



Cruise Report

YK17-24C

"Application for the high accuracy geophysical exploration of the
hydrothermal deposit using AUV YUMEIRUKA"

Off Aogashima, Izu-Ogasawara arc



R/V Yokosuka

8 Dec 2017 – 15 Dec 2017

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Acknowledgements

We would like to thank Captain Mr. Susami and all ship crew of R/V Yokosuka for their safe cruise. We are grateful to marine technicians of NME for their operation. We are pleased to MARITEC/JAMSTEC staff for their supports during our cruise.

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 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.

1. Cruise information and summary of YK17-24C cruise

Cruise information

Cruise number	YK17-24C
Name of the cruise	R/V YOKOSUKA
Chief scientist	Takafumi Kasaya (JAMSTEC)
Representative of the Science Party	Eiichi Kikawa (JAMSTEC)
Title of the cruise	Application for the high accuracy geophysical exploration of the hydrothermal deposit using AUV YUMEIRUKA
Cruise period	8 Dec 2017 – 15 Dec 2017
Ports of call	Yokosuka – Yokosuka
Research Area	Off Aogashima, Izu–Ogasawara arc (Fig.1)

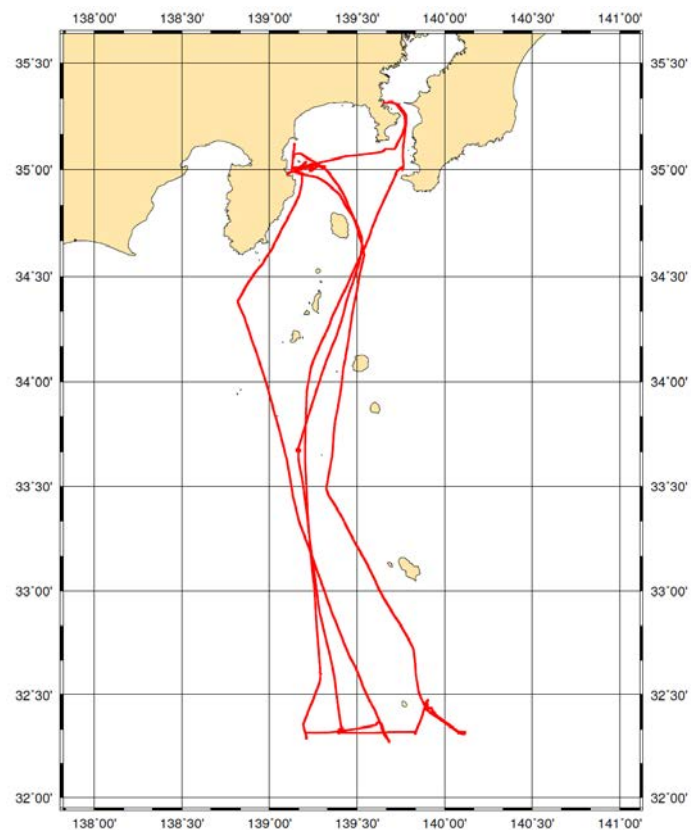


Fig.1 Ship track of this cruise.

Cruise summary

Title of proposal:

” Application for the high accuracy geophysical exploration of the hydrothermal deposit using AUV YUMEIRUKA”

The purpose of this cruise is the trial of the self-potential survey using new middle-class AUV YUMEIRUKA for the hydrothermal deposit survey. Self-potential survey is especially very powerful and easy method to detect the signal of the sub-surface hydrothermal deposit. We carried out two trial dives at the Sagami Bay and one practical dive at the Off Aogashima area. When trial dives, we also used an acoustic buoy with the acoustic, VHF and wireless LAN communication system which are equipped on an ASV to examine the communication from an ASV and an AUV YUMEIRUKA. This buoy was towed from the tail of mother ship in this cruise and a vehicle was monitored by this buoy. All operation were done smoothly and data acquisitions of the self-potential, bathymetric data and some chemical sensors were successfully. Around an active mound week anomaly of self-potential was found. Moreover, we have deployed five OBEMs to obtain magneto-telluric data using an OBEM for characterization a regional structure including some calderas with hydrothermal activity.

This study was supported by the Cross-ministerial Strategic Innovation Promotion Program “Next-generation technology for ocean resources exploration” launched by the Council for Science, Technology and Innovation (CSTI) and managed by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC).

