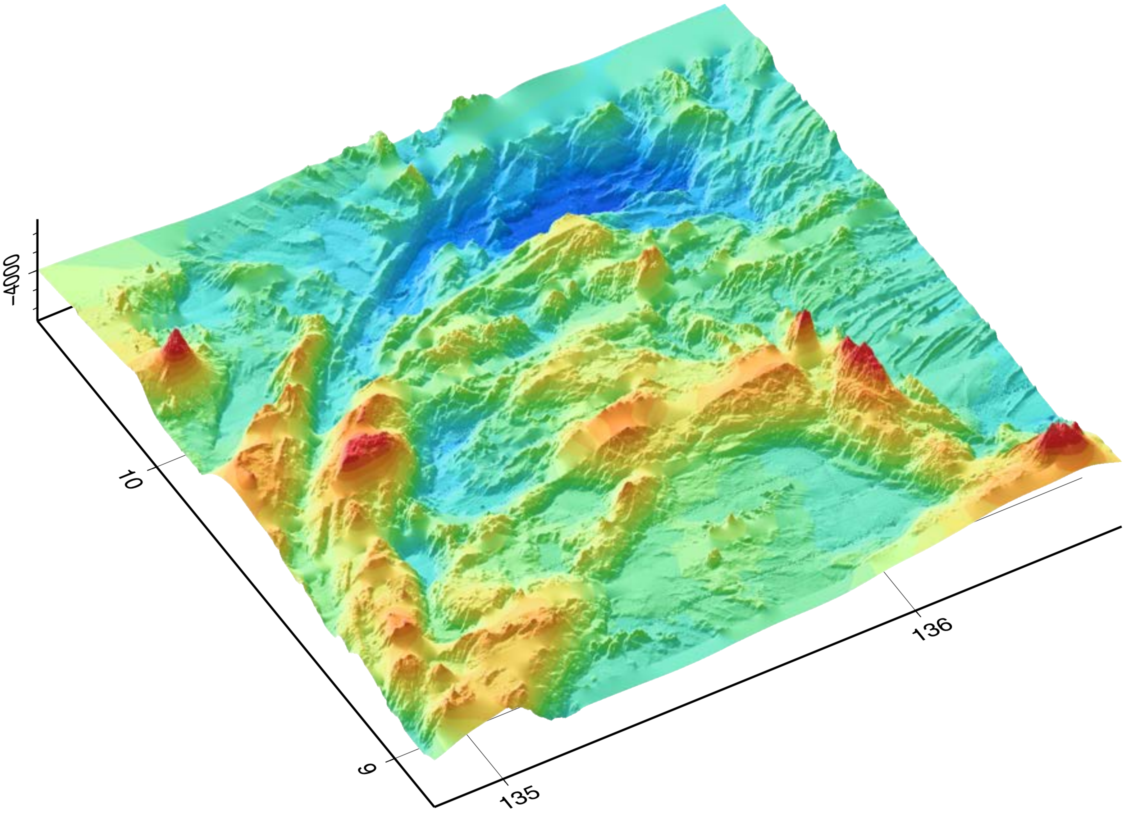
Cruise Report

R/V Hakuho-maru KH05-1-3 cruise

Evolution of the southern tip of the Parece Vela Basin

June 15, 2005 to June 27, 2005
(Guam to Guam)



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Confidentiality

Data and samples obtained during this cruise, most of which are described in this report, should be treated as carefully as possible, in order to protect the priority of the cruise participants.

Confidential and publication policies are as follows:
(1) The participants aboard the KH05-1-3 cruise agreed the future study plan listed in the section 5.
Those appeared in the lists have the priority for each study topics.
(2) No one other than the cruise participants or those listed in the future study plan can submit papers or give oral (or poster) presentations using any data and/or samples of this cruise within 24 month
after the completion of the cruise (June 25, 2007).
(3) Any questions on the data and samples of this cruise, or on the future study plans must be forwarded to the co chief scientists.

Summary

The KH05-1-3 cruise aboard the R/V Hakuho-maru (JAMSTEC) were planned to reveal the evolution history of the southern Parece Vela Basin and the structure of the Yap trench-arc system. The ship left Guam on June 15, 2005 and returned to Guam on June 27, 2005. We successfully conducted the extensive geophysical mapping in the southern tip of the basin, long across-trench multi-channel reflection survey and two dredge hauls.

The highlights of our results are summarized as follows:

1. The southern tip of the Parece Vela Basin has been mapped using state-of-the-art instruments for the first time. The southward propagator tip of the Parece Vela Basin spreading center was discovered. The seismic profile from the Caroline Ridge to the basin was acquired.
2. The western part of the survey area is characterized by “curved” deeps and robust magmatism. The kinematics of the enigmatic “curved” structure remains unsolved but it may be related to the rotational deformation associated with continuous rift propagation and fracture zones. Dredging on the foot of one of the curved deeps recovered some rock samples.

1. Background

Written by Kyoko Okino and Yasuhiko Ohara

1.1 Evolution of the Philippine Sea and the Parece Vela Basin

The Parece Vela Basin (PVB) is an extinct backarc basin behind the Mariana arc-trench system (Fig. 1). The basin was formed in the Miocene by rifting of, and later backarc spreading between the Kyushu-Palau Ridge and the West Mariana Ridge. The evolution of the basin consists of at least two stages, 1) east-west spreading and 2) NE-SW spreading [*Okino et al.*, 1998; *Okino et al.*, 1999](Fig. 2). In the first stage, spreading propagated toward the north in the northern part of the basin, where several propagator tips with associated pseudo-faults are observed. East-west spreading continued from 26 Ma to 19/20 Ma and the spreading half-rate is estimated at 44mm/yr. The spreading direction changed from E-W to NE-SW around 19/20 Ma, similar to the directional change of the Shikoku Basin opening. The ridge axis was highly segmented in this second stage, and prominent fracture zones developed. The spreading rate during NE-SW spreading has not yet been determined due to low magnetic anomaly amplitude and poor data coverage, however we tentatively identified magnetic lineations and estimated the spreading half-rate at 30-35mm/yr. Based on the identification, spreading ceased around 11~12 Ma, about three million years after the cessation of the Shikoku Basin opening. The Ar^{40}-Ar^{39} age dating of a basalt sample dredged from the rift zone also indicates 10~11 Ma. The extinct spreading center remains preserved as a row of depressions deeper than 6500 m, named the Parece Vela Rift (PVR).

Contrary to the previously studied northern PVB, the southern PVB remains almost unmapped. The spindle-shape of the basin may indicate that the initial rifting and spreading propagated toward south in the southern part of the basin, however we have no data directly indicating the ridge propagation.

1.2 Tectonic setting of the southern tip of the PVB and the Yap Trench

The southern tip of the PVB shows unique tectonic setting and geometry. The main part of the basin has developed between the Kyushu-Palau Ridge and the West Mariana Ridge, on the other hand the southern tip of the basin is now located between the southern Kyushu-Palau Ridge and the Yap Trench. The southwestern tip of the Mariana Trench trends nearly E-W toward a junction with the northern Yap Trench, where two trenches form an acute cusp. It seems strange that the southern tip of the PVR (remnant spreading axis) morphologically continues to the Yap Trench. The southern end of the PVR is the North Yap Escarpment, a ~1500 m high escarpment extending N20° E parallel to the PVR fracture zones. The Yap Trench constitutes a link between the Mariana Trench and the Palau Trench, where the Caroline Plate and Philippine Sea Plate converge. The convergent rate is very slow, 0-6 mm/yr [*Seno et al.*, 1993]. The seismicity along the trench is markedly low with no evidence of a Wadati-Benioff zone [*Sato et al.*, 1997]. The arc including the Yap Island is characterized with the proximity of arc and trench (~50km) and with the absence of forearc. The arc consists primarily of metamorphic rocks and lacks active volcanism [*Hawkins and Batiza*, 1977; *Shiraki*, 1971]. These facts cast some doubts on the ongoing subduction along the Yap trench-arc system at present. Submersible dives were conducted and it was found that the gabbroic rocks were exposed on the landward trench slope shallower than the 6000 m [*Fujioka et al.*, 1996].

The seafloor east of the Yap Trench is characterized with the Caroline Ridge, a large topographic high formed in the late Oligocene. The Caroline Ridge is divided into two by the Sorol Trough trending WNW-ESE. The northern wing of the Caroline Ridge collides with the Yap Trench at 10° 30’ N where the trench is deepest, whereas the Yap Island lies in a NNW extension of the Sorol Trough. The style of lithospheric deformation by the collision changes at the Sorol Trough; the extensional features are found on the arc and slab to the north, on the other hand the compressional deformation is dominant to the south [*Lee*, 2004].

McCabe and Uyeda [1983] suggested that the Caroline Ridge collided with the Yap Trench in early Miocene, and that the collision made the volcanic activity in the Yap Arc stop. [*Fujiwara et al.*, 2000] compiled the bathymetry and gravity along the Yap Trench area and proposed a scenario of tectonic evolution as follows (Fig. 3); 1) The Caroline Ridge collided with the Yap Trench at ~25 Ma, however the subduction continues at very low rate. The cessation of volcanism at the yap Arc was contemporaneous with the collision. 2) The frontal part of the trench was removed by the subduction erosion, causing the westward migration of the trench. 3) Lower crustal sections became exposed on the arc-ward trench slope by overthursting. [*Kobayashi*, 2004] also attempted to explain unique morphological and geological characteristics of this region using a simple hydrodynamic model.

1.3 Lithospheric compositions of the PVB and Yap arc system

No systematic rock sampling had been done in the PVB since DSDP Leg 59 [*Kroenke and Scott*, 1980] until KR03-1 by R/V Kairei. During the KR03-1, mantle peridotite and gabbros were recovered from the surface of the Godzilla Mullion and other core complexes. Plagiogranites associated with mantle peridotites were also recovered from the Godzilla Mullion surface, suggesting small amount of melts were highly fractionated in this melt-starved spreading. [*Ohara et al.*, 2003a] described detailed petrological data of serpentinized peridotite and gabbro from the PVR for the first time, and revealed small degree of mantle melting beneath the basin. Peridotites are exposed at mid-points of the northern segments, in addition to the Godzilla Mullion surface. This is anomalous, because segment mid-points are generally considered to be the most magmatically robust part of an entire ridge system, with the highest degree of mantle melting [*Lin et al.*, 1990]. The most notable characteristic of PVR peridotites is the presence of fertile peridotite; spinel Cr # (= Cr/Cr+Al ratio) ~ 0.17, with smaller Cr # indicating a lower degree of depletion of source mantle peridotite [*Dick and Bullen*, 1984]. Fertile peridotites indicate only a minor melting (~ 4 % near-fractional melting of a MORB-type mantle). Recent two submersible dives at the Shinkai Deep in the southern PVR confirmed that the Moho is exposed at ~ 6180 m depth at the deep

Geochemical studies of peridotites and volcanics from the Yap Trench and the North Yap Escarpment shows that the Yap Trench peridotites are highly depleted suduction-related mantle residues and the NYE volcanics have arc-like affinities [*Ohara et al.*, 2002]. It may indicate that the Yap-arc NYE system form as an incipient arc system at the propagation tip of the PVR.

1.4 Previous filed surveys (southern PVB ~ Yap/Palau)

KH84-1 Hakuho-maru Yap/Palau Trench [*Kobayashi*, 1985]
KH86-1 Hakuho-maru: Yap/Palau Trench [*Tomoda*, 1986]
KH87-3 Hakuho-maru: Yap/Palau Trench [*Kobayashi*, 1989]
S/V Takuyo 1989-1990 Northern Yap Escarpment [*Iwabuchi et al.*, 1990]
KH92-1 Hakuho-maru Yap/Palau Trench [*Fujiwara et al.*, 1996a]
Y93-03 Yokosuka/ Shinkai6K#193,195 Yap/Palau Trench [*Fujioka et al.*, 1994]
Y95-06 Yokosuka/ Shinkai6K#287~290 Yap/Palau Trench [*Fujioka et al.*, 1996]
Y96-12 Yokosuka/ Shinkai6K#347~350 Yap/Palau Trench [*Fujiwara et al.*, 1996b; *Fujiwara et al.*, 1997; *Fujiwara et al.*, 2000; *Nishizawa et al.*, 1994] * compilation of Yokosuka mapping
KH03-3 Hakuho-maru southern PVR
YK03-09 Yokosuka/ Shinkai6K#798~800 southern PVR

2. Objectives of the cruise

Written by Kyoko Okino and Yasuhiko Ohara

The primary objective of KH05-1 Leg3 is to reveal the structure of the southern tip of the PVB, and then to confirm the evolution model proposed by [*Fujiwara et al.*, 2000; *Ohara et al.*, 2002]. To tackle this problem, we will conduct the geophysical mapping of the backarc side of the Yap trench-arc, obtain the reflection and gravity profiles across whole trench-arc-basin system, and some dredge hauls. The question to be solved are:

- Evolution process of the southern tip of the PVB
  - Are there N-S and/or NW-SE abyssal hills?
  - Was the area formed as a western wing of the basin?
  - If so, how was the fate of the eastern wing of the basin? Eroded?
  - How did the junction between the PVR and the Yap Trench develop?
- The relationship of the basin evolution and the collision of the Caroline Ridge
  - When and how did the Caroline Ridge collide with the Yap Trench?
  - Did the Yap Island obduct the trench?
  - Is the Caroline Ridge subducting now?
- The lithospheric composition of the southern tip of the basin

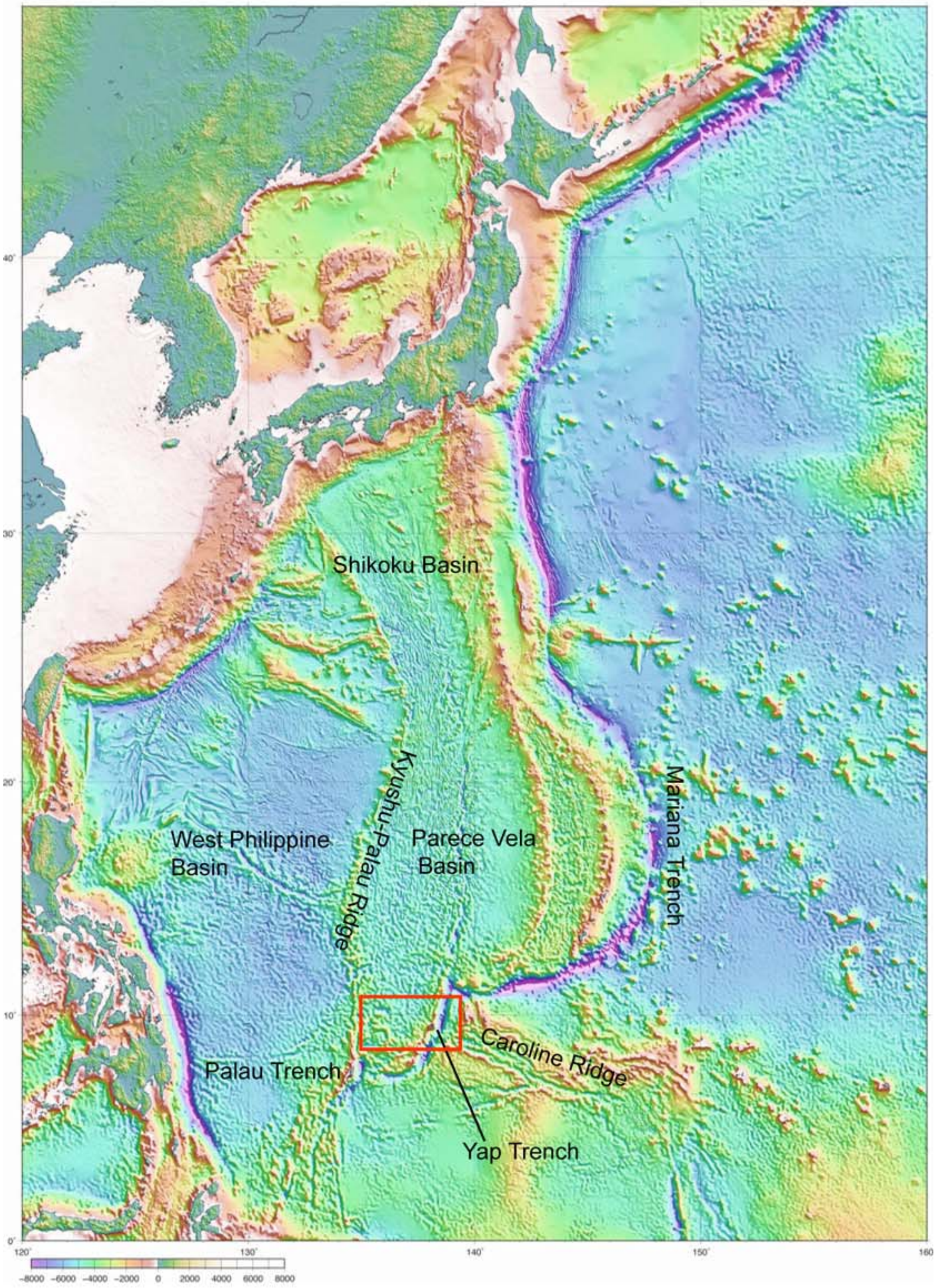


Figure 1 Compiled bathymetry [JTOPO1, JTOPO30, MIRC] of the Philippine Sea and the surrounded areas. Red rectangle indicates the surveye area during the KH05-1-3.

