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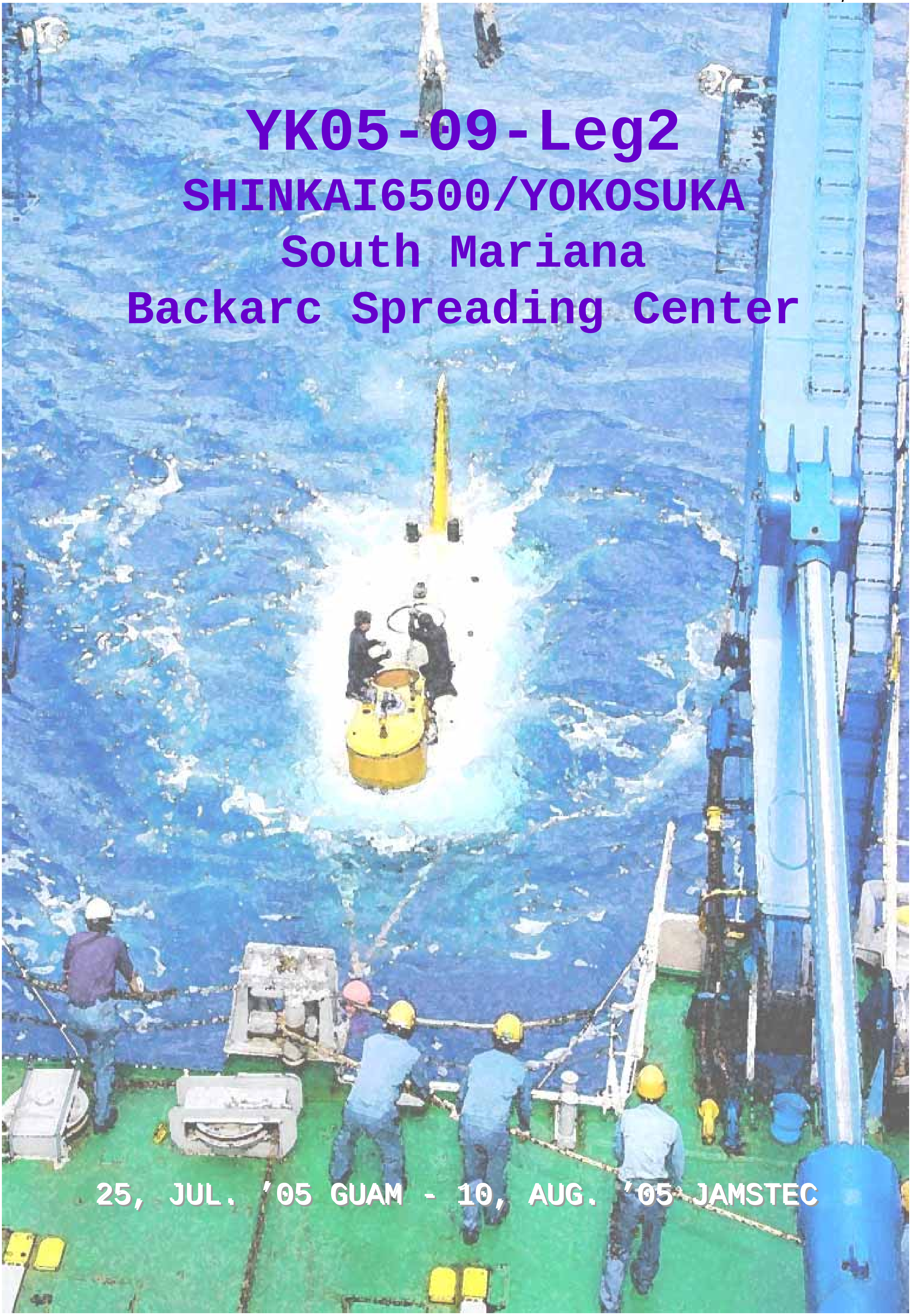

YK05-09-Leg2

SHINKAI6500/YOKOSUKA

South Mariana Backarc Spreading Center

25, JUL. '05 GUAM - 10, AUG. '05 JAMSTEC

Acknowledgement

The cruise started with delay because of the Typhoon, which let us stay in Guam and prohibited from *Yokosuka* to get to the port. However, we could safely persuade eight dives among the scheduled ten dives, and mostly obtain the quested samples and observation results.　All's Well That Ends Well.

We will express our gratitude to crew of *Yokosuka*, who support our safe and comfortable lives during the cruise.　The members of operation team *Shinkai6500* are acknowledged to take us to the wonderful world in the underwater.　We are specially thankful to Captain Ishida, who has a noble soul and strong sense of responsibility, for perfect leading of our expedition.

We also thank to all the people who are supporting our research project, as shore-based supporting staffs in JAMSTEC and shore-based scientists.　A part of the traveling cost was financially supported by a scientific fund by JSPS to Prof. Tamaki (Univ. Tokyo), and NSF to P. Fryer.

YK05-09 Leg.2 Cruise Report Contents

1.1 Cruise summary

Cruise number/Leg/Vessel: YK05-09 Leg 2 YOKOSUKA/ SHINKAI 6500

Project theme: Time and spatial variation of hydrothermal activities and the associating microbiological activity on and around the backarc spreading center of the southern Mariana Trough

Proponent (representative): Harue MASUDA (Department of Geosciences, Osaka City University)

Chief scientist: Harue MASUDA (Department of Geosciences, Osaka City University)

Onboard scientists: Patricia FRYER (HIGP, University of Hawaii), Jun-ichiro ISHIBASHI (Department of Earth and Planetary Science, Kyushu Univerisy), Tomohiro TOKI (Ocean Research Institute, University of Tokyo), Kiminori SHITASHIMA (Central Research Institute of Electric Power Industry), Hiroyuki KIMURA (Department of Biology and Geosciences, Shizuoka University), Ryohei SUZUKI (Department of Earth and Planetary Science, Kyushu University), Seigo SATO (Department of Mineralogy, and Economic Geology, Tohoku University), Kazuo TAKEMOTO (Department of earth and Planetary Science, University of Tokyo), Shingo KATO (Department of Molecular Bology, Tokyo University of Pharmacy and Life Science), Chiyori KOBAYASHI (Department of Molecular Bology, Tokyo University of Pharmacy and Life Science), Mitsuteru KUNO (Department of Geosciences, Osaka City University), Takuroh NOGUCHI (Graduate School of Engineering and Sciences, University of Ryukyus), Misumi AOKI (Marine Science Department, Nippon Marine Enterprises, Ltd).

Research area: Southern Mariana Trough, Philippine Sea

Research period: 24th July – 10th August, 2005

Active backarc spreading is in the eastern part of Mariana Trough south from 14°N, where the spreading ridge shows fast-spreading topography. Active hydrothermal areas have been known in and around the spreading ridge since 2000, when the low temperature hydrothermal fluid formed iron-hydroxide and manganese oxide chimneys at 13°06’N. The spreading ridge was separated into northern and southern segments at about this latitude, and a magma chamber was presumed below that area by seismic profiling. In 2003, clear smoker venting was found at 12°54’N following the first discovery of plumes. Another low temperature field and two black smoker venting sites were found on the ridge and an off-axis seamount in 2003 by SHINKAI 6500. Three of those four hydrothermal areas linearly align, indicating that the hydrothermal venting areas are controlled by tectonic fractures. Variable microbial activities associating with those hydrothermal systems were also observed in those areas.

Based on those findings, two regions are presumed to be the most magmatically active areas in the spreading ridge. We have two targets for this cruise. Tracing the time variation of hydrothermal activities and associated microbial activities in the southern areas around 12°55'N. 2) Reconnaissance survey of the magmatic activities and probable hydrothermal activities in the northern areas aroud 13°06'N. Eight dives by SHINKAI 6500 were persuaded among the scheduled ten dives. Five dives were used for the former purpose, and the northern area was surveyed in the remaining three dives.

We obtained the following results on board. 1) The hydrothermal activities in the southern area have not changed after two years since the area was surveyed, suggesting that the stable activities continue during such a time scale in this area. 2) The northern area was rather quiescent in magmatic activities at present. However, the last eruption must not be very old, since the fresh quenched glass rim occasionally gave sulfide smell. Thus, we can say the magmatic activity of this area is active. Only low temperature hydrothermal activities, which temperature ranges 10~30°C, were found at two locations along the ridge axis in the southern segments. We can not expect active high temperature hydrothermal activities in this area.

Many fresh volcanic rocks and microbial samples comprising hydrothermal fluids and sediments were obtained thorough dives. More detailed feature of the magmatic activity and related hydrothermal systems associated with microbial activity will be able to argue after finishing the shore-based analyses.

1.2 Study area

The study area is indicated by a square in Figure 1. The area is the southernmost part of Mariana Trough, where active spreading ridge, which topography is similar to one of fast-spreading ridge. The bathymetry survey was done mostly in night time and the result is described in elsewhere.

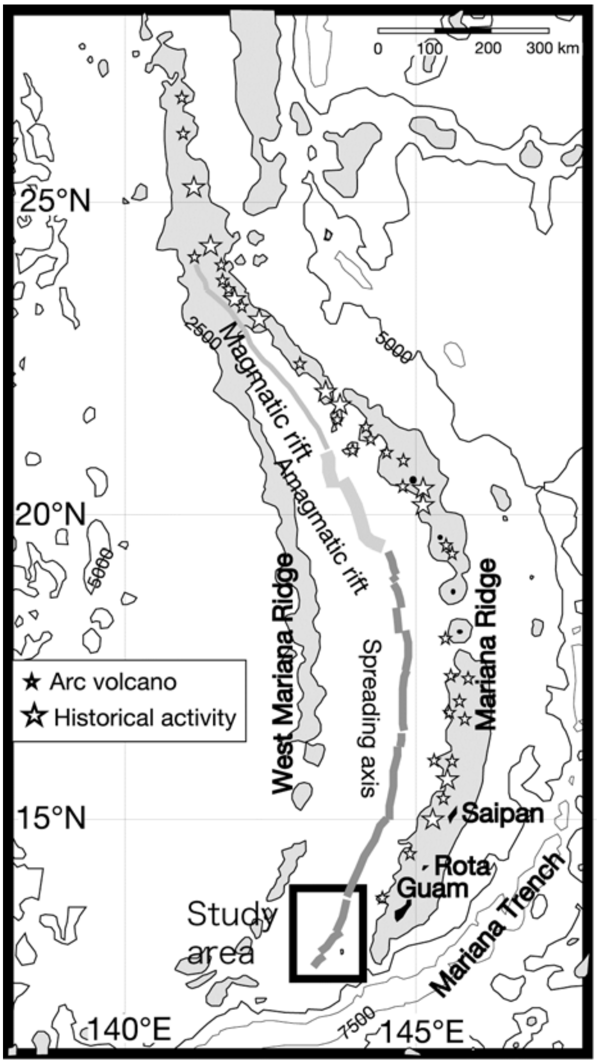

Figure 1.2.1 Index area

The surveyed areas by submersible SHINAKI 6500 are shown in Figure 2. The areas are roughly divided into two, northern and southern areas. The northern area is located on the boundary between ridge segments, and presumed to be the most magmatically active. The southern area would also be magmatically active, and two black smoker and two low temperature hydrothermal areas were found in the previous researches.

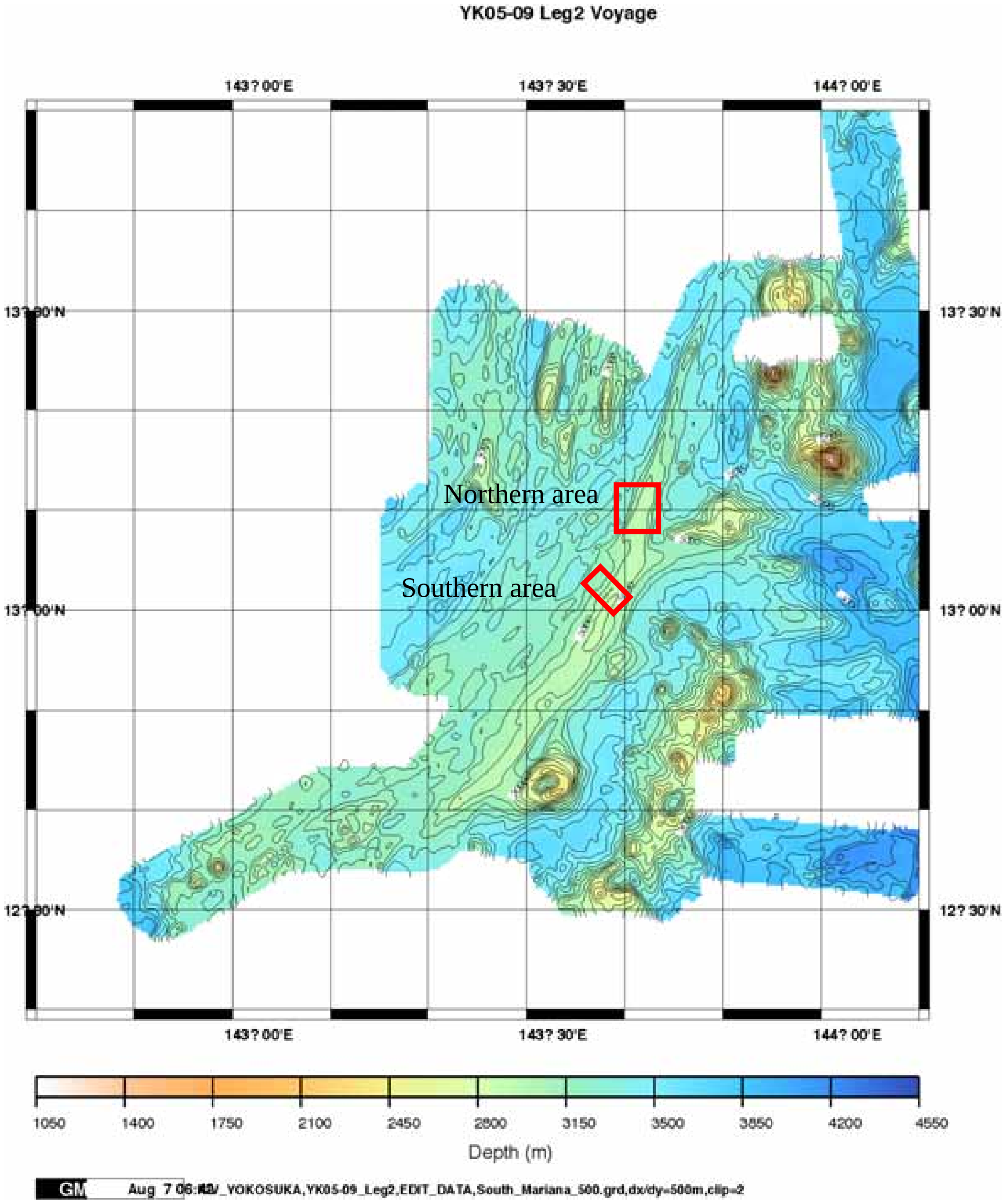

Figure 1.2.2 Bathymetry map and the surveyed areas by submersible SHINAKI 6500

YK05-09_Leg2　Cruise Log

Date& Time (Local)	Descriptions	Remarks	wearther/direction/ wind force /wave/ swell/visibility (at Noon)
(JST+1h)			
Sun. 24-Jul-05			Cloudy/South/4/2/1/8
12:45	scientist onboad	Hotel wharf, Apra, Guam	
14:30-14:50	briefing for safety and life onboad		
15:00-15:30	meeting for dive plan		
16:00	departure from Apra, Guam	Transit	
16:45	Konpira celemony		
18:30-19:30	meeting		
Mon 25-Jul-05			Fine/SE/3/2/5/7
5:54	XBT		
06:29-07:05	NMBES survey for dive		
12:45	start bathymetric mapping		
Tue 26-Jul-05			Fine/East/4/2/5/8
7:26	finish bathymetric mapping		
	6K#900dive	H. Masuda	
9:52	Shinkai at the surface	Southern Mariana Trough	
9:58	start diving		
11:30	landing (2907m)		
16:06	leaving bottom (2893m)		
17:16	come up to the surface		
17:52	on the deck		
18:40	start bathymetric mapping		
19:30-20:10	meeting		
Wed 27-Jul-05			Fine/ENE/4/3/4/8
7:03	finish bathymetric mapping		
	6K#901dive	P. Fryer	
9:55	Shinkai at the surface	Southern Mariana Trough	
10:02	start diving		
11:24	landing (2938m)		
16:08	leaving bottom (2880m)		
17:18	come up to the surface		
17:51	on the deck		
18:40	start bathymetric mapping		
19:30-20:00	meeting		
Thu 28-Jul-05			Fine/ENE/4/3/4/8
6:27	finish bathymetric mapping		
	6K#902dive	H. Kimura	
9:50	Shinkai at the surface	Snail Site	
9:57	start diving		
11:18	landing (2853m)		
16:20	leaving bottom (2848m)		
17:22	come up to the surface		
17:49	on the deck		
18:23	start bathymetric mapping		
	meething		
Fri 29-Jul-05			Fine/ENE/5/3/4/8
7:05	finish bathymetric mapping		
	6K#903dive	J. Ishibashi	
9:48	Shinkai at the surface	Archaean Site	
9:54	start diving		
11:20	landing (3082m)		
15:53	leaving bottom (2969m)		
17:03	come up to the surface		
17:30	on the deck		
19:00	start bathymetric mapping		
20:00-20:40	meething		
Sat 30-Jul-05			Cloudy/East/6/5/4/8
7:05	finish bathymetric mapping		
12:10-20:18	bathymetric mapping		
Sun 31-Jul-05			Cloudy/South/5/4/6/7
	escape from Tropical Depression		
Mon 1-Aug-05			Cloudy/SE/5/4/6/8
10:27	start bathymetric mapping		
Tue 2-Aug-05			Fine/NE/4/2/4/8
7:05	finish bathymetric mapping		

YK05-09_Leg2　Cruise Log

Date& Time (Local)	Descriptions	Remarks	wearther/direction/ wind force /wave/ swell/visibility (at Noon)
	6K#904dive	H. Kimura	
9:52	Shinkai at the surface	Snail Site	
9:58	start diving		
11:16	landing (2852m)		
15:35	leaving bottom (2852m)		
17:02	come up to the surface		
17:30	on the deck		
19:20	start bathymetric mapping		
20:10-20:55	meething		
Wed 3-Aug-05			Fine/NE/4/3/3/8
7:05	finish bathymetric mapping		
	6K#905dive	K. Shitashima	
9:58	Shinkai at the surface	Archaean Site	
10:05	start diving		
11:28	landing (3068m)		
15:58	leaving bottom (2972m)		
17:12	come up to the surface		
17:40	on the deck		
19:10	start bathymetric mapping		
20:00-20:30	meething		
Thu 4-Aug-05			Fine/North/4/3/3/8
7:06	finish bathymetric mapping		
	6K#906dive	T. Toki	
9:50	Shinkai at the surface	Pika Site	
9:56	start diving		
11:17	landing (2788m)		
16:01	leaving bottom (2787m)		
17:02	come up to the surface		
17:30	on the deck		
19:10	start bathymetric mapping		
19:30-19:45	meething		
Fri 5-Aug-05			Fine/East/4/2/3/8
7:05	finish bathymetric mapping		
	6K#907dive	H. Masuda	
	Shinkai at the surface	Southern Mariana Trough	
9:58	start diving		
11:18	landing (2854m)		
16:01	leaving bottom (2854m)		
17:07	come up to the surface		
17:40	on the deck		
18:24-23:15	bathymetric mapping		
19:30-20:00	meething		
Sat 6-Aug-05		transit	Fine/ESE/4/3/3/8
0:00	JST = GMT+9h		
9:00-9:45	Geology and geochemistry of Mariana area -1		
	Dr. Pattricia Fryer		
19:30-20:10	meeting		
Sun 7-Aug-05		transit	Fine/ESE/4/3/3/8
9:00-10:05	Geology and geochemistry of Mariana area -2		
	Dr. Harue Masuda		
13:30-15:00	Shinkai tour for students		
Mon 8-Aug-05		transit	Cloudy/SE/2/1/1/8
9:00-9:50	Geology and geochemistry of Mariana area -3		
	Dr. Junichiro Ishibashi		
20:00-22:00	party		
Tue 9-Aug-05		transit	Fine/SW/3/2/1/7
9:00-10:00	Onboard Seminer; Preriminary results		
	Dr. H. Masuda (Chief scientist)		
16:15	drop anchor		
Wed 10-Aug-05			
7:00	arrive at JAMSTEC		

2.2 List of Scientific Party

研究者氏名/Name	所属機関/Institute	部署名/Department etc.
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コバヤシ チヨリ 小林 智織 Chiyori KOBAYASHI	東京薬科大学 Tokyo University of Pharmacy and Life Science	生命科学部 Department of Molecular Biology
クノ ミツテル 久野 光輝 Mitsuteru KUNO	大阪市立大学大学院 Osaka City University	理学部生物地球系専攻 Graduated School of Science
ノグチ タクロウ 野口 拓郎 Takuroh NOGUCHI	琉球大学大学院 University of Ryukyus	理工学研究科海洋環境学専攻 Graduate school of Engineering and Sciences
アオキ ミスミ 青木 美澄 Misumi AOKI	日本海洋事業株式会社 Nippon Marine Enterprises, Ltd.	海洋科学部 Marine Science Department

2.3 List of submersible team and crew

Shinkai 6500 Operation Team

Yoshiji IMAI	Operation manager
Toshiaki SAKURAI	Assistant operation manager
Yoshitaka SASAKI	1st submersible staff
Kazuki IIJIMA	1st submersible staff
Itaru KAWAMA	1st submersible staff
Fukuo SUDA	1st submersible staff
Yoshio ONO	1st submersible staff
Masanobu YANAGITANI	2nd submersible staff
Keita MATSUMOTO	2nd submersible staff
Hirofumi UEKI	2nd submersible staff
Yousuke CHIDA	3rd submersible staff
Fumitaka SAITO	3rd submersible staff
Kensuke TOZUKA	3rd submersible staff

Yokosuka Crew

Sadao ISHIDA	Captain	Eiji SAKAGUCHI	Chief engineer
Takafumi AOKI	Chief officer	Kimio MATSUKAWA	1st engineer
Tsutomu SATO	2nd officer	Takashi OOTA	2nd engineer
Takeshi EGASHIRA	3rd officer	Yuji MORI	3rd engineer
Makio NAKAMURA	Boat swain	Kiyoshi YAHATA	No.1 oiler
Mikio ISHIMORI	Able seaman	Katsuyuki MIYAZAKI	Oiler
Katsumi SHIMIZU	Able seaman	Tomoyuki HASHIMOTO	Oiler
Takao KUBOTA	Able seaman	Ryota SUZUKI	Assistant oiler
Keiji SHIKAMA	Able seaman	Yoshinori YAMAOKA	Assistant oiler
Shozo FUJII	Able seaman		
Toshiki OKUYAMA	Sailor		
Satoshi WATASE	Chief radio operator		
Katsutoshi KITAMURA	2nd radio operator		
Yoshitaro TAMIYA	Chief steward		
Shinsuke TANAKA	Steward		
Teruyuki YOSHIKAWA	Steward		
Toyonori SHIRAISHI	Steward		
Tadayuki TAKATSU	Steward		

3. Previous studies

3. 1 Geology and tectonics

H. Masuda and P. Fryer

The tectonic history and magmagenesis of the Mariana Trough are well understood in the middle and northern areas of the backarc basin where a two-stage opening process, initially extension with disorganized arc magmatism followed by development of a true seafloor spreading center and the creation of new oceanic lithosphere [*Fryer and Hussong*, 1981; *Clift*, 1995; *Fryer*, 1995; *Martinez et al.*, 1995; *Fryer*, 1996; *Baker et al.*, 1996; *Stern et al.*, 2004].

