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Yokosuka/Urashima “Cruise Report”
YK21-10

# Scientific research toward sustainable utilization of marine resources

Shichito-Ioto Ridge

Jun.12, 2021 - Jun.25, 2021

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

**●Contents**



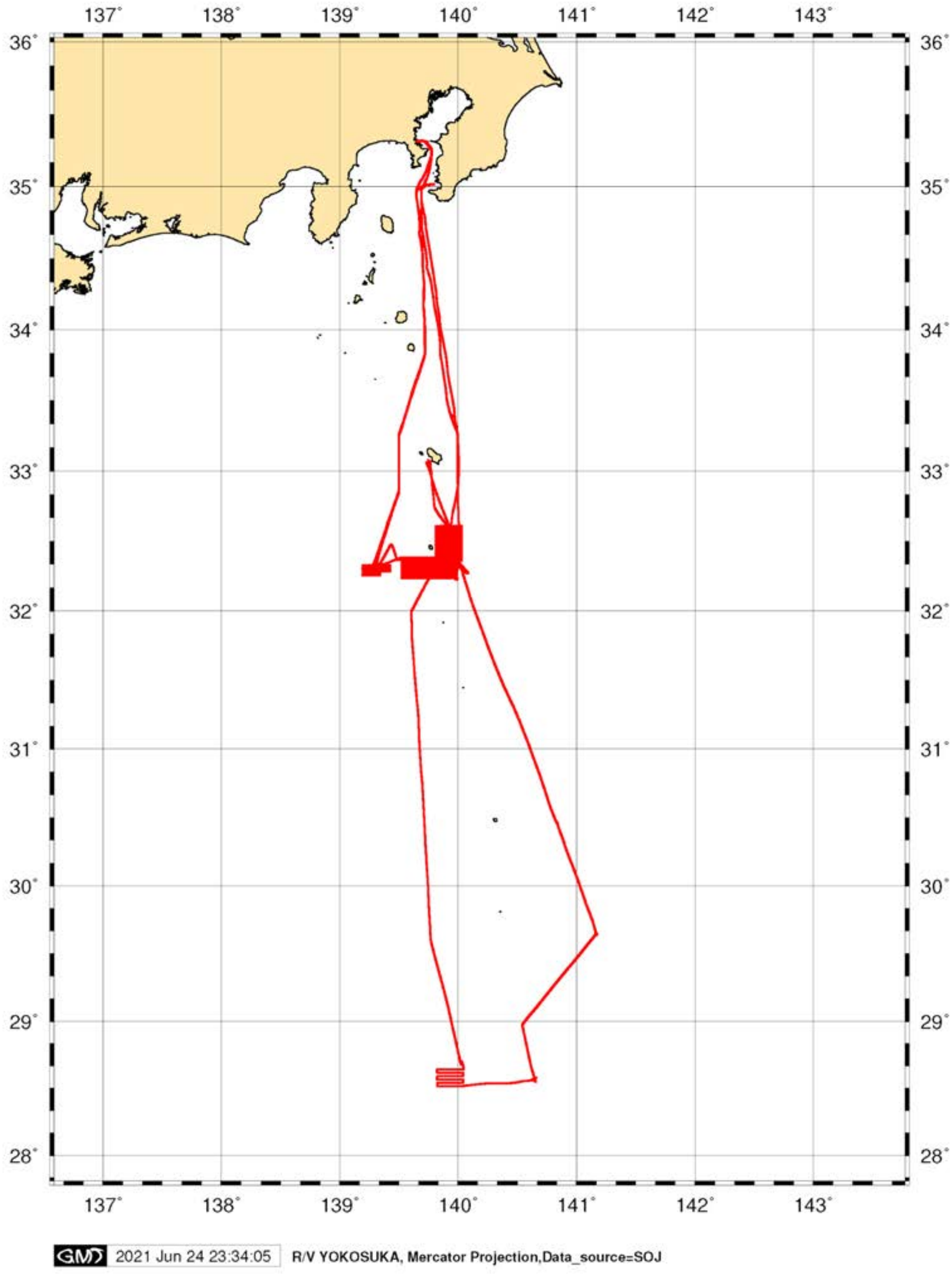
**Acknowledgements:**

We, all the member of the ship-board scientific party, are deeply grateful for the entire supports and advices given by Captain, Operation Manager, Crew and Operation Team throughout the cruise. We also thank MarE$^3$, MRU, X-star and all personnel who support the cruise.

## Section 1 Cruise Information

- Cruise ID: YK21-10
- Vessels: Urashima/Yokosuka
- Title of the cruise: Scientific research toward sustainable utilization of marine resources
- Title of proposal: Scientific research toward sustainable utilization of marine resources

- Period: Jun. 12 – Jun.25, 2021
- Ports: Yokosuka / Yokosuka
- Area:
  Shichito - Ioto Ridge
- Research Map



## Section 2 Science Party and Summary of Research Proposal

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- Research representative: Katsuhiko Suzuki [SRRC, MRU, JAMSTEC]
- Associate chief scientist: Kazuya Kitada [ASTER, X-star, JAMSTEC]
- Jr. associate chief scientist: Junji Kaneko [SRRC, MRU, JAMSTEC]
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  - Naoto Hirano [Tohoku Univ.]
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**Summary of Research Proposal:**

A comprehensive hydrothermal potential survey from the volcanic front to the back-arc depression in the Izu-Ogasawara region will be conducted. The area is known to have high potential for hydrothermal deposits, in order to verify the existence of large-scale hydrothermal deposits worthy of commercial development and to elucidate the formation mechanism of such deposits.

[Original proposal]

In the cruise, a precise AUV bathymetry and natural potential (SP) mapping in the Higashi-Aogashima caldera will be conducted; here the Higashi-Aogashima caldera is a candidate for future BMS drilling to explore sub-seafloor polymetallic deposits. Then, the Shichito-Ioto Ridge and its back arc area westward from the ridge will be surveyed their topography and hydrothermal plume by using a shipboard multi-beam instrument with orthogonal to present day’s volcanic arc swath survey lines to survey the topography in the unknown hydrothermal system between the Bayonnaise Knoll (32°N) and the Suiyo Seamount (28.5°N). If sedimentation is expected, a sub-bottom profiler onboard the "YOKOSUKA" will be used to map the sedimentation.

In terms of AUV survey, an AUV dive around 30.5°N and 139.0°E, where buried ridge-like topography is found, can be confirmed using the compiled bathymetry. Similarly, AUV dive will be conducted when a topographic singularity or hydrothermal plume is observed. After reaching the southern end of the survey area, we will extend the survey line to the Nishi-Shichito Ridge on the back arc side and continue the AUV dives at the singularity. In addition, we will measure the natural potential to estimate the extent of the mineralization zones. In addition to the outward AUV dive in the Higashi-Aogashima Caldera, we plan to dive in the Bayonnaise Knoll Caldera or Myojin Knoll

Caldera, which are alternative target areas for future BMS drilling. The Higashi-Aogashima Caldera has been the focus of attention because of the reported cases of unusually high gold content in the mineralization, but it lacks a detailed AUV survey. On the other hand, the Bayonnaise and Myojin Knoll Calderas have been estimated for their mineralization by geomagnetic anomalies, but no mapping of natural potential anomalies covering the anticipated mineralization area has been done. Therefore, we will dive from the viewpoint of complementing each of them. In addition to the above, no clear upwelling of the hydrothermal plume has been observed by the shipboard multi-beam survey equipment in the Izu-Ogasawara Arc so far, but we will make another observation to check for acoustic scattering by the hydrothermal plume in the water column of the survey record. Even if no plume is detected in the water, AUV diving will be conducted at the topographic singularity, and if the AUV diving provides very strong indications of hydrothermal activity, visual image confirmation by the YKDT onboard the Yokosuka will be conducted.