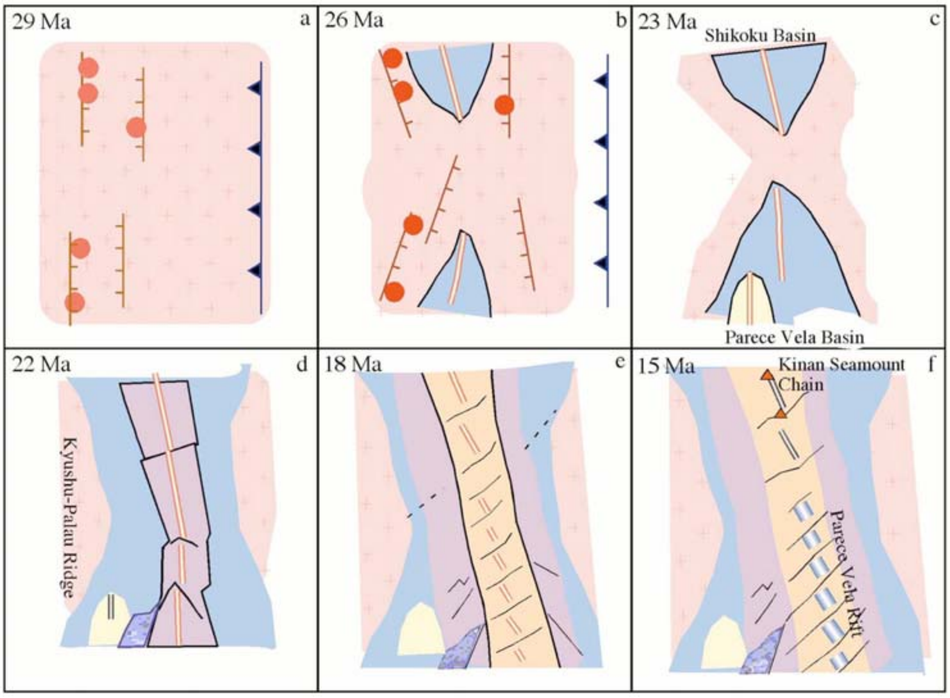


Figure 2 Evolution model of the Shikoku-Parece Vela Basins [modified Okino et al., 1998]

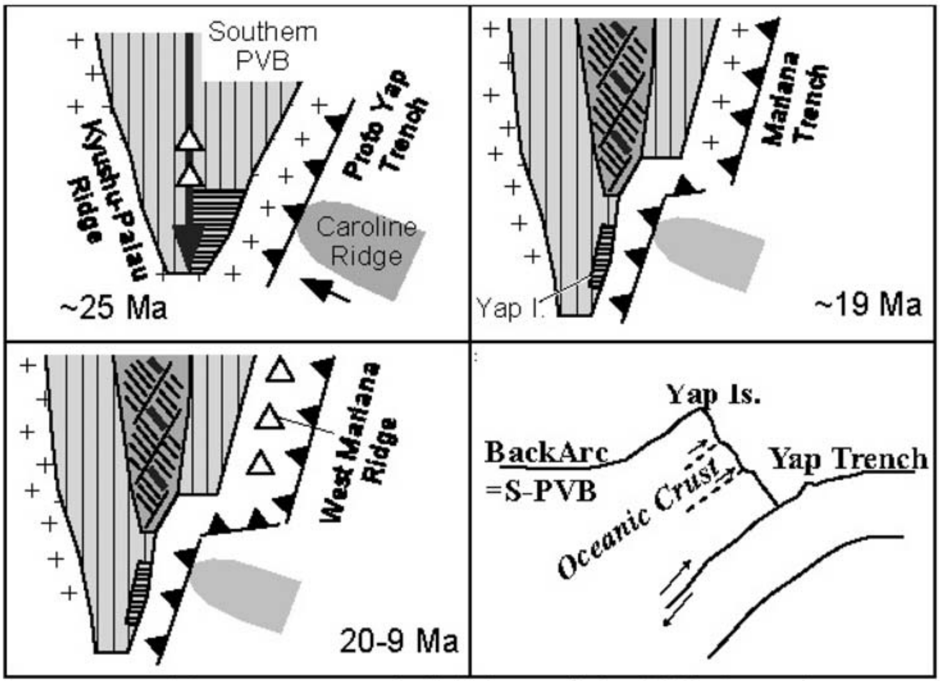


Figure 3 Working hypothesis of the evolution and structure of the southern tip of the basin. [Modified Fujiwara et al., 2000; Ohara et al., 2002]

3. Summary of Operations

Written by Kyoko Okino

We conducted an extensive geophysical mapping with a seismic reflection survey and two dredging in the southern tip of the Parece Vela Basin during the Hakuho-Maru KH05-1-3 cruise. The ship left Apra, Guam on 17 June, 2005 for the survey area. We first conducted a ~150 mile geophysical profiling across the Yap Trench and then started a box surveying in the southern tip of the Parece Vela Basin. The multibeam bathymetry, total and vector magnetics and gravity data were collected along survey lines. A multi-channel seismic reflection survey was done across the Yap Trench from 19 June to 20 June. We also performed two dredges hauls on 24 June. The survey finished on 25 June after another across-trench profile and the ship arrived at Apra, Guam on 27 June, 2005. The sea condition was extremely good during the cruise.

Local Date	Local Time	UT Date(Julian)	UT Time	*Notes*
June 15	14:15	June 15 (166)	04:15	Departure from Guam
	15:00		05:00	Science meeting
	18:30		08:30	Meeting with ship officers
June 16	06:50	June 15 (166)	20:55	SeaBeam Power On
	08:10		22:10	XBT-1 (failed)
	08:20		22:20	Deploy proton magnetometer
	08:49		22:49	XBT-2 at 9-55.5'N, 141-28.9'E
	10:14	June 16 (167)	00:14	Start watch and log, checking instruments
	12:00		02:00	Science meeting
	13:00		03:00	Boat drill
	18:57		08:57	Start geophysical mapping WP2(Profile1-E)
* The MCS team assembled airguns (in day time sift).				
June 17	04:04		18:04	WP3(Profile1-W)
	04:16		18:16	Figure eight turn No.1 start
	04:37		18:37	Figure eight end
	09:50		23:50	XCTD-1 at 10-19'N134-50'E
	10:35	June 17 (168)	00:35	SeaBeam down (slow down)
	10:49		00:49	SeaBeam recover
	11:09		01:09	WP4 (4W)
	12:00		02:00	Science meeting
* The MCS team checked the streamer cable (in day time sift).				
June 18	01:22		15:22	WP5(4E)
	02:21		16:21	WP6(5E)
	08:25		22:25	POS-MV=SeaBeamGPS trouble(slow down)
	08:49		22:49	Start turn to (10-05'N,137-30'E)
	09:23		23:23	Resume SeaBeam survey
	12:00	June 18 (169)	02:00	Science meeting

	15:30		05:30	WP7(5W)
	16:06		06:06	Ship's rudder malfunctioned
	16:16		06:16	WP8(6W)
	16:30		06:30	Course change / fish boat
	16:47		06:47	Back to survey line
* The MCS team checked the depth controller etc. (in day time sift).				
June 19	05:57		18:57	WP9(6E)
	08:45		22:45	Retreive proton magnetometer
	12:00	June 19 (170)	02:00	Science meeting
	13:17		03:17	MCS survey start
June 20	12:00	June 20 (171)	02:00	Science Meeting
	13:53		03:53	MCS survey end; stop SeaBeam recording
	16:00		06:00	XCTD-2 at 10-28'N137-12'E
	16:25		06:25	Deploy proton magnetometer
	17:15		07:15	Resume SeaBeam survey
	18:20		08:20	WP13(4.5E)
June 21	00:31		14:31	WP14(4.5W)
	01:30		15:30	WP15(5.5W)
	06:15		20:15	S-curve maneuver for POS-MV stablization
	06:30		20:30	On course
	09:00		23:00	WP16(5.5E)
	09:57		23:57	WP17(6.5E)
	12:00	June21 (172)	02:00	Science meeting
	16:40		06:40	WP18(6.5W)
	17:12		07:12	WP19(7W)
* Rock sampling team assembled the dredgers.				
June 22	04:22		18:22	WP20(7E)
	05:24		19:24	WP21(8E)
	12:00	June22 (173)	02:00	Science meeting
	15:40		05:40	WP22(8W)
	15:52		05:52	XBT-3 at 9-24.5'N, 134-49.0'E
	16:04		06:04	Figure eight turn No.2 start
	16:24		06:24	Figure eight end
	16:42		06:42	WP23(7.5W)
June 23	0:14		14:14	WP24(7.5E)
				S-curve maneuver for POS-MV stablization
	1:27		15:27	WP25(8.5E)
	7:40		21:40	WP26(8.5W)
	8:06		22:06	WP27(9W)
	12:00	June23 (174)	02:00	Science meeting
	12:15		02:15	Grvitimeter room tour
	20:33		10:33	WP28(9E)

	21:33	11:33	WP29(10E)
June 24	3:34	17:34	WP30(10X)
	5:03	19:03	WP31(8.25E)
	6:16	20:16	WP32(8.25W)
	6:45	20:45	Retrieve magnetometer
	7:00	21:00	ArriveD-1 [9-17.67'N, 135-55.83'E, 4500m]
	7:05	21:05	SeaBeam shut down
	11:00 June 24 (175)	01:00	SeaBeam restart
			WP35(9.5X)
			WP36(9.5Y)
	16:25	06:25	ArriveD-2 [9-17.67'N, 135-55.83'E, 4500m]
	20:30	10:30	XBT-4 at 9-6'N, 134-23'E
	22:06	12:06	Deploy proton magnetometer, resume mapping
			WP39(9.5X)
June 25	3:34	17:15	WP40(9.5W)
	3:49	17:49	WP41(10W)
	4:31	18:31	WP42(10Y)
			WP43(11Y)
	5:52	19:52	WP44(11Z)
	6:45	20:45	WP45(10Z)
	10:41 June25(176)	0:41	WP46(10X)
	12:00	2:00	Science meeting
	13:30	3:30	Engine room tour
	14:20	4:20	Profile2-W
	22:12	12:12	Profile2-W (Survey End)
	22:15	12:15	figure eight
	23:30	13:30	Retrieve magnetometer
June 26	12:30 June 26 (177)	2:30	Group photo
	16:00	6:00	Science meeting
	20:00	10:00	Farewell party
June 27	10:00	0:00	Arrive at Guam

4. Explanatory notes and Preliminary results

Written by Kyoko Okino

4.1 Bathymetry survey

4.1.1 Operations

During the KH05-1-3 cruise, we continued to record bathymetry data in the survey area, except for the area during some station operations. We conducted in total ~ 2800 miles of swath survey during the cruise, mainly along the east-west trending survey lines. The swath coverage is ~90% in the western half of the survey box and ~40% in the eastern half. The survey lines are shown in Fig.4 and the detailed coordinates of the lines are listed in Table 1. We started logging on 2005/06/16 08:57UT on the northern Caroline Ridge and stopped logging from 2005/06/20 03:53UT to 2005/06/20 07:15UT for air-gun recovery and from 2005/06/23 21:05GMT to 2005/06/24 01:00UT for dredge operation D-1. We finally finished mapping on 2005/06/25 12:12UT in the southern Caroline Ridge area. The data logging was stopped for rebooting from 2005/06/22 09:01 to 09:07UT, 2005/06/22 15:27 to 15:30UT, and 2005/06/22 16:13 to 16:15UT because of trouble in the POS-MV positioning system described later.

Bathymetric data were collected by SeaBeam2120 on R/V Hakuho-maru. SeaBeam2120 is a multibeam survey system that generates data for and produces wide-swath bathymetry maps and backscattering images. The system consists of two main subsystems, transmitter and receiver respectively. The basic 20 kHz projector array is a 14-foot long linear array positioned fore and aft along the ship’s keel. The receiver array detects and processes the returning echoes through stabilized multiple athwartship beams in a fan shape. The system synthesizes 1° by 1° narrow beams at an interval of 1°. The swath width decreases from 150° to 60° with increasing water depth. The transmit interval of the sonar also varies from 10sec to 13sec in the survey area. The accuracy of the depth measurement is reported as 0.5% of the water depth. The pinging and signal processing were controlled by “Hydrostar” software on Windows PC in No.1 Laboratory, in which the operator can set the ship parameters (draft = 6.0m, roll bias = 0.2°, pitch bias = 0.0°), sound velocity profiles, ping power and gain, swath width etc. For the automatic swath width control system forced the swath width narrow to 90° in the area deeper than 4000m, we tried to widen it to 110° or 120° manually during the data acquisition. All data were transmitted to the SGI O2 workstation “surveyor”, where the data were logged in mb44 (=mb94) format at an interval of 125 or 250 pings per file for ease in editing and transporting the data.

The ship position and attitude data were collected by POS-MV GPS system customized for multibeam echo sounders. The heading data are usually obtained by integrating the IMU (Inertial Motion Unit) gyro heading and the GAMS (GPS Azimuth Measurement Subsystem = azimuth measurement using two GPS antennas). The integrated heading measurement system provides a heading value with high accuracy (~0.07°), however the decreasing accuracy (> 0.1°) and The jumps and/or errors in heading measurements were frequently encountered during the later half of the cruise. We fixed the problem by simply rebooting the system in case of large heading jump or errors at 2005/06/22 09:01

to 09:07UT, 2005/06/22 15:27 to 15:30UT, and 2005/06/22 16:13 to 16:15UT. We continued the survey with lower accuracy (~0.8°) without GAMS from 2005/06/22 16:15UT to 2005/06/23 21:05UT. During this period, the GAMS was always “Off-Line” or “Not Ready” modes. The same problem was also reported in the previous cruises.

The SeaBeam system uses sound velocity data for both calculating the depth and position of each beam during the ray tracing process, and for the beam forming process. The sound velocity of the surface layer is most important in this regard, so the system includes a surface sound velocity meter for real-time monitoring of the surface velocity. Except for the surface layer, data from XBT and XCTD measurements (max depth = 1830 m) were used for calculating sound velocities. For depths greater than 2000 m, the Levitus database was used. We conducted four XBT measurements (three succeeded, one failed) and two XCTD measurements. The locations of these measurements are shown in Fig.4 and the details are listed in Tables 2. The sound velocity profiles used during the survey are listed in Appendix-A.

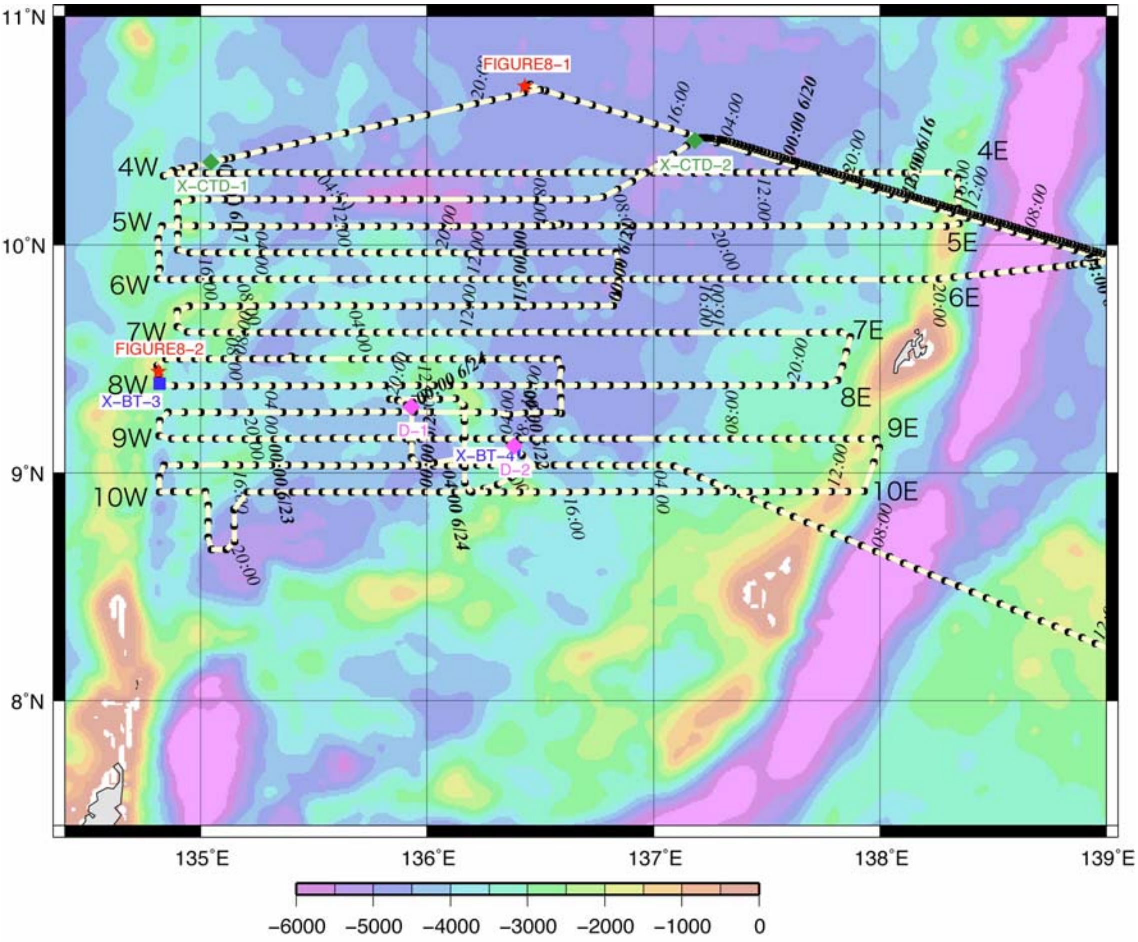


Figure 4 Survey lines of geophysical mapping. Locations of dredge hauls, XBT/XCTD and figure eight turns are also plotted. Numbers indicate main way points (see Table 1).

