



R/V Yokosuka “Cruise Report”

YK14-15

High resolution geophysical mapping and single channel
seismic survey of mud volcanoes off Tanegashima

Aug. 9 - 21, 2014

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

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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.

1. Cruise Information

- Cruise ID: YK14-15
- Name of vessel: R/V Yokosuka
- Title of the cruise: High resolution geophysical mapping and single channel seismic survey of mud volcanoes off Tanegashima
- Title of proposal: High resolution topographical and geological mapping survey of mud volcanoes off Tanegashima, southwestern Japan.
 - Implication for research on the potential of huge hydrocarbon resources -
- Cruise period: 9 Aug 2014 - 21 Aug 2014
- Ports of call: from Ishigaki to Naha
- Research area: Off Tanegashima
- Research Map

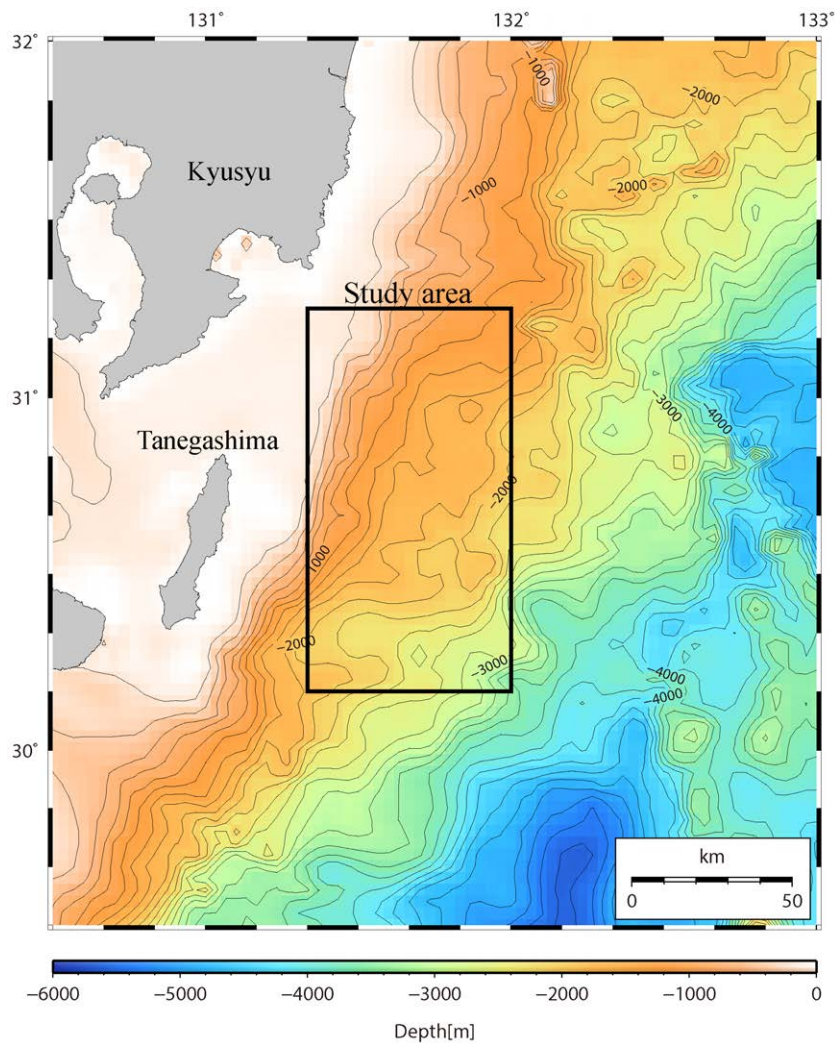


Figure 1 Location map of the study area and adjacent regions

2. Researchers

- Chief scientist [Affiliation]: Kazuya Kitada [JAMSTEC]
- Representative of the science party [Affiliation]: Fumio Inagaki [JAMSTEC]
- Science party (List) [Affiliation, assignment etc.]

Kazuya Kitada [JAMSTEC]

Hideaki Machiyama [JAMSTEC]

Further details are in Appendix A-1.

3. Observation

3.1. Research objectives and summary of observation

There are more than 50 submarine mud volcanoes off Tanegashima. Submarine mud volcanoes, which are common geological features in forearc basin at plate convergent boundaries, have been recognized as windows onto great depths that are otherwise inaccessible to sampling, because gases, liquids, and solid particles expelled by mud volcanos may have been transported from up to several kilometers below the Earth's surface. Also, it has been known that sedimentary samples of fore-arc mud volcanoes sometimes includes methane hydrate. Therefore, it is also expected the fore-arc mud volcano as natural pipeline of methane resource.

We have conducted high resolution geophysical mapping and single channel seismic (SCS) survey of mud volcanoes off Tanegashima (Figure 1), southwestern Japan, during the YK14-15 cruise using R/V Yokosuka of JAMSTEC. The purpose of this cruise is to evaluate the hydrocarbon resource potential, such as methane hydrate and understand the formation process of deep fluid migration driven by seismic faulting on the mud volcanoes. In this cruise, a total of 7 AUV "Urashima" dives were completed on 5 mud volcanoes. During these dives, we have successfully collected high-resolution bathymetric data, side scan sonar and sub-bottom profile images, SCS profiles and magnetic data. Surface geophysical mapping (bathymetry, gravity, total and vector magnetic fields and sub bottom profile) and SCS profile survey by R/V Yokosuka were also conducted over mud volcanoes in order to obtain the regional surface and subsurface structure off Tanegashima. The details of the shipboard log is shown in Appendix A-2.

