

Cruise Report

NT15-17

Scientific research for oceanic mineral resource formation



Okinawa trough, South-West Japan

R/V Natsushima

27 Aug 2015 – 7 Sep 2015

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Acknowledgements

We would like to thank Captain and all ship crew of R/V Natsushima for their safe cruise. We are grateful to ROV HPD operation team and marine technicians of NME for their operation. We are pleased to MARITEC/JAMSTEC staff for their supports during our cruise.

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

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Cruise summary of NT15-17 cruise

1. Cruise information

Cruise number	NT15-17
Name of the cruise	R/V Natsushima
Chief scientist	Takafumi Kasaya (CEAT, JAMSTEC)
Representative of the proposal	Takafumi Kasaya (CEAT, JAMSTEC)
Title of the cruise	『Scientific research for oceanic mineral resource formation』
Title of the cruise proposal	Hydro-thermal structure survey around the hydrothermal deposit and development for the long-term monitoring of hydrothermal activity
Cruise period	27 Aug 2015– 7 Sep 2015
Ports of call	Naha port – Nagasaki port
Research Area	Okinara trough (Fig.1)

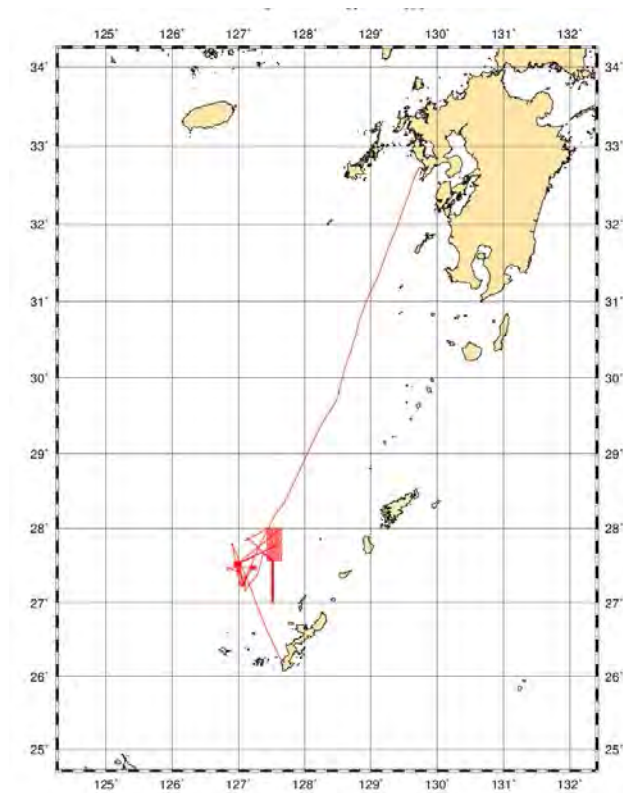


Fig.1 Ship track of NT15-17

List of participant

Science party

Chief scientist	TAKAFUMI KASAYA
Scientist	TADA-NORI GOTO
Scientist	YASUNORI MURAKAMI
Scientist	HISANORI IWAMOTO
Scientist	YUSUKE OTA
Scientist	SHINYA SATO
Marine technician	TAKUYA ONODERA

Ship crew

Captain	HIROAKI MASUJIMA
Chief Officer	MASATO CHIBA
2nd Officer	HIDEHIKO KONNO
3rd Officer	RYO YAMAGUCHI
Chief Engineer	KIYONORI KAJINISHI
1st Engineer	YOSHINOBU HIRATSUKA
2nd Engineer	TAKAATSU INOMOTO
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	YUKI YOSHINO
Able Seaman	SHUN ABE
Able Seaman	TORU NAKANISHI
Sailor	KYOHEI MURAI
No.1 Oiler	YUKIHIRO YAMAGUCHI
Oiler	KAZUOI SATO
Oiler	MASAKI TANAKA
Oiler	TAKUYA WATANABE
Oiler	KOSHI NAKAJIMA
Chief Steward	SUETO SASAKI
Steward	HIDEO FUKUMURA

Steward	AKIO SUZUKI
Steward	KAZUHIRO HIRAYAMA
Steward	KOICHIRO KASHIWAGI

HYPER-DOLPHIN Operation Team

Operation Manager	KAZUHIRO CHIBA
2nd ROV Operator	KATSUSHI CHIBA
2nd ROV Operator	TETSUYA ISHITSUKA
2nd ROV Operator	SHIGERU KIKUYA
2nd ROV Operator	ATSUSHI TAKENOUCHI
3rd ROV Operator	SHINNOSUKE KUMAGAI

2. Ship Logs

2015/8/27 NAHA-ko 3-2 wharf (26-14.3N, 127-40.8E)

