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On Board Cruise Report

YOKOSUKA Cruise: YK13-01

Rodriguez Triple Junction, Indian Ocean

Jan.16-Feb.4, 2013

Japan Agency for Marine-Earth Science and Technology
(JAMSTEC)

Contents

1. Purpose

We deploy four different types of instruments; OBEM (Ocean Bottom Electro-Magnetometer), OBS (Ocean Bottom Seismometer), OBSP (Ocean Bottom Seismometer with Pressure gauge), and OBSM (Ocean Bottom Seismometers with Magnetometer). The OBEM and OBSM are used to observe magnetic and electric field variations at the ocean bottom across the central and southeast Indian Ridges near the Rodriguez Triple Junction. The OBSs including the OBSP and OBSMs are used to conduct seismic observation at the ocean bottom near the "Kairei" hydrothermal vent site in the first segment of the central Indian Ridge. These observations continue up to the recovery of the instruments during another Yokosuka cruise in this March. The OBSs are also used for active seismic surveys to investigate seismic velocity structure during this cruise and the recovery cruise. Further, we conduct surface geophysical survey mainly during night and transit times. The central and southeast Indian Ridges spreading system shows different spreading rate with different topographic characters, which give the one of the best locations to investigate dependence of seafloor-spreading system on a parameter of spreading rate. In the slower spreading central Indian Ridge, the "Kairei" vent site exist and extrude hydrothermal fluid with richer hydrogen content compared to other hydrothermal vents in the world. The observed data will be analyzed to derive upper mantle structure, crustal structure, and hypocenter distribution, which will provide important constraint on following four main points to understand the seafloor-spreading system; 1) imaging melt delivery to the spreading axis, 2) production and character of the crust, 3) relationship between melt supply and crustal formation, and 4) pathway and heat source for hydrothermal circulation with related to its formation. Moreover, we check the TRITON buoy No.18, which is missing after 3 Dec. 2012 due to no satellite communications.

2. Participants

2-1.Onboard Scientists

Nobukazu Seama (Professor; Chief scientist/Representative of the science party)
Department of Earth and Planetary Sciences, Kobe University

Tomoaki Yamada (Assistant Professor)
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2-4. Crew and Operation Team

Captain	Shinya Ryono
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2nd Officer	Takeshi Egashira
3rd Officer	Shunsuke Fujii
Chief Engineer	Eiji Sakguchi
1st Engineer	Takashi Ota
2nd Engineer	Kenta Ikeguchi
3rd Engineer	Katsuto Yamaguchi
Chief Electronics Operator	Taketo Hattori
2nd Electronics Operator	Yoshikazu Kuramoto
Boat Swain	Kazuo Abe
Able Seaman	Masanori Ohata
Able Seaman	Kaito Murata
Able Seaman	Takuya Miyashita
Sailor	Shinsuke Uzuki
Sailor	Ryoma Tamura
Sailor	Kenta Nasu
No.1 Oiler	Kouzo Miura
Oiler	Keita Funawatari
Oiler	Yuji Higashigawa
Assistant Oiler	Makoto Kozaki
Assistant Oiler	Eiji Aratake
Chief Steward	Ryuei Takemura
Steward	Yoshio Okada
Steward	Seiji Honda
Steward	Kazuma Sonoda
Steward	Kei Ito

3. Cruise Information

3-1. Basic Information

Cruise ID: YK13-01
Name of vessel: YOKOSUKA
Title of the cruise: Seafloor spreading dynamics near the Rodriguez Triple Junction: from mantle to hydrothermal activity, part 1
Title of the proposal: Crustal production process of slow spreading ridge system: Any relation to make hydrogen rich hydrothermal fluid?
Cruise period: Jan.16-Feb.4, 2013
Ports of call: Singapore - Port Louis

3-2. Research area

Our research area is the Rodriguez Triple Junction, Indian Ocean (Figure 3-2-1). The ship tracks of the cruise are shown in Figure 3-2-2.

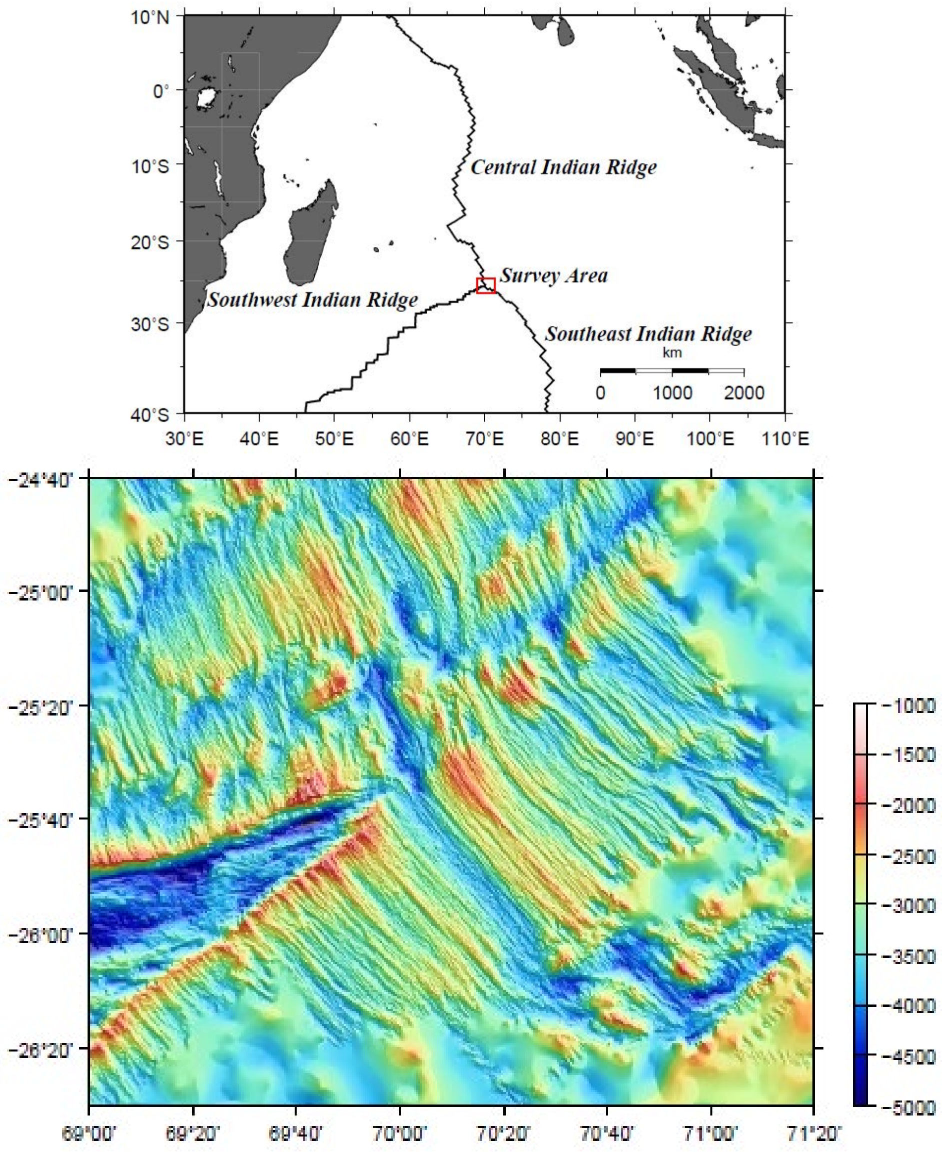

Figure 3-2-1. Bathymetry map of our research area (bottom) and its location shown by red square in the top figure.

