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R/V Kairei Cruise Report

KR18-14 Leg 2

Resource science utilizing artificial hydrothermal vent: mineral deposits cultivation, monitoring of hydrothermal fluid, power generation in deep-sea, measurement of redox potential and resistivity, and electrotrophic ecosystems

Okinawa Trough

Nov. 1, 2018 - Nov. 13, 2018

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

●**Contents**

1. Cruise Information

● Cruise ID: KR18-14 Leg 2

● Name of vessel: R/V Kairei

● Title of the cruise: Resource science utilizing artificial hydrothermal vent: mineral deposits cultivation, monitoring of hydrothermal fluid, power generation in deep-sea, measurement of redox potential and resistivity, and electrotrophic ecosystems

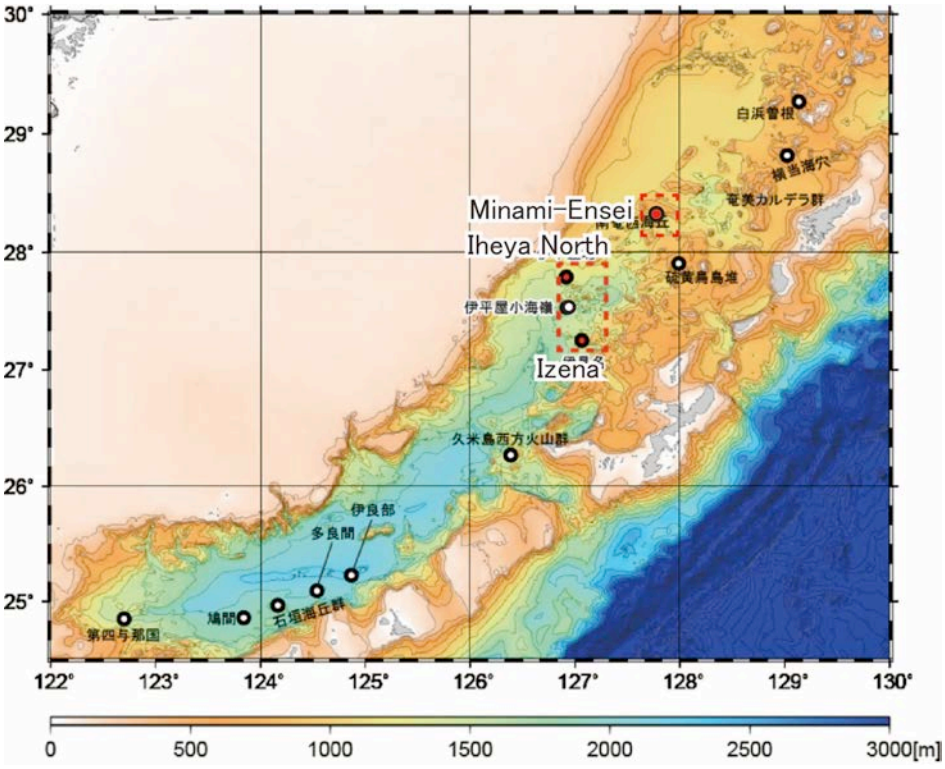
● Title of proposal: same above

● Cruise period: Nov. 1 - Nov. 13, 2018

● Ports of departure / arrival: Taniyama, Kagoshima / Naha, Okinawa

● Research area: Minami-Ensei Knoll, Iheya North Knoll, Inena Holl and the east area of Izena, Okinawa Trough, Japan

● Research Map



2. Researchers

● Chief scientist: Dr. Masahiro Yamamoto [JAMSTEC]

● Science party:

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Dr. Akira Yamaguchi [School of Materials and Chemical Technology, Tokyo Institute of Technology]

Mr. Kouki Kuno [Nippon Marine Enterprises, Ltd]

3. Observation

- Purpose:

We were especially aimed at researches on sustainability and extensibility of power generation with deep-sea hydrothermal vent, survey of concealed deposit with measurement of redox potential and self-potential, and function of electrotrophic ecosystem in deep-sea hydrothermal field, as part of study on resource generation conditions in the mid-term plan of R&D Center for Submarine Resources, JAMSTEC.

- Methods:

(1) Self-Potential (SP) survey in seawater on deep-sea hydrothermal fields

(3) Heat flow measurement in under seafloor

(2) In-situ electrochemical experiments

(3) Power generation on dee-psea hydrothermal vent using fuel cell

(4) Electrotrophic microorganisms enrichment systems

(5) Bacteria mat sampling

(6) Liquid carbon dioxide sampling

(7) Sediment core sampling

(8) Rock sampling

- Instruments:

(1) SP meter (V-CUBE; Clover Tech. Co. Ltd)

(2) Pocket size temperature logger (DEFI2-T; JFE Advantec Co. Ltd)

(3) Stand-alone heat-flow meter (SAHF) (Kaiyo Denshi Co. Ltd)

(4) Deep-sea potentiostat system (D-Pote) (HZ-3000; Hokuto Denko Co. Ltd)

(5) Deep-sea bipotentiostat system (DebPote) (ECstat-101; EC Frontier Co. Ltd)

(6) Hydrothermal fluid - seawater fuel cell

(7) Electrotrophic microorganisms enrichment system (EMES)

(8) Peristaltic pump water sampler with plastic bags

(9) Anti-pressure bottle water sampler

(10) MBARI sediment core sampler

(11) Sample box

(12) Bar

(13) Shovel

(14) Marker

- Research results

We carried out 9 times of dive surveys using the ROV KAIKO at 4 sea areas, Minami-Ensei Knoll, Iheya North Knoll, Izena Hole and the east area of Izena during the cruise. We carried out data collections of electrochemical analyses and sample collections of rocks, sediments, fluids and organisms.

○ Cruise log

Date	Event
01-Nov-18 (Thu)	Boarding and departure from Taniyama port, Kagoshima
02-Nov-18 (Fri)	Dive KK#802
03-Nov-18 (Sat)	Dive KK#803
04-Nov-18 (Sun)	Works on board
05-Nov-18 (Mon)	Dive KK#804
06-Nov-18 (Tue)	Dive KK#805
07-Nov-18 (Wed)	Dive KK#806
08-Nov-18 (Thu)	Dive KK#807
09-Nov-18 (Fri)	Works on board
10-Nov-18 (Sat)	Dive KK#808
11-Nov-18 (San)	Dive KK#809
12-Nov-18 (Mon)	Dive KK#810
13-Nov-18 (Tue)	Arrive at Naha port, Okinawa, and disembarkation

○ Dive information

Dive #	Date	Location	On bottom	Off bottom
KK#802	02-Nov-18	Minami-Ensei Knoll	09:58	14:52
KK#803	03-Nov-18	Minami-Ensei Knoll	10:37	14:32
KK#804	05-Nov-18	Iheya North Knoll	10:15	15:08
KK#805	06-Nov-18	Iheya North Knoll	09:58	14:54
KK#806	07-Nov-18	Izena Hall	10:25	14:43
KK#807	08-Nov-18	Izena Hall	10:20	14:45
KK#808	10-Nov-18	East area of Izena	09:55	14:08
KK#809	11-Nov-18	East area of Izena	09:56	14:49
KK#810	12-Nov-18	Iheya North Knoll	10:29	12:53

