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R/V Yokosuka Cruise Report

YK22-13S

Understanding of pore fluid distribution around subducting seamounts in the Hyuga-nada area based on ocean bottom electromagnetic surveys

Hyuga-nada
July 25, 2022 – July 30, 2022

Contents

1. Cruise Information

Cruise ID: YK22-13S

Name of vessel: S/V Yokosuka

Chief scientist / Representative of Science Party:
Hiroshi ICHIHARA [Nagoya University]

Title of the cruise/ Title of proposal:
S22-34 “Understanding of pore fluid distribution around subducting seamounts in the Hyuga-nada area based on ocean bottom electromagnetic surveys”

Cruise period: July 25, 2022 – July 30, 2022

Ports of call:

July 25	Dept. from Yokosuka (JAMSTEC)
July 30	Arriv. at Yokosuka (JAMSTEC)

Research area: Hyuga-nada

2. Researchers and Crews

Science Party:

Hiroshi ICHIHARA	Nagoya University
Takafumi KASAYA	JAMSTEC
Tadanori GOTO	Hyogo University
Yusuke OHTA	Nagoya University
Singh Kumar ROSHAN	The University of Tokyo
Ayako ODA	Hyogo University
Manaka KURODA	Hyogo University
Noriko Tada (non-boarding)	JAMSTEC

Technical Support Staff:

Hisanori IWAMOTO	Nippon Marine Enterprises, Ltd.

Ship Crews:

Yoshiyuki NAKAMURA	Captain
Tetsuo SHIRAYAMA	Chief Officer
Tomonari KAJISA	2nd Officer
Daisuke MORIYA	3rd Officer
Riku MATSUDA	Jr.3rd Officer
Shinichi IKUTA	Chief Engineer
Kota FUJII	1st Engineer
Kazuki ONO	2nd Engineer
Kohshun IKEZAKI	3rd Engineer
Kazunami MATSUMOTO	Jr.3rd Engineer
Tokinori NASU	Chief Electronic Op.
Ryuji ONIKUBO	2nd Electronic Op.
Kohei MAEDA	3rd Electronic Op.
Yosuke KUWAHARA	BoatSwain
Tsuyoshi CHIMOTO	Quarter Master
Nao ISHIZUKA	Quarter Master
Hotaka HONJO	Quarter Master
Toshiya SAGA	Quarter Master
Takumi MIURA	Quarter Master
RYO NAKANISHI	Sailor
Takuto MIYAKE	Sailor
Junji MORI	No.1 Oiler
Masayuki FUJIWARA	Oiler
Tamaki FUJISHIMA	Assistant Oiler
Masakazu ISHIDA	Assistant Oiler
Yutaro ONO	Assistant Oiler
Syuki KIBE	Assistant Oiler
Kazuhiro HIRAYAMA	Chief Steward
Tsuyoshi NAGATOMO	Steward
Kanjiro MURAKAMI	Steward
Mizuki NAKANO	Steward
Yuki SHIRASAKI	Steward

3. Observation

3.1 Summary of Observations

3.1.1 Recovery of OBEM

We recovered the Ocean Bottom Electromagnetometer (OBEM) (JM106) at site NU14, using the shipboard SSBM system to release anchor weights and track the position. The recovered OBEM recorded electromagnetic field data of good quality.

3.1.2 Deployment of OBEM

We deployed four OBEMs, namely JM406, KB303VT, JM402, and KB302VT, at sites NU28, NU22, NU21, and NU25, respectively. The Yokosuka SSBM system was used to determine the settled positions of JM402 and JM406, while a researcher's acoustic transducer system was used to determine the settled positions of KB303VT and KB302VT.

3.1.3 MBES and STCM surveys

A Multibeam Echosounder (MBES) survey was conducted to image the bathymetry around the OBEM sites, as the local bathymetry strongly affects the electromagnetic data. Shipboard Three Component Magnetometer (STCM) survey was also carried out to elucidate the distribution of subducting seamounts. These surveys were mainly conducted at night.

Table 3-1 Cruise schedule and operations

Date	Events, Operations
July 25	Departure from the JAMSTEC Yokosuka port
July 26	Deployment of an OBEM at site NU28 MBES/STCM survey
July 27	Recovery of an OBEM at site NU14 Deployment of OBEMs at site NU22 and 21 MBES/STCM survey
July 28	Deployment of an OBEM at site NU25 MBES/STCM survey
July 29	Transit to Yokosuka, JAMSTEC
July 30	Arrived at Yokosuka, JAMSTEC

