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CRUISE REPORT

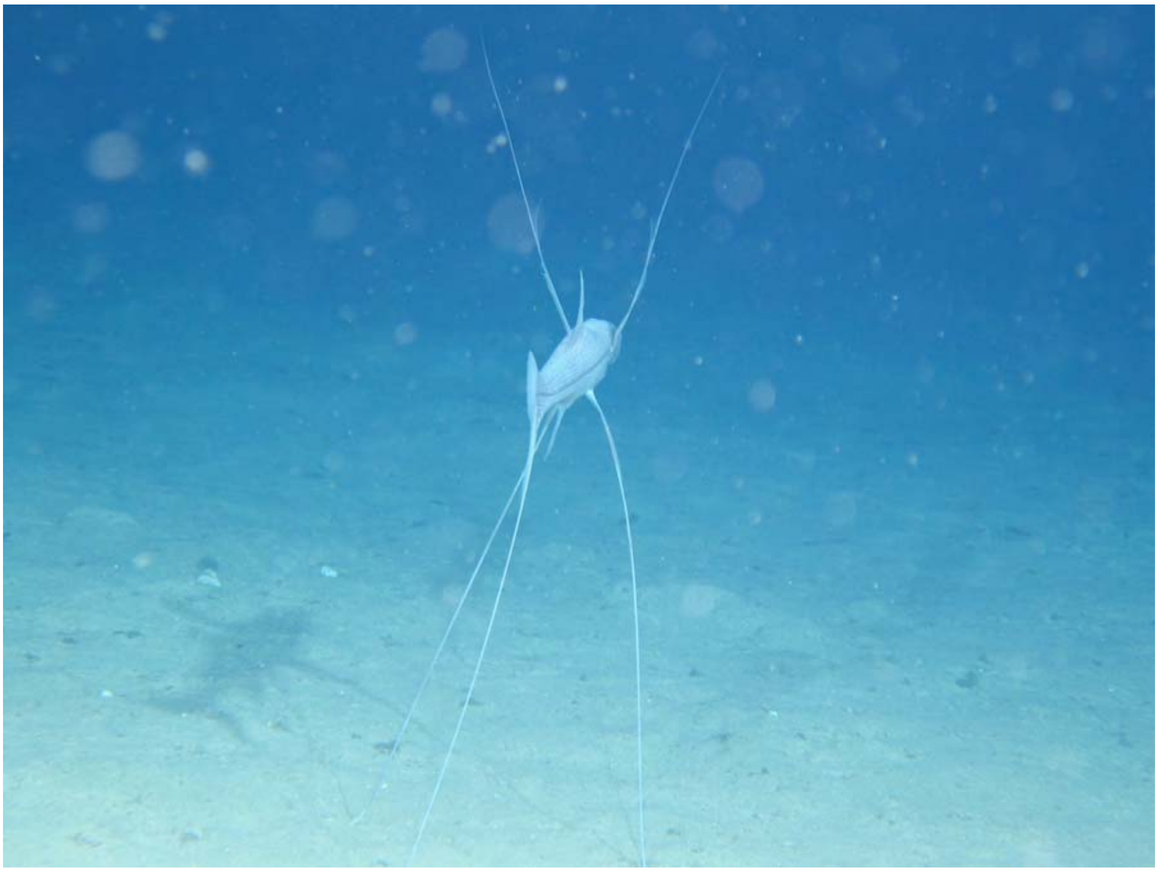
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

R/V Natsushima
Cruise NT09-05 Leg-1

Studies of rear-arc volcanism and crustal structure in the northern Izu Arc

April 2 to April 10, 2009

(JAMSTEC to Hachijo-jima)



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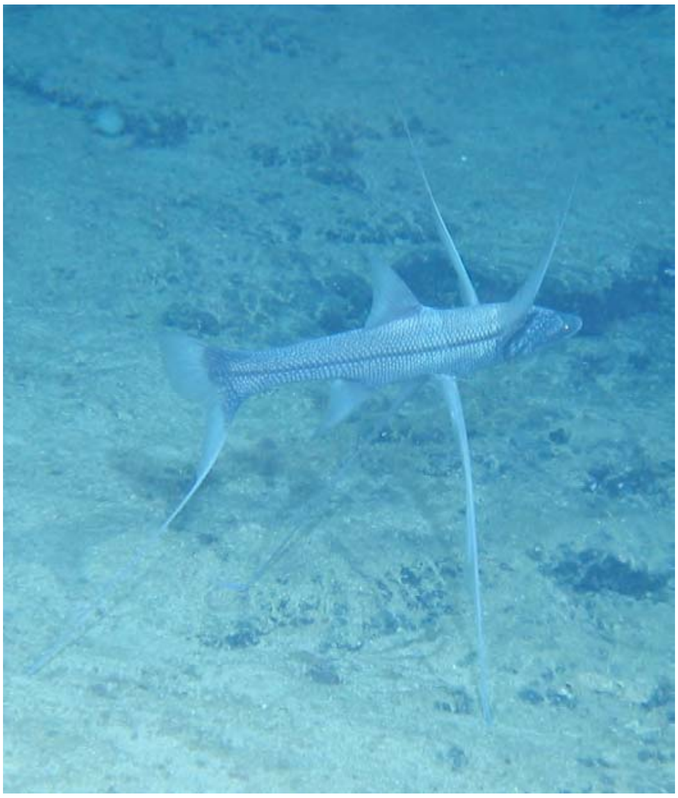

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1. Introduction and Background

The Izu-Bonin-Mariana arc system (IBM) extends over 2800 km south from near Tokyo, Japan, to beyond Guam, U.S.A. (Fig. 1.1), and is an excellent example of an intra-oceanic convergent margin (IOCM). IOCMs are built on oceanic crust and contrast fundamentally with arcs built on continental crust, such as Japan or the Andes. Because IOCM crust is thinner, denser, and more refractory than that beneath Andean- or Japan-type margins, study of IOCM melts and fluids allows a more confident assessment of mantle-to-crust fluxes and processes than is possible for continental arcs. Because IOCMs are far removed from continents they are not affected by the subduction of large volume of fluvial and glacial sediments. The consequent thin sedimentary cover makes it much easier to study arc infrastructure and determine the composition of mantle-derived melts.

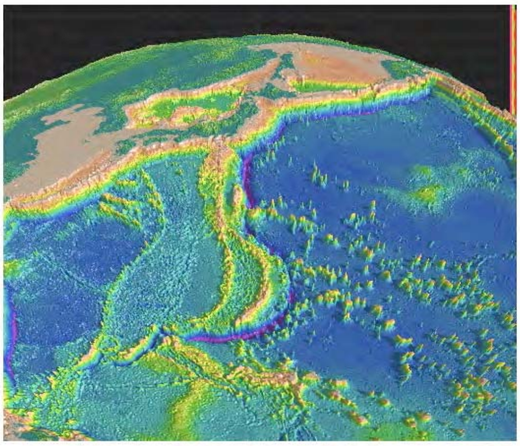


Figure 1.1 (left): Perspective view of the IBM subduction system (courtesy D. Sandwell)

The formation and evolution of the continental crust is a first order problem of terrestrial geochemistry because for many trace and minor elements, this reservoir is quantitatively important despite its volumetric insignificance on a planetary scale. In the latter part of the 1960s, Ross Taylor (1967) proposed the "andesite model" for the origins of continental crust on the basis of similarities between "calc-alkaline" or orogenic andesite formed in island arcs and the "intermediate" bulk composition (~60 wt% SiO_2) of this crustal type. For many arc enthusiasts, this observation has been a prime motivation for studies of island and continental arc systems. Subsequent studies have substantiated Taylor's estimate of continental crust bulk composition, and have noted that distinctive continental trace element fractionations (e.g., high U/Nb and Pb/Ce) are only found in supra-subduction zone magma types (Hofmann, 1988).

The andesites of most young oceanic arcs, however, have been found to be more depleted elementally and isotopically than average continental crust, at least at the volcanic front. An old idea, still generally valid, that may explain part of this problem is the Kuno-Dickinson-Hatherton K-h relationship (Kuno, 1959; Dickinson & Hatherton, 1967): at a given SiO_2 content, the K_2O of related volcanic series is positively correlated with depth (h) to the Wadati-Benioff Zone. Thus geochemical asymmetry in arcs was known prior to the advent of plate tectonics and may be what makes juvenile arc crust "continental" in key elements like Th and LREE as well as intermediate in silica content. Potential processes to produce this asymmetry might be that: (1) magma is first extracted from the mantle in the rear-arc and is then extracted a second time as the depleted mantle moves toward volcanic front where it is fluxed by fluid from the slab (Hochstaedter *et al*., 2000, 2001); (2) there is more slab-derived sediment melt in the rear-arc magma source (Ishizuka *et al*., 2003a, 2006; Tamura *et al*., 2007); (3) the degree of melting is smaller beneath the rear-arc (e.g. Tatsumi *et al*., 1983, Sakuyama & Nesbitt, 1986; Kushiro, 1994); or (4) there is more recycling of old crust at the magmatic front (Kimura & Yoshida, 2006).

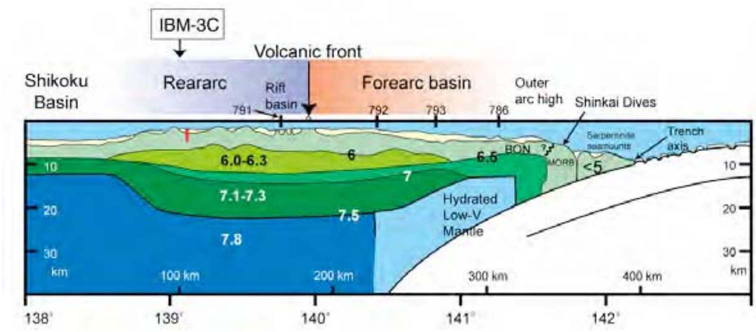


Figure 1.2: Izu-Bonin arc seismic stratigraphy (P-wave velocity, km/s) after Suyehiro et al. (1996). Proposed drilling site IBM-3C (697Full3) is designated as a red bar. Black bars suggest previous sites (ODP 786, 791, 792 and 793).

Full crustal velocity profiles for the IBM arc obtained in the last decade show a velocity structure with continuous layers extending ~200 km across the arc (Fig. 1.2). We do not yet know how these layers developed but testable ideas are being developed (Kodaira *et al.,* 2007a,b; Tatsumi *et al.,* 2008). Given the relatively large volume of crust now in a rear-arc position (Fig. 1.2) and its present day geochemical contrast with the magmas erupted at the volcanic front (see below), it is clearly vital that we understand the structure and compositional variations of the rear-arc through time in the same way that we have unraveled the temporal evolution of the fore- and volcanic front magmas.

Moreover, the newly obtained crustal structure of the Izu rear-arc implies that thick Eo-Oligocene crust also exists below the rear-arc and has the same kind of along-strike variability as at the volcanic front (Fig. 1. 3: Kodaira *et al*., 2008). Thus, the velocity structure and volume of crust are similar to that beneath the volcanic front even though the chemical composition of the crust is likely to be different and closer to that of average continental crust in trace elements and isotopes.

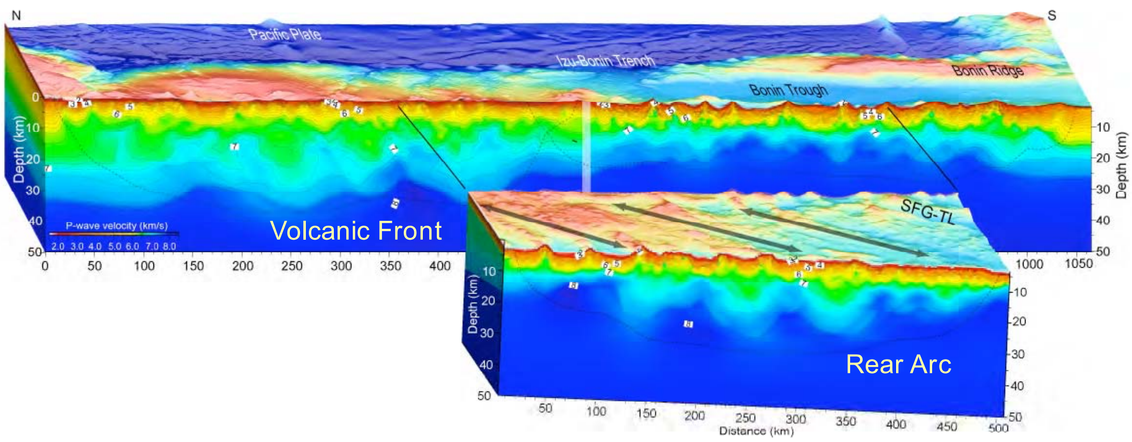


Figure 1. 3: Three dimensional block diagram with seismic images of both the rear-arc and the volcanic front (Kodaira et al., 2008). The velocity structure and volume of crust are similar between the volcanic front and the rear-arc.

2. Scientific Objectives

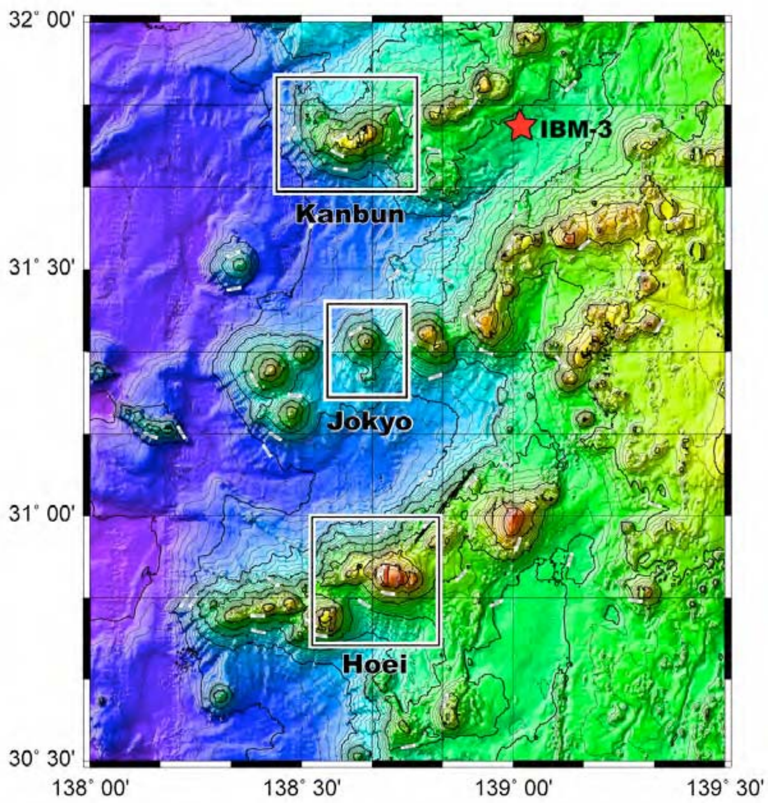


Figure 2. 1: Rear-arc volcanoes of interest to this study (Kanbun, Jokyo and Hoei). Crustal structure of these volcanoes are shown in Fig. 2.2.

