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R/V Kairei Cruise Report

KR16-13

Oct 8, 2016 – Oct 24, 2016

Kaikata Seamount, Takuyo-Daigo Seamount

Japan Agency for Marine-Earth Science and Technology

Kochi University

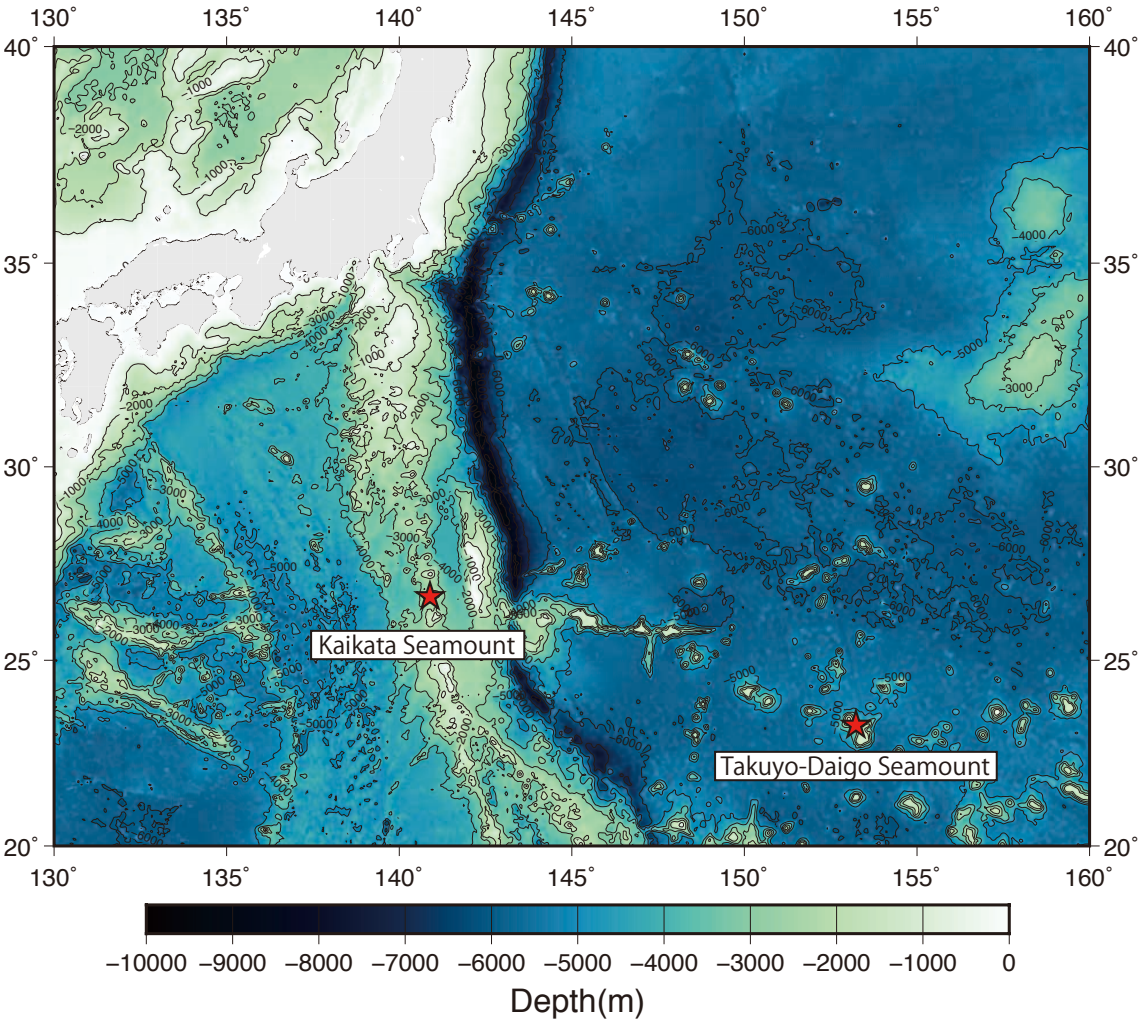
Ibaraki University

The University of Tokyo

Contents

1. Cruise Information

- Cruise ID: KR16-13
- Name of vessel: R/V Kairei
- Cruise period: 2016/10/8-2016/10/24
- Departure / arrival: Sumitomo at Yokosuka – Saipan
- Research area: Kaikata Seamount and Takuyo-Daigo Seamount
- Research Map



- R/V KAIREI CREW

Captain	EIKO UKEKURA
Chief Officer	YASUHIKO SAMMORI
2nd Officer	HIDEHIKO KONNO
3rd Officer	KEIJI ITAHASHI
Chief Engineer	EIJI SAKAGUCHI

1st Engineer	WATARU KUROSE
2nd Engineer	KENICHI SHIRAKATA
3rd Engineer	TOMONORI YAMANE
Chief Electronics Operator	MASAMOTO TAKAHASHI
2nd Electronics Operator	YUKA MORIWAKI
3rd Electronics Operator	RYOSUKE MATSUI
Boat Swain	TADAHIKO TOGUCHI
Quarter Master	KAZUMI OGASAWARA
Quarter Master	NOBUYUKI ICHIKAWA
Quarter Master	YOSHIAKI MATSUO
Quarter Master	DAISUKE YANAGITANI
Quarter Master	SHUN ABE
Sailor	TAKUMI MIURA
No.1 Oiler	YUKIHIRO YAMAGUCHI
Oiler	YUJI HIGASHIGAWA
Oiler	MASAKI TANAKA
Oiler	EIJI ARATAKE
Assistant Oiler	TORU HIDAKA
Chief Steward	TOYONORI SHIRAISHI
Steward	TORU MURAKAMI
Steward	JUN SATO
Steward	KOICHIRO KASHIWAGI
Steward	MAO KIKUCHI