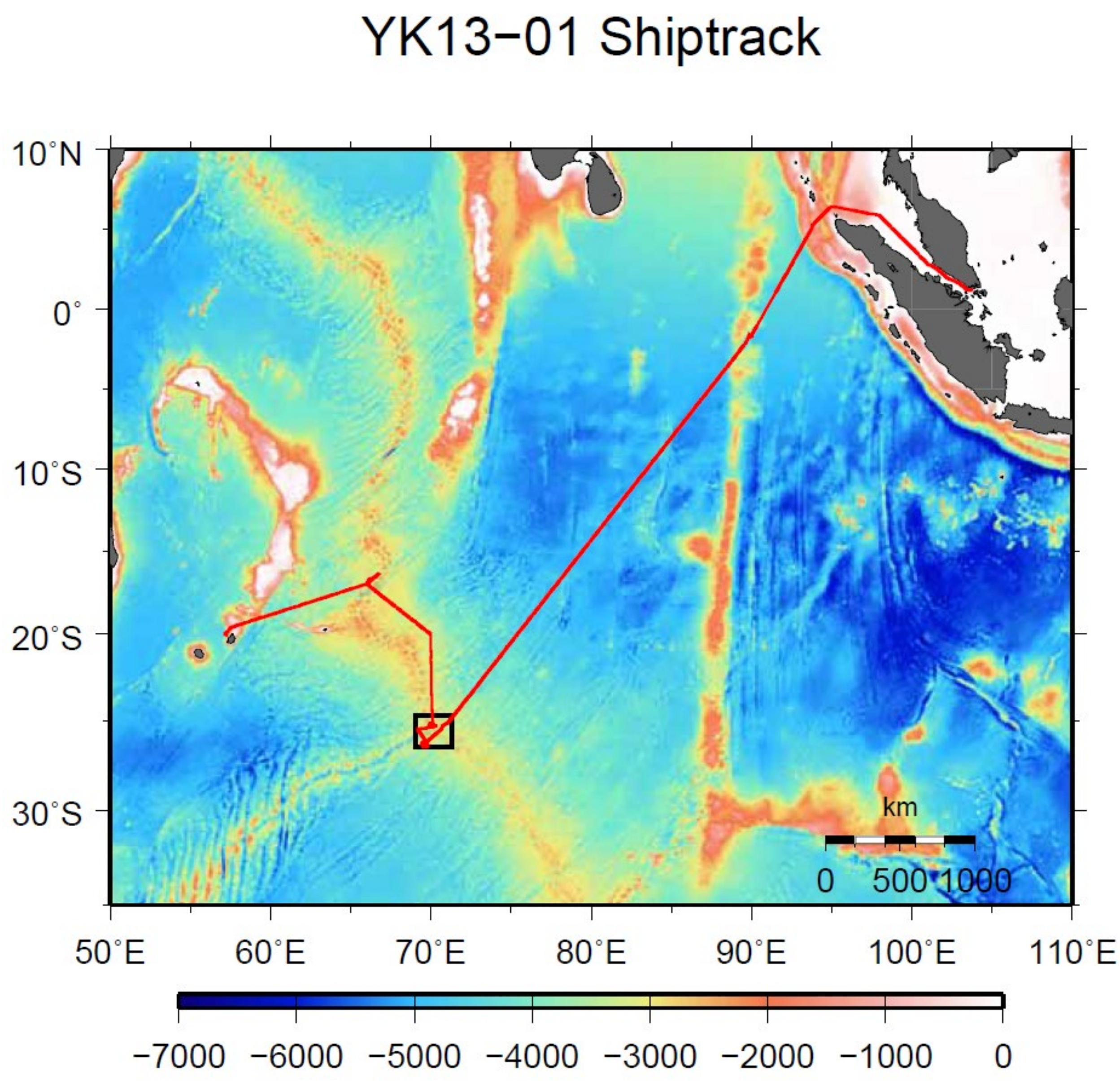

Figure 3-2-2. Ship tracks of the cruise. Our research area is shown by square.

3-3. Ship Log

Date	Local Time	Description	Position/Weather/Wind/Sea condition
15-Jan-13	13:00	scientists onboard	1/15 12:00 (UTC+8h)
	15:00-15:40	lecture for life of shipboard and immiguration	01-15.7N,103-49.1E
			Fine but cloudy
			NNE-3 (Gentle breeze)
			1 (Calm)
			0 (No swell)
			Visibly: 8'
16-Jan-13	08:30-09:05	scientific meeting	1/16 12:00 (UTC+8h)
	10:00	depature from cruise center, Singapore	01-14.0N,103-27.5E
			Cloudy
			NE-4 (Moderate breeze)
			2 (Sea smooth)
			1 (Low swell sea)
			Visibly: 7'
17-Jan-13		tansit to triton No.18 buoy	1/17 12:00 (UTC+8h)
	24:00	shift local time to UTC+7h	04-51.0N,099-02.0E
			Fine but cloudy
			NE-5(Fresh breeze)
			3 (Sea slight)
			1 (Low swell sea)
			Visibly: 8'
18-Jan-13		tansit to triton No.18 buoy	1/18 12:00 (UTC+7h)
	16:40-17:00	pray to KONPIRASAN for safety cruise	05-34.0N,094-04.0E
	24:00	shift local time to UTC+6h	Fine but cloudy
			ENE-7 (Near gale)
			5 (Sea rough)
			4 (Moderate long)
			Visibly: 8'
19-Jan-13		tansit to triton No.18 buoy	1/19 12:00 (UTC+6h)
			01-29.0N,091-45.0E
			Fine but cloudy
			SW-2 (Light breeze)
			2 (Sea smooth)
			1 (Low swell sea)
			Visibly: 8'
20-Jan-13	04:00	arrived at triton No.18 buoy point and search buoy	1/20 12:00 (UTC+6h)
	8:55-09:30	carried out acoustic communication to bottom of buoy mooring system	01-36.0S,089-52.0E
	11:50	finish searching buoy	Fine but cloudy

		transit to research area	
	13:11-13:35	figure of eight turn	West-2 (Light breeze)
			2 (Sea smooth)
			1 (Low swell sea)
			Visibly: 8'
21-Jan-13		transit to research area	1/21 12:00 (UTC+6h)
			05-32.0S,086-59.0E
			Fine but cloudy
			WSW-5 (Fresh breeze)
			4 (Sea moderate)
			2 (Low swell long)
			Visibly: 8'
22-Jan-13		transit to research area	1/22 12:00 (UTC+6h)
	14:30-15:30	onboard tour for student	10-11.0S,083-19.0E
	24:00	shift local time to UTC+5h	Fine but cloudy
			WSW-3 (Gentle breeze)
			2 (Sea smooth)
			2 (Low swell long)
			Visibly: 8'
23-Jan-13		transit to research area	1/23 12:00 (UTC+5h)
	08:30-08:53	figure of eight turn	14-44.0S,079-41.0E
			Fine but cloudy
			ESE-5 (Fresh breeze)
			3 (Sea slight)
			2 (Low swell long)
			Visibly: 8'
24-Jan-13		transit to research area	1/24 12:00 (UTC+5h)
			19-03.5S,076-11.0E
			Fine but cloudy
			East-5 (Fresh breeze)
			3 (Sea slight)
			2 (Low swell long)
			Visibly: 8'
25-Jan-13		transit to research area	1/25 12:00 (UTC+5h)
	13:00-13:30	scientific meeting	23-17.0S,072-40.0E
	18:00-18:22	figure of eight turn	Fine but cloudy
			ENE-5 (fresh breeze)
			4 (Sea moderate)
			2 (Low swell long)
			Visibly: 8'
26-Jan-13	04:13	released XBT	1/26 12:00 (UTC+5h)
	05:11	deployed OBEM (EM1)	25-52.5S,070-09.0E
	06:44	deployed OBEM (EM2)	Fine but cloudy
	08:09	deployed OBEM (EM3)	NE-5 (Fresh breeze)

	09:31	deployed OBEM (EM4)	3 (Sea slight)
	10:36	deployed OBEM (EM5)	2 (Low swell long)
	11:14	deployed OBEM (EM6)	Visibly: 8'
	11:52	deployed OBEM (EM7)	
	12:57	deployed OBEM (EM8)	
	14:21	deployed OBEM (EM9)	
	15:45	deployed OBEM (EM10)	
	16:02-16:23	figure of eight turn	
	17:23-	com'ced MBES survey	
27-Jan-13	05:18	deployed OBEM (EM16)	1/27 12:00 (UTC+5h)
	06:42	deployed OBEM (EM15)	25-17.0S,070-22.0E
	08:12	deployed OBEM (EM14)	Fine but cloudy
	09:08	deployed OBEM (EM13)	NE-5 (Fresh breeze)
	10:41	deployed OBEM (EM12)	4 (Sea moderate)
	11:37	deployed OBEM (EM11)	3 (Moderate short)
	13:01	deployed OBS (S21)	Visibly: 8'
	13:42	deployed OBS (S13M2)	
	14:13	deployed OBS (S12)	
	14:40	deployed OBS (S4)	
	15:08	deployed OBS (S3)	
	15:39	deployed OBS (S2)	
	16:12	deployed OBS (S5)	
	16:33	deployed OBS (S32)	
	16:53	deployed OBS (S31)	
	17:12	deployed OBS (S33)	
	17:27	deployed OBS (S11)	
	17:55	deployed OBS (S14)	
	18:25	deployed OBS (S10)	
	18:51	deployed OBS (S6)	
	19:17	deployed OBS (S1)	
	19:48	deployed OBS (S7)	
	20:18	deployed OBS (S9)	
	20:51	deployed OBS (S8)	
	21:22	deployed OBS (S16)	
	21:54	deployed OBS (S15)	
	22:25	deployed OBS (S20)	
	23:10-23:31	deployed SCS equipment	
28-Jan-13	00:08-01:08	carried out SCS survey (LineA5_0)	1/28 12:00 (UTC+5h)
	02:14-05:01	carried out SCS survey (LineA4_0)	25-17.0S,070-22.0E
	06:05-09:47	carried out SCS survey (LineA3_0)	Fine but cloudy
	10:36-13:22	carried out SCS survey (LineA2_0)	NE-4 (Moderate breeze)
	14:19-16:08	carried out SCS survey (LineA1_0)	3 (Sea slight)
	16:35-18:26	carried out SCS survey (LineC1_0)	3 (Moderate short)
	19:22-22:12	carried out SCS survey (LineC2_0)	Visibly: 8'
	23:01-	com'ced SCS survey (LineC3_0)	
29-Jan-13	-02:41	finished SCS survey (LineC3_0)	1/29 12:00 (UTC+5h)
	03:37-06:15	carried out SCS survey (LineC4_0)	24-41.0S,070-05.5E

