

Cruise Report

NT15-02

Okinawa trough, South-West Japan

R/V Natsushima

(Leg1) 2015年1月11日～1月14日

(Leg2) 2015年1月14日～1月27日

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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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1. Cruise summary of NT15-02 cruise

Cruise information

Cruise number	NT15-02
Name of the cruise	R/V Natsushima
Chief scientist (Leg1)	Masahiro Yamamoto (CEAT, JAMSTEC)
Chief scientist (Leg2)	Takafumi Kasaya (CEAT, JAMSTEC)
Representative of the proposal1	Masahiro Yamamoto (CEAT, JAMSTEC)
Title of the cruise proposal 1	Research of the hydrothermal fields in the Middle Okinawa Trough (proof of spontaneous electricity generation around hydrothermal vents)
Representative of the proposal1	Takafumi Kasaya (CEAT, JAMSTEC)
Title of the cruise proposal 2	Hydro-thermal structure survey around the hydrothermal deposit and development for the long-term monitoring of hydrothermal activity
Representative of the proposal1	Kentaro Nakamura (Univ. of Tokyo)
Title of the cruise proposal 3	Next-generation Technology Development for Seafloor Resource Survey
Cruise period	(Leg1) 2015 年 1 月 11 日 ~ 1 月 14 日 (Leg2) 2015 年 1 月 14 日 ~ 1 月 27 日
Ports of call	Naha port – Naha port
Research Area	Okinawa trough (Fig.1 and 2)

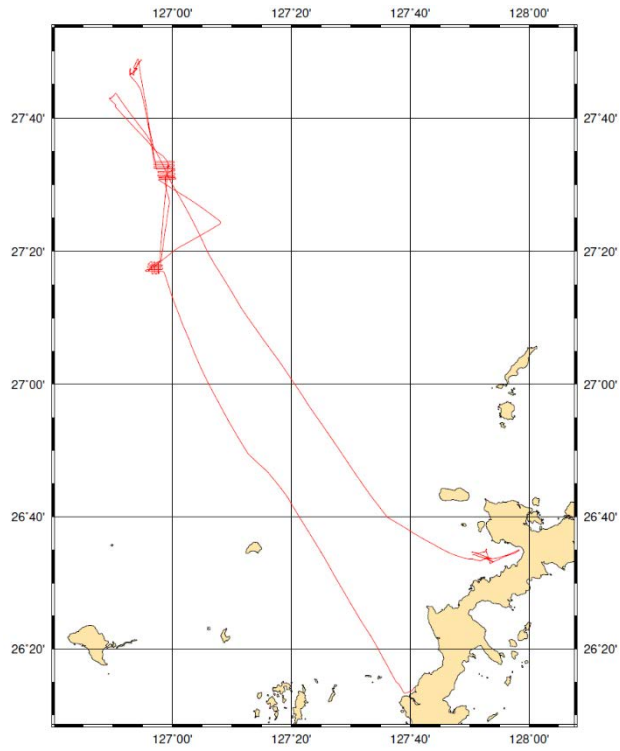


Fig.1 Ship track of NT15-02 leg1.

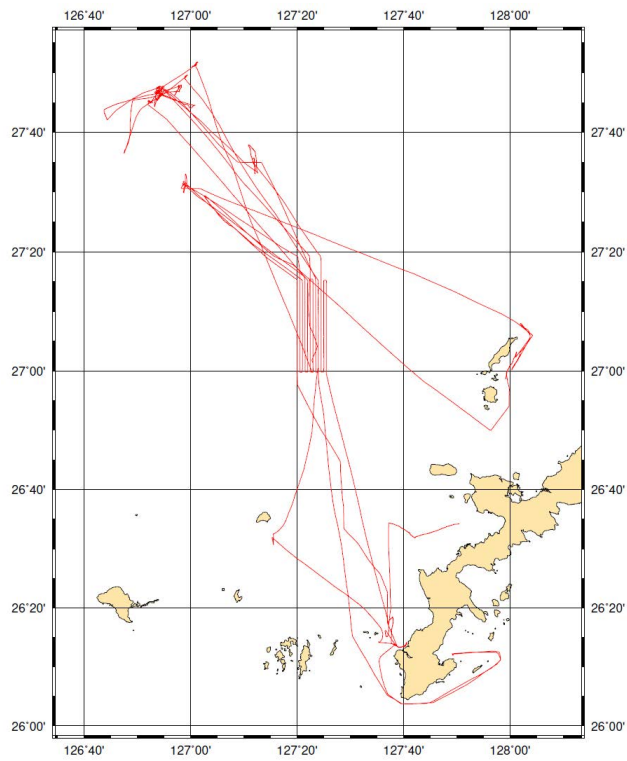


Fig.2 Ship track of NT15-02 leg2.