[Additional proposal proposed in 2021]

Suiyo Seamount is located near the southern end of the study area, and the hydrothermal system has been identified on the floor of the summit caldera on a scale of several hundred meters. The summit caldera is a relatively small caldera (maximum diameter of just over 1 km) and will be mapped with a single dive.

The back-arc minor knoll group was found by shipboard multi-beam survey in around 2000. However, since there is a high possibility that more detailed topography can be obtained due to the improvement of the survey parameters such as the spacing of the survey line, as well as the equipment replacement, it is necessary to conduct the following research. Therefore, the seafloor topography and water column acoustic anomaly survey will be conducted using the EM122 multi-beam onboard the "YOKOSUKA". If the acoustic anomaly is observed in the water column, we will focus on that point as singularity. Even if no water column acoustic anomaly is observed, we will dive the Urashima AUV to investigate the topography, water mass, geomagnetic field, and natural potential for a typical knoll. In addition, high heat flow anomaly areas in the regional crustal heat flow survey, such as the Smith Rift area, will be investigated by the EM122 multibeam onboard the Yokosuka to acquire active volcanic landforms such as calderas.

## Research and Development Activities

## 3. Backgrounds and Objectives

***Hidenori Kumagai, Kazuya Kitada and Junji Kaneko***

Due to the rapid increase of the global metal consumption, submarine polymetallic sulfides have attracted broader interests in this century. Under these circumstances, several national R&D projects toward producting submarine metallic resources have also been conducted. One of such, under the national R&D promotion as SIP, Next Generation Technology for Ocean Resources Exploration in SIP 1st period was conducted and develops an exploration protocol applicable to Okinawa Trough area: here, SIP is a national R&D project, Cross-ministerial Strategic Innovation Promotion Program.

In FY2011, JAMSTEC started an in-house R&D project to utilize submarine polymetallic resources, named the Submarine Resources Research Project (FY2011-2013). In our third mid-term plan, one of the Research and Development Centers, R&D Center for Submarine Resources, was formulated to continue the study to follow the project in the previous three years. In the present 4th mid-to-long term plan of JAMSTEC starting in FY2019, the Submarine Resources Research Center is placed in the Research Institute for Marine Resources Utilization to continue such studies. In this series of R&D activities, Submarine Hydrothermal Deposits is one of the prioritized types of resources to be studied. In the Japanese EEZ, two potential areas have been focused to be explored: Okinawa Trough and Izu-Bonin Arc. In this cruise, the latter area is chosen to be studied.

Under these circumstances, this cruise intend to apply the exploration protocols for submarine massive sulfide deposits established in the R&D activity in Okinawa Trough to Izu-Ogasawara Region. Further, to find some hopeful candidate area for unmapped and buried, i.e. new sub-seafloor ore deposits is also one of the objectives of the cruise.

## 4 Instruments and Methods

### 4.1. R/V Yokosuka

R/V YOKOSUKA was originally designed to serve as the mother vessel for the SHINKAI 6500 HOV (Human Occupied Vehicle). Since the construction of an autonomous underwater vehicle (AUV), URASHIMA, YOKOSUKA has been shared by SHINKAI and URASHIMA. It has a silent engine, advanced acoustic navigation systems and an underwater telephone for its state of the art operations. There are 5 laboratories in Yokosuka, No.1-No.4 laboratories and No.1 Study room. No.1 Lab. has dry space. The permanent installations are a PC and a printer. No.2 Lab. has a semi-dry and wet space. There are two freezers (-40 & -80 °C), an incubator, a Milli-Q ultrapure water supply, and a fumigation chamber at dry one, and wet one. No.3 Lab. has dry space with storage. No.4 Lab. has a semi-dry and wet space. There are a rock saw and another Milli-Q ultrapure water supply. No.1 Study room has dry space, there are a gravity meter (to be repaired at present), a data acquisition system of gravity meter, a 3 axis fluxgate magnetometer and also a proton magnetometer, a workstation for data processing, and a A0 size plotter.

**Table 4-1: 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 |

**Table 4-2: Complement for R/V Yokosuka**

| | |
|---|---|
| Crew | 28 persons |
| Submersible operation staff | 8 persons |
| Researchers | 15 persons |
| | Total 51 persons |

**Observation equipment on R/V YOKOSUKA**

R/V YOKOSUKA is equipped with various kinds of underway geophysical equipment, a multi narrow beam echo sounder (EM122, Kongsberg Maritime, Inc.), a Sub-Bottom Profiler (3300-HM, EdgeTec Inc.), a gravity meter (Type S-63, LaCoste & Romberg Gravity Meters Inc., to be repaired at present), a ship-borne 3 axis magnetometer (Type SFG-1212, Tierra Technica Inc.), and a proton magnetometer (Type STC 10, Kawasaki Geological Engineering Co., Ltd.). The specifications of these available instruments except EM122 are described below.

**Table 4-3: The specifications of 3 axis magnetometer**

| | |
|---|---|
| Type | SFG-1212, Tierra Technica Inc. |
| 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 4-4: The specifications of Proton magnetometer**

| | |
|---|---|
| Type | STC 10, Kawasaki Geological Engineering Co., Ltd. |
| 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) |

**Table 4-5: The specifications of Sub bottom Profiler**

| | |
|---|---|
| Type | 3300-HM, EdgeTec Inc. |
| Transducers | 4×4 plane array |
| Center frequency (kHz) | 2 ~ 16 |
| Type of pulse | FM |
| Band width (kHz) | 2 ~ 16 |
| Length of pulse (ms) | 5 ~ 100 |
| Resolution | 8cm, for 2 ~ 12 kHz |
| Penetration (m) | 6 for sand |
| | 80 for soft clay |
| Width of beam (using 4×4 array) | |
| | 33° for 3.5 kHz |
| | 24° for 4.5 kHz |
| | 20° for 6 kHz |

## 4.2. EM122 MBES and data acquisition

***Junji Kaneko***

EM122 multi beam echo sounder (Kongsberg Maritime, Inc.) is capable of deep water bathymetry and echo within the water column. The specifications of the

EM122 multi narrow beam echo sounder equipped with R/V YOKOSUKA are listed below;

**Table 4-6: 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)<br>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 |

In order to obtain the high resolution bathymetry using ship-hull mounted MBES, the density of the point where the echo reflected is crucial. Thus, during the acquisition of detailed bathymetry, the swath width and speed of the vessel are carefully controlled: swath width is limited to 1,000m for each side, vessel speed is set 6kt or slower.

## 4.3. AUV URASHIMA

*NME*

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 and during its cruising if needed. DVL (TELEDYNE RD INSTRUMENTS WHN300) is maximum 110m of range (altitude) and measure bottom speed using 300kHz Doppler sonar for AUV navigation. In case of the using 200 kHz sonar, the available range for altitude becomes grater. 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 equipment and sensors, side scan sonar, sub-bottom profiler, multi beam echo sounder, and CTD sensor.