Table 1 List of waypoints

way point	Lat [deg]	[min]	Lon [deg]	[min]	Date	Time [UT]	JD
Profile1-E	9	56	139	0	06/16/2005	8:57	167
Profile1-W	10	41	136	30	06/16/2005	14:09	
4W	10	19	134	50	06/17/2005	1:09	168
4E	10	19	138	20	06/17/2005	15:22	
5E	10	5	138	20	06/17/2005	16:21	
5W	10	5	134	50	06/18/2005	5:29	169
6W	9	51	134	50	06/18/2005	6:34	
6E	9	51	138	15	06/18/2005	18:57	
MCS-S	9	57.5	139	0	06/19/2005	2:41	170
MCS-E	10	27	137	20	06/20/2005	3:41	171
4.5E	10	12	136	45	06/20/2005	8:20	
4.5W	10	12	134	55	06/20/2005	14:38	
5.5W	9	58	134	55	06/20/2005	15:36	
5.5E	9	58	136	50	06/20/2005	23:00	
6.5E	9	44	136	50	06/20/2005	23:57	
6.5W	9	44	134	55	06/21/2005	6:36	172
7W	9	37	134	55	06/21/2005	7:09	
7E	9	37	137	51	06/21/2005	18:22	
8E	9	23	137	47	06/21/2005	19:24	
8W	9	23	134	50	06/22/2005	5:40	173
7.5W	9	30	134	50	06/22/2005	6:42	
7.5E	9	30	136	35	06/22/2005	14:16	
8.5E	9	16	136	35	06/22/2005	15:27	
8.5W	9	16	134	50	06/22/2005	21:35	
9W	9	9	134	50	06/22/2005	22:05	
9E	9	9	138	0	06/23/2005	10:34	174
10E	8	55	137	55	06/23/2005	11:33	
10X	8	55	136	10	06/23/2005	17:37	
8.25E	9	19.5	136	10	06/23/2005	19:07	
8.25W	9	19.5	135	50	06/23/2005	20:15	
D-1	9	18	135	56	06/23/2005	21:12	
9X	9	2	135	56	06/24/2005	3:23	175
9.5Y	9	2	136	28	06/24/2005	5:29	
D-2	9	7	136	23	06/24/2005	6:41	
9.5X	9	2	135	58	06/24/2005	13:12	
9.5W	9	2	134	50	06/24/2005	17:16	
10W	8	55	134	50	06/24/2005	17:49	
10Y	8	55	135	2	06/24/2005	18:31	
11Y	8	40	135	2	06/24/2005	19:27	
11Z	8	40	135	9	06/24/2005	19:54	
10Z	8	55	135	9	06/24/2005	20:47	
10X	8	55	136	10	06/25/2005	0:40	176
Profile2-W	9	2	137	4	06/25/2005	4:12	
Profile2-E	8	14	139	0	06/25/2005	12:10	

Table 2 Locations of XBT/XCTD observations

Sites	Date	Time	Lat[d]	[min]	Lon[d]	[min]	Depth[m]
XBT-2	2005/06/15	22:49	9	55	141	29	1833
XBT-3	2005/06/22	05:51	9	24	134	49	1833
XBT-4	2005/06/24	19:17	9	6	134	23	1833
XCTD-1	2005/06/16	23:50	10	19	134	50	1101
XCTD-2	2005/06/20	06:05	10	28	137	12	1951

* XBT-1 failed.

4.1.2 Data editing and processing

After SeaBeam data was logged as ".mb44" files on the SeaBeam workstation, files were ftp-ed to the "mapper" workstation and several other computers on the LAN with MB-System [*Caress and Chayes*, 1996], which was used for data editing, gridding, and map production. The file extension of raw data file is mb44, however the format 44 is identical to format 94 in MB-System and the ".mb94" is appended to the processed file.

A flow chart of the processing procedure and outputs is as follows. The MB-System 5.0.7 and GMT4.0 [*Wessel and Smith*, 1998] were used.

1. **mbedit** – checking data quality ping by ping, editing bad beams. The process creates ".esf" and ".par" files.
2. **mbnavedit**– checking navigation data quality and editing. COG (course may good) data are adopted instead of heading for some periods (see Appendix B). The process creates ".nve" files.
3. **mbprocess** – applying the edits to the original ".mb44" files. The process creates "p.mb94", ".fbt", ".fnv", and ".inf" files.
4. **mblist** – listing the longitudes, latitudes, and depths for all beams for all pings. Usually we can use mblist –D option (dump mode), but the option does not work for mb94 format and "mblist –M0/120 –OXYZ" are used. The process creates ".xyz" files.
5. The masked grid is created using the following script.

```
#! /bin/csh
#        make grid file from xyz files
#
set region = 134:45/139/8:30/10:50              # grid region
set int = 0.05m                         # grid interval
set tension = 0.65    # surface tension factor
set radius = 2k                         # search radius
set blkfile = kh0501-3.blk    # block file
set grdfile = kh0501-3.grd    # grid file
set maskedfile = kh0501-3.masked.grd
#
cat ../xyz/0616/*.xyz ../xyz/0617/*.xyz ../xyz/0618/*.xyz ../xyz/0619/*.xyz ../xyz/0620/*.xyz ../xyz/0
621/*.xyz ../xyz/0622/*.xyz ../xyz/0623/*.xyz ../xyz/0624/*.xyz ../xyz/0625/*.xyz |¥
awk '{if($3 > -8500 && $3 < 0) print $1,$2,$3}' |¥
blockmedian -R$region -I$int -V > $blkfile
```

```
surface $blkfile -R$region -I$int -T$tension    -G$grdfile -V
grdmask $blkfile -R$region -I$int -NNaN/1/1 -S$radius -Gmask.grd -V
grdmath $grdfile mask.grd OR = $maskedfile
```

4.2.3 Morphology of the southern tip of the Parece Vela Basin

The overall bathymetric map is shown in Fig. 5. The survey area covers from the Yap Trench in the east to the foot of the Kyushu-Palau Ridge in the east. West of the topographic highs including the Yap Island, the southern tip of the basin divided into four areas (Fig. 6).

Area A: Along the Yap Trench, the area shallower than 3800 m extends to approximately 50 miles west of the trench axis. The area is characterized by short NW-SE abyssal hills. The abyssal hills are clear in the northern part of the area, and seem to be offset by NE-SW trending discordant zones. The area may be the southern extension of the central area of the Parece Vela Basin.

Area B. West of the Area A, the seafloor is characterized by well-ordered north-south trending abyssal hills. The abyssal hills are relatively continuous and the water depth ranges from 3800 to 4800 m. No clear fracture zones are recognized. The area is V-shaped and its western boundary of is linear and prominent (thick line in Fig. 6). These facts presumably indicate that the area is the propagating tip of the Parece Vela Basin spreading ridge in the east-west spreading stage. The northern extension of this boundary is ambiguous and the north-south abyssal hills are also observed on the western part of the northern two survey lines.

Area C: West of the V-shaped propagator, the trend of abyssal hills abruptly changes to 070°~080°. The area intervenes between the propagator tip and the western curved deeps and may be a kind of transferred lithosphere between two spreading centers. A few conical seamounts are distributed in the southern part of the area.

Area D: The most prominent morphology in the survey area is en echelon, curved deeps east of the Kyushu-Palau Ridge. Two deeps (at10°15’N and at 9°15’N) are crescent shaped and curve towards northward. The northern deep is ~6100 m and the southern one is ~4500 m. The abyssal hills outside the northern deep seem approximately perpendicular to the curved deep structure. The southwestern extension of the northern deep is a narrow curved rift trending 030° and the rift develops within a topographic high. On the other hand, the area north of the southern deep is characterized with voluminous dome, which consists of branched topographic highs. Out of our survey area, the similar curved deep can be recognized on the satellite altimetry map around 8°40’N.

The morphological pattern with curved deeps is very much like those of the Pito Deep of the Easter Microplate [e.g. Naar and Hey, 1991] and of the Endeavor Deep of the Juan Fernandez Microplate [e.g., Kleinrock and Bird, 1994]. It may suggest that a rotational deformation associated with continuous rift propagation and some finite broad transform zone is related to the origin of the enigmatic structure of the area.

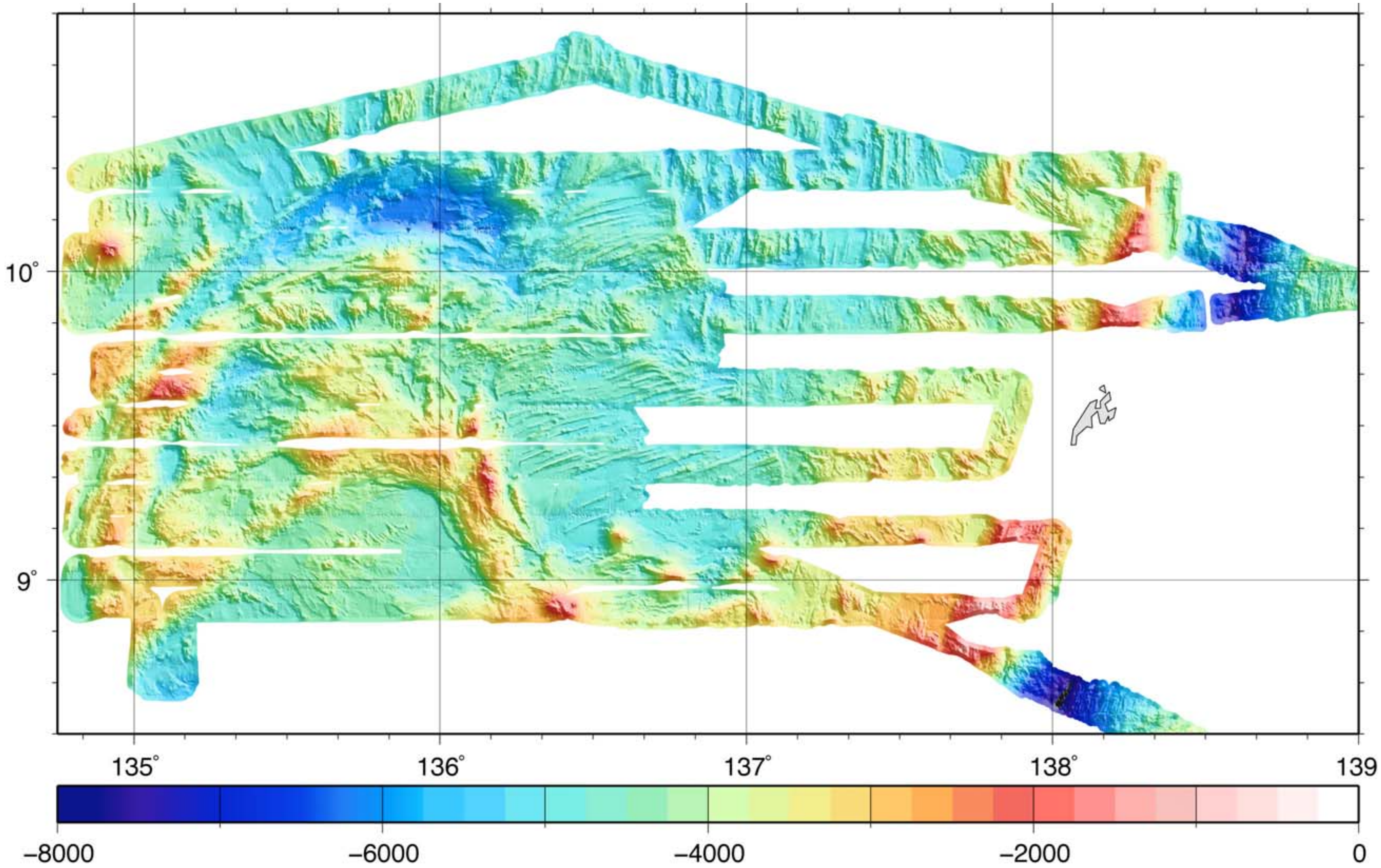


Figure 5 The morphology of the southern tip of the Parece Vela Basin. Illumnated from 045°.

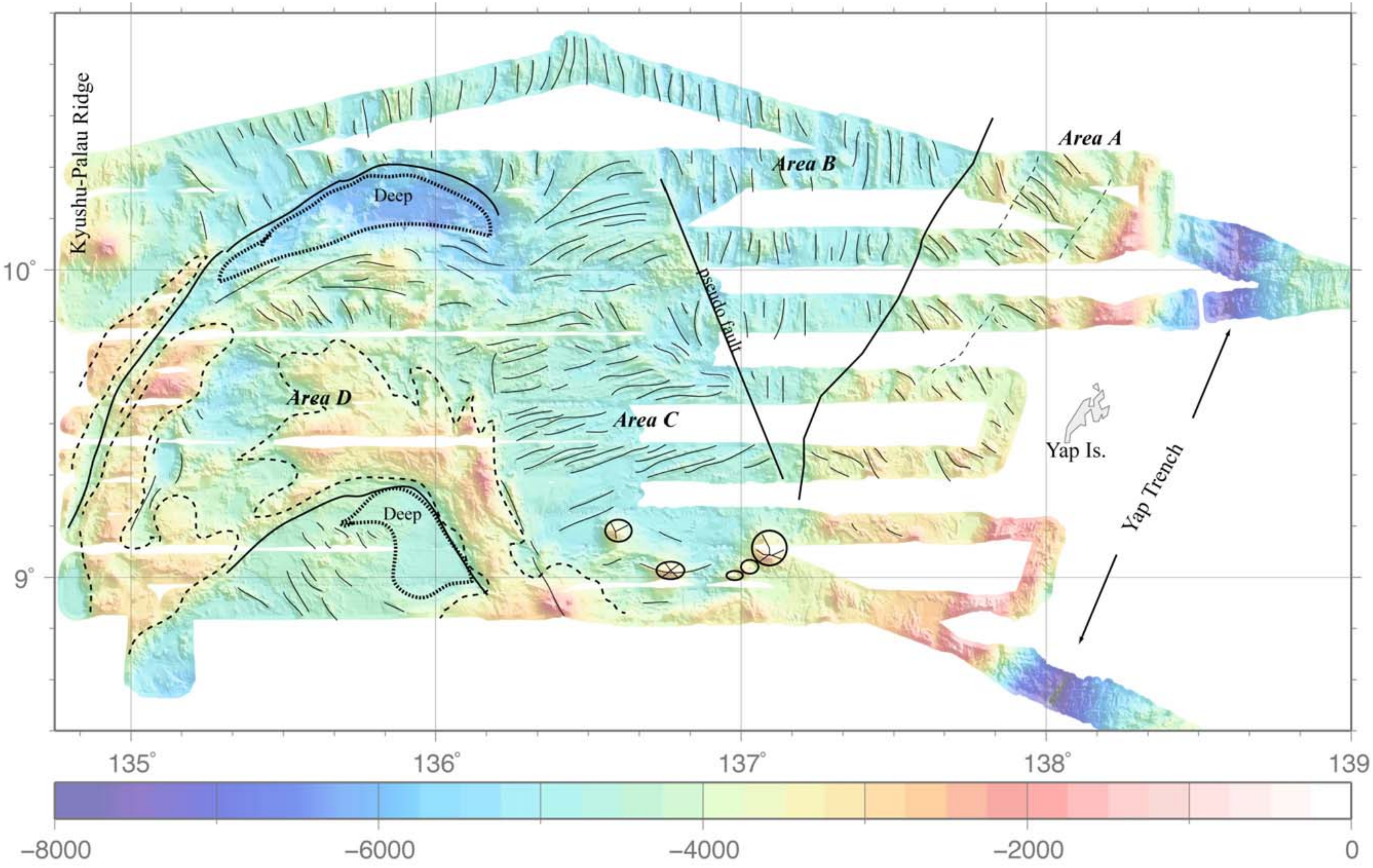


Figure 6 Tectonic fabrics in the survey area and the tentative zoning.

