

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

R/V Yokosuka
Cruise YK15-12

**Tectonic and magmatic processes
at subduction initiation
revealed by submersible survey
of remnant arc crustal section**

July 19 to July 31, 2015

(Saipan to JAMSTEC)



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Cruise Information

- CruiseID: YK15-12
- Name of vessel: R/V Yokosuka
- Title of the cruise: Tectonic and magmatic processes at subduction initiation revealed by submersible survey of remnant arc crustal section
- Chief scientist: Osamu Ishizuka (Geological Survey of Japan/AIST)
- Title of proposal: Tectonic and magmatic processes at subduction initiation revealed by submersible survey of remnant arc crustal section
- Representative of Science Party: Osamu Ishizuka (Geological Survey of Japan/AIST)
- Cruise period: July 19 to July 31, 2015
- Port call: Saipan to JAMSTEC
- Research area: Kyushu-Palau Ridge

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ACKNOWLEDGEMENTS

We are grateful to Captain Eiko Ukekura and the excellent crew of the Yokosuka, for their outstanding efforts to make this scientific program successful. The Shinkai 6500 operation team manager Toshiaki Sakurai and the Shinkai 6500 team for their outstanding efforts to make this scientific program successful. We also thank JAMSTEC for their support of this project.

Cruise narrative and schedule of operations

Date	Time	Descriptions	Position/Weather/Wind, Sea condition (noon)
19.Jul	7:00	All scientists aboard	NW off Saipan
(JST+1H)	8:00	Immigration	15-18.0N, 145-09.3E
(UTC+10H)	9:00	Disembark (Port of Saipan to research area)	Fine but Cloudy
	10:00	Onboard lecture for evacuation and onboard life	East-3 (Gentle breeze)
	10:30	Onboard excursion attend by chief officer	2 (Sea Smooth)
	16:40	KONPIRA-SAN	1 (Low Swell Short)

20.Jul	8:30	Evacuation drill	Westward Mariana Islands
	10:00	Scientific meeting	17-39.0N, 139-52.0E
	13:00	Research dive briefing with 6K team	Fine but Cloudy
	13:20	Lecture of SHINKAI6500 operation	NE-3 (Gentle breeze)
	22:00	Time shift -1 hour (local time = JST)	3 (Sea Slight)
			1 (Low Swell Short)

21.Jul	3:00	arrived at research area Site A	West Philippine basin
(JST+0H)	4:54	XBT measurement	19-17.2N, 135-54.3E
(UTC+9H)	5:19	pre bathymetry survey (~05:47)	Fine but Cloudy
	8:57	6K launched	NNE-2 (Light breeze)
	9:07	6K dove, started her operation dive#1434	2 (Sea Smooth)
	11:37	landed on the sea bottom (Depth: 5805m)	1 (Low Swell Short)
	15:01	left bottom (Depth: 5138m)	
	16:46	6K floated	
	17:12	Recovered 6K, finished the operation	
	17:46	deployed proton magnetometer	
	18:11	pre bathymetry survey (~18:32)	
	19:08	commence MBES survey	
	20:00	scientific meeting	
	20:30	lecture of bathymetry processing	

22.Jul	4:41	finished MBES survey	West Philippine basin
	4:43	figure 8 turn for calibration (~05:03)	19-19.2N, 135-54.4E
	8:49	6K launched	Cloudy
	8:58	6K dove, started her operation dive#1435	Calm
	11:09	landed on the sea bottom (Depth: 5070m)	1 (Sea Calm Rippled)
	15:40	left bottom (Depth: 3721m)	1 (Low Swell Short)
	17:00	6K floated	
	17:28	Recovered 6K, finished the operation	
	18:02	deployed proton magnetometer	
	19:06	commence MBES survey (~03:18)	
	20:12	Scientific meeting	

23.Jul	3:42	XBT measurement	West Philippine basin
	4:01	figure 8 turn for calibration (~04:21)	19-12.0N, 135-37.8E
	4:55	commenced MBES survey	Fine but Cloudy

	8:30	SHINKAI 6500 tour	WSW-3 (Gentle breeze)
	13:00	study for MBES processing	2 (Sea Smooth)
	18:00	Scientific meeting	1 (Low Swell Short)

24.Jul	6:15	finished MBES survey, bound for site B area	Eastward OKINOTORISHIMA
	9:00	introduction of AUV URASHIMA	20-43.5N, 136-21.5E
	10:30	pass through east side of OKINORORI-SHIMA	Fine but Cloudy
	13:10	Research dive briefing with 6K team	SSW-4 (Moderate breeze)
	15:00	scientific seminar, presentation by Yagi-san	3 (Sea Slight)
	16:15	Scientific meeting	2 (Low Swell Long)
	20:00	arrived at research area Site B	
	20:20	XBT measurement	
	21:00	pre bathymetry survey (~21:21)	
	22:07	commenced MBES survey (~05:32)	

25.Jul	6:36	recovered proton magnetometer	Minami Daito basin
	6:40	arrived at research area Site B	22-59.0N, 137-05.3E
	8:55	6K launched	Fine but Cloudy
	9:04	6K dove, started her operation dive#1436	South-3 (Gentle breeze)
	11:15	landed on the sea bottom (Depth: 5230m)	2 (Sea Smooth)
	15:29	left bottom (Depth: 4371m)	4 (Moderate Average)
	17:04	6K floated	
	17:34	Recovered 6K, finished the operation	
	18:10	deployed proton magnetometer	
	19:50	commenced MBES survey (~03:34)	
	21:00	Scientific meeting	

26.Jul	3:34	bounded for research area site C	Kyushu Palau Ridge
	13:10	Research dive briefing with 6K team	25-06.0N, 136-13.5E
	15:00	scientific seminar, presentation by Yokoyama-san	Fine but Cloudy
	16:00	arrived at research area site C	East-2 (Light breeze)
	16:24	XBT measurement	1 (Sea Calm Rippled)
	17:04	commenced pre bathymetry survey (~17:27)	4 (Moderate Average)
	17:47	commenced MBES survey	
	20:23	finished MBES and started pre bathymetry survey	
	20:45	commenced MBES survey	
	21:36	figure 8 turn for calibration (~21:57)	

27.Jul	5:28	finished MBES survey	Daito Ridge
	6:36	recovered proton magnetometer	26-14.0N, 135-51.8E
	8:57	6K dove, started her operation dive#1437	Cloudy
	11:12	landed on the sea bottom (Depth: 5298m)	NW-3 (Gentle breeze)
	15:30	left bottom (Depth: 4030m)	2 (Sea Smooth)
	16:59	6K floated	1 (Low Swell Short)
	17:26	Recovered 6K, finished the operation	
	17:59	deployed proton magnetometer	
	18:53	commenced MBES survey (~04:45)	

	20:00	Scientific meeting	

28.Jul	6:35	recovered proton magnetometer	Daito Ridge
	8:58	6K dove, started her operation dive#1438	26-06.0N, 135-55.6E
	10:42	landed on the sea bottom (Depth: 3881m)	Fine but Cloudy
	15:16	left bottom (Depth: 2362m)	WNW-4 (Moderate breeze)
	16:08	6K floated	3 (Sea Slight)
	16:36	Recovered 6K, finished the operation	1 (Low Swell Short)
	17:11	commenced MBES survey	
	20:00	Scientific meeting	

29.Jul	0:00	finished MBES survey, proceeded to JAMSTEC	Westward Tori-shima
	18:00	Scientific meeting	29-38.0N, 136-55.5E
			Fine but Cloudy
			West-5 (Fresh breeze)
			3 (Sea Slight)
			1 (Low Swell Short)

30.Jul	9:00	onboard seminar	Southwestward Mikura-jima
	13:00	engine room excursion	33-26.5N, 138-38.5E
	18:00	scientific meeting	Mist
	19:30	farewell party	SW-2 (Light breeze)
			1 (Sea Calm Rippled)
			1 (Low Swell Short)

			4
31.Jul	9:00	arrived at JAMSTEC	
		completed voy YK15-12	

1. Cruise objectives

The initiation of subduction and the subsequent birth and evolution of island arcs are still one of the fundamental unsolved questions of plate tectonics (Fig. 1-1: e.g. Stern, 2004; Stern et al., 2011; Gerya, 2011). Subduction initiation is a transient phenomena, so there are few examples of on-going subduction initiation (e.g., Puysegur subduction zone off south New Zealand (LeBrun et al., 2003; Sutherland et al., 2006). Geologic record of subduction initiation is supposed to be preserved in forearc area, and in most cases, the area is deeply buried with sediment. These situations make the understanding of process of subduction initiation difficult.

However, subduction zones where subduction erosion rather than accretion is a dominating process potentially have good exposure of geologic record of earliest part of the arc along the landward slope of the trench. One such example is Izu-Bonin-Mariana arc. Recent geological and geophysical survey in the Izu-Bonin-Mariana forearc, such as Bonin Ridge, SE of Guam and Palau Islands (Fig. 1-2), has revealed that forearc crust was produced at the initial stage of arc formation, and crustal stratigraphy has been preserved and exposed along the trench (e.g., Ishizuka et al., 2006, 2011a, 2014b; Reagan et al., 2010, 2013). These studies revealed the occurrence on the seafloor of oceanic crust generated in the initial stages of subduction and the earliest stage of island arc formation (Fig. 1-1). The earliest magmatism after subduction initiation generated depleted MORB-like basalts associated with seafloor spreading (so-called forearc basalts), and subsequently, boninitic and tholeiitic to calc-alkaline lavas were produced. Collectively, these rocks make up the extrusive sequence of the Izu-Bonin-Mariana forearc oceanic crust. This volcanic stratigraphy and its time-progressive development are analogous to those documented from many suprasubduction zone ophiolites.

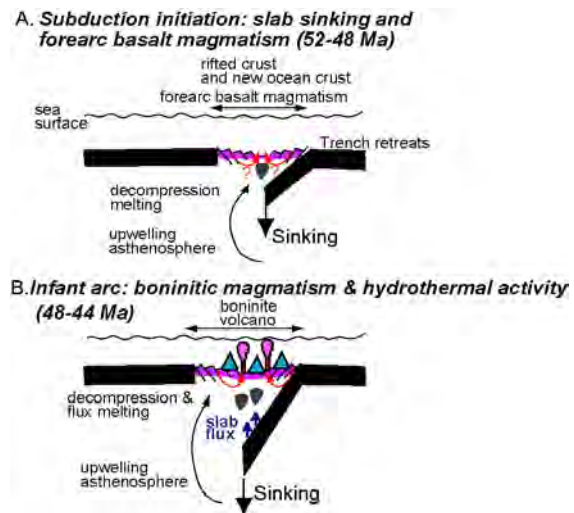


Fig.1-1 Model of subduction initiation and evolution of infant arc (modified from Ishizuka et al. 2014a)

Based on these recent findings from forearc studies, models for subduction initiation have been refined (e.g., Ishizuka et al., 2011a; Stern et al., 2012; Leng and Gurnis, 2011; Leng et al., 2012) to adopt required spatial and temporal variation in magmatism and time scale of geologic events. Now the major remaining question is the tectonic setting when subduction initiated to form Izu-Bonin-Mariana arc. This is critical because initial boundary conditions for numerical modeling need to be assumed based on available tectonic reconstruction at the time of subduction initiation.

This cruise was planned to investigate basal part of Kyushu-Palau Ridge to obtain geological information about the basement of the ridge, i.e., Izu-Bonin-Mariana arc, and early arc magmatic record. If we are able to find along-arc variability of arc basement and associated variation in magmatic history along the arc, that will provide crucial information about overriding plate at subduction initiation, hence, reconstruct tectonic setting during this period.

2. Geologic background

Kyushu-Palau Ridge (KPR) extends continuously over a distance of ~2600 km from off Kyushu to the Palau Islands (Fig. 1-2, 2-1). This ridge is a remnant arc structure, which was separated from Izu-Bonin-Mariana arc by backarc spreading of the Shikoku and Parece Vela Basins. The spreading is estimated to have initiated by c. 25 Ma (Fig. 2-2: Ishizuka et al., 2011b). By 25 Ma, the volcanism along the Kyushu-Palau Ridge appears to have ceased. Accordingly, the Kyushu-Palau Ridge is expected to record arc volcanic record from its inception at c. 52 Ma until around 25 Ma.

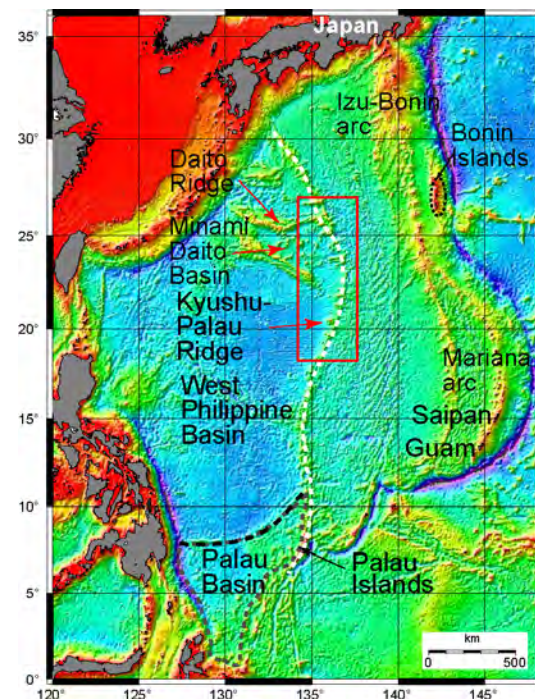


Fig.1-2 Survey area along Kyushu-Palau Ridge. during YK15-12 cruise.

The Oligocene arc has different chemical characteristics to either the Eocene or modern Izu-Bonin-Mariana arcs (Ishizuka et al., 2011b). The KPR magma has been extracted from a more depleted mantle wedge than the post-45 Ma Eocene arc, while the slab-derived components have some similarities such as the involvement of melt of altered oceanic (igneous) crust. This is in contrast to the modern Izu-Bonin-Mariana arc front, where hydrous fluid from altered oceanic crust is prevalent in the Izu-Bonin sector, while pelagic sediment dominates the Mariana sector. Another significant difference between Oligocene and modern arc is that the Oligocene does not show a systematic along-arc geochemical variation as the modern arc does around the Alkalic Volcano Province.

West of KPR shows wide variety in geologic and tectonic features. Northern part of the KPR is Daito Ridge group, including ridges such as Amami Plateau, Daito Ridge and Oki-Daito Ridge, and intervening basins such as Minami-Daito Basin. On the other hand, southern KPR

contacts West Philippine Basin with its western margin. In both area, small volcanic chains extending from KPR to the west are observed, which is interpreted as reararc volcanoes of ancient Izu-Bonin-Mariana arc.

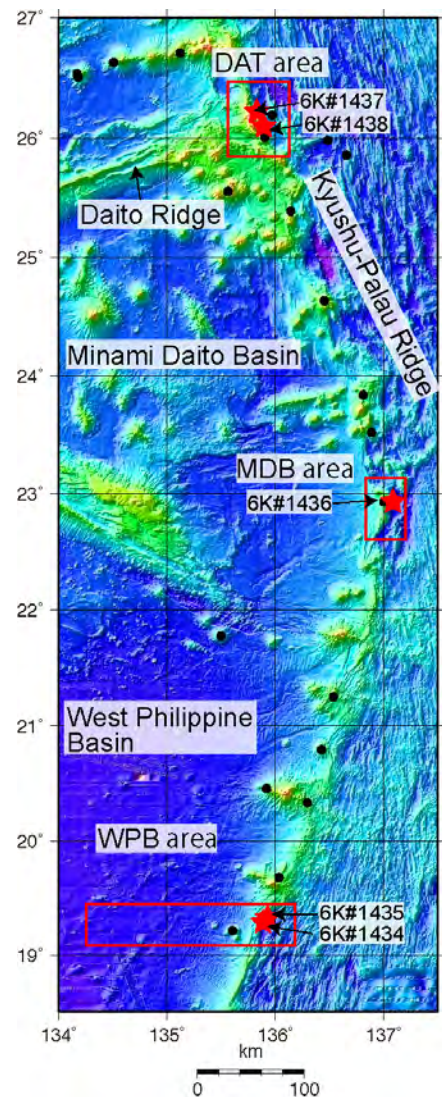


Fig. 2-1 Survey area and dive location during YK15-12 cruise. Black dots show sampling locations of previous cruises.

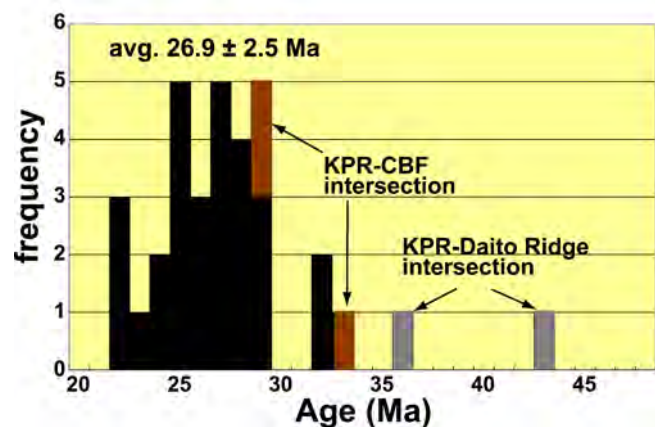


Fig. 2-2 Ar/Ar ages obtained from Kyushu-Palau Ridge volcanics (Ishizuka et al., 2011b).

3. Hypothesis to be tested

Based on current geographic relation, KPR, i.e., Izu-Bonin-Mariana arc, is presumed to have been established on different types of basement crust between its northern and southern parts (Fig. 3-1).

Volcanic rocks recovered from the Daito Ridge are Cretaceous, which is consistent with geological evidence that this ridge is a remnant arc from this period. Geochemical characteristics of volcanic rocks is consistent with the interpretation that the Daito ridge is a part of Mesozoic arc terrane. Plutonic rocks recovered from this ridge gave ages of Jurassic to Cretaceous (Tani et al., 2011), which further supports the idea that the Daito Ridge is a Mesozoic remnant arc, which existed prior to the onset of subduction to form the Izu-Bonin-Mariana arc. Consequently, the northern segments of the KPR might have been established on Cretaceous terranes (Fig. 3-2).

On the other hand, the KPR south of 20°N might have been established on ocean crust of West Philippine Basin. Age of onset of spreading of the West Philippine Basin is not yet clear. Based on magnetic anomaly data, the spreading is estimated to have initiated at 53-54 Ma and ended at 33-30 Ma (Deschamps and Lallemand, 2002; Sasaki et al., 2014). Accordingly, the period of spreading of WPB is overlapped with the active period of Kyushu-Palau Ridge. Since the spreading axis of WPB intersects KPR, it is likely that southern part of KPR formed on the young WPB ocean crust (Fig. 3-2).