	07:12-08:14	carried out SCS survey (LineC5_0)	Fine but cloudy
	08:32-08:47	recovered SCS eqipments	ENE-5 (Fresh breeze)
	09:00-	left research area for Port Louis, Maulitius	4 (Sea moderate)
	13:00-13:10	scientific meeting	4 (Moderate average)
			Visibly: 8'
30-Jan-13		evacuate from cyclone	1/30 12:00 (UTC+5h)
			19-45.0S,069-40.0E
			Fine but cloudy
			East-4 (Moderate breeze)
			3 (Sea slight)
			4 (Moderate average)
			Visibly: 8'
31-Jan-13		evacuate from cyclone	1/31 12:00 (UTC+5h)
			17-11.0S,066-14.0E
			Fine but cloudy
			East-4 (Moderate breeze)
			3 (Sea slight)
			3 (Moderate short)
			Visibly: 8'
01-Feb-13		evacuate from cyclone	2/1 12:00 (UTC+5h)
	12:30	transit to Port Louis	16-40.5S,066-16.5E
			fine but cloudy
			ENE-4 (Moderate breeze)
			3 (Sea slight)
			3 (Moderate short)
			Visibly: 8'
02-Feb-13		transit to Port Louis	2/2 12:00 (UTC+5h)
	24:00	shift local time to UTC+4h	18-07.0S,062-21.5E
			fine but cloudy
			ENE-3 (Gentle breeze)
			3 (Sea slight)
			3 (Moderate short)
			Visibly: 8'
03-Feb-13		transit to Port Louis	2/3 12:00 (UTC+4h)
			19-18.0S,058-29.5E
			Fine but cloudy
			NE-4 (Moderate breeze)
			3 (Sea slight)
			3 (Moderate short)
			Visibly: 8'
04-Feb-13	09:30	attived at Port Louis, Maulitius	2/4 12:00 (UTC+4h)
			Port Louis

4. Instruments

4-1. OBEM (Ocean Bottom Electro-Magnetometer)

OBEMs (Photos 4-1a, 4-1b, and 4-1c) measure three orthogonal components of time-variation of the magnetic field, time-variation of three dimensional electrical potential that will be processed to three orthogonal components of time-variation of the electrical field, two orthogonal components of the instrumental tilt, and the instrumental temperature at seafloor. The magnetic field variation is measured with a fluxgate magnetometer housed in a pressure resistant cylinder case or a glass sphere, and the electrical potential variation is measured using five Ag-AgCl electrodes (Filloux, 1987) equipped to the ends of pipes (~4m in horizontal and ~1-1.5 m in vertical) extending from an instrumental frame. The instrumental tilt and temperature are measured with a tilt meter and a thermometer settled near the fluxgate magnetometer. The sampling rate of the above components is 1 minute (one exception is that the sampling rate of instrumental tilt of BC2 OBEM being described below in detail is 5 minute), and the measured data is recorded internally on flash card. The clock of the OBEM was manually synchronized to the GPS clock at UTC before the deployment, and it will be compared to the GPS clock after the recovery to see the drift of OBEM clock during the observation. The OBEMs are drove by lithium and alkaline batteries packed in a glass sphere or/and a cylinder case. The OBEMs have the transponder unit for acoustic communication to the ship, and radio beacon and flashing light for recovery.

Sixteen OBEMs are totally deployed during the cruise. The deployed OBEMs are assorted into four types by pressure resistant cylinder case and glass sphere, and sensor; 1) one titanium cylinder case and one glass sphere, and fluxgate magnetometer of Bartington Instruments Ltd. (BIL) and data logger of Clover-tech Corp. (CtC) are housed in the titanium cylinder case (BC1, 6 sites) (Photo 4-1a), 2) one titanium cylinder case and one glass sphere, and fluxgate magnetometer of BIL is housed in the glass sphere and data logger of CtC is housed in the titanium cylinder case (BC2, 2 sites), 3) one aluminum cylinder case and one glass sphere, and fluxgate magnetometer of BIL and data logger of CtC are housed in the aluminum cylinder case (BC3, 4 sites) (Photo 4-1b), 4) two glass spheres, fluxgate magnetometer and data logger of Tierra Tecnica Corp. are housed in one glass sphere (T, 4 sites) (Photo 4-1c).

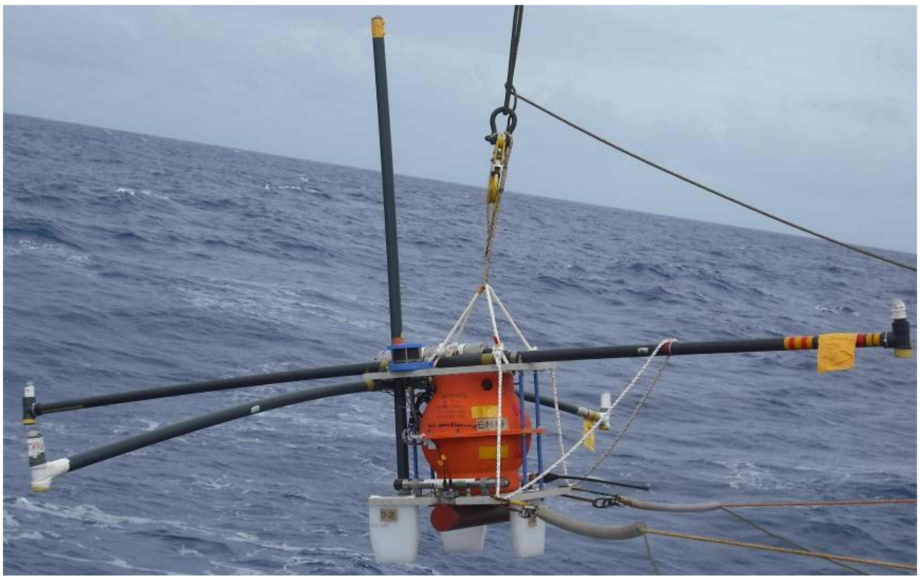

Photo 4-1a. BC1 OBEM. BC2 OBEM shows similar appearance to the BC1 OBEM.

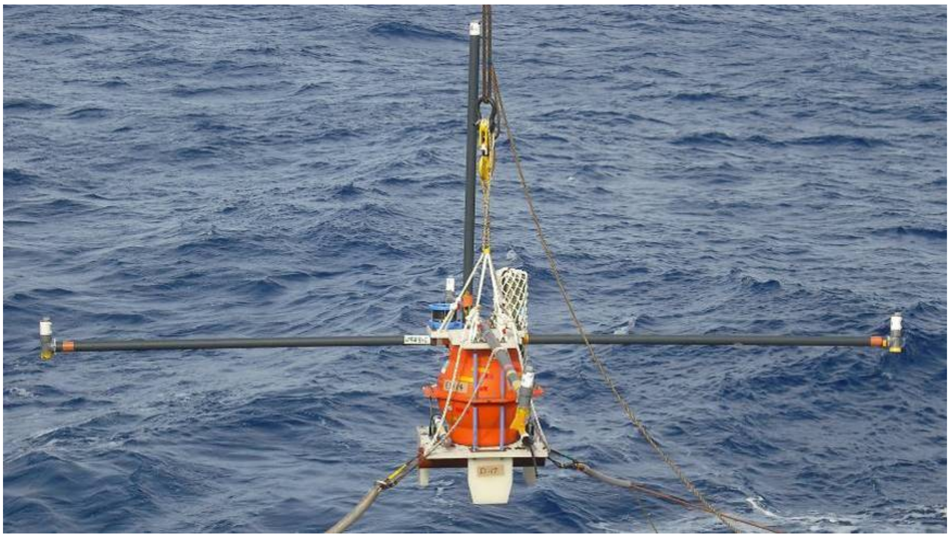

Photo 4-1b. BC3 OBEM.

