



Cruise Report

YK15-06

**Hydro thermal structure survey around the
hydrothermal deposit
and development for the long-term monitoring of
hydrothermal activity**

North Iheya hydrothermal area Izena hole area



R/V Yokosuka

22 Apr 2015 – 9 May 2015

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Acknowledgements

We would like to thank Captain Mr. Nakamura and all ship crew of R/V Yokosuka for their safe cruise. We are grateful to Shinkai 6500 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.

This report may not be corrected even if changes on contents 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.

Cruise summary of YK15-06 cruise

Cruise information

Cruise number	YK15-06
Name of the cruise	R/V YOKOSUKA
Chief scientist	Takafumi Kasaya (CEAT, JAMSTEC)
Representative of the Science Party	Takafumi Kasaya (CEAT, JAMSTEC)
Title of the cruise	Hydro thermal structure survey around the hydrothermal deposit and development for the long-term monitoring of hydrothermal activity
Cruise period	22 Apr 2015 – 9 May 2015
Ports of call	Naha port –Yokosuka
Research Area	North Iheya hydrothermal area Izena hole area (Fig.1)

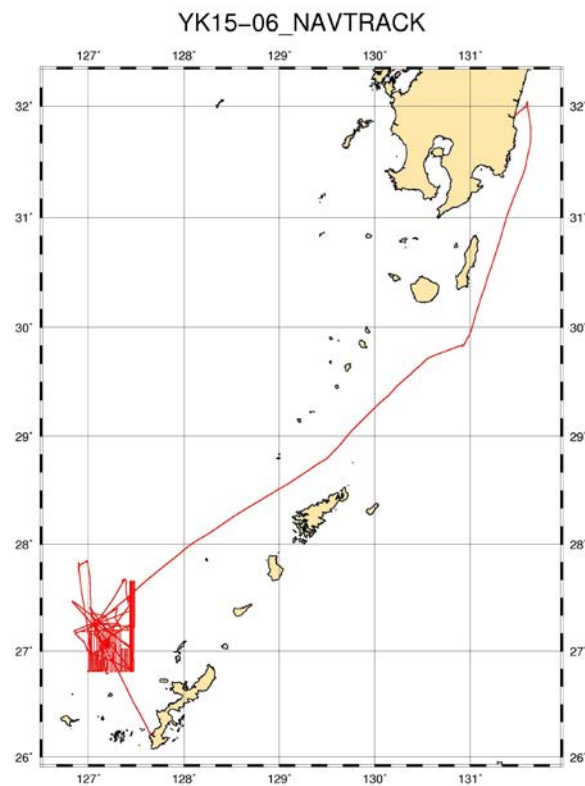


Fig.1 Ship track of this cruise.

Cruise proposal

”Hydro thermal structure survey around the hydrothermal deposit and development for the long-term monitoring of hydrothermal activity”

In recent, the concern with the submarine massive sulfides (SMS) has been growing. However, few exploration techniques were developed to evaluate the thickness of SMS and to find the buried SMS. It is also very important for the study of the origin and formation of SMS to detect the subsurface hydrothermal circulation system and characterization a back-arc basin development .

The Izena hole field is very important area for the hydrothermal deposit survey. In recent, JOGMEC have operated various survey and shallow drilling. They reported the distribution the hydrothermal deposit. However, their result have not been fully obtained the sub-surface image based on the geophysical exploration. Geophysical exploration method based on the electromagnetism is very sensitive to the conductive fluid and mineral resources. Therefore, we have carried out the DC resistivity survey and the controlled source EM survey using the Shinkai 6500 and YKDT at Izena hole. We also carried out the deployment and recovery operation of two pop-up type OBEs for DC resistivity and CSEM survey. Moreover, we deployed six ocean bottom electro-magnetometers (OBEMs) for the regional resistivity structure survey. We also set up the long-term electro-magnetometer with 5ch heat flow meter in the Iheya north knoll field.

2. List of Participants

Scientists

Takafumi KASAYA	JAMSTEC
Yoshifumi KAWADA	JAMSTEC
Yuka MASAKI	JAMSTEC
Ayu TAKAHASHI	JAMSTEC
Yasuyuki MURAKAMI	KAIYO DENSHI Co., Ltd.
Keiichi ISHIZU	JAMSTEC/ Kyoto University
Hisanori IWAMOTO	Nippon Marine Enterprises, LTD.

Marine Technician

Satomi MINAMIZAWA	Nippon Marine Enterprises, LTD.
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S/V YOKOSUKA Crew List

Captain	YOSHIYUKI NAKAMURA
Chief Officer	HIROYUKI KATO
2nd Officer	TETSUO SHIRAYAMA
Jr.2nd Officer	TSUBASA SHIOJIMA
3rd Officer	AKIRA SUZUKI
Chief Engineer	KIYONORI KAJINISHI
1st Engineer	KAZUNORI NOGUCHI
2nd Engineer	KENTA IKEGUCHI
3rd Engineer	YOSHIHIRO OTSUGA
Chief Electronic op.	TAKEHITO HATTORI
2nd Elect. Op.	YUKA MORIWAKI
3rd Elect. Op.	YOSHIKAZU KURAMOTO
Jr.3rd Elect. Op.	EMI SAWAYANAGI
BoatSwain	TADAHIKO TOGUCHI
Quarter Master	YUKITO ISHII
Quarter Master	YUKI YOSHINO
Quarter Master	NAOKI IWASAKI
Sailor	KAZUHO IKEDA
Sailor	JUN SHINODA
Sailor	YUTA MOTOOKA
No.1 Oiler	KAZUAKI NAKAI

Oiler	KATSUYUKI YOSHIDA
Oiler	KAZUO SATO
Oiler	SOTA MISAGO
Assistant Oiler	HIROMU FUKUDA
Assistant Oiler	SEIYA WATANABE
Chief Steward	SUETO SASAKI
Steward	HIRONOBU HODOKUMA
Steward	KATSUYUKI OMIYA
Steward	MASANAO KUNITA
Steward	YOSHITAKA YAMAMOTO

SHINKAI6500 TEAM

Operation Manager	TOSHIAKI SAKURAI
Deputy Submersible Op. Manager	YOSHITAKA SASAKI
1st Submersible Staff	TETSUYA KOMUKU
1st Submersible Staff	MITSUHIRO UEKI
1st Submersible Staff	KEITA MATSUMOTO
2nd Submersible Staff	HIROFUMI UEKI
2nd Submersible Staff	KEIGO SUZUKI
2nd Submersible Staff	FUMITAKA SAITO
2nd Submersible Staff	TAKUMA ONISHI
2nd Submersible Staff	YUDAI TAYAMA
3rd Submersible Staff	NAOTO MINAMINO
3rd Submersible Staff	KENTARO MURASAKI

3. Ship Logs

2015/4/22 Northwest off OKINAWA (26-47.0N, 127-19.2E)

Weather: Overcast / Wind direction: NNE/ Wind force: 4/ Wave scale: 3 /
Swell scale: 3 / Visibility: 7 miles (12:00 JST)

08:00	onboard
09:00	let go all shore line, left NAHA, proceeded to research area
10:00-10:40	carried out education and training for scientist
10:40-12:00	carried out briefing about SHINKAI6500
14:00	arrived at research area (IZENA Hole)
14:59	deployed OBEM @ D5
16:53	deployed OBE @ OBE1
18:16	deployed OBE @ OBE2
19:31	commenced to MBES mapping survey
20:03	released XBT @ 27-04.8944N, 126-59.8829E
21:31-21:53	carried out figure eight running

2015/4/23 IHEYA KITA Knoll in the Mid-OKINAWA Trough (27-47.5N, 126-54.0E)

Weather: Fine but cloudy / Wind direction: NE/ Wind force: 4 /Wave scale: 3 /
Swell scale: 3 / Visibility: 8 miles (12:00 JST)

01:30	finished MBES mapping survey, then commenced proceeding to dive point
06:18	released XBT @ 27-47.8142N, 126-53.8383E
06:49-07:20	carried out MBES pre-site survey
10:02	SHINKAI 6500 dove and started her operation #1423
10:43	SHINKAI 6500 landed on the sea bottom (Depth = 1055m)
16:31	SHINKAI 6500 left the sea bottom (Depth = 1059m)
17:24	recovered SHINKAI 6500 and finished her operation
18:04-18:24	carried out figure eight running
21:28	commenced to MBES mapping survey
23:50	released XBT @ 26-53.0850N, 127-03.6987E