The volcanoes of interest to this study (Kanbun, Jokyo and Hoei) occupy a small segment of the rear-arc seamount chains of Manji, Enpo and Genroku, respectively. All three volcanoes are now submarine but vary in volume from Jokyo, Kanbun to Hoei in volumetric order. The Kanbun and Hoei are flat-topped rear-arc volcanoes, suggesting that their summits reached sea level. There is a positive and linear correlation between the age and depth of flat-topped volcanoes, suggesting that rear-arc volcanoes submerge at a constant rate (~100 m/Ma) (Ishizuka 2008). Thus rear-arc volcanoes deeper than flat-topped volcanoes of similar age were probably always submarine, and we can expect volcaniclastic sediments from both subaerial and submarine eruptions from the IBM-3 drilling.

2.1 The relationships between mantle-derived magmas and crustal structure

Kodaira *et al.* (2008) showed that there is no relationship between the Miocene rear-arc seamount chains and the crustal structure (Fig. 2.2). Instead, the seamount chains directly reflect the 3D character of convection within the mantle wedge (hot fingers) (Tamura *et al.,* 2002). Consequently, volcanic rocks will provide detailed information about the evolution of the mantle wedge after the cessation of back-arc spreading and during the re-establishment of the arc volcanic front. This mantle history is a critical aspect of how the mantle wedge melts and, therefore, how arc crust is formed.

Moreover, Fig. 2.2 shows that the crustal thickness is different at the three rear-arc volcanoes studied in this cruise: at Kanbun 16 km, at Jokyo 13 km, and at Hoei 25 km. Most of the thick crust in the rear-arc could have been produced during the Eo-Oligocene (Kodaira *et al.,* 2008). Anatexis and assimilation may even occur in oceanic arcs and backarcs (Tamura *et al*. 2009, in press). If so, then, the way in which the Eo-Oligocene crust has been affected may be different among the three rear-arc volcanoes. We expect that detailed comparative studies between these three volcanoes will reveal the assimilation of Eo-Oligocene crust and the characteristics of the materials underlying these Miocene volcanoes.

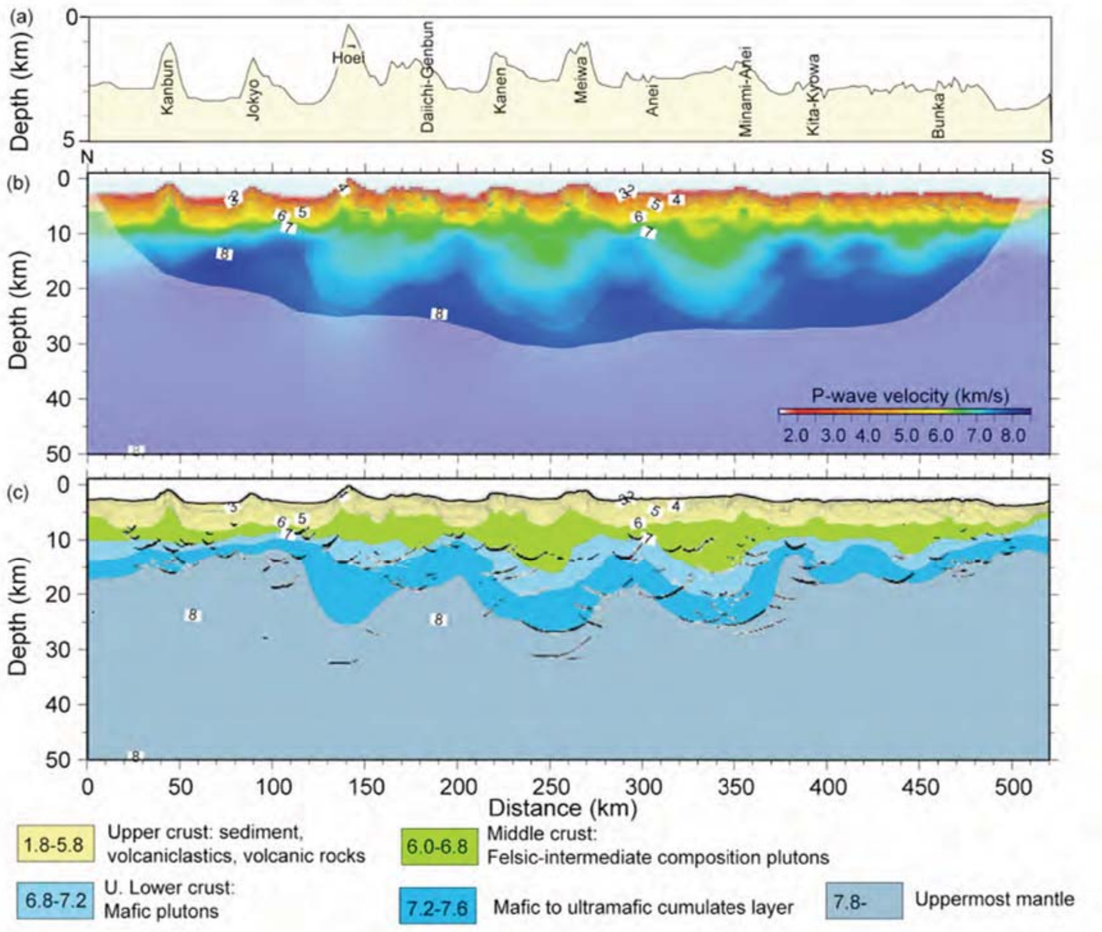


Figure 2. 2: Rear-arc crustal structure. (a) Seafloor topography along the profile. (b) Final seismic velocity image. (c) Geological interpretation of the final seismic velocity with seismic reflectors (Kodaira et al., 2008).

2.2 The Eo-Oligocene basement in the Izu rear-arc

The basement of Quaternary volcanoes in Northeast Japan consists of a wide variety of Tertiary and pre-Tertiary rocks. Interestingly, this basement is topographically higher in areas beneath the volcanoes than it is in surrounding areas, suggesting uplift of basement beneath volcanoes (Fig. 2.3). Moreover, (1) taller volcanoes rest on higher basement, and (2) most of the basement peaks have elevations more than half the height of the volcanoes (Tamura *et al*., 2002). Thus, although volcanoes produce topographic highs, most of this height consists of rocks that are much older than, and are not directly related to, the erupted magmas. Applying this observation to the Izu rear-arc, we hypothesize that lavas and volcaniclastics dredged from Manji (6.5 Ma) and Kanbun (8.8 Ma) volcanoes constitute just the upper portion of topographic highs that are built on older basement. If so, then the basement of these Miocene rear-arc volcanoes is Oligocene or even Eocene.

We will try to collect basement rocks of the rear-arc volcanoes, which have never been dredged before. We will determine whether rear-arc magmatism changed with time, whether Oligocene rear-arc and frontal arc magmas differed in the Oligocene and whether there were across arc variations even at the initial stage of arc development.

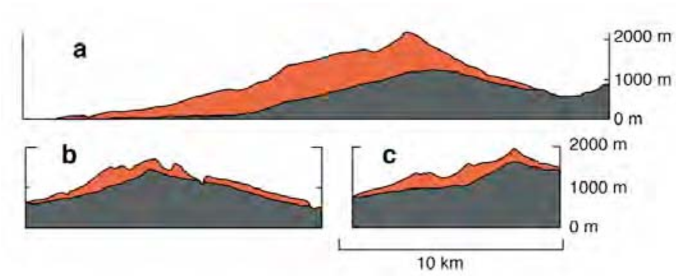


Fig. 2.3. Simplified geologic profile of three Quaternary volcanoes in Northeast Japan. Red and Gray show Quaternary volcanic rocks (lavas and pyroclastic rocks) and basement rocks (Tertiary volcanics and sedimentary rocks and/or Cretaceous granites), respectively. (a) Chokai volcano (Hayashi, 1984) (b) Zao volcano (Sakayari, 1992), and (c) Gassan volcano (Nakazato et al., 1996). Quaternary volcanoes are generally underlain by topographically elevated basement rocks.

3. CRUISE NARRATIVE AND SCHEDULE OF OPERATIONS

R/V Natsushima departed JAMSTEC, Yokosuka at 1000 on April 2nd, 2009. The ship arrived at Kanbun Seamount during the afternoon of April 3rd and some Seabat surveying was completed. Dive operations for HPD#960 were commenced at 8:30 on April 4th. Dive 960 was completed at about 1800. The sea state worsened that evening and some Seabat surveying was completed but dive operations were canceled on Sunday 5th.

Conditions improved on April 6th and Hyper-Dolphin was launched at about 0900. Dive HPD#961 was on the NE slope of Jokyo seamount and left the bottom at 1700. We then moved back to Kanbun to conduct further Seabat surveying of the seamount. This yielded satisfactory results on lines running across the NW part of Kanbun volcano, clearly showing many small knolls aligned in NW-SE direction.

Sea conditions remained suitable for dive operations on April 7th and Hyper-Dolphin was launched about 0830. Dive HPD#962 was on the small knolls on the NW of Kanbun volcano surveyed by Seabat. After completion of the dive we moved to Hoei Seamount and surveyed its eastern half using Seabat.

HPD#963 commenced at 0830 on April 8th. The dive was on a southern slope of Hoei seamount. HPD#963 left bottom at ~1400, after which Seabat surveying continued on lines covering the western half of the Hoei seamount.

The final dive of the cruise, HPD#964, took place on the NW cliff of Hoei Seamount, reaching 2800 m, substantially deeper than the 888 m reached during HPD#963. Dive operations commenced at 0830, the Hyper Dolphin left the bottom at 1650 and was secured on deck at 1800. During the evening we returned to Jokyo to conduct several Seabat survey lines before departing the area and heading to Hachijo-jima at midnight. We arrived at Hachijo-jima at 1400 and disembarked.

4. OPERATIONS AND DATA PROCESSING INFORMATION

The only underway data collection was by the hull-mounted multibeam system Seabat. Data from the Seabat surveys will be merged with existing Seabeam and Seabat data at JAMSTEC.

The Hyper Dolphin usually dived with payloads that included the five rock sampling baskets, one columnar basket, two push or M-type cores, and one lidded box in the sample basket, as well as a temperature probe and water samplers mounted on the body of Hyper-Dolphin.

Data and samples from the dives were archived as customary. Half of all samples will be archived at JAMSTEC. Brief sample descriptions are included in Appendix A. Samples distributed to the scientific party are listed in Appendix B. Standard data products were provided to the shipboard scientific party.

5. Scientific Results

5.1 Bathymetric surveys

R/V Natsushima completed additional Seabat (Figs. 5.1.1, 5.1.2 and 5.1.3) surveys in Kanbun, Jokyo and Hoei volcanoes around the dive sites. These data will be merged with existing multibeam data to produce final maps of each study area.

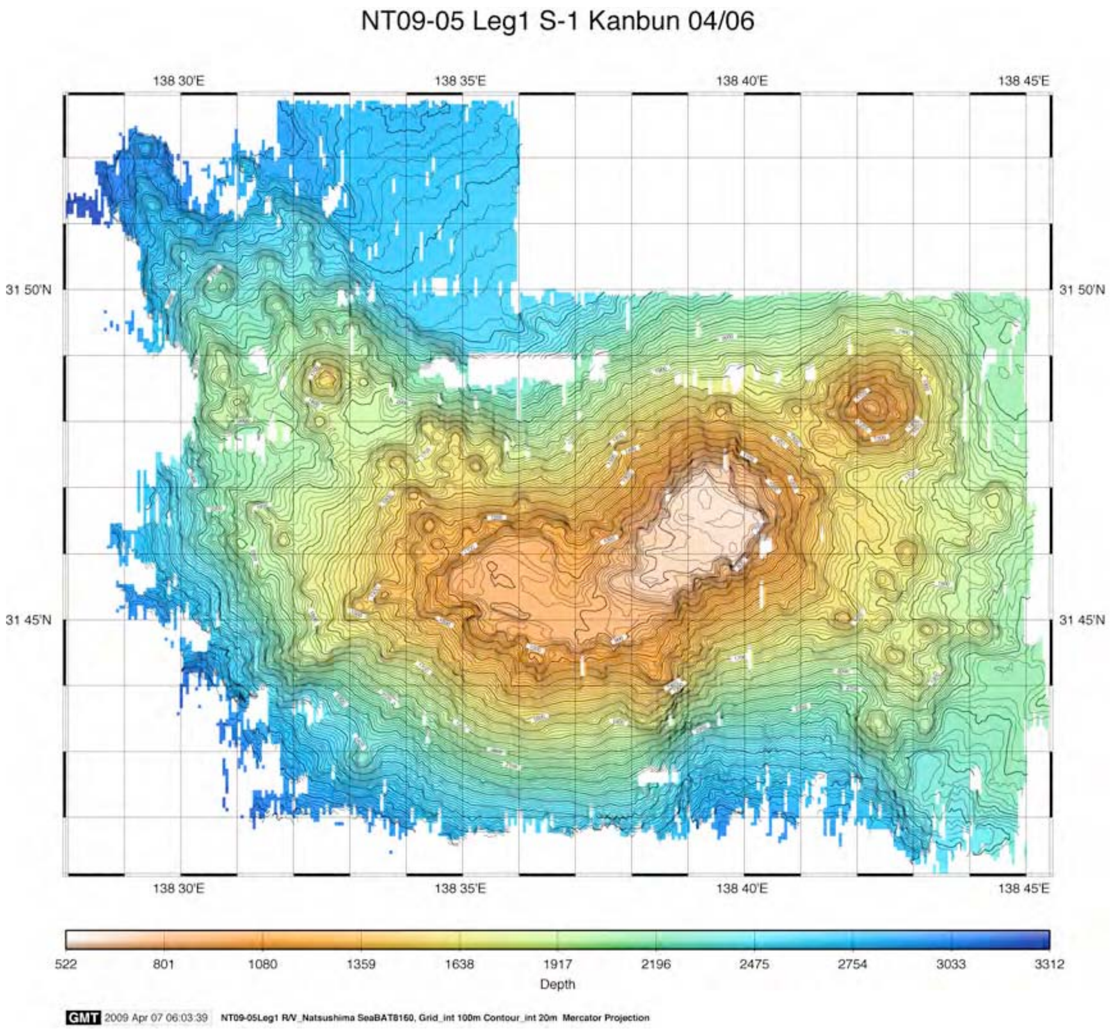


Fig. 5.1.1 Seabat surveys in the vicinity of Kanbun volcano.

