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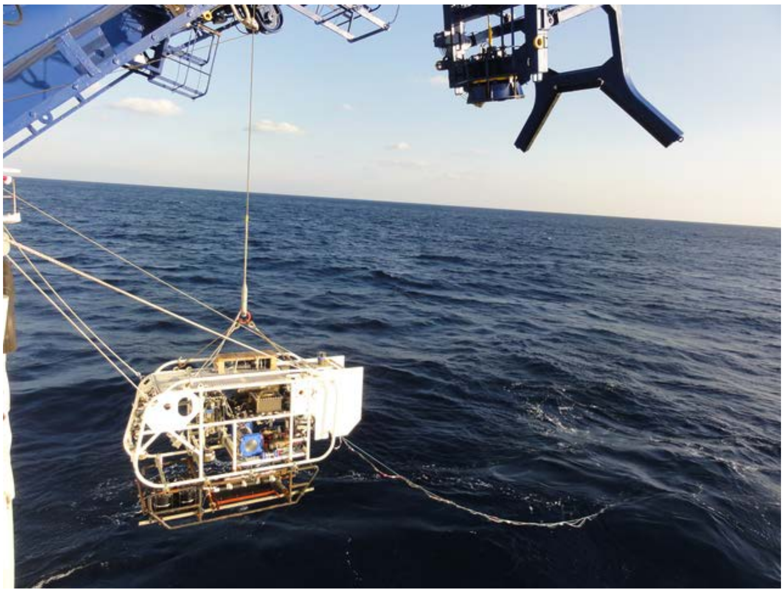
Cruise Report

MR13-E02 Leg1

Iheya caldera, South-West Japan

Marine DC resistivity survey around Iheya North geothermal area



R. V. Mirai

25 Nov 2012- 9 Dec 2012

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Acknowledgements

We would like to thank Captain Mr. Matsuura and all ship crew of R/V MIRAI for their safe cruise. We are grateful to marine technician of GODI, NME and MWJ for their operation. We are pleased to MARITEC/JAMSTEC staff for their supports during our cruise.

1. Cruise summary of MR13-E02 cruise

1.1. Cruise information

Cruise number MR13-E02

Name of the cruise R/V MIRAI

Chief scientist Takafumi Kasaya (IFREE, JAMSTEC)

Representative of the Science Party Hideaki Machiyama (SRRP, JAMSTEC)

Title of the cruise

Marine DC resistivity survey around Iheya North geothermal area

Cruise period 25 Nov 2013 – 9 Dec 2013

Ports of call Yokohama-Shinko port – Naha

Research Area North Iheya hydrothermal area (Fig.1)

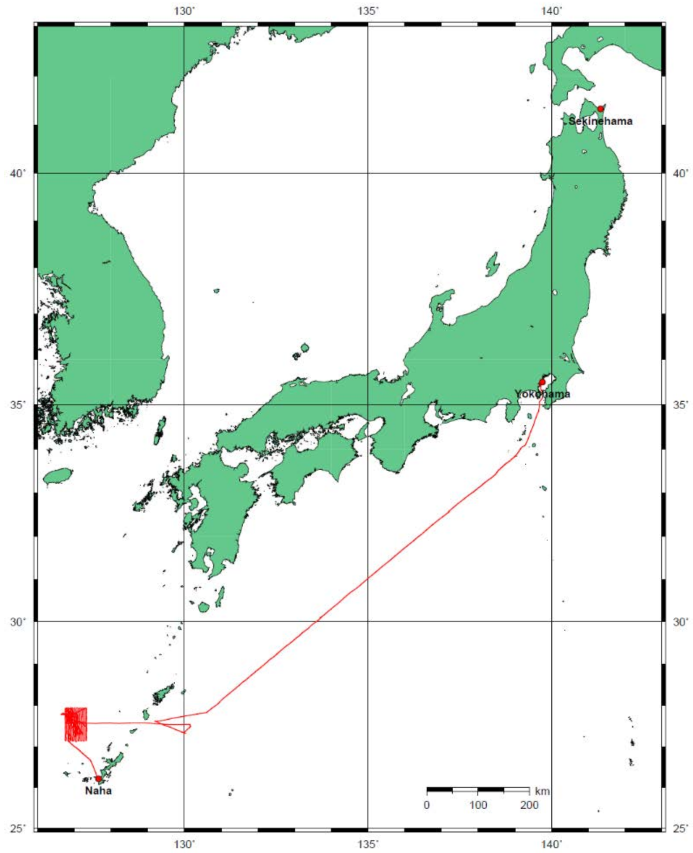

Fig.1 Ship track of this cruise.

1.2. Cruise proposal

”Marine DC resistivity survey around Iheya North geothermal area”

In recent, the concern with the submarine massive sulphides (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.

In the Iheya North knoll field, seismic survey and deep-sea drilling study had carried out. However, their result have not been fully elucidated the whole hydrothermal circulation system. 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 magneto-telluric (MT) survey around Iheya North knoll filed. On this cruise, we deployed six ocean bottom electro-magnetometers (OBEMs) for the EM survey, and carried out the deep-towed controlled source DC and EM survey at three areas in/around the Iheya North geothermal area. Moreover, we tried the deep-towed subbottom profiling.

2. List of Participants

Onboard Scientists

Chief Scientist (JAMSTEC) Takafumi Kasaya

Scientist (JAMSTEC) Hideaki Machiyama

Scientist (JAMSTEC) Yuka Masaki

Scientist (JAMSTEC) Kazuya Kitada

Marine Technicians

Chief Technician (Nippon Marine Enterprises Ltd) Hisanori Iwamoto

Chief Technician (Marine Works Japan Ltd) So Akira

Technician (Marine Works Japan Ltd) Hiroyuki Hayashi

Technician (Marine Works Japan Ltd) Ei Hatakeyama

Technician (Marine Works Japan Ltd) Yuki Miyajima

Technician (Marine Works Japan Ltd) Yasumi Yamada

Chief Technician (Global Ocean Development Inc.) Shinya Okumura

Technician (Global Ocean Development Inc.) Miki Morioka

Technician (Global Ocean Development Inc.) Toshio Furuta

R/V MIRAI Crews

Master Kan Matsuura

Chief Officer Haruhiko Inoue

1st Officer Hajime Matsuo

2nd Officer Nobuo Fukaura

3rd Officer Hiroki Kobayashi

Chief Engineer Minoru Maruta

1st Engineer Hiroyuki Tohken

2nd Engineer Koji Manako

3rd Engineer Keisuke Nakamura

Technical Officer Ryo Oyama

Boatswain Yosuke Kuwahara

Able Seaman Takeharu Aisaka

Able Seaman Masashige Okada

Able Seaman Hiromu Hirokawa

Able Seaman Shuji Komata

Able Seaman Masaya Tanikawa

Ordinary Seaman Hideyuki Okubo
Ordinary Seaman Kotaro Sakai
Ordinary Seaman Tomohiro Shimada
Ordinary Seaman Ryosuke Hiratsuka
Ordinary Seaman Akiya Chishima
No.1 Oiler Yoshihiro Sugimoto
Oiler Toshiyuki Furuki
Oiler Daisuke Taniguchi
Wiper Shintaro Abe
Wiper Kazuya Ando
Wiper Hiromi Ikuta
Chief Steward Ryotaro Baba
Cook Tamotsu Uemura
Cook Sakae Hoshikuma
Cook Isamu Kamei
Steward Shohei Maruyama