○ Dive report

Dive Report for Kaiko-802 dive

Date: November 02 (Fri), 2018
Site: Minami-Ensei Knoll
Operation chief: Tomoe Kondo
Launcher pilot: Homare Wakamatsu
Pilot: Ryo Saigo
Co-pilot: Takuma Goto

Written by Masahiro Yamamoto

Objectives:

Two CO_2 bubbling sites are discovered at the sea area in the past cruise. Therefore, we set targets of this dive as follows;

Two bubble vent sites were reported at the Minami-Ensei in the past cruise

Observation of CO_2 bubble vent site

Collection of liquid CO_2 from CO_2 bubble vent

Electrochemical analysis in liquid CO_2

Self potential and temperature measurement around CO_2 bubble vent

Analysis of heat flow of subseafloor

Collection of sediment core

Payloads:

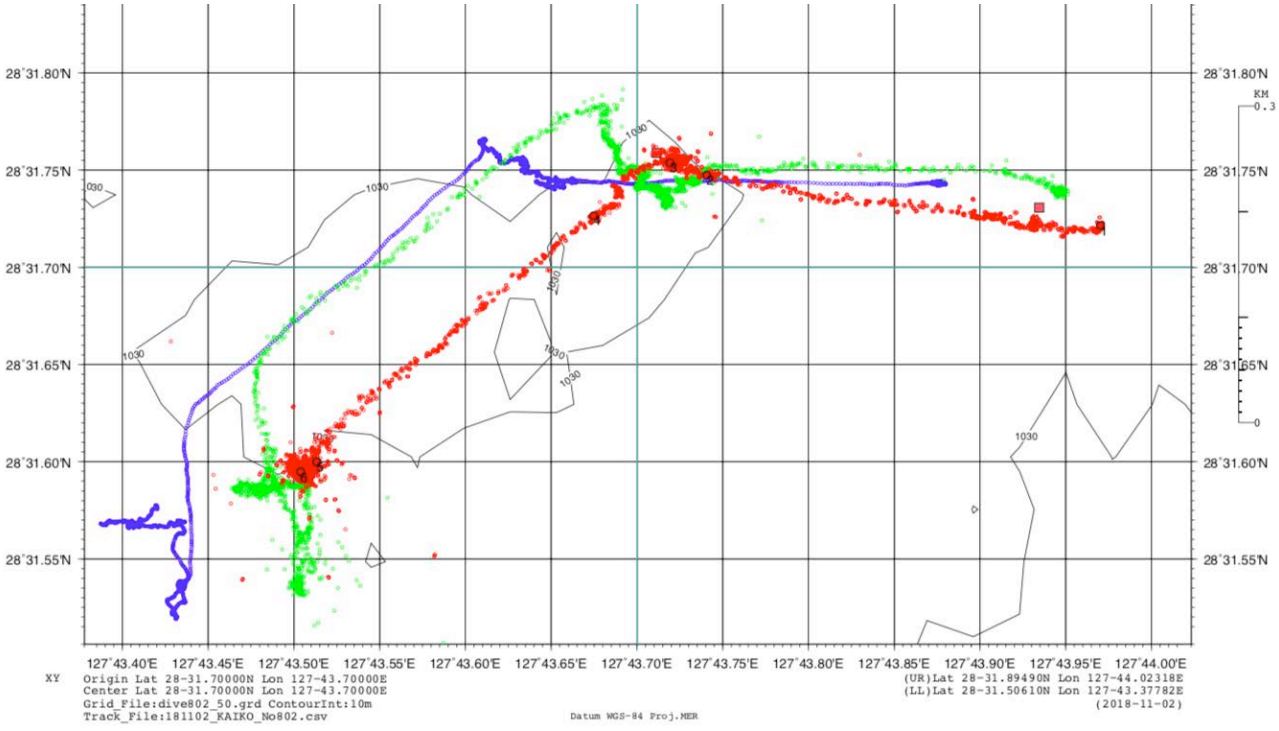
• D-Pote (bi-line) with hater
• Electrometer with 6 elecrodes
• 6 Thermometers
• 2 SAHF
• 2 Anti-pressure water samplers
• 4 MBARI corers
• Sample box

Operation and observation:

The Kaiko was deployed in the water at 8:48. At 9:47, the vehicle was separated from the launcher. At 9:58, we visually confirmed sediment-rich seafloor at 1018 m deep. We headed east for CO_2 bubbling site. At 10:34, a vigorous CO_2 bubbling site was confirmed. We tried to collect sediment

core using MBARI core samplers, and succeeded in obtaining interesting sediment samples though they were shallow (MBARI-Red 2 & 1). We also tried to measure heat flow at sub-seafloor with SAHF, but gave up it because the sediment was too shallow to insert and stand the SAHF. Next, we tried in-situ electrochemical analysis of liquid CO_2 in deep-sea. A glass cap was covered on the CO_2 bubble vent. Two electrodes were set in the cup, and one electrode catalyzed electrolysis and another one analyzed the products. We were successful in collection of very interesting data. We left the site and headed southeast for another CO_2 bubbling site. At 13:09, we confirmed the No. 4 marker, but a CO_2 bubble site was not found near the marker. It seemed that the vent was packed by CO_2 hydrate. This hydrate was very hard and we could not destroy it with manipulator of Kaiko. We found a sediment area with yellow surface near the CO_2 vent, and collected core samples (MBARI-Yellow 2 and 1; 13:33) and subseafloor heat flow data (13:59). In this neighborhood, we discovered another 4 CO_2 vents. We collected the liquid CO_2 samples with two anti-pressure water samplers (LC-Red & Green) at 14:37 and 14:49, respectively. At 14:52, we ended all operations and left the bottom. During the dive, we measured self-potential and temperature in seawater all the time.

Dive Track:



Dive Report for Kaiko-803 dive

Date: November 03 (Sat), 2018
Site: Minami-Ensei Knoll
Operation chief: Tomoe Kondo
Launcher pilot: Yuta Yamamuro
Pilot: Homare Wakamatsu
Co-pilot: Naoki Sato