The possible difference in terms of arc basement between northern KPR and southern KPR is expected to cause difference in igneous stratigraphy. While northern KPR recorded all

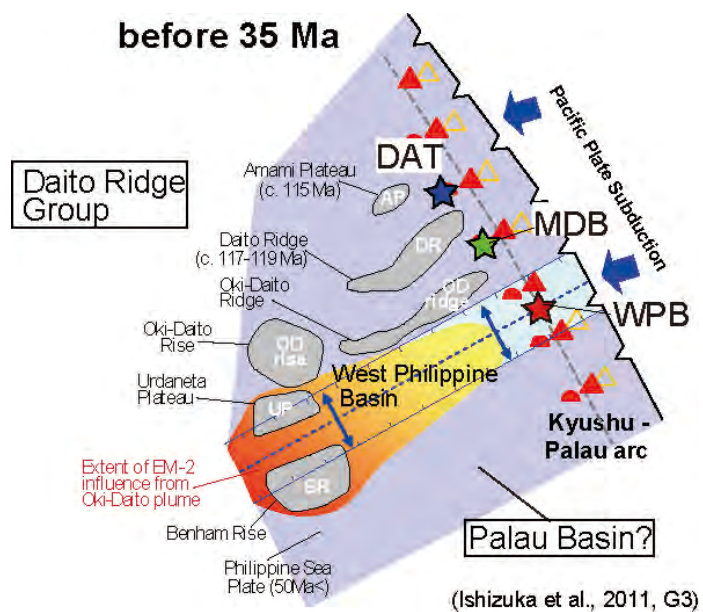


Fig. 3-1 Tectonic reconstruction of KPR area before 35 Ma (Ishizuka et al., 2011b), and each survey area during YK15-12 cruise.

the igneous history subsequent to subduction initiation, southern KPR has volcanic record only after the formation of WPB at each location.

During this expedition, we attempted to evaluate the above hypothesis by looking at stratigraphy of arc crust section exposed along the Kyushu-Palau Ridge in three areas, i.e., KPR-Daito Ridge intersection (DAT area), central KPR where it contacts Minami Daito Basin (MDB area) southern KPR where it contacts with West Philippine Basin (WPB area). Age determination of the stratigraphy as well as petrographic and geochemical analysis will reveal the origin and characteristics of observed stratigraphy, and provide critical information to test above-mentioned hypothesis.

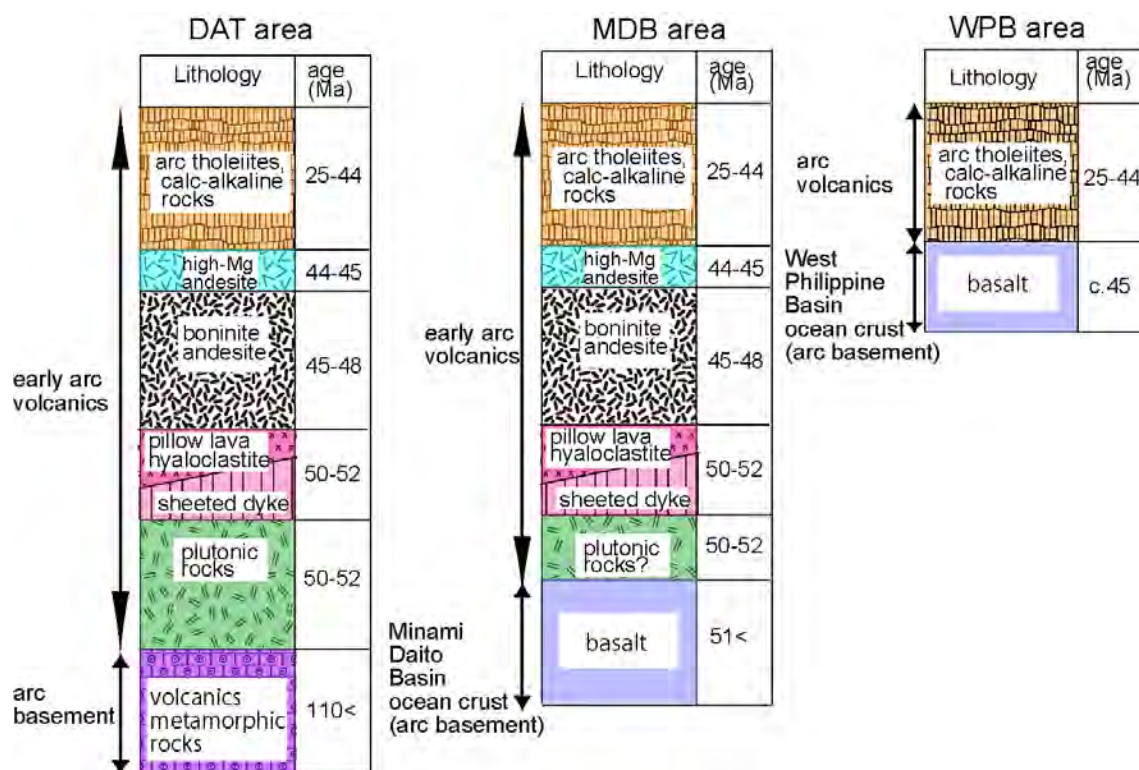


Fig. 3-2 Estimated stratigraphy for each survey area based on a tectonic reconstruction assuming each area has different arc basement.

4. Operations and data processing information

Shinkai 6500 usually dove with payloads that included 2 rock-sampling baskets, with 3 push cores and one scoop sampler.

Data and samples from the dives were archived as customary. Brief sample descriptions are included in Section 5. Samples distributed to the scientific party are listed in Appendix A. Standard data products were provided to the shipboard scientific party.

5. Dive results

Summaries of the results of each dive with representative pictures, track maps, and dive logs are included in the sections below. All dive locations are shown in Fig. 5-1~5-3, and Table 5-1. A comprehensive list of sample descriptions is included in Chapter 6.

Table 5-1 YK15-12 Dive list

Date	St. No.	locality	SP/EP	Time(JST)	Depth(m)	lat.	lon.	observer	pilot	rock type
2015/7/21	6K#1434	Kyushu-Palau Ridge (WPB area)	on bottom off bottom	11:37 15:01	5808 5138	19-17.1873N 19-17.4287N	135-54.3790E 135-53.5630E	O. Ishizuka	H. Ueki K. Suzuki	basalt, scoria, mudstone
2015/7/22	6K#1435	Kyushu-Palau Ridge (WPB area)	on bottom off bottom	11:09 15:40	5070 3721	19-19.0424N 19-19.9264N	135-54.4590E 135-53.9352E	H. Shimoda	T. Onishi Y. Tayama	phyric basalt, aphyric basalt, dolerite, scoria, mudstone
2015/7/25	6K#1436	Kyushu-Palau Ridge (MDB area)	on bottom off bottom	11:15 15:29	5230 4371	22-59.0961N 22-59.0150N	137-05.2415E 137-04.3190E	I. Sakamoto	K. Matsumoto A. Ishikawa	scoria, mudstone, mudstone, sandstone, pumice
2015/7/27	6K#1437	Kyushu-Palau Ridge (DAT area)	on bottom off bottom	11:13 15:31	5298 4030	26-14.2856N 26-13.5723N	135-51.8446E 135-51.0165E	K. Tani	T. Onishi K. Suzuki	gabbro, breccia, mudstone
2015/7/28	6K#1438	Kyushu-Palau Ridge (DAT area)	on bottom off bottom	10:42 15:16	3881 2362	26-6.0511N 26-5.5481N	135-55.6311E 135-55.1174E	S. Umino	H. Ueki A. Ishikawa	gabbro, granite, breccia, metamorphic rock

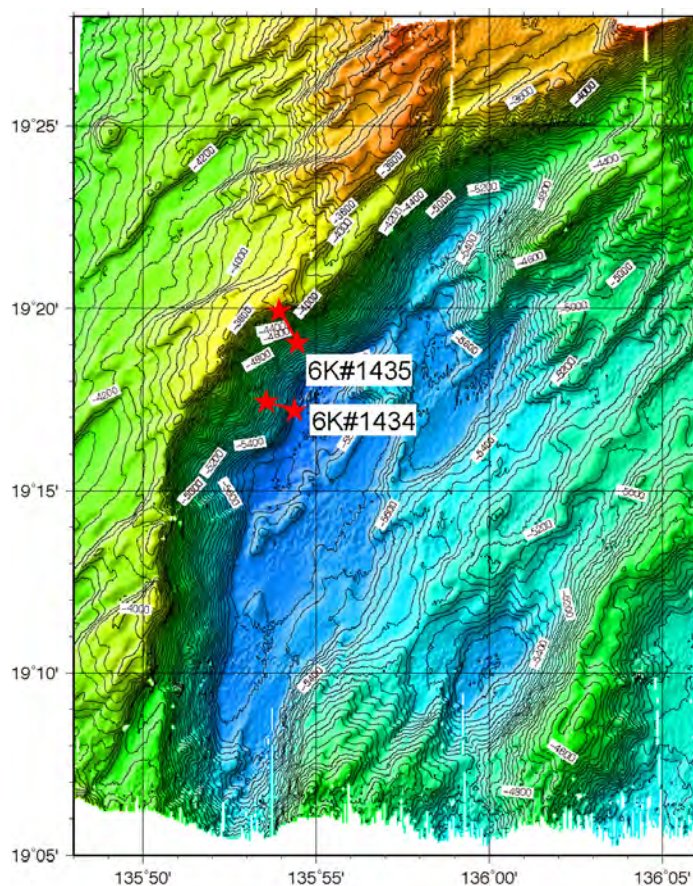


Fig. 5-1 Diving location in WPB area (area A).

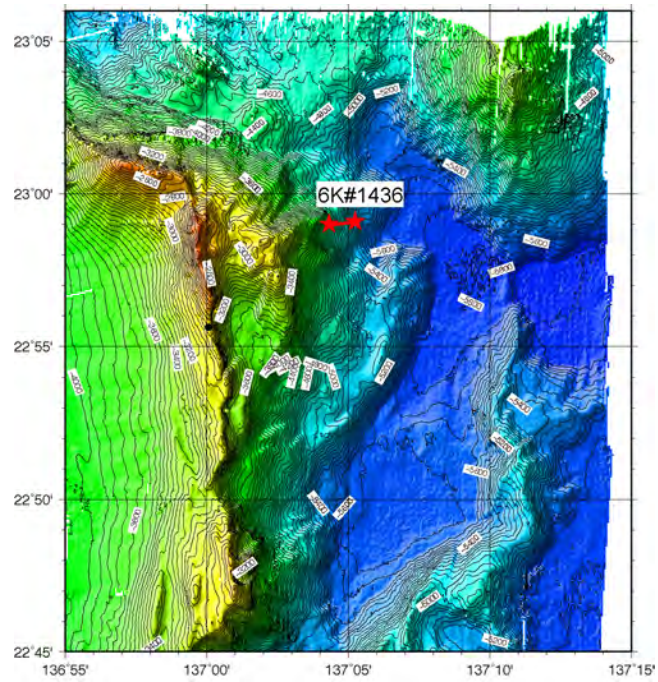


Fig. 5-2 Diving location in MDB area (area B).

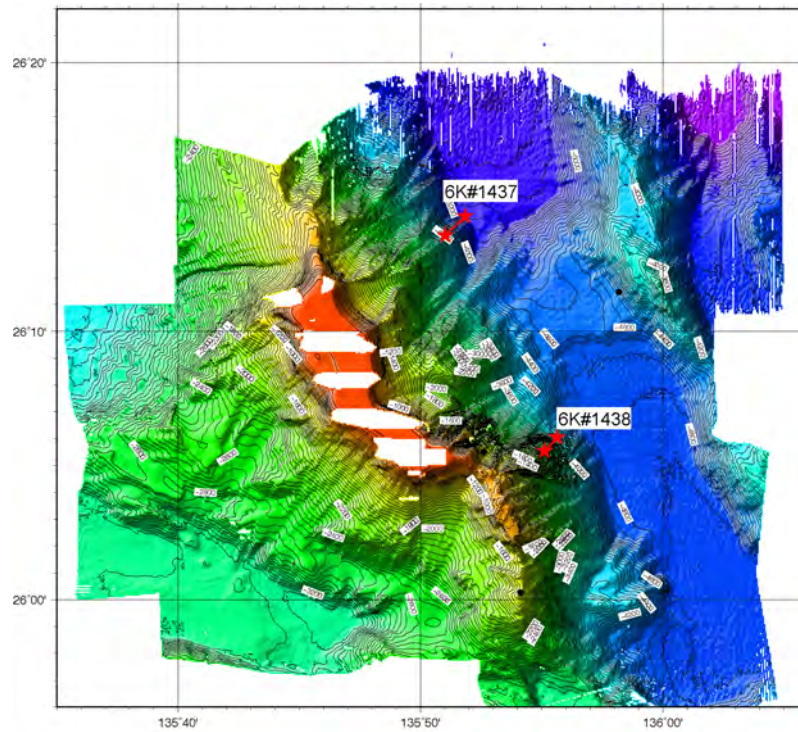


Fig. 5-3 Diving location in DAT area (area C).

Dive 6K#1434 Report

Observer: Osamu Ishizuka

Pilots: Hirofumi Ueki, Keigo Suzuki

Technical information:

Location: Eastern scarp of Kyushu-Palau Ridge (WPB area)

Objective: Observation and rock sampling of arc crust section of Kyushu-Palau Ridge

	On bottom:	Off bottom:
Time (local)	11:37	15:01
Latitude:	19°17.1873' N	19°17.4287' N
Longitude:	135°54.3790' E	135°53.563' E
Depth (m):	5808	5138

5 samples collected

Purpose:

The main purpose of this dive was to observe and sample rocks from the lower part of arc crust, and possibly basement of the Kyushu-Palau Ridge. The diving track is located to the eastern escarpment of southern part of the Kyushu-Palau Ridge, where the ridge forms boundary between Shikoku Basin and West Philippine Basin (Fig. 1). The section that this dive observed should correspond to the earliest volcanic record of the Kyushu-Palau Ridge, i.e., Izu-Bonin-Mariana arc. Lowermost part of the section might correspond to the basement of the arc preexisting the Izu-Bonin-Mariana arc.

This dive aims to observe and collect samples from different levels of arc crust between 5800 mbsl and 5100 mbsl to characterize (age, magma chemistry, etc.) early arc magmatism and its temporal evolution. The data collected from this site will provide information about igneous stratigraphy crucial for understanding magmatic history of reararc side of the arc following the subduction initiation. If arc basement is recovered, it could provide us critical information about the origin of arc basement of the Izu-Bonin-Mariana arc.

Observations:

The dive began at 11:37 and 5808 mbsl (Fig. 1) on a relatively gentle unconsolidated muddy seafloor. The mud bears yellowish to brownish color, and very sticky. Occasionally there are some Mn-coated semiconsolidated mud crusts on the surface of mud layer. As we climbed up the slope, at 11:50, we arrived at Mn-oxides encrusted outcrop. This outcrop has thin or no sediment cover, however, thick coating of Mn-oxides makes the identification of lithology difficult. It seems to be exposure of volcanic breccia. At 12:11, a sample (R01) was collected from Mn oxides-encrusted outcrop (Fig. 2). This sample was turned out to be sparsely px-pl-phyric basalt clast. Similar outcrop continues until 12:28, then more massive-looking outcrop emerged, possibly finer-grained sedimentary rocks. This didn't continue long, and rubbly outcrop appeared shortly. At 12:34 sample R02 was collected from the surface of muddy sediment near the outcrop. This sample was scoria, and it may not

be in-situ rock, i.e., does not represent rock type of observed outcrop. At 12:41, outcrop with fractures parallel to the dip of the slope emerged (Fig. 3). This type of outcrop might be exposure of dykes or fractured lava flows. This type of outcrop continued until at 12:57 when boundary with more massive outcrop appeared. Outcrop with fractures parallel to slope dip reappeared shortly (Fig. 3a-c at 13:04:57), but was transected by massive-looking part occasionally (Fig. 3d at 12:59:34). At 13:15, 15 cm-sized subangular block on the surface of the Mn-oxides crust was recovered (R03: Fig. 4). This sample again was highly-vesiculated scoriaceous rock covered with thin Mn-oxides. It is not clear that this sample is in-situ rock or not. After 13:19, the slope became gentler. Surface was covered with unconsolidated sediment, and outcrop disappeared (Fig. 5 at 13:20:15). At 13:24, strong reflection appeared on sonar, so we changed the course to check it. At 13:26, Mn-oxides encrusted outcrop appeared. This outcrop has platy feature, and the section looks massive. It looks like sedimentary rock (Fig. 6 at 13:37:33). This type of outcrop continued for a while, but occasionally rubbly outcrops were also recognised (e.g., at 13:47:43). At 14:21, outcrop showing fractures parallel to the slope dip appeared again (Fig. 7 at 14:24:00). At 14:37, more irregularly and coarsely-jointed outcrop, possibly lava or lava blocks appeared (Fig. 8 at 14:37). Sample R04 was collected in this area, and it was banded pumiceous rhyolite. Vesiculation of this sample is not particularly high (around 10%), it is unlikely that this block floated and was transported in long distance. Mn-oxides coated outcrop continued. Sample R05 was collected from the surface of the outcrop, and it was mudstone containing clasts of mudstone coated with Mn-oxides (Fig. 9 at 14:56).

The dive ended at about 15:01, 5138 mbsl.

Summary:

Dive #1434 surveyed lower part of east-facing escarpment of Kyushu-Palau Ridge between 5808 mbsl and 5138 mbsl.

There were abundant outcrops during the entire course of the dive. However, it was difficult to identify the rocks and structure of the outcrop, because thick Mn-oxides crust covered the surface. Based on efforts of sampling, surface morphology and appearance of section, lithologies exposed on the slope were estimated to be: a) volcanic breccia, b) lava, c) dyke, d) sedimentary rock. Sample R01 was certainly collected from outcrop, and it was basaltic lava block. It seems to be that the section observed during this dive corresponds to arc crust section proximal to a volcanic edifice.

In summary, even though the number of collected samples was limited, the sample collected from this section will provide important constraints on the age, and characteristics of rear arc magmatism in the early stage of Izu-Bonin-Mariana arc.

