Preliminary Report

of

the Hakuho Maru Cruise KH 92-2

the Tansei Maru Cruise KT 92-7

and

the Kaiko Maru-5 Cruise

May 20 — June 26, 1992

IZU-OGASAWARA CAMPAIGN 92

Marine Geophysical Investigation of Izu-Ogasawara Arc System

Ocean Research Institute
The University of Tokyo
March, 1993

Preliminary Report

of

the Hakuho Maru Cruise KH 92-2

Leg 1: Tokyo — Yokosuka (May 20 — June 3, 1992)
Leg 2: Yokosuka — Tokyo (June 9 — June 26, 1992)

the Tansei Maru Cruise KT 92-7

KT-92-7: Tokyo — Tokyo (May 26 — June 4, 1992)

and

the Kaiko Maru-5 Cruise

Toba — Yokosuka (June 12 — June 20, 1992)

May 20 — June 26, 1992

IZU-OGASAWARA CAMPAIGN 92

Marine Geophysical Investigation of Izu-Ogasawara Arc System

by
The Scientific Members of the Expedition
Edited by
Kiyoshi SUYEHIRO

PREFACE

The plate tectonics theory, which has been the most successful working hypothesis for solid earth scientists for more than a score of years, is by no means a complete theory to explain the earth's evolution and dynamics. Among many important yet unsolved problems, such as the growth of continents or the mantle-core dynamics, we address the problem of how and why island arcs form and plates deform at a subduction boundary as the main objective of this cruise. We have chosen the northern Izu-Ogasawara subduction zone as the target of the survey. Here, an oceanic island arc evolution and active plate deformation are ongoing and the survey can be made over the whole subduction regime by seafaring experiments.

This survey was performed by three vessels, R/V Hakuho-maru, R/V Tansei-maru, and Kaiko-maru-5. The main task of studying the seismic crust and uppermost mantle of the northern Izu-Ogasawara Trench–Arc system was conducted as follows. After R/V Hakuho-maru deployed twenty ocean bottom seismographs (OBS's), two constant offset profiles and nine expanding spread profiles were shot with R/V Tansei-maru, The OBS array, which was to capture airguns and earthquake signals was recovered after the end of Tansei-maru cruise, KT-92-7. Then, the OBS's were redeployed along a long east-west profile transecting the whole subduction regime. Chartered ship, Kaiko-maru-5 performed the deployment of OBS's specially designed for deployments on deeper seafloors and the dynamite explosions amounting to five tons of dynamites in 71 shots. Hakuho-maru also shot airguns simultaneously towing a 24-ch seismic streamer over the whole profile. The survey ended after the recovery of the OBS's (three lost among 26 deployed).

The seismic survey was a success as detailed in this report. Other important components of the campaign included swath bathymetry (SeaBeam), magnetic and gravity surveys.

Chief scientists of the three cruises were Kiyoshi SUYEHIRO on Hakuho-maru, Asahiko TAIRA on Tansei-maru, and Toshihiko KANAZAWA on Kaiko-maru-5. Scientists aboard these cruises highly acknowkledge the captains, officers, and crews of the three vessels for their cooperation and great skill required for difficult maneuvers at instrument deployment and recovery and multi-ship operations.

February 1993

Kiyoshi SUYEHIRO, Asahiko TAIRA, and Toshihiko KANAZAWA

CONTENTS

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2. OUTLINE OF IZU-OGASAWARA CAMPAIGN 92

2.1 Outline of KH 92-2 Cruise

K. Suyehiro

LEG 1

The first half of the cruise, Leg 1, commenced from Harumi Port in Tokyo Bay on May 20, 1992 and ended on June 3, 1992 at Yokosuka.

Twenty ocean bottom seismographs including ten digital OBS's were deployed in order to study the microseismic activity of the area with unprecidented precision. Eleven seismic profilings were made by two-ship expanding spread and constant offset profiling as well as conventional multi-channel seismic reflection profiling between the Shikoku Basin and the forearc of the Izu-Bonin Trench. The KT-92-7 Cruise of R/V Tansei-maru was devoted to accomplish this task together with R/V Hakuho-maru. These data will provide reference crustal structures at different parts of the laterally heterogeneous crust and uppermost mantle of the trench–arc–back-arc system.

An ocean bottom magnetometer and an ocean bottom electrometer were deployed in the forearc for magneto-telluric measurements to study the crustal electrical conductivity structure. This will help improve the previously obtained conductivity structure model of the whole subduction zone.

An inverted echo sounder system was deployed at about 34°N, 139° 54'E to measure ocean current velocity. Detailed SeaBeam swath bathymetry surveys were made across the trench at about 30°50'N including a serpentine diapir image and at back-arc over cross rift seamounts. Swath bathymetry, 3.5 kHz sub-bottom seismic profiling, proton magnetometer, shipboard 3-component magnetometer, and gravity measurements were made during most of the cruise.

LEG 2

The latter half of the cruise, Leg 2, commenced from Shin-Yokosuka Pier in Tokyo Bay on June 3 and terminated on June 26, 1992 at Harumi Port. First, the OBS's deployed on Leg 1 were recovered. Then, they were re-deployed before MCS and dynamite shootings. Large volume airguns were shot over the OBS's together with the MCS survey. Among 26 deployed OBS's, 23 were recovered. Below is the lists of OBS positions.

Swath bathymetry surveys were conducted over a serpentine diapir zone and back-arc seamount chains.

LIST of OBS DEPLOYED on LEG 1 and RECOVERED on LEG 2

OBS	Observational Period	Latitude N	Longitude E	Depth (m)
1 GI - H	5/24/92 9:34 –6/12/92 20:50	32 ° 20.06 '	141 ° 29.98 '	4384.0
2 ORI-1	5/24/92 10:27–6/12/92 17:52	32 ° 20.04 '	141 ° 20.05 '	3641.0
3 GI - I	5/24/92 11:14–6/12/92 14:25	32 ° 20.10 '	141 ° 10.00 '	3384.0
4 ORI-3	5/24/92 12:00–6/12/92 8:49	32 ° 30.00 '	141 ° 9.98 '	2552.0
5 GI - G	5/24/92 12:46–6/12/92 6:38	32 ° 30.06 '	141 ° 19.99 '	3118.0
6 ORI-2	5/24/92 14:01–6/11/92 20:24	32 ° 39.99 '	141 ° 34.91 '	5346.0
7 GI - F	5/24/92 15:06–6/11/92 16:28	32 ° 40.07 '	141 ° 20.15 '	3172.0
8 ORI-6	5/24/92 15:51–6/11/92 12:51	32 ° 40.10 '	141 ° 10.05 '	2554.0
9 GI - B	5/24/92 17:19–6/11/92 9:49	33 ° 00.17 '	141 ° 10.03 '	2911.0
10 GI - C	5/24/92 19:18–6/11/92 6:11	32 ° 49.10 '	140 ° 39.79 '	1875.0
11 GI - A	5/24/92 22:32–6/11/92 0:22	32 ° 05.02 '	140 ° 40.06 '	2621.0
12 GI - E	5/25/92 0:33–6/10/92 20:05	32 ° 15.84 '	140 ° 13.16 '	1553.0
13 GI - D	5/24/92 5:18–6/10/92 18:52	32 ° 17.87 '	139 ° 54.91 '	1341.0
14 ORI*-8	5/24/92 6:31–6/10/92 9:29	32 ° 15.81 '	139 ° 37.89 '	1559.0**
15 ORI*-9	5/24/92 7:05–6/10/92 13:14	32 ° 11.90 '	139 ° 44.07 '	1575.0
16 ORI*-7	5/24/92 7:38–6/10/92 11:21	32 ° 11.94 '	139 ° 37.99 '	1598.0
17 ORI*-10	5/24/92 8:11–6/10/92 7:43	32 ° 12.04 '	139 ° 31.98 '	1263.0
18 ORI -5	5/24/92 8:46–6/2/92 6:33	32 ° 06.99 '	139 ° 37.96 '	1435.0
19 GI - J	5/25/92 9:51–6/10/92 15:34	31 ° 52.93 '	139 ° 45.11 '	1367.0
20 ORI-11	5/25/92 13:02–6/10/92	32 ° 15.93 '	138 ° 59.97 '	1485.0

GI: Dept. of Earth & Planetary Phys., ORI:Ocean Research Institute

* With compass, ** LSR readings

LIST of OBS DEPLOYED and RECOVERED on LEG 2 for EW SHOOTING

OBS	Observational Period	Latitude N	Longitude E	Depth (m)
1A-D(GI)	6/13/92 2:45 – 6/20 17:15	32°14.99'	142°59.92'	5653
2A ORI-9*	6/13/92 1:54 – LOST	32°15.15'	142°50.73'	5849
3A ORI-10	6/13/92 0:56 – 6/21 04:55	32°15.32'	142°39.42'	6258
4A GI (deep)	– 6/21 10:15	32°15.66	142° 21.7'	7641
5A GI (deep)	– LOST	32° 15.97	141° 57.9'	7209
6A GI (deep)	– 6/21 16:39	32° 16.08	141° 47.55	7073
7A CU	– 6/21 19:41	32° 16.18	141° 37.21	5900
8A CU	– 6/21 22:05	32° 16.28	141° 24.79	4000
9A CU	– LOST	32° 16.36	141° 12.38	4000
10A ORI-3	6/14/92 7:20 – 6/22 06:10	32°16.47'	140°59.97'	3414
11A CU	– 6/22 09:36	32°16.46	140° 47.55'	2800
12A -C(GI)	6/14/92 8:59 – 6/22 11:41	32°16.36'	140°35.14'	2226
13A CU	– 6/22 13:25	32°16.48'	140° 24.79'	1870
14A ORI-4	6/14/92 10:17 – 6/22 15:18	32°16.41'	140°14.54	1586

15A -F(GI)	6/14/92 11:25 – 6/22 17:15	32°16.37'	140°04.12'	1394
16A ORI-1*	6/14/92 12:10 – 6/22 19:25	32°16.36	139°53.78'	1451
17A -J (GI)	6/14/92 12:52 – 6/22	32°16.34'	139°43.48	1484
18A ORI-2*	6/14/92 13:41–6/23 06:16	32°16.28'	139°33.06'	1154
19A -A(GI)	6/14/92 14:28–6/23 07:48	32°16.22'	139°22.81'	1184
20A ORI-6	6/14/92 15:16–6/23 09:32	32°16.10	139°12.39'	1429
21A -E(GI)	6/14/92 16:04–6/23 11:11	32°16.01'	139°02.11'	1548
22A ORI-8	6/14/92 17:11–6/23 13:03	32°15.88'	138°51.86'	1611
23A ORI-5	6/14/92 18:00–6/23 15:11	32°15.69	138°41.40'	2288
24A -G(GI)	6/14/92 19:01–6/23 18:07	32°15.53'	138°27.53'	3510
25A ORI-7*	6/14/92 20:00–6/24 17:21	32°15.37'	138°13.73	3784
26A -B(GI)	6/14/92 20:56–6/24 20:15	32°15.01'	138°00.10'	3916

KH92-2 Leg 1 Ship Track Chart

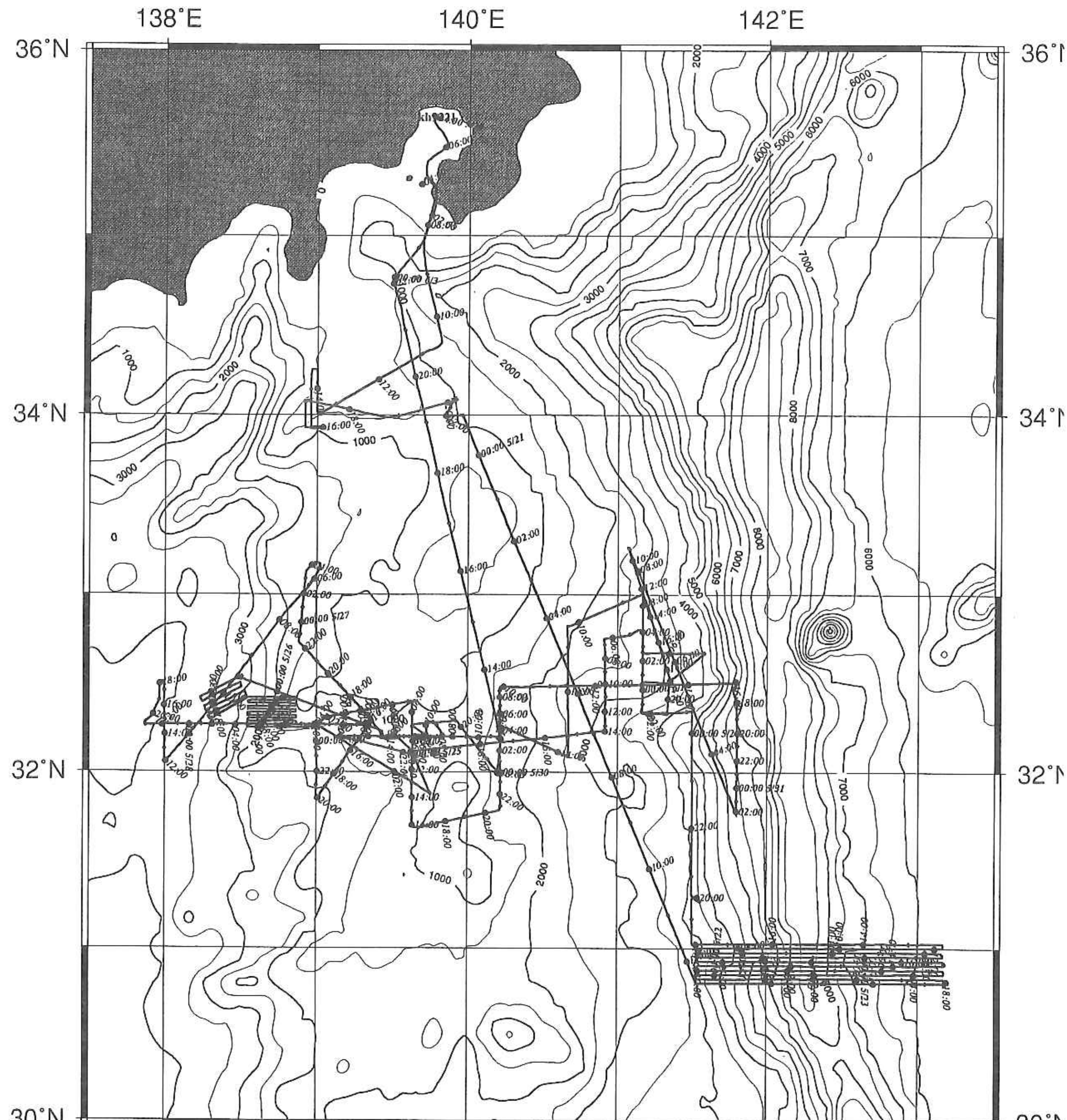

Figure 2-1-1: Ship's track in the northern Izu-Ogasawara island arc system (Leg 1)

KH92-2 Leg 2 Ship Track Chart

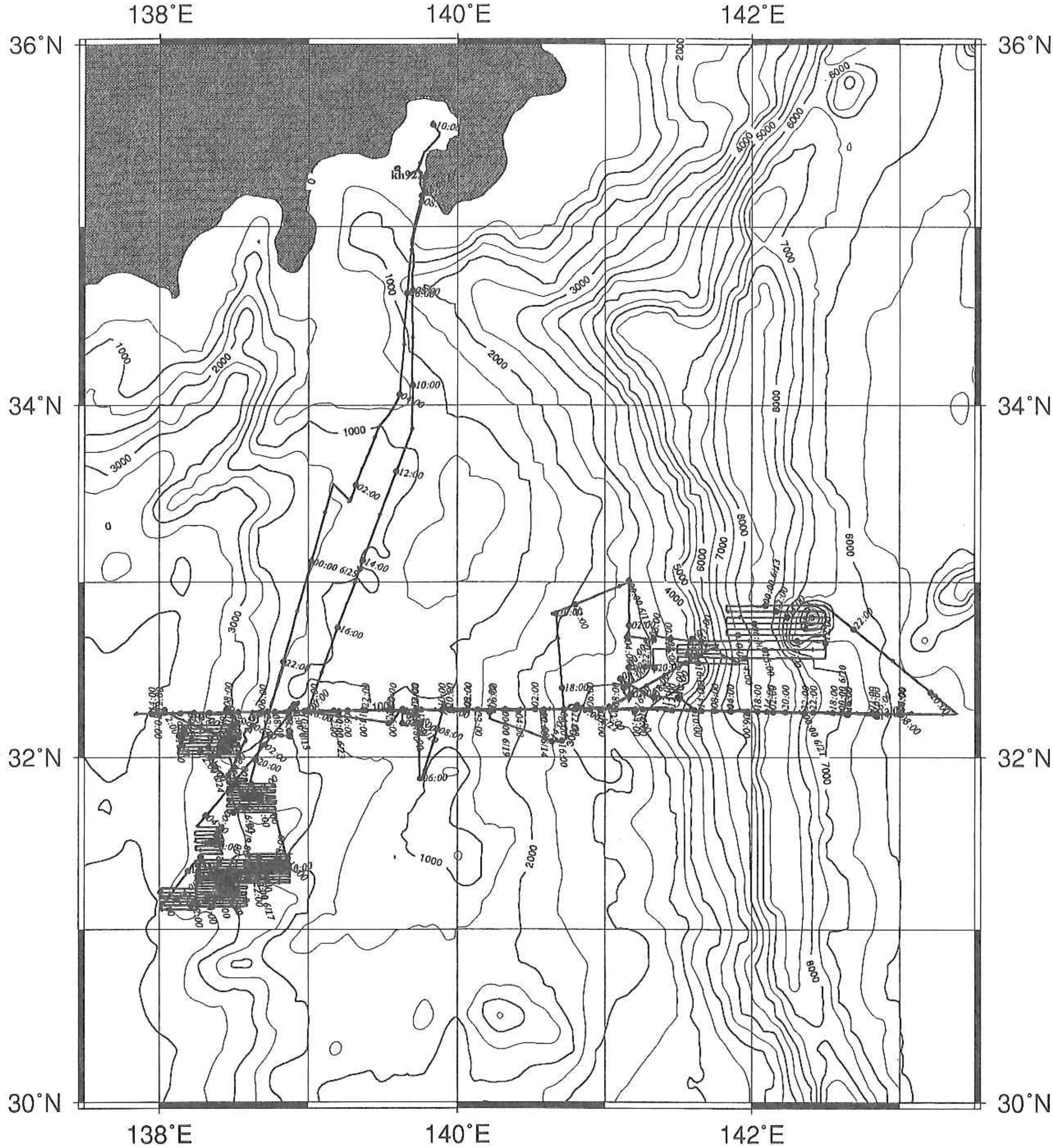

Figure 2-1-2: Ship's track in the northern Izu-Ogasawara island arc system (Leg 2)

2.2 KT 92-7 Cruise: 2-Ship Seismic Wide Angle Reflection/Refraction Survey

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Introduction

The KT92-7 cruise was carried out to obtain a high-resolution seismic structure of the Northern Izu-Ogasawara Arc Trench System using a technique of 2-ship seismic experiment from March 26 to June 4, 1992. The aim of the 2-ship experiment is to reveal the several detailed seismic structures where are important to consider the evolution of the Izu-Ogasawara Arc Trench System as oceanic island arc. The KT92-7 cruise is a part of the extensive seismic survey carried out using Hakuho-maru, Tansei-maru and Daigokaikou-maru from May to June, 1992. Here, we describe the role of KT 92-7 cruise, which is to receive the wide angle reflection/refraction waves of airgun shot by Hakuho-maru during KH92-2, Leg 1. We also show the method of data processing, the example of the records by 6ch-hydrophone streamer of Tansei-maru, and the preliminary results. The signal of airguns were also recorded by the 24ch-hydrophone streamer towed by Hakuho-maru (Suyehiro et al. this volume) and ocean bottom seismometers (Hino et al., this volume).

The 2-ship wide angle reflection/refraction surveys are performed using expanded spread profiles (ESPs) and constant offset profiles (COPs). An ESP is accomplished by simply moving the shot and the receiver apart an equal distance between shots. Therefore, the midpoint between the shot and the receiver remained fixed (Fig.1 a). An ESP has advantages for estimating exact seismic velocity in crusts. On COP, both shooting ship and receiver ship travel at the same speed and in the same direction (Fig.1 b). In this experiment, it is possible to map lateral changes of the seismic structure. A detailed description of ESP and COP can be found in Stoffa and Buhl (1979). We had nine ESPs and two COPs in Izu-Ogasawara Arc Trench System during this cruise (Fig.2). The profiles were laid over the whole arc; from the inner trench wall to the bask-arc basin including the rift zone.

ESP and COP field experiment

The speed of both the shooting ship (Hakuho-maru) and receiving ship (Tansei-maru) was maintained at 5 knots (9 km/h) through the ESP and COP surveys. At distance of 18 km before each ship crosses, the shooting ship began firing 1 or 2 airguns at 20-s intervals and receiving near-vertical incidence multichannel data by 24-ch hydrophone streamer. The receiving ship (Tansei-maru) also started acquiring wide angle reflection/refraction waves by 6-ch hydrophone streamer when shooting began.

The Tansei-maru's 6 ch hydrophone streamer was towed at distance, which is between the stern and the nearest channel, of about 500 m and channel spacing of the streamer is 50 m. The signals are analogly transmitted to a recorder on ship. First, the analog signal were converted to digital data. The sampling rate of analog signals was 4 ms , and the recording length was 8 sec par every shot. The delay time was changed with water depth and distance between the two ship. These on-board data were written to magnetic tapes (1600 bpi) after amplification , filtering and A/D conversion by means of NEC NE-128 digital recording system.

The ship position were determined by GPS and Loran-C by Tansei-maru hybrid navigation system. The hybrid navigation system recorded system positions which are estimated by hybrid processing of GPS data and Loran-C data to 1600 bpi magnetic tapes at every 30 s. The system also recorded GPS data, Loran-C data, PDR water depth data. See Shinohara et al. (this volume) about the navigation data reduction procedure. The distance of the two ships was measured using microwave ranging system. The microwave ranging system was available until the distance of 50 km. The distance data by microwave ranging is accurate, and the error of the distance is within 5 m. To process the seismic data, we mainly used the distance data by microwave ranging, and partly used the position data by the hybrid navigation system.

In conventional two-ship seismic experiment, radio link is used for timing of shot. We did not use radio link due to some problems of equipment preparation. Because this experiment focus on relatively deep structure, we need data of large distances. Another reason to not use radio link is the distance between the shots and the streamer may not be determined due to loss of radio link at large distances.

In this experiment, a digital clock driven by a highly stable oscillator was used both Hakuho-maru and Tansei-maru for experiment timing. Both ship's clocks are adjusted to JST (Japan Standard Time) within 0.5 s using JJY before the experiment and differences of each clock and JST are measured at every 12 hours during the experiment. Because Hakuho-maru always shot at every 0, 20, 40 s by Hakuho-maru's clock, Tansei-maru delay recording after every 0, 20, 40 s by Tansei-maru's clock. For example, if recording delay is 1 s, Tansei-maru starts recording at every 1, 21, 41 s by Tansei-maru's clock. This recording delay is varied as the range increases and the water depth changes. According to calibrating both ship's clock to JST on-shore, we synchronized both ship's time. The timing accuracy in experiment period is estimated to be less than 10 ms.

ESP records and preliminary results

The data are processed using the PHONIX vector system on Alliant mini-super computer system (Fig. 3). The first processing step consists of demultiplex and sort. Demultiplex step includes time shift due to recording delay and synchronizing both ship's clock. After demultiplex, we plotted the nearest channel data (1 ch monitor). The preliminary velocity functions are estimated using intercept time - slope method from the 1 ch monitor. The velocity function is used at partial normal move out (PNMO) correction. The distance for each shots was determined using the microwave ranging data. The trace were sorted using the distance for each shots. Next, we segment the profile into every 100 m (100 m bin), the traces were gathered into subgather. One subgather consists of about 6 traces. After subgahtering, PNMO correction is applied to all subgathers. The velocity information is used to apply NMO corrections to the data to the specified offset. This is in contrast to usual NMO correction which always applies to zero offset. Finally, an average trace is produced from all traces in a subgather by stacking and stacked data were plotted out to Versatec Plotter.

Figure 4 shows record section for ESP2 as the example of ESP records after data processing. The first arrival can be clearly seen up to 20 km. Between the ranges of 7 and 15 km, we can see three arrivals which have apparent velocity are 3.7, 4.9, and 7.0 km/s.

One dimensional (1-D) velocity structures are derived from each ESP records. First, the seismic wave field data in x-t (distance - time) domain are transformed into the tau-p (intercept time - ray parameter) domain (Diebold and Stoffa, 1981). We performed a slowness stack (ray parameter stack) for linear trajectories through the x-t data. After mapping to the tau-p data, the trajectories of wide angle reflections/ refractions are picked. A P-wave 1-D velocity structures are derived from the tau-p trajectory using the tau-sum inversion (Diebold and Stoffa, 1981).

Figure 5 shows the P-wave velocity structure beneath CMP of ESP2. In Figure 5, The velocity structure is compared with the near-vertical reflection profile collected coincidentally by the shooting ship (Hakuho-maru) with the ESP. The acoustic basement (reflector at 6.4 s TWT) and deep reflection at about 6.7 s TWT correspond to a increase in velocity from 3.2 to 3.7 km/s and from 3.8 to 4.9 km/s, respectively. The derived velocity structures show good agreement with the reflection records.

Concluding remarks

We obtained nine ESP records and two COP records over the Izu-Ogasawara Arc Trench System using airguns and hydrophone streamer. The 2-ship seismic experiment has several advantages over the other method of deep crustal studies. Especially, the velocity structure derived by ESP has high-resolution for both velocity and depth. This high-resolution relies on accurate determination of positions, recording with high-dynamic range, and using seismic waves with relative high frequency. It is one of advantages in the ESP experiment that the seismic velocity of each layers can be well-estimated. Then, the velocity structures derived by the ESP experiment should constrain the other velocity models estimated by the airguns/explosions - ocean bottom seismometer experiment.

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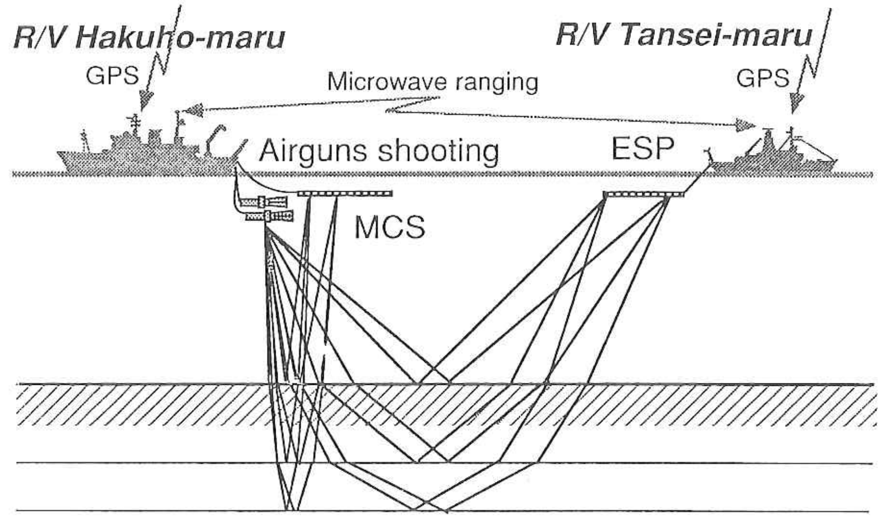

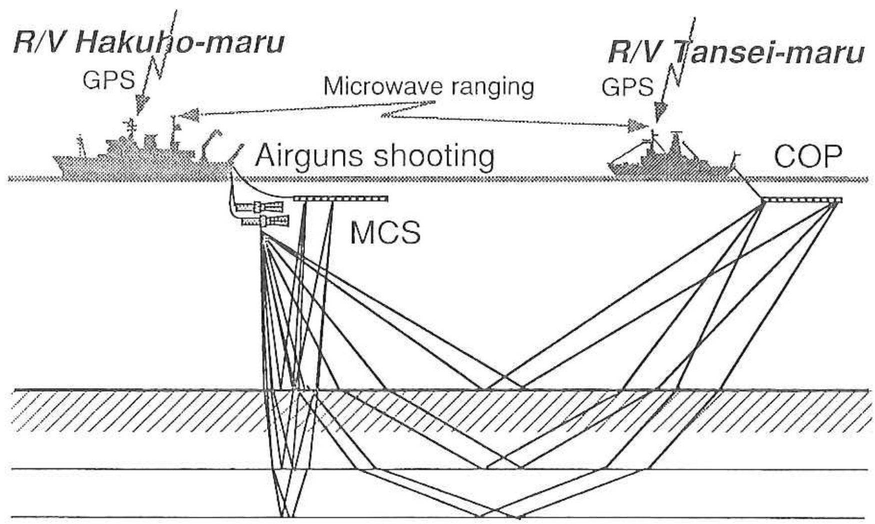

Figure 2-2-1a: The expanded spread profile (ESP) experiment. The two ships start at the center of the diagram and each streams outward at 5 knots. The shooting ship (R/V Hakuho-maru) is on the left, and the receiving ship (R/V Tansei-maru) is on the right. The shooting ship also tows the streamer and records near-vertical reflections. The distance of two ships are measuring by microwave ranging. The position of the two ships are determined by each ship's navigation system using GPS and Loran-C. Refractions are also recorded by the receiving ship, but their ray paths are not shown.

Figure 2-2-1b: The constant offset profile (COP) experiment. Both ship travel at the same speed and in the same direction. The distance of the two ship is continuously monitored by the shooting ship (R/V Hakuho-maru) using microwave ranging system. The shooting ship is also recorded near-vertical reflection.

