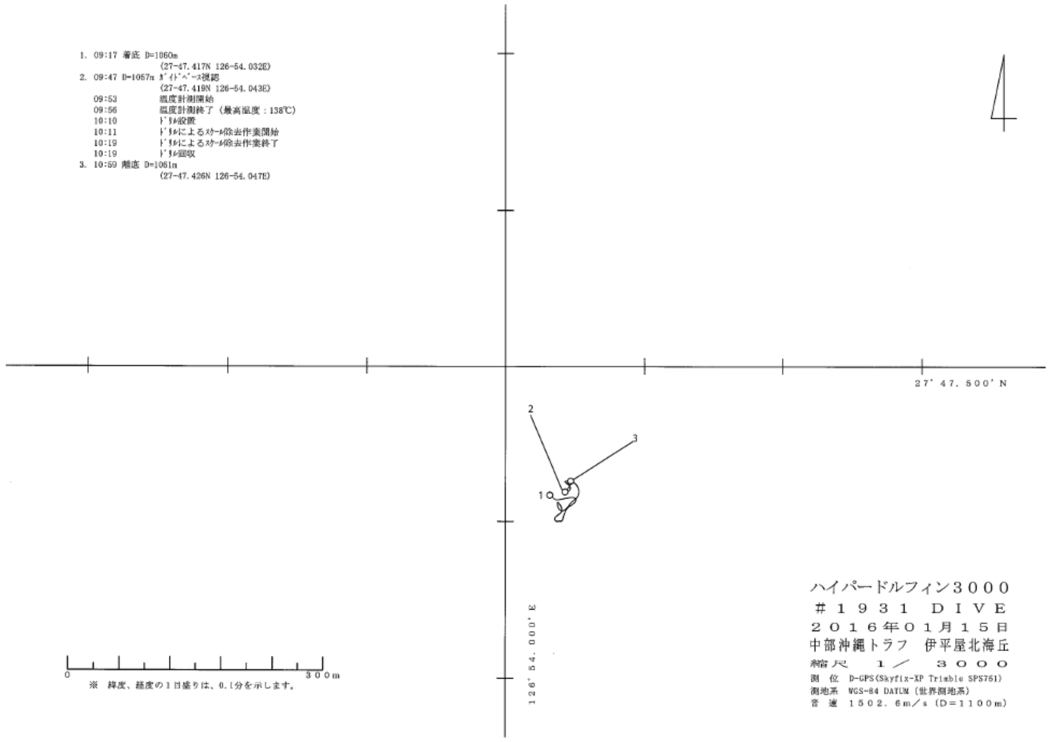

Fig. 3-9 Dive track and operation list of HPD#1931.