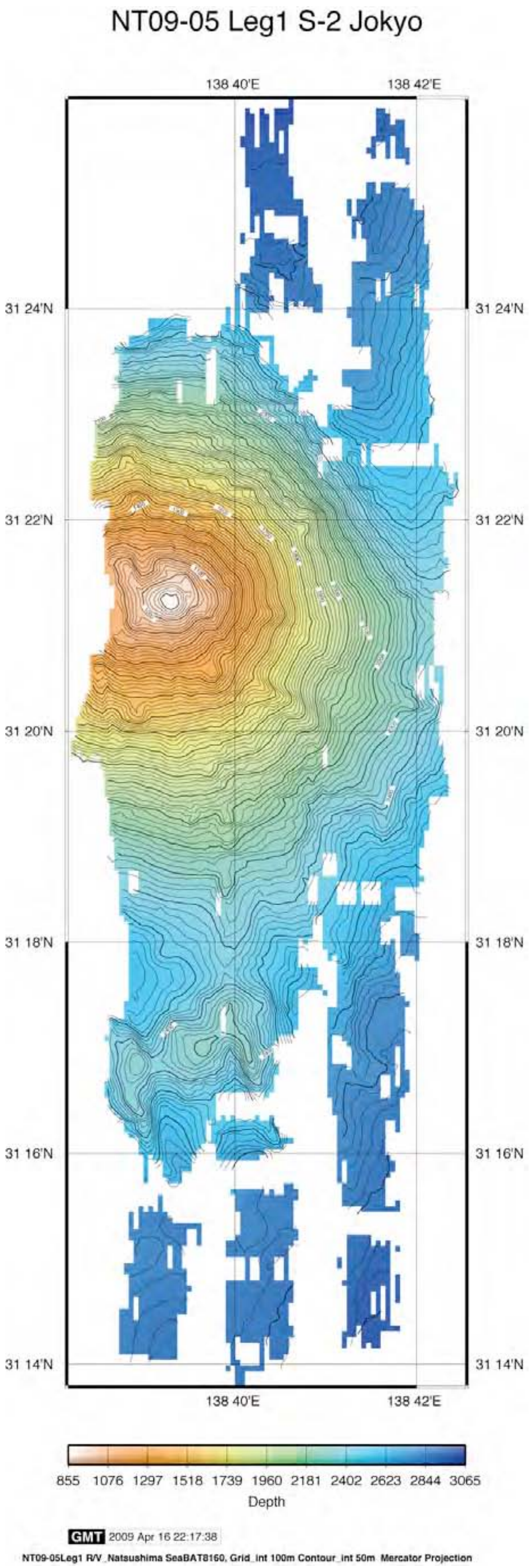


Fig. 5.1.2 Seabat surveys in the vicinity of Jokyo volcano

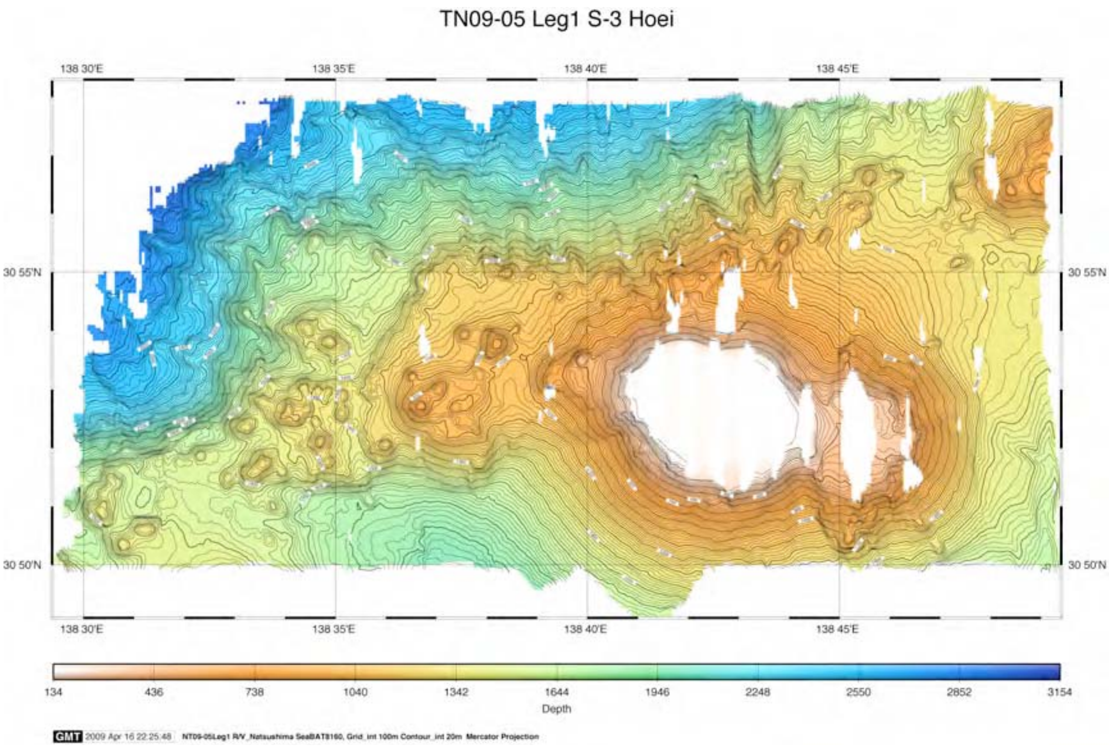


Fig. 5.1.3 Seabat surveys in the vicinity of Hoei volcano

5.2 Hyper-dolphin Studies and Sample Descriptions

Summaries of the results of each dive with representative pictures, start and finish locations, track maps, and dive logs are included in the sections below.

All samples were cut and described aboard ship. A comprehensive list of samples with brief descriptions is included in Appendix A.

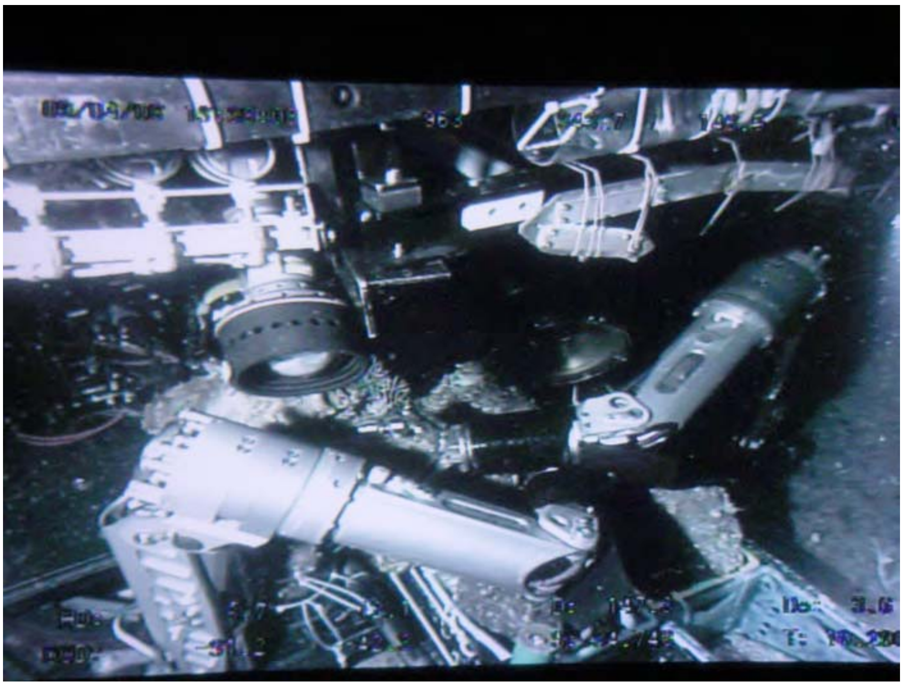


Fig. 5.2.0-1 Hyper-Dolphin securing samples with its arms in preparation to leave the bottom of Hoei

seamount.

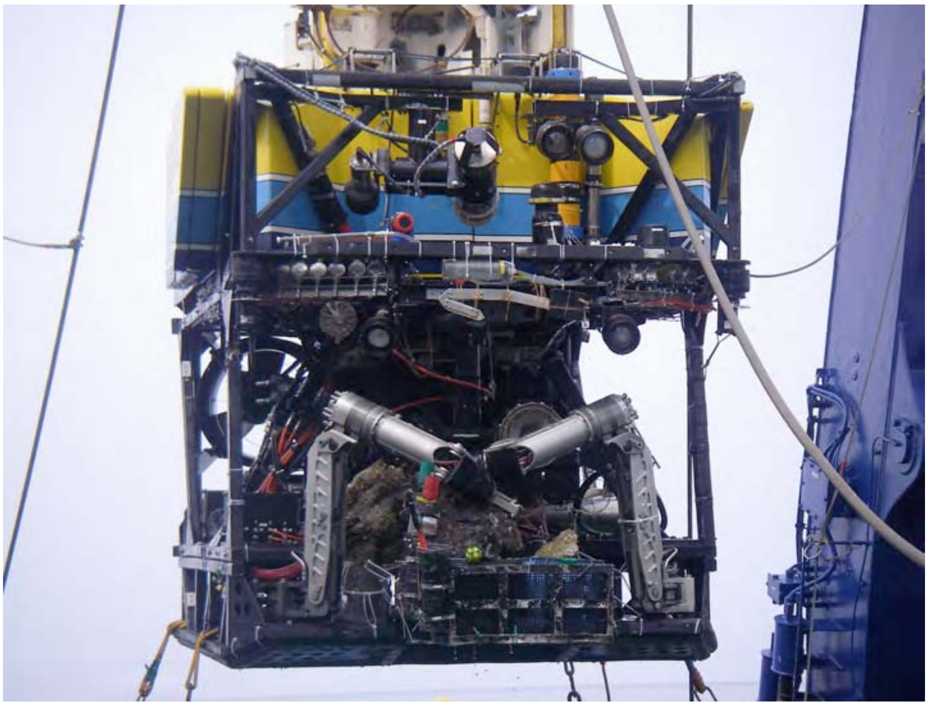


Fig. 5.2.0-2 Return of Hyper-Dolphin with samples from submarine volcano.

5.2.1 Dive 960 (Kanbun)

<u>Technical information:</u>

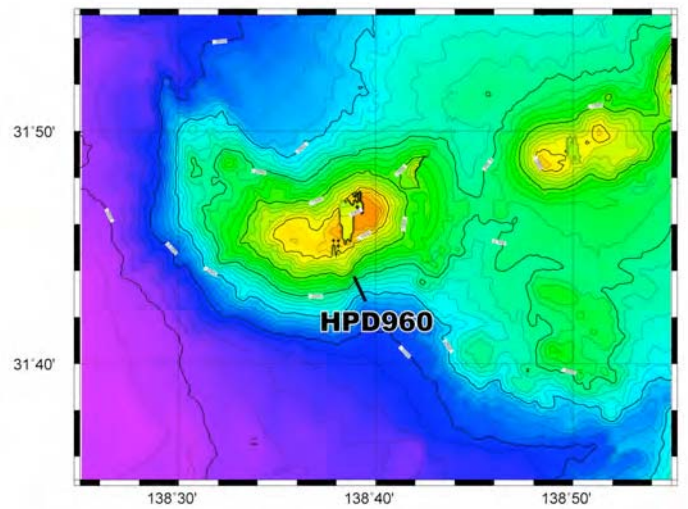
Location: Kanbun Seamount, southern slope

Objective: Survey and sample basement of Kanbun Seamount

DIVE 960	On bottom:		Off bottom:	
Time (local)	10:12		17:09	
Latitude:	31°	42.584'N	31°	43.544'N
Longitude:	138°	39.202'E	138°	38.659'E
Depth (m):	2700		1835	

Samples returned: 14 rocks, 1 core sample

(A)



(B)

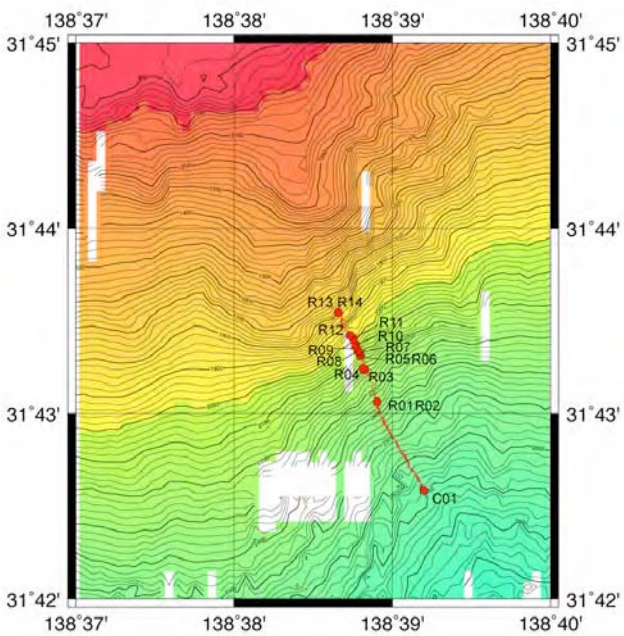


Figure 5.2.1-1 (A), (B): Bathymetry and station locations for HPD#960

Scientific summary:

Background and Purpose

Kanbun Seamount is located at the western end of the Manji Seamount chain. It has an elongated shape in an E-W direction, and is also accompanied by NW-SE ridges on its NW corner. It has a flat summit area. This seamount was first sampled by MW9507 cruise. Dredge 115 recovered ol-bearing cpx basalt, hbl dacite and thick Mn crust from the northeastern flank. These lavas erupted at 8.77 Ma based on $^{40}Ar/^{39}Ar$ dating. The aim of this dive is to recover older igneous rocks from this seamount as well as the basement of the back-arc seamount chains.

Dive HPD#960

Dive 960 reached the bottom at a depth of 2700 meters on the southern flank of Kanbun Seamount. The immediate landing location was a shallow dipping slope covered with white sediment, which was bioturbated in places. Most of the early part of the dive traversed this white clayey sediment, with only occasional strongly altered rocky outcrops of tuff and tuffaceous sandstone (R01 and R02). At a depth of 2230 m outcrops became more prevalent, but largely remained tuffaceous. At around 2000 m what appeared to be lava flows and dykes were observed (R09), but sampling was difficult because of Mn-cementation, and, when they did break off, the fragile nature of the rocks owing to alteration led them to break up in the manipulators.

Fourteen rock samples were successfully recovered. The first seven samples were tuffaceous, sample R08 a pumice, R09 a pyroxene, plagioclase-bearing andesite, while the rest were largely Mn-crusts.

A number of organisms were encountered on the dive, including a "fancy pink creature", a fish that stood on the bottom using extended fins, various other types of fish and eel, sea cucumber, red crinoids and other strange pelagic organisms.