4.2 Gravity survey

Written by Sang-Mook Lee

The measurement of gravity field, checking its quality and subsequent reduction constituted an important part of our field activity during Leg 3 of cruise KH05-1. The survey area, Yap trench system, comprises of subducting Caroline Ridge, the trench itself, Yap arc and the backarc section. The Caroline Ridge, a massive volcanic feature formed on the border of subducting Pacific-Caroline plate, is divided into two along the WNW-ESE trending Sorol Trough. The characteristics of the Yap trench system appear to differ between the north and south of the Sorol Trough, according to the recent study using regional satellite-derived gravity measurement [Lee, 2004]. One of the important aims of our gravity study is to investigate the nature of such structural difference using onboard marine gravity measurement, which is considered to be more precise than that of the satellite. This report describes the gravity field measurement taken during cruise KH05-1 Leg 3.

The measurement was made continuously through the entire length of the cruise, which began on June 15, 2005 in Apra, Guam and ended on June 27, 2005 in Apra, Guam. In this section, we provide a brief description on the gravimeter system onboard R/V Hakuho-Maru, calibration of the instrument, estimated drift, and measurement itself and reduction to free-air gravity anomaly. A comparison is made between the free-air gravity anomalies obtained in this cruise and those derived from satellite altimeter data. Finally, some remarks are given on the direction of post-cruise gravity analyses.

4.2.1 Gravity Meter System

The gravity meter on board R/V Hakuho-Maru is Dynamic Gravity Meter D-004 and ZLS GyroPack (GG-49) made by ZLS Corporation, USA (www.zlscorp.com). It is a Lacoste and Romberg type gravity meter (Figure 7), and the operating system is UltraSys™. The control system basically consists of remote and host computers. The former performs all real-time activity associated with controlling the platform and gravity meter as well as maintaining the system clock. The latter receives the data, computes the cross-coupling correction, and performs the final filtering before archiving the data. Time is kept very accurately by a temperature-compensated crystal oscillator. During this cruise, the gravity meter was set at normal sea mode, which outputs the filtered data at 10-second intervals. These data are reduced to 1-minute-interval outputs by the host computer.

The gravity meter requires a careful calibration in order to estimate the absolute gravity value. This tie is done using a reference station on land. The calibration tie was done at Ocean Research Institute of University of Tokyo and again at Apra Harbour (Wharf H) in Guam before the start of the cruise by technical staff (K. Koizumi). The tie was made using portable Lacoste and Romberg Land Gravity Meter G-124 (Table 3).

While the drift rate of the instrument was not measured at this particular leg, traditionally this value is reported to be less than 2-3 mgal per month.

Figure 7 Photo of ZLS Dynamic Gravity Meter D-004 installed in 2nd deck laboratory of R/V Hakuho-Maru.

Table 3 Result of calibration of D-004 gravity meter on board the ship with a Lacoste and Romberg Model G Land Gravimeter (G-124) in Guam.

Location	Day	G-124	G-124 (Tie)	D-004
Guam (Apra, Wharf H)	2005/06/14	2175.8	978510.3	978510.3
Guam				

4.2.2 Measurement

To dampen the ship's motion, gravity measurement is subject to a special low-pass filter. Due to this filtering, the gravity output from the host computer has a 4-minute delay. At first the gravity is calculated without considering the time delay. This is called the pseudo gravity. The true free-air gravity anomaly, however, comes from the gravity reading corrected for the Eötvös effect and latitudinal variation using navigational data taken 5 minutes ago. Below is an example of output file data format.

```
date            lat      lon       sco       ssp       gyro    log      cur.dir    PDR     SB
Gmat5:50+Et1    Gn          Et1(used) Et2          FA2       Gmat5:56    FAat4:55
Gn         C                                    FAA
06/16 04:55 9.6001 140.11 286.9 +16.68 287.3 15.80 332.3 2683.6 02713 978187.86
978175.46 -118.065 -111.596 000020.33 978314 20.475
06/16 04:56 9.60146 140.106 286.8 +16.70 288.2 16.10 310.2 2666.4 02703 978189.92
978175.50 -118.268 -113.144 000021.22 978316 22.232
06/16 04:57 9.60146 140.106 286.8 +16.70 288.2 16.10 310.2 2666.4 02703 978189.92
978175.50 -118.268 -113.144 000021.22 978316 22.232
06/16 04:58 9.60281 140.101 286.7 +16.73 287.7 16.30 331.2 2658.0 02684 978191.85
978175.54 -118.543 -114.873 000021.93 978317 22.917
06/16 04:59 9.6042 140.097 286.8 +16.77 287.8 16.20 314.9 2659.6 02696 978193.50
978175.58 -118.763 -114.104 000022.47 978317 22.657
06/16 05:00 9.60558 140.092 286.7 +16.81 288.2 16.70 323.0 2595.2 02674 978194.86
978175.62 -119.108 -117.359 000022.85 978318 23.272                               A
                   B
```

A = filtered pseudo gravity at 05:00 valued already added by B
B = Eötvös correction at 05:00
C = Eötvös correction at 04:55
Gn = latitudinal correction at 04:55

Thus the true free-air anomaly (FAA) can be calculated as:

FAA = A – B + C – Gn

which in this case is 20.475 mgal at 04:55.

Figure 8 is a map of free-air gravity anomaly plotted along the survey trackline. It shows a negative free-air anomaly of -320 and -180 mgal across the Mariana trench and Yap trench, respectively. The Yap arc and Caroline Ridge have a large positive anomaly of approximately 50-60 mgal. The back-arc side of the Yap trench in general shows up as having a slightly positive anomaly. However, the deep escarpments have negative anomalies.

The free-air gravity field anomaly measured during our cruise was compared with that derived from the satellite altimetry data [Smith and Sandwell, 1997] (Figure 9). The version satellite free-air gravity anomaly that we used is a 2-minute version. The two measurements appear to match quite well, except for slight differences at the peaks and troughs. This finding suggests that we can use satellite-derived gravity anomalies around the study area for regional studies.

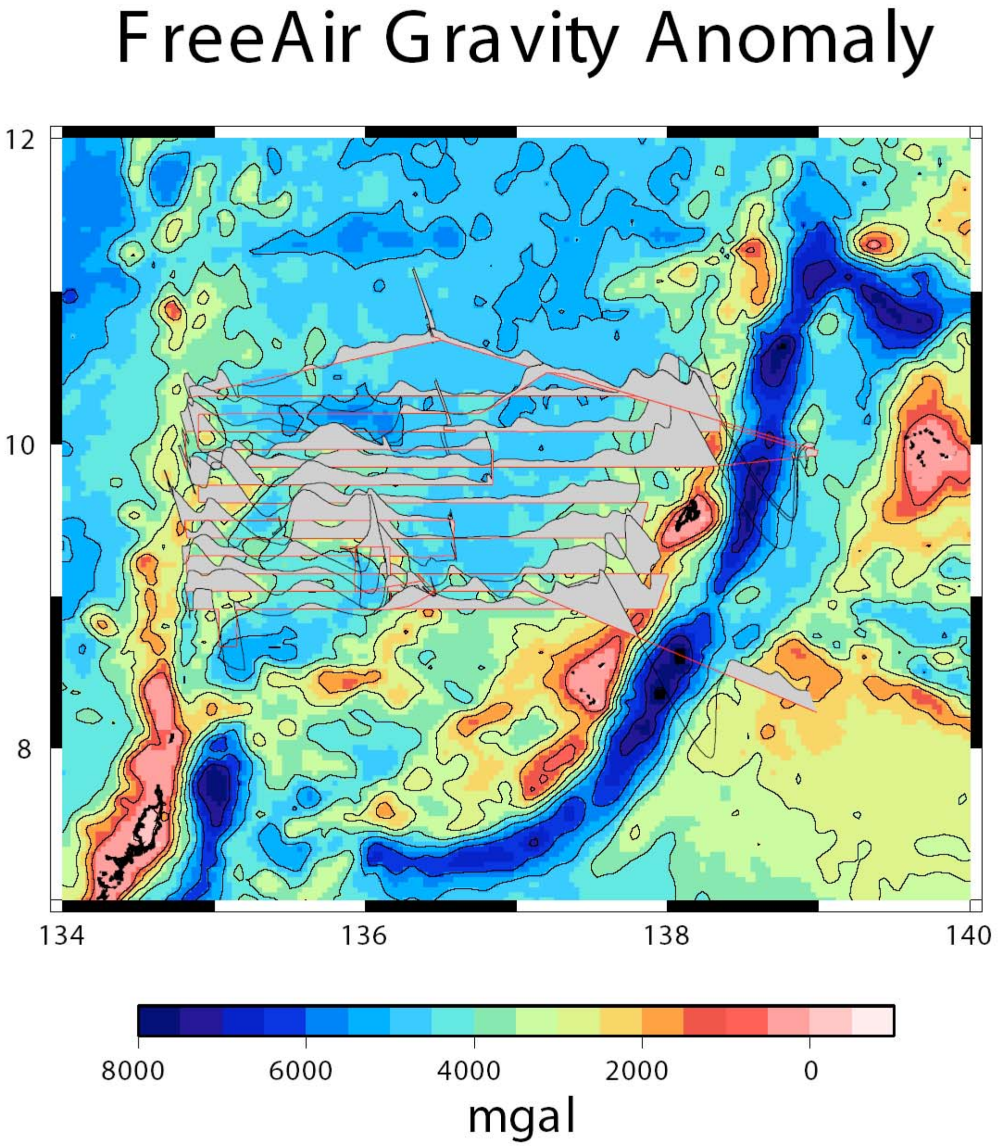


Figure 8. Free-air gravity anomaly plotted along the ship trackline. Seafloor topography of the survey area is also drawn with contours at 1-km intervals.

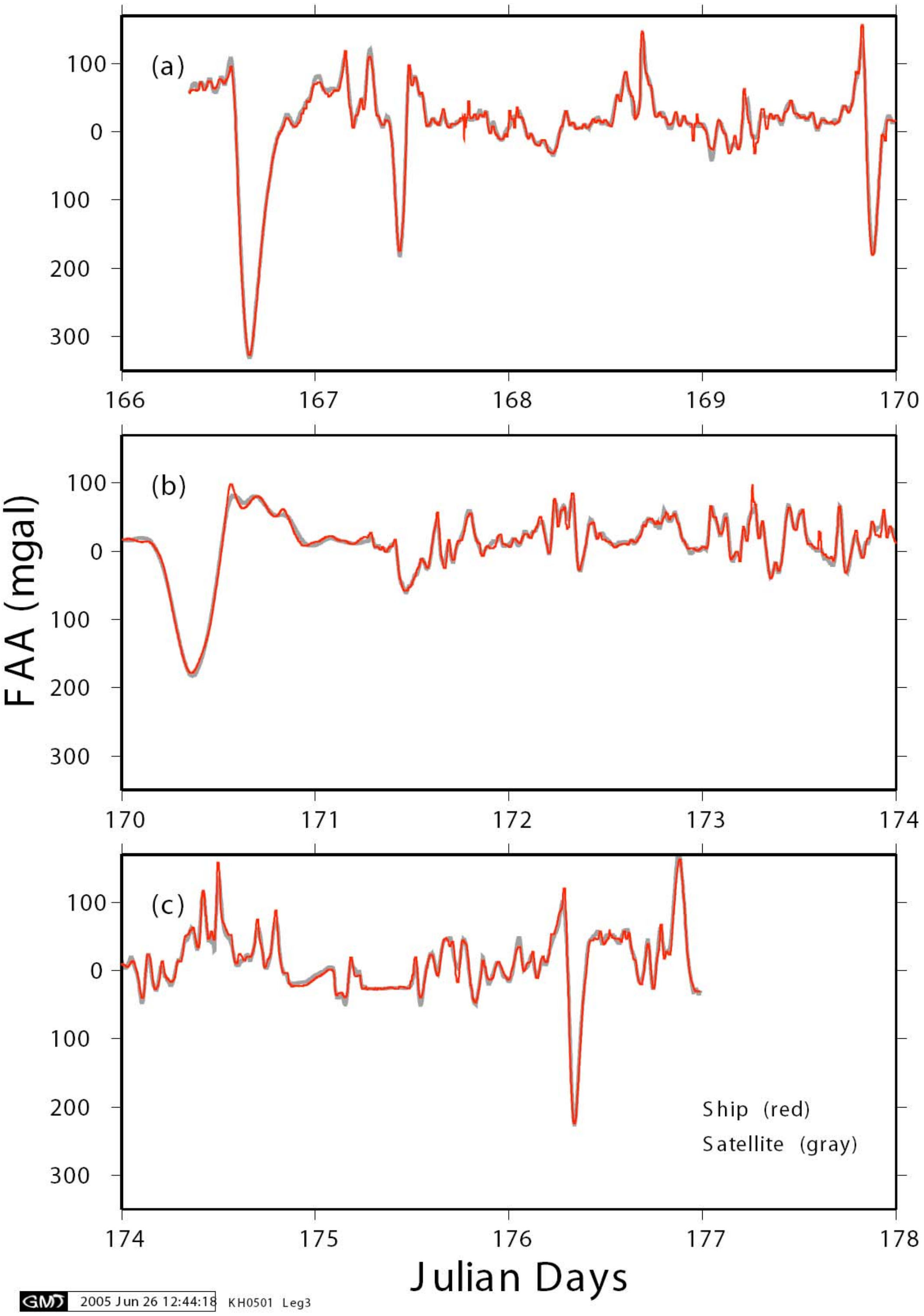


Figure 9. Comparison of ship-board free-air gravity anomalies and those derived from satellite altimetry data. The overall variations match quite well.

4.3 Magnetic survey

Written by Toshiya Fujiwara

4.3.1 Total Force Measurement

During the KH05-01 Leg 3 cruise, underway geophysical surveys, whose items included were gravity and geomagnetics, were conducted aboard the R/V Hakuho-maru. The aim of the geophysical surveys was to provide a detailed geophysical characterization of the lithosphere in the southern tip of the Parece Vela Basin and the Yap Trench, which will be used to unravel tectonic evolution and crustal structure.

Geomagnetic total force data were obtained by using a surface-towed proton precession magnetometer PR-745 (Kawasaki Geol. Eng. Co.) (Fig. 10). The sensor was towed 350 m behind the ship (Fig. 11). The data were collected every 30 seconds. The following data processing was made onboar: After removing spike errors and positioning correction taking into account the sensor cable length, the geomagnetic total force anomaly was calculated by subtracting the International Geomagnetic Reference Field (IGRF) 9th generation [IAGA, 2003] as the reference field.

Figure 10 PR-745 proton precession magnetometer settled in NO.3 Laboratory. The controll unit of the magnetometer is in the left-hand of the photograph, and the computer in the right-hand records magnetic data merged with ship's navigation data.

Figure 11 The winch of sensor cable is on deck. The sensor is towed 350 m behind the ship.

Figure 12 shows wiggle plots of magnetic total force anomaly along the ship track. The magnetic anomaly pattern is complicated as with bathymetric morphology in this area. Some peaks of magnetic anomalies are correlative between parallel tracks, but no magnetic lineation is clearly identified.

Amplitude of the magnetic anomaly in the west side of the Parece Vela Basin (>250 nT peak-to-trough) is generally higher than in the east side (<200 nT). In consideration of bathymetric morphology, the magnetic anomaly amplitudal difference may be caused from that the water depth in the west side of the basin is shallower, therefore shorter distance to the oceanic crust as a magnetic source, the topography is rough, and the seafloor fabric shows omnidirectional. Whereas in the east side, the water depth is deeper, and the strike of the basin fabric, which is the possible magnetic lineation, has a nearly north-south direction which makes the geomagnetic signal a minimum.

Because the study area is situated in low magnetic latitude, diurnal variation may effect the observed magnetic anomaly, significantly, thus correction of the diurnal variation may be needed. Long-wavelength variations, uncorrelated between the ship tracks, appear on the observed magnetic anomaly profiles (Fig. 12). Further data analysis should be processed to remove skewness due to low magnetic latitude and to correct for effects of seafloor topography, and to evaluate the crustal magnetization distribution.

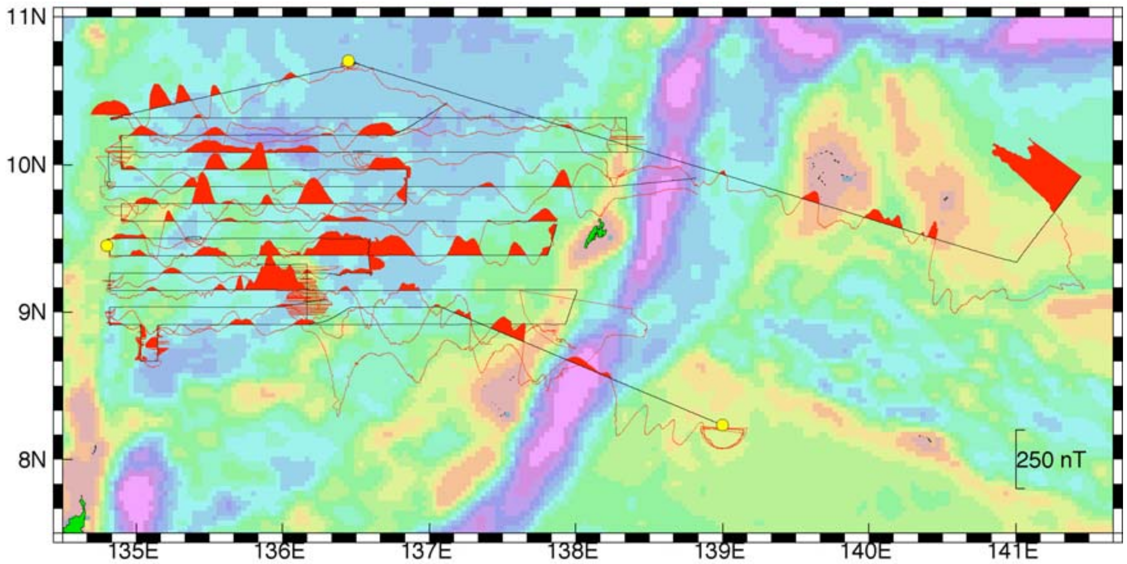


Figure 12 Wiggle plots of magnetic total force anomaly along the ship tracks superimposed on the ETOPO2 bathymetry. Red shade indicates positive anomaly. Yellow circles point locations of "Figure-8" turns (See the next section).