2. List of Participants

Scientists

Takafumi Kasaya	Japan Agency for Marine-Earth Science and Technology
Jyunji Kaneko	Japan Agency for Marine-Earth Science and Technology
Ayu Takahashi	Japan Agency for Marine-Earth Science and Technology
Yutaka Ohta	Japan Agency for Marine-Earth Science and Technology
Tsuyoshi Yoshiume	Japan Agency for Marine-Earth Science and Technology
Yoshinobu Nanbu	Japan Agency for Marine-Earth Science and Technology
Hiroshi Ochi	Japan Agency for Marine-Earth Science and Technology
Tatsuya Aso	Japan Agency for Marine-Earth Science and Technology
Kazuhiro Kanayama	Mitsubishi Heavy Industries, LTD.
Hiroyuki Miyake	Ryoyu System Engineering Co, LTD.
Yoshitaka Watanabe	Japan Agency for Marine-Earth Science and Technology
Koji Meguro	Japan Agency for Marine-Earth Science and Technology
Hiroshi Matsumoto	Japan Agency for Marine-Earth Science and Technology
Hiroaki Hamada	Tokyo University for Marine Science and Technology
Shigeyuki Hasegawa	Japan Agency for Marine-Earth Science and Technology

Marine Technician

Satomi Minamizawa	Nippon Marine Enterprises, LTD.
Yasushi Hashimoto	Nippon Marine Enterprises, LTD.

R/V YOKOSUKA Officers and Crew

Captain	Satoshi Susami
Chief Officer	Toshiyo Ohara
2nd Officer	Shozo Fujii
3rd Officer	Yumihiko Kobayashi
Chief Engineer	Tadashi Abe
1st Engineer	Kazunori Noguchi
2nd Engineer	Katsuto Yamaguchi
3rd Engineer	Takamasa Ochiai
Chief Electronic Operator	Yoichi Inoue
2nd Electronic Operator	Toshihiko Yuasa
3rd Electronic Operator	Ryosuke Matsui
Boat Swain	Kaname Hiroasaki

Quarter Master	Kazumi Ogasawara
Quarter Master	Tsuyoshi Chimoto
Quarter Master	Hiroaki Nagai
Quarter Master	Tsugumi Sasaki
Sailor	Kenta Nasu
Sailor	Tomoki Asakuni
Sailor	Keisuke Isobe
No.1 Oiler	Junji Mori
Oiler	Katsuyuki Miyazaki
Oiler	Tatsuomi Chino
Oiler	Toshinori Matsui
Oiler	Makoto Kozaki
Steward	Kazuhiro Hirayama
Steward	Hideo Fukumura
Steward	Hiroyuki Ohba
Steward	Yoshitaka Yamamoto
Steward	Toshiyuki Saito
Steward	Seiya Matsumoto

3. Ship Logs

2017/12/8 SAGAMI-WAN (35-03.0N,139-25.0E)

Weather: Cloudy / Wind direction: SW / Wind force: 7 / Wave scale: 4 /
Swell scale:1 / Visibility: 8 miles (12:00 JST)

08:00	Scientists onboard.
09:00	Let go all shore line, left YOKOSUKA, for research area (SAGAMI-WAN).
09:30-10:00	Carried out education and training for scientists.
10:30-11:00	Scientists meeting.
13:00-15:35	Carried out “Floating system” trial.
16:40	Konpira ceremony.

2017/12/9 SAGAMI-WAN (35-00.0N, 139-14.0E)

Weather: Fine but Cloudy / Wind direction: E / Wind force: 3/ Wave scale: 2 /
Swell scale: 1 / Visibility: 8 miles (12:00 JST)

07:04	Released XBT @ 35-00.8640N, 139-18.6368E.
09:37	Hoisted up “YUMEIRUKA”.
09:41	Launched “YUMEIRUKA”.
09:42	“YUMEIRUKA” dove and started her operation #31. (Depth = 1,272 m)
09:58	Hoisted up “Floating system”.
09:59	Launched “Floating system”.
11:25	“YUMEIRUKA” com’ced refloated.
11:38	Hoisted up “Floating system”.
11:40	Recovered “Floating system” & “YUMEIRUKA” refloated.
12:12	Hoisted up “YUMEIRUKA”.
12:21	Recovered “YUMEIRUKA” & finished above operation.
14:00	Com’ced proceeding to Research area (East AOGA-SHIMA caldera).
18:00	Scientists meeting.

