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KR03-07 Cruise

R/V KAIREI

Onboard Report

Small Knolls on Japan Trench Oceanward Slope and Outer Swell, and Swath Mapping in NW Pacific

June 29 - July 10, 2003,

Miyako - Miyako

Chief Scientist: Prof. Yujiro Ogawa

(Institute of Geoscience, University of Tsukuba)

Captain: Mr. Hitoshi Tanaka

Table of Contents

Acknowledgments:

All onboard scientists express great thanks to the "KAIREI" crew of their excellent operations. Also shore-base staff of the JAMSTEC had excellent support for our cruise, particularly for Mr. Naoto Kimura. Mr. Masahisa Oyaizu of NME supported our daily jobs during the cruise. We sincerely appreciate his generous support. Not at least we are grateful to Prof. Teruaki Ishii of ORI for his preparation of the dredge system.

1. Background and General Objectives

On the surface of the Earth is covered with various kinds of rocks and sediments. Above all, alkaline igneous rocks are specific, teaching us what occurs in the deep crust and mantle. In a wide ocean, such as the Pacific, there are many kinds of seamounts and knolls, most of which are the products of hotspot magmatism, but some might not be related to hotspots. The latter includes particular type of alkaline basalts. In the NW Pacific, many seamounts and knolls are along the traces of hotspots which are distributed somewhere in the Pacific, mostly in the equatorial areas. Many traces of seamounts and knolls, some are guyots, some are seamounts, and some are oceanic islands, have been well studied. They are mostly known as of Cretaceous magmatism, and those particularly in the NW Pacific are almost such (Ozima et al., 1977; Takigami et al., 1989; Masalu et al., 1997; Hirano et al., 2002). However, Hirano et al. (2001) found a very young alkaline basaltic volcanism which is quite unique and different from the previously known hotspot products from the samples at the Japan trench oceanward slope toe taken by *R/V KAIKO* in 1997 (10K#56) at 39 23.2 N, 145 15.5 E. The age of the rock was determined by Ar-Ar method as to be 5.95 Ma +/- 0.31 MaBp, late Miocene (Hirano et al., 2001). The chemistry shows that it was not the product of typical hotspot type magmatism. This study gave very strong shocks to the petrological scientists, particularly why and how such magmatism occurred, and what the implications for the plate tectonics and magmatism are.

Throughout the recent scientific survey in the area off the Japan trench, there known to be various kinds of seamount chains and isolated seamounts (Masalu et al., 1997; *R/V Hakuho-Maru* cruise rept, 1998 etc.). Among them the present alkaline basaltic rocks off Miyako are peculiar and unique, because it is the first known young magmatism in the NW Pacific, and it consists of several small knolls and mounds in the small area (from the SeaBeam map hitherto obtained). The place of the present location may not be on a previously known hotspot traces (e.g. Joban Seamount Chain, Masalu et al. (1997)). If we assume the magmatism occurred on the westward moving Pacific plate to 290 degrees (this assumption must be true), it was on the Pacific plate approximately 300 miles off the present position to 110 degrees. It is around the deepest basin in the NW Pacific plate, just before it approaches the Hokkaido Rise around 37 40 N, 150 30 E (Fig. 1). If the depth of the original magmagenesis attains to 15 to several tens of kilometers in the lower level of the Pacific plate lithosphere (or even at the plate boundary between the lithospehere and asthenosphere) (as Hirano et al.'s consideration from the olivine xenocrysts chemical and petrological research, in preparation), the magmatism must be very important to know in the lower levels of the oceanic plate magmatism.

Samples taken from only dive by *ROV KAIKO* dive #56 were not sufficient enough to know the details. Therefore we proposed several dives to the knolls of volcanic origin in the Japan trench oceaward slope (in this cruise called the Miyako Knolls) and in addition some possible basaltic knolls in the outer swell (Hokkaido Rise) (in this cruise called the Kobayashi Knolls) (Hirano et al., 2002; JAMSTEC proposal). The original proposal was approved by the committee with some revision to do three dives in the Miyako Knolls and Outer Swell, and SeaBeam swath mapping to the potential eruption site around 37 N, 150 30 E, as we assume the Pacific absolute motion to be 290 degree direction with 10 cm/year as mentioned above. We had originally aimed to dive three times by *ROV KAIKO*.

However, as known, she went astray during a research dive to the Nankai trough in the end of May, 2003. Notwithstanding that she was searched by various ways every day after missing, she could not be found at all. The committee asked us to use alternative way instead of using *KAIKO*. We, the main proponent N. Hirano and the designated chief scientist Y. Ogawa, determined to try to take samples from the same areas by dredging, and asked the Ocean Research Institute of University of Toyo people to help operating a dredger. Very fortunately, Dr. Satoru Haraguchi, a professional dredge operator as well as a petrologist, kindly attended our cruise, which embarked at Fujiwara pier, Miyako, Iwate Prefecture, at 16:00 on 29th of June, 2003. This is the general process and change of the initial plan of the proposal.

The dredge investigation will focus on two points, 1) To know the distribution of alkaline basaltic volcanic rocks and 2) to know how the magmatism is related to any plate tectonic or mantle plume origin or others. In this project, five parts of institutions attended; the chief proponent, Dr. Naoto Hirano is from Department of Earth and Planetary Sciences, Tokyo Institute of Technology. He has his shore-based scientists. They do geochemistry, age determination and other related studies on basaltic rocks. Professor Susumu Umino from Department of Biology and Geology from Shizuoka University, and Dr Satoru Haraguchi from Ocean Research Insititute of University of Tokyo. They take share chiefly submarine basaltic volcanism. Professor Yujiro Ogawa and his students and researchers from Unviersity of Tsukuba work for sedimentary rocks and sediments of the Pacific, including geochemical process and physical property development; Mr. Katsunori Tanaka and Mr. Kazunori Hatsuya, both are graduate students, and Dr. Lee In Tae, now a foreign researcher at Tsukuba from Chonnam National University, Republic of Korea. Mr. Kiichiro Kawamura, Fukada Geological Institute, works for sediment texture, age and deposition to understand physical property change. Some additional shorebased scientists are Professor Teruaki Ishii, Ocean Research Institute, and Professor Masao Nakanishi, Chiba University, will work for the treatment of volcanic rocks and some geophysical data including geomagnetics and gravity, respectively.

Proposed Sites and operations.

1) Small knolls and associated fault scarps (totally named the Miyako Knolls) on the toe of the oceanward slope of the Japan trench around 39 24-23' N, 144 20' E, 7300 m water depth. (named as the Hattori knoll, and Ocarina knoll during the cruise, respectively)
2) Small knoll on the Hokkaido Rise around38 45' N, 145 42' E, 6900 m water depth. (called the Kobayashi knoll). This knoll has been thought to be a kind of mud volcano (Ogawa and Kobayashi, 1993), but no samples have ever been recovered yet.
3) SeaBeam swath mapping in the area C between Miyako and the Shatsky rise (between 38 N, 149 N, and 37 N, 150 30' E), with three-component geomagnetic survey, proton magnetometer, and gravity meter. This area is considered the probable eruption area for the Miyako Knolls 6 MaBP as well as the SES extension of the Hokkaido Fracture Zone.
4) Some additional swath mapping will be planned to fill the un-mapped areas in the previous JAMSTEC cruises. Dr. K. Kanamatsu, JAMSTEC, kindly offered the previous bathymetric data, so that we can know the necessary area.

Additional Comments:

The basic maps for this series of research, we used the following maps.

1. Lamont-Doherty map (1977)
2. AAPG plate tectonic map (1980)
3. Japan Maritime Safety Agency bathymetric maps (Hokkaido and Tohoku) (1980)
4. E-topo-2 (taken on line; www….)
5. Dr. Tomoyuki Sasaki (ORI)'s original bathymetric map edited by ORI SeaBeam data (2003, personal courtesy)
6. JAMSTEC SeaBeam map edited and equipped onboard.
7. Above all online SeaBeam map onboard just obtained during cruise by courtesy of Mr. Tokito Nasu, Chief Electric Operator.
8. others

9. Relevant map data and other important data would be obtained from the following web site:

www.ngdc.noaa.gov/mgg/anoucements for E-Topo-2

//topex.ucsd.edu/marine-topo/globe/html for general topographic map

www.jodc.go.jp/index_j.html for Japan Maritime Safety Agency map

www-es.s.chiba-u.ac.jp/~nakanisi/lineation.html for NW Pacific magnetic lineaments

2. Review

The trench oceanward slopes in the world have not yet been fully studied. Some researches have even identified the general topographic characteristics in the Mariana trench, Aleutian trench, and Kuril to Japan trenches. Among them, Kobayashi et al. (199/) verified the trench-trending normal faults and their effect to the landward slope topography. Seamounts on the oceanic plate side may give significant effect to the landward slope topography, deformation and seismicity. Some important knowledges are such seamounts give rise the trigger of a great earthquake along the subducting plate boundary as operating the asperity for seismogenic slip (Tanioka and Satake, 1997). Thus the study of seamounts and knolls in the oceanic plate is very important for the current topics, but the details are not yet so far known.

In the Japan trench and its oceanward side, many seamounts and knolls have been known. The Daiichi-Kashima seamount is the first to know the rupturing seamount to be normal faulted just on the trench axis in the downgoing slab of the Pacific plate (Mogi et al., 1980; Tani, 1998). After this study, many seamounts have been studied, the Erimo seamount in the junction of the Kuril and Japan trenches (KAIKO Project, 1987, 1989), Joban Seamount Chain off Kanto and Tohoku areas in the Japan trench area (Masalu et al., 1997), and Quesada seamount in the Mariana trench (Hirano et al., 2002). Most of them are of Cretaceous age, erupted either in the Macdonald hotspot or other hotspots, and traveled generally to NW-ward, including sporadic different directions as known in the Middle Pacific Mountains direction (Hirano et al., 2002).

However, the especially young, late Miocene, approximately 6 MaBP, alkaline basaltic rocks have been recovered from the trench oceanward slope toe off Miyako (Hirano et al., 2001) by *ROV KAIKO* of JAMSTEC. This finding gave a strong shock to the plate tectonic and igneous rock science community, as approving more research to the same area by Naoto Hirano's proposal. Thus, we try to collect many more rock samples, as well as obtaining bathymetric and other geophysical data including geomagnetics and gravity. The magmatic and plate tectonic significance of studying those rocks may be given elsewhere in this report, or will be fully discussed in Hirano et al. (in preparation).

Here we have an idea to do swath mapping, other than dredging in the Japan trench oceanward slope areas, in the area A-3, surrounded by the two diagonal points of rectangles of 37 42 N, 149 14.4 E and 37 00 N, 150 30 E. We anticipate some seamounts or knolls, which may be the potential magmatic eruption place for the alkali basalt, if this kind of magmatism is assumed to be the product of some tectonically significant point for bending or buckling of the Pacific plate subduction to produce the Hokkaido Rise, because such bending or buckling may bring the lower plate boundary to be of a horizontally extensional zone. At the same time, the area A-3 is correspondent to the extension of the Hokkaido Fracture Zone from NNW, cutting long in the NW Pacific (Fig. 2-1).