3. Ship Logs

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Latitude	Longitude	
11.24	23:50	11.25	8:50			Departure from Yokohama
11.26	1:00	11.26	10:00	32-34.00N	137-12.00E	Calibration for magnetometer #01
11.26	21:52	11.27	6:52	30-05.70N	133-43.00E	Calibration for magnetometer #02
11.27	5:28	11.27	14:28	29-14.19N	132-31.26E	Calibration for magnetometer #03
11.28	21:54	11.29	6:54	27-31.38N	130-09.57E	Arrival at St. Free Fall
11.28	23:05	11.29	8:05	27-30.06N	130-10.17E	XCTD #01 (for MBES)
11.29	0:35	11.29	9:35	27-30.67N	130-09.97E	Free Fall #01 (3000m)
11.29	4:46	11.29	13:46	27-31.55N	130-09.40E	Free Fall #02 (3000m)
11.29	7:30	11.29	16:30	27-34.56N	128-02.73E	Departure from St. Free Fall
11.29	20:08	11.3	5:08	27-34.20N	127-09.89E	XCTD #02
11.29	23:10	11.3	8:10	27-47.58N	126-50.48E	XCTD #03
11.29	23:10	11.3	8:10	27-47.58N	126-50.48E	Preliminary survey for Deep-Tow in
11.3	0:08	11.3	9:08	27-42.50N	126-49.00E	Preliminary survey for Deep-Tow out
11.3	1:00	11.3	10:00	27-47.44N	126-46.89E	Arrival at St. B-4
11.3	1:04	11.3	10:04	27-47.45N	126-46.96E	OBEM deployment #01
11.3	1:37	11.3	10:37	27-47.60N	126-47.13E	OBEM deployment position fixed (Depth : 1440m)
11.3	1:54	11.3	10:54	27-47.97N	126-47.19E	Departure from St. B-4
11.3	2:24	11.3	11:24	27-51.61N	126-46.41E	Arrival at St. B-3
11.3	3:27	11.3	12:27	27-50.50N	126-46.99E	OBEM deployment #02
11.3	3:58	11.3	12:58	27-50.67N	126-47.19E	OBEM deployment position fixed (Depth : 1391m)
11.3	4:12	11.3	13:12	27-50.99N	126-47.56E	Departure from St. B-3
11.3	4:54	11.3	13:54	27-51.76N	126-53.76E	Arrival at St. B-1
11.3	5:08	11.3	14:08	27-51.54N	126-53.55E	OBEM deployment #03

11.3	5:36	11.3	14:36	27-51.77N	126-53.70E	OBEM deployment position fixed (Depth : 1250m)
11.3	5:48	11.3	14:48	27-51.87N	126-53.88E	Departure from St. B-1
11.3	6:48	11.3	15:48	27-44.46N	126-55.48E	Arrival at St. B-2
11.3	7:07	11.3	16:07	27-44.09N	126-55.19E	OBEM deployment #04
11.3	7:41	11.3	16:41	27-44.33N	126-55.34E	OBEM deployment position fixed (Depth : 1477.5m)
11.3	7:48	11.3	16:48	27-44.33N	126-55.53E	Departure from St. B-2
11.3	8:30	11.3	17:30	27-47.59N	127-00.18E	Arrival at St. B-5
11.3	8:42	11.3	17:42	27-47.37N	126-59.74E	OBEM deployment #05
11.3	9:12	11.3	18:12	27-47.61N	126-59.92E	OBEM deployment position fixed (Depth : 1318m)
11.3	9:25	11.3	18:25	27-47.89N	126-59.93E	Cesium magnetometer towing start #01
11.3	9:48	11.3	18:48	27-50.25N	126-58.40E	Departure from St. B-5
11.3	10:40	11.3	19:40	27-55.00N	126-53.50E	MBES/SBP Survey Line 9 in
11.3	10:43	11.3	19:43	27-55.02N	126-53.51E	XCTD #04
11.3	13:13	11.3	22:13	27-29.72N	126-52.14E	MBES/SBP Survey Line 9 out
11.3	15:25	12.1	0:25	27-55.00N	126-55.40E	MBES/SBP Survey Line 10 in
11.3	15:28	12.1	0:28	27-09.79N	126-55.17E	XCTD #05
11.3	19:34	12.1	4:34	27-55.00E	126-55.40E	MBES/SBP Survey Line 10 out
11.3	19:51	12.1	4:51	27-55.00E	126-57.30E	MBES/SBP Survey Line 11 in
11.3	21:17	12.1	6:17	27-40.00N	126-57.30E	MBES/SBP Survey Line 11 out
11.3	21:30	12.1	6:30	27-39.76N	126-56.14E	Cesium magnetometer towing finish #01
11.3	22:42	12.1	7:42	27-47.45N	126-48.59E	Arrival at 6kC Deep-Tow Survey Line (B4)
11.3	23:15	12.1	8:15	27-47.54N	126-48.30E	6kC Deep-Tow Survey start #01
12.1	7:21	12.1	16:21	27-48.36N	126-40.34E	6kC Deep-Tow Survey finish #01
12.1	7:41	12.1	16:41	27-49.03N	126-40.65E	Cesium magnetometer towing start #02
12.1	7:54	12.1	16:54	27-48.85N	126-41.78E	Departure from 6kC Deep-Tow Survey Line (B4)
12.1	11:44	12.1	20:44	27-40.00N	126-57.30E	MBES/SBP Survey Line 11 in
12.1	12:00	12.1	21:00	27-08.99N	126-57.29E	MBES/SBP Survey Line 11 out
12.1	12:16	12.1	21:16	27-09.87N	126-58.99E	MBES/SBP Survey Line 12 in
12.1	14:52	12.1	23:52	27-38.39N	127-00.05E	MBES/SBP Survey Line 12 out
12.1	16:44	12.2	1:44	27-55.09N	127-01.69E	MBES/SBP Survey Line 13 in

12.1	19:17	12.2	4:17	27-27.09N	127-01.63E	MBES/SBP Survey Line 13 out
12.1	21:28	12.2	6:28	27-38.45N	126-52.52E	Cesium magnetometer towing finish #02
12.1	22:42	12.2	7:42	27-47.66N	126-48.25E	Arrival at 6kC Deep-Tow Survey Line (B4)
12.1	23:39	12.2	8:39	27-47.53N	126-46.49E	6kC Deep-Tow Survey start #02
12.2	7:07	12.2	16:07	27-47.57N	126-40.24E	6kC Deep-Tow Survey finish #02
12.2	7:28	12.2	16:28	27-49.03N	126-40.65E	Cesium magnetometer towing start #02
12.2	7:42	12.2	16:42	27-48.05N	126-42.95E	Departure from 6kC Deep-Tow Survey Line (B4)
12.2	10:12	12.2	19:12	27-21.69N	127-01.61E	MBES/SBP Survey Line 13 in
12.2	11:20	12.2	20:20	27-10.00N	127-01.56E	MBES/SBP Survey Line 13 out
12.2	11:44	12.2	20:44	27-08.81N	127-03.64E	MBES/SBP Survey Line 14 in
12.2	16:02	12.3	1:02	27-55.77N	127-03.79E	MBES/SBP Survey Line 14 out
12.2	16:17	12.3	1:17	27-55.00N	127-05.82E	MBES/SBP Survey Line 15 in
12.2	19:24	12.3	4:24	27-20.50N	127-05.82E	MBES/SBP Survey Line 15 out
12.2	21:28	12.3	6:28	27-39.23N	126-53.79E	Cesium magnetometer towing finish #03
12.2	22:36	12.3	7:36	27-43.62N	126-45.41E	Arrival at 6kC Deep-Tow Survey Line (B4)
12.2	23:17	12.3	8:17	27-54.66N	126-47.09E	6kC Deep-Tow Survey start #03
12.3	6:49	12.3	15:49	27-55.21N	126-47.23E	6kC Deep-Tow Survey finish #03
12.3	7:04	12.3	16:04	27-55.85N	126-47.96E	Cesium magnetometer towing start #03
12.3	7:18	12.3	16:18	27-55.07N	126-49.00E	Departure from 6kC Deep-Tow Survey Line (B4)
12.3	10:11	12.3	19:11	27-22.95N	127-05.97E	MBES/SBP Survey Line 15 in
12.3	11:23	12.3	20:23	27-09.58N	127-05.98E	MBES/SBP Survey Line 15 out
12.3	11:40	12.3	20:40	27-09.98N	127-08.13E	MBES/SBP Survey Line 16 in
12.3	15:48	12.4	0:48	27-55.60N	127-08.18E	MBES/SBP Survey Line 16 out
12.3	16:02	12.4	1:02	27-55.00N	127-10.08E	MBES/SBP Survey Line 17 in
12.3	19:25	12.4	4:25	27-18.46N	127-10.19E	MBES/SBP Survey Line 17 out
12.3	21:28	12.4	6:28	27-39.33N	126-55.27E	Cesium magnetometer towing finish #04
12.3	22:42	12.4	7:42	27-48.11N	126-48.40E	Arrival at 6kC Deep-Tow Survey Line (B4)
12.3	23:10	12.4	8:10	27-47.58N	126-47.36E	6kC Deep-Tow Survey start #04
12.4	7:00	12.4	16:00	27-47.56N	126-41.94E	6kC Deep-Tow Survey finish #04
12.4	7:14	12.4	16:14	27-47.56N	126-42.27E	Cesium magnetometer towing start #04