Weather: Fine but cloudy / Wind direction: North/ Wind force: 3/ Wave scale: 2 /
Swell scale: 1 / Visibility: 7 miles (12:00 JST)

09:00 onboard
13:00-13:30 carried out education and training for scientist

2015/8/28 Off Northwestern Okinawa Shima (27-47.4N, 126-53.9E)

Weather: Rain/ Wind direction: ESE/ Wind force: 3/ Wave scale: 2 /
Swell scale: 1 / Visibility: 5 miles (12:00 JST)

6:00 released XBT.
8:17 hoisted up "HPD3000".
8:22 launched "HPD3000".
8:37 "HPD3000" dove and started her operation #1870.
9:28 "HPD3000" landed on the sea bottom. (Depth=1071m)
16:31 "HPD3000" left the sea bottom. (Depth=1057m)
17:13 hoisted up #HPD3000".
17:20 recovered "HPD3000".
19:00-19:30 scientists meeting

2015/8/29 Off Northwestern Okinawa Shima (27-15.0N, 127-04.0E)

Weather: Cloudy / Wind direction: SSW/ Wind force: 5/ Wave scale: 3 /
Swell scale: 2 / Visibility: 7 miles (12:00 JST)

8:08 hoisted up "HPD3000".
8:11 launched "HPD3000".
8:26 "HPD3000" dove and started her operation #1871.
9:29 "HPD3000" landed on the sea bottom. (Depth= 1634m)
17:02 "HPD3000" left the sea bottom.(Depth= 1634m)
17:54 hoisted up #HPD3000".
17:58 recovered "HPD3000".
19:00-19:15 carried out MBES mapping survey.

2015/8/30 Off Northwestern Okinawa Shima (27-15.0N, 127-04.0E)

Weather: Cloudy / Wind direction: SSE/ Wind force: 5/ Wave scale: 3 /

Swell scale: 2 / Visibility: 7 miles (12:00 JST)

8:06	hoisted up "HPD3000".
8:10	launched "HPD3000".
8:24	"HPD3000" dove and started her operation #1872.
9:17	"HPD3000" landed on the sea bottom. (Depth=1622m)
17:01	"HPD3000" left the sea bottom.(Depth=1640m)
17:55	hoisted up #HPD3000".
18:00	recovered "HPD3000".
19:00-19:10	scientists meeting

2015/8/31 Off Northwestern Okinawa Shima (27-20.0N, 127-03.0E)

Weather: Fine but cloudy / Wind direction: South/ Wind force: 2/ Wave scale: 2 /

Swell scale: 1 / Visibility: 7 miles (12:00 JST)

06:59	sent release command to OBEM (Point : D2)
08:08	recovered OBEM
09:14	sent release command to OBEM(Point : D3)
10:12	recovered OBEM
10:46	sent release command to OBEM(Point : D4)
11:43	recovered OBEM
12:57	sent release command to OBEM(Point : D5)
13:56	recovered OBEM
15:38	sent release command to OBEM(Point : D8)
16:26	recovered OBEM
17:59	sent release command to OBEM(Point : D7)
19:05	recovered OBEM
20:03	carried out MBES mapping survey

2015/9/1 Off Northwestern Okinawa Shima (27-28.0N, 127-32.0E)

Weather: Cloudy / Wind direction: SSW/ Wind force: 4/ Wave scale: 3 /

Swell scale: 1 / Visibility: 7 miles (12:00 JST)

12:37	finished MBES mapping survey
16:17	deployed OBEM(D6)
16:44	OBEM launched the sea bottom & calibration.
17:51	deployed OBEM(D1)
18:18	OBEM launched the sea bottom & calibration.
20:15-	carried out MBES mapping survey

2015/9/2 Off Northwestern Okinawa Shima (27-35.0N, 127-30.0E)

Weather: Cloudy / Wind direction: South/ Wind force: 3/ Wave scale: 2 /

Swell scale: 1 / Visibility: 7 miles (12:00 JST)

All day	MBES mapping survey
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2015/9/3 Off Northwestern Okinawa Shima (27-31.0N, 126-59.0E)

Weather: Fine but cloudy / Wind direction: WSW/ Wind force: 3/ Wave scale: 2 /

Swell scale: 1 / Visibility: 7 miles (12:00 JST)

8:06	hoisted up "HPD3000".
8:10	launched "HPD3000".
8:23	"HPD3000" dove and started her operation #1873
9:15	"HPD3000" landed on the sea bottom. (Depth=1597m)
17:03	"HPD3000" left the sea bottom.(Depth=1548m)
17:46	hoisted up #HPD3000".
18:00	recovered "HPD3000".
19:00-19:30	scientists meeting

2015/9/4 Off Northwestern Okinawa Shima (27-56.0N, 127-36.0E)