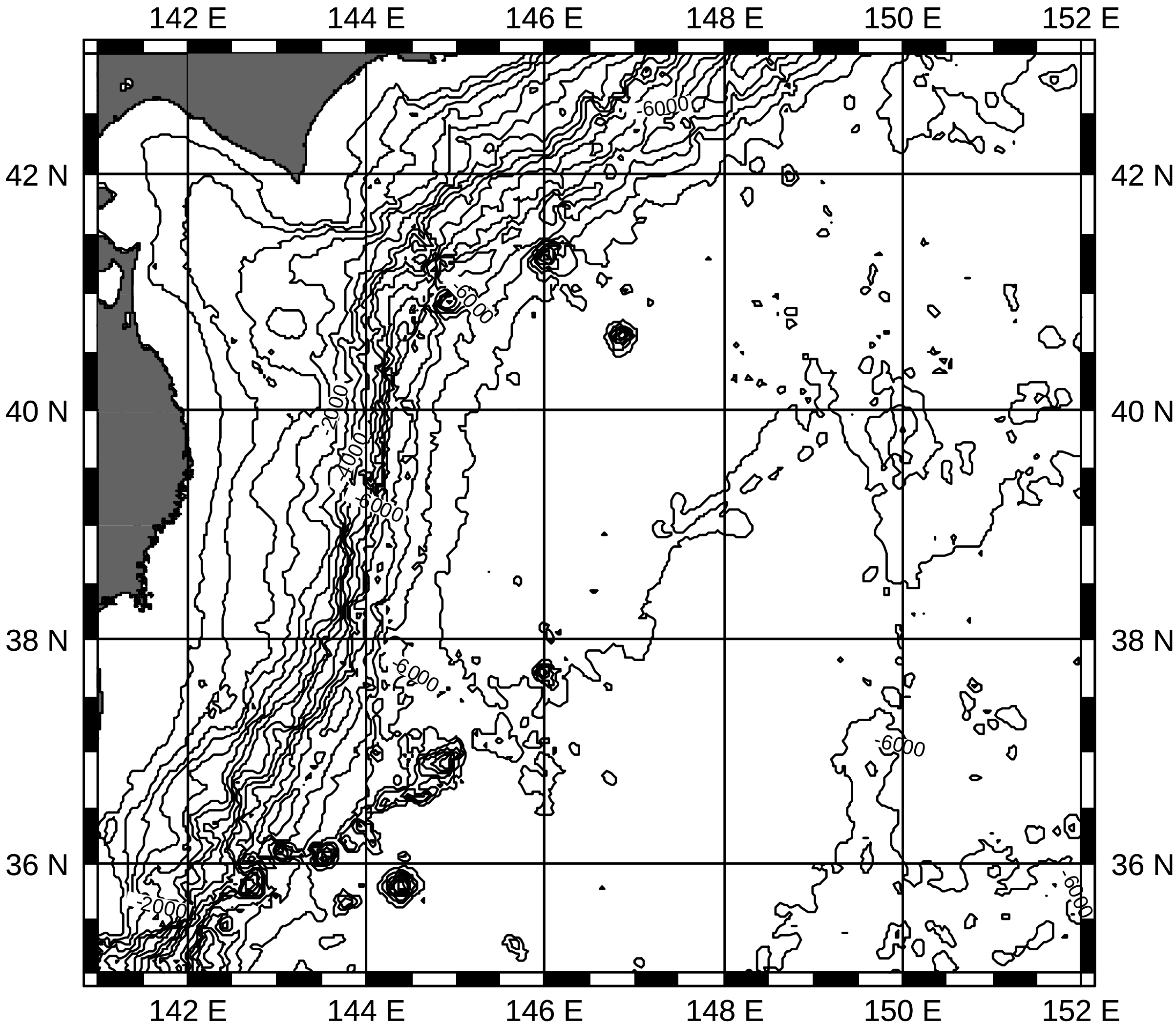


Figure 2-1 Bathymetric map of study area. Data source of the map is ETOPO2 grid, NDGC, NOAA. This image file is included in this CD-ROM /JAPANTRENCH_maps/ etopo2_japantrench.ps

3. Cruise Log

Date	Operation	Area	Lat. & Long.	Notes
June 29, 2003				Depart Fujiwara pier, Miyako @ 16:00
June 30	Dredge 1	A		Basalt, radiolarite
July 1	Dredge 2	A		Basalt, Mn-nodules
July 2	Survey	A		39-degrees Knoll
July 3	Dredge 3	D		Mud; *Shinfukuei No. 16*
July 4	Survey	D		
July 5	Survey	D		
July 6	Survey	D to C		Fukahori Knoll, 38-degrees Knoll
July 7	Survey	C		TIT Knoll, Tanabata Knolls
July 8	Survey	C		
July 9	Survey			Area D to Area F
July 10				Arrive and Disembark at Fujiwara pier, Miyako @ 09:00
July 20				Unloading dredgers and samples at Universal Dock, Tsurumi. 13:00 www.u-zosen.co.jp

(From where? Yes, from “Fishing Island”, Ryukyus, since April 2003)

気色満面！！

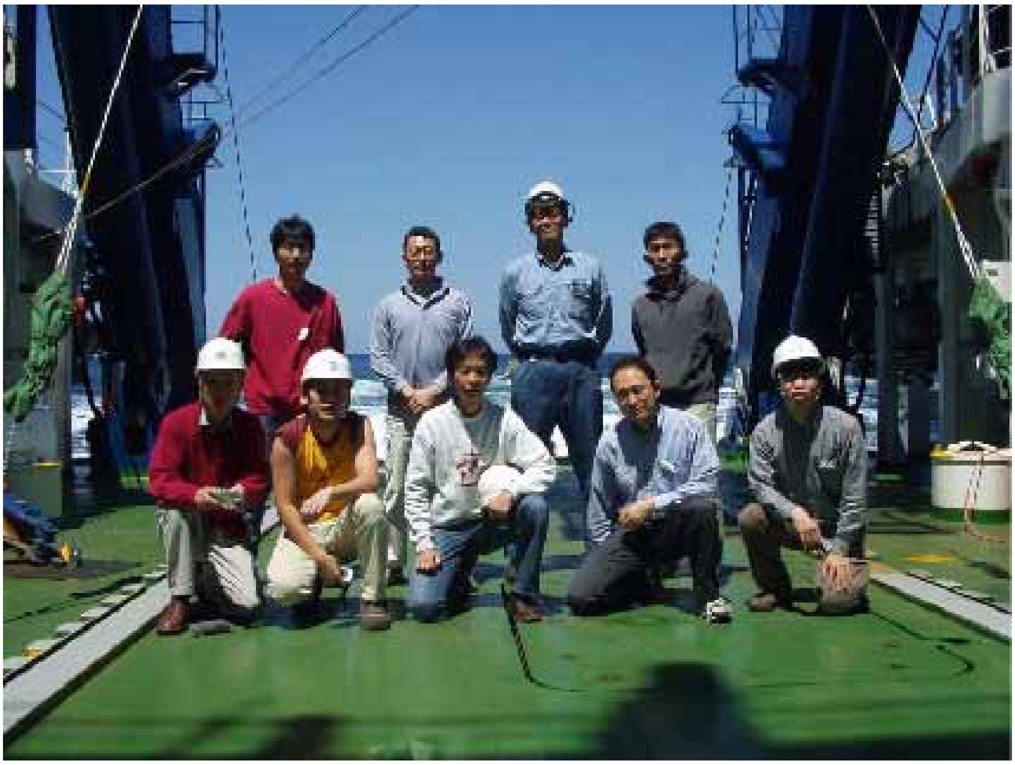
おめでとう、平野君！！！

やったね！

(at Ocarina Knoll)

4. Onboard Participants

Yujiro Ogawa (chief scientist)	Institute of Geoscience, University of Tsukuba		
Naoto Hirano (deputy-chief scientist, Petrology, dating)	Department of Earth and Planetary Sciences, Tokyo Institute of Technology		
Susumu Umino (Petrology)	Department of Biology and Geosciences, Shizuoka University		
Kiichiro Kawamura (Physical properties)	Fukada Geological Institute		
Katsunori Tanaka (Phys. Prop.)	Graduate School of Life and Environmental Sciences, University of Tsukuba		
Kazunori Hatsuya (Geochem.)	Master Program of Science and Technology, University of Tsukuba		
Lee In Tae (Sedimentology)	School of Marine Science, Chonnam National University, Republic of Korea		
Satoru Haraguchi (Igneous petrology)	Ocean Research Institute, University of Tokyo		
Masahisa Oyaizu (Marine Technician)	Nippon Marine Enterprises, LTD.		

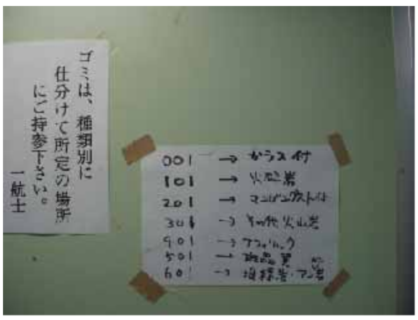


(Onboard photo *R/V KAIREI,* July 5, 2003)

Kawamura Umino Oyaizu Tanaka

Lee Hirano Ogawa Haraguchi Hatsuya

XBT



Work hard or Tidy Rubbish!

Ship Crew

Hitoshi TANAKA	Captain
Yoshiyuki NAKAMURA	Chief Officer
Shin'ichi KUSAKA	2nd Officer
Tetsuya YOKOTA	3rd Officer
Eiji SAKAGUCHI	Chief Engineer
Akimitsu FUKUDA	1st Engineer
Kazunori NOGUCHI	2nd Engineer
Masahiko SATO	3rd Engineer
Tokito NASU	Chief Electric Operator
Jun SUENAGA	2nd Electric Operator
Makio NAKAMURA	Boatswain
Kazuo ABE	Able Seaman
Kiyoshi KANEDA	Able Seaman
Hatsuo ODA	Able Seaman
Katsuhiko SATO	Able Seaman
Kaname HIROSAKI	Able Seaman
Kaito MURATA	Old Seaman
Masayuki MASUNAGA	No.1 Oiler
Kazuaki NAKAI	Oiler
Junji MOURI	Oiler
Keita FUNAWATARI	Oiler
Sukeyuki TANAKA	Oiler
Kiyotoshi TERANISHI	Chief Steward
Teruyuki YOSHIKAWA	Cook
Shinsuke TANAKA	Cook
Isao MATSUMOTO	Cook
Hideki KUBOTA	Cook

5. Operation and Instruments (After KR02-02 explanation by Dr. Shin'ichi Kuramoto)

5.1.1 Research Vessel "KAIREI"

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

Research Vessel "KAIREI"

The principal specifications

Length : 105.22 m

Breadth: 16.0 m

Height : 7.3 m

Draft : 4.5 m

Gross tonnage : 4439 t

Cruising speed : about 16 kts

Cruising range : about 9000 mile

(R/V KAIREI on Fujiwara pier, Miyako Harbor; June 29, 2003)

5.1.3 SEA BEAM 2112

Bathymetric data were collected by the SEA BEAM 2112 (Sea Beam

Instruments). The SEA BEAM 2112 is a multibeam survey system that generates data for and produces wide-swath contour maps and side scan images. It transmits a sonar signal from projectors mounted along the keel of the ship. The sonar signal travels through the sea water to the seafloor and is reflected off the bottom. Hydrophones mounted across the bottom of the ship receive the reflected sonar signals. The system electronics process the signals, and based on the travel time of the received signals as well as signal intensity, calculate the bottom depth and other characteristics such as S/N ratio for echoes received across the swath. Positioning of depths on the seafloor is based on GPS and ship motion input. The data is logged to the hard disk for post processing which allows for additional analysis. Plotters and side scan graphic recorder are also included with system for data recording and display.

The hardware system consists of two main subsystems, transmitter and receiver respectively. Figure 5-1shows a basic diagram of the system. The basic 12 kHz projector array is a 14-foot long linear array positioned fore and aft along the ship's keel. It forms a downward projected acoustic beam whose maximum response is in a plane perpendicular to its axis. The beam angle is narrow, 2° in the fore/aft direction. The receiver array detects and processes the returning echoes through stabilized multiple narrow athwartship beams in a fan shape. The hydrophne array has a flat shape in the case of R/V "KAIREI", although the standard SEA BEAM 2000 series system has a V-shaped array (Fig. 5-1). The system synthesizes 2° ×2° narrow beams at the interval of 1°, and the swath width varies from 120° at depths from 1500 m to 4500 m, 100° from 4500 m to 8500 m and deeper than 8500 m, as shown in Fig. 5-2. The transmit interval of the sonar signal ping interval increases with water depth, for example about 20 sec. at 6500 m. So, the horizontal resolution of the bathymetry data depends on the depth and ship's speed. The accuracy of the depth measurement is reported at 0.5% of the depth.