4.3.2 Vector Field Measurement

Vector magnetic field data were collected using a shipboard three-component magnetometer, SBM-89 (GAUSS) (Figs. 13 and 14). Ship's roll and pitch values were provided from the POS-MV system, and ship's heading value were obtained from TG5000. The data were collected with a sampling rate of 1 second throughout the cruise. "Figure-8 turn"s (a ship runs along an 8-shaped track consisting of two circles) were made for calibration of the ship's magnetic effect, related to magnetic susceptibility of the ship, and a permanent magnetic moment of the ship's body [Isezaki, 1986]. The turns were made at three locations (Table 4). The IGRF 9th model was also employed as the reference magnetic field for calculation of vector geomagnetic anomaly and "Figure-8" calibrations. The resultant calibration coefficients are shown in Table 5.

Magnetic vector anomalies will be utilized to map the strike directions of lineated magnetic boundaries, which are commonly representing lithological boundaries, geomagnetic reversals, or topographic offsets of magnetized layers due to faults. This study area is located near the magnetic equator. It makes the geomagnetic signal small. Magnetic vector anomaly is an effective approach to the study of magnetic anomaly in this area, because the vector anomaly field is free from effects of direction of ambient geomagnetic field.

Figure 13 SBM-89 settled in NO.1 Laboratory. The controll unit of the magnetometer is on lower of the rack, and the computer records magnetic data merged with ship's navigation and motion data.

Figure 14 The fluxgate sensor of SBM-89 is settled on the upper deck above the bridge.

Table 4 Summary of "Figure-8".

1. 6/16 18:16-18:37 (UT)	10°42'N, 136°27'E	IGRF X: 37484 Y: 388 Z: 4118 nT
2. 6/22 06:04-06:27 (UT)	09°27'N, 134°48'E	IGRF X: 37877 Y: 422 Z: 2396 nT
3. 6/25 12:15-12:27 (UT)	08°14'N, 139°00'E	IGRF X: 37330 Y: 1064 Z: 657 nT

Table 5 Coefficients of calibration **A**-matrix. Coefficients a_{11}~a_{33} are related to magnetic susceptibility of the ship, and a_{14}, a_{24}, and a_{34} indicate a permanent magnetic moment of the ship's body.

$a_{11}=0.95666$	$a_{12}=-0.07742$	$a_{13}=-0.00220$	$a_{14}=28.5$
$a_{21}=0.08021$	$a_{22}=0.86709$	$a_{23}=-0.00365$	$a_{24}=-1811.4$
$a_{31}=-0.08564$	$a_{32}=-0.00691$	$a_{33}=1.06336$	$a_{34}=6517.0$

4.4 Multichannel seismic reflection survey

Written by Yasuyuki Nakamura, Hiroyuki Inoue, Hideo Ishigaki and Shinichro Yokogawa

Multichannel seismic (MCS) reflection survey was conducted on one across trench line during KH05-1 Leg3. We started the MCS survey at 0317 on 20th (UTC) and finished at 0353 on 21st (UTC). The length of the survey line was ~100 nautical miles.

4.4.1 Seismic sources

Three Bolt 1500C air guns were towed from stern of the Hakuho-maru with separated towing harness in parallel. The distance from the stern to air guns was ~15 m (Figure 15). The total volume of the chamber of air guns was 57 littres (~3400 inch^3). The starboard and center air guns had 20 littres chamber, and port air gun was 17 littres. Two Hakuho-maru's compressors sent the air with high pressure to air guns. Air guns were fired at 110 bars (~1600 psi) of air pressure. We fired 4355 shots during the MCS survey.

4.4.2 Firing system

Figure 16 shows the block diagram installed in No. 3 Lab. A shot pulse generator, provided by Earthquake Research Institute (ERI), University of Tokyo, generates the shot pulse every 20 seconds. A shot time randomizer, provided by Dr. E. Araki in JAMSTEC, was used to randomize the shot time. The randomizer adds random time between 0-0.6 s to the shot pulse timing so that the multiple reflection from the seafloor can be weaker after stacking. A closure pulse generator, provided Dr. K. Mochizuki in ERI, receives the randomized shot pulse and sends the closure pulse to the firing controller, AutoSync (Input Output Inc.). AutoSync was configured to synchronize the shot timimg 450 ms after receiving the closure pulse. Two AutoSyncs were used to synchronize the shot timing of three air guns. Thus, air guns were fired every ~20 s with +0-0.6 s fluctuation. Hakuho-maru kept her speed against ground at ~ 4kt during MCS survey, which yields that the shot interval was ~40 m in distance.

4.4.3 Seismic receivers

The ORI's 48 channel solid streamer cable made by ITI was used as a receiver array of MCS survey. The streamer cable consists of tail section, active section, and lead-in section. A ~200 m tail rope was attached at the end of the tail section to stabilize the streamer cable. The length of the active section of the streamer cable was 1200 m. The lead-in cable payout was ~114 m from the stern. The streamer cable was powered by a couple of 12 Volts car batteries. The seismic data from the streamer cable was recoded by the acquisition computer (StrataVisorNX48) into DDS-4 tapes and HDD in SEG-D 8058 format. The record length and the sampling interval were 15 s and 2 ms, respectively. Note that the data of #25-#36 channel were recorded as #36-#25 channel due to the wrong cable connection built in the adapter cable between the acquisition computer and the deck cable; e.g. #25 channel in the streamer is recorded as #36 channel in the recorded data, #26 in the streamer is #35 in the data etc. The StrataVisorNX48 receives a trigger signal from the randomizer to start the recording of each shot data, so the timing of the recording and shot was synchronized at each shot. The nearest channel (channel #1) was dead entirely during survey. The depth of the streamer cable was controlled by Syntron's MULTITRAK system using 5 birds. Birds were attached to the streamer cable at the point of 0 (bird #1), 300 (bird #2), 600 (bird #3), 900 (bird #4), 1200 (bird #5) m from the head of the active section (Table 6). Three of them (#1, #3, #5) were also equipped with a compass so that the orientation of the bird is logged and the shape of the streamer cable can be calculated. The bird depth was set at 10 m. During this cruise, bird #3 was not responding when it is in the water. However, the depth of other birds was well controlled at around 10 m, and the streamer shape was kept almost straight.

4.4.4 Log

Watch standers took the log every 15 minutes onto the logbook for following items; Time (UTC), ship position, ship course and speed made good, heading, ship speed against water, water depth, recording file number, bird depth, fire time, air pressure and notes. The log was also taken at any events, e.g. problems, passing waypoints etc.

4.4.5 Problems

Basically the MCS survey was successfully operated during the survey. All of three air guns were fired at all shots, however, minor problems occurred as following.

1. Battery of the closure pulse generator

The closure pulse generator operates with 9V battery. The life of the battery was ~2.5 hours, which was much shorter than expected before the cruise. We needed to change the battery manually when it was dead. It took a few minutes to change the battery. The shooting of air guns was stopped while we were changing the battery. The longest stop was ~ 8 minutes at the trench area because power line broke at that time.

2. Battery cable for streamer cable

In the beginning of the survey, the power cable of the streamer cable was snapped by accident twice. While powered off, the air guns were fired and the acquisition computer continued the data recording but no waveform was sent from streamer cable. This problem happened during the first 75 shots.

3. Miss-triggered acquisition

The triggering of the seismic data recording was sometimes not synchronized with the firing time. The reason was not resolved yet. Eighty-five shots were miss-triggered. Some of them may be able to use for processing after adjusting the trigger time using with the direct wave arrival.

4. Duplicated shot number

The total volume of the seismic data was ~6 GB. Because 6 GB was too large to save them in one partition of the acquisition computer, we needed to switch the partition of the data storage space while the survey was under way. When the switching occurred, the acquisition computer miss-numbered the file number of the data, which were duplicated. The shot number 3291 and 3292 were duplicated files.

4.4.6 Onboard processing and quality check

A Sun Blade 100 workstation was brought from ORI into No.3 Lab., and used for onboard processing and quality check of the seismic data. “Seismic Unix” free software packages installed on the workstation was used for this purpose. We checked the shot gathers and found the triggering of the data acquisition was ~0.2 s earlier than the timing of the randomized shot pulse which is 0.45 s earlier than the real shot timing. We calculated this static time using the arrival of the direct wave, resulting that the data should be shifted upward 0.637 s to adjust to the real shot timing; e.g. the data acquisition was triggered 0.637 s earlier than the real shot time. Filtered neartrace section was created as a preliminary result of the MCS survey. We applied a low cut filter which has a corner frequency at 8 Hz.

Table 6 Bird setting. Distance is measured from the head of active section. Bird #3 equipped a compass but was not working

	Bird #1	Bird #2	Bird #3	Bird #4	Bird #5
Distance	0	300	600	900	1200
S/N	1403	1309	1425	935	1386
Compass	○	N/A	Not working	N/A	○

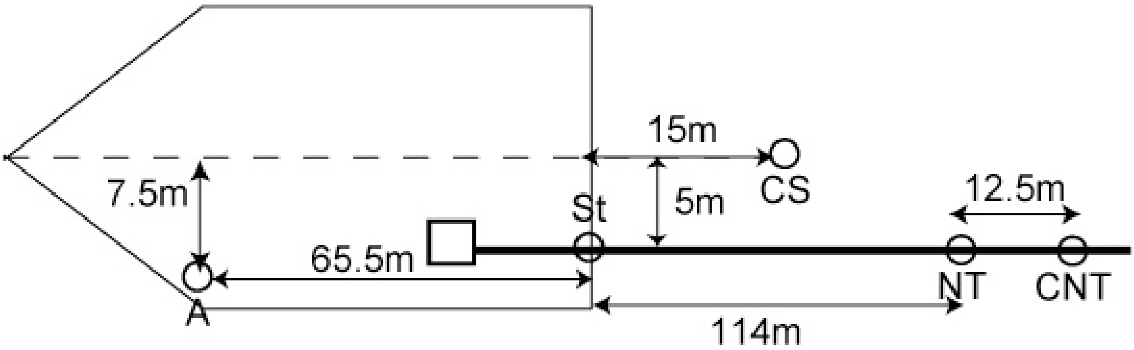


Figure 15 Positioning information. A is the GPS antenna. CS is the center of the source (assumed). St is the streamer cable position at stern. NT is the head of the active section. CNT is the center of the near trace section (channel #1).

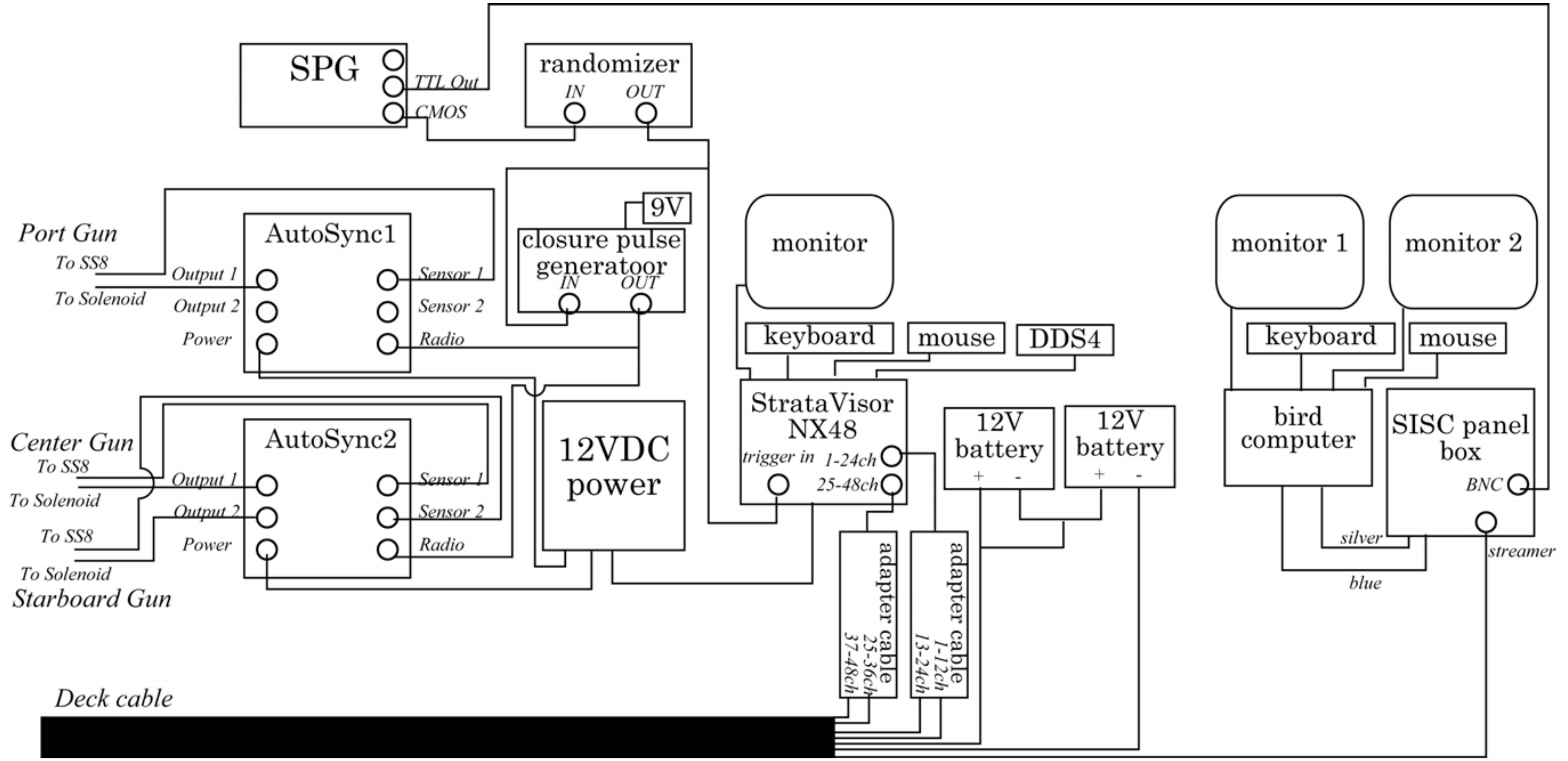


Figure 16 Block diagram of the MCS onboard system installed in No.3 Lab.