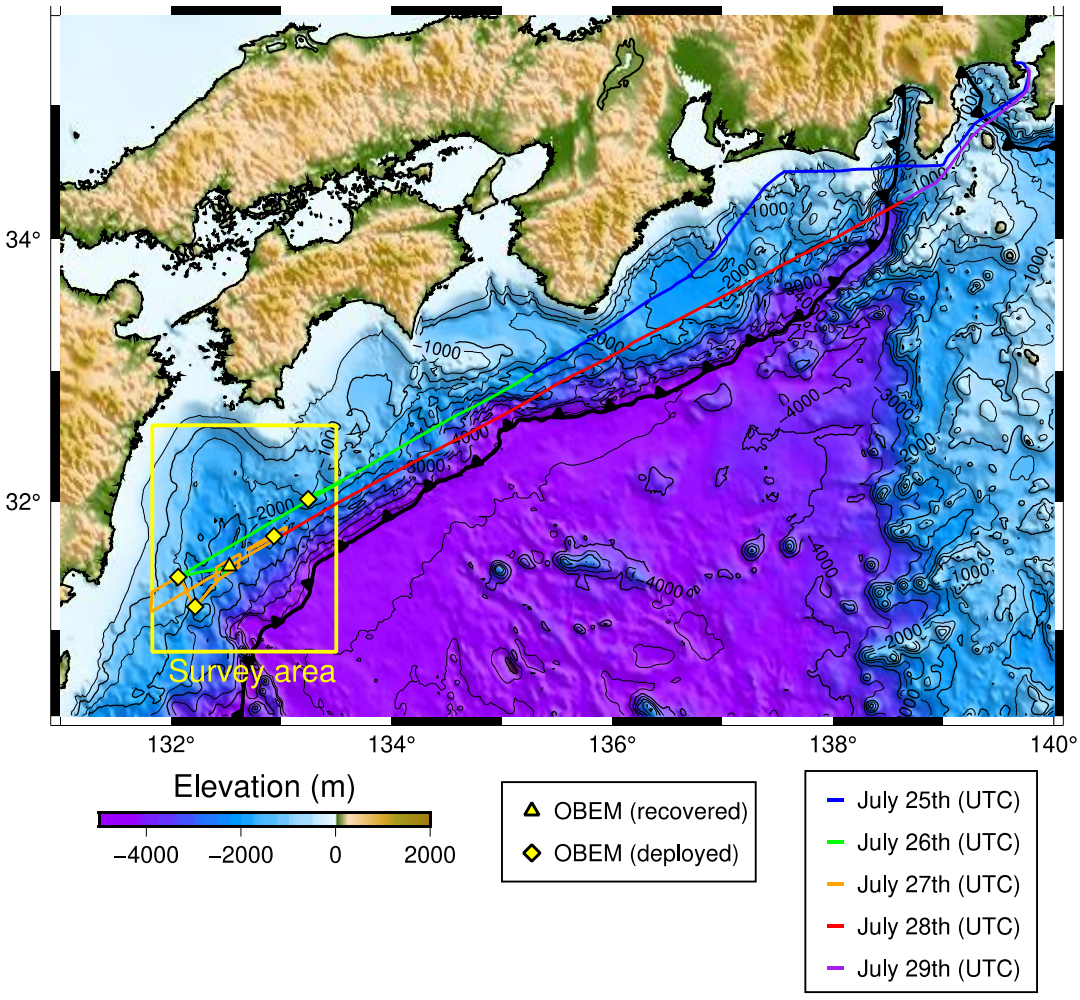

Figure 3-1 Ship track and observation sites of YK22-13S

3.2 Research Objectives

The Hyuga-nada area is an ideal research field for studying fault ruptures because various types of fault slips occur, such as fast fault ruptures (regular earthquakes), slow slips, tremors, and very low frequency earthquakes (Figure 3-2-1). Previous ocean bottom electromagnetic surveys revealed low resistivity zones in the slow earthquake areas and a high resistivity zone in the regular earthquake areas, indicating that pore fluids play a significant role in the fault rupture processes (Figure 3-2-2). We hypothesized that the pore fluid was brought from subducting seamounts. To demonstrate this hypothesis, we conducted ocean bottom electromagnetic and geomagnetic surveys during this research cruise.

