

# NT06-21 Leg 1

## Cruise Report

Nov. 21 (Yokosuka) – Nov. 28 (Chichijima), 2006  
*R/V Natsushima and ROV Hyper-Dolphin*

### Caldera Volcanoes on Izu-Bonin Arc

*Myojin Knoll: Dives 611-613*

*Suiyo Seamount: Dives 614 and 615*



*Photo: 110 °C vent at the Myojin Knoll*

**Japan Agency for Marine-Earth Science & Technology**

**Kyushu University**

**University of Tokyo**

**Kyoto University**

**NASA Jet Propulsion Laboratory**

# CONTENTS

## **1.1 Expedition Overview**

## **1.2 Introduction**

## **1.3 Acknowledgements**

## **2.1 NT06-21 Cruise Participants**

### 2.1.1 Shipboard Scientists

### 2.1.2 *ROV Hyper-Dolphin* Operation Team

### 2.1.3 *RV Natsushima* Crew

## **2.2 *R/V Natsushima & ROV Hyper-Dolphin***

### 2.2.1 General information on *R/V Natsushima*

### 2.2.2 General information on *ROV Hyper-Dolphin*

## **2.3 *NASA/JPL Hydrothermal Vent Biosampler***

## **3. Ship Operation Log**

## **4. Preliminary Results**

### 4.1. Microbiology

### 4.2 Biogeochemistry

## **5. Shore base study**

### 5.1. Microbiology

### 5.2 Biogeochemistry

## **6. Sample List**

## **7. Dive Report**

## 1.1 Expedition Overview

*Satoshi Nakagawa*

We performed NT06-21 Leg1 in the two caldera volcanoes, Myojin Knoll and Suiyo Seamount in the Izu-Bonin Arc, from the 22<sup>th</sup> of July to the 28<sup>th</sup> of November, 2006. The cruise was done for microbial ecological studies in caldera volcanoes having vigorous hydrothermal activity. The survey was conducted by means of ROV *Hyper Dolphin* and its mother vessel R/V *Natsushima*.

First, sampling and characterization of various mixing zones including hydrothermal plume in the caldera volcano were successfully achieved. Previous researches indicated that the caldera volcano of Suiyo Seamount was the natural incubator of potentially chemolithoautotrophic bacteria belonging to gamma- and epsilon-Proteobacteria. Interestingly, gamma-Proteobacteria are reported to be much more dominant than epsilon-Proteobacteria, although the epsilon-Proteobacteria dominate almost all non-caldera hydrothermal fields. The gamma-Proteobacteria are probably key players of biogeochemical cycles in the caldera volcano. However, none of the pure culture of the gamma-Proteobacteria detected there is available. In addition, little is known about microbial distribution in other caldera volcanoes. During this cruise, characterization of mixing zones was carried out by using multiple sensors and geochemical analyses. Together with further geochemical analyses, we will perform wide-range of microbial analyses on this group of bacteria including cultivation-, enzymatic-, DNA-, and RNA-approaches. The multidimensional comparisons of inter-mixing zones and intra-mixing zones will provide new insights into microbial ecosystem in caldera volcanoes and its effects on the geochemical energy flux.

Second, sampling of fluids using Hydrothermal Vent Bio-sampler (HVB) was successfully performed. Vent fluids potentially transport inhabitants of subseafloor of hydrothermal fields (subvent biosphere). However, analyses of the microbial constituents within vent fluids have proven difficult not only due to contamination from the surrounding water column but due to low density of biomass. The HVB sampler made possible to filter huge amount of pristine vent fluids and gather microbial biomass. The samples will undergo further processing including DNA extraction and PCR with functional gene as well as universal Bacterial and Archaeal primers. Clone libraries will be created using select PCR products and phylogenetic analyses performed.

## 1.2 ACKNOWLEDGEMENTS

We are grateful to the crew and captain Ukekura of “*R/V Natsushima*” for their safe navigation and their skillful handling of the vessel. Great thanks are due to the commander Mr. Chiba and “*ROV Hyper Dolphin*” operation team for the sampling and observation of deep-sea hydrothermal terrains at the mid-Okinawa Trough with safe and accurate operations. We also thank Ms. Ito in Nippon Marine Enterprise, Ltd. for their heartfelt supports to our works. We thank all the JAMSTEC personnel who have supported this cruise. Finally, to others who were directly or indirectly involved in helping make this cruise so successful, we extend our wholehearted thanks with all the best regards and wishes.

## **2.1 NT06-21 Leg 1 Participants**

### ***2.1.1 Shipboard Scientists***

*Chief scientist*

**Satoshi Nakagawa**

Research scientist

Subground Animalcule Retrieval (SUGAR) Program,

Extremobiosphere Research Center

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

*Co-chief scientist*

**Ken Takai**

Program Director

Subground Animalcule Retrieval (SUGAR) Program,

Extremobiosphere Research Center

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

**Jun-ichiro Ishibashi**

Associate Professor

Department of Earth and Planetary Sciences,

Faculty of Sciences, Kyushu University

**Michinari Sunamura**

Researcher

Earth and Planetary Science,

Graduated school of Science,

The University of Tokyo

**Takuro Nunoura**

Subground Animalcule Retrieval (SUGAR) Program,  
Extremobiosphere Research Center  
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

**James Bruckner**

Postdoctoral Scholar  
NASA/Jet Propulsion Laboratory  
Biotechnology & Planetary Protection Group

**Alberto Behar**

Senior Member of Technical Staff  
Life Detections and Sample Handling Group  
Jet Propulsion Laboratory

**Masahiro Yamamoto**

Subground Animalcule Retrieval (SUGAR) Program,  
Extremobiosphere Research Center  
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

**Jun-ichi Miyazaki**

Subground Animalcule Retrieval (SUGAR) Program,

Extremobiosphere Research Center

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

**Satoshi Kawaichi**

Student in the master's program

Laboratory of Marine Microbiology,

Division of Applied Biosciences,

Graduate School of Agriculture,

Kyoto University

**Hiroki Nakano**

Undergraduate Student

Faculty of science, Kyushu University

*Technical Assistant*

**Maki Ito**

Marine Technician

Nippon Marine Enterprises, LTD.

### ***2.1.2 ROV Hyper-Dolphin Operation Team***

|                                   |                   |
|-----------------------------------|-------------------|
| Operation Manager                 | Kazuhiro CHIBA    |
| 2 <sup>st</sup> Submersible Staff | Tomoe KONDO       |
| 2 <sup>st</sup> Submersible Staff | Tetsuya ISHITSUKA |
| 3 <sup>nd</sup> Submersible Staff | Katsushi CHIBA    |
| 3 <sup>nd</sup> Submersible Staff | Shigeru KIKUYA    |
| 3 <sup>nd</sup> Submersible Staff | Atsushi TAKENOUGH |
| 3 <sup>nd</sup> Submersible Staff | Teppei KIDO       |
| 3 <sup>rd</sup> Submersible Staff | Yuudai SAKAKIBARA |

### ***2.1.3 R/V NATSUSHIMA Crews***

|                                     |                    |
|-------------------------------------|--------------------|
| Captain                             | Eiko Ukekura       |
| Chief Officer                       | Rikita YOSHIDA     |
| 2 <sup>nd</sup> Officer             | Hiroyuki KATO      |
| 3 <sup>rd</sup> Officer             | Yuki FURUKAWA      |
| Chief Engineer                      | Eiji SAKAGUCHI     |
| 1 <sup>st</sup> Engineer            | Koji FUNAE         |
| 2 <sup>nd</sup> Engineer            | Saburo SAKAEMURA   |
| 3 <sup>rd</sup> Engineer            | Daisuke GIBU       |
| Chief Electronic Operator           | Masamoto TAKAHASHI |
| 2 <sup>nd</sup> Electronic Operator | Yusuke TAKEUCHI    |
| 3 <sup>rd</sup> Electronic Operator | Yohey YAMAMOTO     |
| Boat Swain                          | Yoshikane ODA      |
| Able Seamen                         | Kiyoshi KANEDA     |
| Able Seamen                         | Shuji TAKUNO       |
| Able Seamen                         | Tadahiko TOGUCHI   |
| Able Seamen                         | Shuichi YAMAMOTO   |
| Able Seamen                         | Takashi SOEJIMA    |
| Sailor                              | Toshiki OKUYAMA    |
| No.1 Oiler                          | Seiichi MATSUDA    |
| Oiler                               | Ryouji MARUTA      |
| Oiler                               | Yoshinori KAWAI    |

|               |                    |
|---------------|--------------------|
| Oiler         | Tatsuoshi SENNO    |
| Oiler         | Souta MISAGO       |
| Chief Steward | Kaoru TAKASHIMA    |
| Steward       | Hidetoshi KANEDA   |
| Steward       | Yukio TACHIKI      |
| Steward       | Kouji KIRITA       |
| Steward       | Futoshi HATAKEYAMA |

## ***2.2 R/V Natsushima & ROV Hyper Dolphin***

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

### **2.2.1 General information about *R/V Natsushima***

Length: 67.4m      Bow thruster: 1      Width: 13.0m      Maximum speed: 12kt  
Depth: 6.3m      Duration: 8400 mile      Max capacity: 55 persons  
Gross Tonnage: 1553t      Main prop: 2 axis, CPP

#### ***Research equipment***

##### **(1) 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 ubar at 1m)  
Directivity: conical beam pattern  
Beam width: 15deg. +/-5 deg. (-3dB)  
Pulse width: 1, 3, 10, 30msec

##### **(2) XBT equipment**

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

Maximum measurable depth :1830m, Measure range :-2 deg. - +35 deg.

##### **(3) Navigation equipment**

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

acoustic positioning system.

#### (4) Laboratory

There are laboratories at the back part of second deck. Each room has AC100V power supply and LAN. The video of HPD diving and deck-camera video are distributed to the laboratories and every cabin.

- Second laboratory: There are two desktop PCs (windows and Mac), equipment for video editing, color copy with printer, meeting desk and white board. Hi-vision video of HPD is distributed to this laboratory. You can copy from a digital  $\beta$  cam and S-VHS to S-VHS/VHS, Hi8 and DV.
- Third laboratory: There are two sinks, refrigerator (-80deg. low temperature refrigerator, Incubator, domestic refrigerator, ice maker, ice crusher) and reagent water system (ORGANO, Mili-QSPTOC). And sea water for experiment is supply to the sink.
- Dry laboratory: There are a work desk and a shelf for baggage. This room has 4 beds to be used as a private one in case that there are many researchers.

At the work deck, there is a rock-cutter room

- Rock-cutter room: There are a rock cutter and two grinders. And exclusive video player is set to describe rocks with playing video of ROV diving.

### 2.2.2 General information about *ROV Hyper-Dolphin*

Hyper Dolphin is 3000m ROV which was built by SSI (Canada) in 2001. The vehicle has two manipulators, a Hi-definition super harp TV camera, and a color CCD TV camera. In addition, digital photo camera, black and white TV camera for back side monitoring, altitude sensor, depth sensor (with temperature sensor), sonar for obstacle avoidance sonar.

Principal specification

|                                  |                                        |
|----------------------------------|----------------------------------------|
| Length : about 3.0m              | Depth capability : Maximum 3000m       |
| Breadth : about 2.0m             | Payload weight : -100kg ( in the air ) |
| Height : about 2.3m              | Speed in the water : 0-3kt             |
| Weight in the air : about 3800kg | Manipulators : 2 sets                  |

#### (1) Manipulator capability

Pivot : 7 pivoted , Working load : in the water 68kg (max outreach), Length of arm : 1.53m

Grip strength : 450kg, Hoisting power : max 250kg (vertical)

Hand opening width : right 77mm, left 195mm

(2) TV camera

High-definition TV camera : 1, Color CCD TV camera : 1, Black-and-white TV camera : 1

(3) Digital photo camera

Type : Seamax DPC7000 (DSSI)

(4) Obstacle avoidance sonars

Type : SIMRAD MS1000, Range : 10, 20, 25, 50, 100, 200m change

Detective distance : max 200m, Transmission frequency :  $330\text{kHz} \pm 1\text{kHz}$

(5) Altitude sonar

Type : SIMRAD MS1007, Frequency : 200kHz, Measure range : -200m, Accuracy : -2m

(6) Depth sensor (with temperature sensor)

Type : made by Paroscientific, Inc, Range of measuring depth : -4000m

Range of measuring temperature : -2-40deg.

## ***2.3 NASA/JPL Hydrothermal Vent Biosampler***

Summary: Analyses of the microbial constituents within hydrothermal vent water have proven difficult due to contamination from the surrounding water column. Emanations from vents nutritionally enrich the water column, resulting in localized assemblages of chemosynthetic microorganisms. Most current sampling technology inadvertently collects quantities of this ‘enriched’ bulk water while sampling hydrothermal vent waters, making it impossible to determine the biogeography of the microbes collected (e.g. are they from the vent or bulk water?). Those sampling systems that are capable of collecting ‘pristine’ vent fluids unfortunately collect limited sample volumes. As these environments are extreme with respect to temperature ( $>300^{\circ}\text{C}$ ), organisms present within them are likely in a dormant state and at low biomass, hence the collection of sufficiently large samples is a must. To accurately assess these unique microbial populations, a hydrothermal vent biosampler (HVB) has been designed to

collect large volume ‘pristine’ water samples from hydrothermal vents. The design of the HVB is a closed system capable of preserving sample integrity during transport from sample site (vent) to the research vessel. Although designed for the collection of samples directly from hydrothermal vents, the HVB may also be used to collect other samples from precise locations (i.e. diffuse flow fields or from within hydrothermal plumes). Since the HVB filter concentrates the sample upon collection (final sample volumes = 0.5L), up to 3 relatively large volume samples (>10 L) can be obtained per deployment, regardless of sample site.