2. Ship Logs

Leg 1

Date	Local Time	Note	Description	Position/Weather/Wind/Sea condition
11-Jan-15		Sail out & started NT15-02 Leg1.		1/11 12:00 (JST)
	10:00	Let go all shore lines & left Naha port for Research Area.		26-29.0N 127-29.0E
	13:00-13:30	Carried out shipboard education & training for scientists.		Fine but Cloudy
	17:15	Arrived at research area.		North-4(Moderate breeze)
	17:17	Started MBES survey.		3(Slight)
	17:51	Released XBT at <27-17.0143N, 126-55.7075E>.		1(Low swell short or average)
	22:51	Finished MBES survey.		Visibly: 8'
12-Jan-15		Operation "HPD" Dive#1768 & 1769		1/12 12:00 (JST)
	00:26	Released XBT at <27-31.4767N, 126-58.9698E>.		27-48.5N 126-54.5E
	00:47	Started MBES survey.		Fine but Cloudy
	04:34	Finished MBES survey.		North-5(Fresh breeze)
	06:08	Released XBT at <27-46.3978N, 126-52.9000E>.		4(Moderate)
	07:48	Hoisted up HPD		2(Low swell long)
	07:52	HPD Launched.		Visibly: 8'
	08:05	HPD dove and started her operation #1768.		
	08:56	HPD landed on the sea bottom (D=1050m).		

	11:00	HPD left the sea bottom (D=1056m).		
	11:37	HPD floated.		
	12:10	Recovered HPD and finished her operation.		
	13:47	Hoisted up HPD		
	13:50	HPD Launched.		
	14:02	HPD dove and started her operation #1769.		
	14:50	HPD landed on the sea bottom (D=1046m).		
	17:07	HPD left the sea bottom (D=950m).		
	17:37	HPD floated.		
	17:51	Recovered HPD and finished her operation.		
	19:58	Started MBES survey.		
13-Jan-15		Operation "HPD" Dive#1770		1/13 12:00 (JST)
	00:47	Finished MBES survey.		27-33.0N 126-59.5E
	08:14	Hoisted up HPD		Cloudy
	08:18	HPD Launched.		ENE-5(Fresh breeze)
	08:30	HPD dove and started her operation #1770.		3(Slight)
	09:13	HPD landed on the sea bottom (D=1405m).		2(Low swell long)
	14:00	HPD left the sea bottom (D=1319m).		Visibly: 8'
	14:41	HPD floated.		
	14:56	Recovered HPD and finished her operation.		
	16:08	Sent out release command to OBEM.		
	17:14	Recovered OBEM.		
	17:30	Proceeding to Nago bay		

14-Jan-15		Avoided rough sea at Nago bay & completed NT15-02 Leg1		1/14 12:00 (JST)
	08:00	Arrived at Nago bay and started anchoring.		26-34.9N 127-58.3E
	15:00	Proceeding to Naha port		Cloudy
	24:00	Completed NT15-02 Leg1.		SE-5(Fresh breeze)
				2(Smooth)
				0(No swell)
				Visibly: 8'

Leg 2

Date	Local Time	Note	Description	Position/Weather/Wind/Sea condition
15-Jan-15		Started NT15-02 Leg2		1/15 12:00 (JST)
	00:00	Started NT15-02 Leg2.		26-14.1N 127-40.5E
	09:00	Arrived at Naha port		Fine but Cloudy
	16:00	Let go all shore lines & left Naha port for Research Area.		NW-5(Fresh breeze)
	22:54	Arrived at research area and started MBES survey.		1(Light air)
				0(No swell)
				Visibly: 8'
16-Jan-15		Operation "HPD" Dive#1771		1/16 12:00 (JST)
	01:31	Finished MBES survey.		27-31.0N 126-59.0E
	08:11	Hoisted up HPD		Cloudy

