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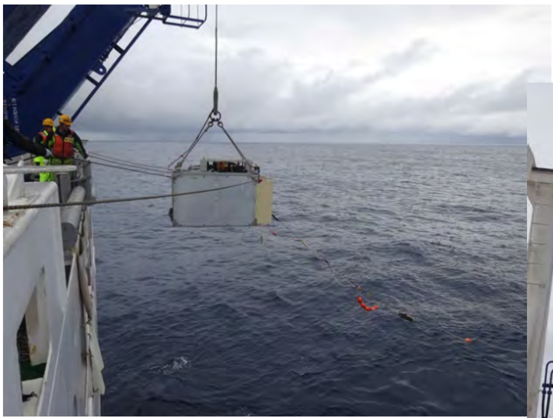
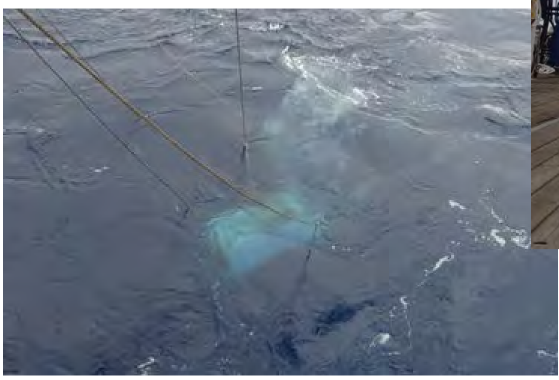
Cruise Report

MR16-E01

Development of the geophysical exploration method using SP and DC resistivity method on the hydrothermal deposit in the Izena hole





Izena hole, South-West Japan

R/V Mirai

24 Feb 2016 - 11 Mar 2016

Contents

1. Cruise information and summary of MR16-E01 cruise
2. List of Participants
    Onboard Scientists
3. Ship Logs
4. Instruments
    4.1. Shipboard observation system
        4.1.1 SEABEAM 3012 Upgrade Model (12kHz system)
        4.1.2 Sub Bottom Profiler
        4.1.3 Magnetometer
        4.1.4 Gradiometer
    4.2 Controlled source deep-tow system
    4.3 Ocean bottom electrometer
5. Operation report
    5.1 Shipboard data
    5.2 Deep-tow dives
    5.3 OBE operations

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 MR16-E01 cruise**

Cruise information

Cruise number	MR16-E01
Name of the cruise	R/V MIRAI
Chief scientist	Takafumi Kasaya (CEAT, JAMSTEC)
Representative of the Science Party	Eiichi Kikawa (JAMSTEC)
Title of the cruise	Development of the geophysical exploration method using SP and DC resistivity method on the hydrothermal deposit in the Izena hole
Cruise period	23 Feb 2015 – 11 March 2015
Ports of call	Shimizu port – Shimizu port
Research Area	Izena hole area (Fig.1)

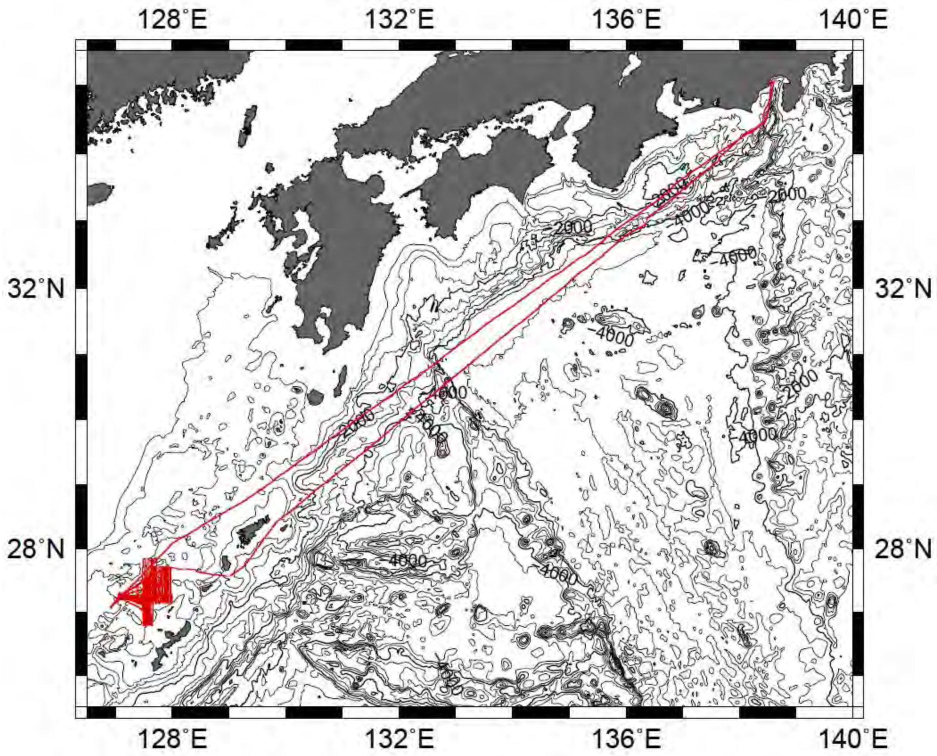


Fig.1 Ship track of this cruise.

Cruise proposal

” Development of the geophysical exploration method using SP and DC resistivity method on the hydrothermal deposit in the Izena hole”

In recent, a 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.

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 around the Izena hole field. The Izena hole field is known as one of the promising hydrothermal deposit. On this cruise, we carried out the towing on six towed DC resistivity survey lines, two controlled source shooting to the six OBEs, three SP survey lines and two sonar deep-tow survey lines in the Izena hole geothermal area. After finishing the all towing survey, we was able to recover all OBEs.

2. List of Participants

Onboard Scientists

Takafumi Kasaya	JAMSTEC (Chief Scientist)
Kazuya Kitada	JAMSTEC
Hisanori Iwamoto	Nippon Marine Enterprises Ltd.
Satomi Minamizawa	Nippon Marine Enterprises Ltd.
Shigeo Matsuda	Clovertech Ltd.
Kenji Kuratsu	Kaiyo Engineering Co., Ltd.
Mikio Fujimaki	Kaiyo Engineering Co., Ltd.
Hiroyuki Hayashi	Marine Works Japan Ltd.
Akira So	Marine Works Japan Ltd.
Yasushi Hashimoto	Marine Works Japan Ltd.
Wataru Tokunaga	Global Ocean Development Inc.
Kazuho Yoshida	Global Ocean Development Inc.
Miki Morioka	Global Ocean Development Inc.