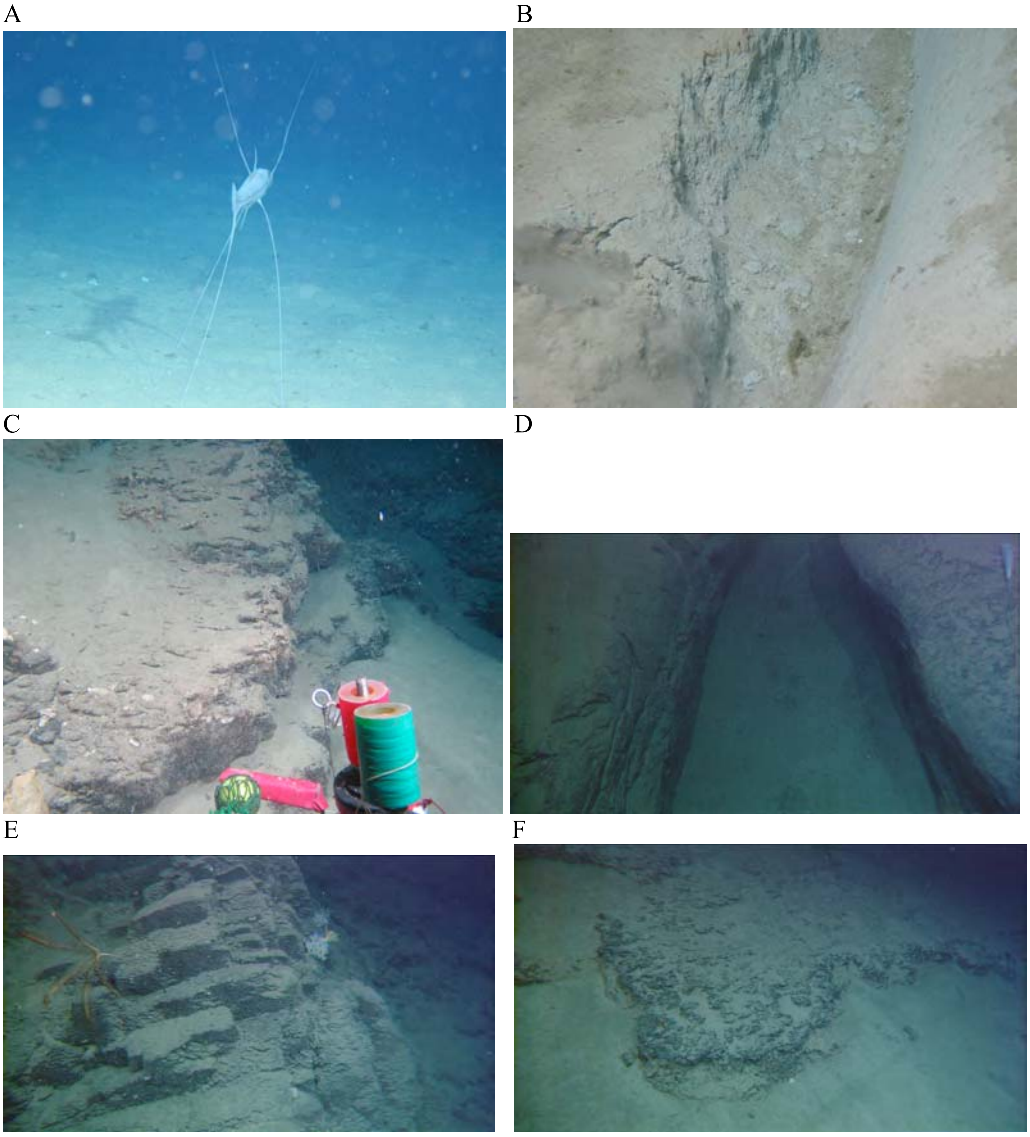


Figure 5.2.1-2: Representative images from dive HPD#960.

A	Strange fish standing on its extended fins (SEAMAX photo: 2009_0404_105716AA.JPG).
B	Crack formed in unconsolidated sediment (SEAMAX photo: 2009_0404_115020AA.JPG)
C	Outcrop of tuffaceous sandstone with abundant burrows (SEAMAX photo: 2009_0404_125618AA.JPG).
D	Mn-oxidized-encrusted gulley (HDTV: hdc20090404132405_1.jpg)
E	Columnar jointing in dyke-like feature (HDTV: hdc20090404161139_1.jpg)
F	Pancake-rock, lava flow? (HDTV: hdc20090404163403_1.jpg)

Table 5.2.1-1: Dive Log NT09-05 HPD#960

Dive #:	**NT09-05 HPD#960**
Date:	April 4, 2009 (local)
Location:	Kanbun Seamount, southern slope
Objectives:	Survey and sample pre-Miocene basement and Kanbun Seamount volcanics

Logger: O. Ishizuka, A. Nichols
samples are noted HPD#xxx-XYY
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)	Vehicle Heading	Notes	Sample #	On deck description
08:15			In water		
10:12	2700	337.3	On bottom. White sediment covered.		
10:18	2702	335.6	MBARI sampling (red). White sticky and soft sediment.	C01 (red)	Mud
10:24	2686	339.3	Moving over white-sediment covered gentle slope.		
10:31	2666	339.5	Still moving over white-sediment covered gentle slope.		
10:36	2657	345.3	Long fish		
10:42	2642	345.5	Still moving over white-sediment covered gentle slope.		
10:44	2641	345.5	Fancy pink-colored creature		
10:50	2622	340.2	Some trace of an animal? (burrow?) rather linear .		
10:55	2607	339.3	Strange fish standing on its fin?? or something.		
11:05	2591	347.4	Fish or eel		
11:14	2542	340.2	Indurated surfce		
11:24	2495	345.8	Jelly fish		
11:29	2473	345.4	Shrimp		
11:35	2449	345.6	Fish		
11:49	2393	345.2	Crack? on the sediment cover surface		
11:56	2376	329.1	Outcrop? Mn-crust terrace? yellowish sediment inside. Try sampling.		
12:08	2376	270.5	Fragile yellowish sedimentary rock covered with Mn collected.	R01 (Box 3)	Tuff
12:18	2376	270.7	Fragile yellowish sedimentary rock covered with Mn collected.	R02 (Box 3)	Tuffaceous sandstone
12:19	2376	270.7	Chain was thrown away.		
12:29	2327	339.9	Weird spiral benthic organism.		
12:41	2268	335.2	Crab scuttling across bottom.		
12:43	2262	334.5	Big nosed fish swimming slowly. Shrimp flitters through light.		
12:48	2231	329.2	Outcrop looms into view.		

12:51	2232	328.9	Pick slab from outcrop, fresh surface reveal pale coloured material.	R03 (Box 2)	Tuffaceous sandstone
12:55	2233	329.3	Sea dollar moving on CCD camera.		
12:58	2233	329.2	Red organism moves across view.		
13:04	2219	328.4	Moved up outcrop. Take another sample, black weathered surface. Cause a lot of disturbance. Crumbly altered rock, orange interior, let go.		
13:09	2217	291.2	Strange invertebrate floats across CCD camera.		
			Keep picking crumbly samples, break up in manipulators.		
13:18	2219	287.5	Small orange-coloured block sampled. Crumbly.	R04 (Box 1)	Tuffaceous silt
13:20	2219	287.8	Look up clayey, crumbling outcrop.		
13:24	2214	319.7	Following ravine, dark curved linear rocks on either side. Lava flows?		
13:31	2157	339.6	Linear dark rock, exposed above clay sediment.		
13:34	2157	324.1	Try to sample ridge…		
13:40	2157	331.1	Take a piece, breaks up in manipulators, fall into box 3		
13:44	2141	329.0	Try to sample a 'free' piece lying in clay. Turns out to be large. Sampling aborted.		
13:52	2141	331.1	Small black sample placed in cylinder.	R05 (cylinder)	Tuffaceous silt
13:55	2141	331.2	Small sample with black exterior, some orange surfaces, placed in cylindrical bucket.	R06 (cylinder)	Tuffaceous silt
14:00	2119	331.2	Plankton floats by.		
14:06	2107	330.6	Break off Mn-coated block from dark exposure. Sample breaks up, thrown away.		
			Sample again, breaks up in manipulators.		
14:15	2107	330.0	Successfully pick up sample. Black and orange surfaces (Mn).	R07 (Box 5)	Tuffaceous silt
14:18	2101	330.0	Some step-like outcrop.		
14:19	2096	331.6	Encountered large outcrop with rugged surface (botryoidal texture of Mn crust).		
14:21	2080	330.9	Steep outcrop continued.		
14:36	2075	330.0	Tried to break off a piece. Stuck fast - Mn.		
14:37	2075	328.2	Attempt to take loose piece from clayey area. Breaks up. Sample a piece.	R08 (Box 4)	Pumice

14:52	2033	318.1	Sample small black rock, Mn-coated.	R09 (Box 1)	Vesiculated hb-bearing(?) plag-px phyric andesite
14:56	2022	343.6	Reach vertical cliff.		
14:58	2018	317.7	Orange lantern-like creature floats past CCD camera.		
15:02	2018	323.3	Multi-limbed organism.		
15:11	2016	310.5	Take browny-black sample. Looks low density. Breaking up, placed in basket 1.	R10 (Box 1)	Mn-block
15:17	1999	335.4	More outcrop now, rubbly sea floor.		
			Several efforts at sampling, but many rocks stuck and fast and coated in black Mn.		
15:49	1991	323.6	Jointed outcrop.		
16:02	1975	302.7	After several attempts, break off a piece, crumbles further in manipulators. Small fragment survives.	R11 (Box 3)	Mn-block
16:06	1975	302.0	Break off another piece. Goes into basket 3.	R11 (Box 3)	Mn-block
16:11	1969	303.1	Jointed outcrops, dyke and lavas.		
16:14	1950	303.8	Red crinoids.		
16:20	1942	339.9	Broken off jointed piece, 15 cm long.	R12 (Box 4)	Mn coated altered andesite (lava?)
16:35	1879	320.3	Pancake-rock feature. Attempt to sample. Move on.		
16:46	1841	328.6	Cliff-face reached. Try to sample…		
16:58	1835	334.5	Finally sample in clayey area.	R13 (Box 5)	Tuffaceous silt
17:05	1835	334.7	Sample another small piece.	R14 (Black box with lid)	Mn-block
17:09			Secure samples and leave the floor.		
17:55			at surface		

5.2.2 Dive 961(Jokyo)

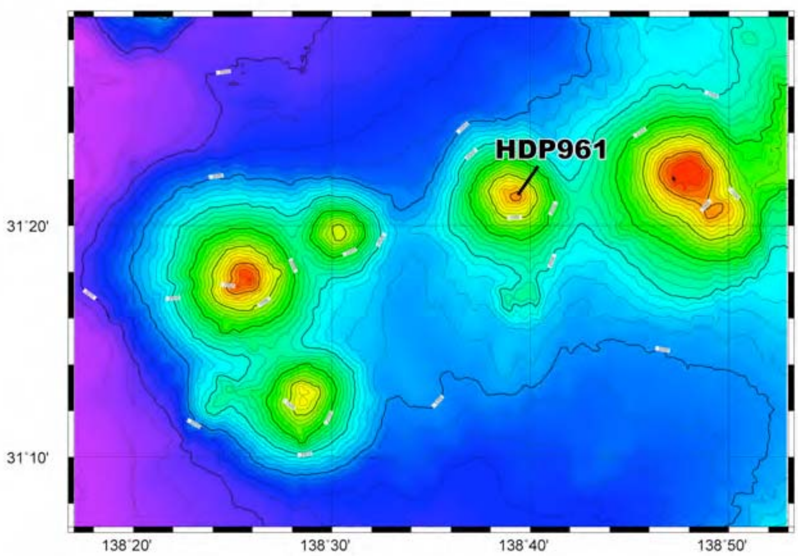
Technical information:

Location: Jokyo Seamount, northeast slope
Objective: survey and sample Jokyo Seamount volcanics and basement

DIVE 961	On bottom:		Off bottom:	
Time (local)	9:31		17:03	
Latitude:	31^{o}	22.485'N	31^{o}	21.484'N
Longitude:	138^{o}	40.321'E	138^{o}	39.460'E
Depth (m):	2006		991	

Samples returned: 18 rocks

(A)



(B)

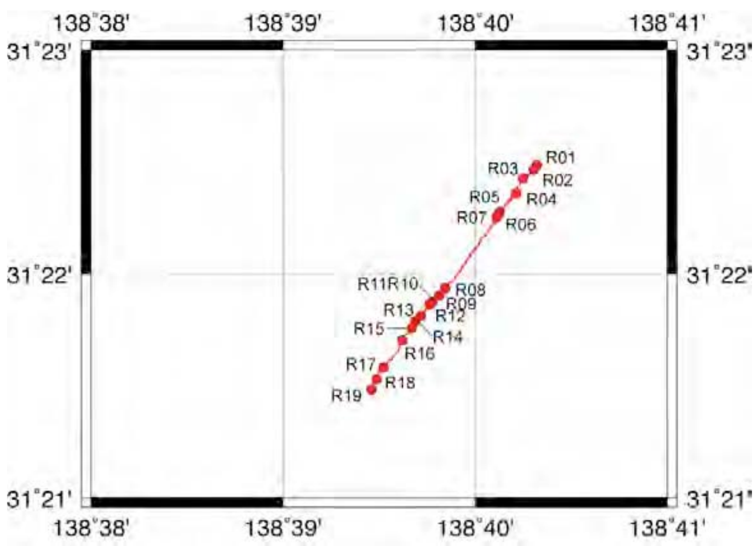


Figure 5.2.2-1 (A) (B): Bathymetry and station locations for HPD#961

Scientific summary:

Background and Purpose

Jokyo Seamount is located in the Enpo Seamount chain. The underlying crust is only 13 km in thickness, which is about a half of the crustal thickness below Hoei volcano, 50 km south of Jokyo. It has a conical shape, and is accompanied by a small knoll in the south. The aim of this dive is to recover Miocene igneous rocks from this seamount, which will be compared with Miocene rocks from Kanbun and Hoei, as well as its Oligocene basement.

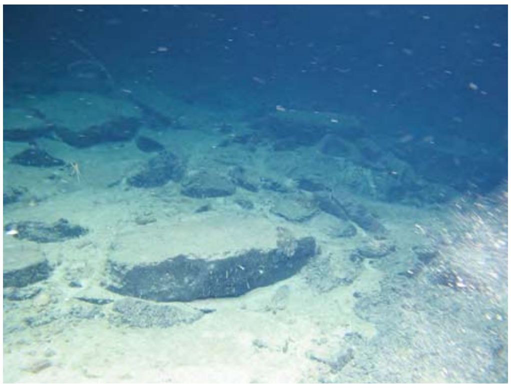
Dive HPD#961

Dive 961 reached the bottom at a depth of 2006 meters on the northeast flank of Jokyo Seamount. The immediate landing location was a muddy slope with many boulder-size angular rocks, which were found to be lapilli stone. In most of the early part of this dive, reworked lapilli stones and volcanic sands were collected. These rock types continued into the upper part of this dive (about 1100 mbsl). All the collected samples were covered with a thick Mn crust (> 5mm). Outcrops and talus deposits are also covered with thick manganese oxides. Therefore, it was hard to identify original rock facies and collect rock samples using the manipulators of the Hyper-Dolphin. Andesite lavas were sampled at depths of ~1500 m and from ~1000 to ~1100 m in the upper part of the slope traversed in this dive. Outcrops of jointed dike were found at 1037 m. The andesite lavas collected in this dive (R17 to R19) are altered and have pyroxene and plagioclase as phenocrysts.