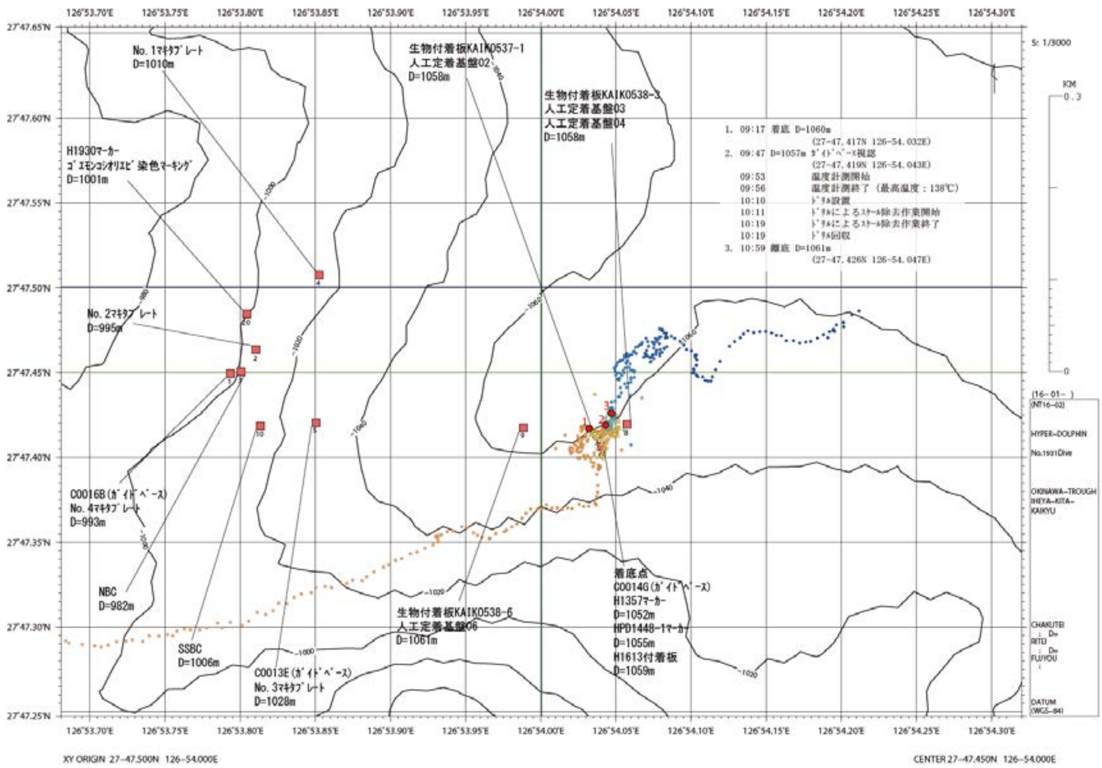

Fig. 3-10 Dive track and operation list of HPD#1931 on a bathymetric map.

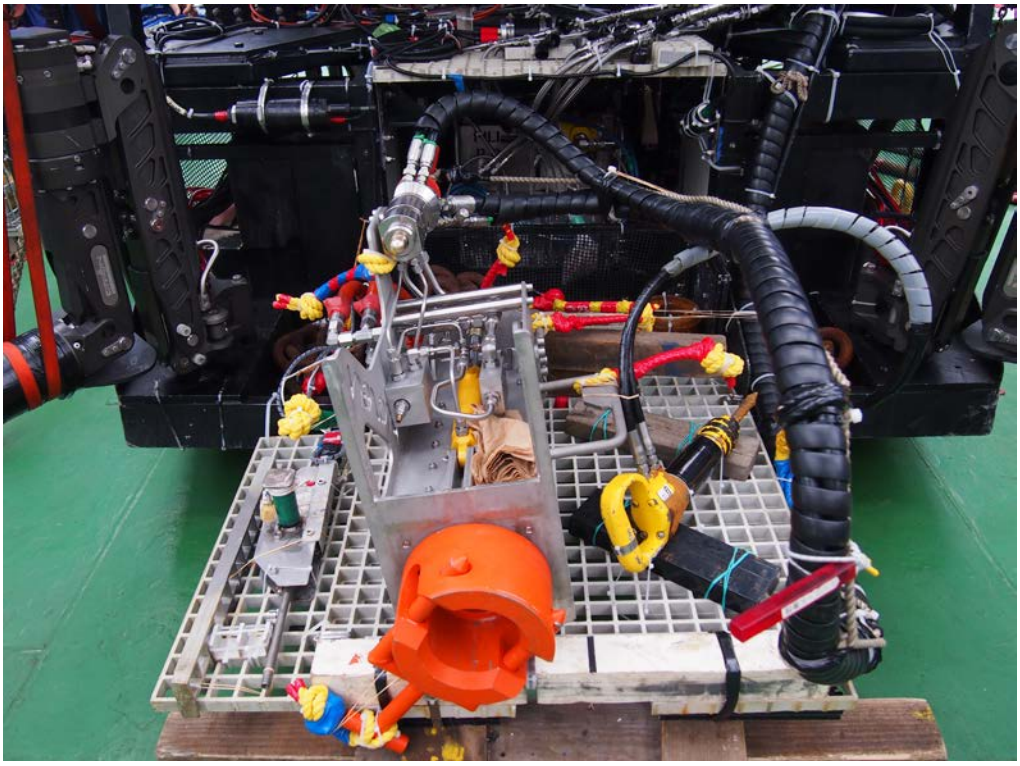

Fig. 3-11 Payload of the dive HPD#1931.