3. Ship Logs

U.T.C.		S.M.T.		Position		Event logs
Date	Time	Date	Time	Latitude	Longitude	
2.24	00:00	2.24	9:00			Departure from Shimizu
2.24	17:20	2.25	2:20	32-30N	135-36E	Calibration for magnetometer #01
2.25	04:29	2.25	13:29	31-00N	133-27E	Calibration for magnetometer #02
2.25	15:19	2.26	0:19	29-30N	131-22E	Calibration for magnetometer #03
2.26	07:15	2.26	16:15	27-41.05N	128-11.18E	Cesium magnetometer towing start #01
2.26	07:33	2.26	16:33	27-40.99N	128-08.35E	XCTD #01
2.26	08:51	2.26	17:51	27-42.31N	127-52.32E	MBES/SBP Survey Line NT-8 in
2.26	10:27	2.26	19:27	27-26.07N	127-52.05E	MBES/SBP Survey Line NT-8 out
2.26	10:36	2.26	19:36	27-26.88N	127-50.91E	MBES/SBP Survey Line NT-7 in
2.26	12:17	2.26	21:17	27-43.14N	127-51.04E	MBES/SBP Survey Line NT-7 out
2.26	12:33	2.26	21:33	27-26.23N	127-49.60E	MBES/SBP Survey Line NT-6 in
2.26	14:10	2.26	23:10	27-26.23N	127-49.54E	MBES/SBP Survey Line NT-6 out
2.26	14:23	2.26	23:23	27-26.50N	127-47.70E	MBES/SBP Survey Line NT-5 in
2.26	16:02	2.27	1:02	27-43.10N	127-47.69E	MBES/SBP Survey Line NT-5 out
2.26	16:16	2.27	1:16	27-42.76N	127-45.75E	MBES/SBP Survey Line NT-4 in
2.26	17:50	2.27	2:50	27-26.69N	127-45.77E	MBES/SBP Survey Line NT-4 out
2.26	21:30	2.27	6:30	27-17.46N	127-11.83E	Cesium magnetometer towing finish #01
2.26	22:54	2.27	7:54	27-13.16N	127-11.17E	Arrival at OBE point
2.26	23:38	2.27	8:38	27-15.02N	127-03.98E	OBE deployment #01
				27-15.17N	127-04.02E	OBE #01 fixed position (Depth : 1636m)
2.27	00:53	2.27	9:53	27-14.77N	127-03.86E	OBE deployment #02
				27-14.93N	127-03.89E	OBE #02 fixed position (Depth :1639m)
2.27	01:55	2.27	10:55	27-14.70N	127-04.01E	OBE deployment #03
				27-14.86N	127-04.05E	OBE #03 fixed position (Depth : 1621m)

2.27	03:04	2.27	12:04	27-14.39N	127-04.10E	OBE deployment #04
				27-14.56N	127-04.13E	OBE #04 fixed position (Depth : 1603m)
2.27	04:08	2.27	13:08	27-14.47N	127-03.83E	OBE deployment #05
				27-14.65N	127-04.00E	OBE #05 fixed position (Depth : 1613m)
2.27	05:09	2.27	14:09	27-14.13N	127-03.94E	OBE deployment #06
				27-14.29N	127-03.99E	OBE #06 fixed position (Depth : 1526m)
2.27	06:05	2.27	15:05	27-14.41N	127-04.26E	Deep-Tow water entry test
2.27	07:06	2.27	16:06	27-14.34N	127-05.15E	Departure from OBE point
2.27	07:32	2.27	16:32	27-13.99N	127-07.23E	Cesium magnetometer towing start #02
2.27	09:00	2.27	18:00	27-09.50N	127-25.16E	XCTD #02
2.27	09:25	2.27	18:25	27-09.94N	127-29.05E	MBES/SBP Survey Line VF-1 in
2.27	13:29	2.27	22:29	27-50.71N	127-29.19E	MBES/SBP Survey Line VF-1 out
2.27	13:46	2.27	22:46	27-50.12N	127-31.42E	MBES/SBP Survey Line VF-3 in
2.27	17:52	2.28	2:52	27-28.62N	127-31.19E	MBES/SBP Survey Line VF-3 out
2.27	18:04	2.28	3:04	27-08.76N	127-31.13E	MBES/SBP Survey Line VF-2 in
2.27	20:05	2.28	5:05	27-30.70N	127-30.06E	MBES/SBP Survey Line VF-2 out
2.27	21:36	2.28	6:36	27-19.54N	127-12.45E	Cesium magnetometer towing finish #02
2.27	22:54	2.28	7:54	27-13.56N	127-02.18E	Arrival at Deep-Tow Survey point
2.28	01:09	2.28	10:09	27-14.77N	127-03.94E	Deep-Tow Survey Line R3 in
2.28	01:55	2.28	10:55	27-15.70N	127-03.95E	Deep-Tow Survey Line R3 out
2.28	03:30	2.28	12:30	27-14.59N	127-03.98E	Deep-Tow Survey Line R4 in
2.28	04:31	2.28	13:31	27-13.75N	127-03.97E	Deep-Tow Survey Line R4 out
2.28	06:09	2.28	15:09	27-14.29N	127-04.07E	Deep-Tow Survey Line R5 in
2.28	07:31	2.28	16:31	27-15.68N	127-04.03E	Deep-Tow Survey Line R5 out
2.28	08:18	2.28	17:18	27-16.19N	127-04.13E	Departure from Deep-Tow Survey point
2.28	08:34	2.28	17:34	27-16.34N	127-04.55E	Cesium magnetometer towing start #03

2.28	10:41	2.28	19:41	27-09.60N	127-33.41E	MBES/SBP Survey Line VF-5 in
2.28	14:47	2.28	23:47	27-50.62N	127-33.52E	MBES/SBP Survey Line VF-5 out
2.28	15:03	2.29	0:03	27-50.38N	127-35.69E	MBES/SBP Survey Line VF-7 in
2.28	19:04	2.29	4:04	27-08.94N	127-35.92E	MBES/SBP Survey Line VF-7 out
2.28	19:28	2.29	4:28	27-09.53N	127-32.42E	MBES/SBP Survey Line VF-4 in
2.28	19:54	2.29	4:54	27-13.66N	127-32.38E	MBES/SBP Survey Line VF-4 out
2.28	23:00	2.29	8:00	27-11.81N	127-32.49E	MBES/SBP Survey Line VF-4' in
2.29	01:24	2.29	10:24	27-34.82N	127-32.52E	MBES/SBP Survey Line VF-4' out
2.29	01:37	2.29	10:37	27-34.53N	127-34.38E	MBES/SBP Survey Line VF-6 in
2.29	04:06	2.29	13:06	27-09.00N	127-34.36E	MBES/SBP Survey Line VF-6 out
2.29	04:29	2.29	13:29	27-09.00N	127-37.56E	MBES/SBP Survey Line VF-9 in
2.29	09:18	2.29	18:18	27-50.66N	127-37.88E	MBES/SBP Survey Line VF-9 out
2.29	09:57	2.29	18:57	27-43.81N	127-40.03E	MBES/SBP Survey Line VF-11 in
2.29	13:21	2.29	22:21	27-09.34N	127-39.94E	MBES/SBP Survey Line VF-11 out
2.29	13:44	2.29	22:44	27-09.42N	127-36.72E	MBES/SBP Survey Line VF-8 in
2.29	16:39	3.1	1:39	27-34.78N	127-36.68E	MBES/SBP Survey Line VF-8 out
2.29	16:54	3.1	1:54	27-34.08N	127-39.02E	MBES/SBP Survey Line VF-10 in
2.29	19:13	3.1	4:13	27-09.27N	127-39.10E	MBES/SBP Survey Line VF-10 out
2.29	21:04	3.1	6:04	27-26.05N	127-41.33E	MBES/SBP Survey Line TN-1 in
2.29	22:57	3.1	7:57	27-43.10N	127-41.23E	MBES/SBP Survey Line TN-1 out
2.29	23:07	3.1	8:07	27-42.85N	127-42.70E	MBES/SBP Survey Line TN-2 in
3.1	00:45	3.1	9:45	27-26.31N	127-42.68E	MBES/SBP Survey Line TN-2 out
3.1	00:56	3.1	9:56	27-26.63N	127-44.14E	MBES/SBP Survey Line TN-3 in
3.1	03:25	3.1	12:25	27-50.69N	127-44.13E	MBES/SBP Survey Line TN-3 out
3.1	03:54	3.1	12:54	27-50.39N	127-38.78E	MBES/SBP Survey Line VF-10' in
3.1	05:30	3.1	14:30	27-33.50N	127-38.87E	MBES/SBP Survey Line VF-10' out
3.1	05:49	3.1	14:49	27-31.75N	127-38.90E	Cesium magnetometer towing finish #03
3.1	06:00	3.1	15:00	27-30.93N	127-38.90E	Arrival at Tail Buoy test point
3.1	06:28	3.1	15:28	27-30.34N	127-38.81E	Tail Buoy attitude control test
3.1	07:18	3.1	16:18	27-29.26N	127-38.77E	Departure from Tail Buoy test point

