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YOKOSUKA Cruise Report
YK10-17

Dec 9 2010 – Dec 19 2010

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

Acknowledgements

We would like to thank all ship officers and crew of R/V YOKOSUKA, the operation team of AUV URASHIMA and YKDT (YOKOSUKA Deep-Tow) and a marine technician of NME for their supports during our cruise. We are pleased to acknowledge cooperation and support of National Institute of Polar Research.

This cruise was partly supported by a development program of fundamental tools for exploration of deep seabed resources that started in 2008 with financial support of the MEXT.

YK10-17 Cruise report contents

1. Objectives and background of YK10-17 cruise

1.1 Development of the seabed resource survey technique

Recently, seafloor hydrothermal deposits including valuable metals like copper, lead, zinc, gold, silver, and germanium have again become a subject of special interest in the world through intensifying competition of resource development for a stable supply of the resources. It is, however, difficult to develop the seafloor hydrothermal deposits because there is no established method to estimate accurate abundance of them. Conventional marine (sea-surface) geophysical explorations do not have enough resolution, and an exploratory drilling needs much time and money. Thus, new technology of geophysical exploration near the seafloor is required in order to discover and estimate the resources precisely. With these points as a background, a development program of fundamental tools for exploration of deep seabed resources started in 2008 with financial support of the Ministry of Education, Culture, Sports, Science and Technology (MEXT). As a part of the program, we have developed new measurement systems for electrical and magnetic explorations by Autonomous Underwater Vehicle (AUV), Remotely Operated Vehicle (ROV) and a deep-tow system.

In 2009, the first test of our magnetic exploration system was carried out in the Kumano Basin using AUV URASHIMA and a towing vehicle, YOKOSUKA Deep-Tow during the YK09-09 cruise. In that cruise, we sank a small magnetic target to the sea bottom, and examined to detect it using the magnetic exploration system made on a trial basis. As a result of this examination, we were able to observe the anomalous signals (vector magnetic anomalies and total intensity magnetic anomalies) of the target.

In this cruise, we have tried to make a magnetic survey using the magnetic exploration system installed in AUV URASHIMA around the Hakurei deposit, seafloor hydrothermal deposit area, which occurs at the southeastern part of the Bayonnaise knoll caldera. The purpose of this test was to evaluate the magnetic exploration system in an actual seafloor hydrothermal deposit area for practical applications of that. We also challenged to tow an overhauser magnetometer, a part of the system, behind AUV URASHIMA in order to reduce the effect of the magnetic noise from the vehicle.

1.2 Cruise information and summary

Cruise number	YK10-17
Ship name	R/V YOKOSUKA, AUV URASHIMA
Chief scientist	Takafumi Kasaya (IFREE, JAMSTEC)
Proposal title	Test of high precision magnetometer by deep-tow system and Autonomous Underwater Vehicle URASHIMA (K. Sayanagi)
Date	9 Dec 2010 – 19 Dec 2010
Ports of call	Yokosuka – Yokosuka (JAMSTEC)
Research Area	Fig.1-1, Fig 1-2

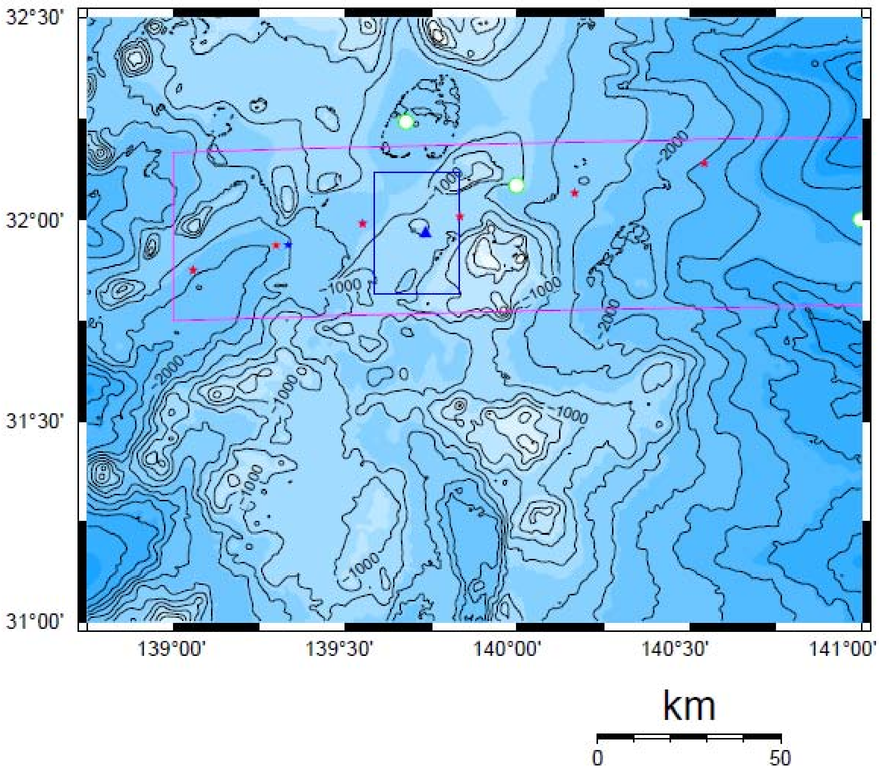

Fig.1-1 Research area of YK10-17 cruise. Red circles show OBEM positions. A red square shows the magnetic survey area used by an AUV URASHIMA.