Written by Masahiro Yamamoto

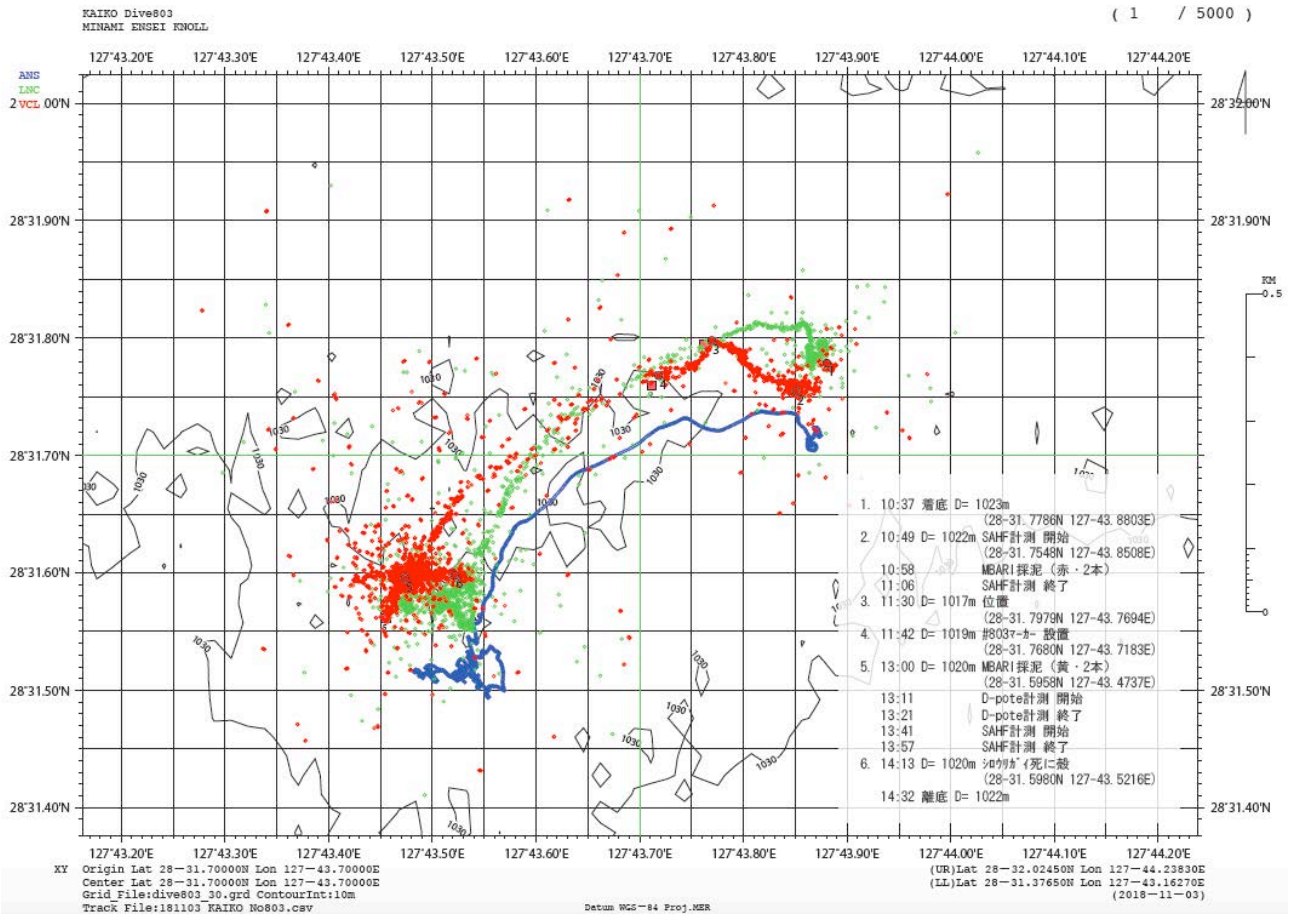
Objectives:
Yesterday, we observed two CO_2 bubbling sites and carried out various operations in this site. Today, we planed to complement our samplings as follows.
Electrochemical analysis in liquid CO_2 with measuring of temperature
Self potential and temperature measurement during fly pass on CO_2 bubble vents
Analysis of heat flow of subseafloor
Collection of sediment core

Payloads:
• D-Pote (bi-line) with hater and thermometer
• Electrometer with 6 elecrodes
• 6 Thermometers
• SAHF
• 4 MBARI corers
• Sample box

Operation and Observation:
We had a communication trouble of D-Pote at operation check before the dive. As a result start time of the dive was delayed for 30 min. The Kaiko was deployed in the water at 9:11. At 10:23, the vehicle was separated from the launcher. At 10:37, we visually confirmed sediment-rich seafloor at 1023 m deep. At the area, we carried out SAHF measurement (10:47) and MBARI core sampling (MBARI-Red 1 and 2; 10:57) as a reference site. Then, we headed northwest and moved to a point on the straight extension line of two CO_2 vent site. From the point, we went straight in the direction of southwest with a constant-altitude (~3 m), and flew pass on two CO_2 vent sites to measure self-potential around the area. On the first CO_2 vent (northeast side), vehicle dropped a marker

(KAIKO803) from 3 m altitude (11:42). After the constant-altitude survey, we went back to a CO_2 site to sampling. We succeeded in collection of core samples of the inside of the CO_2 vent (MBARI-Yellow 2 & 1; 13:00). We also carried out in-situ electrochemical analysis in the liquid CO_2. In addition, we obtained the temperature data of inside of the CO_2 vent by insertion of CO_2 into the vent directly. Finally, we flew pass on the CO_2 vent site twice. At 14:32, we gave up the dive and left the bottom because wave began to rise.

Dive Track:



Dive Report for Kaiko-804 dive

Date: November 05 (Mon), 2018
Site: Original site, Iheya North Knoll
Operation chief: Tomoe Kondo
Launcher pilot: Takuma Goto
Pilot: Naoki Sato
Co-pilot: Syota Ihara

Written by Masahiro Yamamoto

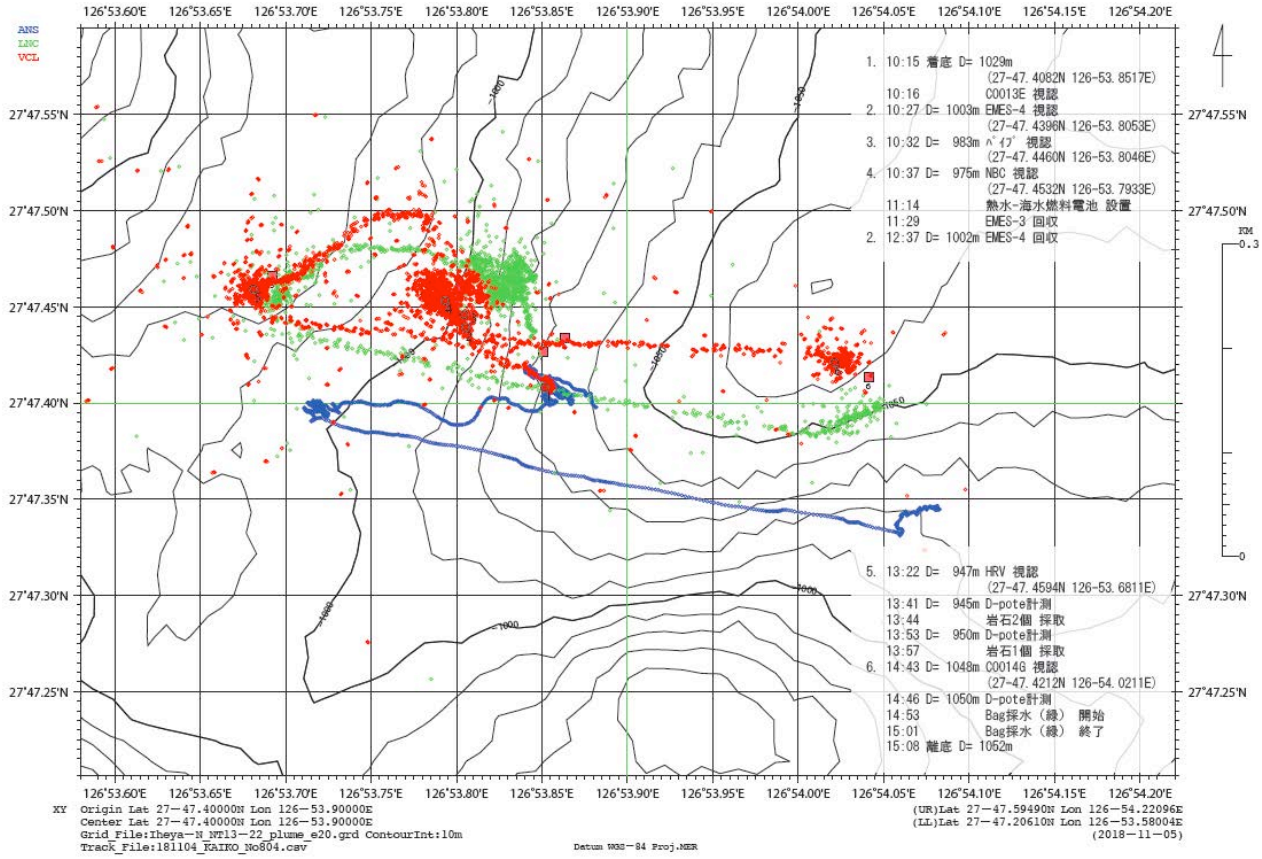
Objectives:
There are deep-sea hydrothermal vents and clogged artificial vent. Therefore, we planed to use them effectively for electrochemistry as follows.
Installation of hydrothermal fluid - seawater fuel cell on a natural vent
Measurement of redox potential of the surface of natural and artificial vent
Self-potential and temperature measurement on deep-sea hydrothermal mineral deposit
Collection of vent minerals
Recovery of electrotrophic microorganisms enrichment system (EMES)
Collection of bacteria mat on an artificial vent
Collection of sediment core