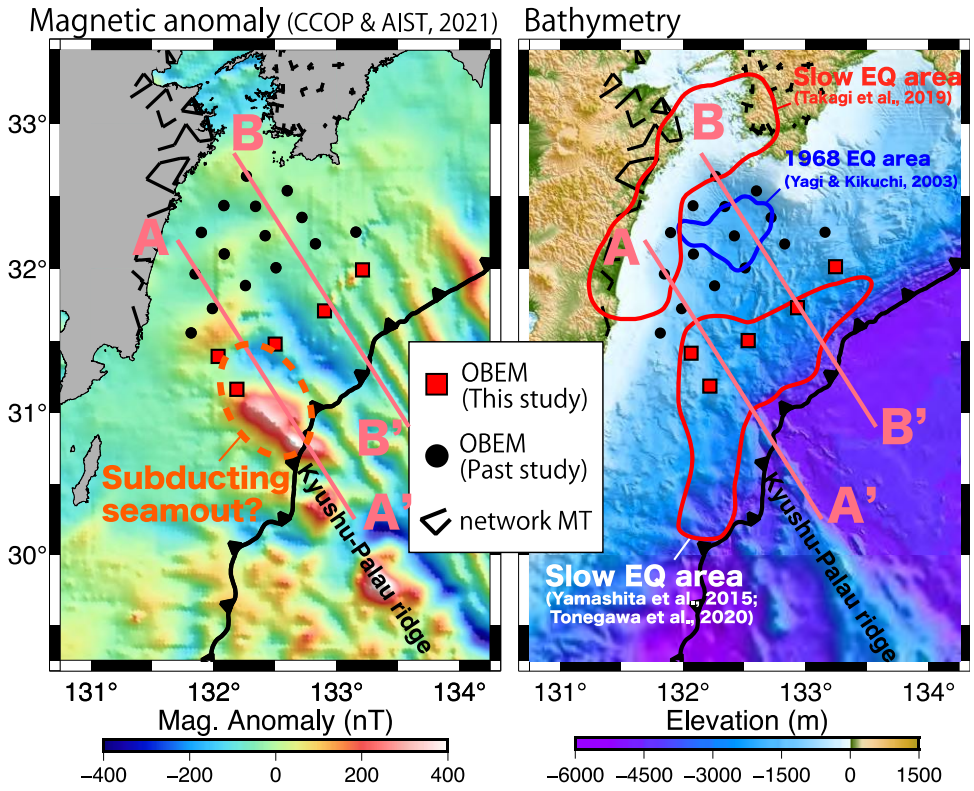

Figure 3-2-1 Magnetic anomaly and bathymetry with OBEM locations.

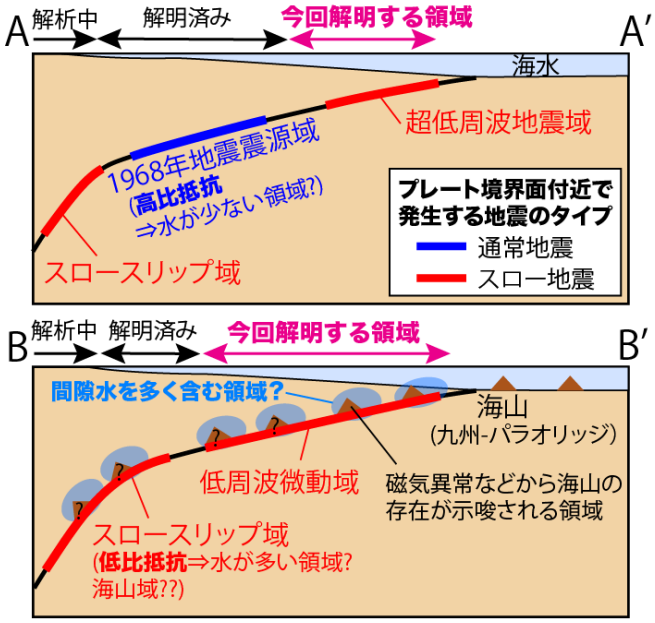

Figure 3-2-2 Schematic illustration for research objective. Locations of the section are shown in Figure 3-2-1.

3.3 Instruments (Ocean bottom electro-magnetometer: OBEM)

We utilized OBEM to measure time variations of three magnetic field components, horizontal electric field, instrumental tilts, and temperature. Three types of OBEMs were used in this study (series JM100, JM400 and KB300VT). Their common specifications are as follows. The high-accuracy fluxgate (FG) magnetometer was used to measure the three-component magnetic field. Sensor units (the FG sensor, tiltmeter and thermometer) and data logger are manufactured by Tierra Technica Co. For electric field, four components of voltage differences between tips of pipes and ground settled around the center of OBEM were measured. To reduce noise due to voltage drift of the electrodes, the electrodes' self-potentials were monitored in the laboratory before the cruise, and pairs with low voltage difference were selected. A transponder unit, radio beacon, and flashlight were also installed on the OBEM.

3.3.1 series JM100

The OBEM "Series JM100" primarily consists of a 17-inch glass sphere, a sensor unit in a titanium pressure housing, and an electrode arm unit (Fig. 3-3-1, Kasaya and Goto, 2009). The glass sphere contains a data logger and a lithium battery pack, while the titanium pressure housing contains the sensor unit (fluxgate sensor, tilt meter, and thermometer). The arm holding mechanism folds the electrode arm when the OBEM surfaces, making recovery operation easier (Fig. 3-3-2). The transponder unit uses a JX acoustic communication system. In this cruise, we retrieved the OBEM JM106 owned by JAMSTEC.