Figures:

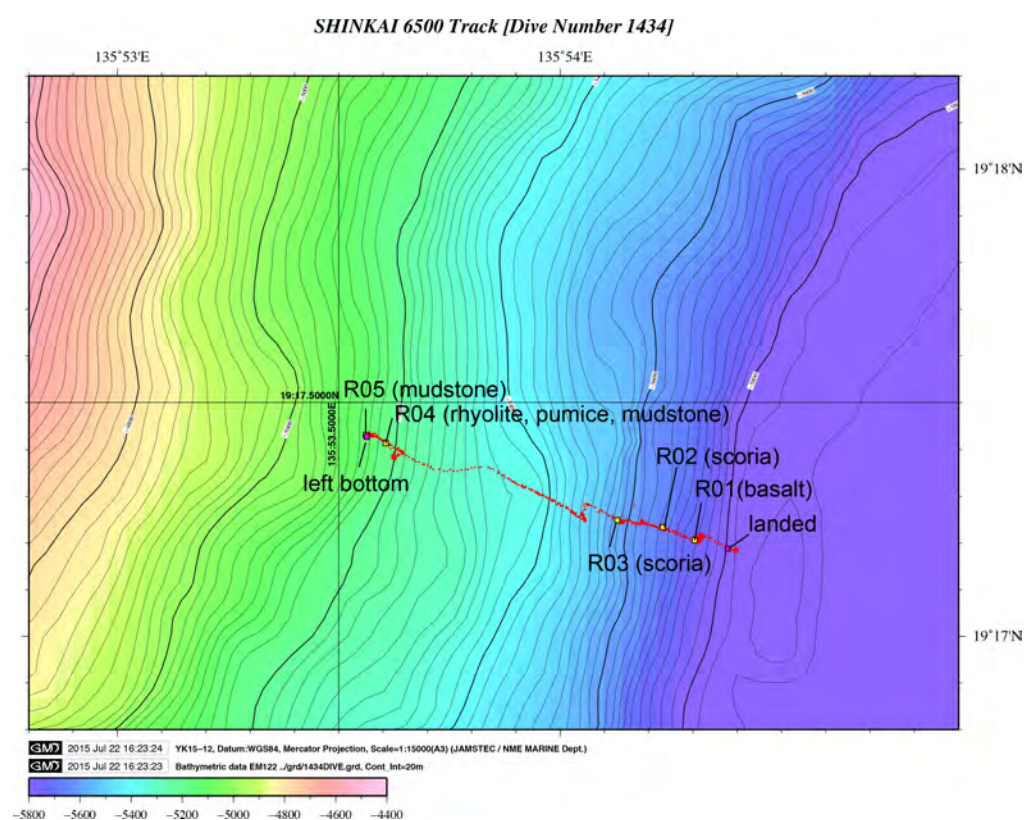


Figure 1 – Submersible track along the dive track. Rock types recovered at each sampling station are also shown.

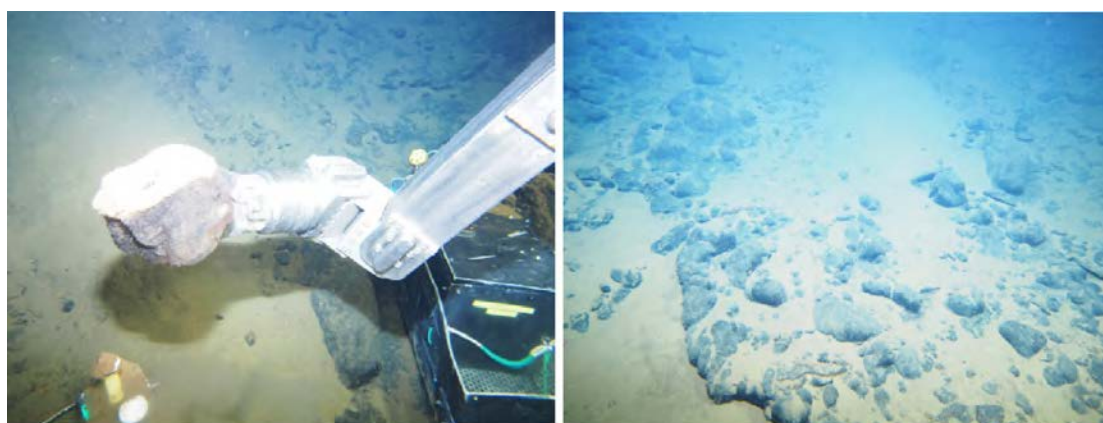


Figure 2 – Mn-oxides coated outcrop and sample R01 collected from outcrop (12:11: OUT P7210101. JPG, 12:09: P7210088.JPG).

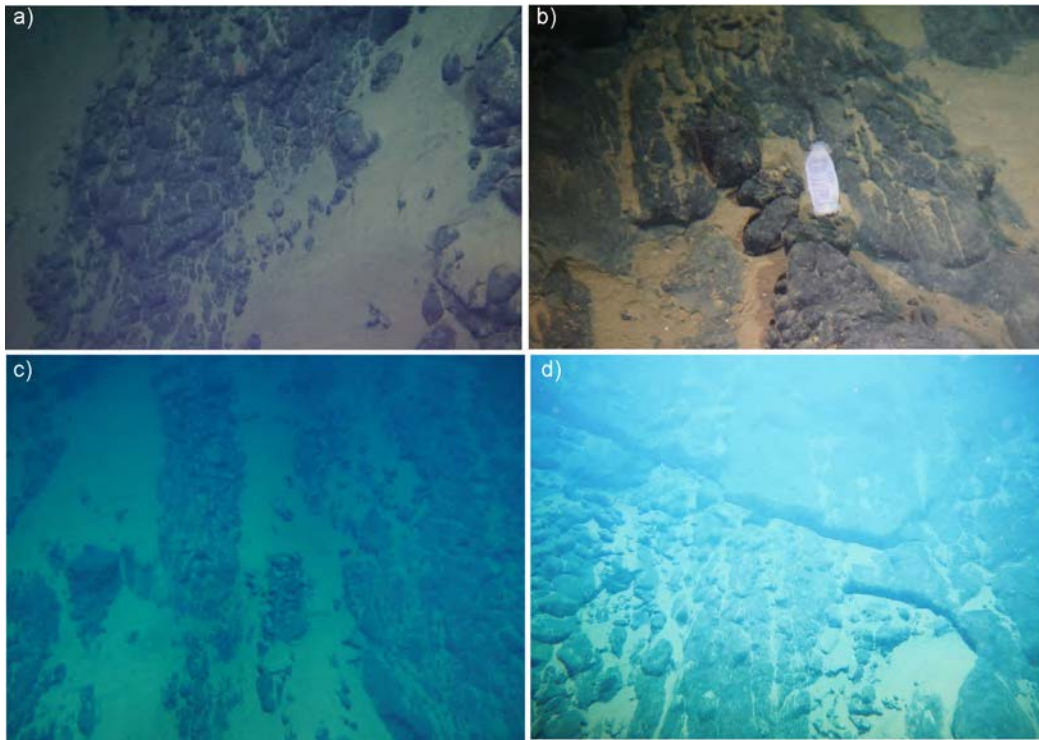


Figure 3 – Outcrop with fractures parallel to the dip of the slope (12:45: In2 DSC03175.JPG, 13:04: DSC03184.JPG, 12:41: OUT P7210191.JPG, 12:59: OUT P7210246.JPG).

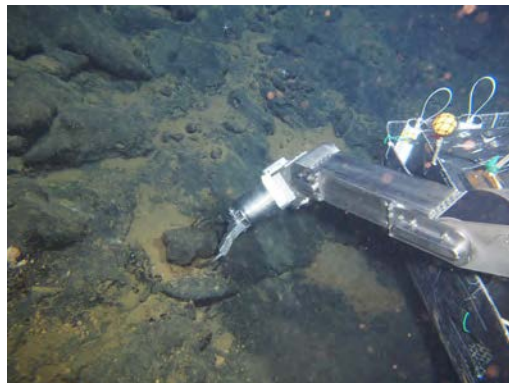


Figure 4 – Sample R03, 15 cm –sized subangular scoriaceous block on the surface of Mn-oxides encrusted floor (13:15: OUT P7210292.JPG).

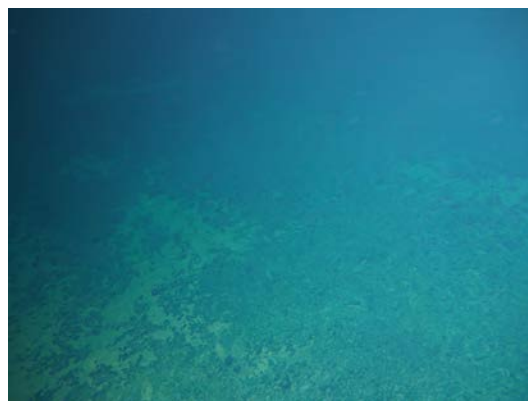


Figure 5– sediment-covered relatively gentle slope. (13:20: OUT P7210310.JPG)



Figure 6– Platy outcrop with massive-looking section surface. (13:37: OUT P7210361.JPG)

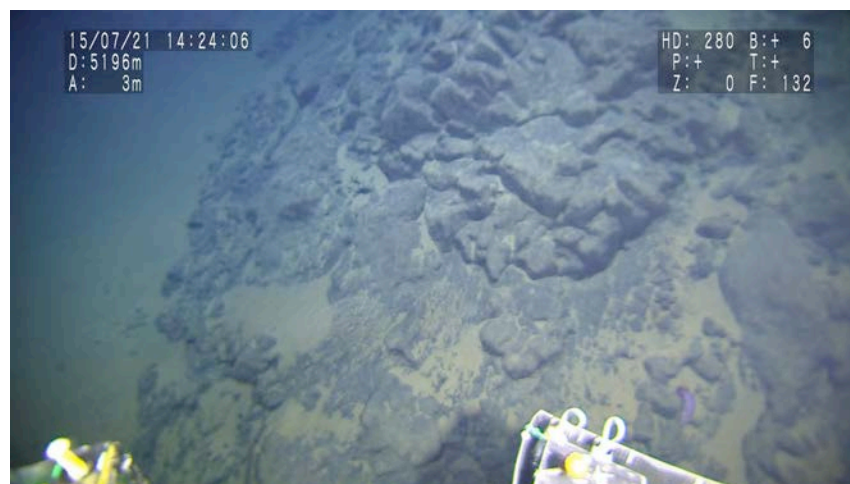


Figure 7 – Upper panel: Outcrop with fractures parallel to the dip of the slope (14:24: OUT P7210502.JPG). b) Lower panel: Radially-jointed lava? in the fractured outcrop.



Figure 8 – Irregularly and coarsely-jointed outcrop (14:37: In2 DSC03194.JPG).

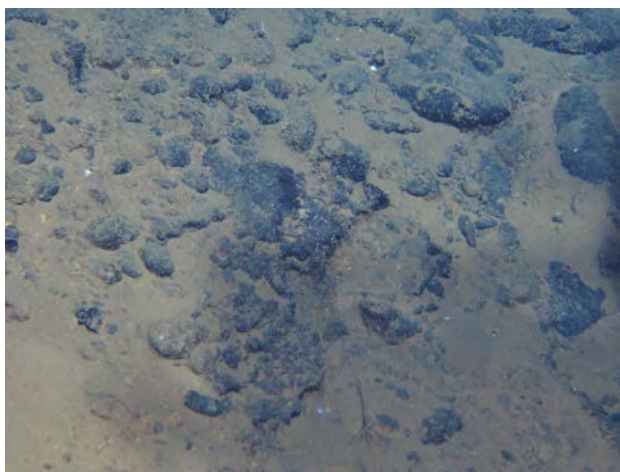


Figure 9 – Mn oxides-encrusted seafloor where sample R05 was collected (14:56: OUT P7210603.JPG).

Table 1 – Dive log for 6K#1434 recorded by Izumi Sakamoto

Dive #:	6K#1434
Date:	2015/7/21
Location:	WPB1
Objectives:	Observation and rock sampling of arc crust section of Kyushu-Palau Ridge

Logger: Izumi Sakamoto

samples are noted 6K#xxx-RYY

where xxx is dive number,

X is S for scoop, R for rock, C for push core, W for water, YY is number

Time (Local)	Depth (m)	Sub Heading	Notes	Sample #	Sample Description
9:07	5835		In water, Start diving		
10:02	2500		6K position at X=?,Y=?		
10:35	3500		6K position at X=-608,Y=1285		
10:46	4350		6K position at X=-710,Y=1215		
11:01	5000		6K position at X=-584,Y=1470		
			On bottom;thick silt sediment at X=-574,Y=1532	Unknown1 in to the No4 box Unknown 2 in to the No.1 box	mudstone
11:32	5808	94			
11:37	5808	97	Landed on the floor at X=-587, Y=1540		
11:41	5811	290	Start to move. Heading 290. Gentle slope covered with soft mud.		
11:50	5785	276	Stop to sample rocks. Outcrop of manganese-coated breccia?		
11:56	5781	280	Searching for sampling site.		
12:00	5780	276	Stop to sample rocks. Outcrop of manganese-coated rounded breccia?		
12:09	5780	288	sheeted Mn-crust covered the bottom surface		
12:12	5779	280	sampling, R1 angular sample collected from outcrop at X=-540,Y=1415	R01 into the No11box	px-pl basalt
12:23	5776	290	start to move, at X=-540,Y=1410		
12:30	5700	296	sheeted and brecciated Mn?-crust observed the bottom surface		
12:34	5691	291	Stop to sample rocks. Outcrop of manganese-coated rounded breccia?at X=-495,Y=1283	R02 into the No.4 box	scoria
12:40		290	start to move, at X=-540,Y=1290		
12:41	5682	286	outcrop with fractures parallel to the dip of the slope		
12:49	5617	305	X=-476,Y=1207, breccia-like outcrop with thin sediment		
12:50	5617	287	X=-467,Y=1202, Stop to sample rocks. Outcrop of manganese-coated rounded breccia?		
12:52	5614	259	X=-459,Y=1197, Outcrop of manganese-nodules		
12:54	5602	290	start to move, at X=-474,Y=1193		
12:57	5583	290	X=-472,Y=1170,stratified volcanic breccia ? With Mn crust		
13:01	5537	285	X=-466,Y=1134, Stop for sampling rocks. Outcrop of manganese-coated breccia?		
13:08	5534	290	start to move, at X=-467,Y=1126		
13:10	5530?		x--442,Y=1121 steep slope with massive Mn crust		
13:14	5509		x--465,Y=1103 Stop to sample rocks. Outcrop of manganese-coated breccia?		
13:17	5509		x--460,Y=1100 Sampling rocks.	R03 into the No.2 box	scoria
13:19	5507	300	start to move, at X=-461,Y=1099		
13:21	5493	300	gentle slope of Mn crust. Mn crust covered on the silt ? Sediment, at x=-444, Y=1066		
13:24	5474	200	changed the head direction to investigate the strong sonar reflection .		
13:29	5473	262	x=-451,Y=971 try to the sampling, blocky rock field.		
13:32	5473	253	start to move, at X=-450,Y=970		
13:40	5458	254	x--430,Y=920 Abandoned sampling because the rocks are fragile.		
13:48	5383	300	x=-360,Y=800 gentle slope with blocky Mn crust.		
13:58	5324	289	x=-260,Y=610		
14:04	5253	307	x=-220,Y=300 try sampling, altered fragments and silt ?		
14:10	5234	280	x=-210,Y=230 Abandoned sampling.		
14:12	5229	320	x=-215,Y=210 try sampling		
14:14	5228	267	jointed lava block?		
14:19	5227		x=-187,Y=248 Abandoned sampling because the rocks are fragile.		
14:21	5222	300	start to move, at X=-196,Y=247		
14:24	5196		x=-164,Y=195 blocky Mn crust.		

14:26	5190	321	x=-150,Y=180 blocky Mn crust.		
14:30	5188	273	x=-146,Y=182 try sampling, angular fragments and unconsolidated silt		
14:33	5187		x=-150,Y=180 rock sample.	R04 into the No.7	pumice, mudstone
14:41	5148	309	x=-126,Y=130 Blocky Mn crust		
14:46	5147	283	x=-128,Y=135 try sampling, angular fragments		
14:48	5147	289	x=-130,Y=130 Stop the sampling.		
14:52	5138	288	x=-126,Y=110 try sampling, angular fragments with brown-colored sediments		
14:54	5139	307	x=-124,Y=107 rock sample.	R05 into the No.6 box	mudstone
15:00	5138		x=-138,Y=110 leave the bottom		

Dive 6K#1435 Report

Observer: Gen Shimoda

Pilots: Takuma Ohnishi, Yudai Tayama

Technical information:

Location: Eastern scarp of Kyushu-Palau Ridge (West Philippine Basin)

Objective: Observation and rock sampling of arc crust section of Kyushu-Palau Ridge

	On bottom:	Off bottom:
Time (local)	11:46	15:40
Latitude:	19°19.042`N	19°19.9264`N
Longitude:	135°54.4590``E	135°53.9352E
Depth (m):	5070	3721

17 samples collected, including 13 rock and 4 sediment samples

Purpose:

The main purpose of this dive was observation and rock sampling of lower crust of arc section of Kyushu-Palau Ridge. This site was selected as lower part of arc crust that could represent the earliest volcanic record of the Kyushu-Palau Ridge. The track of this dive can be an upper succession of the former dive #1434 track that was located at ca. 8 km southwest of this dive site.

SHINKAI 6500 Track [Dive Number 1435]

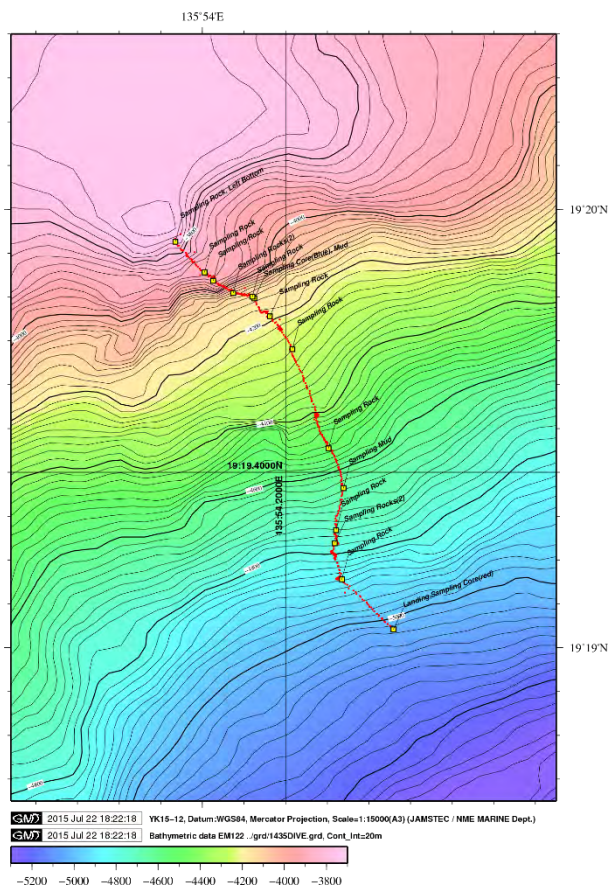


Figure 1. Dive track and sample locations (small dots).