3.2. Cruise track

YK14-15 cruise was started from Ishigaki port on Aug. 9. The vessel went to the off Tanegashima area and arrived at off Tanegashima on Aug. 11. A total of 7 AUV Urashima dives, Single Channel Seismic Survey and surface geophysical surveys were conducted from Aug. 11 to 19 in the study area. Finally, the vessel left the area for Naha on Aug. 19 and arrived at Naha port on Aug. 21. Figure 2 and Table 1 show ship's tracks and the activity log during this cruise, respectively.

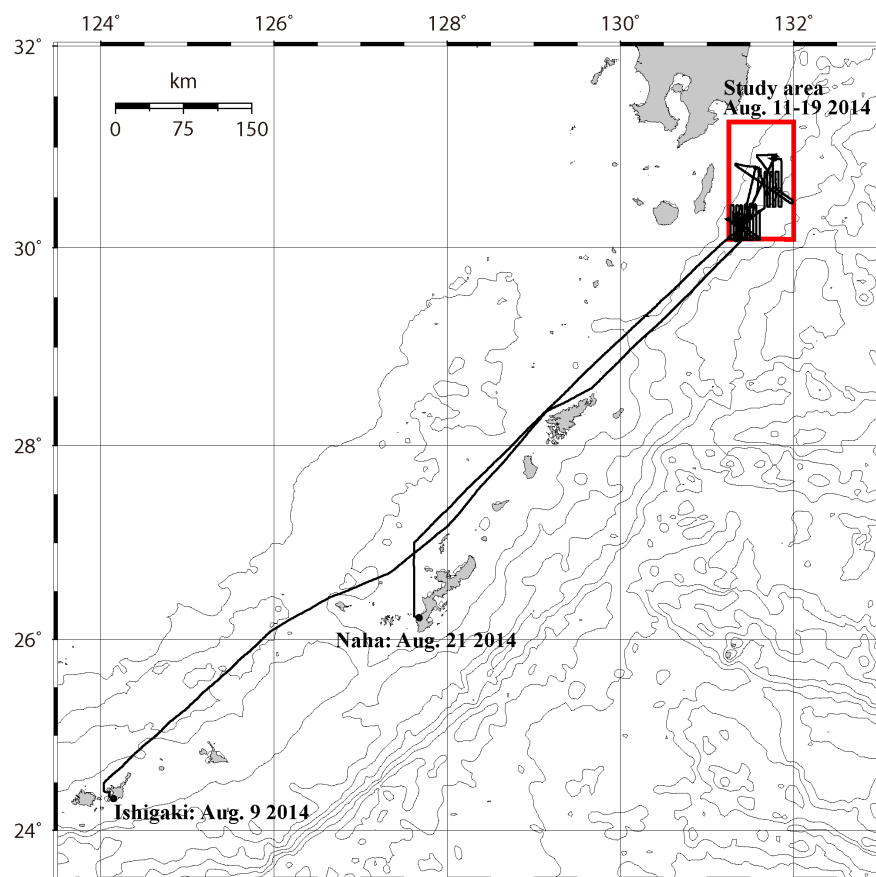


Figure 2 Ship's tracks for the entire YK14-15 cruise

Table 1 Cruise log

Date	Remarks
9 Aug. 2014	Departure from Ishigaki port, transit to the survey area
10	Transit to the survey area
11	Arrived at the survey area, XBT measurement, MBES & SBP survey
12	Single Channel Seismic survey (SCS), MBES & SBP survey
13	Urashima Dive 174, SCS, MBES & SBP survey
14	Urashima Dive 175, MBES & SBP survey
15	Urashima Dive 176, MBES & SBP survey
16	Urashima Dive 177, SCS, MBES & SBP survey
17	Urashima Dive 178, SCS, MBES & SBP survey
18	Urashima Dive 179, SCS, MBES & SBP survey
19	Urashima Dive 180, MBES & SBP survey
20	Transit to Naha
21	Arrived at Naha port

4. Operation

In this cruise, SCS survey and surface geophysical mapping by R/V Yokosuka and a detailed seafloor survey by AUV Urashima were conducted. Figure. 3 shows planned SCS survey lines and Urashima survey area (circles).