12.4	7:30	12.4	16:30	27-46.78N	126-44.08E	Departure from 6kC Deep-Tow Survey Line (B4)
12.4	10:22	12.4	19:22	27-18.46N	127-10.19E	MBES/SBP Survey Line 17 in
12.4	11:21	12.4	20:21	27-09.46N	127-10.28E	MBES/SBP Survey Line 17 out
12.4	11:38	12.4	20:38	27-09.70N	127-12.39E	MBES/SBP Survey Line 18 in
12.4	15:47	12.5	0:47	27-55.80N	127-12.40E	MBES/SBP Survey Line 18 out
12.4	16:04	12.5	1:04	27-55.38N	127-14.91E	MBES/SBP Survey Line 19 in
12.4	19:27	12.5	4:27	27-18.33N	127-14.50E	MBES/SBP Survey Line 19 out
12.4	21:28	12.5	6:28	27-39.04N	127-01.19E	Cesium magnetometer towing finish #05
12.4	22:42	12.5	7:42	27-48.63N	126-55.29E	Arrival at 6kC Deep-Tow Survey Line (B4)
12.4	23:13	12.5	8:13	27-46.64N	126-55.12E	6kC Deep-Tow Survey start #05
12.5	1:56	12.5	10:56	27-46.54N	126-42.25E	6kC Deep-Tow Survey finish #05
12.5	2:00	12.5	11:00	27-46.54N	126-55.20E	Departure from 6kC Deep-Tow Survey Line (B4)
12.5	2:18	12.5	11:18	27-47.51N	126-55.70E	Arrival at 6kC Deep-Tow Survey Line (B4)
12.5	2:45	12.5	11:45	27-47.48N	126-55.34E	6kC Deep-Tow Survey start #06
12.5	5:17	12.5	14:17	27-47.61N	126-53.72E	6kC Deep-Tow Survey finish #06
12.5	5:24	12.5	14:24	27-47.78N	126-53.78E	Departure from 6kC Deep-Tow Survey Line (B4)
12.5	6:18	12.5	15:18	27-47.43N	127-02.95E	Arrival at St. B-6
12.5	6:27	12.5	15:27	27-47.28N	127-02.88E	OBEM deployment #06
12.5	6:57	12.5	15:57	27-47.43N	127-03.13E	OBEM deployment position fixed (Depth : 1318m)
12.5	7:19	12.5	16:19	27-47.82N	127-02.85E	Cesium magnetometer towing start #06
12.5	7:36	12.5	16:36	27-46.95N	127-04.25E	Departure from St. B-6
12.5	7:44	12.5	16:44	27-45.80N	127-03.06E	MBES/SBP Survey Line 13.5 in
12.5	10:28	12.5	19:28	27-15.72N	127-02.93E	MBES/SBP Survey Line 13.5 Out
12.5	11:49	12.5	20:49	27-21.02N	127-14.12E	MBES/SBP Survey Line 19 in
12.5	12:49	12.5	21:49	27-09.50N	127-14.56E	MBES/SBP Survey Line 19 out
12.5	13:10	12.5	22:10	27-09.89N	127-16.67E	MBES/SBP Survey Line 20 in
12.5	13:11	12.5	22:11	27-10.06N	127-16.68E	XCTD #06
12.5	17:20	12.6	2:20	27-55.03N	127-16.71E	XCTD #07
12.5	17:21	12.6	2:21	27-55.16N	127-16.71E	MBES/SBP Survey Line 20 out
12.5	17:46	12.6	2:46	27-55.04N	127-18.82E	MBES/SBP Survey Line 21 in

12.5	19:59	12.6	4:59	27-31.00N	127-18.76E	MBES/SBP Survey Line 21 out
12.5	21:29	12.6	6:29	27-40.54N	127-03.43E	Cesium magnetometer towing finish #06
12.5	22:42	12.6	7:42	27-48.46N	126-55.18E	Arrival at 6kC Deep-Tow Survey Line (B4)
12.5	23:09	12.6	8:09	27-47.91N	126-55.15E	6kC Deep-Tow Survey start #07
12.6	2:24	12.6	11:24	27-46.13N	126-55.18E	6kC Deep-Tow Survey finish #07
12.6	2:30	12.6	11:30	27-46.00N	126-55.17E	Departure from 6kC Deep-Tow Survey Line (B4)
12.6	2:54	12.6	11:54	27-47.80N	126-55.56E	Arrival at 6kC Deep-Tow Survey Line (B4)
12.6	3:02	12.6	12:02	27-47.65N	126-54.85E	6kC Deep-Tow Survey start #08
12.6	6:48	12.6	15:48	27-47.05N	126-52.54E	6kC Deep-Tow Survey finish #08
12.6	7:01	12.6	16:01	27-47.29N	126-52.69E	Cesium magnetometer towing start #07
12.6	7:18	12.6	16:18	27-45.78N	126-53.38E	Departure from 6kC Deep-Tow Survey Line (B4)
12.6	7:20	12.6	16:20	27-45.43N	126-53.44E	MBES/SBP Survey Line 9 in
12.6	10:31	12.6	19:31	27-10.04N	126-53.59E	MBES/SBP Survey Line 9 out
12.6	10:55	12.6	19:55	27-09.89N	126-50.99E	MBES/SBP Survey Line 8 in
12.6	14:56	12.6	23:56	27-55.49N	126-51.39E	MBES/SBP Survey Line 8 out
12.6	15:14	12.7	0:14	27-56.09N	126-49.24E	MBES/SBP Survey Line 7 in
12.6	18:38	12.7	3:38	27-19.70N	126-49.32E	MBES/SBP Survey Line 7 out
12.6	21:18	12.7	6:18	27-39.60N	126-49.10E	Cesium magnetometer towing finish #07
12.6	21:43	12.7	6:43	27-40.00N	126-50.00E	Calibration for magnetometer #03
12.6	22:42	12.7	7:42	27-47.56N	126-49.35E	Arrival at 6kC Deep-Tow Survey Line (W-E-1)
12.6	23:17	12.7	8:17	27-49.21N	126-51.23E	6kC Deep-Tow Survey start #09
12.7	6:58	12.7	15:58	27-54.33N	126-56.77E	6kC Deep-Tow Survey finish #09
12.7	7:05	12.7	16:05	27-54.73N	126-36.96E	Cesium magnetometer towing start #08
12.7	7:18	12.7	16:18	-	-	Departure from 6kC Deep-Tow Survey Line (W-E-1)

4. Instruments

4.1. Shipboard observation system

4.1.1. SEABEAM 3012 Upgrade Model (12kHz system)

R/V MIRAI is equipped with a Multi-narrow Beam Echo Sounding system (MBES), SEABEAM 3012 Upgrade Model (L3 Communications ELAC Nautik). Table 4.1-1 shows the system configuration and performance of SEABEAM 3012 Upgrade.

