doi : 10.17596/0003014

Yokosuka Cruise Report

YK13-03

Kairei-Yokoniwa geophysics, petrology, and biogeochemistry

Feb. 28, 2013 (Port Louis)-Mar. 28, 2013 (Port Louis)

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

Contents

1. Cruise Information

Cruise ID: YK13-03
Name of vessel: R/V Yokosuka
Title of the cruise: Kairei-Yokoniwa geophysics, petrology, and biogeochemistry
Title of proposals:

(1) Integrated geochemical-petrological-geophysical investigations at the Yokoniwa-Rise, Central Indian Ridge.

(2) Crustal production process of slow spreading ridge system: Any relation to make hydrogen rich hydrothermal fluid?

Cruise period: February 28, 2013 (Port Louis)- March 28, 2013 (Port Louis)
Research area: near the Indian Ocean Ridge triple junction

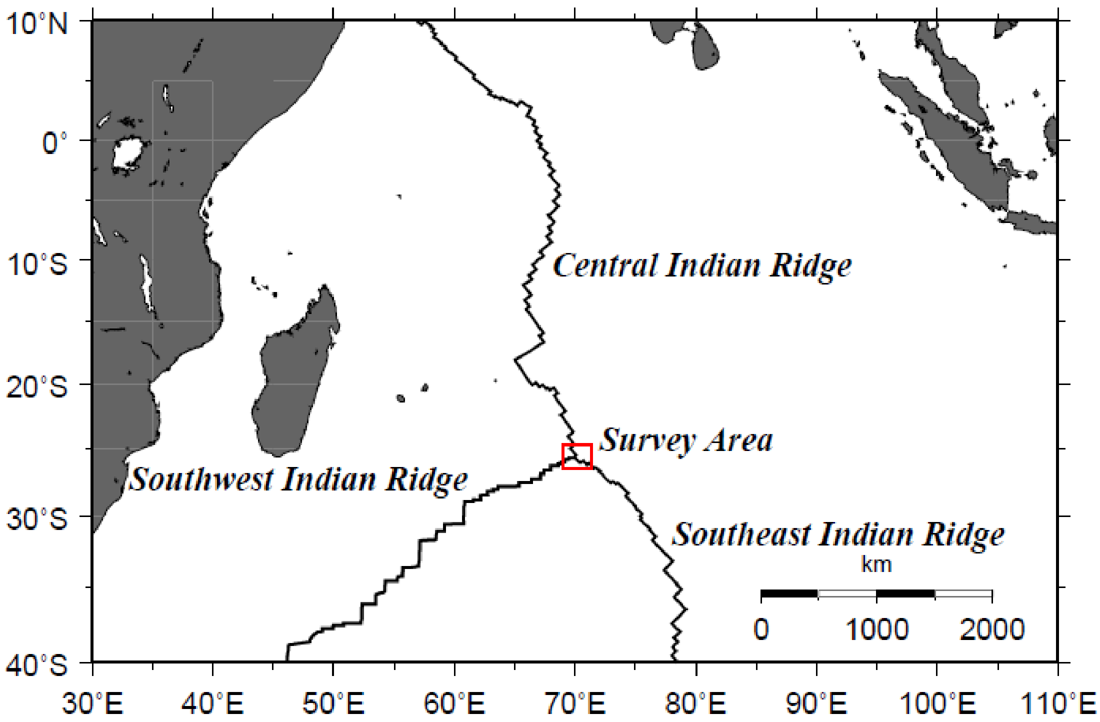


Figure 1.1. Index map showing location of the research area.

Shipboard Log of YK13-03

日付 Date	時間 Local Time	内容 Note	本船位置／気象／海象 Position/Weather/Wind/Sea condition
28-Feb-13		**Sail out & started YK13-03**	2/28 12:00 (UTC+4h)
	07:20	Let go all shore lines,left Port Louis for research area(Rodrigues Triple Junction).	20-39.8S 057-27.7E
	9:00-9:25	On board education for scientists.	Fine but cloudy
	13:00-13:30	SHINKAI 6500 meeting.	SOUTH-2(Light breeze)
	16:40-17:00	KONPIRA pray for safety cruise.	2(Sea Smooth)
	18:00-18:30	Scientists meeting.	4(Moderate average)
	24:00	shift local time to UTC+5h	Visibly: 8'
01-Mar-13		**Proceeding to research area**	3/1 12:00(UTC+5h)
	09:00-09:30	Scientists meeting.	22-10.7S 061-30.0E
			Fine but cloudy
			East-5(Fresh breeze)
			4(Sea Moderate)
			3(Moderate Short)
			Visibly: 8'
02-Mar-13		荒天待機	3/2 12:00(UTC+5h)
	06:45	Com'ced heave to.	21-47.4S 060-11.0E
			Fine but cloudy
			East-6(Strong breeze)
			5(Sea rough)
			4(Moderate average)
			Visibly: 8'
03-Mar-13		**Proceeding to research area**	3/3 12:00(UTC+5h)
	20:00	Finished heave to & com'ced proceeding to research area(Rodrigues Triple Junction).	22-13.5S 061-44.3E
			Fine but cloudy
			East-5(Freshbreeze)

			5(Sea rough)
			5(Moderate long)
			Visibly: 8'
04-Mar-13		**Proceeding to research area**	3/4 12:00(UTC+5h)
			23-30.0S 065-03.3E
			Fine but cloudy
			ESE-4(Moderate breeze)
			4(Sea moderate)
			4(Moderate average)
			Visibly:8'
05-Mar-13		**SCS Survey (LineB1,LineB2,LineB3,LineB4)**	3/5 12:00(UTC+5h)
	13:00-14:00	Scientists meeting.	24-57.1S 69-23.0E
	15:00	Arrived at research area(Rodrigues Triple Junction).	Fine but cloudy
	15:08	Released XBT at (25-07.6958S,69-58.1960E) .	East-5(Fresh breeze)
	15:37-15:44	Launched air gun.	4(Sea moderate)
	15:45-16:01	Launched streamer cable.	4(Moderate average)
	16:14	Com’ced SCS survey on line B1.	Visibly:8'
	18:54	Cleaed out line B1.	
	19:05	Com’ced SCS survey on line B2.	
	19:49	Cleaed out line B2.	
	19:59	Com’ced SCS survey on line B3.	
	22:35	Cleaed out line B3.	
	22:43	Com’ced SCS survey on line B4.	
	23:32	Cleaed out line B4.	
	23:43	Com’ced SCS survey on line B5.	
05-Mar-13		**SCS Survey (LineB1,LineB2,LineB3,LineB4) & Recovered OBS(S20,S14,S15,S16)**	3/6 12:00(UTC+5h)
	02:13	Cleaed out line B5.	25-18.5S 70-08.6E
	02:16	Com’ced SCS survey on line B6.	Fine but cloudy
	02:39	Cleaed out line B6.	East-5(Fresh breeze)

	02:39	Com’ced SCS survey on line B7.	4(Sea moderate)
	03:59	Cleaed out line B7.	4(Moderate average)
	04:00	Com’ced SCS survey on line B8.	Visibly:8'
	04:26	Cleaed out line B8.	
	04:27	Com’ced SCS survey on line B9.	
	04:50	Cleaed out line B9.	
	04:52	Com’ced SCS survey on line B10.	
	05:20	Cleaed out line B10.	
	05:21	Com’ced SCS survey on line B11.	
	06:39	Cleaed out line B11.	
	06:45	Com’ced SCS survey on line B12.	
	06:59	Cleaed out line B12.	
	07:00	Finished SCS survey.	
	07:04-07:08	Recovered streamer cable.	
	07:11-07:13	Recovered air gun.	
	09:13	Recovered OBS(S12)	
	14:43	Recovered OBS(S20)	
	16:37	Recovered OBS(S14)	
	18:34	Recovered OBS(S15）	
	20:20	Recovered OBS(S16)	
07-Mar-13		**Avoid to research area,due to research area is rough sea.**	3/7 12:00(UTC+5h)
	07:59	Recovered OBEM(EM10)	27-03.5S 069-17.1E
	08:20	Avoid to rough area.	Fine but cloudy
			EAST-6(Strong breeze)
			5(Sea rough)
			5(Moderate long)
			Visibly:8'
08-Mar-13		**Stand to out of research area,due to research area is rough sea.**	3/8 12:00(UTC+5h)
	07:45	Arrived at avoiding area.	30-56.3S 068-07.4E
	13:00-15:00	Scientists meeting.	Fine but cloudy
	18:00-18:20	Carried out figure eight running.	ESE-6(Strong breeze)

			5(Sea rough)
			4(Moderate average)
			Visibly:8'
09-Mar-13		**Stand to out of research area,due to research area is rough sea.**	3/9 12:00(UTC+5h)
	10:00-11:30	Scientists seminar.	31-01.0S 068-14.4E
			Fine but cloudy
			ESE-5(Fresh breeze)
			4(Sea moderate)
			4(Moderate average)
			Visibly:8'
10-Mar-13		**Stand to out of research area,due to research area is rough sea.**	3/10 12:00(UTC+5h)
			31-16.4S 69-34.7E
			Fine but cloudy
			ESE-6(Strong breeze)
			5(Sea rough)
			4(Moderate average)
			Visibly:8'
11-Mar-13		**Proceeding to research area**	3/11 12:00(UTC+5h)
	06:30	Proceeding to research area.	29-08.7S 71-05.8E
			Fine but cloudy
			East-6(Strong breeze)
			5(Sea rough)
			4(Moderate average)
			Visibly:8'
12-Mar-13		**Com'ced MBES mapping survey**	3/12 12:00(UTC+5h)
	08:30	Arrived at research area(Rodrigues Triple Junction).	26-30.0S 070-13.5E
	08:39	Com'ced MBES mapping survey.	Fine but cloudy
	09:00	Released proton magnetometer.	East-5(Fresh breeze)
	11:32-11:52	Carried out figure eight running.	4(Sea Moderate)

	16:30-16:39	Recovered proton magnetometer.	4(Moderate average)
	18:53-19:12	Carried out figure eight running.	Visibly:8'
13-Mar-13		**Recovered OBEM(EM9,EM8EM7,EM5,EM4)**	3/13 12:00(UTC+5h)
	01:19	Finished MBES mapping survey.	25-51.5S 070-09.4E
	06:39	Recovered OBEM(EM9)	Fine but cloudy
	10:18	Recovered OBEM(EM8)	ESE-6(Strong breeze)
	13:38	Recovered OBEM(EM7)	5(Sea rough)
	19:30	Recovered OBEM(EM5)	4(Moderate average)
	22:46	Recovered OBEM(EM4)	Visibly:8'
14-Mar-13		**Recovered OBEM(EM3,EM2,EM1,EM11,EM12)**	3/14 12:00(UTC+5h)
	02:19	Recovered OBEM(EM3)	25-14.7S 070-30.5E
	05:32	Recovered OBEM(EM2)	Fine but cloudy
	09:50	Recovered OBEM(EM1)	EAST-5(Fresh breeze)
	14:06	Recovered OBEM(EM11)	4(Sea moderate)
	16:40	Recovered OBEM(EM12)	4(Moderate average)
	17:11	Com'ced MBES mapping survey.	Visibly:8'
15-Mar-13		**Deep Tow operation #153**	3/15 12:00(UTC+5h)
	05:52	Finished MBES mapping survey.	25-16.7S 070-03.9E
	07:00	Suspended "SHINKAI 6500" submergence due to rough sea.	Fine but cloudy
	09:14	Lanched deep tow camera.	ENE-3(Gentle breeze)
	10:21	Com'ced deep tow survey(#153).	4(Sea moderate)
	16:00	Finished deep tow survey(#153).	4(Moderate average)
	16:46	Recovered deep tow camera.	Visibly:8'
	17:04-17:18	Released proton magnetometer.	
	19:10	Com'ced MBES mapping survey.	
16-Mar-13		**Operation "SHINKAI6500" Dive#1330**	3/16 12:00(UTC+5h)
	02:48	Finished MBES mapping survey.	25-19.3S 070-02.4E
	06:08	Recovered proton magnetometer.	Fine but cloudy
	09:44	Hoisted up "SHINKAI 6500" .	SSE-3(Gentle breeze)
	09:50	Launched "SHINKAI6500".	2(Sea smooth)

	09:58	"SHINKAI6500" dove & started her operation # 1331.	3(Moderate short)
	11:07	"SHINKAI 6500" landed on the sea bottom (Depth=2477m).	Visibly:8'
	16:00	"SHINKAI 6500" left the sea bottom (D=2365m).	
	17:21	Hoisted up "SHINKAI 6500"	
	17:29	Recovered "SHINKAI 6500" & finished the operation.	
	18:05-18:15	Released proton magnetometer.	
	19:33	Com'ced MBES mapping survey.	
17-Mar-13		**Operation "SHINKAI6500" Dive#1331 & Recovered OBS(S11)**	3/17 12:00(UTC+5h)
	05:32	Finished MBES mapping survey.	25-15.7S 070-03.5E
	06:30-06:37	Recovered proton magnetometer.	Fine but cloudy
	09:45	Hoisted up "SHINKAI 6500" .	EAST-5(Fresh breeze)
	09:51	Launched "SHINKAI6500".	4(Sea moderate)
	09:59	"SHINKAI6500" dove & started her operation # 1331.	3(Moderate short)
	11:14	"SHINKAI 6500" landed on the sea bottom (Depth=2635m).	Visibly:8'
	16:01	"SHINKAI 6500" left the sea bottom (D=2373m).	EAST-5(Fresh breeze)
	17:16	Hoisted up "SHINKAI 6500"	
	17:24	Recovered "SHINKAI 6500" & finished the operation.	
	19:34	Recovered OBS(S11).	
	20:57	Com'ced MBES mapping survey.	
18-Mar-13		**Operation "SHINKAI6500" Dive#1332 & Recovered OBS(S6,S7)**	3/18 12:00(UTC+5h)
	06:07	Finished MBES mapping survey.	25-16.0S 070-00.1E
	09:45	Hoisted up "SHINKAI 6500" .	Fine but clowdy
	09:51	Launched "SHINKAI6500".	ESE-5(Fresh breeze)
	09:59	"SHINKAI6500" dove & started her operation # 1332.	4(Sea moderate)

	11:26	"SHINKAI 6500" landed on the sea bottom (Depth=3180m).	3(Moderate short)
	15:57	"SHINKAI 6500" left the sea bottom (D=2670m).	Visibly:8'
	17:26	Hoisted up "SHINKAI 6500"	
	17:39	Recovered "SHINKAI 6500" & finished the operation.	
	19:03	Recovered OBS(S10).	
	20:50	Recovered OBS(S6).	
	22:58	Recovered OBS(S7).	
19-Mar-13		**Recovered OBS & OBEM**	3/19 12:00(UTC+5h)
	01:01	Recovered OBS(S1).	25-16.0S 070-00.1E
	02:57	Recovered OBS(S2).	Fine but clowdy
	04:52	Recovered OBS(S3).	ESE-5(Fresh breeze)
	07:29	Recovered OBEM(EM13).	4(Sea moderate)
	09:31	Recovered OBS(S4).	3(Moderate short)
	11:01	Recovered OBS(S32).	Visibly:8'
	12:16	Recovered OBS(S5).	
	13:22	Recovered OBS(S31).	
	14:31	Recovered OBS(S33M1).	
	19:28	Recovered OBS(S9).	
	21:44	Recovered OBS(S8).	
20-Mar-13		**Recovered OBS & OBEM**	3/20 12:00(UTC+5h)
	01:23	Recovered OBEM(EM14).	26-06.2S 069-15.8E
	04:43	Recovered OBEM(EM15).	Fine but clowdy
	08:04	Recovered OBEM(EM16).	EAST-5(Fresh breeze)
	12:59-13:13	Released proton magnetometer.	5(Sea rough)
	14:14	Com'ced MBES mapping survey.	3(Moderate short)
21-Mar-13		**Com'ced MBES mapping survey**	3/21 12:00(UTC+5h)
	03:45	Finished MBES mapping survey & Com'ced heave.	25-09.5S,071-40.0E
	10:24-10:30	Recovered proton magnetometer.	Fine but clowdy
			ESE-6(Strong breeze)
			5(Sea rough)

			4(Moderate average)
			Visibly:8'
22-Mar-13		**Com'ced MBES mapping survey**	3/22 12:00(UTC+5h)
	16:10	Finished heave to.	25-02.7S 72-19.3E
	16:16-16:29	Released proton magnetometer.	Fine but clowdy
	19:32	Com'ced MBES mapping survey.	EAST-6(Strong breeze)
			5(Sea rough)
			4(Moderate average)
			Visibly:8'
23-Mar-13		**Proton magnetometer**	3/23 12:00(UTC+5h)
	05:11	Finished MBES mapping survey.	25-18.4S 70-04.2E
	06:00-06:13	Recovered proton magnetometer.	Fine but clowdy
	14:05-14:18	Released proton magnetometer.	ENE-5(Fresh breeze)
	16:10	Com'ced MBES mapping survey.	4(Sea moderate)
			4(Moderate average)
			Visibly:8'
24-Mar-13		**Deep Tow operation #154,#155**	3/24 12:00(UTC+5h)
	05:11	Finished MBES mapping survey.	25-17.0S 070-04.8E
	06:00-06:08	Recovered proton magnetometer.	Fine but clowdy
	07:00	Suspended SHINKAI 6500 operaion,due to rough sea	ENE-5(Fresh breeze)
	07:41	Hoisted up deep tow camera.	4(Sea moderate)
	07:44	Lanched deep tow camera.	4(Moderate average)
	09:16	Com'ced deep tow survey(#154).	Visibly:8'
	10:44	Finished deep tow survey(#154).	
	11:43	Hoisted up deep tow camera.	
	11:49	Recovered deep tow camera.	
	13:06	Hoisted up deep tow camera.	
	13:08	Lanched deep tow camera.	
	14:34	Com'ced deep tow survey(#155).	
	15:20	Finished deep tow survey(#155).	
	16:24	Hoisted up deep tow camera.	