2015/4/24 IZENA Hole in the Mid-OKINAWA Trough (27-15.1N, 127-03.9E)

Weather: Overcast / Wind direction: ENE / Wind force: 3/ Wave scale: 2 /

Swell scale: 2 / Visibility: 8 miles (12:00 JST)

05:03 finished MBES mapping survey, then commenced proceeding to
dive point

06:18 released XBT @ 27-17.1307N, 127-04.2051E

06:40-07:09 carried out MBES pre-site survey

10:11 SHINKAI 6500 dove and started her operation #1424

10:58 SHINKAI 6500 landed on the sea bottom (Depth = 1628m)

16:20 SHINKAI 6500 left the sea bottom (Depth = 1617m)

17:28 recovered SHINKAI 6500 and finished her operation

19:34 commenced to MBES mapping survey

19:57 released XBT @ 27-06.2687N, 127-07.9008E

2015/4/25 IZENA Hole in the Mid-OKINAWA Trough

(27-15.0N, 127-04.0E)

Weather: Fine but cloudy / Wind direction: NE / Wind force: 4 / Wave scale: 3 /

Swell scale: 3 / Visibility: 8 miles (12:00 JST)

03:24 finished MBES mapping survey, then commenced proceeding to
OBEM setting point

06:15 arrived at OBEM setting point

06:21 deployed OBEM @ D3

10:01 SHINKAI 6500 dove and started her operation #1425

10:58 SHINKAI 6500 landed on the sea bottom (Depth = 1636m)

16:21 SHINKAI 6500 left the sea bottom (Depth = 1617m)

17:27 recovered SHINKAI 6500 and finished her operation

18:05 launched Proton magnetometer

19:57 commenced to MBES mapping survey

20:08 released XBT @ 27-08.8277N, 127-20.0024E

2015/4/26 IZENA Hole in the Mid-OKINAWA Trough

(27-14.9N, 127-03.8E)

Weather: Fine but cloudy / Wind direction: ENE / Wind force: 4 / Wave scale: 3 /

Swell scale: 2 / Visibility: 8 miles (12:00 JST)

03:43 finished MBES mapping survey, then commenced proceeding to
OBEM setting point

06:11 recovered Proton magnetometer

06:36 deployed OBEM @ D4

09:04	SHINKAI 6500 dove and started her operation #1426
09:58	SHINKAI 6500 landed on the sea bottom (Depth = 1639m)
15:30	SHINKAI 6500 left the sea bottom (Depth = 1609m)
16:36	recovered SHINKAI 6500 and finished her operation
17:39	launched Proton magnetometer
19:35	commenced to MBES mapping survey
19:52	released XBT @ 26-51.6623N, 127-12.5017E

2015/4/27 IZENA Hole in the Mid-OKINAWA Trough

(27-15.0N, 127-04.1E)

Weather: Fine but cloudy / Wind direction: ESE / Wind force: 3/ Wave scale: 2 /
Swell scale: 2 / Visibility: 8 miles (12:00 JST)

01:29	finished MBES mapping survey, then commenced proceeding to OBEM setting point
06:12	recovered Proton magnetometer
06:49	deployed OBEM @ D7
10:12	launched YKDT
11:00	commenced towing YKDT and started her operation #164
13:35	finished above her operation
14:20	recovered YKDT
14:30	commenced proceeding OBEM setting point
15:57	deployed OBEM @ D8
17:58	commenced to MBES mapping survey
18:20	released XBT @ 27-01.9948N, 127-13.0961E

2015/4/28 IZENA Hole in the Mid-OKINAWA Trough

(27-14.2N, 127-04.5E)

Weather: Rain / Wind direction: SSW / Wind force: 4/ Wave scale: 3 /
Swell scale: 2 / Visibility: 6 miles (12:00 JST)

04:27	finished MBES mapping survey, then commenced proceeding to YKDT dive point
06:20	arrived at YKDT dive point
08:14	launched YKDT
08:18	commenced towing YKDT and started her operation #165
08:45	suspended above survey due to adjusting machinery
09:12	recovered YKDT

09:34	launched YKDT
10:19	commenced towing YKDT and started her operation #166
12:32	finished above her operation
13:13	recovered YKDT
14:06	launched YKDT
14:23	recovered YKDT
14:40	suspended YKDT towing operation due to machinery trouble
16:43	commenced to MBES mapping survey
18:42	released XBT @ 26-56.7023N, 127-15.6000E

2015/4/29 IZENA Hole in the Mid-OKINAWA Trough

(27-15.1N, 127-04.0E)

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

Swell scale: 2 / Visibility: 8 mile (12:00 JST)

04:55	finished MBES mapping survey, then commenced proceeding to YKDT dive point
06:30	arrived at YKDT dive point
08:15	launched YKDT
08:59	commenced towing YKDT and started her operation #167
16:45	finished above her operation
17:30	recovered YKDT
19:04	recovered OBE @ OBE01
21:00	commenced to MBES mapping survey
23:51	released XBT @ 27-30.0284N, 127-25.9954E

2015/4/30 IZENA Hole in the Mid-OKINAWA Trough

(27-14.7N, 127-04.1E)

Weather: Fine but cloudy / Wind direction: NW / Wind force: 4/ Wave scale: 3 /

Swell scale: 2 / Visibility: 8 miles (12:00 JST)

02:30	finished MBES mapping survey, then commenced proceeding to OBEM setting point
06:00	arrived at OBEM setting point
06:15	deployed OBEM @ D2
08:45	arrived at YKDT dive point
09:05	launched YKDT
09:49	commenced towing YKDT and started her operation #168

15:40	finished above her operation
16:24	recovered YKDT
18:39	commenced to MBES mapping survey
18:46	released XBT @ 27-01.0660N, 127-26.5970E

2015/5/1 IZENA Hole in the Mid-OKINAWA Trough

(27-14.5N, 127-04.1E)

Weather: Fine but cloudy / Wind direction: WNW / Wind force: 3/ Wave scale: 2 /
Swell scale: 2 / Visibility: 8 miles (12:00 JST)

04:18	finished MBES mapping survey, then commenced proceeding to dive point.
07:00	arrived at dive point
10:00	SHINKAI 6500 dove and started her operation #1427
10:55	SHINKAI 6500 landed on the sea bottom (Depth = 1590m)
16:21	SHINKAI 6500 left the sea bottom (Depth = 1622m)
17:28	recovered SHINKAI 6500 and finished the operation
18:35	recovered OBE @ OBE02
22:44	commenced to MBES mapping survey

2015/5/2 IZENA Hole in the Mid-OKINAWA Trough

(27-15.1N, 127-03.9E)

Weather: Fine but cloudy / Wind direction: SE / Wind force: 3/ Wave scale: 2 /
Swell scale: 2 / Visibility: 8 miles (12:00 JST)

05:10	finished MBES mapping survey, then commenced proceeding to dive point.
07:00	arrived at dive point
09:59	SHINKAI 6500 dove and started her operation #1428
10:48	SHINKAI 6500 landed on the sea bottom (Depth = 1628m)
16:19	SHINKAI 6500 left the sea bottom (Depth = 1609m)
17:24	recovered SHINKAI 6500 and finished the operation
18:00	left research area for MIYAZAKI

2015/5/3 South-southeast off YAKUSHIMA (29-47.8N, 130-46.8E)

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

12:30-12:50	carried out figure eight running
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14:30-15:30 scientific meeting

2015/5/4 MIYAZAKI KO

09:00 arrived at MIYAZAKI KO

10:00 disembarked YOKOSUKA

finished YK15-06 cruise

4. Instruments

4.1 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.