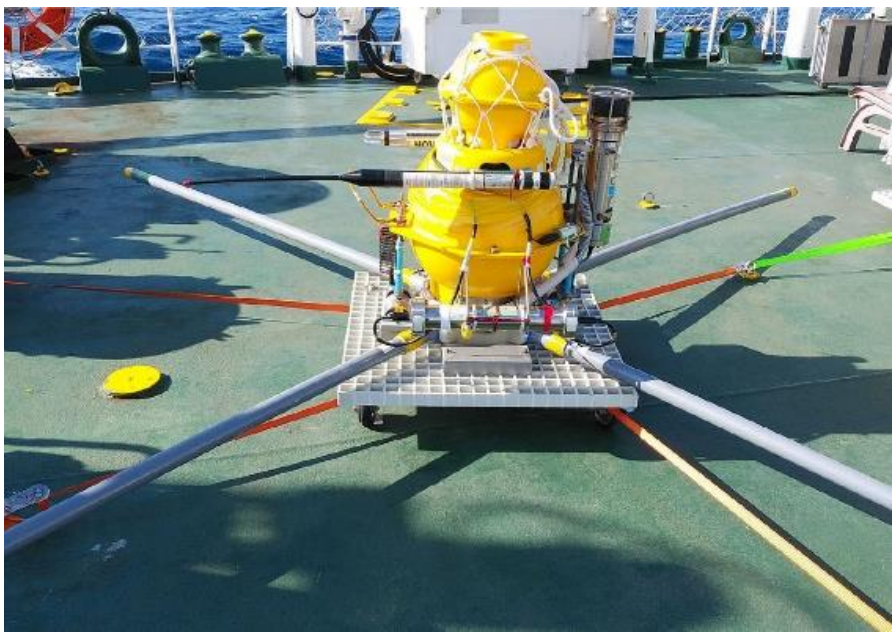

Fig. 3-3-1 OBEM (series JM100)

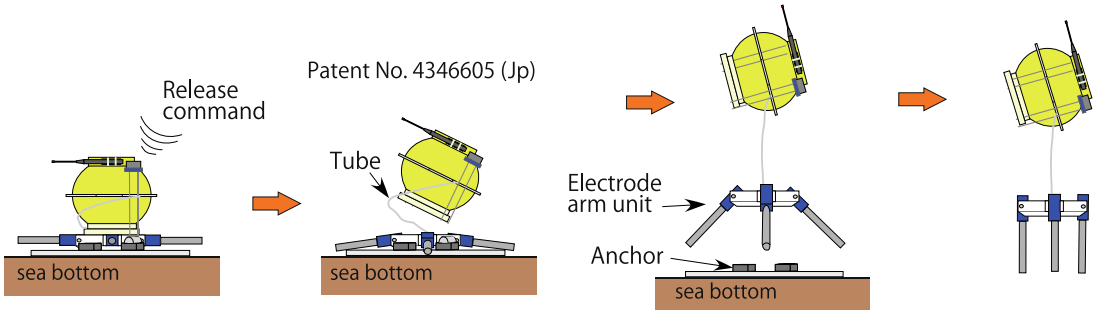

Fig. 3-3-2 Electrode arm-holding mechanism of the OBEM system

3.3.2 Series JM400

"Series JM400" OBEMs consist of three titanium housings for a data logger, battery, and acoustic transponder, one plastic housing for the sensor unit, and four glass spheres for flotation (Fig. 3-3-3). The sensor unit is held in the plastic housing, while the other units are held in titanium housings. The arm-holding mechanism of the JM100 series is adopted (Fig. 3-3-2). The transponder unit uses the JX acoustic communication system. In this cruise, we deployed OBEMs JM402 and JN406 owned by JAMSTEC.

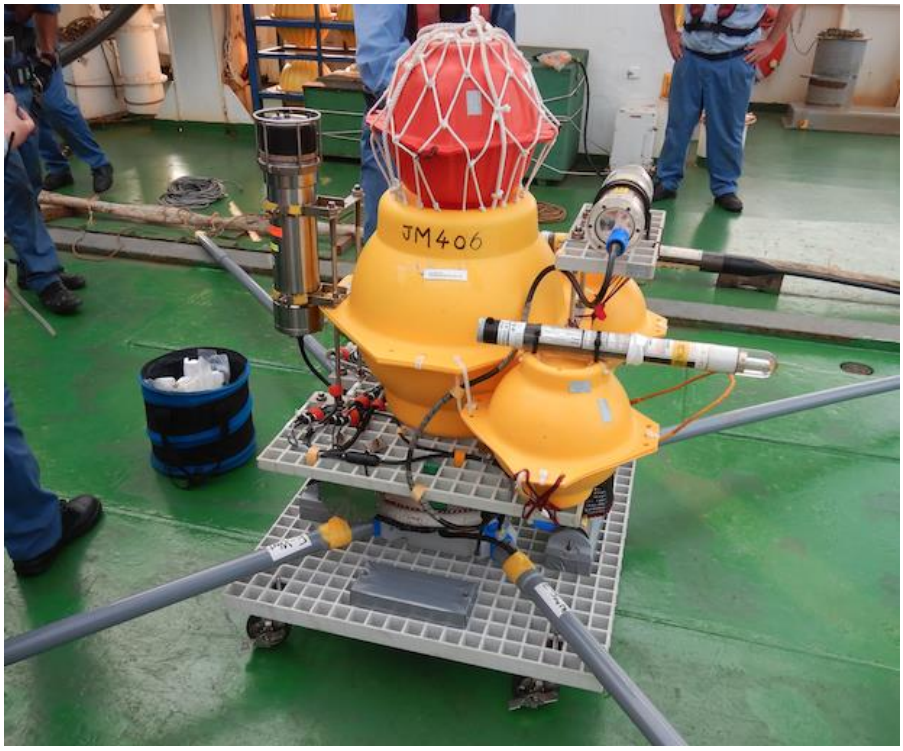

Fig. 3-3-3 OBEM (series JM400)