In the southern part of the Mariana back arc basin between 17 and 14°N, a series of short spreading valleys, about 100km west of the volcanic frontal arc, is offset westward by a series of right-lateral transform fault valleys [*Smoot*, 1990]. The rift valleys are well developed between 15°00’N and 17°33’N, showing the slow spreading morphology typical of MAR spreading axes, and the deeper parts of the valleys are thickly covered by sediments [*Stüben et al.*, 1998]. The southern trough area south from 14°N is topographically different from the other areas of the basin. The area is generally shallower by about 1 km than the rest of the basin. Early explanations for such shallow seafloor included diffuse spreading [*Hawkins*, 1977; *Smoot*, 1990].

The detailed bathymetry along a submarine cable line at 13°45’N showed that small volcanoes were located in a narrow, low-relief spreading axis along the eastern margin of the basin adjacent to the volcanic arc [*Hagen et al.*, 1992]. Such a feature was different from the previous estimation of the location of the spreading axis. The spreading axis of the area was previously suggested to be located in the center of the basin [*Karig and Ranken*, 1983]. The volcanic arc was also estimated to be absent along the southern edge of the backarc basin [*Karig*, 1971]. Tracy Seamount at 13°40’N and 144°50’E was thought to be the southernmost active volcano on the Mariana arc.

Detailed bathymetry data was obtained Mariana Trough south of 14°N on several cruises of the Yokosuka beginning in 1992 (YK92-04). Several large volcanic edifices were mapped and explored with Shinkai 6500 beginning in that year. In 1992, active hydrothermal fluid venting reaching temperatures as high as 202°C and associated biological communities were discovered from one of the submarine volcanoes on the southern boundary of the Mariana Trough [*Gamo et al*, 1993], revealing that the area has currently active arc volcanism [*Masuda et al*., 1994; *Fryer et al*., 1995 and 1998]. It is now recognized that the volcanic front of the Mariana system extends southwestward from Tracey Seamount and arc volcanism is active all along the southern boundary of the Mariana Trough [*Fryer et al*., 1998]. In 1993 a series of en echélon shaped ridge segments, which has a relatively flat crest at 2900 m depths, was discovered in the west from the arc volcanoes during Yokosuka cruise (YK93-03). Only a portion of the ridge was mapped, although it appeared to be a spreading axis [*Kasahara et al*., 1994]. Magnetic anomaly surveys of the region in 1996, were less than successful, because the area is so close to the magnetic equator that vectors are ambiguous [*Yamazaki and Stern*, 1997]. The southern extent of the active spreading ridge was surveyed in 2000 using HMR-1 side-scan sonar [*Martinez et al*., 2000]. The resulting bathymetry and side-scan backscatter imagery revealed that the spreading ridge was largely separated into two segments, and the ridges, unlike the spreading axis in the other part of the trough, showed inflated morphology, lacking a well-defined central graben, and typical of fast spreading ridges (e.g., EPR).

Detailed surveys of the area were conducted with deep-tow instruments along the active spreading axis during Yokosuka cruise (YK99-11) held in January 2000. A ridge shallower than 3000 m developed in the center of the basin between grabens, deeper than 4000 m, which lie to the east and west of the ridge and extend to the acrive volcanic front and to the western edge of the Mariana Trough along the west bounding fault at the base of the remnant West Mariana Arc. Those deeps likely correspond to the extensional basins formed when rifting began. The western part of the basin, north from about 12°40'N, is characterized by graben and horst structure between the West Mariana ridge and the currently active spreading ridge located almost on the eastern edge of the area. In this area, the strike of the graben and horst changes between the northern and southern parts of the basin. The boundary of the changes is not a sharp lineament, although roughly running from NW to SE. The strike of ridges is N-S in the western part of the basin north from T1, and slightly changes into NNE-SSW toward the east. In the southern half of the basin, the strike is NE-SW. The boundary T1 is unclear between the ridges of ON2-OS2 and N-S1 because the overlying structure of the adjacent shallow rise. The most prominent ridge located at the center of the rise (ON2 and OS2 In Fig. 1), is separated into two segments at about 13°12'N and 142°24'E also by T1. This boundary seems to cross the currently active spreading ridge at about 13°00N and extend toward the Mariana Arc.

Both the trend of the ridge direction and the topography are different in the area bordered by

T1. In the northern half, structure comprising the ridges and intervening grabens is well developed inside the basin. There is a deep, relatively smooth-floored graben (D1 in Fig. 1) in the western part of the basin south of T1. The seafloor is shallow and forms a rise between OS2 and the currently active spreading ridges (S1 and S2). The strike of ridges changes to the south of B2, at which the inflated segment of the backarc basin spreading axis is terminated. In the south from T2, the strike of the ridges changes direction toward E-W, roughly parallel to that of the southern end of the Mariana Arc.

The currently active spreading ridges are located on the eastern side of the basin, as noted before. *Martinez et al*. [2000] suggested that this spreading ridge could be divided into two segments, a long northern and a short southern one bordered at about 12°40’E. However, we suggest that the northern segment should be divided into two segments (N and S1) at 13°06’N, where the elongation of the ridge axis changes from NNE-SSW in the north to NE-SW in the south. The northern end of the southern ridge segment extends toward the eastern seamount that is cut by a large E-W trending fault, while the southern end of the northern ridge segment turns to the west. Each segment overlaps at the ends. En echélon arranged ridges make up each segment.

Off-ridge seamounts are located adjacent to the eastern edge of the active spreading ridge segments. The individual edifices become larger toward the south; the summit of the small seamount (A) at 13°15’N lies at 3000 m and is only 500m high from the basin floor. Although fissures run N-S direction at the bottom of the seamount indicating tectonic activity, this seamount appears from Shinkai 6500 observations to be inactive at present [*Masuda et al*., 1993]. Three seamounts are located at 12°50’-12°55’N, and the depth of the summit of the shallowest seamount is 2800 m. A seamount, Patgon-Maslala Seamount, is at 12°40’N. The edifice rises approximately 1 km from the surrounding seafloor, is 17 km by 11 km in diameter and has the largest caldera of any volcano in the Mariana arc. The caldera (TOTO) is 5 km by 3 km in diameter at the bottom and the crest of outer rim of the caldera is 2400 m depth. The caldera has two benches one at about 3 km and one at 2.8 km. Black smoker type hydrothermal activity was found at one of the off axis seamounts at 12°52’N [*Utsumi et al*., 2004] and white and clear smoker activity was observed inside TOTO caldera of Patgon-Masala Seamount [*Gamo et al*, 2004].

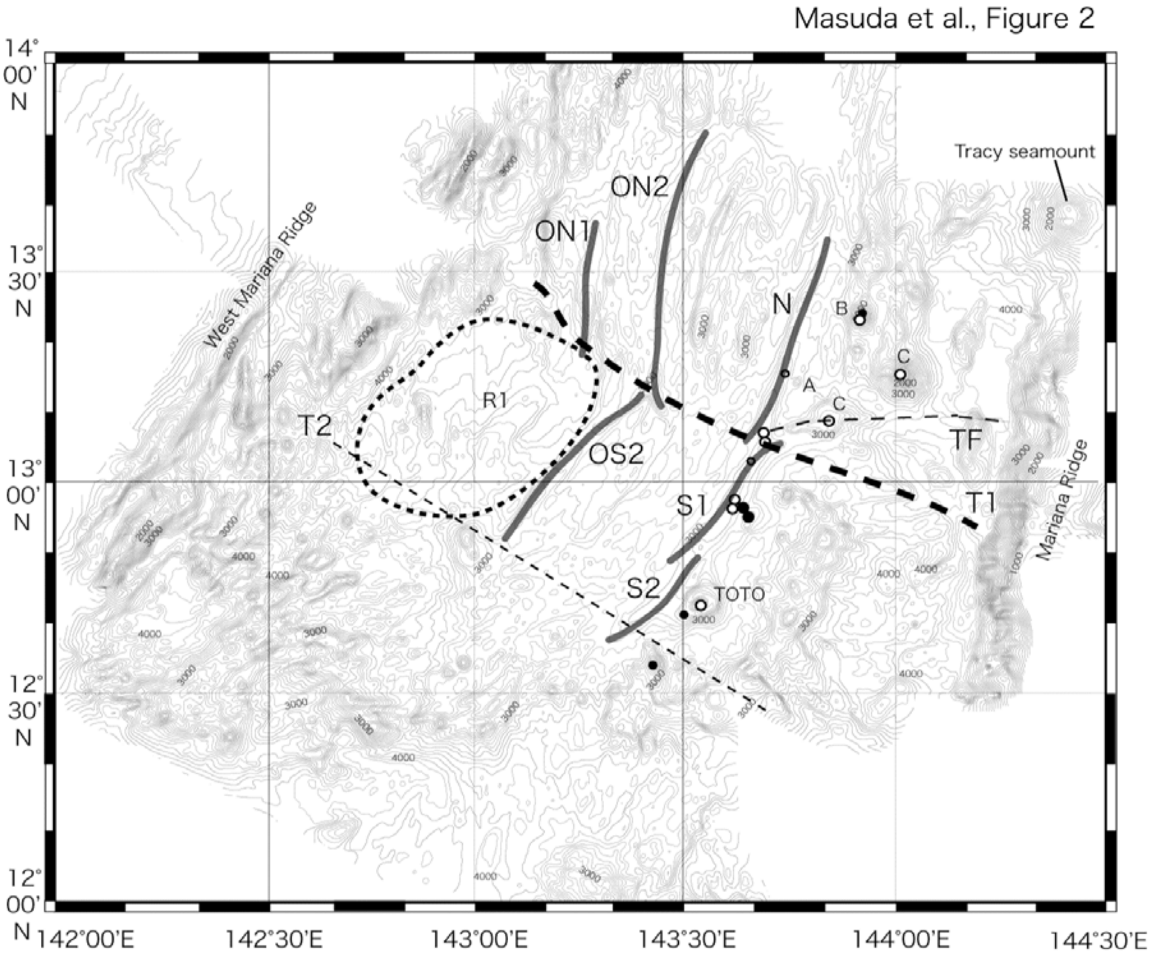

Figure 3.1.1 Map of the southern Mariana Trough

Chemistry of the rocks of the backarc spreading ridge and arc volcanic rocks between 12°30 and 13°30'N are described in Masuda et al. (in preparation). Both backarc and arc rocks of this area must be formed mostly from the wedge mantle having indistinguishable chemistry with addition of slab-derived components; melt including descending sediment and slab-derived fluids. The melted sediment affected more in the rock chemistry of the arc rocks from the southern segment than those of the northern segment where the metasomatic fluids more affected. The rocks of presently active spreading ridge in the northern segment contain a smaller amount of the metasomatic fluid than the adjacent arc rocks. The spreading ridge rocks from the southern part of the southern segment apparently include the composition of melted slab but not metazomatic fluid unlike the northern segment.

We presume that the adiabatically upwelling mantle, source of the magma, was already altered by seawater, which contributes to lower the melting temperature of the backarc magma. However, the hydrated water from descending slab would be more important than the water in the altered mantle to generate the initial melting, suggested by Taylor and Martinez (2003). We should wait until more accurate data set of minor element especially REE and radiogenic isotopes to quantitatively estimate the sources and its relation to the initial formation of backarc magma.

3.2 Hydrothermal activities

After the initial discovery of hydrothermal activity in 1992, various types of hydrothermal activity were observed with submersible dives and ROV lowerings in the area. In Fig. 1, the locations where hydrothermal activity was found are plotted as open circles. The first hydrothermal area was discovered at 13°25’N, 144°00’E on one of the arc submarine volcanoes (Seamount B). It was a clear smoker associating with barite chimney structures [*Gamo et al*., 1993], and a >3 m high dead sulfide chimney complex was observed at the same area [*Johnson et al*., 1993]. Diffuse flow of low-temperature hydrothermal fluid was observed at the summit area of seamount X, where patches of native sulfur thinly covered the surface of exposed volcanics and bacterial mats were found at the various places [*Masuda et al*., 1994]. A low-temperature hydrothermal area was found in association with iron hydroxide precipitation on talus deposits on the edge of the caldera wall of seamount C [*Masuda et al*., 1994].

Deep-tow video camera survey was done on the ridge crest from 12°56’N to 13°08’N [*Mitsuzawa et al*., 2000]. According to the video images, the volcanic activity is most active north from 13°04’N to 13°08’N. Because thick sediment was observed on the ridge crest south of 13°00’N, volcanic activity in the southern part along the surveyed line is assumed to be quiescent compared with the northern area [*Mitsuzawa et al*., 2000]. Volcanic rocks were dredged at the end of this survey at 13°08’N, and the rocks obtained were very fresh, had abundant surface glass, and had a strong sulfide smell. Hydrothermal activity was first observed on the ridge crest during this survey at about 13°05’N, 13°06’N and 13°07’N; the former two locations were on the southern segments, and the latter one was on the end of the axial crest of the northern segment [*Mitsuzawa et al*., 2000; *Masuda et al*., 2001a]. At the same time temperature and Eh anomalies were observed in the seawater column when the video camera passed 13°06’N [*Mitsuzawa et al*., 2000].

Based on those observations, an R/V Kairei deep-tow survey discovered low temperature hydrothermal areas on the axial slope of the northernmost part of ridge S1 at 13°06’N [*Masuda et al*., 2000b]. The area was mostly covered by fresh pillow lava, and two lava lakes ca 200m diameters were found along the trace [*Masuda et al*., 2001a]. Iron hydroxide chimneys were located at 13°05.9’N, iron hydroxide chimneys (thinly coated by manganese oxide) at 13°06.05’N, and manganese chimneys at 13°06.28’N. The mineralogical composition of these chimneys demonstrates an increasingly more oxiding condition for the hydrothermal fluids toward the north. This suggests the presence of more reducing hydrothermal activity to the south [*Masuda et al*., 2000a].

Hydrothermal sediments were dredged in KK03-11. At the summit area of the southern segment S1 at 13°00’N, white smoker and manganese oxide chimneys were recovered with fresh pillow lava blocks. However, we cannot verify that the area is currently active. White smoker and manganese chimneys were also recovered from a mound located on the northern segment at 13°15’N. At this site, no volcanic rocks were recovered, but thick sediments (brown deep sea mud) and calcareous ooze were obtained. Pillow lava with fresh glass rims was dredged at the summit of the spreading ridge, from the shallowest peak of the northern segment, at 13°11’N. The water depth of this northern spreading ridge (N in Fig. 1) becomes deeper toward the north, and it appears that there is current volcanic activity on the ridge south from the shallowest point, but none to the north at present.

Fresh volcanic rocks were dredged from the ridge crest at 12°40’N and 12°45’N. No deep sea sediment was recovered from those sites, thus we infer that volcanic activity is recent on the spreading ridge segment S2.

Hydrothermal activity was presumed inside of the TOTO caldera at 12°40’N based on an Fe anomaly in the seawater column [*Gamo et al*., 1998]. Deep tow video camera observations on the bottom of the caldera and on terraces to the north west show diffuse issuing of clear and white smoker fluids along the faults bordered the terraces [*Masuda et al*., 2001a], and a biological community including tube worms was found at the clear water simmering mound [*Mitsuzawa et al*., 2000]. The clear smoker fluid was sampled by ROV Kaiko after that survey, and *Gamo et al*. [2004] found that the pH of the fluids was notably low probably due to the sulfide oxidation. On the southern edge of caldera rim, dead black smoker chimneys were observed by the ROV deep tow video camera. In 2003 a Jason II ROV lowering complemented the Kaiko work and was conducted in the caldera, rising from the deepest point in the western end of the caldera northward to the summit of the caldera wall. Several areas of diffuse hydrothermal activity with sulfur patches were observed on the wall of the caldera and Fe-oxide chimney structures were observed at the north rim of the caldera on the summit of the seamount. Both pillow lava and friable shelly lava were observed at the summit area. Both lacked sediment cover and suggested recent activity in this part of the seamount.

High temperature hydrothermal activity along the spreading ridge axis was indicated by an intense hydrothermal plume in the water column around 12°50'N [*Embley et al.*, 2004]. High temperature clear fluid venting (202°C) associated with a biological community (Snail Site) was discovered at 12°55'N by ROV JasonII in 2003 [*Fryer et al.*, 2003]. This region was selected as the target field of Archaean Park Project 2nd stage (2003-2004) and extensively investigated. Two high temperature hydrothermal activities were located by successive dive programs conducted under the project.

During YK03-09 cruise using Shinkai6500 in Oct. 2003, black smoker venting of T>280°C (Pika Site) was discovered at the at the summit area of an off-axis seamount at 13°52'N [*Utsumi et al.*, 2004]. This seamount is located 5.5km southeast from Snail site, and the dredged rock samples were fresh with abundant unaltered glass. During TN167A cruise using ROV ROPOS in March 2004, another high temperature venting of T=213°C (Archaean Site) was discovered at the top of a large sulfide complex between two sites [*Ishibashi et al.*, 2004]. Three hydrothermal sites, Snail, Pika and Archaean sites align in the direction of NEE-SWW, which is roughly parallel to T1 in Fig.1. This alignment would suggest that development of hydrothermal activities is controlled by tectonic structure. In spite of these two high temperature activities at off-axis, hydrothermal activity on the ridge axis remains rather low temperature. The YK03-09 dive mission confirmed the fluid temperature of Snail Site decreases to 110°C [*Utsumi et al.*, 2004]. Extensive exploration during the YK03-09 cruise discovered only low temperature diffuse hydrothermal activity was found on the ridge crest southwest of the Snail site [*Yamanaka et al.*, 2004].

Under the Archaean Park Project, Snail and Pika sites were drilled and cased by BMS (Benthic Multi-coring System) during Hakurei-Maru #2 cruise conducted in Jan. 2004 [*Urabe et al.*, 2004]. In Snail Site, holes APM01 and APM04 are located about 5 meters west and about 20 meters southwest of the Marker #24 vent, respectively. The core of APM01 (subbottom depth=7.545 m) is characterized by porous basaltic lava with frequent fractures. Fluid with temperature of 76°C (measured with Kuster thermometer after the drilling) was discharged from one of those fractures at approximate depth of 1.2 mbsf.Pyrite crystals were observed in the pores and fractures especially at shallower depth. During TN167A cruise, ROPOS confirmed venting of the fluid of T=35°C. In Pika site, two cased holes exist; APM02 northeast of the black smokers of the Pika site and APM03 about 150 meters northwest of the black smokers. The APM02 hole (5.61 m) is entirely composed of massive sulfides (pyrite-sphalerite) beneath thin manganese oxide cover. The APM03 (4.61 m) hole shares common features with APM01 and APM04 where we saw fractured basalt lava, however, the occurrence of iron hydroxide along the fractures was found. During TN167A fluid shimmering of fluid (T=10°C) was observed from APM03.

Small pieces of fresh black smoker chimney material was recovered by dredging from the summit area of a seamount at 12°30’N, during HK98-04, suggesting the recent black smoker activity in this region. The inactive black smoker chimneys were found at many places, but only two currently active sites of black smoker venting were observed in the area. Clear smoker venting and low temperature hydrothermal areas were observed at many places along the spreading axis, adjacent off-axis seamounts, and arc volcanoes. This observation implies that the high-temperature black smoker venting occurs over only a short interval and release of heat through white and clear smoker fluids continues longer than the high temperature activity in the study area.

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4. Explanatory Notes

4.1 Research Vessel "Yokosuka"

M. Aoki (NME)

R/V Yokosuka is designed to serve as the mother vessel for Shinkai 6500 and has silent engine, an advanced acoustic navigation systems and an underwater telephone for its state-of-the-art operations. It is also equipped with various kinds of underway-geophysical equipment, i.e., Multi Narrow Beam Echo Sounder (Sea Beam 2112.04, SeaBeam Instruments, Inc.), gravity meter (Type S-63, LaCoste & Romberg Gravity Meters Inc.), ship-borne three-axis magnetometer (Type.SFG-1212, Tierra Tecnica Inc.), and proton magnetometer (Type STC10, Kawasaki Geological Engineering Co.,Ltd.). The wet-lab is equipped with a fumigation chamber, "Milli-Q" water purifier, -80℃ and -40℃deep freezer, incubator, and rock saw. In addition, YOKOSUKA has on-board video editing capability for DVCAM, S-VHS, VHS system.

Research Vessel "Yokoska"

The principal specifications

Length	: 105.22m
Breadth	: 16.0m
Height	: 7.3m
Draft	: 4.5m
Gross tonnage	: 4439t
Cruising speed	: about 16kts
Cruising range	: about 9000mile
Accomodation	: 27 crew, 18 submersible operators, 15 scientists (total 60)

Laboratory

No. 1Lab.	: dry space, video editing system, PC and printer
No.2 Lab.	: semi-dry space, freezer (-40 & -80 deg. C), incubator, Milli-Q, fumigation chamber
	: wet space, rock saw
No.3Lab.	:dry space with storage
No.1 Study Room	: dry space, gravity meter, data acquisition system of gravity meter, 3-axis fluxgate magnetometer and also proton magnetometer, workstation for data processing, A0 size plotter

4.2 Submersible “Shinkai 6500”

M. Aoki (NME)

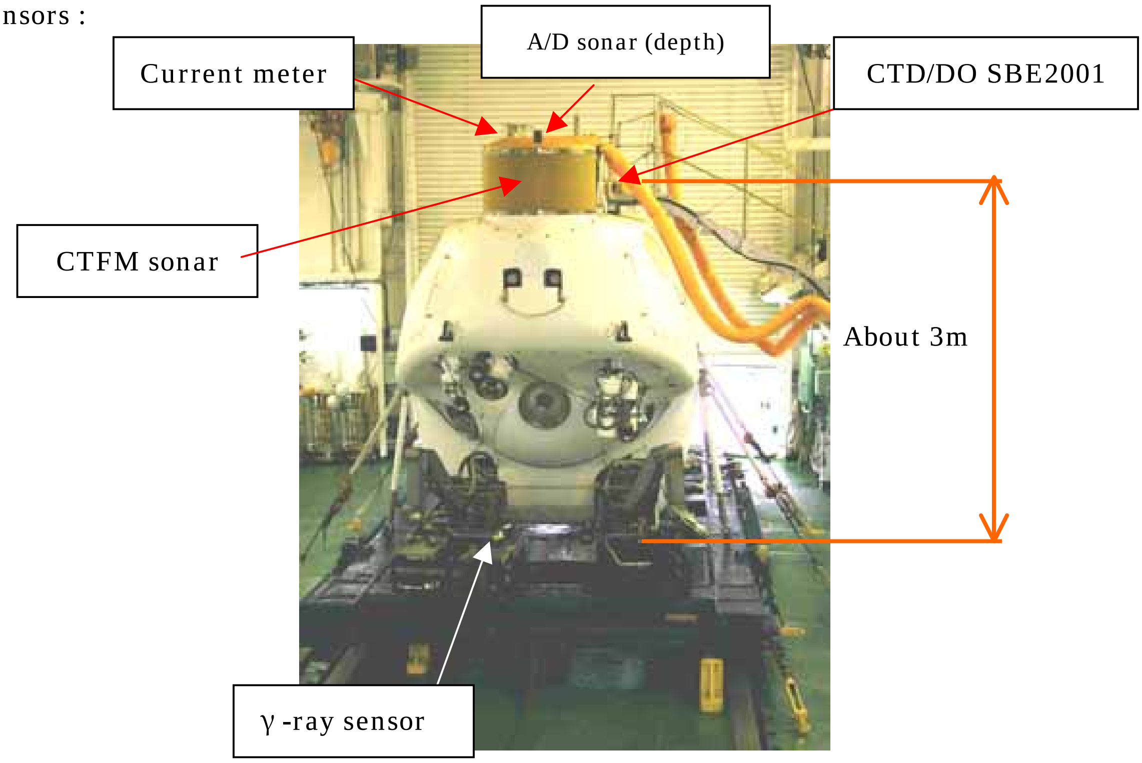
Shinkai 6500 is a manned submersible with dive capability of the world deepest 6,500 meters. Two pilot and one scientist stay in a pressure hull 2 meters in diameter which has three viewing windows. It is equipped with two manipulators, pan-tilt-zoom color video camera, a fixed-view color video camera, a digital still camera, two retractable sample baskets, CTD/DO sensors, Gamma ray spectrometer, CTFM sonar, and a video-image transmission system which enable us to watch full-color seafloor images every 10 seconds on-board the mother vessel Yokosuka. Recent innovation of the Shinkai hardware, which includes two 7-freedom manipulators (Schilling Co., USA) and two retractable baskets, made this submersible even powerful as a tool for deployment of various instruments. The total allowable weight for an observer is less than 150kg (in the air) including collected materials. The underwater speed of the submersible is 0-2.5kts and the speed can be controlled continuously. The top speed of 2.5kts is just for emergency situations.