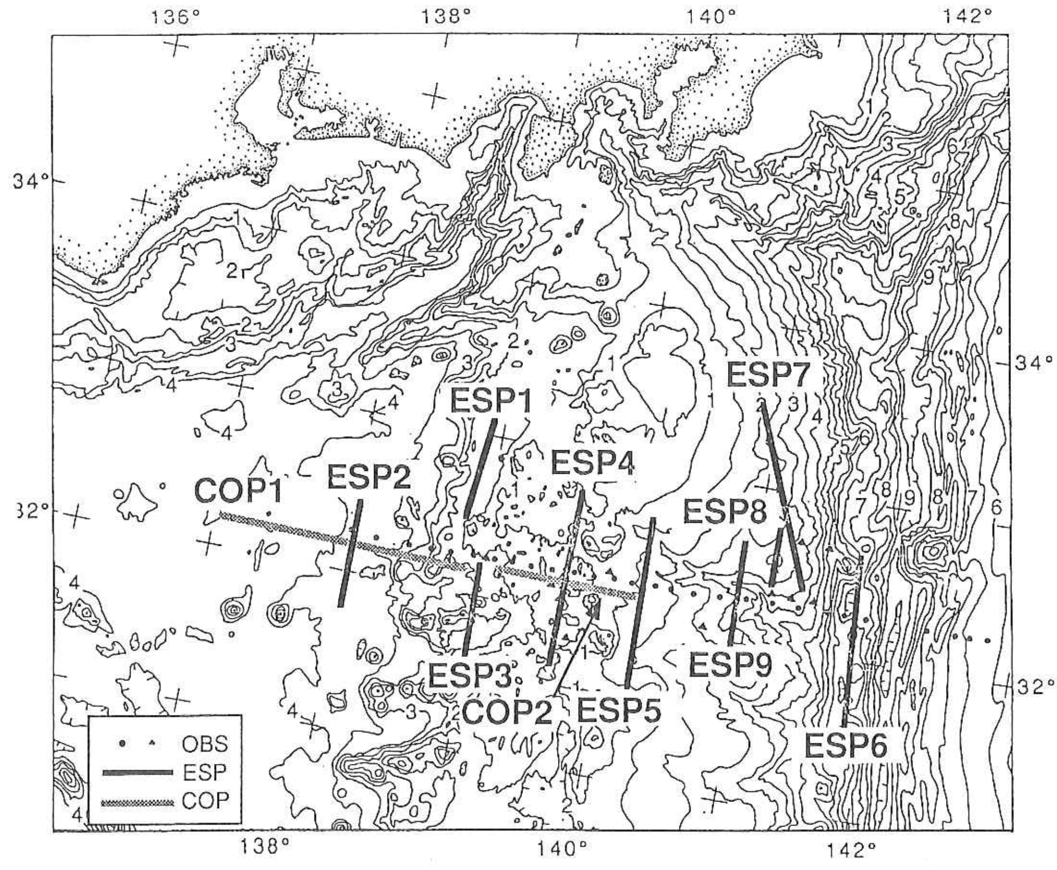

Figure 2-2-2: Map showing locations of nine ESP lines and two COP lines in the Izu-Ogasawara Arc Trench System. Contour interval is 500 m. The ESP lines are covered with the whole arc; from the inner trench wall to the back-arc basin. The positions of OBSs deployed in KH92-2 are also shown (circles and triangles).

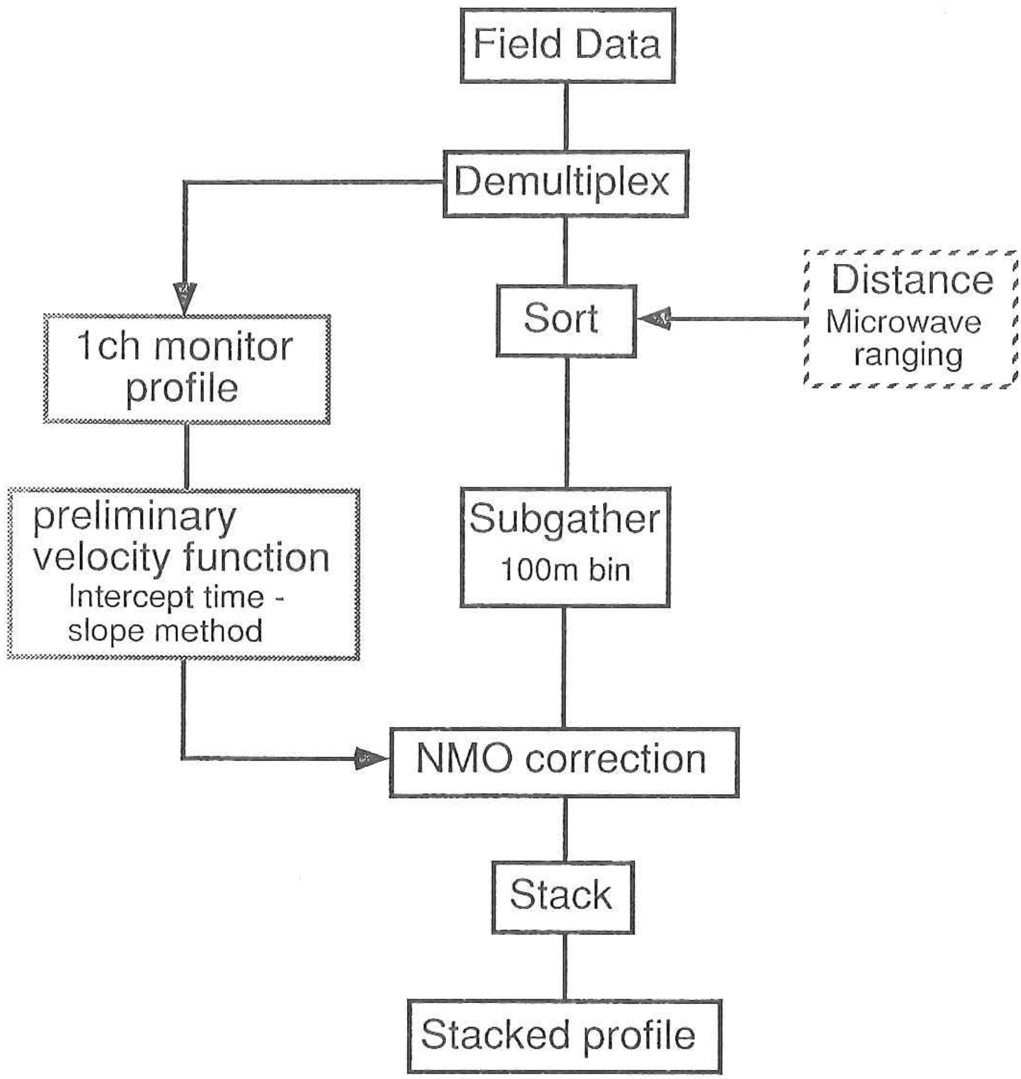

Figure 2-2-3: Flow of the ESP data processing. The field data recorded in 1/2 inch magnetic tapes are processed using PHOENIX VECTOR 2D, seismic processing system on the Alliant mini-super computer at ORI.

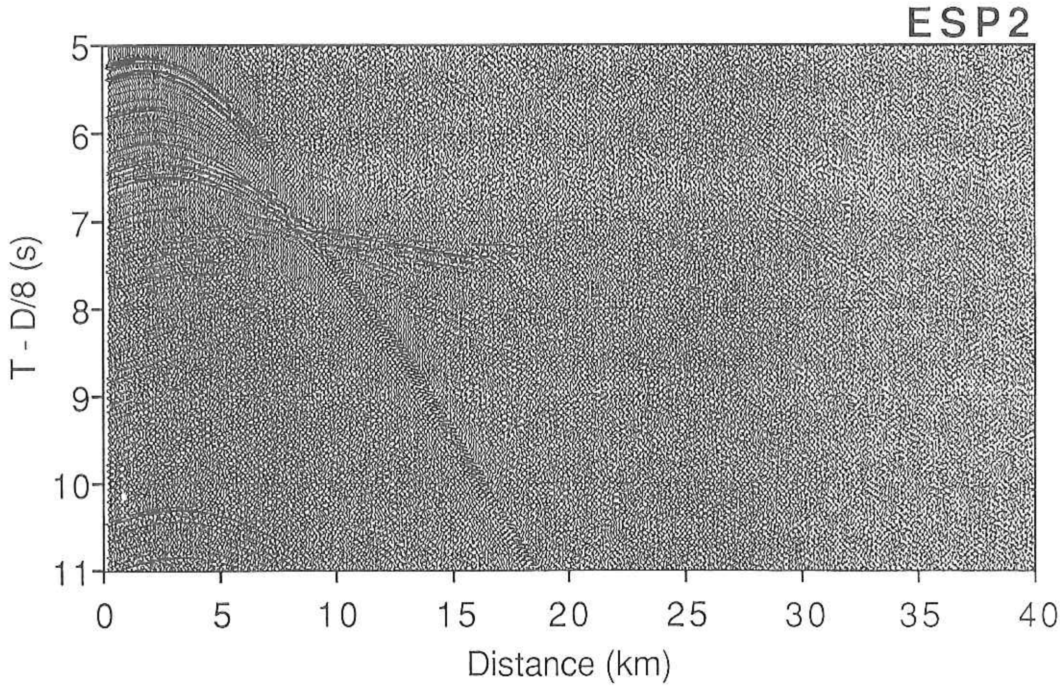

Figure 2-2-4: Example of processed ESP data. Record section of ESP 2 in the back-arc basin are shown. Reduction velocity is 7 km/s. Band-pass filtering is 8-40 Hz. True amplitude is displayed. The first arrival can be seen at up to 20 km, and several later arrival can be seen.

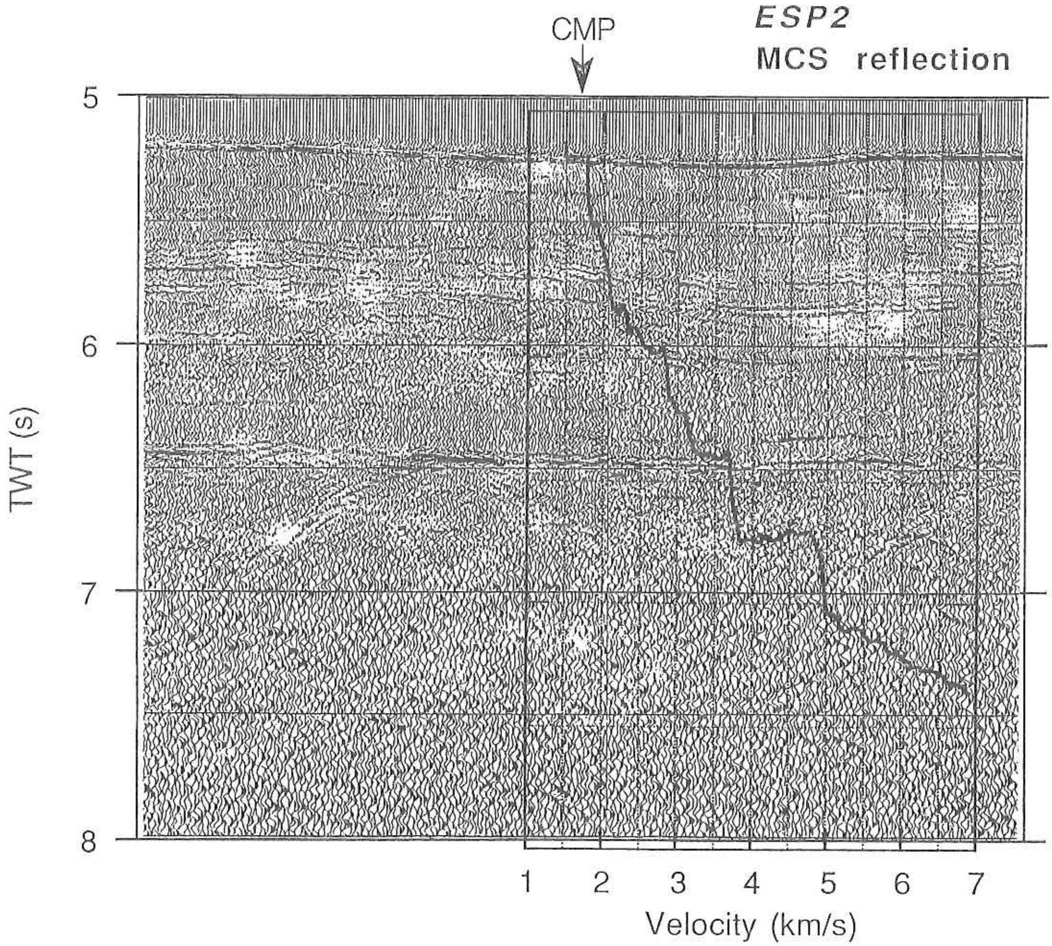

Figure 2-2-5: Comparison of the vertical incidence reflection records which collected by the shooting ship with the tau-sum inversion results for ESP2. The one-dimensional structure is converted to two-way time. P-wave velocity rapidly increase at the acoustic basement and the deep reflector below the acoustic basement.

Table 1 Two-ship positions during ESP and COP experiment

Tansei-maru ESP-1 RESULT

			Lat dg	min	Latitude	Lon dg	min	Longitude	Lat dg	min	Lon dg	min	dist(km)	az(deg)
Tansei-maru			32	56.4	32.94	138	54.44	138.9073	32	35	138	52	39.815	185.49
Hakuho-maru			32	46.1	32.7678	138	53.27	138.8878	33	7	138	56	38.994	6.2346
									dist btwn ships at start				19.218	185.44
			hour	min	latitude	min		longitude	min					
midpoint					32.8539	51.23		138.8976	53.85				9.6088	174.56
-10	km to CMP		8	57.4	32.9435	56.61		138.9077	54.46					
-9			8	4.06	32.9345	56.07		138.9067	54.4					
-8			8	10.7	32.9256	55.54		138.9057	54.34					
-7			8	17.4	32.9166	55		138.9047	54.28					
-6			8	24.1	32.9077	54.46		138.9037	54.22					
-5			9	30.7	32.8987	53.92		138.9027	54.16					
-4			9	37.4	32.8898	53.39		138.9016	54.1					
-3			9	44.1	32.8808	52.85		138.9006	54.04					
-2			9	50.7	32.8718	52.31		138.8996	53.98					
-1			9	57.4	32.8629	51.77		138.8986	53.92					
0	CMP		9	4.06	32.8539	51.23		138.8976	53.85					
1			9	10.7	32.845	50.7		138.8966	53.79					
2			9	17.4	32.836	50.16		138.8955	53.73					
3			9	24.1	32.827	49.62		138.8945	53.67					
4			10	30.7	32.8181	49.08		138.8935	53.61					
5			10	37.4	32.8091	48.55		138.8925	53.55					
6			10	44.1	32.8002	48.01		138.8915	53.49					
7			10	50.7	32.7912	47.47		138.8905	53.43					
8			10	57.4	32.7822	46.93		138.8894	53.37					
9			10	4.06	32.7733	46.4		138.8884	53.31					
10			10	10.7	32.7643	45.86		138.8874	53.25					
15			11	44.1	32.7195	43.17		138.8823	52.94					
20			11	17.4	32.6747	40.48		138.8773	52.64					
25			12	50.7	32.6299	37.8		138.8722	52.33					
30			12	24.1	32.5851	35.11		138.8671	52.03					
35			13	57.4	32.5404	32.42		138.862	51.72					
40			14	30.7	32.4956	29.73		138.8569	51.42					
45			14	4.06	32.4508	27.05		138.8519	51.11					
50			15	37.4	32.406	24.36		138.8468	50.81					

Hakuho-maru ESP-1RESULT

KH-92-2		ESP-1	1992/5/27		JST							
	Start lat°	lat'	**Latitude**	Start lon	lon'	**Longitude**	Endlat°	lat'	End lon	lon'	dist (km)	az (deg
KH	32	46.1	**32.7683333**	138	53.3	**138.888333**	33	7	138	56	38.933612	6.175
KT	32	56.4	**32.94**	138	54.4	**138.906667**	32	35	138	52	39.808662	185.4
dist btwn ships at start											**19.152213**	**5.122**
	KT	KH	latitude	min		longitude	min					
midpoint	*km to CMP*		*32.8542*	*51.25*		*138.8975*	*53.85*				*9.576069*	*185.1*
10			**32.7645**	45.87		**138.8879**	53.28					
9			**32.7735**	46.41		**138.8889**	53.33				57.29578	deg/rad
8			**32.7825**	46.95		**138.8898**	53.39				111.12	km/deg
7			**32.7914**	47.49		**138.8908**	53.45					
6			**32.8004**	48.02		**138.8918**	53.51					
5			**32.8094**	48.56		**138.8927**	53.56			KH at 08:00 32°46.07',		
4			**32.8183**	49.10		**138.8937**	53.62			KT at 08:00 32°56.40',		
3			32.8273	49.64		138.8946	53.68					
2		8:54:00	32.8362	50.17		138.8956	53.73					
1			32.8452	50.71		138.8965	53.79					
0		**9:08:38**	32.8542	51.25		138.8975	**53.85**		53.99	passed at 09:04:30		
-1			32.8631	51.79		138.8984	53.91			tail buoy passed at 09:0		
-2		9:22:15	32.8721	52.33		138.8994	53.96		54.09			
-3			32.8811	52.86		138.9004	54.02					
-4	9:27:00	9:35:08	**32.8900**	53.40		**138.9013**	54.08		54.15			
-5		9:41:45	**32.8990**	53.94		**138.9023**	54.14					
-6	9:41:00	9:48:50	**32.9079**	54.48		**138.9032**	54.19					
-7		9:54:54	**32.9169**	55.01		**138.9042**	54.25		54.28			
-8	9:54:00	10:01:37	**32.9259**	55.55		**138.9051**	54.31		54.36			
-9		10:08:19	**32.9348**	56.09		**138.9061**	54.37		54.41			
-10	10:08:00	10:14:53	**32.9438**	56.63		**138.9071**	54.42		54.50			
-11		10:21:38	**32.9528**	57.17		**138.9080**	54.48					
-12		10:27:59	**32.9617**	57.70		**138.9090**	54.54		54.66			
-13		10:34:33	**32.9707**	58.24		**138.9099**	54.60		54.73			
-14		10:41:47	**32.9797**	58.78		**138.9109**	54.65		54.77			
-15		10:47:20	**32.9886**	59.32		**138.9118**	54.71		54.79			
-16		10:53:46	**32.9976**	59.85		**138.9128**	54.77		54.87			
-17		11:00:33	**33.0065**	0.39		**138.9137**	54.82		54.93			
-18		11:06:50	**33.0155**	0.93		**138.9147**	54.88		54.97			
-19		11:13:24	**33.0245**	1.47		**138.9157**	54.94		55.04			
-20		11:20:56	**33.0334**	2.01		**138.9166**	55.00		55.12			
-21		11:27:25	**33.0424**	2.54		**138.9176**	55.05		55.15			
-22		11:33:25	**33.0514**	3.08		**138.9185**	55.11		55.17			
-23		11:40:06	**33.0603**	3.62		**138.9195**	55.17		55.24			
-24		11:46:38	**33.0693**	4.16		**138.9204**	55.23		55.30			
-25		11:53:09	**33.0782**	4.69		**138.9214**	55.28		55.36			
-26		11:59:19	**33.0872**	5.23		**138.9224**	55.34		55.43			
-27		12:05:54	**33.0962**	5.77		**138.9233**	55.40		55.50			
-28		12:12:15	**33.1051**	6.31		**138.9243**	55.46		55.54			
-29		12:18:07	**33.1141**	6.85		**138.9252**	55.51		55.60			
-30		12:24:22	**33.1231**	7.38		**138.9262**	55.57		55.69			

Tansei-maru ESP-2 RESULT

			Lat dg	min	Latitude	Lon dg	min	Longitude	Lat dg	min	Lon dg	min	dist(km)	az(deg)
Tansei-maru			32	24.15	32.403	137	59.93	137.9988	31	56	138	0	52.1376	179.87
Hakuho-maru			32	7.75	32.129	137	59.97	137.9995	32	36	138	0	52.319	0.0513
									dist btwn ships at start				30.3766	179.87
			Time	min	latitude	min		longitude	min					
midpoint					32.266	15.95		137.9991	59.9				15.1883	180.13
-15	km to CMP		22	1.255	32.401	24.05		137.9988	59.9					
-12.5			22	17.92	32.378	22.7		137.9988	59.9					
-10			23	34.59	32.356	21.35		137.9989	59.9					
-9			23	41.26	32.347	20.81		137.9989	59.9					
-8			23	47.92	32.338	20.27		137.9989	59.9					
-7			23	54.59	32.329	19.73		137.999	59.9					
-6			23	1.255	32.32	19.19		137.999	59.9					
-5			23	7.922	32.311	18.65		137.999	59.9					
-4			23	14.59	32.302	18.11		137.999	59.9					
-3			23	21.26	32.293	17.57		137.9991	59.9					
-2			23	27.92	32.284	17.03		137.9991	59.9					
-1			24	34.59	32.275	16.49		137.9991	59.9					
0	**CMP**		24	41.26	32.266	15.95		137.9991	59.9					
1			24	47.92	32.257	15.41		137.9992	59.9					
2			24	54.59	32.248	14.87		137.9992	60					
3			24	1.255	32.239	14.33		137.9992	60					
4			24	7.922	32.23	13.79		137.9992	60					
5			24	14.59	32.221	13.25		137.9993	60					
6			24	21.26	32.212	12.71		137.9993	60					
7			24	27.92	32.203	12.17		137.9993	60					
8			25	34.59	32.194	11.63		137.9993	60					
9			25	41.26	32.185	11.09		137.9994	60					
10			25	47.92	32.176	10.55		137.9994	60					
12			25	1.255	32.158	9.472		137.9994	60					
14			25	14.59	32.14	8.392		137.9995	60					
15			25	21.26	32.131	7.852		137.9995	60					
16			25	27.92	32.122	7.308		137.9995	60					
18			26	41.26	32.104	6.227		137.9996	60					
20			26	54.59	32.086	5.146		137.9996	60					
22.5			26	11.26	32.063	3.791		137.9997	60					
25			26	27.92	32.041	2.441		137.9997	60					
27.5			27	44.59	32.019	1.122		137.9998	60					

Hakuho-maru ESP-2 RESULT

KH-92-2		ESP-2	1992/5/28		JST							
	Start lat°	lat'	**Latitude**	Start lon°	lon'	**Longitude**	Endlat°	lat'	End lon	lon'	dist (km)	az (deg
KH	32	7.75	**32.1291667**	138	0	**138**	32	29.45	137	60	40.188647	-0.2
KT	32	24.15	**32.4025**	137	59.93	**137.99883**	31	56	138	0	52.133915	179.9
dist btwn ships at start											**30.372998**	**-0.206**
	KT	KH	**latitude**	min		**longitude**	min					
midpoint	*km to CMP*		*32.2658*	*15.95*		*137.9994*	*59.97*				*15.1865*	*179.8*
18			**32.1038**	6.23		**138.0001**	0.01					
17			**32.1128**	6.77		**138.0001**	0.00					
16			**32.1218**	7.31		**138.0000**	0.00					
15			**32.1308**	7.85		**138.0000**	60.00					
14			**32.1398**	8.39		**138.0000**	60.00					
13			**32.1488**	8.93		**137.9999**	59.99					
12			**32.1578**	9.47		**137.9999**	59.99					
11		22:26:24	**32.1668**	10.01		**137.9998**	59.99		0.06			
10	22:34:20	22:33:16	**32.1758**	10.55		**137.9998**	59.99		0.08			
9		22:38:03	**32.1848**	11.09		**137.9998**	59.99		0.14		57.29578	deg/rad
8	22:47:50	22:45:40	**32.1938**	11.63		**137.9997**	59.98		0.13		111.12	km/deg
7		22:52:06	**32.2028**	12.17		**137.9997**	59.98		0.12			
6	23:01:30	22:58:27	**32.2118**	12.71		**137.9996**	59.98		0.12			
5		23:04:58	**32.2208**	13.25		**137.9996**	59.98		0.10			
4	23:14:45	23:11:39	**32.2298**	13.79		**137.9996**	59.97		0.07			
3		23:18:31	**32.2388**	14.33		**137.9995**	59.97		0.02			
2	23:27:55	23:25:06	**32.2478**	14.87		**137.9995**	59.97		0.04			
1		23:31:51	**32.2568**	15.41		**137.9995**	59.97		59.99			
0	23:40:50	23:38:35	**32.2658**	15.95		**137.9994**	59.97		0.00			
-1		23:45:24	**32.2748**	16.49		**137.9994**	59.96		0.04			
-2	23:53:22	23:52:03	**32.2838**	17.03		**137.9993**	59.96		0.04			
-3		23:58:54	**32.2928**	17.57		**137.9993**	59.96					
-4	0:06:40	0:05:34	**32.3018**	18.11		**137.9993**	59.96		0.04			
-5		0:12:16	**32.3108**	18.65		**137.9992**	59.95		0.00			
-6	0:19:25	0:19:23	**32.3198**	19.19		**137.9992**	59.95		59.98			
-7		0:26:27	**32.3288**	19.73		**137.9991**	59.95		59.96			
-8	0:33:00	0:32:43	**32.3378**	20.27		**137.9991**	59.95					
-9		0:39:49	**32.3468**	20.81		**137.9991**	59.94					
-10	0:46:25	0:46:10	**32.3558**	21.35		**137.9990**	59.94		59.90			
-11		0:53:46	**32.3648**	21.89		**137.9990**	59.94		59.88			
-12	1:01:50	1:00:20	**32.3738**	22.43		**137.9990**	59.94		59.88			
-13		1:06:52	**32.3828**	22.97		**137.9989**	59.94		59.87			
-14		1:13:40	**32.3918**	23.51		**137.9989**	59.93		59.86			
-15		1:21:00	**32.4008**	24.05		**137.9988**	59.93					
-16			**32.4098**	24.59		**137.9988**	59.93					
-17			**32.4188**	25.13		**137.9988**	59.93					
-18			**32.4278**	25.67		**137.9987**	59.92					
-19			**32.4368**	26.21		**137.9987**	59.92					
-20		1:54:08	**32.4458**	26.75		**137.9987**	59.92		59.89			
-21		2:00:44	**32.4548**	27.29		**137.9986**	59.92		59.89			
-22		2:07:33	**32.4638**	27.83		**137.9986**	59.91		59.88			
-23		2:13:45	**32.4728**	28.37		**137.9985**	59.91		59.89			
-24		2:20:02	**32.4818**	28.91		**137.9985**	59.91		59.89			
-25		2:26:18	**32.4908**	29.45		**137.9985**	59.91		59.91			

Tansei-maru ESP-3 RESULT

			Lat dg	min	Latitude	Lon dg	min	Longitude	Lat dg	min	Lon dg	min	dist(km)	az(deg)
Tansei-maru			32	8.85	32.148	139	0	139	31	46	139	0	42.3182	180
Hakuho-maru			31	52.8	31.881	139	0	139.0007	32	16	139	0	42.9109	-0.084
									dist btwn ships at start				29.6691	179.88
			Time	min	latitude	min		longitude	min					
midpoint					32.014	0.84		139.0003	0.02				14.8346	180.12
-15	km to CMP		5	28.9	32.149	8.939		139	60					
-12.5			6	45.6	32.1265	7.589		139.0001	0.003					
-12			6	48.9	32.122	7.319		139.0001	0.004					
-10			6	2.23	32.104	6.24		139.0001	0.007					
-9			6	8.9	32.095	5.7		139.0001	0.008					
-8			6	15.6	32.086	5.16		139.0002	0.009					
-7			6	22.2	32.077	4.62		139.0002	0.011					
-6			6	28.9	32.068	4.08		139.0002	0.012					
-5			7	35.6	32.059	3.54		139.0002	0.013					
-4			7	42.2	32.05	3		139.0002	0.015					
-3			7	48.9	32.041	2.46		139.0003	0.016					
-2			7	55.6	32.032	1.92		139.0003	0.017					
-1			7	2.23	32.023	1.38		139.0003	0.019					
0	**CMP**		7	8.9	32.014	0.84		139.0003	0.02					
1			7	15.6	32.005	0.3		139.0004	0.021					
2			7	22.2	31.996	59.76		139.0004	0.023					
3			7	28.9	31.987	59.22		139.0004	0.024					
4			8	35.6	31.978	58.68		139.0004	0.025					
5			8	42.2	31.969	58.14		139.0004	0.027					
6			8	48.9	31.96	57.6		139.0005	0.028					
7			8	55.6	31.951	57.06		139.0005	0.029					
8			8	2.23	31.942	56.52		139.0005	0.031					
9			8	8.9	31.933	55.98		139.0005	0.032					
10			8	15.6	31.924	55.44		139.0006	0.034					
12			8	28.9	31.906	54.36		139.0006	0.036					
14			9	42.2	31.888	53.28		139.0006	0.039					
15			9	48.9	31.879	52.74		139.0007	0.04					
16			9	55.6	31.8699	52.2		139.0007	0.042					
18			9	8.9	31.8519	51.12		139.0007	0.044					
20			9	22.2	31.8339	50.03		139.0008	0.047					
22.5			10	38.9	31.8113	48.68		139.0008	0.05					
25			10	55.6	31.7888	47.33		139.0009	0.054					
27.5			10	12.2	31.7669	46.01		139.001	0.057					
30			10	28.9	31.7444	44.67		139.001	0.061					
32.5			11	45.6	31.722	43.32		139.0011	0.064					