Importance to NASA/JPL: The importance of hydrothermal vent research to the NASA mission is three fold: 1) gain a better understanding of life on earth (NASA’s exploration mission statement also encompasses planet Earth), 2) develop remotely operated ‘sensing/collecting’ technology to aid in the development of future life detection instrumentation, and 3) examine the possibility of the existence of extremely hardy microorganisms that may be resistant to modern spacecraft sterilization techniques (dry heat, hydrogen peroxide vapor, and UV-light).

Hydrothermal Vent Biosampler (HVB): The HVB was developed at the Jet Propulsion Laboratory (Pasadena, CA) with funding from the Astrobiology Science and Technology for Instrument Development (ASTID). Briefly, the unit consists of main control box (containing the electronics, pump, flow meter, and servo-controlled 4 position valve), three filter arrays, a fluid bypass with secondary flow meter, and a temperature array located within the fluid pathway piping. The main control box is fluid filled (FluorInert™ FC-77, 3M) and has an accessory pressure compensation cylinder. The unit is designed to be carried by either manned submersibles or ROVs.

#### *Filter Arrays*

The HVB’s filter arrays consists of three inline pre-filters (pore sizes of 90µm, 60µm, and 7µm, respectively) and a large surface area canister filter (pore size 0.2µm). All filters are composed of sintered 316 stainless steel. Inline filters are off the shelf components (Swagelok TF-filters; i.e., SS-2F-K4-90), whereas the 0.2 canister filter was custom made by Mott, Corporation. Prior to initial deployment all filter pathways were sterilized at the Jet Propulsion Laboratory using a vapor hydrogen peroxide (VHP)

sterilizer. Sterilization in the field was accomplished by flushing the unit's filter arrays and bypass with 20% H<sub>2</sub>O<sub>2</sub>, allowing the H<sub>2</sub>O<sub>2</sub>-filled unit to sit for an hour, and then flushing the unit with sterile water (this sterile water flush also served to recharge the HVB with sterile water for the next dive).

### *Sampling*

Before deployment (on board RV NATSUSHIMA), the HVB's fluid pathways were filled with sterile water. When the vehicle (ROV HYPER DOLPHIN) arrived at the sample site and the nozzle was positioned correctly (verified visually and by temperature readings), the HVB was flushed utilizing the system bypass. This served two purposes: 1) it ensured that the fluid pathway leading to the sterile filter arrays contained only fluid from the sampling objective and 2) provided an on-site system check. To begin sampling, the valve was switched to one of the filter arrays and 10 L of fluid pumped through the filters. Filter arrays remained closed to the external environment via the main four-way valve and the individual one-way check valves, fore and aft of the filter arrays, respectively. After filtering at one site is completed, the ROV HYPER DOLPHIN moved to a new sampling site and the process was repeated using a different filter array. As stated previously, up to three samples were collected on a given dive. In most cases, an HVB sample was taken at the same at the same location as a WHATS sample for direct comparison of the samplers. Sample locations were as follows:

### *Sample Processing*

Upon return to the RV NATSUSHIMA, samples were offloaded from the HVB. Inline pre-filters were removed from the unit and placed in sterile 50-ml tubes. The tubes were filled to the 15-ml line with sterile water and stored at 4°C. Filter canisters (0.2µm) were back flushed with 1 L of sterile water into appropriate sterile containers. These back flushed samples were filtered through 0.22µm cellulose acetate filters aboard the ship and the filters stored in 50-ml tubes at 4°C.

Upon return to JPL, the samples will undergo further processing including DNA extraction and PCR with functional gene as well as universal Bacterial and Archaeal primers. Clone libraries will be created using select PCR products and phylogenetic

analyses performed.

### 3. Ship Operation Log

*Maki Ito*

| Shipboard Log & Ship Track |             |                                              |                                | Position/Weather/Wind/Sea condition (Noon) |
|----------------------------|-------------|----------------------------------------------|--------------------------------|--------------------------------------------|
| Date                       | Time        | Comment.1                                    | dive position                  |                                            |
| 21,Nov,06                  | 9:00        | Scientists on board                          |                                | 11/21 12:00(JST)                           |
|                            | 10:00       | Departure                                    |                                | be(Fine but Cloudy)                        |
|                            | 10:05-11:00 | HDP meeting                                  |                                | North-5(Fresh breeze)                      |
|                            | 11:00-11:30 | Briefing for life and safety                 |                                | Sea Slight                                 |
|                            | 16:40       | Pray for guardian deity of seafarers         |                                |                                            |
|                            | 18:00-19:00 | Scientific meeting                           |                                |                                            |
| 22,Nov,06                  | 5:00        | Arrive at research area(Myojin Sea Knoll)    |                                | 11/22 12:00(JST)                           |
|                            | 6:02        | XBT                                          |                                | be(Fine but Cloudy)                        |
|                            | 10:06-16:05 | Dive HPD#611                                 | 32-06.363N,139-52.191E D=1315m | NW-4(Moderate breeze)                      |
|                            | 19:30-20:30 | Scientific meeting                           |                                | Sea Slight                                 |
| 23,Nov,06                  | -05:15      | MBES                                         |                                | 11/23 12:00(JST)                           |
|                            | 08:33-11:40 | Dive HPD#612                                 | 32-06.363N,139-52.191E D=1315m | r(Rain)                                    |
|                            | 12:44-12:05 | Dive HPD#613                                 | 32-06.363N,139-52.191E D=1315m | ENE-5(Fresh breeze)                        |
|                            | 23:00       | Arrive at Hachijo Island                     |                                | Sea mod                                    |
| 24,Nov,06                  |             | Heavy sea anchoring(Hachijo Island offshore) |                                | 11/24 12:00(JST)                           |
|                            |             |                                              |                                | o(Overcast)                                |
|                            |             |                                              |                                | NE-4(Moderate breeze)                      |
|                            |             |                                              |                                | Sea Slight                                 |
| 25,Nov,06                  | 0:00        | Head for reserch area                        |                                | 11/25 12:00(JST)                           |
|                            | 17:00       | Heavy sea anchoring (Tori Island offshore)   |                                | be(Fine but Cloudy)                        |
|                            |             |                                              |                                | ENE-6(Strong breeze)                       |
|                            |             |                                              |                                | Sea Mod                                    |
| 26,Nov,06                  | 8:00        | Head for reserch area                        |                                | 11/28 12:00(JST)                           |
|                            | 19:30       | Arrive at research area(Suiyo Kaizan)        |                                | be(Fine but Cloudy)                        |
|                            | 19:41       | XBT                                          |                                | East-7(Near gale)                          |
|                            | 19:50-20:27 | MBES                                         |                                | Sea Mod                                    |
| 27,Nov,06                  | 08:08-11:52 | Dive HPD#614                                 | 28-34.30N,140-38.600E D=1390m  | 11/27 12:00(JST)                           |
|                            | 13:22-16:38 | Dive HPD#615                                 | 28-34.30N,140-38.600E D=1390m  | be(Fine but Cloudy)                        |
|                            |             |                                              |                                | SW-4(Moderate breeze)                      |
|                            |             |                                              |                                | Sea Slight                                 |
| 28,Nov,06                  | 07:00-07:30 | Shift onboard scientists                     |                                | 11/28 12:00(JST)                           |
|                            |             |                                              |                                | c(Cloudy)                                  |
|                            |             |                                              |                                | SW-                                        |
|                            |             |                                              |                                | Sea Slight                                 |

### 4. Caldera Volcanoes on Izu-Bonin Arc

*Satoshi Nakagawa and Michinari Sunamura*

#### Myojin Knoll (Dives 611-613; Map 1)

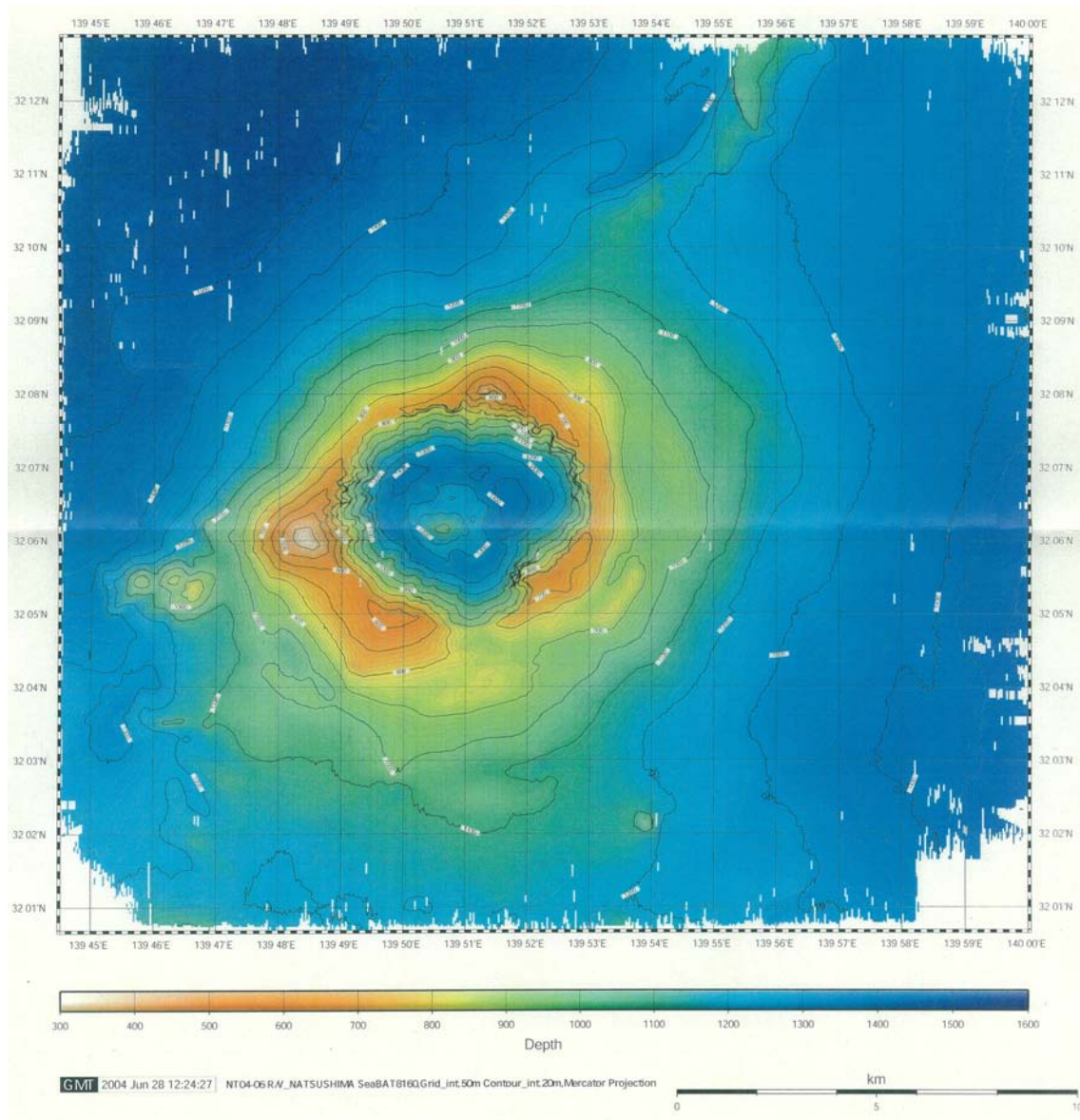
Myojin knoll is a Quaternary submarine caldera, which locates about 400 km south of Tokyo. The caldera seafloor is about 1300-1400 m in depth and is surrounded by near circular, steep wall (>400 m in hight) of 5-7 km in diameter. The discovery of hydrothermal activity was reported in 1999, which was resulting in the gold- and silver-rich sulfide deposit, called Sunrise field (Iizasa). The archaeal diversity in the sulfide deposit was reported by Takai et al. In addition, the concentration and carbon isotopic composition of methane in hydrothermal plume was measured by Tsunogai et

al., which was suggestive of the occurrence of microbial methane-oxidation in the hydrothermal plume. However, none of the microbiological survey was performed on the hydrothermal plume in Myojin Knoll.

