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R/V KAIMEI Cruise Report

KM17-14C

Strategic Innovation Program (SIP), New-generation Technology for Ocean Resources Survey (ZIPANG in ocean), “Extensive investigation of REY-rich mud and Fe-Mn crust around the Minamitorishima offshore”

16th, December 2017 to 7th, January 2018

(except for 30th December to 3rd January)

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

Contents

1. Cruise Information

- Cruise ID: KM17-14C
- Name of vessel: R/V KAIMEI
- Title of the cruise: Strategic Innovation Program (SIP), New-generation Technology for Ocean Resources Survey (ZIPANG in ocean), “Extensive investigation of REY-rich mud and Fe-Mn crust around the Minamitorishima offshore”
- Title of proposal: Strategic Innovation Program (SIP), New-generation Technology for Ocean Resources Survey (ZIPANG in ocean), “Extensive investigation of REY-rich mud around the Minamitorishima offshore”
- Cruise period: 16th, December 2017 to 7th, January 2018 (except for 30th December to 3rd January)
- Ports of departure / arrival: Yokosuka HQ to Yokosuka HQ
- Research area: Minamitorishima offshore, northwestern Pacific Ocean
- Research Map

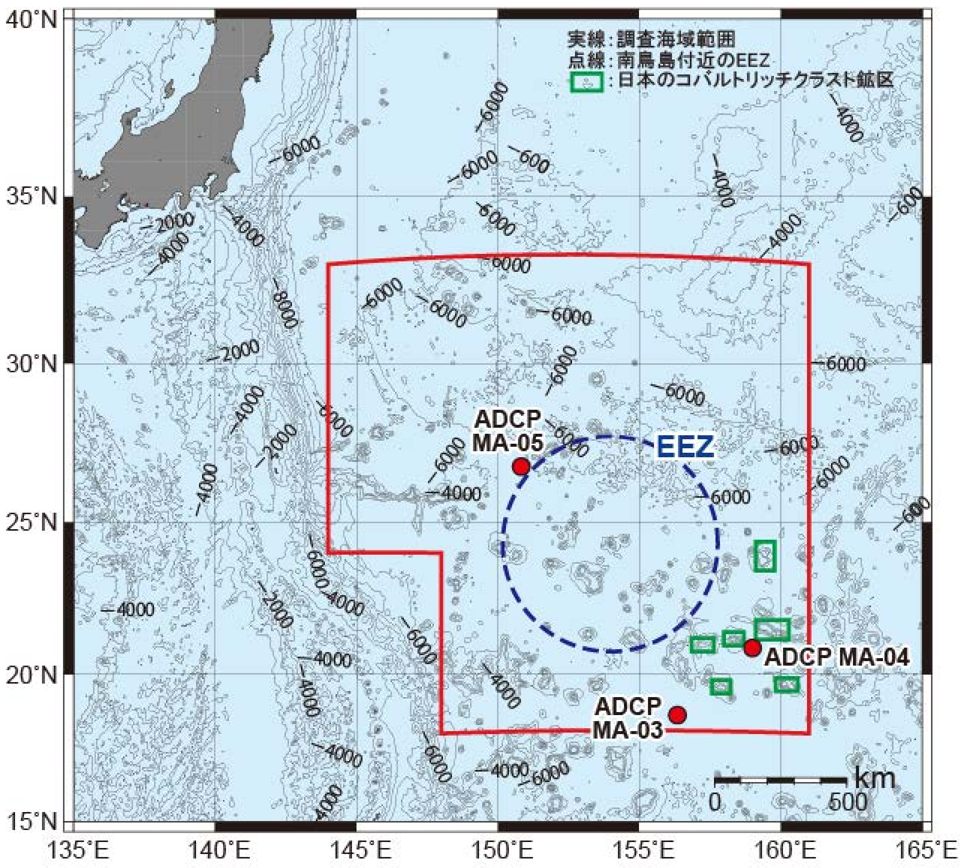

Fig. 1-1 Investigation area of the KM17-14C Cruise.

2. Researchers and Crews

● Chief scientist:

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● Representative of the science party:

Eiichi Kikawa [JAMSTEC]

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Mika Yamaguchi (MWJ)
Keisuke Matsumoto (MWJ)
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Chief Officer	Tatsuo Adachi
2nd Officer	Kazuki Miyake
3rd Officer	Kazuma Yamamoto
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1st Engineer	Kenzo Kato
2nd Engineer	Akira Hanawa
3rd Engineer	Hayato Ryoshu
Chief Electronic Operator	Hiroki Ishiwata
2nd Electronic Operator	Takatomo Shirozume
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Able Seaman	Kaito Murata
Able Seaman	Naoki Iwasaki
Able Seaman	Takuya Miyashita
Sailor	Yuta Ohjiri
Sailor	Shinya Kojima
Sailor	Yuta Yoshimi
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Oiler	Kota Aizawa
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Operation Manager	Atsumori Miura
Operation Manager	Teppei Kido
2nd ROV Operator	Katsushi Chiba
2nd ROV Operator	Tetsuya Ishitsuka
2nd ROV Operator	Shigeru Kikuya
2nd ROV Operator	Yudai Sakakibara
2nd ROV Operator	Atsushi Takenouchi
3rd ROV Operator	Shinosuke Kumagai

3. Observations

3.1 Objectives & Background

In 2011, the wide distribution of deep-sea mud bearing high total REY contents in the Pacific Ocean was reported by Kato et al. (2011) and now deep-sea REY-rich mud has been vigorously studied as the "4th seafloor mineral resources" following ferromanganese nodule, hydrothermal sulfide deposit and ferromanganese crust. Since the publication of this paper, annual research cruises in the exclusive economic zone of the Minamitorishima Island has been performed since 2013, leading to the discovery of an extremely REY-rich mud having more than 5,000 ppm of total REEs (Fujinaga et al., 2016; Iijima et al., 2016). Moreover, bathymetric survey by MBES and subseafloor shallow structural acoustic survey by SBP narrowed the range of promising area of REY-rich mud (Nakamura et al., 2016). In the KM17-14C Cruise, we aimed to perform piston corer (PC) / gravity corer (GC) samplings in the area east from the Takuyo Daigo Seamount that is one of the promising areas for REY-rich mud, together with geophysical survey using MBES, SBP, cesium magnetometer and so on. We also aimed to retrieve three ADCPs deployed in the MR16-07 Cruise, and *in-situ* test of a ROV coring system and an acoustic underwater camera at the Takuyo Daigo Seamount.

Fujinaga, K., Yasukawa, K., Nakamura, K., Machida, S., Takaya, Y., Ohta, J., Araki, S., Liu, H., Usami, R., Maki, R., Haraguchi, S., Nishio, Y., Usui, Y., Nozaki, T., Yamazaki, T., Ichiyama, Y., Ijiri, A., Inagaki, F., Machiyama, H., Iijima, K., Suzuki, K., Kato, Y. and KR13-02, MR13-E02 Leg 2 and KR14-02 Cruise members (2016) Geochemistry of rare-earth elements and yttrium-rich muds in the Japanese Exclusive Economic Zone around Minamitorishima Island. *Geochemical Journal*, **50**, 575-590.

Iijima, K., Yasukawa, K., Fujinaga, K., Nakamura, K., Machida, S., Takaya, Y., Ohta, J., Haraguchi, S., Nishio, Y., Usui, Y., Nozaki, T., Yamazaki, T., Ichiyama, Y., Ijiri, A., Inagaki, F., Machiyama, H., Suzuki, K., Kato, Y. and KR13-02 Cruise members (2016) Discovery of extremely REY-rich mud in the western North Pacific Ocean. *Geochemical Journal*, **50,** 557-573.

Kato, Y., Fujinaga, K., Nakamura, K., Takaya, Y., Kitamura, K., Ohta, J., Toda, R., Nakashima, T. and Iwamori, H. (2011) Deep-sea mud in the Pacific Ocean as a potential resource for rare-earth elements. *Nature Geoscience*, **4,** 535-539.