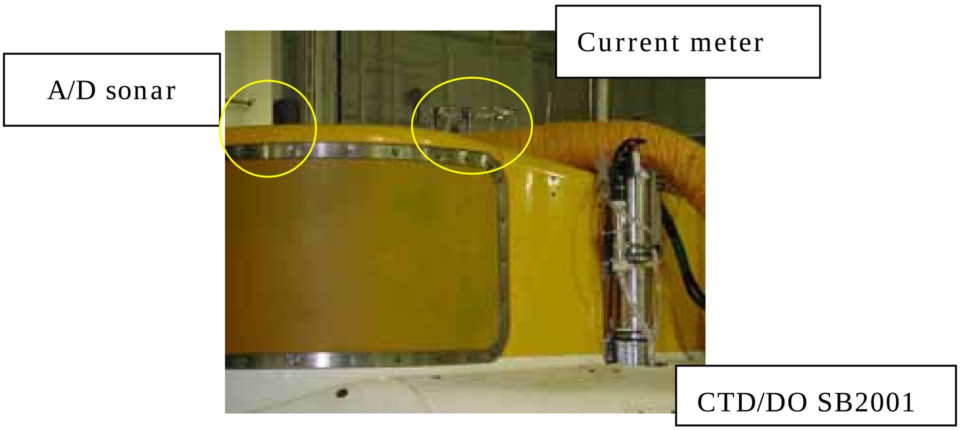
There are two ways to find the position of Shinkai6500; Long Base line system (LBL) and Super Short Base Line system (SSBL). The LBL system needs 3 bottom mounted transponders to be deployed in the survey area. The Shinkai6500 locates her position by herself and the mother ship determines the position and her position based on the position of transponders. The LBL system has the advantages of given very accurate position and the submersible can measure her own position in real time. The disadvantage of the LBL system is the additional time it takes to deploy and recover the transponders. Normally, LBL system covers the area within a circle whose radius is similar to the depth. The SSBL system does not require any transponder but the accuracy is inferior to the LBL system, and only the mother vessel can locate the position of Shinkai6500. In this case, Shinkai6500 must be notified of her position by the mother vessel. However, coverage range is similar to that in LBL system.

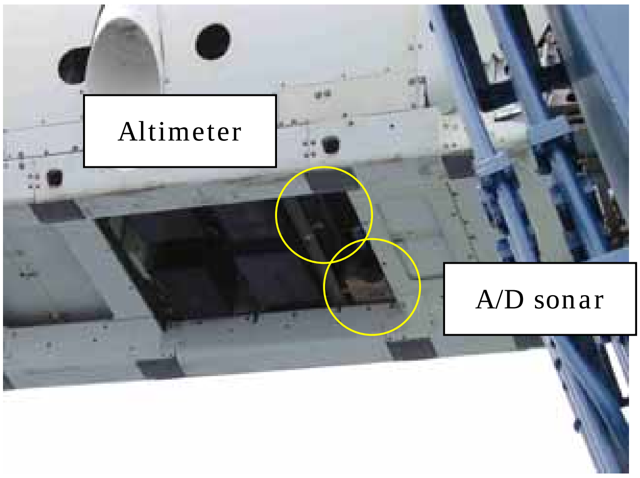
Principal Specifications:

Length over all :	9.5 m
Max. Breadth :	2.7 m
Height:	3.2 m
Weight in air:	26 t
Pressure hull size:	2.0 m (inner diameter)
Accommodation :	2 submersible operators, 1 scientist (total 3)

Sensors :


Current meter
A/D sonar (depth)
CTD/DO SBE2001
CTFM sonar
About 3m
γ -ray sensor


A/D sonar
Current meter
CTD/DO SB2001


Altimeter
A/D sonar

4.3 **WHATS** (Water and Hydrothermal-fluid *Atsuryoku* Tight Sampler)

Tomohiro Toki

Ocean Research Institute

The “WHATS” was designed with the purpose of collecting seafloor venting gas-rich fluids, including hydrothermal fluids, cold seepage fluids, gas hydrate, and gas itself. The collected fluids by the sampler can be held tight at *in situ* pressure during the ascent of a submersible. *Atsuryoku* means pressure in Japanese. It mounts a peristaltic pump, a driving motor, a controller unit contained controller-electronics and batteries, four 150 cc stainless steel sampler bottles, eight ball valves, a motor-driven arm, a rail and a flexible Teflon inlet tube. The internal volume of the sampler bottle is initially occupied with distilled water. The motor-driven arm on the rail can open one of the four cylinder samplers. Then, by pumping out the distilled water that has flooded in a room of the cylinder, the distilled water is replaced by introduction of water samples. After about 5 minutes to fill up one sample room of 150 ml capacity by the sufficiently water flows, the valves at both ends of the cylinder are tightly closed by moving the motor-driven arm again. At this stage, the next sampler becomes to be ready for next sampling. The pump and the ball valves can be controlled by an operator at a submersible cabin. We can take maximum four different gas-tight samples in series. By using only one motor to operate valves makes the sampler small, light (28 kg in seawater), and easy to handle. With the sampler, we can collect almost uncontaminated sample because we pump fluid slowly (180 cc/min.) into the cylinder using the peristaltic pump. To date, the sampler has been used for ca. forty dives of submersibles with the success rate of more than 90 %. The sampler is designed to be used in highly pressured environments to the water depth of 4,000 m. At the same time of the fluid sampling, fluid temperature is monitored using a Pt temperature probe (Nichiyu Giken, S/N0370) attached to the top of the inlet tube.

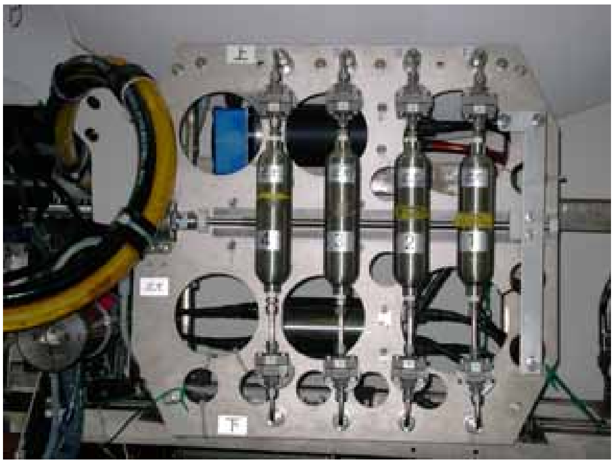


Photo WHATS

4.4 **ROCS** (Rotary Clean Seawater sampler)

Hiroyuki Kimura
Shizuoka University

The ROCS was developed as a second-generation machine of ORI water sampler. The developing concepts of ROCS are as follow:

1. Collected water ample is to use for microbiological and organic and inorganic geochemistry studies,
2. All sampling tubes (Teflon and silicon) and cylinders (made by polycarbonate and Teflon) can be autoclaved,
3. Each cylinder has 500 ml volume and independent sampling tube line,
4. Sampling tube has flushing line to clean up inside tube before sampling,,
5. When it loads by submersible vessel, we can control sampling process by using a PC inside a submersible or at the control room of ROV
6. When it puts on sea-floor for self-supporting water sampling, we can control ROCS as time series water sampler.

Its specification is as follow:

1. maximum usable depth; 4,000 m
2. size; W 50 x D 60 x H 50 (cm)
3. weight in air; total ca. 34 kg
   control unit 2.5 kg
   clump unit 7.5 kg
   pump unit 3.0 kg
   cylinder unit 7.0 kg
   battery unit 3.6 kg
   flame 10.0 kg
4. weight in water; total ca. 19 kgf
   control unit 1.0 kgf
   clump unit 5.0 kgf
   pump unit 1.0 kgf
   cylinder unit 2.0 kgf
   battery unit 1.9 kgf
   flame 8.0 kgf
5. maximum sampling volume of each cylinder; 500 ml
6. maximum number of cylinder; 6
7. sampling period; ca. 5 min / one sylinder.
8. operating environment; 0 to 40oC
9. battery; EI Lithium, 24.5 V and 15 Ah

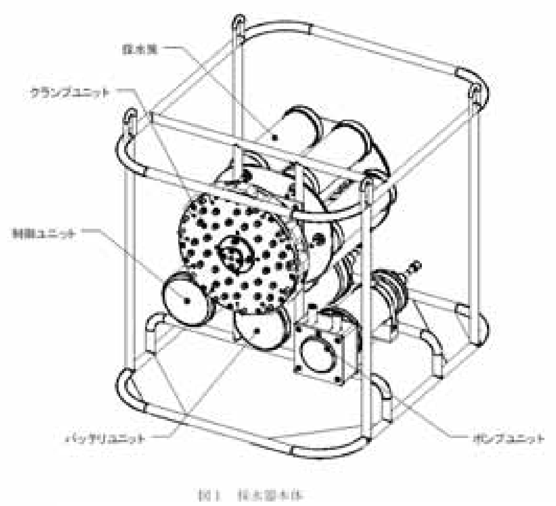


Fig. Diagrammic illustration of ROCS

4. 5　Large volume bag sampler

Hiroyuki Kimura
Shizuoka University

A large volume bag sampler was developed to collect a large volume of hydrothermal fluid in short time. The characterization and advantage of the water sampler are as follow:

7. Deep-sea impeller pump is used for water sampling,
8. The bag has amount of maximum 10 litter,
9. Approximately 8 litter of fluid sample is collected less than 3 min,
10. Sampling tube has flushing line to clean up inside tube before water sampling,
11. Collected water sample is to use for microbiological and organic and inorganic geochemistry studies.

Its specification is as follow:

1. Deep-sea impeller pump
   ・Model 5013A-P
   ・24 Volts DC
   ・Pelagic Electronics (East Falmouth, Mass)
2. Maximum usable depth; 4,000 m
3. Maximum sampling volume of each bag; 10 L
4. Maximum number of bag; 2
5. Sampling period; ca. 3 min / one bag.
6. Operating environments; 0 to 40^{o}C

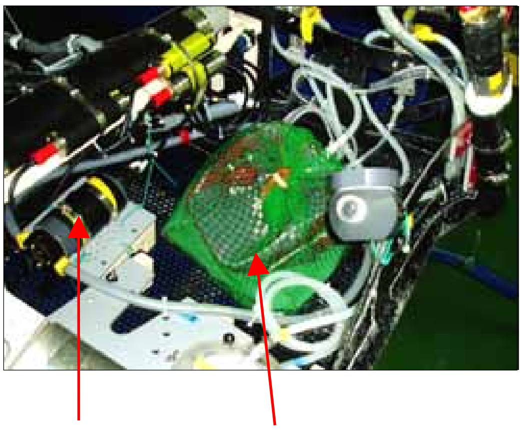


Fig. Photo of large volume bag sampler.

4.6 CTDT-Pyron

Kiminori Shitashima (CRIEPI)

In order to collect the hydrothermal plume over vents with monitoring of salinity, temperature and light turbidity, CTDT-Pyron sampler was mounted on the sample basket of SHINKAI 6500 during dive 905. The CTDT-Pyron sampler consists the sensor package (Conductivity, Temperature and Depth sensors (FSI) and Turbidity meter (Seapoint)) and twelve Niskin bottles (1.2 litters; Ocean Test Equipment) attached to bottle rack with the Pyron (FSI) that is the closing system of the sampler by electric trigger command (Fig.). The CTDT-Pyron sampler was connected to a PC in the pressure hall through an underwater cable and the data from CTDT was recorded in the PC. Niskin bottles were used to sample the hydrothermal plume waters of both diffuse (warm temperature) and focused (high temperature) vents. Niskin bottles are basically composed of polyvinylchloride (PVC) cylinder with PVC cap closures at both ends. The two end closures are attached with rubber tubing that is stretched to cock the bottles open; when tripped the tubing snaps the tops against the cylinder ends, capturing the water within, and hold the caps tightly closed for the duration of the submergence. The Niskin bottles were carried to the lab and put in the racks. Aliquots for gas analysis (Total CO_2 and methane) were removed, poisoned and fixed in septum grass bottles. Next aliquots for pH for onboard analysis and trace metals, nutrients and microbiology for analysis on land were taken.

Fig. CTDT-Pyron sampler

4.7 In-situ pH/pCO$_2$/ORP sensor

Kiminori Shitashima (CRIEPI)

In-situ mapping of the chemical parameters in hydrothermal plumes are the most efficient methods for trying to understand hydrothermal discharge. In-situ chemical sensors are convenient for these purposes. Hydrothermal plumes show pH anomalies because carbon dioxide and/or hydrogen sulfide-rich fluids are injected into the water column. An in-situ pH sensor was developed for mapping of pH anomalies at hydrothermal active areas. The in-situ pH sensor employs an Ion Sensitive Field Effect Transistor (ISFET) as a pH electrode, and the Chloride ion selective electrode (Cl-ISE) as a reference electrode. The ISFET is a semiconductor made of p-type Si coated with SiO_2 and Si_3N_4 that can measure H^+ ion concentration in aqueous phase and has a quick response (within a few second), high accuracy (±0.005pH) and pressure-resistant performance. Before and after observation, the pH prove was calibrated by two different standard solutions (2-aminopyridine (AMP); pH=6.7866 and 2-amino-2-hydroxymethil-1,3-propanediol (TRIS); pH=8.0893) for the proofreading of electrical drift of pH data.

A pCO$_2$ (partial pressure of carbon dioxide) sensor and an ORP sensor were also installed to SHINKAI 6500 with the pH sensor. The principle of pCO$_2$ measurement is as follows: the pH electrode and the Cl-ISE of the pH sensor are sealed with a gas permeable membrane filled with the inner solution. The pH sensor can detect the pCO$_2$ change as the inner solution pH changes which is caused by penetration of carbon dioxide through the membrane. An amorphous Teflon membrane manufactured by U.S. DuPont (Teflon AF™) was used as the gas permeable membrane for this pCO$_2$ sensor. An ORP sensor employs a platinum wire as a working electrode and Cl-ISE as a reference electrode.

The in-situ pH/pCO$_2$/ORP sensors were installed to SHINKAI 6500 and in-situ data were measured every 10 seconds during the operation.

4.8 Zero plume sampler (Iron Dumbbell type sampler; Mr. Iron Dumbbell)

Kiminori Shitashima (CRIEPI)

The iron dumbbell type sampler install ball valve (SS-67TF24) made by Swegelok in both ends of SUS pipe that is done mirror finish of inner face. The funnel that attached to one valve is put on hydrothermal vent. After passing of hydrothermal fluid through the sampler, the zero plume sample is collected by closing the upper valve and the lower valve sequentially. The funnel is removed after recovery, and a plug caps with a stop valve are connected to both valves. Internal pressure is measured in pressure gauge, and gas sample and aqueous sample is collected.

4.9 M-type sampler

Harue Masuda (Osaka City University)

This sampler was designed for scraping the bottom sediment. The lid is connected to the bottom of the sampler using rubber band. Before using, the string tied with the lid connects to the trigger, which attached on the bottom of the sampler. After scraping sample (sediment, biomat, etc.), the string is removed as the trigger push to the bottom surface.

Fig. Before using. The lid is open and connected with the trigger.

Fig. After the trigger got off to close the lid.

4.10　In situ filtration system

R. Suzuki and T. Yamanaka (Kyushu Univ.)

本装置は熱水や海水中の懸濁物もしくは溶存有機成分を現場にて濾過濃縮する装置である。構成は、チタン製吸い口、インライン型のステンレス製フィルターフォルダーと、吸引装置としてのペリスタルポンプ、作動用のバッテリーとスイッチの組み合わせからなる。フィルターフォルダーに取り付けるフィルターの種類を通常のメンブランフィルターか溶存有機物濃縮用の固相抽出膜にすることにより、多量の熱水もしくは海水から濾過濃縮することが出来る。

本航海では最大流量170ml/min.のペリスタルポンプを用い、固相抽出膜3M Empore Disk 18FF（直径 90mm）を組み合わせることで、熱水中溶存有機成分の濃縮（抽出）を行う。フィルターフォルダーへの固相抽出膜の組み込みは、熱水沈殿物による固相抽出膜の目詰まりと懸濁態有機物の膜への吸着を防ぐため、まず、孔経 1μm のガラス繊維製プレフィルターを膜の上に置き、その上に直径40μmのガラスビーズを厚さ約5mmになるように敷き詰めた。その後、50ml のメタノールにて固相抽出膜のコンディショニングを行い、MiliQ 水に置き換えた後、全ての流路をMiliQ水で満たした。

採水口には、離合社の温度計を抱き合わせて、濾過中の水温変化をモニターできるようにした。操作は、本体とバッテリーを採水対象（熱水噴出孔など）のそばに設置後、採水口を差し込み、マニピュレーターでスイッチをオンとする。回収時にはスイッチをオフとし、本体とバッテリーをそれぞれ持ち帰る。　　（YK03-09 Cruise Report より引用）

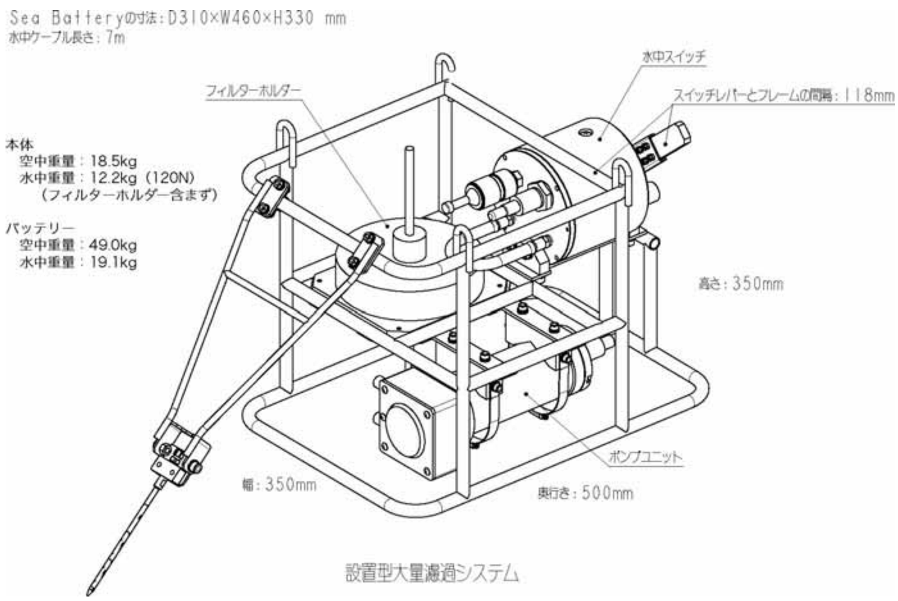


Fig. Scheme of in situ filtration system

5.1 List of dive information

Dive No. Date/Time (Local =UTC+10)	Dive Site	Scientists Institute	Objectives	Pilot Co-pilot	Landing Latitude Longitude Depth, Time	Leaving bottom Latitude Longitude Depth, Time	Payloads	Sample etc.	Master Videos No.1 Quant.	 No.2 Quant.
6K#900 2005/7/26	South Mariana Trough Ridge axis of the Mariana backarc spreading center	H. Masuda OCU	Reconnaisssance survey of the spreading axis and avobe the magma chanber	M.Yanagitani H. Ueki	13-52.0457'S 179-03.4423'E 2,907m 11:22	13-51.5163'S 179-03.5422'E 2,893m 16:19	• WHATS, ROCS, Bag with high temperature probe • Sample box (x 4) •pH, pCO2, ORO sensors • M-type sediment sampler (x 1) • scoop (x 1)	Sample: 14 rock samples from 12 sites. WHATS x 1, ROCS x 1, Bag x 1	2	2
6K#901 2004/10/27	South Mariana Trough Ridge axis of the Mariana backarc spreading center	P. Fryer Univ. of Hawaii	Reconnaisssance survey of the spreading axis and exploration of hydrothermal sites observed previously with KAIKO	K. Iijima Y. Chida	13-07.0898'N 143-41.7380'E 2,938m 11:24	13-05.9428'N 143-41.2897'E 2,880m 16:09	• WHATS, ROCS, Bag with high temperature probe • Sample box (x 4) •pH, pCO2, ORO sensors • M-type sediment sampler (x 1) • scoop (x 1) • Marker (x2)	Sample: yellow deposit by M-type sediment sampler 5 volcanic rocks from 4 sites hydrothermal crust x 1 WHATS x 2, ROCS x 2, Bag x 1 Deploy: • #16 marker	2	2
6K#902 2005/7/28	Snail Site Southern Mariana Trough	H. Kimura Shizuoka Univ.	Time series study of hydrothermal activities in south Mariana Backarc Spresding Center	I. Kawama K. Matsumoto	12-57.2272'N 143-37.0530'E 2,853m 11:18	12-57.1625'N 143-37.1308'E 2,848m 16:20	• WHATS, ROCS, Bag with high temperature probe • in-situ filter (x 1) • Sample box (x 1) • pH, pCO2, ORO sensors • M-type sediment sampler (x 1) • Marker (x 2) • trap (x 1)	Sample WHATS x 4, ROCS x 6, Bag x 1 rock x 1	2	2
6K#903 2005/7/29	Archaean Site Southern Mariana Trough	J. Ishibashi Kyushu Univ.	Time series study of hydrothermal activities in south Mariana Backarc Spresding Center	M. Yanagitani Y. Chida	12-56.2566'N 143-37.9170'E 3,082m 11:20	12-56.3531'N 143-37.9111'E 2,969m 15:53	• WHATS, ROCS, Bag with high temperature probe • Sample box (x 4) • pH, pCO2, ORO sensors • Marker (x 2)	Sample: WHATS x 4, ROCS x 6, Bag x 1 7 hydrothermal deposit from 4 site crabs x4, shrimp x1 Deploy: #12 and #17 marker	2	2
6K#904 2005/8/2	Snail Site Southern Mariana Trough	H. Kimura Shizuoka Univ.	Time series study of hydrothermal activities in south Mariana Backarc Spresding Center	T. Sakurai Y. Sasaki	12-57.1640'N 143-37.1197'E 2,852m 11:16	12-57.1708'N 143-37.1190'E 2,852m 15:35	• WHATS, ROCS, Bag(x 2) with high temperature probe • Niskin water sampler (x 1)l • Sample box (x 1) • pH, pCO2, ORO sensors • M-type sediment sampler (x 1) • Marker (x 2)	Sample: WHATS x 2, ROCS x 5, Bag x 2 rock x 3, sediment x 1 bio mat x 1 gastropods x 48, crab x1	2	2
6K#905 2005/8/3	Archaean Site Southern Mariana Trough	K. Shitasima CRIEPI	Geochemical study of hydrothermal plume in south Mariana Backarc Spresding Center	K. Iijima Y. Ono	12-56.3293'N 143-37.9590'E 3,068m 11:28	12-56.5041'N 143-38.0311'E 2,972m 15:58	• CTD-Pyron with 12 Niskin water sampler • TETSU Array water sampker (x 1) • pH, pCO2, ORO sensors • Off line Thermometer (x 1) • sample box (x 1)	Sample: Niskin x 10 TETSU Array x 1 Deploy: #18 marker	2	2
6K#906 2005/8/4	Pika Site Southern Mariana Trough	T. Toki ORI	Time series study of hydrothermal activities in south Mariana Backarc Spresding Center	I. Kawama M. Yanagitani	12-55.1761'S 143-38.9388'E 2,788m 11:17	12-55.1265'S 143-38.8890'E 2,787m 16:01	• WHATS, ROCS, Bag with high temperature probe • Sample box (x 1) •pH, pCO2, ORO sensor • UZUKI chimney sampler (x1) • Marker (x 2)	Sample: WHATS x 3, ROCS x 5, Bag x 2 rocks x 5 Deploy: #19 marker	2	2
6K#907 2005/8/5	Southern Mariana Trough Ridge axis of the Mariana backarc spreading center	H. Masuda OCU	Reconnaisssance survey of the surface morphology of the spreading ridge and hydrothermal activities	Y. Sasaki Y. Ono	13-06.6677.'S 179-04.1033'E 2,948m 11:18	13-07.6370'S 143-41.22658'E 2,915m 16:01	• WHATS, ROCS, Bag with high temperature probe • Sample box (x 4) • pH, pCO2, ORO sensors • Marker (x 2)	Sample: 14 rock samples from 11 sites. Bag x 1	2	2

5.2 Dive Summary

Dive #900 (25th, Jul. 2005)

Scientist: Harue Masuda

Affiliation: Department of Geosciences, Osaka City University

Pilots: M. Yanagitani & H. Ueki

Target: Ridge axis of the southern Mariana backarc spreading center

Purpose: Reconnaissance survey of the spreading axis and above the magma chamber

Samples: Volcanic rocks (14 samples from 12 sites), ambient seawater (WHATS 1; ROCS 1, Bag sampler 1)

Observation

The landing point seemed to be a lava lake. The submersible mostly moved along the crest of the ridge, where the volcanic rocks were thinly covered white sediments. The volcanic rocks distributed along the track were lava field which covered with splattered fragments and pillow lava. Circular depression, a few to ten meters diameter, are found on the track. Especially this topography was characteristic above the presumed magma chamber. Inside the depression was commonly filled with hyaroclastic lavas. Sheeted lava flows were observed at two locations.