3.3.3 Series KB300VT

"Series KB303VT" OBEMs mainly consist of two 17-inch glass spheres and a titanium frame (Fig. 3-3-4). One of the glass spheres contains the data logger and sensor unit, while the other sphere contains the battery and acoustic transponder. The transponder unit uses an SI2 system for acoustic communication. During this cruise, we deployed OBEMs KB302VT and KB303VT owned by Nagoya University.

Fig. 3-3-4 OBEM (series KB300VT)

3.4 Operation remarks

3.4.1 Recovery of OBEMs

During the YK21-14 cruise, we retrieved OBEM at site NU14. To release the weight of the OBEM, we used the SSBL system equipped on R/V Yokosuka to send and receive acoustic signals. The OBEM were released in the usual time of 13 minutes, with an ascent rate of 41 m/min (Table 3-4-1). The surfaced OBEM was quickly located with the ship's radio beacon signal and then lifted onto the starboard deck (Fig. 3-4-1). After retrieving the OBEM, we synchronized the clock of each data logger with a laptop PC connected to an NTP server unit that was synchronized with GPS (Table 3-4-2). We then removed the arm-unit, sensor unit, and transponder and checked the condition of the OBEMs. As the retrieved OBEM's battery had run out, we opened the glass spheres and collected the data. The OBEM recorded high-quality time series data.

Table 3-4-1 Recovery information

Site ID	OBEM ID	Arrived time to the site (JST)	Releasing duration (min)	Ascent rate (m/min)	On deck time (JST)
NU14	JM106	22/7/27 6:46	13	41	22/7/27 8:20

Table 3-4-2 Clock information

Site ID	OBEM ID	Clock set time (UTC)	Clock compared time (UTC)	Time difference (OBEM-NTP, sec)
NU14	JM106	2021-08-15T11:29:48	2022-07-28T05:25:52	+59.948
NU21	JM402	2022-07-27T05:38:29	N/A	N/A
NU22	KB303VT	2022-07-27T00:09:24	N/A	N/A
NU25	KB302VT	2022-07-27T22:07:01	N/A	N/A
NU28	JM406	2022-07-26T07:35:26	N/A	N/A

Fig. 3-4-1 Recovery of the OBEM (JM106)

Table 3-4-3 Positioning information of OBEMs

Site ID	OBEM ID	Pipe length for electrode (m)	settled position		Sea depth (m)
NU14	JM106	2.0	31:29.9155N	132:31.8977E	2645*
NU21	JM402	2.5	31:24.9306N	132:04.0312E	1232*
NU22	KB303VT	4.0	31:11.1046N	132:13.2369E	1957**
NU25	KB302VT	4.0	31:43.9314N	132-56.0870E	2392*
NU28	JM406	2.5	32:00.9789N	133:14.7598E	1575*

* based on MBES data in this cruise **based on calibration data

Table 3-4-3 Deployment information of OBEMs

Day	released time (JST)	Site name	OBEM ID	T/P ID	T/P code	Beacon ID	Beacon code	Flasher ID	Falling rate (m/min)
7/26	18:45	NU28	JM406	JX1191	6A-1	S12-03	JS1365	F02-023	48
7/27	10:49	NU22	KB303VT	SI2 304	SI2 304	G01-045	JS206	G01-047	30.1
7/27	15:42	NU21	JM402	JX1277	5F-1	D02-002	JS2000	F02-019	50
7/28	8:25	NU25	KB302VT	SI2 303	SI2 303	H01-006	JS208	G01-046	29

3.4.2 Deployment of OBEM

We deployed four OBEMs (Figure 3-1, Table 3-4-3) during this cruis. Specifications such as acoustic code, beacon frequency, and electric dipole length are listed in Table 3-4-4. The clocks of the OBEMs were synchronized with GPS before deployment (Table 3-4-2). We used the A-frame to launch the OBEMs from the stern of the ship and tracked the slant range to the OBEMs using the acoustic communication systems. After confirming to land the OBEMs on the seafloor, we measured their settled positions using the SSBL system of R/V Yokosuka (sites NU21 and NU28) and an acoustic transponder unit brought by researchers (sites NU22 and NU25). In the latter positioning, we measured the distances from the ship to the OBEMs from three directions. We then estimated the settled positions based on the distances using the least-squares method (Figure 3-4-3 and 3-4-4).

