doi : 10.17596/0003352

NATSUSHIMA Cruise Report

NT10-16

Izena, North-East Izena

Nansei Islands, Japan

September 4 to September 11, 2010

Chief Scientist: Tatsuhiro Fukuba

(Institute of Industrial Science, University of Tokyo)

in collaboration with:
Central Research Institute of Electric Power Industry,
Center for Advanced Marine Core Research, Kochi University,
&
Japan Agency for Marin-Earth Science and Technology
(JAMSTEC)

Form version 2010/06/09, revision 2010/09/04

Preface

This report describes preliminary information on the data taken during NT10-16 cruise by R/V Natsushima with ROV HyperDolphin from September 3 to 11, 2010.

NT10-16 cruise was conducted based on the proposal #S10-68 titled “A study on a novel hydrothermal ore mine survey by *in situ* multi parameter measurements” (representative: Tatsuhiro Fukuba / University of Tokyo).

Purpose of the cruise is to examine the feasibility of a novel method to discover new hydrothermal ore mines by utilizing small-sized multi-parameter *in situ* chemical sensors and analyzers.

In this cruise, the research works described in the following has been conducted mostly focusing on the hydrothermal activity in Izena Hole and caldera-like depressions in Northeast Izena (NE-Izena). During the dive # 1179, ROV Hyper Dolphin (HPD) dived to Jade hydrothermal site at Izena-Hole for 1) operational test of chemical sensors and analyzer, 2) water and rock sample collection, and 3) data acquisition through a straight measurement line. At the dive # 1180 to 1182, we tried to find novel hydrothermal activities using chemical sensors and analyzer in one of the depressions at NE-Izena area. As a result of detailed survey followed by wide range survey utilizing *in situ* chemical sensors and analyzer, novel hydrothermal sites with clear hot water eruption were successfully discovered.

Finally, I would like to thank all the members of the ROV HyperDolphin operation team (Chief: Yoshio Ohno), and the crewmembers of R/V Natsushima (Captain: Hitoshi Tanaka) for their dedicated efforts to make this cruise so successful.

September 2010
Tatsuhiro Fukuba (NT10-16 Chief Scientist)

Notice on Using:

This cruise report is a preliminary documentation as of the end of the cruise.

This report may not be corrected even if changes on content (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information.

Users of data or results of this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.

Contents

1. Cruise Information

Cruise ID:	NT10-16
Name of vessel:	R/V Natsushima
Title of the cruise:	FY2010 Deep Sea Survey by ROV HyperDolphin in Nansei Islands
Title of the proposal:	A study on a novel hydrothermal ore mine survey by *in situ* multi parameter measurements
Cruise period:	8 days from September 4 to September 11, 2010
Ports of call:	dep. Naha, ret. Naha
Research area:	Izena Hole and North-east Izena (NE-Izena)

2. Research Map

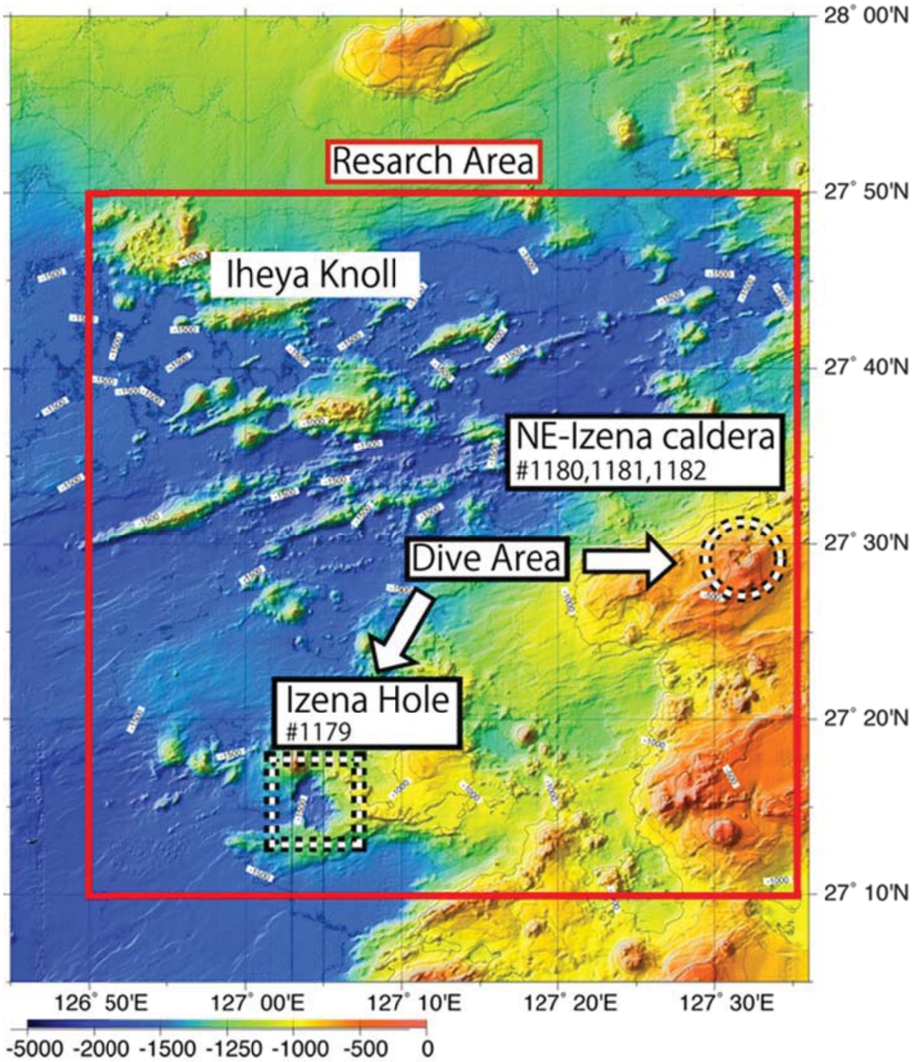

Fig. 1 Research Area and Dive Area (Nansei Islands, Izena Hole and NE-Izena Caldera-like Depression)

