

NT11-17 Cruise Summary

1. Cruise Information

- **Cruise number:** NT11-17
- **Ship name:** R/V Natsushima, ROV Hyperdolphin
- **Title of the cruise:** FY2011 Deep Sea Survey by ROV Hyper Dolphin in Nansei Islands
- **Chief Scientist:** Tatsuhiro Fukuba (University of Tokyo)
- **Representative of scientific party:** Tatsuhiro Fukuba (University of Tokyo)
- **Title of proposal:** A study on a hydrothermal plume mapping and a novel hydrothermal ore mine survey by *in situ* multi parameter measurements
- **Cruise period:** 6 days from September 5 to September 10, 2011
- **Port call:** dep. Naha, ret. Ishigaki
- **Research area:** Yoron Knoll and Irabu Knoll (Fig.1)

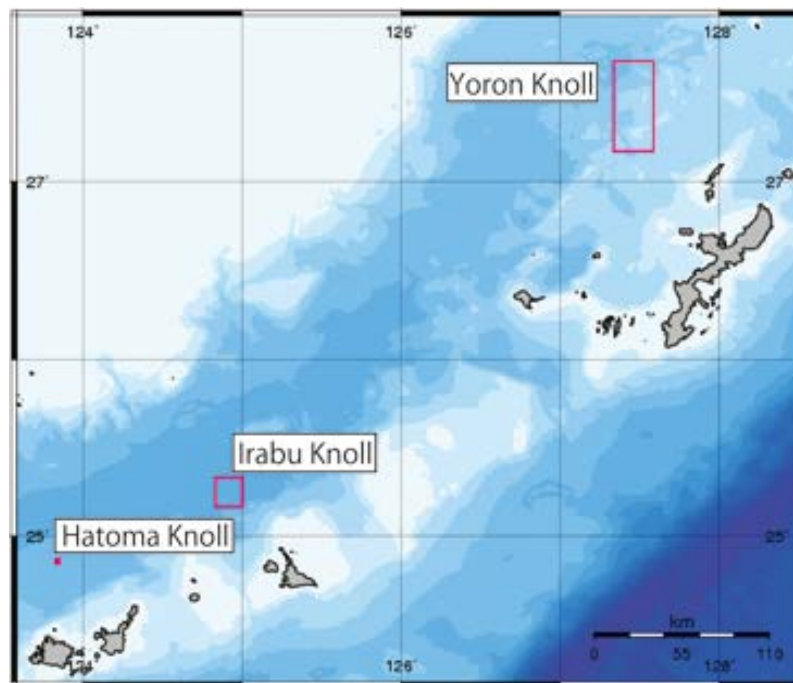


Fig.1 Research Area (Okinawa Trough)

2. Overview of Observation

(Background and Purpose)

NT11-17 cruise was operated based on the proposal #S11-67 titled “A study on a hydrothermal plume mapping and a novel hydrothermal ore mine survey by *in situ* multi parameter measurements (representative: Tatsuhiro Fukuba/ University of Tokyo). The purposes of the cruise are, 1) to examine the feasibility of the observation operations based on miniaturized multi-parameter *in situ* chemical sensors and analyzers to obtain multi-component mapping data of hydrothermal plumes, 2) to discover new hydrothermal active sites using the data from the sensors and analyzers, 3) to obtain photographic mapping data of the hydrothermal sites, and 4) to obtain seawater and rock samples for detailed analysis. Research fields for this cruise are Yoron Knoll (former name: NE-Izena) and Irabu Knoll in Okinawa Trough area. Active hydrothermal sites were newly discovered during NT10-16 scientific cruise conducted in September 2010 in

Yoron Knoll. Existence of the other caldera-like landform is known to the west of Yoron Knoll. Irabu Knoll with hydrothermal sites was discovered in 2000 (YK00-06 scientific cruise), but any detailed surveys had not been conducted there during past 10 years.