Observations:

The dive began (Landing point) at 11:09 and 5070 mbsl on a gentle slope covered with mud and gravel. The surface are mostly covered with the gravel which are coated with Mn-oxide. Push core sampling was conducted and collected sediment and small rock samples (Fig. 2).

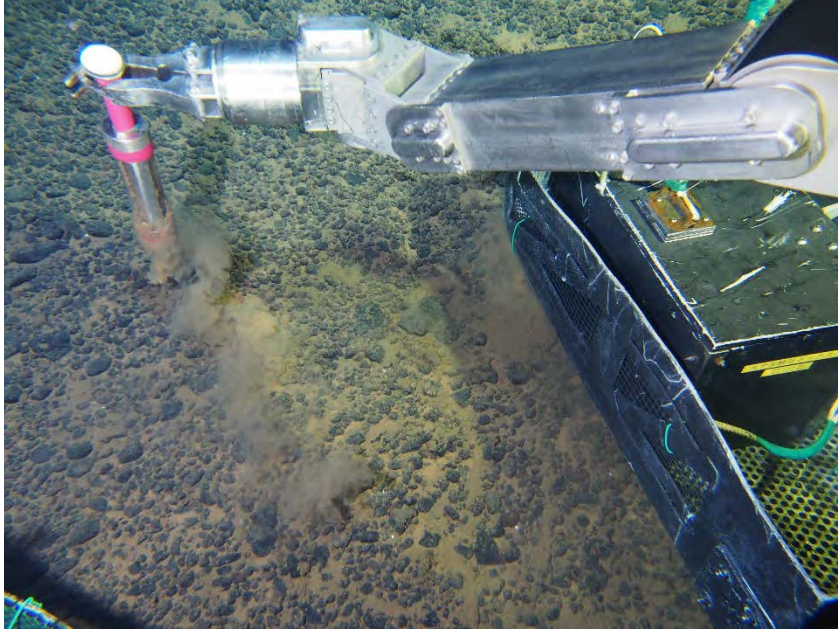


Figure 2. Push core sampling at landing site.

After the sampling, 6K started moving upward. Stop 1 (4953 mbsl, 11:36) was about 20 m northwest away from the landing point. The surface condition was similar to the landing site but mostly covered with brown mud. Relatively big floated rock with subangular shape was selected as the first rock sample (R1) of the dive. The collected sample was strongly vesiculated andesitic rock coated with Mn-oxide (Fig. 3).

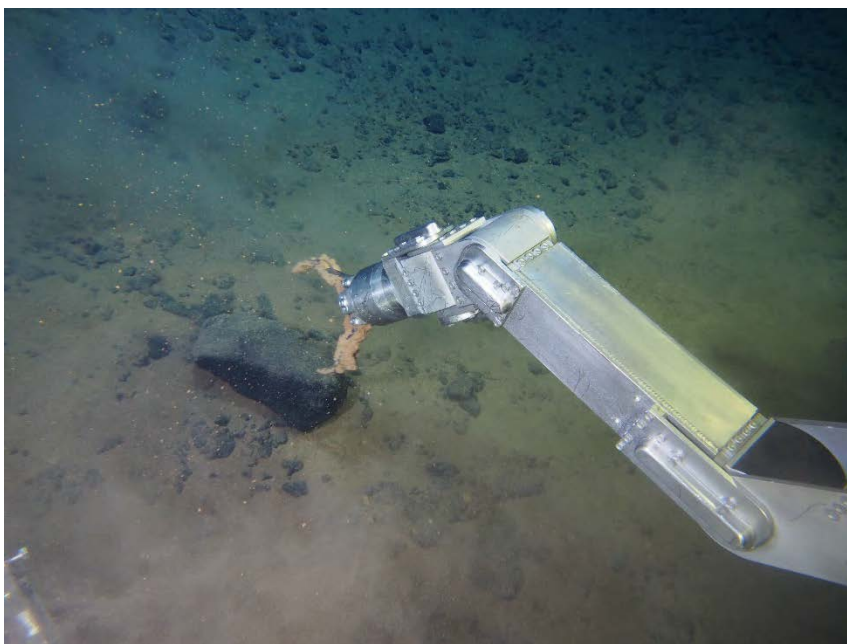


Fig. 3 A sampling view of the first sample (R1).

6K resumed moving upward and then went into an area with relatively steep slope where surface was coated with Mn-oxide smoothly (Fig. 4). It looked like exposure of volcanic breccia but thick Mn-oxides coating makes the identification of lithology difficult.



Fig. 4 A view of area covered with Mn-oxide.

Stop 2 (4948 mbsl; 12:02) was 154 m north-northwest away from Stop 1. The surface was mostly covered with black rocks with minor mud-covered area. Two samples (volcanic sand stones) were collected at the stop which have subangular shape (Fig. 5).

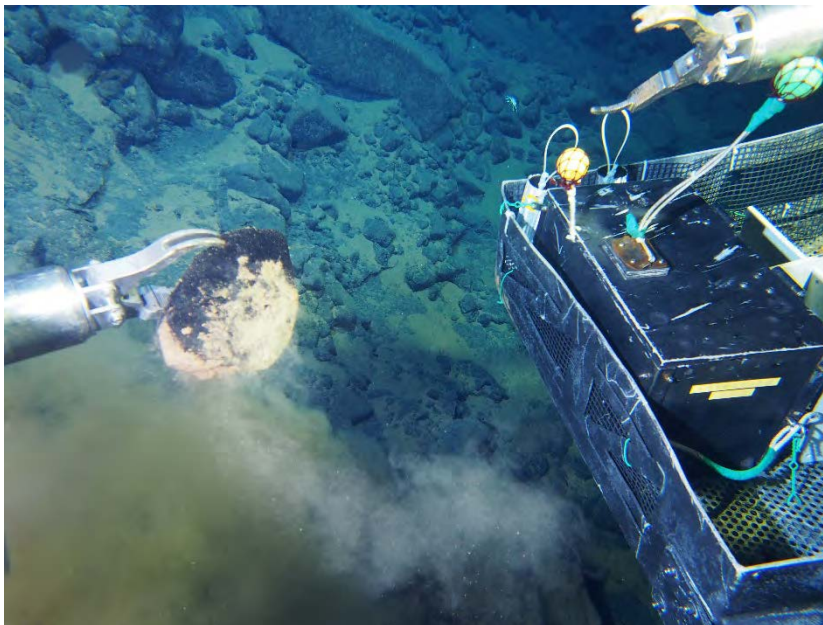


Fig. 5 Sampling of R02 at Stop 2. Two samples were collected at this site.

6K resumed moving upward and pass through area where horizontally layered structure was exposed (4810 mbsl; 12:07). The horizontal structure might be due to sedimentary rocks. This outcrop was followed by area with blocky surface mainly consist of subangular rocks coated with Mn-oxide (Fig. 6).



Fig. 5 a view of layered structure between Stops 2 and 3.



Fig. 6 a view of area outcrop mainly consist of subangular clasts.

Stop 3 (4989 mbsl; 12:14) was 55 m north away from Stop 2 where a sample (R4, lapilli stone) was collected at an outcrop consist of subangular rocks. The surface appearance of this outcrop was similar to that shown in Fig. 6. The outcrop was on the horizontally layered sedimentary rocks shown in Fig. 5. A sampling view is shown in Fig. 7. After the sampling, 6K went into an area where the surface was coated with Mn-oxide smoothly (Fig. 7).

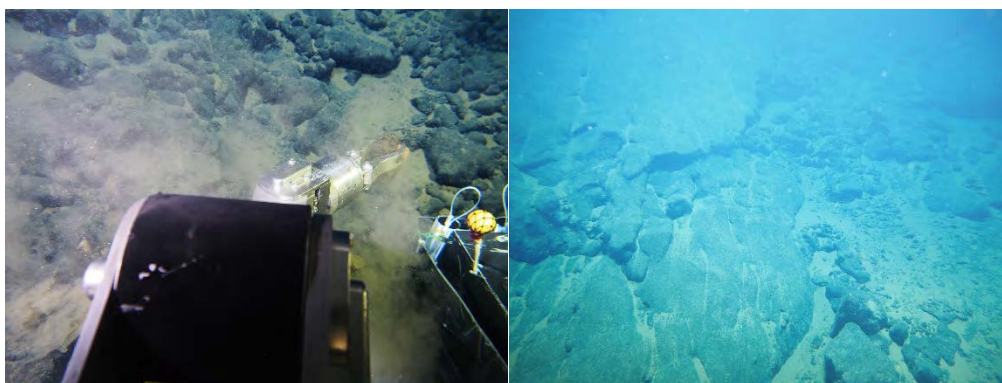


Fig. 7 a view of collection of R4 (left) and nearby area covered with Mn-crust (right).

Stop 4 (4668 mbsl; 12:40) was 245 m north-northeast away from Stop 3. The sampling of mud (S01) was conducted at the foot of rock, probably volcanic breccia, coated with Mn-oxide (Fig. 8).

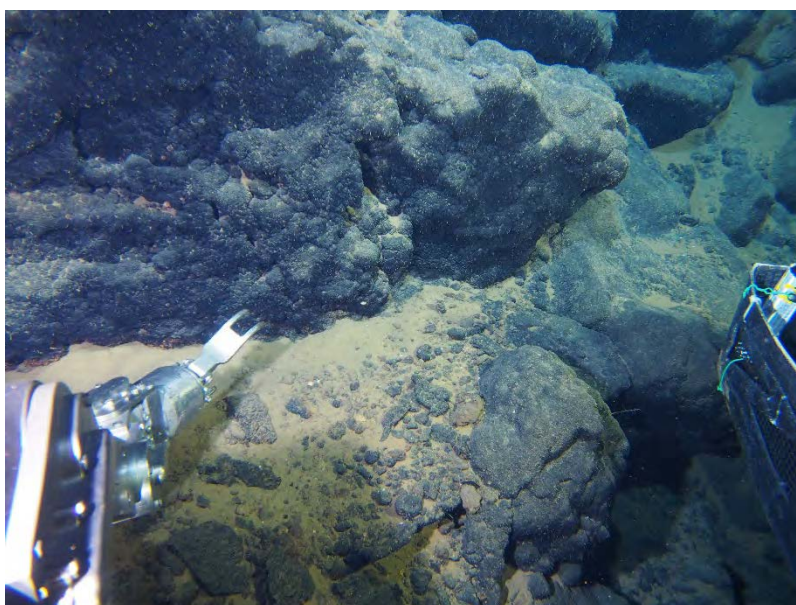


Fig. 8. Sampling site of S01.

6K resumed moving and went up north-northwestward, and then pass through outcrops of columnar jointed rocks, most likely sheeted dikes (Fig. 9). The columnar jointed outcrop was overlain by stony slope that consisted of subangular to subrounded rocks which were coated with Mn-oxide (Fig. 10).

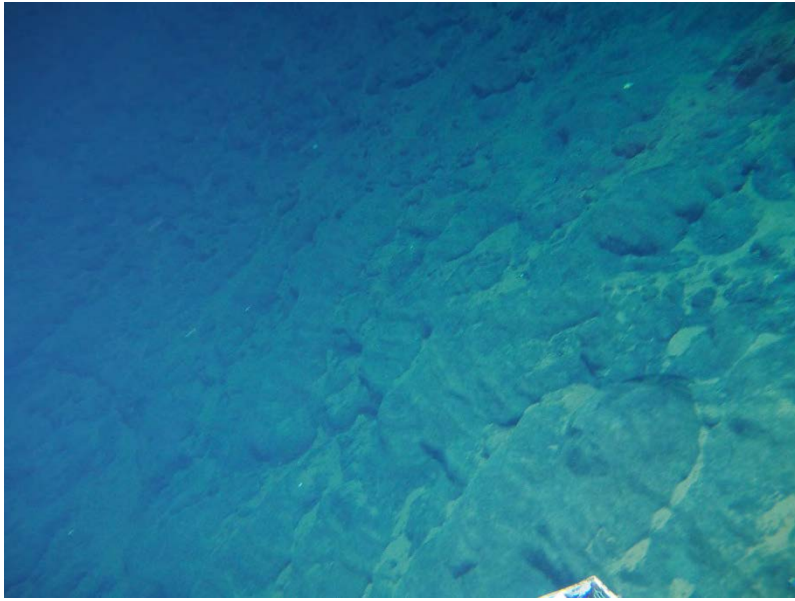


Figure 9. Subvertical columnar jointed dikes exposed between Stops 4 and 5.



Figure 10 Stony slope on the subvertical columnar joint outcrop.

Stop 5 (4531 mbsl; 13:00) was 180 m north-northwest away from Stop 4. Rock sampling (R05) was conducted at the rocky slope and collect ol-px basalt (Fig. 11).



Figure 11. A sampling view of ol-py basalt R05.

The rocky slope was overlain by slope coated with Mn-oxide (Fig. 12). Stop 6 (4269 mbsl; 13:36) was 445 m north-northwest away from Stop 5, upper part of the slope that was smoothly coated with Mn-oxide. A rock sample (R06, mud stone) was collected at this site (Fig. 13).



Figure 12 Slope smoothly coated with Mn-oxide.

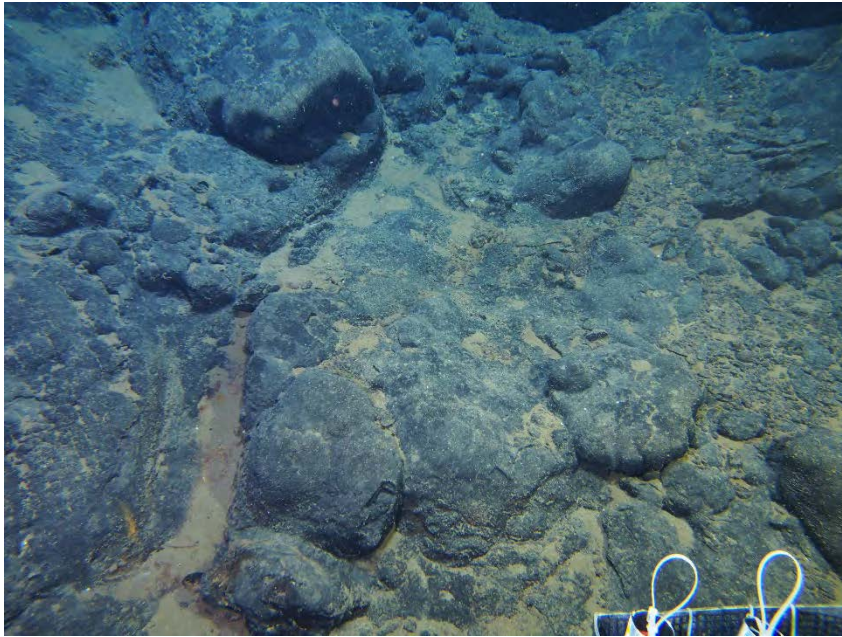


Figure 13. Sampling site of mud stone R06.

Stop 7 (4195 mbsl; 13:58) was 170 m north-northwest away from Stop 6. Rock sampling (dolerite, R07) was conducted at bottom part of columnar jointed dikes (Fig. 14).



Figure 14 Sampling site of mud stone R06 and wall rock of columnar jointed dykes.

Stop 8 (4177 mbsl; 14:19) was 100 m northwest away from Stop 7. Push core sampling (C02) was conducted at the foot of cliff of columnar jointed dikes (Fig. 14).



Figure 15 Sampling site of mud stone C02 (left) and wall rock of columnar jointed dikes (right).

Stop 9 (4121 m; 14:35) was 10 m northwest away from Stop 8 (horizontal distance). Although the sampling was conducted middle to upper part of the columnar jointed dyke, the collected sample was sand stone (R08).

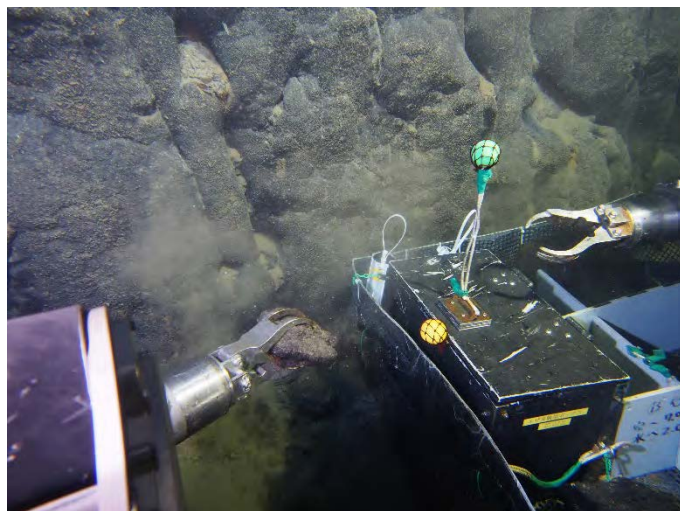


Figure 16. A view of sampling of R08 sand stone.

Stop 10 (4141 mbsl; 14:55) was 80 m west-northwest away from Stop 9 (horizontal distance). Rock sampling was conducted at upper part of columnar jointed dyke and collected two rock samples (R09, andesite; R10, conglomerate).

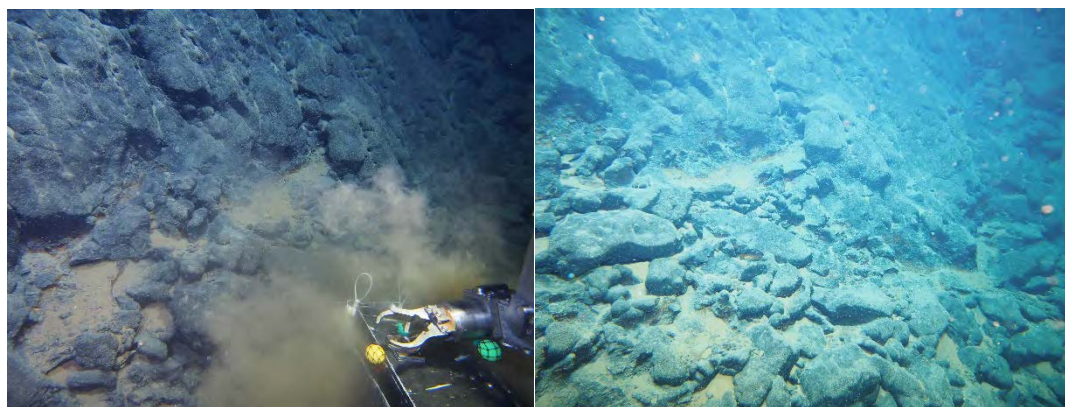


Figure 17. Views of sampling of R09 (left) and neighboring outcrop of Stop 10.

6K went up and reached terrace. Stop 11 (3896 mbsl; 15:11) was 100 m west-northwest away from Stop 10. The surface of terrace was blocky (Fig. 18).