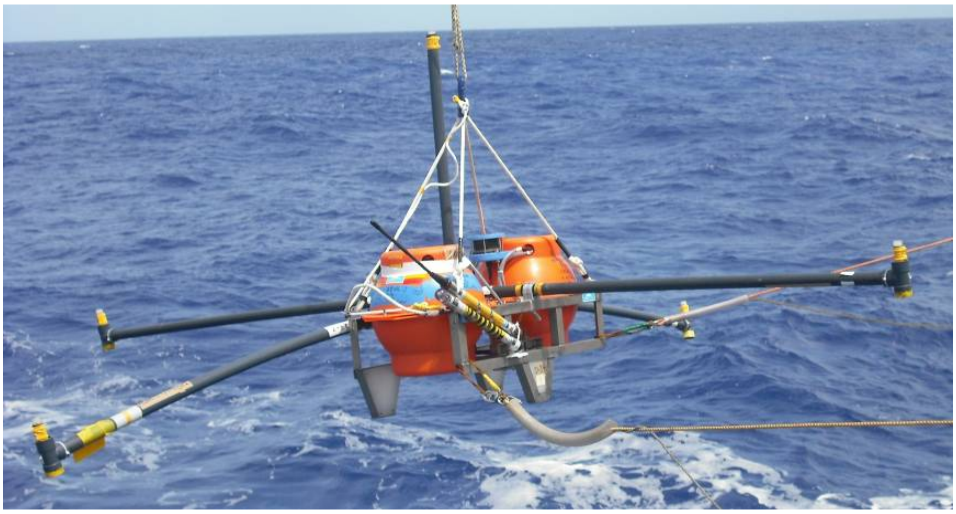

Photo 4-1c. T OBEM

4-2. OBS (Ocean Bottom Seismometer)

We deployed 21 ocean bottom seismometers (OBSs), which include 1 OBS with absolute pressure gauge (OBSP) and 2 OBSs attached with magnetometers (OBSMs), during the cruise (Photo 4-2a). In this section, we focus on 18 OBSs (Photo 4-2b) that have neither absolute pressure gauge nor magnetometer. The others are described in the following sections.

All OBS has a three-component seismometer (Mark Products L25B/L28LB), a data-logger with a precise clock (Katsujima HDDR-2/5) and batteries inside a housing which is single glass sphere (dia. 17") with recovery tools such as an acoustic transponder system, radio beacon and flash light outside the housing. Each seismometer is mounted on a passive gimbal system so that it could keep directions, one of which is vertical and the others are horizontals. The seismic data are recorded continuously after 20/24 bits analogue to digital conversion with 128/200 Hz sampling. You can change settings of the data-logger such as recording period and sampling rate using by both wired communication via RS-232C and wireless communication through the acoustic transponder.

Photo 4-2a. OBSs in this experiment

Photo 4-2b. OBS (glass sphere)

4-3. OBSP (Ocean Bottom Seismometer with Pressure gauge)

One of the OBSs, OBSP (Photo 4-3), is with absolute pressure gauge (Paroscientific 8B7000-2-005, 123849). The OBSP mounts a three-component seismometer (Mark Products L28LB) on the passive gimbal system, a data-logger with a precise clock (LS-9100 T3H, 0029), another logger (LS9150, 0010) and batteries inside a titanium sphere (dia. 500) with the pressure gauge as well as recovery tools such as an acoustic transponder system, radio beacon and flash light outside the sphere. The seismic data are recorded continuously to SD cards in LS-9100 after 24 bits analogue to digital conversion with 200 Hz sampling. Meanwhile, the pressure gauge output 2 quartz oscillations. The data are stored every 1 s into LS-9150 (0010) after frequency counting using by the precise clock on LS-9100.

Photo 4-3. OBSP

4-4. OBSM (Ocean Bottom Seismometer with Magnetometer)

Other 2 OBSs, OBSMs are composed of OBS and ocean bottom magnetometer (OBM) with a recovery system (Photos 4-4a and 4-4b).

The OBSs have same internal components such as a three-component seismometer (Mark Products L28LB) on the passive gimbal system, a data-logger with a precise clock (HDDR-5), and batteries, but the pressure resistant spheres are different. One is a glass sphere (dia. 17”) and the other is a titanium sphere (dia. 500).

The OBMs measure three orthogonal components of time-variation of the magnetic field, two orthogonal components of the instrumental tilt, and the instrumental temperature at seafloor. Each magnetic field variation is measured with a fluxgate magnetometer of Bartington Instruments Ltd. and data logger of Clover-tech Corp housed in a pressure resistant titanium cylinder case. Lithium batteries for OBM measurement are also packed within the titanium cylinder case. The sampling rate is 1 minute for the magnetic field variation, and is 5 minute for the instrumental tilt and temperature. The clock of the OBM was synchronized to the GPS clock (UTC) before the deployment in the same manner as OBEM (See 4-1).

The two OBMs are same size, but their directions to the ground and the attaching positions to OBS are quite different in order both to avoid generating noise against the seismic observation and to keep good signal to noise ratio for magnetometer observation. One OBM is attached horizontally to a glass sphere OBS between the hard hat of the glass and the acoustic transducer (Photo 4-4a), and the other is attached vertically beside the acoustic transducer to a titanium sphere OBS (Photo 4-4b).

Photo 4-4a. OBM (titanium cylinder) attached horizontally to glass sphere OBS.

Photo 4-4b. OBM (titanium cylinder) attached vertically to titanium sphere OBS.

4-5. Equipment for active seismic surveys

We use a single channel seismic survey system including an air-gun and a single channel hydrophone streamer cable (Photo 4-5), together with OBSs including the OBSP and OBSMs, to conduct active seismic surveys. The specification of the single channel seismic survey system is shown in Table 4-5.

Photo. 4-5-1. Air-gun (left) and single channel hydrophone streamer cable (right)

Streamer	
Manufacturer	S.I.G
Active section length	47m
Hydrophone Interval	1m
Type of Hydrophone	S.I.G.16
Hydrophone output	-90 dB,re 1V/μbar, ±1dB
Frequency	flat from 10Hz to 1000Hz
Depth sensor	Yes
Preamplifier	gain 39
Lead in cable	110m
Receiver depth	12m
Source	
Manufacturer	Sercel
Type of airgun	GI-GUN
Volume	355cu.in. [250(G)+105(I)]
Air pressure	143kg/cm^2
Source depth	10m
Depth sensor	No
Gun Controller	Hotshot ver. 2.416
Air Compressor	
Manufacturer	Service Engineering co., ltd.
Type of machine	4SA30-A150K
Air supply Capacity	2m^3/min.

Recording System

Manufacturer	GEOMETRICS
Type of system	Geode ver. 9.28.0.0
Recording format	SEG-D 8058 Rev.1
Recording length	16,000msec
Water Delay	0msec
Sample rate	1msec
High cut filter	None
Low cut filter	None
Recording media	Hard Disk
GPS System	
Manufacturer	Fugro
Type of system	SkyFix XP MultiFix6
DGPS Reference Station	Multi Reference Station (ALL)
GPS System	
Manufacturer	MARIMEX JAPAN
Type of system	Nav log ver. 1.0.64
Shot Point Geometry	
Time mode shooting	See General Information
Geodetic Parameter	
Spheroid	WGS84
Semi-major Axis	6,378,137m
Inverse Flattening	298.26
Projection	U.T.M Zone42

Table 4-5. Specification of the single channel seismic survey system.

5. Preliminary Results

5-1. Deployment of ocean bottom instruments

Sixteen OBEMs, eighteen OBSs, one OBSP, and two OBSMs were deployed at 37 sites across the central and southeast Indian Ridges near the Rodriguez Triple Junction and near the "Kairei" hydrothermal vent site in the first segment of the central Indian Ridge. The site locations are shown in Figure 5-1-1 and Table 5-1-1, and details on the instruments deployed are given in Tables 5-1-2.

Ten OBEMs were deployed across a seafloor spreading axis of the southeast Indian Ridge, which is located to the south from the triple junction, along a NE-SW line, and the other 6 OBEMs were deployed across the Kairei hydrothermal vent along an ENE-WSW line (Figure 1a). The spacing of OBEMs and OBMs is dense near the spreading axis and the hydrothermal vent, and becomes larger to the ends of the observation line. The lengths of the two OBEM and OBM lines are about 150 km. Eighteen OBSs (S1-S21) were deployed in triangular lattice shape around the hydrothermal vent with 3 miles spacing, and the other 3 OBSs (S31, S32, and S33) were focused to be deployed within 1 mile from the hydrothermal vent (Figure 5-5-1b).