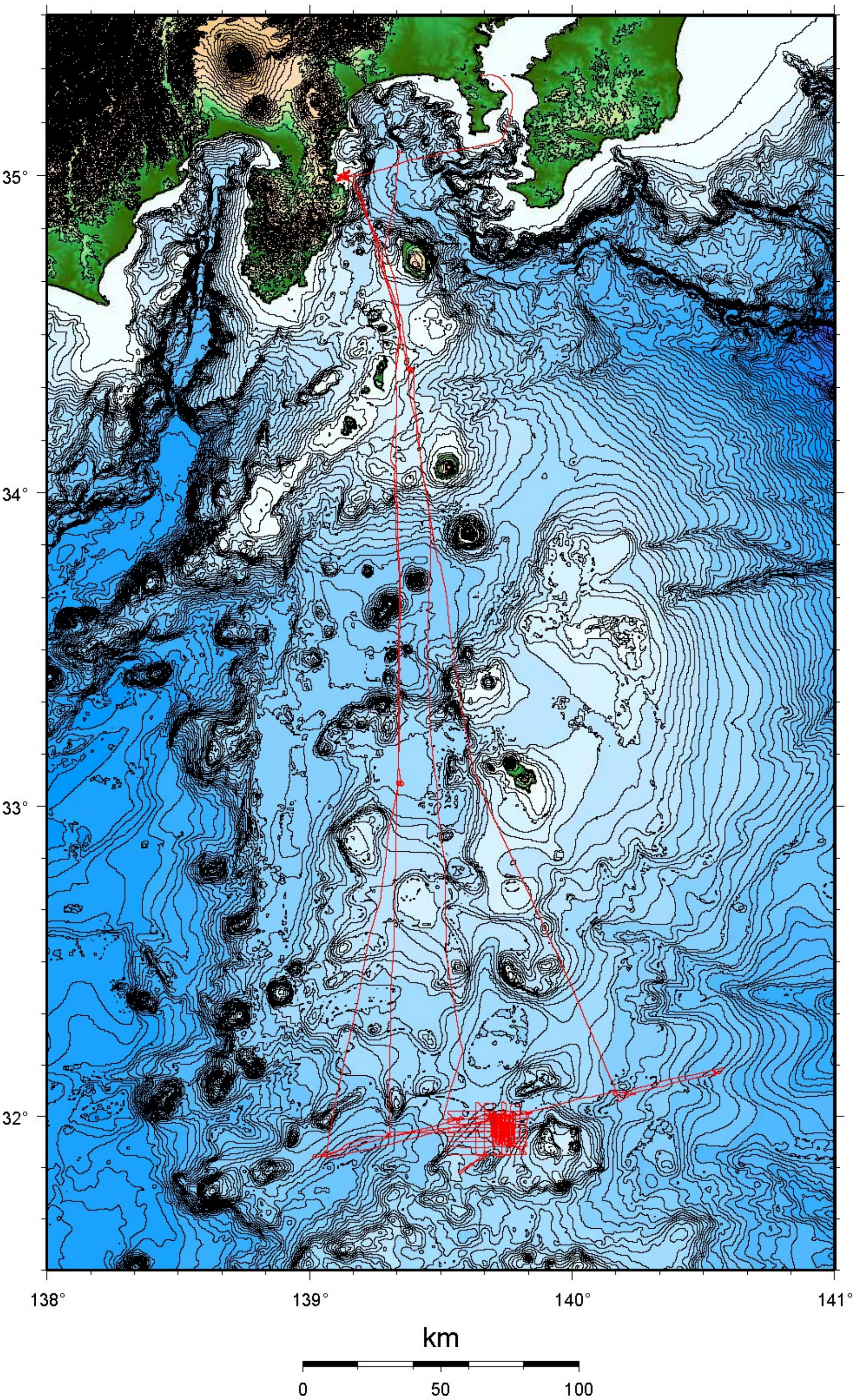

Fig.1-2 Ship track of YK10-17 cruise.

2. Participants List

Onboard Scientists

JAMSTEC	Takafumi KASAYA(Cruise Chair)
Tokai University	Keizo SAYANAGI
Tokai University	Makoto HARADA
Tokai University	Nobuhiro ISEZAKI
Tokai University	Kiyokazu NISHIMURA
Tokai University	Hisatoshi BABA
JAMSTEC	Takao SAWA
Waseda University	Akira SAITO
Waseda University	Keiko NAKAYAMA
OYO Co.	Yoshihiro YAMASHITA

Technical Advisor

JAMSTEC	Shinobu OOMIKA

AUV URASHIMA & Deep Tow Operation Team

Chief Submersible Staff	Toshiaki SAKURAI
1st Submersible Staff	Masanobu YANAGITANI
2ndSubmersible Staff	Akihisa ISIKAWA
2ndSubmersible Staff	Fumitaka SAITO
2nd Submersible Staff	Seiji SHIGETAKE
2nd Submersible Staff	Takuma OONISHI
3rd Submersible Staff	Yudai TAYAMA

R/V YOKOSUKA Crews

Captain	Satoshi SUSAMI
Chief Officer	Naoto KIMURA
2nd Officer	Toshiyo OHARA
3rd Officer	Yumihiko KOMAYASHI
Chief Engineer	Eiji SAKAGUCHI
1st Engineer	Kazunori NOGUCHI
2nd Engineer	Kenichi SHIRAKATA
3rd Engineer	Kenta IKEGUCHI
Chief Radio Operator	Masashi TAKAHASHI
2nd Radio Operator	Isamu KOZONO
3nd Radio Operator	Hiroki ISHIWATA
Junior 3nd Radio Operator	Yoshikazu KURAMOTO
Boat Swain	Kazuo ABE
Able Seamen	Naoki IWASAKI

Able Seamen	Hatsuo ODA
Able Seamen	Katsunori SHIMIZU
Able Seamen	Yuuki YOSHINO
Sailer	Ryouma TAMURA
Sailer	Takuya MIYASHITA
Sailer	Syun MIURA
No.1 Oiler	Kiyoshi YAHATA
Oiler	Yuuki NAKAHARA
Oiler	Shin TORAO
Oiler	Yoshinori KAWAI
Oiler	Yuuji HIGASHIKAWA
Chief Steward	Takeshi MIYAUCHI
Steward	Hiroki FUKUDA
Steward	Mizuki NAKANO
Steward	Yukihide CHIKUBA
Steward	Yoshinobu HASATANI

3. Ship logs

Actual schedule (YK10-17 10/12/9 - 10/12/19)				Position/Weather/Wind/Sea condition (Noon)
Date	Time	Description	Remark	
9,Dec,10	13:30	departure from Yokosuka H/Q		strong wind
	14:30～ 15:00	on board education	for safety YOKOSUKA life	
	16:40～ 17:00	Konpira celemony	Pray for our safe cruise	
	17:30	Arrived at Itou, Sagami-bay	Anchored	
	19:00～ 20:00	Researcher's meeting		
10,Dec,10	2:00	Departure from Itou		
	14:15	OBEM was shifted to aft deck		
	15:00	Arrived at Bayonnaise		Fine
	15:25	Released OBEM	Site #4	31-59.5130N, 139-32.9384E, 1354m
	15:55	OBEM arrived at seafloor		
	15:55～ 16:55	Fixed a position of the OBEM	by LBL acoustic ranging	
	19:00～ 19:10	Researcher's meeting		
11,Dec,10	3:16～ 3:36	Turned figure-eight	Calibration for magnetometer	31-52.5N, 139-40.0E
	6:00	Started pre-dive check for URASHIMA		
	7:46	URASHIMA dived into		
	8:52	Stated observation with URASHIMA		at 500m depth
	15:02	URASHIMA finished a observation		Fine
	15:29	URASHIMA surfaced		
	15:49	URASHIMA retrieved		
	16:40	OBEM was shifted to aft deck		
	17:11	Released OBEM	Site #3	
	17:11～ 18:54	Fixed a position of OBEM	By LBL acoustic ranging	
	19:00～ 19:10	Researcher's meeting		
12,Dec,10	1:48～	Turned figure-eight	Calibration for	31-52.5'N, 139-43.8E