Weather: Cloudy / Wind direction: NNE/ Wind force: 2/ Wave scale: 2 /

Swell scale: 1 / Visibility: 7 miles (12:00 JST)

All day	MBES mapping survey
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2015/9/5 Off Northwestern Okinawa Shima (27-15.0N, 127-04.0E)

Weather: Fine but cloudy / Wind direction: SSW / Wind force: 3/ Wave scale: 2 /

Swell scale: 1 / Visibility: 7 miles (12:00 JST)

7:05	hoisted up "HPD3000".
7:09	launched "HPD3000".
7:23	"HPD3000" dove and started her operation #1874
8:18	"HPD3000" landed on the sea bottom. (Depth=1572m)
9:37	"HPD3000" left the sea bottom. (Depth=1572m)
10:27	hoisted up #HPD3000".
10:32	recovered "HPD3000".
	proceed to Izena
12:15	arrived at Izena
12:44	hoisted up "HPD3000".
12:48	launched "HPD3000".
13:00	"HPD3000" dove and started her operation #1875
13:57	"HPD3000" landed on the sea bottom. (Depth=1603m)
17:50	"HPD3000" left the sea bottom.(Depth=1615m)
18:47	hoisted up #HPD3000".
18:51	recovered "HPD3000".
19:30-20:00	scientists meeting

2015/9/6 Off Western YAKUSHIMA (30-08.0N, 126-36.0E)

Weather: Fine but cloudy / Wind direction: WSW/ Wind force: 6/ Wave scale: 3 /

Swell scale: 3 / Visibility: 7 miles (12:00 JST)

All day transit to NAGASAKI

2015/9/7 Arrive at NAGASAKI KO

09:00 arrived at NAGASAKI KO

scientists disembarked NATSUSHIMA

finished NT15-17 cruise

3. Instruments

3.1 Ocean bottom electro-magnetometer (OBEM)

The OBEM system can measure time variations of three components of magnetic field, two components of horizontal electric field, the instrumental tilts, and temperature. It mainly consists of one 17-inch glass sphere, sensor unit in aluminium/titanium pressure housing and electrode arm unit with arm holding mechanism (Fig. 4.1.1). The glass sphere involves data logger and a lithium battery pack. The sensor unit has a high-accuracy fluxgate magnetometer, tiltmeter and thermometer. The electrodes are Ag-AgCl equilibrium type made by Clover Tech. For electric field, four voltage differences between the electrodes on the tip of the pipes and the ground electrode are measured. The electrodes were monitored their self-potentials in laboratory in advance of the seafloor observation and pairs that the coherence is high enough were selected, in order to reduce the noise due to the voltage drift of electrodes themselves. A transponder unit, radio beacon and a flashlight are also mounted on the OBEM. The acoustic system can communicate with the SSBL system and it is easy for us to detect its position in the sea or on the seafloor. There are a transponder unit mounted on the OBEM system. This transponder unit, of which the acoustic and the pressure case units are combined, has a 2-year battery life.

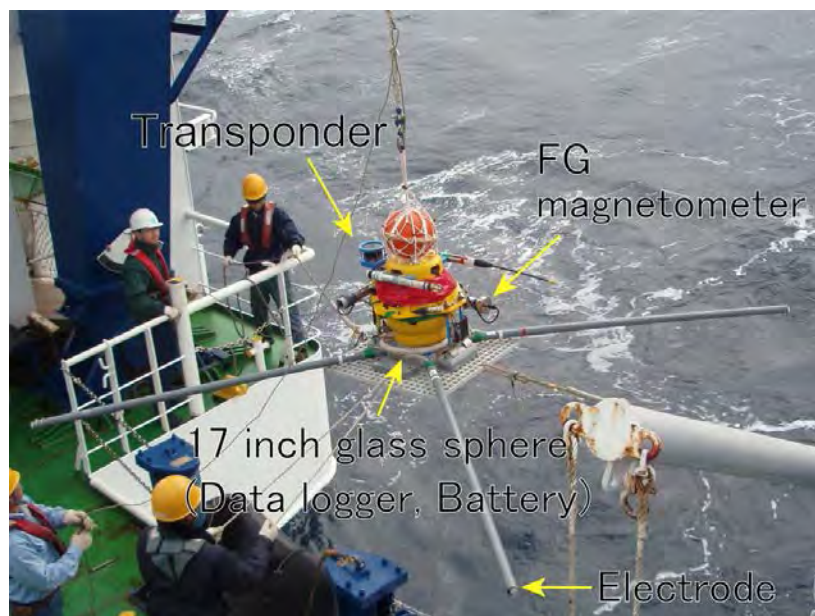


Fig. 3.1.1 OBEM system

Concepts of the type the OBEM system are miniaturization, a high sampling rate, easy assembly and recovery operations, and low costs of construction and operation. The arm holding mechanism, which electrode arm is folded when OBEM is in surfacing (Fig. 4.1.2), enable recovery

operation even by the small ship that do not equip A frame ([Kasaya et al., 2006](#); [Kasaya and Goto, 2009](#)).