All of the deployments were successfully carried out within 47 hours (first OBEMs, and subsequently OBSs). The deployments of the OBEMs were made using an A-frame, while those of the OBSs were made using a davit. Positioning of 6 OBSs around the Kairei hydrothermal vent (S5, S10, S11, S31, S32, and S33) was carried out using a ship bottom transducer at a few knot ship run during the single channel seismic (SCS) survey for Shinkai 6500 dives in a later cruise, while that of the rest of OBSs and all of OBEMs was not carried out using the transducer unit during this cruise. Locations of the OBSs can be determined from the SCS survey data, and those of OBEMs will be determined using the ship bottom transducer unit in the recovery cruise.

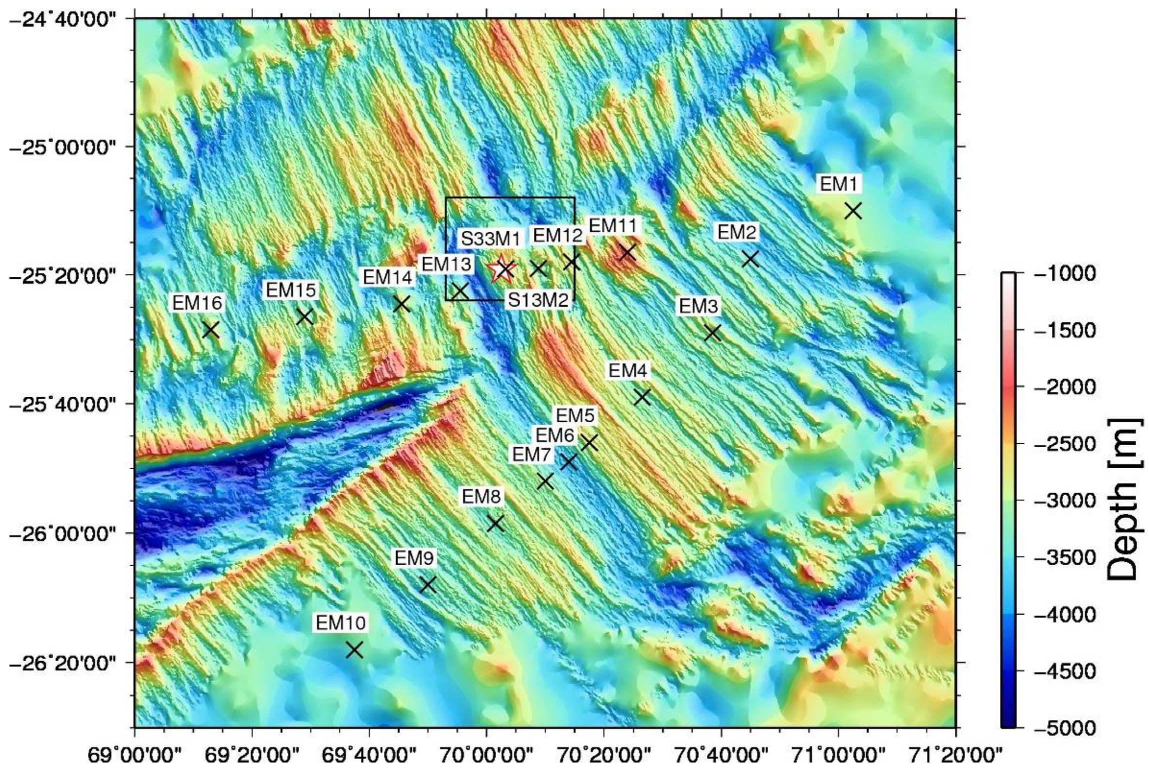

Figure 5-1-1a. Location map of OBEMs and OBSMs (crosses). White star bounded with red line indicates the location of the Kairei hydrothermal vent site. The solid rectangle shows the range of Figure 5-1-1b.

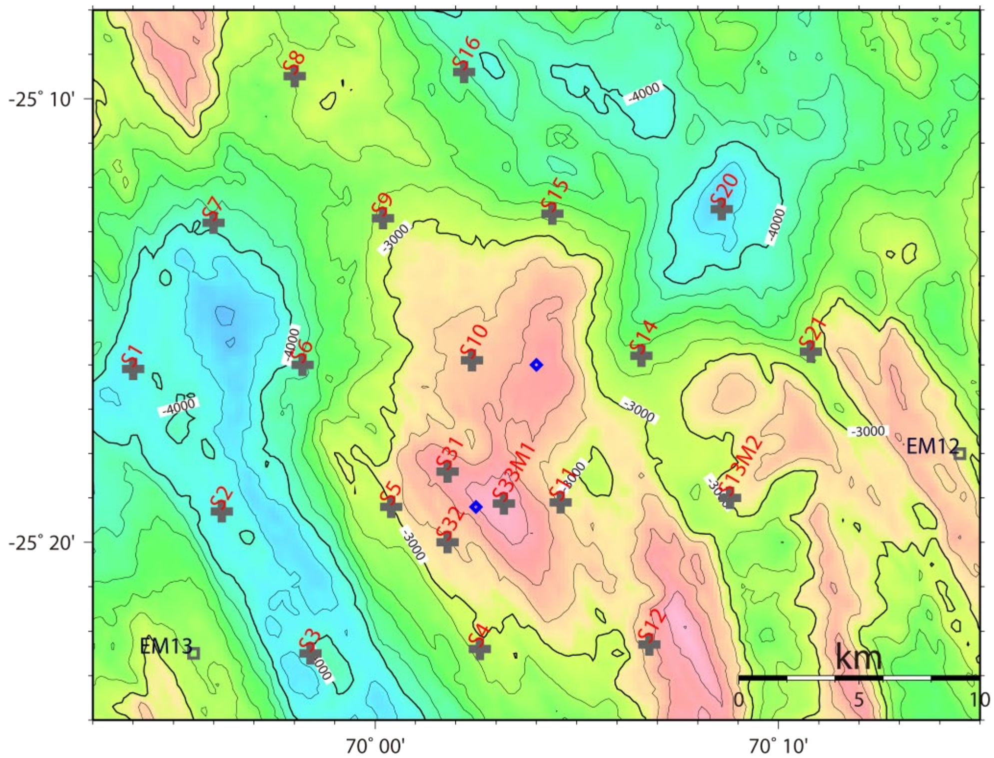

Figure 5-1-1b. Location map of OBEMs (squares) and OBSs (crosses) including OBSP (S10), and OBSMs (S13M2 and S33M1) around the Kairei hydrothermal vent (left blue diamond). Right blue diamond shows the location of the top of the Yokoniwa Rise.

Site	Location					Time (UTC)	
	Latitude (S)		Longitude (E)		Depth (m)	Date	Time
	Deg.	Min.	Deg.	Min.			
EM1	25	08.28	71	01.63	3412	2013/01/26	00:11:39
EM2	25	17.51	70	44.93	3556	2013/01/26	01:44:54
EM3	25	29.01	70	38.42	3071	2013/01/26	03:09:19
EM4	25	39.01	70	26.45	3160	2013/01/26	04:31:21
EM5	25	46.00	70	17.47	2805	2013/01/26	05:36:27
EM6	25	49.03	70	13.96	3640	2013/01/26	06:14:22
EM7	25	52.04	70	09.95	3011	2013/01/26	06:52:21
EM8	25	58.54	70	01.46	3256	2013/01/26	07:57:24
EM9	26	08.02	69	49.98	3335	2013/01/26	09:21:10
EM10	26	18.02	69	37.46	3687	2013/01/26	10:45:09
EM11	25	16.48	70	24.03	2008	2013/01/27	06:37:23
EM12	25	17.97	70	14.53	2952	2013/01/27	05:41:16
EM13	25	22.48	69	55.55	3246	2013/01/27	04:08:34
EM14	25	24.42	69	45.66	2787	2013/01/27	03:12:56
EM15	25	26.46	69	29.07	2857	2013/01/27	01:42:52
EM16	25	28.48	69	13.05	2829	2013/01/27	00:18:19
S1	25	16.12	69	53.97	4157	2013/01/27	14:17:57
S2	25	19.28	69	56.21	4072	2013/01/27	10:39:56

S3	25	22.51	69	58.36	4035	2013/01/27	10:08:42
S4	25	22.41	70	02.56	3110	2013/01/27	09:40:44
S5	25	19.17	70	00.44	2972	2013/01/27	11:12:57
S6	25	16.02	69	58.19	3862	2013/01/27	13:51:40
S7	25	12.80	69	56.05	3912	2013/01/27	14:48:30
S8	25	09.49	69	58.04	3167	2013/01/27	15:51:23
S9	25	12.71	70	00.24	3073	2013/01/27	15:18:45
S10P1	25	15.92	70	02.37	2726	2013/01/27	13:25:44
S11	25	19.07	70	04.64	2893	2013/01/27	12:27:41
S12	25	22.30	70	06.75	2729	2013/01/27	09:13:50
S13M2	25	18.97	70	08.83	2924	2013/01/27	08:42:15
S14	25	15.77	70	06.64	3293	2013/01/27	12:55:29
S15	25	12.60	70	04.44	3219	2013/01/27	16:54:38
S16	25	09.40	70	02.24	3788	2013/01/27	16:22:54
S20	25	12.51	70	08.64	4314	2013/01/27	17:25:09
S21	25	15.70	70	10.83	3213	2013/01/27	08:01:04
S31	25	18.39	70	01.83	2425	2013/01/27	11:53:19
S32	25	19.99	70	01.83	2827	2013/01/27	11:33:13
S33M1	25	19.12	70	03.24	2325	2013/01/27	12:12:04

Table 5-1-1. Location, date and time of OBEM and OBS deployment. EM: OBEM, S: OBS, P: pressure gauge attached to OBS, M: magnetometer attached to OBS.