	2:11		magnetometer	
	5:45	Started pre-dive check for URASHIMA		
	8:35	URASHIMA dived into		
	9:25	Stated an observation with URASHIMA		At 700m depth
	15:15	URASHIMA finished an observation		calm
	15:40	URASHIMA surfaced		
	16:04	URASHIMA retrieved		
	19:00～19:05	Researcher's meeting		
	22:00～23:30	Turned figure-eight	Calibration for magnetometer	31-59.301N, 139-34.231E
13,Dec,10	5:50	Started pre-dive check for URASHIMA		
	7:33	URASHIMA dived into		
	8:38	Stated observation with URASHIMA		
	15:07	URASHIMA finished an observation		Cloudy calm
	15:40	URASHIMA retrieved		
	17:45	OBEM was shifted to aft deck		
	18:11	Released OBEM	Site #5	31-56.2N, 139-17.9E
	19:55	Fixed a position of OBEM	By LBL acoustic ranging	
	20:00	Departure from Bayonnaise		
14,Dec,10	8:00	Arrived at Itou	Avoidance by bad weather	
	9:00～17:00	Processing recorded data		Windy and cloudy
	18:00～18:05	Researcher's meeting		
15,Dec,10	9:00～17:00	Processing recorded data and preparing next observation.	A dive was cancelled	Strong wind over 20m/s
	19:00～19:05	Researcher's meeting		
16,dec,10	2:00	Departure from Itou		
	14:30	OBEM was shifted to aft deck		Windy and rough sea
	14:55	Arrived at Bayonnaise		
	15:19	Released OBEM	Site #2	32-04.74N,140-09.86 E

	16:40	OBEM was shifted to aft deck		
	17:53	Released OBEM	Site #1	32-08.41N,140-32.59 E
	19:50	Fixed a position of OBEM at site #1	By LBL acoustic ranging	
	22:06	Fixed a position of OBEM at site #2	By LBL acoustic ranging	
17,Dec,10	2:21～ 2:43	Turned figure-eight	Calibration for magnetometer	31-55.0N,139-46.2E
	9:30～ 14:40	Towed proton magnetometer		Windy and rough sea
	15:30	OBEM was shifted to aft deck		
	16:15	Release OBEM		31-52.5N, 139-03.4E
	17:55	Fixed a position of OBEM at site #6	By LBL acoustic ranging	
	18:00	Departure from Bayonnaise		
	23:01～ 32:27	Turned figure-eight	Calibration for magnetometer	33-04.386N,139-20.6 99E
18,Dec,10	8:00	Arrived at Sagami-bay	Near sunk submarine	
	6:30	Started pre-dive check for URASHIMA		
	8:21	URASHIMA dived into		
	9:42	Stated observation with URASHIMA		At 1300m depth
	15:13	URASHIMA finished a observation		Fine
	16:07	URASHIMA retrieved		
	16:15	Departure form Sagami-bay		
	19:30	Arrived at Tokyo-bay near Yokosuka H/Q		
19,Dec,10	9:00	Arrived at Yokosuka H/Q		

4. URASHIMA dives

4.1 Outline of the test of the magnetic exploration system

It is necessary to investigate fine-scale structures of the oceanic crust in order to estimate accurate abundance of seabed resources like seafloor hydrothermal deposits. There have been, however, no tools and methods that are effective for such investigation. One of the solutions of this problem is the geophysical exploration near and on the seafloor. For this reason, we have developed new electrical and magnetic exploration systems using AUV, ROV, and a deep-tow system since 2008.

The objective of this cruise was to test the performance of our magnetic exploration system on a trial basis using AUV URASHIMA and/or a towing vehicle, YOKOSUKA Deep-Tow in an actual seafloor hydrothermal deposit area for practical applications of that. A test area was the Bayonnaise knoll, especially around the Hakurei deposit at the southeastern part of its caldera. There were 4 dives of AUV URASHIMA for 11 days during the cruise (see Chapter 3 for details). Three dives of them were conducted in the Bayonnaise knoll area, and the other one was done in the Sagami-bay. The former three dives included one dive for calibration of the three component magnetometer of the magnetic exploration system and two dives for deep-sea surveys of magnetic anomaly, swath bathymetry, acoustic image of the seafloor, and sub-bottom profile around the Hakurei deposit (Fig.4-1-1). A test using the YOKOSUKA Deep-Tow was canceled mainly due to priority of the test using AUV. In the above test, we successfully obtained magnetic and acoustic data including three components and total intensity of the geomagnetic field, swath bathymetry, acoustic image of the seafloor, and sub-bottom profile. The total intensity has been measured by improving a pressure case of the overhauser magnetometer and towing it behind the vehicle with a cable 25m long.

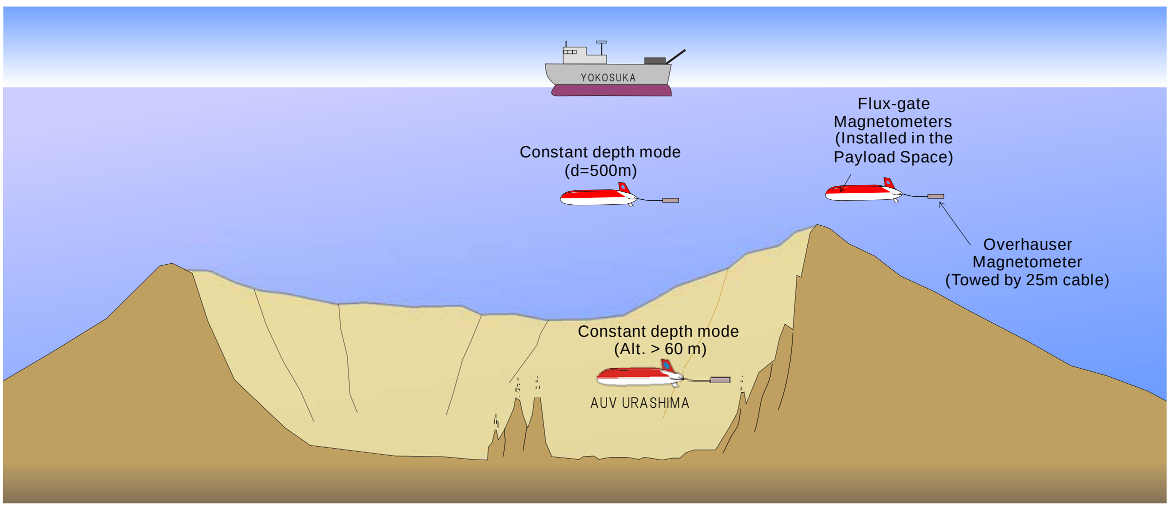

Fig.4-1-1 An image of magnetic and acoustic surveys using AUV URASHIMA

As described later, we carried out sea-surface surveys at night and deployed 6 OBEMs. The sea-surface surveys contained measurements of swath bathymetry, gravity, and magnetic anomaly in a wide area including the Bayonnaise knoll area. Those data were obtained in order to compare to the deep-sea survey data. The OBEMs will observe variations of the electric and magnetic fields. Those data will be used to make correction for daily variation in the data from the magnetic exploration system and to determine an electrical conductivity structure in the surveyed area.