(Research Works and Operations)

In this cruise, the research works described in the following had been conducted using R/V “NATSUSHIMA” and ROV “HYPER DOLPHIN” mostly focusing on the hydrothermal activity in Yoron and Irabu Knoll area. During dive #1318, the ROV HYPERDOLPHIN (HPD) dived to Yoron Knoll hydrothermal site for 1) operational tests of chemical sensors and analyzers, 2) water and rock samples collection, and 3) a practical survey operation of novel hydrothermal sites in Yoron Knoll. Additionally, 4) photographic mapping data was obtained using a novel “seaXerocks” and a vertical structure scanner apparatuses. Western Yoron Knoll was partially surveyed in dive #1319 to discover novel hydrothermal sites. Hydrothermal site at Irabu Knoll was explored in detail during dive #1320, and hydrothermal plume mapping was conducted during dive #1321. Water and rock samples were collected simultaneously during all survey operation.

A) Operation of the ROV with multiple sensors and analyzers for hydrothermal plume mapping and survey

A1) Manganese ion quantitative determination using an IISA-Mn

Concentration of Mn ion in seawater was continuously monitored using a prototype of IISA (Integrated *In Situ* Analyzer) –Mn (Tokyo Univ.) to detect hydrothermal plumes. The IISA-Mn was mounted on the HPD for all dives. As a result, IISA-Mn could obtain positive chemiluminescence peaks (corresponds to Mn concentration anomalies) when the HPD approached to hydrothermal active sites during dive #1320 and 1321. Weak anomaly was observed in western Yoron Knoll. IISA-Mn had a problem on one of the valve and meaningful data was not obtained during the dive #1318 conducted at Yoron Knoll.

A2) Multi parameter chemical sensing

Real-time monitoring of conductivity, temperature, depth, turbidity, and pH/pCO₂/ORP was carried out using the CTD/T profiler and chemical sensors. These sensors detected seawater contents anomalies when the HPD approached to hydrothermal sites except for dive #1319 conducted at western Yoron Knoll. The other multi chemical sensor (conductivity, temperature, turbidity, DO, pH, pCO₂, and ORP) was also mounted on the HPD for *in situ* measurements, and anomalies were detected for all measured parameters (except for dive #1319).

A3) H₂S quantitative determination using an electrochemical sensor “TANSAKUN”

In situ H₂S quantitative determination was conducted using a standalone electrochemical sensor “TANSAKUN” mounted on the HPD. As a result, H₂S concentration anomalies were successfully detected when the HPD approached to hydrothermal active areas except for dive #1318.

A4) pH measurement using ISFET pH sensors

ISFET (Ion Sensitive Field Effect Transistor) based pH sensors were used to detect low-pH anomalies in hydrothermal active areas. Standalone pH sensors (CRIEPI, JAMSTEC, and Tokyo Univ.) were mounted on the ROV Hyper Dolphin (HPD) for all dives. The ISFET pH sensors worked successfully for all

dives and apparent low-pH anomalies were detected at Yoron Knoll and Irabu knoll when HPD approached to hydrothermal active sites (dive #1318, 1320, and 1321).

A5) Radioactivity mapping using a radon sensor

In-situ Rn (gamma rays) sensor using plastic scintillator was installed to the HPD for all dives. As a result, the sensor was able to detect Rn anomalies during dive #1320 and 1321 conducted at Irabu knoll. The Rn sensor had a problem on dive #1318 and data was not obtained. No radioactivity anomalies were detected during dive #1319.

A6) Local current observations using an ADCP

An ADCP (Acoustic Doppler Current Profiler) was employed for the observations of local current to understand dynamics of hydrothermal plumes. The ADCP was employed during dive #1318 and 1321. As a result of observations, local current data at depth of 500 – 600 m (Yoron knoll) and 1600 – 1650 m (Irabu knoll) were successfully obtained.