3.1	07:33	3.1	16:33	27-29.14N	127-38.80E	Cesium magnetometer towing start #04
3.1	08:04	3.1	17:04	27-27.52N	127-42.69E	MBES/SBP Survey Line TN2-2 in
3.1	09:42	3.1	18:42	27-10.94N	127-42.67E	XCTD #03
3.1	09:54	3.1	18:54	27-09.01N	127-42.71E	MBES/SBP Survey Line TN2-2 out
3.1	10:03	3.1	19:03	27-09.05N	127-44.02E	MBES/SBP Survey Line TN2-3 in
3.1	11:58	3.1	20:58	27-27.86N	127-44.01E	MBES/SBP Survey Line TN2-3 out
3.1	12:09	3.1	21:09	27-27.52N	127-45.59E	MBES/SBP Survey Line TN2-4 in
3.1	13:56	3.1	22:56	27-09.30N	127-45.55E	MBES/SBP Survey Line TN2-4 out
3.1	14:08	3.1	23:08	27-09.53N	127-47.24E	MBES/SBP Survey Line TN2-5 in
3.1	16:06	3.2	1:06	27-29.23N	127-46.82E	MBES/SBP Survey Line TN2-5 out
3.1	16:23	3.2	1:23	27-27.82N	127-48.92E	MBES/SBP Survey Line TN2-6 in
3.1	18:09	3.2	3:09	27-09.42N	127-49.28E	MBES/SBP Survey Line TN2-6 out
3.1	18:18	3.2	3:18	27-09.94N	127-50.35E	MBES/SBP Survey Line TN2-7 in
3.1	18:37	3.2	3:37	27-13.58N	127-50.59E	MBES/SBP Survey Line TN2-7 out
3.1	21:31	3.2	6:31	27-13.62N	127-12.15E	Cesium magnetometer towing finish #04
3.1	22:42	3.2	7:42	27-13.03N	127-04.01E	Arrival at Deep-Tow Survey point
3.2	00:50	3.2	9:50	27-14.50N	127-04.02E	Deep-Tow Survey Line CS1 in
3.2	01:07	3.2	10:07	27-14.50N	127-04.02E	Deep-Tow Survey Line CS1 out
3.2	01:57	3.2	10:57	27-15.13N	127-04.01E	XCTD #04
3.2	07:12	3.2	16:12	27-15.43N	127-03.96E	Departure from Deep-Tow Survey point
3.2	08:00	3.2	17:00	27-16.01N	127-05.94E	Cesium magnetometer towing start #05
3.2	10:59	3.2	19:59	27-11.22N	127-50.60E	MBES/SBP Survey Line TN2-7' in
3.2	12:38	3.2	21:38	27-27.66N	127-50.55E	MBES/SBP Survey Line TN2-7'

						out
3.2	12:52	3.2	21:52	27-27.35N	127-52.38E	MBES/SBP Survey Line TN2-8 in
3.2	14:39	3.2	23:39	27-09.37N	127-52.41E	MBES/SBP Survey Line TN2-8 out
3.2	14:51	3.2	23:51	27-09.90N	127-53.80E	MBES/SBP Survey Line TN3-1 in
3.2	18:07	3.3	3:07	27-42.97N	127-53.62E	MBES/SBP Survey Line TN3-1 out
3.2	21:35	3.3	6:35	27-20.30N	127-12.73E	Cesium magnetometer towing finish #05
3.2	22:48	3.3	7:48	27-16.41N	127-04.03E	Arrival at Deep-Tow Survey point
3.3	01:13	3.3	10:13	27-14.97N	127-04.00E	Deep-Tow Survey Line CS1' in
3.3	02:48	3.3	11:48	27-13.14N	127-03.98E	Deep-Tow Survey Line CS1' out
3.3	04:42	3.3	13:42	27-13.85N	127-04.12E	Deep-Tow Survey Line CS2 in
3.3	07:00	3.3	16:00	27-16.24N	127-04.03E	Deep-Tow Survey Line CS2 out
3.3	08:42	3.3	17:42	27-18.14N	127-04.11E	Departure from Deep-Tow Survey point
3.3	09:03	3.3	18:03	27-18.02N	127-04.39E	Cesium magnetometer towing start #06
3.3	12:25	3.3	21:25	27-09.97N	127-55.17E	MBES/SBP Survey Line TN3-2 in
3.3	15:42	3.4	1:42	27-42.98N	127-55.09E	MBES/SBP Survey Line TN3-2 out
3.3	15:56	3.4	1:56	27-42.10N	127-55.76E	MBES/SBP Survey Line TN3-3 in
3.3	18:29	3.4	3:29	27-16.27N	127-55.85E	MBES/SBP Survey Line TN3-3 out
3.3	21:29	3.4	6:29	27-16.33N	127-13.92E	Cesium magnetometer towing finish #06
3.3	22:36	3.4	7:36	27-16.17N	127-04.03E	Arrival at Deep-Tow Survey point
3.4	00:40	3.4	9:40	27-15.24N	127-03.99E	Deep-Tow Survey Line MDCR1 in
3.4	02:35	3.4	11:35	27-13.16N	127-03.98E	Deep-Tow Survey Line MDCR1 out
3.4	05:00	3.4	14:00	27-13.18N	127-00.74E	Departure from Deep-Tow Survey point