- Kaiko Mk-VI Operation Team

Submersible Op. Manager	HOMARE WAKAMATSU
2/Submersible Tec. Officer	JUNYA NIIKURA
2/Submersible Tec. Officer	KEN YATSU
2/Submersible Tec. Officer	KIYOSHI TAKISHITA
2/Submersible Tec. Officer	TETSUYA ISHITSUKA
2/Submersible Tec. Officer	SEIJI SHIGETAKE
2/Submersible Tec. Officer	SHOTA IHARA
2/Submersible Tec. Officer	TAKUMA GOTO

2. Researchers

- Title of the cruise: Revealing processes of formation and growth of hydrogenetic ferromanganese crusts on the Takuyo-Daigo Seamount ~ROV observation and in situ experiments for the growth of crusts and absorption of rare metals~
- Chief scientist: Shingo Kato [JAMSTEC]
- Representative of the science party: Eiichi Kikawa [JAMSTEC]
- Science party on board

SHINGO KATO	Japan Agency for Marine-Earth Science and Technology
TERUHIKO KASHIWABARA	Japan Agency for Marine-Earth Science and Technology
HIROSHI AMAKAWA	Japan Agency for Marine-Earth Science and Technology
SAKIKO KIKUCHI	Japan Agency for Marine-Earth Science and Technology
SATOSHI TOKESHI	Japan Agency for Marine-Earth Science and Technology
YUSUKE FUKAMI	Japan Agency for Marine-Earth Science and Technology
AKIRA USUI	Kochi University
TAKUYA MANAKA	Kochi University
ERI SHIMIZU	Kochi University
YURIKO YAMAUCHI	Kochi University
HIKARU MIURA	The University of Tokyo
TAKASHI ITO	Ibaraki University
TOSHIMASA NASU	Nippon Marine Enterprises, LTD

3. Observation

3.1. Overview of the observation

Ferromanganese crusts, which cover basal rocks such as basalt and limestone, are widely distributed on the slope and flat-top of seamounts. The ferromanganese crusts have been paid attention as potential of mineral resources containing Co, Ni, Pt and REE. Previously, systematic sampling and in situ measurement of thickness of crusts have been performed at the water depth of 3000 m or shallower on the Takuyo-Daigo Seamount as a model seamount for crust research. However, our knowledge about formation of crusts, especially those at deeper water depths, is still extremely limited.

During previous cruises, YK01-04 and KR16-01, electromagnetic velocity meters and/or in situ colonization-absorption instruments have been deployed on the Kaikata Seamount and the Takuyo-Daigo Seamount. The water depths ranged from 1000 m to 5500 m. During this cruise, KR16-13, most of the deployed instruments were successfully recovered. New models of in situ colonization-absorption instruments were deployed. In addition, crusts, sediments and bottom seawater were collected from several points where we had not been investigated at the Takuyo-Daigo Seamount. Dissolved oxygen concentration, pH, temperature, etc, were measured using sensors equipped with ROV Kaiko during each dive. Multidisciplinary analyses (including geological, mineralogical, geochemical, and microbiological approaches) of the recovered instruments and natural samples will help us to understand mechanisms of formation of the ferromanganese crusts.

3.2 Seafloor observation and sampling

A. Usui,T. Manaka, E. Shimizu, Y. Yamauchi (Kochi University), T. Ito (Ibaraki University)

We dove with ROV KAIKO Mk IV once (#698) at the Kaikata seamount, and eight times (#699 - #706) at the Takuyo-Daigo seamount within the range between 1000 m and 5000 m during this successful cruise R/V KAIREI KR16-13 for geoscientific study of ferromanganese crust deposits on the Northwestern Pacific seamounts.

During the first dive #698 at Kaikata, we attempted to recover three traps which were placed for on-site exposure experiment in 2001 with the SHINKAI 6K on the sea floor. We were able to revisited the areas and fortunately found two of them. The Trap 1 was originally placed on the top of a rock outcrop but recovered on nearby sea floor hundreds of meters away from the original position. Another Trap 2 was also found similarly somewhere away from the original position. A piece of hardpan of sample of hydrothermal manganese oxide cemented sandstone was taken in this dive near the Trap 2 by a manipulator.

During the followed eight dives (dive #699 to #706), we observed occurrence of hydrogenetic ferromanganese crusts at various depths through the southern ridge of the Takuyo-Daigo seamount. Dive #699 was conducted at the Southern Slope of the Takuyo Daigo seamount between 1151 m and 1220

m in water depth. The main bottom surfaces were rock, gravels and sediments. The degree of roughness of rock surface varies greatly depending on places from very smooth to rough. Sediments are filled in dips of rock surfaces. The thickness of sediments covering the bedrock greatly varies from place to place. All rocks and gravels are coated with manganese oxide. Many manganese nodules are distributed on the sediments. During this dive, three manganese crust samples were collected. The thickness of the manganese oxide is 4 to 30 mm. Basements of the crusts are volcanic fragments and manganese oxides with phosphatized sedimentary rock.