B) Sampling of seawater for biological and chemical analysis

Seawater samples were collected by using Niskin water samplers, plastic syringe water samplers (Tokyo Univ.), and glass syringe water samples (Tokyo Univ.) mostly near hydrothermal sites. Some of the samples were collected far from the hydrothermal sites as references. Rock samples were collected by using manipulators of HPD.

B1) Microbial activity analysis using an ATP assay

Using the collected water samples, microbial cellular ATP contents were measured onboard using luciferin-luciferase based method to assess microbial activities in hydrothermal plumes. As a result, sample from a few points showed apparently higher or lower activities than the other samples. Samples from Niskin water samplers constantly showed higher value than the water samples that were collected using plastic syringe water samplers.

B2) Sample archiving for microbial diversity analysis

All of the Niskin water samples (1L each) were treated with 0.22 µm pore size membrane filters to concentrate microbial cells on the filter. The filtrated samples were stored in -20 °C. Microbial genomic DNA will be extracted and the microbial diversity will be studied based on a 16S rRNA sequence analysis.

B3) Sample archiving for chemical analysis

All of the water samples collected using the glass syringe water samplers were stored in plastic bottle in 4 °C for detailed chemical analysis (e.g. Mn and Fe concentration measurements).

C) Seafloor image mapping operation using the ROV

C1) 3D seafloor image mapping using “seaXerocks”

During all the dives, 3 dimensional seafloor image data was obtained using a prototype mapping device “seaXerocks” (Tokyo Univ.), mounted on the ROV. Measurements were made from an altitude of 2 to 3m off the seafloor, and the obtained data will be processed to generate 3D colour reconstructions of the surveyed areas. This data will be assessed to determine the dimensions of visible hydrothermal anomalies on the seafloor.

C2) Vertical imaging of chimney structures

During dive #1318, a series of vertical images of chimney structures were obtained by using vertical structure scanner apparatus (Tokyo Univ.) mounted on the ROV. The data was obtained from a distance of 2~3m from the chimneys, and the measured data will be processed to generate 3D reconstructions of the chimneys, and extract information concerning their dimensions.

D) Sampling of rocks and analysis

Rock samples from a dead chimney and active chimneys were successfully collected. All rock samples will be analyzed on its elemental composition in laboratory.

E) Seafloor mapping operation

Prior to dive #1320 and 1321, seafloor-mapping operations were conducted using MBES (Multi Beam Echosounder) equipped on R/V NATSUSHIMA.

3. Summary of the Results

The NT11-17 cruise was successfully carried out as it was planned with 4 HPD dives. During the first dive (#1318), most of the chemical sensors were successfully tested and practical data for hydrothermal plume mapping was obtained, and apparent anomalies on H₂S, pH, pCO₂ and ORP were detected around northeast slope in Yoron Knoll. Video and photographic data were also successfully obtained using seaXerocks and the vertical structure scanner. As a result of survey operation at west and southwest slope of the caldera-like landform, no novel hydrothermal active site was discovered and any chemical anomalies were detected. Thus, hydrothermal active sites in Yoron Knoll seem localized at northeast slope of the caldera-like landform. At the dive #1319, we explored the western caldera-like landform at Yoron Knoll area. As a result, no hydrothermal sites with hot water eruptions were discovered, whereas IISA-Mn showed weak anomaly signals. This result implies the existence of deposition of metal elements formed by hydrothermal activity in the past. A number of cracks were found at the position that IISA-Mn showed anomalies. Dive #1320 and 1321 were conducted at Irabu Knoll area. We visited the hydrothermal sites to survey in detail during dive #1320. As a result of detailed survey, some novel hydrothermal active sites were identified at the previously reported position. Most of the hydrothermal active sites were localized at the top of the knoll. At the last dive of the cruise (#1320), we conducted grid mapping of hydrothermal plume at Irabu Knoll. As a result, apparent anomalies on Mn, H₂S, pH, pCO₂ and ORP were detected. During all the dives, series of water samples, rock samples including active and dead chimneys were successfully collected for further analysis. Seawater current measurements were successfully carried out using the ADCP during dive #1318 and 1321.