4.2 System

4.2.1 Magnetic exploration system

The main features of the magnetic exploration system are to measure three components, total intensity and gradient of the geomagnetic field with high resolution and high sampling rate, and to be a versatile system that are available on multi-platforms like an AUV and a deep-tow system. The magnetic exploration system consists of two 3-axis flux-gate magnetometers, one/two Overhauser magnetometer(s), an optical fiber gyro, a main unit (control, communication, recording), and an onboard unit (Fig. 4-2-1). The three component magnetometer and the optical fiber gyro measure three components of the geomagnetic field and the overhauser magnetometer does total intensity of the geomagnetic field. Gradients of the magnetic field are obtained by a set of the magnetometers. The main unit controls the system, communicates data and commands with sensor units and external devices, and records data. Data sampling rate is 10 Hz for all the data except for total intensity of the geomagnetic field (4Hz to 10sec).

The flux-gate magnetometers were attached to the inside of the frame of the payload section of the AUV. The optical fiber gyro and the main unit were mounted in the payload. The Overhauser magnetometer was towed with a cable 25m long behind the AUV. Electric power for the magnetic exploration system was supplied from the AUV. Navigation data of the AUV were recorded in the main unit through a communication port. Note that we received cooperation and support of Dr. Nogi of NIPR in the construction of this magnetic exploration system.

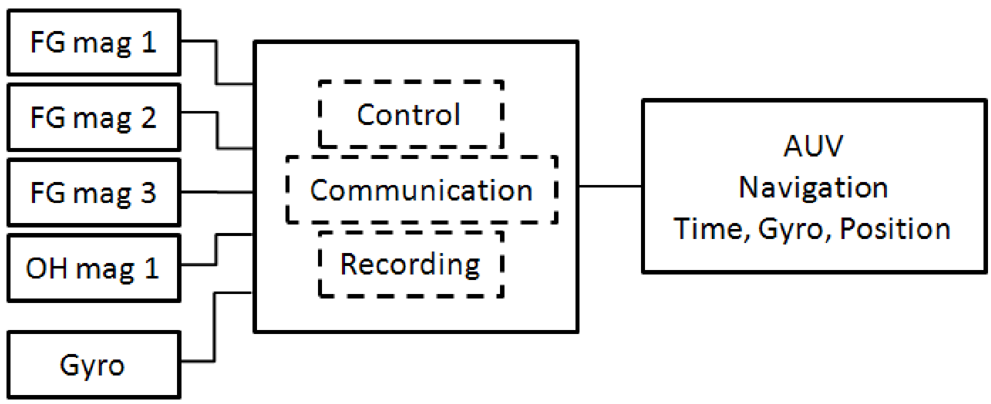

Fig. 4-2-1 Magnetic exploration system for AUV exploration

4.2.2 Acoustic observation system

The AUV URASHIMA loaded multibeam echo sounder (MBES), sidescan sonar (SSS) and subbottom profiler (SBP). The specifications of each instrument are shown in table 4-1. Sebat7125 system consists of transmitter and receiver system mounted on the bottom of AUV URASHIM. Each across-track beam width and along-track beam width is 1.0 and 0.54 degree. Edgtech 2200 system can obtain the backscatter data and shallow subbottom structure. Sidescan system part uses 120 kHz acoustic wave with 0.9 degree beam width. Subbottom profiler system uses chirp signal of 1-6 kHz. A subbottom profiling survey with a sampling rate of 0.046 ms was also conducted in this survey. The SBP data has 15 cm (about 0.2 ms) resolution and provides images of sub-surface sediments up to 20-30 m depth.

Seabat7125 system	
Frequency	400 kHz
Swath Width	128 degree
Beam width (Along-track × Across-track)	1.0×0.54 degree
Range	Max 200m
Edgtech 2200 system	
Sidescan Sonar	
Frequency	120 kHz
Beam Width (Along-track)	0.9 degree
Range	Max 300 m
Range Resolution	6.25 m
Subbottom Profiler	
Frequency	1-6 kHz (Chirp)
Beam Width	28-36 degree
Resolution	15-25 cm

4.3 Preliminary results of the test by AUV URASHIMA

4.3.1 Magnetic survey

Three dives (#118, #119, #120) were carried out in the Bayonnaise knoll area (Fig.4-3-1), and one dive (#121) was done in the Sagami-bay. In the Bayonnaise knoll area, we well obtained vector magnetic anomalies and total intensity magnetic anomalies near the Hakurei deposit in the caldera and above the east part of the caldera. Although the Overhauser magnetometer was not able to measure the total intensity in the previous test during the YK09-09 cruise, it has measured the total intensity in this test by improving a pressure case of that and towing it behind the vehicle with a cable 25m long. In the Sagami-bay, we measured vector magnetic field near a submerged structure (vessel or something). The magnetic survey using AUV was well operated through 4 dives.

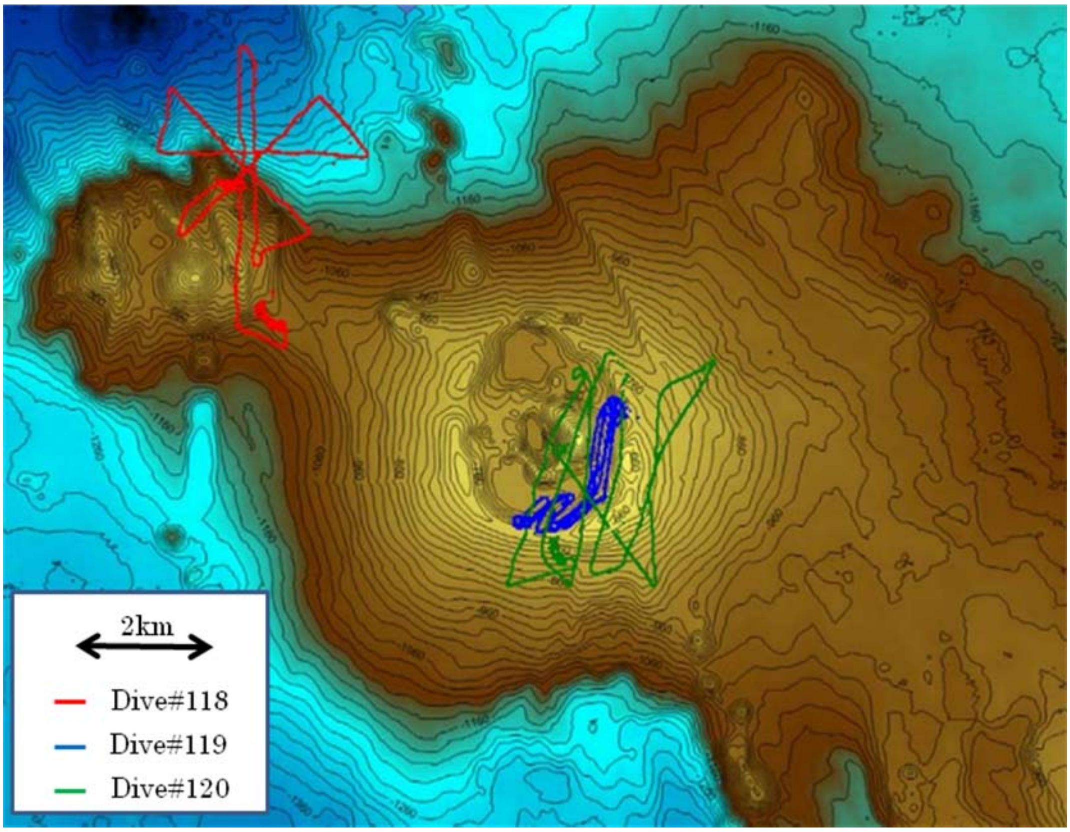

Fig.4-3-1 Track Lines of AUV dives #118, #119, and #120.