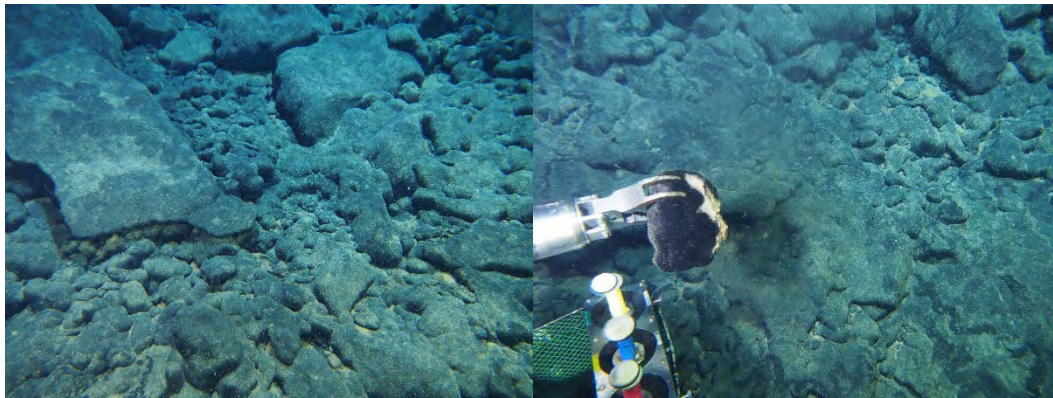


Figure 18. Terrace on the top of columnar jointed dyke (left) and sampling was conducted at this terrace (right).

Stop 12 (3837 mbsl; 15:21) was 50 m northwest away from Stop 11. A basaltic rock sample (R12) with subangular shape with Mn-oxide coating was collected at the stop, i.e., the terrace on columnar jointed dyke as well as stop 11 (Fig. 19). The surface of this stop is similar to the previous stop.

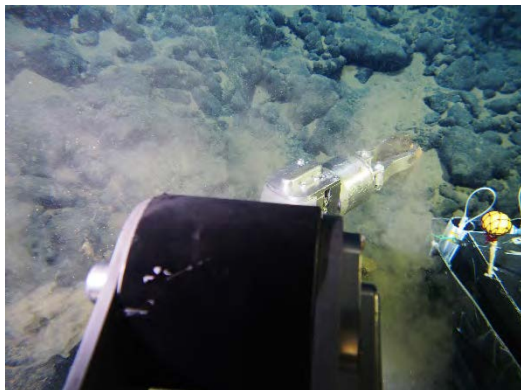


Figure 19. Sampling on the terrace that collected basaltic rock sample (R12).

The final stop 13 (3721 mbsl; 15:40) was 180 m northwest away from Stop 12. A pumice (R13) with subangular shape was collected at the stop (Fig. 19). After the sampling, 6K left the seafloor.

Summary:

The site of dive 1435 can be divided into two parts by horizontally layered structure that was probably outcrop of sediment layers. The upper part consist of columnar jointed dykes. The lower part might be columnar jointed dikes but mostly covered with talus. Although most of part of this dive track was occupied by outcrops, it was difficult to identify the rock types and structure of the outcrop due to thick Mn-oxides crust.

Table 1 – Dive log for 6K#1435 recorded by Ken Tani

Dive #:	6K#1435
Date:	2015/7/22
Location:	WPB2
Objectives:	

Logger: K. Tani

samples are noted 6K#xxx-RYY

where xxx is dive number,

X is S for scoop, R for rock, C for push core, W for water, YY is number

Time (Local)	Depth (m)	Sub Heading	Notes	Sample #
9:05	0 m		6K in water. Start dive.	
9:20	1000 m		Water depth 1000 m.	
9:31	1500 m		Water depth 1500 m.	
9:43	2000 m		Water depth 2000 m.	
9:55	2500 m		Water depth 2500 m.	
10:06	3000 m		Water depth 3000 m.	
10:19	3500 m		Water depth 3500 m.	
10:31	4000 m		Water depth 4000 m.	
10:44	4500 m		Water depth 4500 m.	
10:59			Trim OK. Descend to sea floor (altitude 79 m).	
11:00	5000 m		Water depth 5000 m.	
11:04			Observed sea floor.	
11:09			On bottom. Muddy gravel.	
11:10	5070 m		Start coring (red push core). WD=5070 m.	
11:12	5070 m		Core sample (C01).	C01
11:14		300	Heading 300.	
11:18			Gentle slope covered with dark gravel.	
11:25	4953 m		Start sampling (floated rock). WD=4953 m.	
11:36	4953 m		Collected 1 rock sample in basket No. 3 (R01). Floated rock on gravel slope.	R01
11:38		350	Start to move. Heading 350.	
11:43	4886 m		Stopped to sample. Surficial sediment cemented with thin manganese crust? WD=4886 m.	
11:49	4881 m		Blocky surface. WD=4881 m.	
11:53	4880 m		Canceled sampling and start to observe sea floor. WD=4880 m.	
11:57	4855 m		Start sampling at WD=4855 m.	
12:03	4855 m		Collected 2 rock samples (R02 and R03). Put into basket No.2.	R02 and R03
12:11	4789 m		Start sampling at WD=4789 m.	
12:14	4789 m		Collected one rock sample. Put into basket No.1 (R04) and start moving.	R04
12:23	4660 m		Start sampling at WD=4660 m.	
12:40	4660 m		Canceled sampling rock but collected sediment with scoop (S01) to box B1.	S01
12:44		350	Start moving. Heading 350.	
12:54	4531 m		Rough surface covered with manganese coated blocks. WD=4531 m. Stopped to sample.	
13:00			Sampled one rock sample in basket No. 6 (R05).	R05
13:11	4393 m		Start sampling at WD=4393 m.	
13:15	4393 m	340	Canceled sampling. Start to move. Heading 340.	
13:32	4272 m		Start sampling at WD=4272 m.	
13:36	4272 m		Sampled one rock. Sample in basket No. 11 (R06).	R06

2:42	4232 m		Start sampling at WD=4232 m.	
13:48	4228 m	310	Canceled sampling and start moving. Heading 310. WD=4228 m.	
13:55	4196 m		Start sampling at WD=4196 m.	
13:56	4196 m		Sampled one rock. Put into basket No. 12 (R07).	R07
14:06	4181 m		Dark jointed outcrop finished at WD=4181 m.	
14:10	4178 m		Start sediment sampling using push core at WD=4178 m.	
14:19	4178 m		Sampled one push core (blue) C02. Additionally sampled sediment using scoop and put into box B2 (S02). WD=4178 m.	C02 and S02
14:26	4124 m		Stopped to sample at outcrop. WD=4124 m.	
14:34	4124 m		Sampled one rock sample to basket No. 14 (R08).	R08
14:43			Outcrop of columnar joints?	
14:46	4042 m		Start sampling at WD=4042 m.	
14:53	4042 m		Sampled one rock sample (R09) in basket No. 8. Continue sampling.	R09
14:55			Sampled additional rock sample at the same site (R10) in basket No. 8.	R10
14:57		300	Start to move. Heading 300.	
15:07	3896 m		Stopped to sample. WD=3896 m.	
15:11			Collected one rock sample (R11) to basket No. 7.	R11
15:17:00	3837 m		Stopped to sample. WD=3837 m.	
15:21			Sampled one rock sample (R12) in basket No. 4.	R12
15:33	3721 m		Stopped to sample. WD=3721 m.	
15:38			Sampled one rock sample (R13) and put into basket No. 5. Leave floor.	R13
15:43			Estimated time at the sea surface is 17:05.	

Dive 6K#1436 Report

Observer: Izumi Sakamoto

Technical information:

Location: South Daito Ridge (Mikazuki seamount)

Objective: Geological observation and rock sampling of the east side cliff of the Kyushu-Palau Ridge.

	On bottom:	Off bottom:
Time (local)	11:15	15:02
Latitude:	22°59.0961N	22°59.0150N
Longitude:	137°5.2415E	137°4.319E
Depth (m):	5230	4371

30 samples collected

Purpose:

The main purpose of this dive was to observe and sample rocks from the sea floor in the Eastern slope of Kyushu-Palau ridge. There is only one geological data (Ho andesite) around the top of Mikazuki seamount by the BMS drilling, but no basement rock information around this area. We want to know how the Daito-Basin is related to the formation of Kyushu-Palau ridge. So our target will to get the basement rock and geological information around the basement of the Kyushu-Palau ridge.

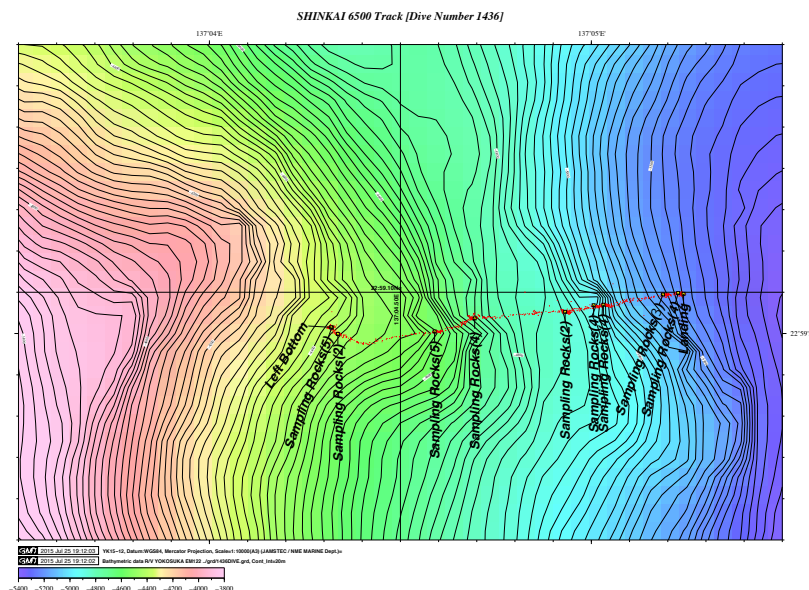


Figure 1. Dive track and sample locations. Observed dike and vein trends are shown.

Observations:

The dive began (Landing point) at 11:15 and 5230 m on a relatively flat surface covered by thin (less than 1cm) sediment and a few isolated subrounded to rounded pebble on the surface (Photo 1). Black flatted surface with Mn crust have observed the whole surface.

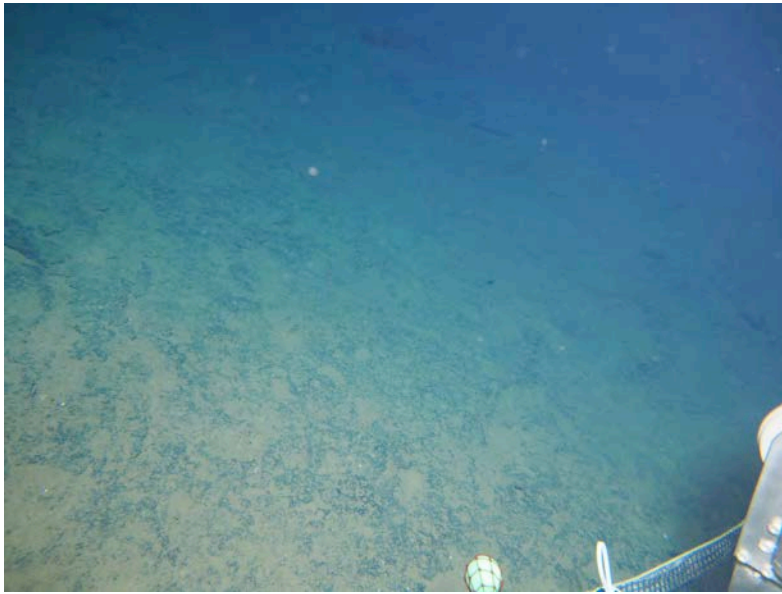


Photo 1

Stop 1 (5228m, 11:15) was almost same as the landing point. Mn sheet (1 to 2cm thick) have observed the whole surface, and thin sediment covered on the Mn sheet. White to dark yellowish mudstone exposed under the Mn pavement (Photo 2). Four samples (R1 to R4) of sedimentary rock were collected.

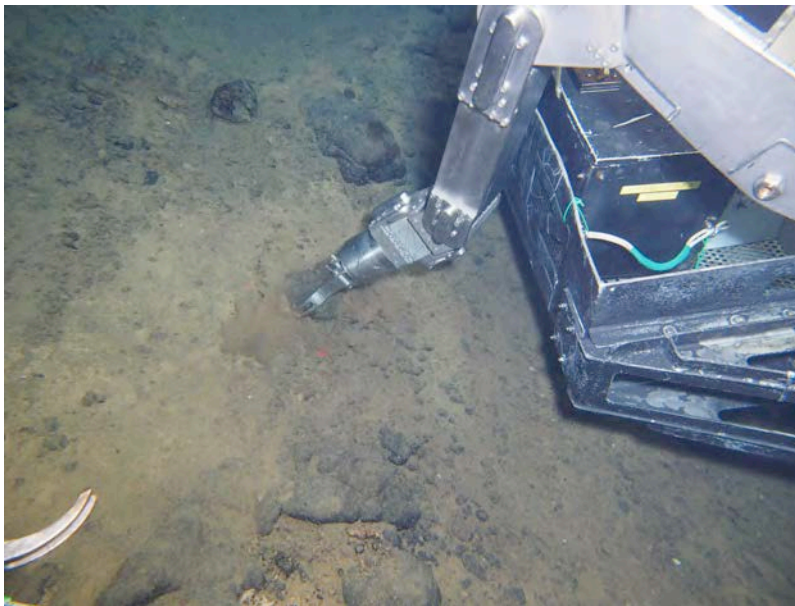


Photo 2

Stop 2 (5200m, 11:58) was just 30m upslope of the landing point in a cluster of sub-rounded cobbles and boulders on gentle slope by the Mn crust. White to dark yellowish mudstone exposed under the Mn crust surface. Three sedimentary rocks (R05 to R07) were sampled. Mn pavement with thin sediment was observed on the steep slope.

Stop 3 (5025m, 12:36): 5 to 20cm rubble with SR to R shape observed on the surface. Inside the rubble also altered mudstone. White to dark yellowish mudstone exposed under the Mn crust surface. Well-developed Mn pavement was observed between St.3 to St.4 (Photo-3). Four rock samples (R08 to R11) of basaltic scoria were sampled.

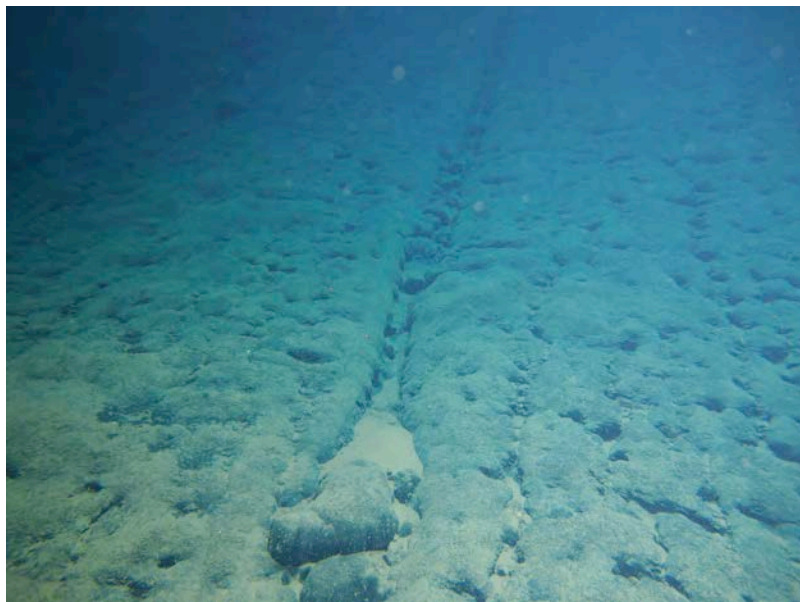


Photo-3

Stop 4 (4992m, 12:55): Stop 4 locates on the steep slope (Photo-3). We could not estimate the basement rocks behind the Mn pavement. Only the small fragments from the groove could get as a sample. These fragments consist the scoria and coarse sandstone. Three scoria samples and one sandstone sample were collected.

Continuous steep slope with thick Mn pavement exposed between stop-3 to stop-4.

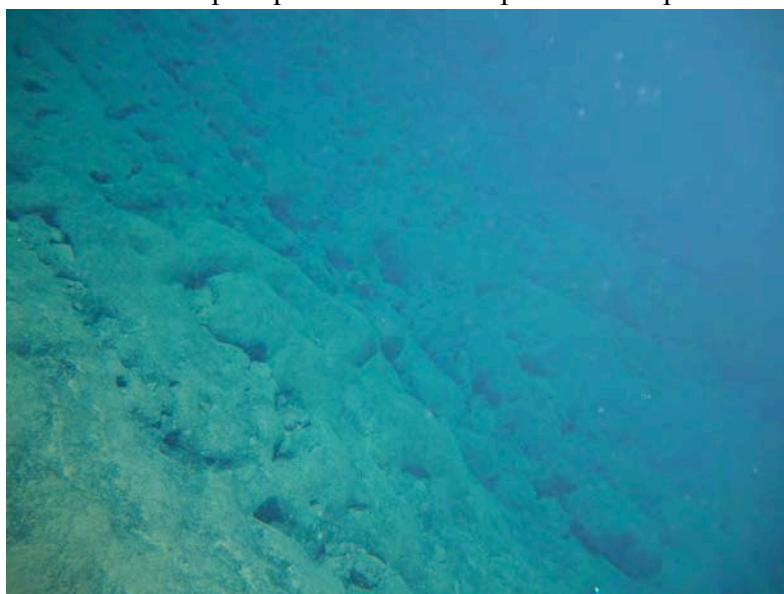


Photo-4:

Stop 5 (4877m, 13:32): Thick (5 to 10cm) Mn crust covers the surface, and we can see the white to yellowish mudstone under the surface (Photo-5). 5 to 20cm Mn

coating breccia (including Mn nodules) also appear on the surface. Two samples including scoria (R17) and coarse sandstone (R16) were collected from this point. Thick Mn pavement exposed on the steep slope surface between stop-5 to stop-6.



Photo-5: Thick Mn crust formed on the surface. White silt or mudstone exposed under the surface.

Relatively gentle slope was developed from -4900m to -4760m. Flat Mn sheet with thin sediment exposed the whole surface.

Steep slope with thick Mn pavement appear from -4780 to 4720m. We could not estimate the core rock type.

Stop-6 (4664m, 14:07): Rough surface with thick Mn pavement. Only the small samples on the groove could get by Shinkai manipulator. Four scoria samples (R18 to R21) with Mn coating were collected from this point.