	16:31	Recovered deep tow camera.	
	16:45-16:59	Released proton magnetometer.	
	20:51	Com'ced MBES mapping survey.	
25-Mar-13		**Left research area for Port Louid.**	3/25 12:00(UTC+5h)
	03:36	Finished MBES mapping survey.	25-33.8S 069-27.0E
	09:16	Com'ced MBES mapping survey.	Fine but cloudy
	16:16	Finished MBES mapping survey.	EAST-5(Fresh breeze)
	16:19-16:38	Carried out figure eight running.	4(Sea moderate)
	16:44-16:51	Recovered proton magnetometer.	4(Moderate average)
	17:00	Left research area for Port Louid.	Visibly:8'
26-Mar-13		**Proceeding to Port Louis**	2/26 12:00(UTC+5h)
	14:20-14:39	Carried out figure eight running.	23-06.6S 065-15.7E
	15:00-16:00	Scientists meeting.	Cloudy
			NE-4(Moderate breeze)
			3(Sea slight)
			4(Moderate short)
			Visibly:8'
27-Mar-13		**Proceeding to Port Louis**	2/27 12:00(UTC+5h)
			20-46.4S 060-11.1E
			Fine but cloudy
			SE-3(Gentle breeze)
			2(Sea smooth)
			2(Low swell long)
			Visibly:8'
28-Mar-13		**Arrived at Port Louis,then finished YK13-03**	2/28 12:00(UTC+5h)
	09:00	Sent out 1st shore line,then arrived at Port Louis.	Port Louis
		Unloaded OBS & OBEM.	Visibly:8'
29-Mar-13		**Anchored at Poat Louis**	2/29 12:00(UTC+5h)
			Port Louis

30-Mar-13		**Disembarkation scientist group**	3/30 12:00(UTC+5h)
			Port Louis

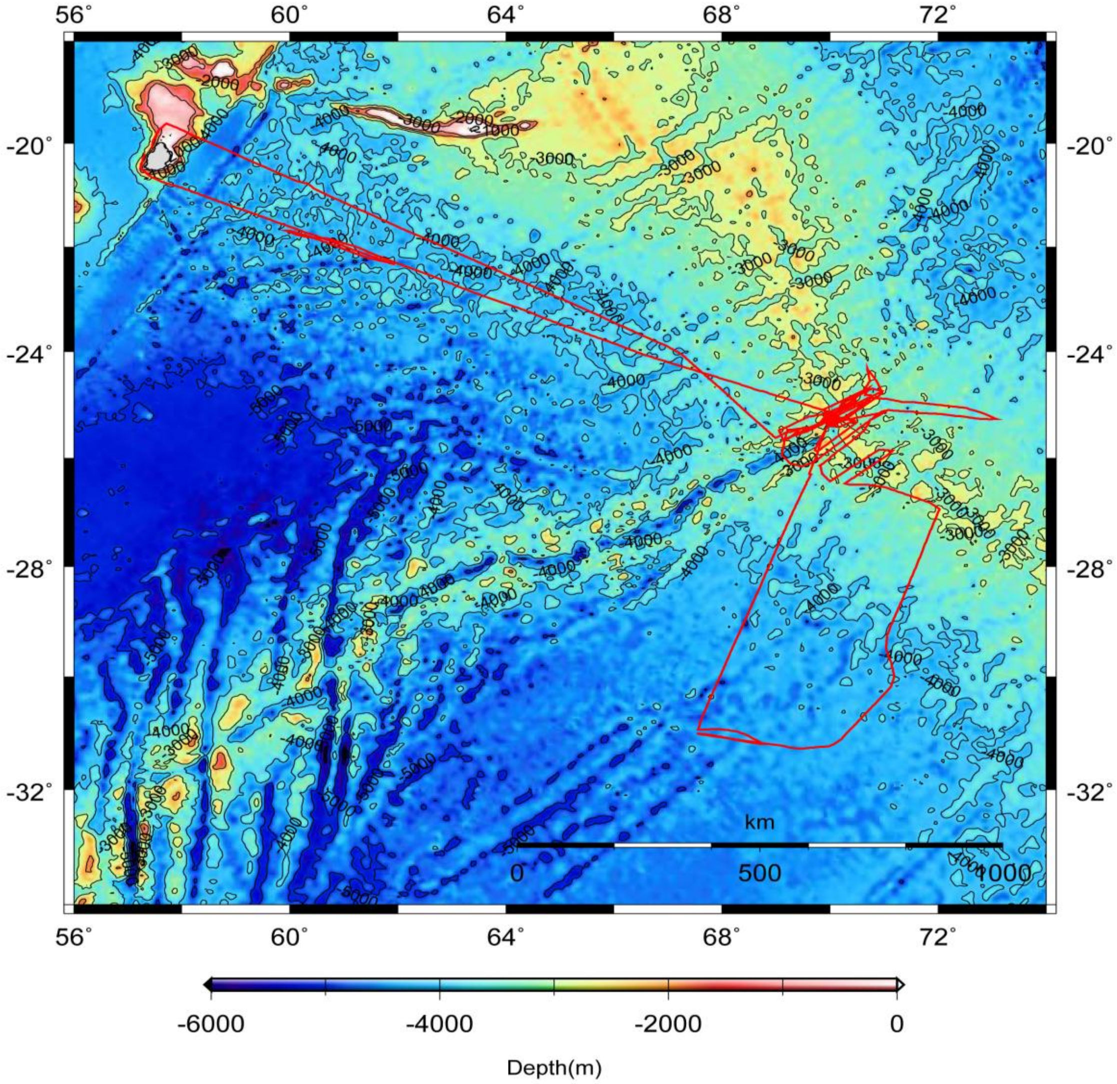


Figure 1.2. Navigation track of YK13-03 cruise.

2. List of participants

Science party

Chief Scientist
Dr. Kentaro NAKAMURA
Petrologist
Precambrian Ecosystem Laboratory (PEL),
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Vice Chief Scientist
Dr. Nobukazu SEAMA
Geophysicist
Department of Earth and Planetary Sciences, Kobe University

Dr. Takazo SHIBUYA
Petrologist
Precambrian Ecosystem Laboratory (PEL),
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Dr. Tomoaki MORISHITA
Petrologist
School of Natural System, College of Science and Engineering, Kanazawa University

Dr. Taichi SATO
Geophysicist
Geological survey of Japan,
National Institute of Advanced Industrial Science and Technology (AIST)

Dr. Tomo-o WATSUJI
Biologist
Subsurface Geobiology Advanced Research (SUGAR) Project,
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Dr. Jun-ichi MIYAZAKI
Microbiologist

Subsurface Geobiology Advanced Research (SUGAR) Project,
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Dr. Toshinori SATO
Geophysicist
Graduate School of Science, Chiba University

Mr. Hiroyoshi TAKADA
Geophysicist
Faculty of Science, Chiba University

Ms. Eri IIZUKA
Geophysicist
Department of Earth and Planetary Sciences, Kobe University

Marine Technician
Mr. Satoshi OKADA
Nippon Marine Enterprises, LTD.

Mr. Koki HISANO
Nippon Marine Enterprises, LTD.

Ms. Akie SUZUKI
Nippon Marine Enterprises, LTD.

Mr. Toshimasa NASU
Nippon Marine Enterprises, LTD.

Operation team of SHINKAI 6500

Submersible Operation Manager	**Toshiaki Sakurai**
Deputy Submersible Op. Manager	**Kazuhiro Chiba**
1st Submersible Technical Officer	**Kazuki Iijima**
1st Submersible Technical Officer	**Keita Matsumoto**
1st Submersible Technical Officer	**Shinobu Omika**
2nd Submersible Technical Officer	**Hirofumi Ueki**
2nd Submersible Technical Officer	**Keigo Suzuki**
2nd Submersible Technical Officer	**Akihisa Ishikawa**
2nd Submersible Technical Officer	**Takuma Onishi**
2nd Submersible Technical Officer	**Masaya Katagiri**
3rd Submersible Technical Officer	**Hitomi Ikeda**
3rd Submersible Technical Officer	**Yudai Tayama**

Captain and crew of the R/V YOKOSUKA

Captain	**Shinya Ryono**
Chief Officer	**Tatsuo Adachi**
2nd Officer	**Takeshi Egashira**
3rd Officer	**Yumihiko Kobayashi**
Chief Engineer	**Eiji Sakaguchi**
1st Engineer	**Takashi Ota**
2nd Engineer	**Kenta Ikeguchi**
3rd Engineer	**Shota Nagano**
Chief Electronic Operator	**Takehito Hattori**
2nd Electronic Operator	**Shunsuke Fukagawa**
3rd Electronic Operator	**Yoshikazu Kuramoto**
Boat Swain	**Kazuo Abe**
Able Seaman	**Masanori Ohata**
Able Seaman	**Kaito Murata**
Able Seaman	**Takuya Miyashita**
Sailor	**Hirotaka Shigeta**
Sailor	**Ryoma Tamura**
Sailor	**Kenta Nasu**

No.1 Oiler	**Kozo Miura**
Oiler	**Keita Funawatari**
Oiler	**Yuji Higashigawa**
Assistant Oiler	**Ryo Sato**
Assistant Oiler	**Eiji Aratake**
Chief Steward	**Isao Matsumoto**
Steward	**Hideo Fukumura**
Steward	**Yoshio Okada**
Steward	**Kazuma Sonoda**
Steward	**Kei Ito**

3. Cruise summary

In this cruise, we successfully recovered fifteen OBEMs, seventeen OBSs, one OBSP, and one OBSM 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. Observation started after the deployment of these ocean bottom instruments during another Yokosuka cruise (YK13-01) in this January; 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 continued up to the recovery of these instruments during this cruise. 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, which cover total 1230 miles in the research area.

We also performed 3 Shinkai 6500 dives (1 dive at the Kairei hydrothermal field and 2 dives at the Yokoniwa Rise) and 3 YKDT dives (at the Yokoniwa Rise). In the Shinkai dive #1330, we collected hydrothermal fluid samples and various hydrothermal vent animals including scary-foot gastropod from the Kairei hydrothermal field. Camera observation in YKDT dive #153 suggested that unseen active hydrothermal vent exists at the western part of the summit of the Yokoniwa Rise. In Shinaki dive #1331, we discovered low-temperature hydrothermal venting at the western part of the summit of the Yokoniwa Rise and sampled hydrothermal fluids and animals. Shinkai dive #1332 confirmed that pillowed basalt is extensively exposed at the southwestern part of the Yokoniwa Rise, boundary between the Hakuho-knoll and Yokoniwa Rise. In addition, camera observations at the Yokoniwa Rise in YKDT dive #154 and #155 suggested that pillowed basalt is also exposed at the southeastern slope, whereas massive rocks (probably gabbro or peridotite) are exposed on the northern slope.

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.

4. General background and research objectives

Since the first discovery of hydrothermal vent site at the Galapagos Spreading Centre in 1977 (Corliss et al., 1979), submarine hydrothermal systems have attracted the particular interest of geoscientists, petrologist, geophysist, geochemists, and biologists (e.g., Humphris et al., 1995; Van Dover, 2000; Wilcock et al., 2004). Although more than 300 of hydrothermal vent sites have been discovered and investigated in the Pacific and Atlantic Oceans (e.g., German and Von Damm, 2004), there are only several hydrothermal vent sites recently discovered in the Indian Ocean (Gamo et al., 2001; Van Dover et al., 2001; Tao et al., 2011; Nakamura et al., 2012). In order to obtain better understanding of geological, geophysical, and geochemical diversities of the MOR hydrothermal systems on a global scale, it is clear that detailed investigations (as well as additional exploration and discovery) on the Indian Ocean hydrothermal systems are important.

In August 2000, the Kairei field, located at the CIR Segment 1 near the Rodriguez Triple Junction, has been discovered as the first directly observed hydrothermal vent site in the Indian Ocean (Gamo et al., 2001). The chemical composition of the vent fluids, including major dissolved species (e.g., Si, Ca, Mg, K, SO_4) and gases (CH_4, CO_2, H_2S), was first reported by Gamo et al. (2001), showing that the Kairei fluids are generally similar to the hydrothermal fluids from typical MORs in the Pacific and the Atlantic oceans. Subsequent investigations, however, revealed that the Kairei fluids have unusually high concentrations of H_2 (up to 8.5 mM) compared to typical MOR hydrothermal fluids (Van Dover et al., 2001; Takai et al., 2004; Gallant and Von Damm, 2006; Kumagai et al., 2008). In 2004, it was suggested that a hydrogen-based hyperthermophilic subsurface lithoautotrophic microbial ecosystem (HyperSLiME) existed in the subseafloor environments of the KHF (Takai et al., 2004). This microbial ecosystem is sustained by the primary production of hydrogenotrophic, hyperthermophilic methanogens, utilizing H_2 and CO_2 as the primary energy and carbon sources. Because both H_2 and CO_2 are completely photosynthesis-independent substances, provided only by hydrothermal (geological) processes, the HyperSLiME is considered as a likely modern analogue for the early Earth ecosystems prior to photosynthesis (Takai et al., 2006). In addition to subseafloor microbes, various hydrothermal vent macrofauna were found in the Kairei field. Although *Rimicaris* shrimp was widely distributed, gastropods, i.e. *Crysomallon squamiferum* and *Alviniconcha* sp., were found only in the lower part of Monju chimney. *Alviniconcha* from the Kairei field is unique in that they harbor epsilonproteobacterial endosymbionts

(Suzuki et al., 2005).

In order to know the cause of the H_2-rich hydrothermal fluids sustaining the unique microbial ecosystem, we have conducted two cruises of the YK05-16 and YK09-13 cruises. In YK05-16, we discovered serpentinized peridotite and troctolites from the 25°S OCC and URANIWA-Hills, respectively (Kumagai et al., 2008). Petrological investigations and geochemical modeling for hydrothermal alteration of the URANIWA troctorites revealed that serpentinization of the troctolitic rocks can produce enough H_2 into the Kairei hydrothermal fluids (Nakamura et al., 2009). In YK09-13 cruise, we further discovered gabbroic rocks and peridotites at NAKANIWA-Ridge and YOKONIWA-Rise, respectively. The results of these cruises demonstrated that the enrichment of H_2 in the Kairei fluids is attributed to the deep-seated rocks exposed around the Kairei hydrothermal field. A question still remains how the deep-seated rocks (originally situated at several kilometers below seafloor) are uplifted and exposed onto seafloor. Additionally, in YK09-13 cruise, we found many of dead chimneys composed of sulfide minerals on top of the YOKONIWA-Rise. This finding suggests that there was/is high-temperature hydrothermal activity at the YOKONIWA-Rise.

To address the question about the uplifting and exposing processes of the deep-seated rocks and activity of the new hydrothermal vent sites at the YOKONIWA-rise, we have conducted integrated study of petrology, geophysics, and geochemistry around the YOKONIWA-rise in this cruise.

References:

Corliss, J. B., Dymond, J., Gordon, L. I., Edmond, J. M., von Herzen, R. P., Ballard, R. D., Green, K., Williams, D., Bainbridge, A., Crane, K. and van Andel, T. H., 1979. Submarine thermal springs on the Galapagos Rift. *Science* **203,** 1073-1083.

Gallant, R.M., Von Damm, K.L., 2006. Geochemical controls on hydrothermal fluids from the Kairei and Edmond Vent Fields, 23°–25°S, Central Indian Ridge. *Geochem. Geophys. Geosys.* **7,** Q06018. doi:10.1029/2005GC001067.

Gamo, T., Chiba, H., Yamanaka, T., Okudaira, T., Hashimoto, J., Tsuchida, S., Ishibashi, J., Kataoka, S., Tsunogai, U., Okamura, K., Sano, Y., Shinjo, R., 2001. Chemical characteristics of newly discovered black smoker fluids and associated hydrothermal plumes at the Rodriguez Triple Junction, Central Indian Ridge. *Earth Planet. Sci. Lett.* **193,** 371–379.

German, C.R. and Von Damm, K.L., 2004. Hydrothermal processes. The Oceans and Marine Geochemistry (Holland, H.D. and Turekian, K.K., eds.), *Treatise on Geochemistry* **6,** 181-222.

Humphris, S.E., Zierenberg, R.A., Mullineaux, S., Thomson, R.E., 1995. Seafloorhydrothermal systems, physical, chemical, biological, and geological interactions. Geophysical Monograph Series, 91, American Geophysical Union, Washington, D.C. 466pp.

Kumagai, H., Nakamura, K., Morishita, T., Toki, T., Okino, K., Shibuya, T., Sawaguchi, T., Neo, N., Joshima, M., Sato, T., Takai, K., 2008. Geological background of the Kairei and Edmond hydrothermal vent fields along the Central Indian Ridge: Insights into the distinct chemistry between their vent fluids. *Geofluids* **8,** 239–251.

Nakamura, K., Morishita, T., Bach, W., Klein, F., Hara, K., Okino, K., Takai, K., Kumagai, H., 2009. Serpentinized troctolites exposed near the Kairei Hydrothermal Field, Central Indian Ridge: Insights into the origin of the Kairei hydrothermal fluid supporting a unique microbial ecosystem. *Earth Planet. Sci. Lett.* **280,** 128–136.

Nakamura, K., Watanabe, H., Miyazaki, J., Takai, K., Kawagucci, S., Noguchi, T., Nemoto, S., Watsuji, T., Matsuzaki, T., Shibuya, T., Okamura, K., Mochizuki, M., Orihashi, Y., Ura, T., Asada, A., Marie, D., Koonjul, M., Singh, M., Beedessee, G., Bhikajee, M., and Tamaki, K., 2012. Discovery of new hydrothermal activity and chemosynthetic fauna on the Central Indian Ridge at 18º-20ºS. *PloS ONE* **7**, e32965. doi:10.1371/journal.pone.0032965.

Suzuki, Y., Sasaki, T., Suzuki, M., Nogi, Y., Miwa, T., Takai, K., Nealson, K.H., Horikoshi, K., 2005. Novel chemoautotrophic endosymbiosis between a member of the Epsilonproteobacteria and the hydrothermal-vent gastropod Alviniconcha aff. hessleri (Gastropoda: Provannidae) from the Indian Ocean. *Appl. Environ. Microbiol.* **71,** 9.

Takai, K., Gamo, T., Tsunogai, U., Nakayama, N., Hirayama, H., Nealson, K.H., Horikoshi, K., 2004. Geochemical and microbiological evidence for a hydrogen-based, hyperthermophilic subsurface lithoautotrophic microbial ecosystem (HyperSLiME) beneath an active deep-sea hydrothermal field. *Extremophiles* **8,** 269–282.

Takai, K., Nakamura, K., Suzuki, K., Inagaki, F., Nealson, K.H., Kumagai, H., 2006. Ultramafics–Hydrothermalism–Hydrogenesis–HyperSLiME (UltraH^3) linkage: a key insight into early microbial ecosystem in the Archean deep-sea hydrothermal systems. *Paleontol. Res.* **10,** 269–282.

Tao, C., Lin, J., Guo, S., Chen, Y. J., Wu, G., Han, X., German, C.R., Yoerger, D. R., Zhou, N., Li, H., Su, X., Zhu, J., and DY115-19 (Legs 1-2) and DY115-20 (Legs 4-7) Science Parties, 2011. First active hydrothermal vents on an ultraslow-spreading center: Southwest indian Ridge. *Geology* **40,** 47–50.

Van Dover, C.L., 2000. The Ecology of Deep-Sea Hydrothermal Vents. Princeton University Press, Princeton. 352pp.

Van Dover, C.L., Humphris, S.E., Fornari, D., Cavanaugh, C.M., Collier, R., Goffredi, S.K., Hashimoto, J., Lilley, M.D., Reysenbach, A.L., Shank, T.M., Von Damm, K.L., Banta, A., Gallant, R.M., Götz, D., Green, D., Hall, J., Harmer, T.L., Hurtado, L.A., Johnson, P., McKiness, Z.P., Meredith, C., Olson, E., Pan, I.L., Turnipseed,M.,Won, Y., Young III, C.R., Vrijenhoek, R.C., 2001. Biogeography and Ecological setting of Indian Ocean hydrothermal vents. *Science* **294,** 818–823.

Wilcock, W.W., DeLong, E., Kelley, D.S., Baross, J.A., Cary, S.C., 2004. The subseafloor biosphere at mid-ocean ridges. Geophysical Monograph Series 144, American Geophysical Union, Washington, D.C., 408pp.