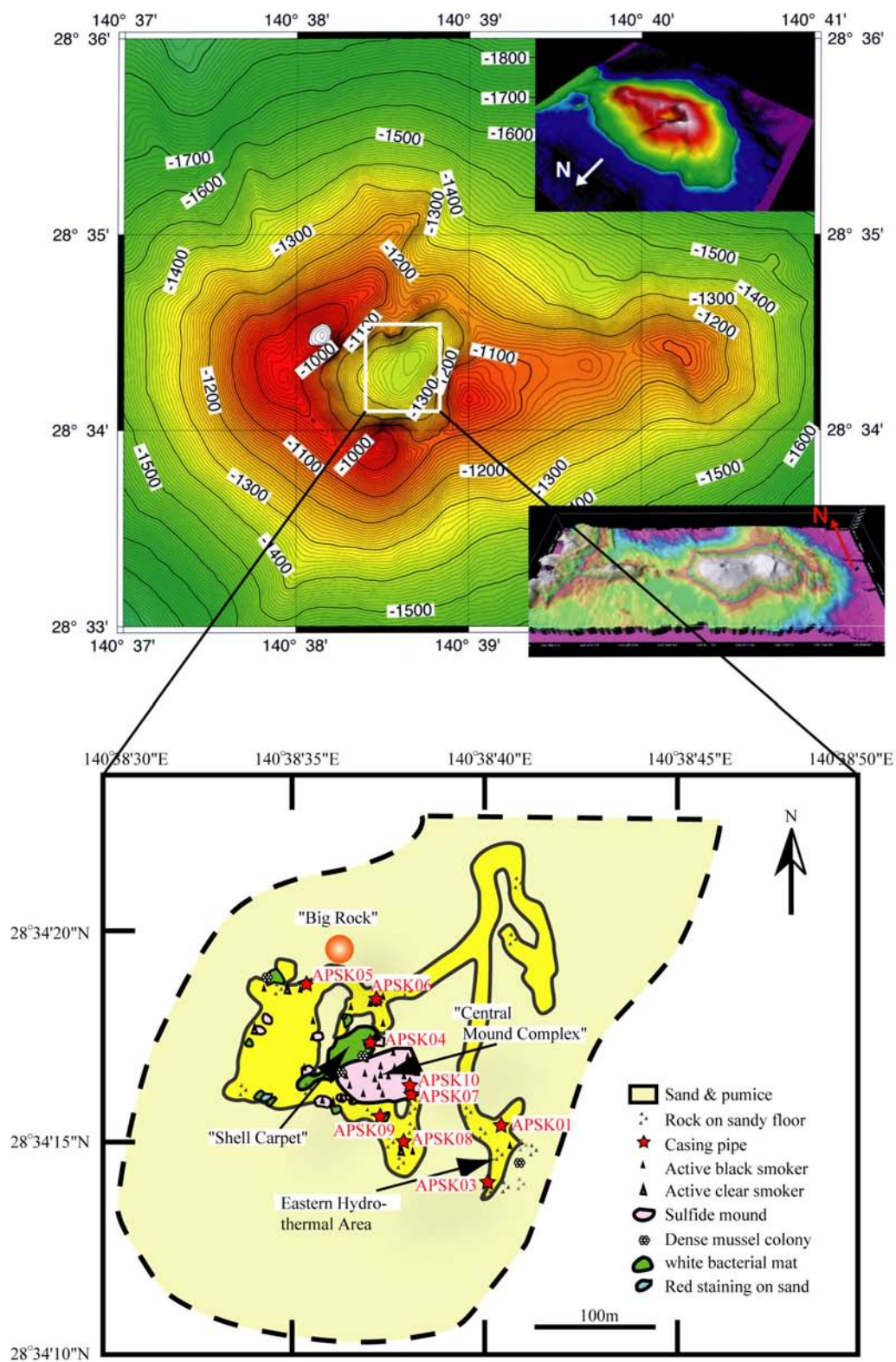
### **Suiyo Seamount (Dives 614 and 615; Map 2)**

Suiyo Seamount is a submarine volcano, which located in the Izu-Bonin islands arc. It has a horseshou-shaped caldera structure of approximately 1.5 km in the diameter. Water depth of the caldera seafloor and the rim top of the caldera is 1380 m and 900-1150 m, respectively. In the center of the caldera seafloor, many active hydrothermal vents has been observed within an area of two hundreds of meters square. The seafloor of the area is covered with pumice-sand. Strong water current and resulting ripple mark has been observed at the seafloor. Up to 310° C hydrothermal fluid is venting from tiny chimney structures in sulfide mound. The hydrothermal activities and fluid chemistry showed that the hydrothermal system has not been changed at least in 15 years. Many mytilids, *Bathymodiolus* sp., colonies habitat nearby the vents and in many cases hydrothermal hot fluids was venting from a huge *Bathymodiolus* sp. mound.

In the Suiyo Seamount caldera, a hydrothermal plume, originated from the hot hydrothermal fluids, has been observed by anomaly of turbidity, transmissivity, manganese concentration, stable carbon isotope ratio of carbon monooxide, and cell densities at a depth between 1100 and 1250 m. A thiotrophic bacterial phylotype, which is closely related with thiotrophic endosymbiontes of hydrothermal bivalves, is predominated up to 70 % of total microbial cells in the hydrothermal plume.



**Map 1. Myojin Knoll**



Map 2. Suiyo Seamount

## **4. Preliminary Results**

### **4-1. Microbiology**

*Satoshi Nakagawa*

During the NT06-21 Leg 1, we collected various hydrothermal samples including hydrothermal plumes, vent fluids, chimney structures, and vent animals from the Myojin Knoll and Suiyo Seamount. Samples were characterized by geochemical analysis (described below) and using multiple sensors. The fluid samples collected by gas-tight bottles (150ml each) of WHATS, Niskin bottles (2.7L), or Bag sampler (approx. 20L) were prepared for cultivation experiments and gas analysis. Some positive cultures were obtained through onboard cultivation experiments.

For molecular analyses on DNA, RNA, enzymes, and etc, the cells in fluid samples collected by either bag sampler (approx. 20L) or Niskin bottles (2.7 L) were harvested on filters (0.2  $\mu\text{m}$  pore size) and immediately stored at  $-80^{\circ}\text{C}$ . For FISH samples, cells in the fluids were fixed, gathered, and stored at  $-80^{\circ}\text{C}$ .

The chimney samples were basically divided into two parts, i.e. exterior surface and inside structure, and then anaerobically slurried for cultivation or stored at  $-80^{\circ}\text{C}$ .

Overall, all samplings for microbiology have been successfully achieved onboard during this cruise.

### **4-2. Biogeochemistry**

*Jun-ichiro Ishibashi*

#### **1. Purpose of geochemical studies**

The chemical composition of hydrothermal fluids is important for revealing the geochemical processes during hydrothermal circulation; such as seawater evolution into hydrothermal fluid by water-rock interaction, hydrothermal alteration of oceanic crust, phase separation during fluid ascent, and oxide and/or sulfide precipitation on the seafloor. Moreover, hydrothermal fluid samples provide important information on the geochemical environment where microbes live. For example, the concentration of reducing species such as hydrogen sulfide is important for the estimation of metabolic sources.

Hydrothermal deposits are important samples not only as the final product of

hydrothermal processes, but also as a microbial habitat. Moreover, hydrothermal deposits often accompany fluid inclusions, which contain hydrothermal fluid trapped in the mineral. Comparison of the chemical composition of fluid inclusions in an active chimney with the hydrothermal fluid itself will provide an important basis for reconstructing the history of ore deposits.

## **2. Explanatory note for onboard analyses**

The fluid samples were basically shared with microbiological studies. After sample for pH and H<sub>2</sub>S determination was drawn, the fluid was filtered with a 0.45µm disk filter. One of the filtrate aliquots was acidified with nitric acid to avoid hydroxide precipitation during storage.

Some chemical species such as nutrients are difficult to be conserved during storage, therefore should be analyzed onboard. In this cruise, potentiometric techniques, colorimetric methods and ion chromatography were employed for onboard analyses as described below. Most of these analytical methods are conventional ones and summarized in Gieskes et al. (1991).

### **2.1 pH and alkalinity**

Determination of pH at room temperature was conducted with a pH meter with a combined glass electrode (Radiometer, PHC2401-8). Measurements were done within an hour after sample distribution from the WHATS bottle. Calibration was conducted daily using JSCS buffer solutions (pH=6.865 and 4.010).

Alkalinity was determined by titration with hydrochloric acid. For calculation of the endpoint, Gran plot method is employed using the pH/ion meter (PHM240). Calibration factor was checked by analysis of IAPSO standard seawater (which alkalinity must be 2.325mM). Analytical precision is estimated as within 3%.

### **2.2 Colorimetric method**

Using a colorimeter (Hach, DR2010), concentrations of dissolved silica (SiO<sub>2</sub>), ammonium ion (NH<sub>4</sub>), and hydrogen sulfide (H<sub>2</sub>S) were analyzed following classical methods; molybdenum blue method ( $\lambda$ =812nm) for SiO<sub>2</sub>, indo-phenol method ( $\lambda$ =640nm) for NH<sub>4</sub>, methylene blue method ( $\lambda$ =670nm) for H<sub>2</sub>S. Analytical precision is usually estimated as within 3% for seawater analysis. However, sometimes the

precision is somewhat worse for the case of hydrothermal fluids, because of wide range of concentrations (SiO<sub>2</sub> and H<sub>2</sub>S), and of interference by specific species (NH<sub>4</sub>).

### 2.3 Ion chromatograph

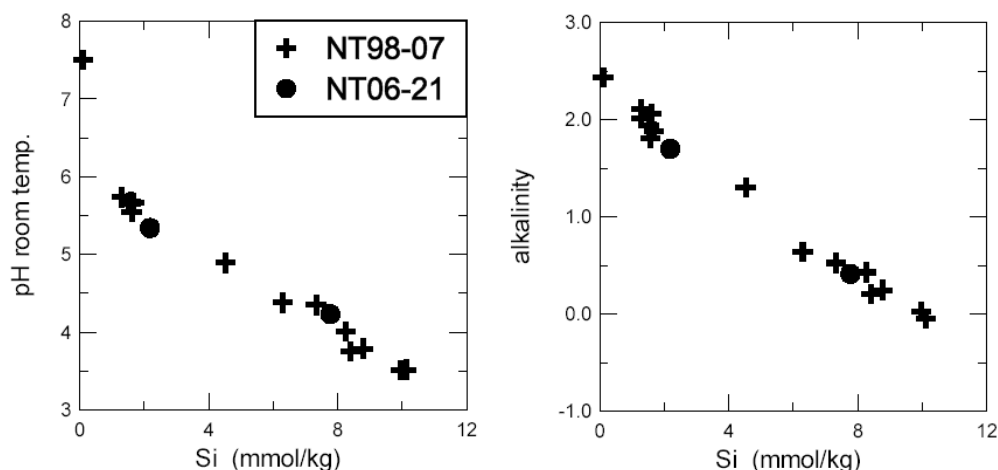
For this cruise, determination of some anions using an ion chromatograph (Shimadzu, LC10AI + SPD10AVP) was conducted on trial base. While nitrate (NO<sub>3</sub>) detection by a UV-detector ( $\lambda=220\text{nm}$ ) is conventional, some new inventions were introduced for seawater analysis (Maruo et al., 2006). In order to eliminate interference of major anions such as Cl and SO<sub>4</sub>, a high capacity anion exchange column (Tosoh, TSK gel-SAX, 4.6mm x 50 mm) and eluent of 1M sodium chloride (NaCl) + 0.1M hydrochloric acid (HCl) solution (at flow rate of 0.8ml/min.) was used. Bromide (Br) was also analyzed in the same procedure.

### 3. Preliminary results

From Sunrise hydrothermal field in Myojin Knoll Caldera, high-temperature fluid venting from sulfide chimneys, low-temperature fluid shimmering associated with *Bathymodiolous* colony, ambient bottom seawater and neutral buoyant plume water were collected.

Figures show relationships between silica concentration and pH, and silica concentration and alkalinity of the obtained fluid samples. In these figures, data of this cruise (solid circles) are plotted together with the data of previous dive program NT98-07 (cross). Both plots follow the same trend in this figure, suggesting that fluid chemistry has not changed during these eight years. The highest temperature of the venting fluid from Dai-Myojin chimney is around 280 degree, which is also in the same range as

1998  
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ment.



## 5. Shore base study

### 5.1 Microbiology

*S. Nakagawa, T. Nonoura, K. Takai and M. Sunamura*

#### Microbial ecology in mixing zones of the caldera volcanoes

We intend to investigate the structures, distribution and variation of microbial communities by the combination of culture-dependent and culture-independent molecular ecological studies. Furthermore, microbiological data will be coupled to geochemical and geophysical data.

#### • Culture-dependent ecological surveys

It is often noted that culturable microbes represent only 0.1-1% of total microbes in the environments, and thus culture-independent molecular ecological surveys have become very popular and indispensable ways to study microbial ecosystems. However, it is very difficult to get direct evidence for physiology and activities of microorganisms. Thus, culture-dependent analyses are still important and effective techniques in microbial ecology. Furthermore, information from culture-independent molecular ecological, geochemical and geophysical analyses provides the logical scheme to culture previously uncultured organisms. In fact, our group has been tried to cultivate previously uncultured organisms with the information of geochemical investigation in hydrothermal vents in Iheya North, Yonaguni Knoll IV, TOTO caldera, Lau Basin, Kermadec Arc, Suiyo Seamount, MAR and CIR hydrothermal systems, and has succeeded in cultivation of more than 10% of the members that were detected in culture-independent analyses in each habitat.

Using hydrothermal samples obtained in this cruise, we will try to culture not only the unique gamma-Proteobacteria previously detected in hydrothermal plume but also these Archaea and Bacteria; Methanogens, autotrophic sulfur reducers such as *Desulfococcales*, *Aquificales*, *Deferribacteriales* and *Epsilonproteobacteria*, autotrophic sulfur oxidizers such as *Aquificales*, *Alphaproteobacteria*, *Gammaproteobacteria* and *Epsilonproteobacteria*, nitrate or nitrite reducers such as *Aquificales*, *Deferribacteriales*, and *Epsilonproteobacteria*, sulfate reducers such as *Archaeoglobales* and *Thermodesulfobacteriales* and *Deltaproteobacteria*, iron oxidizers and fermenters such as *Thermococcales* and *Thermotogales* for each samples; chimneys, vent fluids and fluids collected from so-called “mixing zone” where vent fluids and

surrounding seawater mix. Culturable populations of these microbes will be evaluated by most probably number (MPN) method.

