



R/V Natsushima “Cruise Report”

NT15-20

Cross-ministerial Strategic Innovation Promotion Program (SIP)

Next-generation Technology Development

for Seafloor Resource Survey

Izu-Ogasawara Arc

Nov. 27, 2015 - Dec. 2, 2015

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: NT15-20
- Name of vessel: R/V Natsushima/ AUV Yumeiruka
- Title of the cruise: Cross-ministerial Strategic Innovation Promotion Program (SIP) Next-generation Technology Development for Seafloor Resource Survey
- Title of proposal: Acoustic and magnetic surveys using AUV Yumeiruka around the hydrothermal areas in Izu-Ogasawara Arc
- Cruise period: Nov. 27, 2015 - Dec. 2, 2015
- Ports of call: from Yokosuka to Yokosuka
- Research area: Izu-Ogasawara area
- Research Map:

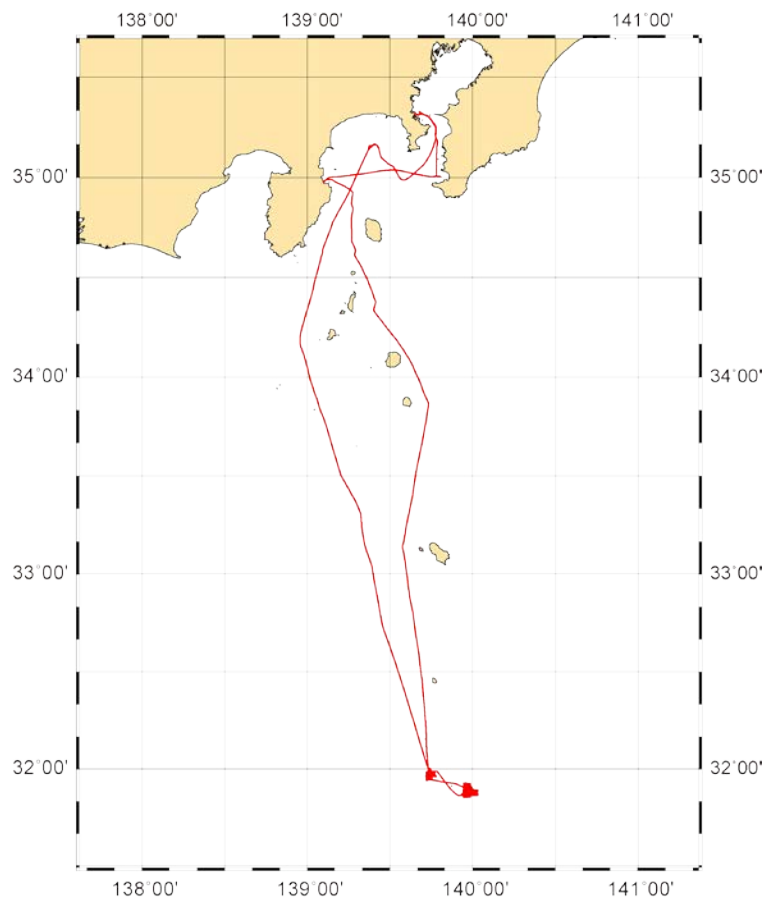


Figure 1: Ship track of the NT15-20 cruise.