5. Instrumentation and methods

5.1. Deep-sea three-component magnetometer

Vector magnetic field data were collected using a deep sea magnetometer attached on the submersible. The deep-sea three-component magnetometer “Shinkai-Miniko” (Clover tech Inc. / Ocean Research Inst. Univ. Tokyo) consists of a three-axis fluxgate-type sensor, a A/D conversion unit, a data controller/logger. The sensor and the A/D conversion unit are stored within a pressure case and the case is attached on the outer shell of the *Shinkai 6500*. The controller/logger unit is installed in the submersible. The main specification is as follows:

Specifications

Sensor and A/D unit

measurement range	± 70000 nT
orthogonality	± 20 min.
accuracy	± 200 nT
temperature stability	0.5nT/°C
resolution	1 nT
temperature range	-30~60°C
sampling rate	10 Hz
operating voltage	DC10~30V
power consumption	80 mA @ DC24V
size (pressure case)	φ70mm × 600m,
weight in air (in water)	4.2 kg (1.9 kg)
cable weight	1.2 kg (0.5 kg)

Controller / logger

recording media	compact flash memory
maximum data size	2GB
port type	RS232C (3 data port and 1 monitor port)

Installation

The sensor case is installed on fore side of the *Shinkai 6500* (Fig. 3-6), slightly biased toward starboard side. The sensor was installed at the center of the submersible during the previous cruises and the data were suffered from the noise from No.2 Camera on port side which was freely moved by observers. We tested the noise level caused by the movement of No.2 Camera and manipulators before YK09-13 and the more suitable position was selected.

The three axes of magnetometer were set to be X-positive: port side, Y-positive: forward, and Z-positive: downward.

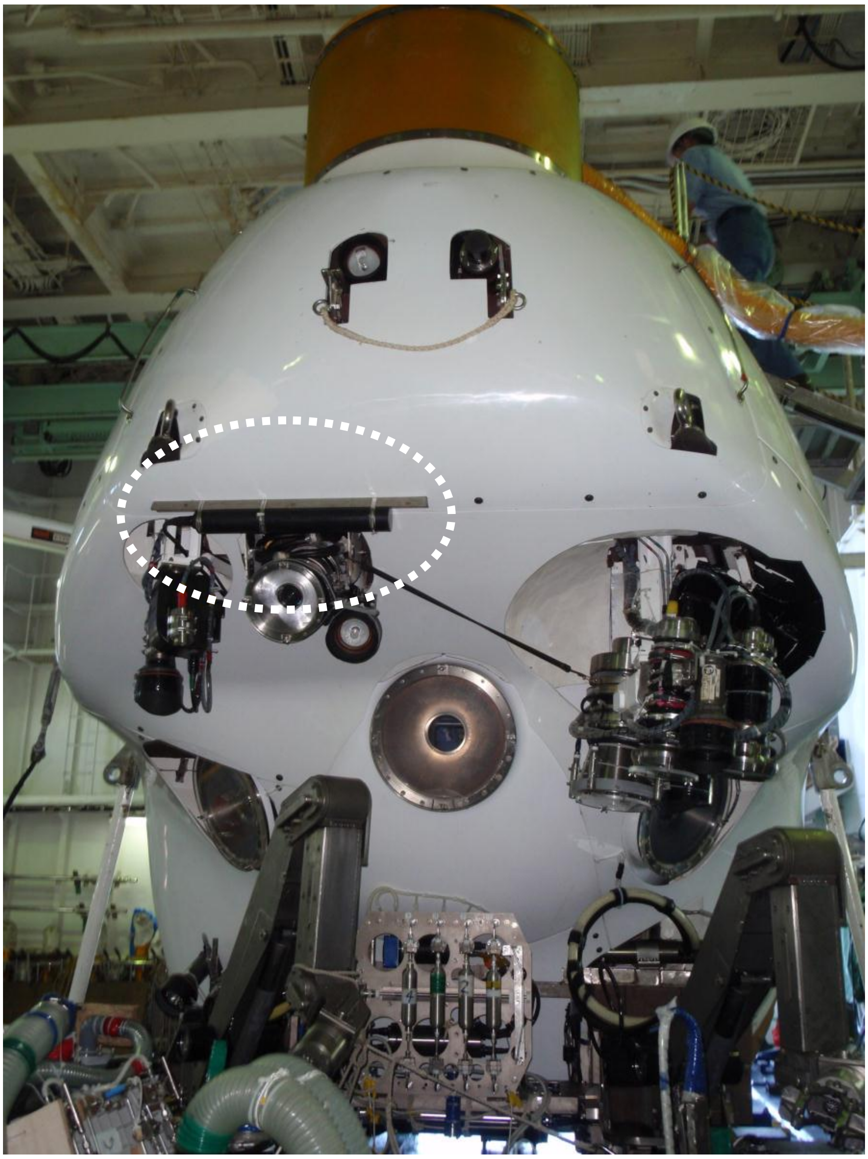


Figure 5.1. Deep-sea three-component magnetometer installed on the *Shinkai 6500*.

5.2. WHATS fluid sampler

WHATS-II (Water Hydrothermal *Atsuryoku* Tight Sampler II) was developed for collecting hydrothermal fluid samples without any loss and atmospheric contamination of gas species. Since it overflows its sample bottle with sampling fluids, it is rather easy to collect fluids close to the endmember.

This sampling system consists of inlet tubing, 4 pressure-resistant sample bottles with ball valves at both ends (volume of one bottle: 150 ml), an arm to open and shut the valve and a deep-sea compatible pump. Usually WHATS is installed just below the shell of *Shinkai 6500* and a sample inlet is handled with a manipulator (Figure 5.2). Operation is controlled from inside the shell. At the time of each sampling, fluid temperature can be monitored using a thermometer attached to the top of the inlet tube. It takes about 7 minutes to fill up one sample bottle of 150 ml capacity. Detailed description of the system is shown bellow.

Description

Dimension of frame:	600 mm × 660 mm
Weight:	35.2 kg in air
	28.0 kg in seawater
Depth range:	4000 m
Sample volume:	150 ml × 4
Sampling rate:	75-300 ml / min.
Electricity:	DC24 V / 1.0 A

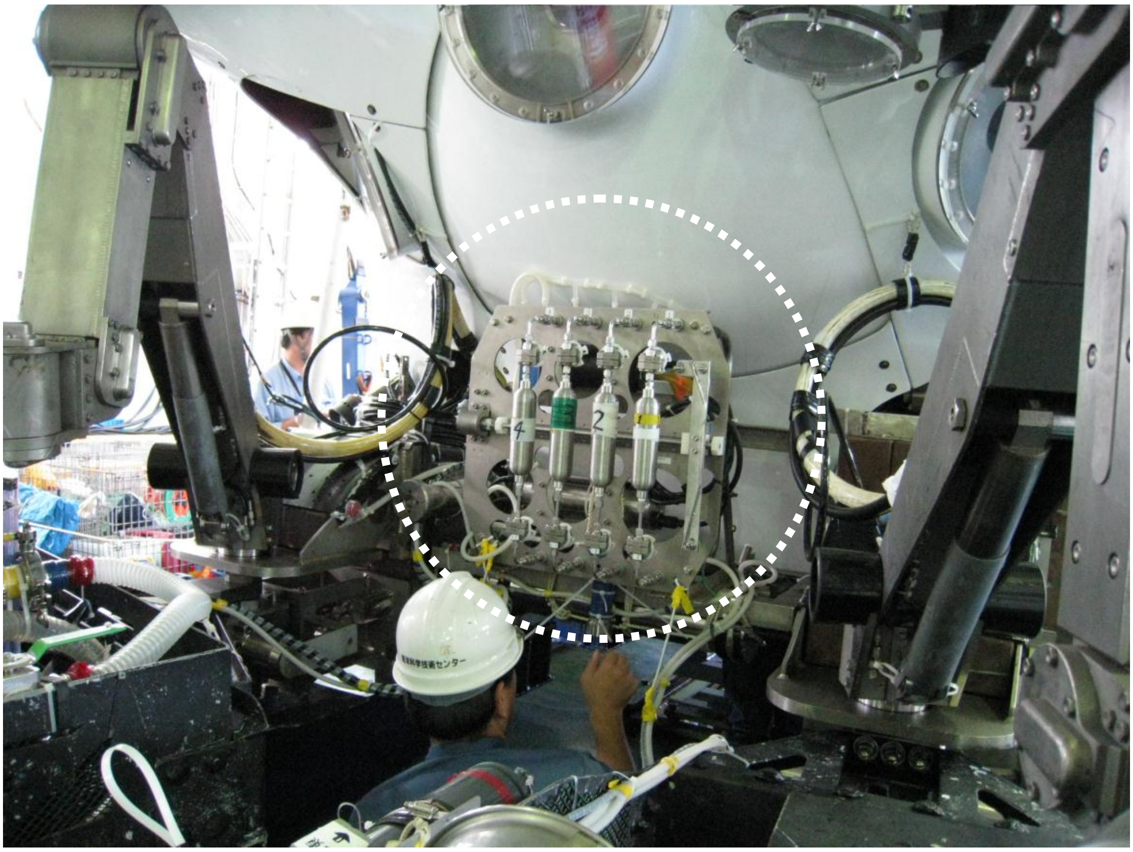


Figure 5.2. WHATS II fluid sampling system attached to Shinkai 6500.

5.3. Ore-type 8-fold fluid sampler

To sample fluid from inside of fauna colonies, we used Ore-type 8-fold fluid sampler (Figure 5.3). This sampler has 8 bottles (each volume was 5 mL) which were linked in series by hose and enable to close all valves by single operation. We used this sampler by connecting control unit and perister pump.

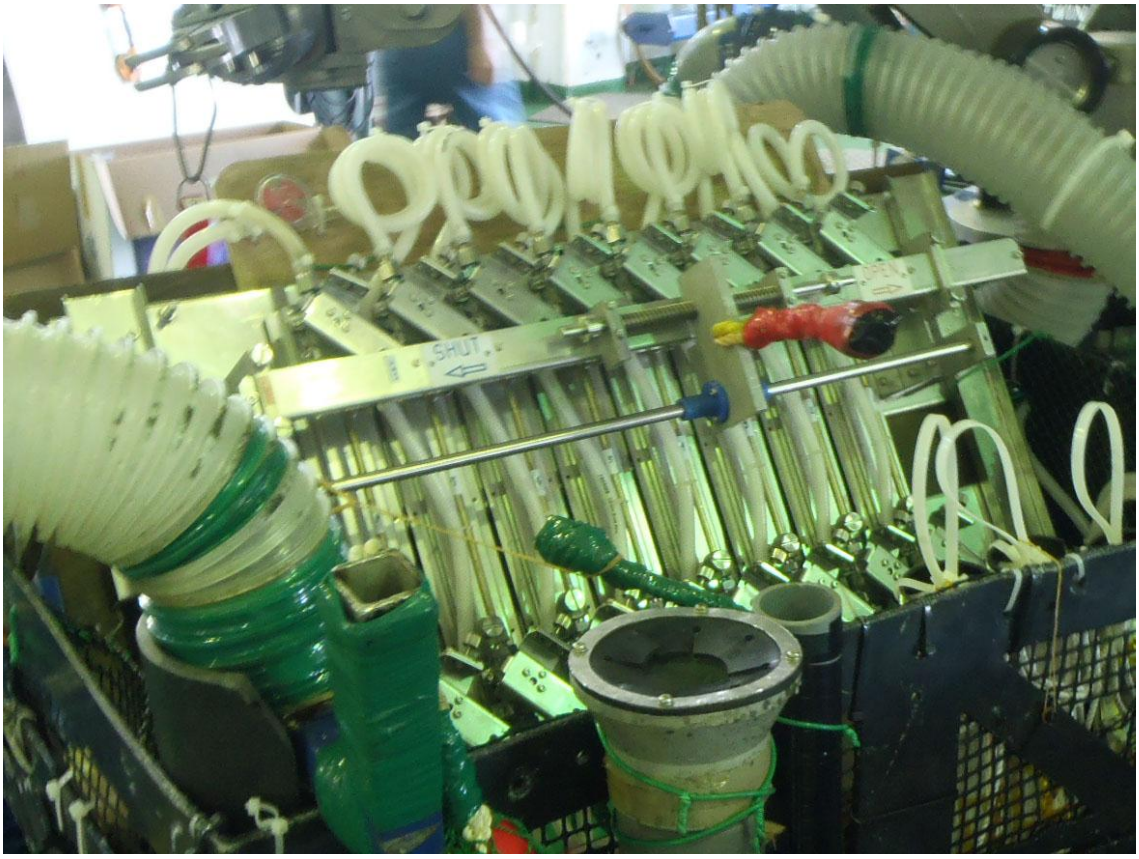


Figure 5.3. Ore-type 8-fold fluid sampler attached to Shinkai 6500.

5.4. Suction sampler

This instrument was used for sampling vent-endemic fauna. In #1330, we prepared two suction samplers. The one was used for sampling vent-endemic faunas. This sampler was composed of large canister (Figure 5.4a). The samples by this sampler were used for the activity measurements, embryological study, and microbiological study. Another was prepared for investigating in situ gene expression pattern of faunas. This sampler was composed with small single canister connected with bags in which the RNase inhibitor was filled (Figure 5.4b). After sampling fauna, RNA inhibitor was introduced into the small canister.

Figure 5.4a. Suction sampler with large canister attached to Shinkai 6500.

Figure 5.4b. Suction sampler with small canister attached to Shinkai 6500.

5.5. Hydrothermal fluid sampling and analysis

Treatment of fluid samples for gas chemistry

In general, for vent fluid sampling, the WHATS (WHATS-II) sample bottles were in pairs, with one of the bottles used for the analysis of soluble components chemistry and the other for gas chemistry. The bottle devoted to gas chemistry was processed on board using a high vacuum line specifically designed for this purpose using the following procedure.

After the WHATS bottle is connected to the vacuum line, all of the connecting lines are evacuated to high vacuum using an oil diffusion pump. When sufficient vacuum is achieved, the vacuum line is closed in a static condition, and the valve on the bottle is opened and the water plus gas is allowed to drop into an evacuated flask. The water in the extraction flask is then agitated by stirring bar. The gas phase was transferred to a total of 150 cm^3 evacuated stainless steel and glass container for compositional and isotope measurements of gas components. After the gas phase was obtained, the liquid phase was taken into a 50 cm^3 polypropylene bottle for major cation and anion measurements.

Onboard analyses of fluid samples for dissolved species

The bottle devoted to fluid chemistry was shared with microbiological study. After sample for pH, Fe^{2+}, and H_2S determination was drawn, the rest of the fluid was filtered with a 0.45 μm disk filter. The filtrate was provided for chemical analysis of major elements, nutrients (NH_4, SiO_2), and trace metals. Because some chemical species such as nutrients and pH are difficult to be conserved during storage, we therefore analyzed pH, H_2S, and Fe(II) onboard following the method described in Gieskes et al. (1991).

Sample treatment for microbiological studies

Chimney samples were divided into several portions (e.g., outside structure with white or orange mats, inside structure, middle-inside structure). Each piece of chimney structure was slurried at 4ºC for cultivation. The remnants of pieces were stored in plastic tubes or bags at -80 °C for DNA/RNA analysis. Microbial cells attached with the samples were fixed in plastic tubes filled with filter-sterilized seawater containing formalin (final 2~4 % v/v) at 4ºC for microscopic observation.

5.6. Microbiology and macrobiology

Sample preparation

For cultivation, water samples collected by the Niskin bottle and WHATS were immediately poured into sterilized glass vials under the atmosphere of nitrogen gas.

Chimney samples were subsampled into several portions (e.g. vent orifice surface, inside structure, middle-inside structure). Each piece of chimney structure was slurried with filter-sterilized seawater under N_2 for cultivation. For molecular analysis, the rest of pieces was kept under -80 °C.

Vent-endemic faunas were dissected, incubated, or fixed once onboard ship. Individuals or their tissues were applied to various onboard experiments (e.g. enzyme activity measurement and incubation under the H_2-containing atmosphere), or kept under -80 °C. Some individuals of hydrothermal vent animals were frozen under -80 °C or fixed with ethanol or formalin.

5.7. OBEM (Ocean Bottom Electro-Magnetometer)

OBEMs (Photos 5.9) 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.

Fifteen OBEMs were totally recovered during the YK13-03 Yokosuka cruise. The recovered 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 5.9a), 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 5.9b), 4) two glass spheres, fluxgate magnetometer and data logger of Tierra Tecnica Corp. are housed in one glass sphere (T, 3 sites) (Photo 5.9c).

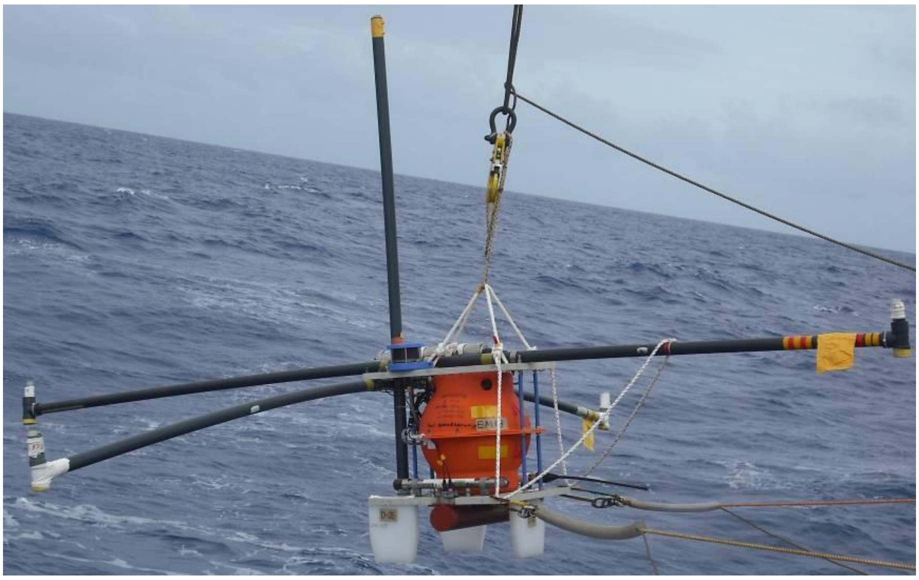


Figure 5.7a. BC1 OBEM. BC2 OBEM shows similar appearance to the BC1 OBEM.

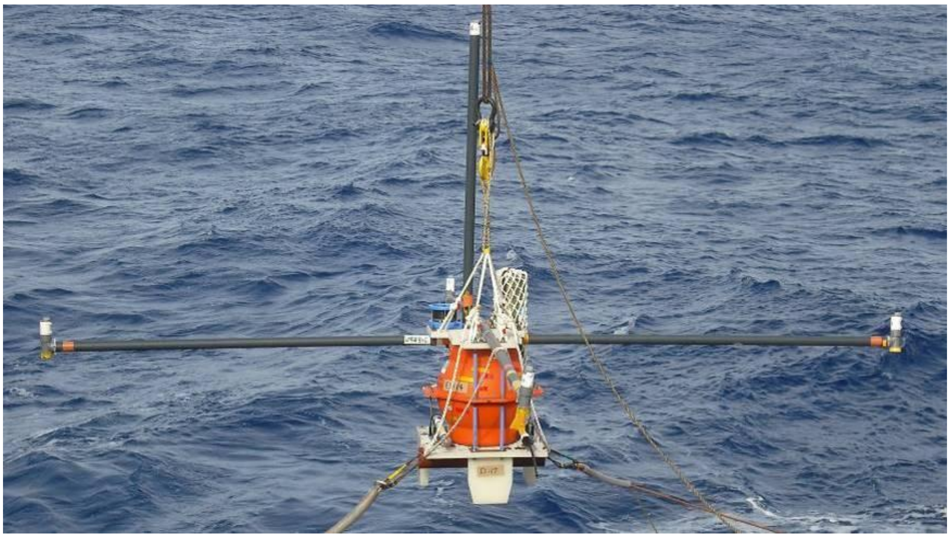


Figure 5.7b. BC3 OBEM.