	08:15	HPD Launched.		NW-4(Moderate breeze)
	08:26	HPD dove and started her operation #1771.		4(Moderate)
	09:25	HPD landed on the sea bottom (D=1595m).		1(Low swell short or average)
	16:29	HPD left the sea bottom (D=1545m).		Visibly: 8'
	17:12	HPD floated.		
	17:28	Recovered HPD and finished her operation.		
	19:33	Released XBT at <27-19.4015N, 127-19.7551E>.		
	20:04	Started MBES survey.		
17-Jan-15		Avoided rough sea at Iheya island		1/17 12:00 (JST)
	01:38	Finished MBES survey.		26-52.0N 127-53.0E
	08:30	Proceeding to Iheya island.		Cloudy
	13:30	Arrived at Iheya island.		NNW-6(Strong breeze)
	23:30	Proceeding to research area.		5(Rough)
				2(Low swell long)
				Visibly: 5'
18-Jan-15		Operation "HPD" Dive#1772		1/18 12:00 (JST)
	08:09	Hoisted up HPD		27-31.0N 126-59.0E
	08:14	HPD Launched.		Cloudy
	08:25	HPD dove and started her operation #1772.		ENE-2(Light breeze)

	09:16	HPD landed on the sea bottom (D=1601m).		3(Slight)
	15:58	HPD left the sea bottom (D=1547m).		1(Low swell short or average)
	16:38	HPD floated.		Visibly: 8'
	16:51	Recovered HPD and finished her operation.		
	19:17	Started MBES survey.		
19-Jan-15		Recovered OBEM and operation "HPD" Dive#1773		1/19 12:00 (JST)
	00:36	Finished MBES survey.		27-47.5N 126-54.0E
	06:28	Sent out release command to OBEM.		Fine but Cloudy
	07:23	Recovered OBEM.		North-5(Fresh breeze)
	08:21	Hoisted up HPD		4(Moderate)
	08:24	HPD Launched.		2(Low swell long)
	08:35	HPD dove and started her operation #1773.		Visibly: 8'
	09:15	HPD landed on the sea bottom (D=1039m).		
	12:05	HPD left the sea bottom (D=980m).		
	12:42	HPD floated.		
	12:55	Recovered HPD and finished her operation.		
	16:37	Released XBT at <27-19.6259N, 127-22.0241E>.		
	17:06	Started MBES survey.		
	23:58	Finished MBES survey.		
20-Jan-15		Recovered OBEM and operation "HPD" Dive#1774 & #1775		1/20 12:00 (JST)
	06:29	Sent out release command to OBEM.		27-47.0N

				126-54.0E
	07:21	Recovered OBEM.		Cloudy
	08:49	Hoisted up HPD		NE-3(Gentle breeze)
	08:52	HPD Launched.		3(Slight)
	09:03	HPD dove and started her operation #1774.		1(Low swell short or average)
	09:44	HPD landed on the sea bottom (D=1078m).		Visibly: 8'
	11:02	HPD left the sea bottom (D=1085m).		
	11:35	HPD floated.		
	11:47	Recovered HPD and finished her operation.		
	13:45	Sent out release command to OBEM.		
	14:38	Recovered OBEM.		
	15:37	Hoisted up HPD		
	15:42	HPD Launched.		
	15:53	HPD dove and started her operation #1775.		
	16:41	HPD landed on the sea bottom (D=1084m).		
	17:31	HPD left the sea bottom (D=1082m).		
	18:03	HPD floated.		
	18:16	Recovered HPD and finished her operation.		
21-Jan-15		Recovered OBEM and operation "HPD" Dive#1776		1/21 12:00 (JST)
	06:21	Sent out release command to OBEM.		27-47.0N 126-54.0E
	07:20	Recovered OBEM.		Cloudy
	08:37	Hoisted up HPD		SE-3(Gentle breeze)
	08:41	HPD Launched.		3(Slight)
	08:50	HPD dove and started her operation		1(Low swell

		#1776.		short or average)
	09:29	HPD landed on the sea bottom (D=1074m).		Visibly: 8'
	16:29	HPD left the sea bottom (D=1087m).		
	17:03	HPD floated.		
	17:20	Recovered HPD and finished her operation.		
	21:20	Started MBES survey.		
22-Jan-15		Changed scientists at Naha		1/22 12:00 (JST)
	00:05	Finished MBES survey.		26-14.1N 127-40.5E
	09:00	Arrived at Naha port.		Fine but Cloudy
	13:00	Let go all shore lines & left Naha port for Yonahara bay.		NNW-6(Strong breeze)
	17:00	Arrived at Yonahara bay.		1(Light air)
				0(No swell)
				Visibly: 8'
23-Jan-15		Avoided rough sea at Yonahara bay.		1/23 12:00 (JST)
	14:00	Proceeding to research area.		26-12.1N 127-49.2E
	22:16	Arrived at research area and then started MBES survey.		Cloudy
				NNW-5(Fresh breeze)
				3(Slight)
				0(No swell)
				Visibly: 8'
24-Jan-15		Recovered OBEM and operation "HPD" Dive#1777 & #1778		1/24 12:00 (JST)
	01:25	Finished MBES survey.		27-46.0N