**Table 4-7: The general specifications of URASHIMA**

| | | |
|---|---|---|
| Length | | 10.5 m |
| Width | | 1.3m |
| Height | | 1.5m |
| Weight | | 7.5 t |
| Cruise range | Li-ion | 100km |
| | Fuel Cell | 300km |
| Maximum operating depth | | 3,500m |
| Speed | Maximum | 3knot |
| | Cruising | 3knot (typically 2.4knot) |

| | |
|---|---|
| Positioning | Inertial Navigation System<br>Doppler Sonar<br>SSBL Sonar |
| Operation Mode | Autonomous<br>Remote (Acoustic / Optical) |

### *4.3.1 Multibeam echo sounder on AUV Urashima*

Bathymetric data were collected by Reson SEABAT 7125 AUV on URASHIMA. SEABAT 7125 AUV is a high-resolution multi-beam sonar system operating at either 200kHz or 400kHz that generates data for wide-swath bathymetry maps and backscattering images. The system consists of two main subsystems, transmitter and receiver. The 200kHz (400 kHz) projector array are positioned fore and aft along the ship's keel. The along-track transmit beam width is 2.0° (or 1.0°). 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 1.0° (0.5°). The "equi-distance mode" was selected in beam forming (meanwhile, "equi-angle mode"). Generally, the ping rate was controlled "range" that is the time between transmitting and receiving. Normally, the ping rate is approximately 2Hz due to 180m altitude of AUV operation. The system swath angle is maximum 165° and maximum number of beams is 256 (or 512). The swath width was about 3 times of center depth until 120 m of altitude, and decreased to 250-300 m at 120-160 m of altitude, and then 50% of center depth at 160-180m of altitude. Above 200 m from the seafloor, no effective data was logged. Actual swath coverage was approximately 120m during this cruise survey. Data was logged in Reson standard s7k format and preliminary onboard processing was done using CARIS ver. 11.3.

**Table 4-8: The general specifications of Reson SeaBat7125 series**

| | | |
|---|---|---|
| Frequency | | 200kHz / 400kHz |
| Beam width | along track | 2.0deg@200kHz / 1.0deg@400kHz |
| | across track | 1.0 deg@200kHz / 0.5deg@400kHz |
| Ping rate | (max) | 50Hz (±1Hz) |
| Pulse width | | 30μsec to 300μsec |
| Beam transmit mode | | Equi-Angle Mode(EA),<br>Equi-Distant Mode(ED) |
| Number of beam | | 256EA/ED@200kHz<br>512EA/ED@400kHz |
| Max Swath angle | | 165deg(EA),140deg (ED) |
| Measurement range | | 200m (Max) |
| Depth Resolution | | 6mm |
| Output format | | 7k (Reson standard format) |

### *4.3.2 Side scan sonar on AUV Urashima*

Acoustic waves are 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 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 observation of a flat floor with constant altitude to a seafloor, and uniform propagation velocity of acoustic waves in seawater. The first returning echo that comes from just below the AUV is considered and is able to determine the altitude. Once the first echo is detected, they catch the magnitude of the pixels. Detected sounds after the first echo are aligned along arrival time from below the fish to the oblique reflection points. Backscattering intensity 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 collection, 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 2200M) installed in AUV URASHIMA are shown below. URASHIMA uses 120 kHz acoustic waves.

**Table 4-9: The general specifications of EdgeTech 2200M**

| | |
|---|---|
| Frequency | 120kHz (full spectrum chirp) |
| Beam angle | 0.9degree |
| Range | 25 to 300m |
| Altitude | up to 120m |
| Vertical Resolution | 6.25cm |
| Output format | jsf (EdgeTech standard format) |

### *4.3.3 Sub bottom profiler*

A sub bottom profiler (Edge-Tech DT106) is installed near the head part of the AUV URASHIMA. The sub bottom profiler transmits chirp signals of 1to 6 kHz, and detects sub-seafloor objects when the seafloor is covered by thick sediments. The record output is formatted in the private format of the manufacturer, jsf format (EdgeTech), but all records are converted into SEGY format at processing after the dives.

**Table 4-10: The general specifications of EdgeTech DT106**

| | | |
|---|---|---|
| Frequency | | 1-6kHz, chirp |
| Beam width | horizontal | 28-36degrees (typically 30degree) |
| Resolution | | 15-25cm |
| Ping interval | | 2Hz |
| Output format | | jsf (EdgeTech standard format) |

### *4.3.4 Other Instruments*

URASHIMA also has a DVL system to its positioning besides the INS and standard CTD equipment.

**Table 4-11: The general specifications of DVL, Teledyne RD Instruments WHN300**

| | |
|---|---|
| Frequency | 300kHz |
| Measurement range | ±10m/s |
| Resolution | 0.1cm/s |
| Ping interval | 7Hz |
| <Ground speed meter> | |
| Standard deviation | ±0.3cm/s@1m/s |
| | ±0.6cm/s@3m/s |
| | ±0.8cm/s@5m/s |
| Accuracy (Long range measurement) | ±0.4%±0.2cm/s |
| Detection depth | Min: 1.0m Max: 200m |

< Speed through the water >

| | |
|---|---|
| Accuracy | ±0.4% ±0.2cm/s |
| Range | Min: 1.0m Max: 110m |

**Table 4-12: The general specifications of SeaBird Electronics SBE49FactCAT, CTD**

| | |
|---|---|
| Measurement range | -5 to + 35 ℃ |
| | 0 to 9 S/m |
| | 0 to 20/100/350/1000/2000/3500/7000dBar |
| Initial accuracy | 0.002 ℃ |
| | 0.0003 S/m |
| | 0.1% full scale |
| Stability(/Monthly) | 0.0002 ℃ |
| | 0.0003 S/m |
| | 0.004 % full scale |
| Resolution | 0.0001 ℃ |
| | 0.00005 S/m (In the case of seawater) |
| | 0.002% full scale |
| Power supply | 9-24 VDC (Standard) |
| | 12-28 VDC (Option)(Submersible pump : |
| Electricity consumption | 3.5W (In the case of 9-28VDC) |
| | 0.8W (Submersible pump: OFF) |
| Housing case | Titanium (3AL/2.5V) |
| Max use Depth | Titanium: 7000m/Plastic |
| External dimensions | 62mm (Outer diameter×620mm (Length) |
| Weight | 2.7kg (Air)/1.4kg (Water) |
| Output format | csv (EdgeTech standard format) |