Nakamura, K., Machida, S., Okino, K., Masaki, Y., Iijima, K., Suzuki, K. and Kato, Y. (2016) Acoustic characterization of pelagic sediments using sub-bottom profiler: Implications for the distribution of REY-rich mud in the Minamitorishima EEZ, western Pacific. *Geochemical Journal*, **50,** 605-619.

3.2 Methods & Instruments

3.2.1 MBES and SBP

R/V KAIMEI is equipped with a Multi-narrow Beam Echo Sounding system (MBES), EM122 (Kongsberg) and Sub-Bottom Profiler (SBP), TOPAS PS18 (Kongsberg). In order to determine an accurate sound velocity of the water column for the ray-path correction of acoustic multibeam, we used the deeper depth sound velocity profiles which were calculated by temperature and salinity profiles from XBT (eXpendable BathyThermograph) data based on the equation in Del Grosso (1974).

Del Grosso, V. A. (1974) New equation for speed of sound in natural water (with comparison to other equations). *The Journal of the Acoustical Society of America*, **56,** 1084-1091.

Table 3-1 System configuration and performance of EM122

Measurement range	20 to 11,000 m
Frequency	10.5 to 13 kHz
Swath width	150° (max)
Depth resolution	37 cm at the shallowest range
Pulse type	CW, FM chirp wave
Pulse length	CW (3, 5, 8 and 15 msec)
FM chirp wave	25, 40, 60 and 100 msec (automatic setting with range)
Maximum oscillation interval	5 Hz depending on water depth
Acquisition range interval	2 kHz (37cm)
Beam number	288
Beam width	50 kHz
Depth measurement point	432 points (864 points at the dual swath mode)
Source level	242dBμPa@1m
Precision	0.2% frequency within swath width 45° (10.5 - 13 kHz)

Table 3-2 System configuration and performance of TOPAS PS18

Measurement range	20 to 11,000 m
Operation principle	Parametric method
Frequency	First and second frequency; 15 to 21 kHz and 0.5 to 6 kHz
Source level	208dBμPa@1m
Pulse type	Continuous wave, linear FM chirp wave, hyperbolic FM chirp wave
Acoustic range resolution	CW 0.5 to 4 cm depending on the sample frequency
Beam width	less than 4.5° (secondary frequency)
Scanning function	20 beams
Percolation depth	more than 200 mbsf

3.2.2 Three-component magnetometer

The shipboard three-component magnetometer system (Tierra Technica SFG2015) is on-board R/V KAIMEI. Three-axes flux-gate sensors with ring-cored coils are fixed on the fore mast. Outputs of the sensors are digitized by a 20-bit A/D converter (1 nT/LSB), and sampled at 8 times per second. Ship's heading, pitch and roll are measured utilizing Inertial Navigation System and ship's position

(GPS), and speed data are taken from LAN every second.

3.2.3 Piston and gravity corer

Piston core (PC) and gravity core (GC) sampler systems consist of weight, duralumin pipes (5 m-long per pipe), trigger which works as the balance and a pilot core sampler. The polycarbonate or polyethylene terephthalate (PET) liner tubes (5 m-long per tube) are installed inside the duralumin pipes. The inner diameter (I.D.) of the liner tube is 74 mm.

In this cruise, a 1.5 ton weight was only used. The total length of duralumin pipes and liner tubes were all 15 m. The pipe length was decided based on the results of SBP site survey data. The long and sharp stainless bit was used at the end of the pipes to promote penetration of the PC/GC into subseafloor. We used a 74 mm (I.D.) Long Type Pilot Corer (called 74 corer) for the pilot core sampler. The total weight of the PC/GC system with the 1.5 ton weight is approximately 1.7 ton in water. The constructions of the PC/GC system in this cruise are shown in Figures 3-1 and 3-2. We used a hybrid type piston which was composed of brass body.

The polycarbonate tubes we used as a liner tube were annealed before cruise. When we divide the core into archive and working halves, non-anneal polycarbonate tubes have transformation internally. However, annealing polycarbonate tubes can lessen transformation. In the KM17-14C Cruise, we also utilized PET inner tubes to prevent deformation of the inner tube.

After deployment of the PC/GC, the swell compensator was started at wire out 200 or 500 m water depth depending on the sea state. After that, the winch was gradually increased the speed up to 1 m/s. The winch was stopped at about 100 m above the seafloor for 3 minutes to reduce pendulum motions of the PC/GC system. After that, the wire was stored out at the speed of 0.3 m/s. When the wire tension decreased suddenly, we confirmed the PC/GC hit the bottom. After that, the winch was immediately stopped and winched up at the speed of 0.3 m/s until the tension gauge indicated the PC/GC was completely lifted off the bottom. After leaving the bottom, the winch speed was at the maximum speed (1.2 m/s). Main winch rope of R/V KAIMEI is 30 mm in diameter.

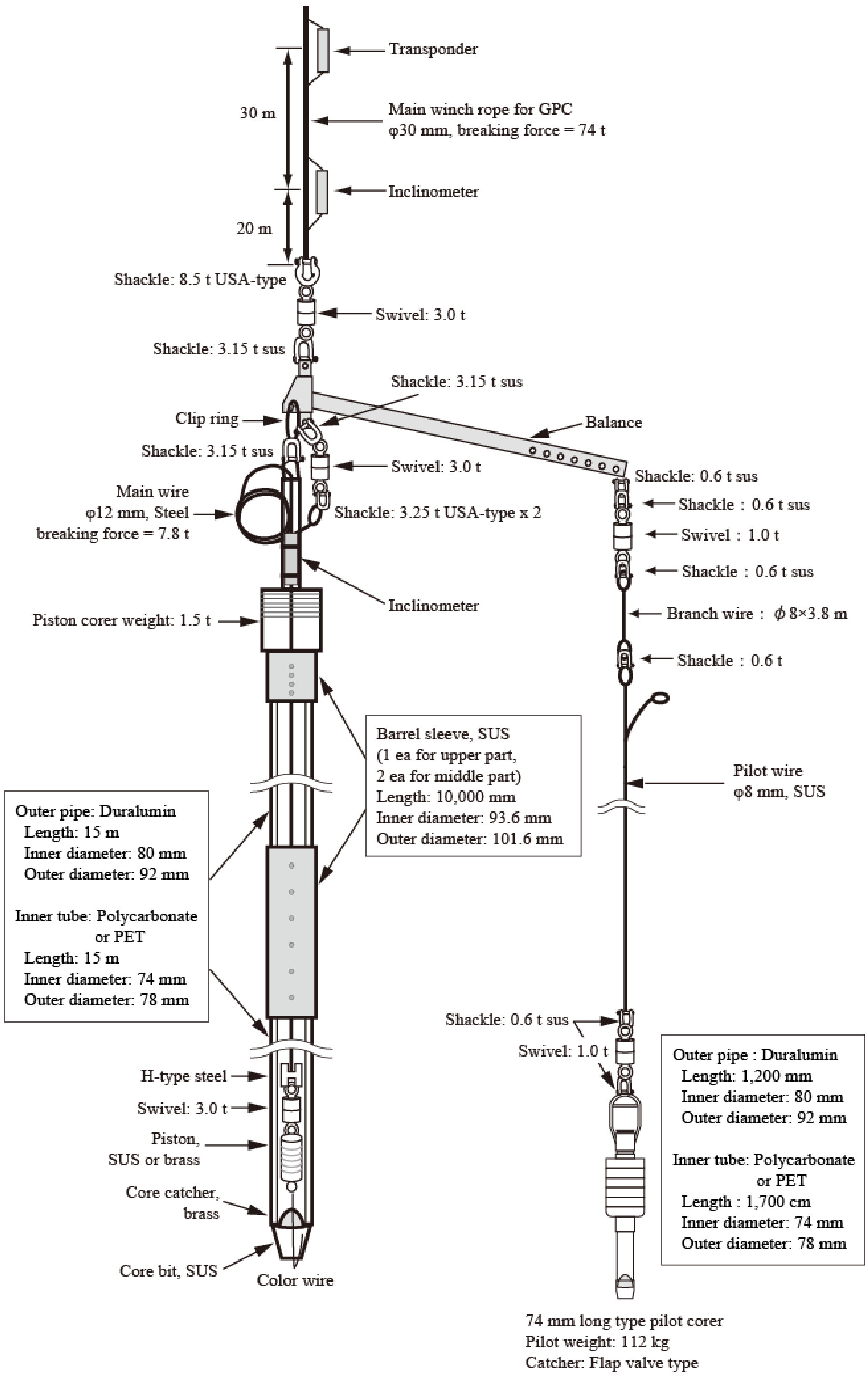

Fig. 3-1 Piston corer system with 1.5 ton weight in the KM17-14C Cruise. Outer and inner pipe lengths were all 15 m. The outer pipe length of the pilot corer was 120 cm.