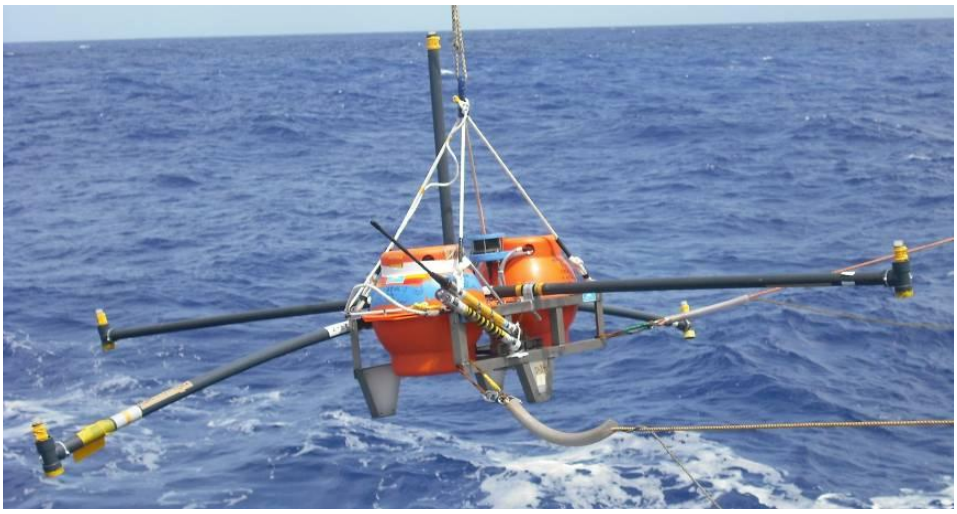


Figure 5.7c. T OBEM

5.8. OBS (Ocean Bottom Seismometer)

We recovered 19 ocean bottom seismometers (OBSs) during the YK13-03 Yokosuka cruise, which include 1 OBS with absolute pressure gauge (OBSP) and 1 OBSs attached with magnetometers (OBSMs), during the cruise (Photo 5.10a). In this section, we focus on 17 OBSs (Photo 5.10b) 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.

Figure 5.8a. OBSs in this experiment

Figure 5.8b. OBS (glass sphere)

5.9. OBSP (Ocean Bottom Seismometer with Pressure gauge)

One of the OBSs, OBSP (Photo 5.11), 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.

Figure 5.9. OBSP

5.10. OBSM (Ocean Bottom Seismometer with Magnetometer)

The other one of the OBSs, OBSM is composed of OBS and ocean bottom magnetometer (OBM) with a recovery system (Photos 5.12). The OBS has 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, and the pressure resistant sphere is a titanium sphere (dia. 500).

The OBM measures 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 5.9). The OBM is attached vertically beside the acoustic transducer to a titanium sphere OBS (Photo 5.12) in order to avoid generating noise against the seismic observation and to keep good signal to noise ratio for magnetometer observation.

Figure 5.10 OBM (titanium cylinder) attached vertically to titanium sphere OBS.

5.11. Equipment for active seismic surveys

We used a single channel seismic survey system including an air-gun and a single channel hydrophone streamer cable (Photo 5.13), 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 5.13.

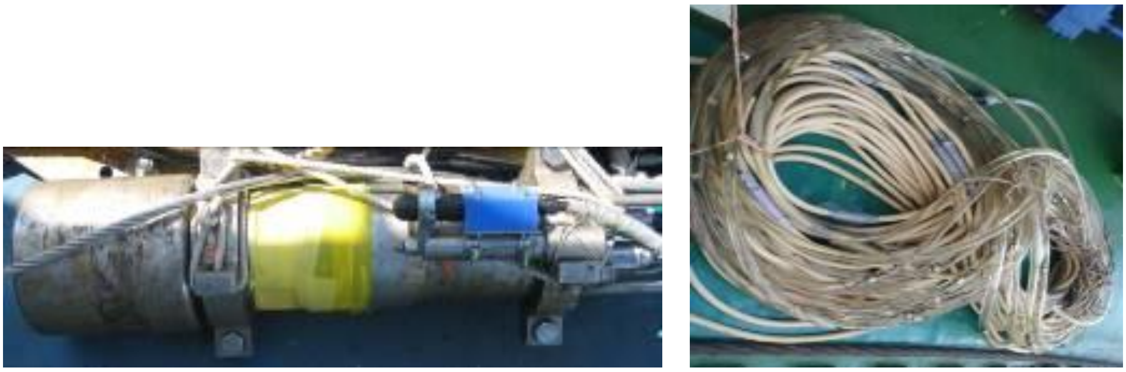


Figure 5.11. Air-gun (left) and single channel hydrophone streamer cable (right)

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 5.11. Specification of the single channel seismic survey system.

6. Preliminary Results

6.1. Shinkai 6500 dive summary

6K#1330 dive (Kairei hydrothermal field)
6K#1331 dive (Yokoniwa Rise)
6K#1332 dive (Yokoniwa Rise)

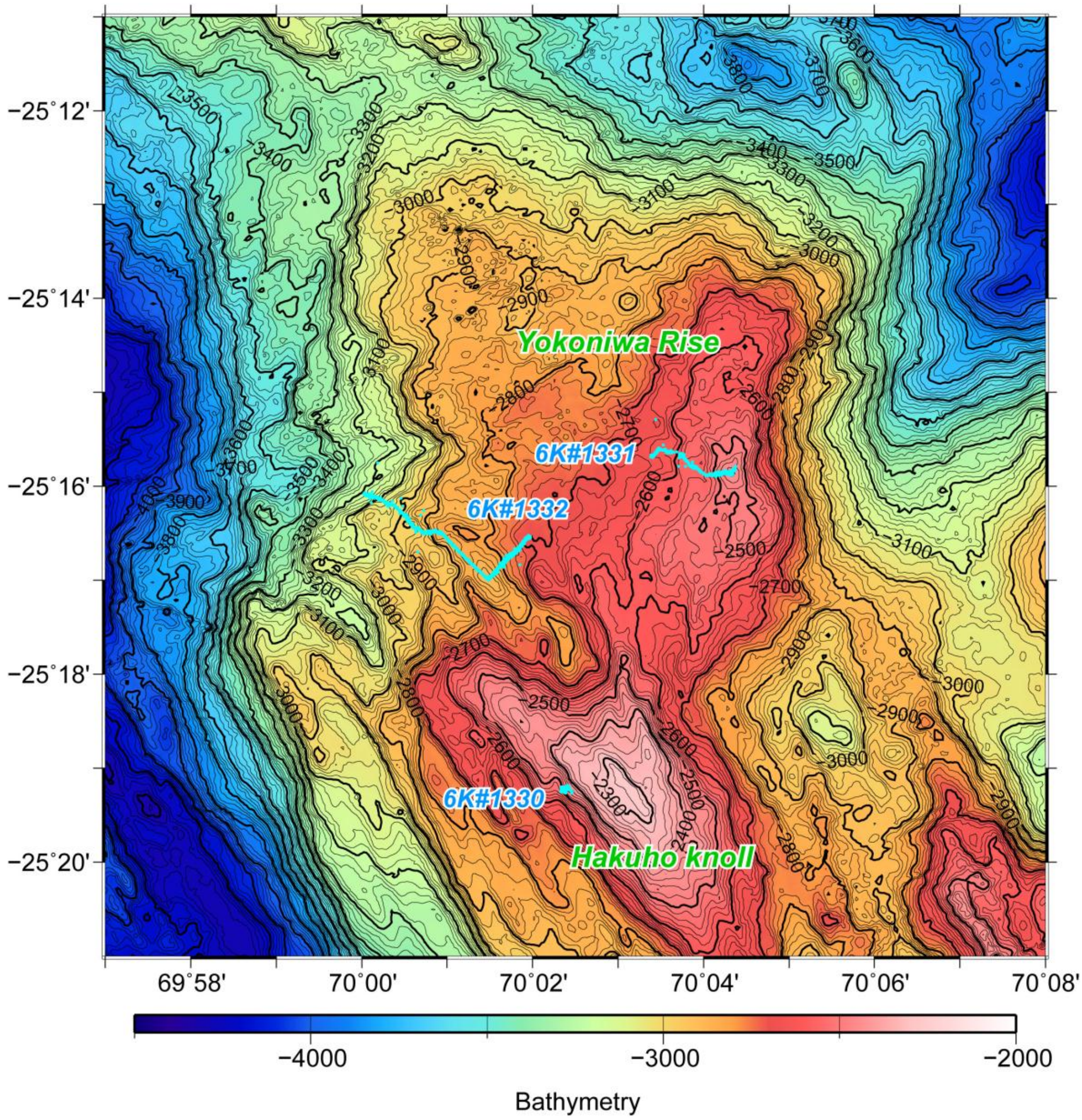


Figure 6.1. Dive tracks of the Shinkai 6500 dives 6K#1330, 1331, 1332.

Dive Report: Shinkai 6500 Dive#1330

Date: March 16, 2013
Site: Kairei hydrothermal field in CIR segment 1
Landing: 11:07; 25°19.2480'S, 70°2.3515'E, 2477 m
Leaving: 16:00; 25°19.2440'S, 70°2.4598'E, 2365 m
Observer: Junichi Miyazaki (JAMSTEC)
Pilot: K. Chiba **Co-Pilot:** A. Ishikawa

Objectives:

Objectives of this dive were collecting hydrothermal vent chimneys, vent fluids and vent endemic macrofauna including black scaly-foot gastropods and snails in Kairei hydrothermal field to obtain physiological properties of microbes on chimney and vent endemic-faunas. And also to capture microbes in hydrothermal fluids, we tried to deploy in situ colonization systems (Miyazaki11's short Bio sampler II) into the vent.

Dive Summary:

At 11:00, we landed on mountain ridge which was located at south side of Kali vent. In this landing position, we could observe many sea anemones. We headed to Kali vent sites, but we could found the vent. Therefore we went up the ridge and we could find the chimneys at which many Rimicaris was attached (After the dive, we identified this chimney as Kissyo chimney). During the approach of this chimney, we could find the black smoker vent in the bottom of a ravine. Therefore we headed to the black smoker vent. At 11:50, we arrived at the black smoker vent chimney (After the dive, we identified this chimney as Kali chimney). The height of chimney was about 1 m and the width of the vent was approximately 80 cm diameter. We first sampled chimney pieces and then sample hydrothermal fluid into WHATS sampler. The maximum temperature was recorded 359.5°C. Next, we deployed Miyazaki11's short Bio sampler II into the vent. Finally we tried to set marker #145 but the marker was broken. Therefore we set marker #146 near the chimney. But the marker was swallowed up by black smoker.

We left the chimney at 12:40, we headed to Monju chimney. But we could not marker #23 which was set near Monju chimney in previous dive. Therefore we approached to the chimney in which the Alviniconcha colony was formed (After the dive, we identified thechimney as Monju chimney). Most of the part of the chimney was covered with Rimicaris. To confirm whether there are sacly-foot gastropods in the chimney, we brushed the shrimps away from the chimney by suction sampler's hose. As a result of blushing, we found black scaly-foot gastropods and then sampling the gastropods by suction sampler with single canister. During the sampling, the hose was broken. Next we deployed two white scaly-foot box near scaly-foot gastropods, and DO measurement of macrofaunas colonies (4 places x 2 min). During the DO measurements, we found marker in the anemones colony but we could not recognize the number. After a while, sluster engine of Shinkai6500 was over heated, therefore we decided to leave the chimney temporally.

To cool the engine, we rambled the Kairei field. In the course of rambling, we found marker #20 and #104 at Fudo chimney. But these were covered with hydrothermal sticks.

We returned to the Monju chimney and sampling water into green section of ore-type water sampler from inside of the Alviniconcha colony. The maximum temperature was recorded 14.5°C. And then we sampled water into red section of ore-type water sampler from gastropods colony. The maximum temperature was recorded 23.5°C. Next, we recovered one of white scaly-foot box. Finally we sampled macrofaunas by suction sampler into single and fixation canister.

Finishing all the works, we sampled dead chimney and active chimney.

At 16:00 we left the bottom.

Payloads:

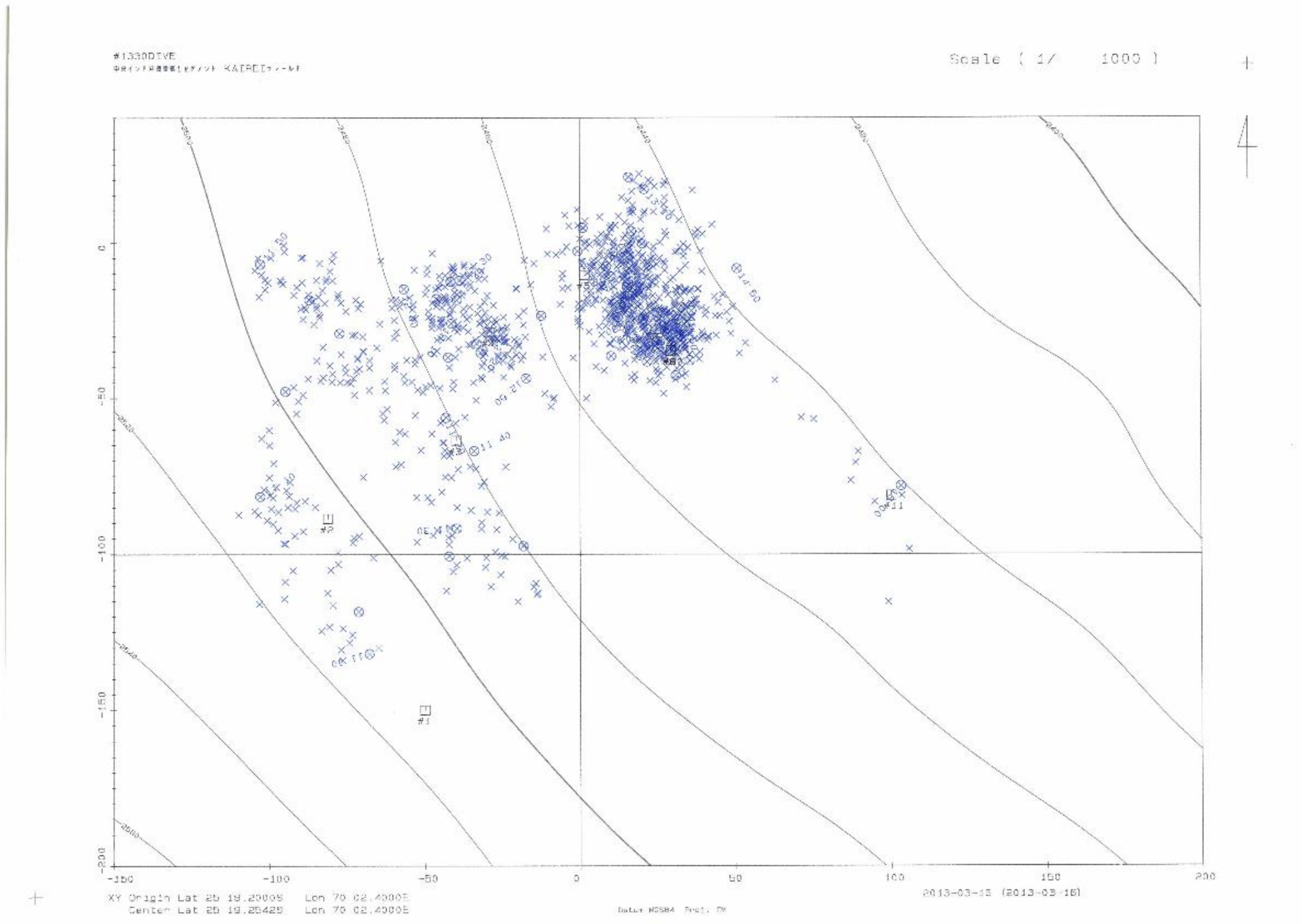
1) 2 x Suction sampler (Single canister and fixation canister)
2) WHATS with 4 bottles
3) Ore type water sampler
4) Ore-shiki Sample box
5) 3 x Sample boxes
6) 2 x White Scaly-foot box
7) Miyazaki11’s short Bio sampler II
8) 3 x Marker (#145, #146)

Event List:

1) 11:07, 25°19.2480'S, 70°2.3702'E, D=2477m Landing.
2) 11:37, 25°19.2345'S, 70°2.3762'E, D=2445m, Finding Black smoker chimney (Kali vent).
3) 12:38, 25°19.2157'S, 70°2.3825'E, D=2449m, Sampling chimneys, hydrothermal fluid (Temp. =359.5), Deploying Miyazaki11’s short Bio sampler II, Setting Marker#146.

4) 12:56, 25°19.2057'S, 70°2.4010'E, D=2433m, Finding chimney (Monju chimney)
5) 14:06, 25°19.2189'S, 70°2.4175'E, D=2420m, Sampling macrofaunas, deploying white-scaly box, DO measurements
6) 15:12, 25°19.2151'S, 70°2.4147'E, D=2421m, Sampling water from inside of Alviniconcha colony (Temp.=14.5°C)
7) 15:28, 25°19.2189'S, 70°2.4175'E, D=2420m, Sampling water from inside of gastropods colony (Temp.=23.5°C)
8) 15:40, 25°19.2189'S, 70°2.4175'E, D=2420m, Recovering 1 of white scaly-foot box.
9) 15:50, 25°19.2189'S, 70°2.4175'E, D=2420m, Sampling macrofaunas chimneys.
10) 16:00, 25°19.2440’S, 70°2.4598’E, D=2364m, Left the bottom

Dive Track:



#1330DIVE
Scale (1/ 1000)
XY Origin Lat 25 19.2000S Lon 70 02.4000E
Center Lat 25 19.2542S Lon 70 02.4000E
2013-03-15 (2013-03-16)

Dive Report: Shinkai 6500 Dive#1331

Date: March 17, 2013
Site: Yokoniwa Rise (NTO massif between CIR segment 1 and 2)
Landing: 11:14; 25°15.6917'S, 70°3.4065'E, 2635 m
Leaving: 16:01; 25°15.8011'S, 70°4.3769'E, 2373 m
Observer: Taichi Sato (AIST)
Pilot: K. Iijima **Co-Pilot:** T. Ohnishi

Objectives:

The purpose of the dive #1331 is to reveal the lithological structure and geophysical characteristics around dead chimney field, which was found in 2009. Diving area is southeastern part of the Yokoniwa Rise, located between CIR segment 1and 2. Rock sampling, deep-sea magnetic survey and discovering new hydrothermal field are planned to conduct during this dive.

Dive Summary:

At 11:14, we landed on seafloor (depth: 2635 m) covered by white colored mud. Then, we headed to the event mark #1. At 11:28, close to the event mark #1, we found an outcrop and sampled two rocks. After that, we headed east to go to the event mark #18. Between the event marks #1 ad #18, we cruised at high altitude (~5m) for geomagnetic measurement. During that time, we saw pillow lavas partly covered with mud on the seafloor. Seafloor was gradually shallow to the east. At 11:54, close to the event mark #18, we found an outcrop of pillow lavas and sampled two rocks. And then, we headed to the next point of event mark #19 and started again geomagnetic measurement by high altitude. Seafloor was still consisted of pillow lavas, and some areas were covered by mud. We observed at least two NNE-SSW trending valleys on the seafloor. At 12:23, we found an outcrop of pillow lavas and sampled one rock. At 12:38, we found a large hill composed of pillow lavas and again sampled two rocks. Passing through the pillow hill, we found ripple textures on sediment surface. We passed through the event mark #19 and headed to the event mark #20. Then, we started to climb a steep slope toward the top of the Yokoniwa Rise. At the slope, we observed a different facies of seafloor from pillow lavas, which was composed of whitish sediment with many pieces of small rock fragments scattered on the sediment surface. At 12:52, brownish sediments began to appear with black blocky rocks found on the seafloor. We tried to sample the blocky rocks, but the rocks were too weak to grab by manipulators.