The points of those dives are as follows. The dive #118 was conducted on the northwest of the Bayonnaise knoll for the calibration of three component magnetometer. In the dive #119, the AUV made the magnetic survey at altitudes of 50m to 100m above the seafloor in order to obtain a detailed distribution of magnetic anomalies near the Hakurei deposit. Figure 4-3-2 shows an example of magnetic data obtained by the AUV. In the dive #120, the AUV made the magnetic survey at depth of 500m above the east part of the Bayonnaise knoll in order to obtain middle-scale distribution of magnetic anomalies in a shallower area compared to the dive #119 area. As natural results, the data closer to the seafloor (dive #119) showed fine distribution of the magnetic anomalies compared to the data at higher altitude (dive #120), and the vector magnetic data clearly provided more information than total intensity data. Finally, the dive #121 was conducted above the submerged structure which was relatively simple target because that was probably made of iron and was easily detected by the multibeam echo sounder and sidescan sonar of the AUV.

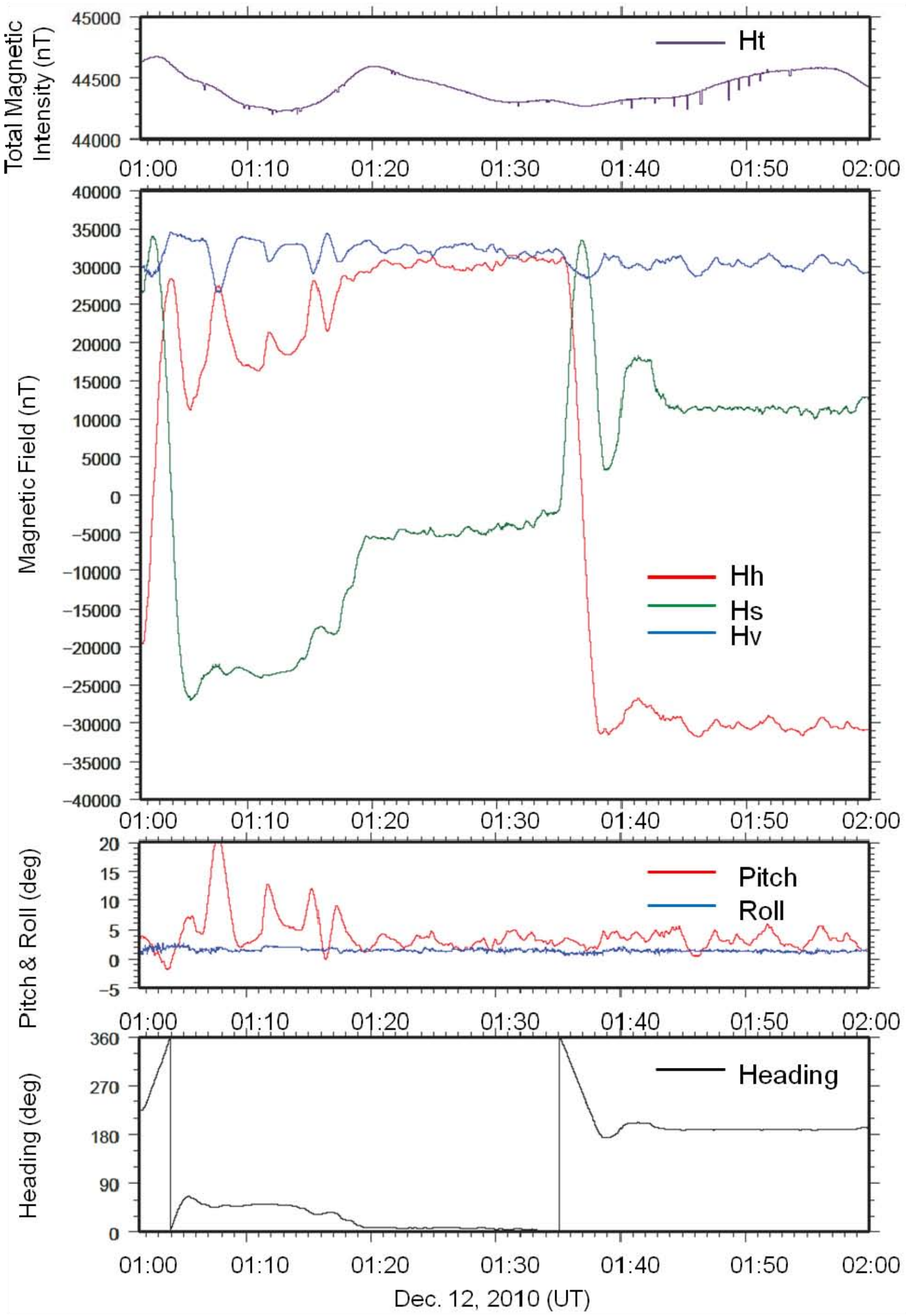

Fig. 4-3-2 An example of obtained deep-sea magnetic (Hh,Hs,Hv) and gyro (heading, pitch, roll) data on 01:00-02:00 , Dec. 12, 2010 (UT) during the dive#119.

4.3.2 Acoustic survey result

We can obtain good quality data through all dives. Second dive data provides the detailed bathymetric information for us in the Bayonnaise caldera. In the geothermal deposit area, MBES and SSS data show the rough features with short wave length. In this area, these structures are not covered by sedimentary layer by SBP data. We only use INS data for onboard analysis. However INS data included some drift error, we need to correct the vehicle position using all navigation data. We will analyze acoustic data carefully, discuss the relationship between the bathymetric information and hydrothermal deposit.

5. OBEM operation

5.1 Outline of our OBEM system

The OBEM system with a high sampling rate was designed to investigate the crustal and mantle structure (Fig. 5-1). It has a folding-arm system to facilitate assembly and recovery operations (Kasaya et al., 2006; Kasaya and Goto, 2009). Concepts of our developed OBEM and OBE system are miniaturization, a high sampling rate, easy assembly and recovery operations, and low costs of construction and operation. Figure 5-2 shows the schematic diagram of the arm-folding system. For measuring the electric field, we used Ag-AgCl electrode mounted at the toe of each electrode arm.