Table 4.1-1 the system configurations and performance

SEABEAM 3012 Upgrade Model (12 kHz system)

Frequency:	12 kHz
Transmit beam width:	1.6 degree
Transmit power:	20 kW
Transmit pulse length:	2 to 20 msec
Receive beam width:	1.8 degree
Depth range:	100 to 11,000 m
Beam spacing:	0.5 degree athwart ship
Swath width:	150 degree (max)
	120 degree to 4,500 m
	100 degree to 8,000 m
	90 degree to 11,000 m
Depth accuracy:	Within < 0.5% of depth or ±1m, whichever is greater, over the entire swath. (Nadir beam has greater accuracy; typically within < 0.2% of depth or ±1m, whichever is greater)

4.1.2. Sub Bottom Profiler

R/V MIRAI is equipped a with Sub-bottom Profiler (SBP), Bathy2010 (SyQwest). Table 4.1-2 shows the system configurations and performance of Sub Bottom Profiler.

Table 4.1-2 the system configurations and performance

Sub bottom Profiler, Bathy2010 (3.5 kHz system)

Frequency:	3.5 kHz, FM Chirp
Transmit beam width:	23 degree
Transmit pulse length:	0.5 to 50 msec
Strata resolution:	Up to 8 cm with 300+ Meters of bottom penetration; bottom type dependant
Depth resolution:	0.1 Feet, 0.1 Meters
Depth accuracy:	±10 cm to 100 m, ±0.3% to 6,000 m

4.1.3. Magnetometer

1) Three-component magnetometer

The shipboard three-component magnetometer system (Tierra Technica SFG1214) is equipped on-board R/V MIRAI. Three-axis flux-gate sensor with ring-cored coils is 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 (Fiber Optical Gyro) installed for controlling attitude of the Doppler radar. Ship's position and speed data are taken from LAN every second.

2) Cesium marine magnetometer

We measured total geomagnetic field using a cesium marine magnetometer (Geometrics Inc., G-882) and recorded by G-882 data logger (Clovertech Co., Ver.1.0.0). The G-882 magnetometer uses an optically pumped Cesium-vapor atomic resonance system. The sensor fish towed 500 m behind the vessel to minimize the effects of the ship's magnetic field. Table 4.1.2-1 shows the system configuration of MIRAI cesium magnetometer system.

Table 4.1.3 the system configurations of MIRAI cesium magnetometer system

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Dynamic operating range:		20,000 to 100,000 nT
Absolute accuracy: < ±2 nT throughout range		
Setting:	Cycle rate;	0.1 sec
	Sensitivity;	0.001265 nT at a 0.1 second cycle rate
	Sampling rate;	1 sec

4.1.4. Gradiometer

The LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) is equipped on-board R/V MIRAI. Table 4.1.3 shows the system configurations of MIRAI gravity meter.

Table 4.1.4 the system configurations

LaCoste and Romberg air-sea gravity meter (S-116)	
Range:	12,000 mGal
Drift rate:	<±3.0 mGal/month
Temperature set point:	46 to 55 deg-C
Resolution:	0.01 mGal
Static repeatability:	0.05 mGal
Accuracy at sea:	1.0 mGal or better
Sampling rate:	1 sec
Relative gravity	Counter unit [CU]
	To change gravity [mGal] = (coef1: 0.9946) * [CU]

4.2. 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. 4.2.1). 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 Mirai's 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.

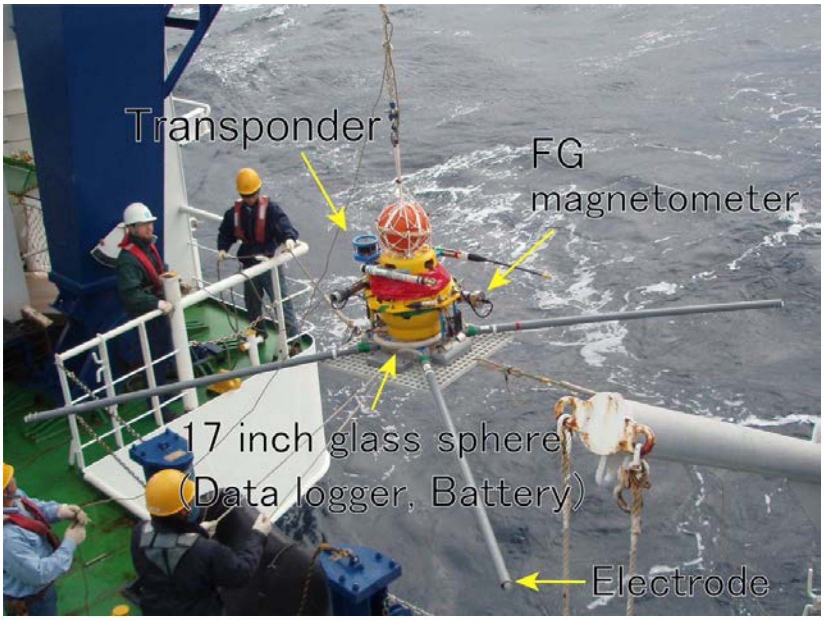

Fig. 4.2.1 OBEM system

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

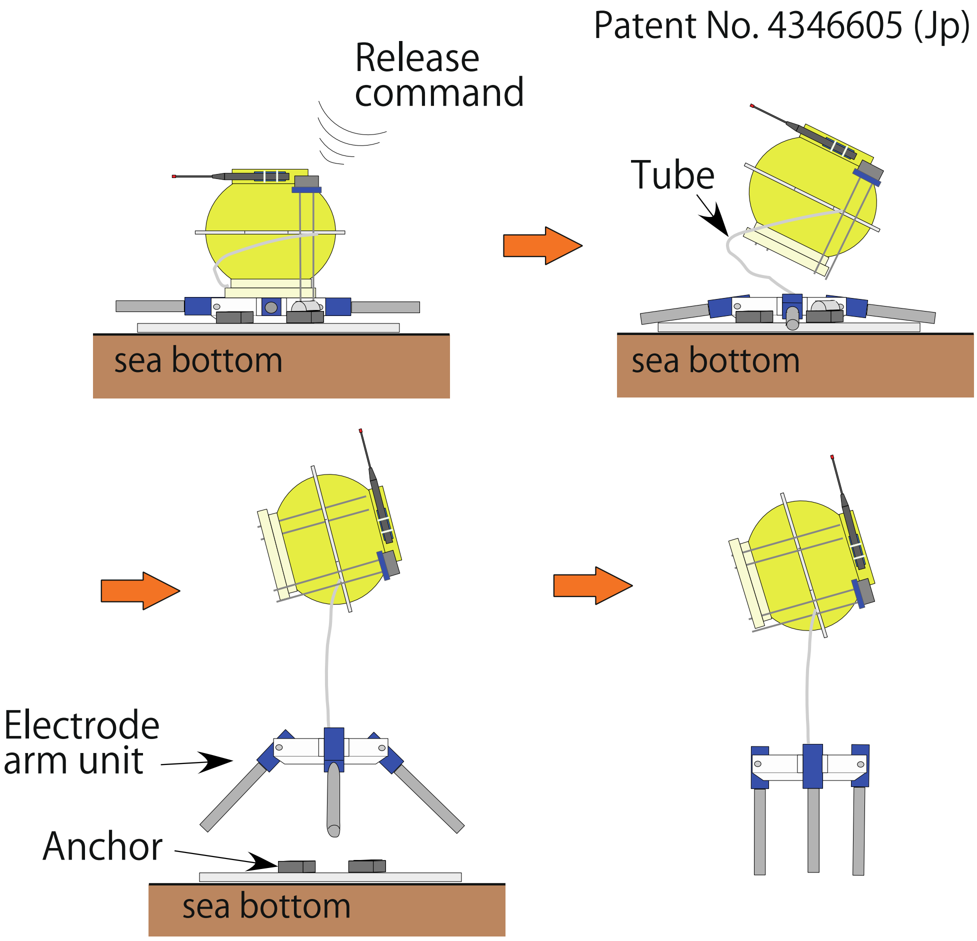

Fig. 4.2.2 Electrode arm-holding mechanism of type A OBEM

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.