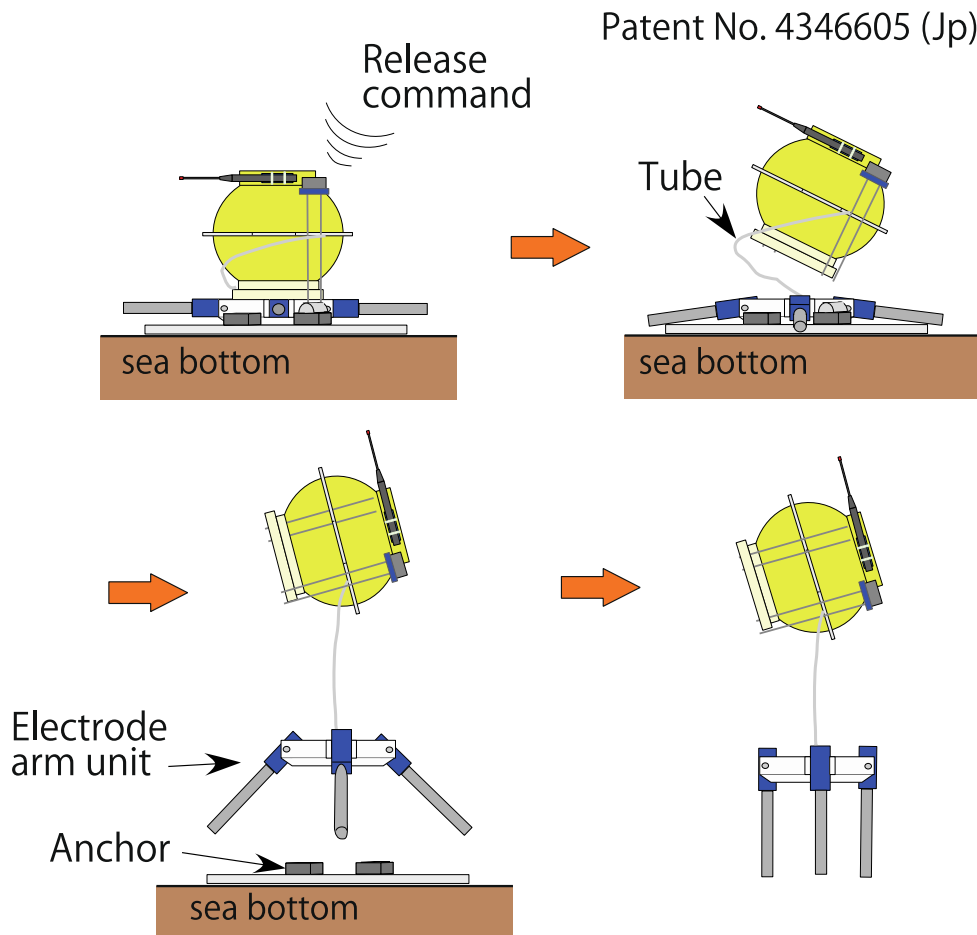


Fig. 3.1.2 Electrode arm-holding mechanism of type A OBEM

References

- Kasaya, T., T. Goto, and R. Takagi, Marine electromagnetic observation technique and its development –For crustal structure survey-, *BUTSURI-TANSA*, **59**, 585-594 (in Japanese with English abstract), 2006.
- Kasaya, T., and T. Goto, A small OBEM and OBE system with an arm folding mechanism, *Exploration Geophysics*, **40**, 41-48, 2009.

3.2 Ocean bottom electrometer (OBE)

The OBE system is designed for the controlled source survey with over 20 Hz sampling. An electric circuit and battery are involved in one cylinder type aluminum pressure case. In this cruise, this OBE system was used as a mobile type with short electrode arms (Fig. 1.2.1), and two mobile OBEs were set up by the ROV HPD.