Dive #700 was conducted at the Southern Slope of the Takuyo Daigo seamount between 5518 m and 5543 m in water depth. The main surface is sediments. The small mounds with several cm in height and wide occur on sediment surface sporadically. Based on the visual observation by the deep-sea camera, the mounds may be composed of semi-consolidated sediments from lower position. Manganese nodules with various sizes are distributed on the sediments.

Dive #701 was conducted at the Southern Slope of the Takuyo Daigo seamount between water depth 2975 m and 3069 m. The main bottom surfaces were rock, gravels and sediments. The degree of roughness of rock surface varies greatly depending on places from very smooth to rough. The thickness of fine sediments covering the bedrock greatly varies from place to place. All rocks and gravels are coated with manganese oxide. Many manganese nodules are distributed on the sediments. In this dive, a large amount of manganese nodules were collected. The thickness of the manganese oxide is 5 mm.

Dive #702 was conducted at the Southern Slope of the Takuyo Daigo seamount between 4366 m and 4478 m in water depth. The main surfaces are gravels and sediments. All gravels are coated with manganese oxide, and the boundary with adjacent gravels is ambiguous because of continuous growth of manganese oxide. Manganese nodules are distributed on the sediment surfaces. Linear structures (fault or crack?) occur on sediment surface sporadically. During this dive totally two manganese crusts were taken. The thickness of the manganese oxide is about 12 mm. The basement rock is basalt with number of vesicles. Many manganese nodules with a diameter of 1 to several cm were collected.

Dive #703 was conducted at the Southern Slope of the Takuyo Daigo seamount between 1426 m and 1429 m in water depth. The main bottom surfaces were rock, gravels and sediments. Topography on the hill is very flat. Screes occur on the slope. Totally 5 manganese crust samples were taken during this dive. The thickness of manganese oxide is 35 to 110 mm. The basement rocks consist of fine-grained phosphatized sedimentary rock.

Dive #704 was conducted at the Southern Slope of the Takuyo Daigo seamount between water depths of 3825 m and 3980 m. The main surfaces were gravels with various sizes. All gravels are coated with manganese oxide. Because of the continuous growth of manganese oxides, the boundary with adjacent gravels is ambiguous rarely. A total of 8 manganese crusts were taken. The thickness of the manganese oxide is 10 to 32 mm. The basement rock consists of altered or unaltered basalts, phosphatized sedimentary rock and manganese nodules.

Dive #705 was conducted at the Southern Slope of the Takuyo Daigo seamount between water depths of 4865 m and 5033 m. The main bottom surfaces were rock, gravels and sediments. All rocks and gravels are coated with manganese oxides. Manganese nodules occur densely on sediments. The bald spots (sediment exposure) with several cm in wide occur on manganese nodule pavement at semi-regular intervals. Totally seven gravel samples were collected. All gravel surfaces are coated with manganese oxide of 1 to 10 mm in thickness. Rock types of gravels are claystone, volcanic fragments and gravel coated with manganese oxide, etc. Many manganese nodules of several centimeters in diameter were taken from one point.

Dive #706 was conducted at northern hill of the Takuyo Daigo seamount between 1166 m and 1319 m in depth. The main bottom surfaces were rock, gravels and sediments. All rocks and gravels are coated with manganese oxide. Manganese nodules are distributed on the sediment surfaces. A total of 8 gravels samples were collected. All gravels are coated with manganese oxide of 15 to 110 mm in thickness. Rock types of gravels are volcanic breccia (or tuff?), volcanic rocks and phosphatized sedimentary rocks.

We plan to analyze the samples in collaboration with SIP/JAMSTEC and share the data and progress of analysis and related data if appropriate. Most of samples will be archived in refridgerator at Kochi Core Center, Kochi University.

3.3. Water depth profile of seawater

S. Kato and H. Amakawa (JAMSTEC)

Water depth profile of conductivity, temperature, salinity, dissolved oxygen (DO) concentration, pH, chromophoric dissolved organic matter (C-DOM), and transmittance was determined using a combined sensor (Fig. 1). Preliminary representative results were shown in Fig. 2.

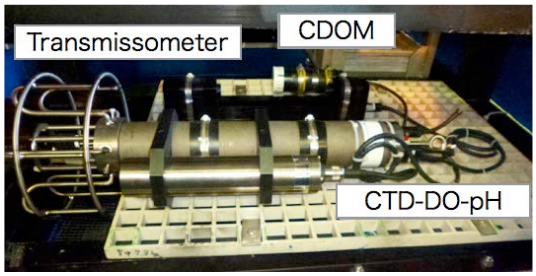


Fig. 1. A CTD-DO-pH sensor with C-DOM and transmissometer.

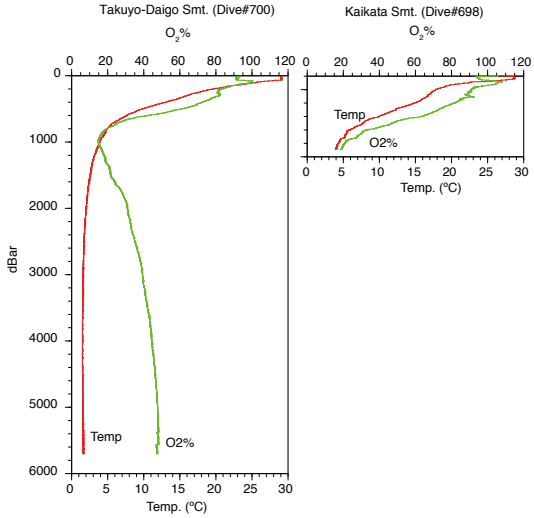


Fig. 2. Water depth profile of temperature and O_2 for Takuyo-Daigo and Kaikata Seamounts.