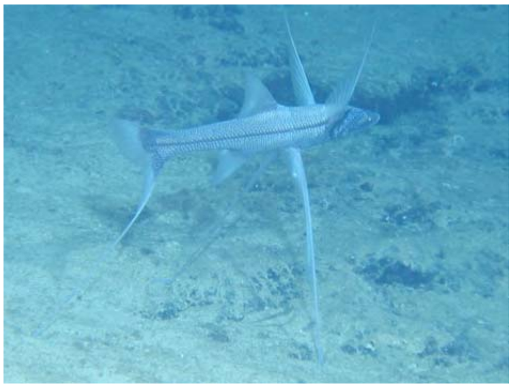
Figure 5.2.2-2: Representative images from dive HPD#961.

A: Many angular rocks (lappili tuff and tuffaceous sandstone) scattered on slope (SEAMAX photo: 2009_0406_093207AA.JPG).
B: Strange fish (Bathypterois grallator), again, standing on its extended fins (SEAMAX photo: 2009_0406_105331AA.JPG).
C: Outcrop of jointed andesite lava or dike (HDTV capture: hdc20090406163612_1.jpg).
D: Andesite blocks covered with Mn (SEAMAX photo: 2009_0406_162702AA.JPG).

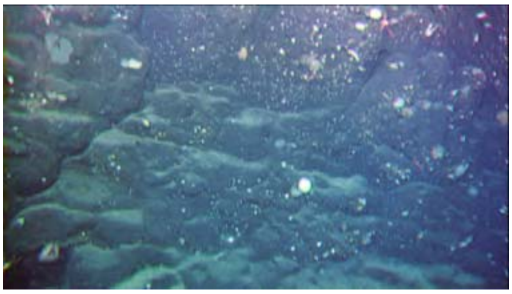
A



B



C



D

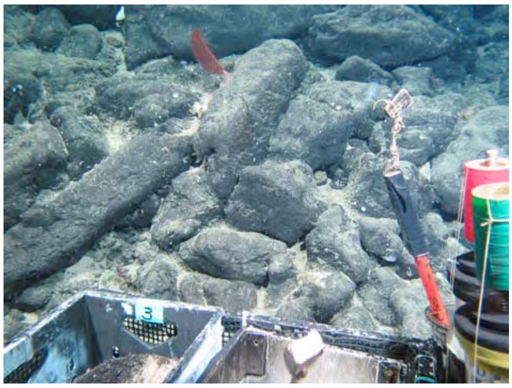


Table 5.2.2-1: Dive Log NT09-05 HPD#961

Dive #:	**NT09-05 HPD#961**
Date:	April 6, 2009 (local)
Location:	Jokyo Seamount, NE slope
Objectives:	survey and sample Jokyo Seamount volcanics and basement

Logger: H. Shukuno, T. Takahashi
samples are noted HPD#xxx-XYY
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)	Vehicle Heading	Notes	Sample #	On deck description
8:19			In water		
9:31	2006	214	On bottom. Bottom covered with fine sediments. Many boulder-size angular rocks scattered on muddy slope. Sampling rock. The collected rock broke during sampling, look like sediments.	R01 (Box1)	Sandy siltstone/ Lapilli stone
9:44	2003	220	Moving up slope. Sometimes see tabular rocks.		
9:49	1991	222	Many angular rocks observed on muddy slope. Sampling rocks.	R02 (ExtraBox)	Lapilli stone- volcanic sand
9:56	1986	221	Many tabular large rocks on muddy slope.		
9:59	1976	229	First sea slug		
10:01	1971	229	Muddy slope. The number of boulder-size rocks relatively decreases.		
10:07	1953	229	Angular rocks sometimes scattered on muddy slope.		
10:09	1948	229	Large rocks with rough surface covered with fine sediments. Try to sample a rock.	R03 (Box2)	Altered lapilli stone
10:17	1940	226	Many tabular and angular rocks scattered on muddy slope.		
10:22	1922	226	Many tabular rocks on slope. Muddy slope sometimes stepwise uneven.		
10:31	1892	226	Angular boulders with rough surface on muddy slope. On bottom and collect samples.	R0 4(Box3)	Altered lapilli stone
10:40	1884	225	Tabular rocks on muddy slope.		
10:41	1878	225	Outcrop starts? But thinly covered with fine sediments. Tabular rocks appear.		
10:49	1856	225	Strange fish.		
10:50	1856	224	Stepwise uneven slope. Outcrop of sedimentary rocks or Mn crust. The surface is rough and covered with fine sediments.		

10:59	1839	226	Mounds composed of rough surface rocks partly on slope. Scratch the surface.		
11:08	1825	226	Tabular rocks on muddy slope.		
11:12	1811	225	Fractured outcrop with layering. The dip is similar to that of slope.		
11:15	1805	221	Collect rock sample.	R05 (Box3)	Pumice (rhyolite)
11:21	1802	221	Many angular and tabular rocks piled on slope.		
11:22	1796	220	Fractured outcrop with layering. The dip is similar to that of slope.		
11:24	1793	215	Many angular rocks scattered on slope. Sampling a rock.	R06 (Box3)	Tuffaceous sandstone (graded)
11:28	1791	210	Huge blocks appear on slope. Many angular rocks concentrate on slope. Talus.		
11:30	1785	209	Collect a big rock. Look at bone???	R07 (Box5)	Altered volcanic sand/clay
11:35	1781	215	Muddy slope.		
11:53	1735	220	Rocks appear again. Rough surface rocks on muddy slope. In CCD view, tabular rocks on slope.		
11:56	1724	230	Outcrop with fracture and layer structure. The surface is rough. Try to sample a rock from outcrop but canceled.		
12:06	1712	220	Fine sediments cover slope.		
12:07	1708	219	Again, muddy slope.		
12:09	1700	216	Angular rocks appear on slope.		
12:11	1692	216	Many angular rocks concentrated on slope. Tabular rocks also confirmed.		
12:15	1677	215	Rocks with layering are observed.		
12:20	1662	216	Many angular rocks concentrated on slope.		
12:25	1646	216	Fractured outcrop. Partly layered?		
12:28	1632	216	Try to sample. Yellowish sedimentary rock (?) covered with Mn.		
12:35	1621	221	Many angular rocks on slope.		
12:36	1615	221	Muddy slope		
12:43	1595	221	Still moving over muddy slope.		
12:46	1589	221	Angular rocks scattered on muddy slope.		
12:47	1585	221	Muddy slope again.		
12:53	1569	221	Angular rocks scattered on muddy slope.		
12:54	1564	221	Muddy slope again.		
12:55	1559	221	Angular rocks scattered on muddy slope.		

13:00	1542	215	Muddy slope again.		
13:03	1527	220	Angular rocks concentrated on slope. Try to sample a rock (sedimentary rock?) but canceled.		
13:08	1514	215	Outcrop? Large tabular rock?		
13:09	1510	215	Angular (~sub angular) rocks scattered on slope.		
13:11	1503	215	Large fish.		
13:13	1498	215	Angular (~sub angular) rocks concentrated on slope.	R08 (Box4)	px-pl andesite
13:20	1486	216	Angular rocks scattered (partly concentrated) on muddy slope.		
13:25	1471	215	Angular-sub angular rocks concentrated on slope.		
13:27	1466	216	Try to sample.	R09 (Box1)	Altered lapilli stone
13:32	1461	215	Outcrop of massive rock.		
13:34	1452	216	Angular rocks concentrated on slope.		
13:36	1446	215	Outcrop of massive rock.		
13:38	1438	215	Large blocks concentrated no slope.		
13:39	1434	215	Crumbling outcrop? Large blocks concentrated.		
13:41	1429	215	Outcrop (cliff) of massive and partly weak layering rock covered with Mn. Try to sample…abandon.		
14:05	1428	221	Try sampling again. Sample R10 is sub angular block on outcrop.	R10 (Box4)	Manganese crust
14:15	1427	220	Try sampling from outcrop, again.	R11 (Box4)	Lost
14:16	1420	220	Crumbling outcrop.		
14:22	1413	220	Angular rocks concentrate on steep slope. Sampling	R12 (Box1)	Manganese block
14:26	1391	214	Angular rocks concentrate on steep slope.		
14:29	1367	210	Fractured or crumbled outcrop		
14:31	1357	215	Angular rocks concentrate on steep slope. Red color fish.		
14:33	1343	215	Outcrop of weak layering rock.		
14:38	1338	214	Angular rocks concentrated on steep slope. Sampling.	R13 (Box4)	Altered lapilli tuff (stone)
14:40	1324	209	Angular rocks concentrated on steep slope. Partly crumbling outcrop?		
14:45	1304	210	Angular rocks on slope. Talus. Collect a rock.	R14 (Box1)	Altered lapilli stone
14:49	1300	209	Rough surface. Outcrop sometimes observed.		
14:51	1290	200	Outcrop with brecciated surface.		
14:54	1278	210	Huge rocks on slope. Many rocks piled on slope. Take sample at 14:58.	R15 (Box1)	Altered lapilli stone

15:00	1270	200	Brecciated outcrop.		
15:01	1264	200	Tabular jointed rocks		
15:02	1260	201	Blocky cliff. Weakly layered.		
15:03	1251	211	Layered outcrop. Artificial materials, look like cans.		
15:06	1243	220	Brecciated surface slope thinly covered with fine sediments.		
15:07	1238	230	Layered outcrop cliff. Massive outcrop continue upwards.		
15:11	1215	211	Step composed of breccia with bedding. Collect a rock just in front of the step at 15:20. Step-wise layered outcrop continues upwards.	R16 (Box1)	Scoriaceous lapilli stone
15:27	1188	200	Brecciated surface on slope. Massive outcrop with weak bedding followed.		
15:35	1144	210	Massive surface (outcrop) continues.		
15:36	1138	213	Brecciated slope appears. Try sampling. Hard to collect. Canceled.		
15:58	1117	223	Rough surface slope continues upwards. Subrounded to subangular rubble observed on surface. Try sampling. Hard to collect due to cementation. Cancel sampling and move up.		
16:09	1108	220	Relatively smooth slope sometimes appears.		
16:11	1101	236	Brecciated slope. Partly to well-sorted subrounded clasts observed. Try sampling a clast.	R17 (Box with lid)	Altered andesite (lava)
16:20	1088	226	Brecciated slope. Large subrouded rock sometimes observed. Size of clasts on slope decreases upwards.		
16:26	1045	221	Many boulder-size subangular-subrounded rocks on slope. A part of them is columnar shaped. Collect rock with columnar shape at 16:34.	R18 (Box with lid)	Altered andesite
16:36	1037	220	Steep cliff. Jointed lava dike outcrop.		
16:39	1022	276	On slope. Try sampling from outcrop. Very hard. Canceled. Moving up.		
16:48	1015	200	Brecciated slope appears again.		
16:49	1010	200	Weakly layered brecciated slope.		
16:52	999	201	Outcrop of breccia.		
16:55	991	196	Sampling from breccias.	R19 (Box5)	px-pl andesite
17:02	991	201	End of observation. Leave the slope.		

5.2.3 Dive 962 (Kanbun)

Technical information:

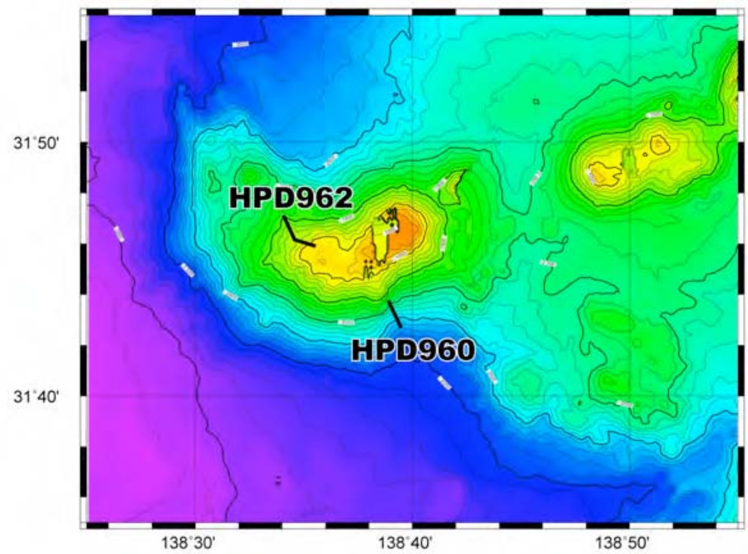
Location: NW slope of Kanbun Seamount

Objective: Survey and sample Kanbun Seamount and the three knolls on its NW slope

DIVE 962	On bottom:		Off bottom:	
Time (local)	9:14		16:49	
Latitude:	31°	47.150'N	31°	45.850'N
Longitude:	138°	34.000'E	138°	35.500'E
Depth (m):	1603		891	

Samples returned: 19 rocks

(A)



(B)

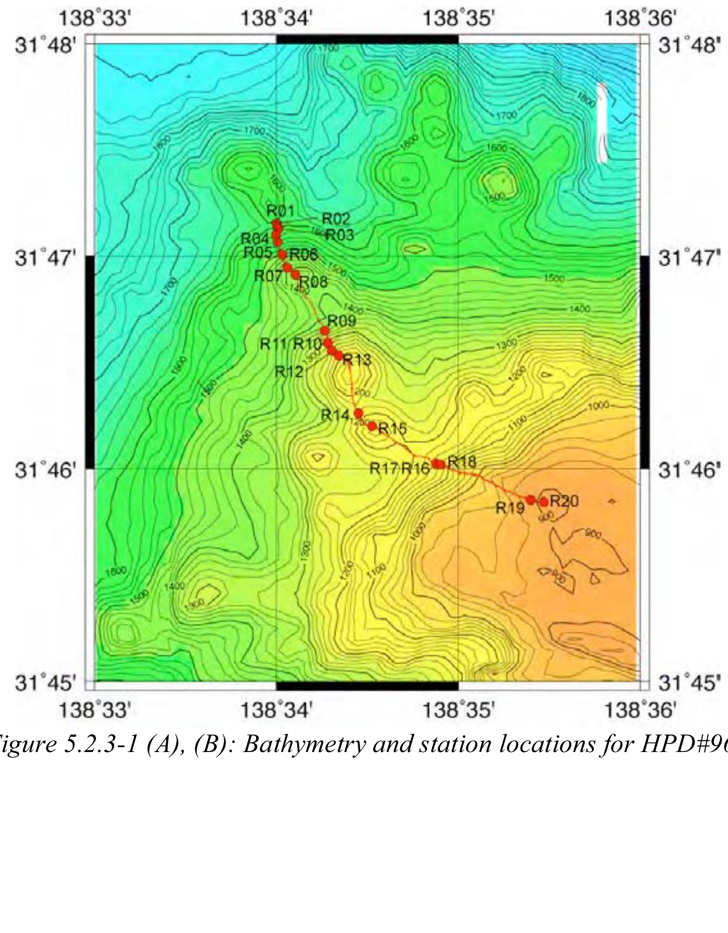


Figure 5.2.3-1 (A), (B): Bathymetry and station locations for HPD#962

Scientific summary:

Background and Purpose

Dive 962 returned to Kanbun seamount, whose southern flanks were dived on in HPD#960. Dive 960 returned only one andesite lava sample along with many Mn covered tuffaceous siltstones. The Seabat surveys conducted over Kanbun seamount during this cruise have determined the bathymetry of the northern slopes in more detail, including the four knolls on the north-western flank. The aim of this dive is to recover additional igneous rocks from Kanbun seamount by traversing the north-western side of three of the four knolls, before finally climbing up to the summit of Kanbun. This will reveal the lithology of the knolls, and in addition it is hoped that basement of the rear-arc seamount chains will be recovered.