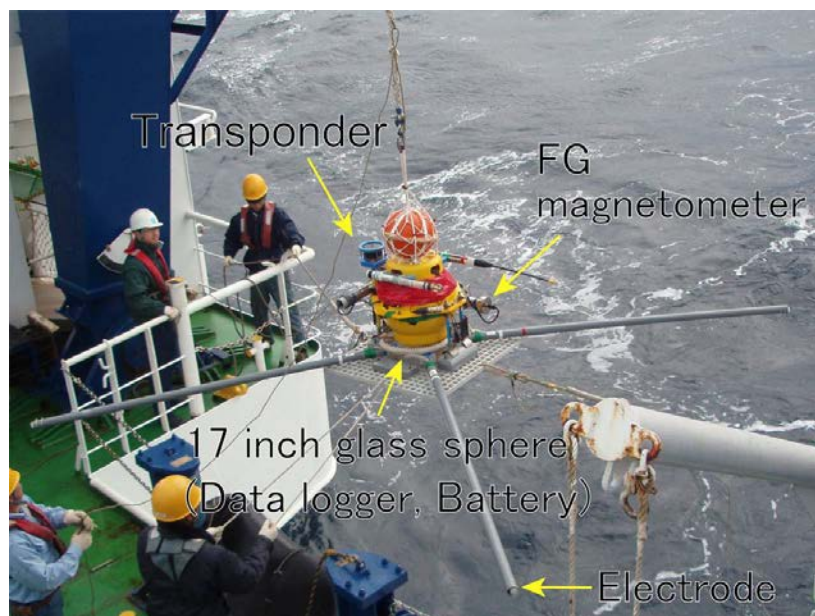


Fig. 4.1.1 OBEM system

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](#)).

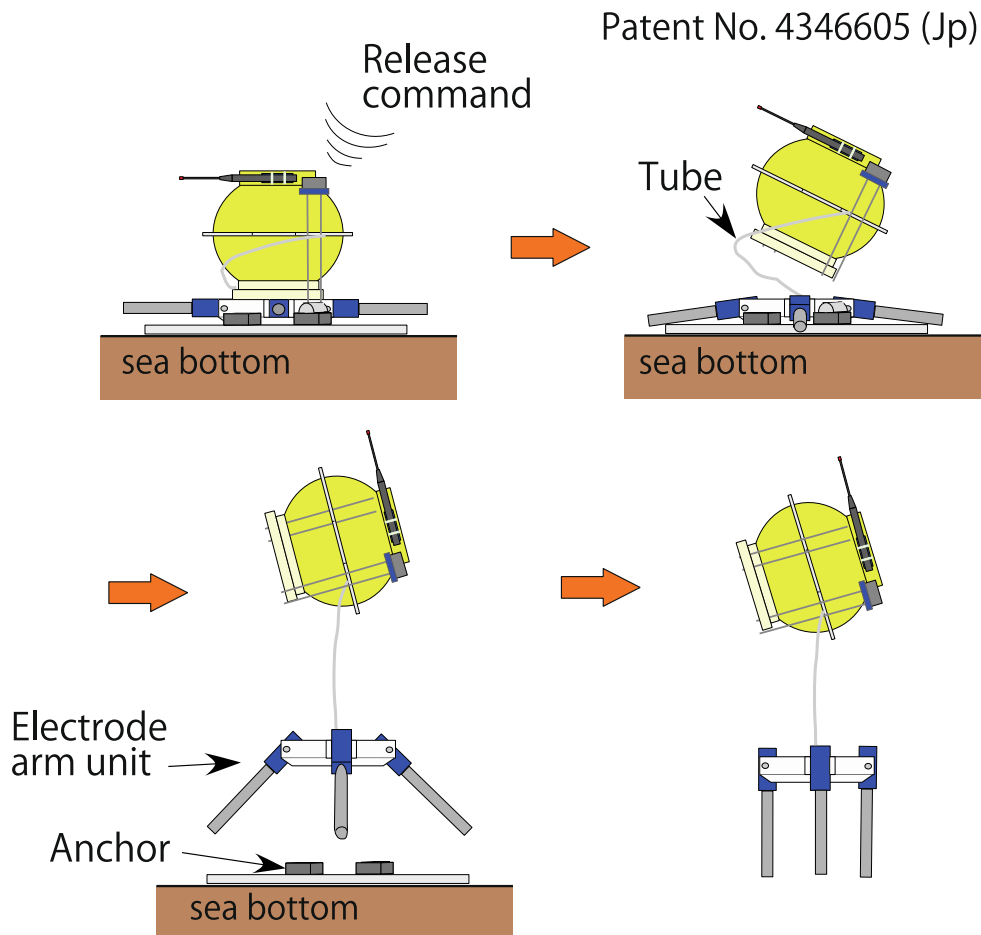


Fig. 4.1.2 Electrode arm-holding mechanism of type A OBEM

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.

4.2 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 (Fig. 4.2.1). These OBEs were used for two observation style. One is a pop-up type with a 17-inch glass float an acoustic transponder and arm folding system (Fig. 4.2.1). Another is a mobile type with short electrode arms (Fig. 4.2.2), and two mobile OBEs were set up by the HOV Shinkai 6500.

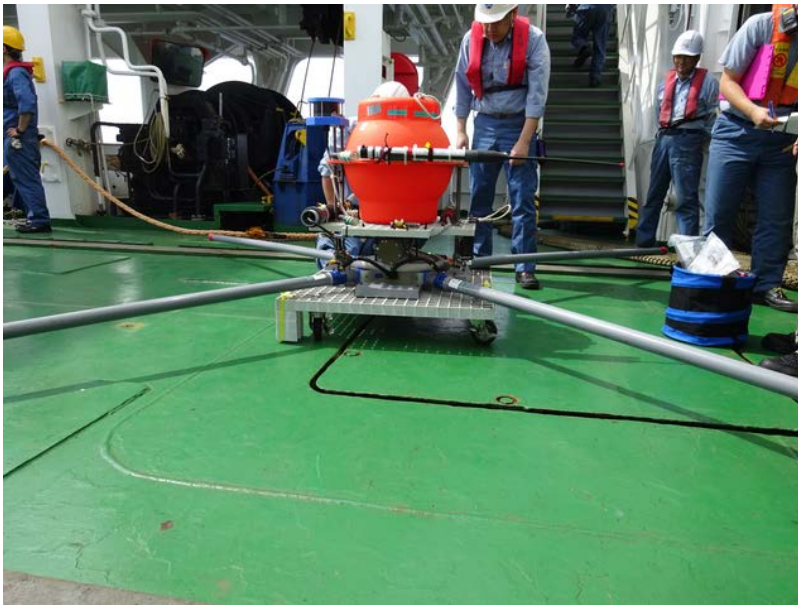


Fig. 4.2.2 Photo of a pop up type OBE system

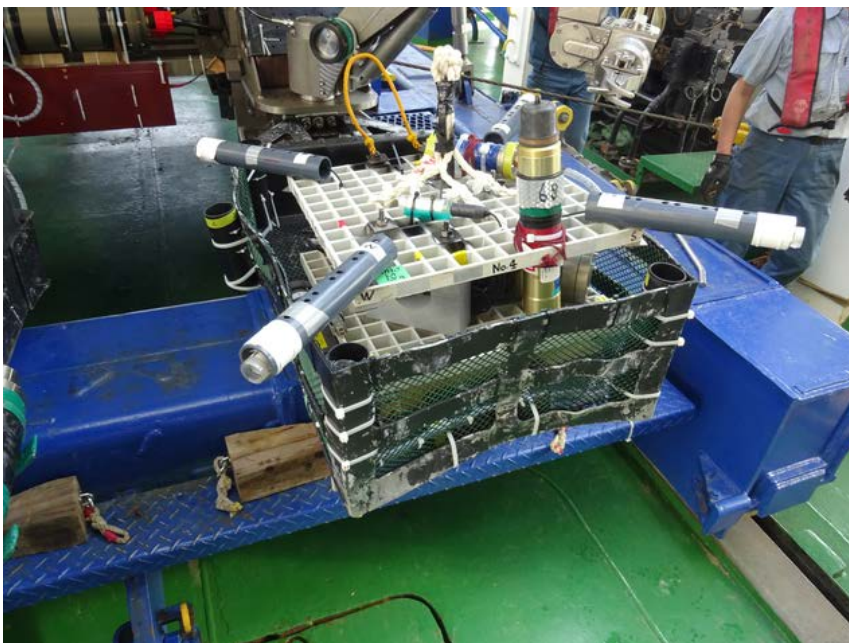
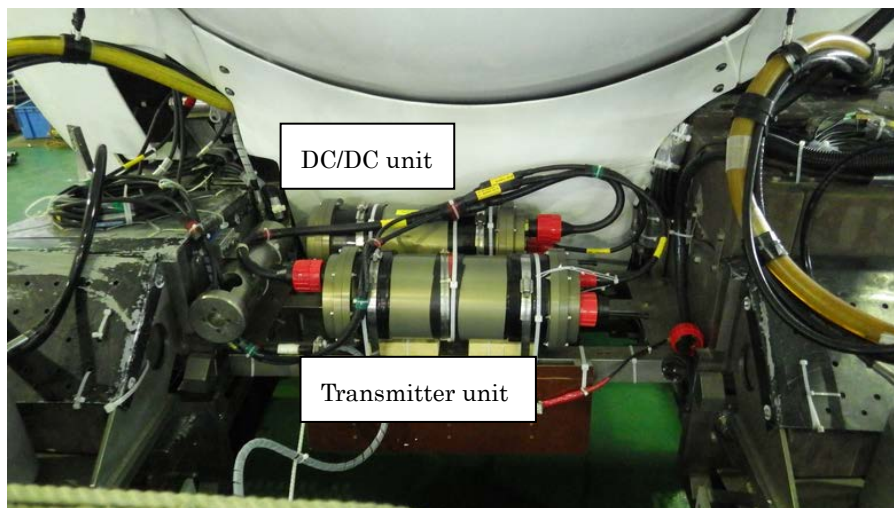