4.3. DC resistivity system

On this cruise, we examined the deep towed DC and controlled-source electromagnetic (CSEM) survey using R/V Mirai and deep-tow system of JAMSTEC. Our controlled source suvey system, called “A-MANTA”, consists of a transmitter unit and a main unit with a data logger, which recorded a transmitting signal and received signal. The AC 100 V supplied from the deep-tow transfers to DC 48 V, and it is input to a transmitter unit. The maximum output power of this transmitter is about 1.2 kW with maximum voltage of 48V peak-to-peak and current of 50A. The logger unit can record data of output power data of a transmitter unit and four electric fields with a 8 Hz sampling rate.

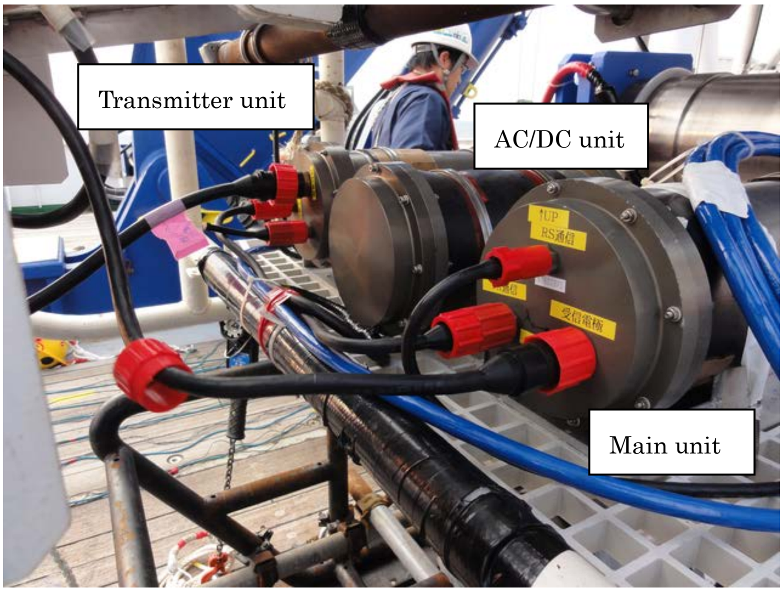

Fig. 4.3.1.2 Photo of a controlled source survey system (A-MANTA).

Table 4.3.1 Specification of a controleld source survey system

<u>Power unit</u>

Max Input Voltage: 120 V

Max Output Current: 50 A

Circuit type: IGBT

Transmit channel: 4 ch

<u>Main unit</u>

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

Logger unit

Measurement channels: 5 CH

Measurement Voltage Range: ±100 mV

A/D converter: 24 bit

Recording Media: SDHC

Sampling rate: 8 Hz

4.4. Sub bottom profiler

The SBP (Sub Bottom Profiler) system was designed as a basis of the System 2200 manufactured by Edgetech using a full spectrum chirp FM pulse with amplitude and phase weighting with 1.5-4.5 kHz frequency range. A special feature of this system is mounting four transmitters to improve a penetrating depth and its resolution. The specification of the system is shown in Table 4.2.1. The SBP (Sub Bottom Profiler) system is mounted on the lower part of the deep-tow (Fig. 4.4.1).

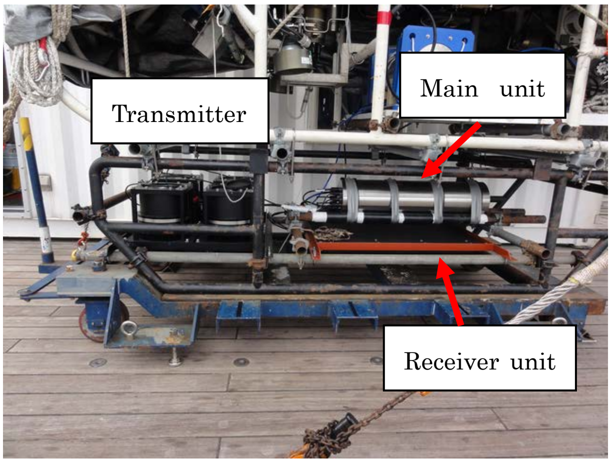

Figure 4.4.1 Sub bottom profiler system on 6k deep-tow.

Table 4.4.1 Specification of SBP system.

SBP: Sub Bottom Profiler

Max. Transmitting Power: 800 W

Frequency Band: 1-6kHz

Pulse selection: 1.5-4.5kHz

Depth Resolution: 15cm – 25cm,

Beam Width: 28°- 36°,

Operating Depth: 8000m

5. Operation report and preliminary results

5.1. Shipboard data

We conducted a surface geophysical survey to characterize back-arc basin development and also the distribution of hydrothermal activity in the northwestern part of Okinawa Trough. Multi-narrow beam bathymetry, backscatter intensity, vertical sub-bottom profile, gravity field, and magnetic field data were collected. The total coverage of about 5000 km^2 was attained using 3~5 km track spacing and ~10.5-kt ship speed.