				126-54.0E
	06:24	Sent out release command to OBEM.		Fine but Cloudy
	07:22	Recovered OBEM.		SSW-3(Gentle breeze)
	09:21	Hoisted up HPD		2(Smooth)
	09:24	HPD Launched.		1(Low swell short or average)
	09:36	HPD dove and started her operation #1777.		Visibly: 8'
	10:11	HPD landed on the sea bottom (D=1027m).		
	10:40	HPD left the sea bottom (D=1060m).		
	11:12	HPD floated.		
	11:26	Recovered HPD and finished her operation.		
	13:07	Hoisted up HPD		
	13:12	HPD Launched.		
	13:23	HPD dove and started her operation #1778.		
	14:06	HPD landed on the sea bottom (D=1097m).		
	16:55	HPD left the sea bottom (D=1090m).		
	17:28	HPD floated.		
	17:43	Recovered HPD and finished her operation.		
25-Jan-15		Operation "HPD" Dive#1779		1/25 12:00 (JST)
	08:55	Hoisted up HPD		27-46.0N 126-54.0E
	08:59	HPD Launched.		Cloudy
	09:09	HPD dove and started her operation #1779.		SE-4(Moderate breeze)
	09:54	HPD landed on the sea bottom (D=1093m).		3(Slight)

	18:51	HPD left the sea bottom (D=1090m).		1(Low swell short or average)
	19:23	HPD floated.		Visibly: 8'
	19:45	Recovered HPD and finished her operation.		
26-Jan-15		Freefall of umbilical cable		1/26 12:00 (JST)
	10:37	Started the freefall of umbilical cable.		27-35.0N 127-12.0E
	12:21	Finished the freefall of umbilical cable.		Cloudy
	12:22	Started the freefall of umbilical cable.		South-5(Fresh breeze)
	14:07	Finished the freefall of umbilical cable.		3(Slight)
	16:07	Released XBT at <27-19.6132N, 127-24.1006E>.		1(Low swell short or average)
	16:40	Started MBES survey.		Visibly: 8'
27-Jan-15		Disembarkation scientist group & completed NT15-02		
	00:05	Finished MBES survey.		
	09:00	Arrived at Naha port. Then completed NT15-02.		

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.

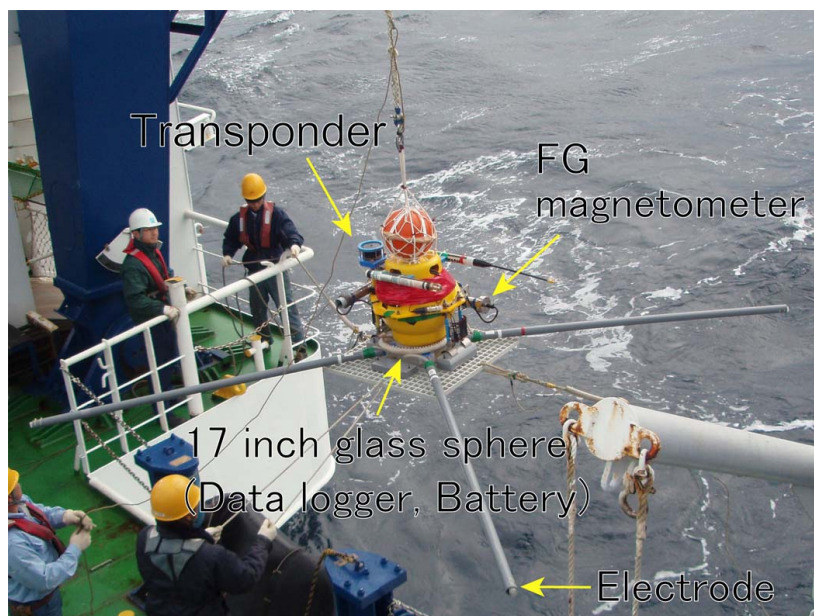


Fig. 3.1.1 OBEM system

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).