Hakuho-maru ESP-3 RESULT

KH-92-2		ESP-3	1992/5/29		JST							
	Start lat°	lat'	Latitude	Start lon°	lon'	Longitude	Endlat	lat'	End lon°	lon'	dist (km)	az (deg)
KH	31	52.83	**31.8805**	139.00	0.04	**139.0007**	32.00	16	139	0	42.91089	-0.0836
KT	32	8.85	**32.1475**	139.00	0	**139.0000**	31.00	46	139	0	42.3182	180
dist btwn ships at start											**29.66911**	**-0.1211**
	KT time	KH time	latitude	min		longitude	min					
midpoint	*km to CMP*		*32.0140*	*0.84*		*139.0003*	*0.02*				*14.8346*	*179.9*
15			**31.8790**	52.74		**139.0007**	0.04					
14			**31.8880**	53.28		**139.0006**	0.04					
13		5:43:03	**31.8970**	53.82		**139.0006**	0.04					
12		5:49:17	**31.9060**	54.36		**139.0006**	0.04		59.91			
11		5:55:54	**31.9150**	54.90		**139.0006**	0.03					
10	6:01:45	6:02:24	**31.9240**	55.44		**139.0006**	0.03					
9		6:09:32	**31.9330**	55.98		**139.0005**	0.03				57.29578	deg/rad
8	6:14:50	6:17:18	**31.9420**	56.52		**139.0005**	0.03		0.16		111.12	km/deg
7		6:23:55	**31.9510**	57.06		**139.0005**	0.03					
6	6:27:10	6:31:10	**31.9600**	57.60		**139.0005**	0.03					
5		6:37:00	**31.9690**	58.14		**139.0004**	0.03					
4	6:40:36	6:42:54	**31.9780**	58.68		**139.0004**	0.03					
3		6:49:12	**31.9870**	59.22		**139.0004**	0.02					
2	6:54:45	6:55:39	**31.9960**	59.76		**139.0004**	0.02		0.26			
1		7:02:17	**32.0050**	0.30		**139.0004**	0.02		0.33			
0		7:07:59	**32.0140**	**0.84**		**139.0003**	**0.02**					
-1		7:14:21	**32.0230**	1.38		**139.0003**	0.02					
-2	7:22:03	7:20:57	**32.0320**	1.92		**139.0003**	0.02		0.30			
-3		7:26:27	**32.0410**	2.46		**139.0003**	0.02					
-4	7:35:03	7:32:35	**32.0500**	3.00		**139.0002**	0.01					
-5		7:39:09	**32.0590**	3.54		**139.0002**	0.01					
-6	&:48:41	7:45:39	**32.0680**	4.08		**139.0002**	0.01		0.12			
-7		7:52:10	**32.0770**	4.62		**139.0002**	0.01					
-8	8:02:00	7:58:32	**32.0860**	5.16		**139.0002**	0.01					
-9		8:06:10	**32.0950**	5.70		**139.0001**	0.01					
-10	8:15:45	8:11:36	**32.1040**	6.24		**139.0001**	0.01					
-11		8:17:49	**32.1130**	6.78		**139.0001**	0.01					
-12			**32.1220**	7.32		**139.0001**	0.00					
-13		8:30:45	**32.1310**	7.86		**139.0000**	0.00					
-14		8:37:00	**32.1400**	8.40		**139.0000**	0.00					
-15		8:43:24	**32.1490**	8.94		**139.0000**	60.00					
-16	8:54:50		**32.1580**	9.48		**139.0000**	60.00					
-17			**32.1670**	10.02		**139.0000**	60.39					
-18			**32.1760**	10.56		**138.9999**	60.00					
-19			**32.1850**	11.10		**138.9999**	59.99					
-20			**32.1940**	11.64		**138.9999**	59.99					
-21			**32.2030**	12.18		**138.9999**	59.99					
-22		9:28:39	**32.2120**	12.72		**138.9998**	59.99					
-23			**32.2210**	13.26		**138.9998**	59.99					
-24		9:42:01	**32.2300**	13.80		**138.9998**	59.99					
-25		9:49:25	**32.2390**	14.34		**138.9998**	59.99					
-26		9:55:43	**32.2480**	14.88		**138.9998**	59.99					
-27			**32.2570**	15.42		**138.9997**	59.98					
-28		10:09:05	**32.2660**	15.96		**138.9997**	59.98					
-29			**32.2750**	16.50		**138.9997**	59.98					

Tansei-maru ESP-4 RESULT

			Latdg	min	Latitude	Lon dg	min	Longitude	Lat dg	min	Lon dg	min	dist(km)	az(deg)
Tansei-maru			32	3.55	32.0592	139	38.04	139.634	32	42	139	38	71.209	180.05
Hakuho-maru			32	21.72	32.362	139	37.99	139.6332	31	42	139	38	73.561	0.0123
									dist btwn ships at start				33.651	180.13
			Time	min	latitude	min		longitude	min					
midpoint					32.2106	12.63		139.6336	38.015				16.825	179.87
15	km to CMP		17	52.17	32.0756	4.536		139.6332	37.993					
14			17	58.84	32.0846	5.076		139.6332	37.994					
12			17	12.17	32.1026	6.156		139.6333	37.997					
10			17	25.5	32.1206	7.235		139.6333	38					
9			18	32.17	32.1296	7.775		139.6334	38.002					
8			18	38.84	32.1386	8.315		139.6334	38.003					
7			18	45.5	32.1476	8.855		139.6334	38.005					
6			18	52.17	32.1566	9.395		139.6334	38.006					
5			18	58.84	32.1656	9.935		139.6335	38.008					
4			18	5.503	32.1746	10.48		139.6335	38.009					
3			18	12.17	32.1836	11.02		139.6335	38.011					
2			18	18.84	32.1926	11.56		139.6335	38.012					
1			18	25.5	32.2016	12.1		139.6336	38.014					
0	**CMP**		19	32.17	32.2106	12.63		139.6336	38.015					
-1			19	38.84	32.2196	13.17		139.6336	38.017					
-2			19	45.5	32.2286	13.71		139.6336	38.018					
-3			19	52.17	32.2376	14.25		139.6337	38.019					
-4			19	58.84	32.2466	14.79		139.6337	38.021					
-5			19	5.503	32.2556	15.33		139.6337	38.022					
-6			19	12.17	32.2646	15.87		139.6337	38.024					
-7			19	18.84	32.2736	16.41		139.6338	38.025					
-8			19	25.5	32.2826	16.95		139.6338	38.027					
-9			20	32.17	32.2916	17.49		139.6338	38.028					
-10			20	38.84	32.3006	18.03		139.6338	38.03					
-12			20	52.17	32.3186	19.11		139.6339	38.033					
-14			20	5.503	32.3366	20.19		139.6339	38.036					
-15			20	12.17	32.3456	20.73		139.634	38.037					
-16			20	18.84	32.3545	21.27		139.634	38.039					
-18			21	32.17	32.3725	22.35		139.634	38.042					
-20			21	45.5	32.3905	23.43		139.6341	38.045					
-22.5			21	2.17	32.4129	24.77		139.6341	38.048					
-25			21	18.84	32.4354	26.12		139.6342	38.052					
-27.5			22	35.5	32.4584	27.5		139.6343	38.056					
-30			22	52.17	32.481	28.86		139.6343	38.06					

Hakuho-maru ESP-4 RESULT

KH-92-2		ESP-4	1992/5/29		JST							
	Start lat°	lat'	Latitude	Start lo	lon'	Longitude	Endlat°	lat'	End lon°	lon'	dist (km)	az (deg)
KH	32	21.72	32.362	139	37.99	139.633167	31	42	139	38	73.5614	0.0123
KT	32	3.55	32.059167	139	38.04	139.634	32	42	139	38	71.2094	180.05
dist btwn ships at start											33.6509	0.1336
	KT time	KH time	latitude	min		longitude	min		true long			
midpoint	km to CMP		*32.2106*	*12.63*		*139.6336*	*38.02*				*16.825*	*180.1*
-17.35		16:38:00	**32.3667**	22.00		**139.6332**	37.99					
-17			**32.3636**	21.81		**139.6332**	37.99					
-16			**32.3546**	21.27		**139.6332**	37.99				*START16:40*	
-15			**32.3456**	20.73		**139.6332**	37.99					
-14			**32.3366**	20.19		**139.6332**	37.99					
-13		17:05:54	**32.3276**	19.65		**139.6333**	38.00					
-12	17:12:50	17:12:42	**32.3186**	19.11		**139.6333**	38.00					
-11		17:19:23	**32.3096**	18.57		**139.6333**	38.00					
-10	17:26:00	17:26:04	**32.3006**	18.03		**139.6333**	38.00		**38.09**			
-9		17:32:45	**32.2916**	17.49		**139.6334**	38.00				57.296	deg/rad
-8	17:39:00	17:39:43	**32.2826**	16.95		**139.6334**	38.00				111.12	km/deg
-7		17:45:52	**32.2736**	16.41		**139.6334**	38.00					
-6	17:52:40	17:52:50	**32.2646**	15.87		**139.6334**	38.01		**38.1**			
-5		17:59:27	**32.2556**	15.33		**139.6335**	38.01		**38.09**			
-4	18:05:15	18:06:07	**32.2466**	14.79		**139.6335**	38.01		**38.08**			
-3		18:12:52	**32.2376**	14.25		**139.6335**	38.01		**38.11**			
-2	18:18:57	18:18:18	**32.2286**	13.71		**139.6335**	38.01		**38.11**			
-1		18:25:54	**32.2196**	13.17		**139.6336**	38.01		**38.14**			
0	18:32:00	18:32:18	**32.2106**	12.63		**139.6336**	38.02		**38.11**			
1		18:39:04	**32.2016**	12.10		**139.6336**	38.02		**38.13**			
2	18:45:55	18:44:36	**32.1926**	11.56		**139.6336**	38.02		**38.23**			
3		18:51:28	**32.1836**	11.02		**139.6337**	38.02					
4	18:58:00	18:59:50	**32.1746**	10.48		**139.6337**	38.02					
5		19:05:25	**32.1656**	9.94		**139.6337**	38.02		**38.31**			
6	18:09:30	19:10:42	**32.1566**	9.40		**139.6337**	38.02					
7			**32.1476**	8.86		**139.6338**	38.03					
8	18:25:04	19:25:13	**32.1386**	8.32		**139.6338**	38.03		**38.25**			
9		19:31:45	**32.1296**	7.78		**139.6338**	38.03		**38.23**			
10	18:39:45	19:38:30	**32.1206**	7.24		**139.6338**	38.03		**38.22**			
11		19:45:36	**32.1116**	6.70		**139.6339**	38.03		**38.16**			
12	18:52:02	19:52:49	**32.1026**	6.16		**139.6339**	38.03					
13			**32.0936**	5.62		**139.6339**	38.03					
14		20:06:39	**32.0846**	5.08		**139.6339**	38.04					
15		20:13:29	**32.0756**	4.54		**139.6340**	38.04					
16			**32.0666**	4.00		**139.6340**	38.04					
17			**32.0576**	3.46		**139.6340**	38.04					
18			**32.0486**	2.92		**139.6340**	38.04					
19			**32.0396**	2.38		**139.6341**	38.04					
20		20:47:13	**32.0306**	1.84		**139.6341**	38.04					
21			**32.0216**	1.30		**139.6341**	38.05					
22			**32.0126**	0.76		**139.6341**	38.05					
23			**32.0036**	0.22		**139.6342**	38.05					
24			**31.9946**	59.68		**139.6342**	38.05					
25			**31.9856**	59.14		**139.6342**	38.05					
26			**31.9766**	58.60		**139.6342**	38.05					
27			**31.9676**	58.06		**139.6343**	38.06					
28			**31.9586**	57.52		**139.6343**	38.06					
29			**31.9496**	56.98		**139.6343**	38.06					
30			**31.9406**	56.44		**139.6343**	38.06					
35			**31.8956**	53.74		**139.6345**	38.07					
40			**31.8506**	51.04		**139.6346**	38.07					
45			**31.8056**	48.34		**139.6347**	38.08					
50			**31.7606**	45.64		**139.6348**	38.09					
55			**31.7156**	42.94		**139.6349**	38.10					
60			**31.6706**	40.24		**139.6351**	38.10					
65			**31.6256**	37.54		**139.6352**	38.11					
70			**31.5806**	34.84		**139.6353**	38.12					
74.08			**31.5439**	32.64		**139.6354**	38.13					

Tansei-maru ESP-5 RESULT

			Lat dg	min	Latitude	Lon dg	min	Longitude	Lat dg	min	Lon dg	min	dist(km)	az(deg)
Tansei-maru			32	13.41	32.2236	140	13.08	140.218	31	46	140	13	50.769	180.14
Hakuho-maru			32	6.16	32.1027	140	12.9	140.215	32	46	140	13	73.784	0.1209
									dist btwn ships at start				13.435	181.19
		CMP	Time	min	latitude	min		longitude	min					
midpoint					32.1631	9.787		140.2165	12.99				6.7177	178.81
-15	km to CMP		10	44.78	32.2981	17.88		140.2198	13.19					
-12.5			10	1.452	32.2756	16.53		140.2192	13.15					
-12			10	4.785	32.2711	16.26		140.2191	13.15					
-10			10	18.12	32.2531	15.18		140.2187	13.12					
-9			10	24.78	32.2441	14.65		140.2185	13.11					
-8			11	31.45	32.2351	14.11		140.2182	13.09					
-7			11	38.12	32.2261	13.57		140.218	13.08					
-6			11	44.78	32.2171	13.03		140.2178	13.07					
-5			11	51.45	32.2081	12.49		140.2176	13.06					
-4			11	58.12	32.1991	11.95		140.2174	13.04					
-3			11	4.785	32.1901	11.41		140.2171	13.03					
-2			11	11.45	32.1811	10.87		140.2169	13.02					
-1			11	18.12	32.1721	10.33		140.2167	13					
0	**CMP**		11	24.78	32.1631	9.787		140.2165	12.99					
1			12	31.45	32.1541	9.247		140.2163	12.98					
2			12	38.12	32.1451	8.707		140.216	12.96					
3			12	44.78	32.1361	8.167		140.2158	12.95					
4			12	51.45	32.1271	7.627		140.2156	12.94					
5			12	58.12	32.1181	7.087		140.2154	12.92					
6			12	4.785	32.1091	6.547		140.2152	12.91					
7			12	11.45	32.1001	6.008		140.2149	12.9					
8			12	18.12	32.0911	5.468		140.2147	12.88					
9			12	24.78	32.0821	4.928		140.2145	12.87					
10			13	31.45	32.0731	4.388		140.2143	12.86					
12			13	44.78	32.0551	3.308		140.2138	12.83					
14			13	58.12	32.0371	2.229		140.2134	12.8					
15			13	4.785	32.0281	1.689		140.2132	12.79					
16			13	11.45	32.0191	1.145		140.2129	12.78					
18			13	24.78	32.0011	0.065		140.2125	12.75					
20			14	38.12	31.9831	58.98		140.2121	12.72					
22.5			14	54.78	31.9605	57.63		140.2115	12.69					
25			14	11.45	31.938	56.28		140.211	12.66					
27.5			14	28.12	31.916	54.96		140.2104	12.62					
30			15	44.78	31.8936	53.62		140.2099	12.59					
32.5			15	1.452	31.8712	52.27		140.2093	12.56					

Hakuho-maru ESP-5 RESULT

KH92-2	ESP-5		30-May									
	Start lat°	lat'	Latitude	Start lo	lon'	Longitude	Endlat°	lat'	End lon°	lon'	dist (km)	az (deg
KH	32	6.16	32.10267	140	12.9	140.215	32	30	140	13	44.151958	0.203
KT	32	13.413	32.22355	140	13.08	140.217967	31	46	140	13	50.769024	180.1
dist btwn ships at start											13.435455	1.189
	KTtime	KH time	latitude	min		longitude	min					
midpoint	*km to CMP*		*32.1631*	*9.79*		*140.2165*	*12.99*				*6.717726*	*181.2*
15			32.0281	1.69		140.2132	12.79				*START 10:30*	
10			32.0731	4.39		140.2143	12.86					
9			32.0821	4.93		140.2145	12.87				57.29578	deg/rad
8			32.0911	5.47		140.2147	12.88				111.12	km/deg
7			32.1001	6.01		140.2149	12.90					
6			32.1091	6.55		140.2152	12.91					
5			32.1181	7.09		140.2154	12.92					
4	11:04:35	11:03:30	32.1271	7.63		140.2156	12.94					
3		11:13:22	32.1361	8.17		140.2158	12.95					
2	11:21:53	11:22:47	32.1451	8.71		140.2160	12.96					
1		11:32:18	32.1541	9.25		140.2163	12.98					
0	11:38	11:41:23	32.1631	9.79		140.2165	12.99					
-1		11:51:07	32.1721	10.33		140.2167	13.00					
-2	11:52:56	12:01:07	32.1811	10.87		140.2169	13.02					
-3		12:10:29	32.1901	11.41		140.2171	13.03					
-4	12:08	12:19:55	32.1991	11.95		140.2174	13.04					
-5		12:29:31	32.2081	12.49		140.2176	13.06		13.12			
-6	12:24:05	12:38:36	32.2171	13.03		140.2178	13.07					
-7		12:48:01	32.2261	13.57		140.2180	13.08					
-8	12:45:13	12:58:45	32.2351	14.11		140.2182	13.09					
-9		13:09:29	32.2441	14.65		140.2185	13.11					
-10	13:03:14	13:19:08	32.2531	15.18		140.2187	13.12					
-11		13:31:28	32.2621	15.72		140.2189	13.13					
-12	13:18:55	13:44:09	32.2711	16.26		140.2191	13.15					
-13		13:55:59	32.2801	16.80		140.2194	13.16					
-14	13:36:14	14:07:03	32.2891	17.34		140.2196	13.17					
-15		14:18:52	32.2981	17.88		140.2198	13.19					
-16		14:33:15	32.3071	18.42		140.2200	13.20					
-17		14:45:34	32.3161	18.96		140.2202	13.21					
-18		14:58:40	32.3251	19.50		140.2205	13.23					
-19		15:11:15	32.3341	20.04		140.2207	13.24					
-20		15:24:22	32.3431	20.58		140.2209	13.25					
-21			32.3521	21.12		140.2211	13.27					
-22			32.3610	21.66		140.2213	13.28					
-23			32.3700	22.20		140.2216	13.29					
-24			32.3790	22.74		140.2218	13.31					
-25			32.3880	23.28		140.2220	13.32					
-30			32.4330	25.98		140.2231	13.39					
-35			32.4780	28.68		140.2242	13.45					
-40			32.5230	31.38		140.2253	13.52					

Tansei-maru ESP-6 RESULT

			Lat dg	min	Latitude	Lon dg	min	Longitude	Lat dg	min	Lon dg	min	dist(km)	az(deg)
Tansei-maru			32	2.08	32.0347	141	48	141.8	32	40	141	48	70.228	180
Hakuho-maru			32	20.69	32.3448	141	48.01	141.8002	31	40	141	48	75.358	-0.012
									dist btwn ships at start				34.466	179.97
			Time	min	latitude	min		longitude	min					
midpoint					32.1898	11.39		141.8001	48.005				17.233	180.03
15	km to CMP		4	44.89	32.0548	3.286		141.8002	48.009					
14			4	51.55	32.0638	3.826		141.8002	48.009					
12			4	4.886	32.0818	4.906		141.8001	48.008					
10			4	18.22	32.0998	5.985		141.8001	48.008					
9			4	24.89	32.1088	6.525		141.8001	48.008					
8			5	31.55	32.1178	7.065		141.8001	48.007					
7			5	38.22	32.1268	7.605		141.8001	48.007					
6			5	44.89	32.1358	8.145		141.8001	48.007					
5			5	51.55	32.1448	8.685		141.8001	48.006					
4			5	58.22	32.1538	9.225		141.8001	48.006					
3			5	4.886	32.1628	9.765		141.8001	48.006					
2			5	11.55	32.1718	10.31		141.8001	48.006					
1			5	18.22	32.1808	10.85		141.8001	48.005					
0	**CMP**		5	24.89	32.1898	11.39		141.8001	48.005					
-1			6	31.55	32.1987	11.92		141.8001	48.005					
-2			6	38.22	32.2077	12.46		141.8001	48.004					
-3			6	44.89	32.2167	13		141.8001	48.004					
-4			6	51.55	32.2257	13.54		141.8001	48.004					
-5			6	58.22	32.2347	14.08		141.8001	48.004					
-6			6	4.886	32.2437	14.62		141.8001	48.003					
-7			6	11.55	32.2527	15.16		141.8	48.003					
-8			6	18.22	32.2617	15.7		141.8	48.003					
-9			6	24.89	32.2707	16.24		141.8	48.002					
-10			7	31.55	32.2797	16.78		141.8	48.002					
-12			7	44.89	32.2977	17.86		141.8	48.002					
-14			7	58.22	32.3157	18.94		141.8	48.001					
-15			7	4.886	32.3247	19.48		141.8	48.001					
-16			7	11.55	32.3337	20.02		141.8	48					
-18			7	24.89	32.3517	21.1		141.8	48					
-20			8	38.22	32.3696	22.18		141.8	47.999					
-22.5			8	54.89	32.3921	23.52		141.8	47.998					
-25			8	11.55	32.4145	24.87		141.8	47.998					
-27.5			8	28.22	32.4376	26.25		141.8	47.997					
-30			9	44.89	32.4601	27.61		141.7999	47.996					
-32.5			9	1.552	32.4827	28.96		141.7999	47.996					

Hakuho-maru ESP-6 RESULT

KH92-2		ESP-6				31-May						
	Start lat°	lat'	Latitude	Start lon	lon'	Longitude	Endlat°	lat'	End lon°	lon'	dist (km)	az (deg
KH	32	20.69	32.34483	141	48.01	141.80017	31	50	141	48	56.837882	-0.016
KT	32	2.08	32.03467	141	48	141.8	32	40	141	48	70.22784	180
dist btwn ships at start											34.465724	-0.026
	TIME	TIME	latitude	min		longitude	min					
midpoi	km to CMP		*32.1898*	*11.39*		*141.8001*	*48.00*				*17.23286*	*180*
-17			32.3427	20.56		141.8002	48.01					
-16			32.3337	20.02		141.8002	48.01					
-15		3:44:55	32.3247	19.48		141.8002	48.01					
-14		3:51:29	32.3157	18.94		141.8002	48.01					
-13		3:57:56	32.3067	18.40		141.8001	48.01					
-12	4:07:22	4:03:52	32.2977	17.86		141.8001	48.01					
-11		4:09:58	32.2887	17.32		141.8001	48.01				*2-GUNS*	
-10	4:19:55	4:16:18	32.2797	16.78		141.8001	48.01					
-9		4:23:11	32.2707	16.24		141.8001	48.01				57.29578	deg/rad
-8	4:33:14	4:29:38	32.2617	15.70		141.8001	48.01		48.15		111.12	km/deg
-7		4:36:00	32.2527	15.16		141.8001	48.01		48.16			
-6	4:47:06	4:42:28	32.2437	14.62		141.8001	48.01					
-5		4:48:57	32.2347	14.08		141.8001	48.01					
-4	5:00:13	4:56:22	32.2257	13.54		141.8001	48.01					
-3		5:03:22	32.2167	13.00		141.8001	48.01		48.26			
-2	5:14:24	5:10:44	32.2077	12.46		141.8001	48.01					
-1		5:18:12	32.1987	11.92		141.8001	48.01					
0	**5:28:58**	**5:25:40**	32.1898	**11.39**		141.8001	**48.00**					
1		5:33:16	32.1808	10.85		141.8001	48.00					
2	5:42:16		32.1718	10.31		141.8001	48.00					
3			32.1628	9.77		141.8001	48.00					
4	5:56:19	5:56:12	32.1538	9.23		141.8001	48.00					
5		6:03:10	32.1448	8.69		141.8001	48.00					
6	6:09:40	6:09:37	32.1358	8.15		141.8001	48.00		48.22			
7		6:16:10	32.1268	7.61		141.8000	48.00		48.18			
8	6:25:57	6:22:41	32.1178	7.07		141.8000	48.00					
9		6:29:16	32.1088	6.53		141.8000	48.00					
10	6:32:10	6:36:08	32.0998	5.99		141.8000	48.00					
11			32.0908	5.45		141.8000	48.00					
12		6:50:00	32.0818	4.91		141.8000	48.00					
13		6:56:27	32.0728	4.37		141.8000	48.00					
14			32.0638	3.83		141.8000	48.00					
15		7:10:35	32.0548	3.29		141.8000	48.00					
16			32.0458	2.75		141.8000	48.00					
17			32.0368	2.21		141.8000	48.00					
18			32.0278	1.67		141.8000	48.00					
19		7:37:11	32.0188	1.13		141.8000	48.00					
20		7:43:58	32.0098	0.59		141.8000	48.00					
21			32.0008	0.05		141.8000	48.00					
22		7:57:54	31.9918	59.51		141.8000	48.00					
23			31.9828	58.97		141.8000	48.00		48.1			
24			31.9738	58.43		141.8000	48.00					
25			31.9648	57.89		141.8000	48.00					
26			31.9558	57.35		141.8000	48.00					
27			31.9468	56.81		141.8000	48.00					
28			31.9378	56.27		141.7999	48.00					
29			31.9288	55.73		141.7999	48.00					
30			31.9198	55.19		141.7999	48.00					
32			31.9018	54.11		141.7999	48.00					

Tansei-maru ESP-7 RESULT

			Lat dg	min	Latitude	Lon dg	min	Longitude	Lat dg	min	Lon dg	min	dist(km)	az(deg)
Tansei-maru			32	52.01	32.8668	141	13.21	141.2202	33	28.7	141	0.2	70.89	343.53
Hakuho-maru			33	11.66	33.1943	141	5.87	141.0978	32	31	141	19.7	78.316	163.99
									dist btwn ships at start				38.145	-17.36
			Time	min	latitude	min		longitude	min					
midpoint					33.0305	1.832		141.1591	9.549				19.071	197.39
15	km to CMP		19	27.15	32.9017	54.1		141.2072	12.43					
14			20	33.82	32.9103	54.62		141.204	12.24					
12			20	47.15	32.9275	55.65		141.1976	11.85					
10			20	0.484	32.9447	56.68		141.1912	11.47					
9			20	7.151	32.9532	57.19		141.188	11.28					
8			20	13.82	32.9618	57.71		141.1848	11.09					
7			20	20.48	32.9704	58.23		141.1816	10.89					
6			20	27.15	32.979	58.74		141.1784	10.7					
5			21	33.82	32.9876	59.26		141.1752	10.51					
4			21	40.48	32.9962	59.77		141.172	10.32					
3			21	47.15	33.0048	0.287		141.1688	10.13					
2			21	53.82	33.0134	0.802		141.1656	9.933					
1			21	0.484	33.022	1.317		141.1623	9.741					
0	**CMP**		21	7.151	33.0305	1.833		141.1591	9.549					
-1			21	13.82	33.0391	2.348		141.1559	9.357					
-2			21	20.48	33.0477	2.863		141.1527	9.164					
-3			21	27.15	33.0563	3.378		141.1495	8.972					
-4			22	33.82	33.0649	3.894		141.1463	8.78					
-5			22	40.48	33.0735	4.409		141.1431	8.588					
-6			22	47.15	33.0821	4.924		141.1399	8.396					
-7			22	53.82	33.0907	5.439		141.1367	8.204					
-8			22	0.484	33.0992	5.954		141.1335	8.011					
-9			22	7.151	33.1078	6.47		141.1303	7.819					
-10			22	13.82	33.1164	6.985		141.1271	7.627					
-12			22	27.15	33.1336	8.015		141.1207	7.243					
-14			23	40.48	33.1508	9.046		141.1143	6.858					
-15			23	47.15	33.1593	9.561		141.1111	6.666					
-16			23	53.82	33.1679	10.07		141.1079	6.474					
-18			23	7.151	33.185	11.1		141.1015	6.09					
-20			23	20.48	33.2022	12.13		141.0951	5.705					
-22.5			24	37.15	33.2236	13.41		141.0871	5.225					
-25			24	53.82	33.245	14.7		141.0791	4.745					
-27.5			24	10.48	33.267	16.02		141.0711	4.264					
-30			24	27.15	33.2886	17.31		141.0631	3.784					
-32.5			25	43.82	33.3101	18.61		141.0551	3.303					

Hakuho-maru ESP-7 RESULT

KH92-2	ESP7		31-May									
	Start lat°	lat'	Latitude	Start lon°	lon'	Longitude	Endlat°	lat'	End lon°	lon'	dist (km)	az (deg
KH	33	11.66	33.194333	141	5.87	141.097833	32	31	141	20	78.315837	16.01
KT	32	52.005	32.86675	141	13.214	141.220233	33	29	141	0.2	70.890227	196.5
dist btwn ships at start											**38.145276**	**17.43**
	KT time	KH time	latitude	min		longitude	min					
midpoint	km to CMP		*33.0305*	*1.83*		*141.1591*	*9.55*				*19.07422*	*197.4*
-24			**33.2366**	14.20		**141.0820**	4.92					
-23			**33.2280**	13.68		**141.0852**	5.11					
-22			**33.2195**	13.17		**141.0884**	5.31					
-21			**33.2109**	12.65		**141.0916**	5.50					
-20			**33.2023**	12.14		**141.0949**	5.69					
-19			**33.1937**	11.62		**141.0981**	5.88					
-18			**33.1851**	11.11		**141.1013**	6.08		*start shooting about 1830*			
-17		19:13:50	**33.1765**	10.59		**141.1045**	6.27				*start esp 1900*	
-16		19:20:36	**33.1679**	10.08		**141.1077**	6.46					
-15	19:25:54	19:27:20	**33.1594**	9.56		**141.1109**	6.66					
-14		19:33:39	**33.1508**	9.05		**141.1141**	6.85		*6.93*			
-13		19:40:03	**33.1422**	8.53		**141.1174**	7.04					
-12	19:46:07	19:46:21	**33.1336**	8.02		**141.1206**	7.23					
-11		19:52:48	**33.1250**	7.50		**141.1238**	7.43		7.48			
-10	20:00:04	19:59:13	**33.1164**	6.98		**141.1270**	7.62		7.69			
-9		20:05:32	**33.1078**	6.47		**141.1302**	7.81		7.82		57.29578	deg/rad
-8	20:14:05	20:12:55	**33.0992**	5.95		**141.1334**	8.01				111.12	km/deg
-7		20:18:09	**33.0907**	5.44		**141.1366**	8.20		8.21			
-6	20:27:11	20:24:23	**33.0821**	4.92		**141.1399**	8.39		8.37			
-5		20:30:34	**33.0735**	4.41		**141.1431**	8.58		8.53			
-4	20:40:18	20:36:50	**33.0649**	3.89		**141.1463**	8.78		8.77			
-3		20:42:56	**33.0563**	3.38		**141.1495**	8.97		8.94			
-2	20:53:43	20:49:27	**33.0477**	2.86		**141.1527**	9.16		9.17			
-1		20:55:36	**33.0391**	2.35		**141.1559**	9.36		9.33			
0	21:06:58	21:02:56	**33.0305**	**1.83**		**141.1591**	**9.55**		9.54			
1		21:08:04	**33.0220**	1.32		**141.1624**	9.74		9.92			
2	21:19:02	21:14:24	**33.0134**	0.80		**141.1656**	9.93					
3		21:20:39	**33.0048**	0.29		**141.1688**	10.13		10.09			
4	21:31:42	21:27:19	**32.9962**	59.77		**141.1720**	10.32					
5		21:34:11	**32.9876**	59.26		**141.1752**	10.51		10.45			
6	21:44:38		**32.9790**	58.74		**141.1784**	10.71		10.71			
7		21:47:44	**32.9704**	58.23		**141.1817**	10.90					
8	21:56:52	21:54:33	**32.9618**	57.71		**141.1849**	11.09		11.07			
9		22:01:12	**32.9532**	57.19		**141.1881**	11.28		11.29			
10	22:09:46	22:07:24	**32.9447**	56.68		**141.1913**	11.48		11.47			
11		22:13:55	**32.9361**	56.16		**141.1945**	11.67		11.65			
12		22:20:11	**32.9275**	55.65		**141.1977**	11.86		11.84			
13		22:26:43	**32.9189**	55.13		**141.2009**	12.06		12.02			
14			**32.9103**	54.62		**141.2042**	12.25					
15			**32.9017**	54.10		**141.2074**	12.44					
16			**32.8931**	53.59		**141.2106**	12.63					
17			**32.8845**	53.07		**141.2138**	12.83					
18			**32.8759**	52.56		**141.2170**	13.02					
19			**32.8674**	52.04		**141.2202**	13.21					
20			**32.8588**	51.53		**141.2234**	13.41					
21			**32.8502**	51.01		**141.2267**	13.60					
22			**32.8416**	50.50		**141.2299**	13.79					
23			**32.8330**	49.98		**141.2331**	13.99					
24			**32.8244**	49.46		**141.2363**	14.18					
25			**32.8158**	48.95		**141.2395**	14.37					
30			**32.7729**	46.37		**141.2556**	15.34					
35			**32.7299**	43.80		**141.2717**	16.30					
40			**32.6870**	41.22		**141.2877**	17.26					
45			**32.6440**	38.64		**141.3038**	18.23					
50			**32.6010**	36.06		**141.3199**	19.19					