Electric circuit used for each system is contained in the pressure glass spheres. The fluxgate magnetometer of the OBEM system is mounted outside the glass sphere (Fig. 5-1). The salient characteristic of our system is its arm-folding mechanism, which facilitates and simplifies our onboard operations. We used an acoustic release system that had been already used by JAMSTEC for Ocean Bottom Seismography (OBS).

Clock synchronization before deployment and calibration after recovery are important. This OBEM system can synchronize to the laptop PC using USB communication. To synchronize the laptop PC to GPS clock, we developed the NTP server unit.

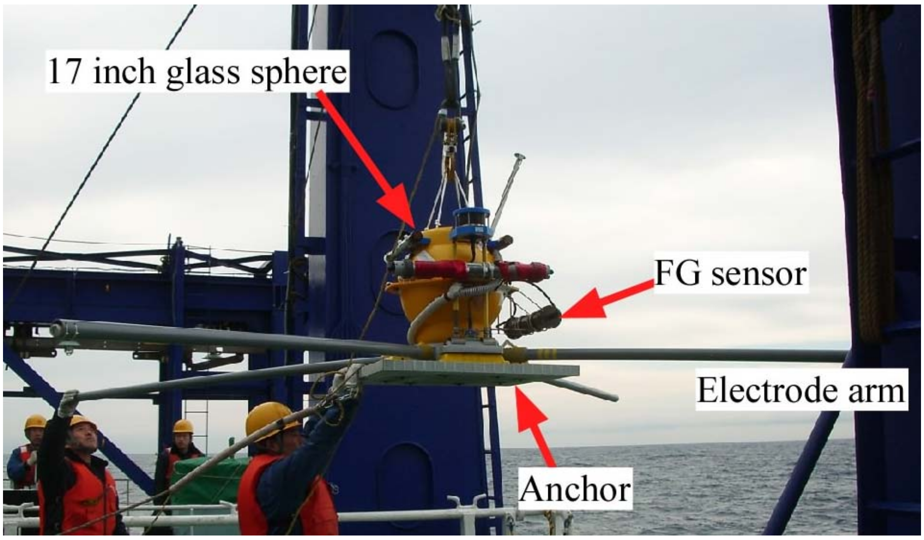

Fig. 5-1 Photo of a small OBEM system.

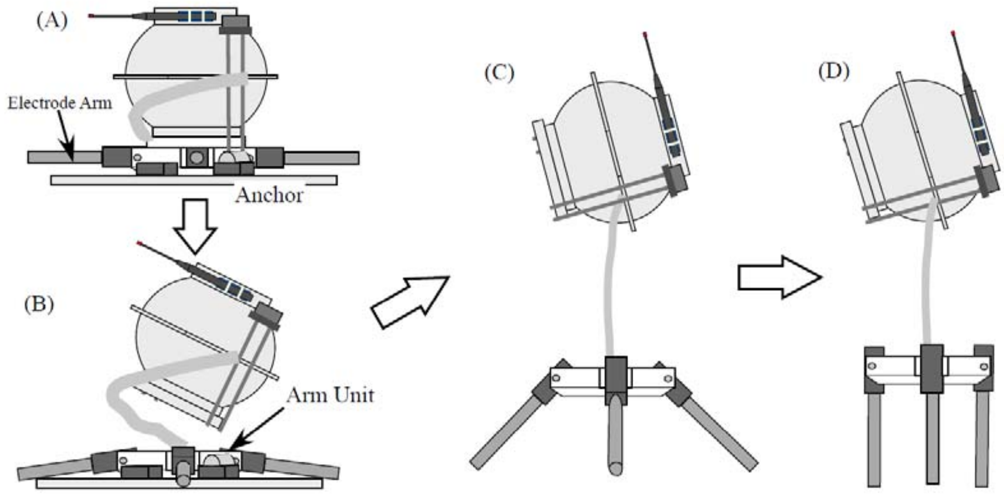

Fig. 5-2 Schematic diagram of the arm-folding system. After starting to pop up, the arm unit is picked up as the sphere ascends (Patent number of Japan: 4346605).

5.2 OBEM operation

OBEMs were launched from deck using A-frame for all stations, and sunk by their own weights. The operations were quick and smooth. We tracked the OBEMs by acoustic signals and confirmed that the OBEMs were successfully settled on the seafloor. Then, the settled positions were determined by measurements of the slant ranges at least three positions surrounding the launched point for each OBEM (Fig.1, Table 5-1). All OBEMs will be recovered in the KR11-02 cruise

Site Name	Release code	Lat(sea floor)	Lon(Sea floor)	Depth
Site1	3D-1	32-8.407746	140-32.62572	2243
Site2	1B-1	32-4.005204	140-9.9939	1615
Site3	4E-1	32-0.494'	139-50.006'	1213
Site4	4D-1	31-59.3388	139-33.0066'	1354
Site5	4C-1	31-56.215326	139-17.9334	1800
Site6	4A-1	31-52.505262	139-3.49368	1925

Table 5-1 Information of the OBEMs.

References

Kasaya, T., T. Goto, and R. Takagi (2006), Marine electromagnetic observation technique and its development –For crustal structure survey-, *BUTSURI-TANSA, 59*, 585-594 (in Japanese with English abstract).

Kasaya, T. and T. Goto (2009), A small OBEM and OBE system with an arm folding mechanism , *Exploration Geophysics*, *40*, 41-48.

6. Shipboard data (Bathymetry and Geophysical data)

6.1 Bathymetry

R/V YOKOSUKA is equipped with SeaBeam 2112 multibeam echo sounder, manufactured by Seabeam Inc.. The echo sounder collects bathymetric and side scan data in deep sea over a wide swath of up to 140 degrees. The system is fully real time motion-compensated to guarantee full coverage even under severe environmental conditions. The specifications of the SeaBeam 2112 are listed in Table 6-1-1.

The Specifications of Multi Beam Echo Sounder (MBES)	
Measurement Depth (m)	100-11,000
Measurement Range (deg.)	90-150
Measurement Frequency (kHz)	12
Measurement Method	Cross fan beam style
Accuracy	0.2%(center)-0.5%(outer)
Beam Width (deg.)	2
Beam Interval (deg.)	1
Swath Width (deg.)	150(～300m) 120(～4,500m) 100(～8,000m) 90(～11,000m)
Roll (deg.)	±20
Pitch (deg.)	±7.5

Table 6-1-1 Specifications of SeaBeam 2112 mutibeam echo sounder

6.2 Gravity

Gravity was measured continuously through the entire length of the cruise, which began on 09st December 2010 and ended on 19th December 2010 in Yokosuka, Japan. The gravity meter on board R/V YOKOSUKA is the Air-Sea Gravity System II (Fig. 6.2.2) made by LaCoste & Romberg Corporation, USA. The control system basically consists of remote and host computers. The former performs all real-time activity associated with controlling the platform and gravity meter as well as maintaining the system clock. The latter receives the data, computes the cross-coupling correction, and performs the final filtering before archiving the data. Time is kept very accurately by a temperature-compensated crystal oscillator. During this cruise, the gravity meter produced filtered data at 10-second intervals. These data were reduced to 1-minute-interval by the host computer. The detailed information are shown in Table 6.2.1.