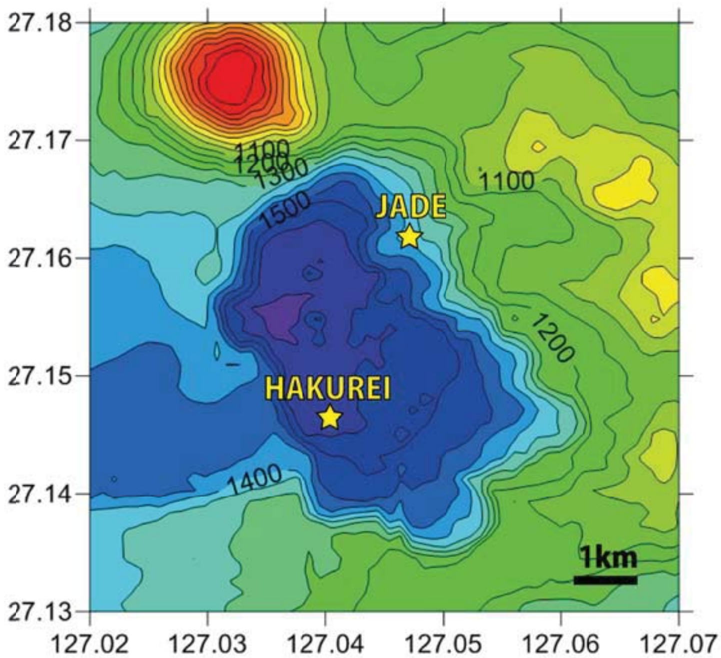

Fig. 2 Izena Hole

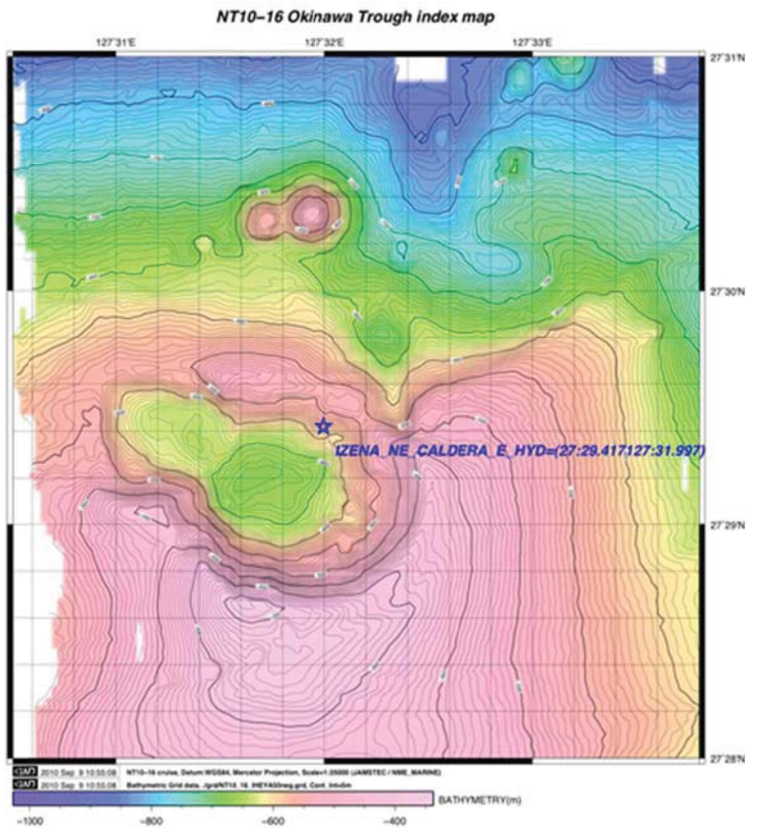

Fig.3 Northeast Izena (NE-Izena) Caldera-like Depression

3. Researchers

3.1. Chief Scientist:

Tatsuhiro Fukuba [IIS, University of Tokyo]

3.2. Representative of the Science Party

Tatsuhiro Fukuba [IIS, University of Tokyo]

3.3. Science Party (*not Onboard)

Teruo Fujii	[IIS, University of Tokyo]*
Kokichi Iizasa	[University of Tokyo]*
Christophe Provin	[IIS, University of Tokyo]
Tomoyuki Kusunoki	[IIS, University of Tokyo]
Ryuhei Shimada	[IIS, University of Tokyo]
Blair Thornton	[IIS, University of Tokyo]
Tatsuya Masamura	[IIS, University of Tokyo]
Sachiko Horii	[University of Tokyo]
Kei Okamura	[Kochi University]
Yoshitomo Narusawa	[Waseda University]
Masanori Kyo	[JAMSTEC]
Kiminori Shitashima	[CRIEPI]
Takeshi Fujii	[The General Environmental Technos Co. Ltd.]

4. Observation

4.1 Introduction

With increasing needs on rare metal materials, hydrothermal ore deposit is focused as one of the promised novel natural resources today. Hydrothermal ore deposit that is rich in Cu, Zn, Pb, Au, Ag and In is formed by underwater volcanic activity. Some large-scale ore deposits are already discovered in Okinawa Trough and Izu-Ogasawara Arc, and detailed survey towards commercial development is undergoing. Currently, major method to survey seafloor ore deposit is based on acoustic apparatus including sub-bottom profilers, multinarrow beam echo sunders and side-scan sonars. These acoustic apparatus can be equipped on research vessels and underwater vehicles including AUVs. In addition to acoustic apparatus, novel *in situ* survey tools are necessary to investigate scale, quality, contents and activity of hydrothermal ore deposits in detail. Assessment of biological activity is also one of the important missions for sustainable development of ore deposits without serious decrease in biodiversity.

4.2 Objectives

One of the objectives of this research is to carryout real-field evaluations of novel chemical or biochemical analyzers and sensors developed for hydrothermal ore deposit survey. For this purpose, we visited Izena Hole in Okinawa Trough (Fig. 2) where existence of large-scale ore deposit with hydrothermal activity is well known. Another important mission is to utilize series of novel analyzers and sensors for practical survey of novel hydrothermal activity in deep-sea environment. We visited northeast area of Izena Hole where Japan Coast Guard founded some caldera-like depressions and small knolls during topographic survey in 2009 (Fig. 1, 3). Collection of filed samples such as seawater and rock is also important mission in this study to perform microbiological and petrological analysis.

4.3 *In Situ* Analyzer and Sensors

4.3.1 Mn Ion Quantitative Determination using an IISA-Mn (IIS, Univ. of Tokyo)

Manganese ion (Mn^{2+}) in seawater can be utilized as useful marker element for hydrothermal activity survey because of its specificity. Major and reliable method for highly sensitive quantitative determination of Mn^{2+} is *in situ* FIA (flow injection analysis) or CFA (continuous flow analysis) utilizing luminol based chemiluminescence reaction. We have developed an IISA (Integrated In Situ Analyzer) –Mn (Fig. 4) for the purpose of hydrothermal activity survey. The most important characteristic of IISA-Mn is utilization of a “microfluidic device” (Fig. 5) as its core analytical element. By applying microfluidic devices and micro pumping unit, a functionally integrated CFA apparatus became small. In this cruise, IISA-Mn was mounted on the HPD for all dives for in situ evaluation of the system and for practical operations to detect Mn^{2+} concentration anomalies.

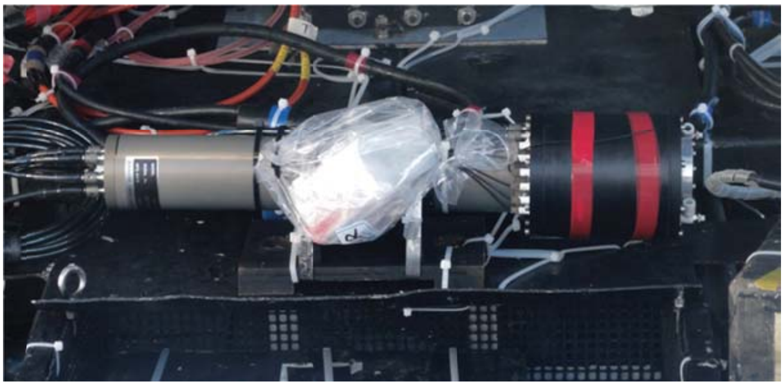

Fig. 4 IISA-Mn Mounted on HPD

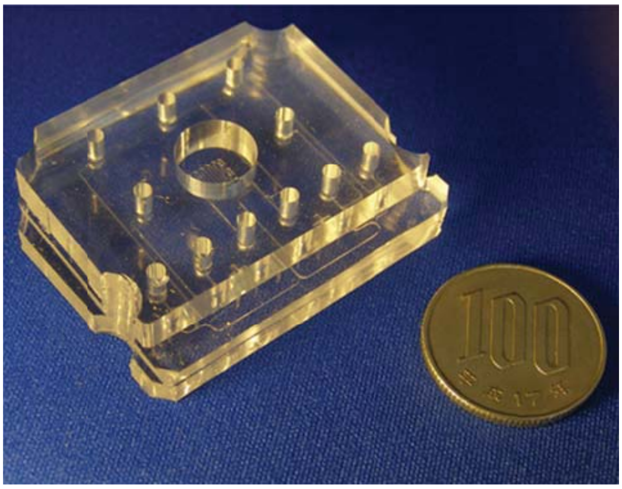

Fig. 5 Microfluidic Device for IISA-Mn

4.3.2 pH Measurement using a Signal Accumulation pH Sensor, IISA-AMISpH (IIS, University of Tokyo)

pH value is one of fundamental parameter of seawater because it influences behavior of water contents and closely related to dissolved CO_2 concentration. In addition, detection of water plumes that have low pH anomaly is one of the most useful methods for hydrothermal activity survey. In this cruise, a prototype of solid-state pH sensor system, IISA-AMISpH (Fig. 6), that utilizing a Signal Accumulation Type Ion sensor (AMIS) was put on the HPD for field testing and practical 2D pH mapping. The AMIS is integrated with a microfluidic device to realize *in situ* sensor calibration for reliable data acquisitions. The IISA-AMISpH was mounted on the HPD for all dives.