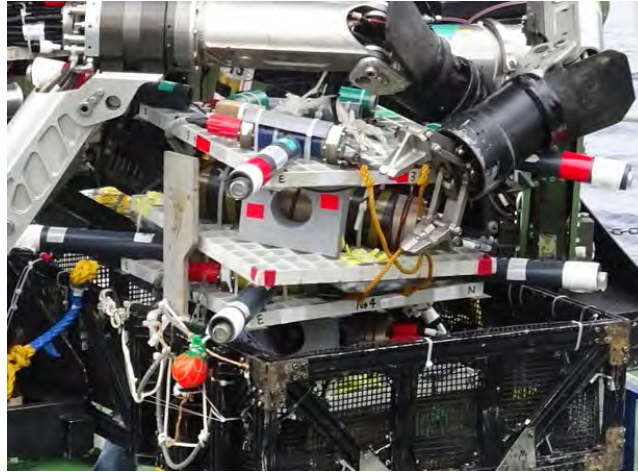


Fig. 3.2.1 Photo of two mobile type OBE on the HPD

3.3 DC resistivity system

On this cruise, we used the improved system based on the A-MANTA, called “HF-MANTA”. This system consists of a transmitter unit and a main unit with a data logger, which recorded a transmitting signal. The AC 100 V supplied from the ROV Hyper Dolphin transfers to DC 48 V, and it is input to a transmitter unit. The logger unit can record data of output power data of a transmitter unit. The maximum output power of both transmitter is about 1.2 kW with maximum voltage of 48V peak-to-peak and current of 50A. A receiver unit was also load on it, and five electric fields were recorded with a 500 Hz sampling rate maximum.

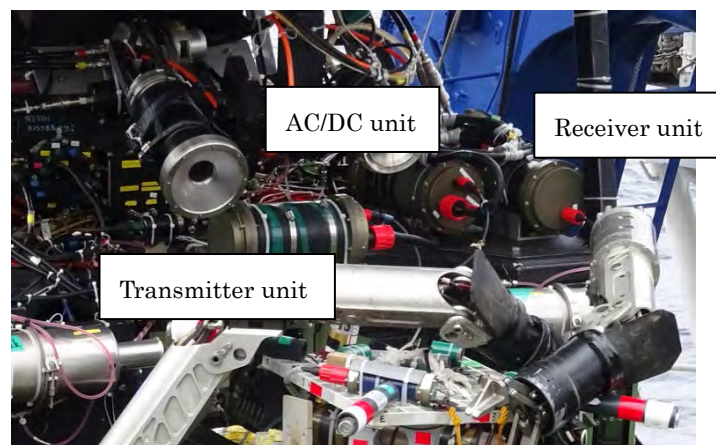


Fig. 3.3.1 Photo of a controlled source survey system on the ROV Hyper Dolphin.

Table 3.3.1 Specification of a control source survey system

Power unit

Max Input Voltage: 120 V

Max Output Current: 50 A

Circuit type: IGBT

Transmit channel: 4 ch

Main unit

Control unit

Max Measurement Current Range: 50 A

Max Measurement Voltage Range: 200V

A/D converter: 24 bit

Recording Media: SDHC

Sampling rate: 500 Hz (Max.)

Logger unit

Measurement channels: 5 CH

Measurement Voltage Range: ± 100 mV

A/D converter: 24 bit

Recording Media: SDHC

Sampling rate: 500 Hz (Max.)

4. Operation report

4.1 Shipboard data

We conducted a surface survey to detect the existence of unknown hydrothermal activity using the water column data of the MBES and to obtain the detailed bathymetry around the Okinawa Trough (Fig.4.1.1). Each survey was obtained with 5 knots and 8 knots ship speed, respectively. Bathymetric data were collected by a hull-mounted multi-narrow beam echo sounder “SEABAT 8160” of the R/V Natsushima. The SEABAT 8160 system used 50 kHz signal and has hydrophone arrays that synthesize narrow, fan-shaped beams. To correct the accurate sound velocity of water column for ray-path correction of acoustic multi-beam signal, we used the deeper depth sound velocity profiles that were calculated from temperature from XBT data by the equation in Mackenzie (1981) during the cruise. Table 4.1.1 shows the information of four XBT observation sites.

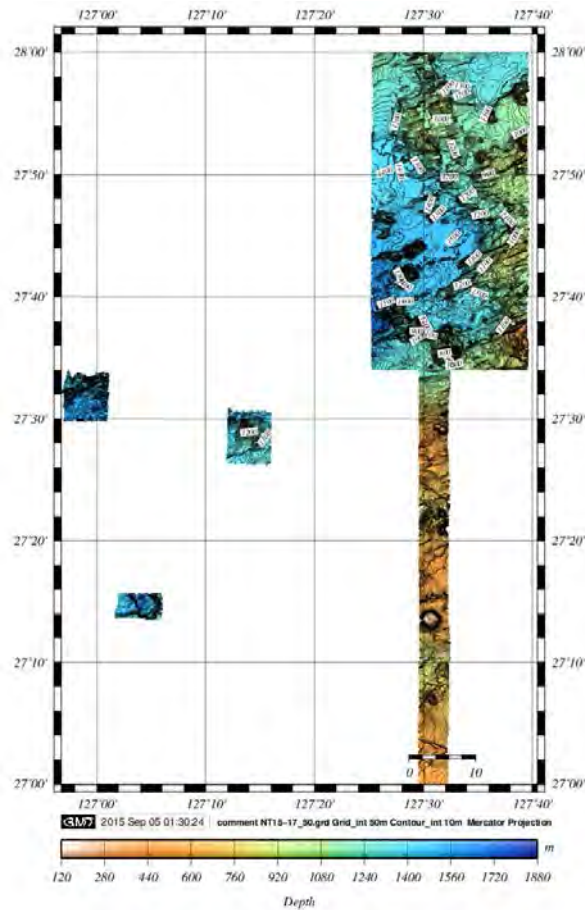


Fig. 4.1.1 Preliminary bathymetry map obtained in this cruise.