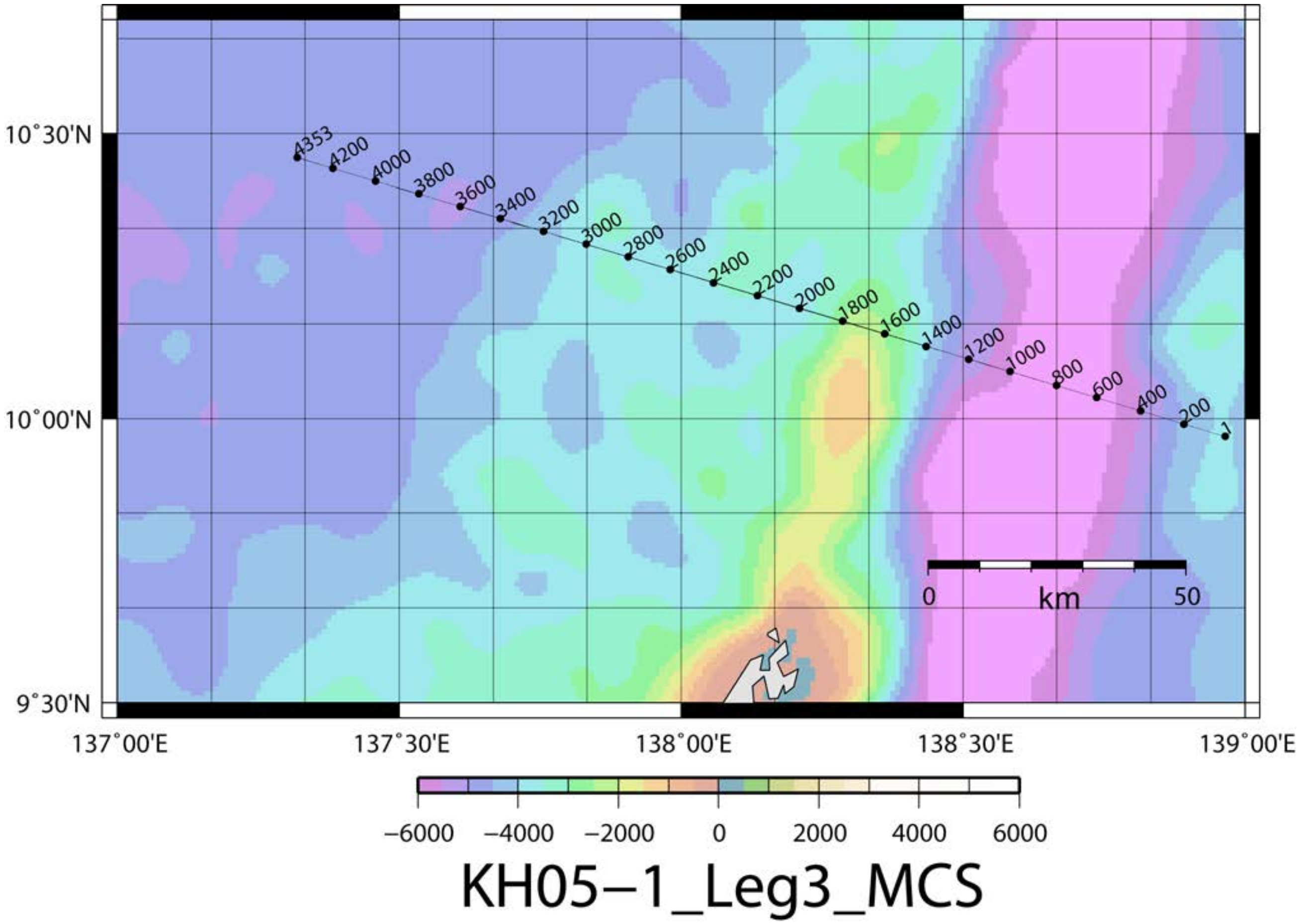


Figure 17 Shotpoint map.

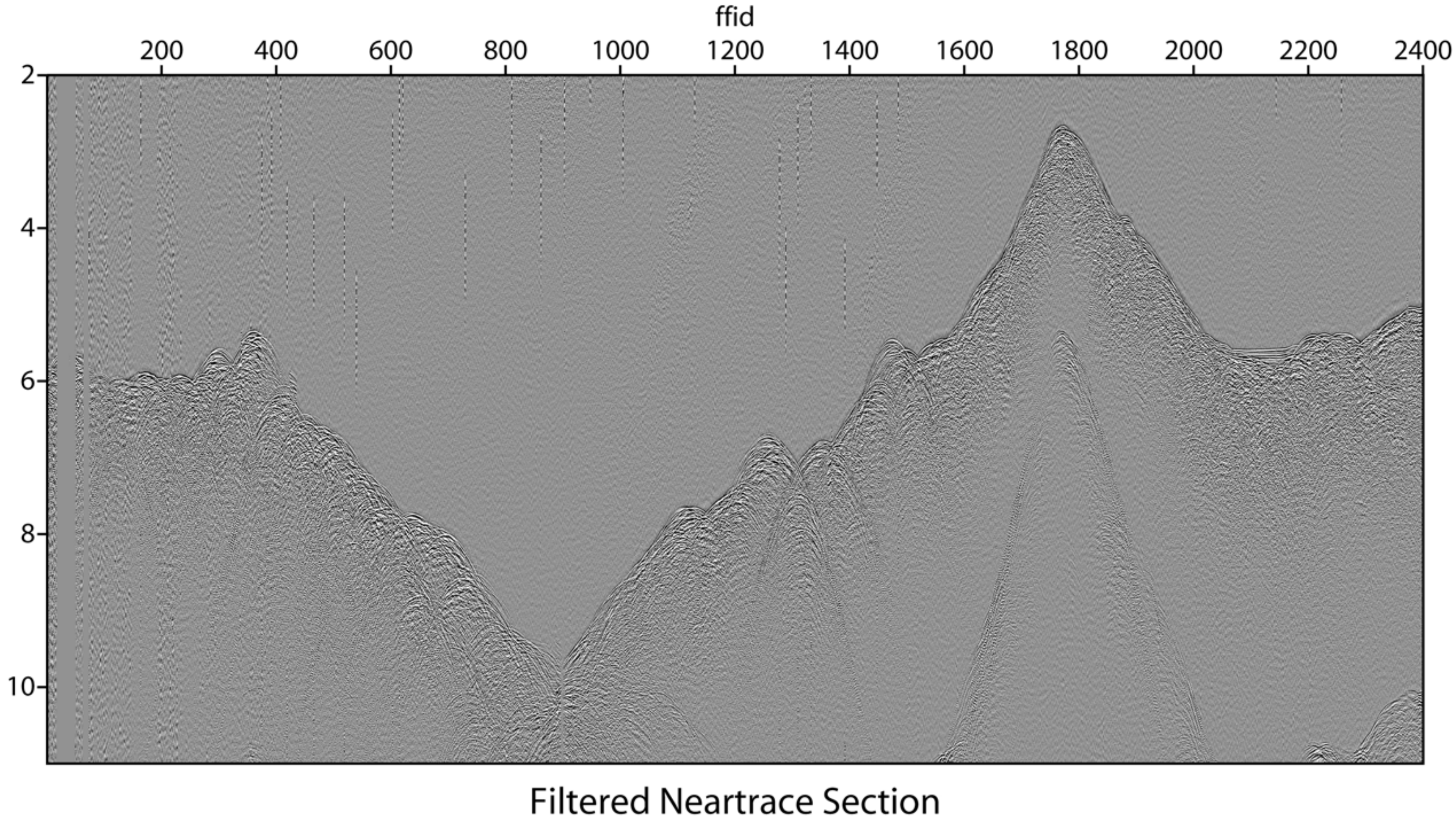


Figure 18(a) Filtered neatrace section for shot 1-2400.

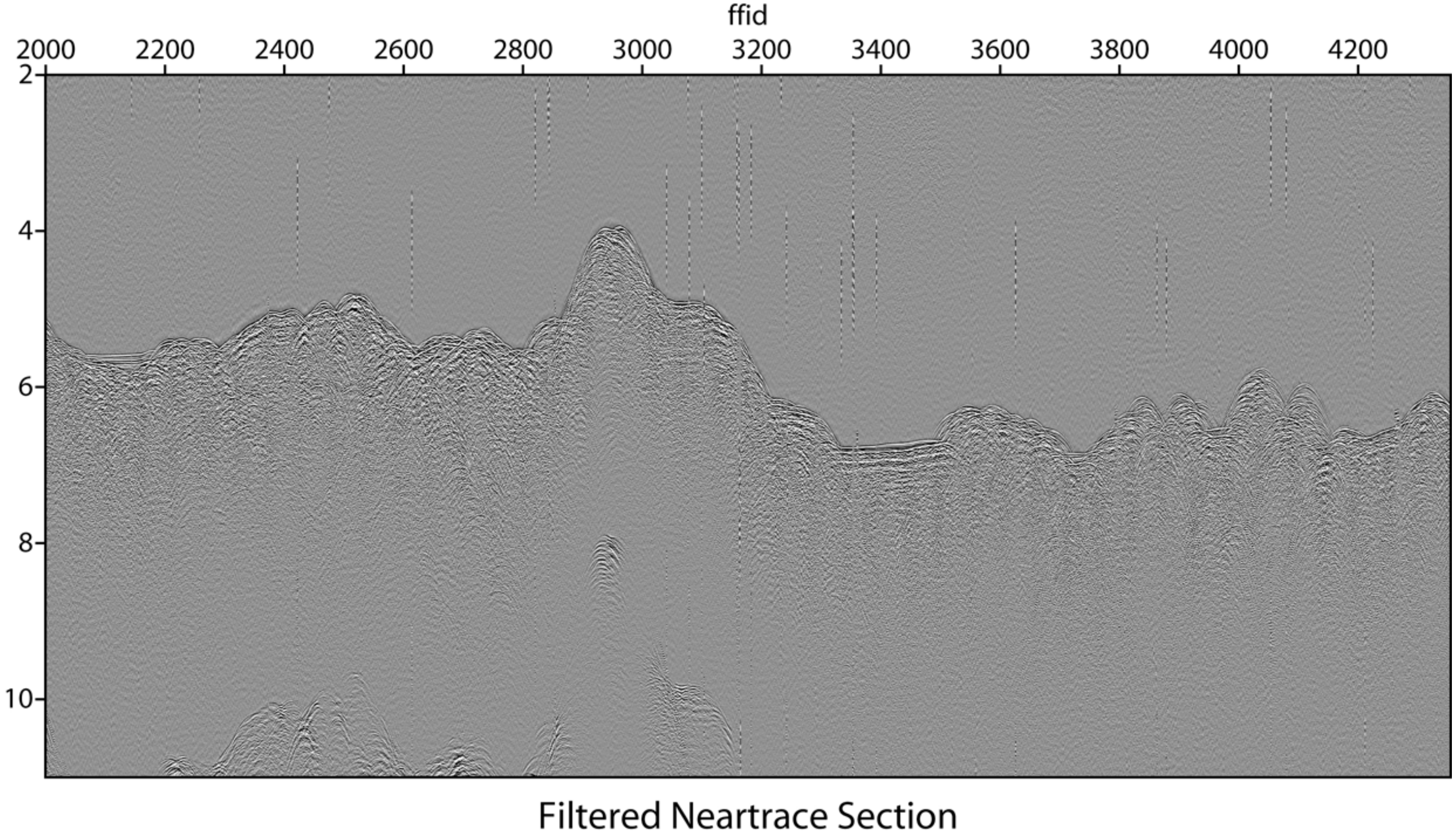


Figure 18(b) Filtered neatrace section for shot 2000-4355.

4.5 Dredging

Written by Yasuhiko Ohara

4.5.1 Dredge assembly

We used the ORI-TI type dredge (Fig. 19) during the KH05-01-Leg3 cruise. This dredge has been used extensively in the JAMSTEC cruises for the past several years. The dredge assembly used in this cruise is slightly different from that used in the previous JAMSTEC cruises (c.f., KR03-01 cruise report; Ohara et al., 2003). The difference includes the size and length of fuse wire. Leader wire was not employed. As shown in Fig. 1, it consists of a normal steel (20 mm thick) box type jaw (60 _ 45 cm mouth, 60 _ 27 cm throat, 16 cm deep) with a steel handle (26 mm diameter, 85 cm long), and a steel chain-bag (6 mm diameter, 100 cm long) with a stainless steel (5 mm thick) box type bucket (27 _ 60 _ 50 cm). The bucket can recover all kinds of geological samples including soft sediments, sands, pebbles and large rocks. It is connected with shackles (16 mm diameter with a square head) to a 25 cm fuse wire (6 mm diameter), together with a second (100 cm long) and a third (200 cm long) fuse wire (8 mm diameter), as described below.

Main wire
It is an installed winch wire of the R/V Hakuho for scientific observation. It is piano wire of 14 mm diameter, ~ 15000 m long, 0.815 kg weight per one meter in the water, having a 16.9 ton breaking strength.

Heavy chain
Heavy chain (18 mm diameter, 5 m long, 50 kg weight and about 6 ton breaking strength) was used to stabilize the dredge assemblage and was connected to the wire leader with a 3 ton swivel and shackles. Two weights (200 kg weight and 50 kg pipe dredge type weight) were attached to the heavy chain to add additional stability and attempt further sample recovery.

200 kg weight
The weight was used to ascertain when the dredge is on the bottom since it can be observed by the tension meter in the operation room. It was connected with shackles to the heavy chain, together with a 1 ton swivel, and two fuse wires (8 mm diameter, 100 cm and 200 cm long, a 2.5 ton breaking strength).

Pipe dredge
This pipe dredge (50 kg weight, 30 cm diameter and 50 cm long) serves both as a stabilizing weight and common small cylinder type dredge. It was also connected to the heavy chain in the same manner as the 200 kg weight, as shown in Fig. 1.

Fuse wire
Fuse wire (6 mm diameter, 25 cm long and a X ton breaking strength) was prepared to release the dredge from big bites that might damage the main wire. It was connected to

the heavy chain with a 3 ton swivel and shackles in the dredge assemblage. In the case of the ORI-TI-type dredge, two additional fuse wires (8 mm diameter, 100 cm and 200 cm long, 2.5 ton breaking strength) were connected as shown in Fig. 20. This allows the ORI-TI-type dredge to be hauled toward a different direction by the second fuse wire if the first fuse wire was broken due to anchoring. The third fuse wire is designed to work in the same manner as the second fuse wire, if the second fuse wire was broken. The change in hauling direction can hopefully release the dredge from big bites that might damage the main wire and/or anchoring.

Life wire

One end of the life wire (10 mm diameter, 7 m long, 3.9 ton breaking strength) was connected parallel with fuse wires and the another end was connected with the upper middle part of the chain-bag, enclosing the chain-bag (see Fig. 19). The life wire was designed to close and recover the chain-bag dredge with rock samples secured in the lower part, in the case all fuse wires were broken by a big bite or anchoring.

4.5.2 Dredge results

We performed in total 2 dredge hauls during the KH05-1-Leg 3 cruise, focusing of the hook-shaped ridge at ~ 9°20’N (Fig. 20). The dredge sites are listed in Table 7 and the detailed bathymetric map of each dredge site and dredge logs are shown in Appendix. The main results are summarized as follows:

(1) The dredge D1 was on the western escarpment of the hook-shaped ridge (Fig. 21) and recovered heavily weathered pillow basalts, coarse-grained suspicious plutonic rocks, pumices and mud balls. Maximum tension during this haul was ~ 6.6 tons. No fuse wires were damaged.

(2) The dredge D2 was on the eastern escarpment of the hook-shaped ridge (Fig. 22). The dredge encountered maximum tension ~ 8.8 tons several times, and the first fuse wire was broken. The dredge recovered a large amount of mud balls.

4.5.3 Description of the dredged samples

Since the onboard rock saw was not available during the cruise, the samples recovered from the KH05-1-Leg 3 cruise were not being able to be curated during the cruise.

Dredge 1: 9°20'N hook-shaped ridge western escarpment

In this dredge haul it was intended to try to sample the lower crust of the western escarpment of the 9°20'N hook-shaped ridge. The bathymetry look similar to the Pito Deep, northern end of the Easter microplate, where deep crustal rocks are exposed. Although we hoped to recover lower crustal rocks, the dredge contained weathered pillow basalts, coarse-grained suspicious plutonic rocks, pumices and mud balls (Fig. 23). The degree of weathering of the pillow basalts are heavy (Fig. 24A). The coarse-grained suspicious plutonic rocks include very large grain of euhedral pyroxene or hornblende (maximum ~ 5 mm in length) (Fig. 24B, 24C). These suspicious plutonic rocks also look very weathered. It should be noted that all the rocks recovered from dredge 1 has only trace amount of Mn-coating (Fig. 23).

Dredge 2: 9°20'N hook-shaped ridge eastern escarpment

In this dredge haul we hoped to sample the Parece Vela Basin lower crust, if any exist. However, the dredge recovered only a large amount of mud balls. These mud balls are relatively thick Mn-coated (Fig. 23).