2. Science Party

- Chief scientist [Affiliation]: Kazuya Kitada [R&D Center for Submarine Resources, JAMSTEC]
- Representative of the science party [Affiliation]: Hidenori Kumagai [R&D Center for Submarine Resources, JAMSTEC]
- Science party (List) [Affiliation, assignment etc.]:
 - Ayu Takahashi [SIP, JAMSTEC]
 - Shojiro Ishibashi [MARITEC, JAMSTEC]
 - Hiroshi Yoshida [MARITEC, JAMSTEC]
 - Makoto Sugawara [MARITEC, JAMSTEC]
 - Kiyotaka Tanaka [MARITEC, JAMSTEC]
 - Yutaka Ohta [MARITEC, JAMSTEC]
 - Frank Hsiao Fan [MARITEC, JAMSTEC]
 - Takuya Shimura [MARITEC, JAMSTEC]
 - Yoshitaka Watanabe [MARITEC, JAMSTEC]
 - Yoshiaki Yamauchi [Mitsubishi Heavy Industries, Ltd.]
 - Kazuhiro Kanayama [Mitsubishi Heavy Industries, Ltd.]
 - Yoshimi Kaneko [Mitsubishi Heavy Industries, Ltd.]
 - Hakuo Nishizato [Mitsubishi Heavy Industries, Ltd.]
 - Hidekiyo Goto [Mitsubishi Heavy Industries, Ltd.]
 - Yusuke Nagata [Mitsubishi Heavy Industries, Ltd.]
 - Masayoshi Abe [Ryoyu System Engineering Co., Ltd.]
 - Kazunari Takahashi [Oki Seatec Co., Ltd.]
 - Hisanori Iwamoto [Nippon Marine Enterprises, Ltd.]

3. Backgrounds and Objectives

This cruise was conducted under an umbrella of one of the project in Cross-ministerial Strategic Innovation Promotion Program (SIP). Our project, Next-generation Technology Development for Seafloor Resource Survey entitled as “Zipangu in the Ocean,” covers three types of the seafloor resources: submarine hydrothermal deposit, Co-rich Fe-Mn oxides and REY-rich mud. Here this cruise focused the submarine hydrothermal deposit in Izu-Ogasawara Arc.

During the NT15-20 cruise in 2015, we conducted the shipboard MBES survey by R/V Natsushima and the near-bottom acoustic and magnetic surveys using AUV Yumeiruka in order to reveal the detailed bathymetric features and the distribution and characteristics of seafloor active hydrothermal area in Izu-Ogasawara Arc (Figure 1). In deep-sea magnetic surveys using AUV, the attitude change strongly affects the calculated magnetic anomalies in addition to the vehicle’s permanent and induced magnetic

field. For that reason, in order to detect small-scale magnetic anomalies with small amplitudes, it is important to effectively correct the artificial magnetic field caused by the magnetization of vehicle body. AUV Yumeiruka was newly developed by JAMSTEC and is equipped with a canard-X rudder which makes it capable of controlling its attitude angles and keeping the vehicle in horizontal plane during the seafloor survey. With this function, it is expected to reduce the effect of the attitude change of vehicle body, a generally serious problem during the deep-sea magnetic survey by AUV.

4. Methods and Instruments

4.1 R/V Natsushima

Ocean research vessel Natsushima was built as a support vessel of submersible SHINKAI 2000 in 1980s. R/V Natsushima was reconstructed as a support vessel of Hyper Dolphin.

General specification of R/V Natsushima

Length: 67.4m	Bow thruster: 4T/1.4T×220kw/110kw×1	1
Width: 13.0m	Maximum speed: 12.0 kt	
Depth: 6.3m	Duration: 5000 mile	
Max capacity: 55 persons (18 scientists)		
Gross Tonnage: 1739 ton		
Main prop: Variable pitch propeller 2 axis×4 Wing CPP,540N		

Research equipment

(1) MBES

Bathymetric data were collected by the SEABAT 8160 (RESON). The SEABAT is a multi-beam survey system that produces wide-swath contour maps and side scan images. It transmits a sonar signal from projectors mounted along the keel of the ship. The sonar signal travels through the sea water to the seafloor and is reflected off the bottom. Hydrophones mounted across the bottom of the ship receive the reflected sonar signals. The system electronics process the signals, and based on the travel time of the received signals as well as signal intensity, calculate the bottom depth and other characteristics such as S/N ratio for echoes received across the swath. Positioning of depths on the seafloor is based on GPS and ship motion input. The data is logged to the hard disk for post processing which allows for additional analysis. Plotters and side scan graphic recorder are also included with system for data recording and display.