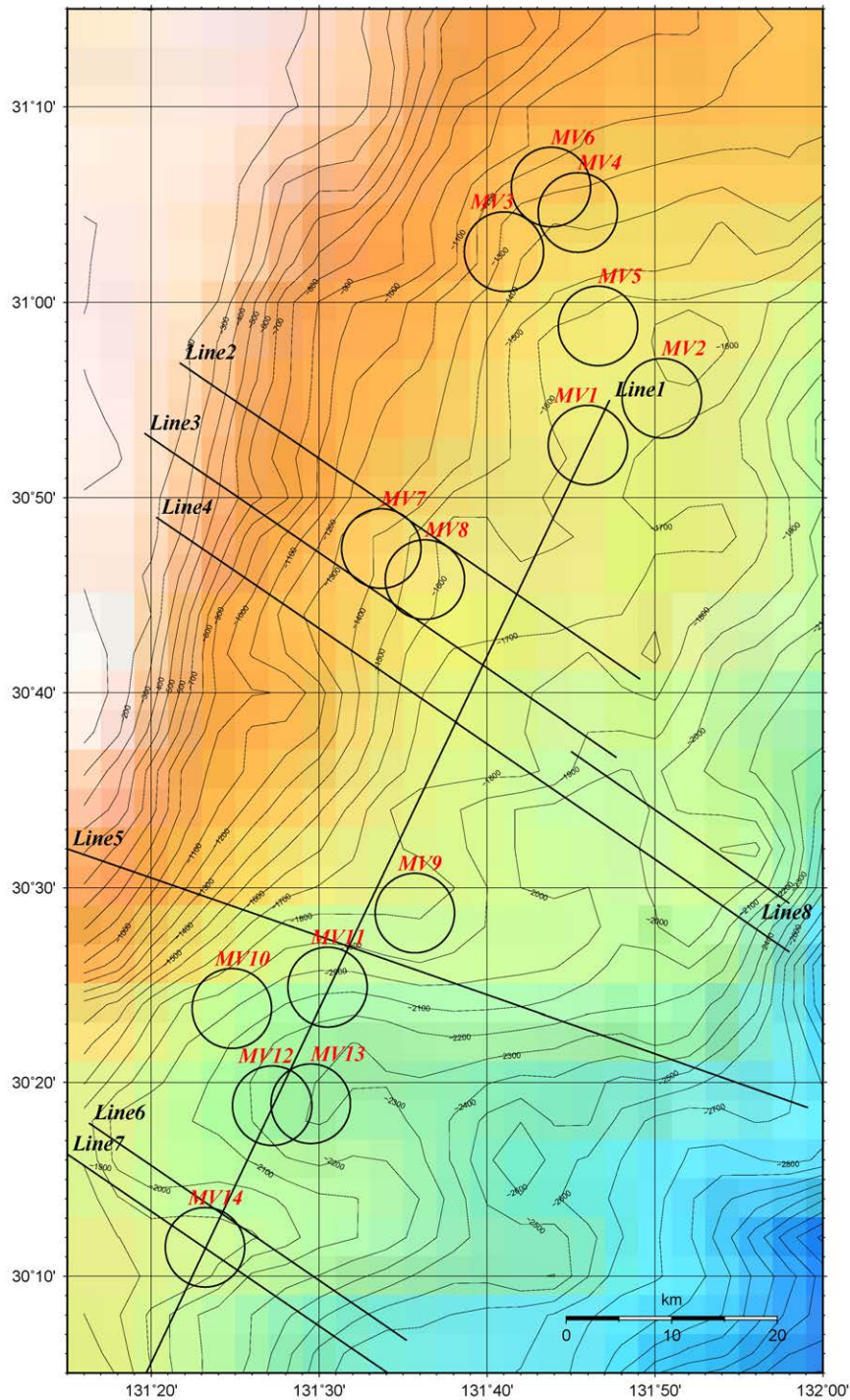


Figure 3 Planned SCS survey lines and Urashima survey area (circles)

4.1 R/V Yokosuka

Bathymetric survey by using ship's hull mounted multi narrow beam echo sounder (EM122, Kongsberg Maritime, Inc. See Appendix A-3 for detail) was conducted to understand seafloor topography in the survey area.

To understand the seafloor structure, a single channel seismic survey was conducted in the survey area. Bolt's 2800LL - X Cluster gun and SIG 16 streamer cable were used for the SCS survey. The cluster gun system is effective to obtain images for the shallower part, down to a few hundred meters. Specifications for the cluster gun system and SIG streamer cable are as follows.

Streamer

Manufacturer	S.I.G
Active section length	65m
Hydrophone Interval	1m
Type of Hydrophone	S.I.G.16
Hydrophone output	-90 dB, re 1V/ μ bar, ± 1 dB
Frequency	flat from 10Hz to 1000Hz
Depth sensor	Yes
Preamplifier	gain 39
Lead in cable length	110m
Receiver depth	3m

Source

Manufacturer	Bolt
Type of airgun	Cluster Gun
Volume	Port(40cu.in $\times$ 2) + Starboard(10cu.in $\times$ 2)
Air pressure	131.5kgf/cm ² (Line name: LineX_X) 137.7kgf/cm ² (Line name: DiveXXX_Line1-1_0)
Source depth	2m
Depth sensor	No
Gun Controller	Hotshot ver. 3.005

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	5,500msec (Line name: LineX_X) 4,500msec (Line name: DiveXXX_Line1-1_0)

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)

Navigation System

Manufacturer	MARIMEX JAPAN
Type of system	Nav log ver. 1.0.64

Shot Point Geometry

Time mode shooting	Simultaneous (6sec interval [Line name: LineX_X]) (5sec interval [Line name: DiveXXX_Line1-1_0])
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Geodetic Parameter

Spheroid	WGS84
Semi-major Axis	6,378,137m
Inverse Flattening	298.26
Projection	U.T.M
	Zone52

4.2. AUV Urashima

The specification of the AUV Urashima is shown in Appendix A-4. For the AUV survey, besides the standard acoustic apparatus on Urashima (i.e. SeaBat7125 MBES, Edgetch2000M Side Scan Sonar/Sub Bottom Profiler), following equipments were applied as the payload.

Three-axis flux gate magnetometers were mounted in the payload space on the Urashima. They were still under development as a fundamental tool for seafloor resource study (under a project funded by MEXT); then, their details will be reported elsewhere. One of three was attached to the head part of AUV in the syntactic form buoyancy medium, and other two were attached to the port and starboard sides of the payload space.

While Urashima was cruising under the water, cruising single channel seismic survey was conducted simultaneously. The system used in this survey consists of 2 parts, hydrophones and data acquisition pressure case (Figs. 4 and 5). To receive air-gun signal coming from surface, 10 hydrophones are mounted inside the URASHIMA. Data acquisition pressure case is also mounted in the payload space in the Urashima. On surface, two clusters gun array (Port: 40 cu. in*2, Starboard: 10cu. in*2) towed behind the vessel was used to produce seismic signal.