We gave up the sampling and started to cruise at high altitude for seafloor observation and geomagnetic measurement. At 13:10, we found EW trending ridge composed by black blocky rocks. We again tried to recover the rocks, but the rocks were also too weak to grab. At 13:26, at the same location, we found some bathymodiolus individuals and a whitish shell of gastropod. At 13:41, we sampled the shell of gastropod and put on the marker #147. After the sampling, we continued to climb the steep slope and went to the east for a while. At 13:48, we found a turtle shell-like texture on the seafloor, which was also recognized by the YKDT#153 during this cruise. At 13:58, we sampled rocks comprising the rim of the turtle shell-like texture with brownish colored mud by a scoop. After the sampling, we started again to climb the slope and then, reached to the top of Yokoniwa Rise at 14:07. At the top, there are no outcrops we could found and therefore, we decided to go back to the marker #147 site to find an active hydrothermal vent. At 14:23, close to the marker, we found bathymodiolus, munidopsis, and paralepetopsis and sampled them by a suction sampler. At 14:42, depth of 2436 m, very close to the animal sampling site, we found a very weak hydrothermal venting. Around the vent, brownish mud was exposed and several individuals of bathymodiolus, munidopsis, paralepetopsis, and sea anemone were found. At 14:42, we started fluid sampling by WHATS. Maximum temperatures observed during the sampling of W1 and W2 were 4.1 and 4.2°C, respectively, while the ambient water temperature was 1.7°C. At 15:32, after the fluid sampling, we sampled several bathymodiolus individuals by a suction sampler. At 15:40, before leaving the site, we sampled two black rocks from the surface of the vent and then, headed to east to find other vents and for geomagnetic measurement. We noticed that western side of Yokoniwa Rise has several EW trending ridges and valleys that cannot be detected by ship borne multibeam bathymetric survey, and the hydrothermal vent was found at one of the ridge. At 15:48, when we reached to the top of the Yokoniwa rise (or terrace in front of the top), we found several NS trending black dead chimneys. These dead chimneys were probably same ones that were found during 6K#1176 dive on November 14, 2009, YK09-13 Leg2 cruise. At 15:56, we sampled one dead-chimney and then, we continued to go to northeast. Finally, at 16:00, we left the bottom.

Payloads:

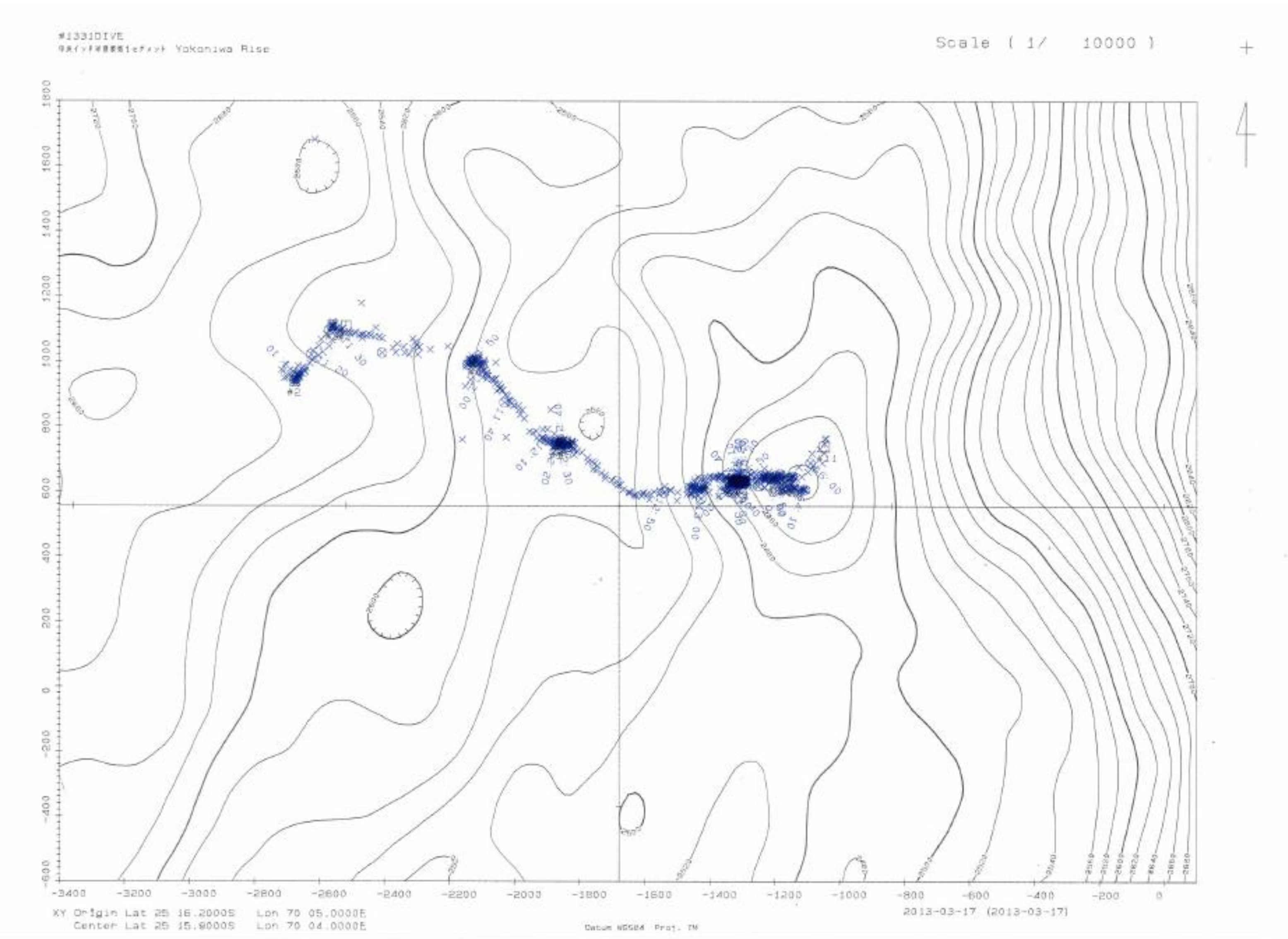
1) Sample baskets w/separation and lids
2) Deep sea three component magnetometer
3) JAMSTEC-SBP
4) WHATS with 4 bottles

5) Suction sampler with a single canister
6) Markers

Event List:

1) 10:00, 25°15.6000'S, 70°3.5000'E, Landing Target.
2) 11:14, 25°15.6917'S, 70°3.4065'E, D=2635 m, Landing.
3) 11:28, 25°15.5989'S, 70°3.4760'E, D=2622 m, Sampling Rocks (2).
4) 11:54, 25°15.6583'S, 70°3.7371'E, D=2556 m, Sampling Rocks (2).
5) 12:23, 25°15.7966'S, 70°3.8872'E, D=2564 m, Sampling Rocks (1).
6) 12:38, 25°15.7948'S, 70°3.9027'E, D=2560 m, Sampling Rocks (2).
7) 13:41, 25°15.8580'S, 70°4.2087'E, D=2439 m, Gastropod, Set #147 Marker.
8) 13:58, 25°15.8542'S, 70°4.2875'E, D=2437 m, Conglomerate.
9) 14:39, 25°15.8604'S, 70°4.2264'E, D=2436 m, S. Mussels, Galatheidae, limpet, WHATS (2), Rocks (2).
10) 15:56, 25°15.8575'S, 70°4.3090'E, D=2415 m, Dead Chimney (1)
11) 16:01, 25°15.8011'S, 70°4.3769'E, D=2373 m, Left bottom

Dive Track:



#1331DIVE
Yokoniwa Rise
Scale (1/ 10000)
XY Origin Lat 25 16.2000S Lon 70 05.0000E
Center Lat 25 15.8000S Lon 70 04.0000E
Datum WGS84 Proj. TM
2013-03-17 (2013-03-17)

Dive Report: Shinkai 6500 Dive#1332

Date: March 18, 2013
Site: Southwestern slope of the Yokoniwa Rise (the boundary to the Hokuho knoll)
Landing: 11:26; 25°16.07555'S, 70° 0.0363'E, 3180 m
Leaving: 15:57; 25°16.5368'S, 70°1.9752’E, 2670 m
Observer: Tomoaki MORISHITA (Kanazawa Univ.)
Pilot: K. Matsumoto **Co-Pilot:** K. Suzuki

Objectives:

Objective of this dive is to understanding of geological relationships between the Yokoniw Rise and the Hakuho knoll.

Dive Summary:

We landed at 3180 m water depth of the northern part of the southwestern slope of the Yokoniwa-Rise. We faced to the southeast to go the bottom of a small steep slope. We found rounded boulders, probably derived from the pillow lava flows, at the landing point. We recovered two loosed blocks of basalts from an outcrop (Event 2) at 3180 m water depth where many fractures were observed. We faced to the east to go up the small steep slope up to 2900 m water depth. We observed pillow lavas along the slope recovered one basalt sample from an outcrop (Event 3) during the slope and 2 loose blocks of basalt from an outcrop (Event 4) just before the top of the steep slope. We faced the southeast to go to the other slope. We also observed many pillow lavas along the southwest facing slope. We recovered a basaltic boulder at (Event 5). Many small hills consisting of small fragments of basalt (because some fragments have pillow-like rounded shape) were observed. They might be basaltic dikes. After the sampling we jumped to the bottom of another slope just before a hill where we dredged basalt samples 2010. We restarted to observe again from 2890 m water depth of the slope. We faced the northeast to go up the hill up to 2700 m water depth. We recovered two loose blocks of basalt from an outcrop (Event 6) where many fractures were observed. We recovered one basaltic sample from outcrop (Event 7) where pillow lavas were well developed. We recovered two loosed blocks of basalt from two outcrops (Event 8). We recovered three angular blocks from a loose outcrop (Event 9) along the slope. We recovered one basalt boulder where pillows lavas were well developed (Event 10). Then we left from the bottom.

Payloads:

1) Sample baskets w/separation and lids
2) WHATS with 2 bottles
3) 2 X Marker (#148, #149)
4) JAMSTEC-SBP

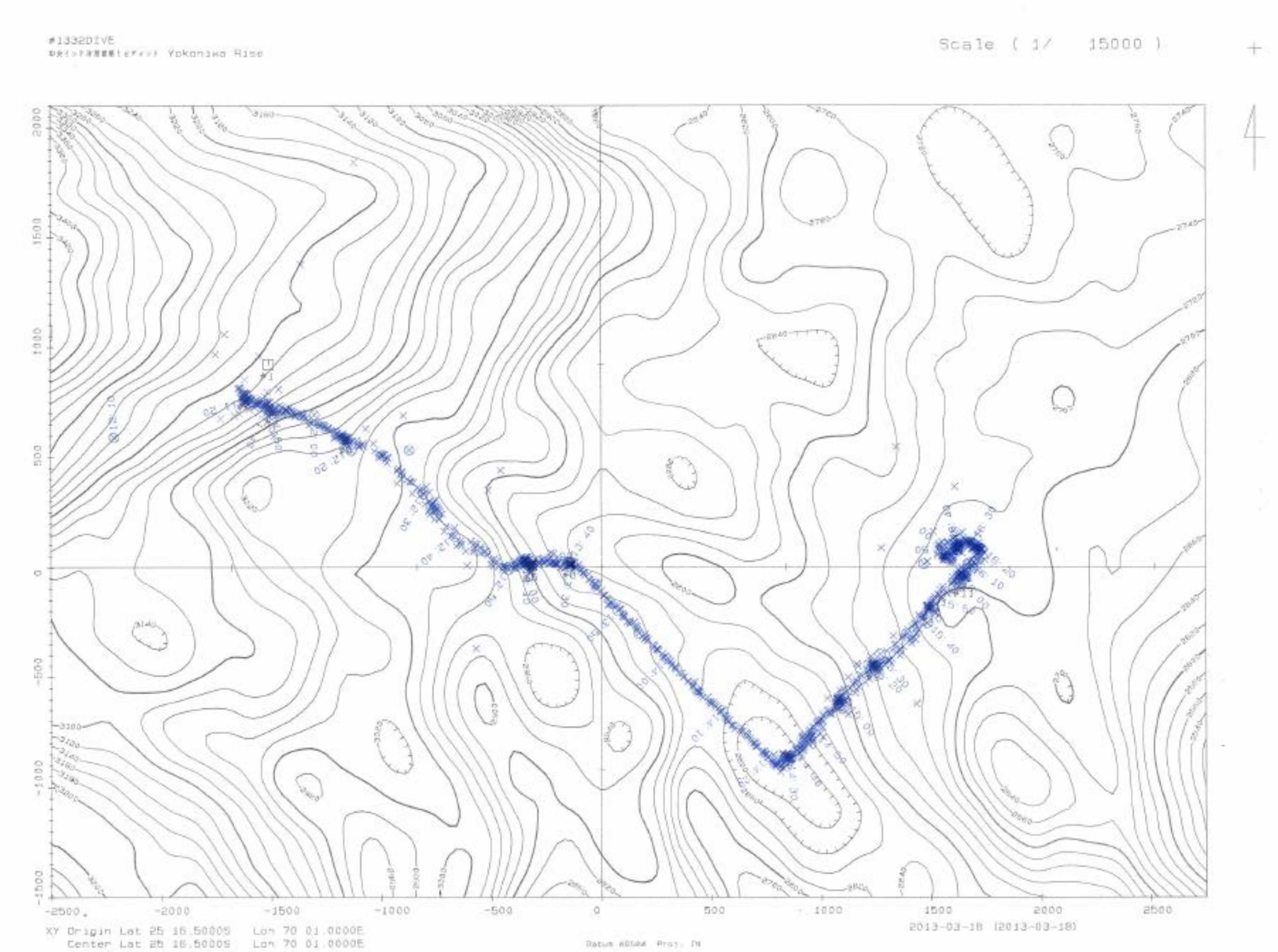
Location of Events:

As in the section, “Event List”.

Event List:

1) 10:00, 25°16.0000'S, 70° 0.1000'E, Landing Target
2) 11:26, 25°16.0755'S, 70° 0.0363'E, Landing, D=3180 m
3) 11:44, 25°16.1113'S, 70° 0.1118'E, Sampling rocks (2), D=3122 m
4) 12:13, 25°16.1840'S, 70° 0.3121'E, Sampling rocks (1), D=3021 m
5) 13:12, 25°16.4953'S, 70° 0.8127'E, Sampling rocks (2), D=2897 m
6) 13:34, 25°16.4902'S, 70° 0.9168'E, Sampling rocks (1), D=2817 m
7) 14:34, 25°16.9673'S, 70° 1.5022'E, Sampling rocks (2), D=2890 m
8) 15:05, 25°16.7423'S, 70° 1.6432'E, Sampling rocks (2), D=2793 m
9) 15:22, 25°16.7423'S, 70° 1.7389'E, Sampling rocks (3), D=2748 m
10) 15:47, 25°16.5989'S, 70° 1.8886'E, Sampling rocks (3), D=2683 m
11) 15:57, 25°16.5368'S, 70° 1.9752'E, Left Bottom, D=2670 m

Dive Track:



#1332DIVE
Yokoniwa Rise
Scale (1/ 15000)
-2500
-2000
-1500
-1000
-500
0
500
1000
1500
2000
2500
XY Origin Lat 25 16.5000S Lon 70 01.0000E
Center Lat 25 16.5000S Lon 70 01.0000E
2013-03-18 (2013-03-18)

6.2. YKDT dive summary

YKDT#153 dive (Yokoniwa Rise)
YKDT#154 dive (Yokoniwa Rise)
YKDT#155 dive (Yokoniwa Rise)

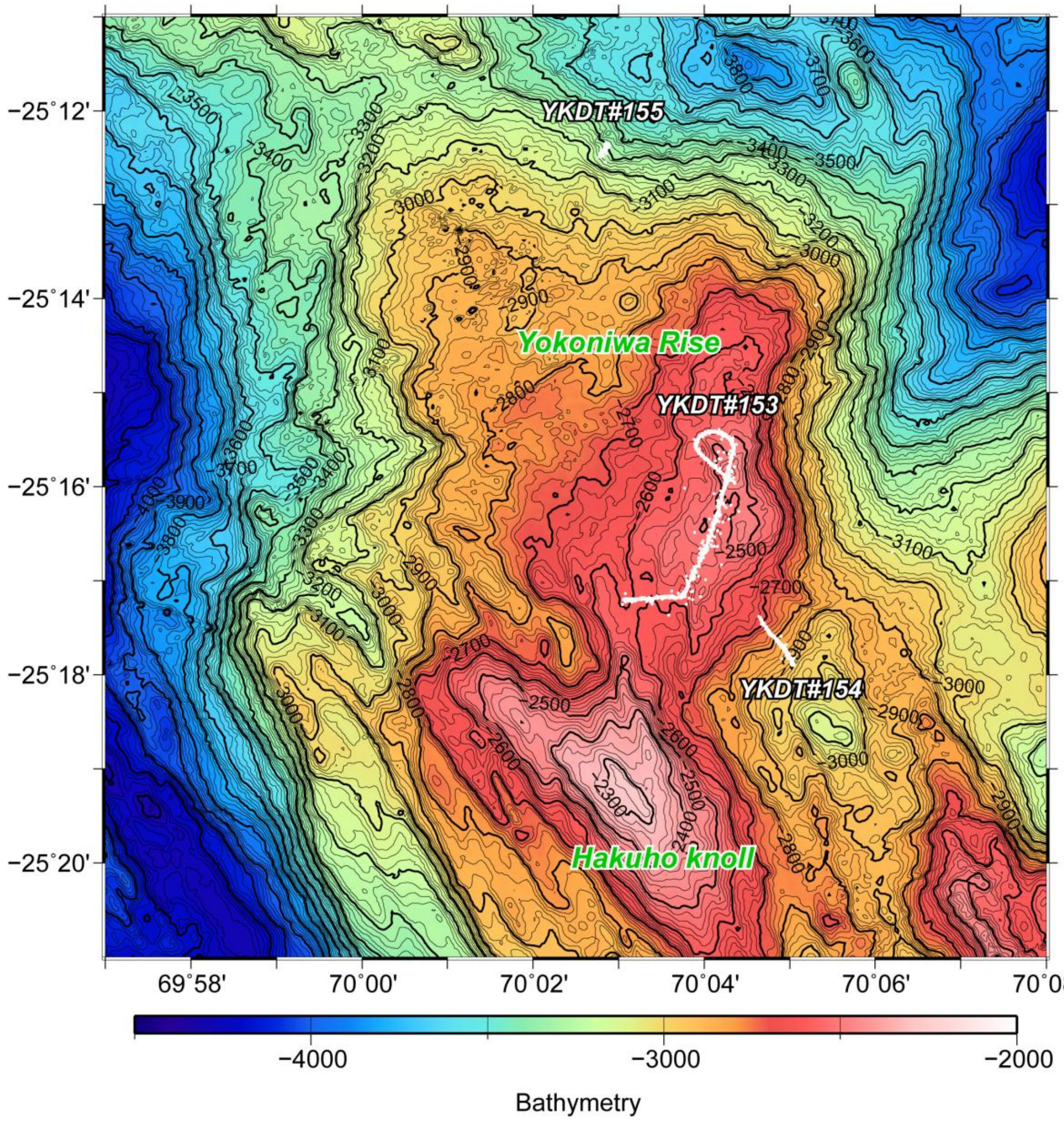


Figure 6.2. Dive tracks of the YKDT dives YKDT#153, 154, 155.