2017/12/10 East OFF AOGA-SHIMA (32-26.0N, 139-54.0E)

Weather: Cloudy / Wind direction: S / Wind force: 3 / Wave scale:2 /
Swell scale: 3 / Visibility: 8 miles (12:00 JST)

05:30	Arrived at research area.
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06:35	Deployed OBEM (Point: OBEM5)
07:05	Above OBEM landed on the sea bottom & calibrated SSBL at 32-18.9237N,140-04.9704E (Water Depth = 1,376 m)
08:01	Released XBT @ 32-24.1230N, 139-57.0964E
09:19	Hoisted up "YUMEIRUKA".
09:23	Launched "YUMEIRUKA".
09:24	"YUMEIRUKA" dove and started her operation #32. (Depth = 658 m)
13:28	"YUMEIRUKA" com'ced refloated.
13:37	"YUMEIRUKA" refloated.
14:06	Hoisted up "YUMEIRUKA".
14:16	Recovered "YUMEIRUKA" & finished above operation.
16:04	Deployed OBEM (Point: OBEM4).
16:35	Above OBEM landed on the sea bottom & calibrated SSBL at 32-18.9407N,139-50.1200E (Water Depth = 1,423 m).
18:51	Deployed OBEM (Point: OBEM2).
19:12	Above OBEM landed on the sea bottom & calibrated SSBL at 32-18.9797N,139-23.9546E (Water Depth = 1,065 m).
19:23-19:44	Carried out eight figure turn measurement
20:00	Proceeded to research area (SAGAMI-WAN).

2017/12/11 OFF ITO (34-58.9N, 139-06.4E)

Weather: Blue sky / Wind direction: West / Wind force: 7 / Wave scale: 4 /
Swell scale: 0 / Visibility: 8 miles (12:00 JST)

00:27-00:47	Carried out eight figure turn measurement
05:30	Arrived at research area (SAGAMI-WAN).
08:00	Proceeded to OFF ITO.
09:10	Let go port anchor in 46 m of water at OFF ITO.
18:30	Scientists meeting.

2017/12/12 OFF ITO (34-58.9N, 139-06.4E)

Weather: Fine but Cloudy / Wind direction: WSW / Wind force:7 / Wave scale:3 /
Swell scale: 0 / Visibility: 8 miles (12:00 JST)

All day	Anchoring at OFF ITO.
19:00	Scientists meeting.

2017/12/13 SAGAMI-WAN (35-01.5N, 139-14.0E)

Weather: Fine but Cloudy / Wind direction: SW / Wind force: 2 / Wave scale: 2 /

Swell scale: 1 / Visibility: 8 miles (12:00 JST)

06:40 Upped anchor & Com'ced proceeding to Research area
 (SAGAMI-WAN).

07:30 Arrived at Research area.

09:00 Hoisted up "YUMEIRUKA".

09:05 Launched "YUMEIRUKA".

09:06 "YUMEIRUKA" dove and started her operation #33.
 (Depth = 1,266 m)

09:24 Hoisted up "Floating system".

09:25 Launched "Floating system".

12:22 "YUMEIRUKA" com'ced refloated.

12:34 Hoisted up "Floating system".

12:37 Recovered "Floating system"

12:59 "YUMEIRUKA" refloated.

13:20 Hoisted up "YUMEIRUKA".

13:29 Recovered "YUMEIRUKA" & finished above operation.

18:30 Scientists meeting.

2017/12/14 West OFF AOGA-SHIMA (32-26.5N, 139-35.5E)

Weather: Fine but Cloudy / Wind direction: NNW / Wind force: 5 / Wave scale: 5 /

Swell scale: 3 / Visibility: 8 miles (12:00 JST)

00:00 Com'ced proceeding to Research area (East AOGA-SHIMA
 caldera).

12:40 Arrived at Research area.

13:37 Deployed OBEM (Point: OBEM3).

16:35 Above OBEM landed on the sea bottom & calibrated SSBL at
 32-19.0606N, 139-39.5512E (Water Depth = 1,439 m).

16:42 Deployed OBEM (Point: OBEM1).

16:35 Above OBEM landed on the sea bottom & calibrated SSBL at
 32-18.9742N, 139-12.5234E (Water Depth = 1,360 m).

17:20 Left Research area for YOKOSUKA.

18:30 Scientists meeting.

2017/12/15 YOKOSUKA (JAMSTEC)

9:00 Arrived at YOKOSUKA(JAMSTEC),
then completed voy. No.YK17-24C

Wind Scale

0	Calm	0~0.2m/s
1	Light air	0.3~1.5m/s
2	Light breeze	1.6~3.3m/s
3	gentle breeze	3.4~5.4m/s
4	Moderate breeze	5.5~7.9m/s
5	Fresh breeze	8.0~10.7m/s
6	Strong breeze	10.8~13.8m/s