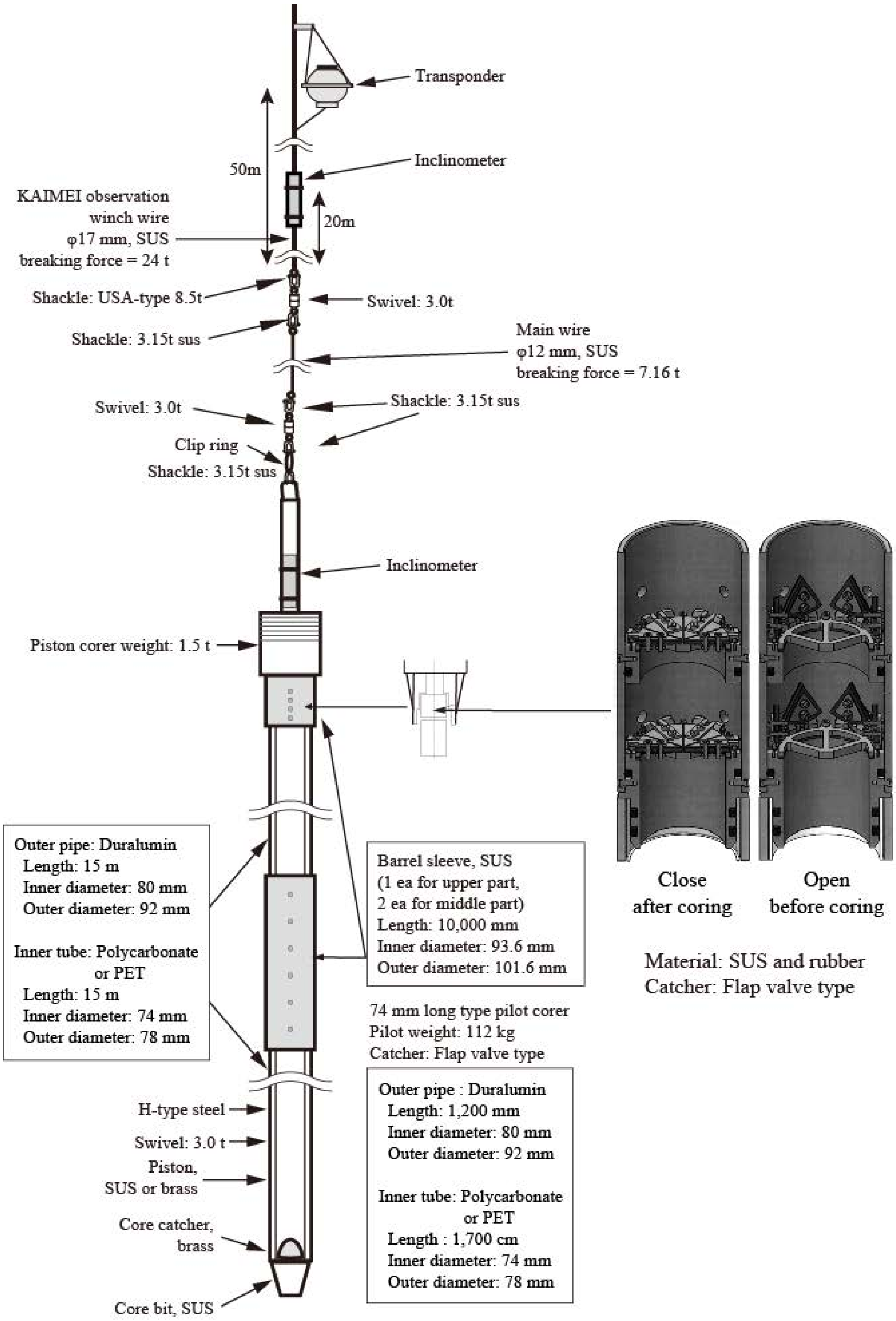

Fig. 3-2 Gravity corer system with 1.5 ton weight in the KM17-14C Cruise. Outer and inner pipe lengths were all 15 m. The outer pipe length of the pilot corer was 120 cm.