Payloads:
• D-Pote (solo-line) with a portable Pt electrode
• Electrometer with 6 elecrodes
• 6 Thermometers
• Hydrothermal fluid - seawater fuel cell
• Bag water sampler with 2 bags
• 2 Sheaths for EMES
• 2 MBARI corers
• 2 Sample boxes without lid (Morinaga)

Operation and Observation:
Start of the dive was delayed about 15 minutes because of bad condition of tide and wind. The Kaiko was deployed in the water at 8:56. At 10:00, the vehicle was separated from the launcher. At 10:15, we visually confirmed rocky seafloor at 1029 m deep. Then, we headed northwest and moved to the

North Big Chimney (NBC). At the top of the chimney, we installed hydrothermal fluid - seawater fuel cell on a vent (11:13). Two EMES (EMES-3 and EMES-4) were recovered around NBC (11:43 and 12:36, respectively). Then, we went to the high radioactivity vent (HRV), and collected rocks (vent minerals of flange) samples from top part (Rock-1 and 2; 13:42 and 13:44) and middle part (Rock-3; 13:56). We also measured redox potential on the surface of the vent minerals. Finally, we went to an artificial vent (C0014G), and measured redox potential on the surface of the vent pipe and collected bacteria mat on the pipe (Bag-1; 15:01). At 15:08, we left the bottom.

Dive Track:



Dive Report for Kaiko-805 dive

Date: November 06 (Thu), 2018
Site: Original site, Iheya North Knoll
Operation chief: Tomoe Kondo
Launcher pilot: Ryo Saigo
Pilot: Seiji Shigetake
Co-pilot: Naoki Sato

Written by Masahiro Yamamoto

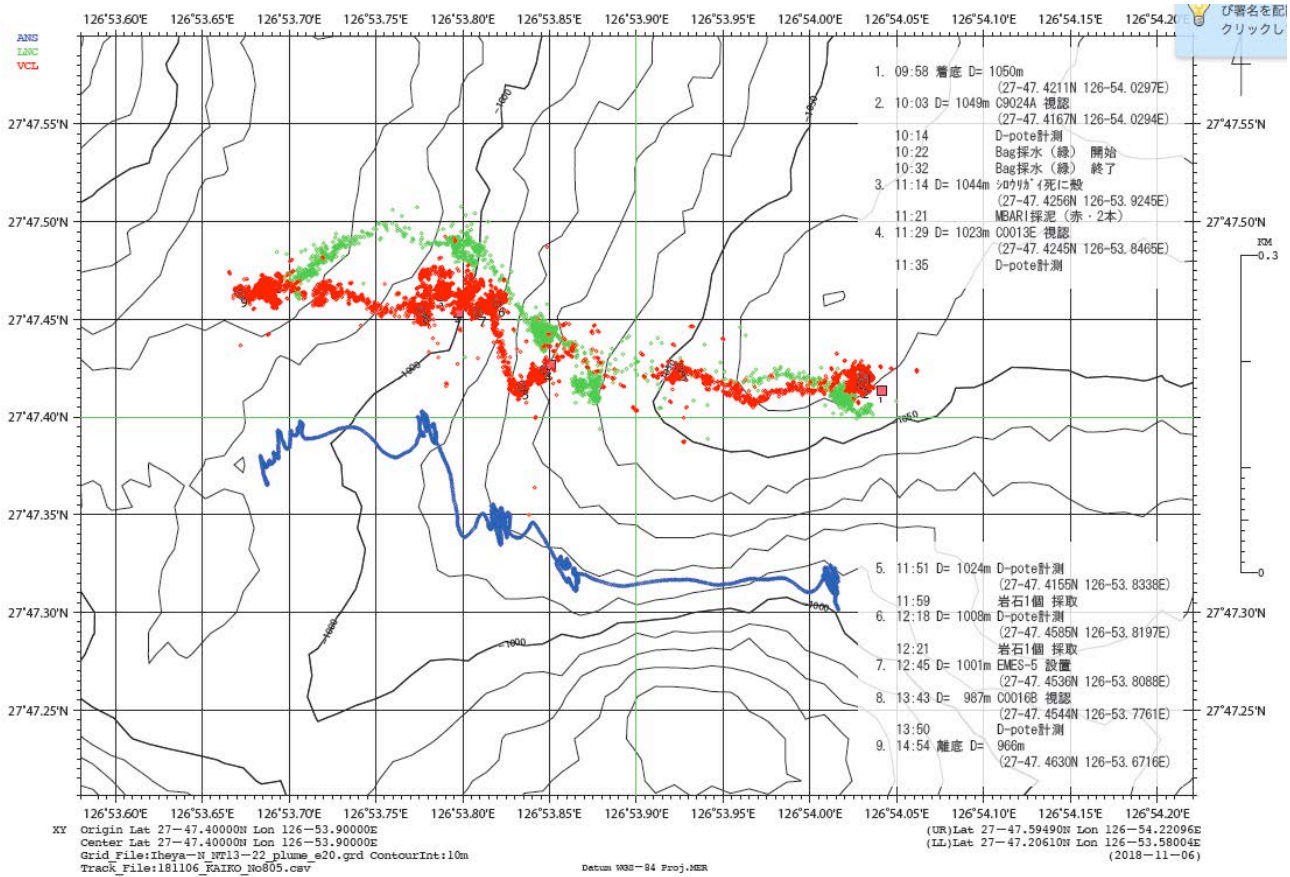
Objectives:
Yesterday, we observed natural and artificial hydrothermal vents and carried out various operations in this site. Today, we planed to complement our samplings as follows.
Self-potential and temperature measurement on deep-sea hydrothermal mineral deposit
Measurement of redox potential of the surface of natural and artificial vent
Collection of rock sample especially at the site where the self-potential showed unusual values
Collection of vent minerals
Installation of electrotrophic microorganisms enrichment system (EMES)
Collection of bacteria mat on an artificial vent
Collection of sediment core