Wave scale

0	Calm (Glassy)	0.0m
1	Calm (Rippled)	0~1/10m
2	Smooth (Wavelet)	1/10~1/2m
3	Slight	1/2~1 1/4m
4	Moderate	1 1/4~2 1/2m

SWELL SCALE

0	No Swell	
1	Low Swell Short or Average	<2m
2	Low Swell Long	<2m
3	Moderate Short	2m~4m

4. Instruments

4.1 Ocean bottom electro-magnetometer (OBEM)

The OBEM system can measure time variations of three components of magnetic field, two components of horizontal electric field, the instrumental tilts, and temperature. It mainly consists of one 17-inch glass sphere, sensor unit in aluminium/titanium pressure housing and electrode arm unit with arm holding mechanism (Fig. 4.1.1). The glass sphere involves data logger and a lithium battery pack. The sensor unit has a high-accuracy fluxgate magnetometer, tiltmeter and thermometer. The electrodes are Ag-AgCl equilibrium type made by Clover Tech. For electric field, four voltage differences between the electrodes on the tip of the pipes and the ground electrode are measured. The electrodes were monitored their self-potentials in laboratory in advance of the seafloor observation and pairs that the coherence is high enough were selected, in order to reduce the noise due to the voltage drift of electrodes themselves. A transponder unit, radio beacon and a flashlight are also mounted on the OBEM. The acoustic system can communicate with the SSBL system and it is easy for us to detect its position in the sea or on the seafloor. There are a transponder unit mounted on the OBEM system. This transponder unit, of which the acoustic and the pressure case units are combined, has a 2-year battery life.

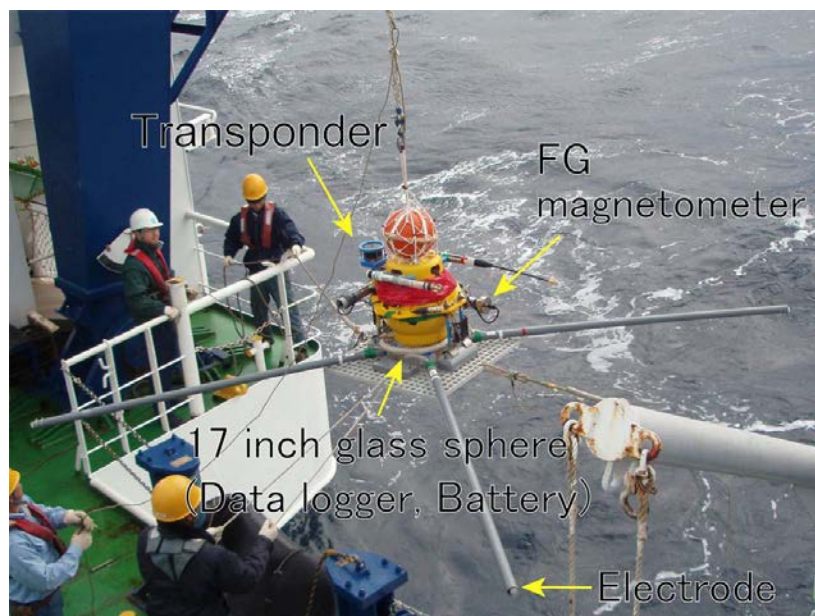


Fig. 4.1.1 OBEM system

Concepts of the type the OBEM system are miniaturization, a high sampling rate, easy assembly and recovery operations, and low costs of construction and operation. The arm holding mechanism, which electrode arm is folded when OBEM is in surfacing (Fig. 4.1.2), enable recovery