The software which controls the system is called the Sea View. It employs the Lynx Operating System. Indy Work Stations (SGI) are used for operation. The obtained raw data includes data records of each ping (bathymetry, side scan image, position), nautical information and correction parameters such as water velocity structure. Post processing consists of editing data (deletion of bad data, correction of position etc.,), making grid data files and various maps. Software used is Sea View and GMT Ver.3.0 (Wessel and Smith, 1995).

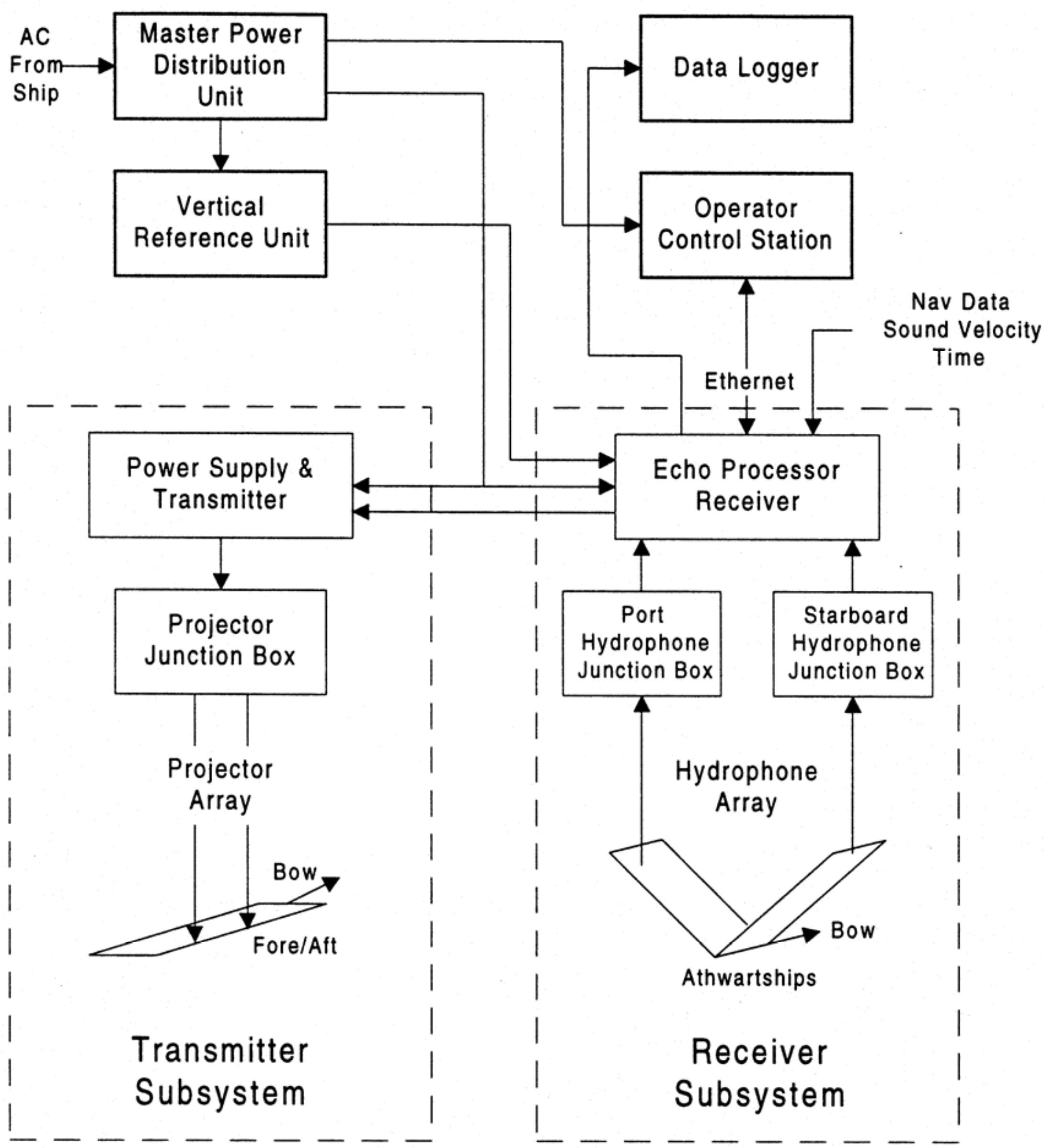


Fig. 5-1: Basic diagram of the SAE BEAM system.. Details are described in the text.

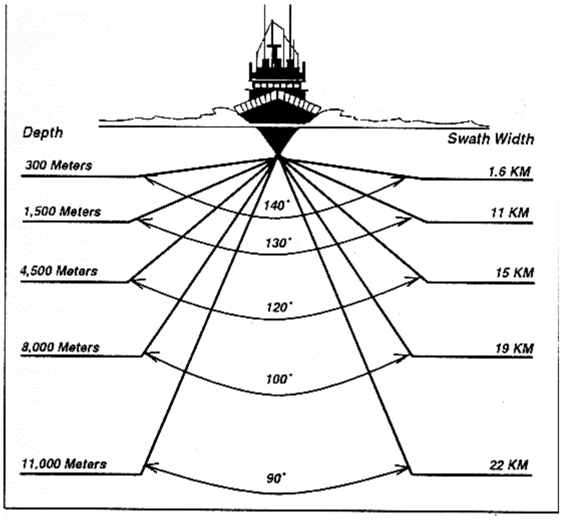


Fig. 5-2: Schematic illustration of swath bathymetric survey.

Sub bottom profiler (This tool was not in this cruise, but for knowledge we put here)

Sub bottom profiles were obtained by using the SEA BEAM 2112.004 Subbottom Profile Subsystem, which is an additional option to the SEA BEAM 2112 Multibeam Bathymetry System. The capability of the system ranges from 50 m to 11,000 m. Depth penetration varies with bottom composition and may be as much as 75 m. The system uses an aray of 60 TR-109 projectors, operating at 4kHz to fprm a vertical beam of 45 ° athwartship and 5 ° fore/aft. The system startup, parameter setting, and real-time control is perfomed by Indy Work Station (SGI). The data is displayed on a terminal and EPC recorder, and stored on harddisk and a data logger.

We basically operated the SEA BEAM survey after dive experiments. We covered mostly the southern part of our proposed area, off Kumano. Because the north part was already taken by previous cruises in 1999, 2000 and 2001. Figure 5-3 shows our survey area and track lines. Figure 5-4 shows a shaded relief bathymetric map using a combined bathymetric data that taken by *R/V KAIREI*.

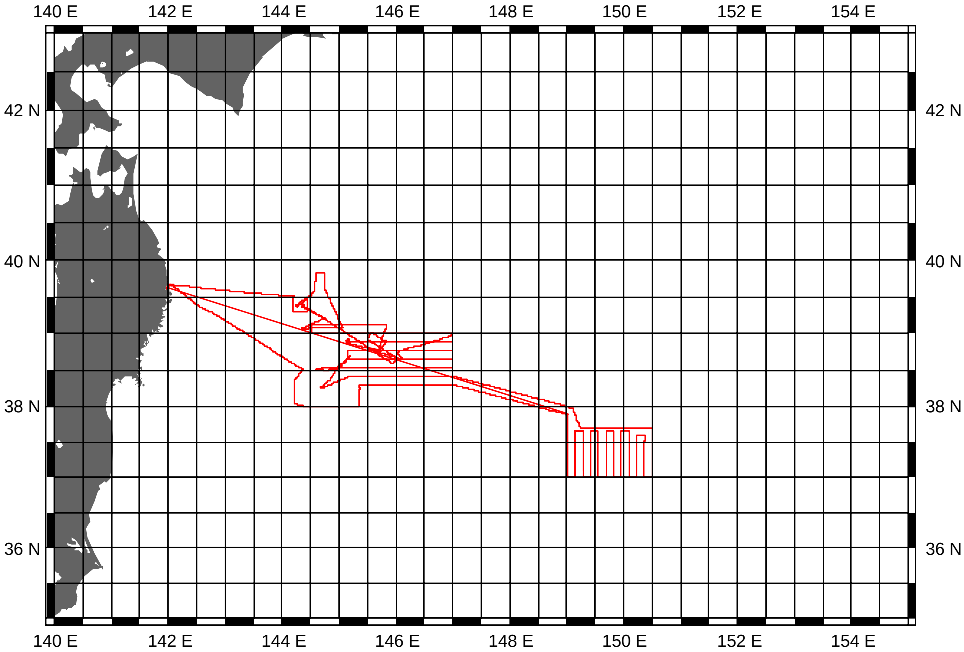


Fig. 5-3: Track chart of seabeam survey. This image file is in this CD-ROM/ shiplog/ KR0307.ps

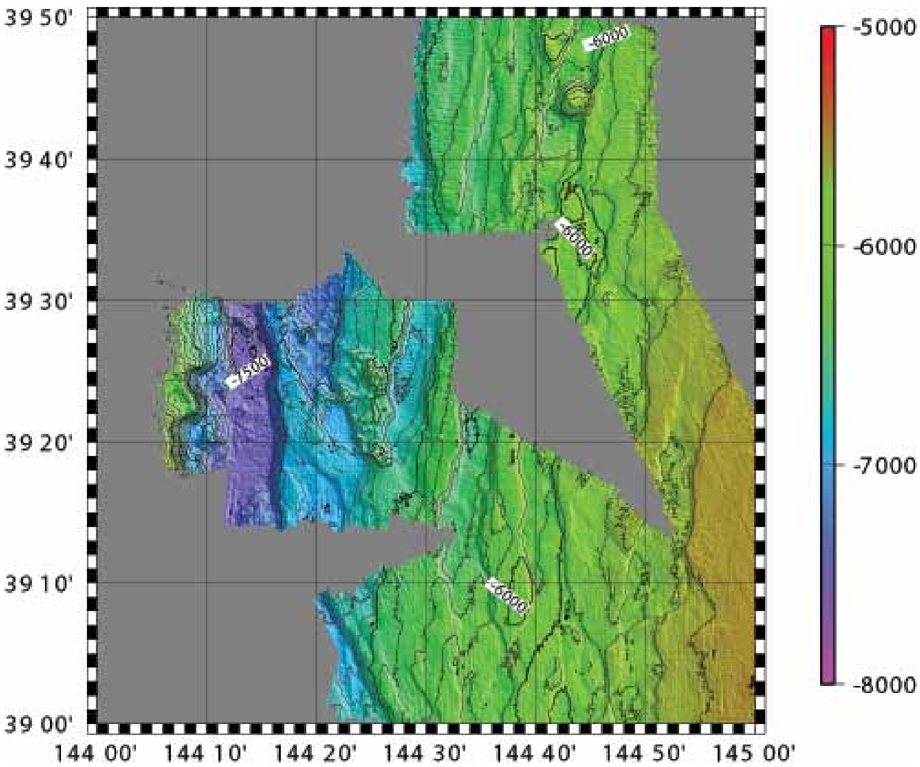


Fig. 5-4: Bathymetric data of KR03-07 cruise are combined and processed during this cruise. This figure shows a shaded relief map of A-1 survey area. Other bathymetric data are included in this CD-ROM /KR03-07_SeaBeam

Dredge Report (by S. Haraguchi)

Dredge-1

Date: June 30, 2003

Site: Hattori Knoll, (Miyako Knolls) on the Japan trench oceanward slope toe

Depth: 7323-7142 m

Landing: 39°23.20040'N, 144°15.71590'E depth 7323 m

Leaving: 39°23.13550'N, 144°16.20430'E depth 7142 m

Operator: Satoru Haraguchi

Objectives:

The overall objectives of this dredge is to recover many more samples from the same place of 10K#56, which collected alkaline basaltic rocks. We tried to take many basaltic rocks and in addition some Manganese nodules or crusts and other kinds of sedimentary rocks. The new findings and implications of the previously taken alkaline basaltic rocks are already described and discussed by Hirano et al. (2001) as to be the product of least partial melting of considerably depleted mantle in the oceanic plate. The age was also known to be approximately 6 MaBP, which is fairly young, and far younger than the NW Pacific seamounts. To collect basaltic rocks from the small knolls around the previous dive site would give us many more sample to treat to study in detail by various geochemical methods. We would know the new type of basaltic magmatism in the descending oceanic plate much more in detail.