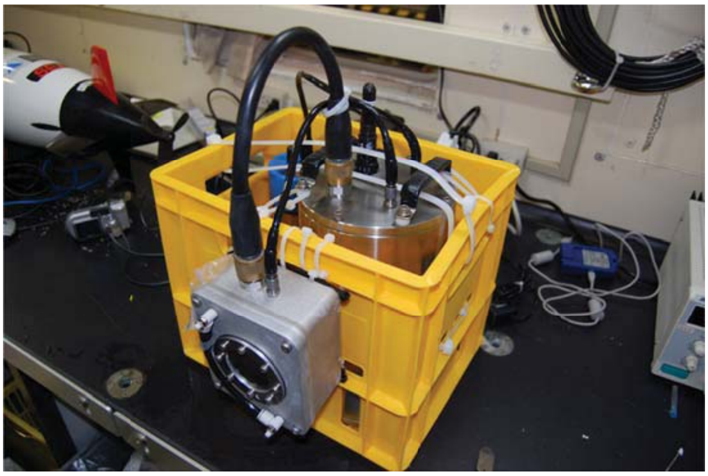

Fig. 6 IISA-AMISpH

4.3.3 H_2S Determination using an Electrochemical Sensor "TANSAKUN"

In situ H_2S quantitative determination was conducted using an electrochemical sensor "TANSAKUN" (Fig. 7) mounted on HPD. H_2S was measured by a linear-sweep voltammetry using an Ag electrode. At first stage, H_2S was collected on the Ag electrode as Ag_2S by adjusted the voltage of the Ag electrode at high for 10 second. At second stage, H_2S was removed from the Ag electrode at low voltage for 1second. Electric current during removal stage was correlated with the concentration of H_2S. As a result, H_2S concentration anomalies were successfully detected when the HPD approached to hydrothermal active areas.

Fig. 7 TANSAKUN

4.3.4 Multi Parameter Chemical Sensing

Real-time monitoring of Conductivity, Temperature, Depth and Turbidity using CTDT sensor (Fig. 8, Left) was carried out in all dives. Standalone pH/pCO_2 (partial pressure of CO_2)/ORP (Oxidation-reduction Potential) sensor (Fig. 8, Right) also was mounted on the HPD for all dives. The pH/pCO_2 sensor used a non-glass type pH electrode, ion-sensitive field-effect transistor (ISFET), and the ORP sensor employed Pt wire as a working electrode. These sensors applied a chloride ion selective electrode (Cl-ISE) as the reference electrode.

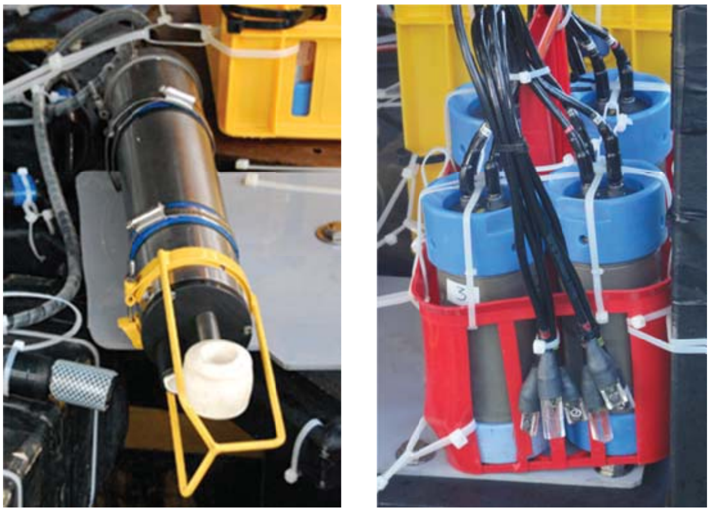

Fig. 8 Multisensor (Left: CTDT, Right: pH/pCO_2/ORP Sensor)

4.3.5 Radioactivity Mapping using an Rn Sensor

In-situ Rn (gamma rays) sensor (Fig. 9) using a NaI(Tl) doped plastic scintillator was installed to HPD on the dives at the NE-Izena caldera-like depression (dive 1180).

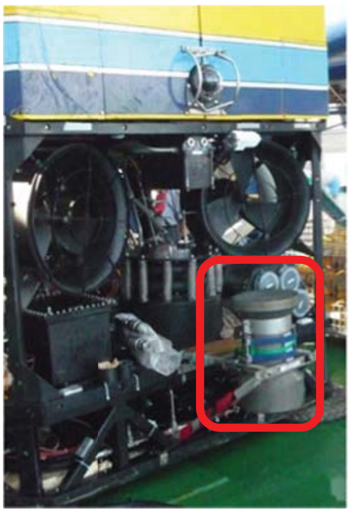

Fig. 9 **Rn Sensor**

4.4 Sample Collections and Onboard Microbiological Analysis

All water samples were collected by using Niskin water samplers and syringe water samplers (Tokyo Univ.) (Fig. 10). Collected water samples were immediately transferred to clean plastic tubes aseptically after each dive. Portions of samples were used for ATP content measurement and MPN based viable cell count assay. Remaining water samples were stored in 4 ˚C for detailed analysis afterwards.

Total (dissolved and particulate) ATP was quantitatively determined onboard using collected samples. Luciferin-luciferase based ATP quantitative determination reagent kit (ChekLite HS Kit (Kikkoman, Japan)) and desktop bioluminescence intensity measurement apparatus (Lumitester C-110, Kikkoman, Japan) was used for the assay. ChekLite HS kit and Lumitester C-110 was used as shown in instruction manual. All measurements were performed 3 times to obtain average value.

Viable cell number was analyzed using MPN (Most Probable Number) method. Here, bacteria with the ability to use thiosulphate as their energy source are targeted. Liquid culture medium (Thiosulphate basal medium) had been prepared according to a paper (T. Naganuma *et al.*, *Deep-sea Res.*, Vol. 36 pp. 1379-1390, 1989) (Table 1). The culture medium contains Bromotymol Blue to visualize pH change caused by growth of targeted microbes. Cultivation was started onboard in 4˚C condition after adding 1 ml of seawater sample to a test tube that contains 9 ml of culture medium in it. The original culture medium was serially diluted by culture medium to obtain 10 to 10,000 times dilution series. 3 parallel series of 10^4 times dilution was prepared for all tested samples for MPN determination. Further cultivations were carried out continuously in laboratory.

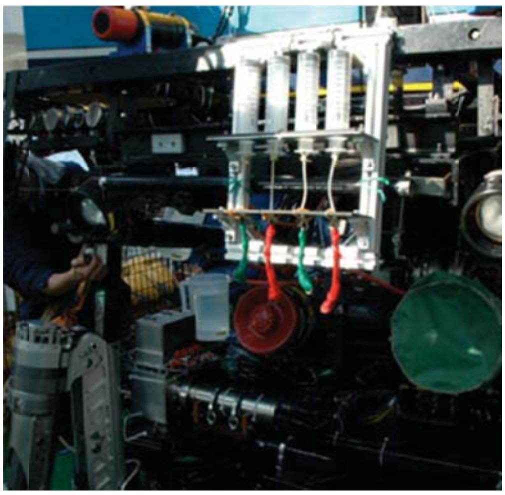

Fig. 10 Syringe Water Samplers

Table 1 Contents of Culture Medium (pH 7.4)

Artificial seawater (Daigo)	1000 mL
$Na_2S_2O_3 \cdot 5H_2O$	10 g
K_2HPO_4	0.25 g
KH_2PO_4	0.25 g
NH_4CI	0.5 g
$MgSO_4 \cdot 7H_2O$	0.25 g
Bromotymol Blue	5 ml

4.5 Sampling of Rocks and Analysis

Series of rock samples including 1) Dead chimneys, 2) Active chimneys, and 3) cap rocks were collected utilizing manipulators of HPD during all dive operations. All rock samples will be analyzed on its elemental composition in laboratory afterwards. All samples were stored for further analysis and sample archival after photographing and radioactivity testing onboard.

5. Preliminary Research Results

5.1 Result of *In Situ* Analyzer and Sensors Operation

5.1.1 Mn Ion Quantitative Determination

IISA-Mn was operated for all dives conducted during this cruise. For the dive #1179 in Izena Hole area, clear increases of chemiluminescence intensity were observed when HPD approached to active hydrothermal sites in Jade site as shown in Fig. 11. Here, we could successfully certify functionality of IISA-Mn in real deep-sea environment.