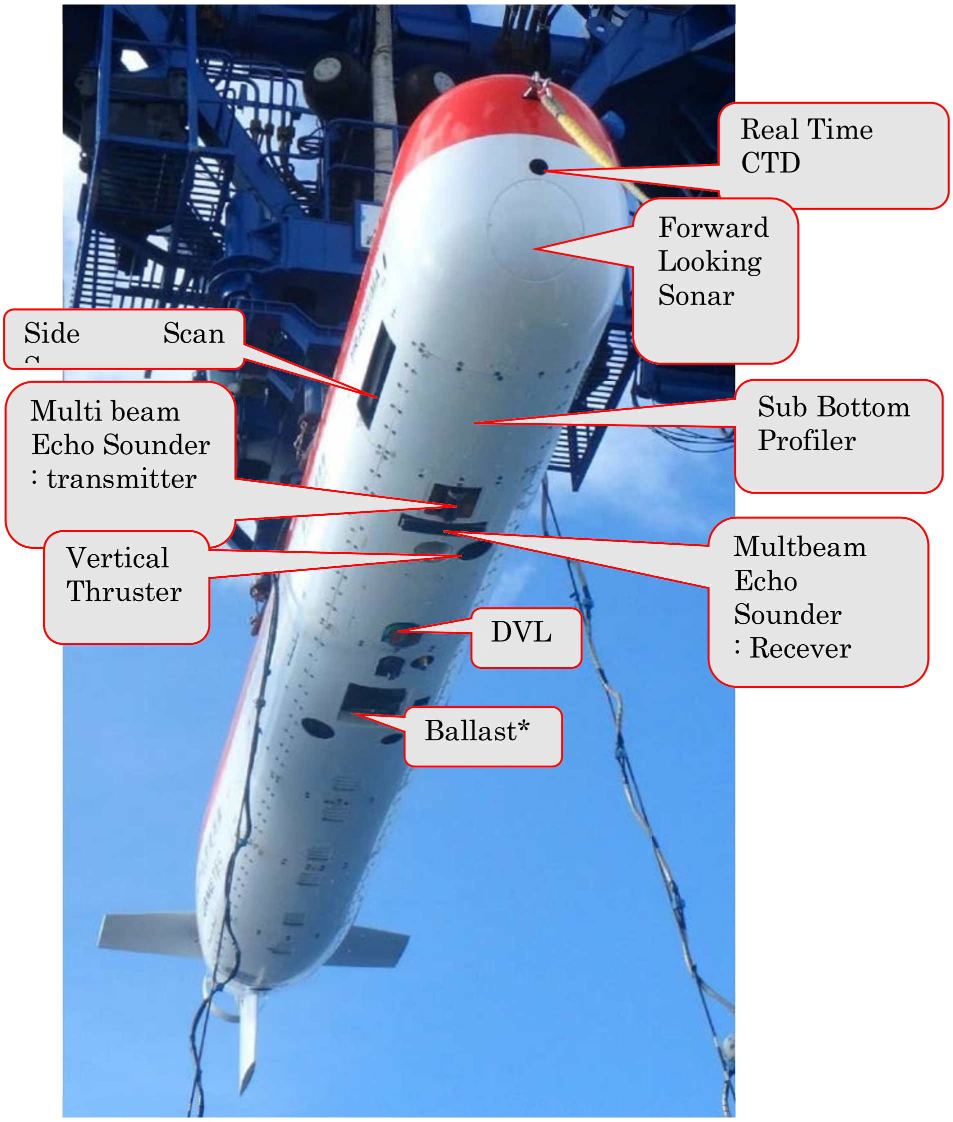



**Figure 4-1: Sensors and instruments on Urashima. *A 125kg ballast assembly is lathed this position, and released at the end of the survey. This photograph was taken at the AUV retrieval.**

### *4.4. YK-DT*

YKDT is one of the towed deep sea observation apparatus equipped with video and still cameras tethered to R/V Yokosuka by the opt-electric armored cable. In this cruise, towed a magnetometer and potential electrodes together with chemical sensors were set as payloads.

<u>**Table 4-14:** Specifications of YKDT</u>

| | |
|---|---|
| Length: | 3.3 m |
| Beam: | 1.0 m |
| Height: | 1.2 m |
| Weight in air: | 1.2 tons |
| Maximum operating depth: | 6,000 m |
| Cameras: | one full high vision, one b/w NTSC |
| Speed: | ~ a few tenths knots |

### *4.5. Voltmeters as payloads for URASHIMA*

*Takafumi Kasaya*

The voltmeter was originally designed for the controlled source survey with 1 kHz sampling rate (Table 4-15). All electric circuits and batteries are installed in a cylinder type aluminum or titanium pressure case. In this cruise, two voltmeters (5ch and 8ch type) were loaded on the AUV URASHIMA for the self-potential survey which is very powerful method to detect the subsurface hydrothermal deposit (Kawada and Kasaya, 2017; Kawada and Kasaya2018). The 5 channels type voltmeter measured the electric field using a towed electrode array, and the 8 channels type voltmeter also measured it using electrodes on the AUV URASHIMA for vector observation of the electric field. Both voltmeters measured with 100 Hz sampling rate. The electrodes are Ag-AgCl equilibrium type manufactured by Clover Tech. For the estimation of electric fields, four voltage differences between each electrode and common electrode are calculated.

**Table 4-15: Specification of a voltmeter**

Measurement channels: 5 or 8 channels
Measurement Voltage Range: ±100 mV
A/D converter: 24 bits
Recording Media: SDHC
Sampling rate: 1 kHz (Max)

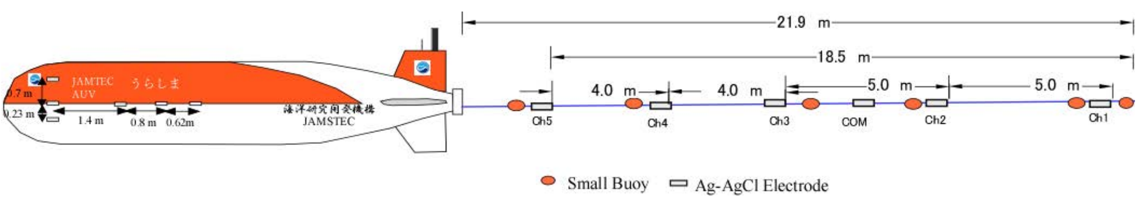



**Figure 4-2 Electrode's configuration on the AUV URASHIMA**

### *4.6. Magnetometers as payloads for URASHIMA*

***Kazuya Kitada***

During all the dives (Dives #297 - #301), magnetic field data were successfully collected by two fluxgate magnetometers to reveal the magnetic signatures around the hydrothermal sites. These magnetometers were attached to the port and starboard sides of the payload space. For two dives (Dives #299 and #300), figure-eight turns were conducted near the bottom at the end of the surveys to correct the effect of the vehicle's permanent and induced magnetic fields.

### *4.7. Biogeochemical sensors as payloads for URASHIMA*

***Tatsuhiro Fukuba and Kazuya Kitada***

A standalone CTD profiler (SBE 19PlusV2, Seabird) equipped with a turbidity sensor (Seapoint, 100X gain) and an optode DO sensor (SBE63, Seabird) was operated for all of Urashima dives. The CTD was operated at "mooring mode" and the sampling interval was set to 10 sec. Water intake tube for CT and DO measurement connected to the pump was fixed at the port side of Urashima along with the turbidity sensor.

Two pH sensors based on the ISFET (Ion Sensitive Field Effect Transistor) technology developed at the University of Tokyo and JAMSTEC were mounted on Urashima to detect low-pH anomalies caused by hydrothermal activity. Sensor output (voltage count) was recorded on the built-in memory every 10 sec. The sensors were calibrated using pH

standard solutions (AMP, TRIS) before and after each dive. The sensor-heads were placed at the starboard of Urashima.
Turbidity (ATU6-CMP; JFE Advantech Co., Ltd.) 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 environments. 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 matter, so it provides high accuracy turbidity measurements. The turbidity meter is attached downward on the bottom of the AUV URASHIMA hull.
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 horizontally on the top of AUV URASHIMA.
Along with the physicochemical parameters, biological activity, abundance, and distribution can be also affected by geological events such as hydrothermal venting. *In situ* ATP analyzer was operated at all of the Urashima dive for the purpose of measuring the concentration of ATP (adenosine triphosphate) as a proxy of microbial biomass. The miniaturized continuous flow analyzer developed at JAMSTEC has capability of quantifying microbial ATP (particulate and total ATP) by means of Luciferin-Luciferase bioluminescence assay. The analyzer was placed at the payload bay of Urashima and the sample intake tube was fixed at the port side of Urashima. During the dive, the analyzer was calibrated using blank and standard solutions for the conversion of bioluminescence intensity to ATP concentration.

# 5 Observations

## *5.1. Bathymetry by R/V Yokosuka*

***Junji Kaneko and Hidenori Kumagai***

Under a careful acquisition of the dense spacing of the survey track, special resolution of ship-hull-mounted MBES approaches 10m in 1000m WD. The parameters applied in this cruise are listed below.

**Table 4-16: Parameters**

| | |
|---|---|
| Angle: | 70deg. |
| Coverage: | 1,000 m |

Applying the parameters listed above, the following areas were mapped: Higashi-Aogashima Caldera, the back-arc minor knoll group in 28°30’-40’N and 139°50’-140°00’E, and Daini-Nishi-Aogashima Knoll. Further, standard bathymetric data under the standard swath width and vessel speed were also obtained in magnetic survey (see below).