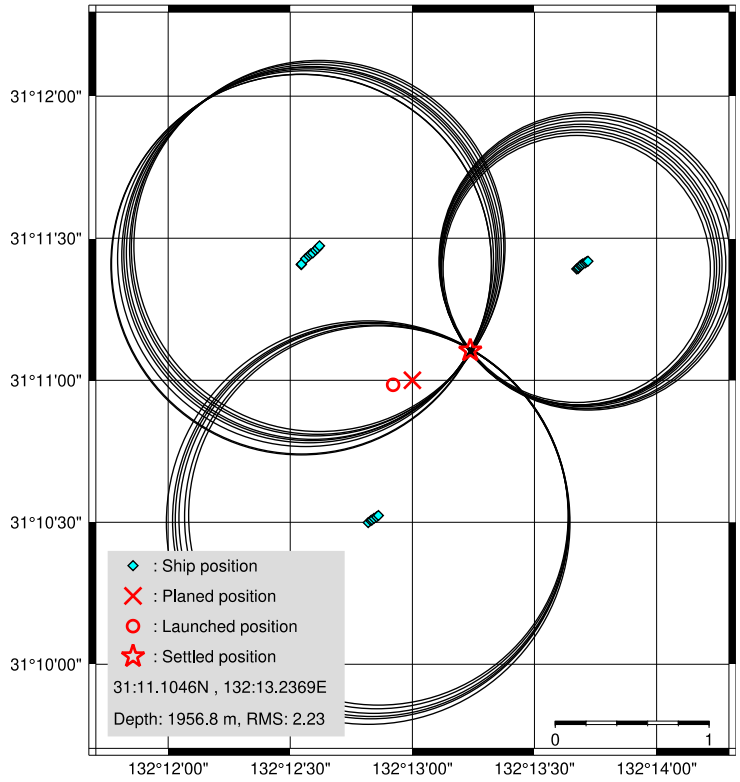

Figure 3-4-2 Calibration of NU22

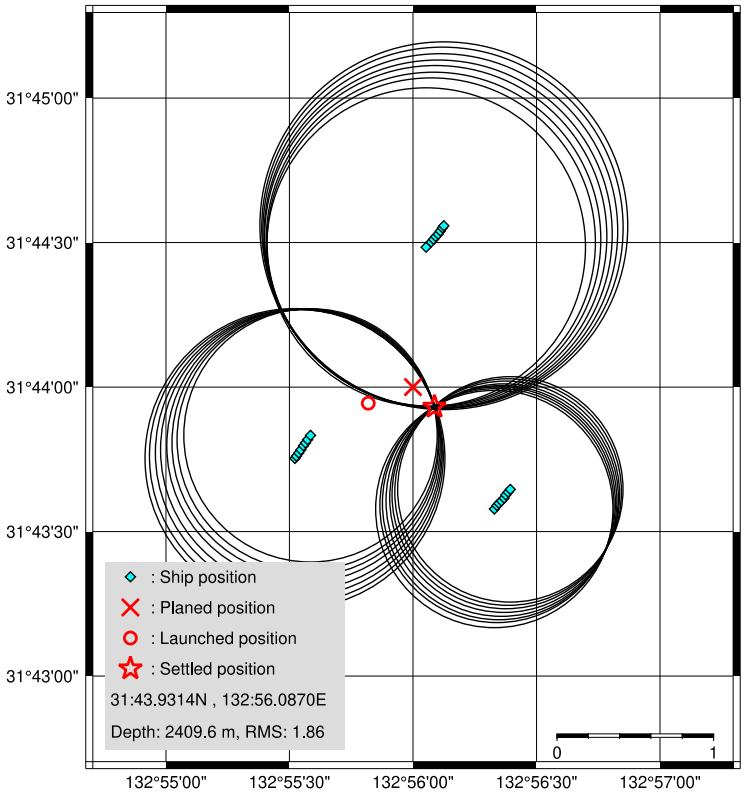

Figure 3-4-3 Calibration of NU25

3.4.3 MBES/STCM survey

To obtain detailed bathymetric data, a multi-beam echo sounder (MBES) survey was carried out using the EM122 system (Kongsberg Maritime, Inc) equipped on R/V Yokosuka. The detailed geometry of the interface between conductive seawater and more resistive underground is essential to model resistivity distribution accurately. The obtained data were calibrated based on the velocity data from expendable bathythermographs that were injected before the MBES survey. As a result, detailed bathymetric data were obtained around the OBEM sites, except for NU22 (Fig. 3-4-4 and 3-4-5).

During the cruise, a shipboard three-component magnetic (STCM) survey was also carried out. To calibrate the STCM data, the Yokosuka conducted the "8-Figure turn" three times during the MBES survey to acquire calibration data.