Table 5.1.3 Information of the XBT observations.

Date (UTC)		Latitude	Longitude
2015/8/27	21:00:06	27-47.4604N	126-54.0657E
2015/8/28	11:52:04	27-16.3681N	127-00.6051E
2015/8/31	09:23:05	27-39.9968N	127-22.3213E
2015/9/03	09:07:04	27-30.9049N	126:59.5013E

4.2 OBEM's recovery and deployment

Table 4.2.1 shows a list of recovered OBEMs set up in the YK15-06 cruise. We tracked the OBEM's positions by SSBL system of R/V Natsushima while they were ascending after sending acoustic release command. The ascent rate was approximately 40 m/min. We found with the ship looking, radio beacon and flasher. We could recover every six units successfully. After finishing recovery operation, the time difference between the OBEM's clock and the laptop pc synchronized by NTP server were measured. We could obtain enough quality EM data including some geomagnetic signals. Moreover, two OBEMs deployed at site D1 and D6 (Fig.4.2.1, Table 4.2.2). Their recovery operation will be carried out in the KR15-17 cruise.

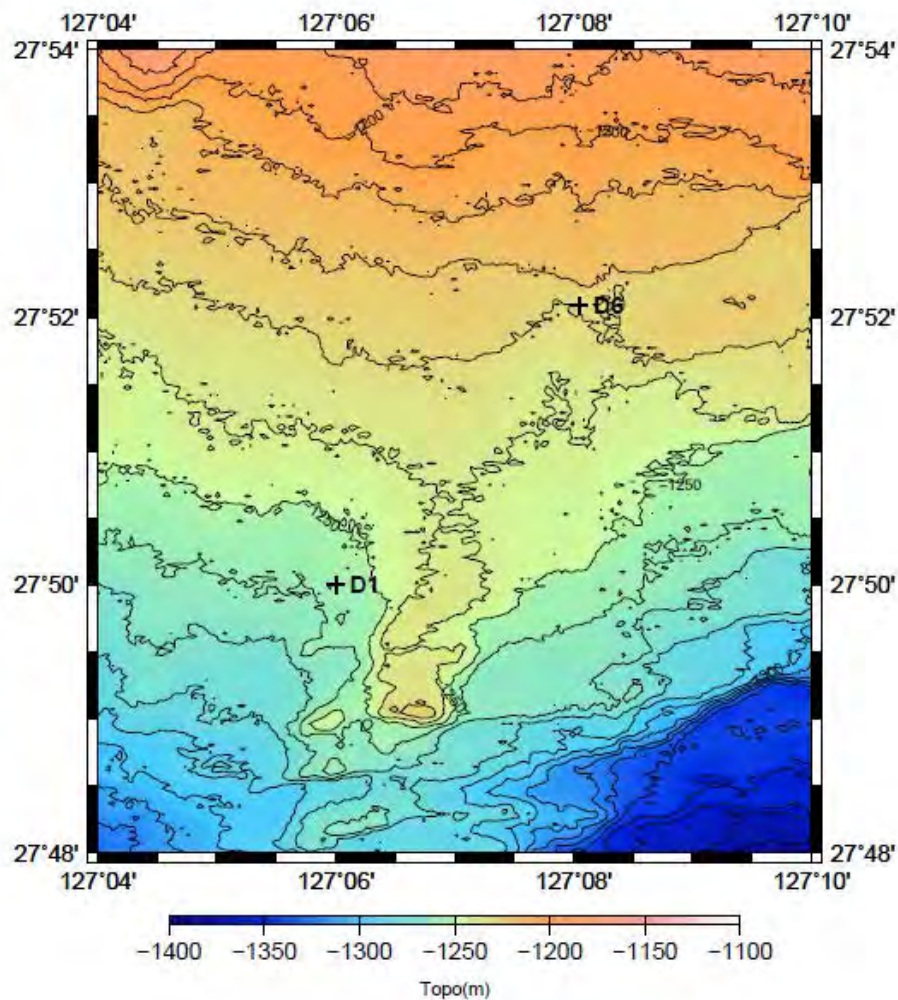


Figure 4.2.1 Site map of deployed OBEMs.