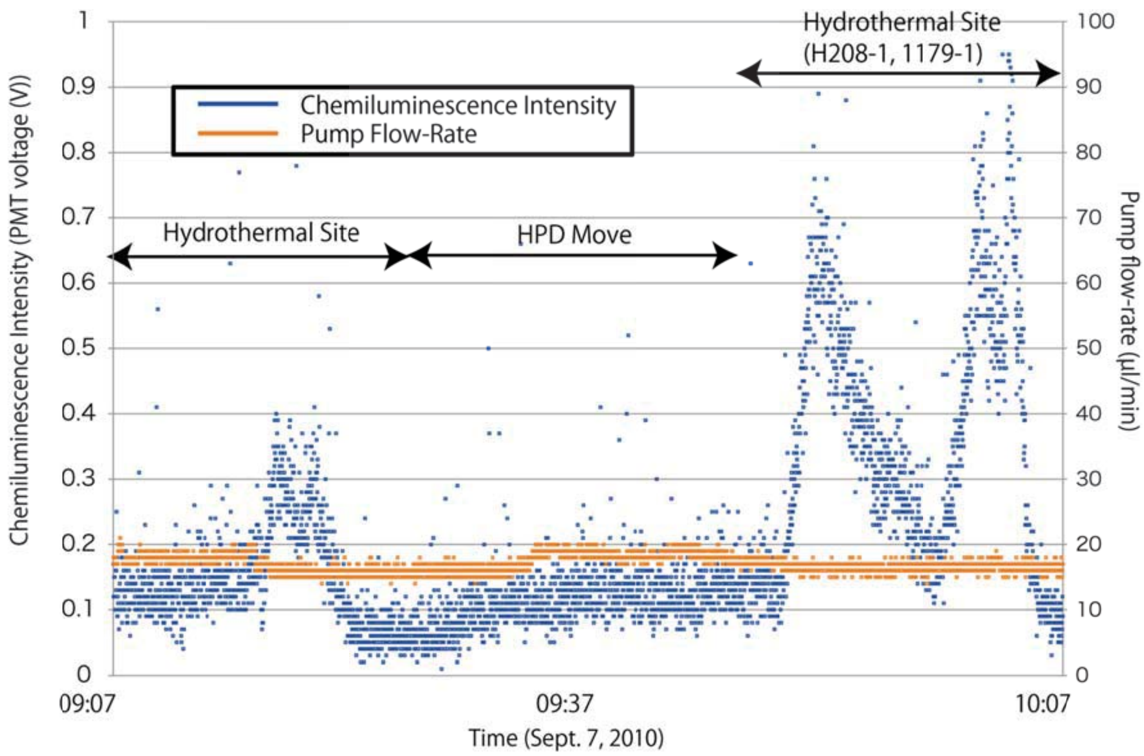

Fig. 11 Chemiluminescence Intensity (Mn Concentration) Anomalies Observed during the Dive #1179. Blue: Chemiluminescence Intensity, Orange: Pump Flow-Rate

On the first dive at NE-Izena (#1180), IISA-Mn was utilized for practical hydrothermal activity survey in a caldera. During radial cruising of HPD in the caldera, IISA-Mn showed chemiluminescence intensity peaks correspond to Mn concentration anomalies. Positions that showed Mn anomalies were plotted on a bathymetric chart as shown in Fig. 12. As a result, most of anomalies were localized on northeast slope of the caldera. Detectable Mn concentration anomalies were not detected at west and south slope. This data was utilized to determine survey strategy for the next dive (#1181).

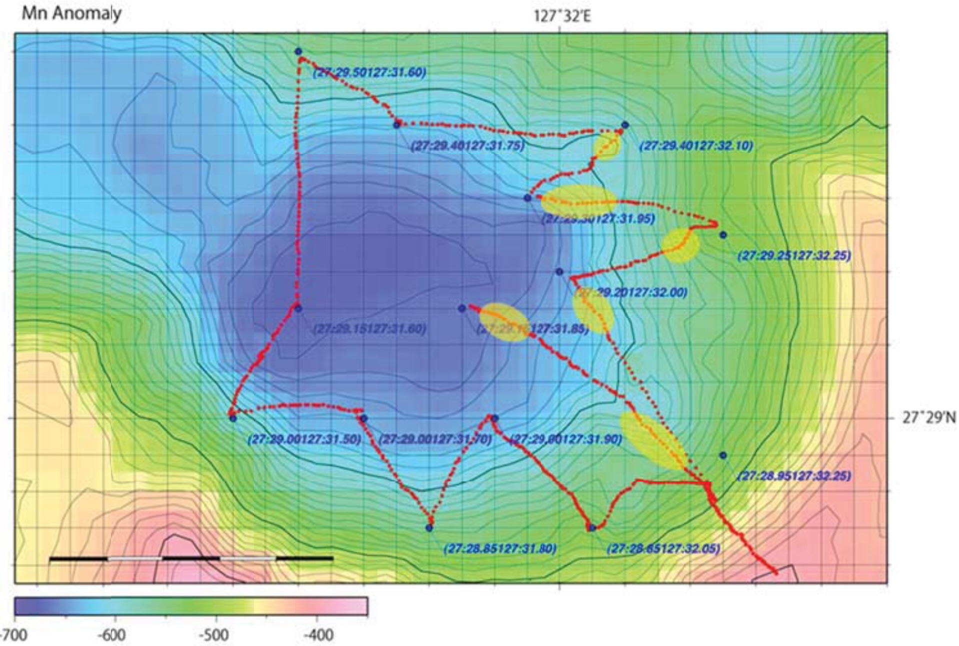

Fig. 12 Points that Showed Mn Anomaly in the Caldera-like Depression (Yellow circle)

During the dive #1181 that was conducted mostly to survey northeast slope, IISA-Mn showed clear Mn concentration anomalies during searching of novel hydrothermal activity and sampling operations near newly discovered hydrothermal vents.

During the last dive (#1182) for detailed survey in newly discovered hydrothermal active sites, IISA-Mn was operated to monitor Mn concentration anomalies. As we expected, clear anomalies were observed near active chimneys. On the other hands, no significant Mn concentration anomalies were observed during long-range measurement line from northeast to southwest slope. Though, much detailed survey is necessary to predict it, the result implies that active hydrothermal sites unlikely to exist at southwest slope.

5.1.2 pH Measurement using IISA-AMISpH

IISA-AMISpH was operated for all HPD dives. Though IISA-AMISpH had been working onboard before each dive operation, meaningful pH data were not obtained during 4 dives because it had serious problems on its wiring in a pressure resistant housing. Because of the wiring problem, pumping unit malfunction, data logging and power supply failure were occurred during operations. Through this cruise, we obtained valuable experiences to develop IISA-AMISpH as a reliable pH measurement system for practical applications in future.

5.1.3 H_2S Quantitative Determination

TANSAKUN was operated for all dives conducted during this cruise. For the #1179 in Izena Hole area, clear increases of H_2S current were observed when HPD approached to active hydrothermal sites in Jade site. On the first dive at NE-Izena (#1180), TANSAKUN was utilized for practical hydrothermal activity survey in a caldera. During cruising of HPD in the caldera, calculated concentration of H_2S was shown in Figure 13. Positions that showed Mn anomalies were plotted on a bathymetric chart as shown in Fig. 14. As a result, most of anomalies were localized on northeast slope of the caldera almost same as Mn. Only H_2S anomalies were shown around north-west wall of the Caldera (12:30-13:00). For dive #1181 and #1182, H_2S concentration data could not retrieved because the data logger of the TANSAKUN did not work well.