Results:

Several alkaline basalt blocks, similar to the previous 10K dive (#56) were obtained, but not distinct pillow lava blocks were included. Some basalt has pelagic coat which is affected by thermal quench or contact metamorphism, so that the basalt lava may have intruded the pelagic (siliceous clayey) sediment forming a sill. Further investigation should verify the interesting emplacement, age and ignificance. Olivine xenocrysts are included.

Dredge-2

Date: July 1, 2003

Site: Ocarina Knoll, (Miyako Knolls) on the Japan trench oceanward slope

Depth: 6893-6483 m

Landing: 39°22.55710'N, 144°20.66160'E depth 6893 m
Leaving: 39°23.31640'N, 144°22.38150'E, depth 6483 m
Operator: Satoru Haraguchi

Objective:

From the good results of D-1, we tried to dredge the similar setting, and chose the distinct ridge of dark back scatter image at presently called Ocarina Knoll from the obtained ocarina-shape large sample (Fig. 6-1). This knoll is extending very complexly, on the east several branches to NE, E and SE, while on the west the ridge was dislocated by the NNW trending normal fault. We tried to dredge the center, and dragged the dredge from WSE to ENE up to the summit of one peak.

Results:

Results were abundant. Huge amount of rocks were in the dredger, and they attain probably more than 400 kg. This is the greatest success in this cruise, and people onboard admired the ability of the operator. Most of the rocks are of basaltic rocks, and some have olivine xenocrysts, and some have even pyroxene (ortho-). It took almost one week to treat, classify and distribute. Other rock types are sedimentary breccia of the same basaltic rocks within pelagic matrix, and others. Manganese nodules or coating are common. Reddish and olive colored mud and clay were also in the pipe dredger.

(Dr. Satoru Haraguchi and his results) “How Fertile!“

Dredge-3

Date: July 3, 2003

Dive site: Kobayashi Knoll (on the Hokkaido Raise)

Depth: 5409-5285 m

Landing: 38°45.24630'N, 145°41.65900'E, depth 5409 m

Leaving: 38°44.73000'N, 145°52.10270'E, depth 5285 m

Operator: Satoru Haraguchi

Objective:

A small knoll of NE trend was thought to be a mud ridge or mud volcano by Ogawa and Kobayashi (1996). However, the reason is not sufficient enough, and one of the proponents may think this could be volcanic ridge. We obtained a back scatter image just before the dredge day, and because it was slightly distinct (means of being hard to be possibly volcanic), we decided to dredge here is the only way to determine whether being a mud volcano or volcanic.

Results:

The obtained samples were only very soopy mud and slightly indurated mud. The former may be from the foot, the sediment on the north moat, while the latter may be from the flank of the knoll. It is still not enough to exclusively note whether, but possibly some volcanic rocks are underlain. We need more if we insist volcanic. However, to decide is for the future project.

(People are anxious and just to wait.)

Dredge Log (by Satoru Haraguchi)

D1 (2002.6.30)

time	wire length (m)	tension (kN)	remarks
8:12			dredge in water
8:20	0		joint to main wire
10:33	7210		wire stopped, ship speed 1kt
10:41			wire out 30m/min
10:47	7270		dredge on bottom 39°23.20040'N, 144°15.71590'E depth 7323 m
10:52	7500	52	wire stopped
11:31			passed on end point, ship speed 0.5kt
11:33			wire in 12m/min
11:46		56	bite, ship backed
11:47		60	bite
11:49		60	bite
11:51		60	bite
11:53		60	bite
11:55	7300	60	bite, off bottom 39°23.13550'N, 144°16.20430'E depth 7142 m
14:40			dredge off water

D2 (2002.7.1)

time	wire length (m)	tension (kN)	remarks
8:03			dredge in water
8:11	0		joint to main wire
10:09	6700		wire stopped, depth 6896 m
10:10			ship speed 1lt
10:15			wire out 30m/min
10:24	6955		dredge on bottom, 39°22.55710'N, 144°20.66160'E depth 6893 m
10:28	7050	47	wire stopped
12:42		52	bite
12:44		52	bite
13:06		54	bite
13:30			wire in 10m/min, ship speed 0.5kt

13:36	7000	60	bite
13:40		64	bite
14:00	6747	61	
14:03		64	bite
14:19	6550	66	wire stopped, ship backed
14:22			wire in 4m/min
14:30			tension falled, wire in 10m/min
14:35		66	wire stopped
14:37			ship backed, wire in 4m/min
14:46		70	wire stopped and wire out 20 m
15:04	6400	57	
15:20	6330		dredge off bottom, 39°23.31640'N, 144°22.38150'E, depth 6483 m
17:30	0		off main wire
17:37			dredge off water

D3 (2002.7.3)

time	wire length (m)	tension (kN)	remarks
8:05			dredge in water
8:14	0		joint to main wire
9:44	5100		wire stopped ship speed 1kt
9:51			wire out 30m/min
9:59	5311		dredge on bottom, 38°45.24630'N, 145°41.65900'E, depth 5409 m
10:02	5400		wire stopped
10:48			wire in 10m/min, ship speed 0.5kt
11:11	5175		dredge off bottom, 38°44.73000'N, 145°52.10270'E, depth 5285 m
13:12	0		off main wire
13:17			dredge off water

Some reports on dredge results (by Susumu Umino)

D1-004, 008: Dense lava showing folded crust of ropy wrinkles on a sheet flows
D1-001 etc.: Vesicular lava block

K56 KAIKO video: Collapsed pahoehoe lobes present, but pillows?. Pahoehoe lobes sporadically expose flat collapsed roofs subparallel on steep, indicative of tilting of the entire block toward the trench. Volcanic breccia on an big outcrop? exposed on the sedimented slope of pahoehoe flows.

Consideration

Recovery of crust of sheet flows from D1 site confirms the presence of sheet flows from K56 dive site. The high backscatter image on the flat, lower terrace below the D1 and K56 sites may be a sheet flow which could be the same one exposed on the sampling sites. Sampling of the high-backscattered area is required to confirm the presence of a sheet flow.

D2: Most highly vesiculated blocks of olivine basalt (both porphyritic and nearly aphyric), and a few samples of dense lava clasts. Rare watermelon-shaped blocks with a glassy rind, suggestive of pillow fragments. Two blocks of greenish aphyric basalt? (D2-301, 302, 303), one of which (D2-302) has a polyhedral shape with aphyanitic chilled margin on one side, may be derived from dikes or bottom of thick flows. Most blocks are free of Mn crust, suggesting that they were recently collapsed part of the volcano.

Consideration

Because plausible pillow fragments from D2 site have the same lithology to the most abundant olivine basalt samples, the D2-site volcano is mainly composed of pillow lava. However, the irregular topography of the volcanic eidfice is unusual for those of pillows. This, and the most dredge samples without Mn crust, suggest a collapse of the volcanic edifice.

If D2-302 is a block of a dike, there are two possibilities: either it derived from the deep oceanic Layer 2B, or it is a part of the conduit which fed the alkali basalt lava composing the volcano. The first one is unlikely as there is no samples of MORB lava dredged. Second one is consistent with the collpase of the volcanic edifice and needs to be verified by the geochemistry.

Keywords:
Alkaline basaltic magma, mantle xenocryst, intraplate fracture, knoll

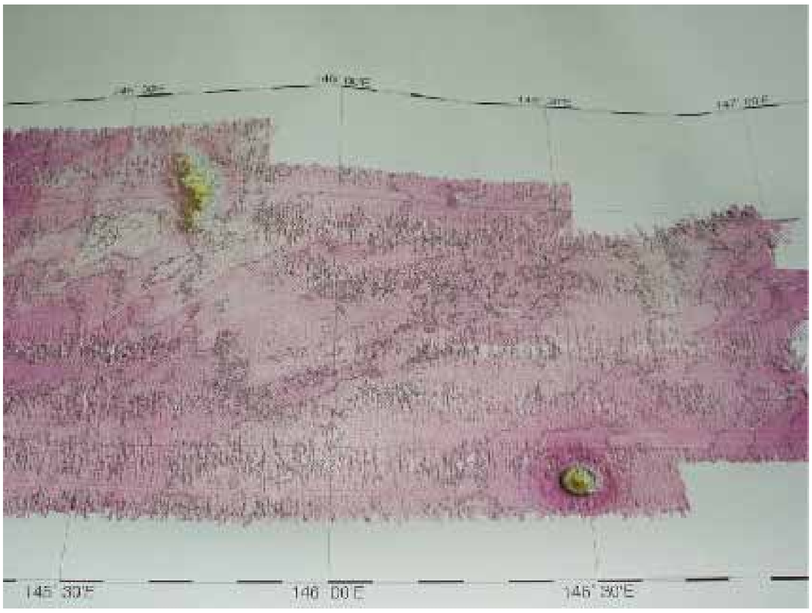
(Proton magnetometer)

(Erratic pebbles and cobbles are common)

9. General results

New seamounts and knolls were found at various places; they are the 39 degrees seamount (at 39 01 N, 145 42 E; summit depth 4740 m, height 510 m), the Fukahori (deep-moat) seamount (at 38 26 N, 146 30 E; summit depth 4770 m, height 620 m), the 38 degrees seamount (at 38 02.5 N, 148 40.6 E; summit depth 5246 m, height 800 m), TIT (Tokyo Institute of Technology seamount (at 37 25.5 N, 150 15.3 E; summit depth 5243 m, height 380 m), etc.

Hokkaido Fracture Zone may extend farther south as to the area C, and has a considerably wide zone of more than 10 km, and has vary significant arrangement of en echelon knolls and ridges (called collectively the Tanabata Knolls (in Japanese, meaning Star Festival on 7th of July), one parallel to the fracture zone, another to N60-70W, which may be the extension of the Miyako Knolls through 39-degrees, Fukahori (alternatively Noritan) Knoll, and 38-degrees Seamount.



A-2 Area (39 degrees knoll in the north, Fukahori knoll in the south)

7. Topography and Geology of the Hokkaido Rise

The Hokkaido Rise is an outstanding swell to the SE of Hokkaido, extending southward as west as off Fukushima Prefecture, Honshu. It is enormous that in any other areas of the Kuril and Japan trenches there are no relative features of topography, although it seems to be the general outer rise in front of the plate subduction boundary. Probably, due to the bending of the trenches on the south of Hokkaido, the stress concentration might occur to form a wide zone of swell.

In front of Miyako, the outer swell has 160 km wide, shallower than 5400 m depth. The rise has several convex and concave ridge and trough of gentle topography. In addition, small ridges run to N60E direction every 10 to 20 km distance. This is almost parallel to the magnetic lineament, so that it might be the remnant of the normal faults at the mid oceanic ridge. The steepest slopes of the ridges are at the southern surface at some places, and vise versa. This trend changes to almost E-W on the east from 145 E.

Small knolls and seamounts are scattered on the Hokkaido Rise, and some may be on a line of N60E or N70E trends, but the systematic analysis might be of the later work.