Dive Report: YKDT #153

Date: March 15, 2013
Site: Yokoniwa Rise at northern part of the Hakuho Knoll
Landing: 10:21; 25°17.2042'S, 70°03.0707'E, 2580m
Leaving: 16:00; 25°15.9713'S, 70°4.3773’E, 2448m

Objectives:

Objective of this Deep-tow survey is searching the hydrothermal venting site around the top of the Yokoniwa Rise.

Dive Summary:

The Deep-Tow system was launch at 09:14 and started the survey. We found the seafloor at 10:15 and then started to observe survey line 1. Basically, the seafloor was mainly covered with sediment but some rocks are observed on the sediment surface. From 10:29, we found outcrops composed of pillowed lavas on the seafloor. At 11:33, we finished survey line 1 and then, turned and went to the start point of the survey line 2. At 11:59 and 12:05, during transit from survey line 1 to 2, we found big blocky rocks on the seafloor, which can be recognized as massive rock fragments rather than pillowed lavas. At 13:58, we started to observe survey line 2 and then found dead chimney at 13:46. We finished survey line 2 at 13:58 and transit to the start point of survey line 3. During the transit, we observed some color changed area (black-colored) and many outcrops composed of pillowed lavas. At 14:34, we started to observe the final survey line of no. 4. At 15:18, we found many brown spots on the seafloor, indicating color change by hydrothermal activity. At 15:43, we found many white materials on the seafloor, and one of them was recognized as shell of mussle. Finally, we finish to observe the survey line 3 and then, left the bottom at 16:00.

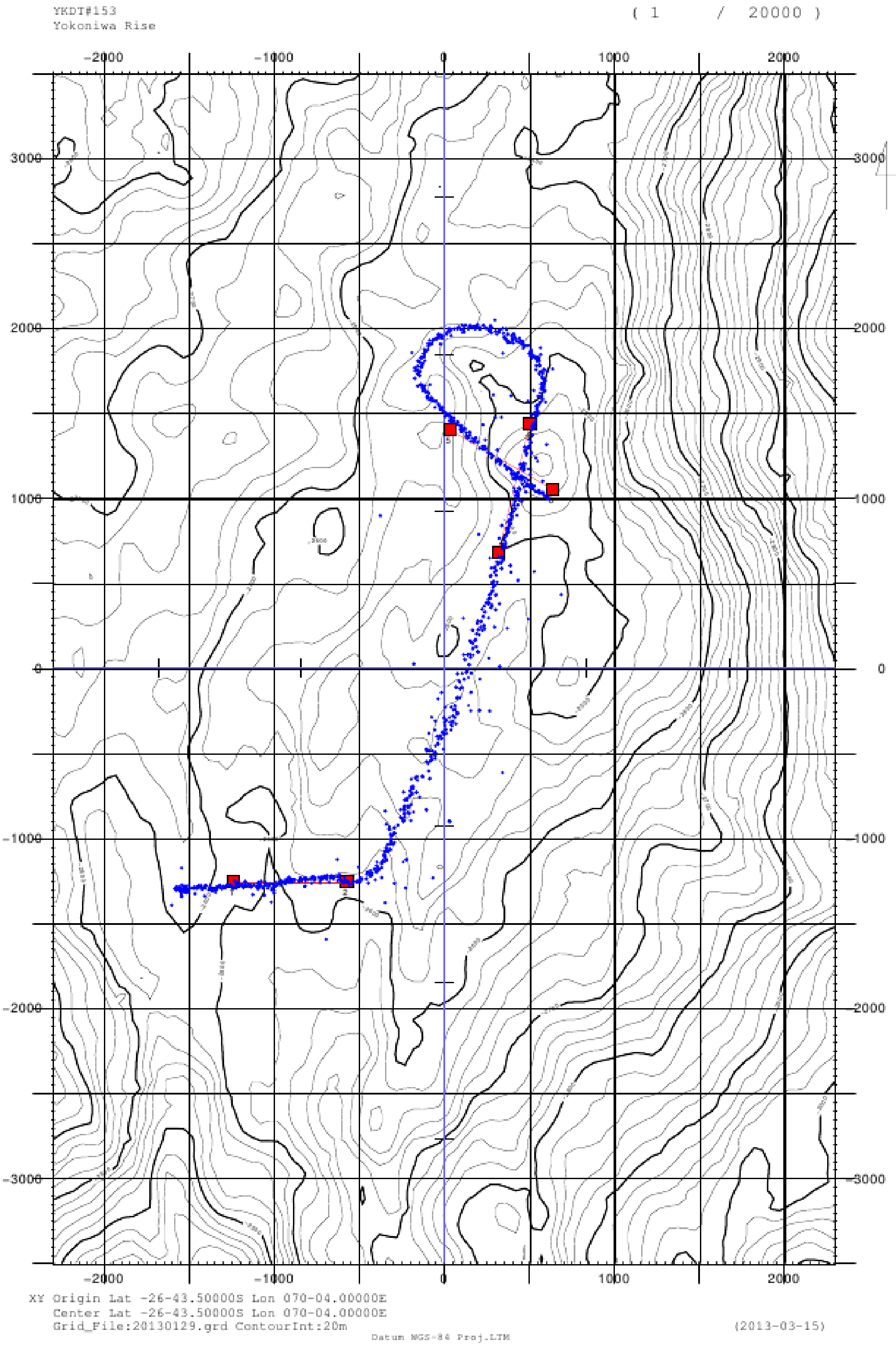
Payloads:

Event List:

1) 2013/03/15 10:21:00, 25°17.2042'S, 70°03.0707'E, Satrt Towing #153dive, D=2580m
2) 2013/03/15 13:48:00, 25°15.8363'S, 70°04.2885'E, Finding Dead Chimney, D=2424m

3) 2013/03/15 14:03:00, 25°15.6875'S, 70°04.3157'E, Finding color changed area (black), D=2480m
4) 2013/03/15 16:00:00, 25°15.9713'S, 70°04.3773'E, End Towing #153dive, D=2448m

Dive Track:


YKDT#153
Yokoniwa Rise
(1 / 20000)
XY Origin Lat -26-43.50000S Lon 070-04.00000E
Center Lat -26-43.50000S Lon 070-04.00000E
Grid_File:20130129.grd ContourInt:20m
Datum WGS-84 Proj.LTM
(2013-03-15)

Dive Report: YKDT #154

Date: March 24 2013
Site: Yokoniwa Rise at northern part of the Hakuho Knoll
Landing: 09:16; 25°17.8841'S, 70°05.0316'E, 2929 m
Leaving: 10:44; 25°17.3937'S, 70°04.6607’E, 2664 m

Objectives:

Objective of this Deep-tow survey is observing and sampling rocks from the southeastern slope of the Yokoniwa Rise.

Dive Summary:

The Deep-Tow system was launch at 07:48 and started the survey. We found the seafloor at 09:16 and then started to observe a survey line. Seafloor was mainly covered with sediment but some small rock blocks are also observed. At 09:30, we found massive rock blocks on the sediment that are considered as an outcrop. After that we observed only sediment on the seafloor. At 09:42, we found again angular rocks on the seafloor and then launched a dredge bag equipped with the Deep-Tow system. At the outcrop, unfortunately, we could not get any rock samples. We decided to continue towing the dredge bag. Twenty minutes after, we found another outcrop composed of pillow lavas and their blocks. However, we again could not get any rock samples at the outcrop. At 10:43, we left the bottom.

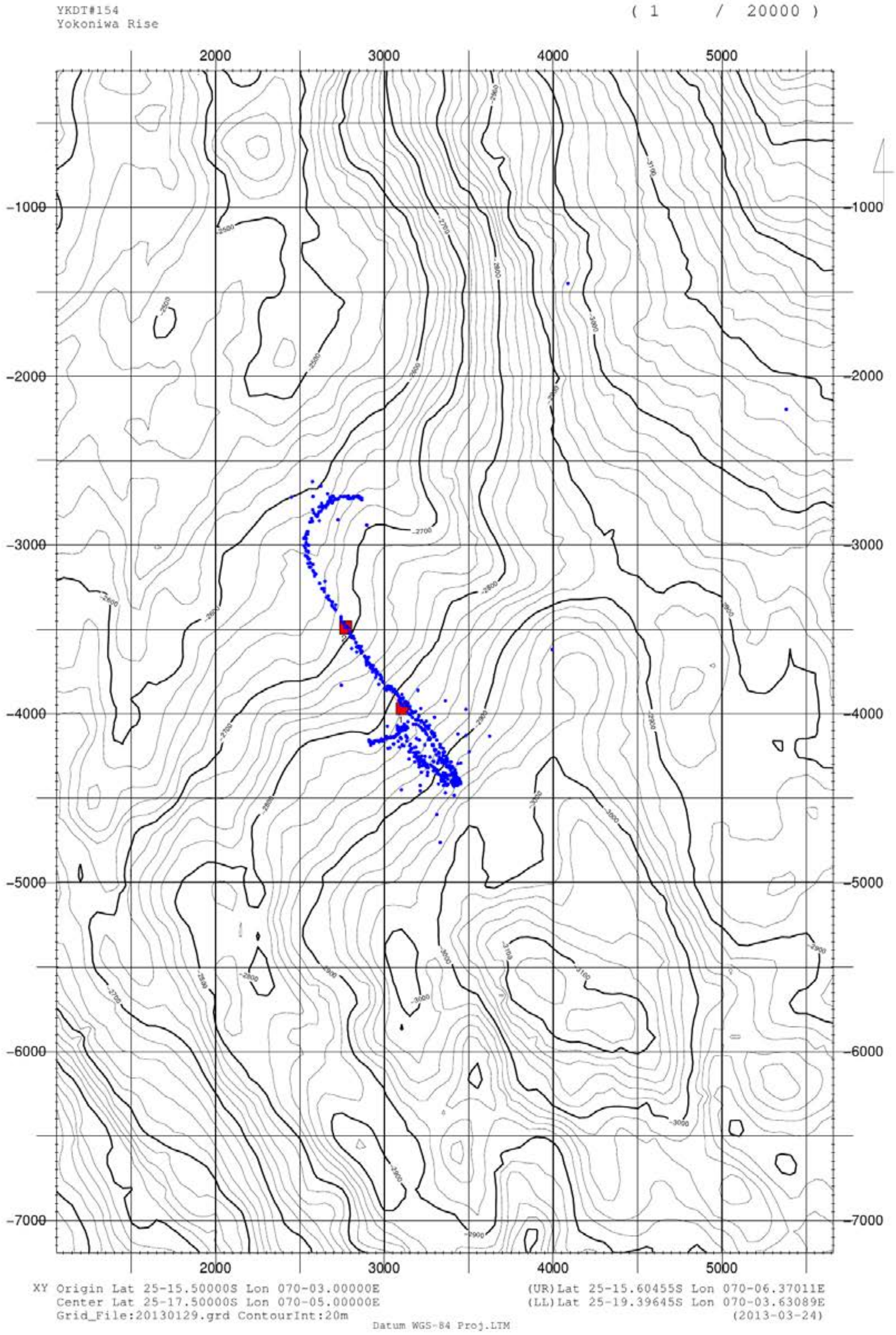
Payloads:

1) dredge bag

Event List:

1) 2013/03/24 09:16:00, 25°17.8841'S, 70°05.0316'E, Satr Towing #154dive, D=2919m
2) 2013/03/24 09:48:00, 25°17.8040'S, 70°04.9768'E, Released Dredger, D=2859m
3) 2013/03/24 10:44:00, 25°17.3937'S, 70°04.6607'E, End Towing #154dive, D=2664m

Dive Track:



YKDT#154
Yokoniwa Rise
(1 / 20000)
2000
3000
4000
5000
-1000
-2000
-3000
-4000
-5000
-6000
-7000
XY Origin Lat 25-15.50000S Lon 070-03.00000E
Center Lat 25-17.50000S Lon 070-05.00000E
Grid_File:20130129.grd ContourInt:20m
(UR)Lat 25-15.60455S Lon 070-06.37011E
(LL)Lat 25-19.39645S Lon 070-03.63089E
(2013-03-24)
Datum WGS-84 Proj.LTM

Dive Report: YKDT #155

Date: March 24 2013
Site: Yokoniwa Rise at northern part of the Hakuho Knoll
Landing: 14:34; 25°12.3438'S, 70°02.8674'E, 3280m
Leaving: 15:20; 25°12.4983'S, 70°02.7737’E, 3233m

Objectives:

Objective of this Deep-tow survey is observing and sampling rocks from the northern slope of the Yokoniwa Rise.

Dive Summary:

The Deep-Tow system was launch at 13:16 and started the survey. We found the seafloor at 14:34 and then started the observation. Seafloor was mainly covered with sediment but some massive angular rock blocks are also observed. At 14:40, we found big massive angular blocks on the sediment that are considered as an outcrop. And then, we observed another outcrop composed of massive angular blocks with many rock fragments. At 15:04, we found found big massive angular blocks in front of the Deep-Tow system and then launched the dredge bag. We continue towing the dredge bag several minutes. At 15:15, the dredge bag suddenly stuck between big angular rock blocks. We stopped towing and try to withdraw the ship in order to release the dredge bag. At 15:18, however, the dredge bag was suddenly lost and thus, we had to finish the survey. At 15:20, we left the bottom.

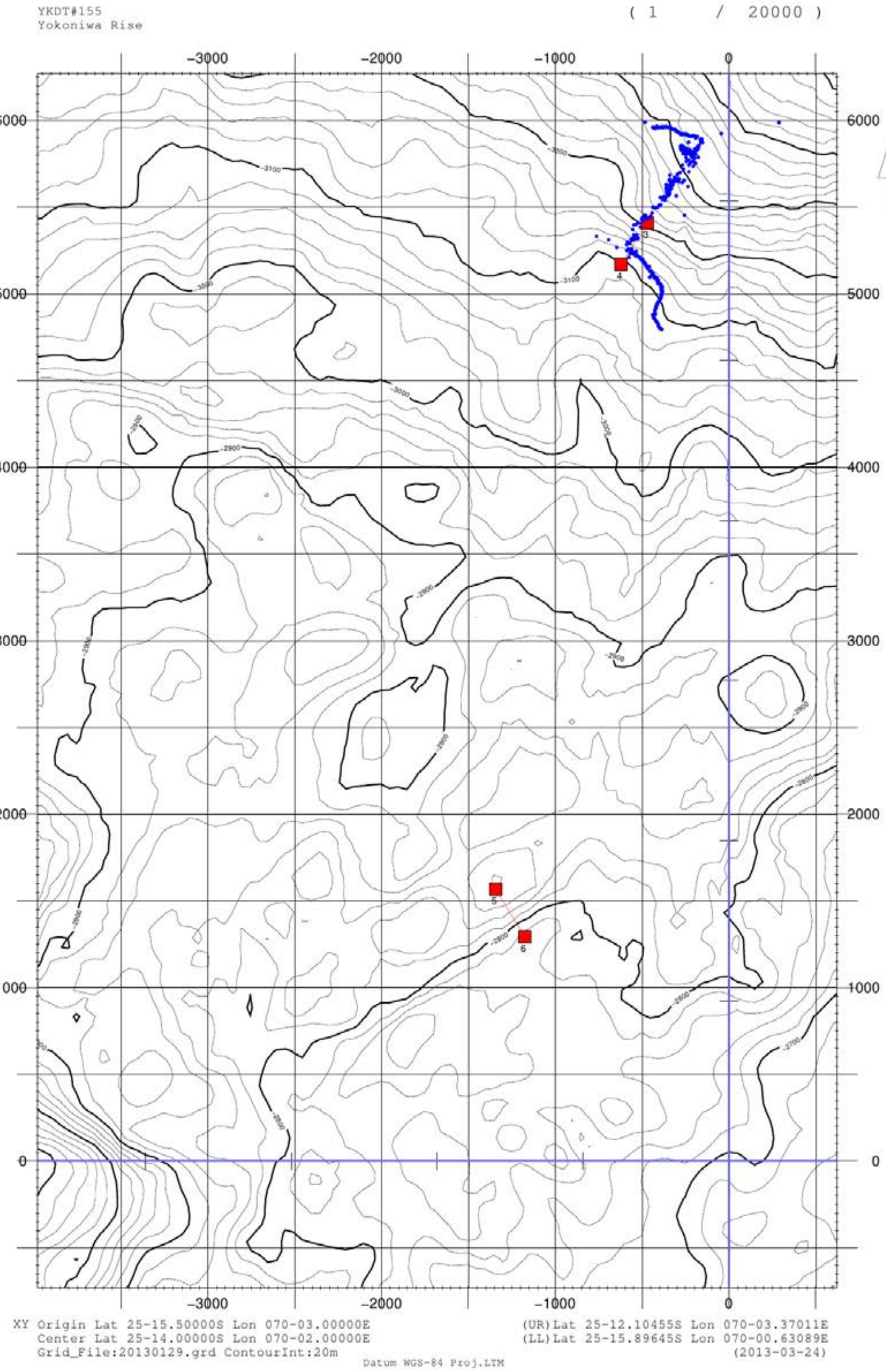
Payloads:

1) dredge bag

Event List:

1) 2013/03/24 14:34:00, 25°12.3438'S, 70°02.8674'E, Satr Towing #155dive, D=3280m
2) 2013/03/24 15:04:00, 25°12.4290'S, 70°02.8150'E, Released Dredger, D=3268m
3) 2013/03/24 15:17:00, 25°12.4738'S, 70°02.7927'E, Lost Dredger, D=3233m
4) 2013/03/24 15:20:00, 25°12.4983'S, 70°02.7737'E, End Towing #155dive, D=3233m

Dive Track:


YKDT#155
Yokoniwa Rise
(1 / 20000)
XY Origin Lat 25-15.50000S Lon 070-03.00000E
Center Lat 25-14.00000S Lon 070-02.00000E
Grid_File:20130129.grd ContourInt:20m
(UR)Lat 25-12.10455S Lon 070-03.37011E
(LL)Lat 25-15.89645S Lon 070-00.63089E
(2013-03-24)
Datum WGS-84 Proj.LTM

6.3. Petrology

Tomoaki MORISHITA (Kanazawa University) Takazo SHIBUYA (JAMSTEC), and Kentaro NAKAMURA (JAMSTEC)

During YK13-03 cruise, 25 rock samples were recovered during the two *Shinkai 6500* dives of 6K#1331 and 1332 (Figure 6.3). All the rock samples are pillowed basalt, except for four hydrothermal ore samples of iron stone, massive sulfide ore, and dead chimney. The basalt samples were recovered from the top and southwestern part (boundary between Yokoniwa Rise and Hakuho knoll) of the Yokoniwa Rise. The basalts from the top of the Yokoniwa Rise are slightly Pl-phyric basalt and Ol-phyric basalts, whereas those from southwestern part of the Yokoniwa Rise are slightly Pl-phyric basalt and Pl-porphyric basalts. The basaltic rocks underwent week, low-temperature seafloor weathering and/or low-temperature alteration, whereas there are no samples that were subjected to high-temperature hydrothermal alteration. Some samples preserve fresh glass in the chilled margin. Further geochemical and mineralogical studies on these rocks will be conducted on shore, revealing the relationships between the Yokoniwa Rise and Hakuho knoll, as well as the structure and origin of the Yokoniwa Rise, a typical NTO massif.