3.2.4 Core flow

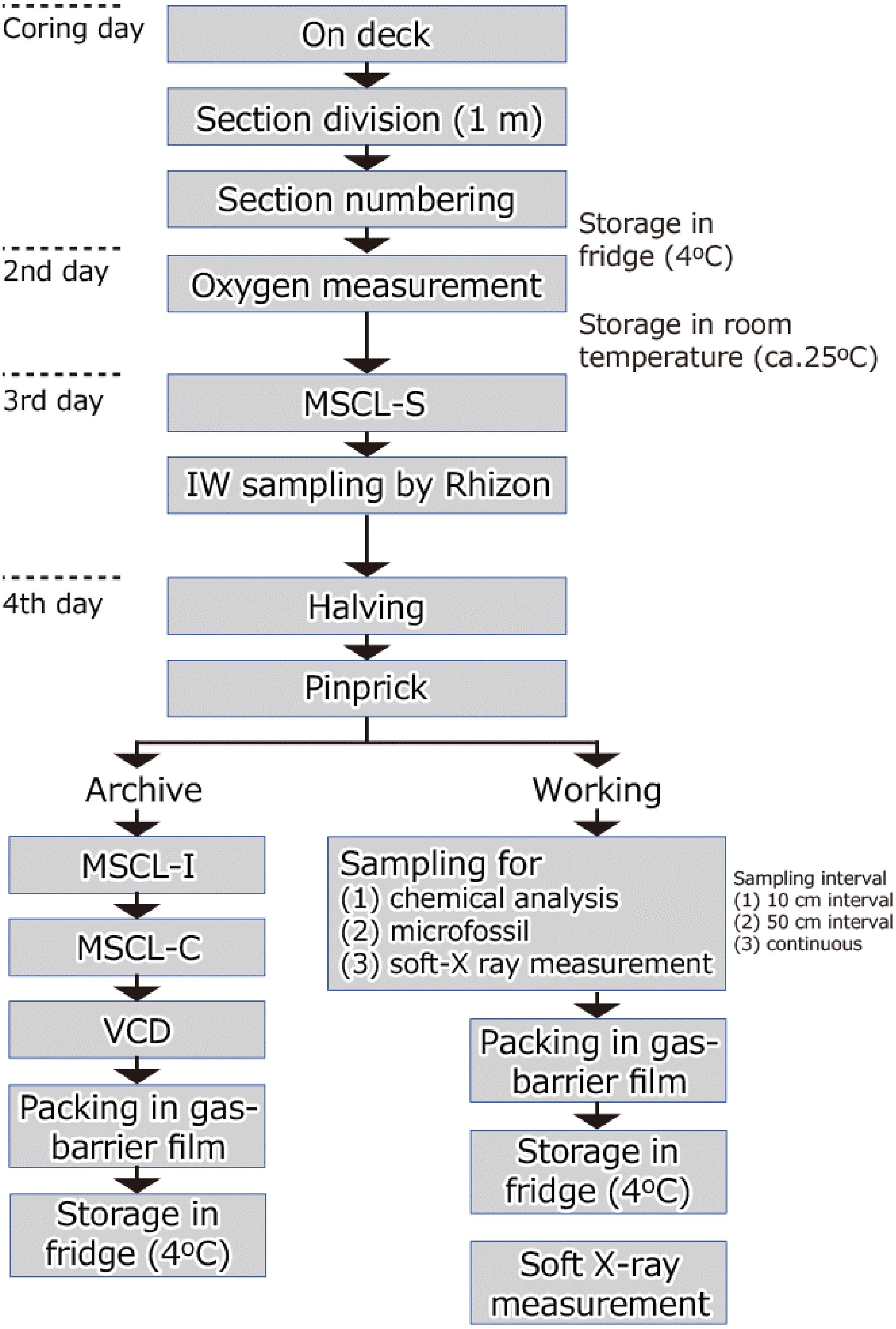

Fig. 3-3 Core flow of the KM17-14C Cruise. In this cruise, we did not measure pH of the interstitial water, and did not conduct interstitial water sampling using a squeezer for the whole-round sample.

3.3 Preliminary Results of Coring & HPD Dive Information

3.3.1 Preliminary Results

We have arrived at the westernmost part of the investigation area on 18th December 2017 and started geophysical survey using SBP, MBES, gravity meter, three-component magnetometer and so on. The ship track and survey lines of these geophysical researches are given in Figures 3-4 and 3-5.

During the KM17-14C Cruise, the sea state was relatively calm and we could perform deck operations continuously for 9 days from 19th to 27th December. We have tried to retrieve ADCP MA-05 on 19th December and sent a release command to acoustic releaser. Although the acoustic releasers did respond, ADCP MA-05 did not come to the surface and we gave up retrieving ADCP MA-05. From 20th to 27th December, HPD4500 dives and PC/GC samplings were conducted three and five times, respectively (Fig. 3-5 and Table 3-1). During the HPD4500 dives at the Takuyo Daigo Seamount, ca. 40 cm-long three core samples composed of upper part Fe-Mn crust whose basal part is coral or mixture of coral and altered basaltic rock were obtained by ROV coring system. Acoustic underwater camera was also utilized as much as possible during the HPD dives and captured detailed bathymetric angulation even under the cloudy condition by the ROV coring operation. At the PC/GC sampling operations, we compared core samples between PC and GC or polycarbonate and PET materials of inner tube to avoid deformation of core samples, and obtained following results; (1) penetration length into seafloor of GC03 was ca. 14 m, however, core length was only ca. 3 m which is much shorter than PC samples. Thus, unless an improvement was made, present specification of GC sampler is not suitable for seafloor sediment around the Minamitorishima Island, (2) comparison between polycarbonate and PET materials of the inner tube was conducted twice and deformation of core samples is slightly weaker in the case of PET inner tube, but additional operation will be necessary to confirm this observation. The KM17-14C Cruise is the first research cruise for full-operation of HPD dive and PC/GC sampling, but these operations were successfully completed.

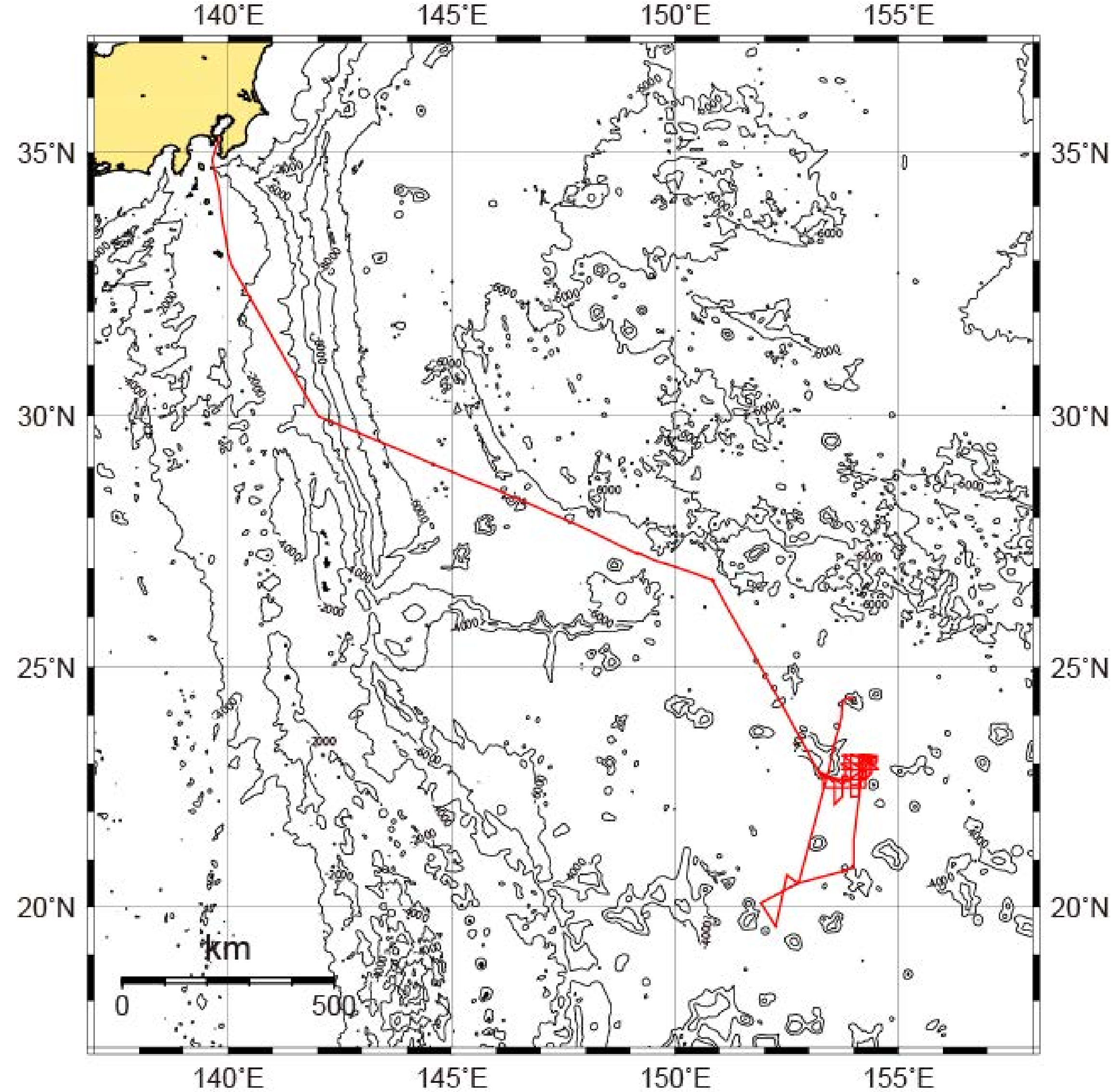

Fig. 3-4 Ship track of the KM17-14C Cruise in the investigation area.