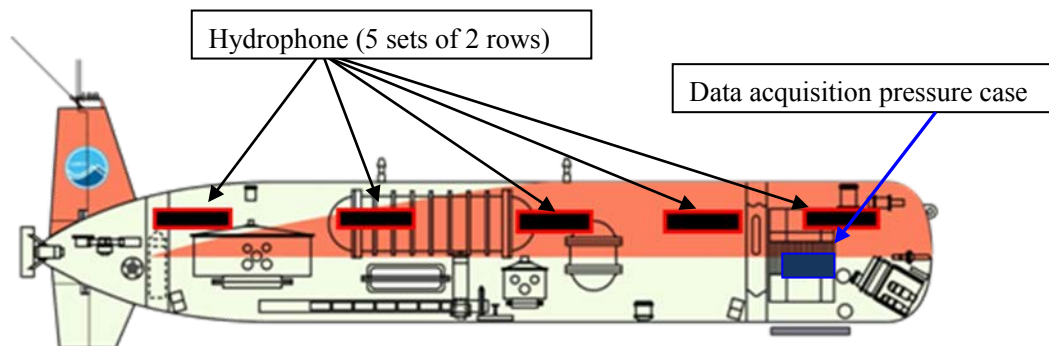


Figure 4 Hydrophones layout

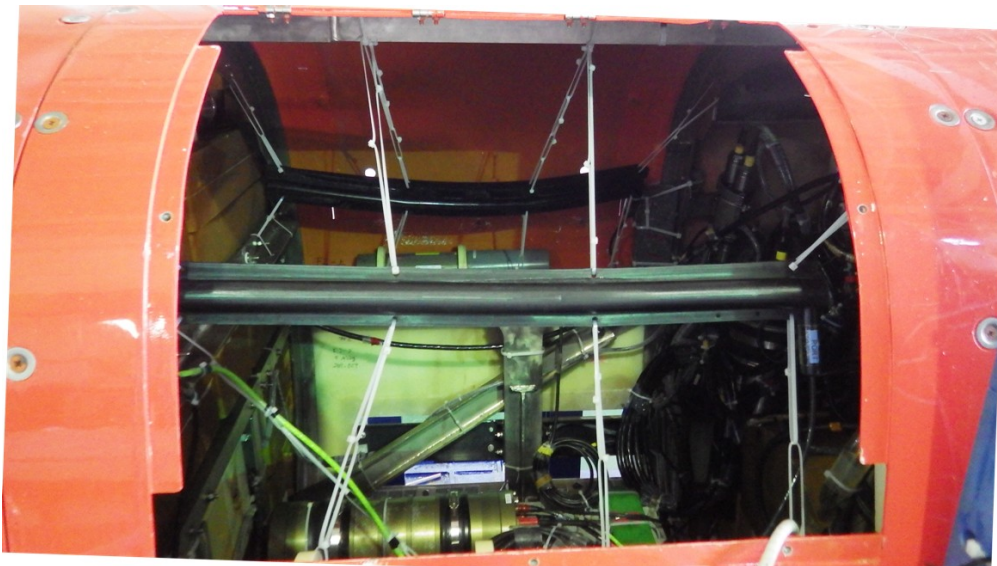


Figure 5 Hydrophones mounted on the Urashima vehicle

5. Preliminary results

5.1. Bathymetric survey and Single Channel Seismic survey (SCS)

Fig. 6 shows the results of bathymetric survey and SCS conducted during the cruise. A total of ~270 km of SCS data was collected in the survey area. Differential Global Positioning System (DGPS) of WGS84 was used for the positioning. Raw SCS reflection data was processed for the purpose of quality control during the cruise. Onboard data processing includes noisy trace editing, band pass filtering. Fig. 7 shows one of the results of the onboard data processing. Interpretation will be performed afterwards.