Tansei-maru ESP-8 RESULT

			Lat dg	min	Latitude	Lon dg	min	Longitude	Lat dg	min	Lon dg	min	dist(km)	az(deg)
Tansei-maru			32	38	32.6333	141	10	141.1667	32	22	138	0	298.24	265.15
Hakuho-maru			32	23.02	32.3837	141	10	141.1667	32	38	138	0	298.03	-83.81
									dist btwn ships at start				27.743	180
			Time	min	latitude	min		longitude	min					
midpoint					32.5085	30.51		141.1667	10				13.871	180
-15	km to CMP		8	52.48	32.6435	38.61		141.1667	10					
-12.5			8	9.143	32.621	37.26		141.1667	10					
-10			8	25.81	32.5985	35.91		141.1667	10					
-9			9	32.48	32.5895	35.37		141.1667	10					
-8			9	39.14	32.5805	34.83		141.1667	10					
-7			9	45.81	32.5715	34.29		141.1667	10					
-6			9	52.48	32.5625	33.75		141.1667	10					
-5			9	59.14	32.5535	33.21		141.1667	10					
-4			9	5.81	32.5445	32.67		141.1667	10					
-3			9	12.48	32.5355	32.13		141.1667	10					
-2			9	19.14	32.5265	31.59		141.1667	10					
-1			9	25.81	32.5175	31.05		141.1667	10					
0	**CMP**		10	32.48	32.5085	30.51		141.1667	10					
1			10	39.14	32.4995	29.97		141.1667	10					
2			10	45.81	32.4905	29.43		141.1667	10					
3			10	52.48	32.4815	28.89		141.1667	10					
4			10	59.14	32.4725	28.35		141.1667	10					
5			10	5.81	32.4635	27.81		141.1667	10					
6			10	12.48	32.4545	27.27		141.1667	10					
7			10	19.14	32.4455	26.73		141.1667	10					
8			10	25.81	32.4365	26.19		141.1667	10					
9			11	32.48	32.4275	25.65		141.1667	10					
10			11	39.14	32.4185	25.11		141.1667	10					
12			11	52.48	32.4005	24.03		141.1667	10					
14			11	5.81	32.3825	22.95		141.1667	10					
15			11	12.48	32.3735	22.41		141.1667	10					
16			11	19.14	32.3644	21.87		141.1667	10					
18			12	32.48	32.3464	20.79		141.1667	10					
20			12	45.81	32.3284	19.7		141.1667	10					
22.5			12	2.477	32.3058	18.35		141.1667	10					
25			12	19.14	32.2833	17		141.1667	10					
27.5			13	35.81	32.2614	15.68		141.1667	10					
30			13	52.48	32.2389	14.34		141.1667	10					
32.5			13	9.143	32.2165	12.99		141.1667	10					

Hakuho-maru ESP-8 RESULT

KH92-	ESP8		1-Jun									
	Start lat°	lat'	**Latitude**	Start lon	lon'	**Longitude**	Endlat°	lat'	End lon°	lon'	dist (km)	az (deg)
KH	32	23.02	**32.383667**	141	9.97	**141.166167**	32	47	141	10	44.410985	0.0603
KT	32	38	**32.633333**	141	10	**141.166167**	32	20	141	10	33.336033	179.92
dist btwn ships at start											**27.74296**	**0**
	KT time	KH time	latitude	min		longitude	min					
CMP	km to CMP		*32.5085*	*30.51*		*141.1662*	*9.97*				*13.87148*	*180*
13			**32.3915**	23.49		**141.1662**	9.97					
12		8:12:24	**32.4005**	24.03		**141.1662**	9.97		10.1		*start 0800*	
11			**32.4095**	24.57		**141.1662**	9.97		10.07			
10	8:25:27	8:26:04	**32.4185**	25.11		**141.1662**	9.97		10.07			
9		8:32:38	**32.4275**	25.65		**141.1662**	9.97		10.02		57.29578	deg/rad
8	8:39:16	8:39:12	**32.4365**	26.19		**141.1662**	9.97		10.05		111.12	km/deg
7		8:45:50	**32.4455**	26.73		**141.1662**	9.97		10.05			
6	8:52:42	8:52:38	**32.4545**	27.27		**141.1662**	9.97					
5		8:59:40	**32.4635**	27.81		**141.1662**	9.97		10.03			
4	9:06:16	9:06:09	**32.4725**	28.35		**141.1662**	9.97		10.01			
3		9:12:26	**32.4815**	28.89		**141.1662**	9.97		10.03			
2	9:19:49	9:18:42	**32.4905**	29.43		**141.1662**	9.97		10.02			
1		9:25:19	**32.4995**	29.97		**141.1662**	9.97		10.01			
0	9:35:02	9:32:05	**32.5085**	**30.51**		**141.1662**	**9.97**		9.98			
-1		9:38:55	**32.5175**	31.05		**141.1662**	9.97		9.95			
-2	9:49:06	9:45:14	**32.5265**	31.59		**141.1662**	9.97		9.95			
-3		9:52:02	**32.5355**	32.13		**141.1662**	9.97		9.94			
-4	10:02:44	9:58:53	**32.5445**	32.67		**141.1662**	9.97		9.94			
-5		10:05:16	**32.5535**	33.21		**141.1662**	9.97		9.93			
-6	10:16:12	10:12:35	**32.5625**	33.75		**141.1662**	9.97		9.96			
-7		10:18:39	**32.5715**	34.29		**141.1662**	9.97		9.98			
-8	10:29:51	10:24:57	**32.5805**	34.83		**141.1662**	9.97		9.99			
-9		10:31:25	**32.5895**	35.37		**141.1662**	9.97		10.01			
-10	10:43:35		**32.5985**	35.91		**141.1662**	9.97					
-11		10:45:16	**32.6075**	36.45		**141.1662**	9.97		10.03			
-12			**32.6165**	36.99		**141.1662**	9.97					
-13			**32.6255**	37.53		**141.1662**	9.97					
-14			**32.6345**	38.07		**141.1662**	9.97					
-15		11:12:03	**32.6435**	38.61		**141.1662**	9.97					
-16			**32.6525**	39.15		**141.1662**	9.97					
-17		11:26:01	**32.6615**	39.69		**141.1662**	9.97					
-18			**32.6705**	40.23		**141.1662**	9.97					
-19			**32.6795**	40.77		**141.1662**	9.97					
-20			**32.6885**	41.31		**141.1662**	9.97					
-25			**32.7335**	44.01		**141.1662**	9.97					
-30			**32.7785**	46.71		**141.1662**	9.97					
-31			**32.7875**	47.25		**141.1662**	9.97					

Tansei-maru ESP-9 RESULT

			Lat dg	min	Latitude	Lon dg	min	Longitude	Lat dg	min	Lon dg	min	dist(km)	az(deg)
Tansei-maru			32	22.09	32.3681	140	55.09	140.9181	32	40	140	55	33.175	359.77
Hakuho-maru			32	38.34	32.639	140	55.03	140.9172	32	22	140	55	30.262	180.09
									dist btwn ships at start				30.101	-0.169
			Time	min	latitude	min		longitude	min					
midpoint					32.5036	30.21		140.9176	55.06				15.05	180.17
15	km to CMP		17	0.336	32.3686	22.11		140.9181	55.09					
14			17	7.002	32.3776	22.65		140.9181	55.09					
12			17	20.34	32.3956	23.73		140.918	55.08					
10			18	33.67	32.4136	24.81		140.918	55.08					
9			18	40.34	32.4226	25.35		140.9179	55.08					
8			18	47	32.4316	25.89		140.9179	55.07					
7			18	53.67	32.4406	26.43		140.9179	55.07					
6			18	0.336	32.4496	26.97		140.9178	55.07					
5			18	7.002	32.4586	27.51		140.9178	55.07					
4			18	13.67	32.4676	28.05		140.9178	55.07					
3			18	20.34	32.4766	28.59		140.9177	55.06					
2			18	27	32.4856	29.13		140.9177	55.06					
1			19	33.67	32.4946	29.67		140.9177	55.06					
0	**CMP**		19	40.34	32.5036	30.21		140.9176	55.06					
-1			19	47	32.5126	30.75		140.9176	55.06					
-2			19	53.67	32.5216	31.29		140.9176	55.05					
-3			19	0.336	32.5306	31.83		140.9175	55.05					
-4			19	7.002	32.5396	32.37		140.9175	55.05					
-5			19	13.67	32.5486	32.91		140.9175	55.05					
-6			19	20.34	32.5576	33.45		140.9175	55.05					
-7			19	27	32.5666	33.99		140.9174	55.05					
-8			20	33.67	32.5756	34.53		140.9174	55.04					
-9			20	40.34	32.5846	35.07		140.9174	55.04					
-10			20	47	32.5936	35.61		140.9173	55.04					
-12			20	0.336	32.6115	36.69		140.9173	55.04					
-14			20	13.67	32.6295	37.77		140.9172	55.03					
-15			20	20.34	32.6385	38.31		140.9172	55.03					
-16			20	27	32.6475	38.85		140.9171	55.03					
-18			21	40.34	32.6654	39.92		140.9171	55.02					
-20			21	53.67	32.6833	41		140.917	55.02					
-25			21	27	32.7281	43.69		140.9169	55.01					
-30			22	0.336	32.773	46.38		140.9167	55					
-35			23	33.67	32.8191	49.15		140.9165	54.99					
-40			23	7.002	32.8643	51.86		140.9164	54.98					
-45			24	40.34	32.9094	54.57		140.9162	54.97					

Hakuho-maru ESP-9 RESULT

KH92-2	ESP9		1-Jun									
	Start lat°	lat'	**Latitude**	Start lon	lon'	**Longitude**	Endlat°	lat'	End lon°	lon'	dist (km)	az (deg)
KH	32	38.34	**32.639**	140	55.03	**140.917167**	32	13	140	55	46.929703	180.06
KT	32	22.087	**32.368117**	140	55.087	**140.918117**	32	49	140	55	50.02826	-0.155
dist btwn ships at start											**30.100688**	**179.83**
	KT time	KH time	latitude	min		longitude	min					
midpoin	km to CMP		*32.5036*	*30.21*		*140.9176*	*55.06*				*15.05034*	*180.2*
-15			**32.6385**	38.31		**140.9172**	55.03		*continued shooting from esp8*			
-14			**32.6295**	37.77		**140.9172**	55.03				*start esp 1700*	
-13			**32.6205**	37.23		**140.9172**	55.03					
-12	17:19:40	17:21:21	**32.6115**	36.69		**140.9173**	55.04		55.04			
-11		17:28:27	**32.6025**	36.15		**140.9173**	55.04					
-10	17:32:32	17:35:47	**32.5936**	35.61		**140.9173**	55.04					
-9		17:43:10	**32.5846**	35.07		**140.9174**	55.04				57.29578	deg/rad
-8	17:46:10	17:50:16	**32.5756**	34.53		**140.9174**	55.04				111.12	km/deg
-7		17:57:38	**32.5666**	33.99		**140.9174**	55.05					
-6	17:59:47	18:05:10	**32.5576**	33.45		**140.9175**	55.05		55.01			
-5		18:12:51	**32.5486**	32.91		**140.9175**	55.05		55.01			
-4	18:13:56	18:21:57	**32.5396**	32.37		**140.9175**	55.05		55.00			
-3		18:28:36	**32.5306**	31.83		**140.9175**	55.05		55.02			
-2	18:28:44	18:36:20	**32.5216**	31.29		**140.9176**	55.05					
-1		18:44:37	**32.5126**	30.75		**140.9176**	55.06					
0	18:43:07	18:52:55	**32.5036**	**30.21**		**140.9176**	**55.06**					
1		19:00:27	**32.4946**	29.67		**140.9177**	55.06		55.21			
2	18:56:40	19:08:52	**32.4856**	29.13		**140.9177**	55.06		55.15			
3		19:16:51	**32.4766**	28.59		**140.9177**	55.06					
4	19:14:08	19:24:35	**32.4676**	28.05		**140.9178**	55.07		55.11			
5		19:32:20	**32.4586**	27.51		**140.9178**	55.07					
6	19:32:47	19:39:33	**32.4496**	26.97		**140.9178**	55.07		55.10			
7		19:46:47	**32.4406**	26.43		**140.9179**	55.07					
8	19:51:50	19:53:45	**32.4316**	25.89		**140.9179**	55.07		55.19			
9		20:00:38	**32.4226**	25.35		**140.9179**	55.08		55.23			
10	20:08:32	20:07:08	**32.4136**	24.81		**140.9180**	55.08		55.19			
11			**32.4046**	24.27		**140.9180**	55.08					
12		20:20:11	**32.3956**	23.73		**140.9180**	55.08		55.11			
13		20:27:14	**32.3866**	23.19		**140.9181**	55.08		55.13			
14			**32.3776**	22.65		**140.9181**	55.09					
15			**32.3686**	22.11		**140.9181**	55.09					
16			**32.3596**	21.57		**140.9181**	55.09					
17			**32.3506**	21.03		**140.9182**	55.09					
18			**32.3416**	20.49		**140.9182**	55.09					
19			**32.3326**	19.95		**140.9182**	55.09					
20			**32.3236**	19.41		**140.9183**	55.10					
25			**32.2786**	16.71		**140.9184**	55.11					
30			**32.2336**	14.01		**140.9186**	55.12					
35			**32.1886**	11.32		**140.9187**	55.12					
40			**32.1436**	8.62		**140.9189**	55.13					

Table 2 Log data on the receiving ship (Tansei-maru)

ESP-1						
Date	Time	Shot #	delay (s)	MT #	Depth (m)	
5/27/92	8:05	101	6	1		
	8:22	151	4	1		
	8:30	173	4	1		
	8:40	202	3	1		
	8:50	231	2	1		
	9:00	260	2	1		
	9:05		2	1		midpoint
	9:17	310	4	1		
	9:28	343	6	1		
	9:30	349	6	1		
	9:41		6	1		+6km point
	9:54	420	8	1		+8km point
	10:00	438	8	1		
	10:23	507	11	1		
	10:30	528	11	1		
	10:37	549	13	1		
	10:47	579	11	2		
	10:48		11	2		+15km point
	11:00	616	11	2		
	11:18	670	11	2		+20km point
	11:30	706	11	2		
	12:00	797	11	2		
	12:26:26	873	11	2		System down
ESP-2						
5/27/92	21:51:48	1	8	3		
	22:00:00	26	8	3		
	22:18:00		8	3		-12.5 km point
	22:30:00	116	8	3		
	22:34:46	128	7	3		
	22:41:00		7	3		-9km point
	22:47:50		7	3		-8km point
	22:54:40		7	3		-7km point
	23:00:00	204	7	3		-6km point
	23:08:29	228	6	3		
	23:14:45		6	3		-4km point
	23:21:20		6	3		-3km point
	23:27:55		6	3		-2km point
	23:30:00	292	6	3		
	23:34:15		6	3		-1km point
	23:39:45		6	3		Hakuho-maru pass
	23:40:50		6	3		CMP point
	23:47:15		6	3		+1km point
	23:53:22		6	3		+2km point
5/28/92	0:00:00	381	6	3		
	0:00:05		6	3		+3km point
	0:14:26	424	7	3		
	0:30:00	471	7	3		
	0:47:07	522	8	4		
	1:00:00		8	4		
	1:18:28	617	9	4		

Table 2 Log data on the receiving ship (Tansei-maru)

	1:30:00	651	9	4		
	1:49:49	710	10	4		
	2:00:00	741	10	4		
	2:05:30	757	11	4		
	2:19:50	800	11	4		System stop
COP-1						
92.5.28	7:03:06	1	7	5		
	7:12:36	5	7	5		
	7:26:53		7	5		10 mile to Hakuho
	7:30:00	81	7	5		
	7:40:06	110	7	5		
	7:50:00			5	4050	
	8:00:00	170	7	5	4042	
	8:10:00			5	4028	3kts (Hakuho)
	8:20:00			5	4025	
	8:30:00				4019	6ch malfunction
	8:40:00				3991	Tansei speed down
	8:50:00				3959	3.5kts (Tansei)
	9:00:00	350		5	3844	
	9:10:00				3930	
	9:12:00					9 mile to Hakuho
	9:20:00				3907	
	9:30:00	440		5	3882	
	9:40:00				3865	
	9:50:00				3851	+2km point
	9:55:06			6		
	10:00:06	530	7	6	3837	
	10:10:06				3818	
	10:20:06				3781	
	10:30:06	620	7	6	3755	
	10:40:06				3745	
	10:50:06				3744	
	11:00:06	710	7	6	3746	
	11:10:06				3748	
	11:20:06				3751	
	11:30:06	800	7	6	3765	
	11:40:06	830	7	6	3773	
	11:50:06	860	7	6	3779	
	12:00:06	890	7	6	3790	
	12:10:06	919	7	6	3790	
	12:20:06	949	7	6	3781	
	12:30:06	979	7	6	3808	
	12:40:06	1009	7	6	3810	
	12:50:06	1039	7	7	3850	
	13:00:06	1069	7	7	3852	
	13:10:06	1099	7	7	3880	
	13:20:06	1129	7	7	3891	
	13:30:06	1159	7	7	3869	
	13:40:06	1188	7	7	3815	
	13:50:06	1218	7	7	3748	
92.5.28	14:00:06	1248	7	7	3715	
	14:10:06	1278	7	7	3692	

Table 2 Log data on the receiving ship (Tansei-maru)

	14:20:06	1308	7	7	3670	
	14:30:06	1338	7	7	3688	
	14:40:06	1368	7	7	3638	
	14:50:06	1398	7	7	3599	
	15:00:06	1427	7	7	3535	
	15:10:06	1457	7	7	3491	
	15:20:06	1487	7	7	3457	
	15:30:06	1517	7	7	3431	
		1530		8		
	15:40:06	1547	7	8	3392	
	15:50:06	1577	7	8	3338	
	16:00:00	1607	7	8	3284	
	16:10:06	1637	7	8	3215	
	16:20:06	1667	7	8	3115	
	16:30:06	1697	7	8	3098	
	16:40:06	1727	7	8	3074	
	16:50:06	1757	7	8	2960	
	17:00:06	1787	7	8	2837	
	17:04:19					MT write error unit1
	17:09:24					MT write error unit1
	17:10:06	1817	7	8	2739	
	17:20:06	1847	7	8	2640	
	17:30:06	1877	7	8	2381	
	17:40:06	1907	7	8	2004	
	17:50:06	1937	7	8	1735	
	18:00:06	1967	7	8	1788	
	18:10:06	1998	7	8	1832	
	18:20:06	2028	7	8	1717	
	18:21:26	2031	7	9		
	18:30:06	2058	7	9	1675	
	18:40:06	2088	7	9	1630	
	18:50:06	2118	7	9	1603	
	19:00:06	2148	7	9	1594	
	19:10:06	2178	7	9	1589	
	19:20:06	2208	7	9	1585	
	19:30:06	2238	7	9	1610	
	19:40:06	2268	7	9	1597	
	19:50:06	2297	7	9	1657	
	20:00:06	2327	7	9	1572	
	20:10:06	2357	7	9	1476	
	20:15:00	2372	7	9		End point
	20:30:00	2417	7	9	1054	
	20:40:00	2447	7	9	1519	
92.5.28	20:50:00	2477	7	9	1456	
	21:00:00	2507	7	9	1483	
	21:10:00	2537	7	9	1498	
	21:20:00	2567	7	10	1527	
	21:30:00	2597	7	10	1533	
	21:40:00	2627	7	10	1634	
	21:50:00	2657	7	10	1634	
	22:00:00	2687	7	10	1629	
	22:10:00	2717	7	10		

Table 2 Log data on the receiving ship (Tansei-maru)

	22:20:00	2747	7	10		
	22:30:00	2777	7	10	1590	
	22:40:00	2807	7	10	1549	
	22:50:00	2837	7	10		Hakuho COP1 end
	23:00:00	2867	7	10	1521	
	23:10:00	2897	7	10	1545	
	23:20:00	2927	7	10		
	23:30:00	2957	7	10	1670	
	23:40:00	2987	7	10	1695	
	23:50:00	3017	7	10	1692	
92.5.29	0:00:00	3047	7	11	1682	
	0:10:00	3076	7	11	1632	
	0:20:00	3106	7	11	1661	
	0:30:00	3136	7	11	1663	
	0:40:00	3165	7	11	1762	
	0:50:00	3195	7	11		
	1:00:00	3224	7	11	1867	
	1:10:00	3254	7	11	1919	
	1:20:00	3284	7	11	1904	
	1:30:00	3314	7	11	1935	
	1:40:00	3343	7	11	1990	
	1:50:00	3373	7	11	2011	
	2:00:00	3403	7	11	2023	
	2:10:00	3431	7	11	2000	Recording stop
ESP-3						
5/29/92	5:25:26	1	7	12		System start
	5:30:06	15	7	12	1915	
	5:32:46	23	7	12		MT reload
	5:40:06	45	7	12	1941	
	5:50:06	75	7	12	1967	
	6:00:06	105	7	12	1981	
	6:01:41		7			-10km point
	6:03:46	115	6			
	6:09:24		4			4.5~5kts
	6:10:06	133			1990	
	6:14:50	148	4	12		-8km point
	6:20:04	163		12	2020	
	6:25:00					6ch malfunction
	6:27:10					-6km point
	6:28:43	188	3	12		
	6:30:03	192	3	12	2043	
	6:40:03	222	3	12	2036	
	6:40:36		3	12		-4km point
	6:50:03	252	3	12	1995	
	6:54:45	266	3		1871	-2km point
	7:00:03	281	3	12	1930	
	7:02:02	285	2			
	7:07:41	302				-0km point
	7:08:22	304	2	12		CMP point
	7:10:02	309	2		1949	
	7:19:23	337	4			
	7:20:03	339	4	12	1598	

Table 2 Log data on the receiving ship (Tansei-maru)

	7:28:18					+3km point
	7:30:03	369	4	12	1420	
	7:35:05					+4km point
	7:39:45	398	6	12		
	7:40:03	399	6	12	1257	
	7:41:30					+5km point
	7:47:00					+6km point(?)
	7:50:03	429	6	12	1339	
	7:55:35					+7km point
	8:00:06	459	6	12	1438	
	8:02:00					+8km point
	8:10:05	489	6	12	1441	
	8:15:43					+10km point
	8:15:46	506	7	12		
	8:20:06	519	7	12	1735	
	8:22:06	525	7	13		
	8:30:07	549	8	13	1751	
	8:40:07	579	8	13	1717	
	8:50:07	609	8	13	1572	
	9:00:07	638	8	13	1547	
	9:10:07	668	8	13	1647	
	9:20:07	698	8	13	1860	
	9:29:15	725	16	13		
	9:30:15	728	16	13	1917	
	9:40:00	757	16	13	1993	
	9:50:00	787	16	13	2070	
	10:00:00	816	16	13	2110	
	10:08:00	841	16	13		Recording stop
ESP-4						
5/29/92	16:44:08	1	8	14		System start
	16:50:08	17	8	14	1428	
	17:00:08	47	8	14	1437	
	17:10:08	77	8	14	1382	
	17:12:50					-12km point
	17:15:27	92	7	14		
	17:20:07	106	7	14	1360	
	17:26:00					-10km point
	17:30:07	136	7	14	1517	
	17:32:20					-9km point
	17:34:31	149	6	14	1484	
	17:39:00					-8km point
	17:40:00	164	6	14	1475	
	17:46:04	181	5	14	1552	
	17:50:00	193	5	14	1613	
	17:52:40					-6km point
	17:59:04					-5km point
	17:59:43	221	4	14		
	18:00:04	222	4	14	1410	
	18:05:15					-4km point
	18:10:04	252	4	14	1556	
	18:11:57					-3km point
	18:12:43	259	3	14		

Table 2 Log data on the receiving ship (Tansei-maru)

	18:18:55					-2km point
	18:20:03	281	3	14	1602	
	18:25:09					-1km point
	18:30:03	311	3	14	1598	
	18:32:05					0km point
	18:39:04					+1km point
	18:40:03	341	3	14	1578	
	18:50:03	371	3	14	1589	
	18:52:04					+3km point
	18:57:58					+4km point
	18:59:03	397	4	14		
	19:00:04	400	4	14	1582	
	19:04:00					+5km point
	19:09:30					+6km point
	19:10:13	429	5	14	1570	
	19:20:05	457	5	14	1569	
	19:25:04					+8km point
	19:25:46	474	6	14		
	19:30:06	487	6	14	1355	
	19:32:30					+9km point
	19:37:05	508		15		
5/29/92	19:40:06	517	6	15	1360	
	19:41:27	520	7	15		
	19:50:07	546	7	15	1449	
	20:00:07	576	7	15	1460	
	20:10:00	606	7	15	1430	
	20:12:50		9	15		
	20:20:00	636	9	15	1373	
	20:30:00	666	9	15	1385	
	20:40:00	695	9	15	1314	
	20:49:00		10	15		
	20:50:00	725	10	15	1327	
	21:00:00	755	10	15	1200	
	21:10:00	785	10	15	1209	
	21:20:00	815	10	15	1164	Recording stop
	21:30:00	845	10	15	1236	
	21:41:00		12	15	1263	
	21:50:00	905	12	15	1273	
	22:00:00	935	12	15	1254	
	22:10:00	965	12	15	1236	
	22:20:00	995	12	15	1275	
	22:25:11	1010	12	16		
	22:30:00	1025	12	16	1285	
	22:40:00	1055	12	16	1269	
	22:50:00	1085	12	16	1242	
	23:00:00	1115	12	16	1216	Shooting stop
	23:01:51	1120				Recording stop
ESP-5						
5/30/92	10:32:00	1	8	17	1571	System start
	10:40:00	25	8	17	1577	
	10:50:00	55	8	17	1580	
	10:58:23	78	4	17	1583	

Table 2 Log data on the receiving ship (Tansei-maru)

	11:00:00	83	4	17	1584	
	11:10:00	113	4	17	1587	
	11:20:00	143	4	17	1599	
	11:25:02	157	3	17	1603	
	11:30:00	171	3	17	1603	
	11:40:00	202	3	17	1607	
	11:43:00	211	3	17	1611	
	11:50:00	232	3	17	1616	
	12:00:00	261	3	17	1626	
	12:09:03	288	4	17		
	12:10:00	291	4	17	1638	
	12:20:00	321	4	17	1652	
	12:25:04	336	5	17		
	12:30:00	351	5	17		
	12:38:06	375	7	17		
	12:40:00	381	7	17	1669	
	12:50:00	411	7	17	1667	
	12:56:47	431	8	17		
	13:00:00	441	8	17	1674	
	13:08:28	465	9			
	13:10:00	470	9	17	1688	
	13:20:00	500	9	17	1695	
	13:22:28	507	9	17		MT#17 end
	13:22:48	508	9	18		MT#18 start
	13:30:00	530	9	18	1693	
	13:40:00	560	9	18	1705	
	13:50:00	590	9	18	1717	
	14:00:00	620	9	18	1749	
	14:10:00	650	9	18	1760	
	14:20:00	680	9	18	1789	
	14:30:00	710	9	18	1812	
	14:40:00	740	9	18	1829	
	14:50:00	770	9	18	1850	
	14:56:50	790	11			
	15:00:00	800	11	18	1864	
	15:10:00	828	11	18	1879	
	15:20:00	858	12	18	1892	
	15:30:00	888	12	18	1898	
	15:40:00	918	12	18	1902	
	15:47:00	937				Recording stop
ESP-6						
5/31/92	3:00:00	2	12	19	6691	System start
	3:10:00	32	12	19	6716	
	3:20:00	62	12	19	6712	
	3:30:00	92	12	19	6678	Experiment start
	3:40:00	112	12	19	6683	
	3:50:00	152	12	19	6632	
	3:56:50	171	11	19		
	4:00:00	181	11	19	6630	
	4:10:11	211	11	19	6565	
	4:20:11	241	11	19	6515	
	4:30:11	270	11	19	6538	

Table 2 Log data on the receiving ship (Tansei-maru)

	4:40:11	300	11	19	6348	
	4:50:11	330	11	19	6316	
	4:53:50	340	10			
	5:00:10	359	10	19	6340	
	5:10:10	389	10	19	6363	
	5:13:49	399	9	19		
	5:20:09	418	9	19	6388	
	5:30:09	448	9	19	6323	
	5:40:09	478	9	19	6287	
	5:50:09	508	9	19	6344	
	5:50:19	507				MT#19 end
	5:52:30	515	10	20		
	6:00:10	538	10	20	6472	
	6:10:10	568	10	20	6608	
	6:18:51	594	11	20		
	6:20:11	598	11	20	6809	
	6:30:11	628	11	20	7094	
	6:34:31	641	12	20		
	6:40:12	658	12	20	7384?	PDR malfunction?
	6:42:13	664	13	20		PDR malfunction?
	6:49:55	687	15	20	7477?	PDR malfunction?
	6:50:15	688	15	20		PDR malfunction?
	7:00:15	718	15	20	7472?	PDR malfunction?
	7:12:15	754	15	20	7462	
	7:23:15	787	15	20	7462	
	7:30:15	808	15	20	7408	
	7:40:14	838	15	20	7370	
	7:50:14	868	15	20	7386	
	8:00:14	898	15	20	7406	
	8:10:14	928	15	20	7348	
	8:12:36	935	17	20		
	8:20:16	958	17	20	7398	
	8:30:16	988	17	20	7242	
5/31/92	8:38	1011	17	21		
	8:40:16	1018	17	21	7192	
	8:50:16	1048	17	21	7201	
	9:00:16	1078	17	21	7084	
	9:10:16	1108	17	21	6982	
	9:20:16	1138	17	21	6855	
	9:30:17	1168	17	21	6554	
	9:33:56	1179				Recording stop
ESP-7						
5/31/92	18:57:27	2	8	22		System start
	19:00:07	10	8	22	2750	
	19:10:07	39	8	22	2808	
	19:20:07	69	8	22	2946	
	19:30:07	99	8	22	3023	
	19:40:07	128	8	22	3000	
	19:50:07	158	8	22	2983	
	19:53:46	168	6	22		
	20:00:05	187	6	22	2972	
	20:10:06	217	6	22	2922	