Payload:

Independent Hydraulic Power Unit (IHPU) with buoyant material, Hydraulic power chisel, Hydraulic power drill and Thermometer

Operation:

During settling down of the ROV, we noticed slow oil leakage (oil bubble) from some pipes and hot stab of the hydraulic power drill. After the arrival on a seafloor, HPD3000 went to the artificial hydrothermal vent of Hole C0014G. White soft sediment (CO_2 hydrate?) covered the uppermost part of the steel pipe of the corrosion cap and hydrothermal fluid weakly discharged. At first, we measured the temperature of hydrothermal fluid and the maximum temperature was 138.1^{o}C. Since upper part of scale within the steel pipe seemed to be soft, we skipped to remove scale by chisel and tried to remove scale by hydraulic power drill. The IHPU and drill were successfully functioned and penetrated into ca. 4 cm, but marked oil leakage occurred from pipes of the hydraulic power drill. After trying to remove scale by drill several times, connection of the IHPU and host PC was stopped. Moreover, the electric circuit of the IHPU was also damaged and seawater invaded into the IHPU. Thus, we decided to stop this dive expedition.

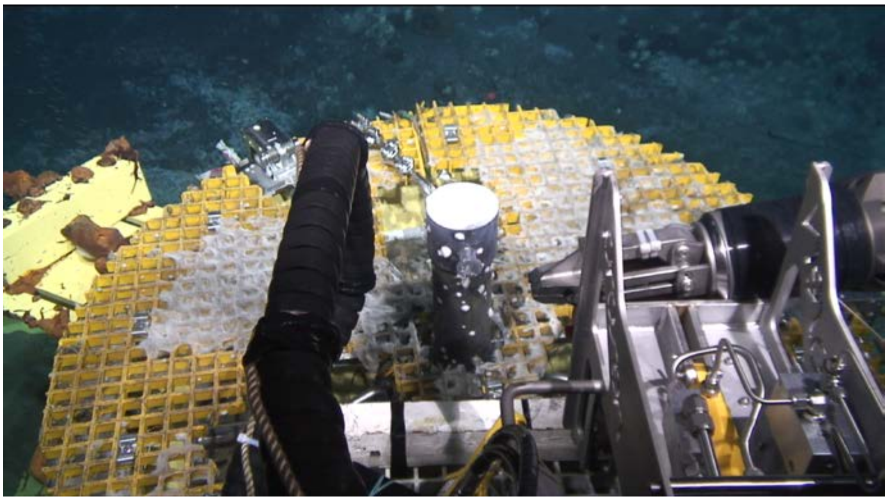

Fig. 3-12 Artificial hydrothermal vent (Hole C0014G) before removing scale within the steel pipe.

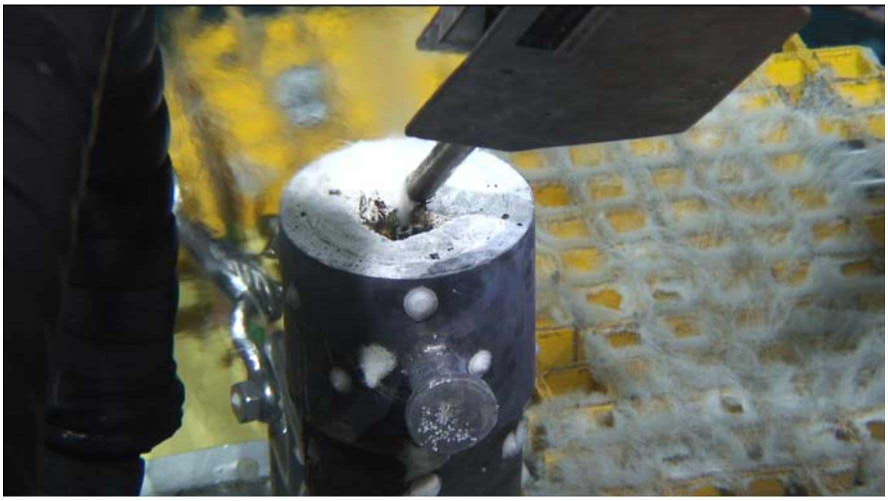

Fig. 3-13 Temperature measurement of hydrothermal fluid (T_{max} = 138.1°C).