Dive HPD#962

Dive 962 landed on the bottom at a depth of 1604 mbsl on the northwestern ridge of Kanbun Seamount, which is defined by four evenly spaced small knolls. The dive was designed to cover the three shallower knolls and an adjacent steep slope up Kanbun Seamount to the flat summit.

The landing location was covered by a debris deposit formed by indurated slabs. Soon the lithology became dominated by rounded to subrounded gravelly debris deposits. The boulder-sized clasts were collected and mainly consisted of basaltic lava. Thus Knoll 1 consists of volcanic breccia or talus deposits.

The flank of Knoll 2 is covered by rounded cobble to boulder gravel, perhaps consisting of talus deposit. The higher slope consists of angular volcanic breccia, of those collected most included clasts of basaltic lava.

The traverse of the slope on Knoll 3 also began with subrounded boulders, which appeared to become blocky massive hyaloclastite near the top. Rocks recovered from the Knoll 3 were mostly basaltic lava clasts.

The final climb to the summit of Kanbun Seamount began with indurated lapilli stone slabs, which as we climbed soon were replaced by gigantic blocks consisting of volcanic breccia of rounded to angular clasts. The overall topography appeared to consist of hummocky blocks typical of large-scale debris avalanches. Upslope the volcanic body has a continuous steep escarpment facing south-south-east, which perhaps formed due to partial collapse of the volcanic edifice resulting in the large scale deposits typical of a debris avalanche observed in the lower slopes. Rocks on the escarpment are volcanic breccias similar to that observed in the blocks within the debris avalanche. Finely layered sediment cover (perhaps formed by grain flow) covers the flat top of the Kanbun in the area traversed by the dive. Very well rounded boulder gravels were occasionally scattered on the flat summit and consist of andesite and dacite lava clasts. These boulders are possibly lag deposits from the erosion that formed the flat top surface.

Figure 5.2.3-2: Representative images from dive HPD#962

A: Rounded small boulder gravel deposit. Clasts are composed of basalt lava (e.g., sample R06) (SEAMAX photo: 2009_0407_123031AA.JPG).
B: Boulder breccia clasts at the top of the Knoll 2 (SEAMAX photo: 2009_0407_095959AA.JPG).
C: Rounded basalt clast sample being taken from the surface of Kanbun edifice (SEAMAX photo: 2009_0407_140557AA.JPG)
D: Blocky slab on the flank of the Kanbun volcanic edifice consisting of basalt lava clasts (sample R17) (SEAMAX photo: 2009_0407_140611AA.JPG).
E: Volcanic breccia consisting of one of the gigantic hummocky blocks on the midslope of Kanbun. Thickly coated in Mn. (SEAMAX photo: 2009_0407_143552AA.JPG).
F: Finely layered sediment cover (perhaps grain flow deposit) covering rounded gravel layer. Top of the Kanbun slope. (SEAMAX photo: 2009_0407_154931AA.JPG)

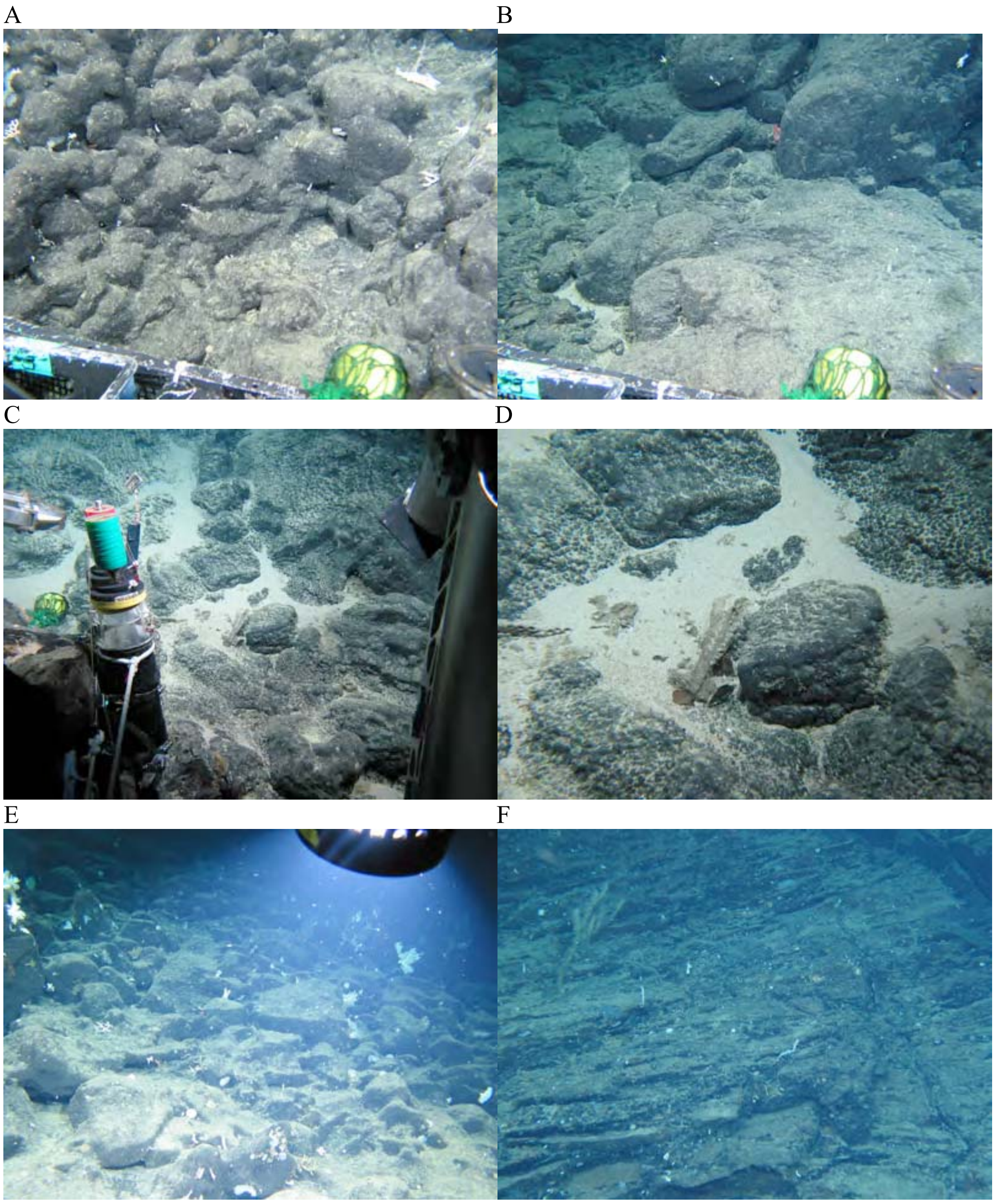


Table 5.2.3-1: Dive Log NT09-05 HPD#962

Dive #:	**NT09-05 HPD#962**
Date:	April 7, 2009
Location:	Kanbun Seamount, NW slope knolls and main volcanic body
Objectives:	Survey and sample pre-Miocene basement and Kanbun Seamount volcanics

Logger: J.-I. Kimura, Q. Chang
samples are noted HPD#xxx-XYY
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)**	**Vehicle Heading**	**Notes**	**Sample #**	**On deck description**
8:13			In water		
9:14	1603	291.6	On bottom. Dark gray gravel. Mn coated.	KNOLL 1	
9:19	1603	293.4	Dark brown slab (Mn crust?) collected.	R01 (Cylinder)	Mn crust, some tuff attached
9:22	1602	150.2	Moving over slabby debris deposit with clay sediment cover.		
9:23	1601	154.6	Moving over bumpy undulated surface (eroded Mn crust?). Rounded gravels covered by Mn crust occur occasionally on the surface.		
9:30	1600	179.1	A small tube worm woke up by HD manipulator and escaped.		
9:31	1600	179.5	Subrounded gravel sample collected.	R02 (Cylinder)	Lapilli stone
9:33	1599	154.5	Moving over cobble to boulder size gravelly debris deposit surface (Mn coated?).		
9:38	1595	163.6	Subrounded gravel on the surface (Mn coated) collected.	R03 (Box 2)	Volcanic breccia
9:39	1593	159.4	Moving over boulder gravel surface Mn coated?		
9:43	1576	155.7	Boulder sized blocky debris deposit.		
9:48	1576	153.2	Subrounded cobble Mn coated collected.	R04 (Box 2)	Volcanic breccia
9:50	1572	155.0	Moving over cobble to boulder gravel surface.		
9:52	1561	149.7	Surface indurated by Mn crust overlying boulder gravel debris deposit. Cracks occasionally visible in the surface crust.		
9:57	1543	151.7	Mn coated rounded cobble collected from gravel in a channel deposit.	R05 (Box 2)	Basalt clast
10:01	1532	150.2	Surface indurated by Mn crust overlying boulder gravel debris deposit. Cracks occasionally visible in the surface crust		

10:04	1511	145.3	Indurated blocky debris deposit? Open cracks developed on the surface.		
10:07	1482	140.2	Passed over a ridge and dropped down into a depression		
10:12	1479	170.1	Rounded small boulder gravel sitting on an indurated surface of boulder gravel deposit (?) collected	R06 (Box 2)	Basalt clast
10:15	1469	151.9	On a ridge, massive block with vertical parallel cracks		
10:17	1448	140.3	Ugly fish (Cod?)		
10:19	1441	139.7	Blocky angular surface talus deposit?		
10:20	1431	134.8	eel		
1:31	1413	121.6	Surface indurated by thick Mn crust. A Mn covered rounded boulder was removed by manipulator and collected	R07 (Box 5)	Brecciated basalt
10:32	1410	118.9	Moving over massive blocky surface with open cracks		
10:37	1376	109.1	Blocks moulded in sandy matrix (outcrop?) apparently volcanic breccia. Massive bumpy outcrop without thick Mn coating.		
10:39	1366	110.0	An angular block sitting on the surface collected. Mn coated. Basement appears to be similar to the one before @ 10:39.	R08 (Box 5)	Olivine basalt
10:43	1364	111.2	Cobble sized angular to sub-angular deposit coated by thin Mn crust (cinder cone deposit?)		
10:45	1350	144.0	See seawater. Topography flattened out. Top of the Knoll 1.		
10:48	1320	137.9	Hovering over the cone top at 50-70 m height		
11:09	1351	150.3	Landed on blocky undulated surface with thin Mn coated	KNOLL 2	
11:12	1353	148.7	Subangular cobble removed from massive debris deposit outcrop collected. Ballast chain thrown away.	R09 (Box 5)	Basalt clast
11:18	1347	150.4	Massive deposit covered by thin Mn coating containing rounded to angular boulder with clast supported sedimentary structure. Talus deposit or volcanic breccia?		
11:30	1282	198.0	Boulder size clast within volcanic breccia outcrop. Sampling attempted but failed due to hard rock.		
11:35	1279	197.5	Surface cover deposit, with boulder rounded gravel matrix supported structure, covering a volcanic breccia.		

11:42	1283	189.6	Angular cobble sitting on volcanic breccia surface collected. Fragile and broken before sampling.	R10 (Box 5)	Lost
11:47	1283	190.8	Subangular cobble, thin Mn coat, sitting on volcanic breccia surface, collected.	R11 (Box 5)	Basalt
11:47	1280	139.7	Clast supported cobble to boulder breccia, talus deposit or volcanic breccia. Linear cracks observed along the HPD track direction		
11:54	1247	143.6	Massive blocky lava (?) outcrop Mn coated. Subangular clast was removed from the outcrop and collected.	R12 (Box1)	Baalt clast
11:58	1242	145.4	Layered gravelly talus deposit surface. Occasionally including big boulder gravel.		
12:01	1230	110.3	Open crack developing on the talus deposit surface running along the HD track.		
12:03	1214	109.8	Move over a ridge consisting of rounded boulder rich talus deposit.		
12:05	1210	122.3	Clast supported rounded gravel (?) coated by thin Mn crust. Easily removed from outcrop and irregular shaped sample with round gravel at the center collected (UFO shape).	R13 (Box 1)	Altered hyaloclastite
12:09	1205	122.9	Subangular blocky aggregate covering on entire surface.		
12:13	1186	120.7	Volcanic breccia outcrop (?). Deep valley on the right side.		
12:15	1178	118.9	Layered sediment surface cover forming a thin ridge topography.		
12:17	1172	129.1	Try to pick up a round dark gravel with white coral?, but failed.		
12:22	1169	130.0	A deep crack		
12:26	1149	159.5	Rubble surface with large open cracks. Apparently scoria sinter.		
12:28	1137	162.0	Red small crabs on sinter surface.		
12:32	1137	159.3	Sampling attempted but not successful. At the top of 2nd knoll.		
12:35	1122	170.1	Hovering over a deep valley.		
12:56	1209	140.9	See ground. Rounded boulder and breccia covered by sandy clay. A fish.	KNOLL 3	
12:58	1215	92.8	Attempt to sample big subrounded boulder sat on the surface. Inside of the clast is light brown with Mn coating. Gave up.		

13:05	1214	107.0	Subangular boulder clast sitting on the surface collected.	R14 (Box 1)	Pervasively altered basalt clast
13:11	1200	139.6	Broken slab of indurated sediment layer.		
13:15	1177	139.8	Hovering over a deep valley (4 m).		
13:19	1152	100.0	Top of the Knoll 3 (No.6 point)		
13:25	1156	85.0	Rugby ball shaped boulder sitting on the surface collected. Broken into half by grip. Interior is white with Mn crust.	R15 (Box4)	Volcaniclastic / brecciated basalt
13:27	1150	50.3	Blocky massive pyroclastics with layered structure (hyaloclastite?).		
13:30	1125	128.0	Depart for site No.7 flying over deep water.		
13:54	1165	120.0	See bottom, rubble surface covered with white clay.	KANBUN EDIFICE	
13:57	1153	119.3	Fragmented slabs consisting of indurated surface to sediment layer.		
14:02	1145	111.5	Smaller piece of fragmented slab covering entire surface. Pavement-like occurrence.		
14:04	1144	108.2	Sampling a slab. Fragile slab was broken into pieces on the sample baskets. Broken pieces were dragged into Box 3. Additional rounded sample was taken from the surface and thrown into Box 3.	R16 (2 pieces) and R17 (Box 3)	Lapilli stone Basalt clast
14:11	1137	119.8	Blocky slabs cover entire surface. A fish.		
14:15	1134	140.5	Picking off a rounded boulder from the floor. Slab has a thick Mn crust.	R18 (Box4)	Basaltic andesite
14:23	1134	140.0	Two fishes.		
14:26	1119	109.5	Number of large to gigantic blocks of talus or volcanic breccia sitting on the surface. Collectively could be a big rock avalanche deposit.		
14:35	1079	141.7	Observe one of the gigantic blocks. Heavily Mn coated. Sampling attempted but not successful.		
14:39	1077	134.4	Sampling attempted but not successful because of thick Mn cover		
14:47	1051	121.0	Big rock avalanche hummocky blocks continue. Each block has jigsaw cracks.		
14:51	1033	99.6	Land on one of the hummocky blocks. Surface is covered by thick Mn coating.		