Site ID	Type	S/N of sensor	Transponder Code	Radio Beacon ID
EM1	BC1	20	2B-2	JS325
EM2	T	KB1	7C-1	JS328
EM3	BC2	22	2C-2	JS326
EM4	BC1	18	1C-1	JS327
EM5	BC3	107	9A-3	JS336
EM6	T	NIPR1	1D-1	JS329
EM7	BC1	17	7B-1	JS324
EM8	BC1	19	2D-2	JS1767
EM9	BC1	21	3D-3	JS337
EM10	T	NIPR3	6B-3	JS323
EM11	BC3	105	5A-2	JS334
EM12	T	NIPR2	6C-3	JS330
EM13	BC1	16	6A-3	JS1766
EM14	BC3	112	8A-2	JS335
EM15	BC2	23	5C-2	JS338
EM16	BC3	103	7A-1	JS333
S33M1	M	24	1C-3 (OBS)	N/A
S13M2	M	23	646 (OBS)	JS1273 (OBS)

Notes:
Abbreviations in Type
BC1: Fluxgate magnetometer of Bartington Instruments Ltd. (BIL) and data logger of Clover-tech Corp. (CtC) housed in titanium cylinder case.
BC2: Fluxgate magnetometer of BIL housed in titanium pressure case and data logger of CtC housed in glass sphere.
BC3: Fluxgate magnetometer of BIL and data logger of CtC housed in aluminum cylinder case.
T: Fluxgate magnetometer and data logger of Tierra Tecnica Corp.
M: Magnetometer attached to OBS.
The frequency of radio beacon is 43.528MHz.
All of the OBEMs have a flashing light, but that for EM13 OBEM may not work properly because of malfunction of tilt switch.

Table 5-1-2a. Instrument information on OBEM and OBSM

Site ID	Type	OBS No.	Transponder Code	Radio Beacon ID
S1	OBS	ERI-2B	3C-3	JS1265
S2	OBS	ERI-2G	2D-1	JS1266
S3	OBS	ERI-2M	3A-1	N/A
S4	OBS	ERI-2E	2A-1	JS1777
S5	OBS	ERI-2J	6B-2	N/A
S6	OBS	ERI-2A	1D-1	JS1318
S7	OBS	ERI-5P	2A-1	N/A
S8	OBS	ERI-5Q	4A-1	JS1245
S9	OBS	ERI-2C	3B-1	JS1319
S10P1	OBS+P	619	619	N/A
S11	OBS	ERI-2H	4A-1	N/A
S12	OBS	ERI-2F	3C-1	JS1778
S13M2	OBS+M	ERI-5S	1C-3	JS1273
S14	OBS	ERI-2K	6C-3	N/A
S15	OBS	ERI-2D	2B-1	JS1279
S16	OBS	ERI-2L	1A-1	JS1277
S20	OBS	ERI-2O	3A-1	JS1241
S21	OBS	ERI-2N	2D-1	N/A
S31	OBS	ERI-5R	5D-1	
S32	OBS	ERI-2I	1A-1	JS113
S33M1	OBS+M	646	646	N/A

Notes:
Abbreviations in Type
P: OBP (absolute pressure gauge)
M: OBM (fluxgate magnetometer)
The frequency of radio beacon is 43.528MHz.
All of the OBSs have a flashing light.

Table 5-1-2b. Instrument information on OBS

5-2. Seismic Reflection and Refraction Survey

We conducted a seismic reflection and refraction survey at the hydrothermal area by using a GI gun, single channel streamer cable and the OBSs (Table 5-2-1, Figure 5-2-1). 5 lines are NNW-SSE direction parallel to the ridge axis, and the other 5 lines, one of which passes through the point just above the Kairei hydrothermal site and another cross the zone above the Yokoniwa Rise, are E-W direction. Line lengths are from 7 km to 30 km, which depended on the OBS distribution as well as ship time. We also fired during transits from end points of lines to start points of the next. 2866 shots were fired in total during the cruise. The air gun was a GI gun with 355 cu. in. (5.5 l; G 250 cu. in., I 105 cu.in.), air pressure was 13.5 Mpa, and the shot interval was 40 s. Seismic reflection data were obtained using a hydrophone streamer. The hydrophone streamer was a single channel combined 48 hydrophone signals, and the data were recorded with recording length of 16 s and sampling rate of 1000 Hz for each shot.

Survey line	Start Location and Time (UTC)						End Location and Time (UTC)					
	Longitude (E)		Latitude (S)		Date	Time	Longitude (E)		Latitude (S)		Date	Time
	Deg.	Min.	Deg.	Min.			Deg.	Min.	Deg.	Min.		
A1_0	69	53.99	25	16.07	1/28	09:17	69	58.52	25	22.67	1/28	11:10
A2_0	70	02.61	25	22.44	1/28	05:36	69	55.87	25	12.62	1/28	08:25
A3_0	69	57.97	25	09.48	1/28	01:05	70	06.90	25	22.45	1/28	04:47
A4_0	70	08.79	25	19.00	1/27	21:13	70	01.99	25	09.09	1/28	00:06
A5_0	70	08.42	25	12.36	1/27	19:08	70	10.92	25	15.87	1/27	20:10
C1_0	69	58.25	25	22.05	1/28	11:32	70	06.91	25	22.29	1/28	13:26
C2_0	70	09.03	25	18.99	1/28	14:20	69	56.00	25	19.30	1/28	17:13
C3_0	69	53.75	25	16.13	1/28	17:59	70	10.95	25	15.70	1/28	21:43
C4_0	70	08.68	25	12.48	1/28	22:28	69	55.85	25	12.80	1/29	01:15
C5_0	69	57.65	25	09.51	1/29	02:09	70	02.38	25	09.39	1/29	03:14

Table 5-2-1. Information on seismic reflection and refraction survey lines.