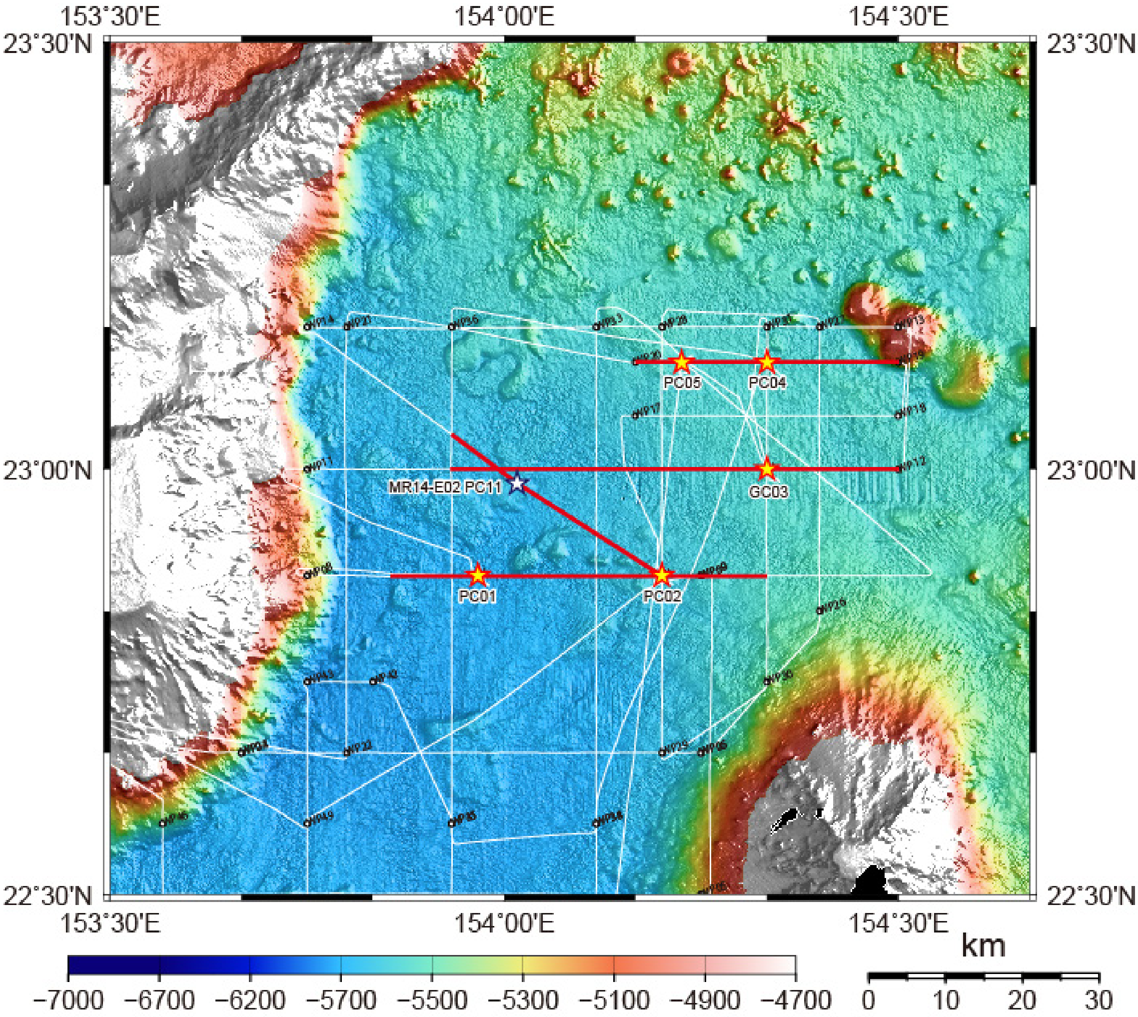

Fig. 3-5 Location map of the piston and gravity core sampling sites during the KM17-14C Cruise.

Table 3-1 Location, water depth, corer type and core length (recovery rate) of five piston and gravity core samples. Outer and inner pipe lengths were all 15 m. The outer pipe length of the pilot corer was 120 cm.

Date (UTC)	Core ID	Location	Water Depth	Position			Corer type		Core length (m)		Tension MAX
yyyymmdd			(m)	Latitude	Longitude	Type	Type*	Weight	PC	PL	(t)
2017/12/21	PC01	East of Takuyo-Daigo Seamount	5,708	22-52.4897N	153-57.9860E	Transponder	Polyca PC	1500 kg	11.71 / 15	1.42	2.8
2017/12/22	PC02	East of Takuyo-Daigo Seamount	5,613	22-52.4880N	154-11.9985E	Transponder	PET PC	1500 kg	12.79 / 15	0.93	3.9
2017/12/24	GC03	East of Takuyo-Daigo Seamount	5,556	22-59.9987N	154-20.0016E	Transponder	Polyca GC	1500 kg	3.08 / 15	0.62	3.3
2017/12/25	PC04	East of Takuyo-Daigo Seamount	5,564	23-07.4922N	154-20.0206E	Transponder	Polyca PC	1500 kg	9.92 / 15	0.32	3.3
2017/12/27	PC05	East of Takuyo-Daigo Seamount	5,568	23-07.4983N	154-13.4982E	Transponder	PET PC	1500 kg	10.71 / 15	0.00	3.1

* "PC" is Piston corer.

* "GC" is Gravity corer.

3.3.2 HPD Dive Information

3.3.2.1 HPD#2038 dive (20th December 2017) at the Takuyo Daigo Seamount

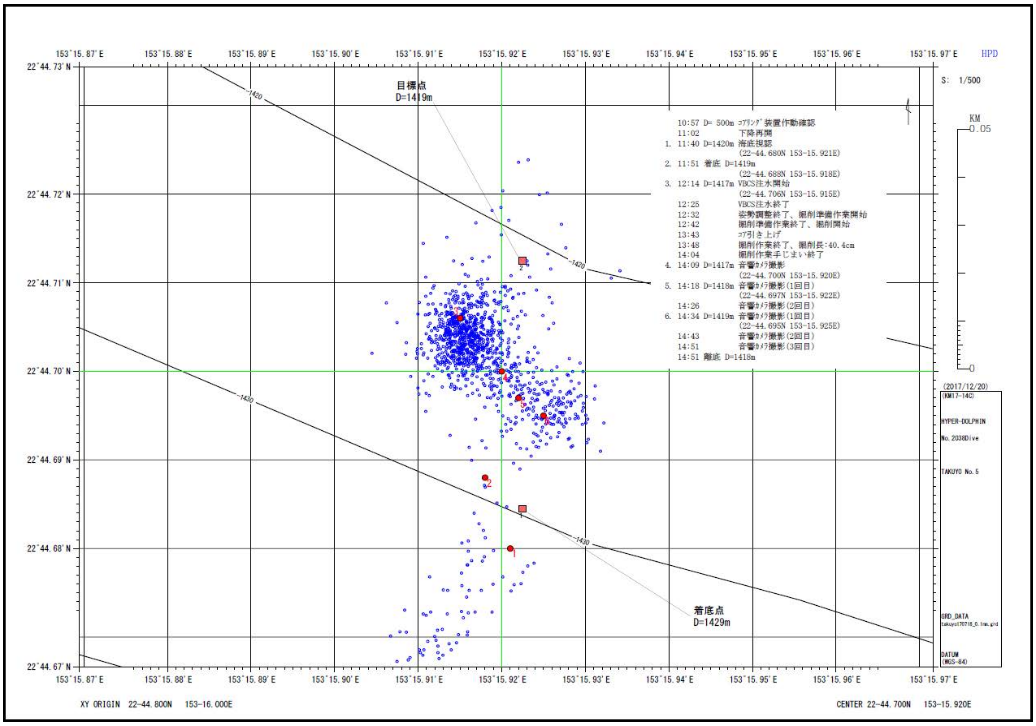

Fig. 3-6 Dive track and operation list of the HPD#2038 dive on a bathymetric map.