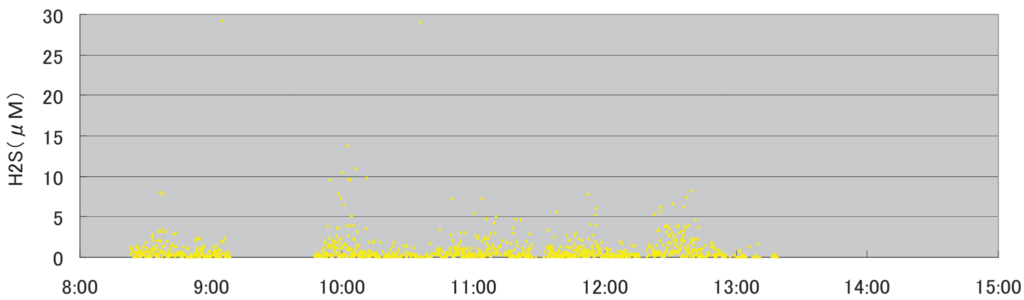

Figure 13 H_2S Concentrations during Dive #1180

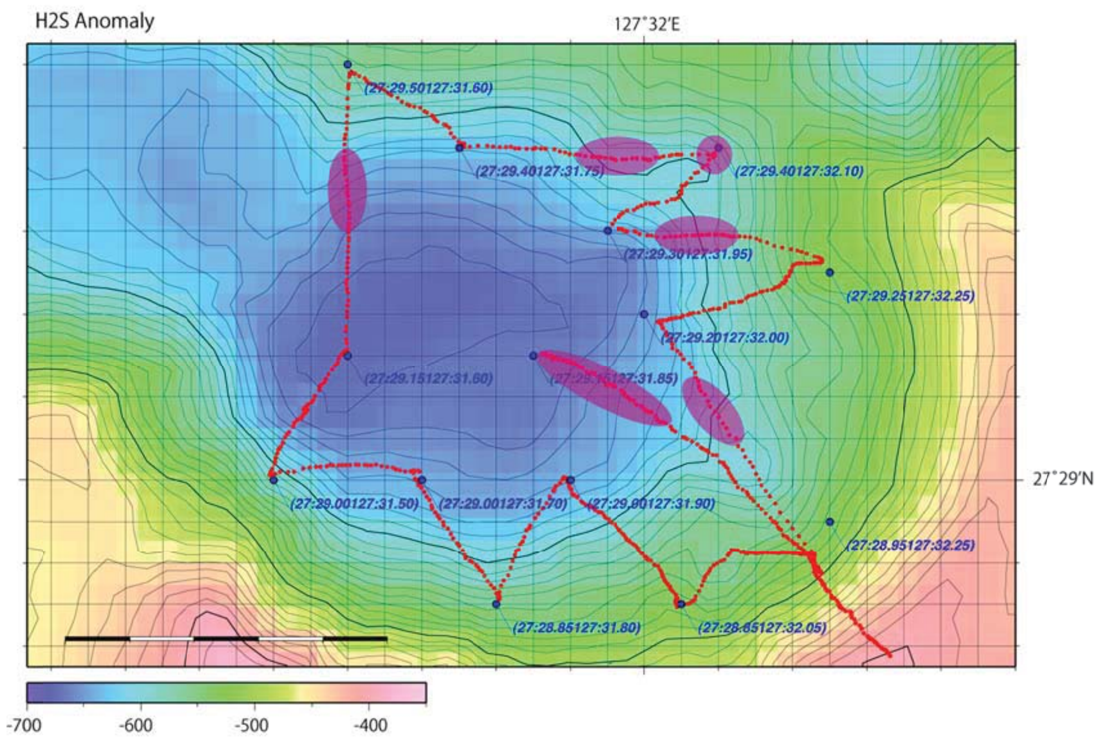

Fig. 14 Points that Showed H_2S Anomaly in the Caldera-like Despression (Red circle)

5.1.4 Multi Parameter Chemical Sensing

Fig. 15 shows results of first mapping survey at the NE-Izena caldera using multi chemical parameter sensors. The slight anomalies of pH, pCO_2, ORP and temperature were detected during HPD cruise in dive 1180. The circled numbers in Fig. 15 correspond to newly discovered hydrothermal active sites in the caldera-like depression shown in Fig. 16. The multi chemical parameter sensors except Rn sensor detected distinguished anomalies in detailed survey dives (#1181 and #1182) in newly discovered hydrothermal active sites.

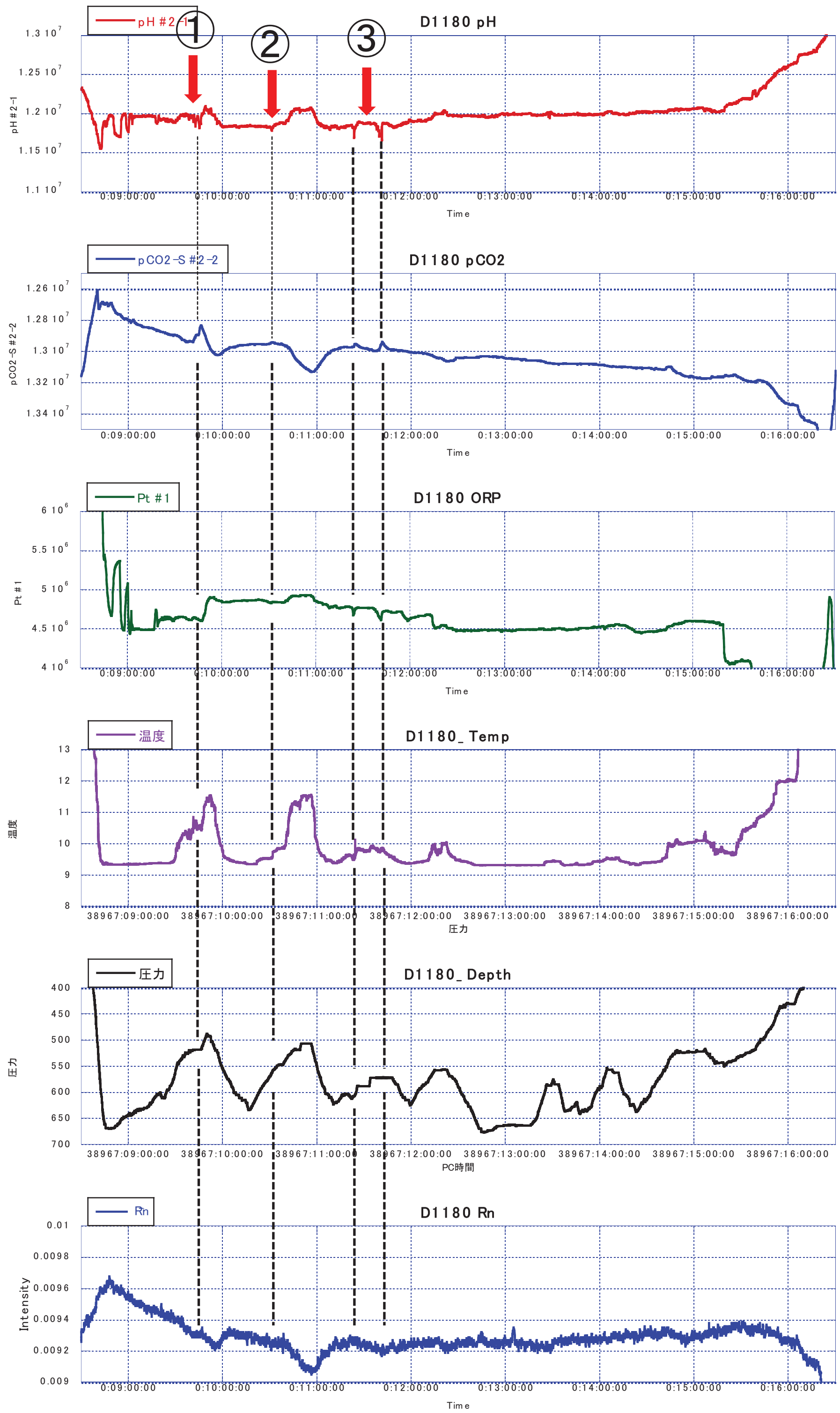

Fig. 15 *In-situ* Time Variation of Multi Chemical Parameter Sensors on Dive 1180