**MPN analysis:** This is a cultivation method to enumerate populations of organisms. Hydrothermal samples were diluted in 10-fold steps into liquid media, which should support the growth and putative population of specific physiological types of microorganisms. The microorganisms in the highest dilutions with positive growth are possibly dominant species in the cultured condition.

- **Culture –independent molecular ecological surveys**

Culture–independent molecular ecological surveys produce high resolution mapping of diversity and distribution of microorganisms. In this study, we will analyze the microbial diversity in the hydrothermal samples by biomass evaluation, 16S rRNA gene clone analysis and quantitative PCR.

**Evaluation of biomass:** In order to evaluate the population and distribution of microbial components, we will evaluate total microbial density by direct counting of DAPI or AO stained cells.

**Quantitative PCR,** a modification of two-step PCR, is essentially a fluorescence assay used to quantify the number of target genes in an environmental sample. In the analysis based on 16S rDNA, we will study the population ratio between the domain Bacteria and Archaea using the specific probe for each domain. In addition, we also quantify the amount of functional genes by using this technique.

**Gene sequencing** is necessary process to obtain the primary information of the gene sequence itself that is essential for all phylogenetic analysis and identification of microorganisms. We will construct clone libraries for target genes (e.g. 16S rDNA, Methyl CoM reductase, dissimilatory sulfite reductase etc.) with each subsamples and compare each library associated with geochemical and geological data.

**FISH** (Fluorescence In Situ Hybridization) analysis is the microscopic observation of the cells that rRNA was hybridized with the specific fluorescence probes designed based on the variability of 16S rRNA sequence. Thus, this technique visualizes the results of clone analysis based on 16S rDNA. Hydrothermal plume harbored chemolithoautotrophic microbes and the microbes were detected as elevated microbial population compared to surrounding non-hydrothermal deep sea water. Methanotrophs, ammoniatrophs, thiotrophs, and reduced metal oxidizers have been

detected in the hydrothermal plume. In the Myojin Knoll caldera, evidence of methane oxidizer have been detected by a stable isotopic analysis of methane. However, there is no microbial study in the hydrothermal plume of Myojin Knoll. In this cruise, we aimed to determine the methane oxidizing population and methane oxidizing activity in the hydrothermal plume of Myojin Knoll by fluorescent in situ hybridization analysis and on board incubation experiment. The samples will analyze by CARD-FISH procedure on shore.

**Environmental enzymology** is a very brand-new techniques to characterize the activity of the microbial community. The microbial community has a variety of metabolic potentials such as hydrogen-oxidation, sulfur-oxidation, methane-oxidation, ammonia-oxidation, sulfur-reduction, sulfate-reduction, nitrate-reduction, CO<sub>2</sub>-reduction. These activities are very difficult to measure at the community level, and are sometimes chased by radio-isotope-labelling experiments. However, radio-isotope-labelling experiments have many defects. Environmental ennzymology is a technique of measurement of key enzyme activity in the community under in situ conditions.

**Stable-Isotope-Probing (SIP)** is a technique of determining a diversity of active microbial components. For example, hydrogen oxidizing chemolithoautotrophic microbial components uptake CO<sub>2</sub> by hydrogen-oxidation if hydrogen is provided. The <sup>13</sup>C-labelled CO<sub>2</sub> will be incorporated into cellular molecules and DNA in the presence of desirable substrates. The <sup>13</sup>C-incorporated DNA becomes heavier than pristine environmental DNA. These can be separated by density-gradient ultra-centrifugation, and then characterized by molecular analyses described above.

## 5.2 Biogeochemistry

*J. Ishibashi and K. Nakano*

For dissolved major elements, analyses will be conducted mainly in Kyushu Univ. using ICP-AES, flame spectrophotometry, Mohr titration and ion chromatography. Determination of trace metal elements concentrations using ICP-MS will be conducted under collaboration with Dr. Takuro Noguchi in University of Ryukyus.

For organic species in the fluid samples, analyses will be conducted by Dr. Toshiro Yamanaka in Kyushu Univ. Determination of VFAs (volatile fatty acids) and DOC using ion chromatography and TOC meter (TOC-V, Shimadzu) will be conducted

in Kyushu Univ. Isotopic analyses of dissolved organic species using GC/ir MS and EA/ir MS will be conducted in Okayama Univ. under collaboration with Profs. Hiroshi Naraoka and Hitoshi Chiba in Okayama Univ.

For the description of mineralogical composition of hydrothermal deposits, observations with microscopy, mineralogical analysis by XRD, and chemical analyses by EPMA will be conducted at Kyushu University. Dating of hydrothermal deposits by radioactivity measurements may be conducted under collaboration with Dr. Cornel de Ronde in GNS, NZ.