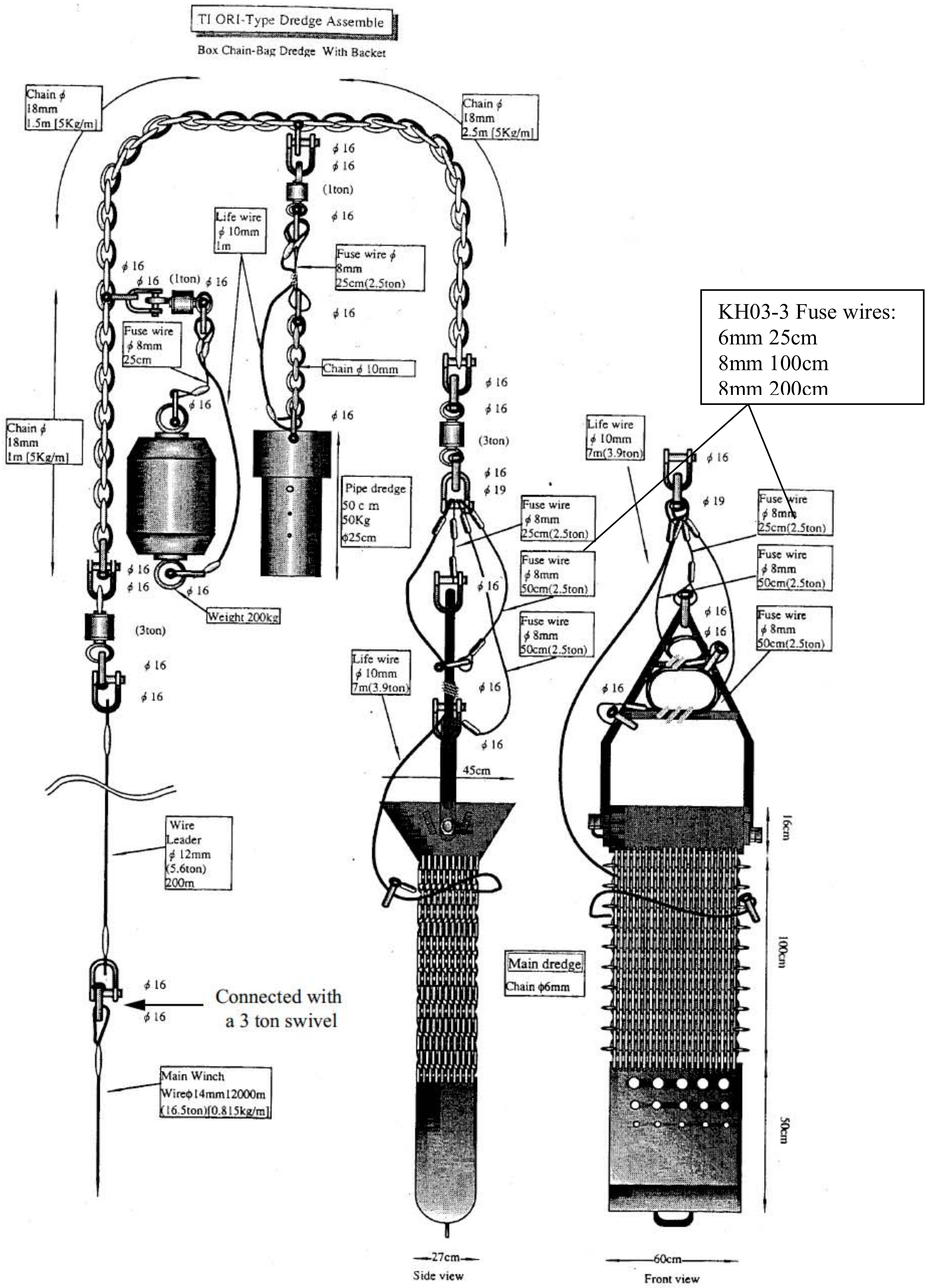


Figure 19. ORI-TI type dredge assembly

Table 7 List of the dredge site during KH05-1-Leg 3 cruise

Dredge Haul	Local time	Start (on bottom)			End (off bottom)			Setting	Main lithologies recovered
		Lat.	Lon.	Depth (m)	Lat.	Lon.	Depth (m)		
1	June 24	9°17.71'N	135°55.85'N	4292	9°18.77'N	135°56.44'N	3634	9°20'N hook-shaped ridge western escarpment	weathered pillow basalt; coarse-grained suspicious plutonic rock; pumice; mud ball
2	June 24	9°06.88'N	136°23.17'N	4893	9°06.15'N	136°23.15'N	4511	9°20'N hook-shaped ridge eastern escarpment	a large number of mud ball

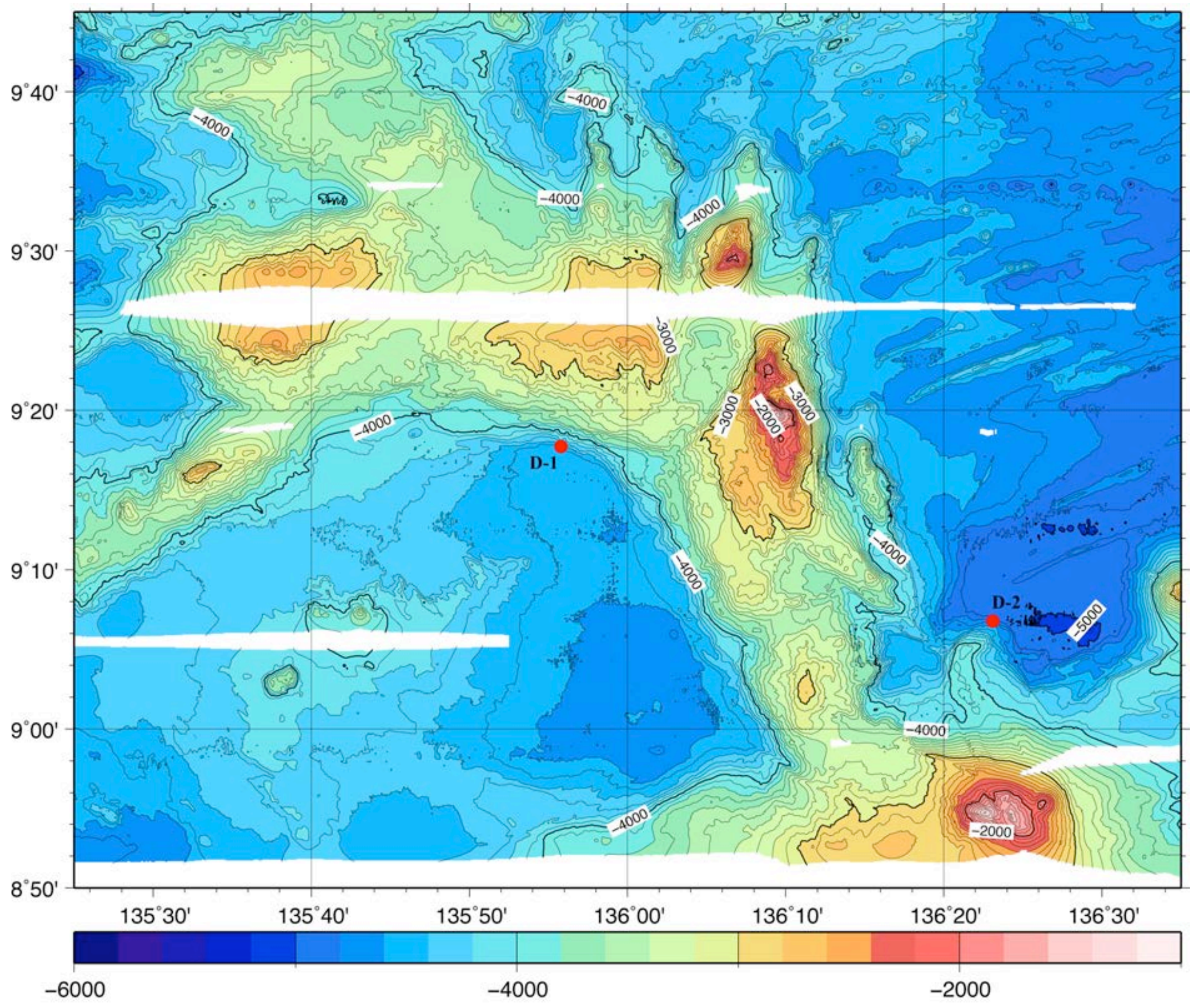


Figure 20 Bathymetry of the dredge sites. Red circles indicate two dredging locations.

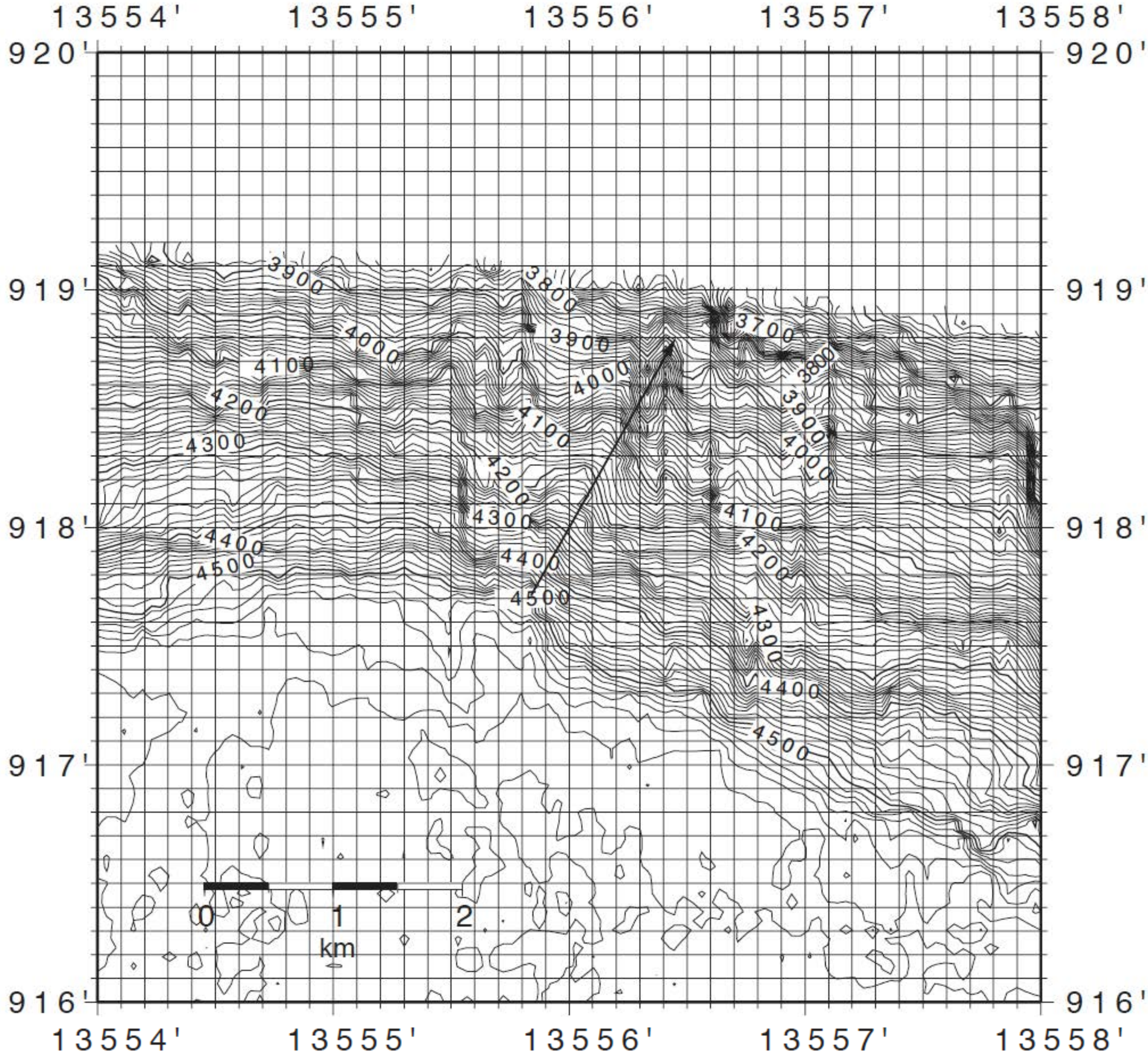
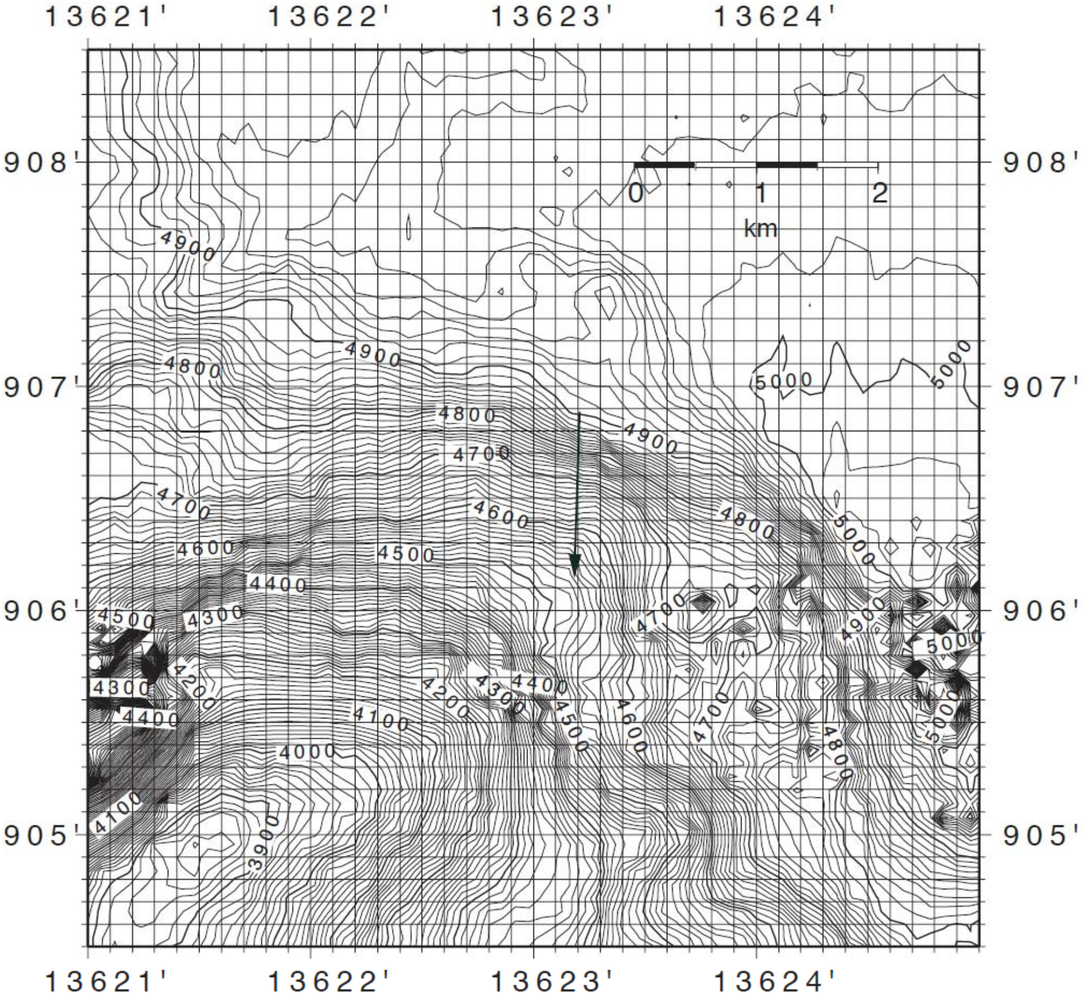
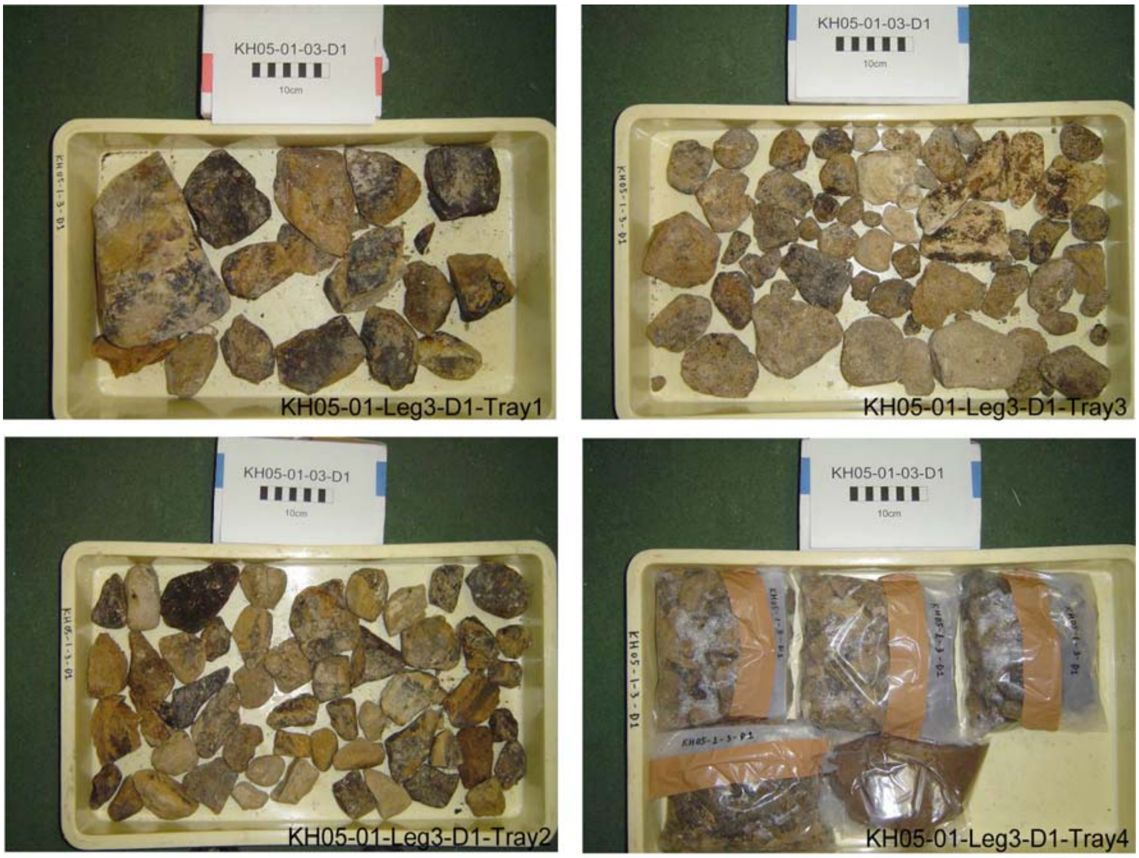


Figure 21 . Detailed bathymetry of the dredge D1. Arrow indicates direction of the dredge haul.