Table 2 Log data on the receiving ship (Tansei-maru)

	20:20:06	246	6	22	2926	
	20:30:06	276	6	22	2933	
	20:36		5	22		
	20:40:05	305	5	22	2910	
	20:50:05	335	5	22	2884	
	20:51:30					2 mile to Hakuho
	20:54:03	346	4	22		
	21:00:04	363	4	22	2819	
	21:04:20					Hakuho pass
	21:10:11	394	4	22	2797	
	21:20:03	423	4	22	2799	
	21:30:03	453	4	22	2775	
	21:38:04	477	5	22		
	21:40:04	483	5	22	2793	
	21:48:24	508	5	23		
	21:50:04	513	5	23	2812	
	22:00:04	543	5	23	2804	
	22:05:45	560	6	23		
	22:10:05	573	6	23	2779	
	22:20:05	603	6	23	2751	
	22:30:05	633	6	23	2719	
	22:38:26	659	7	23		
	22:40:06	663	7	23	2675	
	22:50:06	693	7	23	2640	
	23:00:06	723	7	23	2654	
	23:10:06	753	7	23	2740	
	23:13:07	762	8	23		
	23:20:07	783	8	23	2761	
	23:30:07	813	8	23	2779	
	23:40:07	843	8	23	2757	
	23:45:28	859	9	23		
	23:50:08	873	9	23	2796	
6/1/92	0:00:08	904	9	23	2813	
	0:10:08	933	9	23	2884	
6/1/92	0:15:09	948	10			
	0:20:09	963	10	23	2879	
	0:30:00	993	10	23	2913	
	0:35:03	1005	10	24	2941	
	0:40:00	1022	10	24	2965	
	0:45:50	1038	11	24		
	0:50:00	1051	11	24	3099	
	1:00:00	1081	11	24	3067	
	1:10:00	1111	11	24	3057	Recording stop
ESP-8						
6/1/92	7:56	1	7	25	2580	System start
	8:10:00	44	7	25	2570	
	8:20:00	74	7	25	2541	
	8:26:45	93	5	25		
	8:30:05	103	5	25	2552	
	8:40:05	133	5	25	2556	
	8:50:05	163	5	25	2548	
	9:00:00	193	5	25	2572	

Table 2 Log data on the receiving ship (Tansei-maru)

	9:01:03	194	4			
	9:10:03	221	4	25	2627	
	9:20:03	251	4	25	2544	
	9:30:03	281	4	25	2495	
	9:40:03	311	4	25	2539	
	9:50:03	341	4	25	2581	
	10:00:03	371	4	25	2592	
	10:07:24	391	5	25		
	10:10:04	399	5	25	2644	
	10:20:04	429	5	25	2718	
	10:30:04	459	5	25	2794	
	10:40:04	489	5	25	2777	
	10:41:45	494	6			
	10:47:05	510	6	26		
	10:50:25	519	6	26	2900	
	11:00:05	548	6	26	3040	
	11:10:05	578	6	26	3103	
	11:17:46	601	7	26		
	11:20:06	608	7	26	3150	
	11:30:06	638	7	26	3207	
	11:40:06	668	7	26	3263	
	11:50:06	698	7	26	3385	
	12:00:06	728	7	26	3466	
	12:10:06	758	7	26	3519	
	12:20:07	788	8	26	3556	
	12:27:47	811	8	26		Recording stop
ESP-9						
6/1/92	16:50:46	1	7	27		System start
	17:03:07	38	7	27	3583	
	17:10:15	59	7	27	3444	
	17:20:07	89	7	27	3151	
	17:30:07	119	7	27	3271	
	17:36:05	135	6	27		
	17:40:05	147	6	27	3180	
	17:50:05	177	6	27	3085	
	18:00:05	207	6	27	2971	
	18:09:45	235	5	27		
	18:10:05	236	5	27	2916	
	18:20:05	266	5	27	2900	
	18:30:05	296	5	27	2818	
	18:31:24	299	4	27		
	18:40:04	325	4	27	2784	
	18:50:04	354	4	27	2745	
	19:00:04	384	4	27	2735	
	19:10:04	414	4	27	2731	
	19:21:24	448	4	27	2774	
	19:22:45	452	5	27		
	19:30:13	474	5	27	2766	
	19:40:05	504	5	27	2748	
	19:41:44	509	5	28		
	19:50:05	534	5	28	2735	
	19:51:47	539	7	28		

Table 2 Log data on the receiving ship (Tansei-maru)

	19:52:26	540	6	28		
	20:00:05	563	6	28	2721	
	20:10:05	592	6	28	2706	
	20:20:05	622	6	28	2689	
	20:24:46	636	7	28		
	20:30:06	652	7	28	2673	
	20:40:06	682	7	28	2646	
	20:50:06	712	7	28	2624	
	21:00:06	742	7	28	2606	
	21:01:27	746	8	28		
	21:10:07	772	8	28	2585	
	21:20:07	802	8	28	2559	
	21:30:07	832	8	28	2547	
	21:35:08	847	9	28		
	21:40:08	862	9	28	2524	
	21:50:08	892	9	28	2501	
	22:00:08	922	9	28	2485	Recording stop
COP-2						
6/2/92	8:45	1	2	29		System start
	8:51		2	29	1717	
	9:00	44	2	29	1665	2 mile to Hakuho
	9:06	62	1	29		Shooting start
	9:10	74	1	29	1636	
	9:10	75	3	29		
	9:20	103	3	29	1612	
	9:30	133	3	29	1568	
	9:40	163	3	29	1465	
	9:50	193	3	29	1423	
	10:00	223	3	29	1388	
	10:10	251	3	29	1381	
	10:20	281	3	29	1381	
	10:30	311	3	29	1352	
	10:40	341	3	29	1319	
	10:50	371	3	29	1332	
	11:00	401	3	29	1347	
	11:06		3	29		3 mile to Hakuho
	11:10	431	3	29	1360	
	11:20	461	3	29	1363	
	11:21	466	4	29		
	11:28		4	29		2.8 mile to Hakuho
	11:30	491	4	29	1355	
	11:36:40			30	1361	MT#29->#30
	11:40	520	4	30	1361	
	11:50	551	4	30		
	12:00	580	4	30	1371	
	12:10	609	4	30	1340	
	12:20	639	4	30	1239	start closing to Ha
	12:32	675	4	30	1050	
	12:38:42	694	3	30		
	12:40	698	3	30	1003	
	12:47					1.8 mile to Hakuho
	12:50	728	3	30	1062	

Table 2 Log data on the receiving ship (Tansei-maru)

	13:00	758	3	30	1057	
	13:10	788	3	30	1224	
	13:20	818	3	30	1269	
	13:30	848	3	30	1270	
	13:40	878	3	30	1252	
	13:50	908	3	30	1264	
	14:00	938	3	30	1350	
	14:10	968	3	30	1396	
	14:20	998	3	30	1518	
	14:22:42	1006		31		MT#30->#31
	14:30	1028	3	31	1589	
	14:40	1058	3	31	1601	
	14:50	1088	3	31	1605	
	15:00	1118	3	31	1605	
	15:10	1148	3	31	1552	
	15:20	1178	3	31	1588	
	15:30	1208	3	31	1581	
	15:40	1238	3	31	1576	
	15:50	1268	3	31	1577	
	16:00	1298	3	31	1573	
	16:10:02	1327	3	31	1589	
	16:20:02	1357	3	31	1590	
	16:30:02	1387	3	31	1564	
	16:40:02	1417	3	31	1491	
	16:50:02	1447	3	31	1469	
	17:00:02	1477	3	31	1448	
	17:10:02	1507	3	31	1397	
	17:12	1515	3	31		MT#31 end
	17:12	1516	3	32		MT#32 start
	17:20:02	1537	3	32	1321	
	17:30:02	1567	3	32	1308	
	17:40:02	1597	3	32	1030	
	17:50:02	1627	3	32	1255	
	18:00:02	1657	3	32	1355	
	18:10:02	1687	3	32	1355	
	18:20:02	1716	3	32	1367	
	18:30:02	1746	3	32	1380	
	18:40:02	1776	3	32	1396	
	18:50:02	1806	3	32	1414	
	19:00:02	1835	3	32	1429	
	19:10:02	1865	3	32	1442	
	19:20:02	1895	3	32	1452	
	19:30:02	1925	3	32	1463	
	19:40:02	1955	3	32	1476	
	19:50:02	1985	3	32	1491	
	19:59:02	2012	3	33		MT#33 start
	20:00:02	2015	3	33	1502	
	20:10:02	2045	3	33	1516	
	20:11:02	2048				Recording stop

2.3 Kaiko Maru-5 Cruise: Explosion Seismic Experiment

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Introduction

The seismic structure of the arc system needs to be clarified in order to understand the origin and the dynamics of the arc and the surrounding areas. The Izu-Bonin arc is an oceanic arc located in the Philippine Sea. Because the knowledge of the deep seismic structure of the arc is important, we conducted seismic experiment in the area. We report here the operation of the experiment during the cruise of the *Kaiko Maru-5*.

Experiment

In May and June 1992, a series of seismic refraction/reflection experiment was conducted in the Izu-Bonin arc area. Among the cruises in the experiment, the *Kaiko Maru-5* was chartered during June 12 though 20 to conduct an explosion experiment and to deploy eight ocean bottom seismographs. The operation of the *Kaiko Maru-5* is summarized in Table 1. Her cruise was the cooperative operation of Leg 2 of the *R/V Hakuho-maru* cruise (KH-92-2), from which 18 OBSs were deployed and the airgun profiling was carried out.

The objective of the explosion experiment was to provide seismic energy large enough to penetrate down into the lower crust and the upper mantle.The crustal thickness in the Izu-Bonin arc area is thought to be thicker than that in an oceanic crust and to be comparable to that found in the island arc i.e. 20 - 30 km. For this reason we used large energy seismic sources.

We fired 5-ton dynamite at 71 positions. The shallow crustal structure is well controlled by the multi-channel seismic reflection profiling, the arigun-OBS, and the expanding spread profiling carried out by the *R/V Hakuho-maru* in the present experiment. We used controlled seismic source of chemical explosives of sizes raging from 20 to 280 kg. The position of the refraction line is shown by Takahashi *et al.* (1993) in the present volume of the cruise report.

Operation of explosion

We used 20 explosives along the 50-km-long line running toward the west on the Pacific plate and 51 on the 240-km-long line located on the area from the for-arc basin to the rift-back-arc transition zone. Shooting parameters for individual shot are listed in the report by Takahashi *et al.* (1993). The area between the trench axis and the for-arc basin could not be covered because the heavily rough sea condition.

We used the electric detonator for good control of shot timing. The schematic firing system is shown in Fig. 1 and the actual operation of the shooting is shown in Photo 1. The specification of the dynamite and the detonator used in the experiment is listed in Table 2. For the operations of detonation we used a hydraulic winch which has a firing cable with three conductors, two of which were used to connect a shooting circuit and the charge. The remaining is a spare. We did not use the water as conductor because during the operation of detonation we monitored the resistivity of the firing cable to see if the connection is complete or not. We conducted two kinds of methods of explosion operation: one is a small size explosion. The charge size is from 20 to 80 kg. The other is a large size explosion. We detonated the small size charge with a ship speed of about 5 kt without stopping the vessel while we stop her to operate the large shot. If the sea was calm, we could fire the small shot every 15 minutes using the system. However, since the weather was so rough in the present experiment, we could two or three explosions a hour (Table 1). For the large size explosion we stopped the vessel to lower dynamite packages in sea with a rope and buoys. To enhance the shooting energy, we tried to conduct the dispersed charge shots (Jacob, 1974). However, the rough weather condition did not permit us to perform the dispersed charge shooting. So, the three large shots, E1 (280 kg), E2 (280 kg), and E3 (160 kg) were fired with a single package.

Conclusions

Although the sea condition was fairly rough, we could conducted explosion experiment in the Izu-Bonin arc area. We deployed eight OBSs and completed 5-ton dynamite charges at 71 positions along the 290-km-long refraction line during the 4-day operation. The dispersed shots were needed to be changed to single charge shots due to rough weather. And also 100-km-long part of the entire length of the refraction line could not to be shot.

References

[1] Jacob, A. W., Dispersed shots at optimum depth - an efficient seismic source for lithospheric studies, *J. Geophys.*, 41, 63 - 70, 1975.

[2] N. Takahashi, N. Hirata, T. Kanazawa,T. Yamaguchi, M. Suzuki, T. Sato, M. Sekine, R. Takahashi, Y. Yokoi, M. Shinohara, Y. Ariie, R. Hino, T. Okada, K. Suyehiro, A. Taira, Seismic structure of the Izu-Bonin Arc deduced by the 1992 OBS-Explosive and airgun refraction experiment, *Prel. Rept. Hakuho Maru Cruise KH-92-2*, this volume, 1993.

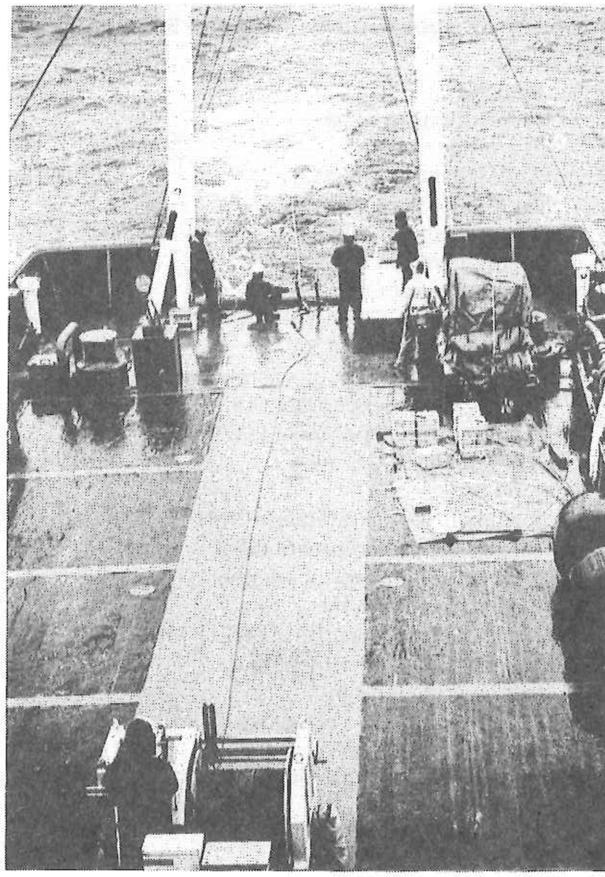

Photo 2-3-1: Operation of shooting. The float of the charge, dynamite packages on the rear deck, and the shooting winch are shown.

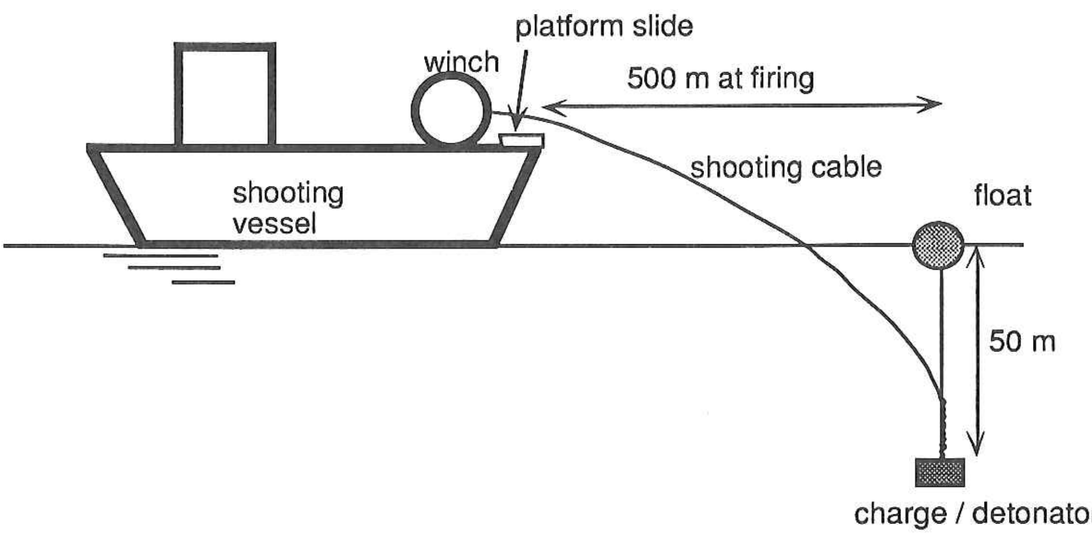

Figure 2-3-1: Arrangement of dynamite shooting. The distance between the vessel and the float of the charge is 500 m for the 20-kg charge and 700 m for the 280-kg charge. The depth of the charge also depends on the size: 50 m for 20 kg and 100 m for 280 kg.

Table 2-3-1. Summary of operation during the 1992 Kaiko Maru-5 cruise

Date	(JST)	Comments
6/12	08:51	Departure from Toba
		Steaming
6/13	07:48	Deployment of OBS#13A
	10:29	Deployment of OBS#11A
	13:20	Deployment of OBS# 9A
	15:28	Deployment of OBS# 8A
	17:35	Deployment of OBS# 7A
	20:34	Deployment of OBS# 6A
6/14	00:25	Deployment of OBS# 5A
		Steaming to the east of seismic line
	12:18	Start explosion experiment (S 1)
	18:55	End explosion experiment (S17)
	23:27	Deployment of OBS# 4A
		Stand by
6/15	10:01	Start explosion experiment (S18)
	11:11	End explosion experiment (S20)
		Drifting under stress of weather
6/16		Drifting and stand by
6/17	05:00	Start explosion experiment (S21)
	18:49	End explosion experiment (E1)
6/18		Drifting and stand by under stress of weather
6/19	06:24	Start explosion experiment (E2)
	12:11	End explosion experiment (E3)
		Steaming
6/20	08:50	Arrival at Yokosuka

Table 2-3-2. Explosives used in the experiment

Dynamite

Constitution	weight %	
nitrogel	50	nitroglycerine, nitroglycol, nitrocellulose
sodium nitrate	28	
combustible	7	woodmeal, etc.
others	15	barium sulfate, etc.

Anti-water pressure capacity:

can be detonated under water pressure of 10 kg cm^{-2} after 5 hrs

Explosion velocity: 7,200 - 7,700 m s^{-1}

Density: 1.55 - 1.62 g cm^{-3}

Electric detonator

Anti-water pressure capacity:

can be detonated under water pressure of 10 kg cm^{-2} after 5 hr

Anti-static electricity capacity: does not ignite at 2,00 pF - 10 kV

Difference between platinum bridge cutting time and explosion time:

less than 0.1 ms

Igniting electric current:

not ignited by 0.25 A for 30 ms and ignited by 1.0 A for 10 ms

3. NAVIGATION

3.1 Reproduction of navigation data of R/V Hakuho Maru and Tansei Maru

M. Shinohara and K. Suyehiro

At processing data collected during KH92-2 and KT92-7 cruises, the ship navigation data of *R/V Hakuho Maru* and *R/V Tansei Maru* are necessary. The ship navigation data output by each ship's hybrid navigation system were recorded on magnetic tapes (MTs) on both ships. Here, we describe the way to reproduce the navigation data from the MTs where the data are recorded. The data were processed using Alliant mini-super computer and SUN Sparc 2 workstation at Marine Geology and Geophysics, ORI, Univ. of Tokyo. Because these two computers are linked by Local Area Network (LAN), files on disk can be accessed and transferred to other computer (NFS and FTP). Then, although only Alliant computer has an MT device, the navigation data on MTs can be copied to both Alliant disk and SPARC disk using NFS or FTP. After copying the data to disk, the information necessary for processing (ship positions, water depth, etc.) are read by programs. Because the reading programs are written by C language, the programs are transportable to any computers. These programs may be freely copied from us.

Hakuho Maru navigation data

The *R/V Hakuho Maru* navigation system (Mitsubishi Heavy Industries Ltd., 1987) is controlled by Maganavox Series 5000 (MX5000). Among many kinds of information collected by the navigation system, the ship positions and water depths are important for the seismic experiments. We chose four kinds of ship position data (GPS, hyperbola mode Loran-C, RHORHO mode Loran-C, and hybrid systems position estimated by navigation system) and two kinds of water depth data (Seabeam, and PDR) from the navigation data for geophysical data processing.

Most of collected data were distributed real-time to shipboard laboratories via LAN and can be obtained by RS-232C serial interface (Nakanishi *et al.*, 1990). GPS positions are based on WGS84. The data logging by a personal computer enables us to obtain data with short time intervals. For example, GPS data are recorded at 4 s interval by a personal computer, whereas the other navigation data are typically collected at 30 or 60 s interval to MT.

MX5000 data are recorded in 4096 byte (physical record) on MT. The physical record is comprised of a 18-word header followed by a variable number of logical records. A logical record contains a 16-word header, followed by the data. The length of a logical record varies according to the data. If a logical record is too large for physical record size, the data is split into two physical records. Hewlett Packard data format is used for integer and floating point data. ASCII code is used for character (Table 1). The informations are written to each ASCII file corresponded to the type of data.

Tansei-maru navigation data

R/V Tansei Maru hybrid navigation system collected many kinds of data and recorded the data to MT at real-time (Sena Ltd., 1986). We picked three kinds of ship positions (GPS, Loran-C, hybrid system positions) and depth data (PDR) for the seismic processing. The recording time interval is 30 s.

Tansei Maru navigation data are recorded in 1024 byte (physical) on MT by hybrid navigation system. The physical record consist of two logical records whose record length is 512 byte. Most of data in MT are represented using EBCDIC code. Hewlett Packard data format is used for integer (Table 2).

References

[1] Mitsubishi Heavy Industries Ltd., Hakuho-maru navigation system data logging format, 1987

[2] Sena Ltd., Tansei-maru hybrid navigation system magnetic tape recording format, 1986

[3] M. Nakanishi, H. Fujimoto, and T. Furuta, Real-time data processing and distribution system of the Hakuho-maru, J. Jpn. Soc. Mar. Surv. Tech., 2, 1-10,1990

Table 3-1-1. Navigation data format on magnetic tape on *Hakuho Maru*.

MT physical format

1 physical record size	4096 byte
Label	No Label
Density	1600 byte

Physical header format

1 physical record (4096 byte) = 36 byte physical header + 4060 byte data

word	Description	Format
1	Physical record number	INT4
3	Pointer to first logical record	INT2
4	First logical record number	INT4
6	Last logical record number	INT4
8	Year logged on MT	INT2
9	Day logged on MT	INT2
10	Hour loged on MT	INT2
11	Minute logged on MT	INT2
12	Second logged on MT	INT2
13	Flag (normally >0)	INT2
14	=18, phisucal record size	INT2
15	Spare	INT2*4

Logical record header

1 logical record = 32 byte logical header + variable lenght data

word	Description	Format
1	Logical record number	INT4
3	Logical record type	INT2
4	Logical record size	INT2
5	Year inserted into buffer	INT2

6	Dat inserted into buffer	INT2
7	Hour inserted into buffer	INT2
8	Minute inserted into buffer	INT2
9	Second inserted into buffer	INT2
10	Time (s) from system start	REAL4
14	Spare	INT2*3

Logical record type (extract)

Type	Contains	
802	JRC 761R	RHORHO mode Loran-C
803	JRC 761	Hyperbola mode Loran-C
1005	Raytheon PDD-200C	Water depth by PDR
1006	SeaBeam	Water depth
2600	Event data	including hybrid system position

Logical record format (extract)

802 and 803 Loran-C data

word	Description	Units	Format
5	Year		INT2
6	Day		INT2
7	Hour		INT2
8	Minute		INT2
9	Second		INT2
126	Latitude (degree)	Deg	ASCII*2
127	Latitude (minute)	Min	ASCII*5
131	Longitude(degree)	Deg	ASCII*3
132.5	Longitude((minute)	Min	ASCII*5

1005 Raytheon PDD-200C PDR

word	Description	Units	Format
5	Year		INT2
6	Day		INT2
7	Hour		INT2
8	Minute		INT2
9	Second		INT2
37	Depth	m	ASCII*5

1006 SeaBeam

word	Description	Units	Format
5	Year		INT2
6	Day		INT2
7	Hour		INT2
8	Minute		INT2
9	Second		INT2
36.5	Depth	m	ASCII*5

2600 Event data (hybird system position)

word	Description	Units	Format
17	Year of event		INT2
18	Day of event		INT2
19	Hour of event		INT2
20	Minute of event		INT2
21	Second of event		INT2
22	Fraction of second of event	.01 s	REAL4
49	Latitude	Rad	REAL4

53	Longitude	Rad	REAL4
57	Parametric latitude	Rad	REAL4
61	Smoothed latitude	Rad	REAL4
65	Smoothed longitude	Rad	REAL4
69	Smoothed system speed	m/s	REAL4

* Day is counted from 1/1 (Julian Day)

Table 3-1-2. Navigation data format on magnetic tape on *Tansei Maru*.

MT physical format

1 physical record size	1024 byte
Label	No Label
Density	1600 byte

Physical header format

1 physical record (1024 byte) = logical record (512 bytes) * 2

Logical record header (Extract)

Byte	Description	Units	Format
1	Record identification No.		INT2
3	Serial No.		INT2
5	Year		INT2
7	Month		INT2
9	Day		INT2
11	Hour		INT2
13	Minute		INT2
15	Second	I	NT2
19	System latitude (degree,Tokyo datum)	Deg	EBCDIC*3
22	System latitude (min., Tokyo datum)	Min	EBCDIC*6
28	System longitude (degree, Tokyo datum)	Deg	EBCDIC*4
32	System longitude (min., Tokyo datum)	Min	EBCDIC*6
39	Error of system latitude	Min	EBCDIC*5
45	Error of system longitude	Min	EBCDIC*5
51	System speed	Knot	EBCDIC*4
213	Water depth (PDR)	m	EBCDIC*6
379	Sign of Loran-C latitude	N or S	EBCDIC*1
380	Loran-C latitude (degree, WGS72)	Deg	EBCDIC*2
382	Loran-C latitude (min., WGS72)	Min	EBCDIC*5
387	Sign of Loran-C longitude	E or W	EBCDIC*1
388	Loran-C longitude (degree, WGS72)	Deg	EBCDIC*3
391	Loran-C longitude (min., WGS72)	Min	EBCDIC*5
399	GMT of GPS position (hour)		EBCDIC*2
401	GMT of GPS position (min.)		EBCDIC*2
403	GMT of GPS position (s)		EBCDIC*2
405	Sign of GPS latitude	N or S	EBCDIC*1
406	GPS latitude (degree, WGS84)	Deg	EBCDIC*2
408	GPS latitude (min., WGS84)	Min	EBCDIC*5
413	Sign of GPS longitude	E or W	EBCDIC*1
414	GPS longitude (degree, WGS84)	Deg	EBCDIC*3
417	GPS longitude (min., WGS84)	Min	EBCDIC*5
423	Heading from GPS data*	Deg	EBCDIC*4
427	Speed from GPS data*	Knot	EBCDIC*4
431	Hdop		EBCDIC*4

* Floating period is not inculded in data.

4. SEISMOLOGY

4.1 MCS Profiling Across the Izu-Ogasawara Trench-Arc System at 32° 15′ N

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Introduction

We describe here the multi-channel seismic (MCS) profile shot during Leg 2 of KH 92-2. Previous MCS surveys in this area can be found in Taylor *et al.* (1990) and Suyehiro *et al.* (1991). This profile extended from 32° 15'N, 137° 56'E to 32° 15'N, 143° 0'E along the great circle so that at about mid-point the coordinate was 32° 17'N, 140° 30'E. This geometry was required since the profile coincided with the OBS-dynamite profile.

MCS operation

During the MCS operation, three guns, a hydrophone streamer, and a proton magnetometer were towed behind. The seismic source was a three-airgun with 56 liter capacity (BOLT 1500C; 1200 cu. in. (19.7 liter) x 2, 1000 cu. in. (16.4 liter) x 1) towed from the stern. The air pressure was maintained at about 1300~1500 psi. An airgun shot time synchronizer (Input/Output Auto Sync I-AG) sensed the actual shot time of each airgun from transducers attached to airguns (Input/Output SS-8) and sync'ed the time. A contact closure signal at a time interval of 20.0 s controlled by a time code generator was fed to Auto Sync. The Auto Sync syncs the actual shot time to 462 ms after the contact closure. These timings are important since OBS's also were observing the airgun signals.

The MCS hydrophone streamer (AMG 37/43) consists of 24 channels of 50 m length sections with 48 hydrophone elements in each section. Each hydrophone (HC 202E) has the sensitivity of 24 volts/bar. The 24 active sections are connected to a stretch section before the tail buoy end, and 3 stretch and 1 weight section on the winch side. Three cable levellers (Syntron RCL-2) were attached between channels 1 and 2, between 13 and 14, and after 24 (winch side). Typically, it takes about 40 minutes to deploy the system and about 80 minutes to recover.

The hydrophone streamer signals were stored digitally onto 6250 bpi 2400 feet magnetic tapes. This profile produced 36 tapes recording 7685 shots of 8 s length with 1 ms sampling. The field data acquisition system (TI DFS-

V) receives the start signal of the data acquisition from the gun control system. Because DFS-V operated in internal time break mode (ITB), there exists a delay of 265 ms before the first data sample is written onto tape. This factor must be accounted for when processing the data.

MCS record section

Figure 1 shows the near trace record section of the whole transect profile. The locations of OBS's and cross points of two-ship ESP seismic profiles are also shown. The dataset is now being processed for stacking and migration. The oceanic crusts of the Pacific Ocean and the Philippine Sea will be more clearly defined. Because of the larger subduction dip angle compared to that in the Japan Trench area, it may be difficult to trace the subducting crust. Also, a careful processing will be necessary to better image the central rift zone (e. g. Taylor *et al.*, 1990).

This dataset is an important constraint to OBS data to image the crust and uppermost mantle in detail.