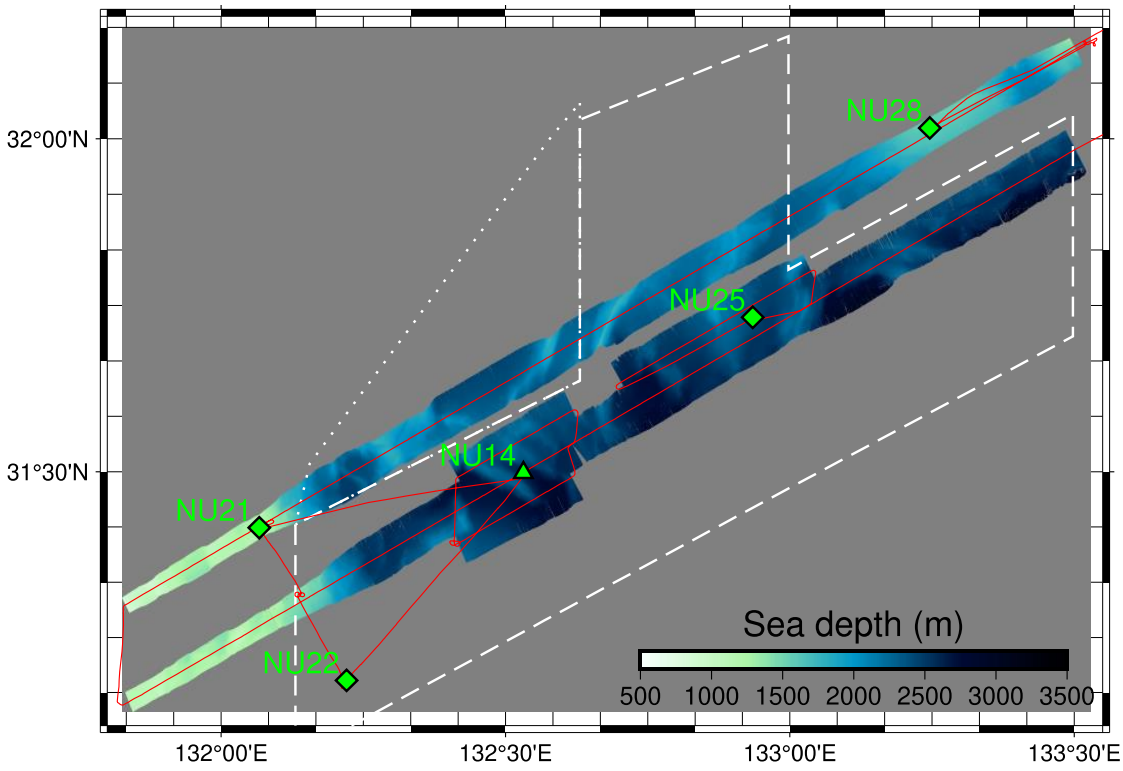

Figure 3-4-4 Bathymetric map based on the MBES survey. White dashed and dotted lines denote US Navy training area "Lima area" and JMSDF training areas, respectively.