3.4	05:57	3.4	14:57	27-14.33N	127-07.89E	Cesium magnetometer towing start #07
3.4	09:18	3.4	18:18	27-17.17N	127-55.81E	MBES/SBP Survey Line TN3-3' in
3.4	10:07	3.4	19:07	27-09.22N	127-55.72E	MBES/SBP Survey Line TN3-3' out
3.4	10:18	3.4	19:18	27-09.63N	127-57.22E	MBES/SBP Survey Line TN3-4 in
3.4	13:38	3.4	22:38	27-42.62N	127-57.22E	MBES/SBP Survey Line TN3-4 out
3.4	13:50	3.4	22:50	27-42.23N	127-58.49E	MBES/SBP Survey Line TN3-5 in
3.4	17:06	3.5	2:06	27-09.43N	127-58.52E	MBES/SBP Survey Line TN3-5 out
3.4	17:20	3.5	2:20	27-10.67N	127-59.99E	MBES/SBP Survey Line TN3-6 in
3.4	17:59	3.5	2:59	27-16.78N	127-59.78E	MBES/SBP Survey Line TN3-6 out
3.4	21:29	3.5	6:29	27-15.85N	127-12.58E	Cesium magnetometer towing finish #07
3.4	22:42	3.5	7:42	27-16.44N	127-04.09E	Arrival at Deep-Tow Survey point
3.5	00:33	3.5	9:33	27-15.17N	127-04.10E	Deep-Tow Survey Line MDCR2 in
3.5	02:12	3.5	11:12	27-13.48N	127-04.08E	Deep-Tow Survey Line MDCR2 out
3.5	05:59	3.5	14:59	27-15.27N	127-04.16E	Deep-Tow Survey Line MDCR4 in
3.5	07:47	3.5	16:47	27-13.42N	127-04.17E	Deep-Tow Survey Line MDCR4 out
3.5	09:00	3.5	18:00	27-12.76N	127-04.62E	Departure from Deep-Tow Survey point
3.5	09:12	3.5	18:12	27-12.68N	127-04.70E	Cesium magnetometer towing start #08
3.5	11:09	3.5	20:09	27-10.06N	127-29.07E	MBES/SBP Survey Line VF2-1 in
3.5	13:17	3.5	22:17	26-48.09N	127-29.17E	MBES/SBP Survey Line VF2-1 out
3.5	13:25	3.5	22:25	26-48.13N	127-30.15E	MBES/SBP Survey Line VF2-2 in
3.5	15:39	3.6	0:39	27-10.70N	127-30.17E	MBES/SBP Survey Line VF2-2 out
3.5	15:48	3.6	0:48	27-10.51N	127-31.37E	MBES/SBP Survey Line VF2-3 in
3.5	17:57	3.6	2:57	26-48.27N	127-31.52E	MBES/SBP Survey Line VF2-3 out
3.5	18:04	3.6	3:04	26-48.40N	127-32.50E	MBES/SBP Survey Line VF2-4 in

3.5	20:02	3.6	5:02	27-08.63N	127-32.16E	MBES/SBP Survey Line VF2-4 out
3.5	21:30	3.6	6:30	27-12.43N	127-13.88E	Cesium magnetometer towing finish #08
3.5	22:42	3.6	7:42	27-13.72N	127-04.77E	Arrival at Deep-Tow Survey point
3.6	00:06	3.6	9:06	27-14.49N	127-04.13E	Deep-Tow Survey Line MDCR3 in
3.6	01:22	3.6	10:22	27-15.57N	127-03.41E	Deep-Tow Survey Line MDCR3 out
3.6	02:40	3.6	11:40	27-14.89N	127-03.89E	Deep-Tow Survey Line MDCR5 in
3.6	02:47	3.6	11:47	27-14.77N	127-03.89E	Deep-Tow Survey Line MDCR5 out
3.6	05:12	3.6	14:12	27-14.54N	127-03.79E	Deep-Tow Survey Line MDCR6 in
3.6	06:27	3.6	15:27	27-15.73N	127-03.78E	Deep-Tow Survey Line MDCR6 out
3.6	07:42	3.6	16:42	27-16.51N	127-03.57E	Departure from Deep-Tow Survey point
3.6	07:56	3.6	16:56	27-16.66N	127-03.54E	Cesium magnetometer towing start #09
3.6	10:05	3.6	19:05	27-07.52N	127-32.38E	MBES/SBP Survey Line VF2-4' in
3.6	10:24	3.6	19:24	27-10.64N	127-32.39E	MBES/SBP Survey Line VF2-4' out
3.6	10:34	3.6	19:34	27-10.05N	127-33.44E	MBES/SBP Survey Line VF2-5 in
3.6	12:20	3.6	21:20	26-52.40N	127-33.59E	XCTD #05
3.6	12:46	3.6	21:46	26-48.23N	127-33.63E	MBES/SBP Survey Line VF2-5 out
3.6	12:54	3.6	21:54	26-48.41N	127-34.50E	MBES/SBP Survey Line VF2-6 in
3.6	15:19	3.7	0:19	27-11.73N	127-34.68E	MBES/SBP Survey Line VF2-6 out
3.6	15:32	3.7	0:32	27-10.52N	127-35.62E	MBES/SBP Survey Line VF2-7 in
3.6	17:43	3.7	2:43	26-48.10N	127-36.10E	MBES/SBP Survey Line VF2-7 out
3.6	17:51	3.7	2:51	26-48.72N	127-36.77E	MBES/SBP Survey Line VF2-8 in
3.6	18:52	3.7	3:52	26-58.70N	127-36.34E	MBES/SBP Survey Line VF2-8 out
3.6	21:32	3.7	6:32	27-14.27N	127-05.82E	Cesium magnetometer towing finish #09
3.6	22:00	3.7	7:00	27-14.78N	127-03.81E	Arrival at OBE point
3.6	22:01	3.7	7:01	27-16.26N	127-03.82E	OBE recovery #01

3.6	23:46	3.7	8:46	27-15.45N	127-04.32E	OBE recovery #02
3.7	01:18	3.7	10:18	27-14.81N	127-04.33E	OBE recovery #03
3.7	02:37	3.7	11:37	27-15.15N	127-04.31E	OBE recovery #05
3.7	04:13	3.7	13:13	27-14.35N	127-04.17E	OBE recovery #04
3.7	05:30	3.7	14:30	27-14.12N	127-04.21E	OBE recovery #06
3.7	06:30	3.7	15:30	27-14.62N	127-04.09E	Departure from OBE point
3.7	06:53	3.7	15:53	27-14.39N	127-04.51E	Cesium magnetometer towing start #10
3.7	08:09	3.7	17:09	27-13.66N	127-22.45E	MBES/SBP Survey Line A-1 in
3.7	09:19	3.7	18:19	27-26.15N	127-22.36E	MBES/SBP Survey Line A-1 out
3.7	09:33	3.7	18:33	27-25.85N	127-24.19E	MBES/SBP Survey Line A-2 in
3.7	10:44	3.7	19:44	27-13.98N	127-24.31E	MBES/SBP Survey Line A-2 out
3.7	12:19	3.7	21:19	26-55.78N	127-36.71E	MBES/SBP Survey Line VF2-8' in
3.7	13:47	3.7	22:47	27-10.74N	127-36.71E	MBES/SBP Survey Line VF2-8' out
3.7	13:56	3.7	22:56	26-10.46N	127-37.76E	MBES/SBP Survey Line VF2-9 in
3.7	16:09	3.8	1:09	26-48.15N	127-38.03E	MBES/SBP Survey Line VF2-9 out
3.7	16:16	3.8	1:16	26-48.62N	127-38.87E	MBES/SBP Survey Line VF2-10 in
3.7	16:57	3.8	1:57	26-55.67N	127-38.90E	MBES/SBP Survey Line VF2-10 out
3.7	17:20	3.8	2:20	26-54.47N	127-39.48E	MBES/SBP Survey Line VF2-10' in
3.7	18:58	3.8	3:58	27-10.72N	127-39.32E	MBES/SBP Survey Line VF2-10' out
3.7	21:30	3.8	6:30	27-13.16N	127-12.46E	Cesium magnetometer towing finish #10
3.7	22:42	3.8	7:42	27-16.01N	127-03.27E	Arrival at Deep-Tow Survey point
3.8	00:35	3.8	9:35	27-15.28N	127-03.74E	Deep-Tow Survey Line1 in
3.8	01:53	3.8	10:53	27-13.77N	127-04.79E	Deep-Tow Survey Line1 out
3.8	03:05	3.8	12:05	27-14.40N	127-04.05E	Deep-Tow Survey Line2 in
3.8	04:23	3.8	13:23	27-16.36N	127-04.07E	Deep-Tow Survey Line2 out
3.8	06:05	3.8	15:05	27-14.83N	127-03.81E	Deep-Tow Survey Line3 in
3.8	06:51	3.8	15:51	27-13.68N	127-03.80E	Deep-Tow Survey Line3 out
3.8	08:12	3.8	17:12	27-50.00N	126-55.00E	Departure from Deep-Tow Survey

						point
3.8	09:15	3.8	18:15	27-05N	126-55E	Calibration for magnetometer #04
3.11	00:00	3.11	09:00			Arrival at Shimizu