Max depth: 3000 m	Number of beams: 126
Frequency: 50 kHz	Swath angle: 150 degree (depend on depth)
Each beam width: 1.5 x 1.5, 3.0, 4.5, or 6.0 degree	

Minimum resolution: 1.4, 2.9, 8.9 cm (depend on above beam width)

Maximum transmit rate: 15 ping/sec

(2) PDR

This can record a water depth at right below and make contour map together with navigation data.

Max depth: more than 3000m

Record Range: 200~800m (changeable)

Frequency: 12kHz +/-5%

Output: more than 110dB (0dB unbar at 1m)

Directivity: conical beam pattern

Beam width: 15deg. +/-5 deg. (-3dB)

Pulse width: 1, 3, 10, 30msec

(3) XBT equipment

XBT profiles a vertical water temperature by free-fall probe.

Maximum measurable depth: 1830m

Measure range: -2 deg.~+35 deg.

(4) Navigation equipment

Position of the ship is measured by DGPS within about 3m error. ROV and transponder are measured by acoustic positioning system.

4.2. AUV Yumeiruka

AUV Yumeiruka was developed to perform seabed resource survey. AUV Yumeiruka is equipped with two sets of X-rudders, one in the front, and one in the rear part of the vehicle (Figure 2 and Table 1). This arrangement of the rudders enables the vehicle to trace the sea bottom with controlled attitude. For example, AUV Yumeiruka can follow the terrain of an irregular seabed with its pitch angle fixed to 0 degree. The attitude control capability allows the vehicle to aim the onboard sensors vertically at the sea bottom, resulting in more efficient survey of the seafloor.

Table 1: General specifications of AUV Yumeiruka

Item	Specification
Dimensions (L, B, H)	5.0 m, 1.4 m, 1.4 m
Weight (in air)	2,700 kg
Maximum Operation Depth	3,000 m
Cruising Speeds	2 knots (Max. 3 knots)
Minimum Operation Altitude	50 m
Propulsion system	4 × 400W thrusters, 2 × X-rudders (fore and aft)
Power Source	Rechargeable lithium ion Battery
Endurance	16 hrs
Navigation sensors	INS, DVL
Observation sensors	CTD, pH meter, fluoro-meter, IFS, SAS, SBP



Figure 2: AUV Yumeiruka

5. Operations

5.1. R/V Natsushima survey

We conducted an acoustic survey using R/V Natsushima to reveal numbers and distribution of seafloor hydrothermal vent sites at the Bayonnaise knoll Caldera and the Myojinsho Caldera. The total coverage of about $\sim 80 \text{ km}^2$ was attained using 0.4~0.8 km track spacing and 5~6-kt ship speed for the purpose of hydrothermal plume survey. Dense bathymetry and water column image data were obtained using Multibeam Echosounder System (MBES) equipped on board R/V Natsushima (SEABAT 8160 (RESON)). Figure 3 shows the collected bathymetric map of the Bayonnaise knoll Caldera. Water column imaging by using MBES are effective for investigating bubble rise through the water column and discovering new hydrothermal vent sites (Nakamura et al., 2015). During the survey, we successfully detected plume signals (acoustic water column anomaly) rising as continuous streams in water columns. The water column image data were processed onboard and the position of the acoustic plumes were confirmed by considering the ship heading angle. The bathymetric data and the position data were used to clarify the precise location of the hydrothermal vents and also understand characteristics of hydrothermal activity.