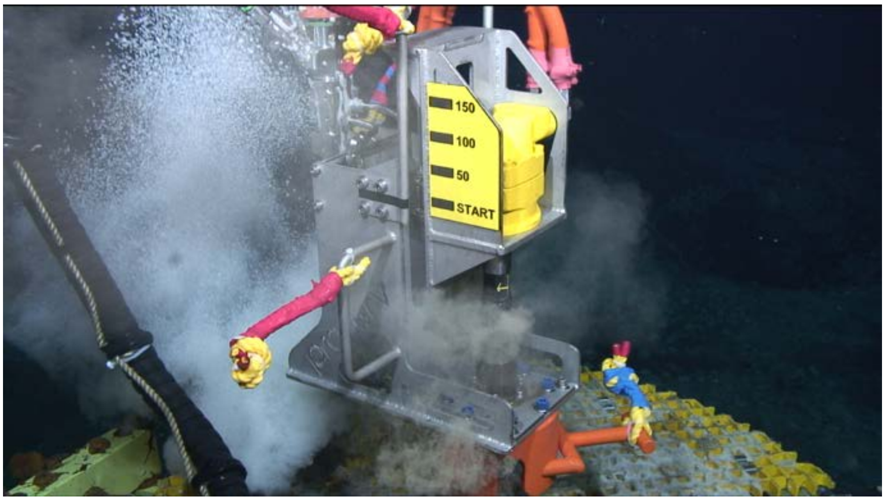

Fig. 3-14 Removing scale within the steel pipe by hydraulic power drill.

3.3.2 Dive HPD#1932 (15th January, 2016)

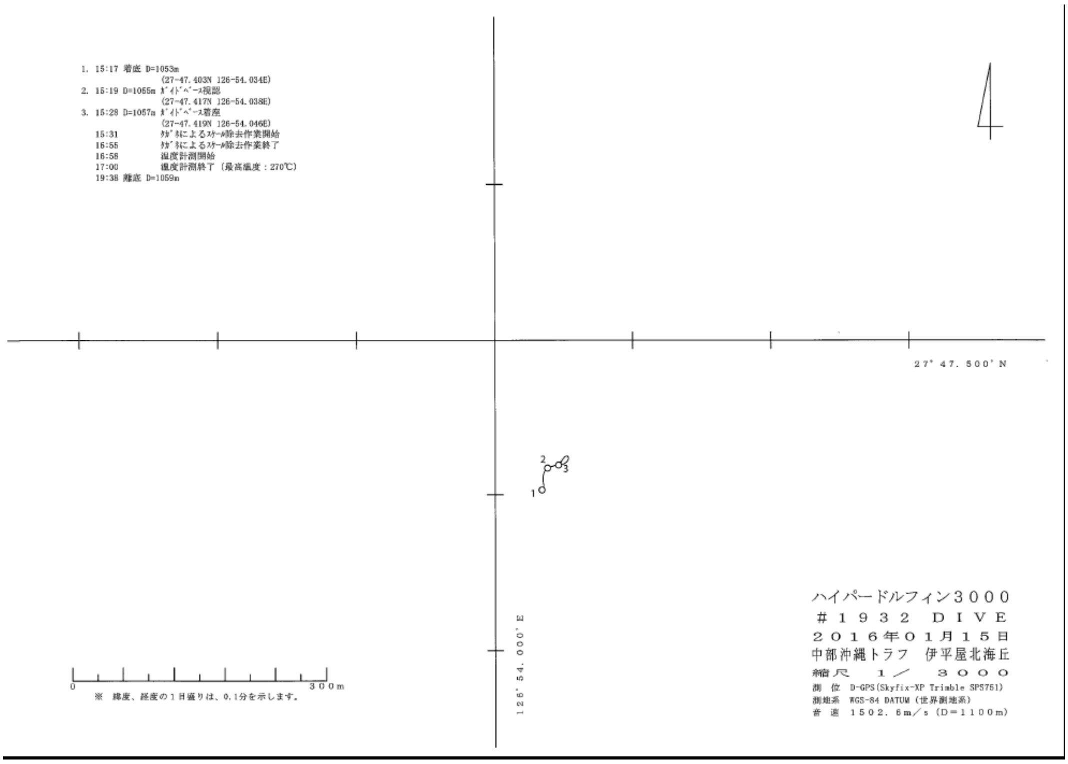

Fig. 3-15 Dive track and operation list of HPD#1932.