8. Topography of the A-3 area

At the last stage of survey, we swath-mapped the A-3 area in the NW Pacific to the east of the Hokkaido Rise. This area was originally chosen as to be the potential place for the magmatism for the Miyako Knolls. At the same time this area corresponds to the SES extension of the Hokkaido Fracture Zone. Therefore, the deepest, complicated topography was anticipated. The mapped area has the diagonal line between 37 42 N, 150 30 E, and 30 00 N, 149 00 E. At the beginning of mapping, just on the 7^{th} of July, we realized that the remarkable straight line from NWN to SES runs in the eastern part of the area. Sharp ridges with seamounts or knolls are also around the line, arranging en echelon. Soon after we passed some N-S lines with 6.5 mi spacing, we recognized this pattern is composed of en echelon ridges of L or “KU” in hiragana. Some reveres “Sadogashima” shape ridges (Sadogashima in the Japan Sea is of S-shape; reverse of which is of Z-shape) were also found. Also the knolls have often moats or wholes around them. The NWS-SES trending lines are sharp enough to think to be faults, cutting or demarcating the ridges. However, some NE-SW trending faults also cut the former trend. Thus we recognized at least three trends of ridges or faults; N20W, N60W, and N45E. The plausible idea to explain such arrangement is these are products of magma intrusion into three trends, and because the NWN trend is on the fracture zone, the N60W trend might be of extension fracture or Riedel shear (R1) under a left-lateral strike-slip (sinistral) shear regime. According to Nakanishi's NW Pacific magnetic lineament map (Nakanishi and Winterer, 1990), it is known that the Hokkaido Fracture Zone has approximately 400 to 600 km apparent displacement-bearing right-lateral strike-slip (dextral) dislocation. As known the NW Pacific Japanese lineament is of Jurassic-Cretaceous-Paleogene plate, younger toward NW. Therefore, the plausible spreading ridge which produced this lineament was already subducted along the NW Pacific convergent margin. This indicate that when the spreading ridge was there, the ridge-ridge transform fault had inversely left-lateral (Fig. ///).

We can easily reconstruct the relevant shear regime with extension fracture, Riedel shears etc. Possibly the N60 W trending ridges are products of magmatism along such extension fractures, whereas the N20W (NWN) trend ridges paralleling the fracture zone would be products along the leaky transform fault. This kind of leaky fault might be of two or more sets (Fig. /////). The N45E trend may be of the ridge trend itself, forming normal faults or others. The ridge and faults area is concentrated in the western part of the area C, so that this part should be the most adequate target for the future study.

R/V KAIREI

10. Peoposal for the Shorebase Study

S. Umino et al.

Eruptive styles of deep submarine volcanoes in the NE Japan Trench

Observation

D1-004, 008: Dense lava showing folded crust of ropy wrinkles on a sheet flows
D1-001 etc.: Vesicular lava block

K56 KAIKO video: Collapsed pahoehoe lobes present, but pillows?. Pahoehoe lobes sporadically expose flat collapsed roofs subparallel on steep, indicative of tilting of the entire block toward the trench. Volcanic breccia on an big outcrop? exposed on the sedimented slope of pahoehoe flows.

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Kiichiro Kawamura (Fukada Geological Institute) and Shunsuke Kawakami (Institute of Geoscience, University of Tsukuba)

We will study thermal alteration process of claystone covering olivine basalt. Some of the olivine basalts of D-1 and D-2 are covered with light brown claystone, which is composed of many siliceous microfossils, radiolatians, diatoms and sponges. Color of the claystone changes from light brown to dark brown gradually from the surface to the contact of the olivine basalt. If this color change indicates alteration of the claystone by thermal contact of the hot olivine basalt, the olivine basalt would be younger than the claystone. Therefore approximate eruption age of the olivine basalt might be estimated by that of the claystone determined by microfossils. In our study, there are two objects. One is formation process of the dark brown claystone; whether by thermal alteration or not, and another is determination of the claystone age by radiolarian fossils.

Microbiology

Siliceous microfossils will be studied by Dr. Shunsuke Kawakami, University of Tsukuba.

Yujiro Ogawa and others

Geology, topography and tectonics

Yujiro Ogawa (University of Tsukuba) will summarize general topography, geology and tectonics of the Hokkaido Rise and Hokkaido Fracture Zone.

Yujiro Ogawa and Susumu Umino and others will summarize the general topographic characteristics in the Area A-3, the Tanabata Knolls, concerning the magma eruption and related shear or extension fractures along the Hokkaido Fracture Zone. We will further propose the extensional survey with dredges in and around this area.

Kazunori Hatsuya

Kazunori Hatsuya (University of Tsukuba) will study geochemistry of manganese nodules, clay and claystone, etc. with Dr. Kosei Komuro of the same university.

Lee In Tae

Lee In Tae (Chonnam National University, Republic of Korea) will study sediments and sedimentary rocks for grain size analysis.

Katsunori Tanaka

Katsunori Tanaka (Graduate School of Life and Environmental Sciences, University of Tsukuba)
Yujiro Ogawa (Institute of Geoscience, University of Tsukuba)
Kiyofumi Suzuki (Institute of Geoscience, University of Tsukuba)

The sediments which were deposited in a forearc basin will undergo diagenesis and in some case acrreted to another forearc in a collision zone. Various structures of deformation, such as faulting and folding are preserved in sediment through acrretion.

In fact, in the southern part of Boso Peninsula, there are young acrretionary prisms, which remain the deformation structures such as duplication,imbricate thrusts and layer-parallel fault. Generally, they are thougt to be deformed during early stage of diagenesis.

By the intense exploration, each deformation structure is divided into many stages. However, the problems of the stress or strain paths, which the sediments undergone, are still remained to solve.

In this cruise, we could get many soft sediment(clay～silt) samples. So we will carry out the experiment of physical and mechanical tests, for the purpose of obtaining fundamental informations of the stress or strain states in the soft sediments.

Physical test

① Calculation of water content
② Distribution of particle size
③ Calculation of specific gravity of the sediment grains
④ The Atterberg limit test

Mechanical test

① Consolidation test (remould sample)

② Triaxial test (remould sample)

Soft X-ray radiographs

11. Future cruise proposal

We will propose the next cruise in many fashions as follows;

Idea A:
Diving to the places shallower than 6500 m to the volcanoes and volcanic ridges. A-1 and other areas.

Idea B:
Dredging to the places elsewhere. A-1, 2, and 3 areas.

Idea C:
Study the Hokkaido Fracture Zone and plausible volcanic sites in A-3 Area.

(unaccomplished)

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(Below is the reference collection under the courtesy of N. Hirano)
(unaccomplished)

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(((((Apendices)))))

Drege Samples (((list)))

Table List of dredged working samples

Dredge site	Sample NO.	Rock type	diameter (cm)	Roundness	Wt (g)	glass	Mn	Lithology and remarks
D1	1	volcanic and volcaniclastic rocks	16*13*10				0.2mm	massive ol-bearing aphjyric ba
D1	2	volcanic and volcaniclastic rocks	15*12*6				0.2mm	massive ol-bearing pahyric bas
D1	3	volcanic and volcaniclastic rocks	14*11*7					medium-vesicularity aphyric b
D1	4	volcanic and volcaniclastic rocks	12*9*8					massive aphyric basalt
D1	5	volcanic and volcaniclastic rocks	8*6.5*5					medium-vesicularity ol-bearing
D1	6	volcanic and volcaniclastic rocks	10*7*5					massive aphyric basalt
D1	7	volcanic and volcaniclastic rocks	8*6.5*5					high vesicularity ol-bearing ap
D1	8	volcanic and volcaniclastic rocks	7*7*5.5					massive ol-bearing aphyric bas
D1	9	volcanic and volcaniclastic rocks	7.5*6*5					aphyric basaltic volcanic tuff b
D1	10	volcanic and volcaniclastic rocks	6.5*5*4.5					massive ol-bearing aphyric bas
D1	11	volcanic and volcaniclastic rocks	6*5.5*4.5					high-vesicularity aphyric basa
D1	12	volcanic and volcaniclastic rocks	7*6*4					high-vesicularith aphyric basa
D1	13	volcanic and volcaniclastic rocks	8*6*4					massive ol-bearing aphyric bas
D1	14	volcanic and volcaniclastic rocks	6:4*3.5					massive ol-bearing aphyric bas
D1	15	volcanic and volcaniclastic rocks	8*4*3					high-vesicularity ol-bearing ap
D1	16	volcanic and volcaniclastic rocks	6*4.5*3					massive basaltic tuff
D1	17	volcanic and volcaniclastic rocks	5*4*4					massive ol-bearing aphyric bas
D1	18	volcanic and volcaniclastic rocks	7*5*2					massive ol-bearing aphyric bas
D1	19	volcanic and volcaniclastic rocks	6.5*4*3					medium-vesicularity ol-beariin
D1	20	volcanic and volcaniclastic rocks	7.5*6*2					massive ol-pl-bearing aphyric b
D1	21	volcanic and volcaniclastic rocks	7*6*3.5					high-vesicularity aphyric basa
D1	22	volcanic and volcaniclastic rocks	7:5*4.5					massive col-pl dolerite
D1	23	volcanic and volcaniclastic rocks	8*6*3.5					medium-vesicularity ol-bearing
D1	24	volcanic and volcaniclastic rocks	7.5*5.5*4					massive aphyric basalt
D1	25	volcanic and volcaniclastic rocks	5.5*5*4					high-vesicularity aphyric basa
D1	26	volcanic and volcaniclastic rocks	7.5*4*3					massive aphyric basalt
D1	201	sedimentary rocks	9*8*5					altered radiolarite
D1	202	sedimentary rocks	7*5*4					altered radiolarite
D1	203	sedimentary rocks	5.5*3.5*3					altered radiolarite

D1	204	sedimentary rocks	4.5*3.5*2			altered radiolarite
D1	205	sedimentary rocks	3.5*3*2.5			altered radiolarite
D1	206	sedimentary rocks	4*4*2.5			altered radiolarite
D1	301	other rocks	3.5*3*2			altered radiolarite, contact of a
D1	302	other rocks				cutted dense basalt (3 blocks),
D1	303	other rocks				10 pebble size aphyric rocks w
D1	304	other rocks	7*5*2			clast consists of mainly block s
D1	305	other rocks				5 radiolarite of pebble size
D1	306	other rocks	3*2*1			tuff breccia with aphyric basal
D1	307	other rocks				9 fragments of aphyric lava
D2	1	vesicular flow with glass rind	24*15*15	7mm	0.2mm	medium-vesicularity moderate
D2	2	vesicular flow with glass rind	13*11*11	9mm		high-vesicularity sparsely ol-p
D2	3	vesicular flow with glass rind	19*15.5*13	10mm		medium-vesicularity sparsely
D2	4	vesicular flow with glass rind	12*10*9	3mm		high-vesicularity sparsely ol-p
D2	5	vesicular flow with glass rind	13*10*8	14mm	2.5mm	high-vesicularity moderately o
D2	6	vesicular flow with glass rind	10.5*10*8	7mm	3mm	high vesicularith ol-bearing ap
D2	7	vesicular flow with glass rind	10.5*10.5*10	8mm		high-vesicularith ol-bearing ap
D2	8	vesicular flow with glass rind	10*8*8	10mm		medium-vesicularity ol-bearing
D2	9	vesicular flow with glass rind	13*10.5*10	12mm	0.5mm	medium-vesicularity ol-bearing
D2	10	vesicular flow with glass rind	12*9*8	5mm	10mm	medium-vesicularity ol-phyric
D2	11	vesicular flow with glass rind	12*10*6	15mm		medium-vesicularity ol-bearing
D2	12	vesicular flow with glass rind	10*8*6	7mm	3mm	high-vesicularity sparesely ol-p
D2	13	vesicular flow with glass rind	11*6*5	3mm		medium-vesicularity sparesely
D2	14	vesicular flow with glass rind	10*8*5	5mm		high-vesicularity sparesely ol-p
D2	15	vesicular flow with glass rind	8:6*5.5	7mm		low-vesicularity aphyric ol-bea
D2	16	vesicular flow with glass rind	10*9*8	5mm		high-vesicularity ol-phyric bas
D2	17	vesicular flow with glass rind	15*11*8	5mm	40~80mm	high-vesicularity aphyric ol-ph
D2	18	vesicular flow with glass rind	9*9*7.5	12mm		low-vesicularity aphyric ol-be
D2	19	vesicular flow with glass rind	10*9.5*5	7mm		medium-vesicularity aphyric o
D2	20	vesicular flow with glass rind	21*17*14	80mm		medium-vesicularity ol-phyric
D2	21	vesicular flow with glass rind	30*22*18	5mm		low-vesicularity ol-bearing aph
D2	22	vesicular flow with glass rind	8*5*3	5mm		high-vesicularity aphyric ol-be
D2	23	vesicular flow with glass rind	10.5*8*6	10mm		low-vesicularity aphyric ol-bea