Fig. 4.2.3 Photo of a mobile type OBE system

4.3 DC resistivity system

On this cruise, we use two type controlled-source systems. One is the original system developed by Kyoto university, called “A-MANTA”. This system was loaded on the deep-tow system. The logger unit can record the data of output power data of a transmitter unit and four electric fields with a 8 Hz sampling rate. Another one is the improved system based on the A-MANTA, called “HF-MANTA”. Both system consists of a transmitter unit and a main unit with a data logger, which recorded a transmitting signal and received signal. In the case of deep-tow, the AC 100 V supplied from the deep-tow transfers to DC 48 V, and it is input to a transmitter unit. On the other hand, the DC 100V power supplied to the HF-MANTA from the battery of the Shinkai 6500 in the operation using the Shinkai 6500. The logger unit can record data of output power data of a transmitter unit and four electric fields with a 50 Hz sampling rate. The maximum output power of both transmitter is about 1.2 kW with maximum voltage of 48V peak-to-peak and current of 50A.



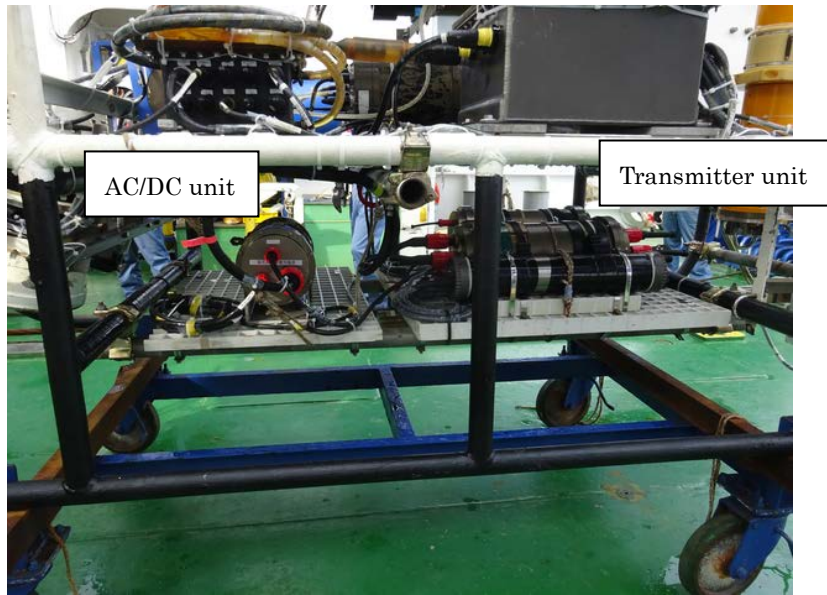


Fig. 4.3.1 Photo of a controlled source survey system. Upper panel shows the HF-MANTA on the Shinkai 6500. Lower panel shows the A-MANTA on the deep-tow system.

Table 4.3.1 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: 8 Hz (A-MANTA), 500 Hz (HF-MANTA)

Logger unit

Measurement channels: 5 CH

Measurement Voltage Range: ± 100 mV

A/D converter: 24 bit

Recording Media: SDHC

Sampling rate: 8 Hz (A-MANTA), 500 Hz (HF-MANTA)

5. Operation report

5.1 Shipboard data

For characterization a back-arc basin development and the distribution of hydrothermal activity in the northwestern part of Okinawa Trough, we obtained the bathymetric data, gravity data and magnetic data using a shipboard equipment (see Appendix). Figure 5.1.1 shows the preliminary bathymetry. In general these surveys were collected with ~10 knots ship speed. Table 5.1.1, 5.1.2, 5.1.3 and 5.1.4 show information of MBES survey lines, eight figure turns, XBT observations and proton magnetometer survey lines, respectively.

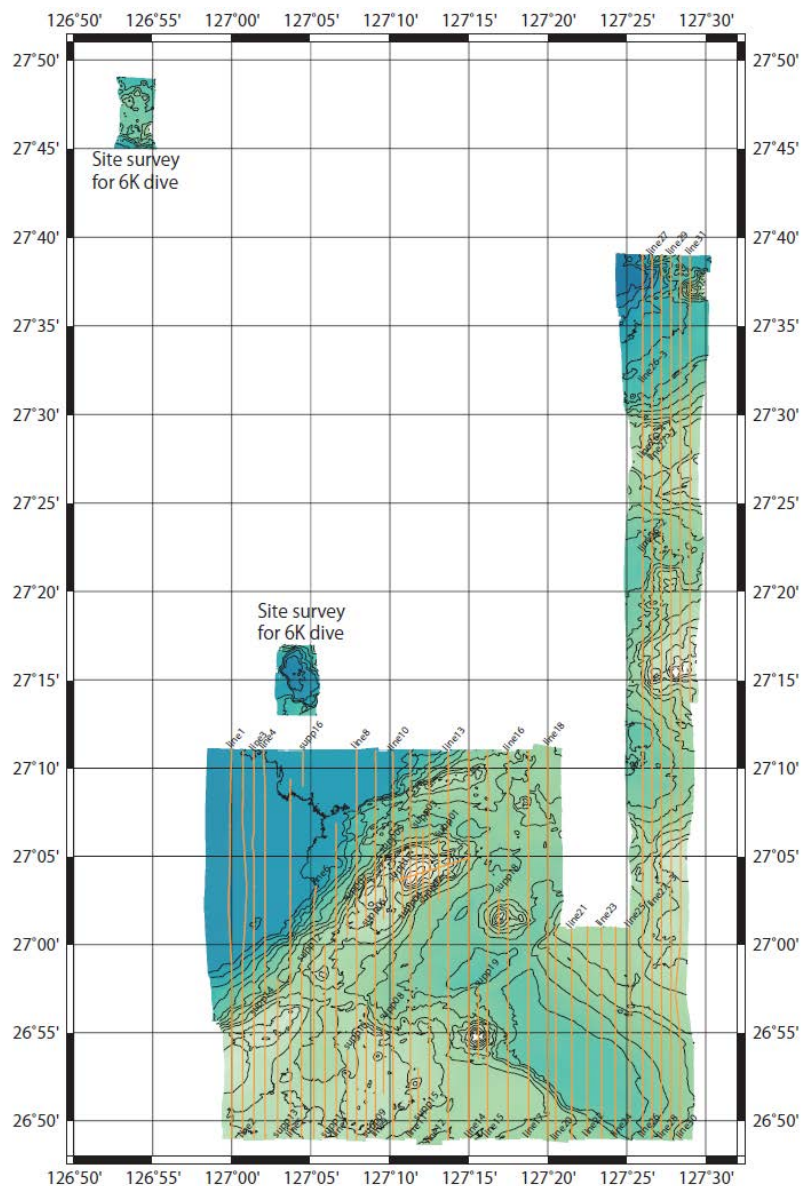


Fig. 5.1.1 Survey tracks of MBES survey.