Table 4.2.1 Information of the recovered OBEMs.

Site ID	OBEM ID	Deployed time (JST)	Landed Latitude	Landed Longitude	Depth (m)	Recovered time (JST)
D2	KYT02	2015/4/30 6:15	27-27.9884N	126-50.0016E	1656.0	2015/8/31 08:08
D3	JM109	2015/4/25 6:21	27-24.4398N	127-00.9945E	1470.0	2015/8/31 10:12
D4	JM401	2015/4/26 6:36	27-21.4519N	127-02.0304E	1449.0	2015/8/31 11:43
D5	KYT01	2015/4/22 14:59	27-10.0440N	127-06.0323E	1489.0	2015/8/31 13:56
D7	JM108	2015/4/27 6:49	27-40.0196N	127-22.2826E	1638.4	2015/8/31 19:05
D8	JM110	2015/4/27 15:57	27-23.9935N	127-17.9387E	1057.0	2015/8/31 16:26

Table 4.2.2 Information of the deployed OBEMs.

Site ID	OBEM ID	Deployed time (JST)	Landed Latitude	Landed Longitude	Depth (m)	Notice
D1	JM402	2015/9/1 17:51	27-50.0020N	127-06.0010E	1257.3	
D6	JM401	2015/9/1 16:17	27-52.0850N	127-08.0460E	1230.1	

4.3 Summary of ROV HPD dives

4.3.1 Outline of ROV HPD dives

In the first dive, we first recovered a long-term electrometer with a 5ch underground thermometer (DOMES) in the Iheya Norh Knoll region (Fig. 4.3.1). Before the recovery operation, the DC resistivity data were collected around the chimney area near by the site a DOMES site. In the DC resistivity survey, we first set up two mobile type OBEs (Fig. 3.2.1) near by the hydrothermal site. Next, we transmit the electric signal to OBEs, and the HPD move along the some survey lines in each survey area. The electric field data were recorded on the data logger of the mobile OBEs. Next, we successfully conducted the DC resistivity survey in HPD #1871 and 1872 dive at the around the North mound and Jade site in the Izena hole (Fig. 4.3.2). We also success the DC resistivity survey using two dive in the Noho sites (Fig. 5.3.3). In last dive (HPD #1875), visual observation was carried out around the southern area of the south mound before the DC resistivity survey.

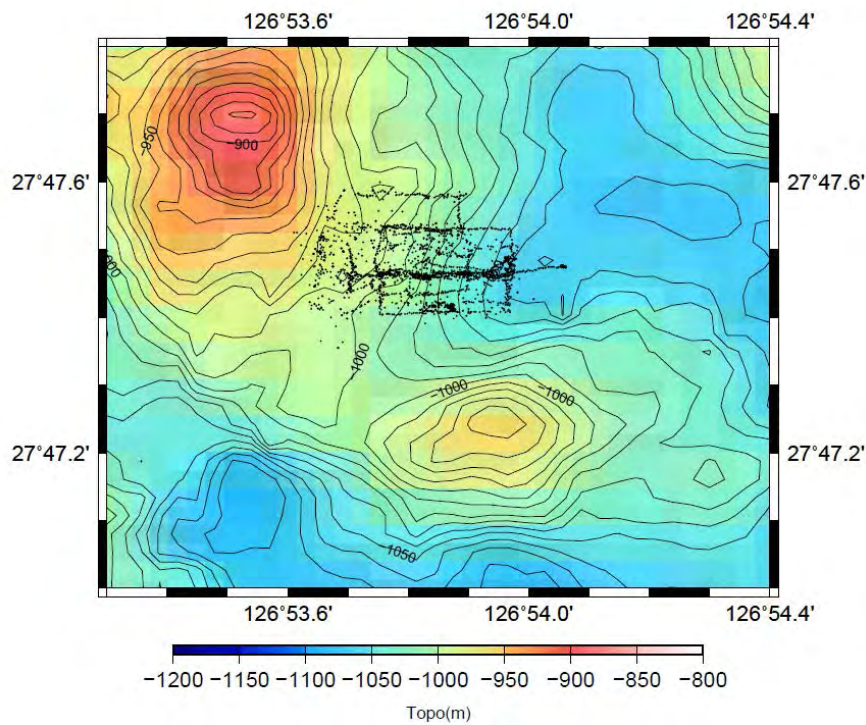


Fig. 4.3.1 HPD #1870 dive track in the North Iheya field.