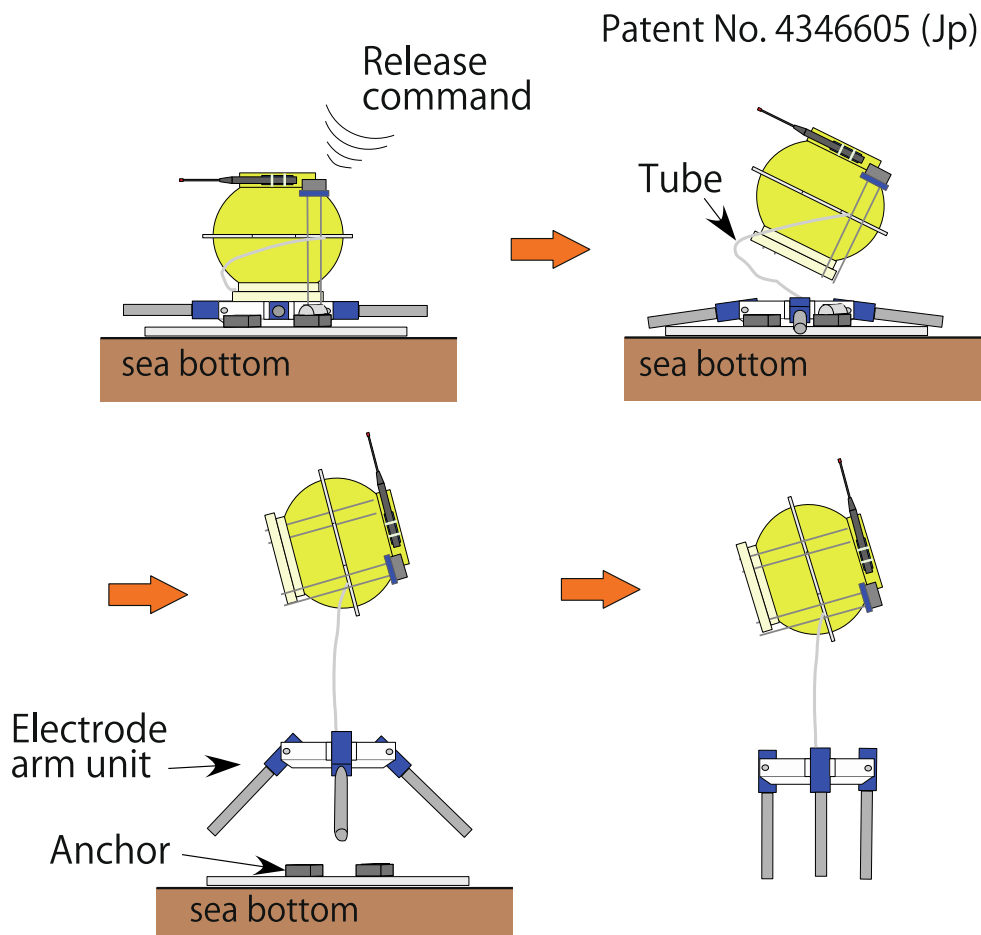


Fig. 3.1.2 Electrode arm-holding mechanism of type A OBEM

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.

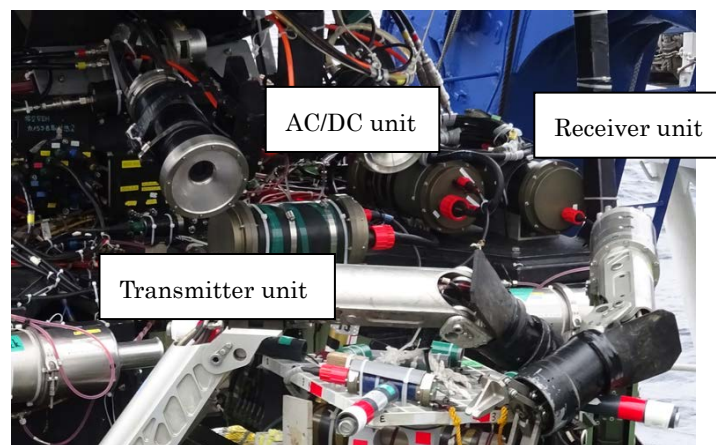


Fig. 3.3.1 Photo of a controlled source survey system on the ROV Hyper Dolphin.

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.)

3.4 Deep-sea potentiostat system (D-Pote)

Deep-sea potentiostat system (D-Pote) is an electrochemical measurement system to use in deep-sea. It is composed of a PC for the operation, a potentiostat in an anti-pressure housing, and electrodes. The potentiostat and electrodes are equipped on an ROV, and we can operate the system by a PC on the mother ship through RS232C communication. Electric power is supplied from the ROV.

References

Yamamoto, M., R. Nakamura, K. Oguri, S. Kawagucci, K. Suzuki, K. Hashimoto and K. Takai, Generation of electricity and illumination by an environmental fuel cell in deep-sea hydrothermal vents, *Angewandte Chemie International Edition*, **52**, 10758-10761, 2013.

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.