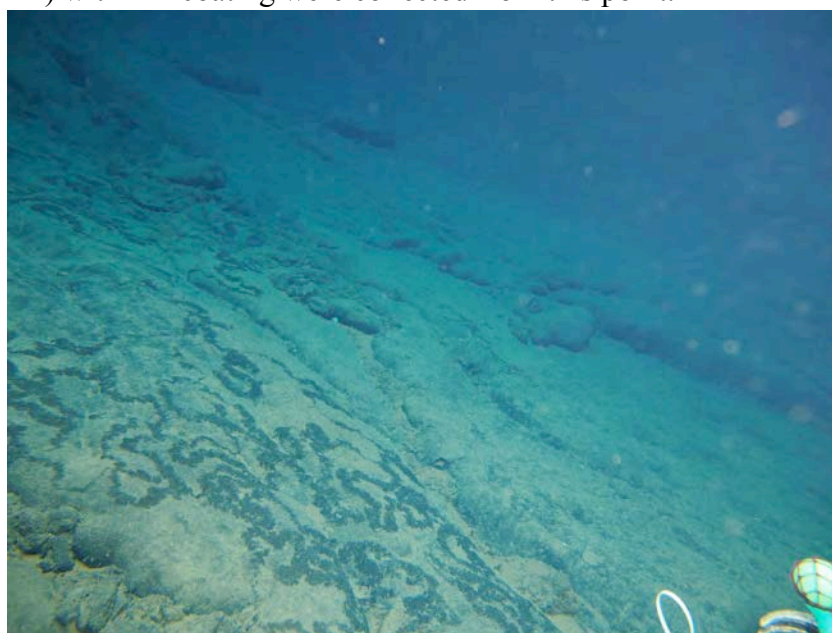


Photo-6:

Steep slope ($>60^\circ$) with Mn pavement appear between Stop-6 to Stop-7. Ripple mark type Mn surface were observed on the steep slope. Black creep mark by the benthos also observed on the Mn pavement surface (Photo-6).

Stop-7 (4517m, 14:33): Flat topped Mn pavement was distributed on the steep slope widely (Photo-6). 10 to 50 cm fragment with thick Mn crust exposed along the groove in the Mn sheet slope. There is no information of the basement rock type. White and dark yellowish mud appears under the thick Mn crust. Five mud and silt stone samples (R22 to R26) were collected from this point.

The steep slope distribute from -4400m to -4500m. Mn pavement exposed on the surface, and we could not get the samples form this slope area.

Stop-8 (4410m, 15:04): Rough surface with 5 to 50cm fragments distribute the whole slope. We take two rock samples of scoria (R27 and R28). We take some mud stone sample from this point, but we have lost at the searface. A relatively flat slope spread out from -4500m to -4200m in depth.

Stop-9 (4371m, 15:26): Thick Mn pavement exposed on the surface. 10 to 50 cm SR to Rounded fragments with thick Mn crust exposed along the groove in the Mn pavement slope. We take two Mn nodules (R29 and R30: photo-7) and tow mudstome samples from this area, but two mud stone samples were lost at the sea surface.

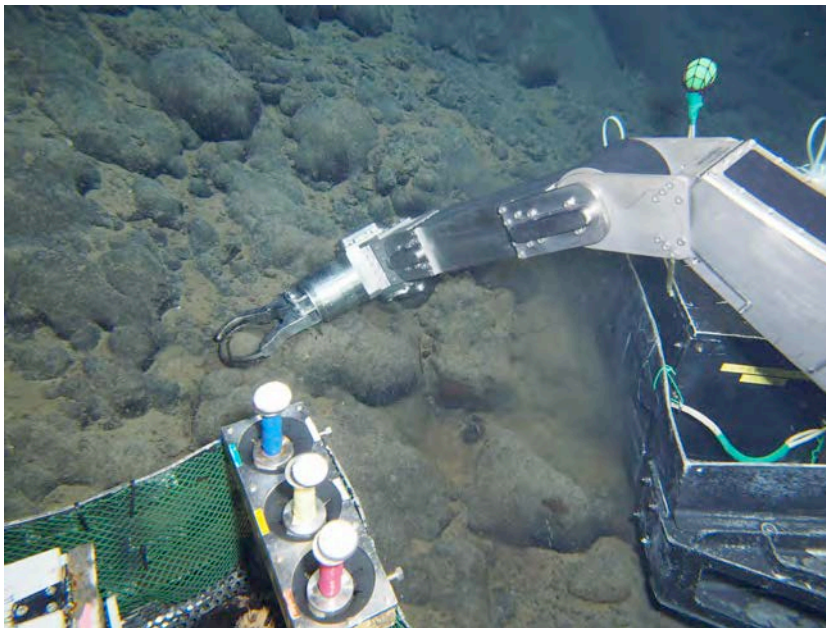


Photo-7

We took off 15:29 at 4319 m.

Summary:

From the start to end point, thick Mn coating pavement expose widely. There is no information for the basement rock and geological structures about the east cliff of Kyushu-Palau ridge (Mikazuki seamount) area. But, some of the steep slope will be showing the structural and geological materials. We hope that we will get the

sampling tools, which will be able to get the samples from the steep slope, in near feature.

Table 1 – Dive log for 6K#1436 recorded by Gen Shimoda

Dive #:	6K#1436
Date:	2015/7/26
Location:	MDB
Objectives:	

Logger: G.Shimoda
 samples are noted 6K#xxx-RYY
 where xxx is dive number,
 X is S for scoop, R for rock, C for push core, W for water, YY is number

Time	Depth(m)	Sub Heading	X	Y	Note	Sample No.
9:04:23			101.8	1327.8	Start dive.	
9:26:09	1000		78.1	1369	WD=1000 m.	
9:36:25	1500		87.2	1310.9	WD=1500 m	
9:47:15	2000		63.5	1298.8	WD=2000 m	
9:58:10	2500		-7.9	1266.9	WD=2500m	
10:09:23	3000		79.6	1304	WD=3000m	
10:23:19	3500		60.6	1310.2	WD=3500m	
10:33:31	4000		63.4	1274.4	WD=4000m	
10:44:38	4500		38.5	1299.2	WD=4500m	
10:57:09	5000		16.4	1282.7	WD=5000m	
11:15:42	5230		-27.9	1277.2	On bottom. Manganese coated floor. WT=1.7'c	
11:18:17	5230		-33.4	1277.2	Stop-1:Start sampling.	
11:30:39			-33.4	1277.2	during sampling	
11:39:04	5228		-4.8	1254	4 samples were collected and put into basket no. 1	R01,02,03,04
11:47:44			-28.9	1203.7	try sampling	
11:58:24	5200		-33.1	1187.2	Stop-2: 3samples were collected and put into basket no. 2 (R05) and no. 4 (R06,R07).	R05,06,07
12:03:08	5175	270	-30.9	1145.2	Start moving. Heading 270. WD=5175m	
12:15:36			-69	956.2	Thick Mn crust (sheet) pavement covered at the surface.	
12:20:25	5025		-69.6	937.9	Start sampling.	
12:23:09			-71.4	930.6	collecting a rock sample.	
12:35:46	5025		-73.3	956.1	Stop-3: 4 samples were collected and put into no. 3 basket (R08 to R11) Resumed moving toward 257.	R08,09,10,11
12:42:31			-74.1	893.3	Apper columnar jointed dyke? The continuous cliff with Mn pavement.	
12:46:28	4991		-79.6	890.6	Stop sampling.	
12:55:21	4993	258	-71.4	897.4	Stop-4: 4 samples were collected and put into basket No. 5 (R12 to R15)	R12,13,14,15
13:12:49	4881		-101.4	742.8	Stop sampling.	
13:31:29	4878	270	-95.9	740	Stop-5: 2 samples were collected and put into basket No. 6 (R16 to R17). Resume moving toward 270.	R16,17
13:42:48	4820		-113.7	607.1	smooth gentle slope covered with sediment. heading 270	
13:49:40	4780	261	-130	432.1	horizontally layered? structure. Heading261	
13:55:20	4700	267	-109.6	357.5	Dark rocky outcrop probably coated with Mn-oxide. Heading267	
13:59:45	4660	242	-125.9	318.2	Start sampling. Heading242.	
14:06:34	4464	270	-130	338.5	Stop-6: 4 samples were collected and put into No. 7 basket (R18 to 21). Heading 270.	R18,19,20,21, unknown1
14:15:58	4595	269	-154.5	299.2	Thick Mn crust (sheet) pavement covered at the surface. The continuous cliff with Mn pavement. Heading269.	
14:27:57	4517	319	-187.3	156.7	Stop sampling. Heading319.	
14:33:30	4464	270	-188.6	162.2	Stop-7: 5 samples were collected and put into No. 8 basket (R22 to 26). Heading 270.	R22,23,24,25,26
14:47:02	4500		-236.3	-121.3	Change direction (heading) from 270 to 290. WD	
15:00:16	4410	285	-190	-281.4	Stop to sample. Heading 285.	

15:04:33	4408	285	-195.4	-270.6	Stop-8: 2 samples were collected and put into No. 11 basket (R27 and R28). Heading 285. Resume moving toward 305.	R27,28
					5 to 20cm SR fragments are observed at the surface.	
15:13:31	4370	250	-161.1	-302.8	Stop to sample. Heading 250.	
15:26:55	4317	315	-167.2	-320.1	Stop-9: 5 sample were collected and put into No. 9 basket (R29 to 33). But three of them were losted at the sea surface by the wave.	R29,30 (Lost:R31,32,33)
15:30:48			-178.1	-310.3	Estimated time at the sea surface is17:05.	

Dive 6K#1437 Report

Observer: Kenichiro Tani

Pilots: Takuma Onishi, Keigo Suzuki

Technical information:

Location: Eastern scarp of Kyushu-Palau Ridge (DAT area)

Objective: Observation and rock sampling of arc crust section of Kyushu-Palau Ridge

	On bottom:	Off bottom:
Time (local)	11:13	15:31
Latitude:	26°14.2856' N	26°13.5723' N
Longitude:	135°51.8446' E	135°51.0165' E
Depth (m):	5298	4030

9 samples collected plus several clasts in the sample baskets from unknown localities.

Purpose:

The main purpose of this dive was to observe and to collect rock samples from the basement of the proto-Izu-Bonin-Mariana (IBM) Arc, potentially exposed at the base of the Kyushu-Palau Ridge (KPR). The dive track is located at the eastern escarpment of the Minami-Koho Seamount, northern KPR, where the ridge intersects with the Daito Ridge. Previous dredge surveys conducted at the Minami-Koho Seamount during the GH76 and GB14 cruises have recovered granodiorite and gabbro. This SHINKAI6500 dive was aimed to confirm and observe the exposures of these plutonic rocks, which may represent the preexisting basement rocks before the inception of the IBM subduction, or the deep crustal section of the Eocene to Oligocene proto-IBM Arc crust.

The dive was planned to observe outcrops and collect samples from steep cliff at the base of northern part of the Minami-Koho Seamount from 5300 mbsl and 3800 mbsl (Fig. 1). Specifically, several clasts of gabbroic rocks were dredged at the same site during the GB14 cruise, and main purpose of the dive was to confirm the outcrops of the gabbroic rocks and to explore what is exposed above the gabbroic layers.

Observations:

The dive started at 8:57, and landed at the seafloor at 11:12, 5298 mbsl. The seafloor was unconsolidated yellowish mud (Fig. 2), and two push cores were immediately obtained at the landing site (C01 and C02). Then we headed southwest to climb up the gentle muddy slope. We encountered the first outcrop at 11:25, 5260 mbsl, which was a roughly bedded exposure, almost parallel to the current dipping of the slope, covered with a thin Mn-oxides crust (Fig. 3). We were able to observe whitish material, probably mud, underneath the Mn-oxides crust. We decided to stop for sampling at 5218 mbsl, and collected one rock sample (R01) from an outcrop at 11:37. Sample R01 was a mudstone coated with thin Mn-oxides crust, confirming our observations.

We continued upslope observing similar bedded outcrops partly covered with soft mud until ~5188 mbsl at 11:41 when outcrops started to be mantled by much thicker

Mn-oxides crust. However, dipping of the Mn-oxides crust was parallel to the current slope, and we could occasionally observe internal whitish to yellowish horizontal beddings at the cross-cutting gullies, inferring sedimentary rocks. We begin to see subangular to subrounded blocks (10 – 30 cm in diameter) standing out from the surface as we climb up. These blocks became dominant from ~5060 mbsl, and the outcrops became more like a breccia (Fig. 4). We tried to sample these blocks from outcrops or talus several times at 5138 mbsl, 5107 mbsl, 5095 mbsl, and 4985 mbsl, but failed because these blocks were strongly anchored to the floor with thick Mn-oxides coating.

We were finally able to sample a rock (R02) from outcrop at 13:18, 4909 mbsl, which was a coarse-grained polymict breccia containing subangular gabbro clast with mud matrix. At 13:28, 4832 mbsl, we stopped at a small talus with several angular blocks which looked like they derived from recent slope failure, and less mantled with Mn-oxides crust. We collected four rocks (R03, R04, R05, and R06) from this talus (Fig. 5) and we were able to confirm plutonic texture of the blocks from the window. Collected samples from this site were all medium- to coarse-grained gabbros.

We decided to find the outcrop of these plutonic rocks and headed uphill towards southwest. But the outcrops were heavily covered with Mn-oxides crusts, and it was difficult to observe the internal structures or to sample rocks. The slope became gentle from ~4800 mbsl and surface began to be covered with soft yellowish mud. We occasionally observed mounds or ribs of rocks pointing out from the mud, but they were horizontally bedded, most likely sedimentary, rocks (Fig. 6). We stopped at 13:54, 4612 mbsl to sample from one of these mounds with beddings, and the rock was a mudstone that was too fragile to be sampled with a manipulator.

We begin to observe more massive, thickly Mn-oxides coated, outcrop from 4591 mbsl at 13:56, which looked like a blocky breccia (Fig. 7). We stopped at the upper part of this outcrop at 14:02, 4582 mbsl, and collected three loose angular blocks (R07, R08, and R09). Samples R07 and R08 were brecciated gabbro (cataclasite) and R09 was a medium-grained gabbro. This breccia-like outcrop continued to 4140 mbsl, and we tried to sample blocks along the way from talus at 14:41, 4410 mbsl, and at 15:10, 4200 mbsl, but all of the rocks were strongly anchored to the seafloor with thick Mn-oxides coating and failed to sample.

Above 4410 mbsl, the slope became gentle and totally covered with soft yellowish mud. The surface of the mud showed weak ripples (Fig. 8), and no reflectance was observed in the sonar. We stopped at 15:28, 4047 mbsl, to obtain one push core (C03) on surficial mud, and moved slightly uphill until we left the floor at 15:31, 4030 mbsl.

Summary:

Dive #1437 surveyed lower part of east-facing escarpment of KPR at the northern Minami-Koho Seamount between 5298 mbsl to 4030 mbsl.

It was surprising that even though the planned dive track was set on a continuous steep cliff, predominant part of the observed seafloor was covered with thick-Mn oxide crusts or soft unconsolidated sediments. It was mostly difficult to observe the internal structures, but we assume that they were mostly alternation of horizontally bedded mudstone (occasionally containing angular blocks) and breccia. All of the collected samples, except R01 and R02, were gabbroic rocks, suggesting that blocks within the breccia are predominantly composed of gabbroic rocks. Sample R02 was collected near the outcrop that showed horizontal beddings with scattered angular blocks. This sample was polymict breccia containing gabbro clast with mud matrix,

suggesting that these sedimentary rocks were deposited after the formation of escarpment, entraining resedimented gabbroic clasts derived from upper outcrops.

The collected gabbroic rocks will provide critical constraints on the nature of basement rocks beneath the KPR, and they may provide important petrological and geochemical information for the genesis of granitic magma that formed part of the Minami-Koho Seamount.

Figures:

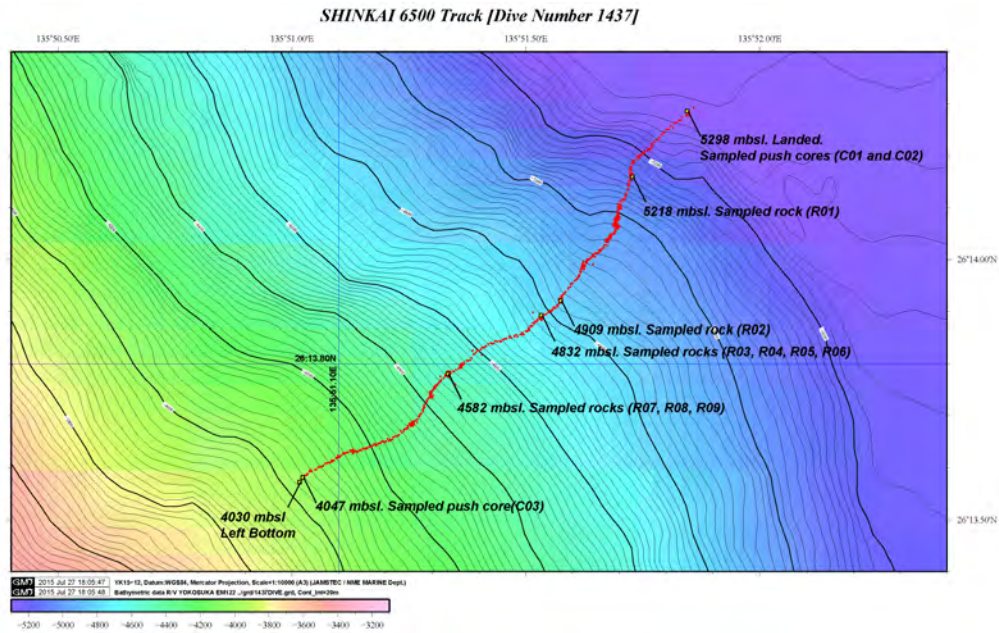


Figure 1 – Submersible track during the 6K1437 dive.