References

[1] K. Suyehiro, C. Igarashi, Y. S. Djajadihardja, M. Okada, H. Nambu, and F. Yamamoto, Multi-channel seismic reflection profiling, 85-101, 1991.

[2] B. Taylor, G. Moore, A. Klaus, M. Systrom, P. Cooper, and M. MacKay, Multi-channel seismic survey of the central Izu-Bonin Arc, Proc. ODP, Init. Repts., College Station, TX, 126, 51-60, 1990.

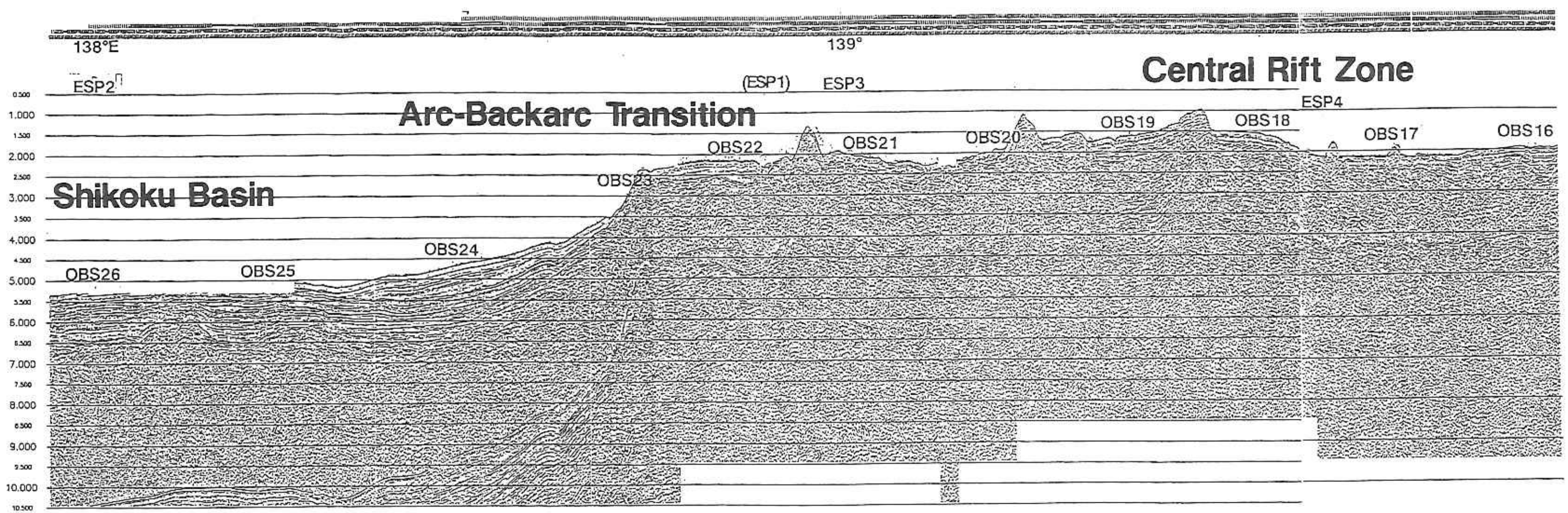

Figure 4-1-1: Near trace record section of MCS survey transecting Izu-Ogasawara island arc system. Locations of OBS's and cross points of two-ship seismic profiles are also indicated.

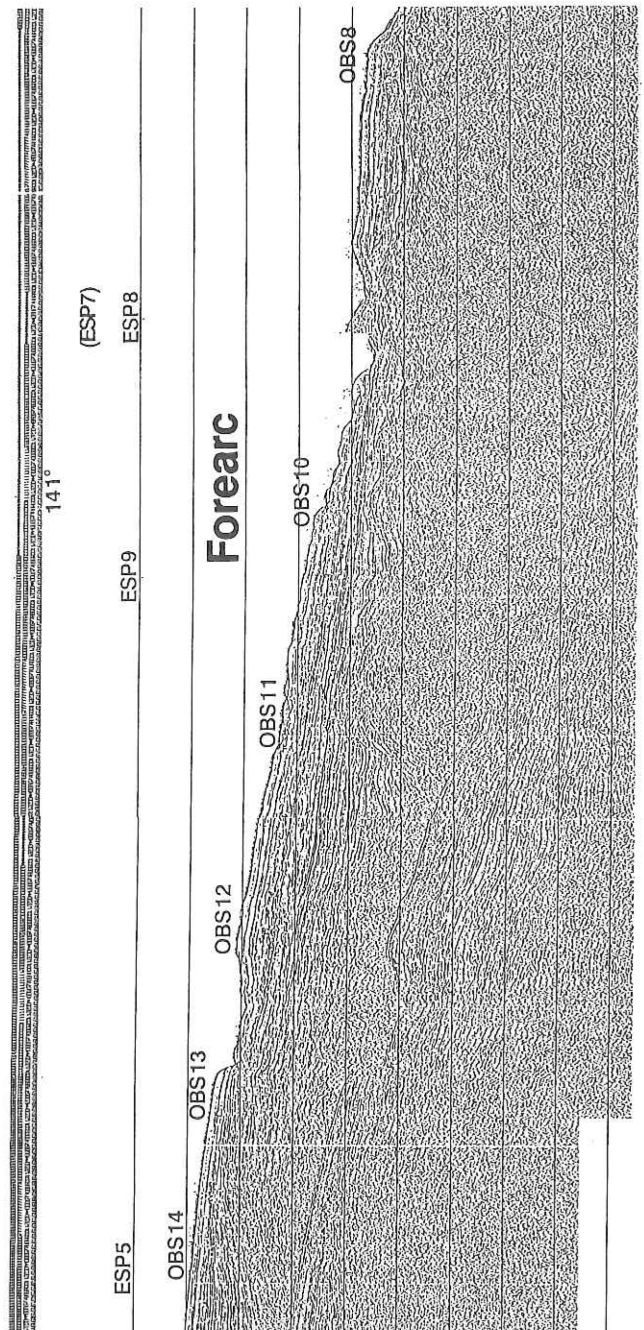

Figure 4-1-1: cont'd.

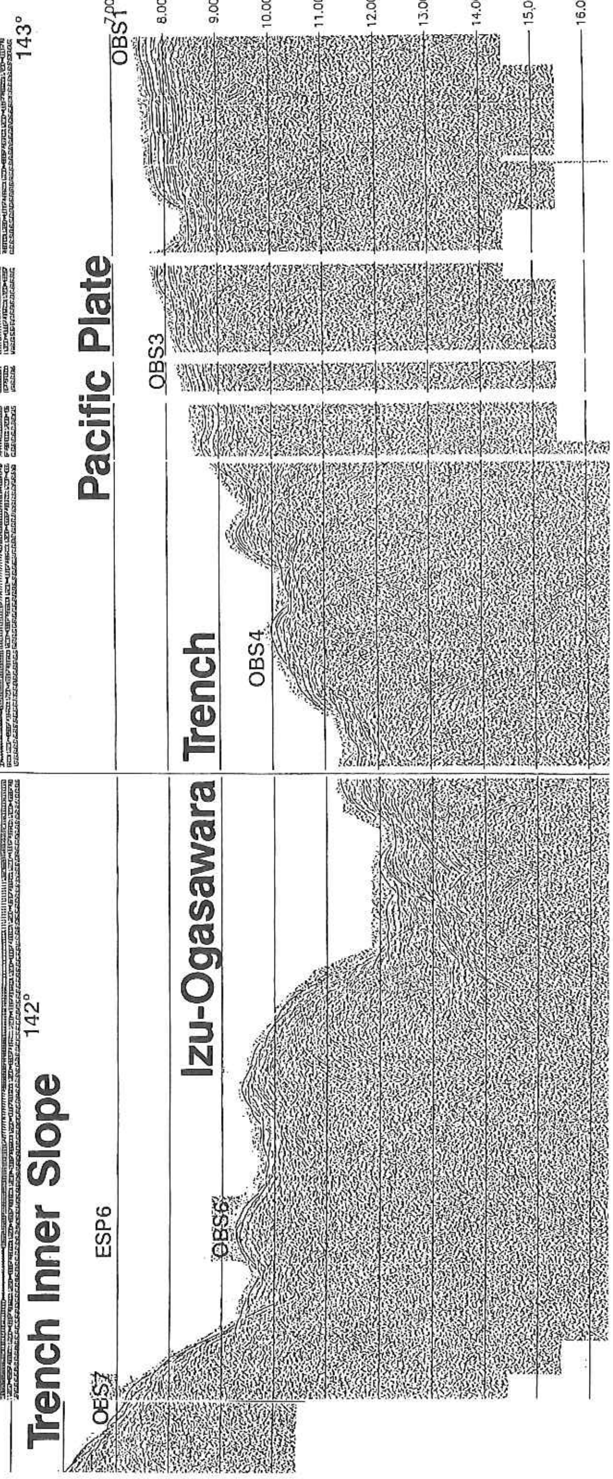

Figure 4-1-1: cont'd.

4.2 Airgun-OBS Seismic Experiment for Detailed Crustal Structure of the Northern Izu-Ogasawara Island Arc

R. Hino, K. Nida, T. Kanazawa, Y. Kaiho, N. Takahashi, N. Hirata, M. Shinohara, and K. Suyehiro

Introduction

During the research cruise KH92-2 Leg. 1, in May to June 1992, we have conducted extensive seismic surveys by using ocean bottom seismographs (OBSs) and large volume airguns in the northern part of the Izu-Ogasawara Island Arc. The object of the surveys is to clarify the detailed crustal structure at several tectonically important provinces of the arc: the inner trench wall, the outer-arc high, the fore-arc basin, the present volcanic front, the back-arc rifting zone, the arc-marginal basin transition, and the marginal basin. By compiling these results, we can discuss how the crustal structure varies across the arc. Although several other seismic surveys have been made at the same time, we describe here outline of the deployment of OBSs and the airgun shooting during the cruise of Leg 1. We will also present several examples of the airgun record sections obtained by analog and digital OBSs. Experimental operations and data of other seismic surveys are reported separately in this issue. Figure 1 shows the locations of the present airgun seismic survey lines.

Ocean Bottom Seismographs

In the cruise, we deployed 20 OBSs (see Section 2.1 of this volume) by *R/V Hakuho Maru*. Ten of them were of free-fall pop-up type, which is developed at Geophysical Institute of the University of Tokyo (Yamada *et al.*, 1981; Kanazawa, 1986). Each of them are equipped with 4.5 Hz three-component geophone and output signals are recorded on Philips C-90 casette tapes by direct analog recording. The others were also similar pop-up type OBSs, but they are equipped with digital data recorders developed at Ocean Research Institute, the University of Tokyo (Shinohara *et al.*, 1992). Each of both types of OBSs has a precise quartz clock and time codes generated by the clock were also recorded with geophone signals. Primary object of the OBS observation by these 20 OBSs is to delineate seismic activity around the northern Izu-Ogasawara Arc, which has been know little by the previous land based seismic observations. Besides the natural earthquake observations, we shot airgun seismic refraction lines across several of these OBSs: sites OBS#4, OBS#5, OBS#7, OBS#9, OBS#8, OBS#12, OBS#14, OBS#15, OBS#16, OBS#17, OBS#18, OBS#20. Airgun signals recorded by these stations were analyzed for the crustal structure. The locations of these OBS sites are indicated in Figure 1 by solid circles.

Airgun Shooting Operation

We utilized large volume airguns as a controlled seismic source during the experiment. Field notes of the airgun shooting are reproduced in Table 1. Navigation throughout the research cruise was controlled by GPS and LORAN-C, and the ship speed during the airgun operation was kept to be 5 knots. Shot timing was controlled by a quartz clock which has the same precision as those installed in the OBS system. A time interval of the shooting was 20 seconds, which corresponds to a spatial interval of about 50 m. Air pressure of the guns in operation about 10 MPa. Total number of shots during the cruise amounts to about 22,000. At first, we had planned to use an airgun array system composed of four Bolt PAR 1500-C airguns; two of them were 1,200 in3 in volume and the others were 1,000 in3. However, the system was seriously damaged due to its own huge energy emission during the test shooting (May 26) and hence we replaced the airgun array by one 1,200 in3 airgun for the experiments until May 30 when another 1,200 in3 airgun had been fixed up. After that, we shot these two guns as an array. These airgun seismic signals were recorded not only by OBSs but also by a 24-channel hydrophone streamer towed behind the shooting ship, *R/V Hakuho Maru*, and further by a 6-channel hydrophone streamer of *R/V Tansei Maru*. The data of the 24- channel streamer were analyzed for seismic reflection profiles (Suyehiro *et al.*, this volume) and 6-channel streamer data were processed for expanded spread profiling (ESP) or constant offset profiling (COP) data analyses (Tokuyama *et al.*, this volume).

OBS Refraction Records

1) Analog recording OBS

The seismic data obtained by analog recording OBSs have been digitized at a sampling rate of 100 /s for each data channel. After correcting for time differences between OBS clocks and the clock of the airgun control unit, we have obtained digital record section for each OBS. A shot-receiver distance was determined from the ship position at every airgun shot and the position of the OBS site location. Figure 2 shows example of airgun signals recorded by OBS. This record section was obtained by OBSs deployed along the airgun shooting line ESP-7 (see Fig. 1 for its location). On this section, first arrivals can be classified as evident three major branches: those of apparent velocities of about 4 km/s (apparent from 5 to 10 km in offset distance), about 6 km/s (10 to 40 km), and about 7 km/s (further than 40 km). All these phases are refracted arrivals and presence of these arrivals indicates that the crust beneath the topmost sedimentary layer has three layered structure. Evident later arrivals with apparent velocity larger than 7 km/s are also apparent around 40 km in offset on record section.We interpreted these arrivals as the wide angle reflections from the Moho discontinuity. From travel time data of the Moho reflections, the PmP arrivals, we can estimate the depth to the Moho. We infer the depth to be about 15 km below the sea level by simple travel time calculations.

2) Digital recording OBS

The seismic data in DAT tapes recorded by digital OBSs are copied to EXA-Byte (8 m/m video) tapes using playback system, which computer can read/write. Next, the seismic data are copied to the hard disk of SUN Sparc 2 work station for processing. See Shinohara *et al.* (this volume) about detailed processing procedure of digital OBS system. After adjusting OBS's timing to JST, we relocated the OBS positions using the traveltimes of direct water waves within 5 km of the OBS. Figure 3 shows example of airguns signal along COP2 (rift zone) recorded by OBS #17. The record section shows in the east section of the OBS. The apparent velocity for the first arrivals is 3.3 km/s at offset distances less than 5 km. At offset distances greater than 15 km, the apparent velocity of the first arrivals is 6.1 km/s. Between the range of 5 and 15 km, The apparent velocity increases from 4.3 km/s, which means the layer corresponding to this phase has velocity gradient. A later arrivals which seems to be the PmP phase are seen at offset distances greater than 50 km. From the seismic data, the structure along COP2 is estimated to have five layers: sedimentary layer, 3.3-km/s layer, 4.3-km/s layer, 6.1-km/s layer, and mantle. The Moho is suggested to be about 20 km deep from the sea level by simple estimating traveltime of the later arrivals interpreted as the PmP.

Concluding Remarks

Our preliminary results indicate following important structural features of the northern Izu-Ogasawara Island Arc:

1) The presence of the 6 km/s layer, similar to upper crustal layer of the continental crust beneath the wide area from the fore-arc to the back-arc regions.

2) Thickening of the 6 km/s layer towards the present volcanic chain.

3) Thin crustal thickness (up to 20 km) compared to the island arcs detached from continents (e.g. NE Japan, SW Japan).

Our next step is to refine our preliminary results and to obtain detailed image of the crustal structure across the arc. These new data must provide us significant constraint on the composition and the tectonic evolution of the crust of intra-oceanic island arcs.

References

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[3] T. Yamada, T. Asada, and H. Shimamura, A pop-up ocean bottom seismograph, Annu. Meet. Seismol. Soc. Jpn. Abstr., 2, 126, 1981 (Abstract, in Japanese)

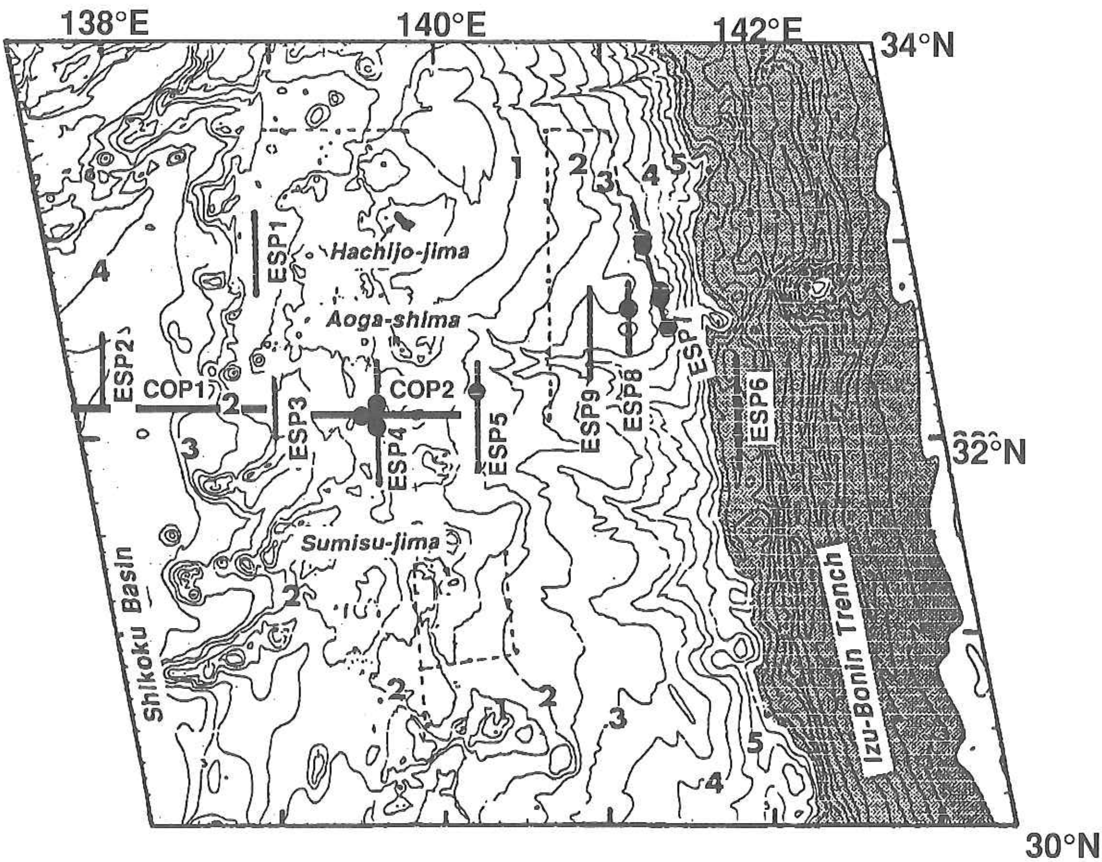

Figure 4-2-1: Locations of the ESP and COP seismic experiment in northern Izu-Ogasawara Arc Trench System with the seafloor topography. Isobaths are in km. Shaded area is trench aixal zone where water depth greater than 6 km. Solid lines indicate ESP and COP lines. The OBS positions using velocity analyses are shown by solid circles. Dashed lines indicate the previous survey profiles.

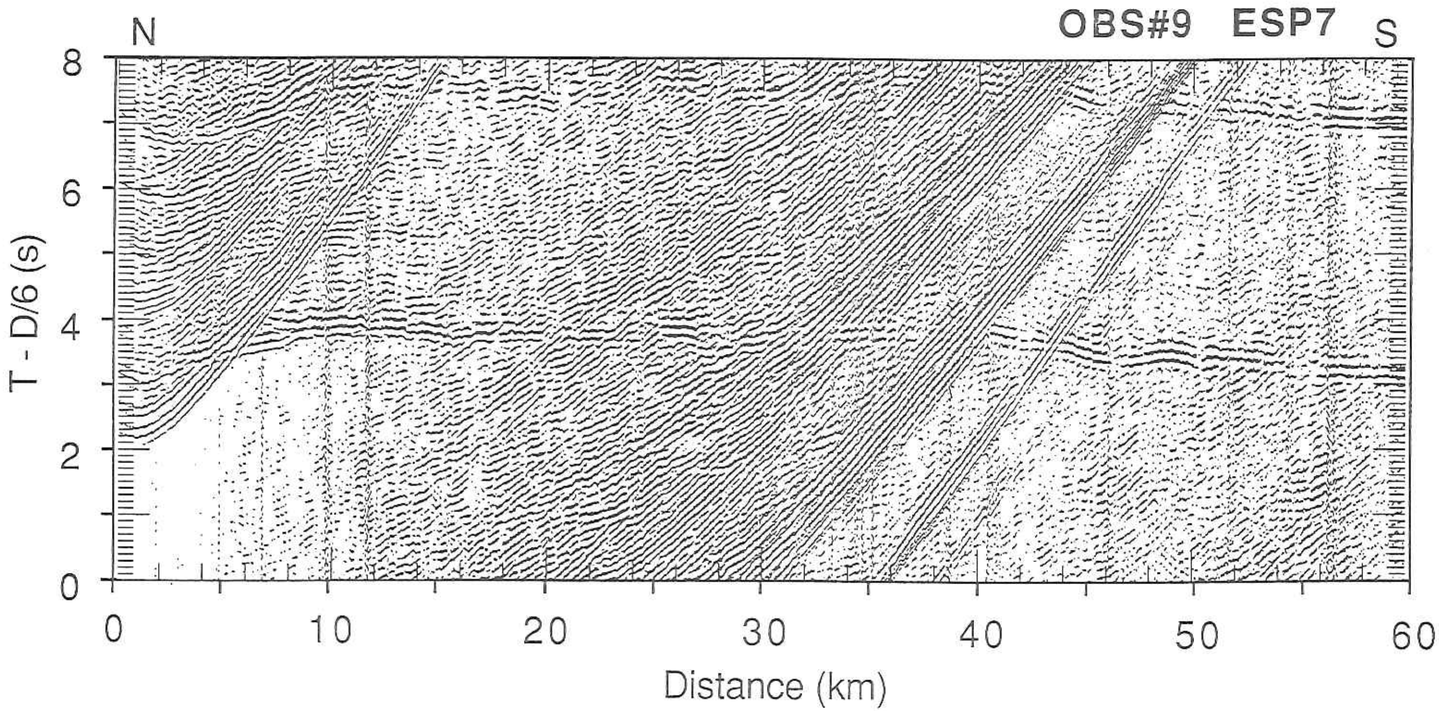

Figure 4-2-2: Record section for the vertical component, high-gain channel of the OBS #9 (analog recording OBS) for ESP7. Reduction velocity is 6 km/s. The first arrivals are clearly seen at the distances greater than 60 km. The later arrivals seems to be the PmP phase can be seen at offset distances greater than 45 km.

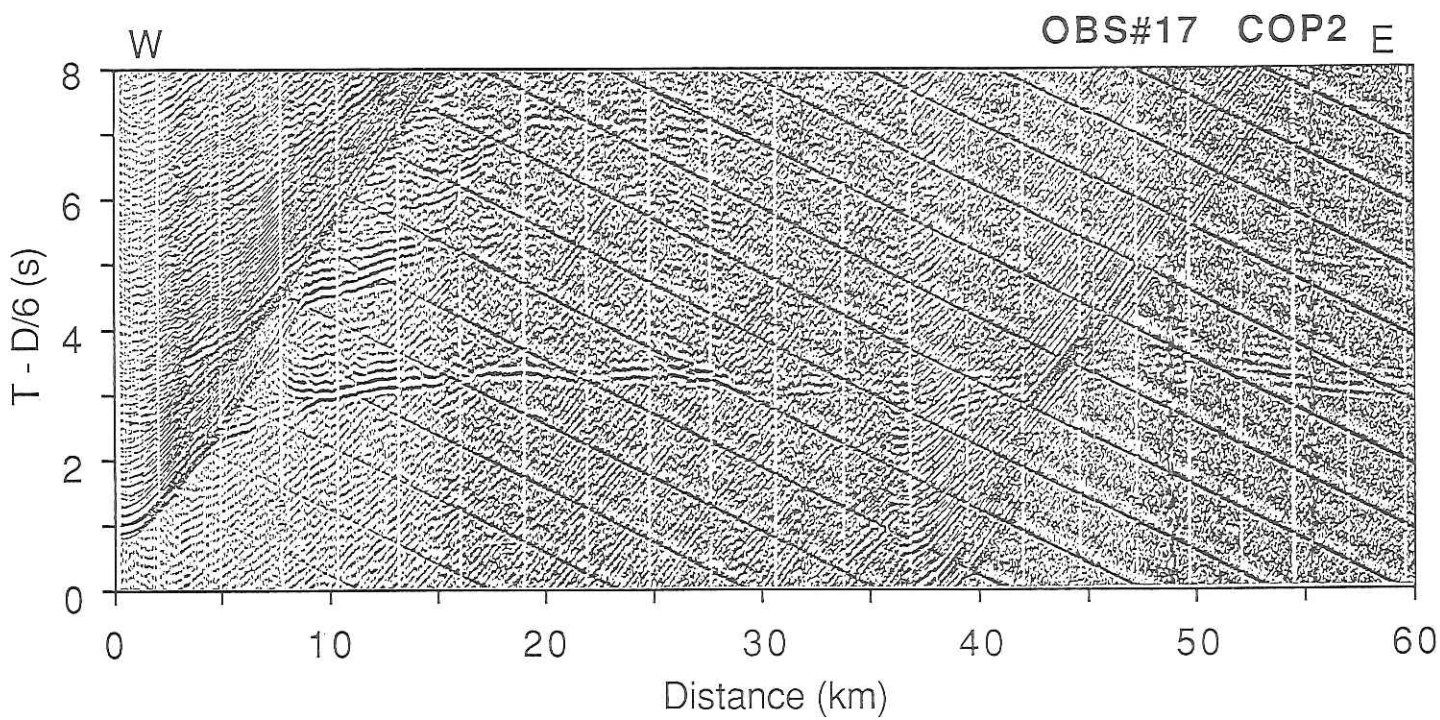

Figure 4-2-3: Record section for the vertical component of OBS #17 (digital recording OBS) for COP2. Reduction velocity is 6 km/s. Each trace is normalized by its maximum amplitude. The first arrivals are seen at the distances grater than 60 km. Slant straight lines appear due to cross talk of timing signals.