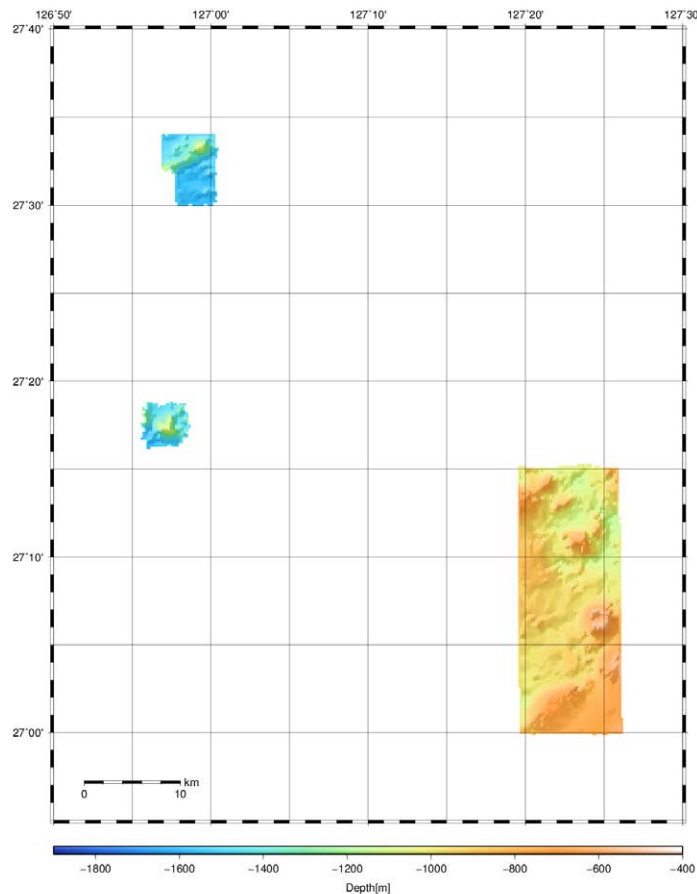


Fig. 4.1.1 Survey tracks of MBES survey.

4.2 OBEM recovery operations

We send each acoustic release signal, and every units were recovered successfully. We tracked the OBEM's positions by SSBL system of R/V Natsushima while they were ascending. The ascent rate was approximately 40-47 m/min. We found with the ship looking, radio beacon and flasher. After finishing recovery operation, the time difference between the OBEM's clock and the laptop pc synchronized by NTP server unit was measured. We could obtain enough quality EM data including some geomagnetic signals.

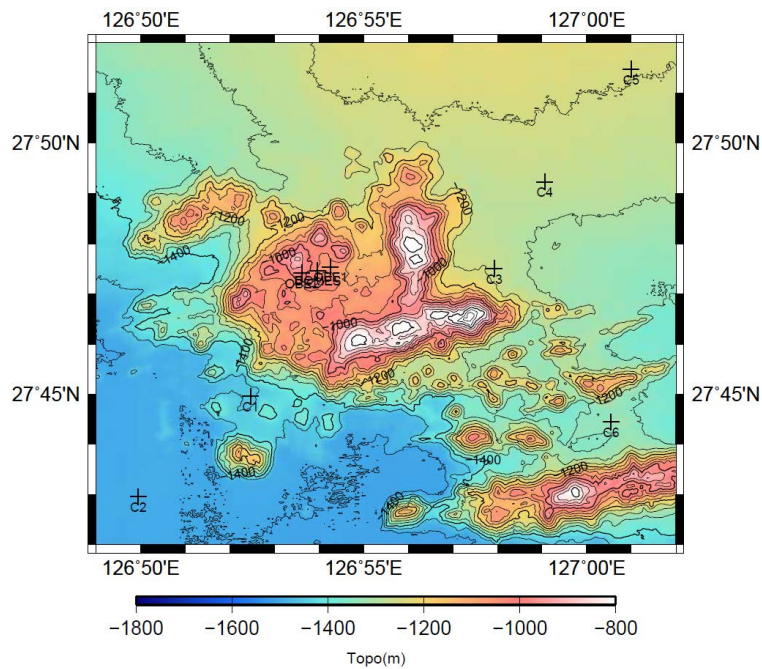


Figure 4.2.1 Site map of deployed OBEMs.