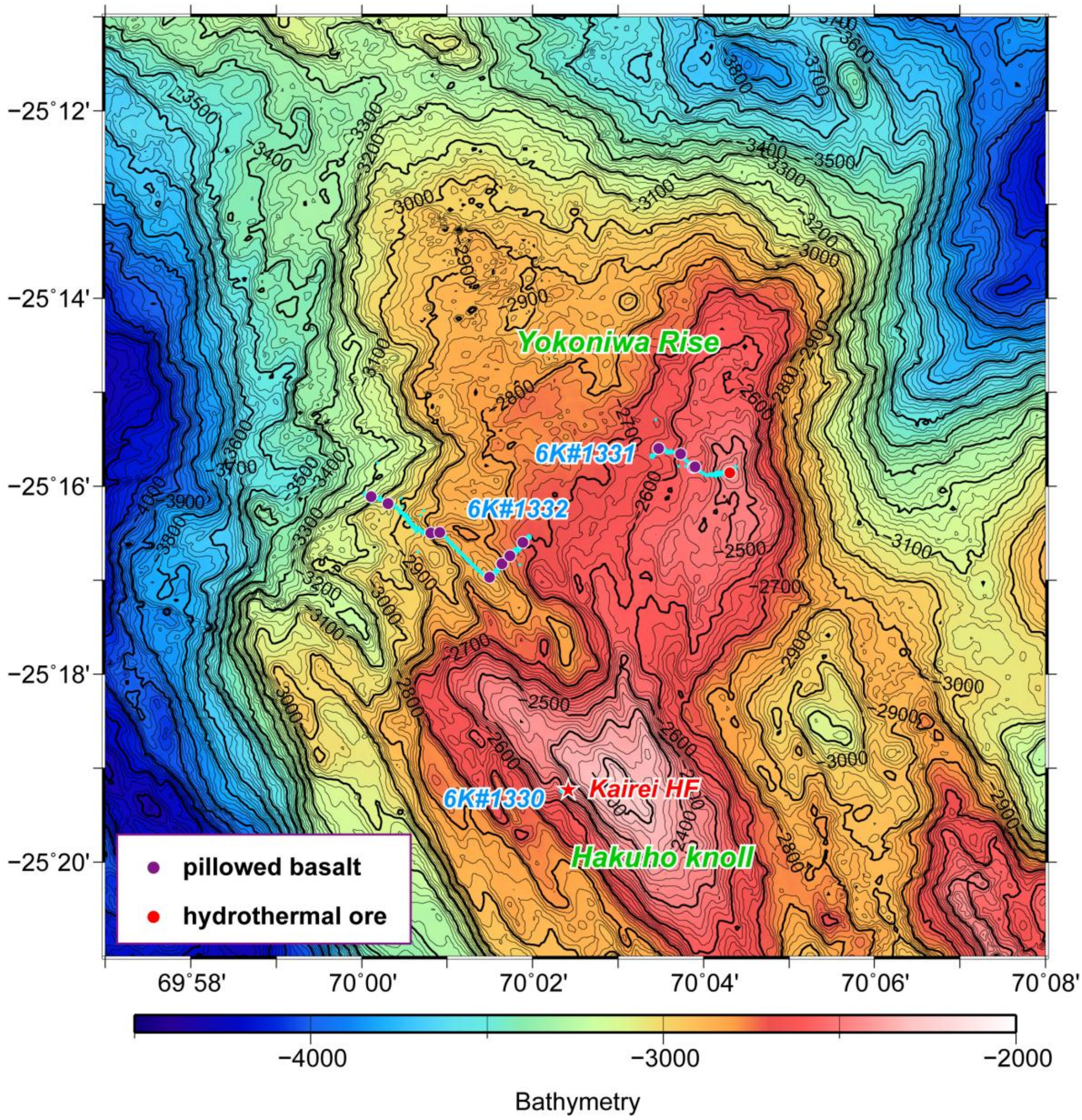


Figure 6.3. Bathymetric map showing dive tracks and lithology of the sampled rocks.

6.4. Deep-sea magnetic survey

Taichi SATO (GSJ, AIST)

During YK13-03, total 3 dives were conducted and the magnetometer data were collected during 2 dives, #1331 and #1332. The dive tracks are shown in Figure 6.4. The data will be used by shore-based study, combined with those obtained by previous cruises.

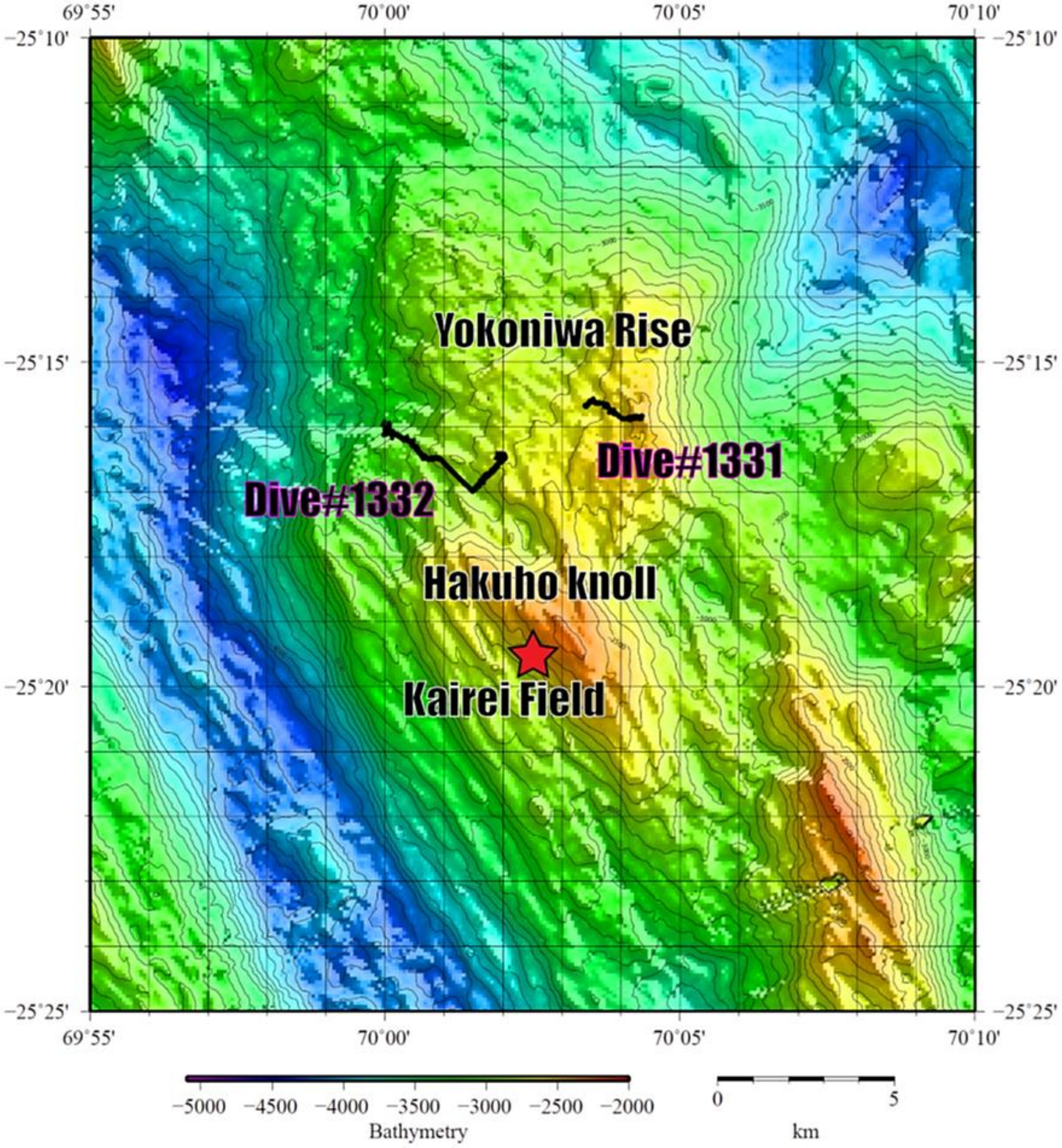


Figure 6.4. Bathymetric map showing the dive tracks obtaining the magnetometer data.

6.5. Recovery of ocean bottom instruments

Nobukazu SEAMA, Eri IIZUKA (Kobe University)
Toshinori SATO, Hiroyoshi TAKADA (Chiba University)
Satoshi OKADA, Mitsuteru KUNO, Akie SUZUKI, and Toshikatsu NASU (NME)

We conducted recoveries of 16 OBEMs and 21 OBSs including 1 OBSP and 2 OBSM 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. Site locations are given in Figure 6.4 and Table 6.4-1, and the instrument information at each site is given in Tables 6.4-2. Positioning of OBEMs and some of OBSs on the ocean floor was performed during their recovery and the SCS surveys, respectively.

15 OBEMs and 19 OBSs were successfully recovered (Tables 6.4-3), and one OBEM and two OBS including 1 OBSM were abandoned because there was no response to the acoustic 'call' or 'release' commands. In most cases, acoustic contact was first established, and then a release command was sent; continuous ranging in the first 20 minutes established the time at which the burn plate corroded sufficiently for the ballast weight to drop and the instrument began to ascend. Instruments were tracked to the surface by using a combination of slant ranges and the ship position along with the starting position and measured ascent rates to calculate the position. By tracking the instruments closely we were able to accurately predict their surface times and positions and quickly find them with the ship. In many cases, radio beacon signal was used to establish the exact time at which the instrument surfaced as it came out of the water. Instruments were recovered using a platform on the starboard side of the ship. The instruments were hooked by the crew and lifted by a chain hoist and crane onto the platform where the instrument was broken down and moved inboard. Recoveries for OBSP, OBSM, and all the OBEMs were through the hero platform on the starboard side of the ship. This operation after an instrument at the surface was quick and took at most 15 minutes to complete.

The three instruments lost were at site EM6, S13M2, and S21 where the instruments did not respond to acoustic signals. Despite waiting and searching after the predicted surface arrival time (assuming receipts of the release commands), no sign of the instrument was observed and they were abandoned as lost.

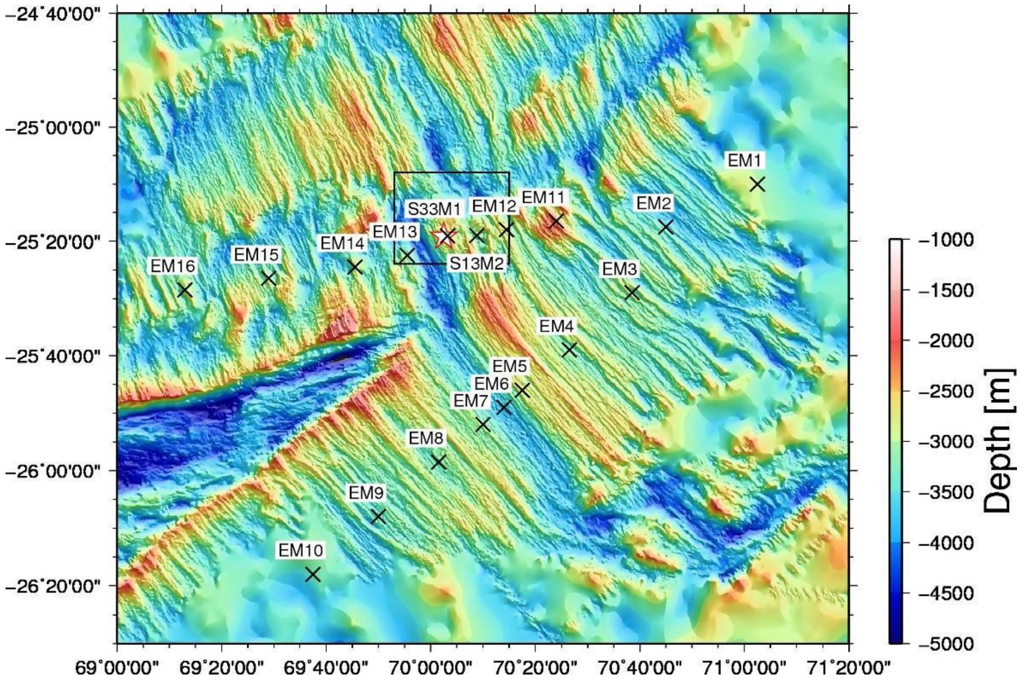


Figure 6.5a. Location map of OBEMs and OBSMs (crosses). White star bounded with red line indicates the location of the Kairei hydrothermal vent site. The solid rectangle shows the range of Figure 6.4b.

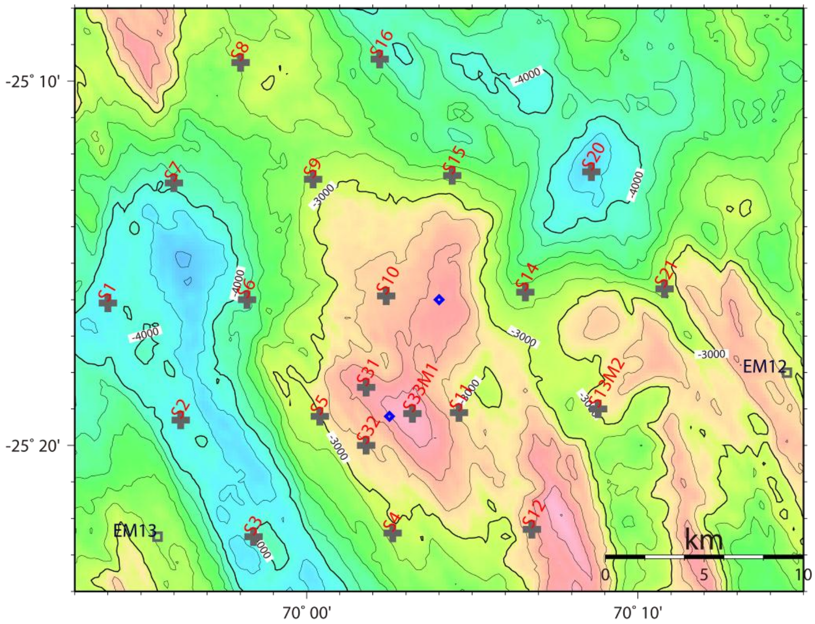


Figure 6.5b. Location map of OBEMs (squares) and OBSs (crosses) including OBSP (S10), and OBSMs (S13M2 and S33M1) around the Kairei hydrothermal vent (left blue diamond). Right blue diamond shows the location of the top of the Yokoniwa Rise.

Site	Deployment Location					Estimated Location				
	Latitude (N)		Longitude (E)		Depth (m)	Latitude (N)		Longitude (E)		Depth (m)
	Deg.	Min.	Deg.	Min.		Deg.	Min.	Deg.	Min.	
EM1	25	08.28	71	01.63	3412	no data for estimation				
EM2	25	17.51	70	44.93	3556	25	17.42	70	44.80	3480
EM3	25	29.01	70	38.42	3071	25	28.93	70	38.42	3130
EM4	25	39.01	70	26.45	3160	25	38.88	70	26.53	3143
EM5	25	46.00	70	17.47	2805	25	45.87	70	17.59	2760
EM6	25	49.03	70	13.96	3640	no data for estimation				
EM7	25	52.04	70	09.95	3011	25	51.85	70	10.02	3062
EM8	25	58.54	70	01.46	3256	25	58.51	70	01.44	3076
EM9	26	08.02	69	49.98	3335	26	07.93	69	50.07	3461
EM10	26	18.02	69	37.46	3687	26	17.97	69	37.49	3642
EM11	25	16.48	70	24.03	2008	25	16.38	70	23.92	1997
EM12	25	17.97	70	14.53	2952	25	17.82	70	14.41	2926
EM13	25	22.48	69	55.55	3246	25	22.44	69	55.41	3257
EM14	25	24.42	69	45.66	2787	25	24.48	69	45.38	2823
EM15	25	26.46	69	29.07	2857	25	26.67	69	28.86	2890
EM16	25	28.48	69	13.05	2829	25	28.72	69	12.85	2842
S1	25	16.12	69	53.97	4157	no data for estimation				
S2	25	19.28	69	56.21	4072	no data for estimation				
S3	25	22.51	69	58.36	4035	no data for estimation				
S4	25	22.41	70	02.56	3110	no data for estimation				
S5	25	19.17	70	00.44	2972	25	19.13	70	00.28	3048
S6	25	16.02	69	58.19	3862	no data for estimation				
S7	25	12.80	69	56.05	3912	no data for estimation				
S8	25	09.49	69	58.04	3167	no data for estimation				
S9	25	12.71	70	00.24	3073	no data for estimation				
S10P1	25	15.92	70	02.37	2726	25	15.84	70	02.26	2726
S11	25	19.07	70	04.64	2893	no data for estimation				
S12	25	22.30	70	06.75	2729	no data for estimation				

S13M2	25	18.97	70	08.83	2924	no data for estimation				
S14	25	15.77	70	06.64	3293	no data for estimation				
S15	25	12.60	70	04.44	3219	no data for estimation				
S16	25	09.40	70	02.24	3788	no data for estimation				
S20	25	12.51	70	08.64	4314	no data for estimation				
S21	25	15.70	70	10.83	3213	no data for estimation				
S31	25	18.39	70	01.83	2425	25	18.36	70	01.70	2446
S32	25	19.99	70	01.83	2827	25	19.97	70	01.71	2783
S33M1	25	19.12	70	03.24	2325	25	19.14	70	03.11	2256

Table 6.5-1. Location of OBEM and OBS. EM: OBEM, S: OBS, P: pressure gauge attached to OBS, and M: magnetometer attached to OBS. The location of instruments were estimated using slant ranges between the transponder of the instrument and that of the ship at different locations around the site.

Site ID	Type	S/N of sensor	Clock Information (second)
EM1	BC1	20	-06
EM2	T	KB1	+09
EM3	BC2	22	-12
EM4	BC1	18	-14
EM5	BC3	107	-13
EM6	T	NIPR1	none
EM7	BC1	17	-19
EM8	BC1	19	-25
EM9	BC1	21	-26
EM10	T	NIPR3	+01
EM11	BC3	105	-09
EM12	T	NIPR2	+03
EM13	BC1	16	-07

EM14	BC3	112	-17
EM15	BC2	23	-14
EM16	BC3	103	-24
S33M1	M	24	-11
S13M2	M	23	none

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.

Clock Information: Clock (OBEM)-Clock (reference, GPS). +: gain, -: delay

Table 6.5-2a. Instrument information on OBEM at each site.

Site ID	Type	OBS No.
S1	OBS	ERI-2B
S2	OBS	ERI-2G
S3	OBS	ERI-2M
S4	OBS	ERI-2E
S5	OBS	ERI-2J
S6	OBS	ERI-2A
S7	OBS	ERI-5P
S8	OBS	ERI-5Q
S9	OBS	ERI-2C

S10P1	OBS+P	619
S11	OBS	ERI-2H
S12	OBS	ERI-2F
S13M2	OBS+M	ERI-5S
S14	OBS	ERI-2K
S15	OBS	ERI-2D
S16	OBS	ERI-2L
S20	OBS	ERI-2O
S21	OBS	ERI-2N
S31	OBS	ERI-5R
S32	OBS	ERI-2I
S33M1	OBS+M	646

Notes:
Abbreviations in Type
P: OBP (absolute pressure gauge)
M: OBM (fluxgate magnetometer)

Table 6.5-2b. Instrument information on OBS at each site.