Table 1. Field note of airgun shooting during KH92-2

AIRGUN OPERATION NOTE KH-92-2LEG 1								
Date	**Tape**	**FFNO**	**Dly**	**Time**	**Latitude**	**Longitude**	**Depth**	**Comments**
5/26/92				13:06:20	32°11.78'	139°28.65'	1064	4-gun
				13:57:00				halt
				18:47:00	32°17.01'	139°43.67'	1429	resume
	1	1	1	18:50:00				length 6
			1	19:02:00	32°15.64'	139°49.68'	1534	
		212	1	20:00:00	32°11.37'	139°44.99'	1569	
	2	343	1	20:43:40				
		362	1	20:50:00				Gun #3 halt
		392	1	21:00:00	32°11.97'	139°40.54'	1605	
		572	1	22:00:00	32°12.06'	139°34.64'	1341	
			1	22:02:50				Gun #4 halt
		619	1	22:15:40				Guns #1, 2 halt
5/27/92				7:07:10	32°42.21'	138°54.58'	1795	1-gun
	3 ESP1-1	1	1	7:10:00				
		151	1	8:00:00	32°46.07'	138°53.27'	1793	
		331	1	9:00:00	32°50.59'	138°53.95'	1950	
	4 ESP1-2	362	1	9:10:00				
		601	1	10:00:00	32°55.41'	138°54.66'	1945	
	5 ESP1-3	690	1	10:58:00				
			1	11:00:00	33°0.35'	138°54.92'	1910	
		871	1	12:00:00	33°5.28'	138°55.43	1824	
		945	1	12:24:40			1833	
				12:26:00	33°7.51'	138°55.43'		EOL ESP-1
5/27/92				21:39:00	32°6.02'	138°0.01'	3962	1-gun 1200 cu in
	6 ESP2-1	45	4	21:53:20				
		64	4	22:00:00	32°7.75'	137°59.97'	3846	
		244	4	23:00:00	32°12.84'	138°0.12'	3884	
	7 ESP2-2	375	4	23:43:20				
5/28/92		424	4	0:00:00	32°17.66'	138°0.05'	3930	
		604	4	1:00:00	32°22.4'	137°59.87'	3931	
	8 ESP2-3	714	4	1:37:00				
		784	4	2:00:00	32°27.24'	137°59.89'	3939	
		866	4	2:27:30	32°29.45'	137°59.91'		EOL ESP-2
		879	4	2:31:50				c/c
		964	4	3:00:00	32°29.61'	137°58.09'	3974	
	9 ESP2-4	1051	4	3:50:00				
		1144	4	4:00:00	32°24.0'	137°57.84'	3961	
			4	5:00:00	32°19.43'	137°55.44'	4024	
	10 Trst 1-2	1392	4	5:23:00				
		1504	4	6:00:00	32°15.79'	137°52.49'	4053	
		1684	4	7:00:00	32°15.92'	137°59.11'	3941	
	11 Trst 1-3	1728	4	7:14:00				
		1774	4	7:30:00	32°15.96'	138°2.14'	3865	COP-1 START
		1864	4	8:00:00	32°15.94'	138°5.24'	3781	
		2044	4	9:00:00	32°15.93'	138°9.72'	3751	
	12 Trst 1-4	2141	4	9:32:20				
		2224	4	10:00:00	32°15.94'	138°14.42'	3787	
	13 Trst 1-5	2406	4	11:00:20	32°15.95'	138°18.7'	3900	MT stop 2411~
	14 COP1-2	2446	4	11:13:50				
		2584	4	12:00:00	32°16.01'	138°23.04'	3678	
		2764	4	13:00:00	32°16.03'	138°28.09'	3507	
	15 COP1-3	2788	4	13:07:00				
		2944	4	14:00:00	32°15.94'	138°32.6'	3294	
		3008	3	14:21:20				change dly
	16 COP1-4	3125	3	15:00:00	32°16.01'	138°37.73'	2865	

		3226	2	15:33:40				change dly
			2	16:00:00	32°15.8'	138°43.72'	1798	
	17 COP1-5	3464	2	16:53:00				
		3484	2	17:00:00	32°15.8'	138°48.66'	1597	
		3664	2	18:00:00	32°16.05'	138°54.05'	1673	
		3715	1	18:16:40				change dly
	18 COP1-6	3804?	1	18:46:00				about
		3844	1	19:00:00	32°16.38'	138°59.86'	1468	
		4021	2	19:58:40				change dly
		4024	2	20:00:00	32°16.00'	139°5.25'	1636	
	19 COP1-7	4157?	2	20:30:00	32°16.04'	139°7.96'	1615	
		4204	2	21:00:00	32°15.98'	139°10.59'	1523	
		4213	1	21:03:00				change dly
		4384	1	22:00:00	32°15.87'	139°15.95'	1358	
		4474	1	22:30:00	32°15.886'	139°18.42'	1298	EOL
	20 COP1-8	4479	1	22:31:00				
		4564	1	23:00:00	32°15.32'	139°20.29'	1270	c/c
5/29/92		4744	1	0:00:00	32°11.30'	139°16.90'		
		4924	1	1:00:00	32°7.34'	139°13.46'	1471	
		5015	2	1:30:00			1532	change dly
		5035	1	1:37:00			1510	change dly
		5105	2	2:00:00	32°3.34'	139°10.34'	1629	change dly
	21 COP1-10	5157	2	2:17:30				
		5210	1	2:35:00				change dly
		5284	2	3:00:00	31°59.19'	139°6.83'	1742	change dly
		5464	2	4:00:00	31°55.08'	139°3.64'	1816	
	22 COP1-11	5498	2	4:11:00				
		5644	2	5:00:00	31°50.98'	139°0.56'	1845	
		5563		5:11:00				MT failure
		0=5730		5:28:40				
	23 ESP3-1	2	2	5:50:40				resume
			2	6:00:00	31°55.25'	138°59.89'	1739	
			1	6:15:40			1494	change dly
		109		6:36:00				MT failure
	24 ESP3-2	110	1	6:55:20				tape dr swtched
		122	2	6:59:20				
			2	7:00:00	32°0.11'	139°0.31'	1755	
			2	8:00:00	32°5.27'	139°0.06'	1999	
	25 ESP3-3	447	2	8:48:00				
			2	9:00:00	32°10.37'	138°59.99'	1912	
		713	1	9:27:20				change dly
			1	10:10:00	32°16.08'	138°59.94'	1486	EOL ESP-3
	26 Trst 4-1	788	1	10:41:40				
	27 Trst 4-2		1	12:33:00				
	28 Trst 4-3	1466	1	14:27:00				
			1	16:00:00	32°23.62'	139°36.38'	1146	
	29 ESP4-1	1949	1	16:30:00	32°22.52'	139°38.00'	1346	
			2	17:55:00				change dly
			2	18:00:00	32°15.30'	139°38.09'	1584	
	30 ESP4-2	2142	2	18:13:00				
			1	19:25:00			1478	change dly
			1	20:00:00	32°5.59'	139°38.13'	1440	
	31 ESP4-3	2487?	1	20:08:00				
	32 ESP4-4	2823	1	22:00:00	31°56.07'	139°38.02'	1280	
	33 ESP4-5	3160	1	23:52:00				
5/30/92			1	0:00:00	31°46.49'	139°37.98'	1086	
			1	0:57:00				EOL c/c
			1	1:00:00	31°41.67'	139°38.04'	1432	
	34 Trst 5-1		1	1:45:20				

		3544	1	2:00:00	31°41.47'	139°44.34'	1460	
	35 Trst5-2	3837	1	3:38:00				
			1	4:00:00	31°44.36'	139°59.36'	1328	
			2	4:13:00			1526	change dly
	36 Trst5-3	4180	2	5:32:00			1864	
			2	6:00:00	31°48.17'	140°13.22'	1956	
	37 Trst 5-4	4518	2	7:24:40				
	end	4574		7:45:00				
	38 Trst 5-5	4575	2	7:49:40				
			2	8:00:00	31°56.46'	140°13.17'	1877	
	39 Trst 5-6	4911	2	9:33:00				
		4966	2	10:00:00	32°3.67'	140°13.05'	1690	
	40 ESP5-1	5252	2	11:35:00				
		5326	1	12:00:00	32°10.80'	140°13.12'		ESP-5
	41 ESP5-2	5588	1	13:28:00				
		5686	1	14:00:00	32°17.01'	140°12.94'	1545	
	42 ESP5-3	5926	1	15:21:20				
			1	15:30:00				no rec 65 shots
		5929	1	15:44:00				resume
			1	16:00:00	32°22.31'	140°12.94'	1719	
		6162	1	17:00:00	32°25.81'	140°12.95'	1606	EOL
				18:13:00				test shots
5/31/92		11	9	3:02:00				1200 cu.in.x2
	tape error			3:04:00	32°23.20'	141°47.96'	7466	ESP-6
	43 ESP6-1	12	9	3:12:20				
		155	9	4:00:00	32°18.17'	141°48.08'	7481	
			8	4:32:40				change dly
	44 ESP6-2	269	8	4:38:00				
		515	8	6:00:00	32°18.96'	141°48.23'	6343	
	45ESP6-3	533	8	6:06:00				
	46ESP6-4	792	8	7:32:20				
		875	8	8:00:00	31°59.35'	141°48.09'	6583	
	47ESP6-5	1055	8	9:00:00	31°54.72'	141°48.01'	6782	
		1234	8	10:00:00	31°50.05'	141°47.18'	6794	
		1244		10:02:00				EOL
5/31/92				18:21:20				START
				18:21:40	33°14.30'	141°4.98'	2793	ESP-7
	48ESP7-1	2		18:31:00				
	49ESP7-2	261	3	19:57:00				
		269	3	20:00:00	33°6.92	141°7.71'	2793	
	50ESP7-3	524	3	21:25:00				
		629	3	22:00:00	32°57.27'	141°11.24'	2940	
		725	4	22:32:00				
	51ESP7-4	784	4	22:51:40				
		922	3	23:31:20				
6/1/92		989	3	0:00:00	32°48.09'	141°14.86'	2712	
	52 ESP7-5	1046	3	0:19:00				
		1276	4	1:36:00				change dly
	53ESP7-6	1305	4	1:45:20				
		1349	4	2:00:00	32°39.19'	141°18.24'	3006	
	54ESP7-7	1567	4	3:12:40				
		1673	4	3:48:00	32°31.00'	141°21.02'	3170	EOL
	55ESP7-8	1826	4	4:39:00				
		1889	4	5:00:00	32°24.77'	141°20.31'	3310	
	56ESP7-9	2090	4	6:07:00				
				8:00:00	32°23.02'	141°9.97'	3186	
		2437		8:04:00				tape stop
	57ESP8-1	2440		8:28:20				
		2448	3	8:31:00	32°27.84'	141°10.03'	2790	ESP-8

	58ESP8-2	2704	3	9:56:00				
		2716	3	10:00:00	32°32.75'	141°9.93'	2618	
	59 ESP8-3	2965	3	11:23:00				
		3076	3	12:00:00	32°42.48'	141°10.10'	2558	
	60ESP8-4	3228		12:50:40				
				12:55:00				EOL
		3256	3	13:00:00	32°47.40'	141°9.98'	2475	
		3274	3	13:06:13				c/c:guns stop
		3293	3	13:30:00				resume
		3303	3	14:00:00	32°46.42'	141°4.79'	2436	
	61ESP8-5	3488	3	14:35:00				
			3	15:23:30	32°45.13'	140°55.40'	2480	c/c:guns stop
		3634	3	15:34:00	32°44.76'	140°54.68'	2487	resume
			3	16:00:00	32°42.90'	140°54.83'	2528	
	62ESP8-7	4009	3	17:39:00				EOL
		4072	3	18:00:00	32°33.82'	140°55.01'	2751	
	63ESP8-8	4342	3	19:30:00	32°27.67'	140°55.08'		
		4376	4	19:41:20			3044	change dly
		4432	4	20:00:00	32°25.40'	140°55.22'	3232	
	64ESP8-9	4532	4	20:33:20				
		4792	4	22:00:00	32°15.69'	140°55.12'	3074	EOL
6/2/92				8:55:00	32°12.02'	139°9.02'	1629	
				9:00:00	32°12.03'	139°9.49'	1597	
	65COP2-1	77	1	9:18:00				
		203	1	10:00:00	32°12.04'	139°15.07'	1391	
	66COP2-2	337	1	10:45:00				
		563	1	12:00:00	32°11.94'	139°26.11'	1570	
	67COP2-3	596	1	12:11:00				
			1	12:28:00				slow down
		859	1	13:39:20				no rewind:ANS,C-6
	68 COP2-4	860	1	13:39:40				
		923	1	14:00:00	32°11.91'	139°36.80'	1552	
	69 COP2-5	1586	1	15:06:40				
	EOT	1123	1	15:16:40				no rewind
	70 COP2-6	1174	1	15:23:40				
			1	16:00:00	32°12.02'	139°48.13'	1593	
	71 COP2-7	1438	1	16:51:00				
		1644	1	18:00:00	32°11.87'	139°59.49'	1372	
	72 COP2-8	1698	1	18:18:00				
		1939	2	19:38:20				
	73 COP 2-9	1960	2	19:45:20				
		2004	2	20:00:00	32°11.97'	140°9.41'	1538	
		2034	2	20:10:00				EOL

4.3 Seismic structure of the Izu-Ogasawara Arc from OBS-explosives/airgun-array refraction experiment

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Introduction

In May 1992, a series of seismic refraction and reflection survey was conducted in the Izu-Ogasawara Arc area, south off Honshu, Japan, at 32° 15'N. The velocity structure of this area was studied by Hotta (1970), but the severe lateral heterogeneity of the area made it difficult to clarify the detailed structure of the deep crust. The objective of the present experiment is to elucidate the entire seismic crustal structure of the island-arc system, including oceanic, fore-arc basin, rift in the island-arc, and back-arc basin crust.

Experiment

During Leg 2 of the *R/V Hakuho Maru* cruise, from June 8 to 26, twenty-six ocean bottom seismometers (OBSs) from three institutions were deployed every 18 km on a 450-km-long line for refraction study of the deep crustal structure (Fig. 1). Three types of OBSs were used. One type of OBS has a digital recording system (Shinohara *et al.*, 1992). Ten digital OBSs were deployed. The second type of OBS is developed for very deep ocean bottom greater than 7000 m (Kanazawa and Kaiho, 1990). Three OBSs for deep ocean bottom were used. Other thirteen OBSs have an analog recording system. Each OBS is equipped with a vertical and one or two horizontal geophones. Twenty-three OBSs were recovered during the cruise after the experiment. Because of an acoustic releaser system trouble, we lost OBS#2A, OBS#5A, and OBS#9A. The positions of the deployed OBSs are listed in Section 2.1.

Seventy-one explosives with charge sizes ranging from 20 to 280 kg (5 tons in total) were fired along the line by *Kaiko Maru-5* as controlled seismic sources. The profile is about 50-km-long on the Pacific plate, and about 240-km-long from a fore-arc basin to a rift - back-arc basin transition zone (Fig. 2). We showed shot time, shot position, and charge size of the explosions (Table 1). We calculated the shot positions using hydrophone signals from shot. The airgun array was also shot for the study of shallow crustal structure (Table 2). An array of airguns, which consisted of two 20-liter and a 17-liter BOLT type airguns, was fired with an interval of 20 s. The ship ran at a speed of about 5 kt (9 km/h) to give shots every 50 m. Signals from the airgun array were recorded by a 24-channel seismic profiling system and an array of ocean bottom seismographs (OBSs).

The explosive shot was positioned by the Global Positioning system (GPS) on the *Kaiko Maru-5*. And the airgun shot and OBS were positioned by the GPS and LORAN-C by the *R/V Hakuho Maru* navigation system.

Data and analysis

All analog OBS records were converted in a digital form with a sampling rate of approximately 100 samples per second after the cruise. The digitized data were edited and processed for analysis. Figure 3 displays an example of a record section of a vertical middle gain component of OBS#15A. The record indicates a phase of about 6 km/s in ranges from 30 to 70 km and about 7 km/s in ranges from 70 km on the eastern side. The record has a clear phase reflected from Conrad. It indicates that there is a distinct contrast in a P-wave velocity above and below Conrad. The record also has a phase reflected from Moho in range from 50 km on the west. The phase refracted from Moho is not clear. The apparent velocity in ranges from 30 km to 70 km changes in western side of record because of a topography of the sea floor. We made the record sections for all OBSs. And we are analyzing the refraction data from explosions by a two-dimensional ray tracing forward modeling.

The crustal structure of the fore-arc area deduced in the Izu-Ogasawara area shows a thick lower crust with P-wave velocities from 7.1 to 7.3 km/s. The total crustal thickness is about 20 km. From the dense airgun shooting data, the upper crustal structure including the sedimentary layer is well resolved.

References

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[3] Kanazawa, T. and Y. Kaiho, Ocean Bottom Seismometer for Deep Sea Observation near Trench Axis, *Prog. Abstr. Seism. Soc. Jpn.*, **1**, 21, 1990 (Japanese).

Table 1 1992 Izu-Ogasawara Explosives Experiment

Shot No. No.	Charge size (kg)	Shot time Mon./Day	Hour:Min.	Second	Shot position Latitude (deg.)	(min.)	Longitude (deg.)	(min.)	Depth (m)
S1	20	6/14	12:18	30.096	32	15.02	142	59.64	5650*
S2	20	6/14	12:53	00.356	32	15.01	142	58.44	5670*
S3	20	6/14	13:19	29.978	32	15.06	142	55.47	5820*
S4	20	6/14	13:36	00.157	32	15.15	142	53.88	5830*
S5	20	6/14	15:21	29.772	32	15.09	142	53.88	5830*
S6	20	6/14	15:35	30.244	32	15.12	142	52.35	5800*
S7	20	6/14	15:48	59.783	32	15.17	142	50.94	5840*
S8	20	6/14	16:02	39.977	32	15.19	142	49.38	6220*
S9	20	6/14	16:16	40.007	32	15.23	142	47.96	6320*
S10	20	6/14	16:30	10.621	32	15.24	142	46.43	6320*
S11	20	6/14	16:45	50.122	32	15.26	142	44.89	5880*
S12	20	6/14	17:00	40.121	32	15.31	142	43.47	5960*
S13	20	6/14	17:14	30.018	32	15.34	142	41.94	6150*
S14	20	6/14	17:28	00.525	32	15.34	142	40.46	6160*
S15	20	6/14	18:26	30.372	32	15.39	142	38.97	6280*
S16	20	6/14	18:41	20.212	32	15.41	142	37.41	6370*
S17	20	6/14	18:55	30.433	32	15.45	142	35.96	6550*
S18	20	6/15	10:01	39.787	32	15.49	142	34.52	6500*
S19	40	6/15	10:29	30.231	32	15.51	142	31.54	7100*
S20	40	6/15	11:10	58.952	32	15.59	142	28.50	7130*
S21	80	6/17	5:00	29.777	32	16.37	141	00.34	3450*
S22	80	6/17	5:24	59.602	32	16.41	140	57.38	3190*
S23	80	6/17	5:48	59.463	32	16.45	140	54.44	3010*
S24	80	6/17	6:12	59.107	32	16.43	140	51.41	2900*
S25	80	6/17	6:34	30.078	32	16.43	140	48.41	2840*
S26	80	6/17	6:54	40.060	32	16.43	140	45.41	2710*
S27	80	6/17	7:23	29.809	32	16.48	140	42.39	2520*
S28	80	6/17	7:42	30.285	32	16.48	140	39.52	2425**
S29	80	6/17	8:02	50.266	32	16.46	140	36.51	2249
S30	80	6/17	8:22	00.302	32	16.46	140	33.55	2132
S31	80	6/17	8:43	00.309	32	16.46	140	30.56	2275
S32	80	6/17	9:03	00.304	32	16.47	140	27.57	2182
S33	80	6/17	9:23	30.308	32	16.48	140	24.62	1828
S34	80	6/17	9:44	20.320	32	16.45	140	21.66	1727
S35	80	6/17	10:07	40.099	32	16.45	140	18.70	1658
S36	80	6/17	10:31	30.201	32	16.44	140	15.75	1585
S37	80	6/17	10:57	20.208	32	16.43	140	12.73	1517
S38	80	6/17	11:22	59.923	32	16.46	140	09.74	1458
S39	80	6/17	11:46	00.176	32	16.44	140	06.75	1402
S40	80	6/17	12:31	29.933	32	16.44	140	03.75	1370
S41	80	6/17	12:54	00.031	32	16.41	140	00.79	1346
S42	80	6/17	13:15	59.832	32	16.37	139	57.76	1354
S43	80	6/17	13:37	29.975	32	16.40	139	54.79	1431
S44	80	6/17	13:58	30.012	32	16.37	139	51.88	1435
S45	80	6/17	14:19	09.936	32	16.35	139	48.85	1541
S46	80	6/17	14:44	19.901	32	16.35	139	45.79	1561

Table 1 1992 Izu-Ogasawara Explosives Experiment (cont)

S47	80	6/17	15:09	30.191	32	16.31	139	42.88	1566
S48	80	6/17	15:30	10.035	32	16.27	139	39.84	1559
S49	80	6/17	15:49	59.800	32	16.26	139	36.78	1482
S50	80	6/17	16:08	49.908	32	16.25	139	33.88	1178
S51	80	6/17	16:27	19.940	32	16.23	139	30.94	1102
S52	80	6/17	16:46	19.863	32	16.23	139	27.96	772
S53	80	6/17	17:04	10.126	32	16.19	139	24.87	1100
S54	80	6/17	17:22	50.140	32	16.16	139	21.96	1195
E1	280	6/17	18:47	59.576	32	16.17	139	19.95	1257
E2	280	6/19	6:23	59.090	32	16.10	139	16.06	1256
S55	80	6/19	6:55	20.125	32	16.10	139	12.89	1379
S56	80	6/19	7:21	29.774	32	16.06	139	10.07	1528
S57	80	6/19	7:48	10.071	32	16.02	139	07.06	1670
S58	80	6/19	8:10	29.954	32	15.99	139	04.11	1589
S59	80	6/19	8:32	30.151	32	15.98	139	01.08	1503
S60	80	6/19	8:53	29.577	32	15.91	138	58.11	1337
S61	80	6/19	9:14	59.899	32	15.88	138	55.17	1529
S62	80	6/19	9:36	20.097	32	15.85	138	52.22	1596
S63	80	6/19	9:57	40.285	32	15.81	138	49.16	1574
S64	80	6/19	10:18	50.016	32	15.78	138	46.14	1703
S65	80	6/19	10:39	00.134	32	15.72	138	43.17	1751
S66	80	6/19	11:05	50.111	32	15.71	138	40.18	2591
S67	80	6/19	11:25	40.214	32	15.64	138	37.23	2927
S68	80	6/19	11:47	00.135	32	15.61	138	34.27	3094
E3	160	6/19	12:11	30.204	32	15.54	138	31.39	3303

* Depth was based on the seabeam data. ** Depth was based on the PDR.
Without an astarisk, we calcurated the depth based on hydrophone signals.

Table 2 1992 Izu-Ogasawara Airgun Shooting (KH 92-2 Leg 2)

Date	Time	Latitude (deg.)	(min.)	Longitude (deg.)	(min.)	(m)	Note
6/14	22:35:00	32	15.06	137	55.66	4033	
6/15	0:00:00	32	15.07	138	2.86	3854	
	2:00:00	32	15.30	138	14.32	3781	
	4:00:00	32	15.46	138	25.69	3606	
	6:00:00	32	15.63	138	37.48	2907	
	7:00:00	32	15.70	138	43.37	1778	End of Line
6/18	16:41:00	32	15.70	138	44.39	1802	
	18:00:00	32	15.87	138	52.66	1600	
	20:00:00	32	16.00	139	4.41	1630	
	22:00:00	32	16.12	139	16.34	1264	
6/19	0:00:00	32	16.26	139	28.53	713	
	2:00:00	32	16.32	139	39.83	1580	
	3:35:00	32	16.35	139	48.84	1551	Gun2 stop
	3:38:20	32	16.37	139	49.16	1524	Gun2 start gun3 stop
	4:00:00	32	16.37	139	51.24	1476	
	4:50:00	32	16.21	139	55.99	1409	Stop for explosion
	5:15:00	32	16.20	139	58.39	1375	Resume
	6:00:00	32	16.34	140	2.57	1379	
	8:00:00	32	16.42	140	13.81	1571	
	9:06:00	32	16.56	140	20.09	1724	Stop
	9:10:40	32	16.57	140	20.54	1735	Resume
	10:00:00	32	16.51	140	25.54	2124	
	12:00:00	32	16.46	140	37.42	2335	
	14:00:00	32	16.51	140	48.62	2813	
	16:00:00	32	16.43	140	59.40	3384	
	18:00:00	32	16.47	141	9.84	3656	
	20:00:00	32	16.40	141	21.56	3865	
	22:00:00	32	16.19	141	33.58	4850	
6/20	0:00:00	32	16.05	141	45.50	5472	
	2:00:00	32	16.03	141	56.92	7155	
	4:00:00	32	15.86	142	8.15	9128	
	6:00:00	32	15.67	142	19.63	8096	
	8:00:00	32	15.54	142	31.10	7186	
	8:24:00	32	15.49	142	33.43	6739	Stop
	8:28:20	32	15.47	142	33.87	6549	Resume
	9:00:00	32	15.43	142	36.87	6503	Stop
	9:08:40	32	15.42	142	37.72	6372	Resume
	9:25:40	32	15.39	142	39.36	6264	Stop
	9:32:20	32	15.41	142	40.03	6213	Resume
	10:00:00	32	15.36	142	42.70	6111	
	10:26:40	32	15.40	142	45.32	5902	Stop
	10:34:40	32	14.35	142	46.18	6240	Resume
	12:00:00	32	15.16	142	54.74	5826	
	12:51:00	32	14.96	143	0.13	5661	End of Line

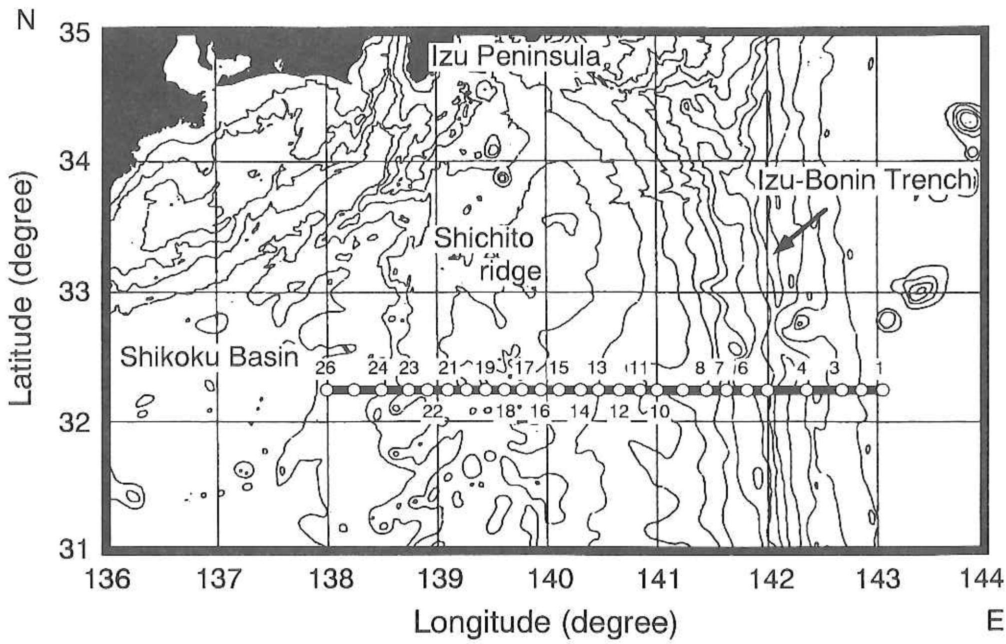

Figure 4-3-1: Position of ocean bottom seismometers (OBS's) (open circles) and the seismic profile.

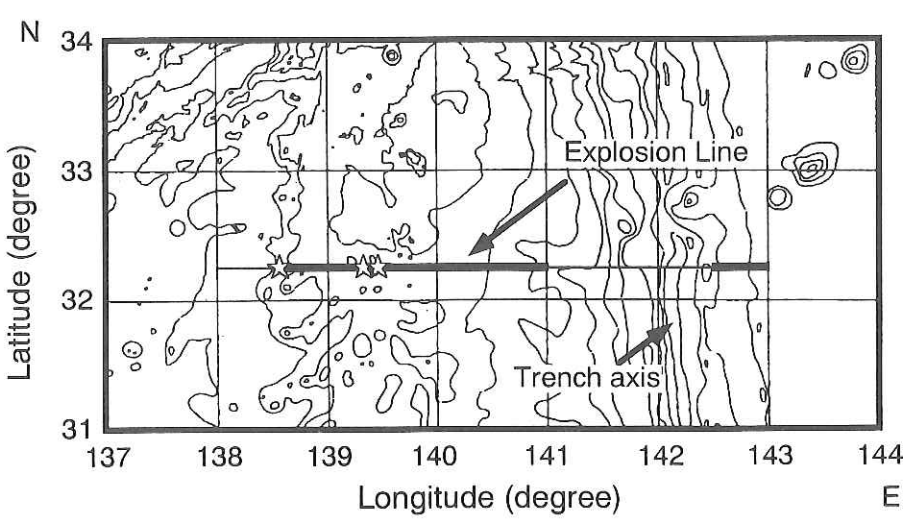

Figure 4-3-2: Explosion profile (bold lines). 5 tons of explosives were shot. Large charge dynamite shots (280 or 160 kg) are indicated by asterisks.

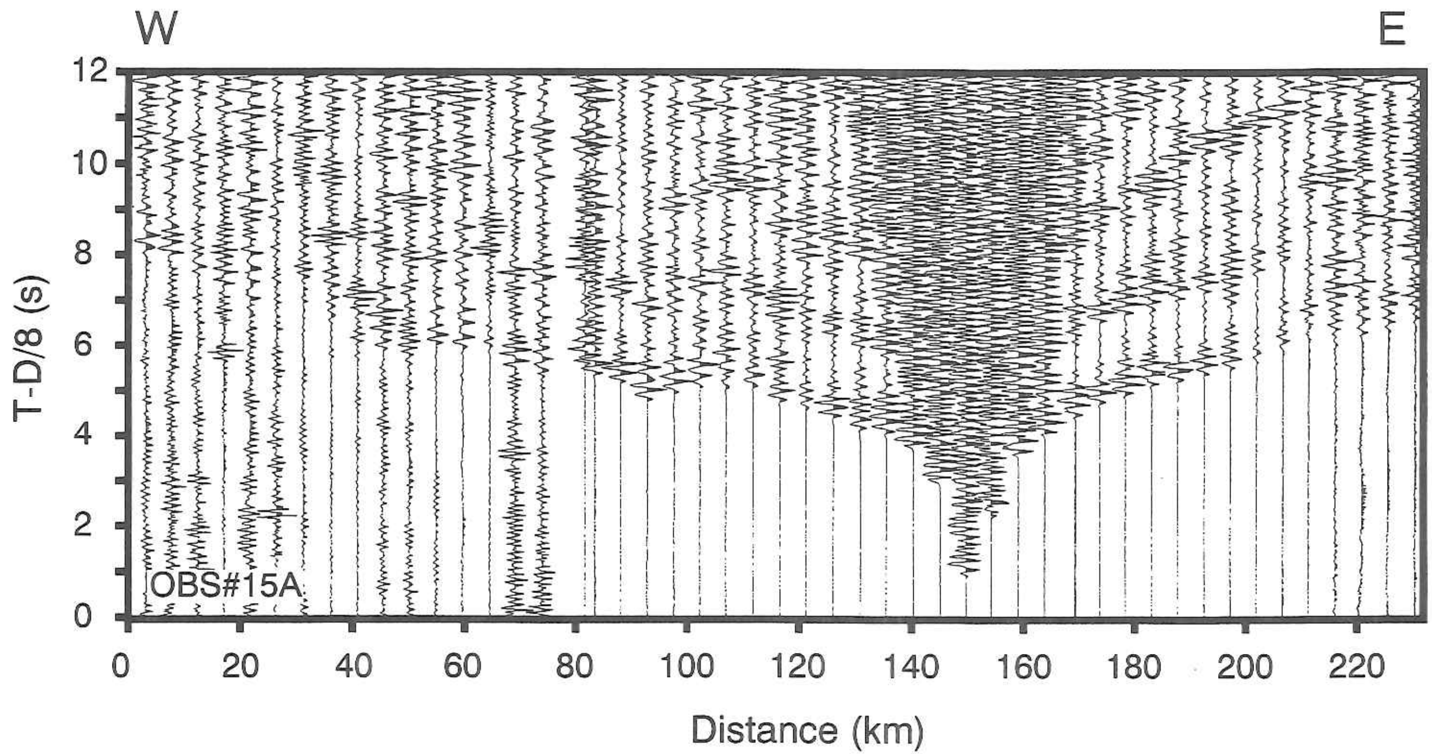

Figure 4-3-3: Record section from OBS #15A data. Horizontal axis is offset from western end of explosion profile. Vertical axis is traveltime reduced at 8 km/s. Each trace is normalized by maximum amplitude.

4.4 Digital recording OBS using portable digital audio tape recorder

M. Shinohara and K. Suyehiro

Introduction

In recent years, ocean bottom seismometers (OBSs) are used to obtained crustal and upper mantle seismic structures and distributions of earthquakes, and we have efficient results. Almost of OBSs used in those experiments have analog recorder. One of advantages which analog recording OBSs have is to be able to record data continuously for more than two weeks. In the other hand, there are some disadvantages of analog OBSs, for example, dynamic range of records is not so large. Therefore, some kinds of digital OBS were developed and used as a test, but no digital OBS uses for seismic experiment as a routine.

We have developed digital recording OBSs, which have the same recording period as analog OBS's, to obtain higher quality data. And we used the new digital OBSs for the first time at KH92-2.

Instrument specifications

1) OBS system

The new digital OBS (ORI-OBS) consists of one pressure vessel, an acoustic release system, a transmitter, and a flasher (Figure 1, Photo 1). The pressure vessel (glass sphere) contains sensors, recorder, and cells. The design of ORI-OBS except a digital recorder is the same as the OBS which was developed at the Geophysical Institute of the University of Tokyo, in cooperation with Laboratory for Ocean Bottom Seismology, Hokkaido University (Yamada, 1980, Kanazawa, 1986). Table 1 shows a summary of the instrument capabilities.