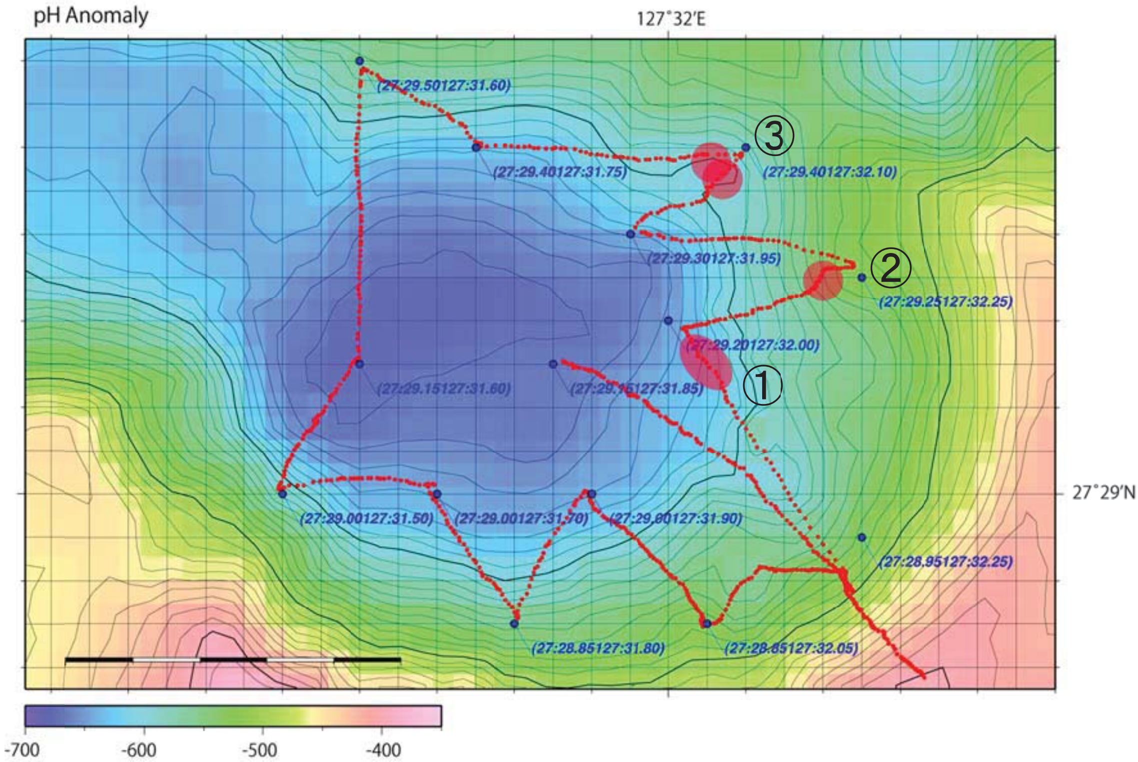

Fig. 16 Points that Showed Multi Chemical Parameter Anomaly in the Caldera-like Depression (Red circle)

5.1.5 Radioactivity Mapping

The Rn sensor was not able to detect remarkable Rn (gamma rays) anomalies, which corresponded with pH and ORP anomalies, at the dive 1180. This may be caused by distance between hydrothermal site and HPD. Unfortunately, *in-situ* Rn sensor did not work during the dive 1181 and 1182 due to trouble of electric circuit board.

5.2 Result of Onboard Microbiological Analysis

5.2.1 Microbial ATP Content

Total ATP contents were successfully measured onboard. Result from #1182 sample is shown in Table 2. Total ATP concentrations were around 15 to 20 pM for most of samples. Sample 1182-W5 that was collected near active hydrothermal vent showed 4-5 times higher ATP content compare to the other site. On the other hands, Sample 1182-W2(S), W4(S), and W5(S) showed average value and were almost same level with the sample W7(S) that was collected far from hydrothermal activity. Samples from event number 3 (near hydrothermal vent) and 16 (far from hydrothermal activity) were collected using both syringe and Niskin water sampler. However, Niskin samples showed apparently higher ATP value than that of syringe samples. This result implies that there is possibility of contamination on Niskin water sampler.

Table 2. Result of ATP Quantification (#1182 dive)

Event number	Sample number N:Niskin S:Syringe	ATP concentration (pmol/L)	SD
3	1182-W2(N)	24.22	±2.41
3	1182-W3(S)	12.74	±1.37
7	1182-W4(S)	16.01	±0.78
9	1182-W5(S)	79.40	±17.3
12	1182-W6(S)	18.01	±1.35
16	1182-W7(S)	20.37	±2.54
16	1182-W9(N)	53.50	±15.26

5.2.2 Viable Cell Count by MPN Method

During the cruise, any positive test tube was not obtained. After transportation of the samples to our laboratory, we continued cultivation under 4˚C condition. As a result of 70 days cultivation, some test tubes have become positive. Numbers of positive tubes for each seawater sample are shown in Table 3. Samples without positive test tubes are not shown in the table. As a result, there was no positive culture with samples from dive #1180, and 1182. For the 1179 dive conducted at Izena hole, 3 samples showed positive results. Calculated MPN cell counts are 140 to 230 cells/ml. All positive cultures were obtained from samples collected near active chimneys. On the other hands, 5 samples collected near active chimneys during temperature measurement operations showed positive results with samples from 1182 dive conducted at NE-Izena. Though sample 1182-W1 (N) and 1182-W2 (S) was collected at same location, 1182-W1 (N) that was collected by using Niskin water sampler showed apparently higher viable cell count than the sample from syringe water sampler. This result implies possibility of contamination on Niskin water samplers.

Table 3 Result of MPN Cell Count Analysis

Sample (S: Syringe) (N: Niskin)	1/1	1/10	1/100	MPN count (cells/ml)
1179-W5 (N)	2	0	1	140
1179-W6 (N)	3	0	0	230
1179-W7 (S)	3	0	0	230
1182-W2 (N)	3	1	0	430
1182-W3 (S)	1	0	0	40
1182-W4 (S)	1	0	0	40
1182-W6 (S)	1	0	0	40
1182-W7 (S)	2	0	0	90

5.3 List of All the Dive & Event Sites

#1179: Sensor Evaluation, Plume Mapping, Sampling (water, rock) [Izena]

Site No	Time	Depth (m)	Event	Location
1	8:05	1359	Reach to Bottom	27-16.108N, 127-04.877E
2	8:14	1358	Rock, Water Sampling	27-16.108N, 127-04.863E
3	8:30	1355	Rock, Water Sampling	27-16.133N, 127-04.843E
4	8:43	1352	Rock, Water Sampling	27-16.145N, 127-04.832E
5	8:53	1354	Rock, Water Sampling	27-16.166N, 127-04.796E
6	8:59	1340	Rock, Water Sampling	27-16.179N, 127-04.782E
7	9:44	1305	Rock Sampling, Marker 1179-1	27-16.296N, 127-04.884E
8	10:18	1297	Water Sampling	27-16.203N, 127-04.942E
9	10:31	1295	Depth Change	27-16.190N, 127-04.826E
10	10:47	1320	Depth Change	27-16.187N, 127-04.688E
11	10:52	1344	Depth Change	27-16.178N, 127-04.646E
12	10:55	1358	Depth Change	27-16.181N, 127-04.623E
13	10:59	1374	Depth Change	27-16.186N, 127-04.574E
14	11:05	1395	Depth Change	27-16.192N, 127-04.532E
15	11:13	1416	Water Sampling, Leave the Bottom	27-16.192N, 127-04.461E

#1180: Sensor Operation, Wide Range Survey, Sampling (water, rock) [NE-Izena]

Site No	Time	Depth (m)	Event	Location
1	8:45	661	Reach to Bottom	27-29.152N, 127-31.859E
2	8:48	662	Red-Colored Bottom	27-29.149N, 127-31.876E
3	9:42	514	Rock Sampling	27-28.904N, 127-32.222E
4	9:51	490	HPD Move	27-28.887N, 127-32.240E
5	10:16	628	Bottom in Sight	27-29.192N, 127-32.019E
6	10:47	515	Water Sampling	27-29.261N, 127-32.239E
7	11:11	615	Bottom in Sight	27-29.303N, 127-31.954E
8	11:30	584	Rock, Water Sampling	27-29.392N, 127-32.094E
9	11:59	618	Bottom in Sight	27-29.402N, 127-31.756E
10	12:17	553	Rock, Water Sampling	27-29.492N, 127-31.605E
11	12:45	671	Bottom in Sight	27-29.157N, 127-31.599E
12	12:59	659	Rock Sampling	27-29.085N, 127-31.541E
13	13:28	582	Water Sampling	27-29.008N, 127-31.494E
14	13:47	636	Bottom in Sight	27-29.157N, 127-31.687E
15	14:06	553	Water Sampling	27-28.856N, 127-31.803E
16	14:23	631	Bottom in Sight	27-29.006N, 127-31.892E
17	15:03	517	Rock, Water Sampling	27-28.852N, 127-32.042E
18	15:19	543	Bottom in Sight	27-28.916N, 127-32.118E
19	16:00	427	Rock, Water Sampling	27-28.840N, 127-32.278E
20	16:16	388	Leave the Bottom	27-28.786N, 127-32.333E

#1181: Sensor Operation, Narrow Range Survey, Sampling (water, rock) [NE-Izena]

Site No	Time	Depth (m)	Event	Location
1	8:46	579	Reach to Bottom	27-29.488N, 127-31.562E
2	9:56	571	Hydrothermal Site in Sight, Rock, Water Sampling, Marker H1181-1	27-29.417N, 127-31.997E
3	11:28	564	Hot Water Discharge in Sight, Water Sampling	27-29.343N, 127-32.144E
4	12:23	560	HPD Move	27-28.999N, 127-32.200E
5	12:31	594	Bottom in Sight	27-29.094N, 127-32.102E
6	14:09	580	Chimney in Sight, Rock,	27-29.327N, 127-32.115E