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 the SEABEAM 3012.

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 are fixed on the foremast. The 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 the 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 the 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 the MIRAI cesium magnetometer system.

Table 4.1.3 the system configurations of the 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 Controlled source deep-tow system

On this cruise, we examined the deep towed DC resistivity surveys using R/V Mirai and deep-tow system of JAMSTEC. Our controlled source deep-tow system consists of a transmitter unit and a main unit with a data logger, which recorded a transmitting signal and received signal. The AC 1200 V is supplied from the optical-electric cable to a transformer on the deep tow, and a transformer converts it to AC 100 V. Although the maximum output power capacity of this transmitter on the design is 10 kW, the electric energy that can be used for this cruise is about 3kW because of the limitation of the which cable. A data logger can record data such as transmit voltage, transmit current and CTD with 1k Hz sampling rate. Onboard computer can monitor the all data including an altimeter and an monitoring camera, control various setting of the deep tow (Fig.4.2.2).

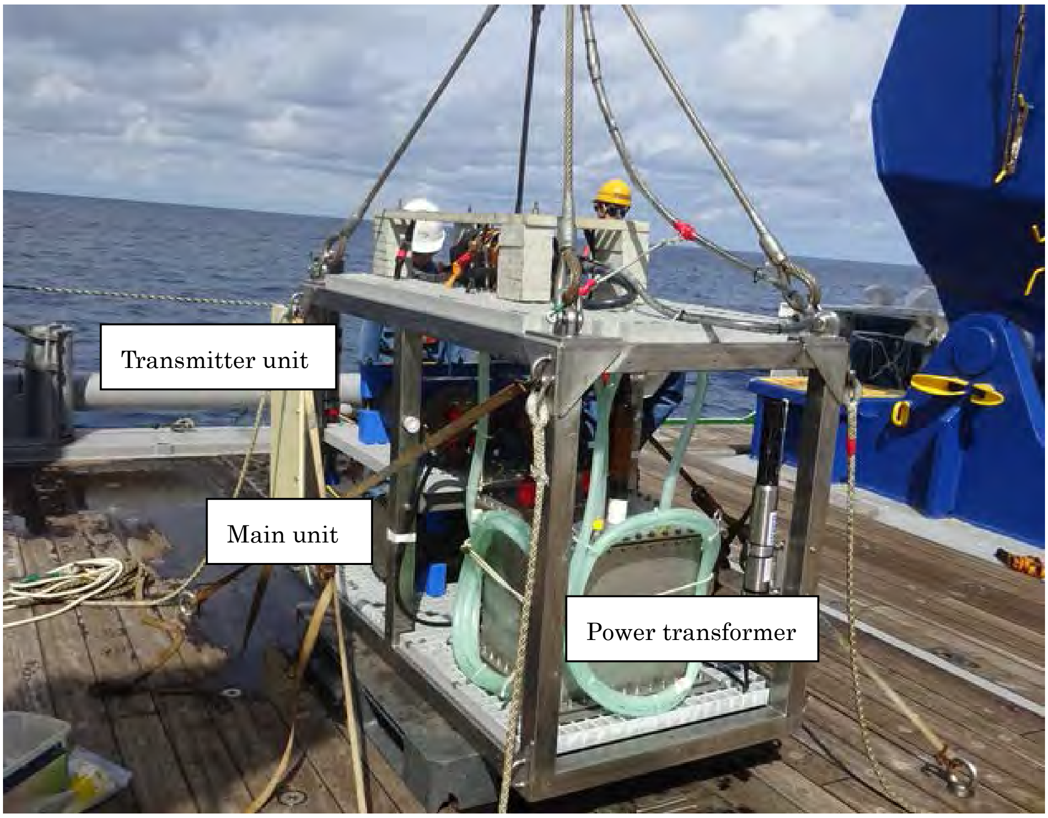

Fig. 4.2.1 Photo of a controlled source deep tow system.

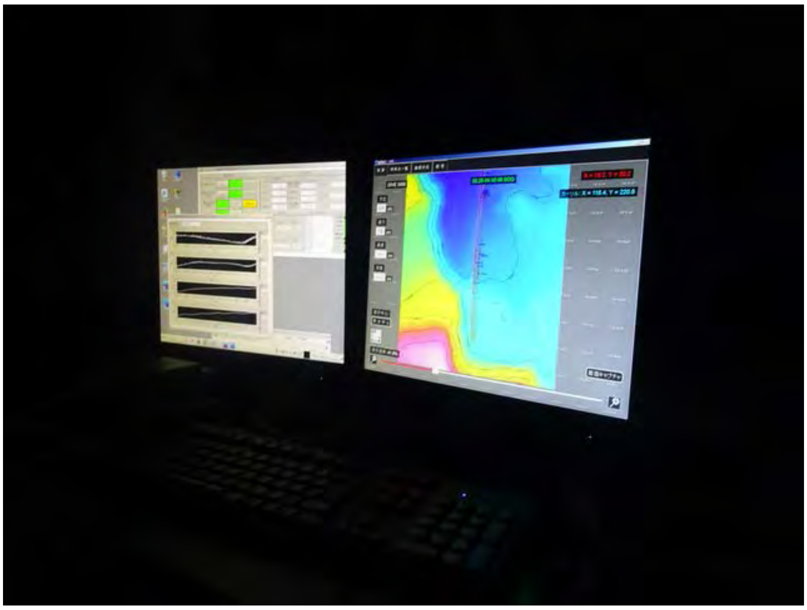

Fig. 4.2.2 Onboard monitoring system.

4.3 Ocean bottom electrometer (OBE)

The OBE system is designed for the controlled source survey with over 250 Hz sampling. An electric circuit and battery are involved in one cylinder type aluminum pressure case (Fig. 4.3.1). This system is a pop-up type with a 17-inch glass float an acoustic transponder and arm folding system (Fig. 4.3.2). 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. 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.