## 6. Sample list

| Sample ID*         | Description         | Depth                                    | Time                        | Distribution | Distribution for geochemistry                                                                                                      |                                                                                                     |                                                                 |
|--------------------|---------------------|------------------------------------------|-----------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| #611               | 611Niskin 1         | Expected upper edge of plume             | 1036m                       | 10:51:35     | 25ml (CLT, SUGAR), 25ml (CLT, KyotoUniv), 25ml (FISH, Tokyo Univ), 2L filtration (SUGAR, KyotoUniv)                                | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
|                    | 611Niskin 2         | Expected hydrothermal plume              | 1199m                       | 11:02:09     | 25ml (CLT, SUGAR), 25ml (CLT, KyotoUniv), 25ml (FISH, Tokyo Univ), 2L filtration (SUGAR, KyotoUniv)                                | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
|                    | 611W1               | Daimyojin vent fluids                    | 1246m                       | 12:24-12:30  | 150ml Magnum -> 116ml Gas (12ml in He vial X2, 24ml in He vial X2) (SUGAR)                                                         |                                                                                                     |                                                                 |
|                    | 611W2               | Daimyojin vent fluids                    | 1246m                       | 12:32-12:39  | 25ml (CLT, SUGAR), 15ml (Gas, SUGAR), 25ml (CLT, KyotoUniv),                                                                       | 35ml (onboard), 30ml (major, Kyushu U), 10ml (organic, Kyushu U.)                                   |                                                                 |
|                    | 611HVB1             | Daimyojin vent fluids                    | 1246m                       |              | NASA (Approximately 10L filtration)                                                                                                |                                                                                                     |                                                                 |
|                    | 611 Chimney Surface | Daimyojin                                | 1246m                       |              | 30ml (CLT&Mol, SUGAR), 30ml (CLT&Mol, Kyoto Univ)                                                                                  | remain (Kyushu U)                                                                                   |                                                                 |
|                    | 611 Chimney Inside  | Daimyojin                                | 1246m                       |              | 50ml (CLT&Mol, SUGAR), 50ml (CLT&Mol, Kyoto Univ)                                                                                  | remain (Kyushu U)                                                                                   |                                                                 |
|                    | 611HVB2             | Just above Bathymodiolus colony (# 1236m |                             |              | NASA (Approximately 10L filtration)                                                                                                |                                                                                                     |                                                                 |
|                    | 611W3               | Just above Bathymodiolus colony (# 1236m |                             | 14:39-14:45  | 150ml Magnum -> 4ml Gas (2ml in He vial)(SUGAR)                                                                                    |                                                                                                     |                                                                 |
|                    | 611W4               | Just above Bathymodiolus colony (# 1236m |                             | 14:46-14:51  | 25ml (CLT, SUGAR), 25ml (CLT, KyotoUniv),                                                                                          | 35ml (onboard), 30ml (major, Kyushu U), 10ml (organic, Kyushu U.)                                   |                                                                 |
|                    | 611Bag1             | Just above Bathymodiolus colony (# 1236m |                             | 14:55-14:59  | 25ml (CLT, SUGAR), 25ml (FISH, Tokyo Univ), 25ml (CLT, KyotoUniv), 33.5L filtration (cut into 4 filters)                           | 35ml (onboard), 30ml (major, Kyushu U), 10ml (organic, Kyushu U.), 130ml (trace, Kyushu U)          |                                                                 |
|                    | 611Bag2             | Just above Bathymodiolus colony (# 1236m |                             | 15:01-15:04  |                                                                                                                                    | 30ml (onboard)                                                                                      |                                                                 |
|                    | 611Bag3             | Expected hydrothermal plume              | 1200m                       | 15:11-15:19  | 25ml (CLT, SUGAR), 25ml (FISH, Tokyo Univ), 25ml (CLT, KyotoUniv), 25.6L filtration (cut into 4 filters)                           | 35ml (onboard), 30ml (major, Kyushu U), 10ml (organic, Kyushu U.), 130ml (trace, Kyushu U)          |                                                                 |
|                    | 611Bag4             | Expected hydrothermal plume              | 1200m                       | 15:11-15:19  |                                                                                                                                    | 30ml (onboard)                                                                                      |                                                                 |
| #612               | 612Niskin1          | Expected hydrothermal plume              | 1100m                       | 9:21         | 25ml (CLT, SUGAR), 25ml (CLT, KyotoUniv), 25ml (FISH, Tokyo Univ), 2L filtration (SUGAR, KyotoUniv)                                | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
|                    | 612Niskin2          | Expected hydrothermal plume              | 1150m                       | 9:26         | 25ml (CLT, SUGAR), 25ml (CLT, KyotoUniv), 25ml (FISH, Tokyo Univ), 2L filtration (SUGAR, KyotoUniv)                                | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
|                    | 612W1               | Landing point (control)                  | 1321m                       | 9:38-9:43    | 150ml Magnum -> 2.8ml Gas (1.2ml in He vial, 1.2ml in Ar vial) (SUGAR)                                                             |                                                                                                     |                                                                 |
|                    | 612W2               | Landing point (control)                  | 1321m                       | 9:45-9:50    | 25ml (CLT, SUGAR), 15ml (Gas, SUGAR), 25ml (CLT, KyotoUniv)                                                                        | 35ml (onboard), 30ml (major, Kyushu U), 10ml (organic, Kyushu U.)                                   |                                                                 |
|                    | 612B1               | Landing point (control)                  | 1321m                       | 10:01        |                                                                                                                                    | 35ml (onboard), 30ml (major, Kyushu U), 130ml (trace, Kyushu U)                                     |                                                                 |
|                    | 612B2               | Landing point (control)                  | 1321m                       | 10:09        | 25ml (CLT, SUGAR), 25ml (FISH, Tokyo Univ), 25ml (CLT, KyotoUniv), 35.5L filtration (4 filters, 8.6L each)                         | 30ml (onboard)                                                                                      |                                                                 |
|                    | 612HVB              | Landing point (control)                  | 1321m                       |              | NASA (Approximately 10L filtration)                                                                                                |                                                                                                     |                                                                 |
|                    | 612M                | Landing point                            | 1321m                       |              | 22 cm core; 5 sections in total; 30ml (CLT&Mol, SUGAR) and 5ml (CLT, Kyoto Univ) from each section                                 |                                                                                                     |                                                                 |
|                    | 612W3               | Expected hydrothermal plume              | 1100m                       | 10:32-10:38  | 150ml->Head space 55ml (6ml in Ar vial, 6ml in He vial) (SUGAR)+150ml Magnum -> 2.2ml Gas (1ml in Ar vial, 6ml in He vial) (SUGAR) |                                                                                                     |                                                                 |
|                    | 612W4               | Expected hydrothermal plume              | 1100m                       | 10:39-10:44  | 25ml (CLT, SUGAR), 15ml (Gas, SUGAR), 25ml (CLT, KyotoUniv)                                                                        | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
|                    | 612B3               | Expected hydrothermal plume              | 1100m                       | 10:46        | 25ml (CLT, SUGAR), 25ml (FISH, Tokyo Univ), 25ml (CLT, KyotoUniv), 35.3L filtration (4 filters, 8.6L each)                         | 35ml (onboard), 30ml (major, Kyushu U), 130ml (trace, Kyushu U)                                     |                                                                 |
|                    | 612B4               | Expected hydrothermal plume              | 1100m                       | 10:46        |                                                                                                                                    | 30ml (onboard)                                                                                      |                                                                 |
|                    | #613                | 613Niskin1                               | Expected hydrothermal plume | 900m         | 13:24                                                                                                                              | 25ml (CLT, SUGAR), 25ml (CLT, KyotoUniv), 25ml (FISH, Tokyo Univ), 2L filtration (SUGAR, KyotoUniv) | 35ml (onboard), 30ml (major, Kyushu U)                          |
|                    |                     | 613B1                                    | Expected hydrothermal plume | 900m         | 13:28                                                                                                                              | 25ml (CLT, SUGAR), 25ml (FISH, Tokyo Univ), 25ml (CLT, KyotoUniv), 38.6L filtration (4 filters)     | 35ml (onboard), 30ml (major, Kyushu U), 130ml (trace, Kyushu U) |
| 613B2              |                     | Expected hydrothermal plume              | 900m                        | 13:34        |                                                                                                                                    | 30ml (onboard)                                                                                      |                                                                 |
| 613W1              |                     | Expected hydrothermal plume              | 900m                        | 13:45-13:51  | 150ml Magnum -> 3.1ml Gas (1.5ml in He vial, 1.5ml in Ar vial) (SUGAR)                                                             |                                                                                                     |                                                                 |
| 613W2              |                     | Expected hydrothermal plume              | 900m                        | 13:52-13:57  | 25ml (CLT, SUGAR), 15ml (Gas, SUGAR), 25ml (CLT, KyotoUniv)                                                                        | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
| 613W3              |                     | Event #12                                | 1314m                       | 14:39-14:45  | 150ml Magnum -> 33ml (12ml in Ar vial, 12ml in He vial) (SUGAR)                                                                    |                                                                                                     |                                                                 |
| 613Chimney Surface |                     | Event #12                                | 1314m                       |              | 30ml (CLT&Mol, SUGAR), 30ml (CLT&Mol, Kyoto Univ)                                                                                  | remain (Kyushu U)                                                                                   |                                                                 |
| 613Chimney Inside  |                     | Event #12                                | 1314m                       |              | 50ml (CLT&Mol, SUGAR), 50ml (CLT&Mol, Kyoto Univ)                                                                                  | remain (Kyushu U)                                                                                   |                                                                 |
| 613W4              |                     | Event #12                                | 1314m                       | 14:46-14:51  | 25ml (CLT, SUGAR), 15ml (Gas, SUGAR), 25ml (CLT, KyotoUniv)                                                                        | 35ml (onboard), 30ml (major, Kyushu U), 10ml (organic, Kyushu U.)                                   |                                                                 |
| 613B3              |                     | Event #12                                | 1314m                       | 14:52-14:58  |                                                                                                                                    | 35ml (onboard), 30ml (major, Kyushu U), 10ml (organic, Kyushu U.), 130ml (trace, Kyushu U)          |                                                                 |
| 613B4              |                     | Event #12                                | 1314m                       | 14:52-14:58  | 25ml (CLT, SUGAR), 25ml (FISH, Tokyo Univ), 25ml (CLT, KyotoUniv), 28.2L filtration (4 filters)                                    | 30ml (onboard)                                                                                      |                                                                 |
| 613HVB             |                     | Event #12                                | 1314m                       |              | NASA (Approximately 10L filtration)                                                                                                |                                                                                                     |                                                                 |
| 613Bathymodiolus   |                     |                                          | 1314m                       |              | 30 individuals (SUGAR)                                                                                                             |                                                                                                     |                                                                 |
| 613Niskin2         |                     | Expected hydrothermal plume              | 970m                        | 15:19        | 25ml (CLT, SUGAR), 25ml (CLT, KyotoUniv), 25ml (FISH, Tokyo Univ), 2L filtration (SUGAR, KyotoUniv)                                | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
| #614               | 614N1               | Control                                  | 1000m                       | 8:51         | 25ml (CLT, SUGAR), 25ml (CLT, KyotoUniv), 25ml (FISH, Tokyo Univ), 2L filtration (SUGAR, KyotoUniv)                                | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
|                    | 614N2               | Control (10m above plume)                | 1100m                       | 8:58         | 25ml (CLT, SUGAR), 25ml (CLT, KyotoUniv), 25ml (FISH, Tokyo Univ), 2L filtration (SUGAR, KyotoUniv)                                | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
|                    | 614W1               | Bottom seawater                          | 1390m                       | 9:17-9:23    | 150ml Magnum -> XXml Gas (1.5ml in He vial, 1.5ml in Ar vial) (SUGAR)                                                              |                                                                                                     |                                                                 |
|                    | 614W2               | Bottom seawater                          | 1390m                       | 9:25-9:30    | 25ml (CLT, SUGAR), 15ml (Gas, SUGAR), 25ml (CLT, KyotoUniv)                                                                        |                                                                                                     |                                                                 |
|                    | 614B1               | Bottom seawater                          | 1390m                       | 9:17         | 25ml (CLT, SUGAR), 25ml (FISH, Tokyo Univ), 25ml (CLT, KyotoUniv), 38.6L filtration (4 filters)                                    | 30ml (onboard)                                                                                      |                                                                 |
|                    | 614B2               | Bottom seawater                          | 1390m                       | 9:27-9:32    |                                                                                                                                    | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
|                    | 614W3               | Vent fluids                              | 1385m                       | 9:57-10:02   | 150ml Magnum -> XXml Gas (1.5ml in He vial, 1.5ml in Ar vial) (SUGAR)                                                              |                                                                                                     |                                                                 |
|                    | 614W4               | Vent fluids                              | 1385m                       | 10:04-10:09  | 25ml (CLT, SUGAR), 15ml (Gas, SUGAR), 25ml (CLT, KyotoUniv)                                                                        |                                                                                                     |                                                                 |
|                    | 614HVB              | Vent fluids                              | 1385m                       |              |                                                                                                                                    |                                                                                                     |                                                                 |
|                    | 614B3               | Hydrothermal plume                       | 1250m                       | 11:03-11:13  | 25ml (CLT, SUGAR), 25ml (FISH, Tokyo Univ), 25ml (CLT, KyotoUniv), 38.6L filtration (4 filters)                                    | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
|                    | 614B4               | Hydrothermal plume                       | 1250m                       | 11:03-11:13  |                                                                                                                                    | 30ml (onboard)                                                                                      |                                                                 |
|                    | #615                | 615N1                                    | Hydrothermal plume          | 1200m        | 14:11                                                                                                                              | 25ml (CLT, SUGAR), 25ml (CLT, KyotoUniv), 25ml (FISH, Tokyo Univ), 2L filtration (SUGAR, KyotoUniv) | 35ml (onboard), 30ml (major, Kyushu U)                          |
|                    |                     | 615N2                                    | Hydrothermal plume          | 1300m        | 14:16                                                                                                                              | 25ml (CLT, SUGAR), 25ml (CLT, KyotoUniv), 25ml (FISH, Tokyo Univ), 2L filtration (SUGAR, KyotoUniv) | 35ml (onboard), 30ml (major, Kyushu U)                          |
|                    |                     | 615W1                                    | Vent fluids                 | 1386m        | 14:36-14:40                                                                                                                        | 150ml Magnum -> 95ml Gas (30ml in He vial, 30ml in Ar vial) (SUGAR)                                 |                                                                 |
| 615W2              |                     | Vent fluids                              | 1386m                       | 14:41-14:47  | 25ml (CLT, SUGAR), 15ml (Gas, SUGAR), 25ml (CLT, KyotoUniv)                                                                        | 35ml (onboard), 30ml (major, Kyushu U), 10ml (organic, Kyushu U.)                                   |                                                                 |
| 615HVB             |                     | Vent fluids                              | 1386m                       |              |                                                                                                                                    |                                                                                                     |                                                                 |
| 615ChimneySurface  |                     | 313degC vent                             |                             | 15:07        | 30ml (CLT&Mol, SUGAR), 30ml (CLT&Mol, Kyoto Univ)                                                                                  | remain (Kyushu U)                                                                                   |                                                                 |
| 615ChimneyInside   |                     | 313degC vent                             |                             | 15:07        | 50ml (CLT&Mol, SUGAR), 50ml (CLT&Mol, Kyoto Univ)                                                                                  | remain (Kyushu U)                                                                                   |                                                                 |
| 615B1              |                     | Just above Bathymodiolus colony          | 1386m                       | 15:24-15:29  | 25ml (CLT, SUGAR), 25ml (FISH, Tokyo Univ), 25ml (CLT, KyotoUniv), 38.6L filtration (4 filters)                                    | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
| 615B2              |                     | Just above Bathymodiolus colony          | 1386m                       | 15:30-15:35  |                                                                                                                                    | 30ml (onboard)                                                                                      |                                                                 |
| 615W3              |                     | Hydrothermal plume                       | 1320m                       | 15:48-15:53  | 150ml Magnum -> 3.6ml Gas (1.5ml in He vial, 1.5ml in Ar vial) (SUGAR)                                                             |                                                                                                     |                                                                 |
| 615W4              |                     | Hydrothermal plume                       | 1320m                       | 15:54-15:59  | 25ml (CLT, SUGAR), 15ml (Gas, SUGAR), 25ml (CLT, KyotoUniv)                                                                        | 35ml (onboard), 30ml (major, Kyushu U)                                                              |                                                                 |
| 615B4&4            |                     | Hydrothermal plume                       | 1320m                       | 15:47-15:57  | 25ml (CLT, SUGAR), 25ml (FISH, Tokyo Univ), 25ml (CLT, KyotoUniv), 38.6L filtration (4 filters)                                    |                                                                                                     |                                                                 |

\*W. WHATS: B. Bag: M. MBARI core: HVB. Hydrothermal Vent Biosampler

## 7. Dive Report

### 7-1. Dive Report #611

*Satoshi Nakagawa*

**Date:** November 22, 2006

**Site:** Myojin Knoll

**Landing:** 11:07; 32°06.368'N, 139°52.144'E, 1315m

**Leaving:** 15:06; 32°06.236'N, 139°52.159'E, 1236m

#### **Objectives:**

The major objectives are 1) to evaluate hydrothermal plume distribution, 2) to survey the hydrothermal field (called Sunrise field), and 3) to take hydrothermal samples including vent fluids, chimneys, hydrothermal plumes, vent animals, and fluids surrounding vent animals.

#### **Dive Summary:**

We collected fluids sample at the depth of 1036 m by using a Niskin bottle. Previous reports suggest this sampling point should be located on the upper edge of hydrothermal plume. When we arrived at the depth of around 1100 m, seawater became turbid (by visual inspection). We thus collected fluids sample at the depth of 1200 m by using the other Niskin bottle. After these samplings, we landed on the seafloor which seems to consist of sandy clay (we will take sediments during dive 612), and then headed to event #12. We found several vents discharging fluids there. We measured the temperature of fluids, it was found to be approximately 60 deg C. Since the temperature was not so high, we skipped this vent (we will take samples at this site on dive 613) and headed to event #5 (Daimyojin chimney).

Although several previous reports noted that the Daimyojin was a black smoker, it appears that it is a clear smoker at least now. We measured the temperature of vent fluids of Daimyojin, and found it was over 200 deg C. We collected the vent fluids by using WHATS sampler (2 bottles) and HVB sampler (1 cylinder; filtration, about 10L). In addition, we took pieces of chimneys there. Then, we headed to #19 in order to find *Bathymodiolus* colonies.

We found a big colony of *Bathymodiolus* at 23 m northern point of #19. We

collected fluids surrounding the *Bathymodiolus* with WHATS sampler (2 bottles), Bag sampler (2 Bags), and HVB sampler (1 cylinder; filtration, about 10L). Although we also collected several bodies of Bathymodiolus, these were gone during the recovery of ROV. Then, we started to go up. At the depth of 1200m, we collected the potential hydrothermal plume with Bag sampler (two bags).

#### **Payloads:**

- 1) WHATS with a temperature probe for fluid sampling
- 2) Bag pump sampler (x4)
- 3) Sample box
- 4) Niskin bottles (2 bottles)
- 5) DO meter
- 6) Turbidity meter
- 7) HVB sampler

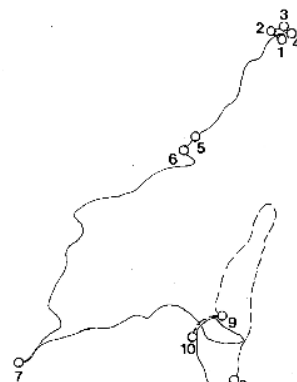
#### **Event List:**

|       |                         |         |                                  |
|-------|-------------------------|---------|----------------------------------|
| 10:52 | 32-06.364N, 139-52.180E | D=1036m | Plume sampling (Niskin)          |
| 11:02 | 32-06.367N, 139-52.184E | D=1199m | Plume sampling (Niskin)          |
| 11:07 | 32-06.368N, 139-52.194E | D=1315m | Landed                           |
| 12:06 | 32-06.215N, 139-52.047E | D=1252m | Daimyojin                        |
| 12:41 | 32-06.215N, 139-52.047E | D=1252m | Sampling vent fluids (WHATS x 2) |
| 12:53 | 32-06.215N, 139-52.047E | D=1252m | Sampling vent fluids (HVB)       |
| 13:37 | 32-06.215N, 139-52.047E | D=1252m | Sampling chimney                 |
| 14:22 | 32-06.236N, 139-52.159E | D=1236m | Mussel colony (HVB sampling)     |
| 14:42 | 32-06.236N, 139-52.159E | D=1236m | WHATS sampling (2 bottles)       |
| 15:04 | 32-06.236N, 139-52.159E | D=1236m | Sampling fluids (2Bags)          |
| 15:06 | 32-06.236N, 139-52.159E | D=1236m | Leaving bottom                   |
| 15:19 | 32-06.236N, 139-52.159E | D=1200m | Sampling fluids (2 Bags)         |

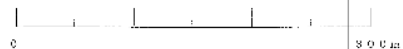
#### **Dive Track:**

1. 10:49 D=1000m 中島観察開始  
(32-06.363N 139-52.189E)
2. 10:52 D=1036m 水深採水(深・1本)  
(32-06.364N 139-52.189E)
3. 11:02 D=1196m 水深採水(深・1本)  
(32-06.369N 139-52.184E)
4. 11:07 着底 D=1315m  
(32-06.368N 139-52.184E)  
中島観察終了
5. 11:15 D=1310m シタイバ(3'長)白色域確認  
(32-06.367N 139-52.144E)
6. 11:17 D=1311m 熱水噴出  
(32-06.314N 139-52.138E)
- 11:30 D=1513m WILTS温度計測
7. 12:06 D=1252m ヒツクイタニ樹液 A=10m  
(32-06.215N 139-52.047E)
- 12:41 D=1246m WILTS温度計測(2本)
- 12:53 HVBツグア
- 13:37 熱水片採取
8. 13:57 D=1213m 南度と向き移動開始  
(32-06.207N 139-52.165E)
9. 14:17 D=1236m 海底復縁  
(32-06.226N 139-52.159E)
- 14:22 HVBツグア
- 14:42 WILTS温度計測(2本)
- 15:04 Seg採水(2本)
- 15:06 シタイバ(3'長)採集(取留棒)
- 15:06 着底 D=1238m
10. 15:19 D=1200m Seg採水(2本) A=20m

139° 52.000 E



32° 06.200 N



※ 緯度、経度の1目盛りは、0.1分を表します。

ハイパードルフィン  
 4 6 1 1 D I V E  
 2 0 0 6 年 1 1 月 2 2 日  
 伊豆・小笠原 明神海 氏  
 縮尺 1/3000  
 計器 D-GPS(MX940CN LEICA)  
 観測系 WGS-84  
 速度 1503.0 m/s (D=1300m)

## **7-2. Dive Report #612**

*Takuro Nonoura*

Date: 23 Nov, 2006

Site Name: Myojin Knoll

Landing: 9:35; 32°06.367'N, 139°52.190'E, 1321 m

Leaving: 10:19; 32°06.367'N, 139°52.190'E, 1321 m

### **Objectives**

The one is sampling of ambient bottom seawater by hydrothermal active area in order to determine the ambient microbial community structure and geochemistry in the Myojin Knoll Caldera. The other is collecting hydrothermal plume.