## *5.2. Magnetic survey by R/V Yokosuka*

***Kazuya Kitada***

Detailed magnetic survey was conducted with a line spacing of 1 arc min at a ship speed of ~10 knots over the Higashi-Aogashika Caldera and off the south side of Aogashima Island. The survey aims to clarify the spatial distribution of the crustal magnetization and the sub-seafloor structures. Magnetic field data were collected by two equipment; a shipboard three-component magnetometer (STCM, Tierra Tecnica SFG-1212) and a ship-towed proton magnetometer (Kawasaki Geological Engineering Co., Ltd., STC 10). The STCM data contain the effects of the ship's magnetic field, which is required to be corrected to derive the real geomagnetic field. The 360° rotation data of both clockwise and counter-clockwise, called figure-eight turns, were conducted for the calibration and the twelve constants (B(1,1)-B(3,4)) related to the ship’s permanent and induced magnetic field were estimated using the calibration data. During this cruise, figure-eight turns were conducted three times. Total geomagnetic fields were measured by using a proton marine magnetometer. The length of the towed cable was ~300 m to reduce the ship’s magnetic effect.

## *5.3. AUV Dives*

***Hidenori Kumagai and Junji Kaneko***

Five dives in total were conducted in the cruise: three at Higashi-Aogashima Caldera (Dives #297, 298, and 300), one at Suiyo Smt. (Dive # 299) and one at Daini Nishi-Aogashima Knoll (Dive # 301).

**<u>Dive information</u>**

<u>Urashima Dive #297</u>

Date: June 13, 2021

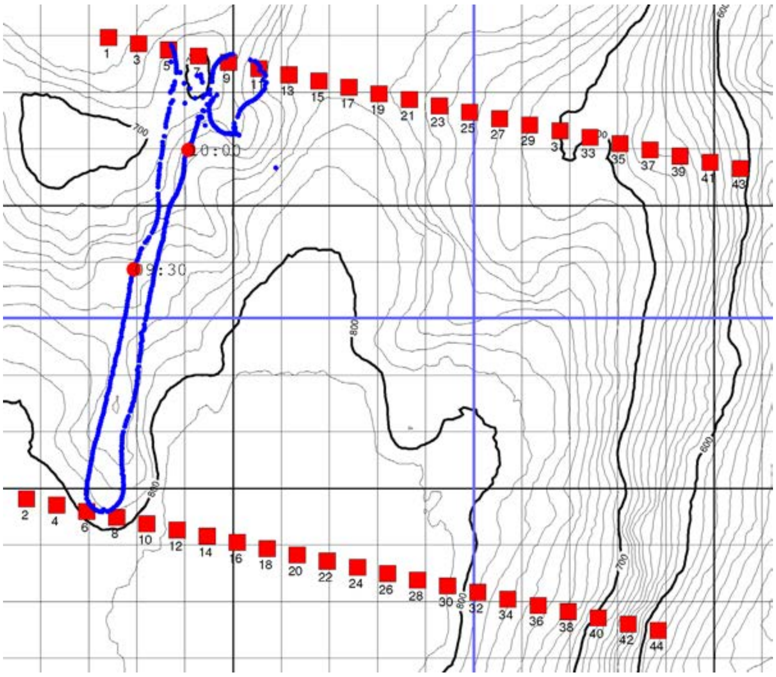
Location: Central Cone and Southeast hydrothermal area in Higashi-Aogashima Caldera
Area: 32°25.96'-26.83'N, 139°53.69 – 54.06'E, 700 – 790 mWD

Payloads: Potential Electrodes, three-component magnetometer, turbidity meter, pH sensor, ORP sensor, CTD, ATP sensor

Description:

Sediment sampled from Higashi-Aogashika Caldera is known for its high concentration of Au (Iizasa et al., 2019). There are three vent areas, central cone, southeast and east, respectively. In this dive, southern two of three were chosen to survey. The dive started from the area of the central cone site; however, the vehicle got into an emergency mode of immediate leaving the bottom at the end of the second track line. Thus, the central cone area just around the tall chimney has been mapped in this dive.

Dive Map:




Map center: 32°26.3’N, 139°54.5’E. Grid intervals: 0.1min.

<u>Urashima Dive #298</u>

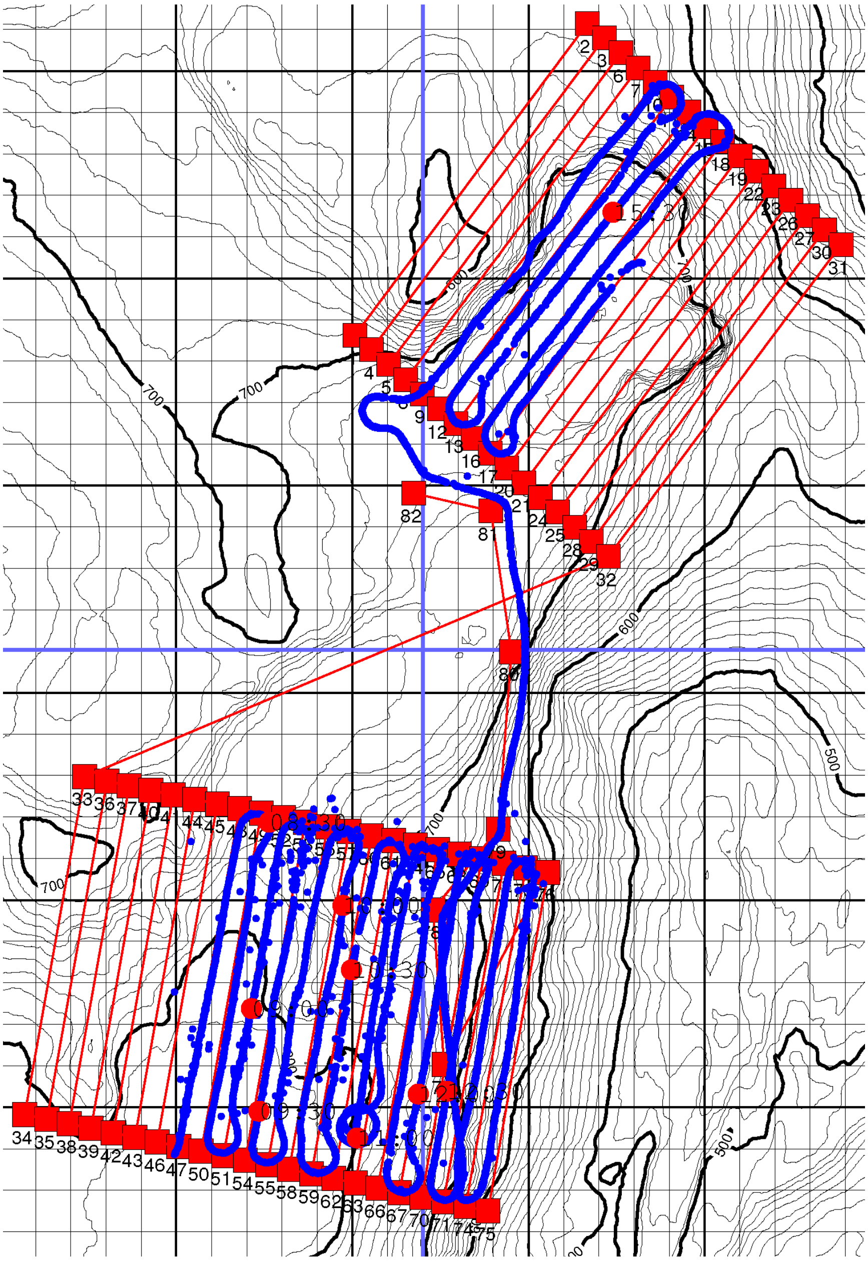
Date: June 14, 2021

Location: Southeast and East hydrothermal area in Higashi-Aogashima Caldera
  Area: 32°25.77'-28.47'N, 139°54.00 – 55.58'E, 600 – 810 m WD

Payloads: Potential Electrodes, three-component magnetometer, turbidity meter, pH sensor, ORP sensor, CTD, ATP sensor

Description:

Followed to the previous dive, the remaining two hydrothermal vent areas, i.e. southeast and east sites, were mapped. Duiring the transit from the southeast site to the east one, located high backscatter intensity areas on the EM122 MBES were intended to pass as the waypoints.