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

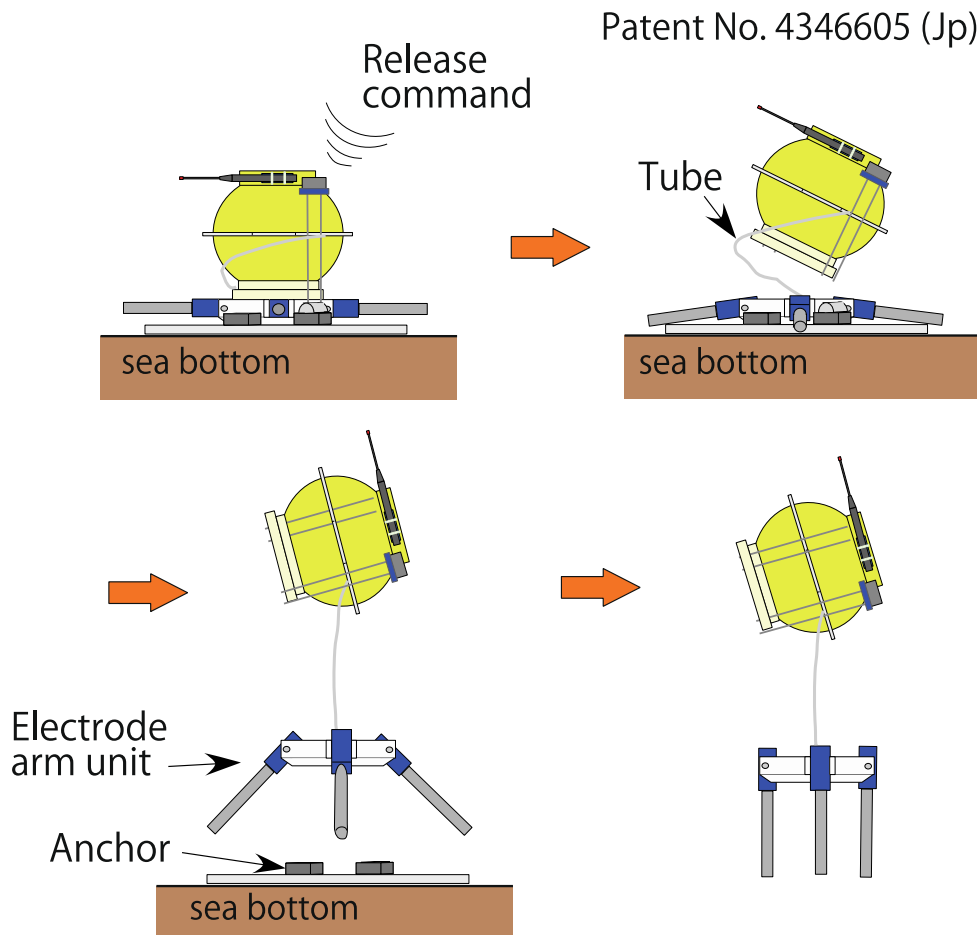


Fig. 4.1.2 Electrode arm-holding mechanism of type A OBEM

References

- Kasaya, T., T. Goto, and R. Takagi, Marine electromagnetic observation technique and its development –For crustal structure survey-, *BUTSURI-TANSA*, **59**, 585-594 (in Japanese with English abstract), 2006.
- Kasaya, T., and T. Goto, A small OBEM and OBE system with an arm folding mechanism, *Exploration Geophysics*, **40**, 41-48, 2009.

4.2 Ocean bottom electrometer (OBE)

The OBE system is originally designed for the controlled source survey with over 500 Hz sampling. An electric circuit and battery are involved in one cylinder type aluminum pressure case. In this cruise, we loaded this OBE in an AUV YUMEIRUKA. Figure 4.2.1 shows the configuration of the self-potential survey to detect some signal of the hydrothermal deposit, and this electrode array were towed from the tail of an AUV.

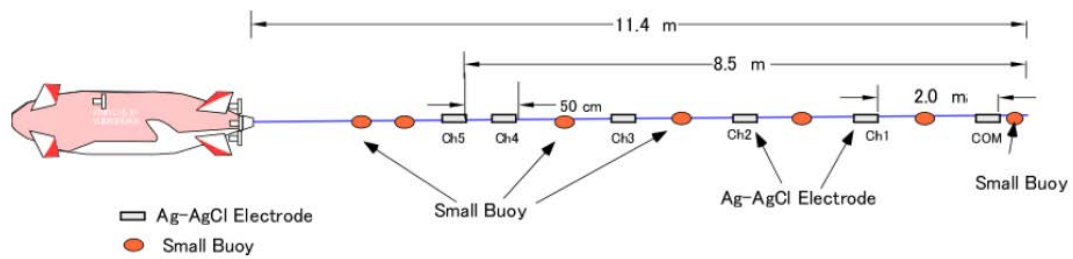


Fig. 4.2.1 Configuration of the electrodes on an AUV YUMEIRUKA.

4.3 AUV YUMEIRUKA

Autonomous Underwater Vehicle (AUV) YUMEIRUKA has a streamline shape to reduce hydro resistance, and its body is covered with thin FRPs. Four 400 Watts direct driver thrusters were attached at rear. Two pairs of X-rudders are mounted on the bow and the stern to control the stable vehicle attitude. The AUV navigation consists of two sub-system, INS (Inertial Navigation System) and DVL (Doppler Velocity Log) with 600 kHz, and an AUV can be navigated under the DVL-INS hybrid navigation program. This vehicle was equipped some scientific instruments (Table 4.3.1). she also has some payload space to load some auxiliary instruments on.