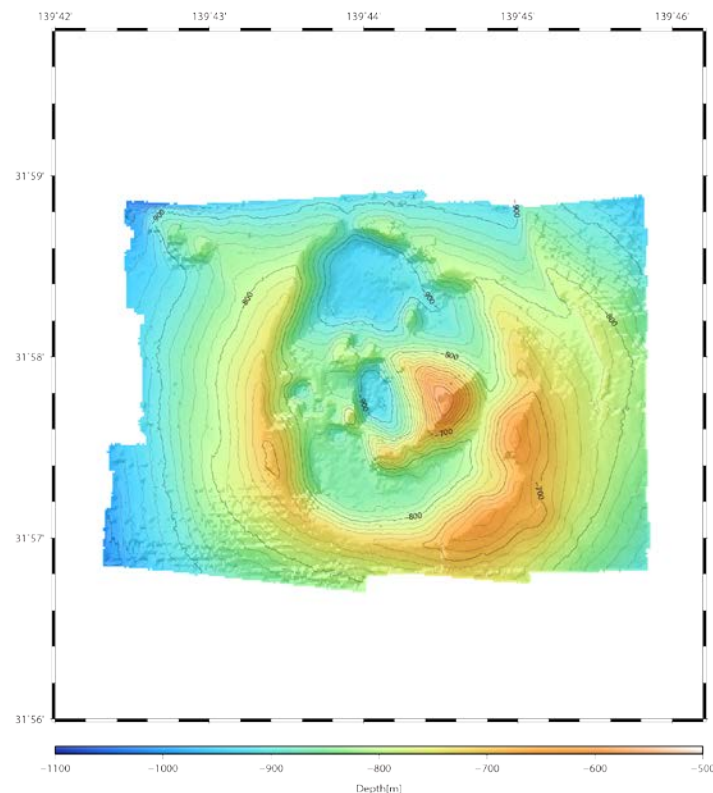


Figure 3: Bathymetric map of the Bayonnaise knoll Caldera collected by using MBES system on board R/V Natsushima.

5.2. AUV Yumeiruka dives

5.2.1 Acoustic and magnetic survey

In the AUV dives (Yumeiruka Dives 16 and 17), we conducted a detailed bathymetric survey by interferometry sonar (IFS) (Kongsberg Maritime, Inc. GeoSwath Plus AUV 250kHz), a high-resolution magnetic anomaly mapping by using the small-type 3-components fluxgate magnetometers mounted on the both side of AUV Yumeiruka and a hydrothermal plume mapping by using temperature, ORP, turbidity and pH sensors at the Bayonnaise knoll Caldera and in Sagami bay. During these dives, we performed acoustic survey for a detailed topographical mapping by interferometry sonar (IFS) and successfully obtained high-resolution bathymetric data. In the first dive (Dive#16) at the Bayonnaise knoll Caldera, we mapped over the southern part of the caldera with the constant altitude of ~100m and the survey line spacing of ~150m. Figure 4 shows the survey area and track line of AUV Yumeiruka dive#16. In the second dive (Dive#17) at the Sagami knoll in the Sagami bay, we surveyed over the knoll with the constant altitude of ~70m and the survey line spacing of ~150m.