### **Dive summary**

During the way to seafloor, we collected two Niskin bottles of hydrothermal plume at the depth 1100 and 1150m below sea-surface (bss). At the landing point, seafloor was covered by sand and any signals of hydrothermal activity were not observed. We collected ambient bottom seawater by WHATS water sampler, HVB water sampler and Bag type water sampler, and sediments by MBARI type push corer at landing point. Then, we left bottom and stayed in hydrothermal plume at 1100m bss and collected hydrothermal plume by WHATS and Bag type water sampler.

### **Keywords:**

Hydrothermal activity, hydrothermal plume

### **Payloads:**

- 1) WHATS with temperature probe
- 2) Bag water sampler system (20L x 4 bags)
- 3) HVB water sampler
- 4) MBARI type push corer x 2
- 5) Niskin bottle x 2
- 6) Turbidity sensor
- 7) DO sensor
- 8) Sample box x 2

**Location of Events:**

| Time   | Position                  | Depth  | Event                                |
|--------|---------------------------|--------|--------------------------------------|
| 9: 22  | 32°06.367'N, 139°52.178'E | 1100 m | Plume sampling by Niskin bottle (N1) |
| 9: 25  | 32°06.369'N, 139°52.189'E | 1150 m | Plume sampling by Niskin bottle (N2) |
| 9: 35  | 32°06.367'N, 139°52.190'E | 1321 m | Landing                              |
| 9: 50  | 32°06.367'N, 139°52.190'E | 1321 m | Water sampling by WHATS (x 2)        |
| 10: 08 | 32°06.367'N, 139°52.190'E | 1321 m | Water sampling by HUB                |
| 10: 14 | 32°06.367'N, 139°52.190'E | 1321 m | Water sampling by Bag sampler (x2)   |
| 10: 18 | 32°06.367'N, 139°52.190'E | 1321 m | Sediment sampling by MBARI x1        |
| 10: 19 | 32°06.367'N, 139°52.190'E | 1321 m | Leaving bottom                       |
| 10: 43 | 32°06.367'N, 139°52.190'E | 1100 m | Plume sampling by WHATS (x2)         |
| 10: 54 | 32°06.368'N, 139°52.191'E | 1100 m | Plume sampling by Bag sampler (x2)   |

**Dive track:**

1. 09:24 D=100m 砂泥採取(計・1本)  
(25-06.367N 139-52.173E)
2. 09:25 D=150m 砂泥採取(計・1本)  
(21-06.388N 139-52.159E)
3. 09:26 深度 D= 321m  
(21-06.367N 139-52.190E)
- 09:50 WHATS(2本)
- 09:52 DVBログ
- 10:14 3kg採水(2個)
- 10:19 潮API採取(黄・1本)
- 10:19 深度 D=1321m
4. 10:14 D=150m WHATS(2本)  
(32-06.368N 139-52.191E)
- 10:54 3kg採水(2個)

139° 52' 18.1

1 2 3 4

32° 06.200N

0 100m

※ 深度、位置の100m単位は、0.1km単位です。

ハイパードルフィン  
# 6 1 2 0 1 V E  
2 0 0 6 年 1 1 月 2 3 日  
伊豆・小笠原 明神海丘  
新船名 1 / 3 0 0 0  
計 位 D-GPS (MX9403N LEICA)  
測地系 WGS-84  
音 速 1500.0 m/s (D=1000m)

### 7-3. Dive Report #613

Takuro Nunoura

Date: 23 Nov, 2006

Site Name: Myojin Knoll

Landing: 14:12; 32°06.334'N, 139°52.177'E, 1311 m

Leaving: 15:05; 32°06.311'N, 139°52.146'E, 1321 m

#### Objectives

The major objectives of this dive were to collect hydrothermal fluids and chimney structure from small active chimneys that locate north-east from Dai-Myojin chimney, and hydrothermal plume in caldera of the Myojin Knoll.

#### Dive summary

Before landing, we collected hydrothermal plume at the depth 900 m below sea-surface (bss) by Niskin bottle, WHATS water sampler and HVB water sampler. After landed on seafloor, we soon found many dead chimneys and active chimneys. The ROV landed in from of small chimneys, and we determined temperature of hydrothermal fluids from three vents and collected chimney structure. The temperature of first and second fluids was below 40°C. We took hydrothermal fluids from a third vent by WHATS and HVB water sampler. During the water sampling by HVB, we took mixture of hydrothermal fluids and seawater using Bag water sampler. The maximum temperature of hydrothermal fluids during water sampling was 110 °C. Because of the bad weather, we had to end this dive at that moment. We took a colony of *Bathymodiolus* at this site and the ROV left the bottom. On the way to sea surface, we collected hydrothermal plume at 970m bss.

#### Keywords:

Hydrothermal activity, hydrothermal vent, subvent biosphere, hydrothermal plume, *Bathymodiolus*

#### Keywords:

Hydrothermal activity, hydrothermal plume

#### Payloads:

- 1) WHATS with temperature probe
- 2) Bag water sampler system (20L x 4 bags)
- 3) HVB water sampler
- 4) MBARI type push corer x 1
- 5) Niskin bottle x 2
- 6) Turbidity sensor
- 7) DO sensor
- 8) Sample box x 2

**Location of Events:**

| Time   | Position                  | Depth  | Event                                |
|--------|---------------------------|--------|--------------------------------------|
| 13: 25 | 32°06.380'N, 139°52.199'E | 900 m  | Plume sampling by Niskin bottle (N1) |
| 13: 45 | 32°06.379'N, 139°52.190'E | 900 m  | Plume sampling by HVB sampler        |
| 13: 40 | 32°06.369'N, 139°52.193'E | 900 m  | Plume sampling by Bag sampler (x2)   |
| 13: 57 | 32°06.372'N, 139°52.209'E | 900 m  | Plume sampling by WHATS (x2)         |
| 14: 12 | 32°06.334'N, 139°52.177'E | 1311 m | Landing                              |
| 14: 31 | 32°06.311'N, 139°52.146'E | 1314 m | sampling chimney structure           |
| 14: 50 | 32°06.311'N, 139°52.146'E | 1314 m | Vent fluids by WHATS (x 2)           |
| 14: 59 | 32°06.311'N, 139°52.146'E | 1314 m | Hydrothermal fluids sampling HVB     |
| 15: 58 | 32°06.311'N, 139°52.146'E | 1314 m | Water sampling by Bag sampler (x1)   |
| 15: 05 | 32°06.311'N, 139°52.146'E | 1316 m | Collecting <i>Bathymodiolus</i>      |
| 15: 05 | 32°06.311'N, 139°52.146'E | 1321 m | Leaving bottom                       |
| 15:19  | 32°06.311'N, 139°52.146'E | 970 m  | Plume sampling by Niskin             |

**Dive track:**

1. 13:25 D= 900m 浅く採水(赤・1本)  
(02-06.380N 139-52.199E)
2. 13:30 D= 900m HVB採取  
(32-06.379N 139-52.190E)
3. 13:40 D= 900m 浅く採水(2本)  
(32-06.369N 139-52.193E)
4. 13:57 D= 900m WHATS(2本)  
(32-06.372N 139-52.209E)
5. 14:12 青森 D=1311m  
(32-06.394N 139-52.177E)
6. 14:31 D=1314m 採取  
(32-06.311N 139-52.140E)
- 14:51 WHATS(2本)
- 15:01 HVB採取
- 15:05 離底 D=1316m
- 15:07 シンボル付(採集(数超外))
7. 15:15 D= 970m 浅く採水(緑・1本)  
(02-06.366N 139-52.126E)

139° 52' 00"E



32° 06.200'N



※ 緯度、経度の1秒値は、0.1分を意味する。

ハイパードルフィン  
# 6 1 3 D I V E  
2 0 0 6 年 1 1 月 2 3 日  
伊豆・小笠原 明神海丘  
水深 1 / 3 0 0 0  
船位 D-GPS(MRS4005 L1/L2)  
測深系 TRS-84  
速度 1502.0 m/s (D=1400m)

## **Dive Report:Hyper Dolphine Dive #614**

*Ken Takai*

**Date:** 27 Nov, 2006

**Site Name:** Suiyo Seamount

**Landing:** 9:11; 28°34.300'N, 140°38.626'E, 1391 m

**Leaving:** 10:54; 28°34.291'N, 140°38.618'E, 1386 m

### **Objectives**

The objectives are samplings of ambient bottom seawater, hydrothermal fluid, and potential plume water in the hydrothermal active area in order to determine the microbial communities and geochemistry in the Suiyo Seamount Caldera.

### **Dive summary**

During the way to seafloor, we collected potential plume waters by Niskin water samplers (red & green) at depths of 1000 and 1100 m, respectively. No apparent turbidity was observed. We landed on the pumice bottom at a depth of 1391 m (28°34.300'N, 140°38.626'E) and approx. 40 L of ambient bottom water (two bags) by a pump water sampler and approx. 300 ml by WHATS were collected. Then, we headed 210°. We found a great bacteria mat. In the mat area, a hydrothermal vent with a small chimney was found (28°34.291'N, 140°38.618'E; 1386 m). The rest two bottles of WHATS were collected from a vent (max. 270 °C). The HVB sampler was run. But it did not work well. Several individuals of mussels were collected very adjacent to the hydrothermal vent. After sampling of mussels, chimneys were tried to be sampled. Several pieces of sulfide structures were successfully collected. Then we left the bottom to the horizontal buoyant plume at a depth of 1250 m. At a depth of 1250 m, approx. 40 L of plume water was obtained by a pump water sampler (28°34.287'N, 140°38.572'E).

Keywords:

Island Arc, Hydrothermal activity, hydrothermal plume

Payloads:

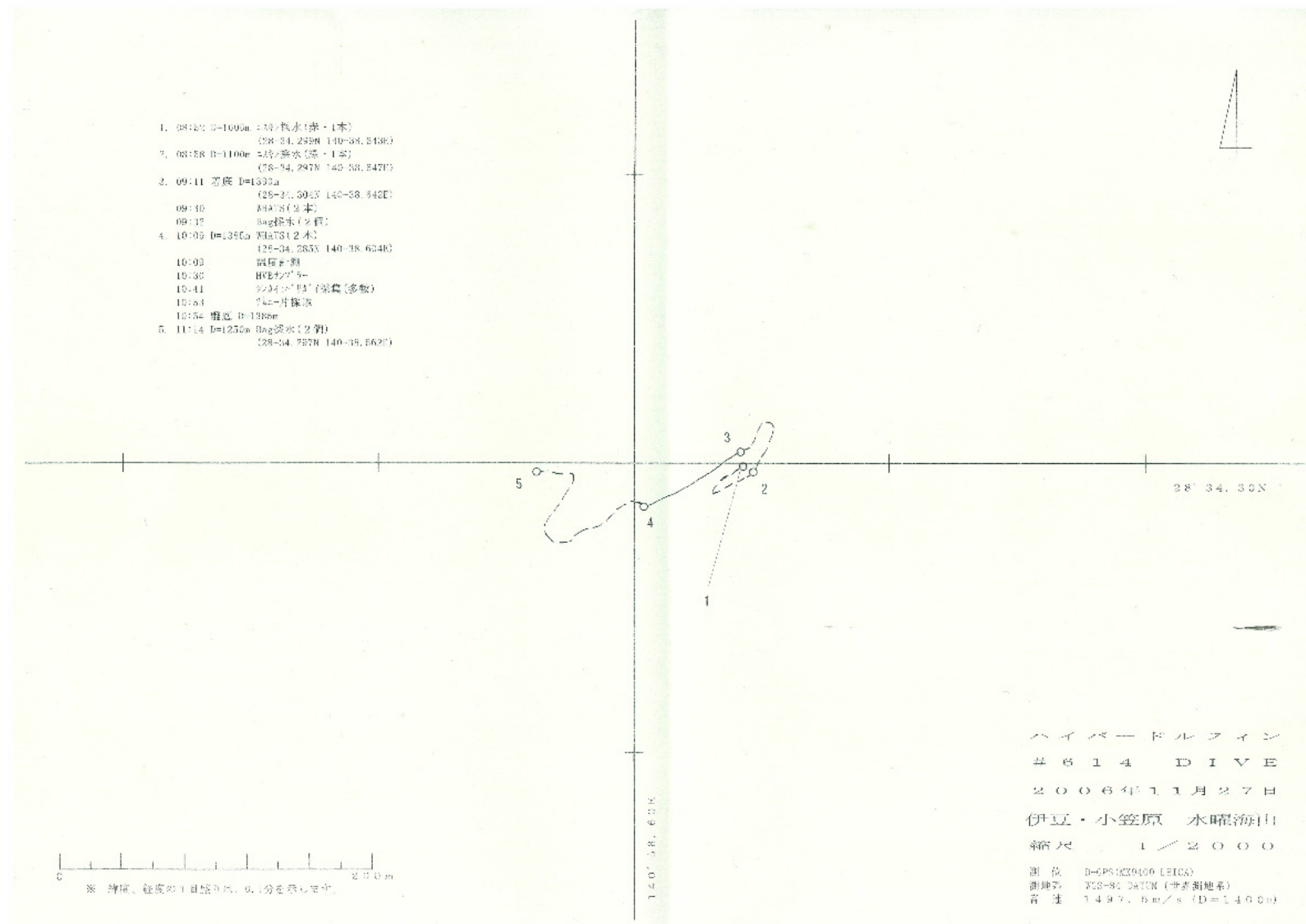
1) WHATS with temperature probe

- 2) Bag water sampler system (20L x 4 bags)
- 3) HVB water sampler
- 4) Niskin bottle x 2
- 5) Turbidity sensor
- 6) DO sensor
- 7) Sample box x 2

Location of Events:

| Time   | Position                  | Depth  | Event                              |
|--------|---------------------------|--------|------------------------------------|
| 8: 52  | 28°34.299'N, 140°38.643'E | 1000 m | Plume sampling by Niskin bottle    |
| 8: 58  | 28°34.297'N, 140°38.647'E | 1100 m | Plume sampling by Niskin bottle    |
| 9: 11  | 28°34.300'N, 140°38.626'E | 1391 m | Landing                            |
| 9: 32  | 28°34.300'N, 140°38.626'E | 1391 m | Finish WHATS & Bag (x2)            |
| 10: 08 | 28°34.291'N, 140°38.618'E | 1386 m | Water sampling by WHATS (x 2)      |
| 10: 35 | 28°34.291'N, 140°38.618'E | 1386 m | Water sampling by HVB but not work |
| 10: 41 | 28°34.291'N, 140°38.618'E | 1386 m | Collected mussels                  |
| 10: 53 | 28°34.291'N, 140°38.618'E | 1386 m | Collected chimneys                 |
| 10: 54 | 28°34.291'N, 140°38.618'E | 1386 m | leaving bottom                     |
| 11: 05 | 28°34.287'N, 140°38.572'E | 1250 m | Plume sampling by bags (x2)        |

**Dive track:**



## **Dive Report:Hyper Dolphine Dive #615**

*Ken Takai*

**Date:** 27 Nov, 2006

**Site Name:** Suiyo Seamount

**Landing:** 14:20; 28°34.284'N, 140°38.632'E, 1385 m

**Leaving:** 10:19; 32°06.367'N, 139°52.190'E, 1321 m

### **Objectives**

The objectives are samplings of ambient bottom seawater, hydrothermal fluid, and potential plume water in the hydrothermal active area in order to determine the microbial communities and geochemistry in the Suiyo Seamount Caldera.

### **Dive summary**

During the way to seafloor, we collected potential plume waters by Niskin water samplers (red & green) at depths of 1200 and 1300 m, respectively. No apparent turbidity was observed at the depths. We landed on the pumice bottom at a depth of 1385 m (28°34.284'N, 140°38.632'E). Then, we headed 250°. We found a casing pipe of the Archean Park (28°34.272'N, 140°38.627'E). Several meters northwest, we found a vigorous black smoker (28°34.278'N, 140°38.623'E). The two bottles off WHATS were taken from this vent (max. 313 °C). After WHATS, we tried to collect hydrothermal fluid by HVB sampler. Approx. 10 L was filtrated. In addition, we took pieces of chimney structures. Then, we moved to the mussel colonies (28°34.271'N, 140°38.621'E). Just on the colony, the water was sampled by HVB sampler and Bag (x 2). HVB sampler had a problem. Then we left the bottom to the horizontal buoyant plume at a depth of 1320 m. At a depth of 1320 m, approx. 40 L of plume water was obtained by a pump water sampler and WHATS (28°34.294'N, 140°38.594'E).

### **Keywords:**

Island Arc, Hydrothermal activity, hydrothermal plume

### **Payloads:**

1) WHATS with temperature probe

- 2) Bag water sampler system (20L x 4 bags)
- 3) HVB water sampler
- 4) Niskin bottle x 2
- 5) Turbidity sensor
- 6) DO sensor
- 7) Sample box x 2

Location of Events:

| Time   | Position                  | Depth  | Event                                                    |
|--------|---------------------------|--------|----------------------------------------------------------|
| 14: 11 | 28°34.304'N, 140°38.651'E | 1200 m | Plume sampling by Niskin bottle                          |
| 14: 16 | 28°34.305'N, 140°38.639'E | 1300 m | Plume sampling by Niskin bottle                          |
| 14: 20 | 28°34.284'N, 140°38.632'E | 1385 m | Landing                                                  |
| 14: 27 | 28°34.272'N, 140°38.627'E | 1386 m | Found a casing pipe                                      |
| 14: 34 | 28°34.278'N, 140°38.623'E | 1386 m | Found a vigorous black smoker                            |
| 14: 47 | 28°34.278'N, 140°38.623'E | 1386 m | Water sampling by WHATS (x 2)                            |
| 15: 03 | 28°34.278'N, 140°38.623'E | 1386 m | Water sampling by HVB                                    |
| 15: 15 | 28°34.278'N, 140°38.623'E | 1386 m | Collected chimneys                                       |
| 15: 36 | 28°34.271'N, 140°38.621'E | 1386 m | Finish Bag samples (x2) and<br>unsuccessful HVB sampling |
| 15: 40 | 28°34.271'N, 140°38.621'E | 1386 m | leaving bottom                                           |
| 16: 00 | 28°34.294'N, 140°38.594'E | 1320 m | Plume sampling by bags (x2) and<br>WHAT'S (x2)           |