3.4. in situ adsorption and incubation experiments using Fe/Mn (oxyhydr)oxides on the deep seafloor

T. Kashiwabara, S. Kikuchi, H. Amakawa, S. Tokeshi, Y. Fukami, S. Kato (JAMSTEC)

Marine ferromanganese crusts are hydrogenetic metal deposits considered as potential mineral resources as well as archives of paleoceanographic environments. However, mechanisms of their formation on the deep-sea seafloor and the enrichment of trace elements from seawater are still unresolved. The purpose of our project in this cruse is to understand chemical/biological reactions at the seawater/ferromanganese oxide interface responsible for incorporation of trace elements by using in situ adsorption and incubation experimental systems. The system, called HOSHIGAKI, consists of acrylic cells entrapping various minerals and the frame hanging them in the flow of ambient seawater. In contrast to natural samples which are the mixtures of polygenetic minerals produced through geological timescale, this system allows us to examine ongoing reactions on each surface of constituent minerals of ferromanganese oxides with modern seawater.

In this cruse, we have successfully collected the instruments which we set up on slopes of three

different water depths in the previous cruise (Fig. 3a; Table 1). These depths offer different chemical/oceanographic conditions relative to Oxygen Minimum Zone (OMZ) and Carbonate Compensation Depth (CCD), which should be reflected in chemical composition of ferromanganese crusts. For the next step, we will analyze chemical reactions on minerals collected from different water depth to investigate whether they can explain the enrichment of elements into natural ferromanganese crusts or not.

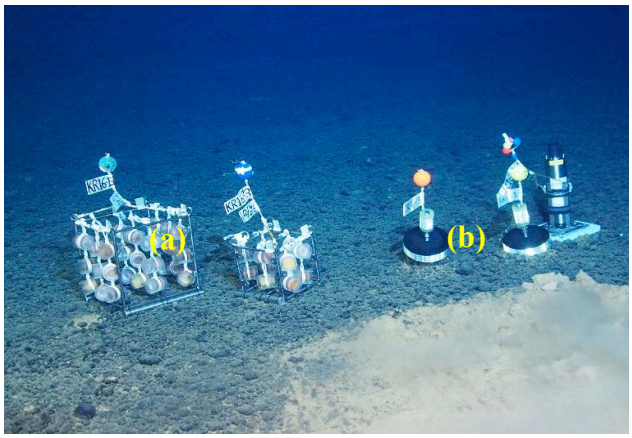


Fig. 3 *in situ* adsorption experimental system.

In addition, we have developed a new-type of instruments, DAIKON, which can investigate the chemical processes within the sediments. We also have successfully put them into the sediments on several sites deeper than CCD, where small ferromanganese nodules prevail on the surface sediments (Fig. 3b; Table 2). These systems, in the future, will allow us to investigate the influences of diagenetic processes in the sediments on the formation of ferromanganese crusts and nodules.

Table 1 Recovery information

DIVE No.	Instrument	Water depth	Latitude			Longitude			
699	HOSHIGAKI L	1151	22	51.1129	N	153	26.9967	E	Takuyo
699	Electromagnetic currernt direction and velocity profiler	1151	22	51.0825	N	153	27.074	E	Takuyo
700	HOSHIGAKI L	5533	22	30.8018	N	153	13.0568	E	Takuyo
701	HOSHIGAKI L	2987	22	40.921	N	153	14.4425	E	Takuyo
701	Electromagnetic currernt direction and velocity profiler	2986	22	40.9396	N	153	14.52	E	Takuyo
702	quickly-made HOSHIGAKI	4478	22	37.448	N	153	12.9379	E	Takuyo
703	Electromagnetic currernt direction and velocity profiler	1426	22	44.6371	N	153	15.9925	E	Takuyo

Table 2 Deployment information

DIVE No.	Instrument	Water depth		Latitude			Longitude		Site
698	HOSHIGAKI L	998	26	40.1618	N	140	53.7404	E	Kaikata
699	HOSHIGAKI L	1151	22	51.1129	N	153	26.9967	E	Takuyo
699	HOSHIGAKI S	1151	22	51.1129	N	153	26.9967	E	Takuyo
700	HOSHIGAKI L	5533	22	30.8018	N	153	13.0568	E	Takuyo
700	HOSHIGAKI S	5533	22	30.8018	N	153	13.0568	E	Takuyo
700	DAIKON (Y)	5533	22	30.8018	N	153	13.0568	E	Takuyo
700	DAIKON (R)	5533	22	30.8018	N	153	13.0568	E	Takuyo
700	ROV homer（ID:59）	5531	22	30.8018	N	153	13.0568	E	Takuyo
701	HOSHIGAKI L	2987	22	40.921	N	153	14.4425	E	Takuyo
701	HOSHIGAKI S	2987	22	40.921	N	153	14.4425	E	Takuyo
701	ROV homer（ID:60）	2986	22	40.921	N	153	14.4425	E	Takuyo
702	HOSHIGAKI L	4373	22	37.5729	N	153	13.1537	E	Takuyo
702	HOSHIGAKI S	4373	22	37.5729	N	153	13.1537	E	Takuyo
702	DAIKON（O）	4373	22	37.5729	N	153	13.1537	E	Takuyo
702	DAIKON (Y)	4373	22	37.5729	N	153	13.1537	E	Takuyo
702	ROV homer（ID：61）	4373	22	37.5729	N	153	13.1537	E	Takuyo
703	HOSHIGAKI L	1426	22	44.6371	N	153	15.9925	E	Takuyo
703	HOSHIGAKI S	1426	22	44.6371	N	153	15.9925	E	Takuyo
704	HOSHIGAKI S	3928	22	38.1531	N	153	13.6844	E	Takuyo
705	HOSHIGAKI L	5000	22	33.1085	N	153	13.403	E	Takuyo
706	HOSHIGAKI S	1166	23	15.8852	N	153	14.1726	E	Takuyo