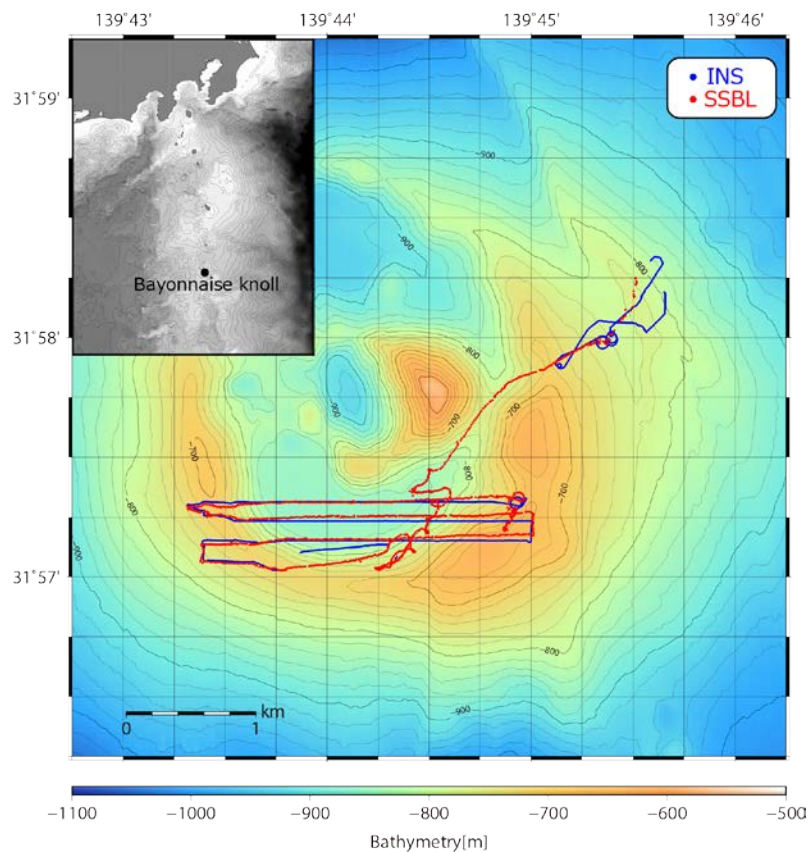


Figure 4: Track line of AUV Yumeiruka Dive16 on the Bayonnaise knoll Caldera. Blue and red dots show the vehicle positions by the INS system onboard AUV Yumeiruka and the SSBL positioning system by R/V Natsushima, respectively.

Magnetic field data were collected by two fluxgate magnetometers to reveal the characteristics of crustal magnetic structures. For each dive (Dives #16 and #17), figure-eight turns were conducted for calibration at half the depth of the survey area before the vehicle reached the bottom in order to correct the effect of the vehicle's permanent and induced magnetic fields.

5.2.2 Chemical sensor observation

5.2.2.1 Turbidity meter (ATU6-CMP; JFE Advantech Co., Ltd.)

Turbidity is the optical property caused by suspended particles and dissolved matters, such as solid deposits, precipitates, clay, silt, phytoplankton, other microscopic organisms, dissolved organic matters and etc. It is an index commonly used to describe water clarity in marine and freshwater environment. ATU6-CMP measures near-infrared backscattering as an index of turbidity. The turbidity sensor is calibrated by formazine solutions.

The instrument has a LED of near-infrared (880nm) and a detector with an optical filter that transmits the near-infrared backscattering to measure turbidity. The near-infrared light is less likely to be influenced by colors of suspended particles and dissolved matters, so it provides high accuracy turbidity measurements. The turbidity meter is attached horizontally on the starboard bow of AUV Yumeiruka hull (Figure 5).



Figure 5: Turbidity meter on the starboard bow of AUV Yumeiruka hull.

5.2.2.2 ORP meter (ORP-14HI; Kimoto Electric Co., Ltd.)

Oxidation-reduction potential, or ORP, is a measurement in millivolts (mV) of the oxidation level in the water. This value reflects an aqueous system's capacity to either release or accept electrons from chemical reactions. An ORP probe measures the voltage across a circuit formed by a reference electrode (in effect, the negative pole of the circuit), and a measuring electrode (the positive pole), with the water in between. The ORP meter is mounted upward near the tail fins of AUV Yumeiruka (Figure 6)

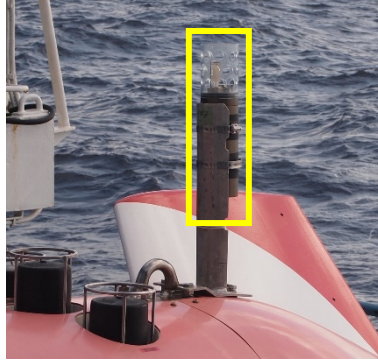


Figure 6: ORP meter on board near the tail fins of AUV Yumeiruka.

6. Acknowledgements

We would like to thank Captain S. Ryono and the crews of the R/V Natsushima for the skillful operations of the ship and assistance in the collection of the geophysical data during the cruise. We also thank H. Iwamoto from NME for their excellent support. The GMT software package (Wessel and Smith, 1998) was used for some of the figures.