The Specifications of Gravity Meter	
Measurement Range (mGal)	12,000
Drift	3 mGal Per month or less
Stabilized Platform	
Platform Pitch (dig.)	±22
Platform Roll (deg.)	±25
Platform Period (min.)	4 ～ 4.5
Beam Interval (deg.)	1
Control system	
Recording Rate (Hz)	1
Serial Output	RS-232
System Performance	
Resolution (mGal)	0.01
Static Repeatability (mGal)	0.05
50,000 mGal Horizontal Acceleration (mGal)	0.25
100,000mGal Horizontal Acceleration (mGal)	0.50
100,000mGal Vertical Acceleration (mGal)	0.25
Dimension (cm)	71×56×84
Weight (kg)	Meter:86, UPS:30

Table 6-2-1 Information of the Air-Sea Gravity System

Fig. 6-2-2 Photo of the Air-Sea Gravity System

6.3 Geomagnetic field vector on the sea

A shipboard three-component magnetometer (STCM: Isezaki, 1986) and a ship-towed proton precession magnetometer were used for the measurements of the geomagnetic field during the cruise. The STCM (SFG-1212, TIERRA TECNICA) is a 3-axis flux-gate magnetometer installed on the Nav. deck above the bridge (Fig. 6-3-4). The specifications of the STCM are shown in Table 6-3-1.

The logging PC is connected to the vessel's GPS. The clock was manually synchronized to GPS time (ship- time), at the start of the survey. To obtain information of ship's attitude and direction (roll, pitch and heading), a gyro system was installed on board. These data were collected with a sampling rate of 8Hz during the cruise.

The STCM data contains the effects of the ship's magnetic field, which must be corrected in order to derive the geomagnetic field. "8-shaped navigation" were made for calibration of the ship's magnetic effect, related to magnetic susceptibility of the ship, and a permanent magnetic moment of the ship's body (Isezaki, 1986). The "8-shaped navigation" is made by steering ship in a tight circle, both clockwise and counter clockwise. The "8-shaped navigation" were conducted five times as shown in Table 6-3-3.

The Specifications of 3 axes Fluxgate Magnetometer	
System	Ring core Fluxgate
Number of Component	Directly 3 axes
Cable Length (m)	50
Sensor Dimension (mm)	ϕ280×130H
Measurement Range (nT)	±100,000
Resolution (nT)	1

Table 6-3-1 Information of the three-component magnetometer.

No.	ON/ OFF	Mm/dd	Time (UT)	Lat (deg)	Lon (deg)	Area, Track
1	ON	12/10	10:58	35.00410987	138.53739256°	
	OFF	12/10	18:11	31.88257622	139.62767529	
2	ON	12/11	10:22	31.96280313	139.79033026	
	OFF	12/11	19:59	32.02202786	139.63349964	
3	ON	12/12	08:22	31.98216687	139.71590893	
	OFF	12/12	20:58	31.94659571	139.73130032	
4	ON	12/13	08:05	31.94544779	139.53714634	
	OFF	12/13	22:58	34.95527339	139.17647250	
5	ON	12/15	17:23	34.95343041	139.17770214	Sagami Bay~Site2~Site1~ Bayonnaise
	OFF	12/16	20:52	31.94229182	139.74598254	
6	ON	12/17	00:13	31.95902834	139.69659643	Bayonnaise E-W lines~ site6～Sagami-Bay
	OFF	12/17	21:36	34.86252094	139.30918561	

Table 6-3-2 Information of the sea-surface magnetic surveys.

Information of “8-shape navigation”			
MM/DD	TIME (JST)	Locations	
12/11	03:16～03:34	31° 52.6691′	139° 39.7569′
12/12	01:49～02:09	31° 52.5217′	139° 43.8525′
12/12	22:01～22:29	31° 59.3395′	139° 34.2933′
12/17	02:22～02:45	31° 54.6489′	139° 45.7684′
12/17	22:59～23:31	33° 04.5705′	139° 20.5522′

Table 6-3-3 Information of “8-shape navigation”, calibration of the STCM.

Fig. 6-3-4 The fluxgate magnetometer sensor is mounted on the Nav. Deck (left). The SFG-1212 system is installed in No.1 study room.

6.4 Geomagnetic field intensity on the sea

A towing proton precession magnetometer system was used to measure the total intensity of the geomagnetic field. The system consists of a sensor, a tow cable, a deck mounted winch, and a computer running system PM-217 (TIERRA TECNICA Inc.) to visualize and log the data (Fig.6-4-2 and Fig. 6-4-3). The logging PC in No.1 study room was connected to the R/V YOKOSUKA to feed navigation information. Data were acquired at every 20sec. The clock used to tag the logged data, was manually synchronized to GPS time at the start of the survey. Table 6-3-1 shows the specifications of the proton magnetometer.

The Specifications of Subsurface-Towed Proton Magnetometer	
Measurement Range (nT)	3～7×10^4
Resolution (nT)	0.01
Sampling Rate	10 sec, 20 sec, 1 min, manual, external
Time of Applying Field (sec)	3～10
Sensor Dimension (mm)	ϕ200×1,050
Weight (kg)	28.6 in the air, 6.2 in the sea

Table 6-4-1 Specifications of the proton magnetometer.

Fig. 6-4-2 A view of the proton magnetometer sensor (left) and tow cable winch (right).

Fig. 6-4-3 A view of the logging PC.

6.5 Data summary

We carried out sea-surface surveys in a wide area including the Bayonnaise knoll. In the surveys, bathymetry and geophysical data were collected along the ship tracks as shown in Fig. 6-5-1. The geophysical data include gravity and three components and total intensity of the geomagnetic field. Those data were obtained in order to be used as basic information on geophysical features of the survey area and for comparison of them with the deep-sea data.