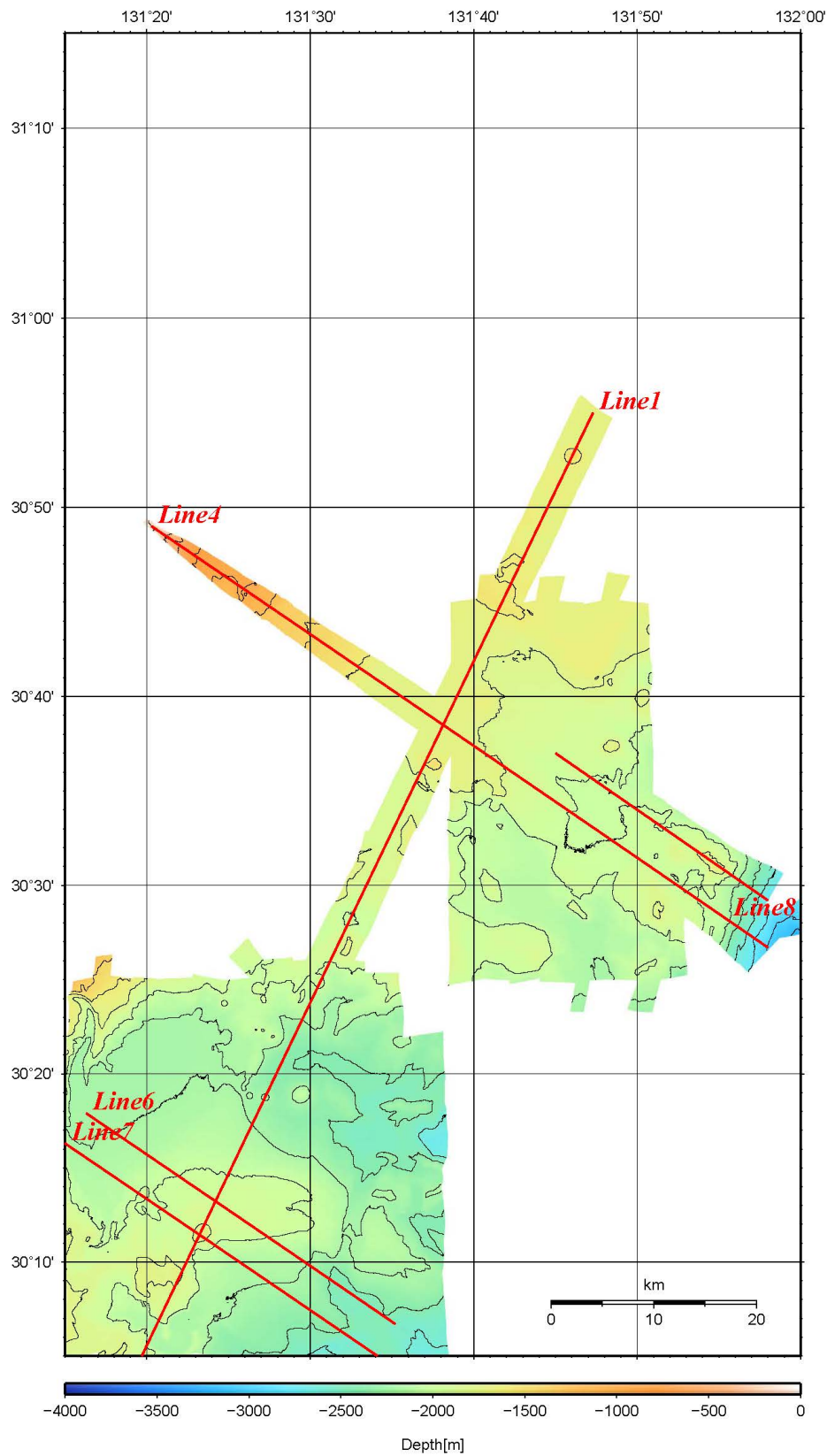


Figure 6 Results of bathymetric survey and SCS lines conducted during YK14-15 cruise

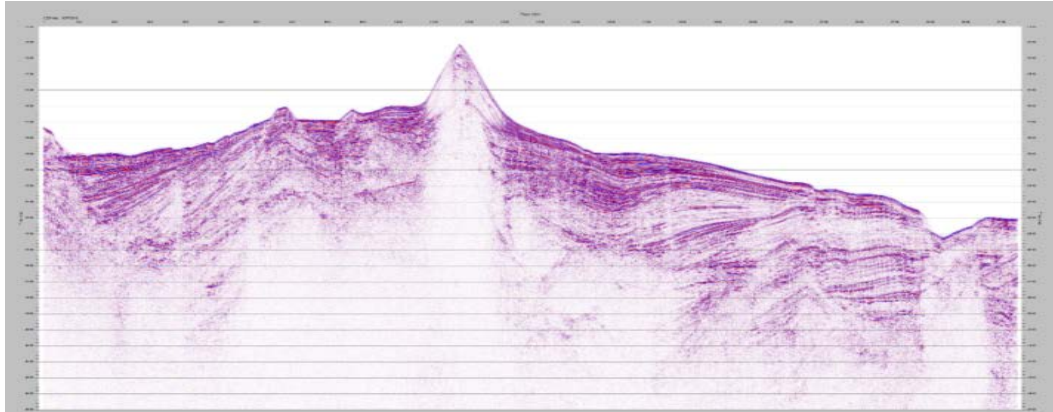


Figure 7 Example of the collected SCS profile along mud volcano

5.2. AUV Urashima survey

High resolution bathymetric and side scan data were collected in the survey area. Fig. 8 shows the result of the onboard data processing for AUV Urashima multibeam echo sounder. MV14 mud volcano is clearly imaged on the figure. Interpretation will be performed afterwards.

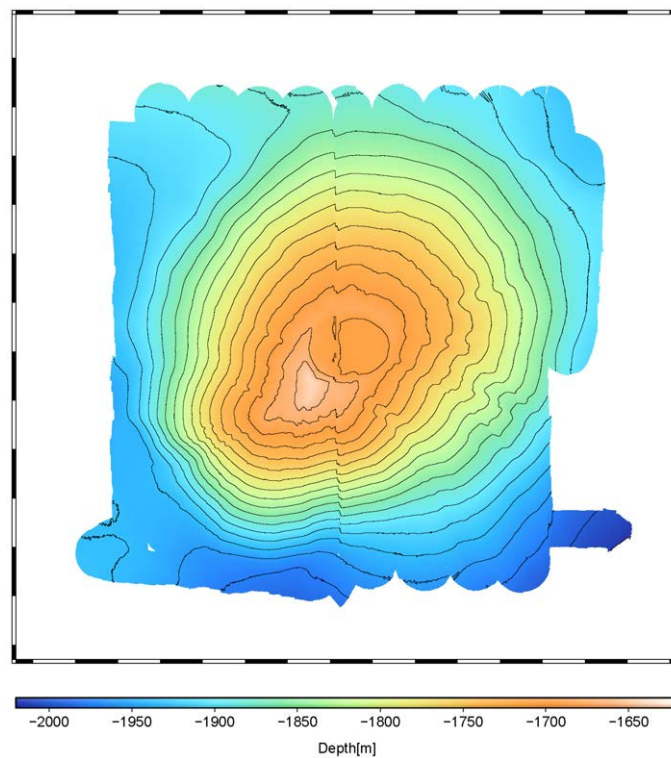


Figure 8 Example of the collected bathymetric map over the mud volcano

Magnetometer

Correction for the vehicle magnetization will be applied for offline data processing. Interpretation will be performed afterwards.

Cruising single channel seismic survey

Data editing with air gun shot time and band-pass filtering will be applied for offline data processing. Interpretation will be performed afterwards.

6. Acknowledgements

We would like to thank Captain Y. Nakamura and the crews of the R/V Yokosuka for skillful operations of the ship and assistance in the collection of the geophysical data during the cruise. We are also grateful to the operation manager of AUV Urashima, K. Chiba and the members of the AUV Urashima operation team for giving us great assistance in research works throughout the cruise. We also thank S. Okada, I. Kozono, M. Kuno, T. Nasu and Y. Fuwa from NME for their excellent support. The GMT software package (Wessel and Smith, 1998) was used for some of the figures.