D2	24	vesicular flow with glass rind	12*9*5	3mm		medium-vesicularity ol-phyric
D2	25	vesicular flow with glass rind	11*9*6	4mm		high-vesicularity ol-bearing ap
D2	26	vesicular flow with glass rind	10*8*7	8mm		high-vesicularity ol-bearing ap
D2	27	vesicular flow with glass rind	7.5*6.3*4.3	5mm		medium-vesicularity ol-bearing
D2	28	vesicular flow with glass rind	8*6*4.5	12mm		medium-vesicularity ol-bearing
D2	29	vesicular flow with glass rind	7.5*6.5*5.5	7mm		high-vesicularity ol-phyric bas
D2	30	vesicular flow with glass rind	7.6*5*4.3	5mm		medium-vesicularity ol-bearing
D2	31	vesicular flow with glass rind	7*6*3.5	12mm		medium-vesicularity ol-phyric
D2	32	vesicular flow with glass rind	15*10*8	10mm		medium-vesicularity ol-phyric
D2	33	vesicular flow with glass rind	6*5*4	6mm		medium-vesicularity ol-phyric
D2	34	vesicular flow with glass rind	36*24*21	10mm		medium-vesicularity ol-phyric
D2	35	vesicular flow with glass rind	16*10*9	5mm		medium-vesicularity ol-phyric
D2	36	vesicular flow with glass rind	10*8*5.5	3mm		medium-vesicularity ol-phyric
D2	37	vesicular flow with glass rind	11*11*8	10mm		high-vesicularity ol-phyric bas
D2	101	volcaniclastic rocks	11*9*5			scoriaceous basalt clast cemen
D2	102	volcaniclastic rocks	7*5*4.5			round bebble of darkbrown tuf
D2	103	volcaniclastic rocks	9*6*3			porphyritic gabbro with plagio
D2	104	volcaniclastic rocks	8*6*2			angular clast of sandstone
D2	201	vesicular flow with Mn crust	7.5*7*6.5		4mm	massive aphyric basalt
D2	202	vesicular flow with Mn crust	24*17*11		34mm	low-vesicularity aphyric basalt
D2	203	vesicular flow with Mn crust	12*10*9		9mm	low-vesicularity aphyric basalt
D2	204	vesicular flow with Mn crust	13.5*12.5*8		4mm	medium-vesicularith ol-phyriic
D2	205	vesicular flow with Mn crust	13*10*9		3mm	high-vesicuularity ol-bearing a
D2	206	vesicular flow with Mn crust	20*14*6		10mm	medium-vesicularity ol-phyric
D2	207	vesicular flow with Mn crust	12*10.5*4.5		10mm	medium-vesicularity aphyric b
D2	208	vesicular flow with Mn crust	9*8*8		20mm	low-vesicularity aphyric basalt
D2	209	vesicular flow with Mn crust	7*7*5		2mm	low-vesicularity aphyric basalt
D2	210	vesicular flow with Mn crust	24*17*11		8mm	medium-vesicularity ol-bearing
D2	211	vesicular flow with Mn crust	19*18*13		3mm	high-vesicularity aphyric basa
D2	212	vesicular flow with Mn crust	7.5*7*6.5		3mm	medium-vesicularityy aphyric
D2	213	vesicular flow with Mn crust	22*20*16		25mm	medium-vesicularity ol-phyric
D2	214	vesicular flow with Mn crust	37*28*18		3mm	medium-vesicularity ol-bearing
D2	215	vesicular flow with Mn crust	8*7*7		18mm	medium-vesicularity ol-bearing

D2	301	other volcanic rocks	23*12*12		massive aphyric basalt, flow st
D2	302	other volcanic rocks	15*10.5*9		massive aphyric basalt, chilled
D2	303	other volcanic rocks	12*7.5*6	28mm	massive aphyric basalt
D2	304	other volcanic rocks	16*12*8		low-vesicularity altered aphyri
D2	305	other volcanic rocks	11*8*6		massive abundantly aug-ol-ph
D2	306	other volcanic rocks	6*4*3.5		low-vesicularity aphyric basalt
D2	307	other volcanic rocks	5*3.5*3.2		hb-pl holocrystalline diorite po
D2	308	other volcanic rocks	25.5*25*16		mussive abundantly pl-aug-ph
D2	309	other volcanic rocks	15*15*8	thin	very low-vesicularity ol-px bea
D2	310	other volcanic rocks	9*8*5	8mm	high-vesicularity altered ol-ph
D2	311	other volcanic rocks	9.5*8*4.2		massive ph-phyric basalt
D2	401	vesicular aphyric flow	17*11*7		medium-vesicularity ol-bearin
D2	402	vesicular aphyric flow	15*12*10		medium-vesicularity ol-bearin
D2	403	vesicular aphyric flow	14*12*9		medium-vesicularity ol-bearin
D2	404	vesicular aphyric flow	10*9*7		medium-vesicularity ol-bearin
D2	405	vesicular aphyric flow	14*13*8		medium-vesicularity ol-bearin
D2	406	vesicular aphyric flow	10*7*6		medium-vesicularity ol-bearin
D2	407	vesicular aphyric flow	10*8*7	thin	medium-vesicularity ol-bearin
D2	408	vesicular aphyric flow	9*6*4		medium-vesicularity ol-bearin
D2	409	vesicular aphyric flow	7*6*5		medium-vesicularity aphyric b
D2	410	vesicular aphyric flow	9*7*6		high-vesicularity ol-bearing ap
D2	411	vesicular aphyric flow	7*5*5		medium-vesicularity ol-bearin
D2	412	vesicular aphyric flow	7*5*3		medium-vesicularity ol-bearin
D2	413	vesicular aphyric flow	13*11*7	thin	medium-vesicularity ol-bearin
D2	414	vesicular aphyric flow	10*9*7		medium-vesicularity ol-bearin
D2	415	vesicular aphyric flow	12*12*9	thin	medium-high-vesicularity ol-be
D2	416	vesicular aphyric flow	12*9*7		medium-vesicularity ol-bearin
D2	417	vesicular aphyric flow	14*13*9		medium-vesicularity ol-bearin
D2	418	vesicular aphyric flow	13*10*9		low-vesicularity ol-bearing aph
D2	419	vesicular aphyric flow	9*8*6		medium-vesicularity aphyric b
D2	420	vesicular aphyric flow	7*6*5		medium-vesicularity ol-bearin
D2	421	vesicular aphyric flow	18*15*9		medium-vesicularity aphyric b
D2	422	vesicular aphyric flow	8*8*5	thin	high-vesicularity ol-bearing ap

D2	423	vesicular aphyric flow	14*8*4			medium-vesicularity ol-bearing
D2	424	vesicular aphyric flow	14*10*6			medium-vesicularity ol-bearing
D2	425	vesicular aphyric flow	11*9*8			medium-vesicularity ol-bearing
D2	426	vesicular aphyric flow	15*12*9			high-vesicularity ol-bearing ap
D2	427	vesicular aphyric flow	12*10*7			medium-vesicularity ol-bearing
D2	428	vesicular aphyric flow	13*11*9			medium-vesicularity ol-bearing
D2	429	vesicular aphyric flow	13*10*8		thin	high-vesicularity aphyric basa
D2	430	vesicular aphyric flow	18*13*13			medium-vesicularity ol-bearing
D2	431	vesicular aphyric flow	12*6*5		thin~1mm	medium-vesicularity ol-bearing
D2	432	vesicular aphyric flow	14*7*5		thin	medium-vesicularity ol-bearing
D2	433	vesicular aphyric flow	12*8*8			medium-vesicularity ol-bearing
D2	434	vesicular aphyric flow	12*8*7			medium-vesicularity ol-bearing
D2	435	vesicular aphyric flow	13*10*5			medium-vesicularity ol-bearing
D2	436	vesicular aphyric flow	11*6*5		thin	medium-vesicularity ol-bearing
D2	437	vesicular aphyric flow	6*5*4			medium-vesicularity aphyric b
D2	438	vesicular aphyric flow	10*6*5			medium-vesicularity ol-bearing
D2	439	vesicular aphyric flow	9*8*6			medium-vesicularity ol-bearing
D2	440	vesicular aphyric flow	9*6*3		thin	high-vesicularity aphyric basa
D2	441	vesicular aphyric flow	8*6*5			medium-vesicularity ol-bearing
D2	442	vesicular aphyric flow	8*6*5			medium-vesicularity ol-bearing
D2	443	vesicular aphyric flow	7*6*5			medium-vesicularity ol-bearing
D2	444	vesicular aphyric flow	8*7*6			medium-vesicularity ol-bearing
D2	445	vesicular aphyric flow	7*6*4			medium-vesicularity ol-bearing
D2	446	vesicular aphyric flow	6*6*4			high-vesicularity ol-bearing ap
D2	447	vesicular aphyric flow	4*4*2.5			medium-vesicularity ol-bearing
D2	448	vesicular aphyric flow	12*10*9		thin	high-vesicularity ol-bearing ap
D2	449	vesicular aphyric flow	11*10*7			medium-vesicularity ol-bearing
D2	450	vesicular aphyric flow	8*7*5			medium-vesicularity ol-bearing
D2	451	vesicular aphyric flow	20*19*13		thin	low-vesicularity ol-bearing aph
D2	452	vesicular aphyric flow	10*7*5			meduim-vesicularity ol-bearing
D2	453	vesicular aphyric flow	10*5*5	thin		meduim-vesicularity ol-bearing
D2	454	vesicular aphyric flow	10*7*6			meduim-vesicularity ol-bearing
D2	455	vesicular aphyric flow	10*8*6		thin~1mm	meduim-vesicularity ol-bearing
D2	456	vesicular aphyric flow	10*8*8		thin~1mm	meduim-vesicularity ol-bearing
D2	457	vesicular aphyric flow	9*5*5	thin		meduim-vesicularity ol-bearing