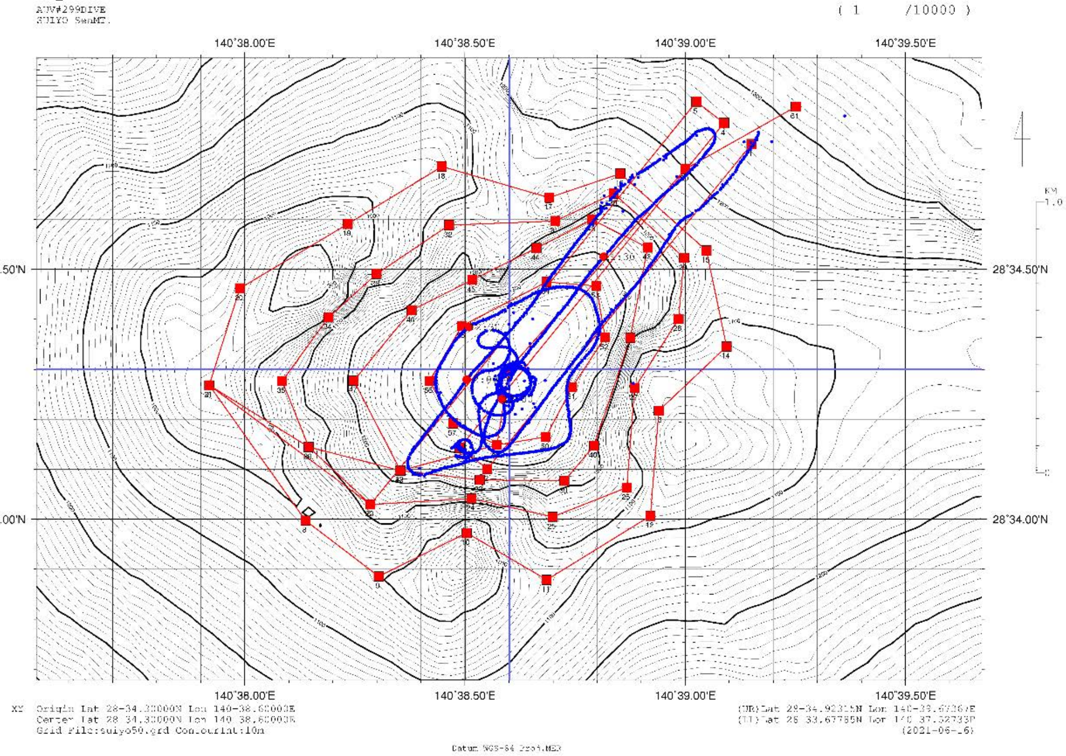


Map center: 32°27.1’N, 139°54.7’E. Grid intervals: 0.1min.

<u>Urashima Dive #299</u>
Date: June 16, 2021
Location: Suiyo Smt.
Area: 28°34.09'-34.78'N, 140°38.36 – 39.17'E, 1150 – 1410 mWD
Payloads: Potential Electrodes, three-component magnetometer, turbidity meter, pH sensor, ORP sensor, CTD, ATP sensor
Description:
Suiyo Smt is one of the focused study sites for volcanic arc hydrothermalism in early 2000s (see. Urabe?). A vent-concentrated area was located in the eastern rim of the crater floor (Kinoshita et al., 2006). The crater is rather narrow and deep, approx. 900 × 500 m in area, surrounded by the crater rim of more than 350m of height from

the bottom of the crater floor. The dive was initially planned to cover the entire crater; however, due to the deterioration of sea state, the dive was suspended approx. 2.5 hrs from its commencement with three swath lines and one circle track on the edge of the crater floor.

Dive Map:




Urashima Dive #300

Date: June 19, 2021

Location: East hydrothermal area in Higashi-Aogashima Caldera

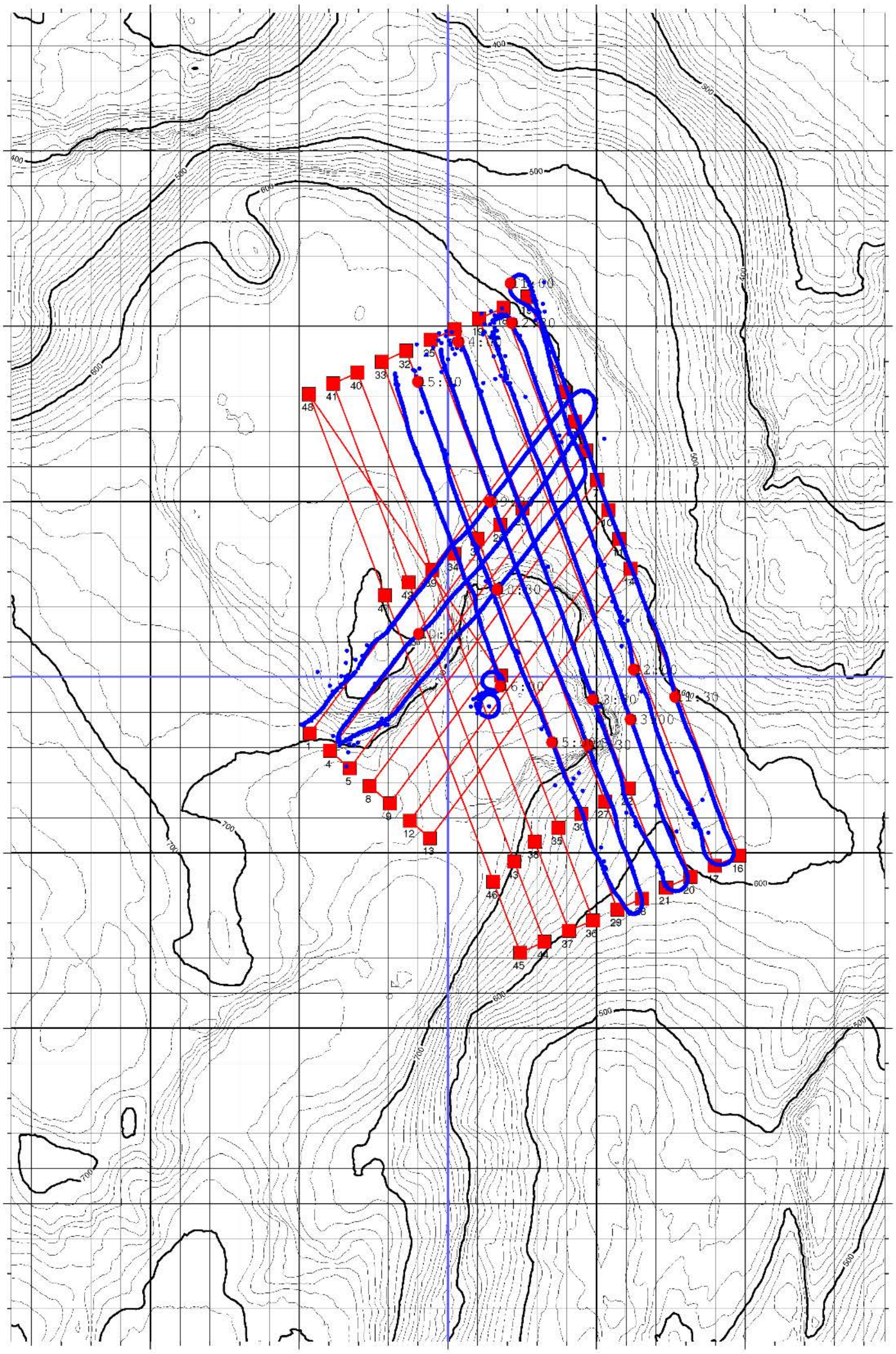
Area: 32°27.33'–29.14'N, 139°54.50 – 55.96'E, 600 – 760 m WD

Payloads: Potential Electrodes, three-component magnetometer, turbidity meter, pH sensor, ORP sensor, CTD, ATP sensor

Description:

This memorial 300th dive of URASHIMA is planned to cover the SP anomaly area of the northern part of East Hydrothermal area of Higashi-Aogashima caldera.