15:00	1026	110.0	Same material. Ridge topography with a steep cliff on the right hand side. Suggesting an escarpment formed by avalanche forming collapse event. Landed on the surface and sampling attempted. Not successful.		
15:09	1020	110.2	Volcanic breccia (?). Crust supported rocky outcrop. Thick Mn coating.		
15:16	1015	105.4	Ditto.		
15:20	1003	104.6	Ditto.		
15:21	1000	105.0	Ditto.		
15:25	996	106.5	Rounded boulder gravel in talus deposit. Heavily Mn coated. Sampling attemped on a small notch. Not successful.		
15:33	989	89.6	Moving over a rocky surface. Angular to rounded boulders are exposed.		
15:39	965	98.8	Moving along a ridge with steep scarp to the right. Weak stratification is seen on the cliff inclining to the left.		
15:39	965.3	101.0	Zoom in on organisms.		
15:45	941	88.5	Sediment cover on the surface. Cross section exposed on the cliff wall. Inclined to North following the slope.		
15:47	37	99.8	Finely layered sediment cover (perhaps grain flow deposit) covering rounded gravel layer. Top of the Kanbun slope.		
13:53	922	100.2	Moving on soft sediment cover with lots of worms.		
16:01	912	111.1	White organisms.	FLAT TOP	
16:10	898	100.6	Sandy, flat with cracks.		
16:14	897	99.3	A strange big boulder on sandy flat surface. Sampling attempted. Done.	R19 (Box2-5)	Hornblende dacite
16:25	892	101.1	Sandy surface with occasional rounded gravels.		
16:26	892	99.7	Two-handed manipulator operation attempted to collect rounded boulder sample sitting on the surface.		
16:45	893	98.1	Two-hands manipulator operation finished successfully in the end.	R20 (Lid Box)	Andesite
16:49	891	100.7	Secure samples and leave the floor.		
17:16			at surface		
17:32			HPD on deck		

5.2.4 Dive 963 (Hoei)

<u>Technical information:</u>

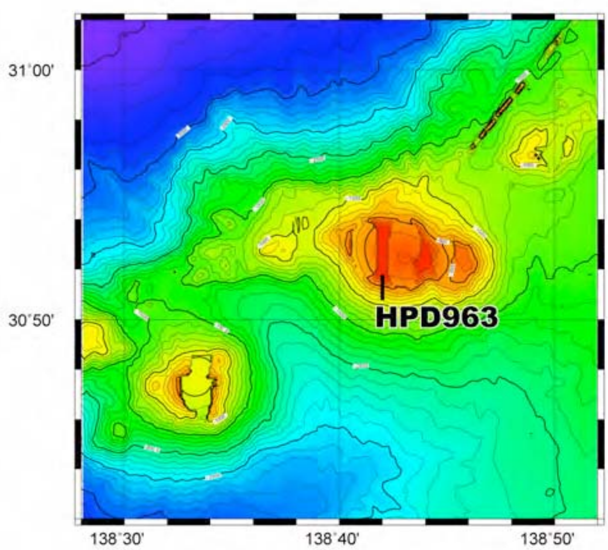
Location: Southern slope of Hoei Seamount

Objective: Survey and sampling on southern slope of Hoei Seamount

DIVE 963	On bottom:	Off bottom:
Time (local)	8:49	13:39
Latitude:	30-50.79'N	30-52.094'N
Longitude:	138-42.007'E	138-42.092'E
Depth (m):	890	146

Samples returned: 9 rocks and 2 push cores

(A)



(B)

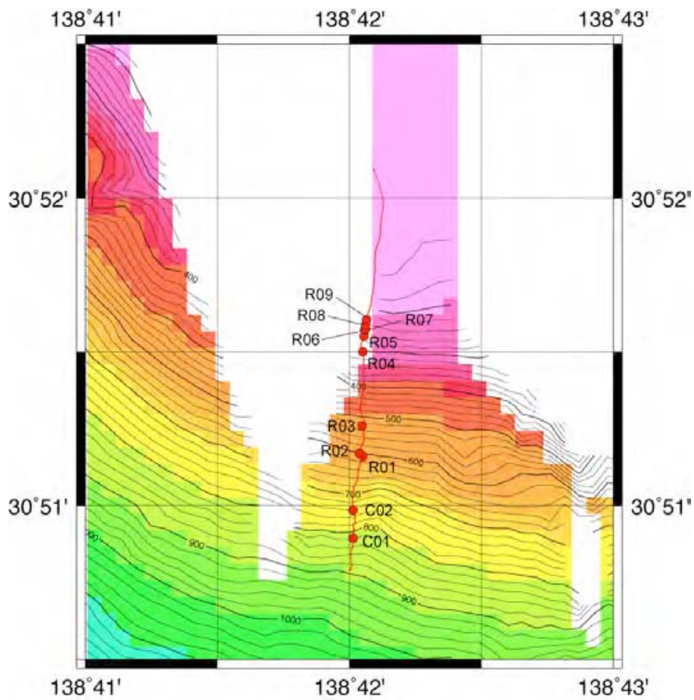


Figure 5.2.4-1 (A), (B): Bathymetry and station locations for HPD#963

Scientific summary:

Background and Purpose

Hoei Seamount is located at the center of the Genroku seamount chain. It has a sub-conical shape and rises to a flat summit area at a water depth of 140 m. Previous sampling (cruise MW9507) did not recover any fresh volcanic rock. The purpose of Dive HPD#963 is to recover igneous rocks from the southern slope of Hoei Seamount. This will reveal the lithology of the seamount, and in addition it is hoped that basement of the rear-arc seamount chains will be recovered.

Dive HPD#963

Dive 963 landed on the bottom at a depth of 886 m on the southern slope of Hoei Seamount. The landing location was covered by white sandy sediments with many fragments of shell and coral. The sediments locally show significant ripple marks. We collected two push core samples (C01, C02). Around a depth of 500-600 m, several large andesite blocks (sometimes showing platy (or columnar) joints) were found on the sediments (R01, R02, R03). At a depth of 300 m, we found a cave, near the entrance to which R04 was collected. At 260 m, we found further several large andesite blocks (R05). At a depth of 200-250 m, the outcrop exhibited clear columnar jointing, samples R06, R07, R08 and R09). On the flat summit, shallower than 190 m, many small pebbles occur on sandy sediments, but we were not able to find any remarkable rock samples.

This dive recovered, for the first time ever, fresh volcanic material from Hoei Seamount on the Genroku rear-arc seamount chain. They show that the upper ~700 m is composed of andesite lavas, which exhibit columnar jointing in places. No basement material was recovered. In tomorrow's dive we plan to go deeper (starting at 2800 m) on the northern slope of Hoei in search of the elusive rear-arc basement and, in addition, discover what the lower slopes of the seamount are composed of.

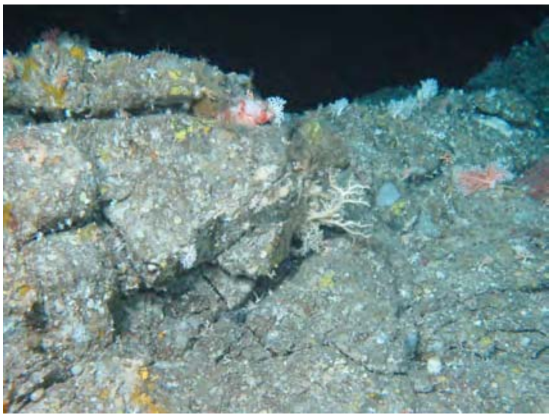
Figure 5.2.4-2: Representative images from dive HPD#963

A: Bottom sediments showing ripple marks (HDTV photo: hdc20090408090451_1.JPG).
B: Moray eel attacking Hyper Dolphin (SEAMAX photo: 2009_0408_105940AA.JPG).
C: Cave and andesite blocks (SEAMAX photo: 2009_0408_111212AA.JPG).
D: Outcrop showing columnar joints. (SEAMAX photo: 2009_0408_113943AA
E: Outcrop showing columnar joints. (SEAMAX photo: 2009_0408_115753AA.JPG).
F: Outcrop showing platy joints. (SEAMAX photo: 2009_0408_12314AA.JPG).

A

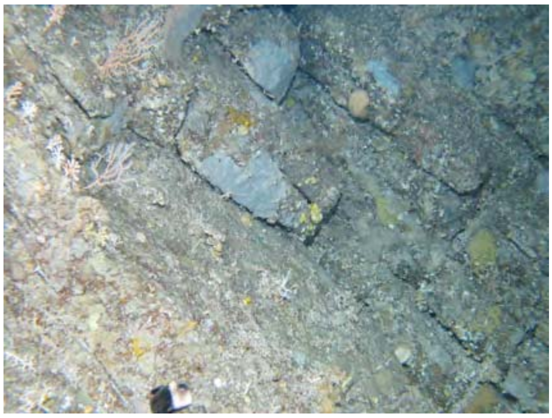
B

C



D

E



F

Table 5.2.4-1: Dive Log NT09-05 HPD#963

Dive #:	**NT09-05 HPD#963**
Date:	April, 8, 2009 (local)
Location: Objectives:	Southern slope of Hoei Seamount survey and sample pre-Miocene basement and Hoei Seamount volcanics

Logger: Y. Ichiyama and S. Okada
samples are noted HPD#xxx-XYY
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)	Vehicle Heading	Notes	Sample #	On deck description
8:16			In water.		
8:48	888	0	On bottom. The bottom is covered with sandy sediments and fragments of shell and coral.		
8:50	888	359	Moving over sandy bottom.		
8:56	866	359	Sediments showing ripple mark.		
9:07	816	350	Stop moving. Sampling MBARI Core (Red).	C01 (Red)	Sand with many fragments of shell and coral
9:09	811	350	Moving over sandy bottom.		
9:10	809	350	Sediments showing ripple mark.		
9:23	732	355	Stop moving. Sampling MBARI Core (Green).	C02 (Green)	Sand with many fragments of shell and coral
9:27	731	356	Moving over sandy bottom.		
9:48	604	18	Large andesite block (outcrop?) with platy (or columnar) joints.		
10:06	604	333	Sampling rock above the block.	R01 (Box 5)	Pl-Px andesite
10:13	598	355	Sampling rock on sediments.	R02 (Box 1)	Pl-Px andesite
10:17	586	355	Moving over rocky and sandy bottom.		
10:32	527	350	Sampling rock on sediments.	R03 (Cylinder)	Pl-Px andesite
10:58	357	353	Yellow moray eel attacks HPD.		
11:09	297	354	Stop moving. Find a cave.		
11:24	297	350	Sampling rock near the cave.	R04 (Box 5)	Pl-Px andesite
11:35	259	300	Stop moving.		
11:42	259	330	Sampling rock on sediments.	R05 (Box 2)	Pl-Px andesite
11:53	248	0	Sampling rock from outcrop.	R06 (Box 4)	Pl-Px andesite
12:04	244	358	Sampling rock from blocky outcrop with columnar-like structure.	R07 (Box 2?)	Pl-Px andesite

12:27	221	359	Sampling rock from outcrop with columnar joints.	R08 (On the Box)	Pl-Px andesite
12:32	202	351	Outcrop with significant columnar joints.		
12:34	194	350	Outcrop with rough surface.		
12:38	195	20	Sampling rock from outcrop with columnar joints.	R09 (Box 3)	Pl-Px andesite
12:40	193	15	Moving over outcrop		
12:43	193	15	Sandy bottom		
13:02	150	10	Arrived at target 6		
13:23	141	5	Sandy bottom		
13:31	146	345	Stop moving		
13:39	146		Off bottom		
13:46			At surface		
13:59			HPD on deck		

5.2.5 Dive 964 (Hoei)

<u>Technical information:</u>

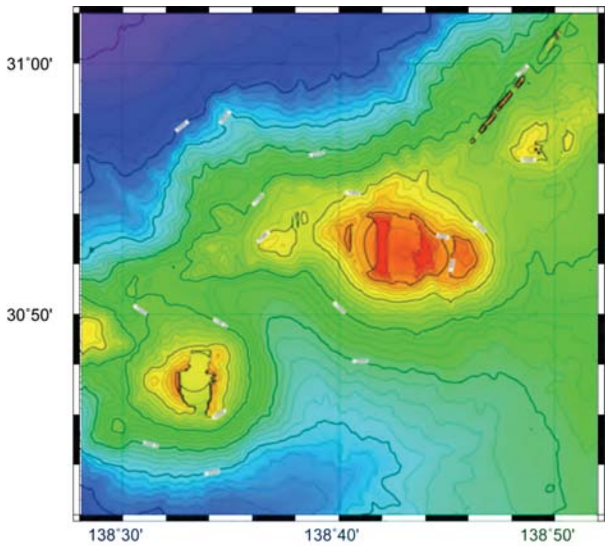
Location: Hoei Seamount, deeper part of northern slope

Objective: obtain samples from nearer the base of Hoei Seamount to compare with those recovered from the upper slopes in HPD Dive 963 and look for rear-arc basement

DIVE 960	On bottom:		Off bottom:	
Time (local)	09:51		16:54	
Latitude:	30^o	56.114'N	30^o	55.448'N
Longitude:	138^o	32.013'E	138^o	32.692'E
Depth (m):	2834		2146	

Samples returned: 17 rocks, 2 core samples

(A)



(B)

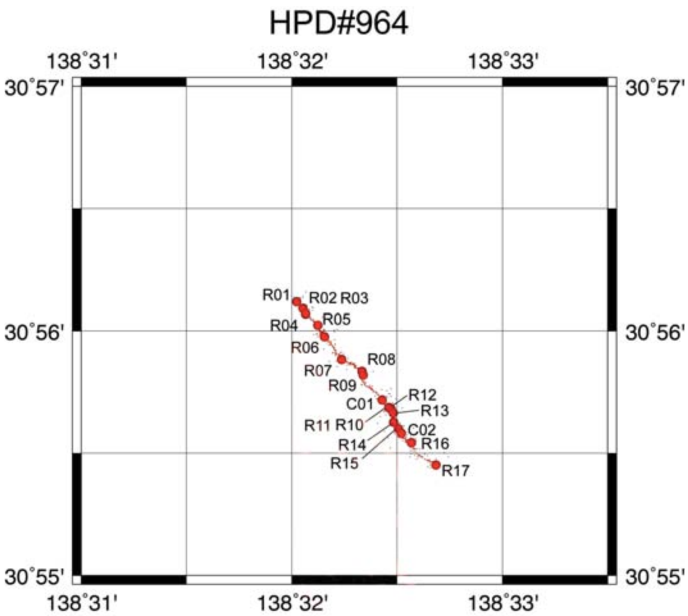


Figure 5.2.5-1 (A), (B): Bathymetry and station locations for HPD#964

Scientific summary:

Background and Purpose

Hoei Seamount is located in the Genroku seamount chain. It has an elongated shape in an E-W direction, and is also accompanied by many small cones. It has a flat summit area with a water depth of around 140m. This seamount was first sampled by MW9507 cruise, but no fresh volcanic rocks were recovered. The aim of this dive is to recover older igneous rocks from this seamount than those obtained during HPD#963 and also to sample the basement rock of the back-arc seamount chains.