D2	458	vesicular aphyric flow	13*12*11	10mm		meduim-vesicularity ol-bearing
D2	459	vesicular aphyric flow	8*6*3			meduim-vesicularity ol-bearing
D2	460	vesicular aphyric flow	10:8*6		thin~5mm	high-vesicularity ol-bearing ap
D2	461	vesicular aphyric flow	9*8*5			low-vesicularity ol-bearing aph
D2	462	vesicular aphyric flow	13*10*5			low-vesicularity ol-bearing aph
D2	463	vesicular aphyric flow	10*6*5			low-vesicularity ol-bearing aph
D2	464	vesicular aphyric flow	6*5*4			low-vesicularity ol-bearing aph
D2	465	vesicular aphyric flow	10*6*4	thin		low-vesicularity ol-bearing aph
D2	466	vesicular aphyric flow	10*10*5			low-vesicularity ol-bearing aph
D2	467	vesicular aphyric flow	8*5*4	thin		low-vesicularity ol-bearing aph
D2	468	vesicular aphyric flow	14*12*6			low-vesicularity ol-bearing aph
D2	469	vesicular aphyric flow	10*7*5			high-vesicularity ol-bearing ap
D2	470	vesicular aphyric flow	8*5*5		~15mm	low-vesicularity ol-bearing aph
D2	471	vesicular aphyric flow	8*6*5			low-vesicularity ol-bearing aph
D2	472	vesicular aphyric flow	11*5*4		~2mm	high-vesicularity ol-bearing ap
D2	473	vesicular aphyric flow	14*9*6			low-vesicularity ol-bearing aph
D2	474	vesicular aphyric flow	9*7*4	thin		low-vesicularity ol-bearing aph
D2	475	vesicular aphyric flow	15*12*9		~2mm	low-vesicularity ol-bearing aph
D2	476	vesicular aphyric flow	12*9*5		thin	low-vesicularity ol-bearing aph
D2	477	vesicular aphyric flow	7*6*6			medium-vesicularity ol-bearing
D2	478	vesicular aphyric flow	9*6*6			medium-vesicularity ol-bearing
D2	479	vesicular aphyric flow	10*8*8			medium-vesicularity ol-bearing
D2	480	vesicular aphyric flow	7*6*5			medium-vesicularity ol-bearing
D2	481	vesicular aphyric flow	5*4*3			medium-vesicularity ol-bearing
D2	482	vesicular aphyric flow	8*6*5			medium-vesicularity ol-bearing
D2	483	vesicular aphyric flow	2*2*3			high-vesicularity ol-bearing ap
D2	484	vesicular aphyric flow	17*9*8		~3mm	high-vesicularity ol-bearing ap
D2	485	vesicular aphyric flow	11.6*8.5*6.2		thick	medium-vesicularity ol-bearing
D2	486	vesicular aphyric flow	10.2*7.3*6.4			low-vesicularity ol-bearing aph
D2	487	vesicular aphyric flow	9.3*8*6.4			high-vesicularity ol-bearing ap
D2	488	vesicular aphyric flow	10.6*7.4*6.2			medium-vesicularity ol-bearing
D2	489	vesicular aphyric flow	7*7*4.2			high-vesicularity ol-bearing ap
D2	490	vesicular aphyric flow	9.6*8.4*6.0			medium-vesicularity ol-bearing
D2	491	vesicular aphyric flow	8.2*8*6			medium-vesicularity ol-bearing
D2	492	vesicular aphyric flow	8.2*5.5*5			medium-vesicularity ol-bearing

D2	493	vesicular aphyric flow	9.2*6.4*5.5	high-vesicularity ol-bearing ap
D2	494	vesicular aphyric flow	9.2*4.4*4	medium-vesicularity ol-bearing
D2	495	vesicular aphyric flow	4.6*4.5*3.6	medium-vesicularity ol-bearing
D2	496	vesicular aphyric flow	7*6.5*4.5	low-vesicularity ol-bearing aph
D2	497	vesicular aphyric flow	6.9*4.7*4	medium-vesicularity ol-bearing
D2	498	vesicular aphyric flow	9.3*5.6*4.7	medium-vesicularity ol-bearing
D2	499	vesicular aphyric flow	6.9*5.9*5	medium-vesicularity ol-bearing
D2	1400	vesicular aphyric flow	10*5*3.8	medium-vesicularity aphyric b
D2	1401	vesicular aphyric flow	6.4*5*4.4	medium-vesicularity ol-bearing
D2	1402	vesicular aphyric flow	9*6.1*2.8	medium-vesicularity ol-bearing
D2	1403	vesicular aphyric flow	7.6*5.6*4.4	high-vesicularity aphyric basa
D2	1404	vesicular aphyric flow	6.3*5.6*3.8	medium-vesicularity ol-bearing
D2	1405	vesicular aphyric flow	8.5*4.6*4.6	medium-vesicularity ol-bearing
D2	1406	vesicular aphyric flow	7.4*5.5*4.6	medium-vesicularity aphyric b
D2	1407	vesicular aphyric flow	7.3*5.4*2	low-vesicularity ol-bearing aph
D2	1408	vesicular aphyric flow	5.6*4.9*3.9	low-vesicularity ol-bearing aph
D2	1409	vesicular aphyric flow	5.9*5.6*4	low-vesicularity ol-bearing aph
D2	1410	vesicular aphyric flow	6.3*5.5*4.9	high-vesicularity ol-bearing ap
D2	1411	vesicular aphyric flow	7.3*5.3*4.3	medium-vesicularity ol-bearing
D2	1412	vesicular aphyric flow	6.5*5.4*4	medium-vesicularity ol-bearing
D2	1413	vesicular aphyric flow	5.5*4.9*4.3	medium-vesicularity ol-bearing
D2	1414	vesicular aphyric flow	6.3*5*4.2	medium-vesicularity ol-bearing
D2	1415	vesicular aphyric flow	6.7*5.6*3.9	medium-vesicularity ol-bearing
D2	1416	vesicular aphyric flow	6.5*5.5*4.2	medium-vesicularity ol-bearing
D2	1417	vesicular aphyric flow	5.5*4.3*4.3	medium-vesicularity ol-bearing
D2	1418	vesicular aphyric flow	6.6*4.9*4.7	medium-vesicularity ol-bearing
D2	1419	vesicular aphyric flow	7.1*5*3.6	medium-vesicularity aphyric b
D2	1420	vesicular aphyric flow	6.8*4.7*4	high-vesicularity ol-bearing ap
D2	1421	vesicular aphyric flow	7.3*5.6*3.9	medium-vesicularity ol-bearing
D2	1422	vesicular aphyric flow	8*6*2.9	high-vesicularity ol-bearing ap
D2	1423	vesicular aphyric flow	5.5*4.6*3.8	high-vesicularity ol-bearing ap
D2	1424	vesicular aphyric flow	8.5*3.6*3.4	medium-vesicularity ol-bearing
D2	1425	vesicular aphyric flow	6.7*5.5*4	high-vesicularity ol-bearing ap
D2	1426	vesicular aphyric flow	5.9*4.9*4.6	medium-vesicularity ol-bearing
D2	1427	vesicular aphyric flow	7.2*4.6*3.9	medium-vesicularity ol-bearing

D2	1428	vesicular aphyric flow	6.4*6.3*3.4		medium-vesicularity ol-bearing
D2	1429	vesicular aphyric flow	5*4.6*3.9		medium-vesicularity ol-bearing
D2	1430	vesicular aphyric flow	5.2*5.1*3.9		high-vesicularity ol-bearing ap
D2	1431	vesicular aphyric flow	4.9*4.4*3.8		medium-vesicularity ol-bearing
D2	1432	vesicular aphyric flow	8.5*5*3.9		medium-vesicularity ol-bearing
D2	1433	vesicular aphyric flow	8.2*4.5*2.6		high-vesicularity ol-bearing ap
D2	1434	vesicular aphyric flow	5.6*4.3*4		medium-vesicularity ol-bearing
D2	1435	vesicular aphyric flow	5.5*4.3*4.2		medium-vesicularity ol-bearing
D2	1436	vesicular aphyric flow	5.9*3.8*3.8		medium-vesicularity ol-bearing
D2	1437	vesicular aphyric flow	6.5*4*2.9		medium-vesicularity ol-bearing
D2	1438	vesicular aphyric flow	4.4*3.2*2.3		medium-vesicularity ol-bearing
D2	1439	vesicular aphyric flow	4.7*3.4*2.6		high-vesicularity ol-bearing ap
D2	1440	vesicular aphyric flow	7.7*5.6*3.9		low-vesicularity ol-bearing aph
D2	1441	vesicular aphyric flow	9.6*6.6*5.5		low-vesicularity ol-bearing aph
D2	501	vesicular olivine-phyric flow	13*9*9		medium-vesicularity ol-phyric
D2	502	vesicular olivine-phyric flow	19*19*13		low-vesicularity ol-phyric basa
D2	503	vesicular olivine-phyric flow	16*13*12		medium-vesicularity ol-phyric
D2	504	vesicular olivine-phyric flow	13*12*9		low-vesicularity ol-phyric basa
D2	505	vesicular olivine-phyric flow	20*18*9	thin~3mm	medium-vesicularity ol-phyric
D2	506	vesicular olivine-phyric flow	11*10*5		low-vesicularity ol-phyric basa
D2	507	vesicular olivine-phyric flow	15*9*5	thin~1mm	medium-vesicularity ol-phyric
D2	508	vesicular olivine-phyric flow	13*8*6		low-vesicularity ol-phyric basa
D2	509	vesicular olivine-phyric flow	11*8*6		low-vesicularity ol-phyric basa
D2	510	vesicular olivine-phyric flow	12*10*10		low-vesicularity ol-phyric basa
D2	511	vesicular olivine-phyric flow	11*9*7		high-vesicularity ol-phyric bas
D2	512	vesicular olivine-phyric flow	13*8*6		medium-vesicularity ol-phyric
D2	513	vesicular olivine-phyric flow	11*11*7		medium-vesicularity ol-phyric
D2	514	vesicular olivine-phyric flow	12*10*8		medium-vesicularity ol-phyric
D2	515	vesicular olivine-phyric flow	12*9*6		medium-vesicularity ol-phyric
D2	516	vesicular olivine-phyric flow	14*12*8		medium-vesicularity ol-phyric
D2	517	vesicular olivine-phyric flow	14*11*7		medium-vesicularity ol-phyric
D2	518	vesicular olivine-phyric flow	14*9*6	thin	medium-vesicularity ol-phyric
D2	519	vesicular olivine-phyric flow	12*8*7		medium-vesicularity ol-phyric
D2	520	vesicular olivine-phyric flow	9*8*4		medium-vesicularity ol-phyric

D2	521	vesicular olivine-phyric flow	13*11*7		medium-vesicularity ol-phyric
D2	522	vesicular olivine-phyric flow	13*8*6	thin~1mm	low-vesicularity ol-phyric basa
D2	523	vesicular olivine-phyric flow	10*7*4		medium-vesicularity ol-phyric
D2	524	vesicular olivine-phyric flow	12*7*6		medium-vesicularity ol-phyric
D2	525	vesicular olivine-phyric flow	8*6*4		medium-vesicularity ol-phyric
D2	526	vesicular olivine-phyric flow	8*6*5	~3mm	high-vesicularity ol-phyric bas
D2	527	vesicular olivine-phyric flow	9*8*6		low-vesicularity ol-phyric basa
D2	528	vesicular olivine-phyric flow	9*6*4		very low-vesicularity ol-phyric
D2	529	vesicular olivine-phyric flow	10*8*5		medium-vesicularity ol-phyric
D2	530	vesicular olivine-phyric flow	8*7*5		low-vesicularity ol-phyric basa
D2	531	vesicular olivine-phyric flow	8*7*6		medium-vesicularity ol-phyric
D2	532	vesicular olivine-phyric flow	7*6*5		medium-vesicularity ol-phyric
D2	533	vesicular olivine-phyric flow	7*7*5		low-vesicularity ol-phyric basa
D2	534	vesicular olivine-phyric flow	7*5*4		medium-vesicularity ol-phyric
D2	535	vesicular olivine-phyric flow	8*5*4		low-vesicularity ol-phyric basa
D2	536	vesicular olivine-phyric flow	7*6*4		medium-vesicularity ol-phyric
D2	537	vesicular olivine-phyric flow	8*5*4		high-vesicularity ol-phyric bas
D2	538	vesicular olivine-phyric flow	9*7*5		very low-vesicularity ol-phyric
D2	539	vesicular olivine-phyric flow	11*8*4		low-vesicularity ol-phyric basa
D2	540	vesicular olivine-phyric flow	9*6*4		medium-vesicularity ol-phyric
D2	541	vesicular olivine-phyric flow	7*6*5		medium-vesicularity ol-phyric
D2	542	vesicular olivine-phyric flow	7*6*3		low-vesicularity ol-phyric basa
D2	543	vesicular olivine-phyric flow	9*5*3		medium-vesicularity ol-phyric
D2	544	vesicular olivine-phyric flow	6*5*4		medium-vesicularity ol-phyric
D2	545	vesicular olivine-phyric flow	8*5*3		very low-vesicularity ol-phyric
D2	546	vesicular olivine-phyric flow	10*7*5		medium-vesicularity ol-phyric
D2	547	vesicular olivine-phyric flow	9*6*4	thin	medium-vesicularity ol-phyric
D2	548	vesicular olivine-phyric flow	15*10*5		medium-vesicularity ol-phyric
D2	549	vesicular olivine-phyric flow	11*10*7		low-vesicularity ol-phyric basa
D2	550	vesicular olivine-phyric flow	18*13*10		medium-vesicularity ol-phyric
D2	551	vesicular olivine-phyric flow	26*20*16		medium-vesicularity ol-phyric
D2	552	vesicular olivine-phyric flow	7*7*7		medium-vesicularity ol-phyric
D2	553	vesicular olivine-phyric flow	16*14*10		medium-vesicularity ol-phyric
D2	554	vesicular olivine-phyric flow	26*12*8		medium-vesicularity ol-phyric
D2	555	vesicular olivine-phyric flow	10*8*6		medium-vesicularity ol-phyric