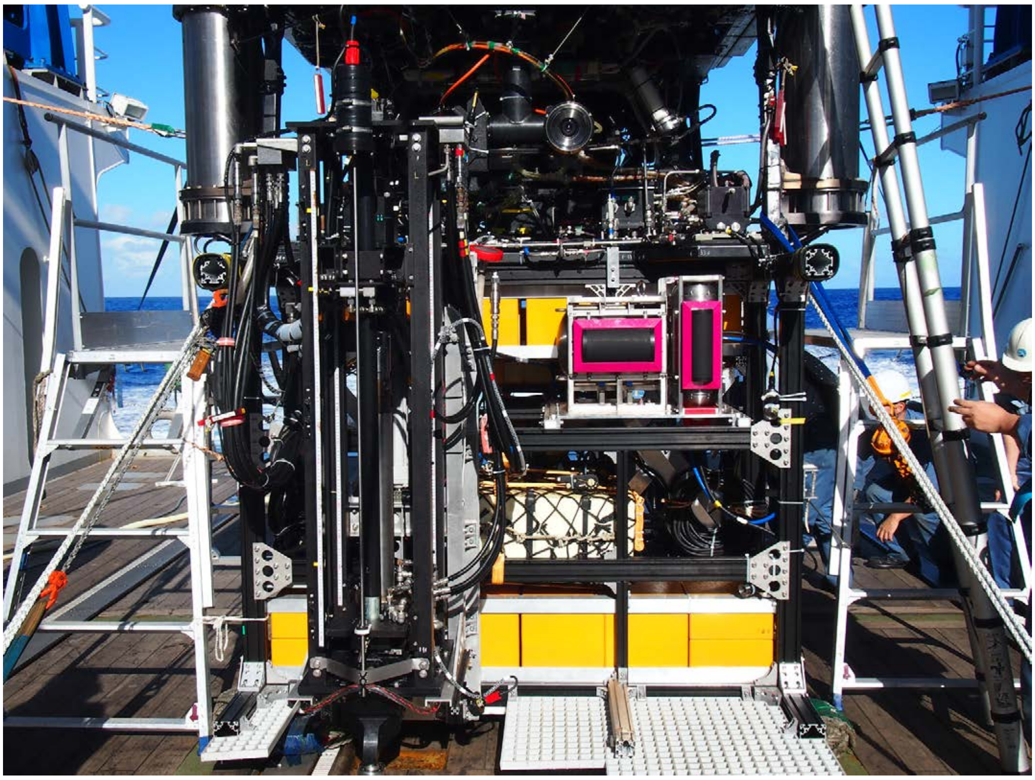

Fig. 3-7 Payload of the HPD#2038 dive.

Payload:

Isolated Hydraulic Power Unit (IHPU), VBCS (Variable ballast control system), ROV coring system, Acoustic underwater camera.

Operation:

As the first HPD dive site, we selected southwestern part of the Takuyo Daigo Seamount where a previous dive expedition was conducted (Fig. 3-6). At the water depths of 100, 500 and 1,000 mbsl, *in-situ* function tests of the ROV coring system with an attitude controlling system and acoustic underwater camera were performed. The *in-situ* function test all went well and then approached the tabular shape Fe-Mn crust (Fig. 3-8) whose basal part seemed to be composed of coral. ROV coring operation started at 12:42 (JST) and finished at 13:48. During this dive expedition, acoustic underwater camera took 15 images. The core sample is 38.0 cm in length and is composed of ca. 7 cm-thickness Fe-Mn crust and 31 cm-thickness basal coral. Sample disturbance by coring operation is very small and a high-quality core sample preserving the original texture and stratigraphy was obtained (Fig. 3-9).

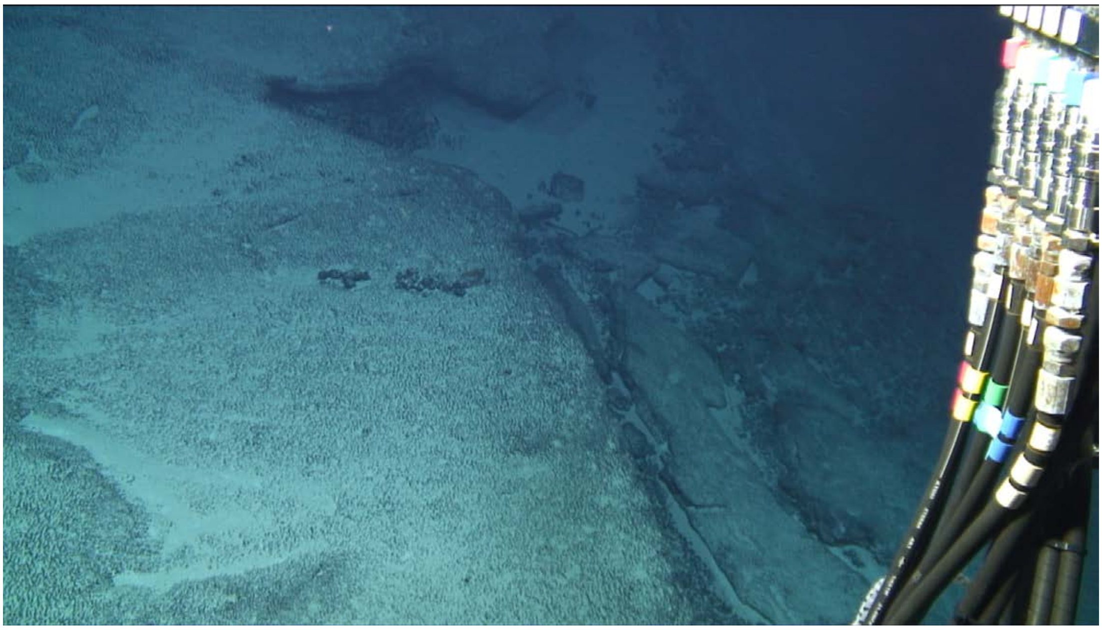

Fig. 3-8 Outcrop of tabular shaped Fe-Mn crust where ROV coring was performed.

Fig. 3-9 Sample photograph of HPD#2038 MC01.

3.3.2.2 HPD#2039 dive (23rd December 2017) at the Takuyo Daigo Seamount

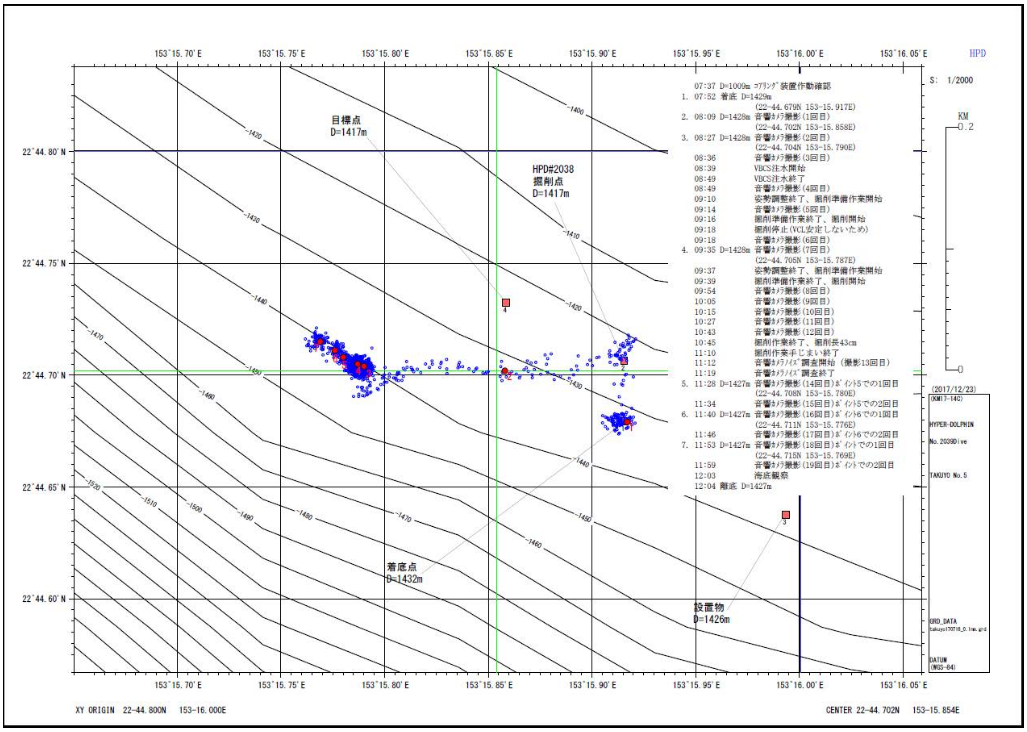

Fig. 3-10 Dive track and operation list of the HPD#2039 dive on a bathymetric map.