Figure 5.1.1 Ship tracks of survey lines

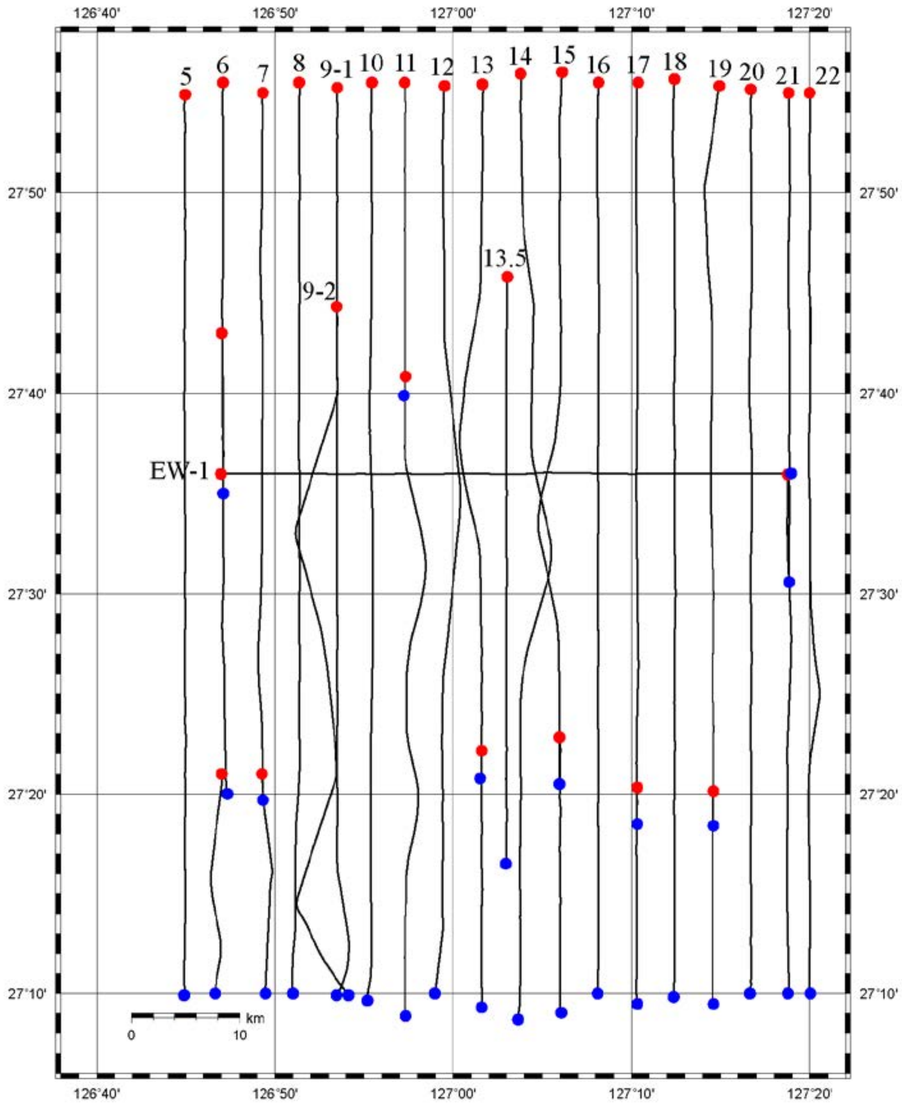

Table 5.1.1 Surface geophysical survey lines list

Line No.	Start		End	
	Date Time (UTC)	Position (Lat., Lon.)	Date Time (UTC)	Position (Lat., Lon.)
5	2013/12/8 8:22:07	27-54.862N, 126-44.967E	2013/12/8 12:44:12	27-09.887N, 126-44.925E
6	2013/12/6 18:50:33	27-19.919N, 126-47.315E	2013/12/6 20:56:33	27-43.233N, 126-46.989E
	2013/12/7 8:05:02	27-55.502N, 126-47.086E	2013/12/7 9:53:28	27-35.445N, 126-47.108E
	2013/12/8 13:03:05	27-10.050N, 126-46.656E	2013/12/8 14:10:18	27-21.210N, 126-47.064E
7	2013/12/6 15:21:27	27-54.951N, 126-49.276E	2013/12/6 18:38:13	27-19.676N, 126-49.314E
	2013/12/8 14:26:39	27-21.092N, 126-49.288E	2013/12/8 15:26:07	27-09.780N, 126-49.469E
8	2013/12/6 10:55:50	27-10.053N, 126-50.990E	2013/12/6 14:56:21	27-55.560N, 126-51.390E
9-1	2013/11/30 10:40:04	27-55.250N, 126-53.511E	2013/11/30 15:19:20	27-09.148N, 126-54.862E
9-2	2013/12/6 7:25:44	27-44.382N, 126-53.503E	2013/12/6 10:31:58	27-09.894N, 126-53.511E
10	2013/11/30 15:25:47	27-09.616N, 126-55.136E	2013/11/30 19:34:25	27-55.215N, 126-55.406E
11	2013/11/30 19:51:33	27-55.686N, 126-57.255E	2013/11/30 21:17:47	27-39.939N, 126-57.295E
	2013/12/1 9:10:03	27-40.647N, 126-57.304E	2013/12/1 12:00:51	27-08.837N, 126-57.298E
12	2013/12/1 12:16:54	27-10.039N, 126-59.012E	2013/12/1 16:22:56	27-55.344N, 126-59.475E
13	2013/12/1 16:44:44	27-54.969N, 127-01.686E	2013/12/1 19:50:42	27-20.662N, 127-01.599E
	2013/12/2 10:11:19	27-22.011N, 127-01.601E	2013/12/2 11:20:21	27-09.382N, 127-01.643E
13.5	2013/12/5 7:44:57	27-45.787N, 127-03.055E	2013/12/5 10:28:06	27-15.712N, 127-02.926E
14	2013/12/2 11:44:51	27-08.989N, 127-03.665E	2013/12/2 16:03:14	27-55.968N, 127-03.818E
15	2013/12/2 16:17:26	27-56.126N, 127-06.096E	2013/12/2 19:29:53	27-20.459N, 127-05.957E
	2013/12/3 10:11:13	27-22.898N, 127-05.975E	2013/12/3 11:27:21	27-08.891N, 127-06.284E
16	2013/12/3 11:40:04	27-10.002N, 127-08.129E	2013/12/3 15:48:32	27-55.695N, 127-08.182E
17	2013/12/3 16:02:00	27-55.746N, 127-10.307E	2013/12/3 19:25:14	27-18.444N, 127-10.276E
	2013/12/4 10:21:54	27-20.320N, 127-10.286E	2013/12/4 11:21:06	27-09.449N, 127-10.289E
18	2013/12/4 11:38:48	27-09.850N, 127-12.394E	2013/12/4 15:46:59	27-55.790N, 127-12.401E
19	2013/12/4 16:04:09	27-55.358N, 127-14.908E	2013/12/4 19:26:48	27-18.365N, 127-14.554E
	2013/12/5 11:53:58	27-20.190N, 127-14.553E	2013/12/5 12:49:05	27-09.488N, 127-14.558E
20	2013/12/5 13:10:57	27-09.986N, 127-16.674E	2013/12/5 17:21:29	27-55.205N, 127-16.715E
21	2013/12/5 17:46:08	27-55.008N, 127-18.819E	2013/12/5 19:59:55	27-30.567N, 127-18.836E
	2013/12/7 13:14:52	27-35.979N, 127-18.775E	2013/12/7 15:38:33	27-09.906N, 127-18.823E
22	2013/12/7 15:52:49	27-10.014N, 127-19.987E	2013/12/7 19:59:41	27-55.053N, 127-20.023E
EW-1	2013/12/7 10:17:10	27-35.997N, 126-47.094E	2013/12/7 12:56:02	27-35.993N, 127-18.937E

5.1.1. Bathymetric survey data

Multi-narrow beam bathymetric feature was obtained by "SEABEAM 3012 Upgrade Model" installed onboard R/V MIRAI during the MR13-E02 Leg1 cruise from 25 November to 9 December 2013. The real-time sound velocity data by Surface Sound Velocimeter (SSV) at the sea surface (6.62m depth) and the sound velocity vertical profiles estimated by the results of XCTD (eXpendable Conductivity Temperature Depth profiler) were used for the ray-path correction of acoustic multi-beam. The sound velocity was calculated by using the equation in Del Grosso (1974). Seven XCTDs in total were done in the survey area as shown in Fig. 5.1.2 and Table 5.1.2.

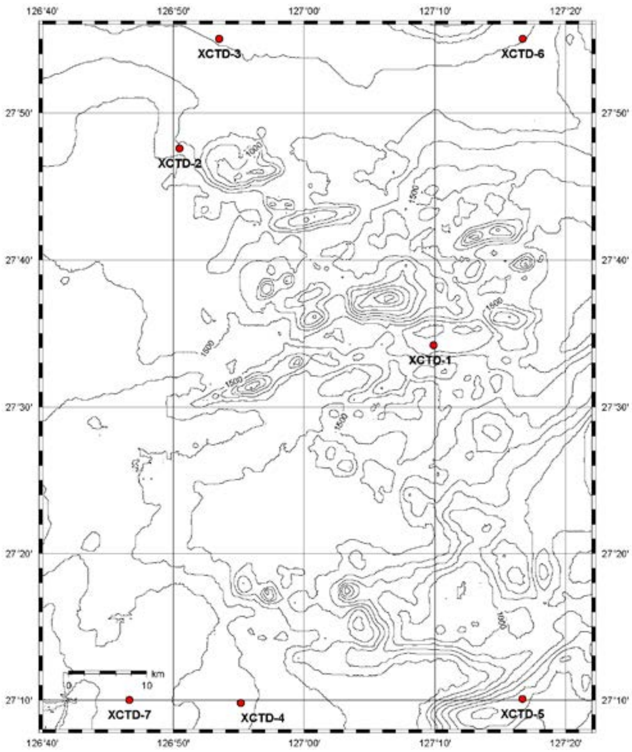

Figure 5.1.2 Location on the bathymetric map of XCTD stations

Table 5.1.2 XCTD measurement list

No.	Date	Time(UTC)	Latitude	Longitude
XCTD-1	2013/11/29	20:08	27-34.195N	127-09.844E
XCTD-2	2013/11/29	23:10	27-47.580N	126-50.482E
XCTD-3	2013/11/30	10:43	27-55.022N	126-53.510E
XCTD-4	2013/11/30	15:27	27-09.789N	126-55.172E
XCTD-5	2013/12/05	13:11	27-10.061N	127-16.679E
XCTD-6	2013/12/05	17:19	27-55.028N	127-16.709E
XCTD-7	2013/12/08	13:02	27-10.001N	126-46.650E

5.1.2. Geophysical survey data

Magnetic field data were collected by two equipments; a shipboard three-component magnetometer (STCM, Tierra Tecnica SFG1214), which can measure the vector of the geomagnetic field using deck-mounted fluxgate magnetometers and gyros, and a ship-towed cesium magnetometer (Geometrics Inc., G-882) which can measure the intensity of the geomagnetic field. The STCM is the system which has been already installed on board R/V Mirai.