Appendix A-1

List of participants

Scientists Parties

Kazuya Kitada	Japan Agency for Marine-Earth Science and Technology
Hedeaki Machiyama	Japan Agency for Marine-Earth Science and Technology

Marine Technician

Satoshi Okada	Nippon Marine Enterprises, LTD.
Isao Kozono	Nippon Marine Enterprises, LTD.
Mitsuteru Kuno	Nippon Marine Enterprises, LTD.
Toshimasa Nasu	Nippon Marine Enterprises, LTD.
Yuji Fuwa	Nippon Marine Enterprises, LTD.

Operation team of URASHIMA

Operation Manager	Kazuhiro Chiba
1 st Submersible Technical Officer	Akihisa Ishikawa
2 nd Submersible Technical Officer	Keigo Suzuki
2 nd Submersible Technical Officer	Fumitaka Saito
2 nd Submersible Technical Officer	Ryo Saigo
2 nd Submersible Technical Officer	Yudai Tayama

Captain and crew of the R/V YOKOSUKA

Captain	Yoshiyuki Nakamura
Chief Officer	Yasuhiko Sammori
2 nd Officer	Tomoyuki Takahashi
3 rd Officer	Tomohiro Yukawa
Jr. 3 rd Officer	Yusuke Ishi
Chief Engineer	Tadashi Abe
1 st Engineer	Wataru Kurose
2 nd Engineer	Kenta Ikeguchi
3 rd Engineer	Koichi Hashimoto
Jr. 3 rd Engineer	Kazuki Ono
Chief Electronic Operator	Hiroyasu Saitake
2 nd Electronic Operator	Yoshikazu Kuramoto
3 rd Electronic Operator	Ryosuke Komatsu

Boat Swain	Hatsuo Oda
Able Seaman	Yasuo Konno
Able Seaman	Tsuyoshi Chimoto
Able Seaman	Hiroaki Nagai
Sailor	Yoshihiro Ogawa
Sailor	Yuta Motooka
Sailor	Kento Kanda
No.1 Oiler	Toshikazu Ikeda
Oiler	Kazuo Sato
Oiler	Keita Funawatari
Assistant Oiler	Ryo Matsuuchi
Assistant Oiler	Seiya Watanabe
Chief Steward	Yukio Tachiki
Steward	Hideo Fukumura
Steward	Akio Suzuki
Steward	Toru Murakami
Steward	Yoshie Hidaka
Steward	Manami Takahashi

Appendix A-2

YK14-15 Shipboard Log

Date	Local Time	Note	Position/Weather/Wind/Sea condition
9-Aug-14		Left ISHIGAKI then started YK14-15	8/9 09:00 (UTC+9h)
	8:00	Embarked 7 persons (2 scientists & 5 marine technicians).	<Ishigaki port>
	9:00	Left ISHIGAKI port, then started YK14-15 at 09:00 JST.	24-20.2N 124-08.8E
	9:50	Anchored Yokosuka at Nakura Wan near Ishigaki island.	
	11:00	On board education for scientists and marine technicians.	8/9 12:00 (UTC+9h)
	13:00	Held meeting for research schedule.	<Nakura Wan>
	16:35	Left Nakura Wan for research area.	24-24.1N 124-06.2E
			Fine but cloudy
10-Aug-14		Bound for Research Area	8/10 12:00 (UTC+9h)
	13:00	Held meeting about submergible operation.	26-21.5N 126-29.3E
	16:40	Konpira worship.	Cloudy
			SSW-2 (Light breeze)
			2 (Low long swell)
11-Aug-14		Bound for Research Area	8/11 12:00 (UTC+9h)
	16:00	Arrived at research area (Off Tanegashima).	29-21.0N 130-34.4E
	16:04	XBT measurement.	Rain
	17:04	Started MBES & SBP survey.	SW-4 (Moderate breeze)
		(measurement of geographical features)	3 (Sea Slight)
			1 (Low short swell)
			Visibility: 6mile
12-Aug-14		S.C.S. survey	8/12 12:00 (UTC+9h)
	4:40	Finished MBES & SBP survey.	30-10.8N 131-24.2E
	08:56-09:13	Launched AIR-GUN (Starb'd & Port sides).	Fine but cloudy
	09:21-09:30	Veered out streamer cable from stern side.	NNW-2 (Light breeze)
	9:48	Started S.C.S. survey (Line7.0).	2 (Sea smooth)
	14:28	Finished S.C.S. survey (Line7.0).	1 (Low short swell)
	15:06	Started S.C.S. survey (Line6.0).	Visibility: 8mile
	19:00	Finished S.C.S. survey (Line6.0).	
	19:01-19:07	Took in streamer cable.	
	19:07-19:17	Recovered AIR-GUN (Starb'd & Port sides).	
13-Aug-14	20:11	Started MBES & SBP survey.	
		URASHIMA#174 & S.C.S. survey	8/13 12:00 (UTC+9h)
	4:25	Finished MBES & SBP survey.	30-10.8N 131-22.7E
	7:32	Dove URASHIMA and started Operation #174.	Fine but cloudy
	09:20-09:24	Launched AIR-GUN (Starb'd side).	South-3 (Gentle breeze)
	09:29-09:33	Veered out streamer cable from stern side.	2 (Sea smooth)
	9:38	Started S.C.S. survey (Dive174 Line1.0).	1 (Low short swell)
	10:20	Finished S.C.S. survey (Dive174 Line1.0).	Visibility: 8mile
	10:21-10:26	Took in streamer cable.	
	10:26-10:30	Recovered AIR-GUN (Starb'd side).	
	17:28	Started to ascend URASHIMA.	
14-Aug-14	18:00	Surfaced URASHIMA.	
	18:24	Recovered URASHIMA, then finished above operation.	
	19:45	Started MBES & SBP survey.	
		URASHIMA#175	8/14 12:00 (UTC+9h)
	4:22	Finished MBES & SBP survey.	30-11.0N 131-23.7E
	7:33	Dove URASHIMA and started Operation #175.	Blue sky
	17:04	Started to ascend URASHIMA.	SSW-5 (Fresh breeze)
	17:32	Surfaced URASHIMA.	3 (Sea Slight)
	17:56	Recovered URASHIMA, then finished above operation.	2 (Low Swell Short or Average)
	19:31	Started MBES & SBP survey.	Visibility: 8mile
15-Aug-14		URASHIMA#176	8/15 12:00 (UTC+9h)
	4:05	Finished MBES & SBP survey.	30-53.3N 131-45.6E
	6:07	XBT measurement.	Overcast
	7:31	Dove URASHIMA and started Operation #176.	SSW-4 (Moderate breeze)
	17:07	Started to ascend URASHIMA.	3 (Sea Slight)
	17:33	Surfaced URASHIMA.	1 (Low short swell)
	17:59	Recovered URASHIMA, then finished above operation.	Visibility: 8mile