Appendix A-1

Captain and crew of the R/V NATSUSHIMA

Captain	Shinya Ryono
Chief Officer	Masato Chiba
2nd Officer	Hidehiko Konno
3rd Officer	Yumihiko Kobayashi
Chief Engineer	Kazunori Noguchi
1st Engineer	Yoshinobu Hiratsuka
2nd Engineer	Takaatsu Inomoto
3rd Engineer	Kazuki Ono
Chief Electronics Operator	Hiroyasu Saitake
2nd Electronics Operator	Tatsuhiro Takakuwa
3rd Electronics Operator	Takayuki Mabara
Boat Swain	Hideo Isobe
Able Seaman	Shuichi Yamamoto
Able Seaman	Tsuyoshi Chimoto
Able Seaman	Shun Abe
Able Seaman	Toru Nakanishi
Sailor	Shinya Mogi
Sailor	Kyohei Murai
No.1 Oiler	Yukihiro Yamaguchi
Oiler	Katsuyuki Miyazaki
Oiler	Takuya Watanabe
Oiler	Toru Hidaka
Oiler	Shogo Iboshi
Chief Steward	Kazuhiro Hirayama
Steward	Hideo Fukumura
Steward	Akio Suzuki
Steward	Mizuki Nakano
Steward	Koichiro Kashiwagi

Appendix A-2

NT15-20 Shipboard Log

2015/11/27 TATEYAMA bay (35-00.4N, 139-47.7E)

Weather: Fine but cloudy / Wind direction: SW / Wind force: 9 / Wave scale: 6 /
Swell scale: 2 / Visibility: 8 miles (12:00 JST)

08:00	onboard
09:00	left JAMSTEC, proceeded to TATEYAMA bay
10:00-10:15	carried out education and training for scientist
10:15-10:25	scientists meeting
11:30	arrived at TATEYAMA bay
13:00	left TATEYAMA BAY, proceeded to off ITO
17:00	arrive at off ITO
18:30-20:50	YUMEIRUKA first dive meeting

2015/11/28 west off IZU-OOSHIMA (34-45.1N, 139-16.3E)

Weather: Fine but cloudy / Wind direction: East / Wind force: 2 / Wave scale: 2 /
Swell scale: 4 / Visibility: 7 miles (12:00 JST)

10:00	left off ITO
18:00-18:30	scientists meeting

2015/11/29 south off AOGASHIMA (31-57.8N, 139-44.2E)

Weather: Cloudy / Wind direction: NW / Wind force: 5 / Wave scale: 4 /
Swell scale: 3 / Visibility: 7 miles (12:00 JST)

05:50	arrived at research area
05:52	released XBT
09:45	dive was postponed
10:28-	start MBES survey
13:00-13:30	scientists meeting

2015/11/30 south off AOGASHIMA (31-57.2N, 139-45.0E)

Weather: Rain / Wind direction: NNE / Wind force: 3 / Wave scale: 3 /
Swell scale: 1 / Visibility: 5 miles (12:00 JST)

-04:55	finish MBES survey
07:04-12:40	AUV YUMEIRUKA #16 dive
13:30	transit to SAGAMI WAN

18:30-19:20 scientists meeting

2015/12/1 SAGAMI bay (35-09.1N, 139-23.0E)

Weather: Fine but cloudy / Wind direction: NNE / Wind force: 4 / Wave scale: 3 /

Swell scale: 1 / Visibility: 6 mile (12:00 JST)

08:00 arrive at SAGAMI bay

08:03 released XBT

11:33-14:46 AUV YUMEIRUKA #17 dive

15:30 transit to off YOKOSUKA

2015/12/2 Arrived at JAMSTEC

09:00 arrived at JAMSTEC

11:30 disembarked NATSUSHIMA

finished NT15-20 cruise