			Water Sampling, Marker H1181-2	
7	15:09	573	HPD Move	27-29.139N, 127-32.124E
8	15:53	635	Bottom in Sight	27-29.701N, 127-32.285E
9	16:19	534	Leave the Bottom	27-29.545N, 127-32.177E

#1182: Sensor Operation, Water Temperature Measurement, Narrow Range Survey, Plume Mapping, Sampling (water, rock) [NE-Izena]

Site No	Time	Depth (m)	Event	Location
1	8:46	580	Reach to Bottom	27-29.381N, 127-31.958E
2	8:55	582	Hot Water Discharge in Sight	27-29.412N, 127-31.977E
3	9:08	569	Temp. Measurement, Rock, Water Sampling	27-29.417N, 127-31.997E
4	10:20	580	Bottom in Sight	27-29.395N, 127-31.960E
5	10:27	570	Bottom in Sight	27-29.419N, 127-31.956E
6	10:31	560	HPD Move	27-29.389N, 127-31.947E
7	10:56	558	Bottom in Sight, Hydrothermal Site in Sight, Water Sampling, Temp. Measurement Marker H1182-1	27-29.433N, 127-31.947E
8	12:09	559	Bottom in Sight	27-29.283N, 127-32.129E
9	12:43	561	Hot Water Discharge in Sight, Rock, Water Sampling, Temp. Measurement	27-29.351N, 127-32.143E
10	13:18	557	HPD Move	27-29.378N, 127-32.140E
11	13:26	584	Bottom in Sight	27-29.321N, 127-32.078E
12	13:37	580	Water Sampling, Temp. Measurement	27-29.329N, 127-32.115E
13	14:10	585	Bottom in Sight, Hydrothermal Site in Sight, Temp. Measurement	27-29.408N, 127-31.986E

14	14:48	564	Chimney in Sight, HPD Move	27-29.427N, 127-31.990E
15	15:39	618	Bottom in Sight	27-29.198N, 127-31.431E
16	16:22	454	Water Sampling, Leave the Bottom	27-29.101N, 127-31.232E

5.4 Preliminary Dive Results

In an original cruise plan, totally 5 dives were planned to be conducted during NT10-16 cruise. However, one of the dives was cancelled because of a typhoon approached to research area. As a result, totally 4 dives were conducted.

The first dive (#1179) was conducted at Izena Hole area. HPD was equipped with chemical sensors, analyzers, syringe water samplers and Niskin water samplers. Dive track of this dive is shown in Fig. 17. During the dive, HPD approached to hydrothermal activities in JADE site. One marker (H1179-1) was placed near an active chimney. Water and rock samples were successfully collected around active chimneys. After sampling operations and observation of hydrothermal site, HPD cruised to the west for plume mapping using chemical sensors and analyzers. We finished the dive in morning to move R/V Natsushima towards NE-Izena area for topographic survey.

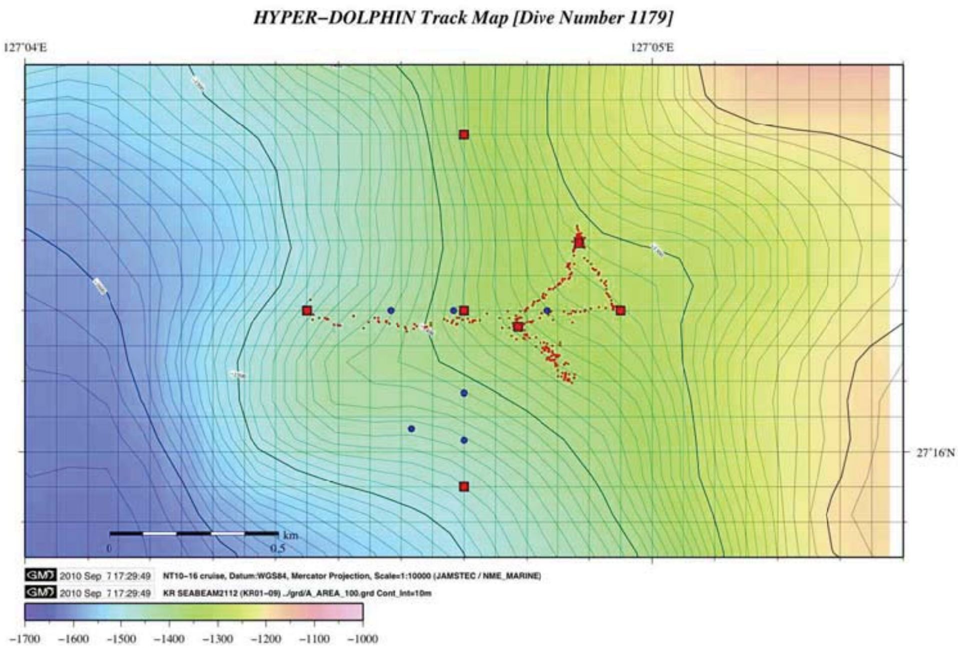

Fig. 17 Hyper-Dolphin Track Map on dive #1179 at Izena Hole

Second dive (#1180) was performed at NE-Izena area to survey novel hydrothermal activity in a caldera-like landform. In this dive, HPD cruised in radial with following inside slope of a caldera for wide range survey as shown in Fig. 10. During the survey operation, water and rock samples were successfully collected. Sensors and analyzers were successfully operated during the dive. During this dive, we discovered dead chimney at southwest slope of the caldera (Fig. 18 and 19). However, any active chimneys were not discovered.

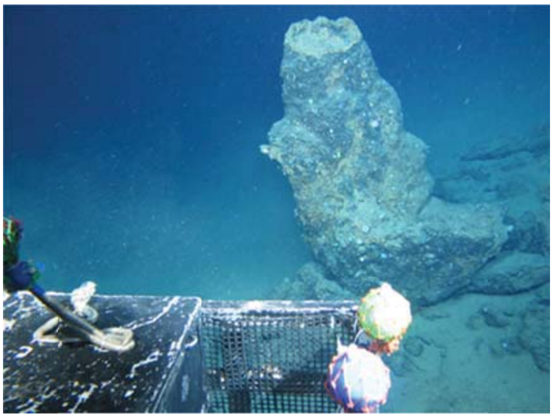

Fig. 18 Dead chimney

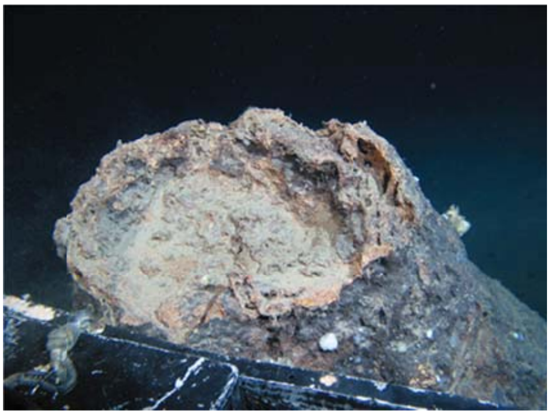

Fig. 19 Close-up view of the dead chimney

For the third dive (#1181), we choose northeast slope for narrow range detailed survey because most of data from chemical sensors and analyzers operated during #1180 dive showed clear anomalies of water contents at northeast area of the caldera-like depression. As a result of the survey, novel hydrothermal sites were successfully discovered during HPD was traversing the northeast slope. First, hydrothermal active sites with many active chimneys that emit clear hot water were discovered (Fig. 20). We named this site as “Achijah” site (“Hot tea” in Okinawan Japanese). Consequently, hydrothermal site that has weaker eruption of clear hot water was found (Fig. 21). We named this site as “Heajah” site (“Spring” in Okinawan Japanese). Here, rocks were partially covered with while colored objects. The white objects were seemed like sea sponges. One large chimney (named as “Deeji” (“Large or important in Okinawan Japanese) chimney) was also discovered near Heajah site (Fig. 22). Hot water was erupted various position of Deeji chimney. 2 markers (H1181-1, 2) were placed near active chimneys at Achijah site and Deejina chimney, respectively. Before the end of the dive, HPD climbed up northeast slope to survey outside of the caldera-like depression. However, no hydrothermal activity was discovered. Water and rock samples were successfully collected. Location of each hydrothermal site was shown in Fig. 23.