Dive MAP:

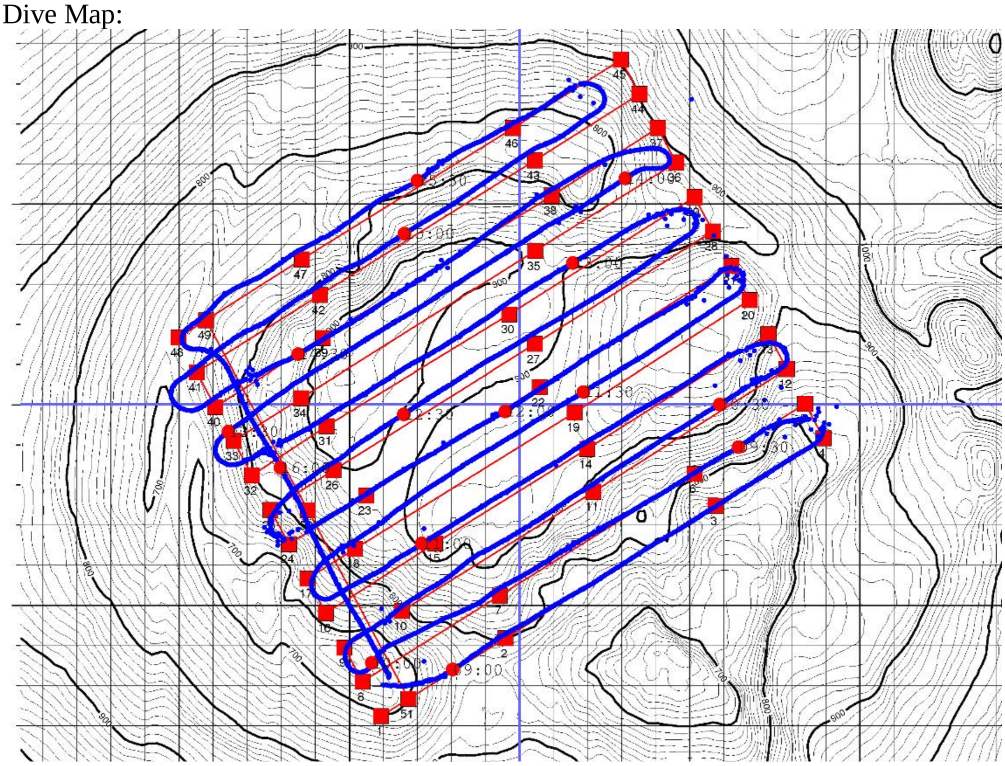


Map center: 32°28.0’N, 139°55.0’E. Grid Intervals: 0.1min.

<u>Urashima Dive #301</u>
Date: June 21, 2021
Location: Inside the caldera of Daini-Nishi-Aogashima Knoll
Area: 32°17.30'-18.90'N, 139°16.47 – 18.39'E, 660 – 980 m WD
Payloads: Potential Electrodes, three-component magnetometer, turbidity meter, pH sensor, ORP sensor, CTD, ATP sensor

Description:
Approx.50 km eastward from the present day's volcanic front, an elongated 2km-long caldera is located on the Daini-Nishi-Aogashima Knoll. The bottom of the caldera floor is not flat, a 10 m elevation ridge in the northwestern quadrant of the caldera striking NE-SW direction, a 50-m deeper round-shape deep in the northeastern side.

Dive Map:



Map center: 32°18'N, 139°17.5'E. Grid intervals: 0.1min.

### *5.4. YKDT dive*

In order to investigate the locality of SP anomaly and ground truth of the acoustic nature reflecting geological environment, YKDT #212 dive was planned in the caldera of Daini Nishi-Aogashima Knoll. The dive tracks are set as a series of ENE-WSW and NNW-SSE crossings. Unfortunately, mechanical troubles occurred before arrival to the caldera floor, thus, no visual images nor sensor data were acquired.

●Dive information

YKDT Dive #212

Date: June 23, 2021

Location: Daini Nishi-Aogashima Knoll

Target: 32°17.80', 139°16.90, 855 m WD

Payloads: Potential Electrodes, towing magnetometer, turbidity meter, pH sensor, ORP sensor, CTD, ATP sensor

Description:

Firstly, we conducted a towing magnetometer check in water. In the test, the trouble of the connector near the magnetometer releaser made YKDT immediate retrieval. After fixing this trouble, YKDT directed to the caldera floor. Passing down approx. 600m in water depth the tow-fish has fallen into mechanical trouble. Then, it was forced immediate retrieval again.

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## R/V "YOKOSUKA" YK21-10 Cruise Log

| Date & Time | Note | NoonPosition /Weather/Wind/SeaCondition |
|---|---|---|
| 2021/06/12 Sat. | | Westward SUSAKI |
| 08:00 | Science party onboard a vessl | 34-49.7N, 139-40.0E |
| 09:00 | Let go all shore lines & left YOKOSUKA JPP | Cloudy |
| 10:30-11:15 | Briefing about ship's life and safety | SE-3 (Gentle breeze) |
| 13:15-13:30 | Meeting for deploy and recover sequence with ship crew | 2 (Sea Smooth) |
| 14:00-14:40 | Pre-Dive Meeteing for "URASHIMA" | 2 (Low Swell Slong) |
| 18:00-19:00 | Scientific meeting | Visibly: 8' |
| 18:57-19:18 | Carried out eight figure running | |
| 23:05 | Released XBT | |
| 23:38- | Commenced MBES mapping survey | |
| | | |
| 2021/06/13 Sun. | **"URASHIMA" Dive #297** | Higashi-Aogashima caldera |
| -04:45 | Finished MBES mapping survey | 32-26.5N, 139-53.8E |
| 08:26 | Hoisted up "AUV-URASHIMA". | Cloudy |
| 08:32 | Launched above AUV. | SSE-4 (Moderate breeze) |
| 08:32 | "AUV-URASHIMA" dove & started her operation UR#297 | 3 (Sea Slight) |
| 10:40 | Refloated "AUV-URASHIMA". | 2 (Low Swell Slong) |
| 11:24 | Hoisted up above AUV. | Visibly: 8' |
| 11:36 | Recovered "AUV-URASHIMA" & finished above operation. | |
| 14:09 | Commenced MBES mapping survey | |
| 18:00-18:15 | Scientific meeting | |
| | | |
| 2021/06/14 Mon. | **"URASHIMA" Dive #298** | Higashi-Aogashima caldera |
| -05:08 | Finished MBES mapping survey | 32-26.4N, 139-54.5E |
| 07:17 | Hoisted up "AUV-URASHIMA". | Fine but Cloudy |
| 07:25 | Launched above AUV. | SE-2 (Light breeze) |
| 07:25 | "AUV-URASHIMA" dove & started her operation UR#298 | 2 (Sea Smooth) |
| 16:29 | Refloated "AUV-URASHIMA". | 2 (Low Swell Slong) |
| 17:16 | Hoisted up above AUV. | Visibly: 8' |
| 17:25 | Recovered "AUV-URASHIMA" & finished above operation. | |
| 18:08-18:18 | Started towing Total magnetometer | |
| 18:41 | Commenced MBES & Magnetometer survey | |
| 19:00-20:05 | Scientific meeting & Seminar | |
| 19:24 | Finished MBES & Magnetometer survey | |
| 19:25 | Departured from Research Area (Higashi-Aogashima caldera) | |
| | | |
| 2021/06/15 Tue. | | Back arc small knoll cluster |
| 13:55 | Arrived at Research Area (Area of Back arc small knoll cluster) | 29-04.1N, 139-55.6E |
| 14:15 | Released XBT | Fine but Cloudy |
| 14:55- | Commenced MBES & Magnetometer survey | NE-5 (Fresh breeze) |
| 18:00-18:40 | Scientific meeting | 3 (Sea Slight) |
| | | 4 (Moderate Average) |
| | | Visibly: 8' |
| | | |
| 2021/06/16 Wed. | **"URASHIMA" Dive #299** | Suiyo Smt. |
| -01:47 | Finished MBES & Magnetometer survey | 28-34.8N, 140-39.2E |
| 01:47 | Departured from Research Area (area of Back arc small knoll cluster) | Fine but Cloudy |
| 06:30 | Arrived at Research Area (Suiyo Smt.) | ESE-3 (Gentle breeze) |
| 06:32-06:40 | Finished towing Total magnetometer | 2 (Sea Smooth) |
| 09:30 | Hoisted up "AUV-URASHIMA". | 2 (Low Swell Slong) |
| 09:38 | Launched above AUV. | Visibly: 8' |
| 09:38 | "AUV-URASHIMA" dove & started her operation UR#299 | |
| 13:28 | Refloated "AUV-URASHIMA". | |
| 13:56 | Hoisted up above AUV. | |
| 14:04 | Recovered "AUV-URASHIMA" & finished above operation. | |
| 14:45 | Departured from Research Area (Suiyo Smt.) | |
| 15:23-17:09 | MBES mapping survey | |
| 17:55-18:25 | Scientific meeting | |
| 20:56-21:17 | Carried out eight figure running | |
| | | |