Payloads:
• D-Pote (solo-line) with a portable Pt electrode
• Electrometer with 6 elecrodes
• 6 Thermometers
• Bag water sampler with 2 bags
• EMES
• 2 MBARI corers
• 2 Sample boxes with lid

Operation and Observation:
The Kaiko was deployed in the water at 8:43. At 9:45, the vehicle was separated from the launcher. At 9:57, we visually confirmed conglomerate seafloor at 1050 m deep. Then, we found artificial vents, C9024A and C0014C. We landed on the guide base of the C9024A, and measured the redox potential on the parts of guide base and collected bacteria mat using bag water sampler (Bag-1;

10:32). After the operations, we observed experimental apparatuses installed in leg 1. We moved to west and collected core samples at sediment-rich area (MBARI-Red 1 and 2; 11:18). We landed on the C0013E guide base, and measured the redox potential on the pipe of vent. On the way to the north big chimney (NBC), we collected two rock samples at the seafloor where the self-potential showed unusual values (Rock-1 and 2; 11:55 and 12:20). An EMES was installed at the bottom area of NBC (EMES-5; 12:44). We were unsuccessful in collection of rock sample from the top part of NBC because the rock was too hard to crash in the manipulator. We measured redox potential on a flange rock of hydrothermal vent on the C0013E guide base. Finally, we went to the high radioactivity vent (HRV), and collected a rock sample from the top part (Rock-3; 14:34). During a try of collection of rock samples from middle part of the chimney, the vehicle was suddenly swung back by tide, and lost the chimney from our view. Operation chief decided to stop the operation considering the risk of damage of umbilical cable from hydrothermal fluid. At 14:54, we left the bottom.

Dive Track:



Dive Report for Kaiko-806 dive

Date: November 07 (Wed), 2018
Site: Jade site, Izana Hole
Operation chief: Tomoe Kondo
Launcher pilot: Syota Ihara
Pilot: Yuta Yamamuro
Co-pilot: Seiji Shigetake

Written by Yoshifumi Kawada

Objectives:

• Measurements of self-potential and water temperature above deep-sea hydrothermal mineral deposits of the Jade site
• Measurements of Eh of ambient seawater
• Collection of sediment core at a site without hydrothermal activity
• Preliminary visual observation for the subsequent sampling and electrochemical surveys during this cruise

Payloads:

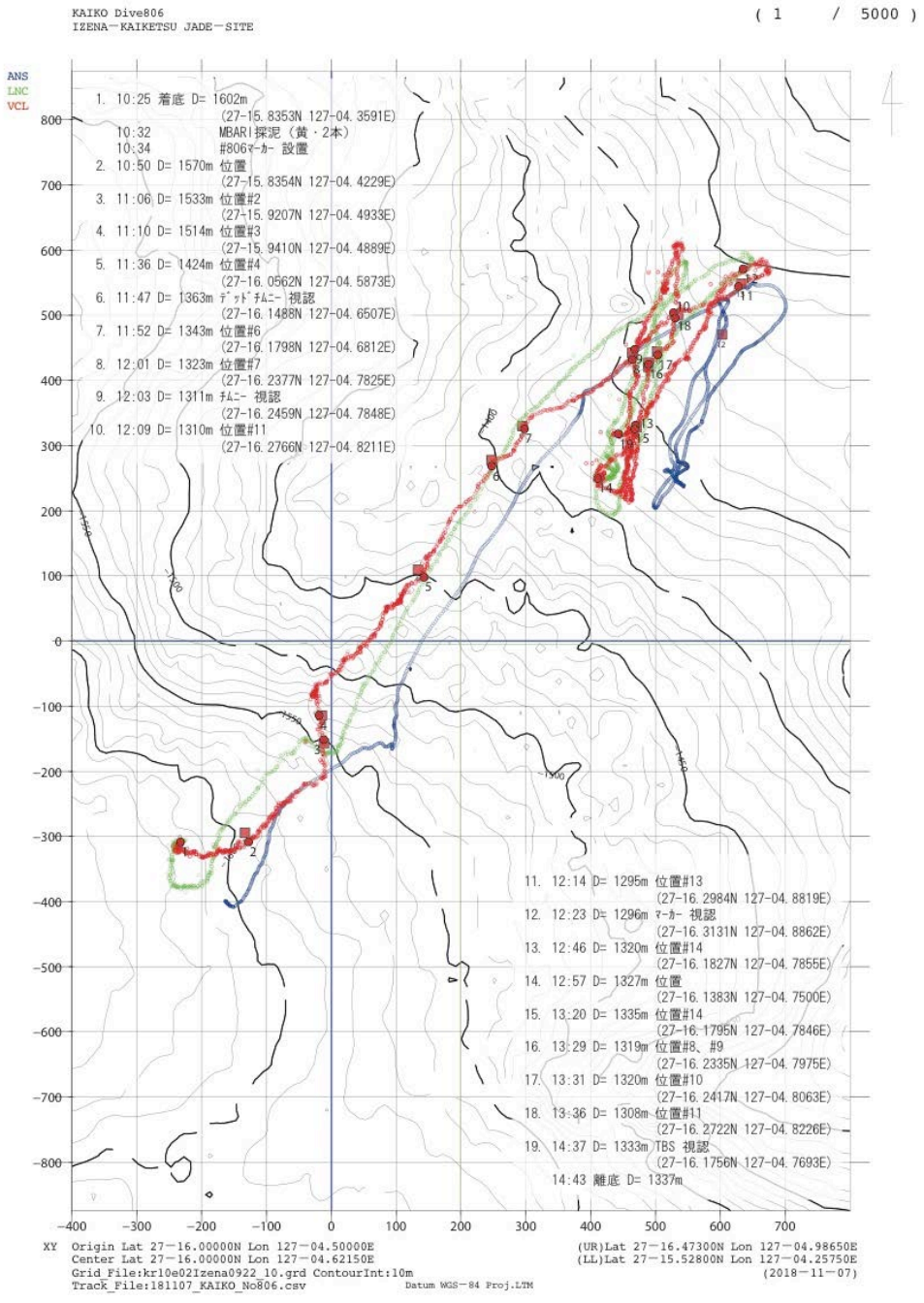
• D-Pote (solo-line) with a portable Pt electrode
• Electrometer with 6 electrodes
• 6 Thermometers
• 2 MBARI corers

Operation and observation:

The Kaiko was deployed in the water at 8:54 (delayed about 10 minutes). At 10:13, the vehicle was separated from the launcher. At 10:25, we visually confirmed muddy seafloor at 1607 m deep, at which we carried out MBARI core sampling twice (MBARI-Yellow 1 and 2; 10:31) and placed a marker (KAIKO-804; 10:34). Then, we started the self-potential survey (Eh of ambient seawater was measured continuously throughout the survey). Between 10:35 and 12:17, we carried out a constant-altitude (~3 m) survey along a transect running from southwest to northeast, climbing the caldera slope up to 1288 m deep. We found a few dead chimney sites along the transect. Between 12:37 and 12:57, we conducted a constant-depth (1220 m) survey to the south over the TBS chimney (an active black-smoker). Between 13:08 and 13:42, we returned to a constant-altitude (~3 m) survey along a transect running from south to north, which crosses the TBS chimney. At 14:00, in transit to

a next transect, we found the dead chimney site (which we encountered before in the present dive). Between 14:05 and 14:19, we conducted a constant-depth survey (1230 m) to the south over the TBS chimney. Finally, at 14:37, we approached the TBS chimney for a visual observation. At 14:43, we left the bottom.