All rocks obtained during this dive were fresh and had quenched glass rim. Some of them were coated with iron oxyhydroxide but not manganese oxide. This feature indicates that this area is magmatically active at present.

Hydrothermal activity was not observed during this dive. However, the transparency of the seawater was not very good due to the white suspended matters flew from west in the most of time on the ocean bottom. Thus, the active hydrothermal area can be expected on the west of the ridge crest.

Dive #901 (26th, Jul. 2005)

Scientist: Patricia Fryer

Affiliation: Hawaii Institute of Geophysics and Planetology, University of Hawaii

Pilots K. Ijima & Y. Chida

Target: The northernmost tip of the southern Mariana backarc spreading center

Purpose: Reconaissance survey of the spreading axis and exploration of hydrothermal sites observed previously with Kaiko.

Samples: volcanic rocks (4 samples), hydrothermal crust (1), hydrothermal sediment (possibly microbial mat) (1) and hydrothermal fluid (WATS (2), ROCS (2) and Bag sampler (3 min)).

Observations:

The dive started (1119L) at the northern end of the Malaguana-Gadau Ridge and proceeded south for more than 2 km. The landing site was in a field of large pillows. **Rock #1** was a sample of a pillow that had very little sediment. The area looked relatively young. There were many small grabens (~ 1-3 m deep), the bottoms of which were covered with ropy lava or fragments of lava that was very thin, almost like shelly pahoehoe in places. We headed south at 190 and encountered an area of hydrothermal activity at 11:45L. Several holes between pillows were emitting shimmering water. WE chose one that had orange coating and two anemones. the maximum temperature we measured was ~11°C max. A few crabs hovered near or within the vent sites. This area also hosted some yellow, stalked animals with frond-like appendages (looked like a frilled fan). I saw one small (~2 cm) white snail on a pillow surface. There were numerous very tiny (1-2 cm tall) anemones scattered over the surfaces of the pillows and pillow tubes.

After sampling we headed at 190° again and continued traversing large pillows. At 1210L we saw a small (3-m-diamter, 1.5m high) mound of highly vesicular spatter with very large “vesicles” (~20 cm diameters) and was extremely thin-walled and very friable (too delicate to sample). This material resembles reticulite. From 1212 to 1230L we traversed a series of pillow tubes some of which had collapse structures interspersed with sheet flows. We tried to sample a rock (~1231L) from an area of spatter at the top of a narrow ridge surrounded by sheet flows on one side and ropy lava on the other, but the material was too friable to sample with the manipulator. **Rock #2** came from close to the friable material, but the lava where we sampled had a more ropy texture.

After sampling we headed south again at ~190° and traversed a series of large pillows and pillow tubes interspersed with areas of shelly or ropy lava. Some areas of pillows had collapse structures. The skin of the collapsed pillow tubes was varied from ~20 cm wide to very thin (~2-3 cm) shells. Some collapsed tubes had interiors with partial remains of structures that looked like septa (between large vesicles), suggesting that the lava was very volatile rich. One tube had a breakout that looked as though it had been very fluid and likely only 5-10 cm thick. The break-out lava flow extended for about 4-5 m beyond the end of the broken tube and fanned out to a width of about 2 m. The interiors of some collapsed tubes were sometimes “layered” as if they had the typical 'tide" marks left in Hawaiian lava tubes as the lava level fluctuates and the flow drains from the tube. In a depression observed at about 1216L we saw two lava pillars. At the edge of this depression and on the adjoining ridge we saw exclusively shelly to ropy lava, very contorted. At ~1335L we approached a narrow ridge with large pillows (some with collapse features) until at 1338L we dropped into a narrow graben with shelly contorted lava. Then at ~1340L we again saw large pillows and stopped to sample (**Rock #3**) from one of them. Immediately to the east of the pillow ridge was a narrow (3-4-m-wide) depression with a sheet flow surface. After sampling we continued south and for the next 15 minutes the seafloor alternated between low ridges of large pillows with interspersed depressions of ropy lava and sheet flows.

At 1404L we changed course toward the west (270°) to rise up to the ridge crest and follow it southward. Rising the east edge of the ridge crest we saw pillow tubes (one of which had collapsed) and for a short time (~1 min) we observed smooth sheet lava blanketing the flank of the ridge. Above the sheet lava we saw more ropy, thin flows. At 1414L we reached the summit of the ridge and saw a small graben about 6-7 m wide and ~3 m deep that was floored with ropy, and contorted lava.

At 1414L we changed course to 190° and one minute later saw large pillows again, followed another minute later by very ropy lava. We approached a scarp where large pillows had been truncated and in a narrow recess we saw hydrothermal detritus covering the edges of the scarp. As we maneuvered to approach the hydrothermal crust we noticed small (1-5 cm) fragments of glassy pillow lava dislodged from the part of the scarp surface not covered with hydrothermal material. We scooped some orange crust (**Hydrothermal Sample #4**) and fragments of the pillow lava adjacent to the sub that were dislodged during maneuvering fell into the starboard sample basket (**Rock #4**).

At 1441L we moved up the scarp and at the top the seafloor had the spikey appearance of Hawaiian aa lava, but from previous observations in this area with Jason2 it was clear that this material was not lava, but small hydrothermal chimneys with a dark manganese oxide (?) coating. There was no evidence of shimmering water.

At 14:58:30 we changed course to 200° to head for the “Kaiko” hydrothermal area. The lava we observed in this area was ropy and there were occasional very small (10-20 cm diameter) patches of bright orange material (microbial mat?) between the ropes (I took a hand-held picture of one patch).

At 1510L we changed course to west (270°) to go up hill. The flank of the hill has very large lava blocks (with streaks of light-gray hydrothermal alteration. At the top of the hill we saw small chimney structures with black bases and orange (bacterial mats?) coating on top and inside of vents where shimmering water was emanating. There were several areas of shimmering water. We measured temperature in what appeared to be the most actively venting orifice and got a maximum temperature of 33°C. We sampled for hydrothermal fluids (**Fluid samples: WATS (2), ROCS (2) and Bag sampler (3 min)**). We then used the sediment sampler to collect orange material from beneath the surface of the vent. We left **Marker #16** and ended the dive.

Dive #902 (27th, Jul. 2005)

Scientist: Hiroyuki Kimura

Affiliation: Department of Biology and Geosciences, Shizuoka University

Pilots: I. Kawama & K. Matsumoto

Target: Marker #24 in Snail site (Fryer site) and a casing pipe (APM01)

Purpose: (1) Observation of hydrothermal activities and biological communities in Snail site, and (2) Sampling of the hydrothermal fluids, biomats and rocks.

Observations:

The landing point was in a field of lava that was thinly covered with yellow sediments. We headed at 120^{o} and run to **Mk#24** in Snail site. After arriving at the **Mk#24**, the submersible landed around the vent that was covered with the snails (Depth=2849m). We tried sampling of hydrothermal fluids by using water samplers [**WHATS (W-1, W-2, W-3), ROCS (R-1, R-2, R-3, R-4), Bag (B-1)**]. However, the water sampling using ROCS and Bag miscarried. During the water sampling, we measured temperature of the fluid and got a maximum temperature of **53^{o}C**.

After sampling at **Marker #24**, we headed at 190^{o} and run to a casing pipe **(APM01)** that was constructed in drilling project in HAKUREI No2 cruise. After arriving at **APM01**, submersible landed around the casing pipe (Depth=2853m). We observed very week shimmering fluids flowing out from a top of the casing pipe. We collected the shimmering fluid by using water samplers [**WHATS (W-4), ROCS (RC-5, RC-6)**]. We measured temperature of the shimmering fluid during the water sampling. The highest temperature was **36^{o}C**. We then left the casing pipe and ended the dive.

Dive #903 (28th, Jul. 2005)

Scientist: Jun-ichiro Ishibashi

Affiliation: Faculty of Science, Kyushu University

Pilots M. Yanagitani & Y. Chida

Target: Archaean site in the Southern Mariana Backarc Spreading Center

Purpose: Time series study of hydrothermal systems in south Mariana

Samples: Ore deposits (7 samples), animal (2 crabs) and hydrothermal fluids from three vents (WHATS (4), ROCS (6) and Bag sampler).

Observations:

At 11:20 (Local time), we arrived at the bottom (depth=3082m) covered with red sandy sediment. After a short run, we landed again to collect rocks at 11:26. Although we tried to grab basaltic rocks, both of two pieces obtained were sulfide blocks (sample **R-1**). A few meters far from this point, I found a nice shape pillow lava, however missed it, which is the last basalt I observed during this dive. Around 11:45, we observed talus of sulfide blocks and started climb up the cliff.

At 11:50, we found active venting site along the slope top (depth=3001m). Chimneys of 1 to 2 meters high venting black smokes stood on a mound structure of 10m-width covered with white material (see the picture). We observed also clear fluid shimmering from the whole surface of the mound, and animals such as crabs on the surface. At first, we collected hydrothermal fluids from a small black smoker (sample **W1-2, RC1-2**). The highest temperature during the sampling was 343°C. We noticed fluid is boiling at the orifice of another black smoker. After the fluid sampling, we grabbed the chimney and an ore block just beneath the chimney (sample **R-2**). Then, we focused the foot of the mound, and collected clear fluid from a fissure (sample **W3, RC3-4, B**). The highest temperature during the sampling was 117°C. We also collected ore samples around the fluid sampling point (sample **R-3**). Additionally, we grabbed one active chimney (sample **R-4**) and stored in the sample box. Before we left the site, we deployed **Marker #12**.

At 14:03, we started to sail along the slope to the top of Archaean mound. On that way, we found a few weak fluid shimmerings surrounded by white patches. At 14:15, we sampled a block of sulfide covered with red surface (sample **R-5**) at a step-like place in the middle of a cliff.

At 14:22, we climb up the cliff and found an active site (depth=2974m). Clear fluid was emitting from white colored area of 5-10m width, and a few dead chimney shape structures were observed in the neighbor. At first, we deployed a bio-trap to collect shrimps and crabs. After some trials for searching suitable orifices, we start fluid sampling (sample **W4, RC5-6**) from a tiny chimney. The fluid temperature was around 30-40°C in the beginning, however came up to 90°C during the sampling. After we recovered the bio-trap in the sample box, we started sampling of ore blocks. After we collected some blocks with red surface (sample **R-6**), we tried to grab a crust material from the active area, but in vain. Finally, grabbed another piece of crust-like block just beside the active area, and we found it was too big to store in a sample box and decided to put it on the sample boxes (sample **R-7**). After we deployed **Marker #17**, we left the site and ended the dive at 15:50.

Dive #904　(2nd, Aug. 2005)

Scientist: Hiroyuki Kimura

Affiliation: Department of Biology and Geosciences, Shizuoka University

Pilots: T. Sakurai & Y. Sasaki

Target: a casing pipe (APM01) and Mk#24 in Snail site (Fryer site)

Purpose: (1) Observation of hydrothermal activities and biological communities in Snail site, and (2) Sampling of the hydrothermal fluids, biomat, snails and rocks.

Observations:

The landing point was in a field of lava that was covered with thin sediments. We headed at 120^o and run to a casing pipe **(APM01)**, which was constructed by drilling project with BMS in HAKUREI No2 cruise. After arriving at the **APM01**, the submersible landed around the casing pipe (Depth=2853m). We observed shimmering fluid flowing out from top of the casing pipe. We measured temperature of the shimmering fluid and got a maximum temperature of **40.2^{o}C**. We collected the shimmering fluid from the casing pipe by using the fluid samplers [**WHATS (W-1), ROCS (RC-1, RC-2), Bag (B-1)**].

After the water sampling, the submersible run to **Mk#18** and collected yellow biomats by using M-type sediment sampler (Depth=2852m).

After sampling of the yellow biomats, we headed at 10^o and run to **Mk#24**. The submersible landed around **Mk#24**, and temperature of hydrothermal fluids was measured (Depth=2849m). The highest temperature of hydrothermal fluid was **116^{o}C**. We collected the hydrothermal fluids with water samplers [**WHATS (W2-), ROCS (RC-3, RC-4, RC-5), Bag (B-1)**]. After the water sampling, we carried out the sampling of snails (ca. 50 samples).

We headed at 230^o and run to southwest. We started to survey along Mk#24 to Yamanaka site, and collected rocks. We left the seafloor and ended the dive.

Dive #905　(3rd, Aug. 2005)

Scientist: Kiminori Shitashima

Affiliation: Central Research Institute of Electric Power Industry (CRIEPI)

Pilots: K. Iijima & Y. Ohno

Target:　Archaean site in the Southern Mariana Backarc Spreading Center

Purpose: 1) Hydrothermal plume sampling and 2) chemical mapping of hydrothermal plume diffusion at the Archaean site

Samples: Hydrothermal plume; 11 samples, Zero plume (hydrothermal fluid); 1 sample

Observations:

We landed at the bottom (depth; 3068m) of the east of the **Marker #12** at 11:28 and started running in west direction to find the **Marker #12**. At 11:42, we found shimmering site covered with white material, but continued a search of the **Marker #12**. At 12:04, we found a new black smoker site in the northeast side of the **Marker #17**. This site resembled the **Marker #12** site very much. There were many chimneys venting black and clear smokes on the top of white mound, the greatest chimney was height of 1 to 2 meters. However, we gave up sample collection from this chimney, because the scale of this site is smaller than it of **Marker #12**. We deployed **Marker #18** (depth; 3003m) in this site and started a search of the ROPOS site that found on the ROPOS cruise in 2003.

At 12:22, we found a big dead chimney of about 5 meters high and mound at 30 meters west of the **Marker #17**. This mound covered with white material in patches and clear fluid shimmering was observed there. We confirmed the **Marker #17** in a few minutes. We gave up to find the ROPOS site and went to the **Marker #12** site.

We arrived at **Marker #12** site at 12:37 and landed in front of main chimney. At first, we measured temperature of zero plume (just above the orifice of black smoker; highest temperature was 345.1°C) and collected the zero plume using the iron dumbbell type sampler **(**sample **ID**). After the zero plume sampling, we started the plume sampling by taking the distance above the black smoker vent gradually (sample **N-1 (1m), N-2 (10m), N-3 (40m), N-4 (50m), N-5 (100m), N-6 (200m)**).

At 13:46, we start mapping of hydrothermal plume. The SHINKAI 6500 had grid cruising at two horizontal layers of 30m altitude (B-30m; 2965m deep) and 50m altitude (B-50m; 2945m deep) within the 400m X 400m area around the vent. The B-30m layer cruised north-south direction and the B-50m layer cruised east-west direction. We collected two plume samples (sample **N-7 (X:490, Y:110), N-8 (X:510, Y:-130)**) at B-50m layer and four plume samples (sample **N-9 (X:530, Y:-70), N-10 (X:470, Y:90), N-11 (X:520, Y:230), N-12 (X:680, Y:220)**) at B-30m layer. After the mapping finished, we started ascent to the surface (15:56).

Unfortunately, the sample of **N-11** could not take by a mechanical trouble and the samples of **N-1, N-2, N-3, N-9** and **N-12** mixed with surface water at surface by very bad sea condition during recovery of SHINKAI 6500.

Dive #906 (4th, Aug. 2005)

Scientist: Tomohiro Toki

Affiliation: Ocean Research Institute, the University of Tokyo

Pilots: I. Kawama and M. Yanagitani

Target: Pika site

Purpose: Chronicle of the hydrothermal activity off the axis of the south Mariana back-arc spreading center

Samples: Hydrothermal fluids (WHATS 3, ROCS 3), chimneys (3), rocks (1), seawater (ROCS 2)

Recovery: ROV homer

Deployment: Marker #19

Operations:

We observed a dead chimney of ca. 15 meters, shimmering water, white-colored seafloor, and crabs related to hydrothermal systems around the landing point and sampled a rolling rock from the seafloor, the D906 R-1. The SHINKAI 6500 ran heading southward, 190 degree. We arrived at the Pika site with the ODP-P marker and the ROV homer at 11:45. At 12:13, hydrothermal fluid was sampled from one of black smokers at the Pika site by WHATS (D906 W-1) recording 330 degree C of the maximum temperature during the fluid sampling. At 12:27, the following sampling of hydrothermal fluid was carried out from the same smoker by ROCS (D906 RC-1; max temperature: 311 degree C). At 13:12, shimmering fluid from white-colored seafloor was taken using WHATS (D906 W-2; max temp.: 11 degree C), followed by sampling using ROCS from 13:30 (D906 RC-2, up to 15 degree C). At 13:37, the chimney venting shimmering water less than 60 degree C near the sampling point of the D906 W-2 and RC-2 was taken by the manipulator. At 13:53, other shimmering fluid from the foot of the chimney venting black-colored fluid sampling the D906 W-1 and RC-1 was sampled by WHATS (D906 W-3; < 32 degree C) and by ROCS from 13:04 (D906 RC-3; < 12 degree C).

We tried to sample the chimney venting the black smoker sampled D906 W-1 and RC-1 using UZUKI. But the sampling was failed and the chimney was broken out into pieces. We collect the pieces of the chimney from the seafloor around the submersible (D906 R-3, -4, and -5). At 14:46, the ROV homer was recovered. At 14:48, the marker #19 was placed near the ODP-P marker. At 14:50, we left the Pika site, and start to quest the casing pipe (APM03). The D906 RC-4 and -5 were collected from deep seawater (15:45 ~ 15:55). At all, the pipe couldn't find during the dive, and we left the seafloor at 16:00.

Dive #907 (5th, Aug. 2005)

Scientist: Harue Masuda

Affiliation: Department of Geosciences, Osaka City University

Pilots: Y. Sasaki & Y. Ohno

Target: Ridge axis of the southern Mariana backarc spreading center

Purpose: Reconnaissance survey of the spreading axis and above the magma chamber

Landing location: 13°06.6770'N, 143°40.8915'E

Leaving location: 13°07.6370'N, 143°41.2265'E

Samples: Volcanic rocks (14 samples from 11 sites), ambient seawater (Bag sampler 1)

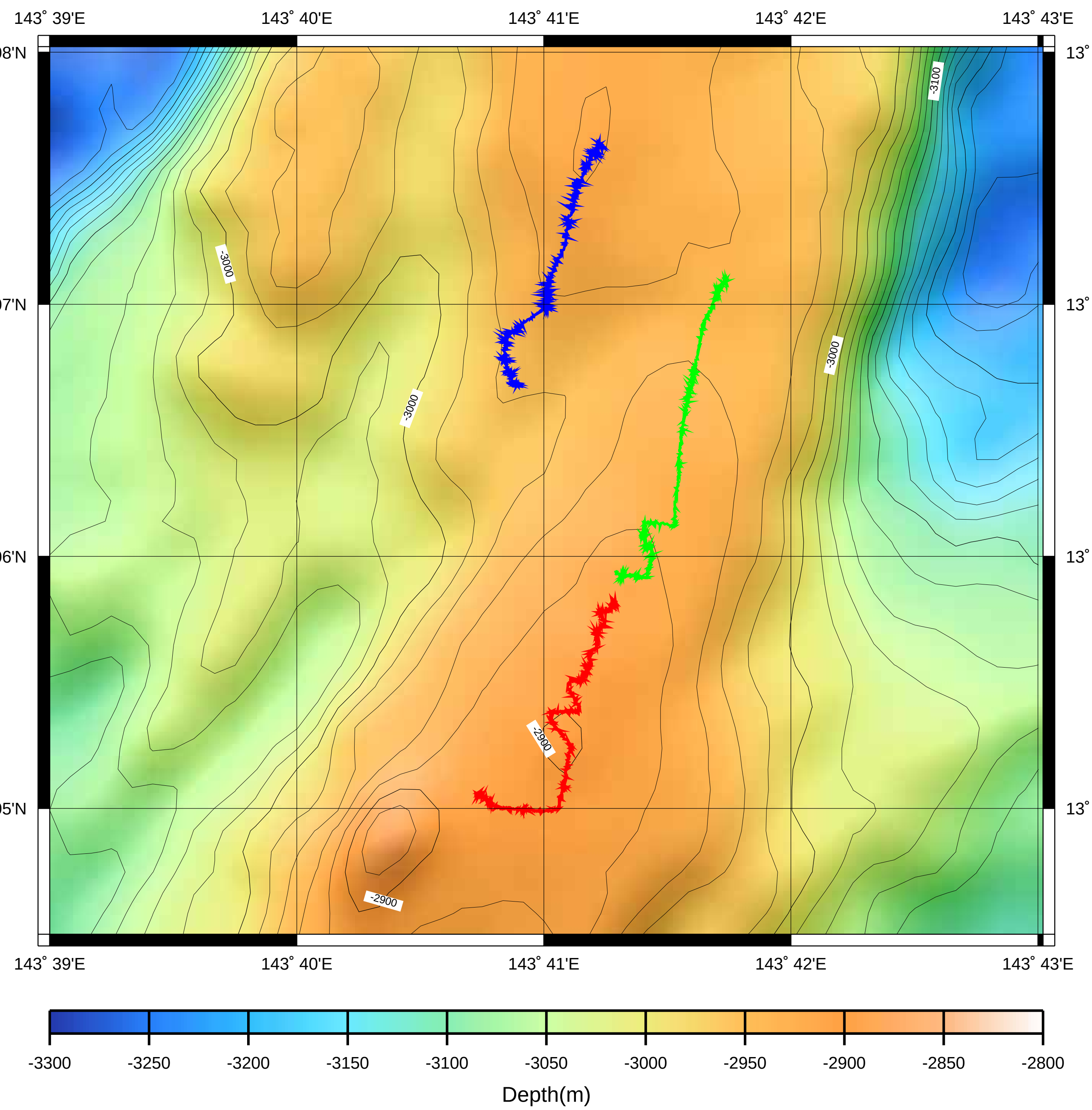
Observation:

Target of the dive was tracing along the ridge crest to observe the volcanic activities. The landing area was foot of the spreading ridge axis of the southernmost part of the northern segment, where the pillow lava field was thinly covered with sediments, suggesting no present activity of the volcanisms in the area. The submersible moved toward NNW to climb to the ridgeline. Small part of the rock surface colored white due to the hydrothermal alteration occurred when the eruption occurred in this area. After arriving the ridge crest, the submersible started moving toward NNE along the running direction of ridge axis. The ridge crest was mostly covered by roapy lava flow, and occasionally pillow lava appears.