The STCM data were collected during the MR13-E02 Leg1 cruise from 25 November 2013 to 9 December 2013. The STCM data contain the effects of ship's magnetic field, which is required to be corrected in order to derive the real geomagnetic field. Twelve constants (B(1,1)-B(3,4)) related to the ship's permanent and induced magnetic field are estimated using the data of "Eight figure turn". "Eight figure turn" are made by steering ship tight circle, both clockwise and counter clockwise rotation. During the cruise, "Eight figure turn" were conducted four times and those are listed below.

Table 5.1.3 "Eight figure turn" position list

No.	Date	Time(UTC)	Latitude	Longitude
1	2013/11/26	00:59-01:25	32°34.377'N	137°11.713'E
2	2013/11/26	21:52-22:16	30°05.831'N	133°42.604'E
3	2013/11/27	05:27-05:51	29°14.303'N	132°31.310'E
4	2013/12/6	21:43-22:08	27°40.388'N	126°50.258'E

Total geomagnetic field were measured by using a cesium marine magnetometer (Geometrics Inc., G-882) and recorded by G-882 data logger (Clovertech Co., Ver.1.0.0) during the site survey from 30 November 2013 to 9 December 2013. Geomagnetic total intensity anomaly is obtained by subtracting the International Geomagnetic Reference Field from the cesium magnetometer data.

Gravity field data were obtained from a shipboard gravimeter (S-116, LaCoste & Romberg Air-Sea Gravity Meter – System II) during the MR13-E02 Leg1 cruise from 25 November 2013 to 9 December 2013. Free-air gravity anomaly is calculated with subtracting the normal gravity field and correction of the Eotvos effect using the GPS data. The gravity field data at the Yokohama and Naha ports measured by the portable gravimeter (Scintrex gravity meter CG-5) will be used to correct the data drift.

5.2. OBEM deployment

OBEMs were launched using an articulated crane for all stations (Fig. 5.2.1), and sunk by their own weights. The operations were quick and smooth. We tracked the OBEMs by acoustic signals and confirmed that the OBEMs were successfully settled on the seafloor. Then, thier positions were determined by the SSBL system equipped on the R/V Mirai (Fig. 5.2.2, Table 5.2.1). All OBEMs will be recovered in the KR14-03 cruise

Figure 5.2.1 Photo of the operation of an OBEM deployment.

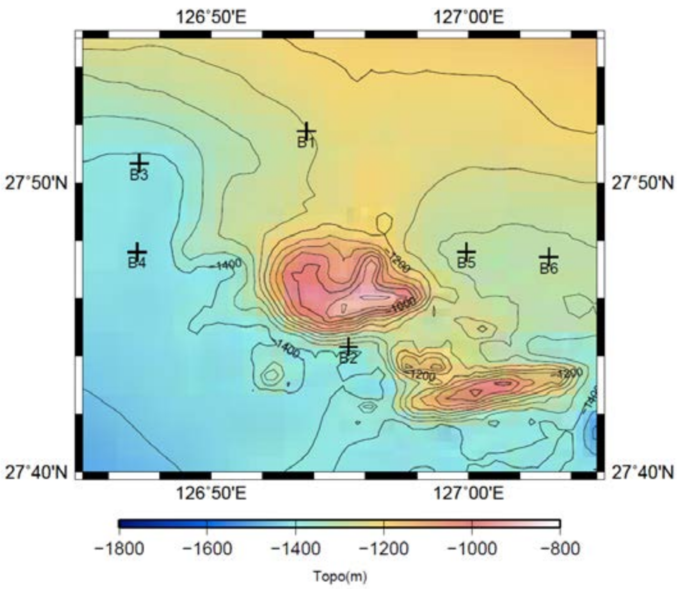

Figure 5.2.2 Site map of deployed OBEMs.

Table 5.2.1 Information of the OBEMs.

site ID	OBEM ID	Deployed time (JST)	Deployed Latitude	Deployed Longitude	Landed time (JST)	Landed Latitude	Landed Longitude	Depth (m)
B1	JM109	2013/11/30 14:07	27-51.53N	126-53.55E	2013/11/30 14:40	27-51.7769N	126-53.7060E	1251.7
B2	JM100	2013/11/30 16:06	27-44.09N	126-55.19E	2013/11/30 16:39	27-44.3259N	126-55.3392E	1479.3
B3	JM103	2013/11/30 12:27	27-50.48N	126-46.99E	2013/11/30 12:56	27-50.6716N	126-47.1980E	1389.5
B4	JM105	2013/11/30 10:05	27-47.45N	126-46.96E	2013/11/30 10:34	27-47.6028N	126-47.1261E	1475.4
B5	JM108	2013/11/30 17:41	27-47.37N	126-59.74E	2013/11/30 18:10	27-47.6095N	126-59.9238E	1317.0
B6	JM110	2013/12/5 15:27	27-47.28N	127-02.88E	2013/12/5 16:00	27-47.4315N	127-03.1333E	1335.5

5.3. Deep-tow dives

We conducted ten deep-tow dives in this cruise for a controlled electro-magnetic source survey and a filed test of the towed subbottom profiling. Figure 5.3.1 shows all survey line of deep-tow dives carried out in this cruise, and the dive information is summarized in table 5.3.1. On this cruise, we examined the deep towed DC and controlled-source electromagnetic (CSEM) survey using R/V Mirai and deep-tow system of JAMSTEC. These operations are first operation using the built-in optical-electrical cable in R/V Mirai. We should have been able to control the main unit and confirm a recording data in real-time by our original plan. However it has become a off-line survey because of a problem of the optical communication. We could conduct six EM dives and three SBP dives in and around the North Iheya hydrothermal area (Fig. 5.3.1.1). In these operation, output current was controlled with 20 A because of a limitaton of the power supply of the deep-tow system. Towed hight of EM survey and SBP survey is 25-30 meters and 100 meters, respectively. Electrode configurations of each EM dives are shown in Fig. 5.3.3.

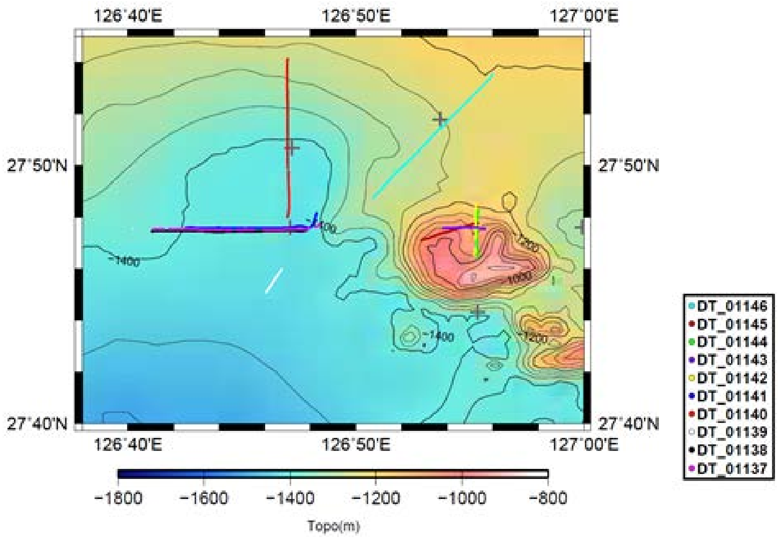

Fig. 5.3.1 Deep-tow survey lines carried out on MR13-E02 cruise.