Dive Track



Dive Report for Kaiko-807 dive

Date: November 08 (Thu), 2018
Site: Jade site, Izana Hole
Operation chief: Tomoe Kondo
Launcher pilot: Yuta Yamamuro
Pilot: Takuma Goto
Co-pilot: Homare Wakamatsu

Written by Masahiro Yamamoto

Objectives:

• Measurements of self-potential and water temperature above deep-sea hydrothermal mineral deposits of the Jade site
• Measurements of Eh of ambient seawater
• Collection of sediment core at a site with hydrothermal activity
• Collection of rock samples based on the signal of self-potential survey

Payloads:

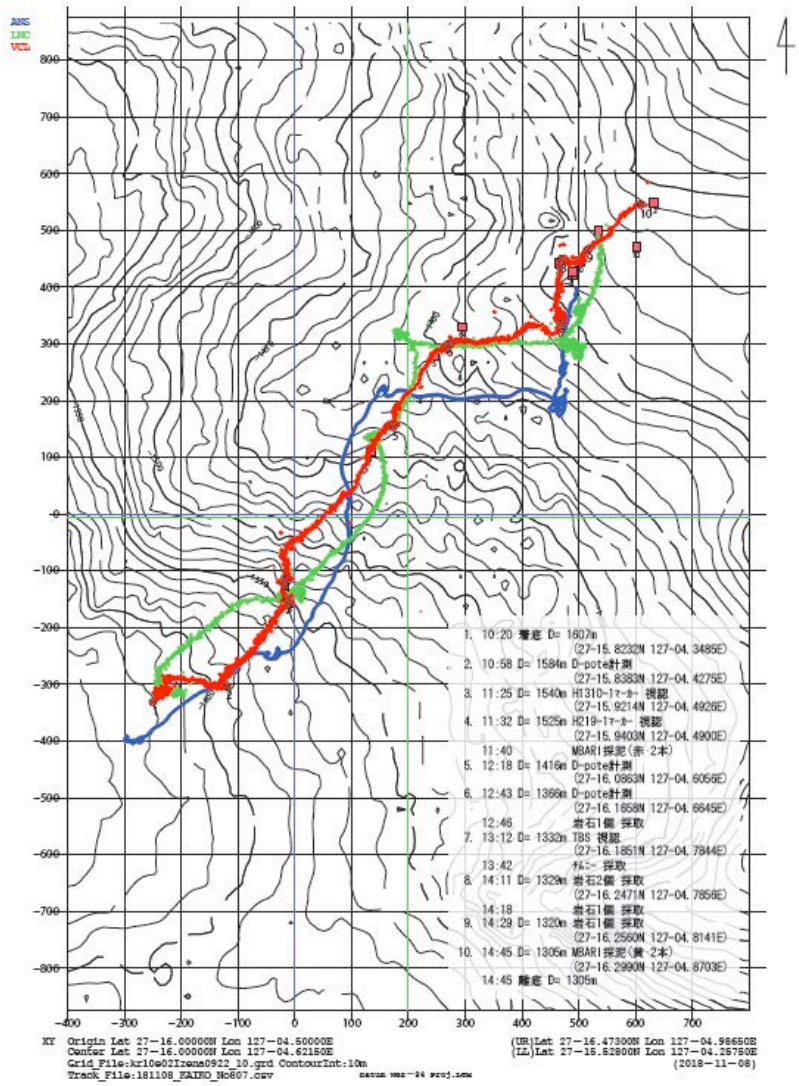
• D-Pote (solo-line) with a portable Pt electrode
• Electrometer with 6 electrodes
• 6 Thermometers
• 4 MBARI corers
• 2 Sample boxes with lid
• SAHF
• Bar
• Shovel

Operation and observation:

The Kaiko was deployed in the water at 8:48. At 10:07, the vehicle was separated from the launcher. We headed for yesterday's landing point. At 10:20, we visually confirmed muddy seafloor at 1610 m deep. We could not find a marker that was set yesterday. At 10:36, we left this point and moved to a CO_2 bubbling vent. On the way, we tried to collect rock samples twice, however it was too fragile to catch by manipulator at the first time, and it was difficult to land for vehicle with the positions between vehicle, cliff and launcher at the second time. Therefore, we skipped over the operations. At 11:29 we arrived at the point of CO_2 bubbling vent, however we could not find it. We gave up

searching the vent and headed north. At 50 m north from the point, we found the marker H219-1, that was set at the CO_2 bubbling vent. Therefore, we noticed the location of vehicle measured by sonar was dislocated 50 m south. After that, we went on the dive with revision of position. We could not confirm CO_2 bubbling vent at the position. Two sediment core samples were collected (MBARI-Red 2 and 1; 11:39). At 12:45, one rock sample was collected from a dead chimney (Event 5; Rock-1). At 13:11, we arrived at the TBS chimney, and collected top part of the chimney in a sample box (Rock-2; 13:42). We also collected top part of chimney from other active vent (Event 7; Rock-3; 14:08). Another rock sample was also collected from the bottom part of the chimney (Rock-4; 14:15). One rock sample was collected at event 10 (Rock-5; 14:29). Finally, two sediment core samples were collected near the event 13 (MBARI-Yellow 1 and 2; 14:45). At 14:45, we left the bottom.

Dive Track:



Dive Report for Kaiko-808 dive

Date: November 10 (Sat), 2018
Site: Payao site, Ieyama
Operation chief: Tomoe Kondo
Launcher pilot: Seiji Shigetake
Pilot: Naoki Sato
Co-pilot: Yuta Yamamuro

Written by Masahiro Yamamoto

Objectives:

• Measurements of self-potential and water temperature in the Payao site, Ieyama
• In-situ electrochemical experiment in liquid CO_2
• Collection of sediment core at a CO_2 bubbling vent
• Collection of liquid CO_2
• Collection of rock samples

Payloads:

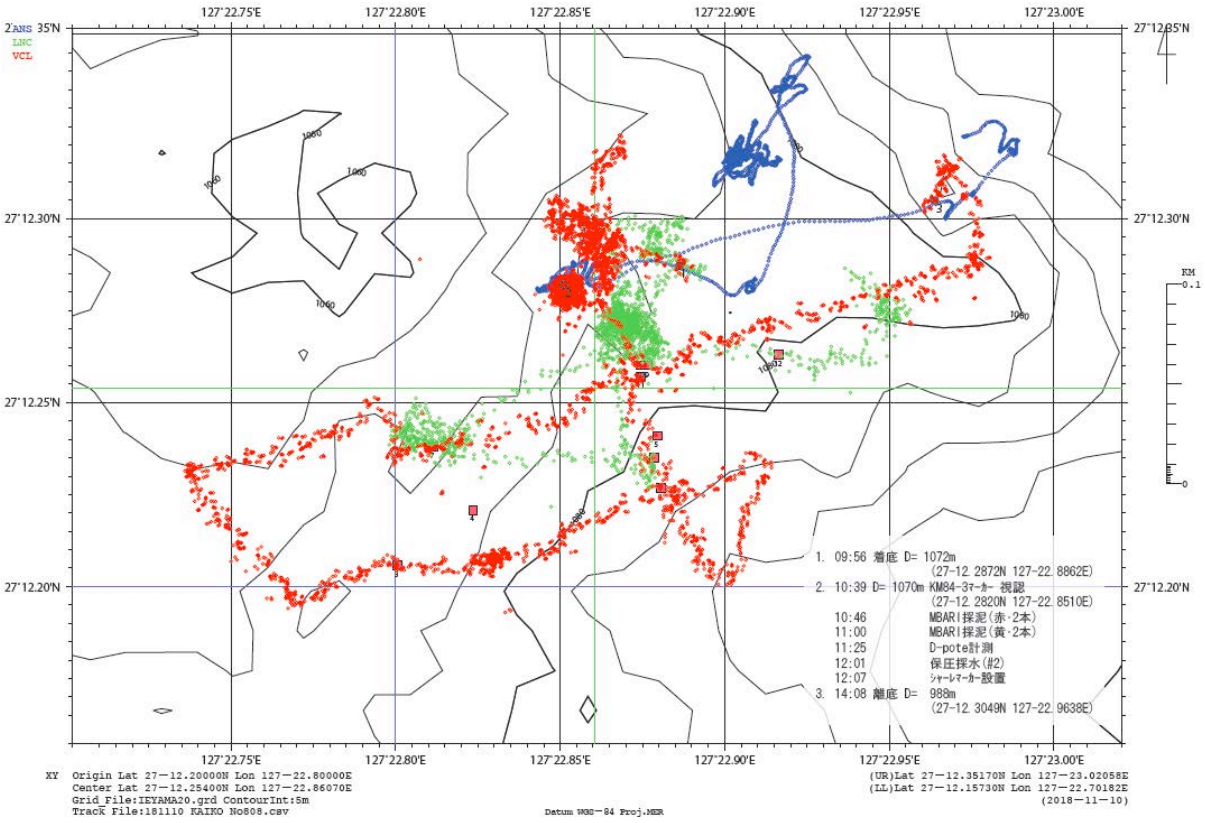
• D-Pote (bi-line) with heater and thermometer
• Electrometer with 6 electrodes
• 6 Thermometers
• 4 MBARI corers
• 2 Anti-pressure water sampler
• Sample box with lid
• Bar
• 2 Markers

Operation and observation:

The Kaiko was deployed in the water at 8:43. At 9:41, the vehicle was separated from the launcher. At 9:55, we visually confirmed muddy seafloor at 1070 m deep. We found out a marker, KM84-3, and a bubbling vent site. Two core samples were collected from out of the vent hole (MBARI-Red 2 and 1; 10:45), and two more core samples were collected from inside of the vent hole (MBARI-Yellow 1 and 2; 10:59). At 11:26, we carried out in-situ electrochemical experiment. Liquid CO_2 bubbles were collected into a glass cup. In the middles of the collection, we used a bar for insertion into the hole to keep the spout out of bubbles. Then, we tried to collect liquid CO_2 into

two anti-pressure bottles. However, CO_2 bubbling was stopped after collection into the first bottle (LC-2, yellow; 11:59), the second bottle collection was postponed until tomorrow. At 12:07, a marker (KAIKO808-1) was placed on the seafloor approximately 5 m distant from the bubbling vent. From 12:13, vehicle had a constant altitude (10 or 3 m) and ran straightly on the points of event marks to measure self-potential. At 14:03, suddenly, vehicle got out of control of thrusters. This dive was discontinued and the vehicle left the bottom (14:08). At 14:14, vehicle could not combine with launcher. At 14:48, Kaiko was rebooted, and the control of thrusters was restored. At 15:56, Kaiko was lifted up.

Dive Track:



Dive Report for Kaiko-809 dive

Date: November 11 (Sun), 2018
Site: Payao site, Ieyama
Operation chief: Tomoe Kondo
Launcher pilot: Homare Wakamatsu
Pilot: Ryo Saigo
Co-pilot: Takuma Goto

Written by Masahiro Yamamoto

Objectives:

• Measurements of self-potential and water temperature in the Payao site, Ieyama
• Collection of liquid CO_2
• Collection of sediment core
• Collection of rock samples
• Measurements of redox potential on surfaces of rocks

Payloads:

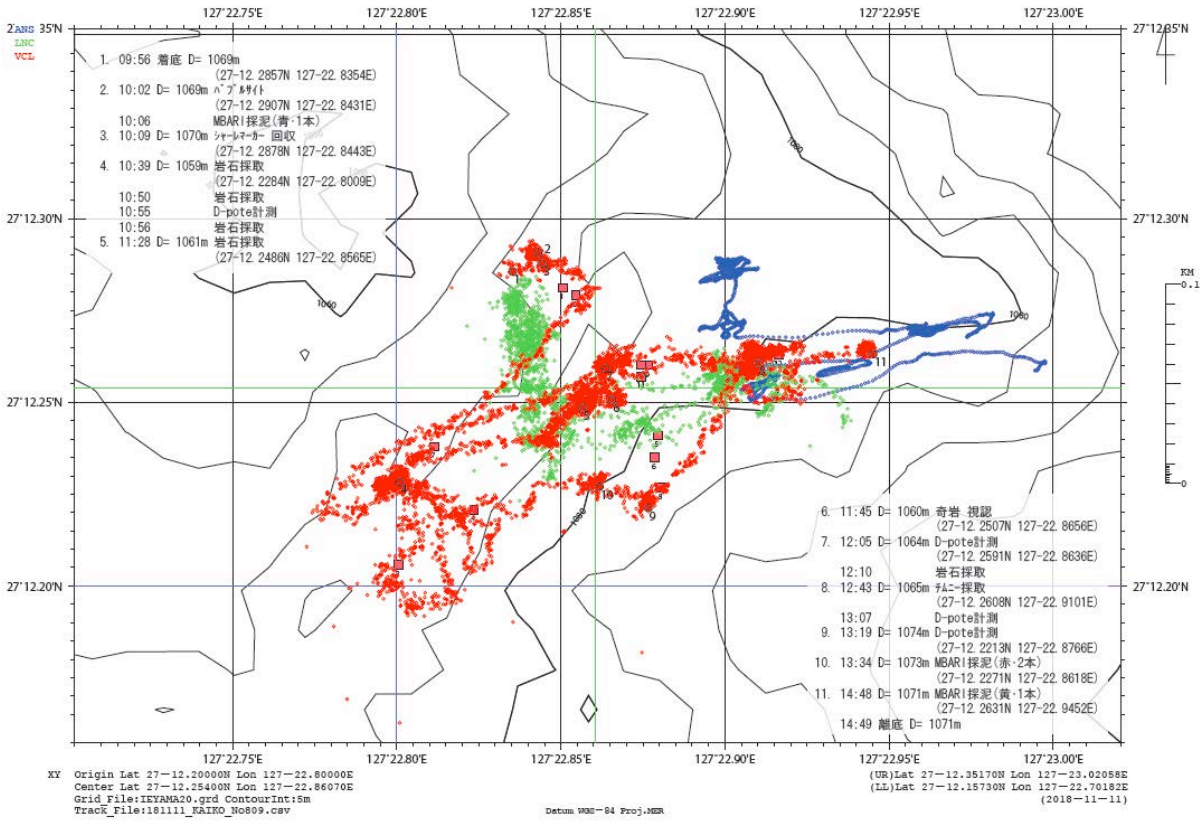
• D-Pote (solo-line) with a portable Pt electrode
• Electrometer with 6 electrodes
• 6 Thermometers
• 4 MBARI corers
• Anti-pressure water sampler
• 2 Sample box with lid
• Bar
• Shovel