Table 4.2.1 Information of the OBEMs.

site ID	OBEM ID	Landed Latitude	Landed Longitude	Depth(m)
C1	JM109	27-44.9557N	126-52.4649E	1454.4
C2	JM108	27-42.9587N	126-49.9471E	1504.3
C3	KYT01	27-47.5009N	126-57.9293E	1273.3
C4	JM400	27-49.2273N	126-59.0596E	1302.1
C5	KYT02	27-51.4721N	127-00.9912E	1242.6
C6	JM110	27-44.4423N	127-00.5470E	1337.1

4.3 ROV HPD dives and summary

Proposal 1

We successfully restored spout from the C0014G artificial hydrothermal vent and installed the hydrothermal fluid fuel cell system onto the artificial deep-sea hydrothermal vent in the Dive HPD1768. The hydrothermal fluid fuel cell system was collected in the Dive HPD1777. Deep-sea samples of animals and rocks were collected to analyze the electrical properties and influences through the Dives HPD1769-1773. We tried in-situ measurements of redox potential around natural hydrothermal vents during the Dives HPD1773-1776 and 1778-1779. Although the measurements were in failure in the Dives HPD1773 and 1774 because of break down of the underwater cable, they were successful in the Dives HPD1775, 1776, 1778 and 1779. In addition, measurements of specific resistance on/in the seafloor around natural hydrothermal vents were also carried out during the Dives HPD1774-1776 and 1778-1779.

Proposal 2

We first recovered a long-term electrometer with a 5ch underground thermometer in the HPD 1768. When the HPD was lifted and recovered on the ship deck, resistivity cables were twined around the ship screws. We successfully carry out the DC resistivity survey using HPD at the Natsu site and Aki site in the North Iheya field. The electric field data were recorded on the data logger on the mobile OBEs. However, a trouble of new transmitter unit was occurred in the HPD 1774 dive, and a test dive was carried out in the HPD 1775 dive. We were able to carry out the DC resistivity surveys in other three dives (HPD 1776, 1778, 1779).

Proposal 3

YK14-17 cruise was conducted at Iheya North– Izena– zone in mid Okinawa trough to discover newly hydrothermal fields. In this cruise, EM 122, the acoustic system equipped on R/V Yokosuka was used to survey bathymetric feature and plumes coursed by hydrothermal activities. And also to describe detailed bathymetric maps, dives by Urashima, an AUV, were conducted in putative hydrothermal fields. We found that EM 122 was useful to survey plumes and we could specify 3 positions of putatively hydrothermal sites (Awa field and Hitoshi site and Noho site in Sakai field). And also we acquired the detailed bathymetric map of these sites by Urashima.

Based on the results from YK14-17 cruise, in this NT15-02 cruise, we conducted 3 HPD (Hyperdolphin) dives to confirm whether the hydrothermal activities in Hitoshi site and Noho site in Sakai field. Through the observation by HPD dives, we will estimate how large these hydrothermal sites have. And also we sampled hydrothermal fluids, chimney structures and macrofaunas in the hydrothermal sites to

characterize these hydrothermal sites. Moreover, we will attempt to bind chemical properties and plume detection by the acoustic systems on ship.