It is interesting that the pillow and roapy lavas are different not only from those shapes but also the fragility. When the manipulator tried to pick up the rocks, it was hard to remove pillow lava from the bottom surface. While the roapy lava was too fragile to pick up by manipulator. Those two lavas must have the different chemistry and are attributed to the different stage of the same eruption or different period of the eruption.

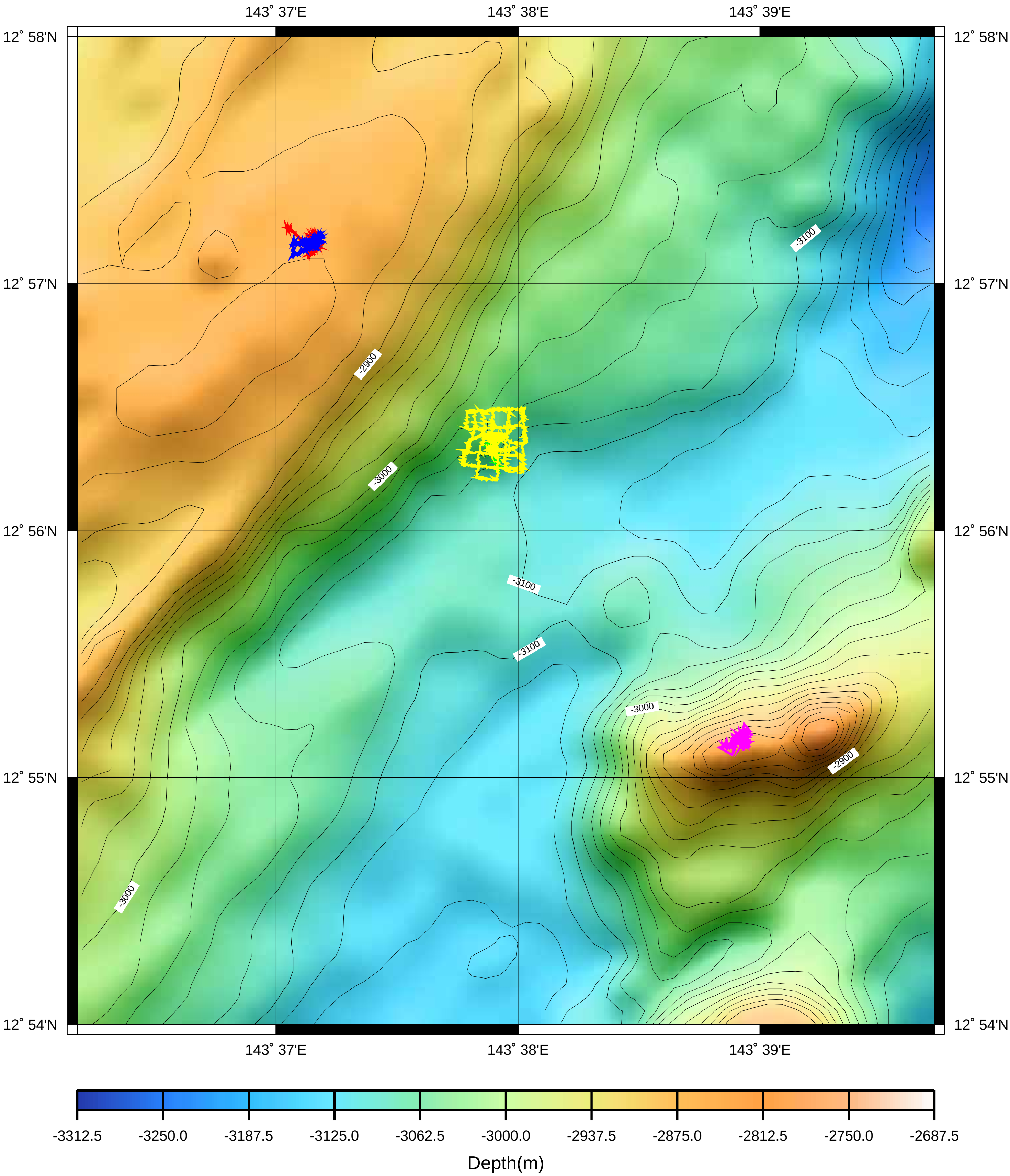
Although low temperature hydrothermal activity was expected, he water was clear along the track, indicating no hydrothermal activities. Close to the summit, there are many bowl-shaped depressions, which have 3~10 m diameters and depth. Inside the depressions, fragmental rocks were scattered. Those would be formed by collapse of lava flow after cooling the surface.

YK05-09 SUB_TRACK North Area



GMT Aug 9 10:33 **R/V_YOKOSUKA,YK05-09_Leg2,subtrak_north.grd,cmd,dx/dy=100m,contour=100m**

YK05-09 Leg2 SUB_TRACK South Area



GMT Aug 9 10:42 R/V_YOKOSUKA,YK05-09_Leg2,subtrak_south.grd,cmd,dx/dy=150m,contour=100m

6. Preliminary results

6.1 Bathymetry Data from YK05-09-Leg 2

Patricia Fryer (Univ. Hawaii)

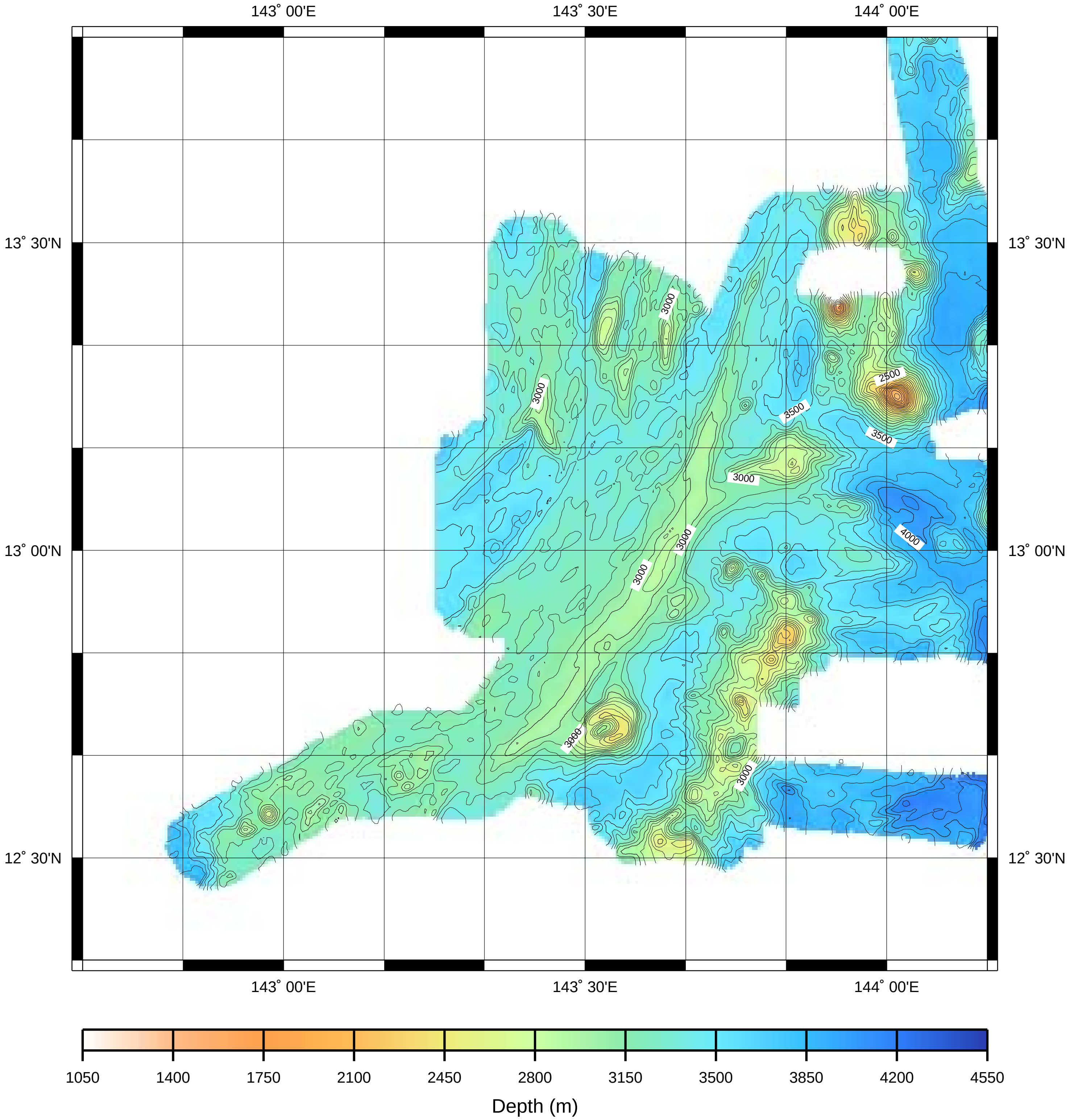
During cruise YK05-09, Leg 2 we surveyed areas of the southern Mariana backarc basin with the *Yokosuka* hull-mounted multi-narrow-beam bathymetry system. The surveys took place at night, weather permitting, therefore it was not possible to survey very far from the next day's dive site. The surveying concentrated on the seafloor northwest of the dive sites and on the volcanoes off–axis to the east of the spreading center. In addition, we surveyed two tracks along the extension of the spreading axis to the west. Most survey tracks were spaced 2.5 nautical miles apart to maximize coverage and to avoid gaps in the surveys over shallow features. The area surveyed included from 12°25'N to 13°35'N, and from 142°45'E to 144°10'E (see bathymetry map)). Previous surveys of the region were also conducted in this area using the Yokosuka multi-narrow beam system (as well as other bathymetry systems) and the survey data collected during this cruise will augment existing data by providing information to fill in gaps in previous surveys.

The spreading center of this part of the basin can be considered to consist of 3 distinct sections. (1) North of about 13°05'N the axis of spreading has the morphology of a typical slow-spreading mid-ocean ridge (like the Mid-Atlantic Ridge). It has a central graben, a modest central volcanic construct along short lengths of the graben, but also several separate volcanic cones. Most of the volcanic cones along the graben are very small >1-2 km in diameter. This part of the spreading axis is not as volcanically active and the next segment to the south. This may be related to the presence of several large arc volcanic edifices to the east of the spreading center (Seamounts A, B, D, and X). (2) From about 13°05'N southward to 12°38'N the spreading ridge is a broad feature with low relief, the Malaguana-Gadau (M-G) Ridge. It lacks an axial graben. Martinez et al. (2000) and Becker et al. (in prep) suggest it has formed as a consequence of the diversion of arc magma to the ridge. There are few large active arc volcanoes to the east of this segment. The summit of the ridge lacks a central graben, thus resembles a fast-spreading ridge (like the East Pacific Rise) (Martinez et al., 2000). There are several areas of this ridge that have a smoother surface and are thus more likely to be more volcanically active than others. The more volcanically active areas dominate between 12°30'N and 13°05'N. South of 12°30'N the ridge is narrower and lies adjacent to a large arc volcano (Patgon-Masala Smt.) with an exceptionally large (5 by 8 km) and deep (3 km) caldera (Toto Caldera). Just west of Patgon Masala there is a shallow knoll along the MG-Ridge that may represent a return to volcanic activity along this segment. The M-G Ridge terminates at about 143°20'E. From the west tip of the M-G Ridge to until about 143° 05'E, lineaments on the seafloor have a more E-W orientation. Relief of the seafloor is very low in this short interval. There is no well-defined central spreading ridge, but instead there is a series of low ridges and troughs that may represent the center of extension in this part of the basin. Several small (> 1.5 km diameter, and 300 m high) volcanic cones lie at about 12°36-37°N, 143°12-13'E. The topography suggests that these lie between two low ridges. Thus, they may indicate current volcanic activity along the center of extension. Another series of low ridges and troughs may represent the center of extension From about 143°05'E to 142°51'E, but the orientation is NE-SW. The morphology in this area may also represent extension. There is a 3.5-km-diameter volcanic cone at 142°59'E that is at least 5 km in diameter and 700 m high. A second smaller (~300 m diameter 200 m high) cone lies along strike of the lineaments to the west of the larger cone. These two volcanoes may mark the end of the spreading center in this part of the basin.

The survey data for this cruise provides a context in which to interpret the dive results. The dives on the spreading axis (Dives 900, 901 and 907) concentrated on the northern tip of the M-G Ridge and on the southern tip of the slow-spreading segment that lies just north of the M-G Ridge. Most of the seafloor on the ridge dives was covered with pillow lava. However, the more highly inflated appearing areas of Dives 900 and 901 display increasingly large amounts of ropy lava similar to pahoehoe, and volcaniclastic material including fragmental lava blocks composed of mostly friable glass and spatter. Much of this material was very fresh. The presence of what appears to be moderately explosive eruptive material suggests proximity to a more gas-rich magma source. Dive 907 on the southern tip of the slow-spreading segment north of 13°05'N, was conducted along a narrow ridge that lies between two inward facing fault scarps. It encountered much less volcaniclastic material and less fresh lava. Dives 902 and 904 were conducted on an inflated part of the M-G Ridge segment that has very active hydrothermal sites. Although most of the work on these dives was concentrated at the hydrothermal mound, previous dives in the area show abundant volcaniclastic material. Dives 903, 905, at a black-smoker hydrothermal site (Archean Park) off-ridge to the east of the Dives 902 and 904 area lies along a fault scarp that parallels the ridge axis. Another black smoker hydrothermal site (Pika Site) at the summit of a large off-ridge volcanic center to the east of the ridge lies along a line connecting the Dive 903/905 site with the 902/904 site. This may represent a cross-axis fracture trend. During this dive series very little volcanic material was surveyed, so we do not yet know what the nature of volcanism is on the seamount that supports the Dive 906 hydrotherma site (Pika Site). What we can say with regard to the tectonic control over the volcanic activity observed during this cruise is that there are discrete sites of recent active volcanism along the ridge and that faults, which parallel the ridge, down-dropped dominantly to the SE channel hydrothermal fluids to the seafloor. Hydrothermal activity is most active at the summits of the more inflated sections of the ridge and along fault scarps adjacent to these areas. There are, as yet unexplored, features similar to the Archean Park and Pika sites elsewhere along the eastern flank of the ridge that were mapped during the bathymetry survey and which may serve to provide future sites of investigation.

Martinez, F., P. Fryer, and N. Becker, 2000, Geophysical Characteristics of the southern Mariana Trough, Journal of Geophysical Research, 105(B7), 16,591-16,607.

YK05-09 Leg2 Voyage



GMT Aug 7 06:42 R/V_YOKOSUKA,YK05-09_Leg2,EDIT_DATA,South_Mariana_500.grd,dx/dy=500m,clip=2

6.2 Geological observation

Harue Masuda (Osaka City University)

Three dives were performed in the boundary area between the northern and southern segments of the active spreading ridge at 13°05'N-13°07'N. The surveyed track was mostly along the ridge axis where most recent volcanic activities were expected. The whole surveyed area was lava field thinly covered with sediments.

The southern segment was observed from the northern end to the location where the magma chamber was presumed to be by Becker et al. (submitted). The landing area of the first dive at 13°06.7'N was the field of large pillow lava. The large pillow lava and clustered lava. The former was occasionally had was lava tubes, and the latter was probably formed by spattering of erupting magma, were alternately distributed along the ridge crest from that location to 13°05.0'N. Sheeted lava flow was also observed, indicating low viscosity of the magma in this area. Bowl-shaped depressions of a few to ~10m diameter and depth are occasionally observed, implying that some of those would be vents or that low viscose flow caused collapsed after cooling the surface. The slope from the ridge crest at 13°05.0'N, 143°41.1'E to west above the magma chamber at 143°40.7'E, was topographically undulated and clustered lavas were conspicuous.

Large pillow lava with ropy pillow lava was extended along the northernmost area of the southern segment ridge between 13°07.1'N and 13°05.9'N, where low temperature hydrothermal area was discovered. Low temperature hydrothermal simmering water was also observed near the landing site, indicating active volcanism of this area. There were depressions similar to those observed during the first dive on this diving track. The lavas are often collapsed and remained the shell of the pillow lava surface. Observation of the fragile lavas in the northernmost area of the southern ridge segment including the area above magma chamber indicates the volatile rich composition of the magmas of this area.

The northern segment ridge is different from the surface morphology of the above described area. Large pillow and ropy lava was distributed on the most of the surface along the ridge crest. It is notable that the clustered lavas are rarely observed on this dive track. It is probably because the magma of this area less contains volatiles unlike that of the southern segment.

The rocks obtained from three dives are very fresh, preserving unaltered quenched glass rim. The rocks can be categorized largely into two types of rocks. One is fragile and delicate to grab the sample rock by a manipulator. It is typically occurred at the clustered lava field. Another one is the large pillow lava, which has hard surface. Those different rocks would be attributed to the different stages of the same eruption. However, it would be explained by the different period of the eruption.

6.3 Onboard analysis of hydrothermal fluids

Hiroyuki Toki (ORI) and Jun-ichiro Ishibashi (Kyushu Univ.)

Methods

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, titration and ion chromatography were employed for onboard analyses as described below. Using the same apparatus, some conservative species were also analyzed.

Samples collected by ROCS were divided into several bottles for geochemical and microbiological studies. After sample for pH and H_2S determination was drawn into a glass vial, samples were taken into a plastic syringe and filtered with a 0.45µm disk filter.

(a) pH and alkalinity

Determination of pH at room temperature was conducted with a pH meter with a combined glass electrode (IWAKI, IW055-BNC). 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 is employed using the pH meter (Corning, M-250). Calibration factor was checked by analysis of IAPSO standard seawater (which alkalinity must be 2.45mM). Analytical precision is estimated as within 3%.

(b) Colorimetric method

Using a colorimeter (Hach, DR2010), concentrations of dissolved silica (SiO_2), ammonium ion (NH_4), and hydrogen sulfide (H_2S) were analyzed following classical methods; molybdenum blue method (λ=812nm) for SiO_2, indo-phenol method (λ=640nm) for NH_4, methylene blue method (λ=670nm) for H_2S. 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_2 and H_2S), and of interference by specific species (NH_4).

(c) Titration

Chloride (Cl) concentration was determined by titration technique, using silver nitrate solution as titrant and chromate solution as indicator. Although this technique is rather classical, high precision for determination (usually within 1%) is important for the charge balance calculation because Cl is the dominant anion.

(d) Ion chromatograph

For this cruise, determination of some anions using an ion chromatograph (Shimadzu, LC10AI + SPD10AVP) was conducted on trial base. While nitrate (NO_3) detection by a UV-detector (λ=220nm) is conventional, some new inventions were introduced for seawater analysis (Maruo et al., in preparation). In order to eliminate interference of major anions such as Cl and SO_4, a high capacity anion exchange column (Tosoh, TSK gel-SAX, 4.6mm x 50 mm) and eluent of 1M sodium chloride (NaCl) solution (at flow rate of 0.8ml/min.) was used. Bromide (Br) was also analyzed in the same procedure.

Results

Analytical results of Si, pH, alkalinity, NH_4, NO_3, Cl, and H_2S of hydrothermal fluids are shown in Table 6.3.1. Si concentration in the samples exhibit a good linear relationship with fluid temperature recorded during sampling. The Si concentration approximate quartz saturation at the pressure of depth at each site and the venting temperature, suggesting that the recorded temperature is considered reasonable. The highest temperature among these samples is 341 degree C of D903 W-1 from the black smoker near the marker No.12 at the Archaean site, suggesting that this site should be regarded as one of the most active venting sites in the south Mariana Trough. Lower NO_3 concentration in the purer hydrothermal fluid was observed, indicating that NO_3 would originate from seawater and reduce in hydrothermal circulation. As for NH_4, hydrothermal fluid is generally considered as NH_4-poor in sediment-starved hydrothermal systems, including the Mariana back-arc spreading center. The significant low concentration of NH_4 in the samples can be explained by this view.

The samples taken from the on-axis ridge of spreading center during D901, D902, and D904 were the following features: (1) relatively low temperature less than 117 degree C, (2) clear smoker, (3) low H_2S concentration less than 0.37 mM, and (4) Chloride concentration comparable to ususal seawater. The hydrothermal fluid would be mixed by the ambient seawater during ascending of hydrothermal fluid and sulfide precipitation would occur due to abiogenic and/or microbiological process in the hydrothermal system.

The fluid samples from the Archaean site on the ridge skirt during D903 and D905 were characterized by (1) significantly high temperature as high as 340 degree C, (2) black smoker and clear smoker, (3) high concentrations of H_2S more than 10 mM,. (4) Chloride depletion when compared with deep seawater (manimum 418 mM comparable to 23 % depletion from deep seawater). Such anomalies in the chemical composition of the samples from the Archaean site strongly suggest that phase separation of hydrothermal fluid occurred in subseafloor hydrothermal circulation system (Massoth, 1989). The process that hydrothermal fluid would be separated in two phases, gaseous and aqueous phases, forms phase-segregated (gas phase) fluid and subsequently mix with seawater to form a vapor-rich and chloride-poor fluid because of its fractionation during boiling. These results are consistent with the previously report (Ishibashi et al., AGU2004).

The following features in the samples collected from the Pika site on the off-axis seamount during D906 were observed: (1) Significant high temperature up to 311 degree C, (2) black smoker, (3) high concentration of H_2S (more than 17 mM), (4) enrichment of chloride as high as 601 mM (ca. 10% enrichment compared to deep seawater). The hydrothermal fluid rich in H_2S and chloride vented from the Pika site, suggesting that the most plausible source of the fluid is magmatic volatiles.

Table 6.3.1 Results of onboard analysis

Dive	ID	Site	Location	Vent T (max) (deg C)	Si (mM)	pH	alk. (mM)	NH_4 (μM)	NO_3 (μM)	Cl (mM)	H_2S (μM)	Note
900	W1	13 05'N	deep SW	3.3	0.145	7.82	2.31	8.1	37.2	556	0	
	RC1	13 05'N	deep SW	3.3	0.144	7.91	2.25	7.5	38.3	550	0	
	B	13 05'N	deep SW	3.3	0.138	7.92	2.35	8.4	33.7	532	0	contaminated with DW
901	RC1	13 06'N	Mk#16	33	1.52	6.90	2.44	7.2	0.4	540	0	
	RC2	13 06'N	Mk#16	33	1.54	6.85	2.46	8.1	0.0	544	0	
	B	13 06'N	Mk#16	33	1.34	n.a.	n.a.	7.5	2.1	547	0	
902	W1	Snail	Mk#24	51	0.479	6.43	1.90	9.0	20.9	549	15.4	
	W2	Snail	Mk#24	53	1.06	6.28	1.76	8.7	17.5	555	139	
	RC1	Snail	Mk#24	41 - 51	0.725	6.59	1.87	9.0	16.2	554	34.6	
	RC5	Snail	APM01	36	0.781	6.65	2.01	7.5	13.5	554	0.5	
	RC6	Snail	APM01	36	0.781	6.57	1.95	7.2	12.4	536	0.7	
903	W1	Archaean	Mk#12 BS	341	16.6	3.19	-0.69	9.8	0.0	418	10400	
	RC1	Archaean	Mk#12 BS	341	5.08	5.00	0.34	12.3	25.7	509	2290	significantly mixed with SW
	RC2	Archaean	Mk#12 BS	341	15.6	3.18	-0.88	15.4	2.2	423	8710	
	RC3	Archaean	Mk#12 mound	117	3.12	5.50	0.48	9.8	9.6	527	1180	
	RC4	Archaean	Mk#12 mound	117	3.06	5.53	0.36	9.1	11.1	529	1010	
	RC5	Archaean	Mk#17	30 - 90	2.57	5.89	1.57	4.1	30.6	544	503	
	RC6	Archaean	Mk#17	30 - 90	2.56	5.91	1.55	4.4	30.8	545	418	
	B	Archaean	Mk#12 mound	117	1.86	5.95	0.92	5.7	21.5	540	254	
904	N	Snail	ambient SW	1.6	0.095	8.08	2.72	0.0	25.8	554	0.7	
	RC1	Snail	APM01	40.2	1.84	6.45	2.18	0.0	6.6	552	1.2	
	RC2	Snail	APM01	40.2	1.87	6.45	2.26	0.3	6.8	554	2.6	
	RC3	Snail	Mk#24	84	2.27	6.30	2.02	1.6	21.1	554	265	
	RC4	Snail	Mk#24	43	2.18	6.32	2.02	2.2	22.1	551	200	
	RC5	Snail	Mk#24	116	4.22	5.84	1.42	1.3	8.2	554	371	
	B-1	Snail	APM01	40.1	1.85	6.51	2.18	0.0	7.5	549	3.0	
	B-2	Snail	Mk#24	95	3.30	5.92	1.41	1.9	10.8	551	0	
905	ID	Archaean	Mk#12 BS	345	9.24	3.39	-0.55	12.2	n.a.	467	10300	
906	RC1	Pika	Black Smoker	303 - 311	14.9	2.86	n.a.	2.2	0.0	601	17700	
	RC2	Pika	Shimmering	13 - 15	0.395	6.48	2.06	5.3	34.8	552	227	
	RC3	Pika	Shimmering	11 - 19	0.150	7.44	2.39	0.0	32.6	542	23.0	
	RC4	Pika	ambient SW	3.3	0.138	7.63	2.45	0.0	36.9	550	0	
	RC5	Pika	ambient SW	3.3	0.149	7.75	2.39	0.0	36.4	n.a.	0	
907	B	13 07'N	deep SW	3.3	0.150	7.89	2.48	0.0	35.7	n.a.	n.a.	

n.a. = not analyzed

6.4 Onboard results for plume studies

Kiminori Shitashima (CRIEPI)

Hydrothermal plume sample

The hydrothermal samples collected by CTDT-Pyron were shared for geochemical and microbiological research. The CTD data of Niskin sampling and the results of shipboard measurements of pH and TCO_2 are listed in Table 6.4.1. The methods of pH and TCO_2 measurements are described below. For dissolved trace metal analysis, the samples were immediately filtered by acid cleaned 0.4um Tefron filter in an onboard clean bench. Unfiltered sample for analysis of total (particulate + dissolved) trace metal and filtered sample were acidified to pH 1 and stored.