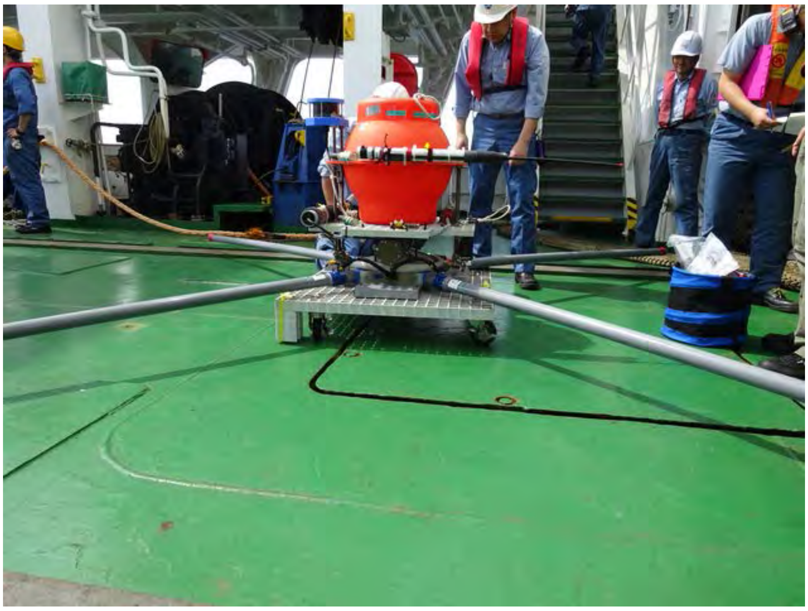

Fig. 4.3.1 Photo of a pop up type OBE system

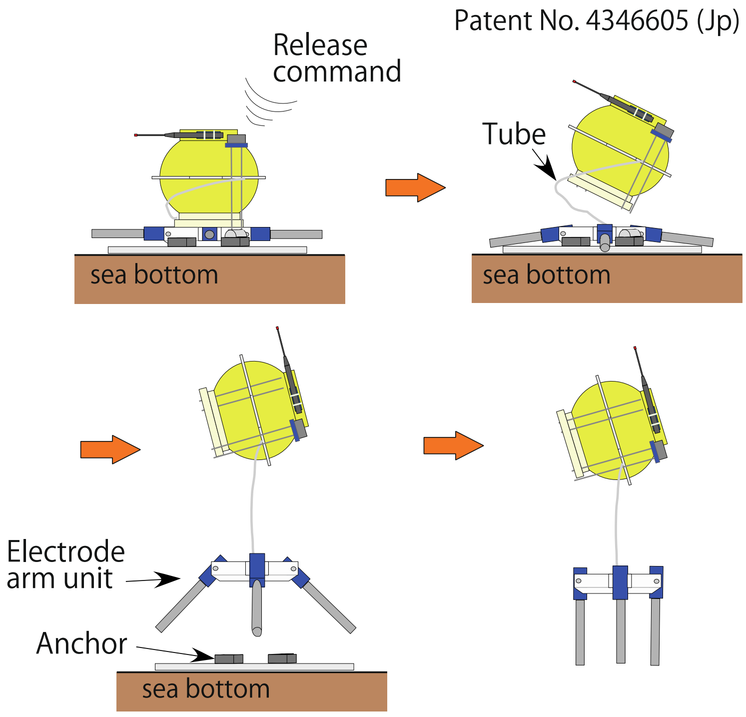

Fig. 4.3.2 Electrode arm-holding mechanism.

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.

5. Operation reports

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 with ~10.5-kt ship speed (Fig. 5.1.1). 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). Five XCTD observation in total were done in the survey area as shown in Fig. 5.1.1 and Table 5.1.1. Survey lines information shows in Table 5.1.2.

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 data contain the effects of ship's magnetic field. To be corrected in order to derive the real geomagnetic field, "Eight figure turn" were conducted four times (Table 5.1.2). Gravity field data were obtained from a shipboard gravimeter (S-116, LaCoste & Romberg Air-Sea Gravity Meter – System II). Free-air gravity anomaly is calculated by 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.

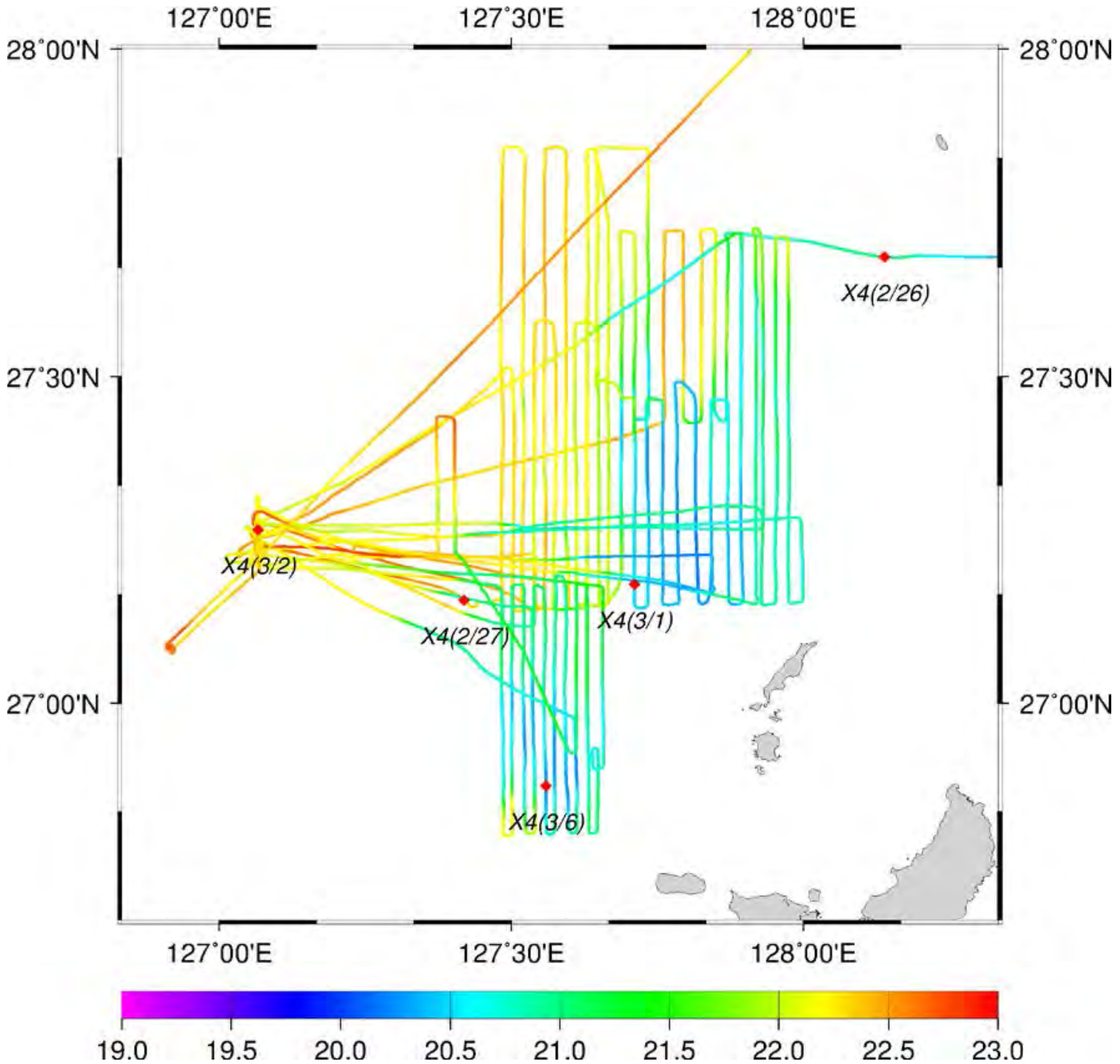

Figure 5.1.1 Ship tracks of survey lines with sea surface temperature and observation points of XCTD (Red circle).