Operation and observation:

The Kaiko was deployed in the water at 8:43. At 9:43, the vehicle was separated from the launcher. At 9:56, we visually confirmed muddy seafloor at 1074 m deep. We found out a marker, KAIKO808-1, and then a bubbling vent site. One core sample was collected in the bubbling vent by using a 50 cm-long MBARI core sampler (MBARI-Blue; 10:06). After the coring, no bubbling up was observed from the core hole. Therefore we cancelled collection of liquid CO_2 with anti-pressure bottle water sampler. At 10:09, KAIKO808-1 marker was recovered into a basket of the vehicle. Then, we moved to event 7, and observed hydrothermal vents. At 10:34, we tried to collect a top part

of chimney with manipulator. Some parts of the chimney were collected into the front sample box (Rock-1), and other parts were collected into the front of the basket (Rock-2). At the same site, we collected flange minerals from another active vent into the second sample box (Rock-3; 10:47). At the top part of the whole chimney, we measured redox potential on the surface of minerals with D-Pote, and collected the minerals into the basket (Rock-4; 10:55). At the event 10, so called 'high chimney', we observed hydrothermal vent chimney, and collected a chimney mineral rock (Rock-5; 11:21). On the south of the high chimney, there was the 'strange rock' chimney. We observed whole of the chimney, and measured redox potential on the surface of the minerals and collect the rock into a basket at the bottom part of the chimney (Rock-6; 12:09). At event 12, we observed the 'gigantic' chimney. A thin chimney was collected into a basket (Rock-7, 12:43). At event 8, we observed small chimney. At 12:32, two core samples were collected from muddy seafloor (MBARI-Red 2 and 1). From 50 m of upstream of event 7 to 50 m of downstream of event 12, vehicle ran straightly with 10 m altitude, via event 7, 11, and 12, for the self-potential survey. Finally, a core sample was collected from muddy seafloor (MBARI-Yellow; 14:45), and left the bottom at 14:49.

Dive Track:



Dive Report for Kaiko-810 dive

Date: November 12 (Mon), 2018
Site: Original site, Iheya North Knoll
Operation chief: Tomoe Kondo
Launcher pilot: Yuta Yamamuro
Pilot: Homare Wakamatsu
Co-pilot: Naoki Sato

Written by Masahiro Yamamoto

Objectives:

• Installation of electrotrophic microorganisms enrichment system (EMES)
• Recovery of two gold-adsorption systems
• Recovery of hydrothermal fluid - seawater fuel cell
• Collection of rock samples
• Measurements of redox potential on surfaces of rocks
• Measurements of self-potential

Payloads:

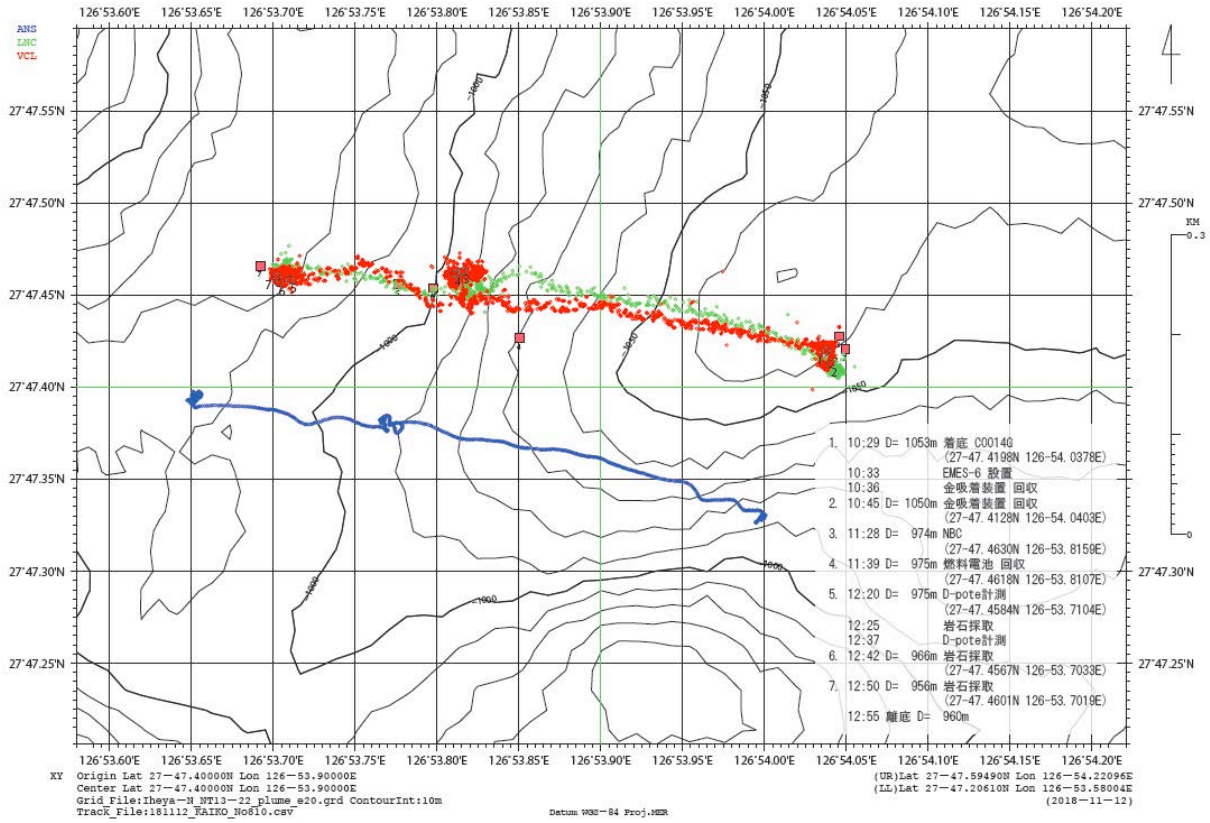
• D-Pote (solo-line) with a portable Pt electrode
• Electrometer with 6 electrodes
• 6 Thermometers
• Bar
• EMES-6

Operation and observation:

This dive was delayed for 30 min because of a communication trouble of D-Pote. The Kaiko was deployed in the water at 9:15. At 10:12, the vehicle was separated from the launcher. We visually confirmed C0014G at 10:26, and then C9024A at 10:27. At 10:32, the vehicle landed on the seafloor of 1057 m depth. EMES-6 was installed on the seafloor at 10:34. Two gold-adsorption systems were recovered into a basket at 10:35 and 10:45, respectively. These system contained chimney minerals (Rock-1 and 2). We headed for the NBC. On the top of NBC, we visually confirmed the hydrothermal fluid - seawater fuel cell at 10:26. The fuel cell was uninstalled from hydrothermal vent at 11:39, and recovered into a basket at 11:54. We headed for the HRV. Three rock samples were collected into a basket around the bottom of HRV (Rock-3, 12:24; Rock-4, 12:40; Rock-5,

12:51). We left the bottom at 12:53.

Dive Track:



● 4. Notice on Using

Notice on using: Insert the following notice to users regarding the data and samples obtained.

This cruise report is a preliminary documentation as of the end of the cruise.
This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information.
Users of data or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.

●5. Acknowledgement

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