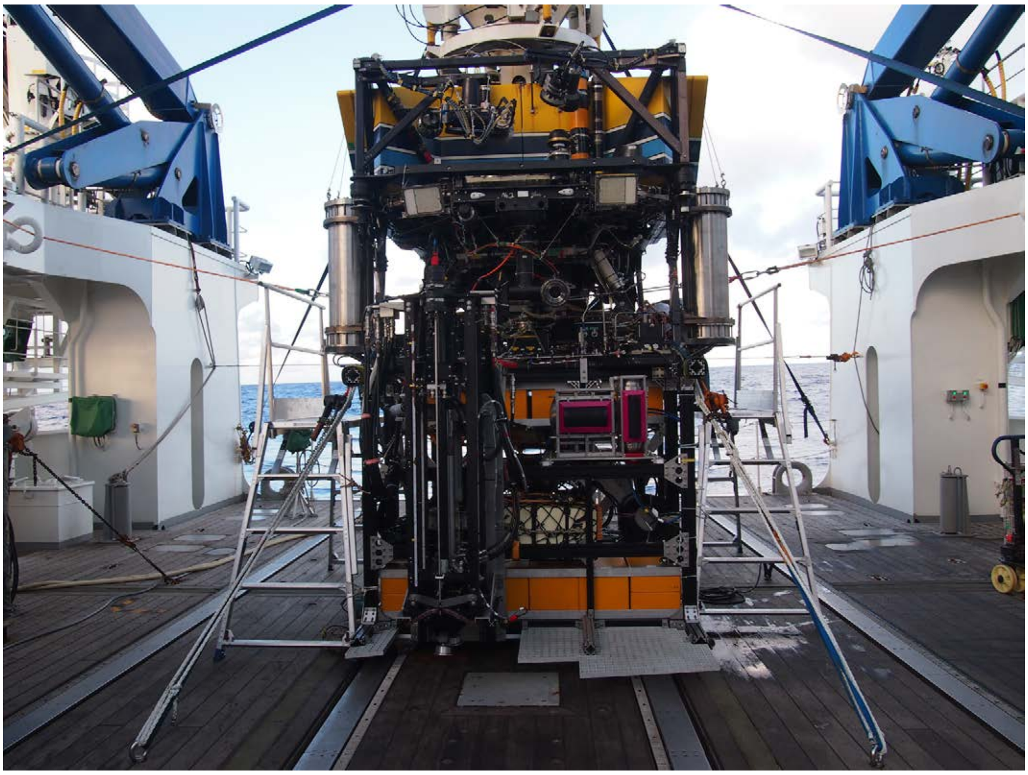

Fig. 3-11 Payload of the HPD#2039 dive.

Payload:

Isolated Hydraulic Power Unit (IHPU), VBCS (Variable ballast control system), ROV coring system, Acoustic underwater camera.

Operation:

As the second HPD dive site, we selected southwestern part of the Takuyo Daigo Seamount where a previous dive expedition was conducted (Fig. 3-10). At the water depths of 100, 500 and 1,000 mbsl, *in-situ* function tests of the ROV coring system with an attitude controlling system and acoustic underwater camera were performed. The *in-situ* function test all went well and then approached the pillow lava like shaped Fe-Mn crust (Fig. 3-12) whose basal part seemed to be composed of seamount basalt. ROV coring operation started at 09:16 (JST) and finished at 10:46. During this dive expedition, acoustic underwater camera took 19 images. The core sample is 39.0 cm in length and is composed of ca. 15 cm-thickness Fe-Mn crust and 24 cm-thickness mixture of altered seamount basalt and coral. Sample disturbance by coring operation is very small and a high-quality core sample preserving the original texture and stratigraphy was obtained (Fig. 3-13).

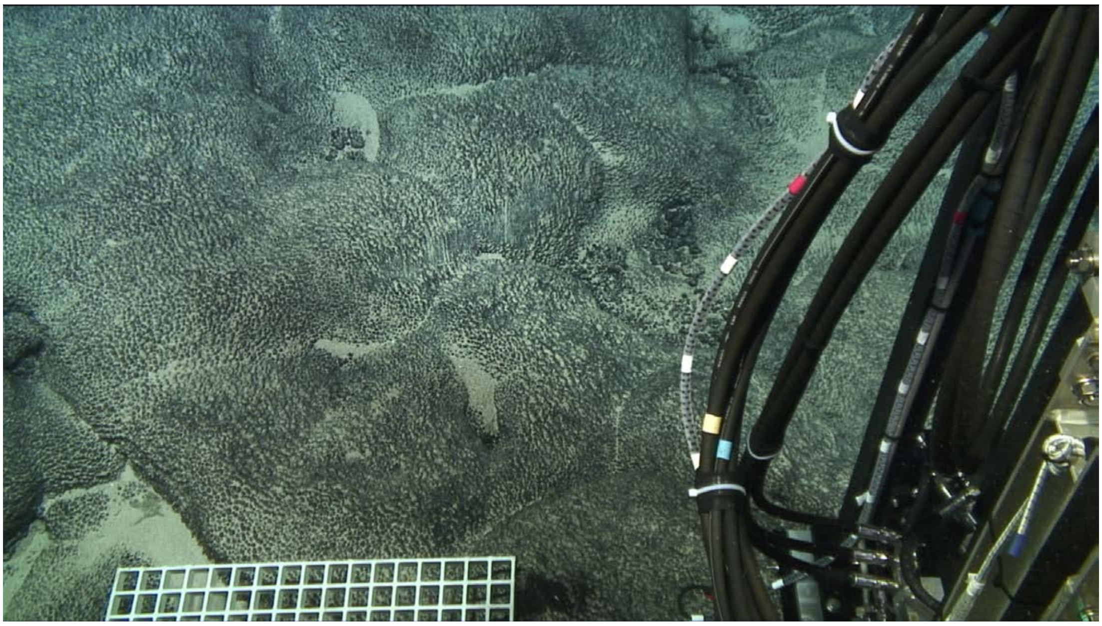

Fig. 3-12 Outcrop of pillow lava like shaped Fe-Mn crust where ROV coring was performed.

Fig. 3-13 Sample photograph of HPD#2039 MC01.