(a) pH

Seawater samples were collected in 100ml polyethylene bottles with inner caps from Niskin bottles. All samples were stored at room temperature after sampling and analyzed within a few hours. Samples were transferred into a closed and jacketed glass measurement cell with a volume of ~30ml. The cell temperature was maintained at a constant temperature of 25ºC ± 0.1ºC. The electric potential and temperature of the sample were measured for 10 minutes with a Ag/AgCl combined electrode (Radiometer Analytical A/S, GK2401C) and a temperature sensor (Radiometer Analytical A/S, T901) connected to a high precision pH meter (Radiometer Analytical A/S, model PHM93). NBS buffers (pH 4.010 and pH 7.005) and SWS buffers (Tris and 2-Aminopyridine buffers ; Dickson and Goyet, 1994) were employed to calibrate pH electrodes.

(b) Total Carbon Dioxide (TCO_2)

The total carbonate concentration in plume and fluid samples were determined by using the coulometric titration system explicated by Jhonson et al. (1985) with the modified CO_2 extraction system described by Shitashima et al. (1996). Samples for total carbonate analysis were drawn from the Niskin bottles into a glass vial bottle and immediately poisoned with $HgCl_2$ in order to restrict biological alteration prior to sealing the bottles. All samples were stored in a thermostatic water bath (25ºC ± 0.1ºC) before measurement. The CO_2 was extracted from the sample for 6 minutes by bubbling with the CO_2-free air after phosphoric acid addition and measured with a Coulometer (UIC Inc., Carbon Coulometer model 5011). The total carbonate concentration in sample was calculated using the Certified Reference Solutions (CRM (batch 51) supplied by Dr. Andrew Dickson of Scripps Institution of Oceanography (SIO). The standard deviation was ±1.8 μmol/kg (n=19).

In-situ pH/pCO_2/ORP sensor

The in-situ pH/*p*CO_2/ORP sensors were installed to SHINKAI 6500 during all the dives in YK05-09. Figure 6.4.1 shows results of the monitoring of pH, pCO_2, ORP during dive 905 (dive for plume sampling and mapping). Because the data of pCO_2 and ORP are not calibrated, these data are raw data (count data). The in-situ sensors responded immediately the pH change derived from hydrothermal activity and sharp anomalies were detected when the submersible landed on the Mk#18 black smoker (11:56-12:10), Mk#17 shimmering (12:25-12:35) and Mk#12 black smoker (12:40-13:20).

Table 6.4.1 CTD data of Niskin sampling and onboard results of pH and TCO_2

FIRE	Time	Temp. (C)	Depth (dB)	Salinity	**σ T**	pH (NBS)	TCO2 (uM/L)	
FIRE #1	2005/8/3 13:14:48	5.863	3033	36.323	28.617	7.913	2236.26	*Bad Sample
FIRE #2	2005/8/3 13:15:57	3.470	3021	34.487	27.431	8.073	2136.81	*Bad Sample
FIRE #3	2005/8/3 13:17:12	1.857	3001	34.642	27.696	7.819	2338.37	*Bad Sample
FIRE #4	2005/8/3 13:18:30	1.915	2980	34.570	27.634	7.698	-	
FIRE #5	2005/8/3 13:22:33	1.650	2931	34.681	27.743	7.705	2425.95	
FIRE #6	2005/8/3 13:29:12	1.660	2829	34.673	27.736	7.702	2426.92	
FIRE #7	2005/8/3 14:17:22	1.651	2993	34.670	27.734	7.695	2432.77	
FIRE #8	2005/8/3 14:23:18	1.650	2980	34.676	27.739	7.703	2429.93	
FIRE #9	2005/8/3 15:09:23	1.650	3001	34.679	27.741	7.805	-	*Bad Sample
FIRE #10	2005/8/3 15:41:17	1.647	3001	34.655	27.723	7.705	2424.57	
FIRE #11	2005/8/3 15:53:17	1.645	2997	34.676	27.739			*No Sample
FIRE #12	2005/8/3 15:56:30	1.651	3005	34.674	27.737	8.080	2153.75	*Bad Sample

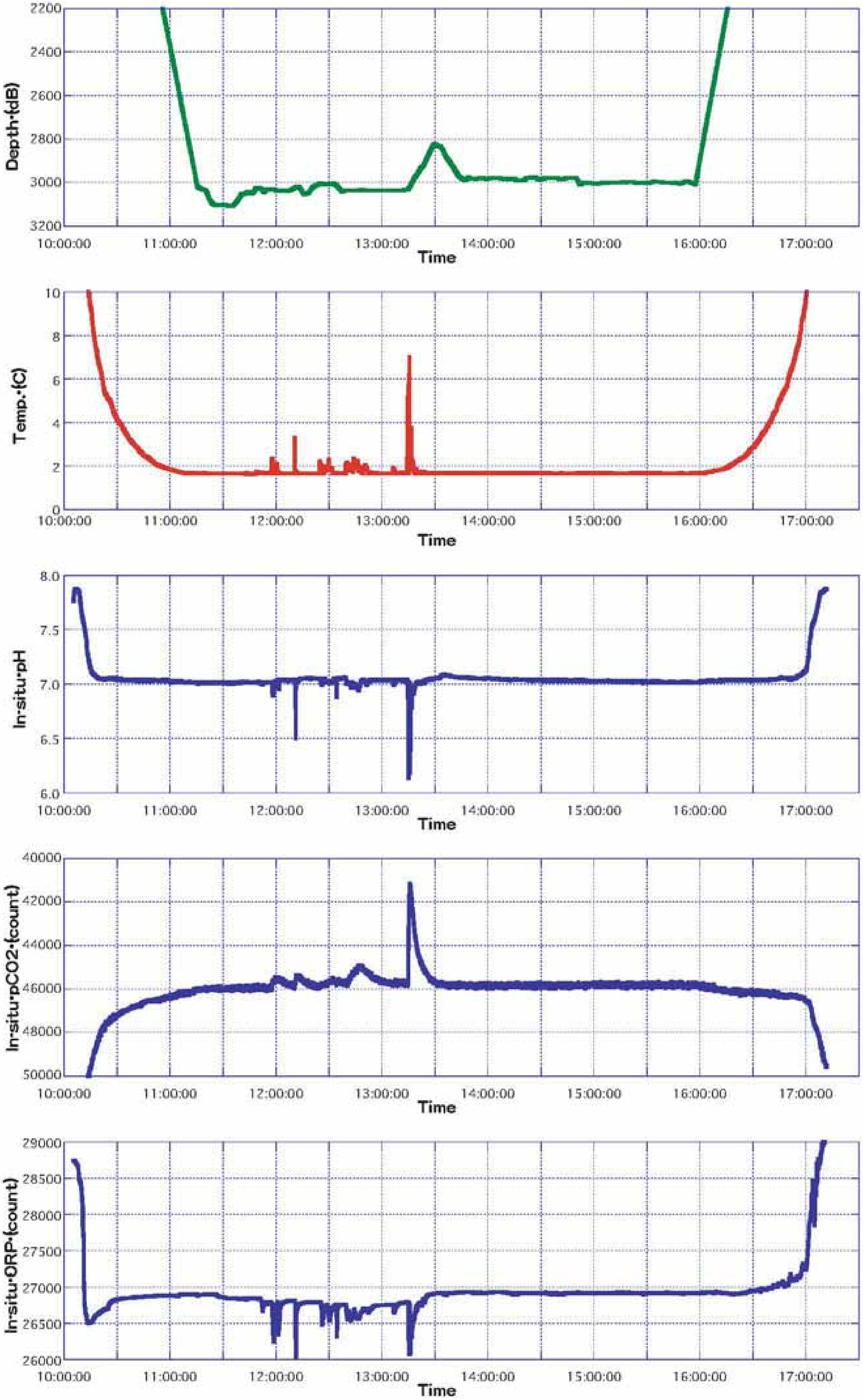


Fig. 6.4.1 Results of the monitoring of pH, pCO2, ORP during Dive 905

6.5 Microbiological studies

Hiroyuki Kimura (Shizuoka Univ.)

To perform phylogenetic analysis and cultivations of the microbial communities, hydrothermal fluids and active chimneys were sampled from the hydrothermal vents and artificial casing pipes. The fluid samples were aseptically filtrated with membrane filters (pore size, 0.22 μm) on board, and then the filters were stored at -30°C. These filter samples will be used for DNA analysis or fluorescence in situ hybridization (FISH). The active chimneys were separated and stored at 4°C for cultivation and -30°C for DNA analysis, respectively.

The collected samples for microbiology are as follows;

1. Hydrothermal fluids:
   Dive#900 [B-1 (1.6°C), RC-1 (1.6°C)]
   Dive#901 [RC-1(33℃), RC-2 (33 °C), B-1 (33°C)]
   Dive#902 [W-1 (51°C), RC-1 (43 °C), RC-5 (29℃), RC-6 (29 °C)]
   Dive#903 [RC-1(343℃), RC-2 (343°C), RC-3 (117°C), RC-5 (93℃), RC-6 (93 °C), B (117°C)]
   Dive#904 [RC-1 (40.2°C), RC-2 (40.2 °C), RC-3 (84℃), RC-5 (116℃), B1 (40.2 °C), B2 (95°C)]
   Dive#905 [N-1, N-2, N-3, N-4, N-5, N-6, N-7, N-8, N-9, N-10, N-12]
   Dive#906 [RC-2 (11℃)]; Dive#907 [B-1 (1.6°C)]
2. Active chimneys:
   Dive#903 (R-2, R-3, R-4, R-6)
   Dive#906 (R-2)

6.6 Time series study of hydrothermal activity in Snail Site

Jun-ichiro Ishibashi (Kyushu Univ.) and Hiroyuki Kimura (Shizuoka Univ.)

The time evolution of seafloor hydrothermal activity is an important and interesting issue with respect to metal sulfide ore deposition, changes in fluid chemistry, and the successional response of microbial and macrofaunal communities. Magmatic events can drastically increase the concentrations of volatile species in the hydrothermal fluids, forcing a shift in the associated microbial ecosystem. Since back-arc spreading systems often have magma located at shallow depths, they can be an excellent locality for studying the impact of magmatic input on microbial and faunal communities.

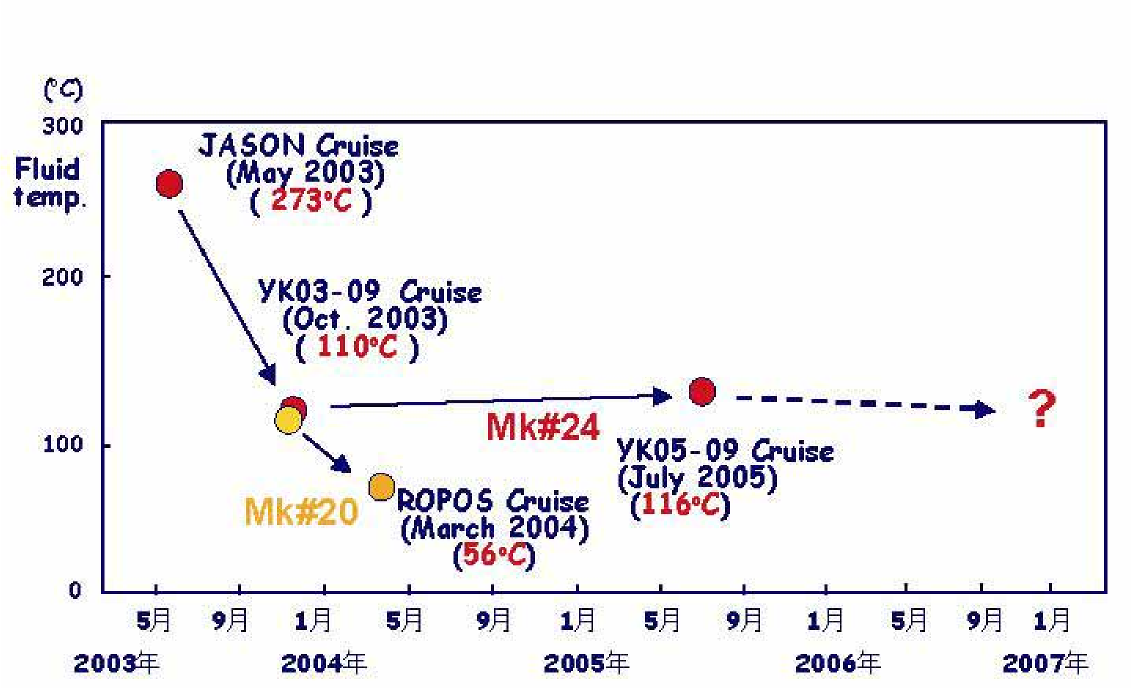


Fig. 6.6.1 Time series change of fluid temperature in Snail Site

Snail site located on the ridge axis of SMBSC at 12º57'N was discovered by Jason Dive mission conducted in May 2003. In that time the maximum temperatures of 248ºC (Wheat et al., 2003) or 273ºC (P. Fryer, Pers. Comm.) were recorded 30cm into cracks covered with abundant large provannid snails among extinct mounds (Mk#24 vent). When this site was revisited by SHINKAI6500 in Oct. 2003 (YK03-09 Cruise), the fluid temperature at Mk#24 vent was decreased to 110ºC (Fig.1). During TN167A cruise with ROPOS, fluid temperatures in Snail Site were observed as 40 to 70ºC, however no measurements at Mk#24 vent. In Dive904 in this cruise, the fluid temperature at Mk#24 vent was confirmed as high as 110ºC. This may suggest the hydrothermal activity in Snail Site is in rather stable stage.

The faunal community, mainly snails and crabs, around Mk#24 vent was observed in Dive902 and Dive904 in this cruise (Fig. 2A). Size and individual number of the faunal community are comparable to those observed in Oct. 2003 by SHINKAI6500 (YK03-09 Cruise) (Fig. 2B). These observations agree with the stable fluid temperature at Mk#24 for these two years.

Fig. 6.6.2A Photo of faunal community at Mk24 observed by Dive904 in YK05-09 cruise (Aug. 2005).

Fig. 6.6.2B Photo of faunal community at Mk24 observed by Dive793 in YK03-09 cruise (Oct. 2003).

Geochemical studies of the obtained fluid samples in previous cruises have demonstrated that mixing between a single hydrothermal endmember and seawater well explains fluid chemistry in

Snail Site (Fig. 3). Based on the Si-Mg relationship, the endmember silica concentration is estimated as 15mM which corresponds to T=330ºC hydrothermal fluid. Comparing with the hydrothermal endmbmer value reported for the May 2003 fluids (Wheat et al., 2003) shown as a star mark in Fig.2, the fluids collected in Oct. 2003 and March 2004 are likely to be well explaind by the same endmember composition. Moreover, it is obvious that seawater dilution increases, as fluid temperature decreases from 2003 to 2004 (Ishibashi et al., 2004).

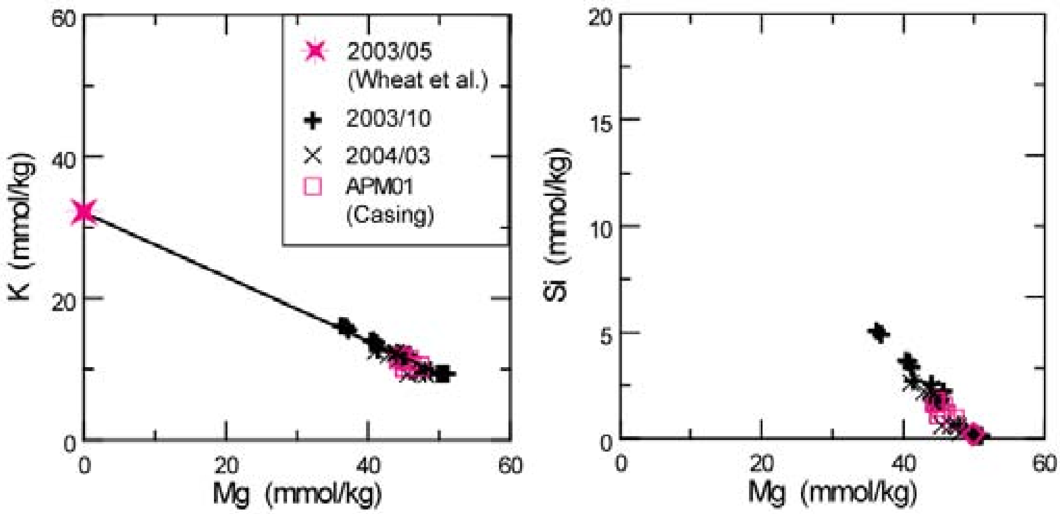


Fig. 6.6.3 Chemical composition of the obtained fluid samples from Snail Site

One of the goals in this cruise is to record the time series change of fluid chemistry in Snail Site. From the results of onboard analyses, we draw Si-NO_3 and pH-NO_3 diagram (Fig.4). In spite of some scatter of the data, no significant difference was found between Oct. 2003 and July 2005. This result agrees with no significant change of the fluid temperature.

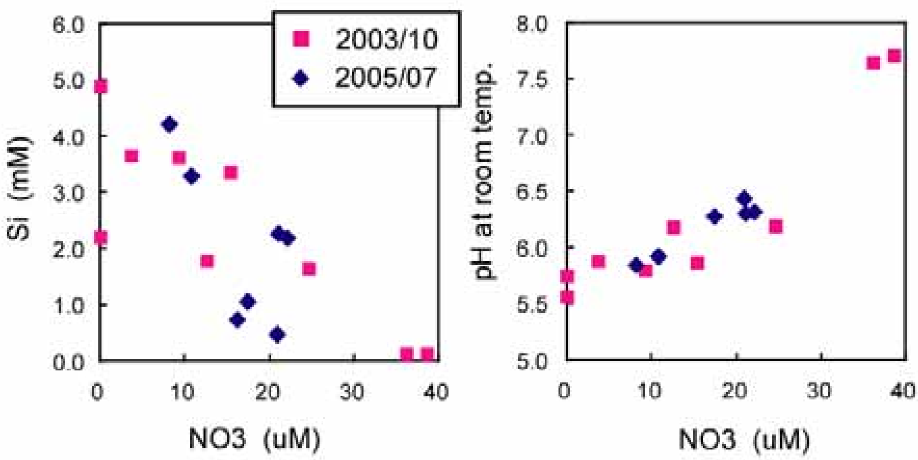


Fig. 6.6.4 Comparison of the fluid composition obtained from Mk#24 vent

7 Future Studies

Harue Masuda (Osaka City University)

Evolution process of backarc magma in the southern Mariana Trough:

<Samples> All rocks

<List of analyses (coworker)>

Major and minor elements (including some REE) by XRF: Dr. K. Furuyama (OCU)

H_2O, CO_2 and S contents and H, C and S isotopes: Dr. M. Kusakabe (Okayama Univ.)

Rare gas: Dr. Matsuda (Osaka Univ.)

<Purpose>

Chemical analyses will be done for characterizing the source magmas in the active spreading ridge, especially the volatile contents and those origins. The results can be expected to demonstrate how the water and other volatile components works to initiate the magma formation in the area. The analyses will be performed with M. Kuno.

Tracing thermal stability of amino-acids and RNA in hydrothermal environment:

<Samples> Hydrothermal sediments (active black smoker chimney, Fe-oxyhydroxide and Mn-oxide), hydrothermal fluid

<Analyses> Amino-acids, RNA: Masuda with M. Itoh (OCU), H. Kawahata (AIST)

<Purpose>

Thermal stability of amino acids has been experienced at the laboratory hydrothermal synthesis. The hydrothermal fluids and sediments taken during this cruise are examined to compare the results of laboratory experiments. RNA is another and direct tracer of the life. Thus, we will try to detect the RNA from the same samples analyzed amino-acids.

Mitsuteru Kuno and Harue Masuda (Osaka City University)

Active hydrothermal activity and fresh volcanic rocks widely distributed along the spreading ridge in southern Mariana trough demonstrate the active volcanism in this area. Volcanic rocks sampled during this cruise have much fresh quenched glass rim. Since the glass preserve volatile at the erupting depth, those are useful to trace the nature of source magma. In my study, I will analyze the content and isotope ratios of H, C and S of the quenched glass. The isotope ratios will reveal the source of volatile in magmas. It must be important to constrain the factor of magma formation related to spreading of back arc basin in Mariana trough.

<Samples> All rocks

<Analyses> Content and isotope ratios of the quenched glass

Patricia Fryer (Univ. Hawaii)

Analysis of bathymetry data

Petrographic analysis of all rock samples

XRF analysis of bulk rock samples (to compare with glass analyses of Masuda for crystal fractionation study).