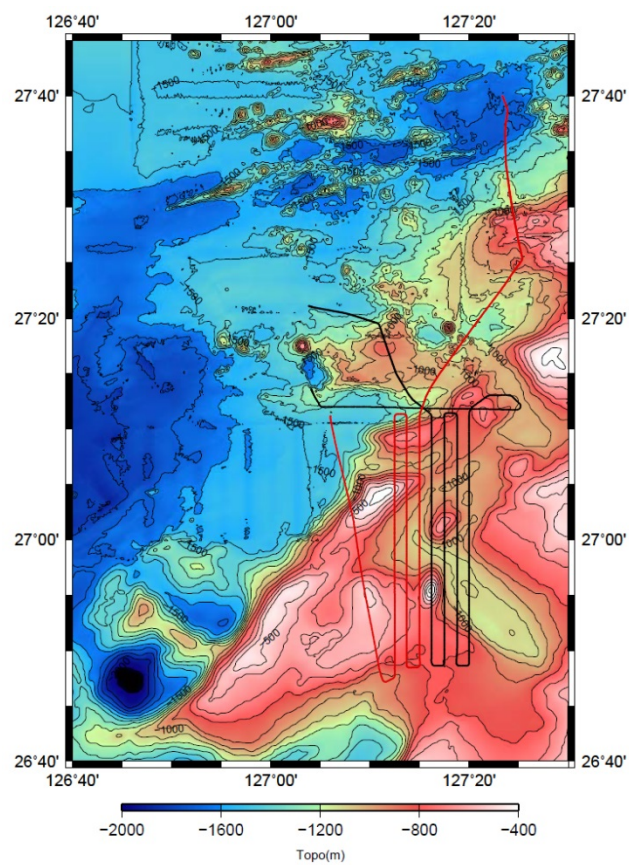


Fig. 5.1.1 Survey Lines of a proton magnetometer survey.

Table 5.1.1 MBES survey lines list.

YK15-06					
	Date(UTC)	Time(UTC)	Lat.	Lon.	Remarks
line 1	2015/4/22	10:30:51	27-11.1087N	126-59.9932E	IN
"	"	12:30:01	26-49.0051N	126-59.9888E	OUT
line2	"	13:02:22	26-49.0088N	127-00.7053E	IN
"	"	15:02:22	27-10.9825N	127-00.7029E	OUT
line3	"	15:10:01	27-10.9607N	127-01.4018E	IN
"	"	16:30:19	26-55.0042N	127-01.3968E	OUT
line4	2015/4/23	12:28:26	27-11.0458N	127-02.0104E	IN
"	"	14:19:39	26-48.9518N	127-02.1107E	OUT
line 5	"	14:29:47	26-49.0280N	127-03.7086E	IN
"	"	16:11:33	27-09.3666N	127-03.7390E	OUT

line 6	"	16:50:03	27-03.3496N	127-05.3501E	IN
"	"	18:01:16	26-48.8714N	127-05.2042E	OUT
line 7	"	18:10:38	26-49.0399N	127-06.6026E	IN
"	"	19:40:37	27-06.9103N	127-06.6035E	OUT
line 8	2015/4/24	10:34:59	27-11.0542N	127-07.8918E	IN
"	"	12:21:50	26-48.8930N	127-07.8953E	OUT
line9	"	12:30:15	26-49.0413N	127-09.0856E	IN
"	"	14:32:47	27-11.0232N	127-09.1014E	OUT
line10	"	14:40:12	27-10.9599N	127-10.1747E	IN
"	"	16:27:48	26-48.9353N	127-10.2036E	OUT
line 11	"	16:35:11	26-49.0161N	127-11.2988E	IN
"	"	18:25:05	27-11.0720N	127-11.2992E	OUT
Line18	2015/4/25	10:57:38	27-11.2564N	127-20.0024E	IN
"	"	12:48:13	26-49.0026N	127-19.9979E	OUT
Line 17	"	12:57:02	26-49.0421N	127-18.7237E	IN
"	"	14:47:41	27-11.0399N	127-18.7997E	OUT
Line 16	"	14:57:03	27-10.9639N	127-17.4885E	IN
"	"	16:46:09	26-48.9759N	127-17.4979E	OUT
Line 15	"	16:54:13	26-49.0222N	127-16.1957E	IN
"	"	18:43:48	27-11.0206N	127-16.2035E	OUT
Line 12	2015/4/26	10:35:56	26-48.6868N	127-12.5045E	IN
"	"	12:25:01	27-11.0353N	127-12.4892E	OUT
Line 13	"	12:33:45	27-10.9503N	127-13.6863E	IN
"	"	14:27:08	26-48.9160N	127-13.6982E	OUT
Line14	"	14:37:29	26-49.0232N	127-15.0393E	IN
"	"	16:29:36	27-11.0220N	127-15.0013E	OUT
Line01-2	2015/4/27	8:58:10	27-06.0564N	127-13.1020E	IN
"	"	9:16:06	27-02.4815N	127-13.1000E	OUT
Line02 -2	"	9:29:33	27-02.2626N	127-12.1083E	IN
"	"	9:50:42	27-06.5686N	127-12.0973E	OUT
Line03-2	"	9:56:24	27-06.5745N	127-11.6928E	IN
"	"	10:17:30	27-02.4233N	127-11.7005E	OUT
Line04 -2	"	10:27:48	27-01.4051N	127-10.7900E	IN

"	"	10:53:17	27-06.5686N	127-10.7970E	OUT
Line05-2	"	11:05:44	27-05.1562N	127-09.5991E	IN
"	"	11:24:52	27-01.4067N	127-09.6089E	OUT
Line06-2	"	11:32:40	27-01.0021N	127-08.4733E	IN
"	"	11:47:48	27-04.0485N	127-08.4971E	OUT
Line07-2	"	12:01:33	27-02.4238N	127-07.2814E	IN
"	"	12:11:15	27-00.4752N	127-07.3139E	OUT
Line08-2	"	12:36:57	26-55.6753N	127-09.5906E	IN
"	"	12:57:39	26-51.5111N	127-09.6028E	OUT
Line09-2	"	13:16:02	26-49.0324N	127-08.5019E	IN
"	"	13:53:15	26-56.5581N	127-08.5018E	OUT
Line10-2	"	14:10:59	26-54.0005N	127-07.3181E	IN
"	"	14:35:59	26-48.9712N	127-07.2942E	OUT
Line11-2	"	14:44:52	26-49.0253N	127-05.9156E	IN
"	"	15:38:40	27-00.0098N	127-05.8973E	OUT
Line12-2	"	15:50:29	26-58.9972N	127-04.4004E	IN
"	"	16:40:32	26-48.9859N	127-04.3979E	OUT
Line13-2	"	16:49:44	26-49.0251N	127-02.8773E	IN
"	"	17:34:12	26-58.0223N	127-02.9022E	OUT
Line14-2	"	17:50:31	26-55.9630N	127-01.3935E	IN
"	"	18:25:29	26-48.9836N	127-01.4042E	OUT
Line15-2	"	19:12:46	26-49.9970N	127-11.7961E	IN
"	"	19:27:16	26-53.0339N	127-11.7936E	OUT
Line16-2	2015/4/28	7:43:51	27-11.0175N	127-04.5015E	IN
"	"	7:54:25	27-08.9789N	127-04.4978E	OUT
Line17-2	"	8:32:11	27-03.5717N	127-10.1679E	IN
"	"	8:55:37	27-04.9162N	127-15.0544E	OUT
Line18-2	"	9:09:22	27-02.9173N	127-16.9015E	IN
"	"	9:21:19	27-00.4813N	127-16.9049E	OUT
Line19-2	"	9:36:58	26-57.5567N	127-15.6016E	IN
"	"	9:56:38	26-53.5060N	127-15.5997E	OUT
Line20	"	10:29:35	26-48.8623N	127-20.4855E	IN
"	"	11:29:25	27-01.0500N	127-20.4996E	OUT
Line21	"	11:37:05	27-00.9187N	127-21.4910E	IN