	19:34	Started MBES & SBP survey.	
16-Aug-14		URASHIMA#177 & S.C.S. survey	8/16 12:00 (UTC+9h)
	4:30	Finished MBES & SBP survey.	30-52.4N 131-46.8E
	8:00	Dove URASHIMA and started Operation #177.	Cloudy
	15:37	Started to ascend URASHIMA.	SW-4 (Moderate breeze)
	16:01	Surfaced URASHIMA.	3 (Sea Slight)
	16:24	Recovered URASHIMA, then finished above operation.	1 (Low short swell)
	17:27-17:46	Launched AIR-GUN (Starb'd & Port sides).	Visibility: 8mile
	17:48-17:55	Veered out streamer cable from stern side.	
	18:07	Started S.C.S. survey (Line1_0).	
17-Aug-14		URASHIMA#178 & S.C.S. survey	8/17 12:00 (UTC+9h)
	6:00	Finished S.C.S. survey (Line1_0).	30-47.7N 131-33.9E
	6:03-6:08	Took in streamer cable.	Fine but cloudy
	6:08-6:24	Recovered AIR-GUN (Starb'd & Port sides).	SSW-4 (Moderate breeze)
	8:53	Dove URASHIMA and started Operation #178.	2 (Sea smooth)
	10:15-10:17	Launched AIR-GUN (Starb'd Side).	1 (Low short swell)
	10:20-10:25	Veered out streamer cable from stern side.	Visibility: 8mile
	10:26	Started S.C.S. survey (Dive178_Line1_0).	
	10:55	Finished S.C.S. survey (Dive178_Line1_0).	
	10:56-11:01	Took in streamer cable.	
	11:02-11:09	Recovered AIR-GUN (Starb'd Side).	
	13:37	Started to ascend URASHIMA.	
	13:58	Surfaced URASHIMA.	
	14:24	Recovered URASHIMA, then finished above operation.	
	15:50-16:04	Launched AIR-GUN (Starb'd & Port sides).	
	16:08-16:14	Veered out streamer cable from stern side.	
	16:28	Started S.C.S. survey (Line4_0).	
18-Aug-14		URASHIMA#179 & S.C.S. survey	8/18 12:00 (UTC+9h)
	2:01	Finished S.C.S. survey (Line4_0).	30-45.7N 131-36.3E
	2:54	Started S.C.S. survey (Line8_0).	Fine but cloudy
	6:00	Finished S.C.S. survey (Line8_0).	SSW-5 (Fresh breeze)
	6:05-6:10	Took in streamer cable.	3 (Sea Slight)
	6:11-6:27	Recovered AIR-GUN (Starb'd & Port sides).	1 (Low short swell)
	8:49	Started URASHIMA dove & Operation #179.	Visibility: 8mile
	10:07-10:14	Launched AIR-GUN (Starb'd Side).	
	10:17-10:22	Veered out streamer cable from stern side.	
	10:28	Started S.C.S. survey (Dive179_Line1_0).	
	11:20	Finished S.C.S. survey (Dive179_Line1_0).	
	11:22-11:28	Took in streamer.	
	11:28-11:31	Recovered AIR-GUN (Starb'd Side).	
	15:49	Started to ascend URASHIMA.	
	16:13	Surfaced URASHIMA.	
	16:38	Recovered URASHIMA, then finished above operation.	
	17:44-18:03	Launched AIR-GUN (Starb'd & Port sides).	
	18:03-18:08	Veered out streamer cable from stern side.	
	19:18	Started S.C.S. survey (Line1_1).	
19-Aug-14		URASHIMA#180	8/19 12:00(UTC+9h)
	4:05	Finished S.C.S. survey (Line1_1).	
	6:00-6:05	Took in streamer cable.	Fine but Cloudy
	6:05-6:16	Recovered AIR-GUN (Starb'd & Port sides).	South-5 (Fresh breeze)
	8:41	Started URASHIMA dove & Operation #180.	3 (Sea Slight)
	16:27	Started to ascend URASHIMA.	1 (Low short swell)
	17:01	Surfaced URASHIMA.	Visibility: 8mile
	17:24	Recovered URASHIMA, then finished above operation.	
	18:41	Started MBES & SBP survey.	
	23:20	Finished MBES & SBP survey.	
	23:20	Left Research area for Naha	
20-Aug-14		Bound for NAHA (OKINAWA)	8/20 12:00 (UTC+9h)
	6:54-7:12	Carried out figure 8 turn.	28-44.6N 129-35.6E
			Fine but Cloudy
			SE-4 (Moderate breeze)
			3 (Sea Slight)
			1 (Low short swell)
			Visibility: 8mile
21-Aug-14		Arrived at NAHA (OKINAWA)	