3.5. Isotope and trace element geochemistry

Hiroshi Amakawa (JAMSTEC)

Many elements in seawater, such as rare earth elements (REE), show very low concentrations less than nmol/kg. To analyze abundance and isotopic composition of those elements, we have to deal with a large volume of seawater sample. For that purpose, we deployed a manganese oxide (MnO_2) fiber in three depths (1100 m, 3000 m, and 5500 m) at Takuyo-Daigo seamount during KR16-01 cruise (January, 2016) to absorb trace elements and have recovered them during KR16-13 cruise (October, 2016). At the same time, we have deployed a new manganese oxide (MnO_2) fiber to the same depths.

3.6. Microbiological analyses

S. Kato (JAMSTEC)

Our previous studies have shown that microbes are rich and phylogenetically diverse on Mn crusts at the Takuyo-Daigo Seamount (Nitaraha et al., 2011; Kato et al., submitted). However, it is still unclear whether and how they contribute to the formation of Mn crusts. To this end, in this cruise, we collect Mn crusts for DNA/RNA analyses, microscopy and cultivation, and also collect surrounding sediments and seawater as references. Furthermore, to reveal what microbes are initially attached to basement rocks and whether and how the microbes contribute to trigger the formation of Mn crusts, we put a newly developed in situ colonization device on the seafloor, which will be recovered after 10 months or later. The microbiological analyses/experiments will provide insights into mechanism of formation of Mn crusts.

Samples of Mn crusts were collected at water depths ranged from 1000 m to 5000 m (Table 3). To bring Mn crust samples and the deployed *in situ* colonization devices from the seafloor and or to newly deploy *in situ* colonization devices to the seafloor without microbial contaminations from surface seawater, we used a sealable "biobox" made of aluminum with a 0.2-um-pore-size membrane filter unit to balance internal pressure (Fig. 4). The collected Mn crusts were trapped in the biobox on the seafloor. We collected sediments using a push-core sampler and bottom seawater using NISKIN bottle samplers (6 L) equipped with the ROV around the sampling points of the Mn crusts as references.

Table 3. Sample list

Dive #	Date	Depth (m)	Sample
#698	2016/10/10	0	Seawater
		1048	Seawater
		1054	Seawater
		999	Mn crust
#699	2016/10/13	0	Seawater
		1150	Seawater
		1150	In situ devices
		1262	Sediment
		1150	Mn crust
		1150	In situ devices
#700	2016/10/14	5533	In situ devices
		5533	Sediment
		5531	In situ devices
#701	2016/10/15	3064	Seawater
		2987	In situ devices
		2989	Mn crust
		2986	In situ devices
#702	2016/10/16	4472	Seawater
		4478	In situ devices
		4373	Sediment
#703	2016/10/17	1435	Seawater
		1428	Mn crust
		1428	Mn crust
		1428	In situ devices
#704	2016/10/18	3975	Seawater
#705	2016/10/19	5030	Seawater
		5030	Mn crust
		4987	Sediment
#706	2016/10/21	1317	Seawater
		1295	Mn crust

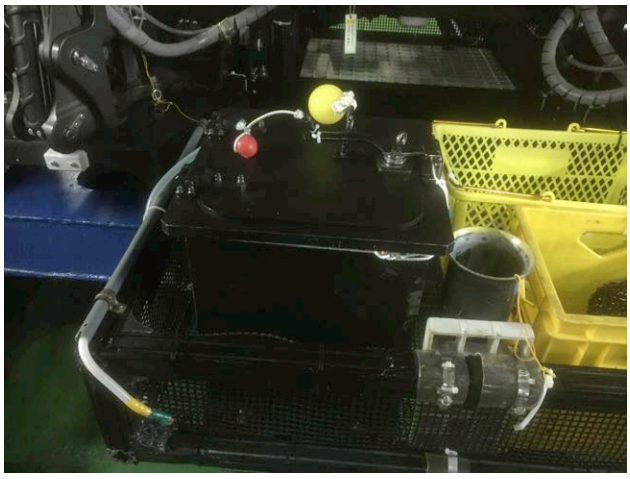


Fig. 4. Biobox equipped with ROV KAIKO.