"	"	12:37:15	26-48.9317N	127-21.5030E	OUT
Line22	"	12:44:58	26-49.0808N	127-22.4936E	IN
"	"	13:43:57	27-01.0647N	127-22.4996E	OUT
Line23	"	13:50:38	27-00.9993N	127-23.3463E	IN
"	"	14:51:20	26-48.9849N	127-23.4037E	OUT
Line24	"	14:58:14	26-49.0263N	127-24.2927E	IN
"	"	15:57:30	27-01.0231N	127-24.2972E	OUT
Line25	"	16:04:27	27-00.9751N	127-25.1874E	IN
"	"	17:04:25	26-48.9800N	127-25.1977E	OUT
Line26	"	17:10:52	26-49.0237N	127-26.0031E	IN
"	"	19:55:15	27-22.2433N	127-25.9935E	OUT
Line26-2	2015/4/29	12:00:38	27-22.2281N	127-25.9981E	IN
"	"	12:27:57	27-27.6167N	127-26.0011E	OUT
Line26-3	"	12:50:50	27-31.7586N	127-26.0139E	IN
"	"	13:27:54	27-39.0719N	127-25.9985E	OUT
Line27	"	13:33:14	27-38.9633N	127-26.5754E	IN
"	"	14:30:17	27-27.4154N	127-26.5960E	OUT
Line26-2	"	14:36:39	27-27.5019N	127-25.9828E	IN
"	"	14:59:13	27-31.9434N	127-25.9934E	OUT
Line27-3	"	15:23:53	27-27.3393N	127-26.5970E	IN
"	"	17:30:18	27-01.8825N	127-26.6014E	OUT
Line27-4	2015/4/30	9:39:48	27-02.0952N	127-26.5964E	IN
"	"	10:43:56	26-48.9514N	127-26.5980E	OUT
Line28	"	10:49:54	26-48.9469N	127-27.1832E	IN
"	"	15:05:46	27-39.0155N	127-27.1976E	OUT
Line29	"	15:11:39	27-38.9665N	127-27.7971E	IN
"	"	19:19:17	26-48.9173N	127-27.8040E	OUT
Line30	2015/5/1	13:44:28	26-48.9616N	127-28.3933E	IN
"	"	18:00:12	27-39.0133N	127-28.3966E	OUT
Line31	"	18:05:46	27-38.9871N	127-28.9872E	IN
"	"	20:10:13	27-13.7444N	127-29.0013E	OUT

Table 5.1.2 Information of eight figure turns.

	Date (JST)	Start time	Latitude	Longitude	Seafloor
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		(JST)			depth (m)
1	2015/4/22	21:31	26-48.82190N	126-59.98760E	585.3
2	2015/4/23	18:04	27-50.22350N	126-58.31800E	1254
3	2015/5/3	12:30	29-50.10980N	130-54.51230E	1741.4

Table 5.1.3 Information of the XBT observations.

Date (UTC)		Latitude	Longitude
2015/4/22	11:03:57	27-04.8944N	126-59.8829E
2015/4/22	21:18:56	27-47.8142N	126-53.8383E
2015/4/23	14:50:06	26-53.0850N	127-03.6987E
2015/4/23	21:18:42	27-17.1307N	127-04.2051E
2015/4/24	10:57:59	27-06.2687N	127-07.9008E
2015/4/25	11:08:49	27-08.8277N	127-20.0024E
2015/4/26	10:52:25	26-51.6623N	127-12.5017E
2015/4/27	09:20:43	27-01.9948N	127-13.0961E
2015/4/28	09:42:45	26-56.7023N	127-15.6000E
2015/4/29	14:51:21	27-30.0284N	127-25.9954E
2015/4/30	09:46:34	27-01.0660N	127-26.5970E

Table 5.1.4 List of proton magnetometer survey lines

Date (UTC)	Start time (UTC)	Latitude	Longitude	END time (UTC)	Latitude	Longitude
2015/4/25	9:10:32	27-13.6092N	127-04.0860E	20:54:08	27-21.0971N	127-03.8371E
2015/4/26	8:49:50	27-11.1612N	127-06.0090E	20:54:47	27-39.9822N	127-23.3778E

5.2 Pop-up type OBEM and OBE operations

For characterization a back-arc basin development, we have obtained Magneto-telluric data using an OBEM. In this cruise, OBEMs were launched using an articulated crane for all stations (Fig. 5.2.1), and sunk by their own weights. Two OBEs were deployed in the Izena hole for controlled source electro-magnetic survey (Fig. 5.3.2). The operations were quick and smooth. We tracked the OBEMs and OBEs by acoustic signals and confirmed that all equipment were successfully settled on the seafloor. Then, each position was determined by the SSBL system equipped on the R/V Yokosuka (Fig. 5.2.2, Table 5.2.1). Two OBEs were recovered successfully in this cruise. All OBEMs will be recovered in the NT15-17 cruise.

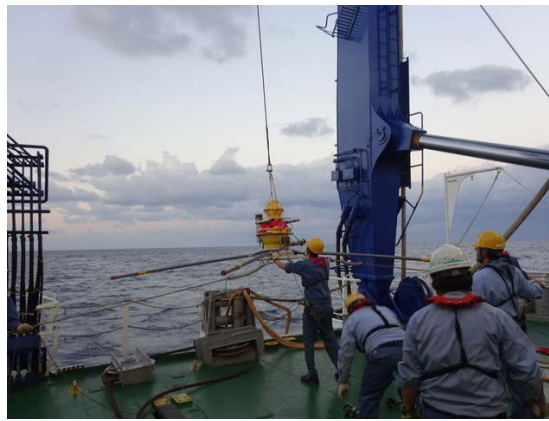


Figure 5.2.1 Photo of the OBEM deployment.

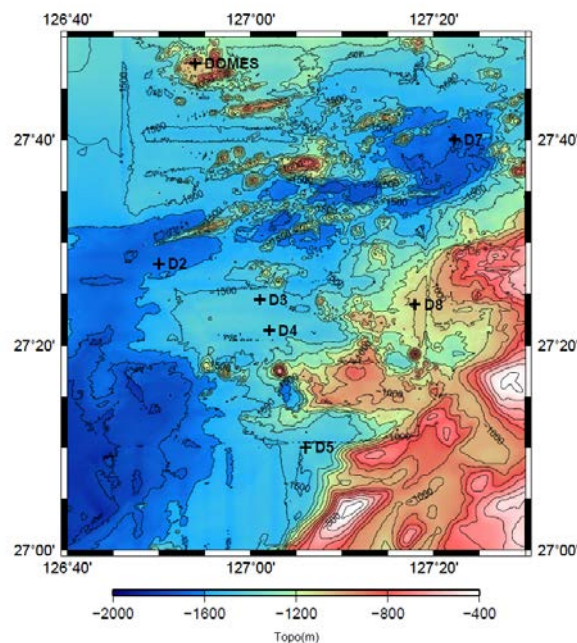


Figure 5.2.2 Site map of deployed OBEMs and DOMES.

Site ID	OBEM ID	Deployed time (JST)	Landed Latitude	Landed Longitude	Depth (m)	Notice
OBE1	VCUBE05	2015/4/22 16:53	27-15.7956N	127-03.8129E	1653.0	Recovered 2015/4/29 19:04 (JST)
OBE2	VCUBE06	2015/4/22 18:16	27-14.1935N	127-4.5767E	1555.0	Recovered 2015/5/1 18:35 (JST)
D2	KYT02	2015/4/30 6:15	27-27.9884N	126-50.0016E	1656.0	
D3	JM109	2015/4/25 6:21	27-24.4398N	127-00.9945E	1470.0	
D4	JM401	2015/4/26 6:36	27-21.4519N	127-02.0304E	1449.0	
D5	KYT01	2015/4/22 14:59	27-10.0440N	127-06.0323E	1489.0	
D7	JM108	2015/4/27 6:49	27-40.0196N	127-22.2826E	1638.4	
D8	JM110	2015/4/27 15:57	27-23.9935N	127-17.9387E	1057.0	
DOMES	DOMES-R	2015/4/23 13:00	27-47.4662N	126-53.9654E	1052.0	

Table 5.2.1 Information of the OBEMs, OBEs and DOMES.