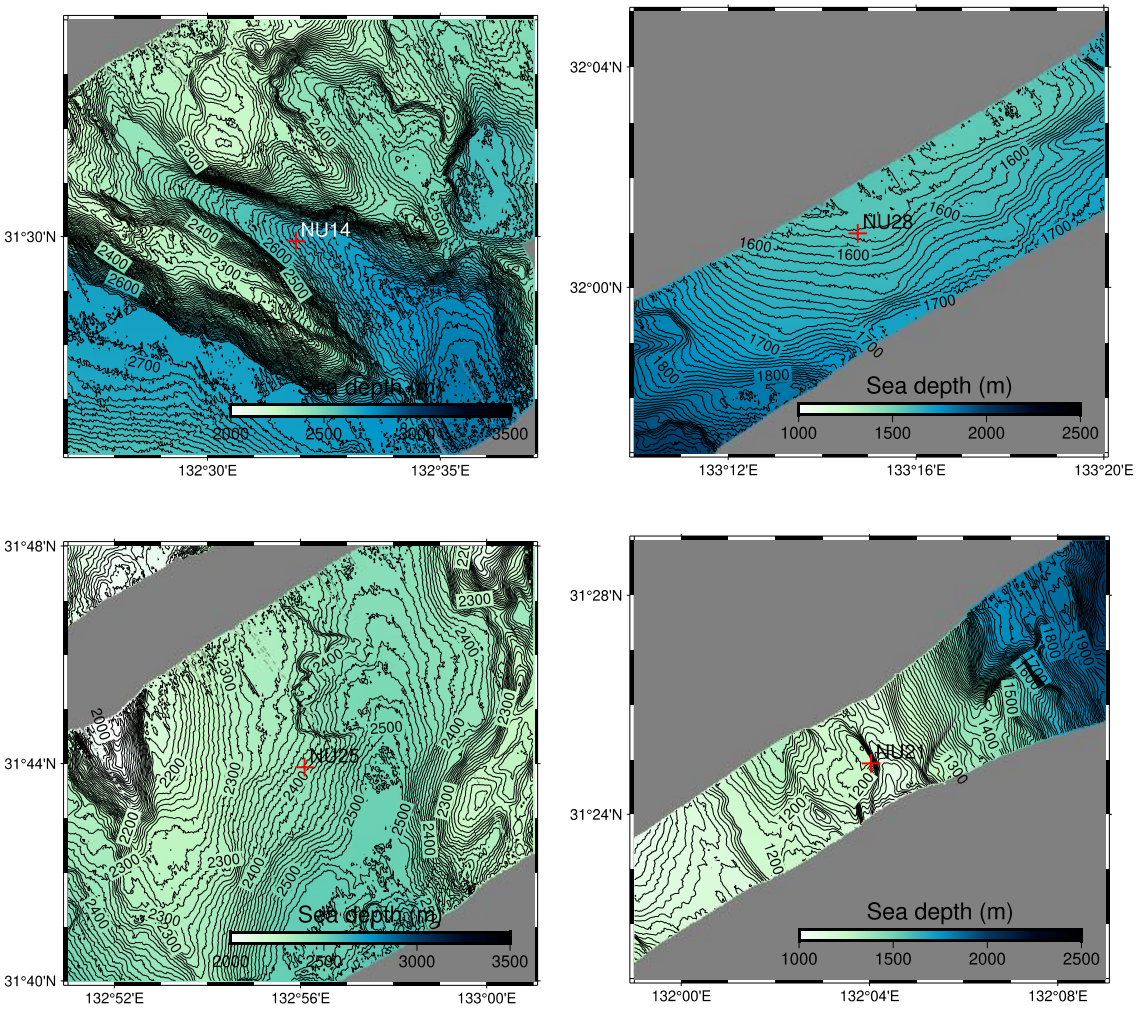

Figure 3-4-5 Detailed bathymetric map around the OBEM sites based on the MBES survey.

4. Notice on Using

This cruise report is a preliminary documentation as of the end of cruise.
This report is not necessarily corrected even if there is any inaccurate description (i.e. taxonomic classifications). This report is subject to be revised without notice. Some data on this report may be raw or unprocessed. If you are going to use or refer the data on this report, it is recommended to ask the Chief Scientist for latest status.
Users of information on this report are requested to submit Publication Report to Cooperative Research Cruise office.

E-mail: kyodoriyo@aori.u-tokyo.ac.jp

5. Acknowledgements

We are grateful to Captain Nakamura and the crews of the R/V Yokosuka for skillful operations of the ship and research equipment. We also thank to Dr. H. Iwamoto for great assistance in research works throughout the cruise. Generic Mapping Tools software (Wessel and Smith, 1998) was used to draw some of the figures. Prof. K. Baba, the University of Tokyo provided us the software for calibration of OBEM location.

6. References

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Appendix: Cruise log

Date	Local Time	Note	Position/Weather/Wind/Sea condition
25-Jul-22	08:00	Scientists onboarded.	12:00 (UTC+9h)
	09:00	Let go all share line and left YOKOSUKA for research area.	34-54.8N,139-22.6E
	10:00-10:30	Carried out education and training for scientists.	Southeast of Oshima
	10:40-11:00	Practiced fite,water proof and life boat station drill.	Weather:bc
	18:00-18:50	scientist meeting	Wind:SSE-4
			Wave scale:3
			Swell scale:2
			Visibly: 7
26-Jul-22	02:00-02:20	Eight figure turns.	12:00 (UTC+9h)
	17:40-19:30	Deployed and position calibration OBEM NU 28.	32-39.3N,134-34.5E
	18:00	Arrived at reserch area.	Southern part of off Muroto
	18:05	Relesed XBT.	Weather:bc
	20:40-21:00	Eight figure turns.	Wind:North-2
	21:17-	MBES survey.	Wave scale:2
			Swell scale:2
			Visibly: 7'
27-Jul-22	-04:40	MBES survey.	12:00 (UTC+9h)
	06:55-08:30	Recovered OBEM NU14.	31-10.5N,132-12.7E
	08:30-13:00	Deployed and position calibration OBEM NU22.	Hyuganada
	14:00-16:30	Deployed and position calibration OBEM NU21.	Weather:bc
	16:12-	MBES survey.	Wind:East-4
			Wave scale:3
			Swell scale:2
			Visibly: 7'

Cruise log (continued)

Date	Local Time	Note	Position/Weather/Wind/Sea condition
28-Jul-22	-06:50	MBES survey.	12:00 (UTC+9h)
	06:45-10:30	Deployed and position calibration OBEM NU25.	31-51.0N,133-14.2E
	11:02-13:12	MBES survey.	Hyuganada
	13:12	Left reserch area.	Weather:bc
			Wind:East-4
			Wave scale:3
			Swell scale:3
			Visibly: 7'
29-Jul-22		Transit to Yokosuka	12:00 (UTC+9h)
	15:40	Let go anchor Yokosuka No.4.	34-45.4N,139-14.9E
			West of Ohima
			Weather:bc
			Wind:SSW-3
			Wave scale:2
			Swell scale:2
			Visibly: 8'
30-Jul-22	08:00	Heave anchor, proceeded to JAMSTEC.	
	08:50	Arrived at JAMSTEC. Finished YK22-13S cruise.	