**Dive track:**

1. 14:11 D=1200m 100% 排水 (線 + 1.5%)  
(28-34, 3032 140-38.549)
2. 14:16 D=1300m 20% 排水 (線 + 1.5%)  
(28-34, 3036 140-38.618)
3. 14:20 排水 D=1300m  
(28-34, 3040 140-38.687)
4. 14:28 D=1300m 排水  
(28-34, 3044 140-38.756)
5. 14:36 D=1300m 排水  
(28-34, 3048 140-38.825)
6. 14:44 D=1300m 排水  
(28-34, 3052 140-38.894)
7. 14:52 D=1300m 排水  
(28-34, 3056 140-38.963)
8. 15:00 D=1300m 排水  
(28-34, 3060 140-39.032)
9. 15:08 D=1300m 排水  
(28-34, 3064 140-39.101)
10. 15:16 D=1300m 排水  
(28-34, 3068 140-39.170)
11. 15:24 D=1300m 排水  
(28-34, 3072 140-39.239)
12. 15:32 D=1300m 排水  
(28-34, 3076 140-39.308)
13. 15:40 D=1300m 排水  
(28-34, 3080 140-39.377)
14. 15:48 D=1300m 排水  
(28-34, 3084 140-39.446)
15. 15:56 D=1300m 排水  
(28-34, 3088 140-39.515)
16. 16:04 D=1300m 排水  
(28-34, 3092 140-39.584)
17. 16:12 D=1300m 排水  
(28-34, 3096 140-39.653)
18. 16:20 D=1300m 排水  
(28-34, 3100 140-39.722)
19. 16:28 D=1300m 排水  
(28-34, 3104 140-39.791)
20. 16:36 D=1300m 排水  
(28-34, 3108 140-39.860)
21. 16:44 D=1300m 排水  
(28-34, 3112 140-39.929)
22. 16:52 D=1300m 排水  
(28-34, 3116 140-40.000)
23. 17:00 D=1300m 排水  
(28-34, 3120 140-40.071)
24. 17:08 D=1300m 排水  
(28-34, 3124 140-40.142)
25. 17:16 D=1300m 排水  
(28-34, 3128 140-40.213)
26. 17:24 D=1300m 排水  
(28-34, 3132 140-40.284)
27. 17:32 D=1300m 排水  
(28-34, 3136 140-40.355)
28. 17:40 D=1300m 排水  
(28-34, 3140 140-40.426)
29. 17:48 D=1300m 排水  
(28-34, 3144 140-40.497)
30. 17:56 D=1300m 排水  
(28-34, 3148 140-40.568)
31. 18:04 D=1300m 排水  
(28-34, 3152 140-40.639)
32. 18:12 D=1300m 排水  
(28-34, 3156 140-40.710)
33. 18:20 D=1300m 排水  
(28-34, 3160 140-40.781)
34. 18:28 D=1300m 排水  
(28-34, 3164 140-40.852)
35. 18:36 D=1300m 排水  
(28-34, 3168 140-40.923)
36. 18:44 D=1300m 排水  
(28-34, 3172 140-40.994)
37. 18:52 D=1300m 排水  
(28-34, 3176 140-41.065)
38. 19:00 D=1300m 排水  
(28-34, 3180 140-41.136)
39. 19:08 D=1300m 排水  
(28-34, 3184 140-41.207)
40. 19:16 D=1300m 排水  
(28-34, 3188 140-41.278)
41. 19:24 D=1300m 排水  
(28-34, 3192 140-41.349)
42. 19:32 D=1300m 排水  
(28-34, 3196 140-41.420)
43. 19:40 D=1300m 排水  
(28-34, 3200 140-41.491)
44. 19:48 D=1300m 排水  
(28-34, 3204 140-41.562)
45. 19:56 D=1300m 排水  
(28-34, 3208 140-41.633)
46. 20:04 D=1300m 排水  
(28-34, 3212 140-41.704)
47. 20:12 D=1300m 排水  
(28-34, 3216 140-41.775)
48. 20:20 D=1300m 排水  
(28-34, 3220 140-41.846)
49. 20:28 D=1300m 排水  
(28-34, 3224 140-41.917)
50. 20:36 D=1300m 排水  
(28-34, 3228 140-41.988)
51. 20:44 D=1300m 排水  
(28-34, 3232 140-42.059)
52. 20:52 D=1300m 排水  
(28-34, 3236 140-42.130)
53. 21:00 D=1300m 排水  
(28-34, 3240 140-42.201)
54. 21:08 D=1300m 排水  
(28-34, 3244 140-42.272)
55. 21:16 D=1300m 排水  
(28-34, 3248 140-42.343)
56. 21:24 D=1300m 排水  
(28-34, 3252 140-42.414)
57. 21:32 D=1300m 排水  
(28-34, 3256 140-42.485)
58. 21:40 D=1300m 排水  
(28-34, 3260 140-42.556)
59. 21:48 D=1300m 排水  
(28-34, 3264 140-42.627)
60. 21:56 D=1300m 排水  
(28-34, 3268 140-42.698)
61. 22:04 D=1300m 排水  
(28-34, 3272 140-42.769)
62. 22:12 D=1300m 排水  
(28-34, 3276 140-42.840)
63. 22:20 D=1300m 排水  
(28-34, 3280 140-42.911)
64. 22:28 D=1300m 排水  
(28-34, 3284 140-42.982)
65. 22:36 D=1300m 排水  
(28-34, 3288 140-43.053)
66. 22:44 D=1300m 排水  
(28-34, 3292 140-43.124)
67. 22:52 D=1300m 排水  
(28-34, 3296 140-43.195)
68. 23:00 D=1300m 排水  
(28-34, 3300 140-43.266)
69. 23:08 D=1300m 排水  
(28-34, 3304 140-43.337)
70. 23:16 D=1300m 排水  
(28-34, 3308 140-43.408)
71. 23:24 D=1300m 排水  
(28-34, 3312 140-43.479)
72. 23:32 D=1300m 排水  
(28-34, 3316 140-43.550)
73. 23:40 D=1300m 排水  
(28-34, 3320 140-43.621)
74. 23:48 D=1300m 排水  
(28-34, 3324 140-43.692)
75. 23:56 D=1300m 排水  
(28-34, 3328 140-43.763)
76. 00:04 D=1300m 排水  
(28-34, 3332 140-43.834)
77. 00:12 D=1300m 排水  
(28-34, 3336 140-43.905)
78. 00:20 D=1300m 排水  
(28-34, 3340 140-43.976)
79. 00:28 D=1300m 排水  
(28-34, 3344 140-44.047)
80. 00:36 D=1300m 排水  
(28-34, 3348 140-44.118)
81. 00:44 D=1300m 排水  
(28-34, 3352 140-44.189)
82. 00:52 D=1300m 排水  
(28-34, 3356 140-44.260)
83. 01:00 D=1300m 排水  
(28-34, 3360 140-44.331)
84. 01:08 D=1300m 排水  
(28-34, 3364 140-44.402)
85. 01:16 D=1300m 排水  
(28-34, 3368 140-44.473)
86. 01:24 D=1300m 排水  
(28-34, 3372 140-44.544)
87. 01:32 D=1300m 排水  
(28-34, 3376 140-44.615)
88. 01:40 D=1300m 排水  
(28-34, 3380 140-44.686)
89. 01:48 D=1300m 排水  
(28-34, 3384 140-44.757)
90. 01:56 D=1300m 排水  
(28-34, 3388 140-44.828)
91. 02:04 D=1300m 排水  
(28-34, 3392 140-44.899)
92. 02:12 D=1300m 排水  
(28-34, 3396 140-44.970)
93. 02:20 D=1300m 排水  
(28-34, 3400 140-45.041)
94. 02:28 D=1300m 排水  
(28-34, 3404 140-45.112)
95. 02:36 D=1300m 排水  
(28-34, 3408 140-45.183)
96. 02:44 D=1300m 排水  
(28-34, 3412 140-45.254)
97. 02:52 D=1300m 排水  
(28-34, 3416 140-45.325)
98. 03:00 D=1300m 排水  
(28-34, 3420 140-45.396)
99. 03:08 D=1300m 排水  
(28-34, 3424 140-45.467)
100. 03:16 D=1300m 排水  
(28-34, 3428 140-45.538)
101. 03:24 D=1300m 排水  
(28-34, 3432 140-45.609)
102. 03:32 D=1300m 排水  
(28-34, 3436 140-45.680)
103. 03:40 D=1300m 排水  
(28-34, 3440 140-45.751)
104. 03:48 D=1300m 排水  
(28-34, 3444 140-45.822)
105. 03:56 D=1300m 排水  
(28-34, 3448 140-45.893)
106. 04:04 D=1300m 排水  
(28-34, 3452 140-45.964)
107. 04:12 D=1300m 排水  
(28-34, 3456 140-46.035)
108. 04:20 D=1300m 排水  
(28-34, 3460 140-46.106)
109. 04:28 D=1300m 排水  
(28-34, 3464 140-46.177)
110. 04:36 D=1300m 排水  
(28-34, 3468 140-46.248)
111. 04:44 D=1300m 排水  
(28-34, 3472 140-46.319)
112. 04:52 D=1300m 排水  
(28-34, 3476 140-46.390)
113. 05:00 D=1300m 排水  
(28-34, 3480 140-46.461)
114. 05:08 D=1300m 排水  
(28-34, 3484 140-46.532)
115. 05:16 D=1300m 排水  
(28-34, 3488 140-46.603)
116. 05:24 D=1300m 排水  
(28-34, 3492 140-46.674)
117. 05:32 D=1300m 排水  
(28-34, 3496 140-46.745)
118. 05:40 D=1300m 排水  
(28-34, 3500 140-46.816)
119. 05:48 D=1300m 排水  
(28-34, 3504 140-46.887)
120. 05:56 D=1300m 排水  
(28-34, 3508 140-46.958)
121. 06:04 D=1300m 排水  
(28-34, 3512 140-47.029)
122. 06:12 D=1300m 排水  
(28-34, 3516 140-47.100)
123. 06:20 D=1300m 排水  
(28-34, 3520 140-47.171)
124. 06:28 D=1300m 排水  
(28-34, 3524 140-47.242)
125. 06:36 D=1300m 排水  
(28-34, 3528 140-47.313)
126. 06:44 D=1300m 排水  
(28-34, 3532 140-47.384)
127. 06:52 D=1300m 排水  
(28-34, 3536 140-47.455)
128. 07:00 D=1300m 排水  
(28-34, 3540 140-47.526)
129. 07:08 D=1300m 排水  
(28-34, 3544 140-47.597)
130. 07:16 D=1300m 排水  
(28-34, 3548 140-47.668)
131. 07:24 D=1300m 排水  
(28-34, 3552 140-47.739)
132. 07:32 D=1300m 排水  
(28-34, 3556 140-47.810)
133. 07:40 D=1300m 排水  
(28-34, 3560 140-47.881)
134. 07:48 D=1300m 排水  
(28-34, 3564 140-47.952)
135. 07:56 D=1300m 排水  
(28-34, 3568 140-48.023)
136. 08:04 D=1300m 排水  
(28-34, 3572 140-48.094)
137. 08:12 D=1300m 排水  
(28-34, 3576 140-48.165)
138. 08:20 D=1300m 排水  
(28-34, 3580 140-48.236)
139. 08:28 D=1300m 排水  
(28-34, 3584 140-48.307)
140. 08:36 D=1300m 排水  
(28-34, 3588 140-48.378)
141. 08:44 D=1300m 排水  
(28-34, 3592 140-48.449)
142. 08:52 D=1300m 排水  
(28-34, 3596 140-48.520)
143. 09:00 D=1300m 排水  
(28-34, 3600 140-48.591)
144. 09:08 D=1300m 排水  
(28-34, 3604 140-48.662)
145. 09:16 D=1300m 排水  
(28-34, 3608 140-48.733)
146. 09:24 D=1300m 排水  
(28-34, 3612 140-48.804)
147. 09:32 D=1300m 排水  
(28-34, 3616 140-48.875)
148. 09:40 D=1300m 排水  
(28-34, 3620 140-48.946)
149. 09:48 D=1300m 排水  
(28-34, 3624 140-49.017)
150. 09:56 D=1300m 排水  
(28-34, 3628 140-49.088)
151. 10:04 D=1300m 排水  
(28-34, 3632 140-49.159)
152. 10:12 D=1300m 排水  
(28-34, 3636 140-49.230)
153. 10:20 D=1300m 排水  
(28-34, 3640 140-49.301)
154. 10:28 D=1300m 排水  
(28-34, 3644 140-49.372)
155. 10:36 D=1300m 排水  
(28-34, 3648 140-49.443)
156. 10:44 D=1300m 排水  
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157. 10:52 D=1300m 排水  
(28-34, 3656 140-49.585)
158. 11:00 D=1300m 排水  
(28-34, 3660 140-49.656)
159. 11:08 D=1300m 排水  
(28-34, 3664 140-49.727)
160. 11:16 D=1300m 排水  
(28-34, 3668 140-49.798)
161. 11:24 D=1300m 排水  
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162. 11:32 D=1300m 排水  
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163. 11:40 D=1300m 排水  
(28-34, 3680 140-50.011)
164. 11:48 D=1300m 排水  
(28-34, 3684 140-50.082)
165. 11:56 D=1300m 排水  
(28-34, 3688 140-50.153)
166. 12:04 D=1300m 排水  
(28-34, 3692 140-50.224)
167. 12:12 D=1300m 排水  
(28-34, 3696 140-50.295)
168. 12:20 D=1300m 排水  
(28-34, 3700 140-50.366)
169. 12:28 D=1300m 排水  
(28-34, 3704 140-50.437)
170. 12:36 D=1300m 排水  
(28-34, 3708 140-50.508)
171. 12:44 D=1300m 排水  
(28-34, 3712 140-50.579)
172. 12:52 D=1300m 排水  
(28-34, 3716 140-50.650)
173. 13:00 D=1300m 排水  
(28-34, 3720 140-50.721)
174. 13:08 D=1300m 排水  
(28-34, 3724 140-50.792)
175. 13:16 D=1300m 排水  
(28-34, 3728 140-50.863)
176. 13:24 D=1300m 排水  
(28-34, 3732 140-50.934)
177. 13:32 D=1300m 排水  
(28-34, 3736 140-51.005)
178. 13:40 D=1300m 排水  
(28-34, 3740 140-51.076)
179. 13:48 D=1300m 排水  
(28-34, 3744 140-51.147)
180. 13:56 D=1300m 排水  
(28-34, 3748 140-51.218)
181. 14:04 D=1300m 排水  
(28-34, 3752 140-51.289)
182. 14:12 D=1300m 排水  
(28-34, 3756 140-51.360)
183. 14:20 D=1300m 排水  
(28-34, 3760 140-51.431)
184. 14:28 D=1300m 排水  
(28-34, 3764 140-51.502)
185. 14:36 D=1300m 排水  
(28-34, 3768 140-51.573)
186. 14:44 D=1300m 排水  
(28-34, 3772 140-51.644)
187. 14:52 D=1300m 排水  
(28-34, 3776 140-51.715)
188. 15:00 D=1300m 排水  
(28-34, 3780 140-51.786)
189. 15:08 D=1300m 排水  
(28-34, 3784 140-51.857)
190. 15:16 D=1300m 排水  
(28-34, 3788 140-51.928)
191. 15:24 D=1300m 排水  
(28-34, 3792 140-52.000)
192. 15:32 D=1300m 排水  
(28-34, 3796 140-52.071)
193. 15:40 D=1300m 排水  
(28-34, 3800 140-52.142)
194. 15:48 D=1300m 排水  
(28-34, 3804 140-52.213)
195. 15:56 D=1300m 排水  
(28-34, 3808 140-52.284)
196. 16:04 D=1300m 排水  
(28-34, 3812 140-52.355)
197. 16:12 D=1300m 排水  
(28-34, 3816 140-52.426)
198. 16:20 D=1300m 排水  
(28-34, 3820 140-52.497)
199. 16:28 D=1300m 排水  
(28-34, 3824 140-52.568)
200. 16:36 D=1300m 排水  
(28-34, 3828 140-52.639)
201. 16:44 D=1300m 排水  
(28-34, 3832 140-52.710)
202. 16:52 D=1300m 排水  
(28-34, 3836 140-52.781)
203. 17:00 D=1300m 排水  
(28-34, 3840 140-52.852)
204. 17:08 D=1300m 排水  
(28-34, 3844 140-52.923)
205. 17:16 D=1300m 排水  
(28-34, 3848 140-53.000)
206. 17:24 D=1300m 排水  
(28-34, 3852 140-53.071)
207. 17:32 D=1300m 排水  
(28-34, 3856 140-53.142)
208. 17:40 D=1300m 排水  
(28-34, 3860 140-53.213)
209. 17:48 D=1300m 排水  
(28-34, 3864 140-53.284)
210. 17:56 D=1300m 排水  
(28-34, 3868 140-53.355)
211. 18:04 D=1300m 排水  
(28-34, 3872 140-53.426)
212. 18:12 D=1300m 排水  
(28-34, 3876 140-53.497)
213. 18:20 D=1300m 排水  
(28-34, 3880 140-53.568)
214. 18:28 D=1300m 排水  
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215. 18:36 D=1300m 排水  
(28-34, 3888 140-53.710)
216. 18:44 D=1300m 排水  
(28-34, 3892 140-53.781)
217. 18:52 D=1300m 排水  
(28-34, 3896 140-53.852)
218. 19:00 D=1300m 排水  
(28-34, 3900 140-53.923)
219. 19:08 D=1300m 排水  
(28-34, 3904 140-54.000)
220. 19:16 D=1300m 排水  
(28-34, 3908 140-54.071)
221. 19:24 D=1300m 排水  
(28-34, 3912 140-54.142)
222. 19:32 D=1300m 排水  
(28-34, 3916 140-54.213)
223. 19:40 D=1300m 排水  
(28-34, 3920 140-54.284)
224. 19:48 D=1300m 排水  
(28-34, 3924 140-54.355)
225. 19:56 D=1300m 排水  
(28-34, 3928 140-54.426)
226. 20:04 D=1300m 排水  
(28-34, 3932 140-54.497)
227. 20:12 D=1300m 排水  
(28-34, 3936 140-54.568)
228. 20:20 D=1300m 排水  
(28-34, 3940 140-54.639)
229. 20:28 D=1300m 排水  
(28-34, 3944 140-54.710)
230. 20:36 D=1300m 排水  
(28-34, 3948 140-54.781)
231. 20:44 D=1300m 排水  
(28-34, 3952 140-54.852)
232. 20:52 D=1300m 排水  
(28-34, 3956 140-54.923)
233. 21:00 D=1300m 排水  
(28-34, 3960 140-55.000)
234. 21:08 D=1300m 排水  
(28-34, 3964 140-55.071)
235. 21:16 D=1300m 排水  
(28-34, 3968 140-55.142)
236. 21:24 D=1300m 排水  
(28-34, 3972 140-55.213)
237. 21:32 D=1300m 排水  
(28-34, 3976 140-55.284)
238. 21:40 D=1300m 排水  
(28-34, 3980 140-55.355)
239. 21:48 D=1300m 排水  
(28-34, 3984 140-55.426)
240. 21:56 D=1300m 排水  
(28-34, 3988 140-55.497)
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(28-34, 3992 140-55.568)
242. 22:12 D=1300m 排水  
(28-34, 3996 140-55.639)
243. 22:20 D=1300m 排水  
(28-34, 4000 140-55.710)
244. 22:28 D=1300m 排水  
(28-34, 4004 140-55.781)
245. 22:36 D=1300m 排水  
(28-34, 4008 140-55.852)
246. 22:44 D=1300m 排水  
(28-34, 4012 140-55.923)
247. 22:52 D=1300m 排水  
(28-34, 4016 140-56.000)
248. 23:00 D=1300m 排水  
(28-34, 4020 140-56.071)
249. 23:08 D=1300m 排水  
(2