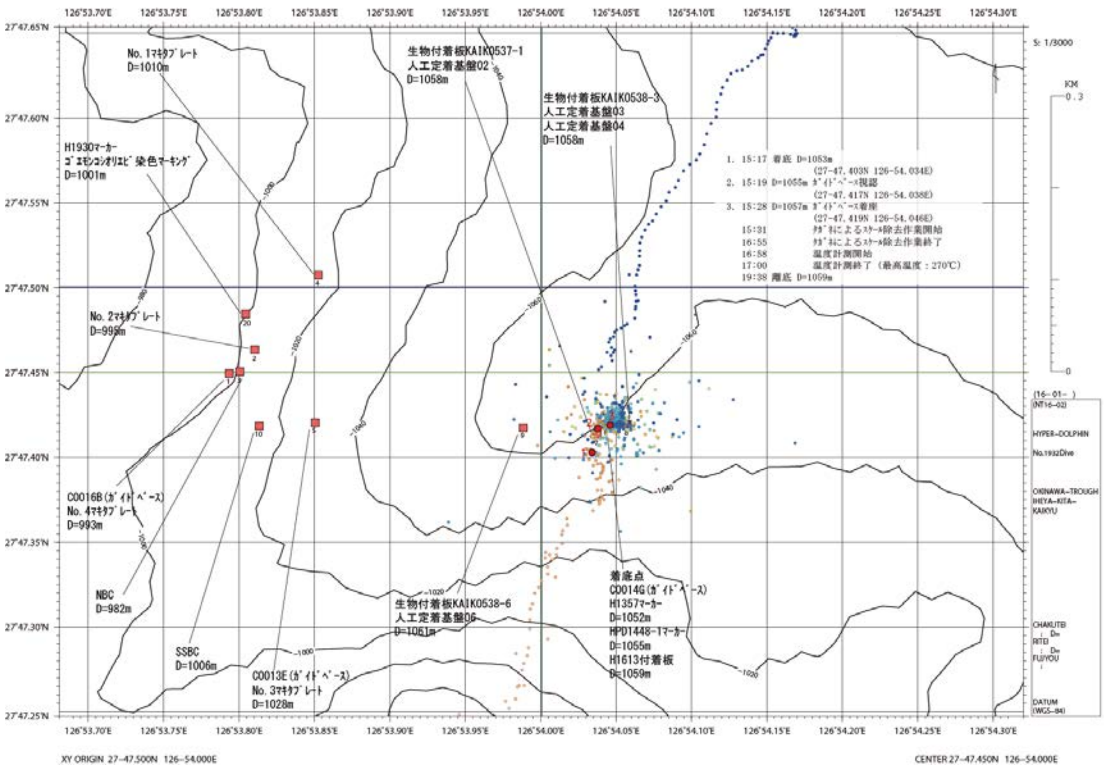

Fig. 3-16 Dive track and operation list of HPD#1932 on a bathymetric map.