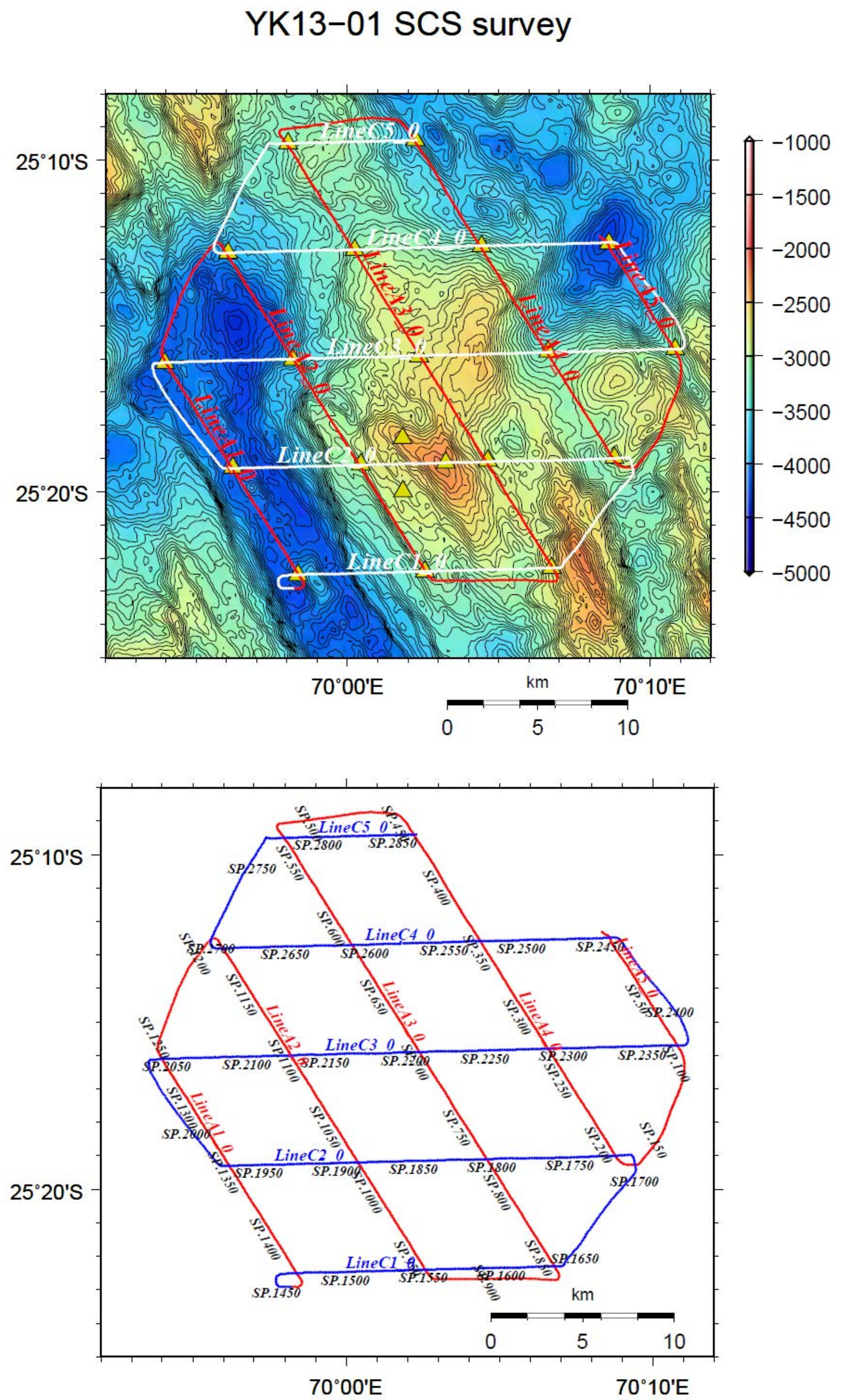

Figure 5-2-1. Location map of OBSs (triangles) and seismic reflection and refraction survey lines are shown in the top figure and SP numbers in the bottom figure denote air-gun shot numbers.

5-3. Surface Geophysical Survey

We conducted a surface geophysical survey to collect multi-narrow beam bathymetry, magnetic field, and gravity field data. The ship tracks of the research area are shown in Figure 5-3-1. Multi-narrow beam bathymetric data were obtained using a SeaBeam 2112 (Swath width 150°; 150 beams with its width and interval of 2°and 1°, respectively), which also provides a backscatter image that will be processed after the cruise. An example of the bathymetric data is shown in Figure 5-3-2. We could cover total 360 miles in the research area. An XBT was done at 23:15 on January 25 (UTC). The GPS (Global Positioning System) was used to derive the ship's location. Magnetic field data were collected with two instruments: a shipboard three component magnetometer (STCM: Isezaki, 1986) that can measure the vector geomagnetic field using deck-mounted fluxgate magnetometers and gyros, and a ship-towed proton precession magnetometer that can measure the intensity of the geomagnetic field. The STCM data contain the effects of the ship's magnetic field that must be corrected in order to derive the real geomagnetic field. Twelve constants related to the ship's permanent and induced magnetic field will be estimated using data from "Figure 8 turns". "Figure 8 turns" is made by steering the ship in a tight circle, both clockwise and counter clockwise. During the cruise, "Figure 8 turns" were conducted four times and it is listed in Table 5-3-1. Gravity field data were obtained from a shipboard gravimeter (Model S-63, Lacoste & Romberg). The gravity field data measured at three ports (Yokosuka, Singapore, and Port Louis) with a portable gravimeter will be used to correct the instrument drift.