| | | |
|---|---|---|
| 2021/06/17 Thu. | | Eastward Aogashima |
| 14:25 | Arrived at off Hachijo-shima Island | 32-38.7N, 139-54.3E |
| 18:00-18:40 | Scientific meeting | Cloudy |
| | | NE-6 (Strong breeze) |
| | | 4 (Sea Moderate) |
| | | 3 (Moderate Short) |
| | | Visibly: 8' |
| | | |
| 2021/06/18 Fri. | | Off Hachijo-shima Island |
| 12:30 | Departured from off Hachijo-shima Island | 33-02.7N, 139-45.9E |
| 14:59-15:08 | Started towing Total magnetometer | Fine but Cloudy |
| 15:33- | Commenced MBES & Magnetometer survey | NW-3 (Gentle breeze) |
| 18:00-18:40 | Scientific meeting | 2 (Sea Smooth) |
| | | 2 (Low Swell Slong) |
| | | Visibly: 8' |
| | | |
| 2021/06/19 Sat. | **"URASHIMA" Dive #300** | Higashi-Aogashima caldera |
| -05:40 | Finished MBES & Magnetometer survey | 32-27.8N, 139-55.9E |
| 06:30-06:42 | Finished towing Total magnetometer | Fine but Cloudy |
| 8:12 | Hoisted up "AUV-URASHIMA". | SSE-4 (Moderate breeze) |
| 8:20 | Launched above AUV. | 3 (Sea Slight) |
| 8:23 | "AUV-URASHIMA" dove & started her operation UR#300 | 3 (Moderate Short) |
| 16:23 | Refloated "AUV-URASHIMA". | Visibly: 8' |
| 17:07 | Hoisted up above AUV. | |
| 17:15 | Recovered "AUV-URASHIMA" & finished above operation. | |
| 18:11 | Started towing Total magnetometer | |
| 18:55-19:25 | Scientific meeting | |
| 19:55- | Commenced MBES & Magnetometer survey | |
| | | |
| 2021/06/20 Sun. | | Westward Aogashima |
| -07:56 | Finished MBES & Magnetometer survey | 32-21.1N, 139-25.6E |
| 08:20- | Commenced MBES & Magnetometer survey | Overcast |
| -11:25 | Finished MBES & Magnetometer survey | West-5 (Fresh breeze) |
| 12:27- | Commenced MBES & Magnetometer survey | 3 (Sea Slight) |
| 18:00-19:15 | Scientific meeting | 3 (Moderate Short) |
| | | Visibly: 7' |
| | | |
| 2021/06/21 Mon. | **"URASHIMA" Dive #301** | Daini Nishi-Aogashima Knoll |
| -06:12 | Finished MBES & Magnetometer survey | 32-17.2N, 139-17.2E |
| 06:30-06:41 | Finished towing Total magnetometer | Rain |
| 8:16 | Hoisted up "AUV-URASHIMA". | East-4 (Moderate breeze) |
| 8:24 | Launched above AUV. | 3 (Sea Slight) |
| 8:25 | "AUV-URASHIMA" dove & started her operation UR#301 | 2 (Low Swell Slong) |
| 16:27 | Refloated "AUV-URASHIMA". | Visibly: 5' |
| 16:53 | Hoisted up above AUV. | |
| 17:02 | Recovered "AUV-URASHIMA" & finished above operation. | |
| 17:46-18:08 | Carried out eight figure running | |
| 18:10 | Departured from Research Area (Daini Nishi-Aogashima Knoll) | |
| 19:00-19:30 | Scientific meeting | |
| | | |
| 2021/06/22 Tue. | | Tateyama bay |
| 7:30 | Arrived at Tateyama bay | 35-01.0N, 139-47.8E |
| 16:40 | Departured from Tateyama bay | Fine but Cloudy |
| 18:00-18:30 | Scientific meeting | East-3 (Gentle breeze) |
| | | 1 (Sea Calm Rippled) |
| | | 1 (Low Swell Short) |
| | | Visibly: 8' |
| | | |

| | | |
|---|---|---|
| 2021/06/23 Wed. | **"YKDT" Dive #212** | Daini Nishi−Aogashima Knoll |
| 7:30 | Arrived at Research Area (Daini Nishi-Aogashima Knoll) | 32-17.7N, 139-16.5E |
| 09:16-10:14 | "YKDT" payload test | Rain |
| 11:48 | "YKDT" dove & started her operation #212 | ENE-4 (Moderate breeze) |
| 12:23 | Suspended "YKDT" diving operation due to System trouble. | 3 (Sea Slight) |
| 12:36 | Refloated "YKDT" | 2 (Low Swell Slong) |
| 12:47 | Recovered "YKDT" & finished above operation. | Visibly: 7' |
| 14:34-14:43 | Started towing Total magnetometer | |
| 16:22- | Commenced MBES & Magnetometer survey | |
| 18:00-18:10 | Scientific meeting | |
| 2021/06/24 Thu. | | Southward Aogashima |
| -14:39 | Finished MBES & Magnetometer survey | 32-15.0N, 139-32.0E |
| 15:50 | Commemomorative photo | Fine but Cloudy |
| 16:00-16:11 | Finished towing Total magnetometer | East-3 (Gentle breeze) |
| 16:20 | Departured from Research Area (Daini Nishi-Aogashima Knoll) | 2 (Sea Smooth) |
| 18:00-18:15 | Scientific meeting | 2 (Low Swell Slong) |
| | | Visibly: 8' |
| 2021/06/25 Fri. | | |
| 9:00 | Sent out 1st shore line, arrived at YOKOSUKA JPP | |
| | Scientists disembarked, then completed voyage YK21-10 | |