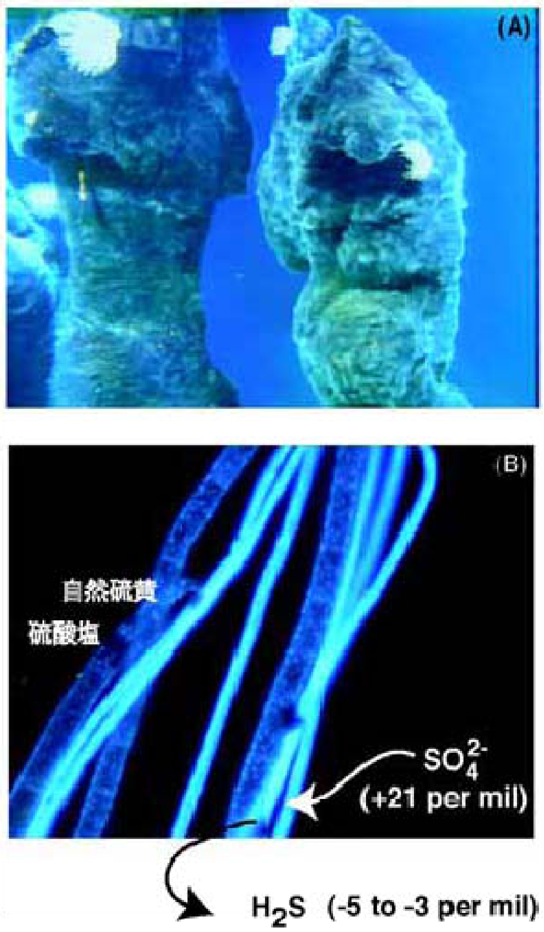
Trace element analysis for REE, Ta, Yb, Hf, Ba, Th, Li. B

Isotopes: Isotopes: Pb (208/204, 206/204), Nd (143/144), Sr (87/86),

I will write one paper as first author with Masuda-san and N. Becker: A description of the volcanic processes occurring along the Southern Mariana backarc basin ridge area: “Volcanology of the Southern Mariana Trough Spreading center: sidescan surveys and seafloor observations“ (I will need files of bathymetry data collected during this cruise)
I will contribute to second paper (Masuda-san first author) on the composition of the lavas.
I will contribute to work of Masuda-san and Noguchi-san (and others?) on sulfide chimney material by contributing data from reflected-light petrography and SEM imagery of sulfide chimney structures. (I already have some samples, may need samples of radioactive chimney, but cannot take them home on the airplane – may need to have them mailed later)

Seigo Sato and Takeshi Kakegawa (Tohoku Univ.)
バクテリアマットと無機物との関連:
<試料> バイオマット、水、フィルター、チムニー、岩石

本航海における調査地域ではフライヤーポイントやヤマナカサイト、BMS 航海におけるケーシングパイプ内などにバクテリアマットの発達が確認されてきている（右図）。このバクテリアマット内では顕微鏡サイズで鉱物と微生物が共存している。微生物が鉱物を生きてゆくための住処として利用している可能性が著しく高い。本来沈殿しにくい鉱物（溶解度以上のシリカの沈殿量など）が沈殿しているケースがしばしば見られる。これら試料には以下の疑問が含まれている。(1)微生物が生息する上で鉱物（特に安定鉱物になる前のアモルファス相）を利用しているか、(2) 微生物の酵素の前駆体となり得るような金属‐有機分子複合体が積極的に形成されているか、(3)微生物‐鉱物が具体的にどのような空間範囲、物質代謝量で結びついているかなどである。これらの疑問に答えるために、以下の研究を行う。また本研究において微生物解析なども重要な役目を担うが、それは東京薬科大学と共同研究で進める。



(a) SEM, TEM を用いた微生物‐鉱物空間分布マップの作成
(b) X 線卓上顕微鏡を用いた Wet 試料の元素マップ作成
(c) FT-IR スペクトロスコピーや Time of Flight Tube 質量分析計、NMR を用いた有機‐金属錯体の検出
(d) 微量安定同位体分析による硫化鉱物、自然硫黄生成と微生物活動の関係

特に着目しているのが、アモルファス相鉱物である。アモルファス鉱物には多くの元素を吸着、

保存する力が存在する。この中には熱水、海水中に多く含まれないリン酸など生物活動に重要な元素も含まれる。(a) と (b) の研究をとおして、(1) の疑問に答えられる。また生物活動が行われる場では、様々な有機酸が形成され、その有機酸をもとに金属錯体が形成される事が知られている。これもフリーな空間で行うよりもアモルファス相鉱物や粘土鉱物など有機酸、金属を同時に吸着できる鉱物上で錯体形成を行った方が効率がよい。(a)~(c)の研究をとおして、この問題を明らかにする。また硫黄を例にとり、微生物マットや濃集体のなかで形成される生物起源硫化鉱物の量や、系に入る硫酸量、輩出される硫化水素量などの見積もりも行う。これは(d)の研究をとおして行う。これによって硫黄を例にした微生物マットとその周辺環境との間での物質移動 (物質代謝) の様式が明らかにされる。

Ryohei SUZUKI and Jun-ichiro ISHIBASHI (Kyushu Univ.)
Inorganic geochemistry of metallogenesis:

Sulfide ores collected from active/inactive chimneys and seafloor were distributed to Kyushu Univ. The following analyses on land will reveal the process of ore formation and origin of hydrothermal fluids in submarine hydrothermal systems of the Southern Mariana Trough:

(1) Mineralogy

We will study mineral compositions of sulfide ore samples by microscopy and X-ray diffractometry to describe mineral assemblages. Chemical analyses of ore-forming minerals by electron microprobe, together with microscopic observations, will provide us with clues to determine the mineral paragenesis and physicochemical environment of mineral depositions.

(2) Fluid inclusion study.

Microthermometric analyses of fluid inclusions in sulfide and sulfate minerals will yield information about temperatures of mineral precipitation and salinities of solutions trapped as fluid inclusions. In addition, we will attempt qualitative/quantitative analyses of trapped fluids by laser Raman spectroscopy, gas chromatography, and ion chromatography. It will be of great help in reconstructing the history of hydrothermal activities to compare the chemical compositions of fluid inclusions with those of vent fluids analyzed independently.

(3) Sulfur isotope study

We plan to analyze isotopic compositions of sulfur in sulfide and sulfate minerals to deduce the source of sulfur and behaviors of sulfur species through hydrothermal circulation. Furthermore, the result may reflect isotopic fractionations induced by microbial metabolism within chimneys and substrate crust. Isotopic measurements of sulfur species will be conducted in collaboration with Dr. Hitoshi Chiba at Okayama Univ.

T. Noguchi, T. Oomori (Univ. of Ryukyus)
Precipitation age determination of hydrothermal ore deposit:

<Purpose>

Hydrothermal ore deposits have some important information on the hydrothermal processes and the environment of microbial habitation. Especially, the discussions on the hydrothermal process and hydrothermal ore deposits formation have to include the time scale, therefore our laboratory progressed the precipitation age determination of sulfides and sulfate ore deposits (Noguchi et al.,

2004). In this cruise, we collected the hydrothermal ore deposits and I will determine the precipitation age them by gamma-ray spectrometry. Based on these results, I try to discuss on the growth process of collected chimneys.
<Sample> sulfide and/or sulfate chimneys
<Method> gamma-ray spectrometry

Jun-ichiro Ishibashi (Kyushu University)
Inorganic geochemistry of hydrothermal fluid:

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 fluids provide important information on the geochemical environment where microbes live. For example, the concentration of reducing species such as methane and hydrogen sulfide is important for the estimation of metabolic sources.

In order to determine the concentrations of major elements in the fluid samples, both onboard and shore based analyses are employed. The onboard studies were conducted as described in the preliminary results section, with collaboration with Tomohiro Toki (ORI, UT), Takuroh Noguchi (Univ. Ryukyus), and Ryohei Suzuki (Kyushu Univ.). The shore based analyses will be conducted at Kyushu University using conventional techniques such as ion chromatography, flame ionization spectrophotometry, ICP-AES and so on. Isotopic measurements for sulfur species will be conducted in collaboration with Dr. Hitoshi Chiba at Okayama Univ.

T. Noguchi, T. Oomori, (Univ. of Ryukyus), J. Ishibashi (Kyushu Univ.)
Heavy metal and REE analysis on the hydrothermal fluid:

<Purpose>
It has been known that the large amounts of heavy metals were supplied to the ocean by the hydrothermal activities. Moreover, some metals such as iron, manganese, arsenic and so on have not only the different species relative to the redox, but also the influence to the chemosynthetic microbial activity as the electron accepter and/or donor. In this study, I will determine the heavy metal and REE composition of hydrothermal fluid by the ICP-MS.
<Sample> hydrothermal fluid
<Method> ICP-MS in Kyushu Univ.

T. Toki (ORI), U. Tsunogai (Hokkaido Univ.), Y. Sano (ORI), J. Zhang (Toyama Univ.), and T. Gamo (ORI)
Gas chemistry and chloride isotope in hydrothermal fluid:

<CH_4, CO_2, H_2, and $\delta^{37}Cl$ in hydrothermal fluid>
Chemical and isotopic compositions of the expelled fluids at the seafloor are controlled by two sets of processes: deep reservoir conditions and secondary processes during ascent. During

circulation, a drop in pressure and temperature can initiate phase separation and mineral precipitation, causing a change in fluid composition. Recent studies have referred to existence of enormous biological productivities in submarine hydrothermal systems, which supported by the mixing environments between reduced state of high-temperature hydrothermal fluids in the subsurface and the cooler and oxidized condition of seawater in the ocean. Chemically reactive constituents should record physicochemical changes prior to venting from the seafloor. The characterization of dissolved CH_4, CO_2, and H_2 in associated with microbial metabolism provides us with useful information about microbial process in deep-sea hydrothermal systems. The isotope of chloride in non-associated with microbial metabolism gives us with information about abiogenic process in the systems.

Sample:
(1) Gas in stainless steel sample bottle and hydrothermal fluid in glass vial

The dissolved gas was retrieved from hydrothermal fluids taken by WHATS. The hydrothermal fluids were sampled by ROCS. The chemical and isotopic compositions of CH_4 and CO_2 in the gas and fluid samples will be measured in Hokkaido University (U. Tsunogai). The concentration of H_2 in the gas samples will be measured in Hokkaido University (U. Tsunogai). The chemical and isotopic compositions of H_2 will be measured in ORI (T. Gamo).

(2) Hydrothermal fluid in polypropylene bottle

The hydrothermal fluids were sampled by ROCS. The isotopic compositions of chloride in the fluid samples will be analyzed in Toyama University (J. Zhang).

<CH_4 in plume water>

In the south Mariana back-arc spreading center, plume of $\delta^{13}C(CH_4)$ of -50 permil PDB has been observed in water column during the R/V Thompson expeditions in 2003 and 2004. Source of the methane in the plume has been missing. We collected relatively numerous samples of hydrothermal fluids from the hydrothermal vents and seawater in the area. By comparing the measured stable carbon isotopic compositions of methane among these samples, the variation will reveal the source of the methane in the plume.

Sample:
Plume water in glass vial

The plume water was sampled by Niskin during Dive 905. The chemical and isotopic compositions of CH_4 in the fluid samples will be measured in Hokkaido University (U. Tsunogai).

< $^3He/^4He$ in hydrothermal fluid>

Numerous studies on this subject have revealed that hydrothermal activity is a ubiquitous concomitant phenomenon to shallow heat magmatic sources. Hydrothermal circulation can lead to fluid mixing with seawater and a source of heat. Chemically inert species could provide information about their sources. It is expected that the ratio of $^3He/^4He$ in the venting fluids should contain imprints of the origin of heat source.

Sample:
Gas in stainless steel sample bottle

The dissolved gas was retrieved from hydrothermal fluids taken by WHATS. The ratio of $^{3}He/^{4}He$ in the gas samples will be measured in ORI (Y. Sano).

Ryohei SUZUKI and Toshiro YAMANAKA (Kyushu Univ.)
Organic geochemistry:

Main purpose of this study is understanding of distribution and origin of organic matter dissolved in hydrothermal fluids. In addition we aim to clarify the nutrient and energy sources of vent community especially molluscs (Alviniconca sp. etc.) using stable isotopic technique.
For attain the above aims, we plant some analyses as follow;
1. Concentration of dissolved organic carbon (DOC) in the hydrothermal fluid samples: T. Yamanaka (Kyushu University)
2. Composition of volatile fatty acids (Formic acid, acetic acid, propanoic acid) in the hydrothermal fluid samples : T. Yamanaka, I. Kita, & J. Ishibashi (Kyushu University)
3. Molecular level carbon isotopic ratios of the volatile fatty acids: T. Yamanaka (Kyushu University) & H. Naraoka (Okayama University)
4. Bulk and molecular level stable isotopic (H, C, N, S) compositions of the animal samples: T. Yamanaka (Kyushu University), H. Naraoka & H. Chiba (Okayama University)

Kiminori Shitashima (CRIEPI)
Plume studies:

Deep-sea hydrothermal systems play an important role in the oceanic geochemical cycles of trace metals. The hydrothermal plume is widely diffused to the ocean by mixing with ambient seawater. Particulate and dissolved trace elements (Al, Mn, Fe, Ni, Cu, Zn, Cd) in hydrothermal plume samples are measured to reveal solute/particle interactions and input/scavenging pathway of trace elements in hydrothermal systems. Trace element concentration of filtered (dissolved) and unfiltered (dissolved + particulate) samples acidified to pH 1 are determined in a clean room on land using graphite furnace atomic absorption spectrophotometery (GFAAS) with Zeeman background correction.
Mapping of the diffusion of hydrothermal plume at the Archaean site using in-situ sensors (CTD, Turbidity, pH/pCO_2/ORP).
Hydrothermal fluids are highly enriched in CO_2, suggesting the discharge of CO_2 to deep ocean by hydrothermal activities. In order to estimate the flux of CO_2 through the southern Mariana Trough, total carbonate concentration in the plume samples is determined by using the coulometric titration system onboard.
Nutrients will be measured as an index of biological production by micro and macro organisms in the southern Mariana Trough.

Kazuo Takemoto, Katsunori Yanagawa and Michinari Sunamura (Department of Earth and Planetary Sciences, University of Tokyo)
Quantification of Microbes by fluorescent microscopy:

<Object in this cruise>

Since a discovery of deep-sea hydrothermal vents in 1970's, microbiologists have studied microbes nearby hydrothermal vents by using cultivation and/or molecular techniques. These studies gave us quite significant information about the qualitative microbial community structures and their functions in the hydrothermal ecosystem. The hydrothermal microbial community is believed to be sustained by chemolithoautotrophic microbes, e.g. sulfur oxidizers, methane oxidizers, hydrogen oxidizers, metal oxidizers, and methane producers. However, the importance and impact of these hydrothermal vent microbial community is not clear, because most of microbiological studies have been focused on the novel unique microbial isolation and qualitative community structure analysis. By quantification of microbial community structures, it is possible to compare with chemical data and presume the role and impact of microbes to the ocean and hydrothermal ecosystems. The quantification of microbial community structures have been difficult, however, now a day, it comes to be possible with the development of molecular biological techniques. Recently, microbial community structures have been quantified in hydrothermal plume at Suiyo seamount (Sunamura et. al 2004) and Fuan de Fuca ridge (Lam et. al 2004) by fluorescent microscopic observation using fluorescent in situ hybridization (FISH) techniques. These studies revealed that sulfur oxidizing related bacteria are predominant in the Suiyo Seamount hydrothermal plume and ammonia oxidizing bacteria are dominant in the Fuan de Fuca hydrothermal plume.

Our object in this cruise is quantification of microbial community in the hydrothermal fluid to presume the role and impact of the subsurface microbial community for the deep-sea hydrothermal ecosystems.

<Future plan>

Hydrothermal fluid samples were collected by ROCS and Bag type hydrothermal fluid sampler attached to Shinkai 6500. After retrieval of the water samples, 100 to 200 ml of the water samples were sub-sampled for total and specific microbial-cell analysis. The sub-samples were fixed by addition of one tenth volume of 38% formalin and stored in refrigerator at 4°C for 1 to 3 days. Microbial cells in the fixed samples were filtered on poly-L-lysine coated poly-carbonate membrane filter (Maruyama and Sunamura 2000) on board, and then stored at -80°C to bring back to laboratory. The rest of fixed samples, which could not filtered on board, were frozen at -80°C to bring back to laboratory.

In the laboratory, microbial cells on the filter samples will be stained using DNA fluorochrome and/or fluorochrome labeled specific oligonucleotide probes to detect the microbial cell of total, each domain, and sub-Domain levels. The stained cells will be enumerated using fluorescent microscope (BX-51; Olimpus, Tokyo, Japan).The hydrothermal fluid samples have been collected also in the R/V Yokosuka-Shinkai 6500 cruise (YK0309) in 2003 and R/V Thompson –ROPOS cruise in 2004 . Together with these hydrothermal fluid samples, the hydrothermal fluid samples obtained in this cruise will be analyze to investigate microbial distribution and succession in Southern Marina hydrothermal region.

If it will be needed, the plume sample will be analyzed by same method in order to know microbial distribution of plumes.

< Samples> Hydrothermal fluid, Hydrothermal plumes, Rocks

Hiroyuki KIMURA (Shizuoka University)
Phylogenetic and metabolic analysis of microorganisms in the hydrothermal fluids

< Background and Purpose of This Study>
Little is known about relationship between fluctuation of deep-sea hydrothermal activity and microbial community in the hydrothermal vents. Temperatures of hydrothermal fluids flowing from Snail site (Mk#24) have suggested 273^{o}C (May 2003 in JASON cruise), 110 ^{o}C (Oct. 2003 in YK03-09) and 116^{o}C (Aug. 2004 in YK05-09). We have already analyzed the diversity of archaea and bacteria in these hydrothermal fluids collected from Mk#24 in YK03-09 cruise. The DNA analysis has revealed that the majorities of microbial community were thermophilic archaea (genera Thermococcus and Pyrococcus) in fluid sample. The purpose of this study is to elucidate the microbial community in the current hydrothermal fluid (116^{o}C)

< Methods>
Fluorescence microscopy
Microbes in the fluid samples were fixed with 3% (final concentration) formaldehyde and stored at 4^{o}C. The microbial cells will be stained with DAPI (4’, 6-diamidino-2-phenylindole) that is specific to DNA, and observed by fluorescence microscopy, directly. The microbial cells stained with DAPI will be counted to estimate microbial abundance in each fluid sample.

Culture-independent DNA analysis using 16S rRNA gene and functional enzyme genes
Fluid samples were filtered to collect microbial cells in Sterivex-filters on board. The filters were stored at -40 ^{o}C. These samples will be used for the DNA extraction. Small subunit ribosomal RNA and functional enzyme genes will be amplified by PCR using appropriate primer sets. The amplified DNA fragments will be cloned, and the sequences will be determined for the phylogenetic and metabolic analysis.

Quantitative PCR analysis of archaeal and bacterial communities
Archaeal and bacterial 16S rDNAs in the bulk DNA extracted from the hydrothermal fluids were quantified by the quantitative fluorescent PCR method with prokaryotic universal and Archaea-specific primer sets, as well as with TaqMan probes. The quantitative PCR analysis will show that "bacteria are numerically superior to archaea in the microbial community" or "archaea are numerically superior to bacteria in the microbial community".

Shingo Kato, Chiyori Kobayashi and Akihiko Yamagishi
(Tokyo University of Pharmacy and Life Science)
Culture-dependent and independent analysis of microbes in the hydrothermal system:

< Background and Purpose of This Study>
Little is known about the microbial community in the deep-sea sub-seafloor around the hydrothermal area, especially in a basaltic aquifer. Previous studies have suggested that there is diversity in the microbial habitat and the presence of novel microbial groups in the deep-sea sub-seafloor. Novel

microbes included extremophiles have been isolated from these deep-sea hydrothermal areas. However, these researches are often limited to the samples corrected above the seafloor, and could not access to the sub-seafloor directly. Recent molecular phylogenetic studies on environmental samples, especially those collected around hydrothermal systems, have suggested the presence of unique and previously unrecognized microbes. Isolated organisms are estimated to constitute less than 1% of all microbial species present in the area. To reach the comprehensive understanding of the physiology of these organisms, and of the complex environmental processes, cultivation of these uncultured microbes is undoubtedly required.

We have already analyzed the diversity of archaea and bacteria in fluid samples collected from hydrothermal vents and drilled holes in the caldera of the Suiyo Seamount (Hara et al, 2005). The analysis has revealed the presence of hydrogen-dependent hyperthermophiles and chemoautotrophic sulfate-reducing microbes in the samples of vent fluids. However, the density of chemoautotrophic microorganisms was lower than expected, probably because of low concentration of reducing compounds in the hydrothermal fluids collected at Suiyo seamount. We have also analyzed the various samples, such as the fluids collected from the natural vent and drilling holes, active and inactive chimneys, around the hydrothermal vent on the Southern Mariana Trough. By the culture-independent analysis of the fluid samples using 16S rRNA gene, it was suggested that there are novel microbes in the sub-seafloor around the hydrothermal vent (Kato et al, 2005). By the 16S rRNA gene analysis of the black smoker chimney, the deep-branching PCR clones in the archaeal phylogenetic tree were detected. The presence of the species closed to the common ancestor in the black smoker chimney has been also suggested. By the culture dependent method, we have succeeded in isolating two hyperthermophiles, belonging to the genera Archaeoglobus and Pyrodictium. These species are hyperthermophilic, sulfate-reducing chemoautotrophic archaea. One of them belongs to Pyrodictium that is able to grow optimally at 105ºC.

The purpose of the current research is to elucidate the microbial community and to cultivate not-yet-cultured microbes, especially thermophiles, which is expected to be present in the hydrothermal systems on the Southern Mariana Trough.

<Methods>

Enrichment culture of thermophiles: on land

Samples were stored under anaerobic conditions in a refrigerator. On land, the samples will be used to inoculate media, which are going to be incubated under various conditions at the temperature above 80ºC.

Culture-independent phylogenetic analysis using 16S rRNA gene: on land

Chimneys and rocks were stored at –80ºC. Fluid samples were filtered to collect microbes onto membrane-filters on board. The filters were stored at -80ªC. These samples will be used for the DNA extraction. Small subunit ribosomal RNA sequence will be amplified by PCR using appropriate primer sets. The amplified DNA fragments will be cloned, and the sequences will be determined for the phylogenetic analysis.

Microscopic observation and counting of particle stained by DAPI: on land

Samples were treated with 3.7%(final concentration) formaldehyde and stored in a refrigerator. The samples will be observed by microscopy, directly. In addition, the samples will be stained with DAPI (4’, 6-diamidino-2-phenylindole), which is specific to DNA. They will be inspected with fluorescence microscopes. The particle stained with DAPI will be counted to estimate the number of microbes in each sample.

< Result>

The details of samples collected in this cruise are noted in the sample list. Hydrothermal fluids were obtained from drilled holes and (a) natural vents. Ambient seawater samples were also collected. Parts of black and clear smoker chimneys erupting 343 or 117ºC fluid were sampled. Unique rocks that were covered with red sediment and those including pyrite were collected. These samples were treated as described in Method section.

< Future plans>

The analysis of the microbial community in the hydrothermal systems

Collected samples will be treated as described in Method section. The microbial diversity and the number of microbes in the samples will be estimated. Phylogenetic analysis of the sequence will be used to assess the relationship between the flora of microorganisms and the environment.

The cultivation of the uncultured microbes

The detailed conditions of the hydrothermal environment will be analyzed chemically and physically. The culture medium for the unique microbes will be decided based on thus determined environmental conditions. Using these culture media, it will be able to culture not-yet-cultured microbes.

List of Dive Data / YK04-05 Leg2

Dive No.	CTDO*1	Sub Data*2	ANS*3	Sub Track*4	Dive Photo*5
6K#900 (05/07/25)	ctdo900.asc ctdo900.txt	900sub_data.slc	900anssub.list	D900track.pdf (1:10,000 / A3) 900event.list	inside camera=33 outside camera=343
6K#901 (05/07/26)	ctdo901.asc ctdo901.txt	901sub_data.slc	901anssub.list	D901track.pdf (1:10,000 / A3) 901event.list	inside camera=32 outside camera=395
6K#902 (05/07/27)	ctdo902.asc ctdo902.txt	902sub_data.slc	902anssub.list	D902track.pdf (1:5,000 / A3) 902event.list	inside camera=0 outside camera=383
6K#903 (05/07/28)	ctdo903.asc ctdo903.txt	903sub_data.slc	903anssub.list	D903track.pdf (1:5,000 / A3) 903event.list	inside camera=93+13 outside camera=210
6K#904 (05/08/02)	ctdo904.asc ctdo904.txt	904sub_data.slc	904anssub.list	D904track.pdf (1:5,000 / A3) 904event.list	inside camera=145+5 outside camera=431
6K#905 (05/08/03)	ctd905.asc ctd905.txt	905sub_data.slc	905anssub.list	D905track.pdf (1:5,000 / A3) 905event.list	inside camera=27 outside camera=356
6K#906 (05/08/04)	ctd906.asc ctd906.txt	906sub_data.slc	906anssub.list	D906track.pdf (1:2,500 / A3) 906event.list	inside camera=72+26 outside camera=246
6K#907 (05/08/05)	ctd907.asc ctd907.txt	907sub_data.slc	907anssub.list	D907track.pdf (1:10,000 / A3) 907event.list	inside camera=47+23 outside camera=416

CTDO*1	: CTD/DO on 6K, ctdo***.asc= 1dbar pressure bin, ctdo***.txt= 1 sec time bin
Sub Data*2	: Varias data taken by Shinkai dive such as current, altitude, roll, pitch etc.. ASCII type file
ANS*3	: (x, y) position data of Shinkai by using Acoustic Navigation System, Refference point is described in top of each file
Sub Track*4	: Track plotting on bathymetric map (D***track.pdf) and list of descriptions for event No. (***event.list)
Dive Photo*5	: Digital still camera data number of the inside and outside camera of Shinkai.