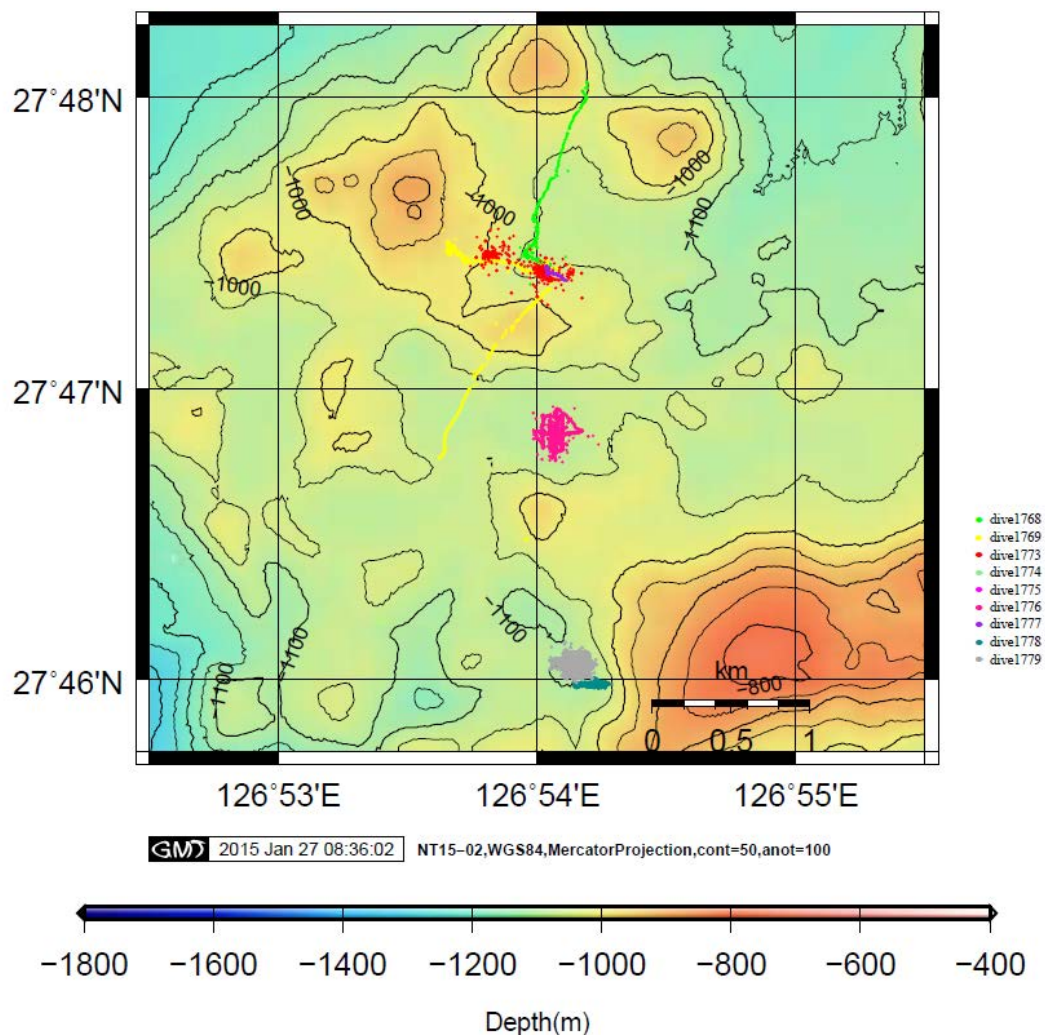
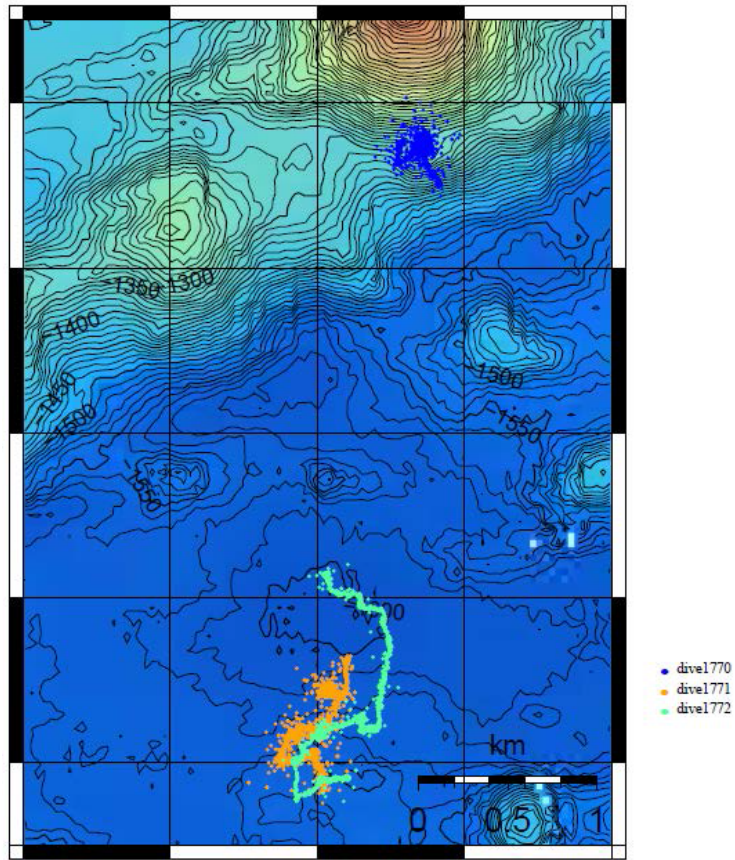


Fig. 5.3.1 HPD dive tracks carried out in the North Iheya field.



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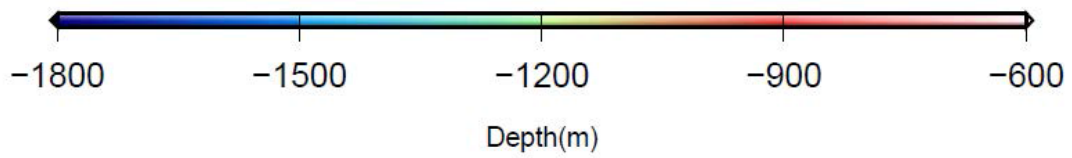


Fig. 5.3.2 HPD dive tracks around the North Iheya ridge.