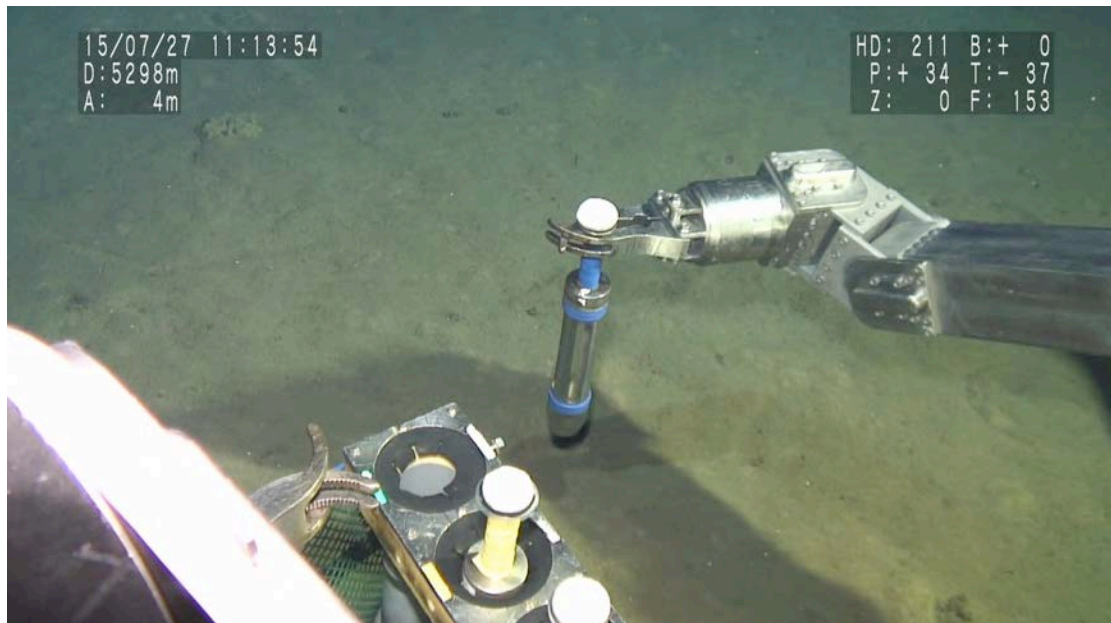


Figure 2 – Soft muddy slope at the landing site. Collecting sample C01 (11:03, 5298 mbsl: captured image from C001 video).



Figure 3 – Outcrop of bedded rocks dipping almost parallel to the current slope (11:29, 5226 mbsl: captured image from C002 video).



Figure 4 – Outcrop of breccia? Thickly covered with Mn-oxides crust (11:46, 5146 mbsl: P7270015.jpg of OUT still camera).

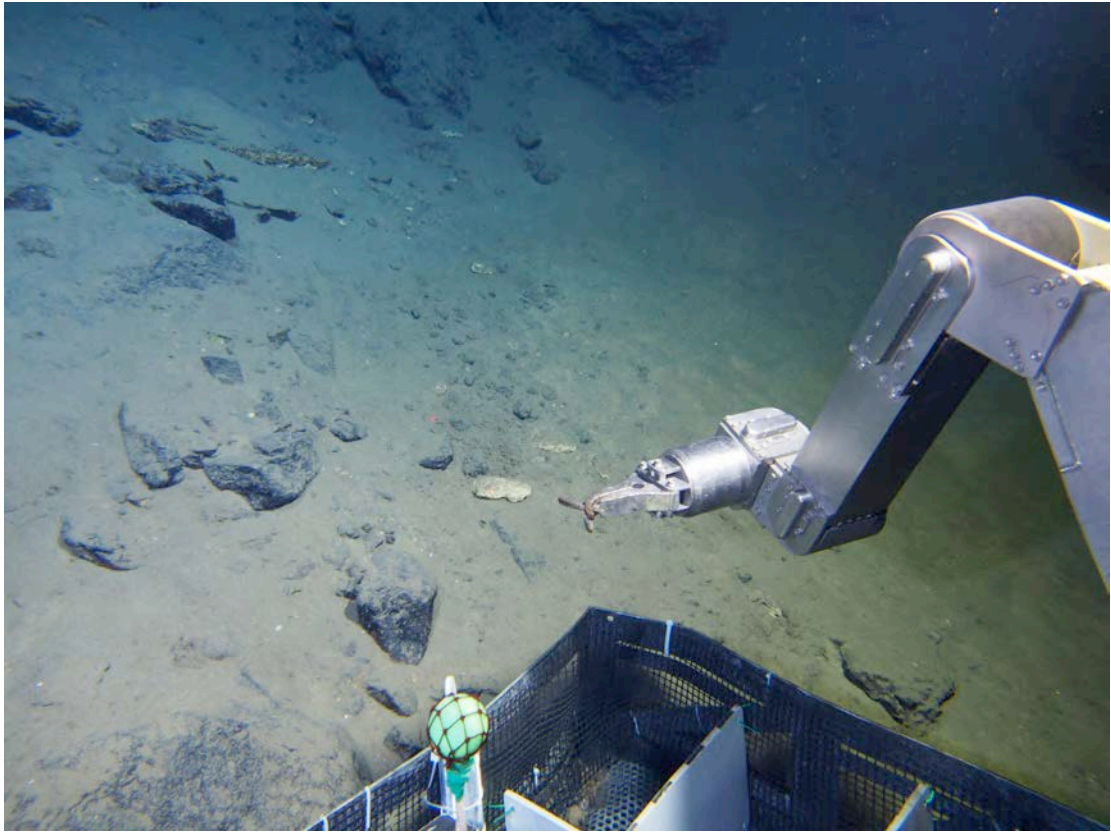


Figure 5 – Collecting angular gabbroic blocks from the talus beneath the breccia outcrop. Samples R03, R04, R05, and R06 were collected from this site (13:28, 4832 mbsl: P7270317.jpg of OUT still camera).



Figure 6 – Outcrop of “ribs” of horizontally bedded mudstone covered with unconsolidated mud (13:42, 4748 mbsl: P7270358.jpg of OUT still camera).

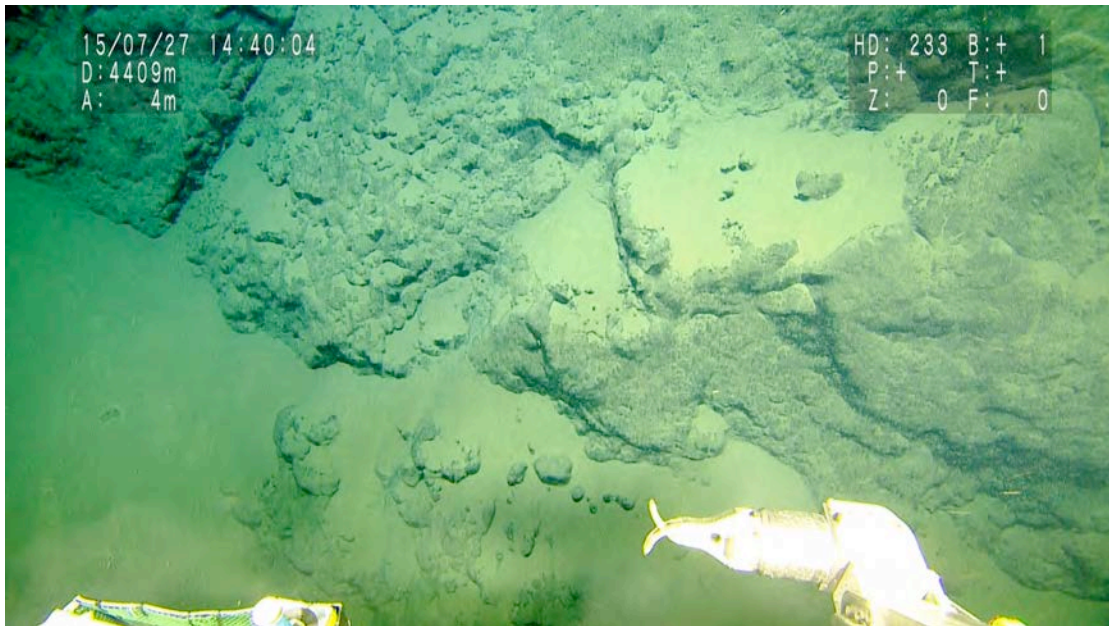


Figure 7 – Outcrop of breccia? Thickly mantled with Mn-oxides crust (14:40, 4409 mbsl: captured image from C002 video).



Figure 8 – Soft sediment with weak ripples observed at the uppermost part of the dive track (15:20, 4098 mbsl: P7270647.jpg of OUT still camera).

Table 1 – Dive log for 6K#1437 recorded by Izumi Sakamoto

Dive #:	6K#1437
Date:	2015/7/27
Location:	DAT1
Objectives:	

Logger: I.Sakamoto
 samples are noted 6K#xxx-RYY
 where xxx is dive number,
 X is S for scoop, R for rock, C for push core, W for water, YY is not

Time	Depth(m)	Sub Heading	X	Y	Note	Sample No.
8:58:53			724.9	1351.9	In water.	
9:08:24	500		779.2	1340.4	WD=500 m.	
9:19:18	1000		820.4	1334.7	WD=1000 m.	
9:30:21	1500		788.6	1341.3	WD=1500 m.	
9:41:32	2000		766.6	1347.8	WD=2000 m.	
9:53:19	2500		685.2	1305.2	WD=2500 m.	
10:05:33	3000		535.3	1356.8	WD=3000 m.	
10:17:35	3500		730.8	1379.8	WD=3500 m.	
10:31:10	4000		939.9	1182.6	WD=4000 m.	
10:43:29	4500		921.1	1203.4	WD=4500 m.	
10:56:19	5000		891.4	1224.3	WD=5000 m.	
11:12:57	5298		886.4	1250.2	WD=5298 m on bottom.	
11:14:20	5298		881.5	1250.2	Sampled 2 push cores (Blue and yellow). Thick sediment are observed.	C01,C02
11:16:48		210	878.5	1251.2	Change the direction to 210.	
11:19:14	5295	230	850.8	1208.4	Start running to 230.	
11:22:46			775.7	1120.9	Thick sediment.	
11:23:31			760.9	1118.9	Thick sediment with small amount of dark floated rocks.	
11:25:49			736.1	1081.1	Blocky surface with Mn coating.	
11:28:33			701.5	1052.3	Gentle slope with Mn pavement	
11:31:29			662	1044.3	Mud.	
11:32:19			662	1048.3	Stop to sample. Rocks on mud.	
11:34:10	5215	257	654	1048.3	Stopped to sample. Heading 257.	
11:35:21	5219	249	648.1	1050.3	Collect a rock sample. Heading 249.	
11:37:50	5219	249	648.1	1049.3	The sample was put into No. 1 basket.	R01
11:43:31			574.9	1023.4	Some cracks on the Mn pavement are observed	
11:47:22			550.2	1005.5	Angular boulders in the crack are observed	
11:49:46	5139	213	550.2	1007.5	Try to sample rock. Subrounded, 20 - 30 cm, blocks in the outcrops are observed.	
11:51:51			550.2	1005.5	10-20cm thick Mn crust?	
11:53:12	5134	208	547.2	1005.5	Shinkai try to get the rock sample from the middle part of the 1m cliff. The surface are rounded with Mn crust. Canceled sampling and start to move. Heading 208.	
11:58:12			519.5	1004.5	~1 m cliff observed at the left side of Shinkai.	
12:01:33			504.7	1005.5	Mn pavement with gentle slope. 1m cliff observed towards the 250 degree direction.	
12:03:16	5115	232	518.6	1003.6	Stopped to sample.	
12:04:42	5109	220	513.6	994.6	Canceled sampling and start to move. Heading 235.	

12:08:16	5105	209	510.6	989.6	Whitish to yellowish sediments are observed in the cliff beneath the Mn crust. Stopped to sample.	
12:14:25	5103	214	491.9	988.6	Canceled sampling.	
12:19:18	5095	225	494.8	995.6	Try to sample at the base of a 50-100 cm gully.	
12:29:18	5093	235	476	991.6	Rough surface of angular blocks (20-50 cm) with Mn crust. Canceled sampling and start to move at 235 degree.	
12:35:26			443.4	975.7	Subangular to subrounded blocks on the surface.	
12:41:11	5025	244	428.6	963.8	Stopped to sample.	
12:43:08	5025	225	428.6	954.8	Canceled sampling and start to move towards 220 degree.	
12:46:20			402.8	950.8	Gentle slope with thin sediment.	
12:59:06	4988	207	337.6	878.2	Stopped to sample. Rough surface with Mn crust (10 cm thick). Whitish and yellowish sediments are observed under the Mn crust.	
13:06:06	4985	202	342.5	875.3	No sample. Start to move towards 202 degree.	
13:07:58	4972	201	326.7	869.3	Changed the heading to 240 degree.	
13:12:05			275.3	831.5	Steep slope with thin sediment	
13:18:24	4909	242	217.9	790.7	Try to sample at the middle part of a cliff.	
13:20:57	4909	240	215.9	793.7	1 rock sample (R02) into the basket No.2. Start moving. Heading 240.	R02
13:27:03			165.5	740	Jointed blocky surface on the cliff	
13:29:50	4832	237	155.6	726.1	Stopped to sample.	
13:35:21	4825	235	164.5	727.1	3 rock sample(R03-R05) put into basket No.3 and 1 rock sample (R06) put into the basket No.2.	R03,04,05,06
13:43:35			84.4	600.8	Ripple marks.	
13:47:38			51.8	523.2	Flat surface with thick? sediment	
13:52:26			-2.6	442.7	Continuing cliffs are observed at the left side of submersible.	
13:54:01	4608	255	-16.5	442.7	Stopped to sample. 20 cm-thick Mn crust and white mudstone are observed under the crust.	
14:01:02	4582	252	-48.1	396.9	Start sampling	
14:03:31	4582	252	-41.2	394.9	Sampled one rock sample in basket No.4 (R07).	R07
14:15:03	4580	279	-35.3	389	2 samples (R08 and R09) into basket No.7.	R08,09
14:17:03	4576	248	-44.2	394.9	Start moving. Heading 240.	
14:19:21			-63.9	371.1	Steep slope with 20 cm-sized blocks.	
14:25:23			-105.5	334.3	Coarse sediments are observed on the surface.	
14:27:32	4501	247	-118.3	335.3	Stopped to sample. Failed.	
14:33:02	4500	240	-125.3	337.2	Start moving. Heading 240.	
14:46:38	4410	270	-224.1	268.6	Stopped to sample. Failed.	
14:52:31	4402	240	-212.3	267.6	Start moving. Heading 240.	
14:58:27			-262.7	205	Flat surface with thin sediment. Occasional blocky fragments are observed on the surface.	
15:06:12			-309.2	84.6	1 m-high wall on the left side of the Shinkai.	
15:07:13			-314.1	80.7	Mudstone layers observed at the middle part of the cliff.	
15:10:30	4200	245	-317.1	60.8	Stopped for sampling. Searching for sampling site.	
15:13:00	4184	255	-317	61	Canceled sampling.	
15:25:52	4049	235	-409.1	-123.2	Stopped to sample. Thick sediments.	
15:28:12	4041	213	-410.1	-121.2	1 push core (red) obtained.	C03
15:30:40	4030	201	-424.9	-133.1	4030 m leave the bottom.	

Dive 6K#1438 Report

Observer: Susumu Umino

Copilots: Hirofumi Ueki, Akihisa Ishikawa

Technical information:

Location: Eastern scarp of the Kyusyu-Palau Ridge at the junction of the Daito Ridge

Objective: Geological observation and rock sampling of the lower part of the Kyusyu-Palau Ridge

	On bottom:	Off bottom:
Time (local)	10:40	15:15
Latitude:	26°6.0511'N	26°5.5481N
Longitude:	135°55.6311'E	135°55.1174E
Depth (m):	3881	2362

Collected 1 push core sample at 1 site and 21 rock samples at 11 sites

Purpose:

The main purpose of this dive was to observe and sample rocks from the lower part of the Kyushu-Palau Ridge expected to expose the earliest magmatic basement of the proto-Izu-Ogasawara-Mariana (or IBM) Arc. This site was chosen because 48 Ma granitic rocks were dredged, which coincides with the age of boninitic magmatism in the IBM forearc region, and may expose the earliest arc magmatic product of the Kyushu-Palau Ridge.

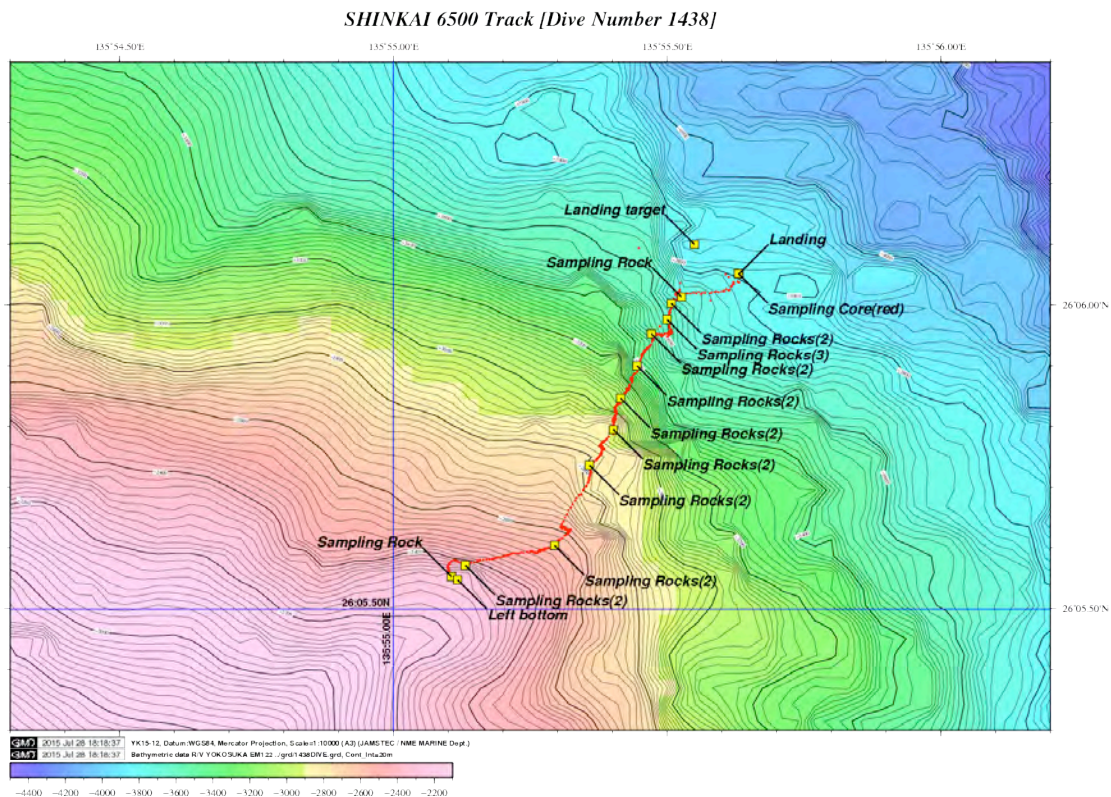


Figure 1. Dive track and sample locations.

Observations:

Stop 1: 10:45, 3881m

The dive began (Landing point) at 10:40 and 3881 m on a relatively flat surface covered by mud underlain by subround to subangular gravel, which probably are fragments of granite and gabbro. Stop2 and upslope (Figure 1). Push core sample (C-01) was obtained from the muddy floor.

We then headed 270°, went upslope dipping 40° over gravel and mud. Mn-coated outcrops of massive bodies are sporadically exposed on the gravel and mud floor.

Stop 2: 11:02, 3808 m

Mn-crusts breccia of a talus deposit covers the seafloor between ridges of massive rocks. Rock sample R-01 is collected from this gravel bed.