Table 5.1.1 XCTD measurement list.

Date	Time	Latitude	Longitude	Btm.Depth
[YYYY/MM/DD]	[hh:mm]	[degS]	[degE]	[m]
2016/02/26	07:23	27-40.9915N	128-08.3507E	773
2016/02/27	09:00	27-09.4958N	127-25.1613E	829
2016/03/01	09:42	27-10.9358N	127-42.6689E	933
2016/03/02	01:57	27-15.9783N	127-04.0089E	1649
2016/03/06	12:20	26-52.3972N	127-33.5926E	767

Table 5.1.2 Survey line list.

Line No.	North/West		South/East		Distance[nm]
	Latitude	Longitude	Latitude	Longitude	
TN-1	27°42.00'N	127°41.36'E	27°27.00'N	127°41.36'E	15.0
TN-2	27°42.00'N	127°42.72'E	27°27.00'N	127°42.72'E	15.0
TN-3	27°50.00'N	127°44.08'E	27°27.00'N	127°44.08'E	23.0
TN-4	27°42.00'N	127°45.71'E	27°27.00'N	127°45.71'E	15.0
TN-5	27°42.00'N	127°47.61'E	27°27.00'N	127°47.61'E	15.0
TN-6	27°42.00'N	127°49.51'E	27°27.00'N	127°49.51'E	15.0
TN-7	27°42.00'N	127°50.87'E	27°27.00'N	127°50.87'E	15.0
TN-8	27°42.00'N	127°52.23'E	27°27.00'N	127°52.23'E	15.0
TN2-2	27°27.00'N	127°42.72'E	27°10.00'N	127°42.72'E	17.0
TN2-3	27°27.00'N	127°44.08'E	27°10.00'N	127°44.08'E	17.0
TN2-4	27°27.00'N	127°45.71'E	27°10.00'N	127°45.71'E	17.0
TN2-5	27°27.00'N	127°47.34'E	27°10.00'N	127°47.34'E	17.0
TN2-6	27°27.00'N	127°48.97'E	27°10.00'N	127°48.97'E	17.0
TN2-7	27°13.00'N	127°50.39'E	27°10.00'N	127°50.39'E	3.0
TN2-7'	27°27.00'N	127°50.60'E	27°13.00'N	127°50.60'E	14.0
TN2-8	27°27.00'N	127°52.23'E	27°10.00'N	127°52.23'E	17.0
TN3-1	27°42.00'N	127°53.70E	27°10.00'N	127°53.70'E	32.0
TN3-2	27°42.00'N	127°55.22'E	27°10.00'N	127°55.22'E	32.0
TN3-3	27°42.00'N	127°55.78'E	27°17.00'N	127°55.78'E	25.0
TN3-3'	27°17.00'N	127°55.78'E	27°10.00'N	127°55.78'E	7.0
TN3-4	27°42.00'N	127°57.24'E	27°10.00'N	127°57.24'E	32.0
TN3-5	27°42.00'N	127°58.58'E	27°10.00'N	127°58.58'E	32.0
TN3-6	27°42.00'N	127°59.92'E	27°16.00'N	127°59.92'E	32.0
A-1	27°25.50'N	127°22.50'E	27°14.50'N	127°22.50'E	11.0
A-2	27°25.50'N	127°24.25'E	27°14.50'N	127°24.25'E	11.0
NW-1	27°40.00'N	126°20.50'E	27°00.00'N	126°20.50'E	30.0
NW-2	27°40.00'N	126°23.50'E	27°00.00'N	126°23.50'E	30.0

NW-3	27°40.00'N	126°26.50'E	27°00.00'N	126°26.50'E	30.0
NW-4	27°40.00'N	126°29.50'E	27°00.00'N	126°29.50'E	30.0
VF-1	27°50.00'N	127°29.10'E	27°10.00'N	127°29.10'E	40.0
VF-2	27°34.00'N	127°30.19'E	27°10.00'N	127°30.19'E	24.0
VF-3	27°50.00'N	127°31.28'E	27°10.00'N	127°31.28'E	40.0
VF-4	27°13.00'N	127°32.37'E	27°10.00'N	127°32.37'E	3.0
VF-4'	27°34.00'N	127°32.37'E	27°13.00'N	127°32.37'E	21.0
VF-5	27°50.00'N	127°33.46'E	27°10.00'N	127°33.46'E	40.0
VF-6	27°34.00'N	127°34.55'E	27°10.00'N	127°34.55'E	24.0
VF-7	27°50.00'N	127°35.64'E	27°10.00'N	127°35.64'E	40.0
VF-8	27°34.00'N	127°36.73'E	27°10.00'N	127°36.73'E	24.0
VF-9	27°50.00'N	127°37.82'E	27°10.00'N	127°37.82'E	40.0
VF-10	27°34.00'N	127°38.91'E	27°10.00'N	127°38.91'E	24.0
VF-10'	27°50.00'N	127°38.91'E	27°34.00'N	127°38.91'E	16.0
VF-11	27°42.00'N	127°40.00'E	27°10.00'N	127°40.00'E	32.0
VF2-01	27°10.00'N	127°29.10'E	26°49.00'N	127°29.10'E	21.0
VF2-02	27°10.00'N	127°30.19'E	26°49.00'N	127°30.19'E	21.0
VF2-03	27°10.00'N	127°31.28'E	26°49.00'N	127°31.28'E	21.0
VF2-04	27°10.00'N	127°32.37'E	27°08.00N	127°32.37E	2.0
VF2-04'	27°08.00N	127°32.37E	26°49.00'N	127°32.37'E	19.0
VF2-05	27°10.00'N	127°33.46'E	26°49.00'N	127°33.46'E	21.0
VF2-06	27°10.00'N	127°34.55'E	26°49.00'N	127°34.55'E	21.0
VF2-07	27°10.00'N	127°35.64'E	26°49.00'N	127°35.64'E	21.0
VF2-08	26°58.00N	127°36.73'E	26°49.00'N	127°36.73'E	9.0
VF2-08'	27°10.00'N	127°35.64'E	26°58.00N	127°35.64'E	12.0
VF2-09	27°10.00'N	127°37.82'E	26°49.00'N	127°37.82'E	21.0
VF2-10	27°10.00'N	127°38.91'E	26°55.00'N	127°38.91'E	15.0
VF2-10'	26°55.00'N	127°39.50'E	26°49.00'N	127°39.50'E	6.0
VF2-11	27°10.00'N	127°40.00'E	26°49.00'N	127°40.00'E	21.0

5.2 Deep-tow dives

We carried out the towing operation on six DC resistivity survey lines, two CSEM, three SP survey lines and three sonar deep-tow survey lines in the Izena hole. Figure 5.2.1 shows all survey tracks of deep-tow dives carried out in this cruise for the DC resistivity survey and CSEM survey. Figure 5.2.2 also shows the tracks the SP surveys and the sonar observation.