VC02	VCUBE02	2015/4/24 14:16	27-14.8238N	127-04.0395E	1621.0	Recovered 2015/5/2 13:13 (JST)
VC03	VCUBE03	2015/4/24 13:30	27-14.9115N	127-03.9464E	1630.0	Recovered 2015/5/2 13:45 (JST)
CUBE2	CUBE2	2015/4/26 15:22	27-14.8245N	127-04.0990E	1613.0	Recovered 2015/5/1 14:26 (JST)

5.3 Shinkai 6500 and deep-tow dives

The first “Shinkai 6500” dive of this cruise was carried out at the Iheya North knoll area to set up the DOEMS (Fig. 5.3.4) and a 5ch heat flow meter for long-term monitoring. This will be recovered on the NT15-17 cruise. Figure 5.3.3 shows the dive track of this dive. Figure 5.3.1 show all “Shinkai 6500” dive tracks carried out at the Izena hole, and our controlled-source unit loaded on “Shinkai 6500” (Fig.4.3.1). Two mobile OBE (Fig. 4.2.3) was set up near the north mound of the Izena hole to receive the electric signal (Fig. 5.3.1, Table 5.2.1). In these operation, output current was controlled with 20-25 A. Moreover, a 5ch heat flow meter was set up near the OBE (VC03), and 8 days heat gradient data was obtained (Fig. 5.3.5). The temperature data was stable after penetrated to the seafloor. We recognized the temperature variation at the top of SAHF’s sensor. This may suggest the effect of subsurface water temperature including a current and tidal fluctuation. The thermal gradient was approximately 14 K/m. Figure 5.3.2 shows all YKDT dive tracks carried out at the Izena hole. We loaded the controlled source unit on the YKDT, and carried out the YKDT 164 and 165 dives. In other two YKDT operations, we tried to detect the natural signal related with the hydrothermal area.

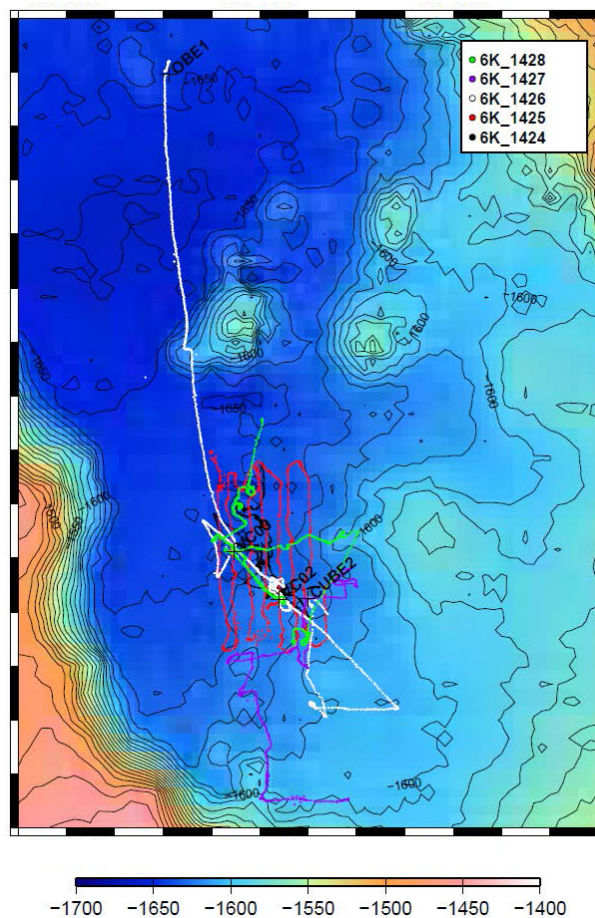


Fig. 5.3.1 Shinkai 6500 dive tracks at the Izena hole.

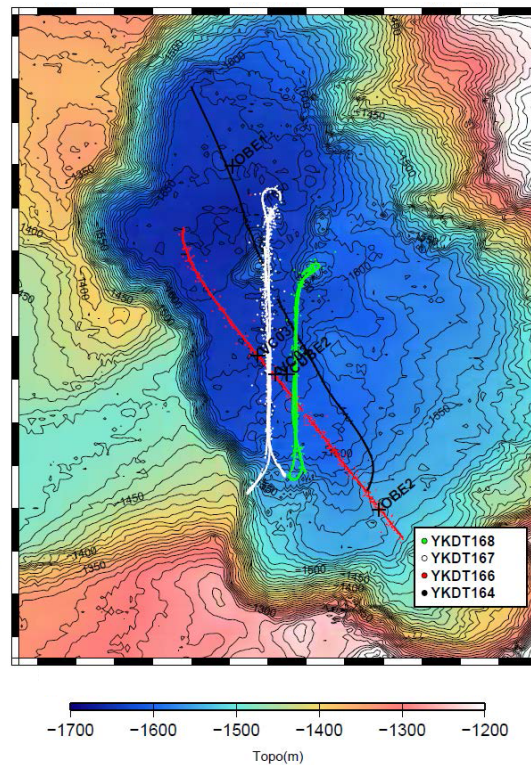


Fig. 5.3.2 Deep-tow tracks carried out on YK15-06 cruise.

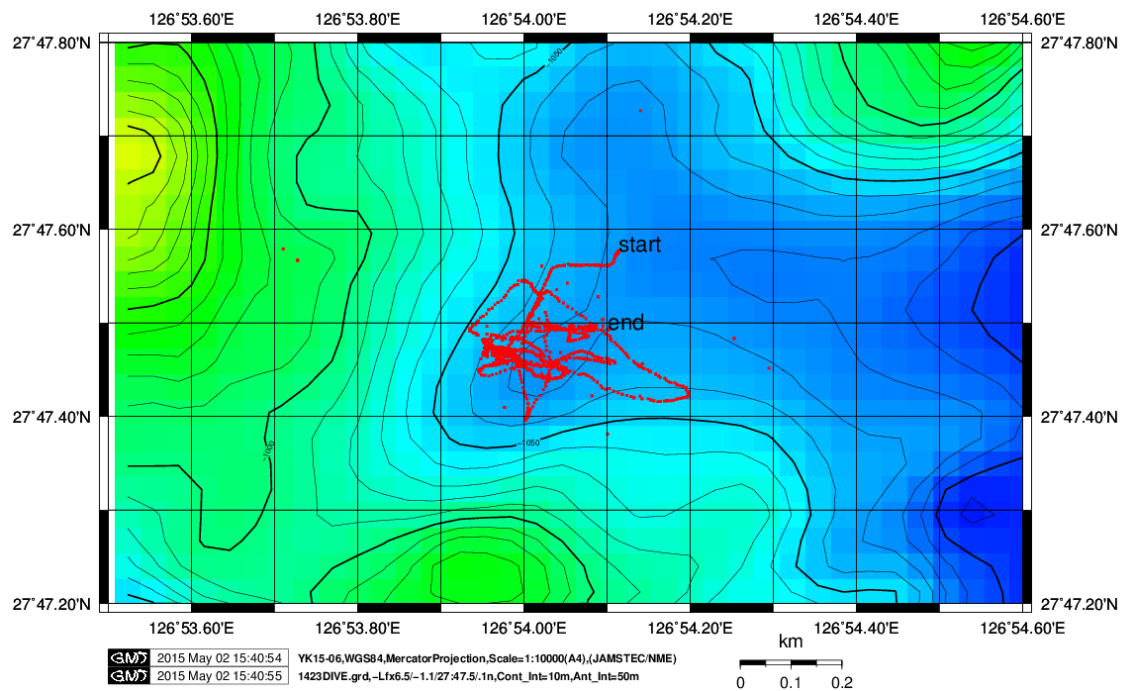


Fig. 5.3.3 Shinkai 6500 dive track at the North Iheya knoll.