3.3.2.3 HPD#2040 dive (26th December 2017) at the Takuyo Daigo Seamount

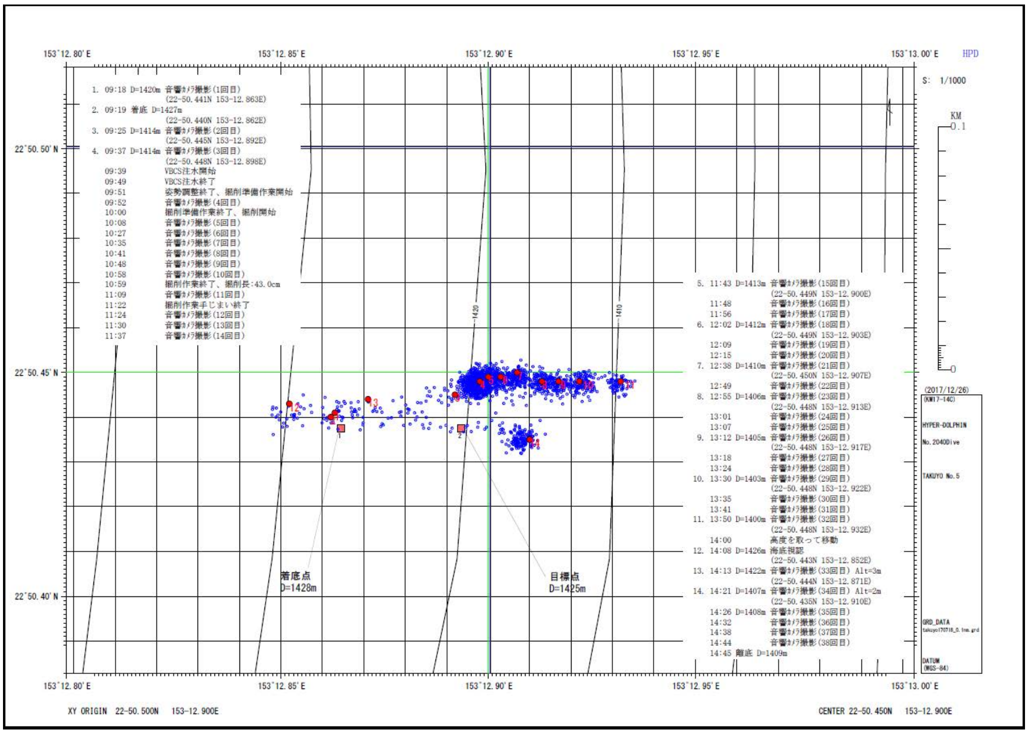

Fig. 3-14 Dive track and operation list of the HPD#2040 dive on a bathymetric map.

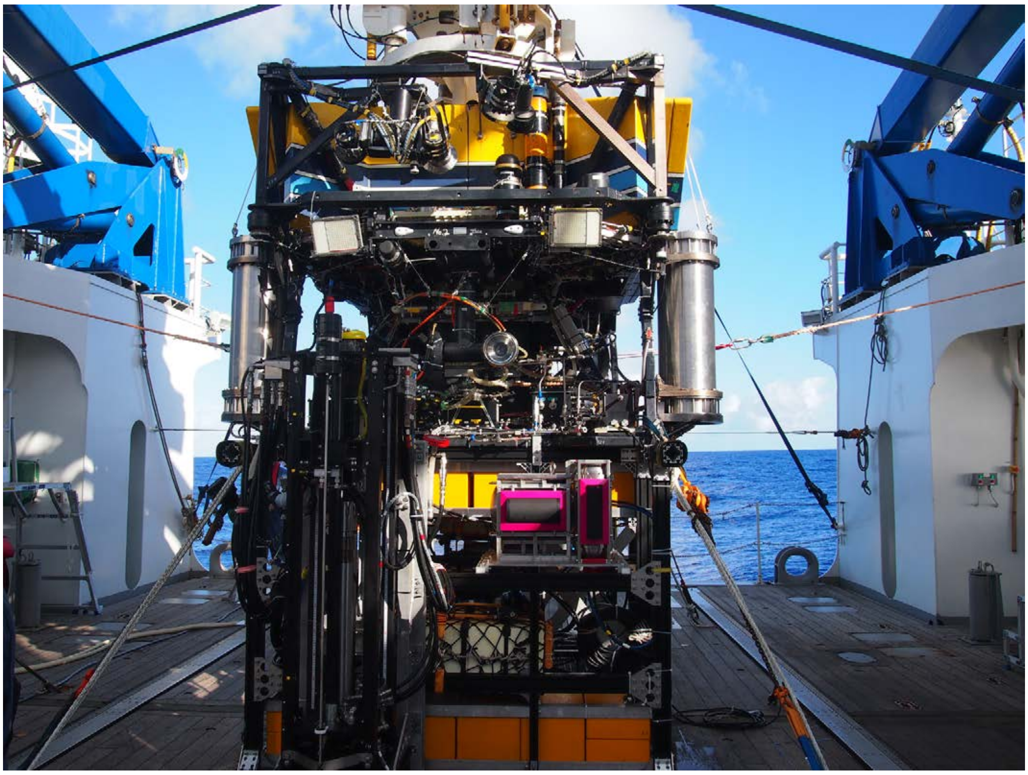

Fig. 3-15 Payload of the HPD#2040 dive.

Payload:

Isolated Hydraulic Power Unit (IHPU), VBCS (Variable ballast control system), ROV coring system, Acoustic underwater camera.

Operation:

As the third HPD dive site, we selected western part of the Takuyo Daigo Seamount where a previous dive expedition was conducted (Fig. 3-14). At the water depths of 100, 500 and 1,000 mbsl, *in-situ* function tests of the ROV coring system with an attitude controlling system and acoustic underwater camera were performed. The *in-situ* function test all went well and then approached the tabular shaped Fe-Mn crust (Fig. 3-16) whose basal part seemed to be composed of coral. ROV coring operation started at 10:00 (JST) and finished at 10:59. During this dive expedition, acoustic underwater camera took 38 images. The core sample is 45.0 cm in length and is composed of ca. 7 cm-thickness Fe-Mn crust and 38 cm-thickness of coral. Sample disturbance by coring operation is very small and a high-quality core sample preserving the original texture and stratigraphy was obtained (Fig. 3-17).

Fig. 3-16 Outcrop of tabular shaped Fe-Mn crust where ROV coring was performed.

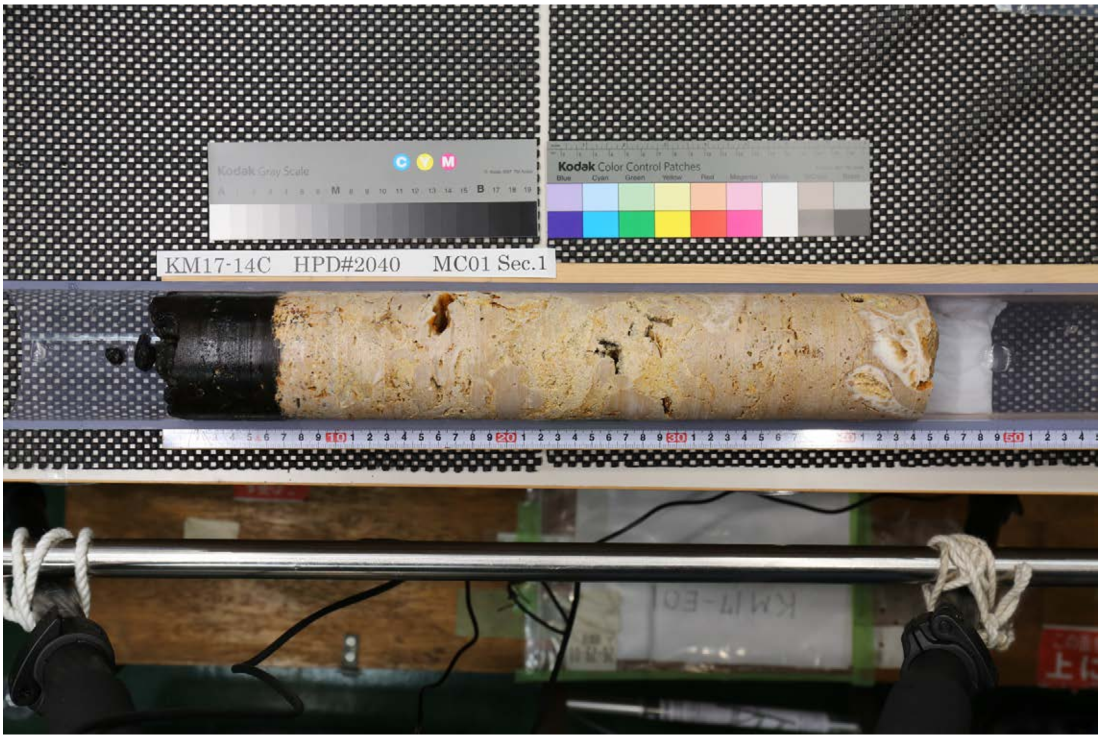

Fig. 3-17 Sample photograph of HPD#2040 MC01.

4. Notice on Using

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.