A.2 List of fluid samples of YK05-09 cruise

Dive #	Sample ID	time	Latitude N	Longitude E	depth m	event #	marker #	temperature	note
D900	2005/7/26 (observer H. Masuda)								
	W1	15:47 - 15:5	13 05.0576	143 40.7377	2893	13	no marker		
	RC1	15:47 - 15:5	13 05.0576	143 40.7377	2893	13			
	B	15:58 - 16:0	13 05.0576	143 40.7377	2893	13			
D901	2005/7/27 (observer P. Fryer)								
	W1, W2	15:37	13 05.9240	143 41.3218	2885	7	#16	33	W1, W2 failed
	RC1, RC2	15:41	13 05.9240	143 41.3218	2885	7	#16	33	
	B	15:53	13 05.9240	143 41.3218	2885	7	#16	33	
D902	2005/7/28 (observer H. Kimura)			Snail Site					
	W1-W3	12:44 - 13:2	12 57.1882	143 37.1533	2852	3	Mk#24	20 - 51	
	RC1-RC4	13:24 - 13:4	12 57.1882	143 37.1533	2852	3	Mk#24	37 - 42	RC2-RC4 failed
	B	13:50	12 57.1882	143 37.1533	2852	3	Mk#24	30 - 61	
	W4	16:18	12 57.1593	143 37.1404	2854	4	APM01	28 - 36	
	RC5-RC6	16:08 - 16:1	12 57.1593	143 37.1404	2854	4	APM01	29	
D903	2005/7/29 (observer J. Ishibashi)			Archaean site					
	W1, W2	12:07 - 12:3	12 56.3361	143 37.8941	3001	4	#12	280 - 343	
	RC1, RC2	12:36 - 12:4	12 56.3361	143 37.8941	3001	4	#12	343	
	W3	13:02 - 13:1	12 56.3361	143 37.8941	3002	4	#12	117	
	RC3, RC4	13:17 - 13:2	12 56.3361	143 37.8941	3002	4	#12	117	
	B	13:31 - 13:3	12 56.3361	143 37.8941	3002	4	#12	117	
	W4	14:57 - 15:1	12 56.3625	143 37.9000	2974	6	#17	30 - 93	
	RC5, RC6	14:56 - 15:0	12 56.3625	143 37.9000	2974	6	#17	30 - 93	
D904	2005/8/2 (observer H. Kimura)			Snail Site					
	N	12:13	12 57.1625	143 37.1585	2853	3		1.6	
	W1	12:24 - 12:3	12 57.1625	143 37.1585	2853	3	APM01	40.1 - 40.2	
	RC1-RC2	12:43 - 12:5	12 57.1625	143 37.1585	2853	3	APM01	39.9 - 40.1	
	B1	12:58 - 13:0	12 57.1625	143 37.1585	2853	3	APM01	40.0 - 40.1	
	W2	13:52 - 14:0	12 57.1842	143 37.1739	2850	5	Mk#24	58.5 - 105	
	RC3	14:04 - 14:1	12 57.1842	143 37.1739	2850	5	Mk#24	66 - 84	
	RC4	14:13 - 14:1	12 57.1842	143 37.1739	2850	5	Mk#24	32 - 43	
	B2	14:31 - 14:3	12 57.1842	143 37.1739	2850	5	Mk#24	76 - 95	
	RC5	14:35 - 14:3	12 57.1842	143 37.1739	2850	5	Mk#24	101 - 116	
D905	2005/8/3 (observer K. Shitashima)			Archaean site					
	ID	12:56	12 56.3307	143 37.8912	3001	5	#12	345	
	N1		12 56.3307	143 37.8912	2995		1m above		
	N2		12 56.3307	143 37.8912	2985		10m above		
	N3		12 56.3307	143 37.8912	2955		40m above		
	N4		12 56.3307	143 37.8912	2945		50m above		
	N5		12 56.3307	143 37.8912	2895		100m above		
	N6		12 56.3307	143 37.8912	2795		200m above		
	N7	14:18	X=490	Y=110	2945	6			
	N8	15:09	510	-130	2945	7			
	N9	15:25	530	-70	2965	8			
	N10		470	90	2965				
	N11		520	230	2965				failed
	N12		680	220	2965				
D906	2005/8/4 (observer T. Toki)			Pika site					
	W1	12:13 - 12:1	12 55.1446	143 38.9314	2762	3	#19	330	
	RC1	12:27 - 12:3	12 55.1446	143 38.9314	2762	3	#19	311	
	W2	13:15 - 13:3	12 55.1417	143 38.9277	2761	4	#19	11	
	RC2	13:30 - 13:3	12 55.1417	143 38.9277	2761	4	#19	15	
	W3	13:54 - 14:0	12 55.1446	143 38.9314	2761	5	#19	32	
	RC3	14:04 - 14:0	12 55.1446	143 38.9314	2761	5	#19	32	
	RC4	15:57	12 55.1298	143 38.8555	2780	6	deep SW		
	RC5	15:57	12 55.1298	143 38.8555	2780	6	deep SW		
D907	2005/8/5 (observer H. Masuda)								
	B	15:47	13 07.6370	143 41.2265	2915	13	deep SW		

A.3 Record of fluid sample distribution

		QU	QU	ORI	ORI	QU	QU	ORI	UR	OCU	CRIEPI	CRIEPI	TU	UT	SU	TUP
		vial	pp	extract	vial	vial	pp	pp	pp	glass	vial	pp				
		pH	major	gas	gas	organic	delta-S	delta-Cl	metal	amino	CO2	metal	particle	FISH	DNA	DNA
D900	W-1	15	45		80											
	RC-1	15	45			10		50						100	50	
	B	15	45			10								100	2050	
D901	RC-1	15	45		40	60		10	60	10			50	100	50	
	RC-2	15	45		40	30										360
	B	15	45										50	50	600	
D902	W-1	15	45												50	
	W-2	15	45		80	10		10								
	W-3			150												
	W-4			150												
	RC-1	15	25			10			30					50		160
	RC-5	15	45		40	60		10					50	100		
	RC-6	15	45		40											440
D903	W-1	15	45		80			10								
	W-2			150												
	W-3			150												
	W-4			150												
	RC-1	15	45			60		10	100	10			50	100		
	RC-2	15	75			60	30	10	100		60				50	
	RC-3	15	75		80	60	30	10	60	30			50	100		
	RC-4	15	45		40											400
	RC-5	15	45		40	60	30	10	60		60		50	100		
	RC-6	15	45		40			10								400
	B	15	75				30		60				50	100	6000	
D904	W-1			150												
	W-2			150												
	RC-1	15	45		40	60		10	60				50	100		50
	RC-2	15	45		40		30									400
	RC-3	15	45		80	60	30	10	60					100		
	RC-4	15	45				10		100						20	
	RC-5	15	75		80	60	30	10	60	10			50	100		
	B-1	15	45						60				50	100		7800
	B-2	15	45						60				50	100	8000	
	N	15	45		250	10		10	90							500
D905	ID	30	45		80											
	N	15			125						125	400		100		
D906	W-1			150												
	W-2			150												
	W-3			150												
	RC-1	15	75		40	60	30	10	120	10			50			
	RC-2	15	75		80	60	30	10	120				50	100		
	RC-3	15	75		80	60	30	10	120				50			
	RC-4	15	45		125											300
	RC-5	15	45		125											300
D907	B	15	45												8000	250

QU:	Kyushu Univ.
ORI:	Ocean Research Institute
UR:	Univ. Ryukyus
OCU:	Osaka City University
CRIEPI:	Central Res. Inst. Electr. Power Industries
TU:	Tohoku Univ.
UT:	Univ. Tokyo
SU:	Shizuoka Univ.
TUP	Tokyo Univ. of Pharmacy & Life Science

A.4 Record of sample distribution

Rock and Chimney fragment

	#900 R-1	OCU,UH,JAM
	R-2	OCU,UH,JAM
	R-3	OCU,UH,JAM
	R-4	OCU,UH,JAM
	R-5	OCU,UH,JAM
	R-6	OCU,UH,JAM
	R-7	OCU,UH,JAM
	R-8	OCU,UH,JAM
	R-9	OCU,UH,JAM
	R-10	OCU,UH,JAM
	R-11-1	OCU,UH,JAM
	R-11-2	OCU,UH,JAM
	R-12-1	OCU,UH,JAM
	R-12-2	OCU,UH,JAM
	#901 R-1	OCU,UH,JAM
	R-2	OCU,UH,JAM
	R-3	OCU,UH,JAM
	R-4-2	OCU,UH,JAM
	#902 R-1	OCU,UH,JAM
	#903 R-1	TUP,UR,TU,OCU,UH,QU
	R-2	TUP,UR,TU,OCU,UH,JAM,QU
	R-3	TUP,UR,TU,OCU,UH,JAM,QU
	R-4	TUP,UR,TU,OCU,UH,QU
	R-5	UR,QU
	R-6	TUP,UR,TU,OCU,QU
	R-7	UR,QU
	#904 R-1	TU,JAM
	R-2	OCU,UT,UH,JAM
	R-3	OCU,UT,UH,JAM
	#906 R-1	UH,QU,UR,JAM
	R-2	TUP,UR,QU
	R-3	UH,UR,QU,JAM
	R-4	UH,UR,QU,JAM
	R-5	UH,UR,QU,JAM
	#907 R-1	OCU,UH,JAM
	R-2	OCU,UH,JAM
	R-3-1	OCU,UH,JAM
	R-3-2	OCU,UH,JAM
	R-4	OCU,UH,JAM
	R-5	OCU,UH,JAM
	R-6	OCU,UH,JAM
	R-7	OCU,UH,JAM
	R-8-1	OCU,UH,JAM
	R-8-2	OCU,UH,JAM
	R-9-1	OCU,UH,JAM
	R-9-2	OCU,UH,JAM
	R-10	OCU,UH,JAM
	R-11	OCU,UH,JAM
Fe-oxide,Mn-oxide		
	#901 R-4-1	OCU,TUP,TU
Biomat+Fe-oxide precipitates		
	#901 MS-4	SU,TU,TUP,OCU
Biomat	#904 MS	TUP,TU

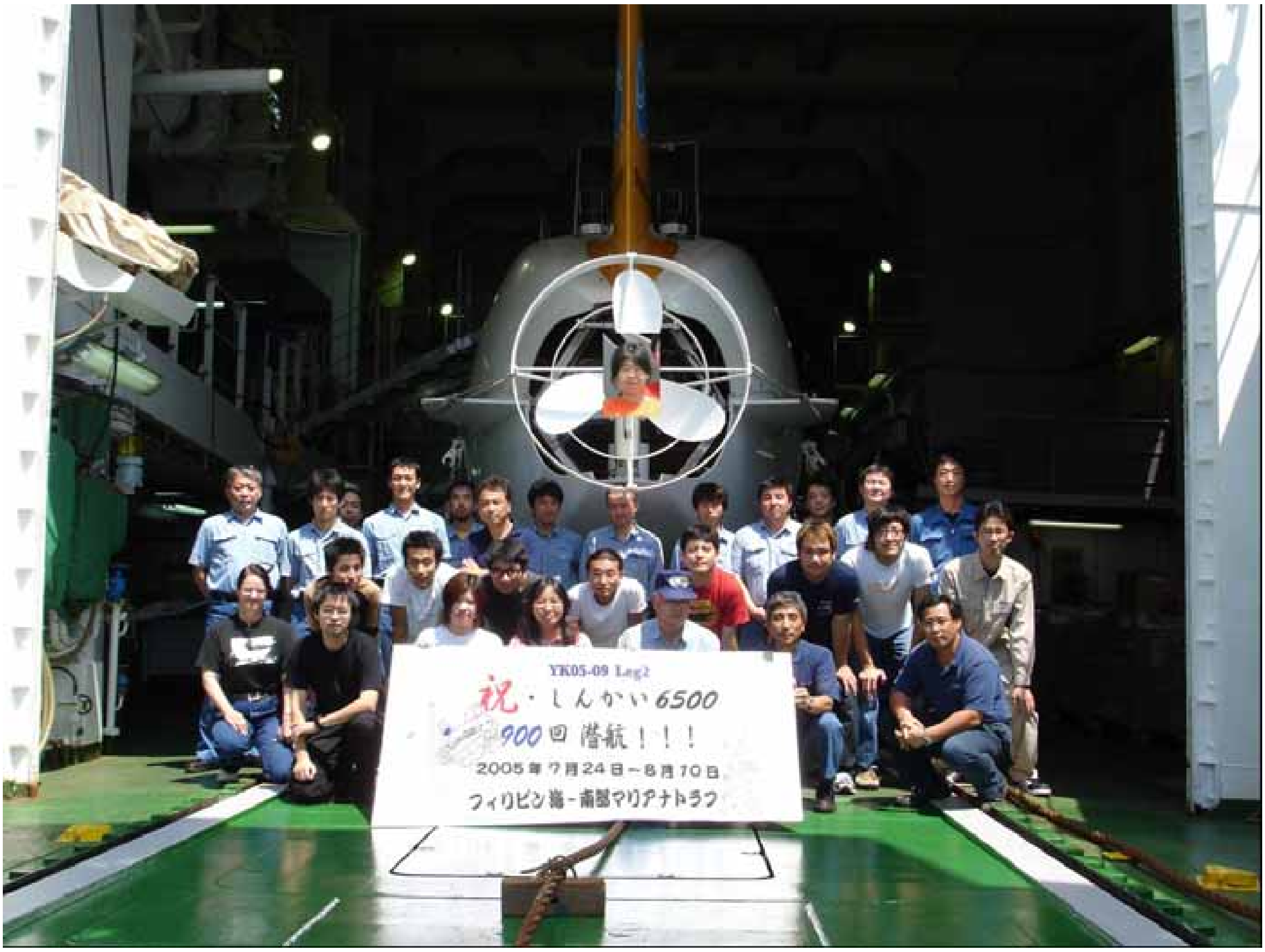
Biological samples

		SU	QU
D903	Crabs		4
	Shrimps		1
D904	Gastropods	18	30
	Crabs		1

A.5 List of Video Images

		Master Tape			MPEG2			AVI		Movie
Date	Dive No.	Camera	No.	Start (Local) - End (Local)	filename	Start (Local) - End (Local)	file size	Start (Local) - End (Local)	remarks	Start (Local) - End (Local)
2005/7/26	6K#900	No.1	1/4	11:12 - 14:14	#900camera1-01.mpg	11:12 - 12:20	2,047,919			11:12 - 12:59
			2/4	14:14 - 16:05	#900camera1-02.mpg	12:20 - 13:28	2,047,917			12:59 - 14:13
					#900camera1-03.mpg	13:29 - 14:38	2,047,915			14:14 - 16:05
					#900camera1-04.mpg	14:38 - 15:45	2,047,915			
					#900camera1-05.mpg	15:45 - 16:05	562,109			
	6K#900	No.2	3/4	11:12 - 14:14	#900camera2-01.mpg	11:12 - 12:20	2,047,919	11:12 - 14:14	1ファイル 2GBに分割	11:12 - 13:12
			4/4	14:14 - 16:05	#900camera2-02.mpg	12:20 - 13:28	2,047,917	14:14 - 16:05		13:12 - 14:13
					#900camera2-03.mpg	13:29 - 14:38	2,047,915			14:13 - 16:05
					#900camera2-04.mpg	14:38 - 15:45	2,047,917			
					#900camera2-05.mpg	15:45 - 16:05	567,553			
2005/7/27	6K#901	No.1	1/4	11:14 - 14:17	#901camera1-01.mpg	11:15 - 12:22	2,047,919			11:15 - 13:12
			2/4	14:17 - 16:09	#901camera1-02.mpg	12:23 - 13:31	2,047,917			13:12 - 14:17
					#901camera1-03.mpg	13:31 - 14:39	2,047,915			14:17 - 16:09
					#901camera1-04.mpg	14:40 - 15:48	2,047,911			
					#901camera1-05.mpg	15:48 - 16:09	609,201			
	6K#901	No.2	3/4	11:14 - 14:16	#901camera2-01.mpg	11:15 - 12:23	2,047,919	11:14 - 14:16	1ファイル 2GBに分割	11:15 - 13:13
			4/4	14:17 - 16:09	#901camera2-02.mpg	12:23 - 13:31	2,047,917	14:17 - 16:09		13:13 - 14:17
					#901camera2-03.mpg	13:31 - 14:41	2,047,915			14:17 - 16:09
					#901camera2-04.mpg	14:41 - 15:49	2,047,909			
					#901camera2-05.mpg	15:49 - 16:08	569,121			
2005/7/28	6K#902	No.1	1/4	11:08 - 14:08	#902camera1-01.mpg	11:11 - 12:19	2,047,919			11:08 - 13:08
			2/4	14:08 - 16:21	#902camera1-02.mpg	12:19 - 13:28	2,047,917			13:08 - 14:09
					#902camera1-03.mpg	13:28 - 13:40	380,055			14:09 - 14:23
					#902camera1-04.mpg	13:41 - 14:08	923,541			14:23 - 16:21
					#902camera1-05.mpg	14:08 - 15:17	2,047,919			
					#902camera1-06.mpg	15:17 - 16:21	1,884,375			
	6K#902	No.2	3/4	11:08 - 14:08	#902camera2-01.mpg	11:08 - 12:16	2,047,919			11:08 - 13:06
			4/4	14:08 - 16:21	#902camera2-02.mpg	12:16 - 13:25	2,047,917			13:06 - 14:08
					#902camera2-03.mpg	13:25 - 13:38	380,211			14:08 - 14:22
					#902camera2-04.mpg	13:38 - 14:08	818,687			14:22 - 16:21
					#902camera2-05.mpg	14:09 - 15:17	2,047,919			
					#902camera2-06.mpg	15:17 - 16:21	1,899,567			
2005/7/29	6K#903	No.1	1/4	11:12 - 14:13	#903_camera1-01.mpg	11:12 - 12:22	2,097,057			11:12 - 13:12
			2/4	14:14 - 15:53	#903_camera1-02.mpg	12:22 - 13:32	2,095,057			13:12 - 14:14
					#903_camera1-03.mpg	13:32 - 14:14	1,246,537			14:14 - 15:53
					#903_camera1-04.mpg	14:15 - 15:25	2,097,057			
					#903_camera1-05.mpg	15:25 - 15:53	831,609			
	6K#903	No.2	3/4	11:12 - 14:13	#903_camera2-01.mpg	11:12 - 12:22	2,097,057			11:12 - 13:12
			4/4	14:14 - 15:53	#903_camera2-02.mpg	12:22 - 13:32	2,097,057			13:12 - 14:15
					#903_camera2-03.mpg	13:32 - 14:43	2,097,057			14:15 - 15:53
					#903_camera2-04.mpg	14:43 - 15:53	2,068,919			
2005/8/2	6K#904	No.1	1/4	11:08 - 14:07	#904camera1-01.mpg	11:07 - 12:15	2,047,919			11:07 - 13:07

		Master Tape			MPEG2			AVI		Movie
Date	Dive No.	Camera	No.	Start (Local) - End (Local)	filename	Start (Local) - End (Local)	file size	Start (Local) - End (Local)	remarks	Start (Local) - End (Local)
			2/4	14:07 - 15:54	#904camera1-02.mpg	12:15 - 13:24	2,047,919			13:07 - 14:07
					#904camera1-03.mpg	13:24 - 14:33	2,047,919			14:07 - 15:54
					#904camera1-04.mpg	14:33 - 15:42	2,047,919			
					#904camera1-05.mpg	15:42 - 15:54	347,115			
	6K#904	No.2	3/4	11:08 - 14:07	#904camera2-01.mpg	11:07 - 12:15	2,047,919			11:07 - 13:05
			4/4	14:07 - 15:54	#904camera2-02.mpg	12:15 - 13:24	2,047,919			13:05 - 14:07
					#904camera2-03.mpg	13:24 - 14:33	2,047,919			14:07 - 15:54
					#904camera2-04.mpg	14:33 - 15:42	2,047,919			
					#904camera2-05.mpg	15:42 - 15:53	352,087			
2005/8/3	6K#905	No.1	1/4	11:20 - 14:24	#905camera1-01.mpg	11:20 - 12:28	2,047,919			11:20 - 13:20
			2/4	14:24 - 15:58	#905camera1-02.mpg	12:28 - 13:37	2,047,919			13:20 - 14:25
					#905camera1-03.mpg	13:37 - 14:46	2,047,919			14:25 - 15:15
					#905camera1-04.mpg	14:46 - 15:55	2,047,919			15:15 - 15:58
					#905camera1-05.mpg	15:55 - 15:58	88,535			
	6K#905	No.2	3/4	11:20 - 14:24	#905camera2-01.mpg	11:20 - 12:28	2,047,919			11:20 - 13:16
			4/4	14:24 - 15:58	#905camera2-02.mpg	12:28 - 13:37	2,047,919			13:16 - 14:24
					#905camera2-03.mpg	13:37 - 14:46	2,047,919			14:24 - 15:18
					#905camera2-04.mpg	14:46 - 15:55	2,047,919			15:18 - 15:58
					#905camera2-05.mpg	15:55 - 15:58	97,655			
2005/8/4	6K#906	No.1	1/4	11:03 - 14:00	#906camera1-01.mpg	11:03 - 12:21	2,047,919			11:03 - 13:03
			2/4	14:01 - 16:01	#906camera1-02.mpg	12:21 - 13:20	2,047,919			13:03 - 14:02
					#906camera1-03.mpg	13:20 - 14:30	2,047,919			14:02 - 16:01
					#906camera1-04.mpg	14:30 - 15:38	2,047,919			
					#906camera1-05.mpg	15:38 - 16:01	702,587			
	6K#906	No.2	3/4	11:03 - 14:02	#906camera2-01.mpg	11:03 - 12:21	2,047,919			11:03 - 13:03
			4/4	14:02 - 16:01	#906camera2-02.mpg	12:21 - 13:20	2,047,919			13:03 - 14:00
					#906camera2-03.mpg	13:20 - 14:30	2,047,919			14:01 - 16:01
					#906camera2-04.mpg	14:30 - 15:38	2,047,919			
					#906camera2-05.mpg	15:38 - 16:01	695,141			
2005/8/5	6K#907	No.1	1/4	11:11 - 14:09	#907camera1-01.mpg	11:11 - 12:21	2,047,919			11:11 - 14:09
			2/4	14:09 - 16:03	#907camera1-02.mpg	12:21 - 13:31	2,047,919			14:10 - 15:09
					#907camera1-03.mpg	13:31 - 14:42	2,047,919			15:09 - 16:03
					#907camera1-04.mpg	14:42 - 15:52	2,047,919			
					#907camera1-05.mpg	15:52 - 16:03	347,151			
	6K#907	No.2	3/4	11:11 - 14:09	#907camera2-01.mpg	11:11 - 12:19	2,047,919	11:11 - 14:09	1ファイル2GBに分割	11:11 - 14:09
			4/4	14:10 - 16:03	#907camera2-02.mpg	12:19 - 13:28	2,047,919	14:10 - 16:03		14:10 - 15:09
					#907camera2-03.mpg	13:28 - 14:37	2,047,919			15:09 - 16:03
					#907camera2-04.mpg	14:37 - 15:45	2,047,919			
					#907camera2-05.mpg	15:45 - 16:03	537,365			
Digest Video			1/1		.mpg					


YK05-09 Leg2
祝・しんかい6500
900回潜航！！！
2005年7月24日～8月10日
フィリピン海－南部マリアナトラフ