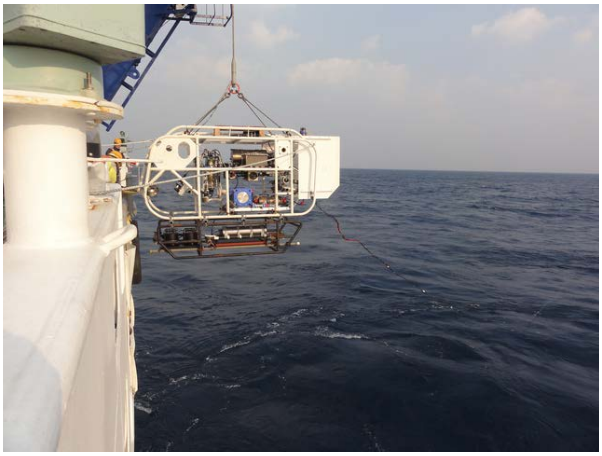

Fig. 5.3.2 Deployment of the A-MANTA system.

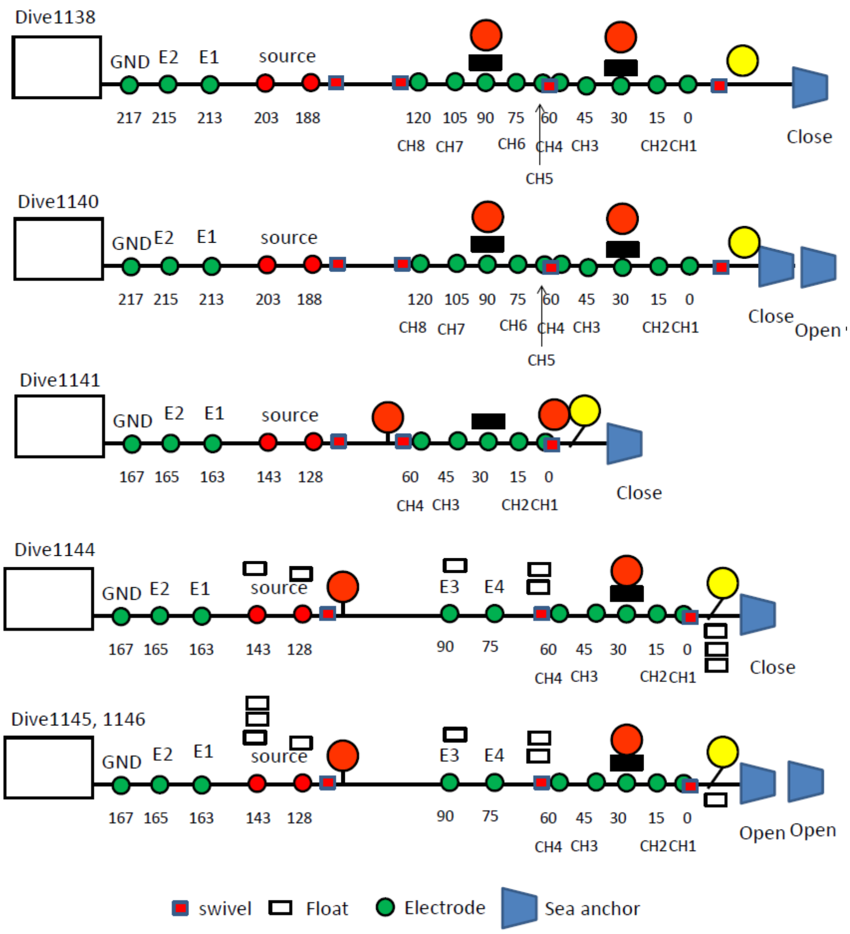

Fig. 5.3.3 Schematic diagram of electrode configuration of each EM survey dive. Green circles show the receiver electrodes. E1-E4 show receiver electrodes of control unit of A-MANTA. Othere green circles show the receiver elecrodes of indivisual electrometer(s).

Table 5.3.1 Deep-tow survey line list

Date (JST)	line No.		Time (JST)	DT position				Seafloor depth(m) : A+B	Notice
				Latitude	Longitude	A:CTD depth(m)	B:Altitude (m)		
2013/12/1	DT_01137	Start	9:38	27-47.546N	126-47.946E	1298	150	1448	SBP survey Towing alititude are 100, 150, and 200 m Towing speed is 1.0 knt ①: Altitude 200 m ②: Altitude 100 m
		①	13:38	27-47.519N	126-43.223E	1235	200	1435	
		②	14:46	27-47.533N	126-41.895E	1325	100	1425	
		End	15:45	27-47.533N	126-40.787E	1327	100	1427	
2013/12/2	DT_01138	Start	10:16	27-47.601N	126-47.705E	1405	32	1437	EM survey Towing altitude is30 m Towing speed is 1.0~1.2 knt After survey line finished, DT set to depth 700 m
		End	14:45	27-47.608N	126-41.678E	1379	33	1412	
2013/12/3	DT_01139	Start	8:41	27-45.257N	126-46.198E	201	-	-	Test for transmit current DT depth is 200 m
		End	9:01	27-45.819N	126-46.625E	201	-	-	
2013/12/3	DT_01140	Start	10:19	27-48.157N	126-47.062E	1395	30	1425	EM survey Towing altitude is 30 m Towing speed is 1.0~1.2 knt After survey line finished, DT set to depth 700 m for calibutration
		End	14:45	27-53.643N	126-46.992E	1289	30	1319	
2013/12/4	DT_01141	Start	10:28	27-47.607N	126-47.813E	1411	32	1443	EM survey Towing altitude is30 m Towing speed is 1.0~1.2 knt ①: Altitude 20 m After survey line finished, DT set to depth 700 m for calibration
		①	10:48	27-47.637N	126-47.393E	1420	20	1440	
		End	14:45	27-47.595N	126-42.832E	1402	20	1422	
2013/12/5	DT_01142	Start	8:43	27-48.422N	126-55.258E	1000	-	-	SBP survey Towing depth is 1000m Towing speed is 1.0 knt
		End	10:30	27-46.741N	126-55.232E	1000	-	-	
2013/12/5	DT_01143	Start	12:16	27-47.531N	126-55.633E	1000	-	-	SBP survey

		End	13:50	27-47.576N	126-54.033E	1001	-	-	Towing depth is 1000m Towing speed is 1.0 knt
2013/12/6	DT_01144	Start	9:07	27-48.168N	126-55.275E	1138	30	1168	EM survey Towing altitude are 25 and 30 m Towing speed is 1.0~1.2 knt ①: Altitude 25 m After survey line finished, DT set to depth 500 m for calibration
		①	9:45	27-47.579N	126-55.243E	1105	25	1130	
		End	10:38	27-46.648N	126-55.277E	1005	25	1030	
2013/12/6	DT_01145	Start	12:55	27-47.745N	126-55.161E	1113	30	1143	EM survey Towing altitude are 25 and 30 m Towing speed is 1.0~1.2 knt ①: Altitude 25 m After survey line finished, DT set to depth 500 m for calibration
		①	13:10	27-47.681N	126-54.946E	1119	25	1144	
		End	14:55	27-47.180N	126-53.172E	1017	25	1042	
2013/12/7	DT_01146	Start	9:35	27-49.114N	126-51.168E	1263	20	1283	EM survey Towing altitude are 20 and 10 m Towing speed is 1.0~1.2 knt ①: Altitude 10 m After survey line finished, DT set to depth 700 m for calibration
		①	13:11	27-51.791N	126-54.115E	1228	10	1238	
		End	15:07	27-53.324N	126-55.835E	1197	13	1210	
2013/12/8	DT_01147	Start	8:53	confidential	confidential	confidential	confidential	confidential	Seafloor observation and SP survey
		End	11:35	confidential	confidential	confidential	confidential	confidential	
13/12/8	DT_01148	Start	12:51	confidential	confidential	confidential	confidential	confidential	Seafloor observation and SP survey
		End	15:32	confidential	confidential	confidential	confidential	confidential	