Microbes in the seawater (approx. 6 L) were collected on 0.2 μm-pore-size membrane filters by filtration. The Mn crusts were crashed into small pieces by a sterile hummer and chisel in a clean booth. Some pieces were stored at -80ºC for DNA analysis. For cultivation, some pieces were stored in glass bottles with N2 gas at 4ºC. The other pieces of the samples were fixed with formalin (final 3.7%) or glutaraldehyde (final 2%) at 4ºC for microscopy.

3.7. Cruise log

KR16-13 Shipboard Log
(7. Oct., 2016 - 24. Oct., 2016)

日付 Date	時間 Local Time	内容 Note	特記事項 Description	本船位置／気象／海象 Position/Weather/Wind/Sea condition
7-Oct-16		**Scientists onboard.**		12:00 (UTC+9h)
	11:00	Scientists onboard.		YOKOSUKA
	13:00-13:30	Scientists meeting.		35-19.4N,139-39.7E
	15:30-14:30	Carried out Shipboard education & traning for scientist.		Fine but coudy
				NE-3 gentle breeze
				2 Sea sooth
				0 No swell
				Visibly: 8'
8-Oct-16		**Left YOKOSUKA for Research area.**		12:00 (UTC+9h)
	09:00	Let go all shore lines & left YOKOSUKA for Research area(KAIKATA sea mount).		OFF South NOJIMAZAKI
	10:00-11:00	Scientists meeting.		34-43.7N,139-47.8E
	13:00-13:45	KAIKO team briefing.		Cloudy
	16:40-17:00	Carried out KONPIRA pray.		SSE-7 Near gale
	18:00-20:00	Scientists meeting.		4 Sea moderate
				3 Moderate short
				Visibly: 8'
9-Oct-16		**Proceeded to Research area.**		12:00 (UTC+9h)
	09:00-09:30	Carried out boat station drill & fire station drill.		OFF South SOUHUIWA
	10:00-10:30	Scientists meeting.		28-51.2N,140-09.3E
	11:00-11:45	Cruise meeting(Scientist & KAIKO team).		Fine but coudy
	20:00	Arrived at research area.	Area = KAIKATA sea mount	ESE-6 Strong breeze
	20:21	Released XBT.	26-43.1681N,140-51.8506E	3 Sea slight
	20:45-21:07	Carried out MBES site survey.		1 Low swell sea
	21:30-21:49	Carried out eight figure running.		Visibly: 8'
10-Oct-16		**KAIKO Mk-IV Dive#698.**		12:00 (UTC+9h)
	05:53	Hoisted up "KAIKO Mk-IV".		KAIKATA sea mount
	06:00	Launched "KAIKO Mk-IV" then it dove & Com'ced her operation.	Dive No.698	26-38.3N,140-55.4E
	07:23	"KAIKO Mk-IV" landed on the sea bottom.	Depth = 1,074m	Fine but coudy
	09:54	"KAIKO Mk-IV" left the sea bottom.	Depth = 998m	NE-5 Fresh breeze
	10:58	Hoisted up "KAIKO Mk-IV".		3 Sea slight
	11:12	Recovered "KAIKO Mk-IV" & finished the operation.		1 Low swell sea
	12:00	Proceeded to next research area.	Area = TAKUYO No.5 sea mount	Visibly: 8'
11-Oct-16		**Proceeded to next research area.**		12:00 (UTC+9h)
	13:00-14:00	Scientists meeting.		MARIANA trench
				22-52.6N,145-04.8E
				Fine but coudy
				West-3 Gentle breeze
				2 Sea smooth
				1 Low swell sea
				Visibly: 8'
12-Oct-16		**Proceeded to next research area.**		12:00 (UTC+10h)
	00:00	Put ship's clock ahead 1hour for S.A.T. in long.150-00E.		OFF East MINAMITORISHIMA
	14:00-15:30	Scientists meeting.		22-52.6N,145-04.8E
				Fine but coudy
				South-4 Moderate breeze
				3 Sea slight
				2 Low swell long
				Visibly: 8'
13-Oct-16		**KAIKO Mk-IV Dive#699.**		12:00 (UTC+10h)
	01:00	Arrived at research area.	Area = TAKUYO No.5 sea mount	TAKUYOU No5. sea mount
	05:20	Released XBT.		22-51.1N,153-27.0E
	05:56-06:12	Carried out MBES site survey.		Fine but coudy
	09:19	Hoisted up "KAIKO Mk-IV".		ESE-4 Moderate breeze
	09:26	Launched "KAIKO Mk-IV" then it dove & Com'ced her operation.	Dive No.699	3 Sea slight
	10:54	"KAIKO Mk-IV" landed on the sea bottom.	Depth = 1,189m	3 Moderate short
	14:50	"KAIKO Mk-IV" left the sea bottom.	Depth = 1,153m	Visibly: 8'
	15:57	Hoisted up "KAIKO Mk-IV".		
	16:15	Recovered "KAIKO Mk-IV" & finished the operation.		
14-Oct-16		**KAIKO Mk-IV Dive#700.**		12:00 (UTC+10h)
	07:39	Hoisted up "KAIKO Mk-IV".		TAKUYOU No5. sea mount
	07:46	Launched "KAIKO Mk-IV" then it dove & Com'ced her operation.	Dive No.700	22-30.7N,153-13.0E
	10:44	"KAIKO Mk-IV" landed on the sea bottom.	Depth = 5,543m	Fine but coudy
	13:32	"KAIKO Mk-IV" left the sea bottom.	Depth = 5,531m	East-4 Moderate breeze
	16:15	Hoisted up "KAIKO Mk-IV".		3 Sea slight
	16:26	Recovered "KAIKO Mk-IV" & finished the operation.		3 Moderate short
	18:00-18:30	Scientists meeting.		Visibly: 8'
15-Oct-16		**KAIKO Mk-IV Dive#701.**		12:00 (UTC+10h)
	08:33	Hoisted up "KAIKO Mk-IV".		TAKUYOU No5. sea mount
	08:40	Launched "KAIKO Mk-IV" then it dove & Com'ced her operation.	Dive No.701	22-40.9N,153-14.4E
	10:46	"KAIKO Mk-IV" landed on the sea bottom.	Depth = 3,069m	Coudy
	14:01	"KAIKO Mk-IV" left the sea bottom.	Depth = 2,975m	East-3 Gentle breeze
	16:02	Hoisted up "KAIKO Mk-IV".		3 Sea slight
	16:11	Recovered "KAIKO Mk-IV" & finished the operation.		3 Moderate short
	18:00-18:30	Scientists meeting.		Visibly: 8'
16-Oct-16		**KAIKO Mk-IV Dive#702.**		12:00 (UTC+10h)
	07:35	Hoisted up "KAIKO Mk-IV".		TAKUYOU No5. sea mount