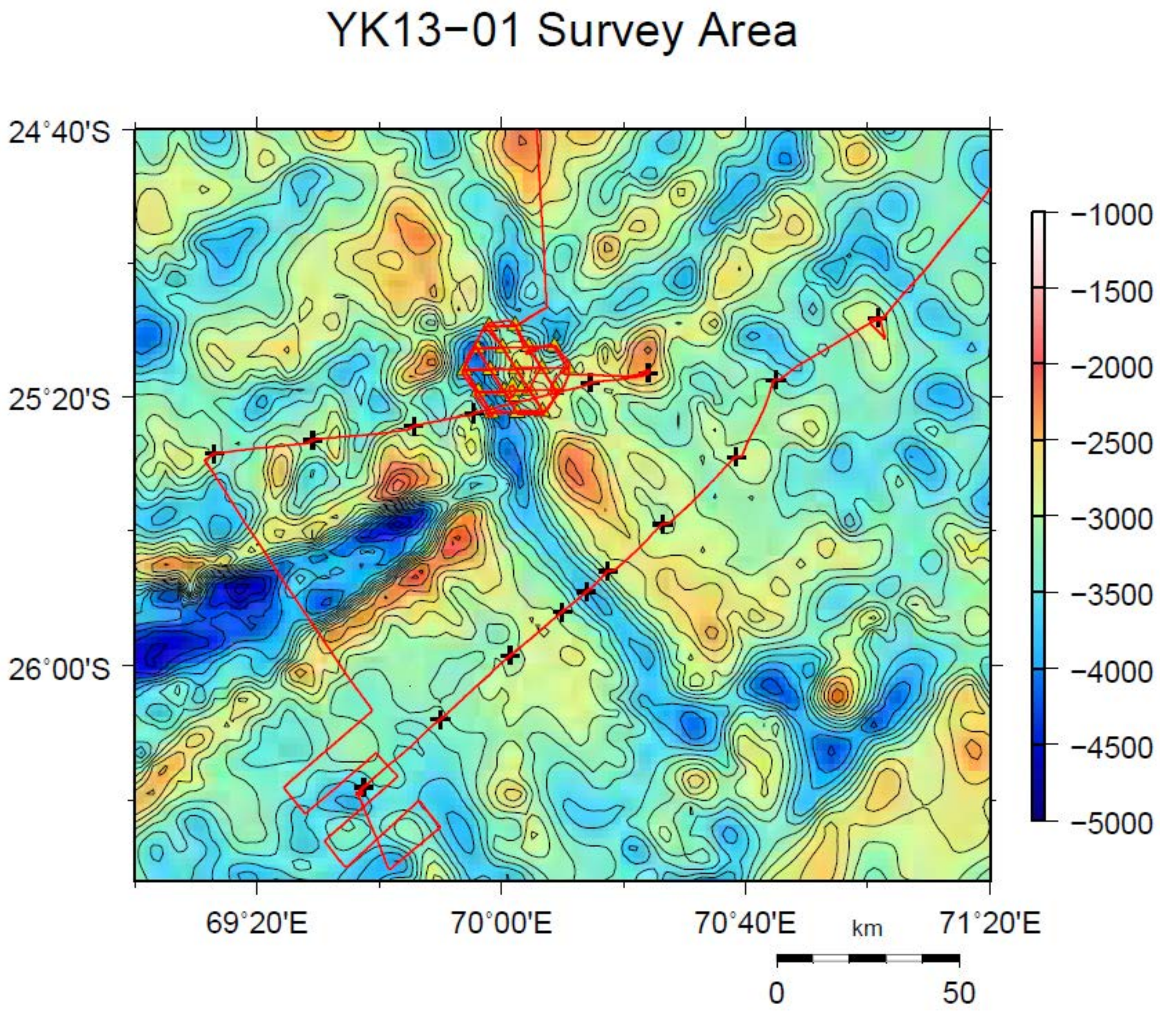

Figure 5-3-1. Ship tracks in the research area

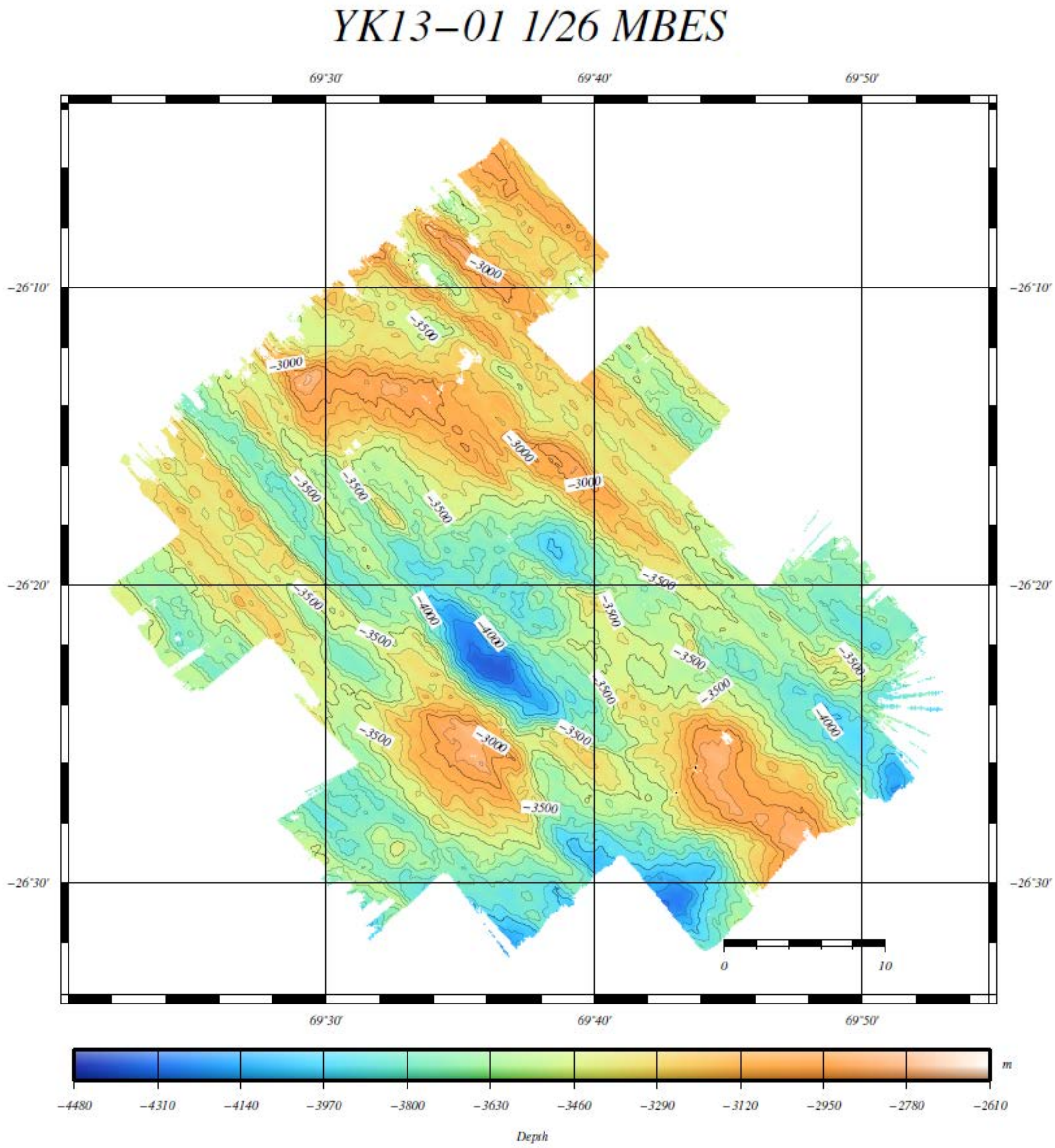

Figure 5-3-2. Bathymetric data obtained in the south-west part of the research area.

No.	Date	Time(UT)	Latitude	Longitude
1	20/Jan.	07:11-07:35	1°38.8'S	89°51.8'E
2	23/Jan.	03:30-03:53	14°09.7'N	80°09.0'E
3	25/Jan.	13:00-13:22	24°03.1'N	71°59.3'E
4	26/Jan.	11:01-11:23	26°18.8'N	69°36.6'E

Table 5-3-1. List of "Figure 8 turns"

5-4. Checking on TRITON Buoy No.18

5-4-1 Personnel

Masayuki Yamaguchi (JAMSTEC) : Buoy Operation Engineer
Keisuke Matsumoto (MWJ) : Buoy Operation Technician

5-4-2 Objectives

TRITON buoy No.18 is missing after 3 Dec. 2012 due to no satellite communications. First of all we need to confirm the presence of the surface buoy around the deployment point. (1°39.34'S, 89°59.74'E) If the buoy is found successfully and sea condition is allowable to use a workboat, we install an emergency ARGOS transmitter on the buoy for continuous tracking.

5-4-3 Process and Results

We could not find the surface buoy through 8 hour-long efforts. The existence of an acoustic releaser near sea-bottom, however, was confirmed by the transducer. Searching progress and ship tracking are as follows.

20 Feb. 2013 LST (=UTC+6)

04:00 start searching by radar detection and visual check (flash light)
06:05 sunrise and visual check (surface buoy)
09:00 checking of an acoustic releaser at anchor position by transducer
09:40 restart searching by radar detection and visual check (surface buoy)
11:50 quit searching

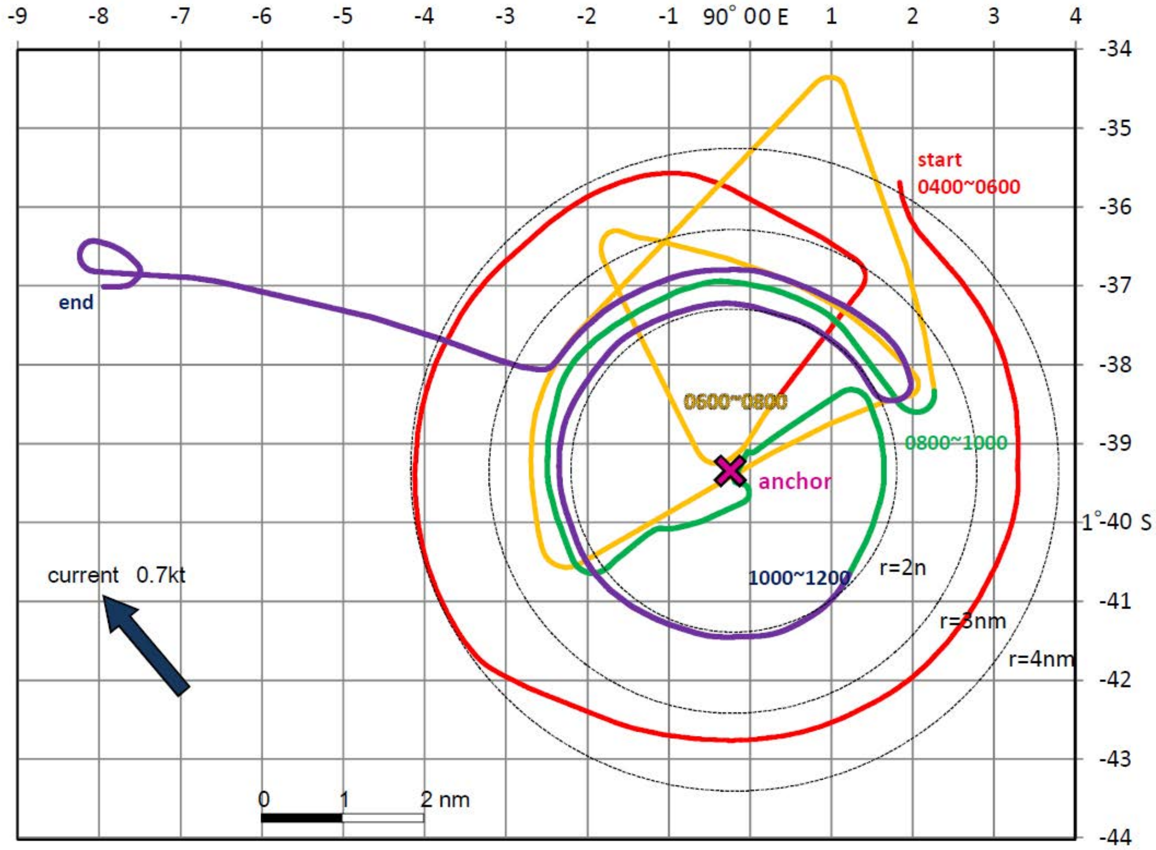

Figure 5-4-1. Ship tracks (color lines) for the check on TRITON Buoy No.18

6. Summary

We successfully deployed sixteen OBEMs, eighteen OBSs, one OBSP, and two OBSMs across the central and southeast Indian Ridges near the Rodriguez Triple Junction and near the "Kairei" hydrothermal vent site in the first segment of the central Indian Ridge. We started our observation at the ocean bottom; the measurement of magnetic and electric field variations by the OBEMs and OBSMs and seismic observation by the OBSs including the OBSP and OBSMs. The observation continues up to the recovery of these instruments during another Yokosuka cruise in this March. We also conducted active seismic surveys to investigate seismic velocity structure using the OBSs, an air-gun, and a single channel hydrophone streamer. Further, we conducted surface geophysical survey to collect multi-narrow beam bathymetry, magnetic field, and gravity field data mainly during night and transit times, which cover total 360 miles in the research area. The observed data will be analyzed to derive upper mantle structure, crustal structure, hypocenter distribution, and tectonic history, which will provide important constraint on geodynamics of this seafloor-spreading system together with hydrothermal activities. Moreover, we checked the TRITON buoy No.18 that has been missing since 3 Dec. 2012, and we found that only the acoustic releaser near sea-bottom exists and that the surface buoy was probably lost.

Acknowledgement

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