Table 4.3.1 The general specifications of YUMEIRUKA

Length	5.0 m
Width	1.2 m
Height	1.2 m
Weight	2.7 tons (in Air)
Maximum operation depth	3,000 m
Speed	Cruising typically 2 knots
Positioning	Inertial Navigation System Doppler Velocity Log SSBL
Operation Mode	Autonomous Remote (Acoustic / Optical)
Observation sensor	SAS, CTD, Turidity, pH

5. Operation report

5.1 Pop-up type OBEM operations

For characterization a regional structure including some calderas with hydrothermal activity, Magneto-telluric data using an OBEM is very useful. In this cruise, OBEMs were launched using an articulated crane for all stations (Fig. 5.2.1), and they sunk by their own weights. The operations were quick and smooth. We tracked the OBEMs by acoustic signals and confirmed that they were successfully settled on the seafloor. Then, each position was determined by the SSBL system equipped on the R/V Yokosuka (Fig. 5.2.2, Table 5.2.1). All OBEMs will be recovered in the KM18-02C cruise.

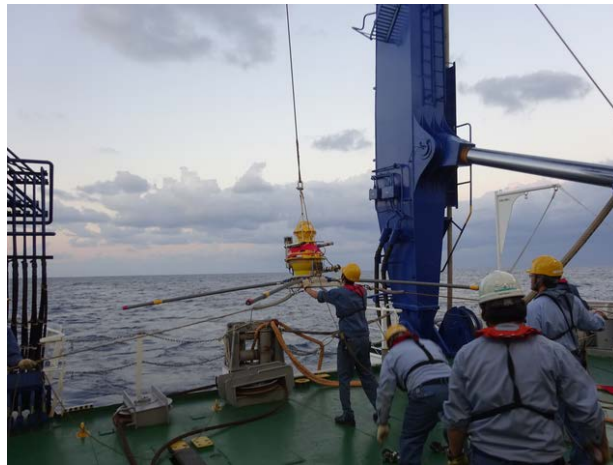


Figure 5.2.1 Photo of the OBEM deployment.

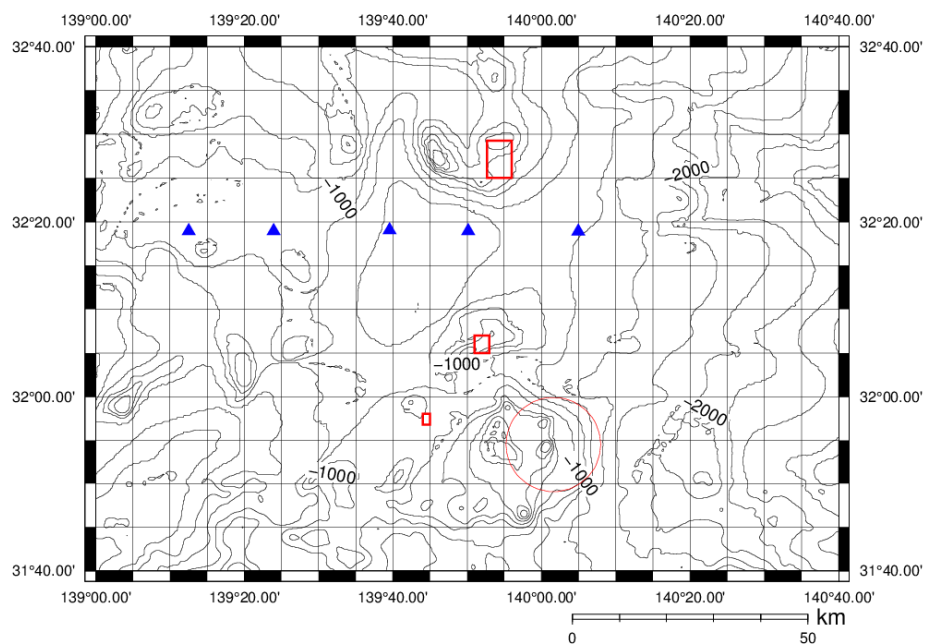


Figure 5.2.2 Site map of deployed OBEMs.

Table 5.2.1 Information of the OBEMs.

site ID	OBEM ID	Deployed time (JST)	Deployed Latitude	Deployed Longitude	Landed time (JST)	Landed Latitude	Landed Longitude	OBEM Depth
OBEM 1	JM402	2017/12/14 16:42:01	32-18.7811N	139-12.4011E	2017/12/14 17:15:03	32-18.9742N	139-12.5234E	1707m
OBEM 2	JM109	2017/12/10 18:51:47	32_18.7886N	139_23.7933 E	2017/12/10 19:12:40	32-18.9797N	139-23.9546E	1065 m
OBEM 3	JM406	2017/12/14 12:37:06	32-18.7231N	139-39.4545E	2017/12/14 14:09:24	32_19.0606 N	139_39.5512 E	1767m
OBEM 4	JM404	2017/12/10 16:03:54	32_18.7830N	139_49.7630 E	2017/12/10 16:34:48	32_18.9407 N	139_50.1200 E	1423 m
OBEM 5	JM401	2017/12/10 6:35:33	32_18.7720N	140_04.7651 E	2017/12/10 7:05:51	32_18.9237 N	140_04.9704 E	1376 m