Dive HPD#964

Dive 964 reached the bottom at a depth of 2900 meters on the northwestern flank of Hoei Seamount. The immediate landing location was a steeply dipping slope covered with white sticky sediment, with some Mn-oxides-encrusted outcrops rising above the sediment. This morphology continued for most of the dive with varying amounts of outcrop.

The first five samples collected, starting at 2823 m, were all basalts. At 2640 m the first tuff was collected and this became the dominant lithology in the rest of the samples recovered. The only exceptions were a scoria at 2572 m (R07), and a basalt at 2402 m (R10). The first clear evidence of an in-situ outcrop of tuff was at 2436 m (below the highest basalt, R10). This suggests that the lower northwestern slopes of Hoei Seamount are constructed of basaltic lava flows with tuff present in the mid-slope. It is possible that some of the lower tuffs encountered on the dive had fallen from higher up the slope and that the white sediment seen on the dive was derived from erosion of the tuff.

Despite the depth of this dive a number of pelagic and benthic lifeforms were encountered. Macrofauna in the water column included many blunt-headed fish, eels and jelly-fish, while a number of crinoids, brittle stars, crabs, and unidentified multi-limbed organisms were seen on the ocean floor.

Figure 5.2.5-2: Representative images from dive HPD#964.

A Exposure from which basalt R01 was sampled (SEAMAX: 2009_0409_104214AA.jpg)
B Blunt headed fish/eel (HDTV: hdc20090409112826_1.jpg)
C Loose scoria sample, R07 (HDTV: hdc20090409131734_1.jpg)
D Transparent jelly fish with internal organ visible (HDTV: hdc20090409133032_1.jpg)
E In situ exposure of bedded tuff at 2436 m (HDTV: hdc20090409142029_1.jpg)
F Maneuvering R16, a block of tuff, with both manipulators (HDTV: hdc20090409161632_1.jpg)

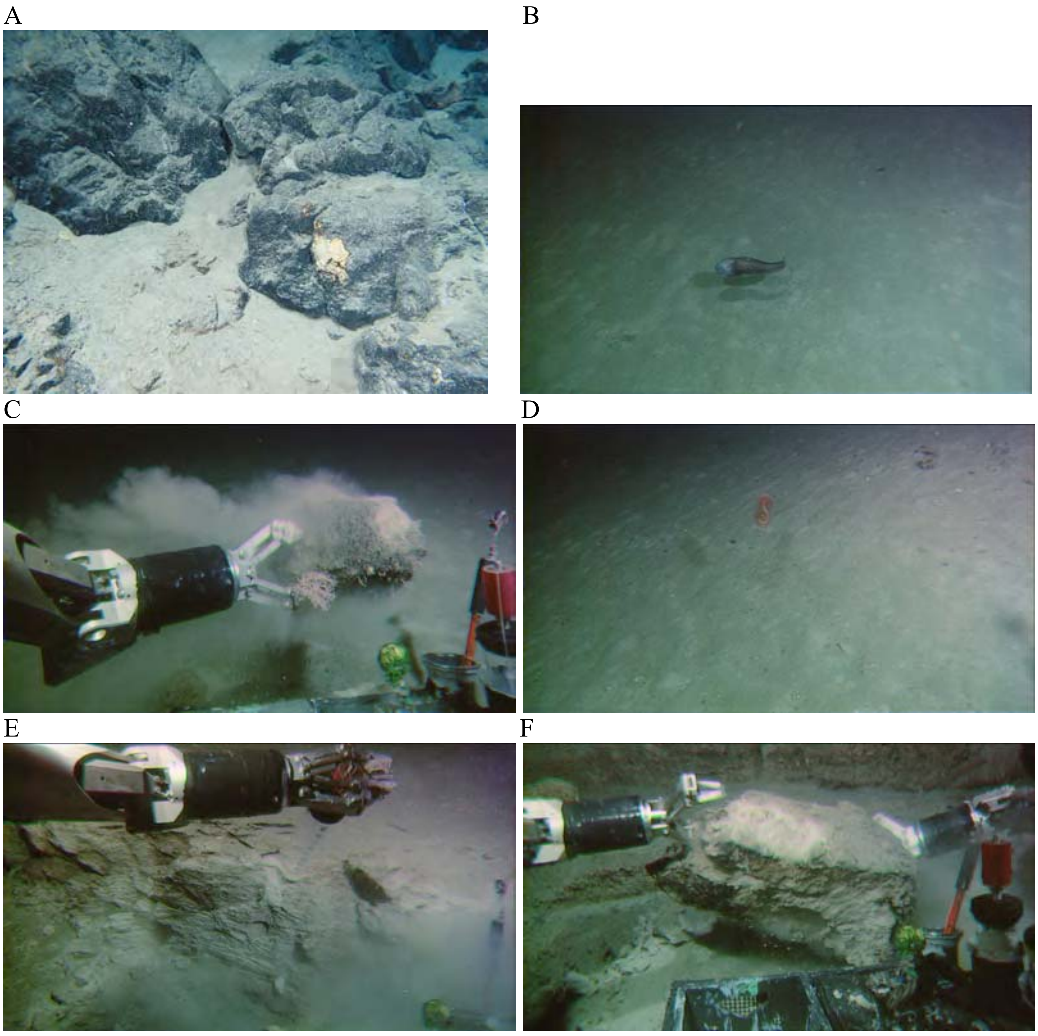


Table 5.2.5-1: Dive Log NT09-05 HPD#964

Dive #:	**NT09-06 HPD#964**
Date:	April, 9, 2009 (local)
Location:	Hoei Seamount, northwestern slope
Objectives:	survey and sample pre-Miocene basement of Hoei Seamount

Logger: O. Ishizuka, A. Nichols
samples are noted HPD#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)	Vehicle Heading	Notes	Sample #	On deck description
08:10			In water		
08:30	164	176.0	A small fish swims down with us for 20-30m.		
09:51	2834	129.4	On bottom. White sediment with ripple marks. Some outcrops sticking out from sticky white sediment.		
09:56	2833	131.0	Trying to collect black-colored block or outcrop sticking out from the sediment.		
10:01	2833	114.0	Trying another outcrop.		
10:04	2833	114.0	Trying another outcrop.		
10:09	2829	109.0	Fresh surface of the outcrop seems to have yellowish color.		
10:16	2827	064.0	Facing large Mn-oxides-encrusted outcrop.		
10:27	2822	123.6	Maybe outcrop of volcanic breccia or lava. Trying to get samples.		
10:40	2823	124.8	Finally collect a large piece of sample from outcrop. Jointed lava sample?	R01 (Box 5)	Fine-grained basalt
10:43	2821	129.5	Start ascending the slope. White sediment covered.		
10:50	2806	159.7	Blocky outcrop encountered. Landed.		
10:54	2808	125.2	Collect an angular block half-buried in white sediment.	R02 (cylinder)	Basalt
10:57	2808	125.2	Collect another angular block half-buried in white sediment. Larger than R02, maybe columnar jointed.	R03 (Box2)	Basalt
11:02	2799	123.3	Outcrop of lava. Radial jointing observed.		
11:04	2783	124.5	Fresh tube-like lava flow sections.		
11:07	2781	110.0	Landed in front of an outcrop.		
11:23	2781	114.0	Collect jointed large piece of rock sample just in front of the outcrop.	R04 (Box1)	Basalt

11:28	2770	124.6	ascending white-sediment-covered slope.		
11:34	2726	130.0	Blocky outcrop, possibly lava. Landed.		
11:41	2713	131.0	Lava outcrop with beautiful radial joint.		
11:44	2713	155.0	Landed to try sampling again.		
11:53	2707	161.0	Landed to try sampling again.		
12:03	2707	146.0	Collect a sample from surface of the outcrop. Surface of lava?	R05 (Box2)	Basalt
12:08	2692	130.5	ascending white-sediment-covered slope.		
12:12	2668	126.2	Landed in front of a rocky outcrop.		
12:19	2668	121.5	Looking around. Pale sediment and dark angular outcrops. Slopes steepness apparent on CCD camera.		
12:23	2662	126.0	Look to sample. Abandon, move on.		
12:26	2654	129.7	Reach another outcrop. This one rounded, pillowy (caused by Mn-crust rather than being a primary feature?). A manipulator moves in. CCD reveals steep slope again and more outcrops.		
12:30	2654	128.3	Scratch sample, black powder -> Mn. Difficult to break samples directly off outcrop. Searching for free boulders at foot of another outcrop. Rocks that look free turn out to be connected to outcrop. Move on again...		
12:41	2651	141.8	"Pac-man ghost" jelly-fish descends in front of HPD. Futile attempts to sample outcrops. See a smaller rock sitting in sediment. Is it connected to outcrop? Afraid so…		
			Plenty of outcrop, just a problem getting any sample off.		
12:52	2640	182.7	Radial jointing on outcrops on CCD, curved surfaces. Manage to sample nearby. Dark exterior, pale interior. Fragile, breaks up into two pieces. After all the effort searching for sample carefully place in basket.	R06 (Box1)	Tuff
13:00	2628	129.5	Black jelly fish passes by.		
13:02	2622	130.0	Multi-limbed organism on ocean floor.		
13:05	2608	129.7	Blunt-nosed fish swims in opposite direction.		
13:06	2607	129.8	Sediment covered ocean floor. Patterns across it, appear circular and sinusoidal at times - bioturbation.		
13:08	2597	130.1	Jelly fish.		

13:10	2588	123.7	Another multi-limbed organism on ocean floor.		
13:12	2585	120.2	And another one…		
13:16	2572	120.4	Land on bottom sediment near sub-angular boulder (talus). Free; swiftly peak up and unfussily place into basket. Black exterior covered in sponges and crinoids.	R07 (Box2)	Basaltic scoria
13:30	2559	120.3	"Pac-man ghost" jelly fish displaying internal organs floats past.		
13:38	2535	125.7	After 20 minutes or so of sediment and various marine life see some outcrop on CCD, head over to it.		
13:41	2534	156.0	Find some loose sample. Mn coated, breaks up in manipulator. Finally pick a piece up. Rapidly placed in basket. Black.	R08 (Box with lid)	Tuff
13:56	2514	150.8	Another sample picked up. Black exterior.	R09 (Box1)	Tuff
14:16	2436	188.4	White escarpment ~ 1m high, move into sample. Very soft. Decide to use red MBARI push core.	CO1 (red)	Fine tuff
14:33	2402	150.0	Encounter 2-3m high rocky outcrop. Land to collect a block on the slope. Trying hard to break off piece directly from the outcrop. Break a piece off. Also take a boulder lying on the steep slope. Black exterior and subrounded.	R10 (Box4) R11 (Box4)	Basalt Tuff
14:55	2396	147.9	Take large loose boulder. Slab shaped. Black exterior, orange staining.	R12 (Box4)	Tuff
15:01	2375	129.1	Climbing across outcrop and loose boulders.		
15:05	2371	165.6	Move in to sample. Scratch surface, Mn. Orange-coloured. Remove boulder from outcrop.	R13 (Box4)	Tuff
15:10	2367	142.3	Move on across slabby outcrop.		
15:13	2352	135.9	Bottom becomes sediment covered.		
15:15	2341	129.8	Red crinoid.		
15:17	2324	130.8	Rockier again. Take boulder from small gulley between tongues of outcrop on steep slope. Coated in pale sediment.	R14 (Box5)	Tuff
15:27	2304	119.1	Across lava top, see cable. Extending beyond range of view. Splayed in places. Climb high to avoid it.		
15:30	2295	120.8	Poorly defined columnar jointing?		
15:33	2283	114.5	Take loose block, one surface flat, black exterior.	R15 (Box1)	Tuff

15:39	2263	117.4	Steeply dipping flows? Or parallel jointing? Too soft for lava, breaks up easily, pale fresh surfaces, layers/bedding of volcaniclastics? Sample with yellow MBARI corer.	C02 (yellow)	Pumice/tuff
15:50	2251	130.3	Pale coloured outcrop.		
15:55	2226	118.5	Sediment, occasional black boulders, erratics, sitting on sediment.		
16:05	2214	114.4	Trying to sample a large loose boulder. Soft and too big. Take chisel to break up a chip. Chisel slips through manipulator jaws. Decide to lift with two manipulators. Successfully rest huge boulder across all baskets (16:18). Now try to secure with right arms to prevent it rolling off. Pushing back into rear of basket area.	R16 (covering Box 1 and 2)	Tuff
16:27	2214	110.4	Large pale sediment covered boulder finally secured (hopefully). Pushed back to rear of baskets to surprisingly allow sampling to continue. Move on.		
16:34	2202	100.6	Sparse boulder strewn sediment surface. Sediment exhibits linear ripple marks. Ripple marks show up well on CCD camera (16:36). Clear on HDTV (16:37).		
16:42	2175	097.6	Attack one of the larger boulders. Loose. Abort and move on.		
16:46	2164	093.8	Depressions or maybe holes in sediment. Animal burrows?		
16:50	2148	094.8	Loose block picked. Black exterior, Mn-coating, scratched, orangey coloured.	R17 (Box3)	Tuff
16:54	2146	094.6	Secure samples and begin ascent.		
17:56			at surface		
18:09			HPD on deck		

6. Future studies

The shipboard scientific party developed a comprehensive work plan for the rock and sediment samples. This work will include major element analyses, trace element analyses, geochronologic studies, mineral analyses, fluid inclusion studies, petrographic characterization, and radiogenic isotope characterization. Petrographic study, major element data by XRF and trace element data by XRF and by ICP-MS will be completed by IFREE. Sr, Nd and Pb isotope data and some geochronologic study will be completed by GSJ/AIST. Additional Hf and Os isotope data will be made by IFREE if they need to complete the study. The work will be completed at the various labs of the shipboard scientific party. Bathymetric data will be merged with existing databases at the JAMSTEC and will be provided to all participants.

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