D2	556	vesicular olivine-phyric flow	11*10*9		thin~3mm	medium-vesicularity ol-phyric
D2	557	vesicular olivine-phyric flow	10*6*6		thin~3mm	medium-vesicularity ol-phyric
D2	558	vesicular olivine-phyric flow	13*7*6		~2mm	medium-vesicularity ol-phyric
D2	559	vesicular olivine-phyric flow	12*11*7			medium-vesicularity ol-phyric
D2	560	vesicular olivine-phyric flow	19*12*8			medium-vesicularity ol-phyric
D2	561	vesicular olivine-phyric flow	10*6*5			low-vesicularity ol-phyric basa
D2	562	vesicular olivine-phyric flow	11*10*5			medium-low-vesicularity ol-ph
D2	563	vesicular olivine-phyric flow	10*10*8			low-vesicularity ol-phyric basa
D2	564	vesicular olivine-phyric flow	10*6*2			low-vesicularity ol-phyric basa
D2	565	vesicular olivine-phyric flow	12*7*6			medium-vesicularity ol-phyric
D2	566	vesicular olivine-phyric flow	9*8*6			medium-vesicularity ol-phyric
D2	567	vesicular olivine-phyric flow	7*6*5	thin		medium-vesicularity ol-phyric
D2	568	vesicular olivine-phyric flow	14*10*7	3mm		medium-vesicularity ol-phyric
D2	569	vesicular olivine-phyric flow	20*13*10			medium-vesicularity ol-phyric
D2	570	vesicular olivine-phyric flow	8.5*7.2*6.9			medium-vesicularity ol-phyric
D2	571	vesicular olivine-phyric flow	9.4*8.5*5.1			medium-vesicularity ol-phyric
D2	572	vesicular olivine-phyric flow	8.6*7*4.8			medium-vesicularity ol-phyric
D2	573	vesicular olivine-phyric flow	6.3*5.8*5.1			medium-vesicularity ol-phyric
D2	574	vesicular olivine-phyric flow	8.7*8.4*6/9			low-vesicularity ol-phyric basa
D2	575	vesicular olivine-phyric flow	8.4*6.2*6			low-vesicularity ol-phyric basa
D2	576	vesicular olivine-phyric flow	10.4*6.5*5.2	4mm		medium-vesicularity ol-phyric
D2	577	vesicular olivine-phyric flow	8.4*6.8*5.3			medium-vesicularity ol-phyric
D2	578	vesicular olivine-phyric flow	7.9*5.6*4.9			medium-vesicularity ol-phyric
D2	579	vesicular olivine-phyric flow	10*7.4*4.8			high-vesicularity ol-phyric bas
D2	580	vesicular olivine-phyric flow	7*5.9*4.5			medium-vesicularity ol-phyric
D2	581	vesicular olivine-phyric flow	7.1*5.7*4.5	1mm		low-vesicularity ol-phyric basa
D2	582	vesicular olivine-phyric flow	9.1*5.5*4.4			medium-vesicularity ol-phyric
D2	583	vesicular olivine-phyric flow	5.6*5.5*3.1			low-vesicularity ol-phyric basa
D2	584	vesicular olivine-phyric flow	6.1*4.8*4			high-vesicularity ol-phyric bas
D2	585	vesicular olivine-phyric flow	6.2*5.8*4.7			medium-vesicularity ol-phyric
D2	586	vesicular olivine-phyric flow	7*4.8*2.5	1mm		high-vesicularity ol-phyric bas
D2	587	vesicular olivine-phyric flow	6.1*6>4.9			low-vesicularity ol-phyric basa
D2	588	vesicular olivine-phyric flow	5.4*5*4			low-vesicularity ol-phyric basa
D2	589	vesicular olivine-phyric flow	6.3*5.9*3.5			low-vesicularity ol-phyric basa
D2	590	vesicular olivine-phyric flow	7.3*4.3*3.7			medium-vesicularity ol-phyric

D2	591	vesicular olivine-phyric flow	6.2*4.7*3.2		low-vesicularity ol-phyric basa
D2	592	vesicular olivine-phyric flow	6.2*5.4*3.1		low-vesicularity ol-phyric basa
D2	593	vesicular olivine-phyric flow	6.6*4.7*4.1		medium-vesicularity ol-phyric
D2	594	vesicular olivine-phyric flow	6*5.7*3.7		medium-vesicularity ol-phyric
D2	595	vesicular olivine-phyric flow	6.9*5.8*5.3		medium-vesicularity ol-phyric
D2	596	vesicular olivine-phyric flow	8.3*7.2*4		low-vesicularity ol-phyric basa
D2	597	vesicular olivine-phyric flow	5.9*4.2*3.2		low-vesicularity ol-phyric basa
D2	598	vesicular olivine-phyric flow	7.3*4*3.3		low-vesicularity ol-phyric basa
D2	599	vesicular olivine-phyric flow	6.2*5.7*4		low-vesicularity ol-phyric basa
D2	1500	vesicular olivine-phyric flow	7.2*6*5.3		medium-vesicularity ol-phyric
D2	1501	vesicular olivine-phyric flow	6.7*5.4*4.1		medium-vesicularity ol-phyric
D2	1502	vesicular olivine-phyric flow	6.5*5.5*3.4		low-vesicularity ol-phyric basa
D2	1503	vesicular olivine-phyric flow	7*4.2*3.9		medium-vesicularity ol-phyric
D2	1504	vesicular olivine-phyric flow	9.4*4.2*1.9		medium-vesicularity ol-phyric
D2	1505	vesicular olivine-phyric flow	5:4*2.7		low-vesicularity ol-phyric basa
D2	1506	vesicular olivine-phyric flow	5*4.4*3.1		low-vesicularity ol-phyric basa
D2	1507	vesicular olivine-phyric flow	5*3.5*3		medium-vesicularity ol-phyric
D2	601	other rocks	15*13*6		medium-grained sandstone, co
D2	602	other rocks	8*7*4		chert
D2	603	other rocks	10.5*8*7		massive ol-bearing aphyric bas
D2	604	other rocks	6.5*6*2		medium-grained sandstone, an
D2	605	other rocks	9*7*6.5	2mm	pumice with Mn oxide and sed
D2	606	other rocks	13.5*7*5		Mn clast
D2	607	other rocks	5.5*5*3.5		Mn clast with yelllowish brow
D2	608	other rocks	25*19*17		Mn nodule including small peb
D2	609	other rocks	9*8.5*8		Mn nodule including small peb
D2	610	other rocks	9*7*6.5		Mn nodule including small peb
D2	611	other rocks	14*9*4.5		Mn nodule
D2	612	other rocks	11*8*6		Mn nodule, with aphyric basal
D2	613	other rocks	10*8*6.5		Mn nodule with small pebbles
D2	614	other rocks	25*10*12		Mn nodule
D2	615	other rocks	9*7*4	5mm	volcanic breccia in red ooze
D2	616	other rocks	4*3*1		brecciated serpentinite
D2	617	other rocks	7*4*3		sheared breccia

D2	618	other rocks	6*5*1		ultramafic rock~serpentinite
D2	619	other rocks	4*3*1		probably aphyric basaltic rocks
D2	620	other rocks	7*5*3		fine grained granite, dropped s
D2	621	other rocks	4*3*2		breccia
D2	622	other rocks	5*4*3	1mm	pumice
D2	623	other rocks	7*6*6		Mn nodule with small pebbles
D2	624	other rocks	6*5*4	15mm	Mn nodule with massive ol-phy
D2	625	other rocks	6*4*4		tuff breccia
D2	626	other rocks	5*4.5*2		altered acidic tuff
D2	627	other rocks	8*8*6		Mn nodule with mussive basal
D2	628	other rocks	9*5*3		Mn clast with with clay blork
D2	629	other rocks	6.5*5*2.5		massive acidic tuff
D2	630	other rocks	6*5*4.5		Mn clast
D2	631	other rocks	6*3*2		Mn nodule with massive basal
D2	632	other rocks	10*4*3		light gray tuffaceous sandston
D2	633	other rocks	9*5*3		layered silt-sandstone
D2	634	other rocks	5*4*4		aphyric basalt with sediment l
D2	635	other rocks	5*3*2.5		claystone
D2	636	other rocks	20*15*9		Mn crust with pebbles, mudsto
D2	701	undescribed rocks			
D2	702	undescribed rocks			
D2	703	undescribed rocks			
D2	704	undescribed rocks			
D2	705	undescribed rocks			
D3	1	pebbles			pebbles

ドレッジマニュアル　文責：石井輝秋（東大海洋研）2003 年 6 月 28 日

船側との事前打ち合わせ事項

（1）ドレッジの研究目的を説明し、理解を得る。

（2）着底点、目標点の位置、水深の数値と地形図のプロットを知らせる。

（3）ドレッジの曳く方向の選定に関しては、急峻な地形に正対し、後進可能な方向を選ぶ（潮、風を考慮）---船側と相談する。

（4）船長には後部制御室での操船をお願いする。

（5）モニター上に出るドレッジごとの航跡のハードコピーを依頼する。

ドレッジ作業

０・ドレッジとテンションメーターのセットアップ。

１・着底予定点上で停船。

２・ドレッジ投入後着底直前まで船位を保持、ワイヤーは full で出す。

３・W.O（ワイヤーアウト）を水深-200m で stop。

４・目標点に向かい、前進を開始し、1kt の行き足がついたらワイヤーを full で出す。

５・テンションメーターで着底を確認できたら W.O.を 0.5m/s に落とす。

６・着底から 100m ワイヤーを出してウインチをストップ、ドレッジの対地速度を 0.5m/s（約 1kt）に保つようにドレッジを曳きながら前進。

７・テンションが 6mm ヒューズワイヤーの破断荷重 1.5t を超えないように主にウインチそして船速とでコントロールする--メインワイヤーを着底させないように注意！

８・1.0t 程度の大きな当たりが３、４回あれば巻き上げ開始

９・この時 W.I.（ワイヤーイン）0.2m/s (0.4kt)、船速を 0.5kt とする（つまりこの時のドレッジの対地速度は 0.9kt）

１０・離底を確認したら full で引き上げる

スタックした時

１・ヒューズワイヤーφ=6mm、破断荷重 1.5t と、命綱　φ=6mm、破断荷重 1.5t が同じ強度のため、ドレッジ作業はより困難となるが躊躇せずにヒューズワイヤーを切断する程度には曳かなくてはならない（良質のサンプルが採集できない)。しかし、命綱を切断してはいけない。

２・ヒューズワイヤーの切断後もドレッジ本体がスタックしている場合は、船を後退させ、テンションが弛んだらウインチを巻き上げ、これをくり返す。

じっと我慢してひたすら前進時の航跡上を正確に後退させる（反転厳禁）

時には投入点付近まで後退せざるを得ないこともある。

以上

Sea is Here, and Ocean is there. The boat is sailing as we are here.

(Photo by Y. Ogawa)