A deep-tow operation of this cruise is a first examination of our new developed EM deep tow. Therefore, in the first three dives, the electric field data acquisition with the short electrode array was conducted for the SP survey, in addition to the confirming the operation of each instruments. After that, two CSEM dives and six DC resistivity survey dives were conducted. Transmitter unit worked well, and output current could send over 40 A. Figure 5.2.3 shows the photo of EM deep-tow deployment. Finally, we tried to test the sonar deep tow on the three lines (Fig. 5.2.2).

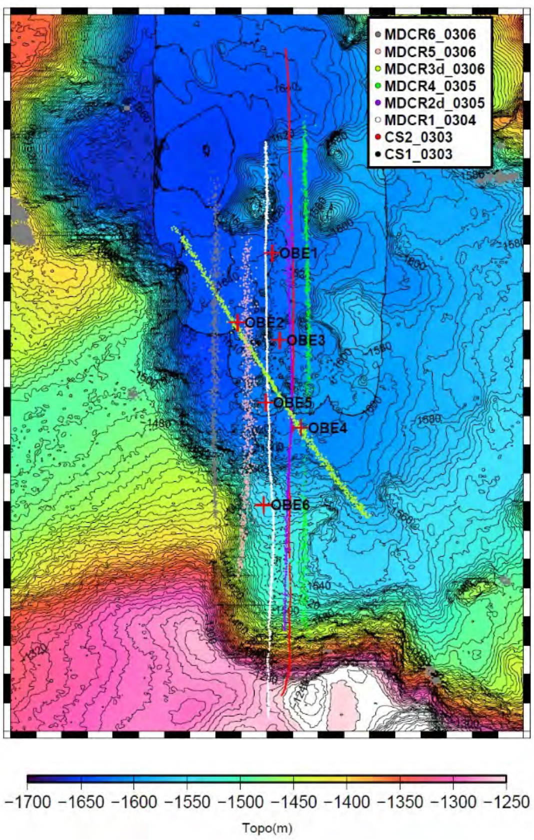

Fig. 5.2.1 Deep-tow survey lines for the DC resistivity surveys and CSEM surveys carried out on a MR16-E01 cruise.

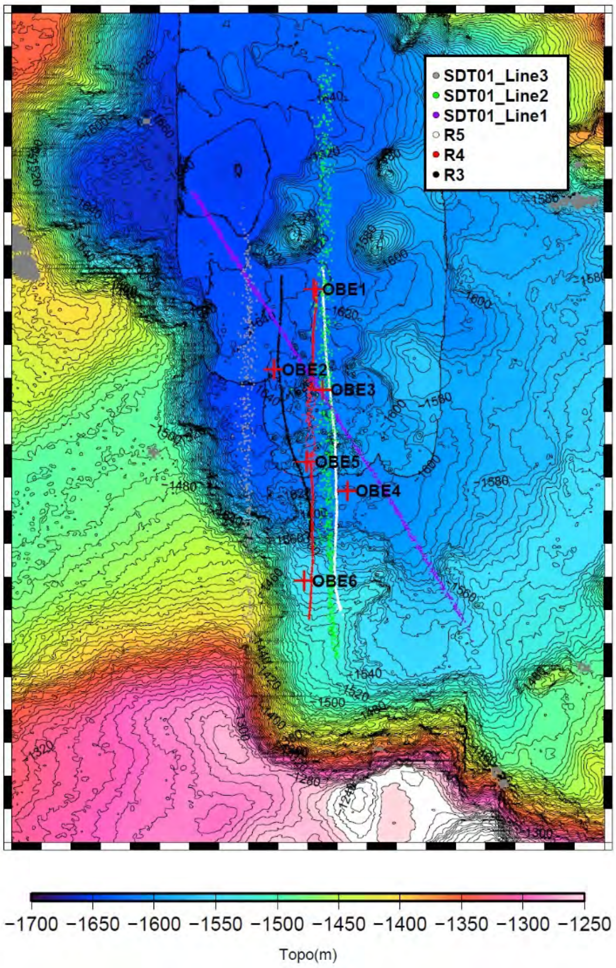

Fig. 5.2.2 Deep-tow survey lines for a SP survey and sonar deep tow survey carried out on a MR16-E01 cruise.

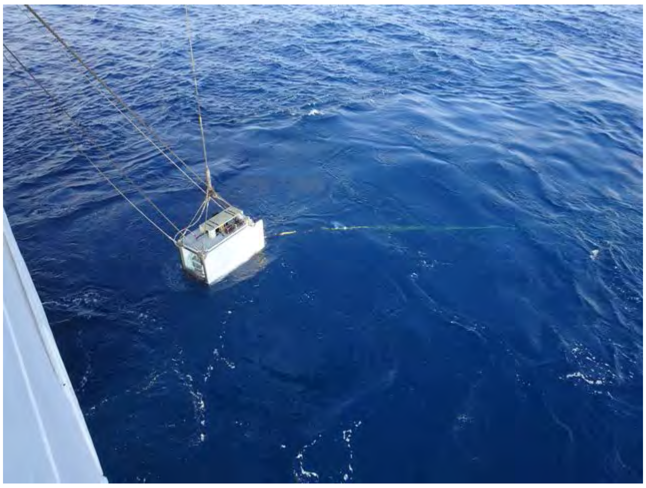

Fig. 5.2.3 Deployment of the EM deep-tow.

5.3 OBE operations

As the receiver of the DC resistivity surveys and CSM surveys, six OBEs were deployed in the Izena hole (Fig. 5.3.2). The operations were quick and smooth. We tracked OBEs by acoustic signals and confirmed that all equipments were successfully settled on the seafloor. Then, each position was determined by the SSBL system equipped on the R/V Mirai (Fig. 5.3.1). All OBEs were recovered successfully in this cruise.

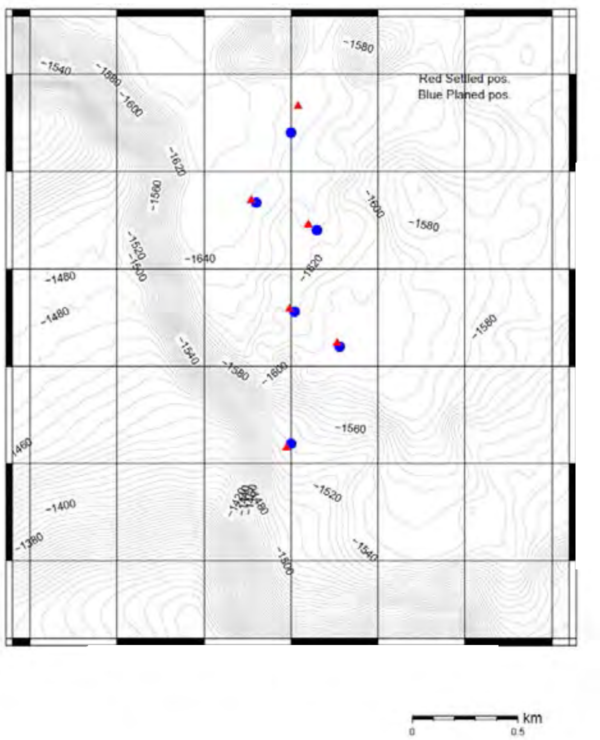

Fig. 5.3.1 Six OBE's position in the Izena hole. Blue and red symbols show the planed position and settle position, respectively.