Site	Type	Depth (m)	Date (UTC)	Send release command	Lift off confirmed	On Surface confirmed	On deck
EM1	BC1	3412	03/14	02:16:00		04:24:00	04:50:00
EM2	T	3556	03/13-14	22:36:30	22:52:00	00:16:00	00:32:00
EM3	BC2	3071	03/13	19:14:30	19:32:00	21:05:30	21:19:00
EM4	BC1	3160	03/13	15:39:00	15:55:19	17:32:30	17:46:00
EM5	BC3	2805	03/13	12:32:15	12:49:15	14:19:10	14:30:00
EM6	T	3640	03/13				
EM7	BC1	3011	03/13	06:27:11	06:41:00	08:16:48	08:38:00
EM8	BC1	3256	03/13	03:05:45	03:35:00	05:02:57	05:18:00
EM9	BC1	3335	03/12-13	23:20:15	23:40:02	01:24:48	01:39:00
EM10	T	3687	03/07	00:58:40	01:14:00	02;42:00	02:59:00
EM11	BC3	2008	03/14	07:34:30	07:50:40	08:53:40	09:06:00
EM12	T	2952	03/14	10:03:20	10:19:00	11:28:20	11:40:00

EM13	BC1	3246	03/19	00:19:00	00:35:59	02:19:40	02:29:00
EM14	BC3	2787	03/19	18:17:30	18:35:00	20:08:00	20:23:00
EM15	BC2	2857	03/19	21:49:40	22:09:00	23:29:20	23:43:00
EM16	BC3	2829	03/20	01:07:30	01:24:59	02:54:45	03:04:00
S1	OBS	4157	03/18	18:31:40	18:49:00	19:47:53	20:01:00
S2	OBS	4072	03/18	20:30:30	20:49:00	21:43:02	21:57:00
S3	OBS	4035	03/18	22:26:00	22:45:00	23:41:00	23:52:00
S4	OBS	3110	03/19	03:24:15	03:40:00	04:25:00	04:31:00
S5	OBS	2972	03/19	06:03:00	06:22:00	07:06:29	07:16:00
S6	OBS	3862	03/18	14:36:15	14:53:00	15:45:23	15:50:00
S7	OBS	3912	03/18	16:33:20		17:48:32	17:58:00
S8	OBS	3167	03/19	15:00:00	15:20:00	16:19:28	16:44:00
S9	OBS	3073	03/19	13:13:00	13:33:00	14:14:23	14:28:00
S10P1	OBS+P	2726	03/18	12:56:15	13:17:00	13:50:25	14:03:00
S11	OBS	2893	03/17	13:30:00		14:29:02	14:34:00
S12	OBS	2729	03/06	02:58:38	03:20:00	03:59:30	04:13:00
S13M2	OBS+M	2924	03/06				
S14	OBS	3293	03/06	10:24:05	10:42:00	11:30:25	11:37:00
S15	OBS	3219	03/06	12:19:30	12:40:00	13:21:00	13:34:00
S16	OBS	3788	03/06	14:03:00	14:24:00	15:10:40	15:20:00
S20	OBS	4314	03/06	08:22:45	08:39:45	09:34:32	09:43:00
S21	OBS	3213	03/19				
S31	OBS	2425	03/19	07:18:00	07:36:00	08:14:09	08:22:00
S32	OBS	2827	03/19	04:56:30	05:14:00	05:52:15	06:01:00
S33M1	OBS+M	2325	03/19	08:25:00	08:49:00	09:19:20	09:31:00

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.
P: Absolute pressure gauge attached to OBS.

Table 6.5-3. Timetable for OBEM and OBM recovery at each site

6.6. Seismic Reflection and Refraction Survey

Toshinori SATO, Hiroyoshi TAKADA (Chiba University)
Satoshi OKADA, Mitsuteru KUNO, Akie SUZUKI, and Toshikatsu NASU (NME)

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 6.5, Figure 6.5). Three lines are NE-SW direction, and other 5 lines pass around the point just above the Kairei hydrothermal site and the Yokoniwa Rise. We also fired during transits from end points of lines to start points of the next. 1318 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.		
B1_0	70	02.27	25	09.33	3/5	11:14	69	56.14	25	19.39	3/5	13:54
B2_0	69	56.49	25	12.93	3/5	14:05	69	58.48	25	22.66	3/5	14:51
B3_0	69	58.60	25	22.23	3/5	14:59	70	04.49	25	12.54	3/5	17:35
B4_0	70	04.95	25	12.57	3/5	17:43	70	08.71	25	12.50	3/5	18:32
B5_0	70	08.42	25	12.97	3/5	18:43	70	02.61	25	22.27	3/5	21:13
B6_0	70	02.40	25	22.26	3/5	21:16	70	01.56	25	20.82	3/5	21:39
B7_0	70	01.55	25	20.78	3/5	21:39	70	04.47	25	15.86	3/5	22:59
B8_0	70	04.46	25	15.81	3/5	23:00	70	03.41	25	14.25	3/5	23:26
B9_0	70	03.36	25	14.22	3/5	23:27	70	01.57	25	14.35	3/5	23:50
B10_0	70	01.45	25	14.40	3/5	23:52	70	00.31	25	15.97	3/6	00:20
B11_0	70	00.31	25	16.01	3/6	00:21	70	03.52	25	20.60	3/6	01:39
B12_0	70	03.84	25	20.75	3/6	01:45	70	04.95	25	20.69	3/6	01:59

Table 6.6. Information on seismic reflection and refraction survey lines.

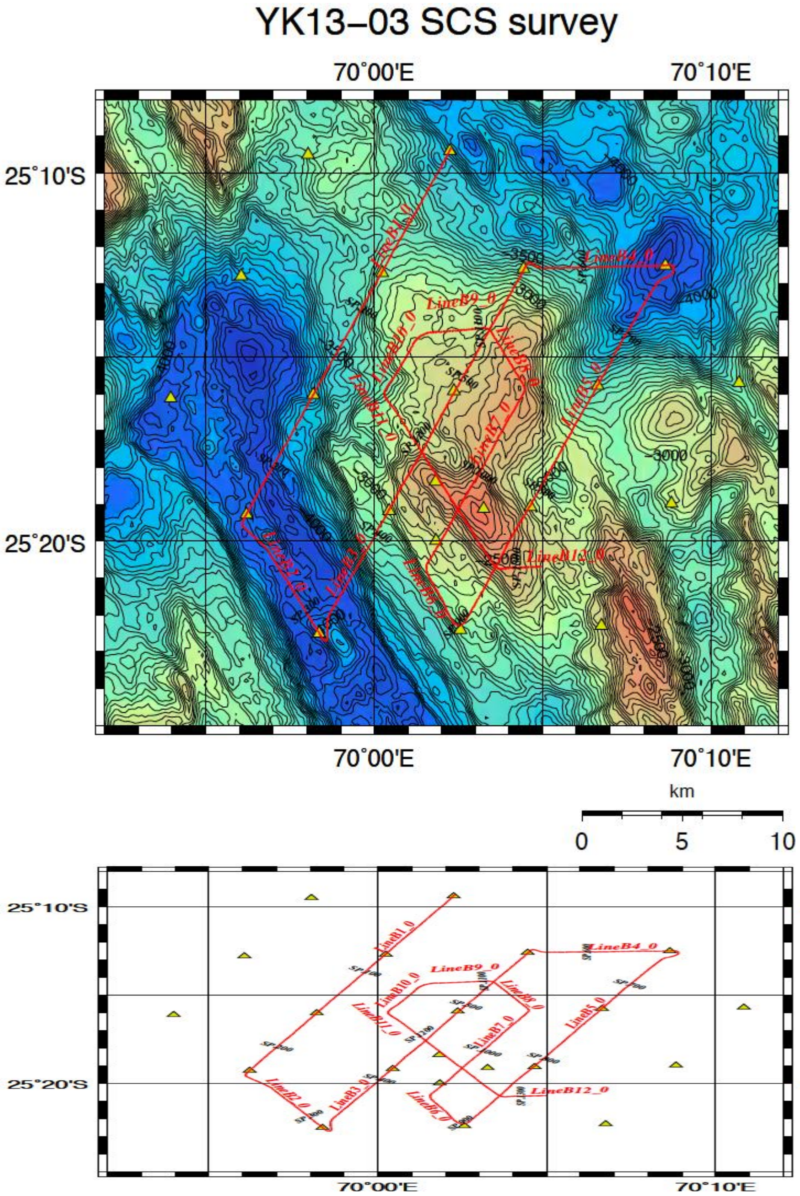


Figure 6.6. Location map of OBSs (triangles) and seismic reflection and refraction survey lines are shown in the top figure and SP numbers in the bottom figure denote air-gun shot numbers.

6.7. Surface Geophysical Survey

Taichi SATO (GSJ, AIST) and Nobukazu SEAMA (Kobe University)

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 6.6-1. 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 6.6-2. We could cover total 1230 miles in the research area. An XBT was done at 10:08 on Mar 5 (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 five times and it is listed in Table 6.6. Ship-towed proton precession magnetometer was towed 380 m behind the GPS position.

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.

No.	Date	Time(UT)	Latitude	Longitude
1	8/Mar.	13:00-13:20	31°12.9'S	68°47.9'E
2	12/Mar.	6:32-6:53	26°30.0'S	70°13.3'E
3	12/Mar.	13:53-14:12	25°52.7'S	71°10.3'E
4	25/Mar.	11:19-11:38	25°37.0'S	68°59.2'E
5	26/Mar.	9:20-9:39	22°53.2'S	64°44.9'E

Table 6.7. List of "Figure 8 turns"

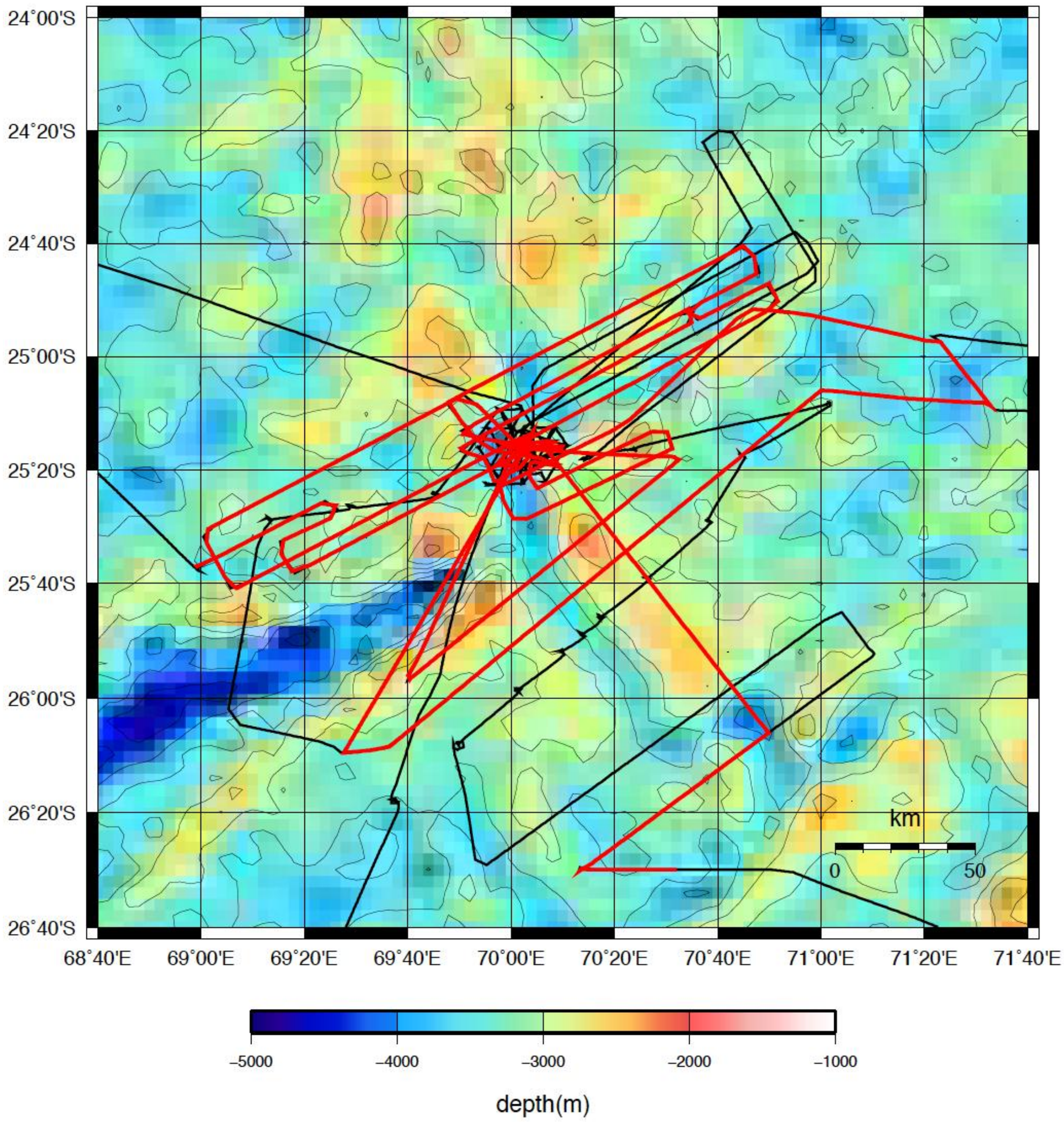


Figure 6.7-1. Ship tracks (red and black lines) of the cruise in the survey area and red lines shows ship tracks for the surface geophysical survey using a ship-towed proton precession magnetometer.

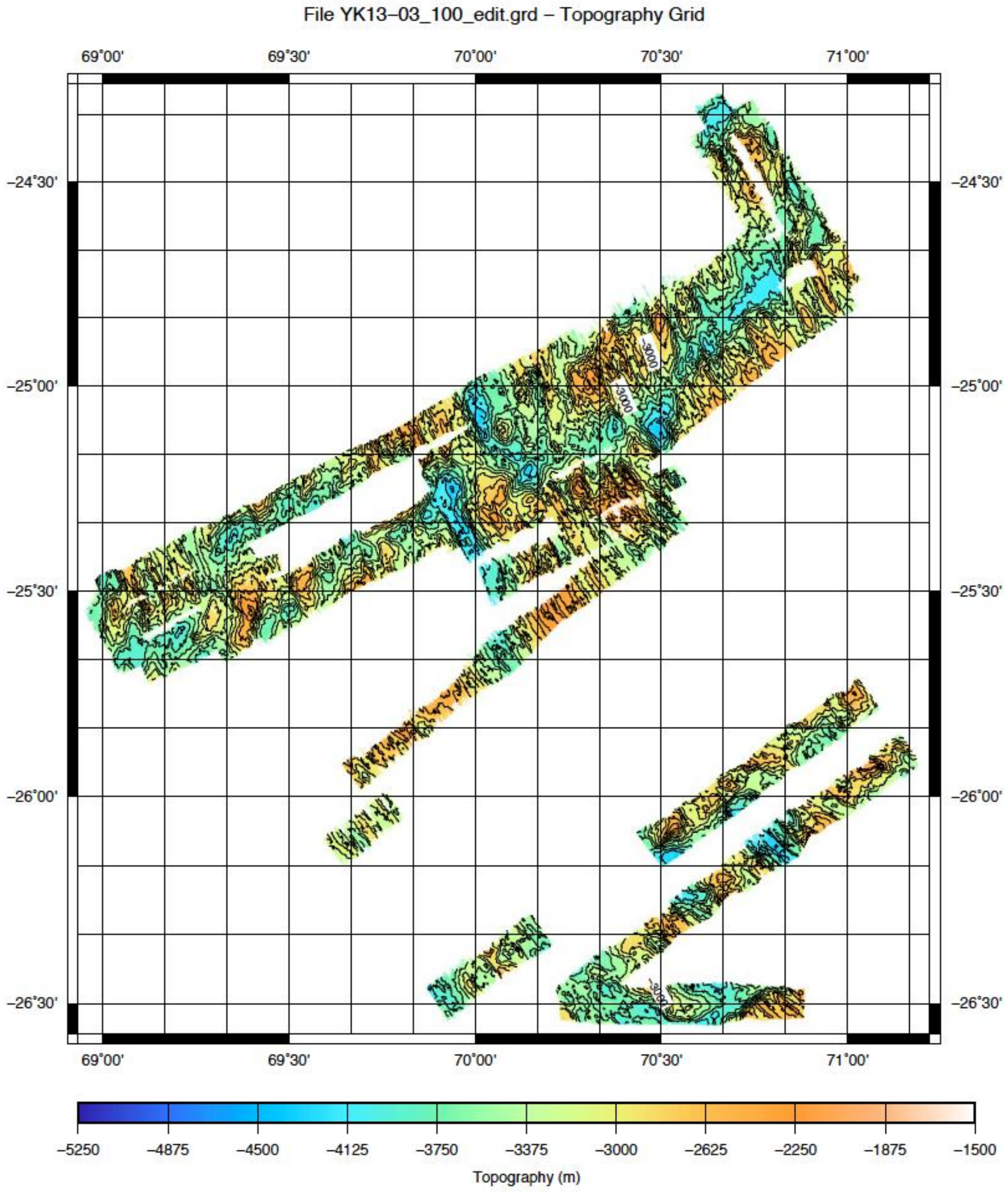


Figure 6.7-2. Bathymetric data obtained in the research area.

6.8. Biogeochemistry

Tomo-o WATSUJI and Junichi MIYAZAKI (JAMSTEC)

We have obtained chimneys and chemosynthetic macrofaunas during the 6k dive#1330 at Kairei field. Especially more than 80 individuals of scaly-foot gastropods were sampled. To estimate energy flux of these samples, we carried out the biological activity measurements of these samples on-board. And also to analyze molecular biological analyses on shore, we treated these samples properly. Especially, since we will perform expression analyses to evaluate which metabolisms are preferred for microbes and macrofaunas, these samples were treated with RNase inhibitor.

And also in this dive, we collected hydrothermal fluid from Kali vents and animal colonies. The gas composition of hydrothermal fluid from Kali vents were similar to previously obtained fluid sample. And also pH were 3.4, indicating that hydrothermal activity in Kairei field were almost same compared with previous investigations.

7. Notice on Using

This cruise report is a preliminary documentation as of the end of the cruise. This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information. Users of data or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.

Acknowledgements

We are grateful to Captain Shinya RYONO and the crew of *R/V Yokosuka* for their safe and skillful navigation. Great thanks are also due to Operation Manager Toshiaki SAKURAI and *Shinkai 6500* operation team for taking us to deep seafloor and accurate operations in sampling. We thank Satoshi OKADA, Koki HISANO, Akie SUZUKI, and Toshimasa NASU, Nippon Marine Enterprise, Ltd., for their attentive supports. We also thank all the JAMSTEC personnel who have supported us, as well as all the persons who have supported directly or indirectly this cruise. This research are financially supported, in part, by the scientific program "TAIGA (Trans-crustal Advection and In-situ reaction of Global sub-seafloor Aquifer)" sponsored by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.