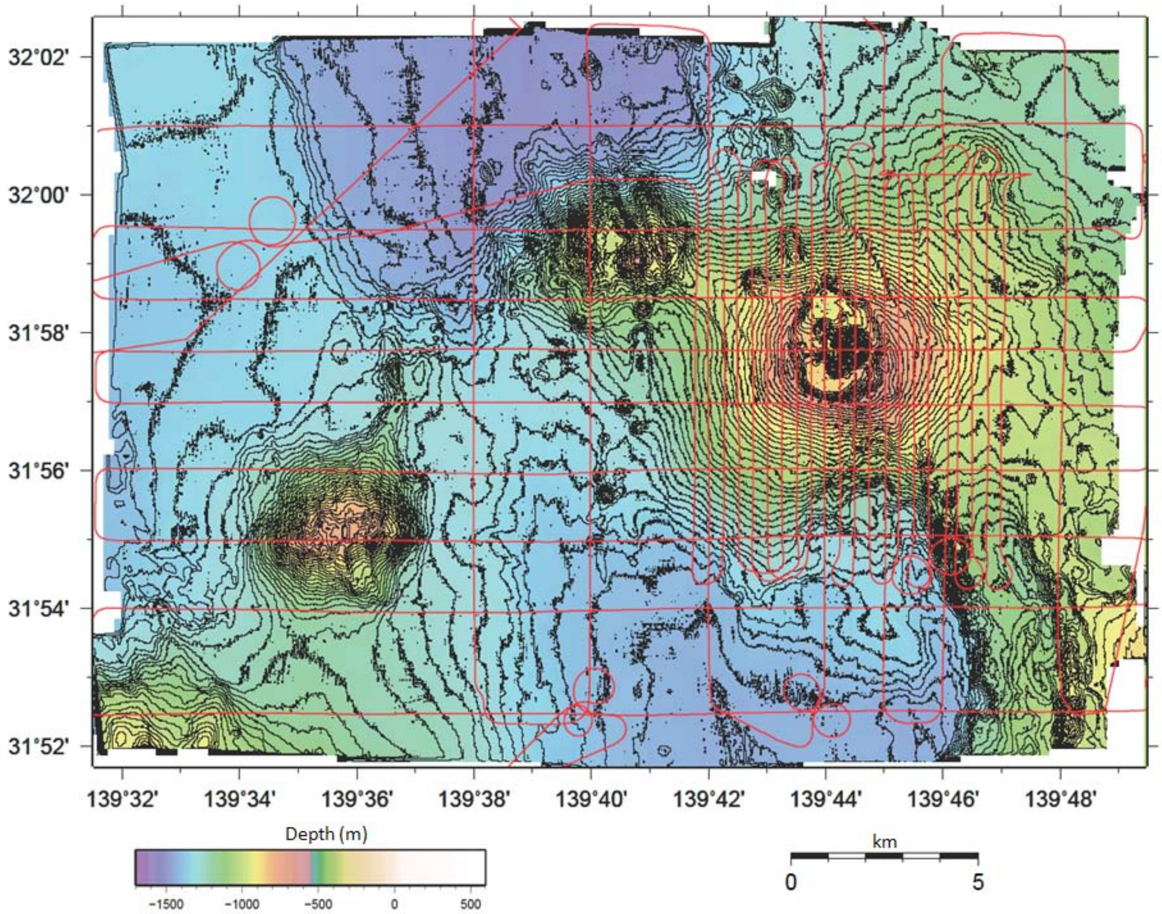

Fig. 6-5-1 Survey track map

7. Summary

Seabed resources like seafloor hydrothermal deposits have recently attracted much attention. It is, however, difficult to estimate accurate abundance of those resources. From such a standpoint, we have been developing new electrical and magnetic exploration systems by using AUV, ROV, and a deep-tow system in order to estimate structures of the seafloor in detail. Since this study started with financial support of MEXT in 2008, we have made each device of magnetic and electrical exploration systems on an experimental basis.

In this cruise, we have tried to make a magnetic survey using the magnetic exploration system installed in AUV URASHIMA around the Hakurei deposit, seafloor hydrothermal deposit area, which occurs at the southeastern part of the Bayonnaise knoll caldera. The purpose of this test was to evaluate the magnetic exploration system in an actual seafloor hydrothermal deposit area for practical applications of that. We also challenged to tow an overhauser magnetometer, a part of the system, behind AUV URASHIMA in order to reduce the effect of the magnetic noise from the vehicle.

There were 4 dives of AUV URASHIMA during the cruise (11 days). Three dives were conducted in the Bayonnaise knoll area, and the other one was done in the Sagami-bay. In the Bayonnaise knoll area, we successfully observed vector and total intensity magnetic anomalies, swath bathymetry, acoustic image of the seafloor, and sub-bottom profile near the Hakurei deposit in the caldera and above the east part of the caldera. The total intensity has been measured by improving a pressure case of the overhauser magnetometer and towing it behind the vehicle with a cable 25m long. These data are valuable and useful as a complete set of deep-sea acoustic and magnetic data near seafloor hydrothermal deposits. In the Sagami-bay, we measured vector magnetic field near a submerged structure (vessel or something). Furthermore, we also carried out sea-surface surveys and deployed 6 OBEMs. These data from this cruise will contribute to develop the magnetic exploration system for seabed resources, to study magnetic and electrical structures of the seafloor hydrothermal deposit area and the subduction zone, and to develop observation methods using AUV.

Appendices

Explanatory notes

A1. Research Vessel YOKOSUKA

R/V YOKOSUKA is designed serve as the mother vessel for Shinkai 6500 and Autonomous Underwater Vehicle URASHIMA. It has silent engine an advanced acoustic navigation systems and an underwater telephone for its state of the art operations.

There are 4 laboratories on YOKOSUKA, No.1～No.3 laboratories and No.1 Study room. No.1 Lab. has dry space. Permanent installations are video editing system, PC and printer. No.2 Lab. has semi - dry and wet space. There are two freezers (-40 & -80 deg.C), incubator, Milli-Q, fumigation chamber at dry one, and wet one has rock saw. No.3 Lab. has dry space with storage.No.1 Study room has dry space, there are gravity meter, data acquisition system of gravity meter, 3 axis fluxgate magnet meter and also proton magnet meter, work station for data processing, and A0 size plotter.

Length overall	105.2 m
Beam overall	16.0 m
Depth	7.3 m
Draft	4.5 m
Gross tonnage	4,439 tons
Service speed	16knot
Complement	
Crew	27 persons
Submersible operation staff	18 persons
Researchers	15 persons
Total	60persons
Main propulsion system	Diesel engines: 2,206kW x 2
Main propulsion method	Controllable pitch propeller x 2

Table A-1 Principal specifications of R/V YOKOSUKA

A2. AUV URASHIMA

Autonomous Underwater Vehicle (AUV) URASHIMA is cruised by oneself for built in control system. It is not connected by the cable between the mother vessel, therefore it can survey the sea floor widely and clearly. There are acoustic sonar equipments and sensors, Side Scan Sonar, Sub Bottom Profiler, Multi Narrow Beam Echo Sounder, and CTDO sensor.

Dimensions	Length(m) Width(m) Height(m) Weight(t)	10 1.3 1.5 10
Cruising Range(km)	Li-ion Fuel Cell(km)	100 300
Max Depth	3500m	
Cruising Speed	3kn	
Positioning	Inertial Navigation System Doppler Sonar SSBL Sonar	
Operation Mode	Autonomous Remote(Acoustic, Optical)	
Payload	300kg in air	
Equipments	Side Scan Sonar Multi Narrow Beam Echo Sounder Forward Looking Sonar CTDO	

Table A-2 The specifications of AUV URASHIMA