Fugure 22 Detailed bathymetry of the dredge D2. Arrow indicates direction of the dredge haul.



KH05-01-Leg3-D1

KH05-01-Leg3-D2

Figure 23 Overall photos of the dredges D1 and D2 samples.

Figure 24 Close-up photos of the samples from dredge D1. (A) Heavily weathered pillow basalt. (B) Coarse-grained suspicious plutonic rock. (C) Very large grain of euhedral pyroxene or hornblende (maximum ~ 5 mm in length) in coarse-grained suspicious plutonic rock.

5. Future works

Rapid publications

1. Okino , Ohara et al. to be submitted to InterRidge News or GRL.
2. Okino, Ohara et al. to be submitted to AGU Fall meeting in 2005.

Morphology and Tectonics

Okino plan to process the side-scan data collected by seabeam2120 and to study the tectonics of the survey area. The comparative study with rotational tectonics in other mid-ocean ridges will be done. Okino and Ohara will continue to establish the complete scenario of the Parece Vela Basin evolution.

Gravity

Lee and Kim shall analyze the marine gravity data to improve our knowledge of the tectonic and magmatic structure and processes of the Yap trench-arc-backarc system and interaction between the Pacific-Caroline and Philippine Sea plates. This study will involve the use of complementary data set such as the multi-channel seismic profile from which one derive information on the crustal density structure from seismic velocities. Lee and Kim also plan to continue the analysis of gravity anomaly on a regional scale. In particular, it will be important to understand how the topography of the Yap trench system is maintained. We intend to compare between various isostatic models and flexural models. Another important item for our research is to understand the difference in the subduction style of Caroline and Pacific plates with respect to the Sorol Trough. Our previous study has shown that there is a difference, but this argument needs to be validated by data set with a greater coverage. The acquisition of marine gravity data set along several new profiles should enable us to improve the understanding of the geological evolution of this region. The gravity data collected during the cruise will be used in Kim’s MS thesis.

Magnetics

Fujiwara will continue the data processing on magnetic anomaly data (both total force and vector magnetics). Additional figure eight turns will be done for calibration in Kh05-1 Leg 5 by Okino.

Seismics

Nakamura will process the seismic data at ORI using the “Focus” software.

Rock samples

Samples are distributed to Ohara, Harigane and Yang. Ohara will study the geochemistry and tectonic interpretation and Harigane will study on rheology. Yang will in charge of age dating. Fujiwara plan to study on rock magnetism.

Scheduled cruise
R/V Hakuho-maru KH05-1 Leg5 (additional 1-day mapping in July 2005)

Cruise proposal (to be proposed)
R/V Kairei (2006 or 2007)

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Appendices

Appendix A; Sound velocity table
Appendix B: List of SeaBeam navigation editing
Appendix C: Dredge logs

Appendix A: Sound velocity table

	Sound Velocity [m/s] used in SeaBeam Survey				
Depth	~2005.6.17 0:48	~2005.6.20 6:25	~2005.6.22 5:52	~2005.6.24 10:30	~End of survey
5	1543.5	1535.6	1544.4	1544.9	1543.9
10	1544.0	1544.0	1544.5	1544.5	1544.1
20	1544.2	1544.2	1544.4	1544.6	1544.3
30	1544.3	1544.2	1544.5	1544.8	1544.4
40	1544.5	1543.8	1544.1	1545.0	1544.4
50	1544.5	1543.5	1544.1	1545.1	1543.3
60	1543.5	1543.6	1543.6	1544.7	1543.0
70	1542.5	1542.7	1543.1	1544.0	1541.5
80	1542.1	1541.5	1542.7	1542.2	1540.1
90	1540.9	1540.3	1541.3	1540.3	1538.7
100	1540.4	1538.0	1540.4	1537.4	1535.6
120	1534.0	1533.6	1536.2	1531.2	1528.8
140	1523.1	1530.4	1529.9	1522.9	1521.4
160	1519.4	1525.6	1523.3	1517.2	1516.3
180	1516.1	1518.2	1517.2	1512.5	1512.7
200	1510.9	1511.4	1514.5	1505.4	1511.5
300	1495.1	1495.0	1493.0	1493.6	1493.6
400	1490.4	1490.7	1488.8	1490.9	1489.0
500	1489.0	1488.0	1486.3	1487.5	1487.3
600	1489.0	1486.5	1485.6	1486.8	1487.0
700	1489.2	1486.1	1485.0	1486.0	1487.8
800	1487.6	1486.0	1484.6	1485.1	1487.6
900	1486.7	1485.9	1484.5	1484.5	1486.8
1000	1486.7	1485.5	1484.5	1484.8	1486.4
1100	1486.7	1485.7	1484.7	1485.2	1485.8
1200	1486.4	1486.4	1484.8	1485.0	1485.3
1300	1486.5	1486.5	1484.9	1485.4	1485.8
1400	1486.9	1486.9	1485.4	1485.9	1486.5
1500	1487.3	1487.3	1486.1	1486.4	1487.1
1600	1487.9	1487.9	1487.2	1487.1	1487.9
1700	1488.8	1488.8	1488.3	1488.5	1488.8
1800	1489.8	1489.8	1489.7	1489.8	1489.4
1832	1490.0	1490.0		1490.1	1489.9
1900			1490.8		
2000	1491.4	1491.4	1491.4	1491.4	1491.4
2500	1498.3	1498.3	1498.3	1498.3	1498.3
3000	1506.4	1506.4	1506.4	1506.4	1506.4
3500	1514.5	1514.5	1514.5	1514.5	1514.5

4000	1523.2	1523.2	1523.2	1523.2	1523.2
4500	1532.1	1532.1	1532.1	1532.1	1532.1
5000	1541.1	1541.1	1541.1	1541.1	1541.1
5500	1550.1	1550.1	1550.1	1550.1	1550.1
6000	1559.1	1559.1	1559.1	1559.1	1559.1
6500	1568.2	1568.2	1568.2	1568.2	1568.2
7000	1577.4	1577.4	1577.4	1577.4	1577.4
7500	1586.6	1586.6	1586.6	1586.6	1586.6
8000	1595.8	1595.8	1595.8	1595.8	1595.8
8500	1605.0	1605.0	1605.0	1605.0	1605.0
9000	1614.3	1614.3	1614.3	1614.3	1614.3
	XBT-2 (yellow) Levitus (white)	XBT-1(yellow) XCTD-1(blue) Levitus (white)	XCTD-2(blue) Levitus (white)	XBT-3 (yellow) Levitus (white)	XBT-4 (yellow) Levitus (white)

Appendix B: List of SeaBean navigation editng

SeaBeamFileName	start time	end time	comments
sb200506161809.mb44	2005/06/16 18:11:18	2005/06/16 18:36:27	not used (figure eight turn)
sb200506170039.mb44	2005/06/17 00:41:30	2005/06/17 00:50:18	not used (no sound velocity correction)
sb200506172148.mb44	2005/06/17 21:50:37	2005/06/17 22:37:32	navigation edited (bad heading, use COG)
sb200506172235.mb44	2005/06/17 22:37:32	2005/06/17 22:47:48	not used (bad heading)
sb200506272306.mb44	2005/06/17 23:03:08	2005/06/17 23:22:50	not used (bad heading)
sb200506172321.mb44	2005/06/17 23:23:10	2005/06/18 00:09:37	navigation edited (bad heading, use COG)
sb200506182329~06190059.mb44	2005/06/18 23:31:29	2005/06/19 01:24:02	not used (deploying air gun, slow speed)
sb200506201959.mb44	2005/06/20 20:01:12	2005/06/20 20:29:44	navigation edited (bad heading, use COG)
sb200506220546~06220609.mb44	2006/06/22 05:48:29	2005/06/22 06:31:02	not used (figure eight turn)
sb200506220815~06220845.mb44	2005/06/22 08:17:15	2005/06/22 09:12:48	navigation edited (bad heading, use COG, cut 9:01-9:07)
sb200506221415~06221510.mb44	2005/06/22 14:17:26	2005/06/22 15:38:44	navigation edited (bad heading, use COG, cut 14:29-14:34, 15:27:20-15:30:0)
sb200506221603.mb44	2005/06/22 16:04:51	2005/06/22 16:29:32	navigation edited (bad heading, use COG, cut 16:13-16:15:30)
sb200506232020~06232044.mb44	2005/06/23 20:21:37	2005/06/23 21:03:50	not used (dredge, slow speed)
sb200506240623~06240637.mb44	2005/06/24 06:24:31	2005/06/24 06:38:46	not used (dredge, sow speed)

Appendix C

Station : KH05-01-Leg 3-D1 Date : June 24, 2005 Weather : Fine-cloudy Sea state : Calm

Target position (Lat., Lon.) : 9°17.67', 135°55.83' Target water depth (m) : 4500 m

Description of the target : southern-facing escarpment of a hook-shaped deep

Dredged assembly employed : Chain-bag dredge + two pipe dredges + 200 kg weight

Watch stander : Yasuhiko Ohara, Yumiko Harigane and Shin'ichiro Yokogawa

Comment : None

Time (local)	Wire length (m)	Tension (t)	Water depth (m)	Heading (deg)	Current direction (deg)	Lat.	Lon.	Note
7:22	0	-	4502	-	-	-	-	Deploy dredge
7:34	300	-	4481	-	-	9°17.52'	135°55.81'	
8:26	3100	3.60	4411	-	-	-	-	
8:35	3569	4.08	4461	-	-	9°17.63'	135°55.82'	
8:40	4003	4.58	4388	-	-	-	-	
8:50	4500	5.20	4333	70.0	267.1	9°17.69'	135°55.85'	Wire stop; Start 50 m wire-out at wire speed 0.3 m/sec
8:53	4537	4.44	-	-	-	-	-	On bottom
8:54	4550	4.42	4292	75.3	267.6	-	-	Wire stop; Finish 50 m wire-out
9:01	4550	4.48	4278	60.5	267.4	9°17.71'	135°55.85'	Ship speed 1 knot
9:09	4550	4.90	4220	65.0	267.7	9°17.77'	135°55.88'	
9:11	4550	5.16	4161	59.7	269.0	9°17.87'	135°55.93'	Ship speed 1.6 knot
9:20	4550	5.36	4150	65.0	264.5	9°17.90'	135°55.94'	
9:23	4562	4.54	4111	58.0	263.3	9°18.00'	135°56.00'	Start 50 m wire-out at wire speed 0.3 m/sec
9:26	4600	4.48	4092	57.8	270.9	9°18.05'	135°56.03'	Wire stop; Finish 50 m wire-out; Ship speed 1.7 knot
9:29	4600	4.76	4066	58.2	268.5	9°18.09'	135°56.05'	
9:31	4600	5.12	4052	-	-	9°18.14'	135°56.08'	

Time (local)	Wire length (m)	Tension (t)	Water depth (m)	Heading (deg)	Current direction (deg)	Lat.	Lon.	Note
9:34	4600	5.66	-	-	-	-	-	
9:37	4600	5.74	-	-	-	-	-	
9:39	4600	5.60	-	-	-	-	-	
9:44	4600	6.66	3938	65.2	269.0	9°18.33'	135°56.17'	Max tension 1
9:50	4600	5.78	-	-	-	-	-	
9:52	4600	5.82	-	-	-	-	-	
9:53	4600	5.98	-	-	-	-	-	
9:53	4600	6.52	3883	55.3	275.1	9°18.46'	135°56.24'	Max tension 2
9:56	4600	5.72	-	-	-	-	-	
9:58	4600	6.18	-	-	-	-	-	Max tension 3
9:59	4600	5.02	3866	60.0	269.3	9°18.52'	135°56.27'	Start 50 m wire-out at wire speed 0.2 m/sec
10:05	4516	5.04	3837	70.7	284.8	9°18.58'	135°56.30'	
10:06	4516	5.98	-	-	-	-	-	
10:07	4516	6.42	-	-	-	-	-	
10:09	4516	6.28	-	-	-	-	-	
10:15	4375	5.00	3838	66.8	274.9	9°18.61'	135°56.32'	Change amplitude of wire length meter
10:27	4209	5.06	3795	61.8	256.7	9°18.72'	135°56.41'	Off bottom; Change wire speed from 0.2 m/sec to 0.3 m/sec
10:32	4115	4.90	3634	-	-	9°18.77'	135°56.44'	
10:37	4020	4.86	3622	61.5	262.7	9°18.81'	135°56.46'	Change wire speed from 0.3 m/sec to 0.5 m/sec
10:47	3710	4.60	3606	61.8	263.9	9°18.90'	135°56.49'	
10:51	3600	4.54	3601	-	-	9°18.94'	135°56.51'	Change wire speed from 0.5 m/sec to 1.0 m/sec
~ 12:00	-	-	-	-	-	-	-	Dredge on deck

Appendix C

Station : KH05-01-Leg 3-D2 Date : June 24, 2005 Weather : Fine Sea state : Calm

Target position (Lat., Lon.) : 9°06.95', 136°23.15' Target water depth (m) : 4900 m

Description of the target : noutheastern-facing flank of hook-shaped abyssal hill

Dredged assembly employed : Chain-bag dredge + two pipe dredges + 200 kg weight

Watch stander : Yasuhiko Ohara, Yumiko Harigane and Shin'ichiro Yokogawa

Comment : 1st fuse wire (6 mm diameter), 25 cm long at the chain-bag dredge was broken.

Time (local)	Wire length (m)	Tension (t)	Water depth (m)	Heading (deg)	Current direction (deg)	Lat.	Lon.	Note
16:42	0	-	-	-	-	-	-	Deploy dredge
17:03	532	1.08	4893	93.5	268.9	9°06.93'	136°23.17'	Wire length meter start operating
18:15	4838	5.56	4896	80.2	277.3	9°06.90'	136°23.17'	Change wire speed from 0.3 m/sec to 0.1 m/sec
18:16	4850	5.62	4889	79.8	262.1	9°06.90'	136°23.17'	Wire stop; Start 50 m wire-out at wire speed 0.2 m/sec
18:19	4900	5.62	4894	90.8	272.1	9°06.89'	136°23.18'	Wire stop; Start 50 m wire-out at wire speed 0.3 m/sec
18:22	4920	4.90	4893	100.5	256.3	9°06.88'	136°23.17'	On bottom
18:23	4937	4.92	4891	109.3	276.4	-	-	Wire stop
18:29	4937	4.90	4858	117.5	266.3	-	-	Wire stop; Start 50 m wire-out at wire speed 0.3 m/sec
18:32	4986	4.84	4847	102.8	267.6	9°06.73'	136°23.14'	Wire stop; Ship speed 1.3 knot
18:44	4986	4.94	4665	116.2	262.1	9°06.55'	136°23.14'	
18:51	4986	5.46	4620	115.7	264.5	9°06.44'	136°23.13'	
18:55	4986	5.56	4588	113.2	260.0	9°06.39'	136°23.13'	
19:03	4986	5.46	4548	112,2	270.6	9°06.26'	136°23.15'	Start 50 m wire-in at wire speed 0.2 m/sec
19:08	4900	5.72	4520	114.8	264.2	9°06.17'	136°23.16'	
19:10	4867	5.58	4500	115.3	269.7	9°06.14'	136°23.15'	Wire stop

Time (local)	Wire length (m)	Tension (t)	Water depth (m)	Heading (deg)	Current direction (deg)	Lat.	Lon.	Note
19:20	4867	5.52	4471	112.0	271.1	9°06.00'	136°23.15'	
19:22	4872	8.80	4470	113.8	269.7	9°05.97'	136°23.15'	Max tension 1; wire-out
19:23	4893	5.72	4472	112.8	272.0	9°05.95'	136°23.15'	
19:25	4915	5.92	4478	113.2	270.0	9°05.93'	136°23.16'	In order to leave the bottm, change heading to left; Reduce ship speed
19:28	4912	5.46	4477	80.7	267.9	9°05.92'	136°23.15'	Wire stop
19:29	4902	5.90	4476	79.5	266.3	9°05.93'	136°23.15'	Start wire-in
19:30	4900	7.92	-	-	-	-	-	Wire stop
19:33	4898	7.38	-	-	-	-	-	Start wire-in at wire speed 0.2 m/sec
19:34	4895	-	-	-	-	-	-	Wire stop
19:36	4884	6.70	4467	64.8	270.0	9°06.00'	136°23.19'	Start wire-in
19:37	-	8.88	4483	-	-	-	-	Max tension 2 ; Fuse wire break?
19:39	-	6.32	-	-	-	-	-	Start wire-in at wire speed 0.2 m/sec
19:41	4862	8.86	-	-	-	-	-	Max tension 3
19:42	4857	5.90	4500	-	-	-	-	Off bottom?
19:43	4835	5.50	4502	57.5	269.6	-	-	Change wire speed from 0.2 m/sec to 0.3 m/sec
19:52	4686	5.60	4511	84.2	264.2	9°06.14'	136°23.15'	Change wire speed from 0.3 m/sec to 0.5 m/sec; Off bottom
19:57	4509	5.58	4508	84.5	269.0	9°06.15'	136°23.14'	Change wire speed from 0.5 m/sec to 1.0 m/sec; Start wire-in
20:22	-	-	-	-	-	-	-	Dredge on deck