KR16-13 Shipboard Log
(7. Oct., 2016 - 24. Oct., 2016)

日付 Date	時間 Local Time	内容 Note	特記事項 Description	本船位置／気象／海象 Position/Weather/Wind/Sea condition
	07:41	Launched "KAIKO Mk-IV" then it dove & Com'ced her operation.	Dive No.702	22-37.5N,153-13.2E
	10:26	"KAIKO Mk-IV" landed on the sea bottom.	Depth = 4,478m	Coudy
	13:35	"KAIKO Mk-IV" left the sea bottom.	Depth = 4,366m	East-4 Moderate breeze
	16:02	Hoisted up "KAIKO Mk-IV".		3 Sea slight
	16:13	Recovered "KAIKO Mk-IV" & finished the operation.		3 Moderate short
	18:00-19:00	Scientists meeting.		Visibly: 8'
17-Oct-16		**KAIKO Mk-IV Dive#703.**		12:00 (UTC+10h)
	13:26	Hoisted up "KAIKO Mk-IV".		TAKUYOU No5. sea mount
	13:33	Launched "KAIKO Mk-IV" then it dove & Com'ced her operation.	Dive No.703	22-44.3N,153-15.6E
	15:06	"KAIKO Mk-IV" landed on the sea bottom.	Depth = 1,429m	Overcast
	17:01	"KAIKO Mk-IV" left the sea bottom.	Depth = 1,426m	ESE-5 Fresh breeze
	18:14	Hoisted up "KAIKO Mk-IV".		4 Sea moderate
	18:25	Recovered "KAIKO Mk-IV" & finished the operation.		3 Moderate short
	20:00-20:30	Scientists meeting.		Visibly: 8'
18-Oct-16		**KAIKO Mk-IV Dive#704.**		12:00 (UTC+10h)
	08:36	Hoisted up "KAIKO Mk-IV".		TAKUYOU No5. sea mount
	08:43	Launched "KAIKO Mk-IV" then it dove & Com'ced her operation.	Dive No.704	22-38.1N,153-13.6E
	11:08	"KAIKO Mk-IV" landed on the sea bottom.	Depth = 3,980m	Fine but croudy
	13:50	"KAIKO Mk-IV" left the sea bottom.	Depth = 3,825m	ESE-4 Moderate breeze
	16:07	Hoisted up "KAIKO Mk-IV".		3 Sea slight
	16:26	Recovered "KAIKO Mk-IV" & finished the operation.		3 Moderate short
	18:00-19:30	Scientists meeting.		Visibly: 8'
19-Oct-16		**KAIKO Mk-IV Dive#705.**		12:00 (UTC+10h)
	07:34	Hoisted up "KAIKO Mk-IV".		TAKUYOU No5. sea mount
	07:41	Launched "KAIKO Mk-IV" then it dove & Com'ced her operation.	Dive No.705	22-33.0N,153-13.3E
	09:00-10:00	Scientists meeting.		Fine but croudy
	10:31	"KAIKO Mk-IV" landed on the sea bottom.	Depth = 5,033m	East-3 Gentle breeze
	13:25	"KAIKO Mk-IV" left the sea bottom.	Depth = 4,865m	3 Sea slight
	15:57	Hoisted up "KAIKO Mk-IV".		3 Moderate short
	16:05	Recovered "KAIKO Mk-IV" & finished the operation.		Visibly: 8'
	18:00-18:30	Scientists meeting.		
20-Oct-16		**Com'ced heave to.**		12:00 (UTC+10h)
	08:28	Released XBT.	23-00.1830N,153-14.3171E	TAKUYOU No5. sea mount
	18:00-18:30	Scientists meeting.		23-00.2N,153-17.4E
				Fine but croudy
				East-2 Light breeze
				2 Sea smooth
				3 Moderate short
				Visibly: 8'
21-Oct-16		**KAIKO Mk-IV Dive#706.**		12:00 (UTC+10h)
	08:33	Hoisted up "KAIKO Mk-IV".		TAKUYOU No5. sea mount
	08:39	Launched "KAIKO Mk-IV" then it dove & Com'ced her operation.	Dive No.706	23-16.4N,153-14.0E
	10:08	"KAIKO Mk-IV" landed on the sea bottom.	Depth = 1,319m	Fine but croudy
	14:56	"KAIKO Mk-IV" left the sea bottom.	Depth = 1,182m	WNW-2 Light breeze
	16:01	Hoisted up "KAIKO Mk-IV".		2 Sea smooth
	16:14	Recovered "KAIKO Mk-IV" & finished the operation.		1 Low swell sea
	18:00-18:30	Scientists meeting.		Visibly: 8'
22-Oct-16		**Proceeded to SAIPAN.**		12:00 (UTC+10h)
	18:00-18:30	Scientists meeting.		MARIANA sea noll
				20-06.7N,150-11.2E
				Fine but croudy
				NE-3 Gentle breeze
				2 Sea smooth
				1 Low swell sea
				Visibly: 8'
23-Oct-16		**Proceeded to SAIPAN.**		12:00 (UTC+10h)
	09:00	Scientist seminar.		TAKUYOU No5. sea mount
				22-33.0N,153-13.3E
				Fine but croudy
				East-3 Gentle breeze
				3 Sea slight
				3 Moderate short
				Visibly: 8'
24-Oct-16		**Arrived at SAIPAN**		
	09:00	Sent out 1st shore line, arrived at SAIPAN,completed KR16-13.		