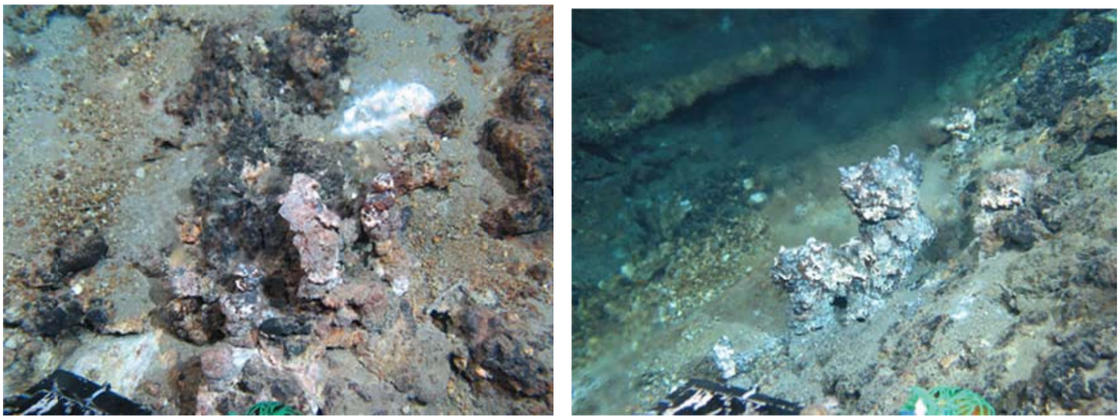

Fig 20 Active Chimneys at “Achijha Site”

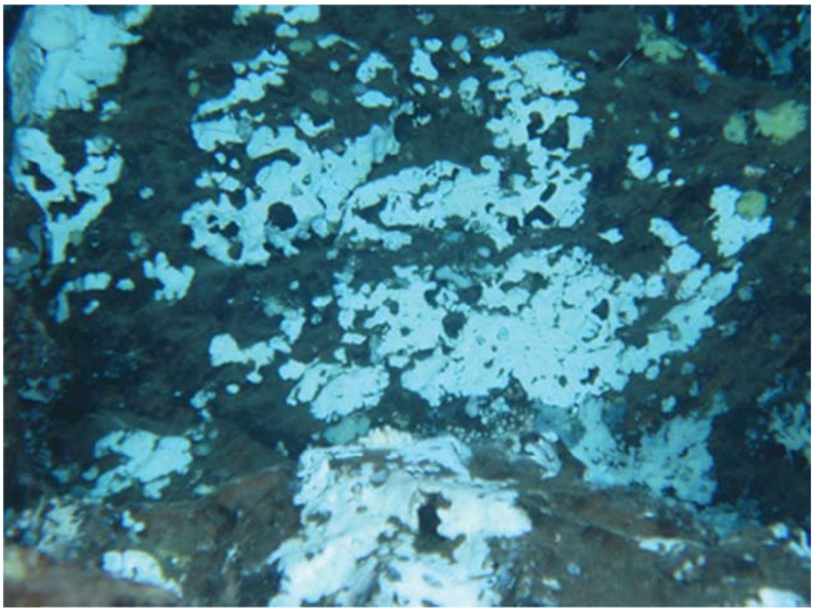

Fig. 21 Rocks Covered with White Objects at “Heajah Site”

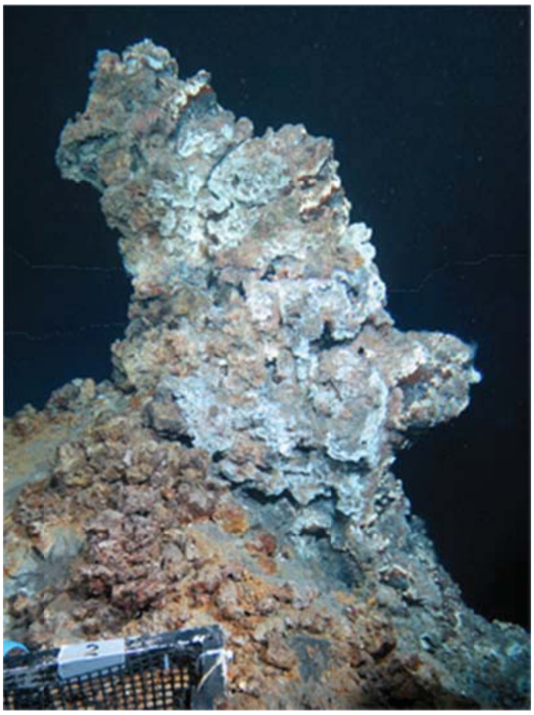

Fig. 22 Deejina Chimney

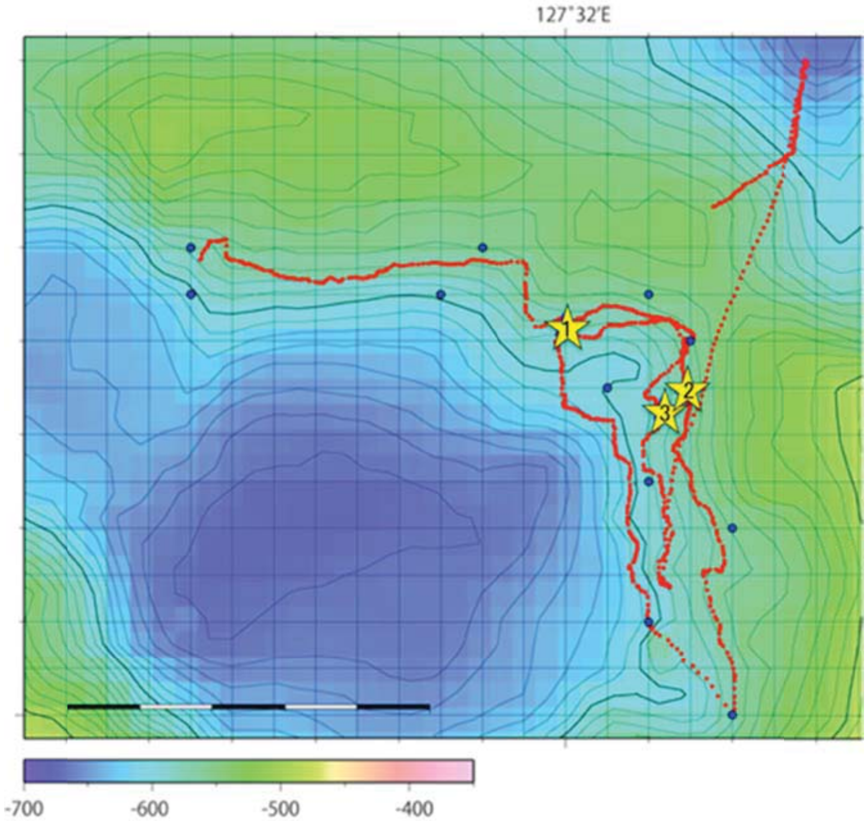

Fig. 23 Hyper-Dolphin Track Map on Dive #1181 at NE-Izena
1: Achijah Site, 2: Heajah Site, 3: Deejina Chimney

The last dive (#1182) was conducted for detailed survey of novel hydrothermal sites and opposite (southwest) side of the caldera-like depression. Temperatures of hydrothermal fluids were successfully measured using a temperature sensor equipped on HPD. One marker (H1182-1) was placed near an active chimney. After temperature measurements, water and rock sampling, HPD cruised towards southeast slope of the depression. Novel hydrothermal active site was not discovered in southwest slope of the depression.

6. Proposal for the Future Plans

Through this cruise, potential of novel *in situ* chemical sensors and analyzers were successfully demonstrated. The data from the *in situ* sensors and analyzers were fully utilized for novel hydrothermal activity survey in real environment. The next step is to improve the reliability and stability of the sensors and analyzers. The best way is to repeat *in situ* evaluation processes concurrently with system development and improvement in the lab. Currently, only specially trained researchers or developers can use or operate the novel sensors or analyzers because they are still in prototype phase. To build up highly systematic and standardized apparatus is important issue to use them widely for practical operations. Further miniaturization of the apparatus is one of the most important missions to utilize small AUVs for practical survey operations aiming discovery of novel hydrothermal ore deposits.

7. Acknowledgment

I would like to thank all the members of the ROV HyperDolphin operation team (Chief: Yoshio Ohno), and the crewmembers of R/V Natsushima (Captain: Hitoshi Tanaka) for their dedicated efforts to make this cruise so successful. I also would like to thank Mr. Morifumi Takaesu (Nippon Marine Enterprises, LTD) for his helpful assistance on all scientific activities onboard.

8. Appendix

a. List of samples
b. Dive log
c. Shipboard log
d. Specification of vessel, instrument & submersible vessel