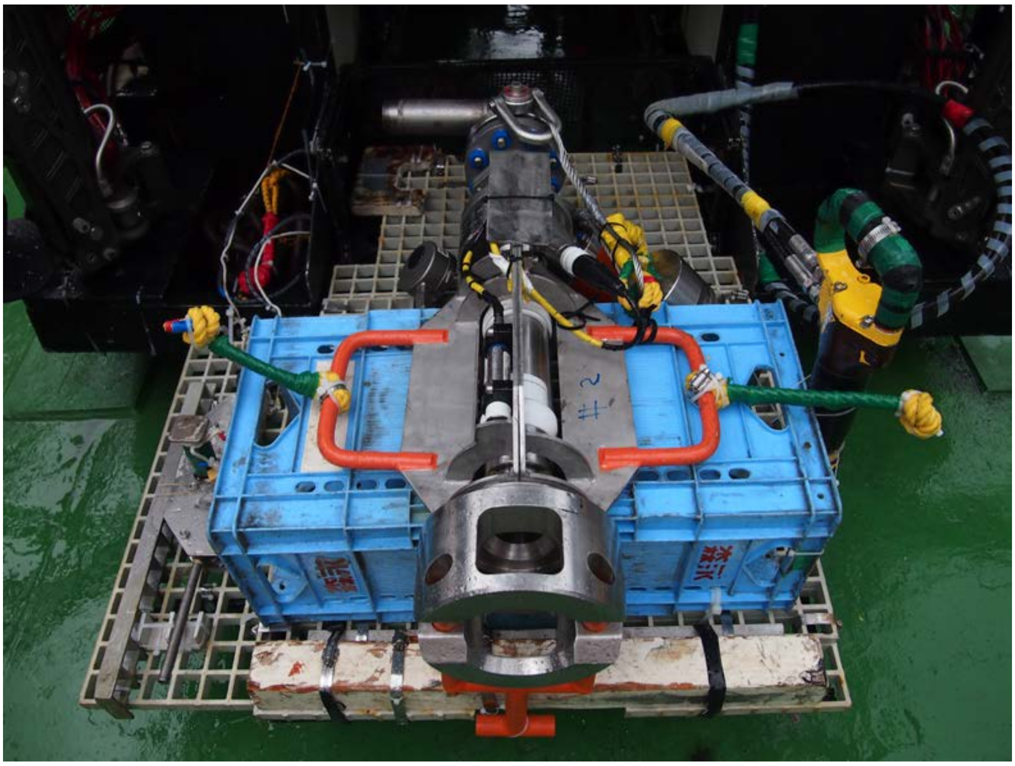

Fig. 3-17 Payload of the dive HPD#1932.

Payload:

Simplified flow meter, Hydraulic power chisel and Thermometer

Operation:

After the arrival on a seafloor, ROV HPD again went to the artificial hydrothermal vent of Hole C0014G and continued to remove scale within the steel pipe of the corrosion cap by using a hydraulic power chisel, followed by temperature measurement whose maximum value was 270.7^{o}C. Then, we tried to install the simplified flow meter on the steel pipe many times. However, the simplified flowmeter was not easy to handle by HPD3000 due to its height, weight and weight balance. Although we have tried to install the simplified flow meter many times, we could not attain to install it.

Because of the hard sea state condition, we could not do *in-situ* tests of hydraulic torque tool and jack as well as a mooring cable movement/recovery tests. However, we have successfully tested the IHPU and hydraulic drill, we are convinced that these unique operations should be useful to the future recovery operation of the Kuroko-ore cultivation apparatus by ROV.

Fig. 3-18 Removing scale within the steel pipe by hydraulic power chisel.

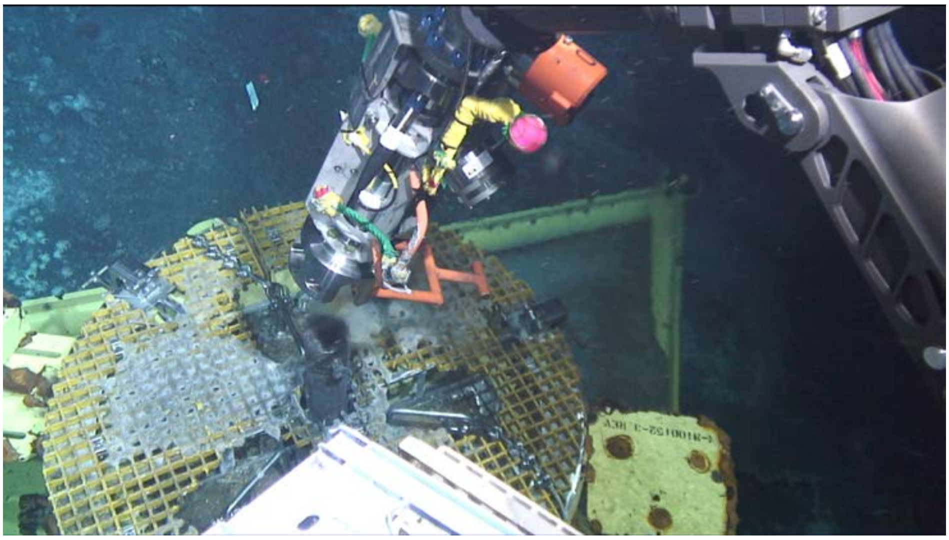

Fig. 3-19 ROV HPD3000 tried to install the simplified flow meter on the corrosion cap after removing scale within the steel pipe.

4. Notice on Using

Notice on using: Insert the following notice to users regarding the data and samples obtained.

> This cruise report is a preliminary documentation as of the end of the cruise.
> This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information.
> Users of data or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.