We then headed 280° through massive rock bodies roughly jointed at 90° strike and 80°S.



Figure 2. Scarps of jointed rocks with fine banding. Both major jointing and banding strike 90°.

Stop 3: 11:25, 3774 m

Finely banded rock from the outcrop is on rectangular roughly jointed outcrop. Rock samples R-02 and 03 were collected from the outcrop of banded massive body (Figure 2).

We moved toward 215°. Massive body jointed at striking 90° and dipping 80°S.

Stop 4: 11:44, 3724 m

Rock sample R-04, 05, 06 were taken from blocks on a steep slope below the outcrop of banded rock.

We headed 270° and faced normal to vertical cliffs. Alternation of finely banded and roughly jointed rocks form high cliffs with tiered terraces covered by mud.

Stop 5: 12:15, 3640 m

Massive wall with thin Mn coating and joints striking 90° have subparallel and oblique fractures to jointing. Rock samples R-07 and 08 were taken from jointed outcrop.

Heading 215° ; Massive body with joints striking 90° and fine banding form high cliffs and ridges

Stop-6: 12:32, 3539 m

Jointed massive wall with thin Mn coating. Fractured subparallel to joints. Rock samples R-09 and 10 were collected from blocks in a talus deposit on the foot of the jointed wall.



Figure 3. Jointed massive wall with thin Mn coating.

Headed 215° uptrim nearly vertical cliffs. Moved into Mn-crust area.

Stop 7: 12:55, 3350 m

Rock samples R-11, 12 from a fractured wall.

Headed 210° . Blocks with banding striking obliquely at 50° and 90° are in contact with a sharp shear zone.



Figure 4. Blocks with banding striking obliquely at 50° and 90° are in contact with a sharp shear zone.

Stop 8: 13:14, 3095 m

Collected rock samples R-13 and 14 on a terrace over vertical cliff of banded rock.

Heading 230°; massive body with joints striking 90° and dipping 80°S and 40°N, forming tiered terraces

Stop-9: 13:38, 2908 m

Rock samples R-15, 16 taken from irregularly jointed body with thin Mn coating.

Headed 230° and swam over deep valleys and high cliffs of jointed body.

Stop-10: 14:21 2681 m

Collected rock samples R-17 and 18 from gravel on jointed body.

Headed 270° and climbed nearly vertical cliffs of fine banding striking 90°. Then we moved into sedimented floor with large cobbles and boulders.

Stop-11: 14:52, 2560 m

Collected rock samples R-19 and 20 from blocks embedded in muddy matrix near finely banded outcrops.

Headed 230° and went upslope over cobbles and boulders, and then we reached high walls of a finely banded massive rock body. Climbed up the nearly vertical walls with 90°-striking banding and N-S striking joints with occasional subhorizontal terraces.

Stop-12: 15:14, 2362 m

Stop on a terrace in the subvertical wall and collected a block covered with sediments (rock samples R-21).

We took off 15:15 at 2362 m.

Summary:

The entire area along the dive track is underlain by finely banded massive rock bodies with joints striking 90° and dipping very steeply to the south. Rock failure along the main and minor joining perpendicular to each other resulted in subvertical cliffs tiered by subhorizontal terraces. Shear zones subparallel to the main joints displaced, rotated and fragmented adjacent gabbroic blocks with fine banding. Talus rubble and breccia deposit at the foot of cliffs and steep gauges between high walls of jointed gabbros.

Dive 6K#1438
 Site C Junction of Daito Ridge and Kyushu-Palau Ridge
 Date 2015/7/28 (Tue)

Locality	Time	Depth	Latitude	Longitude	Depth	Sample	Note
	10:40		26- 6.0511N	135-55.6311E	3881		On bottom
Stop-1	10:45	3881	26- 6.0519N	135-55.6300E	3881	C-01	Gravel bed covered with mud Heading 270°; Upslope 40° over gravel mud Mn-crusted breccia of talus deposit between massive outcrop
Stop-2	11:02	3808	26- 6.0134N	135-55.5261E	3799	R-01	Heading 280°; Roughly jointed outcrop Finely banded rock from the outcrop
Stop-3	11:25	3774	26- 6.0029N	135-55.5077E	3774	R-02, 03	Heading 215°; Massive body jointed at striking 90° and dipping 80°S Alternation of finely banded & roughly jointed body making tiered terraces
Stop-4	11:44	3724	26- 5.9761N	135-55.4999E	3723	R04, 05, 06	Heading 270°; facing against vertical cliffs Massive wall 90° joint
Stop-5	12:15	3640	26- 5.9527N	135-55.4712E	3638	R-07, 08	Heading 215°; Massive body jointed at striking 90° with fine banding forming high cliffs and ridges Blocks below jointed massive wall, no Mn
Stop-6	12:32	3539	26- 5.9001N	135-55.4450E	3534	R-09, 10	Heading 215° uptrim nearly vertical cliffs Thin Mn covered to Mn covered area
Stop-7	12:55	3350	26- 5.8466N	135-55.4151E	3347	R-11, 12	Heading 210°; Two blocks with banding of 50° and 90° strikes meet along a deep gully Terrace over vertical cliff
Stop-8	13:16	3095	26- 5.7953N	135-55.4018E	3095	R-13, 14	Heading 230°; massive body with joints striking 90° and dipping 80°S and 40°N, forming tiered terraces Fine irregular jointing
Stop-9	13:38	2908	26- 5.7366N	135-55.3581E	2907	R15, 16	Heading 230°; swim over deep valley between high cliffs of jointed body Gravel on jointed body
Stop-10	14:21	2681	26- 5.6044N	135-55.2947E	2681	R-17, 18	Heading 270° Cobbles and boulders in muddy matrix; Finely banded outcrop nearby
Stop-11	14:52	2560	26- 5.5719N	135-55.1315E	2480	R-19, 20	Heading 230°; upslope over cobbles and boulders Steep cliff with fine banding
Stop-12	15:14	2362	26- 5.5532N	135-55.1061E	2362	R-21	Left bottom
	15:15		26- 5.5481N	135-55.1174E	2362		

Table 1 – Dive log for 6K#1438 recorded by Izumi Sakamoto

Dive #:	6K#1438
Date:	2015/7/28
Location:	DAT2
Objectives:	

Logger: I.Sakamoto
 samples are noted 6K#xxx-RYY
 where xxx is dive number,
 X is S for scoop, R for rock, C for push core, W for water, YY is number

Time	Depth(m)	Sub Heading	X	Y	Note	Sample No.
8:58:00			1050.2	928.1	In Water	
9:20:39	1000		1091.3	919.9	WD=1000m	
9:32:50	1500		1099.2	902.4	WD=1500m	
9:44:14	2000		1069.1	908.1	WD=2000m	
9:56:20	2500		1041.5	922.4	WD=2500m	
10:09:07	3000		990.4	953.7	WD=3000m	
10:24:20	3500		1100.5	1023.7	WD=3500m	
10:40:45	3882	238	1004.5	1055.7	arrive at the bottom 3882m, thick sediment exposed on the surface. W.T.=1.5°C	
10:44:35	3881	225	1007.1	1056.7	pushcore (red)	C01
10:48:24	3858	230	1001.9	1052.4	start moving Heading 230	
10:50:29	3850	270	973.3	1035	heading 270	
10:54:35			952.5	948.3	Steep slop with thick sediments.	
10:57:51			948.6	886.4	Outcrop Steep slop	
10:58:49	3807	223	947.3	872.3	Start sampling.	
11:02:35			953.8	872.3	Stratified layers dip > 20 degree with 300 degree direction (brecciated mud stone?)	
11:18:47	3796	264	942.1	883.2	Sampled one rock Sample in basket No.1 (R01) Start moving Heading 270	R01
11:23:41	3774	294	921.3	851.7	Start sampling	
11:27:26	3773	284	920	852.8	Sampled two samples Samples in basket No.9 (R02 and R03 shape is Sub rounded)	R02,03
11:29:12	3766	210	913.5	855	Heading 210	
11:37:37			869.2	837.6	Stopped to try sampling at the outcrop.	
11:48:07	3724	249	872.1	837.7	Sampled three samples Sample in basket No.4 (R04-R06)	R04,05,06
11:50:17	3724	210	875.1	833.3	Start moving heading 210	
11:52:37	3712	210	864.5	844	Heading 210	
11:57:11	3596	270	835.7	853.5	Heading 270	
12:09:56	3539	284	830.4	792.2	Start sampling	
12:15:42	3538	279	828.9	787.8	Sampled 2 rocks (R07,R08) in basket No.8	R07,08
12:19:11	3528	215	826.6	791	Start to move. Heading 215.	
12:19:37			828.9	799.2	Dark jointed outcrop. Partly covered with soft mud.	
12:25:18			775.9	766.9	Jointed outcrop	
12:31:28	3540	230	731.9	746.1	Start sampling	
12:34:07	3537	245	732.7	748	Sampled 2 rocks (R09,10) in basket No.6.	R09,10
12:37:28	3531	215	706.9	736	Heading 215	

12:51:19	3351	215	635.7	695.6	Start sampling	
12:55:37	3350	220	636.5	698.1	Sampled 2 rocks (R11,12) in basket No.12.	R11,12
13:03:14			600.9	679.1	Jointed outcrop with sub_unit and amall structure	
13:07:32			578.6	680	Jointed outcrop steep slop	
13:14:30	3095	219	543.3	670	Start sampling	
13:17:26	3095	253	536.9	674.7	Sampled 2 rocks (R13,14) in basket No.7.	R13,14
13:19:10	3090	230	535.5	675.9	Heading 230	
13:29:00			479.9	638.7	Jointed outcrop	
13:38:31	2908	230	430.1	605.6	Start sampling	
13:45:40	2905	233	423.9	608.1	Sampled 2 rocks (R15,16) in basket No.1(R15) and No.2(R16)	R15,16
13:48:26	2880	220	419.3	608.1	Heading 220	
14:04:10	2800		236.5	530	Steep slop outcrop WD=2800m	
14:06:16	2771	240	228.9	535.1	Heading 240	
14:14:27	2578	272	183.4	501.7	Start sampling Blocky angular fragment surface with thin sediments WD=2578	
14:21:57	2581	251	180.2	499.1	Sampled 2 rocks (R17,18) in basket No.3.	R17,18
14:23:58	2577	270	177	500.4	Start moving heading 270	
14:44:22	2483		133.8	270.7	Rough surface with thick sediments WD=2483m	
14:46:13	2461	273	121	226.6	Start sampling	
14:51:26	2481	299	121	227.9	Sampled 2 rock (R19,20) in basket No.7(R19) and No.11(R20).	R19,20
14:54:23	2455	210	135.4	199.9	Start moving heading 210	
14:59:11	2404		109.8	175.9	Jointed outcrop with steep slop WD=2404m	
15:14:53	2351	275	84.2	195.9	Sampled one rock (R21) in basket No.10 WD=2351	R21
15:15:58	2352	259	79.3	203.9	Off bottom WD=2352	

6. Geophysical Survey

Geophysical survey including bathymetry, magnetic and gravity anomalies have been conducted during the YK15-12 cruise in the Kyushu Palau Ridge to better characterise the dive site and its geologic and tectonic context. Eastern margin of the West Philippine Basin was also investigated to understand seafloor fabric and magnetic lineation of this area, hence mode of spreading and age of this part of the basin.

6.1. Instruments and Measurements

Multi-narrow beam bathymetric data were obtained using a KONGSBERG EM122 (Swath width 100°; 288 beams with its width of 2°), which also provides a backscatter image that will be processed after the cruise. Sub bottom profile data were also obtained along with bathymetric data using EdgeTech 3300-HM. Sound velocity correction was applied using XBT data. Four XBTs were done in the research area. The bathymetric data is shown in Figures 5 and 7-1. A shipboard gravity meter (Lacoste-Romberg Air-Sea S-63) was used for gravity measurement. Shipboard gravity meter reading on 31 July 2015 at the JAMSTEC pier in the Yokosuka Port was 10813.6, which was tied to absolute gravity value 979758.159 mgal.

For magnetic anomaly measurements, a towed proton magnetometer (PM-217, Kawasaki Geological Engineering & Tierra Technica) and onboard three-component magnetometers, a Tierra Technica SFG-1212 system equipped with R/V Yokosuka was used. Processing of magnetic anomaly data will be conducted by shore-based collaborator.

6.2. Preliminary results

6.2.1 WPB area (Fig. 5-1)

The dive sites (6K#1434 and 1435) were located on the NE-SW-trending and east-facing scarp of the KPR. Relative height of the scarp reaches 2000 m. In this area, NE-SW trending lineaments are widely observed on KPR, which are probably fault scarps. Fault-bounded blocks are tilted to SE. These structures were assumed to have formed associated with rifting and spreading of Shikoku and Parece Vela basins.

NE-SW-trending abyssal hills were recognized in the eastern margin of the West Philippine Basin. Anti-J pattern of abyssal hills is associated with NE-SW trending transform fault, and this fault offsets the abyssal hills near ODP Site 1201. Eastern margin of the basin, i.e., western slope of KPR show well-developed “sediment wave” and gullies extending from the ridges of KPR.

6.2.2 MDB area (Fig. 5-2)

KPR in this area extends N-S to NNW-SSE. Eastern scarp facing Shikoku Basin show multiple steps, and total relief is about 3000 m. These scarps show strikes of NE-SW, which are different from those of the ridge crests of KPR. Western margin of the rift zone (westernmost fault scarp on KPR) is prominent in this area (along 137°E).

6.2.3 DAT area (Fig. 5-3)

Minami Koho Seamount forms axis of KPR in DAT area, and is on the extension of Daito Ridge. This seamount has a flat summit of about 15 km (NW) x 3 km (SE) with a water depth of around 300 m, indicating the summit was subaerially exposed. Total relief from neighboring Shikoku Basin floor reaches c. 5000m. Eastern scarp of the seamount, i.e., scarp facing Shikoku Basin, has steeper slope than its western slope. Northeastern slope shows clear fan-shaped morphology. Southeastern part of the seamount where 6K#1438 was conducted shows unique topographic feature. This area has rugged morphology, and extensive gullies are developed. This area is distinguished from surrounding area by clear change in slope angle.

7. Shore-based studies

A comprehensive work plan for the rock samples was developed by the shipboard scientific party. This work will include major element analyses, trace element analyses, geochronology studies, mineral analyses, petrographic characterization, and stable and radiogenic isotope characterization. The work will be completed at the Geological Survey of Japan/AIST, National museum of nature and science, Kanazawa University, Tokai University, and other possible collaborators. Analytical responsibilities include:

Volcanic rocks:

Petrological, geochemical and geochronological study on volcanic rocks will be conducted to reveal age, magmatic processes and geochemical characteristics of magma sources.

- Whole rock chemical composition (XRF, ICP-MS): GSJ
- Mineral chemistry: GSJ, Kanazawa
- Ar/Ar dating: GSJ
- Radiogenic isotopes (Sr, Nd, Pb, Hf?): GSJ etc.
- Melt inclusion studies, if applicable: Kanazawa, GSJ
- Description of volcanic textures for marginal part of subaqueous volcanic rocks: Tokai University
- Clay-minerals and rock alteration process: Tokai University.

Metamorphic and deformed rocks

• Petrogenesis and deformation condition (including pressure, temperature, strain rate and stress) will be studied by microstructural analysis (deformation microstructure, fabrics and mineral chemistry) using SEM-EBSD system and EPMA: GSJ

Volcaniclastic rocks

- SHRIMP zircon U-Pb dating: National Museum of Nature and Science
- LA-ICP-MS zircon trace element analyses: National Museum of Nature and Science
- LA-ICP-MS analyses on other minerals and glass: GSJ, Kanazawa
- XRF and EPMA analysis on relatively fresh clast and glass will be conducted at GSJ.

Sedimentary rocks

- Description of sediments and sedimentary rocks: Tokai University
- SHRIMP zircon U-Pb dating: National Museum of Nature and Science
- LA-ICP-MS zircon trace element analyses: National Museum of Nature and Science
- Melt inclusion study of heavy minerals: Kanazawa

Geophysical data

•Bathymetric and magnetic data will be merged with existing data and synthesized at GSJ and Tokai University.

Other shore-based studies include:

•Volcanic and geologic synthesis will be done at GSJ, National Museum of Nature and Science, Kanazawa University and Tokai University.

8. Summary

YK15-12 cruise mainly surveyed eastern scarp of Kyushu-Palau Ridge to investigate crustal section and basement of ancient Izu-Bonin-Mariana arc. Major goals of this cruise were: 1) to obtain crucial information about overriding plate at subduction initiation, hence, reconstruct tectonic setting during this period, 2) to recover volcanic record of earliest stage of Izu-Bonin-Mariana arc and reveal temporal variation of magmatism, 3) to evaluate possible along-arc variation of magmatism depending on the variation of arc basement (and sub-arc lithospheric mantle).

Five Shinkai 6500 dives as well as bathymetric, geomagnetic and gravity survey were conducted during this cruise. Three focused areas were chosen, i.e., WPB area (West Philippine Basin area), MDB area (Minami Daito Basin area), DAT area (Daito Ridge area) based on the variation of geologic feature west to the KPR.

Two dives in WPB area observed 2000m-high crustal section of KPR. Basaltic volcanic rocks were recovered from several locations. These volcanic rocks could provide information about magmatic history of earliest part of arc volcanism at KPR. It is also possible that lowermost part of section corresponds to arc basement prior to subduction initiation.

One dive in MDB area recovered sedimentary rocks covering steep scarp of KPR. Even though no igneous rocks were recovered, abundant sedimentary rocks were collected, which could provide information about crustal section of KPR in this area.

Two dives were conducted in KPR-Daito Ridge intersection area (DAT area). These dives, particularly 6K#1438, observed excellent exposure of plutonic rocks, dominantly composed of gabbro and minor amount of granitic rocks. Minor amount of metamorphic rocks with deformation texture were also recovered. The plutonic rocks show wide variation in petrography, and could correspond to either arc basement or lower part of arc crust. Dating and geochemical analysis of these rocks will determine their origin and tectonic environment where they were formed.

Bathymetric, geomagnetic and gravity surveys were conducted in and around the diving areas. In WPB area, eastern margin of West Philippine Basin including western slope of KPR and ODP Site 1201 were surveyed along E-W survey lines. This survey delineated NW-SE trend of abyssal hills and intersecting transform fault. This data combined with dating of basement rocks of ODP Site 1201 will provide reliable, and

tight constraint on age and mode of spreading of this part of the basin, accordingly, arrangement of plates at subduction initiation to form Izu-Bonin-Mariana arc.

In conclusion, YK15-12 cruise successfully observed and recovered igneous section of KPR where arc basement might be different. Shore-based studies on the collected samples will provide information about earliest history of KPR and possible variability of magma depending on the type of arc basement.

9. Notice on Using

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

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

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

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

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