5.2 AUV YUMEIRUKA dives

To examine the communication from an ASV and an AUV YUMEIRUKA, we used an acoustic buoy with the acoustic, VHF and wireless LAN communication system which are equipped on an ASV (Fig. 5.2.1). This buoy was towed from the tail of mother ship in this cruise and a vehicle was monitored by this buoy. These examinations using this buoy were carried out in two trial dives at Sagami Bay (Figure 5.2.2 and 5.2.3). Figure 5.2.4 shows the dive tracks of first practical dive of an AUV YUMEIRUKA carried out in the caldera structure with hydrothermal activity at off Aoga-shima. All operation were done smoothly and data acquisitions of the self-potential, bathymetric data and some chemical sensors were successfully. Around a active mound week anomaly of self-potential was found.

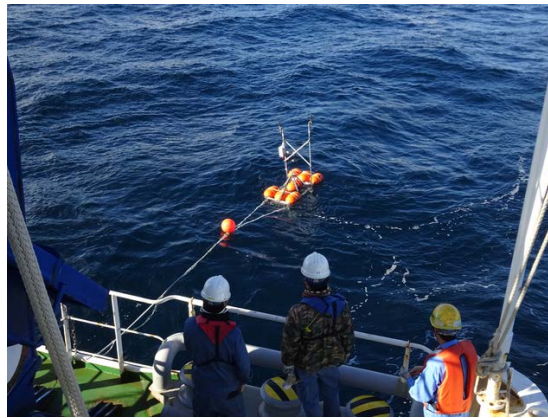


Fig. 5.2.1 Photo of an acoustic buoy towed from the mother ship.

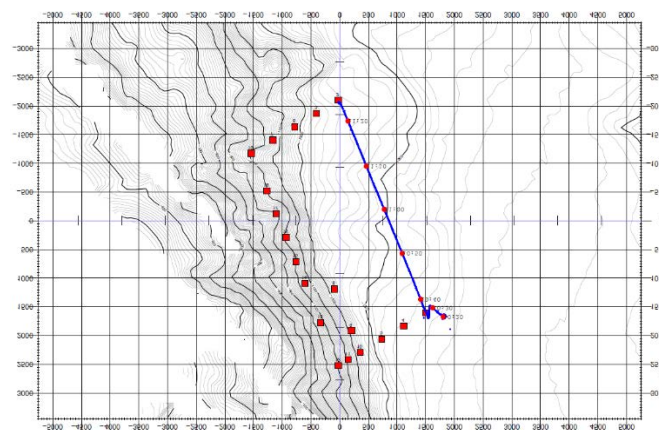
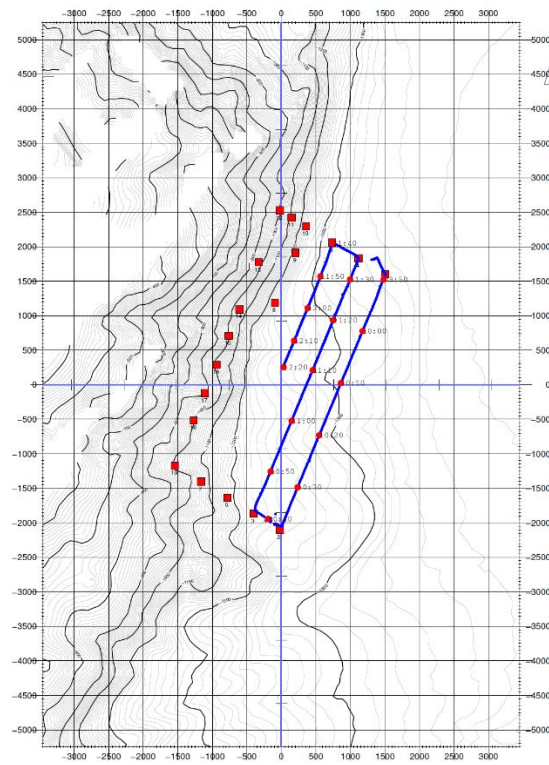


Fig. 5.3.2 Dive tracks of first trial dive of AUV YUMEIRUKA at Sagami Bay.