3.8. Dive information

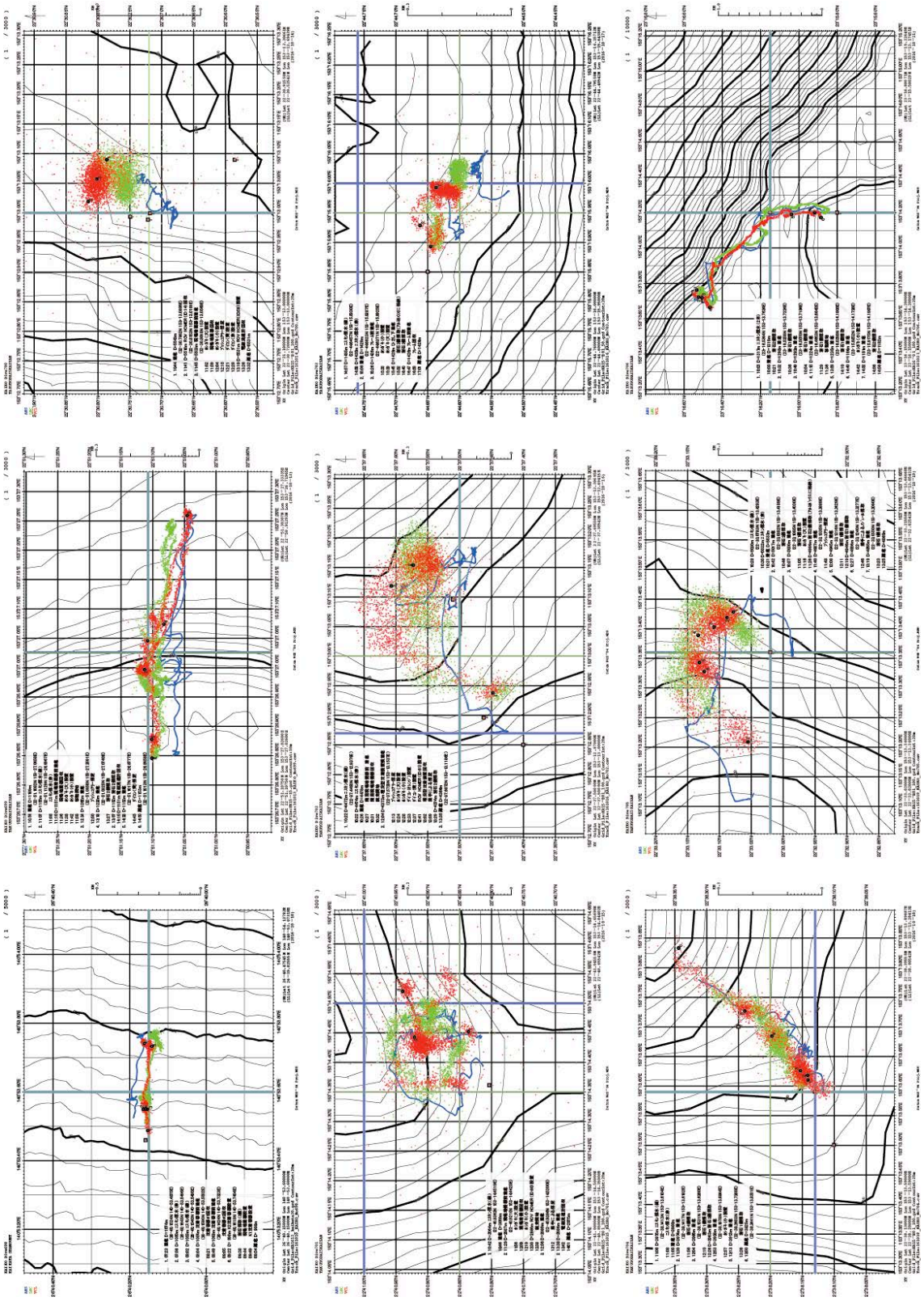


Fig. 5. Dive track for each dive.

Acknowledgement

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4. Notice on Using

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