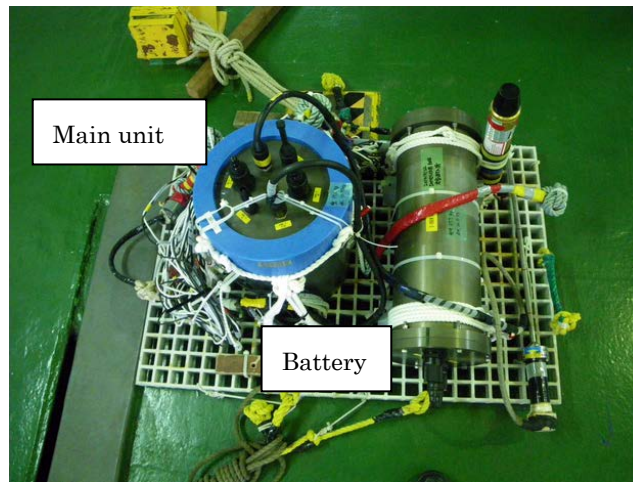


Fig. 5.3.4 Long-term electro-magnetometer system.

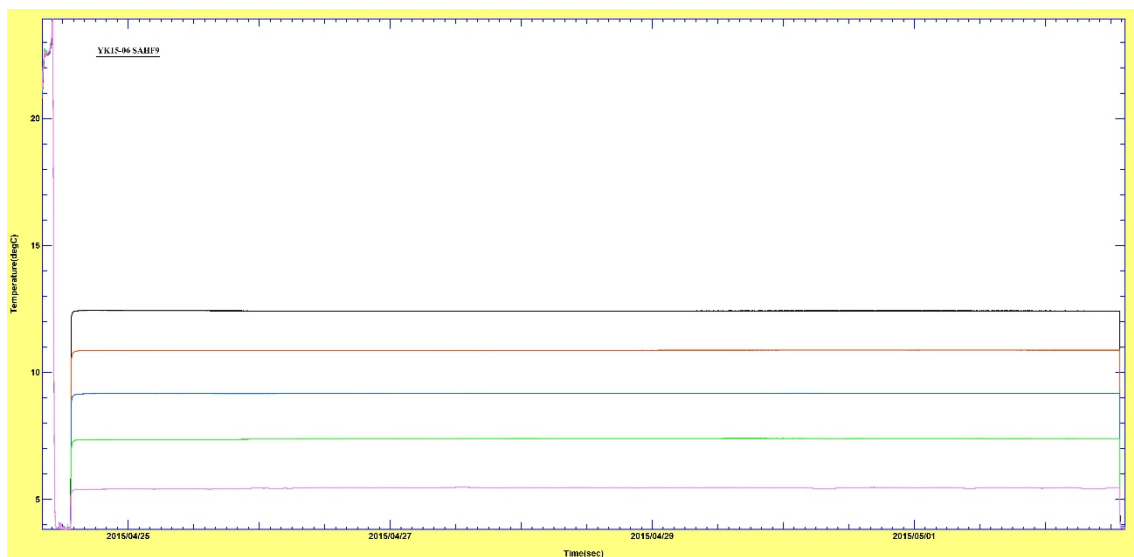


Fig. 5.3.5 Temperature data obtained 5ch heat flow meter.

Appendix

Research Vessel YOKOSUKA

R/V YOKOSUKA is designed serve as the mother vessel for SHINKAI 6500 and Autonomous Underwater Vehicle (AUV) URASHIMA. It has silent engine, an advanced acoustic navigation systems and an underwater telephone for its state of the art operations. There are 5 laboratories on Yokosuka, No.1-No.4 laboratories and No.1 Study room. No.1 Lab. has dry space. The permanent installations are an video editing system, a PC and a printer. No.2 Lab. has semi-dry and wet space. There are two freezers (-40 & -80 deg.C), a incubator, a Milli-Q, and a fumigation chamber at dry one, and wet one has a rock saw. No.3 Lab. has dry space with storage. No.4 Lab. has semi-dry and wet space. No.1 Study room has dry space, there are a gravity meter, a data acquisition system of gravity meter, a 3 axis fluxgate magnet meter and also a proton magnet meter, a work station for data processing, and a A0 size plotter.

The general specifications of R/V YOKOSUKA

Length overall	105.2 m
Beam overall	16.0 m
Depth	7.3 m
Draft	4.5 m
Gross tonnage	4,439 tons
Service speed	16knot
Main propulsion system Diesel engines	2,206kW x 2
Main propulsion method	Controllable pitch propeller x 2

Complement

Crew	28 persons
Submersible operation staff	8 persons
Researchers	6 persons
Total 52 persons	

R/V YOKOSUKA MBES / magnetometers / gravity meter

YOKOSUKA is equipped with various kinds of underway geophysical equipment, a multi narrow beam echo sounder (EM122, Kongsberg Maritime, Inc.), a gravity meter (Type S-63, LaCoste & Romberg Gravity Meters Inc.), a portable gravity meter (Type CG-5, SCINTREX Limited), a ship borne 3 axis magnet meter (Type SFG-1212, Tierra Technica Inc.), and a proton magnet meter (Type STC 10, Kawasaki Geological Engineering Co., Ltd.). The specifications of these instruments are listed below.

The specifications of EM122

Measurement depth (m)	20 ~ 11,000
Measurement frequency (kHz)	12
Measurement method	cross fan beam style
Beam numbers	288
Mesurement point	432
Pulse lengths	2/5/15msec CW(~2000m) 100msec FM(2000m~)
Beam width (deg.)	2
Beam interval (deg.)	2
Swath width (deg.)	150 (Max)
Sampling rate (msec.)	0.33
Roll (deg.)	±15
Pitch (deg.)	±10
Yaw (deg.)	±10

The specifications of Gravity meter

Measurement range (m Gal)	12,000
Drift	3mGal per month or less
<u>Stabilized platform</u>	
Platform pitch(deg.)	±22
Platform roll(deg.)	±25
Platform period(min.)	4 to 4.5
Beam interval(deg.)	1
<u>Control system</u>	
Recording rate(Hz)	1
Serial out put	RS-232

System performance

Resolution (mGal)	0.01
Static repeatability (mGal)	0.05
50,000m Gal horizontal acceleration (mGal)	0.25
100,000m Gal horizontal acceleration (mGal)	0.50
100,000m Gal vertical acceleration (mGal)	0.25
Dimension (cm)	71×56×84
Weight (kg)	Meter:86, UPS:30

The specifications of Portable Gravity meter

Sensor Type:	Fused Quartz using electrostatic nulling
Reading Resolution:	1 microGal
Standard Field Repeatability:	<5 microGal
Operating Range:	8,000 mGal without resetting
Residual Long-Term Drift:	Less than 0.02 mGal/day (static)
Automatic Tilt Compensation:	±200 arc sec
Tares:	Typically less than 5 microGals for shocks up to 20 G
Automated Corrections:	Tide, Instrument Tilt, Temperature, Drift, Near Terrain, Noisy Sample, Seismic, Noise Filter
Operating Temperature:	-40°C to +45°C (-40°F to 113°F)
Ambient Temperature Coefficient:	0.2 microGal/°C (typical)
Pressure Coefficient:	0.15 microGal/kPa (typical)
Magnetic Field Coefficient:	1 microGal/Gauss (typical)
Memory:	Flash Technology (data security)
Dimensions (cm) :	30 cm (H) x 22 cm x 21 cm (12" (H) x 8.5" x 8")
Weight (including batteries):	8 kg (17.5 lbs)
Battery Capacity:	2 x 6.6 Ah (11.1 V) rechargeable Lithium-Ion Smart Batteries. Full day operation in normal survey conditions with two fully charged batteries
Power Consumption:	4.5 W at +25°C (77°F)
Standard System:	CG-5 Console, Tripod base, 2 rechargeable batteries, Battery Charger 110/240 V, External Power Supply 110/240 V, RS-232 and USB Cables, Carrying Bag, Data dump and utilities software, Operating Manual (CD), Transit Case

The specifications of 3 axis magnet meter

System	ring core fluxgate
Number of component directly	3 axes
Cable length (m)	50
Sensor dimension (mm)	φ280×130H
Measurement range (nT)	±100,000
Resolution (nT)	1

The specifications of Proton magnet meter

Measurement range (nT)	$3 \sim 7 \times 10^{*4}$
Resolution (nT)	0.01
Sampling rate	10sec, 20sec, 1min, manual, external
Time of applying field(sec.)	3 to 10
Sensor dimension (mm)	φ200×1050
Weight (kg)	28.6(in the air), 6.2(in the sea)