Appendix

Research Vessel YOKOSUKA

R/V YOKOSUKA is designed serve as the mother vessel for SHINKAI 6500 and Autonomous Underwater Vehicle (AUV) URASHIMA. It has silent engine, an advanced acoustic navigation systems and an underwater telephone for its state of the art operations. There are 5 laboratories on Yokosuka, No.1-No.4 laboratories and No.1 Study room. No.1 Lab. has dry space. The permanent installations are a video editing system, a PC and a printer. No.2 Lab. has semi-dry and wet space. There are two freezers (-40 & -80 deg.C), a incubator, a Milli-Q, and a fumigation chamber at dry one, and wet one has a rock saw. No.3 Lab. has dry space with storage. No.4 Lab. has semi-dry and wet space. No.1 Study room has dry space, there are a gravity meter, a data acquisition system of gravity meter, a 3 axis fluxgate magnet meter and also a proton magnet meter, a work station for data processing, and a A0 size plotter.

The general specifications of R/V YOKOSUKA

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
Main propulsion system	Diesel engines 2,206kW x 2
Main propulsion method	Controllable pitch propeller x 2

Complement

Crew	28 persons
Submersible operation staff	8 persons
Researchers	6 persons
Total 52 persons	

R/V YOKOSUKA MBES / magnetometers / gravity meter

YOKOSUKA is equipped with various kinds of underway geophysical equipment, a multi narrow beam echo sounder (EM122, Kongsberg Maritime, Inc.), a gravity meter (Type S-63, LaCoste & Romberg Gravity Meters Inc.), a portable gravity meter (Type CG-5, SCINTREX Limited), a ship borne 3 axis magnet meter (Type SFG-1212, Tierra Technica Inc.), and a proton magnet meter (Type STC 10, Kawasaki Geological Engineering Co., Ltd.). The specifications of these instruments are listed below.

The specifications of EM122

Measurement depth (m)	20 ~ 11,000
Measurement frequency (kHz)	12
Measurement method	cross fan beam style
Beam numbers	288
Mesurement point	432
Pulse lengths	2/5/15msec CW(∼2000m) 100msec FM(2000m∼)
Beam width (deg.)	2
Beam interval (deg.)	2
Swath width (deg.)	150 (Max)
Sampling rate (msec.)	0.33
Roll (deg.)	±15
Pitch (deg.)	±10
Yaw (deg.)	±10

The specifications of Gravity meter

Measurement range (m Gal)	12,000
Drift	3mGal per month or less
<u>Stabilized platform</u>	
Platform pitch(deg.)	±22
Platform roll(deg.)	±25
Platform period(min.)	4 to 4.5
Beam interval(deg.)	1
<u>Control system</u>	
Recording rate(Hz)	1
Serial out put	RS-232

System performance

Resolution (mGal)	0.01
Static repeatability (mGal)	0.05
50,000m Gal horizontal acceleration (mGal)	0.25
100,000m Gal horizontal acceleration (mGal)	0.50
100,000m Gal vertical acceleration (mGal)	0.25
Dimension (cm)	71×56×84
Weight (kg)	Meter:86, UPS:30

The specifications of Portable Gravity meter

Sensor Type:	Fused Quartz using electrostatic nulling
Reading Resolution:	1 microGal
Standard Field Repeatability:	<5 microGal
Operating Range:	8,000 mGal without resetting
Residual Long-Term Drift:	Less than 0.02 mGal/day (static)
Automatic Tilt Compensation:	±200 arc sec
Tares:	Typically less than 5 microGals for shocks up to 20 G
Automated Corrections:	Tide, Instrument Tilt, Temperature, Drift, Near Terrain, Noisy Sample, Seismic, Noise Filter
Operating Temperature:	-40°C to +45°C (-40°F to 113°F)
Ambient Temperature Coefficient:	0.2 microGal/°C (typical)
Pressure Coefficient:	0.15 microGal/kPa (typical)
Magnetic Field Coefficient:	1 microGal/Gauss (typical)
Memory:	Flash Technology (data security)
Dimensions (cm) :	30 cm (H) x 22 cm x 21 cm (12" (H) x 8.5" x 8")
Weight (including batteries):	8 kg (17.5 lbs)
Battery Capacity:	2 x 6.6 Ah (11.1 V) rechargeable Lithium-Ion Smart Batteries. Full day operation in normal survey conditions with two fully charged batteries
Power Consumption:	4.5 W at +25°C (77°F)
Standard System:	CG-5 Console, Tripod base, 2 rechargeable batteries, Battery Charger 110/240 V, External Power Supply 110/240 V, RS-232 and USB Cables, Carrying Bag, Data dump and utilities software, Operating Manual (CD), Transit Case

The specifications of 3 axis magnet meter

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

The specifications of Proton magnet meter

Measurement range (nT)	$3 \sim 7 \times 10^{**4}$
Resolution (nT)	0.01
Sampling rate	10sec, 20sec, 1min, manual, external
Time of applying field(sec.)	3 to 10
Sensor dimension (mm)	φ200×1050
Weight (kg)	28.6(in the air), 6.2(in the sea)