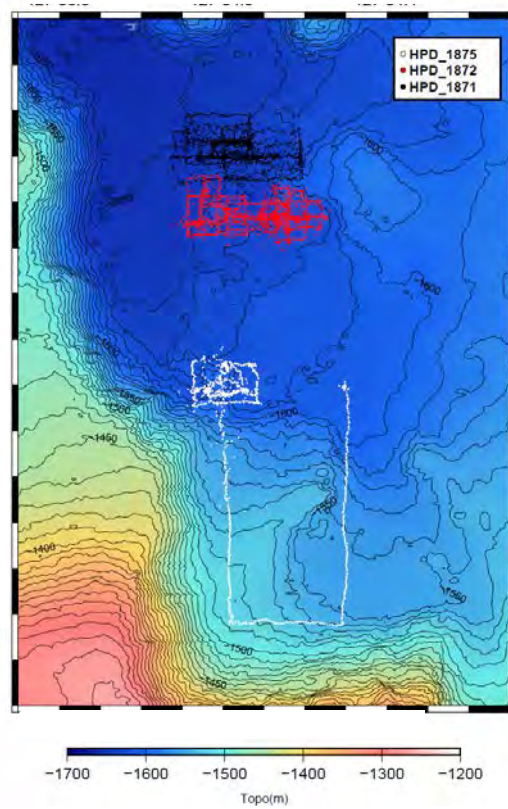


Fig. 4.3.2 HPD dive tracks around the Izena hole.

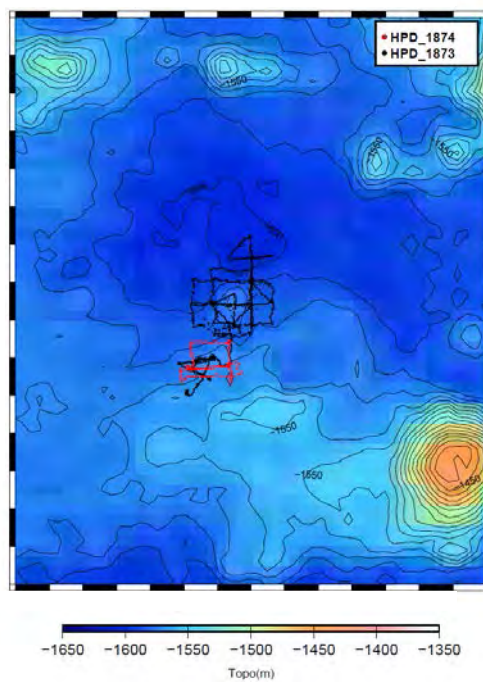


Fig. 4.3.3 HPD dive tracks in the Noho sites.

4.3.2 Rock sampling

Rock sampling and measurements of physical properties of the samples are essential for detailed interpretation of sub-seafloor structure inferred by geophysical explorations. In this cruise, we carried out rock sampling around the hydrothermal venting areas in Okinawa trough by using the ROV “Hyper Dolphin”.

During this cruise, seven rock samples are collected by the ROV. Six of them are from the Noho hydrothermal site (at Dive #1873), and one sample is obtained at the Iheya South mound (at Dive #1875). Most of them is possibly sulphide. Fig. 4.3.4 indicates an example of rock sample. The sample is collected at the top of hydrothermal mound (Fig. 4.3.5). The details of rock samples are summarized in Tables 4.3.1 and 4.3.2.

These rock samples will be used for laboratory measurements (e.g., resistivity, seismic velocity, density, magnetization etc.). The physical properties can be integrated to physical models of seafloor massive sulphide, which is quite useful for geological interpretation of structures below the seafloor proposed by electromagnetic, seismic, magnetic and gravity surveys.



Fig. 4.3.4. Sampled rock “R5” onboard.



Fig. 4.3.5. Photograph at the sampling of “R5” (HPD Dive #1873).

Table 4.3.1. Rock samples obtained at HPD Dive #1873

ID	Time (JST)	Latitude			Longitude			Dep. [m]	Size [cm]	Description
		Deg.	Min.	N/S	Deg.	Min.	E/W			
R1	15:48	27	31.097	N	126	58.957	E	1570	30x30x15	a rock on a slope, possibly sulphide.
R2	15:59	27	31.091	N	126	58.929	E	1566	15x10x5	a rock on a slope, possibly sulphide.
R3	16:02								25x20x10	piece of chimney dropped on a slope
R4	16:05								45x40x30	a rock on a slope, possibly sulphide.
R5	16:26	27	31.099	N	126	58.98	E	1566	45x35x20	a part of big mound (active chimney is located at the top)
R6	16:55	27	31.004	N	126	58.908	E	1557	40x35x20	a rock near the small chimney, possibly sulphide.

Table 4.3.2. Rock samples obtained at HPD Dive #1875 (Iheya South Mound)

ID	Time (JST)	Latitude			Longitude			Dep. [m]	Size [cm]	Description
		Deg.	Min.	N/S	Deg.	Min.	E/W			
R7	17:47	27	14.485	N	127	03.958	E	1614	20x15x5	a rock dropped on a slope, possibly pumice.