Appendix A-3

General description of 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 42 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 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
Measurement 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 output	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 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 ~ 7 x 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)

Appendix A-4

General description of AUV URASHIMA

Autonomous Underwater Vehicle (AUV) URASHIMA is cruised by oneself for built in control system. It is not connected by the cable with the mother vessel. Therefore it can survey the sea floor widely and clearly due to stable cruising attitude. The AUV navigation consists of two sub-system, INS (Inertial Navigation System) and DVL Doppler Velocity Log). Horizontal navigation error has approximately 1% of travel distance, therefore INS error is dissolved by correction of SSBL position before cruising sea floor. DVL (TELEDYNE RD INSTRUMENTS WHN300) is maximum 110m of range (altitude) and measure bottom speed using 300 kHz doppler sonar for AUV navigation. INS and DVL data logged in Nav_results format include status of AUV behavior. URASHIMA have large size of payload space in front of body, there are acoustic sonar equipments and sensors, side scan sonar, sub-bottom profiler, multi beam echo sounder, and CTDO sensor.

The general specifications of URASHIMA

Length	10.0 m
Width	1.3m
Height	1.5m
Weight	7.0t
Maximum operation depth	3,500m
Speed	3knot (typically 2.4knot)
Positioning	Inertial Navigation System Doppler Sonar SSBL Sonar
Operation Mode	Autonomous Remote (Acoustic / Optical)

Multibeam echo sounder on AUV

Bathymetric data were collected by Reson SEABAT7125AUV on URASHIMA. SEABAT7125 is a multibeam survey system that generates data for wide-swath bathymetry maps and backscattering images. The system consists of two main subsystems, transmitter and receiver. The 400 kHz projector array is positioned fore and aft along the ship's keel. The along-track transmit beam width is 1°. The receiver array detects and processes the returning echoes through stabilized multiple athwart ship beams in a fan shape. The across-track receive beam width is 0.54°. The "equi-distance mode" was selected in beam forming (meanwhile, "equi-angle mode"). Generally, the ping rate was controlled "range" that is time

between transmitting and receiving. The system swath angle is maximum 128° and maximum number of beams is 512. Actual swath coverage is approximately 80m during this cruise survey. Data were logged in Reson standard s7k format and preliminary onboard processing was done using CARIS software.

The general specifications of Recon SeaBat7125 series

Frequency		200, 400 kHz
Beam width	along track	2.2deg@ 200 kHz, 1.0deg@ 400 kHz
	across track	1.1deg@ 200 kHz, 0.54deg@ 400 kHz
Ping rate	(max)	50 Hz (± 1 Hz)
Pulse width		30 usec to 300 usec
Beam transmit mode		Equi-Angle (EA), Equi-Distant (ED)
Number of beam	EA	256@ 200 kHz, 512@ 400 kHz
	ED	256 @ 200 kHz, 512@ 400 kHz
Swath width		128 degrees (max)
Measurement range		up to 450m@200kHz
		up to 175m@400kHz
Resolution	vertical	6mm
	Horizontal	1.75 x 0.94m@ 100m of altitude
Output format		s7k (Reson standard format)

Side scan sonar on AUV

Acoustic wave is the best and often only means to investigate the water column and seafloor efficiently and accurately. Side scan sonar system is one of the acoustic mapping systems. AUV URASHIMA emits a pulse of sound energy that radiates away from the source transducer and detects backscattering strength. When the sound energy impinges on objects harder than water, the energy is scattered in a new directions. Some of the energy is scattered back toward the source of the sound (= echo). The source transducer detects the returning energy for a fixed period of arrival time. The side scan sonar system assumes that observation of flat floor with constant altitude to a seafloor, and uniform propagation velocity of acoustic wave in seawater. The first returning echo is considered that come from just below the AUV and is able to determine the altitude. Once the first echo was detected, they catch the magnitude of the pixels. Detected sounds after the first echo are aligned along arrival time from below the fish to side. Backscattering strength shows information of seafloor materials (sand or rock), seafloor roughness (fine grains or cobbles, for example), and inclination of seafloor (facing or opposite slope to the vehicle), in jumble magnitude. A series of processing, including gain control, slant range correction, altitude correction, noise reduction, bottom tracking, radiometric correction, and positioning correction, is needed

for analyzing the side scan sonar data. Specifications of side scan sonar (Edge-Tech 2200-M) installed in AUV URASHIMA are shown below. URASHIMA enables to use 120 kHz and 410 kHz acoustic wave but only 120 kHz wave was worked during the YK13-14cruise.

The general specifications of EdgeTech 2000-M

Frequency		120/410kHz (full spectrum chirp)
Beam angle	Vertical	60degree
	Horizontal	0.9degree
Range		25 to 300m (typically 300m)
Altitude		up to 120m
Resolution	Vertical	6.25cm
	Horizontal	1.57 to 3.54m @ 100m of altitude
Output format		jsf (Edgetech standard format)

Sub bottom profiler

Sub bottom profiler (Edge-Tech DT106) is installed near the head part of the AUV URASHIMA. The sub bottom profiler transmits chirp signals of 1 to 6 kHz, and detects sub-seafloor objects when the seafloor is covered by thick sediments.

The general specifications of EdgeTech DT106

Frequency		1-6 kHz, chirp
Beam width		horizontal 28-36 degrees (typically 30 degree)
Resolution		15-25 cm
Output format		jsf (Edgetech standard format)