2) Digital recorder using DAT

We use commercial portable digital audio tape (DAT) recorder as data recorder for long period recording, low power, and low cost. Figure 2 shows the block diagram of DAT recorder. Signals from sensors are amplified, and are convert to digital data. The digital data are stored in the S-RAM memory. When the memory is full of data, the stored data are written to DAT through DAT interface. An 8-bit CPU controls these devices. Timing of data is carried out using real-time clock (RTC) controlled by the CPU. Adjustment of the RTC, setup of functions which the recorder has are performed by the other computer from the outside of the pressure vessel through communication port. A pluse with 10 s cycle is output to the outside of the pressure vessel to calibrate the RTC. The data are recorded in 1

M byte (physical record) on DAT. Zero values are written in gaps of physical records. A physical record consists of 256 logical records whose size is 4 K byte. The logical record is comprised of a 80-byte header where some informations are written followed by the 5.02-s data at sampling frequency of 100 Hz from 4 sensors. Figure 3 shows flow of data acquisition program.

3) Reproduction of DAT data

The playback system of DAT tapes consists DAT recorder for playback, VMEbus computer, and EXA-Byte (Figure 4). The EXA-Byte system uses an 8mm video tape as a recording media, and is available on almost kinds of computer. The data on DAT are copied to EXA-Byte tape using the playback system. First, the system search the data within a target time using the time stamp on header of logical record. After finding the data, the system copy the data of 1 block to memory, stop running a DAT tape, and start copying the data to an EXA-Byte tape. When the system completes copying the data to the EXA-Byte tape, the system starts running the DAT tape, and starts copying the data again. A file on EXA-Byte tape consists of the data of 1 block on DAT tape.

The data on EXA-Byte tape are copied to the disk of SUN Sparc 2 work station (Figure 4). After the data processing, we obtain digital record section for OBSs.

Concluding Remarks

We have developed the digital recording OBS using DAT recorder. The digital OBS has continuous recording period of 12 days and 16 bit dynamic range. We used the digital OBS at first time in KH92-2, and obtained the good data of earthquakes, airguns, and explosions. In 1992, the total number of 34 OBSs were deployed in seismic experiments. At end of 1992, we have 9 digital OBSs.

Although the digital OBS still has a few troubles of instrumentation, we will fix the troubles, and will uses the OBS in seismic experiment in future.

References

[1] T. Kanazawa, Seven-component low-power acoustic release ocean bottom seismograph, Annu. Meet. Seismol. Soc. Jpn. Abstr., 2, 240, 1986 (Abstract, in Japanese)

[2] T. Yamada,Spatial distribution of microearthquakes and crust in the subduction area revealed by ocean seismographic observations [Ph. D. dissert.], Univ. Tokyo, 1980 (in Japanese)

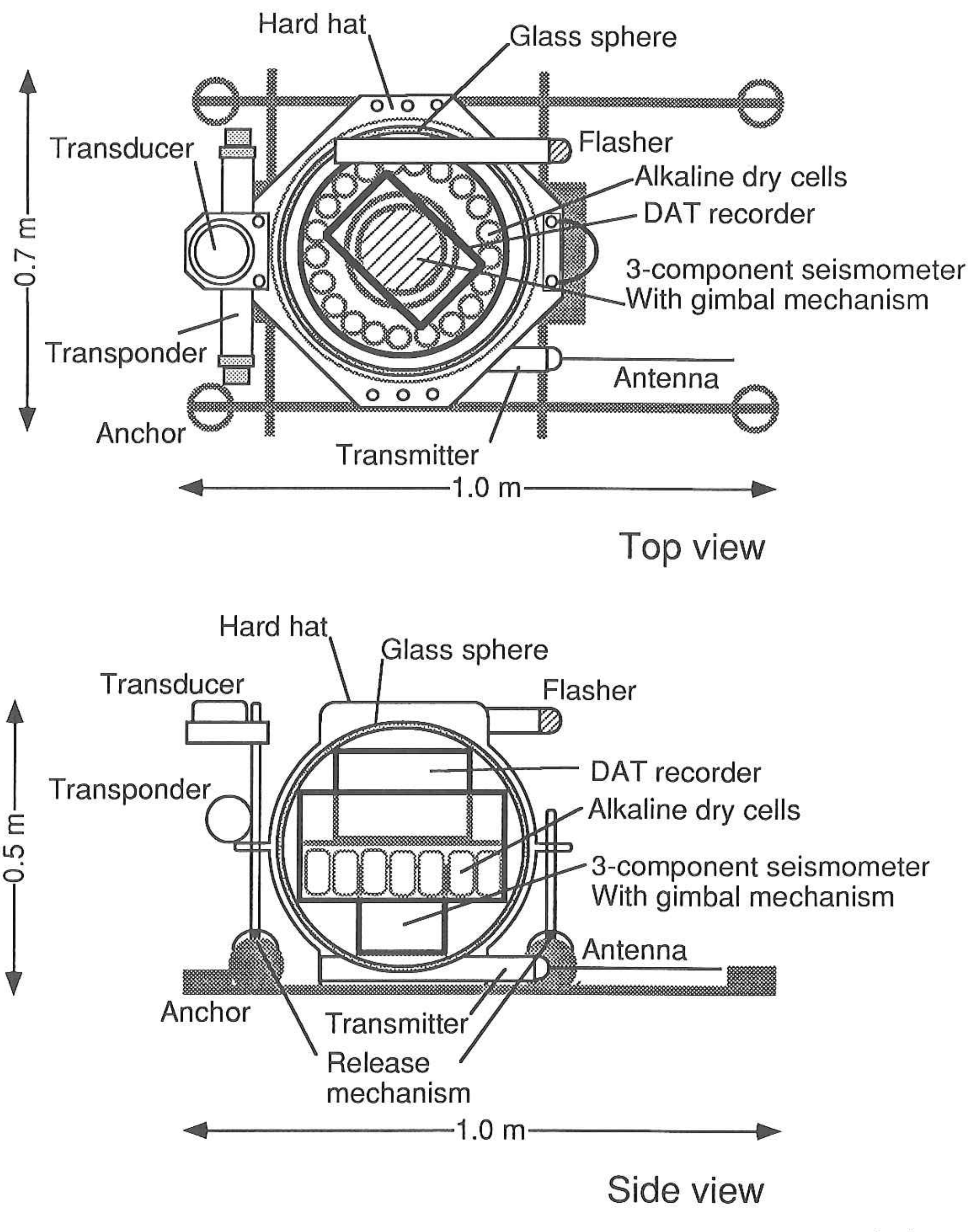

Figure 4-4-1: Layout of ORI-OBS at deployment. The design of ORI-OBS except recorder is the same as the University of Tokyo and Hakkaido university type OBS. All equipments in one glass sphere plus an acoustic release system, a transmitter, and a flasher.

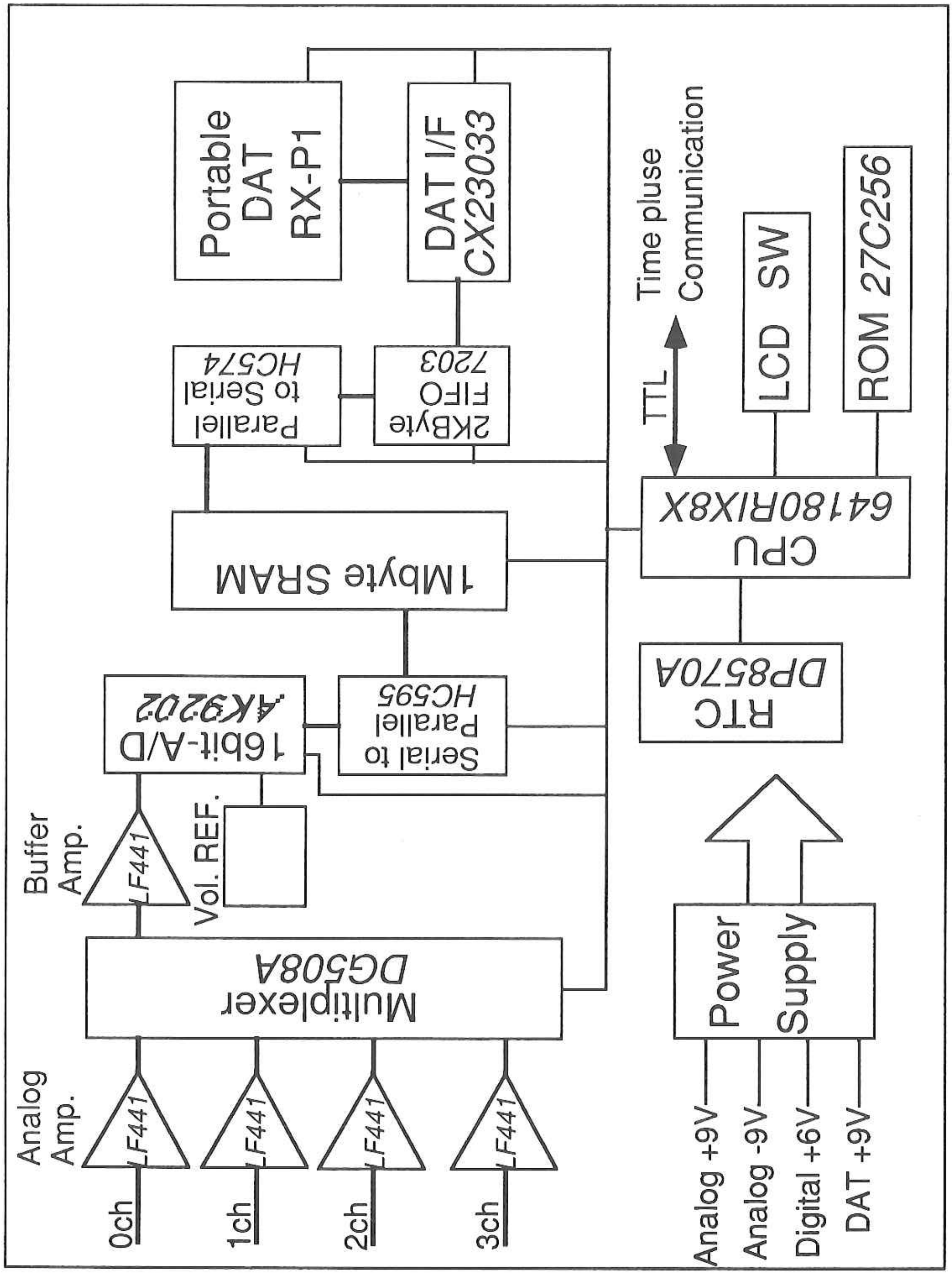

Figure 4-4-2: Block diagram of DAT recorder. The system is controlled by an 8-bit CPU.

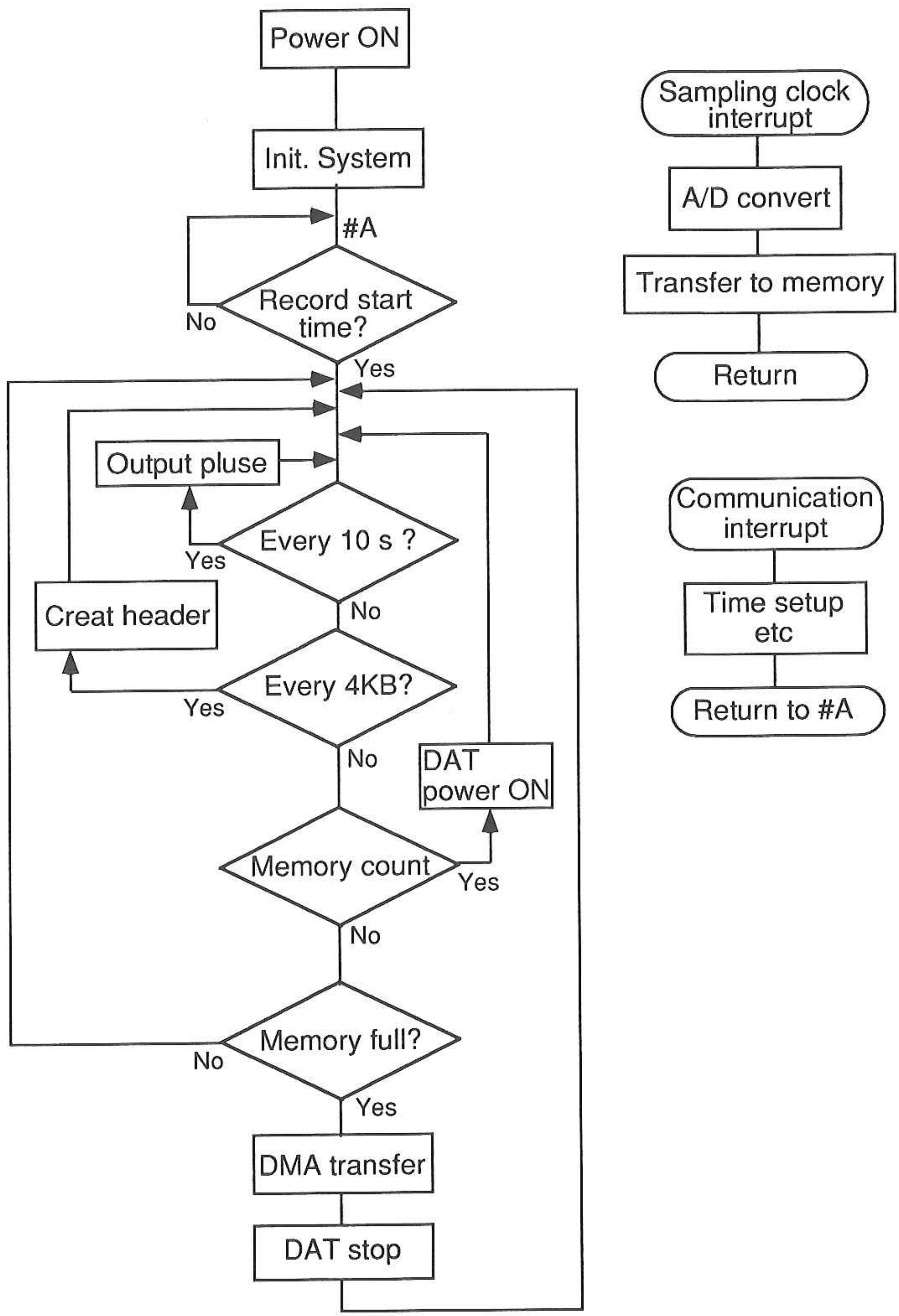

Figure 4-4-3:Flow of data acquisition program. Timing of A/D conversion is controlled by real-time clock using interrupt process.

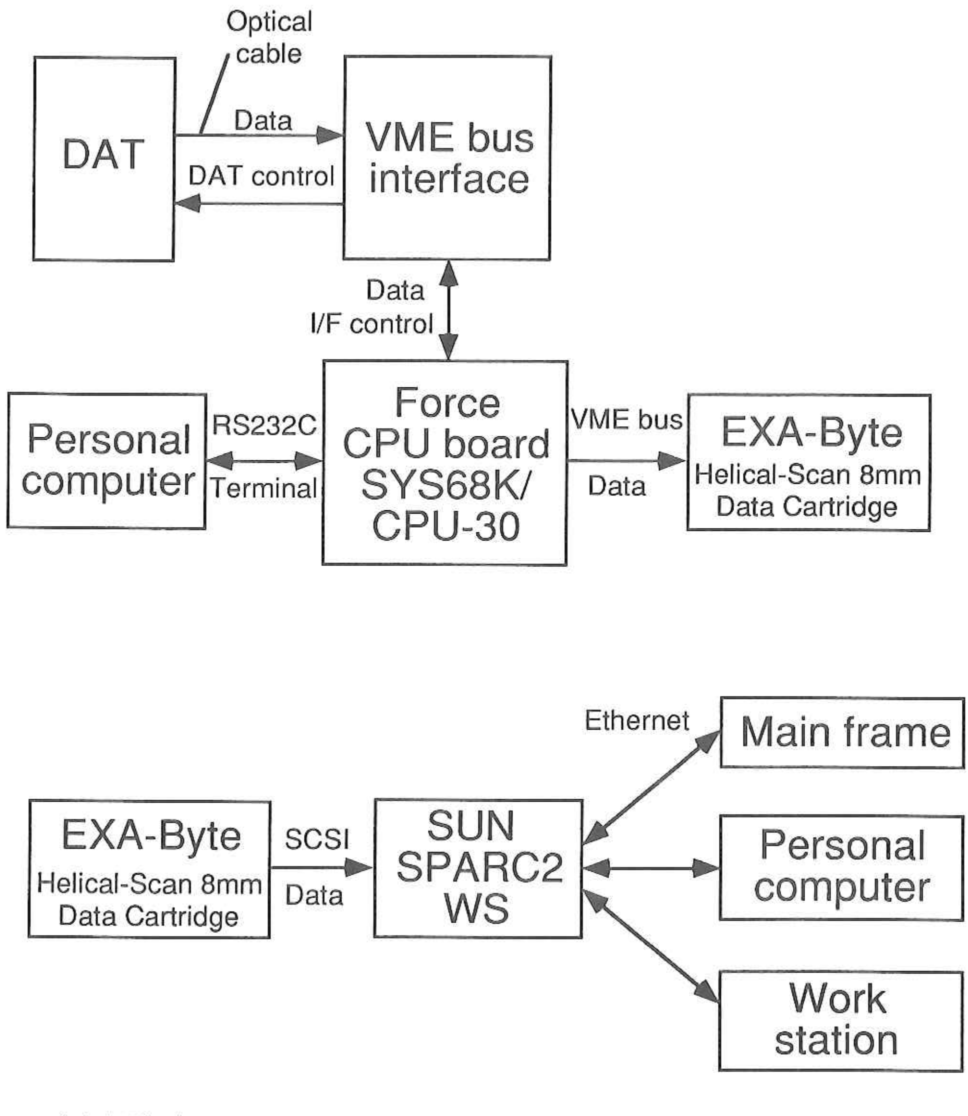

Figure 4-4-4: Block diagram of playback system. The data on DAT are copied to EXA-Byte (8 mm video) tape. EXA-Byte data-storage system is widely used at almost kinds of computer.

Table 1. Summary of instrument specifications of ORI-OBS.

Digital OBS using DAT recorder

Low power, low cost digital recording OBS using commercial portable DAT (Digital Audio Tape) recorder.

All equipments in one pressure vessel plus an acoustic release system, a transmitter, and a flasher.

• Sensor	3-component seismometer (4.5Hz) with gimbal mechanism
• Recorder	DAT recorder 8 bit CPU, 1MB RAM
A/D resolution	16bit
Recording period	12 days (100 Hz sampling, 4 ch, continuous recording)
Recording capacity	1GB
XO stability	$\pm 5*10^{-7}$
• Power supply	32 alkaline dry cells (AM1)
• Pressure vessel	17 inch glass sphere (BENTHOS)
• Release mechanism	Electric corrosion by acoustic commands
• Weight	80 kg at deployment, 40 kg at recovery
• Size	1.0 m(L) 0.7m (W) 0.5m (H) at deployment

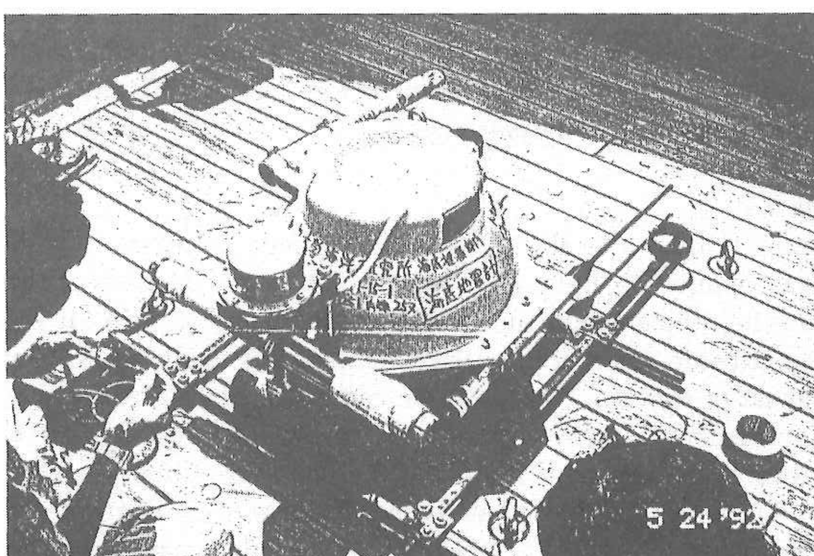

Photo 4-4-1: One of the ORI-OBS is being checked just before a deployment on *R/V Hakuho Maru.*

4.5 *In-situ* determination of OBS orientation by a small compass

Y. Kaiho and K. Suyehiro

Introduction

A mutually orthogonal tri-axis configuration of single-component seismic sensors are necessary to describe the three dimensional ground motion. The orientation of an ocean bottom seismograph (OBS) is usually not controlled because in most cases it is deployed from a vessel to freely descend through water and to rest on the seafloor. The three-component sensors are usually supported by gimbal mechanism so that the vertical and horizontal directions are automatically adjusted. However, it requires an independent measurement to obtain the orientation of horizontal sensors relative to say north.

We have developed a small and simple device to measure the orientation of an OBS. The OBS we use is compact in size, namely, the sensors, recorder, clock, and batteries are housed in a single 17" glass sphere. Also, many OBS's undergo multi-deployment in a single cruise. So, any device to measure orientation must be small, light and simple.

Previous attempts to measure orientation of horizontal sensors include circle shooting of a controlled source (Duennebier, 1987; Kanazawa *et al.*, 1992) or an inclusion of a measuring device (Nishizawa and Nakao, 1986). Our type may be considered an improvement over the device developed by Nishizawa and Nakao (1986). A circle shooting of an airgun is time consuming particularly when many OBS's are deployed and the effect of the local crustal structure must be accounted for. We describe in this paper our device and the results of measurements.

Principle

Figure 1 illustrates the device. A magnetic compass is installed in a small case opaque to light to always point in north-south direction. The compass is held by a needle and a tube made of acrylic resin. It will not part even when upside down and measurements can be made up to 25 degrees of tilt. A sheet of film for Polaroid-type camera is placed below the compass. Upon deployment, a timer is pre-set to operate at a certain time to light an LED placed at the center of the lid of the box once while the OBS is on the seafloor. Thus, an LED is used as the light source to photograph the compass needle direction. The film is developed and printed manually after retrieval by passing the film together with the printing sheet through a roller taken out of a Polaroid-type camera. Care must be taken to shut off light. The case can be attached at the top of the glass housing, which is most distant from the seismic sensor.

Calibration of system

We measured the effect of magnetic noise from OBS system. Calibration test was done by using the whole OBS system on under half grass sphere and hard hat. OBS system direction was rotated 360° to measure the perturbation by the magnetic field. The test was done for two cases with the iron anchor set and without anchor. The calibration test was dône on the asphalt covered outdoor field. We used the marker lines of north to south and east to west which were detected from natural magnetic field. The magnetic field of compass position, a top of OBS was measured by a clinocompass (Fig. 2).

The magnetic perturbation caused by the OBS system in glass housing is about a few degrees. The perturbation pattern includes a is 1q sine component and an asymmetric component. It was found that the effect of the anchor is not negligible. The noise from the anchor is random, but the range of total perturbation value is almost the same as the value for OBS system wihout anchor. The range of perturbation value is less than $\pm$10°.

Results of measurements on KH 92-2

Four OBS's with digital recorders were equipped with the photograph kits. They were deployed in Aogashima rift zone in the northern Ogasawara Arc system. Their coordinates are given in Table 1. Two horizontal sensors, H-1 and H-2, are housed at the bottom of the lower glass hemisphere such that H-1 is orthogonal to the direction of the arrow for correct mating of the two hemispheres. The polarities of the sensors were checked before the deployment. All H-1 and H-2 components gave positive outputs for motions in 270° and 0° azimuth relative to the arrow direction, respectively.

All the OBS's were successfully recovered and the film development was made aboard the R/V Hakuho-maru on Jun 11 morning in the dark room. By accident, the film from OBS#14 was not developed correctly. The other three films were developed and clear images were printed.

The printed image includes the compass needle, identification number, and an oriented circle (Fig. 3). The N-S polarity can be determined from the assymetric shape of the compass needle.

Conclusions

A simple device to measure the orientation of horizontal seismic sensors for OBS's was developed. A small opaque case houses a compass needle, a light source controlled by an external timer, and a sheet of film for Polaroid-type camera. At a predetermined time, the light source, which is a small LED, lights to expose the film. Upon retrieval the film is developed instantly.

This method can detect the orientation of sensors in the range of ±10°. This system require no ship time, no extra glass shere and no special instruments and laboratory in resarch vessel.

References

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[2] T. Kanazawa, K. Suyehiro, N. Hirata, and M. Shinohara, Performance of the ocean broadband downhole seismometer at Site 794, Proc. ODP Sci. Repts., 127/128 Pt. 2, 1157-1171, 1992.

[3] A. Nishizawa and S. Nakao, A new apparatus for azimuth determination of ocean bottom seismograph, Preliminary Rept. of the Hakuho Maru Cruise KH86-5, 187-189, 1988.

Table 1. OBS Parameters

	Latitude	Longitude	Depth	Period
OBS#14	32° 15.81'N	139° 37.89'E	1559	May-24~Jun-10
OBS#15	32° 11.90'N	139° 44.07'E	1575	May-24~Jun-10
OBS#16	32° 11.94'N	139° 37.99'E	1598	May-24~Jun-10
OBS#17	32° 12.04'N	139° 31.98'E	1263	May-24~Jun-10

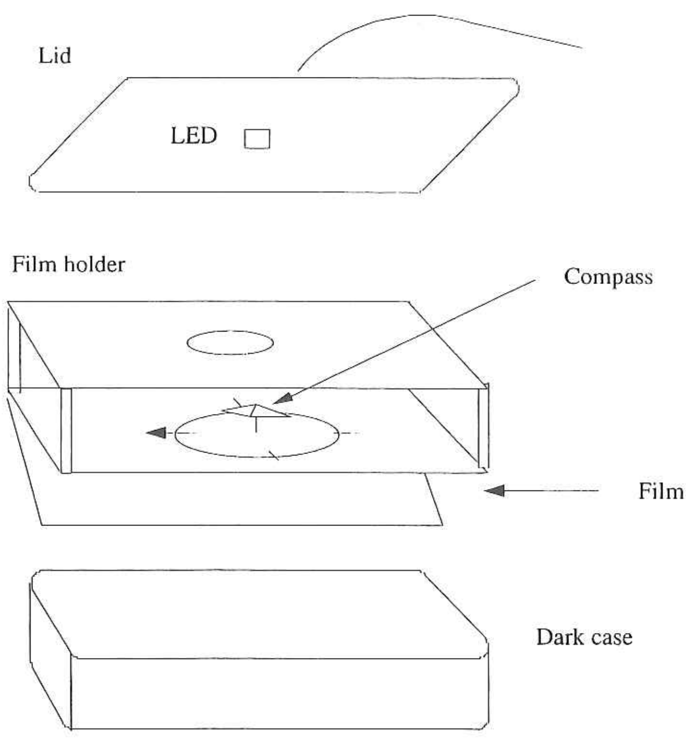


Figure 4-5-1: Illustration of timed record-once azimuth "camera". LED is activated at a pre-set time.

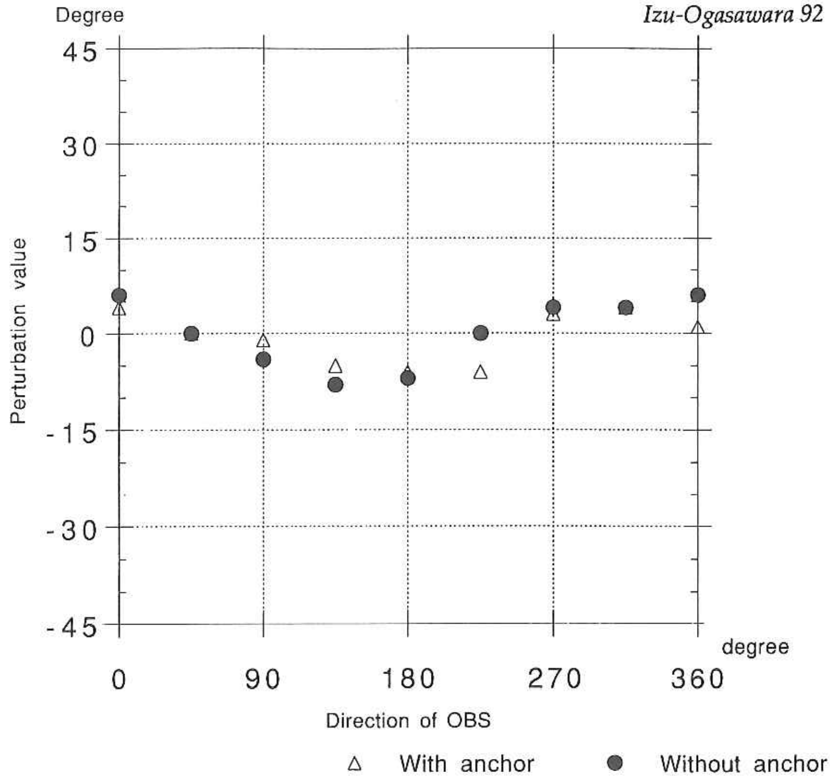
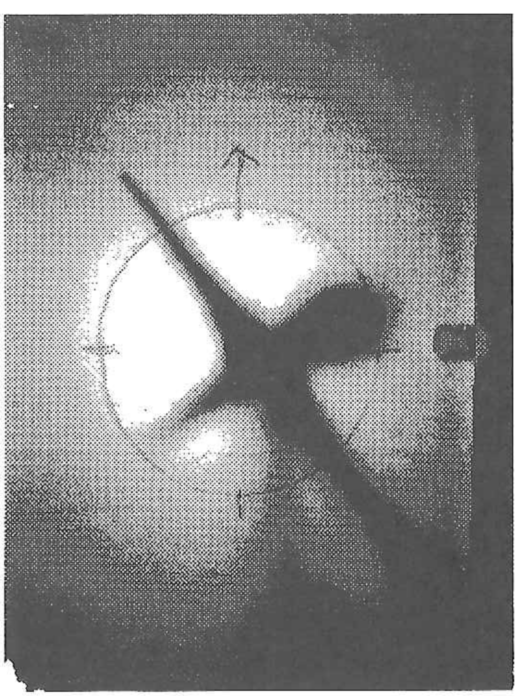


Figure 4-5-2: Magnetic perturbation caused by OBS. Deflections from true magnetic directions are plotted.



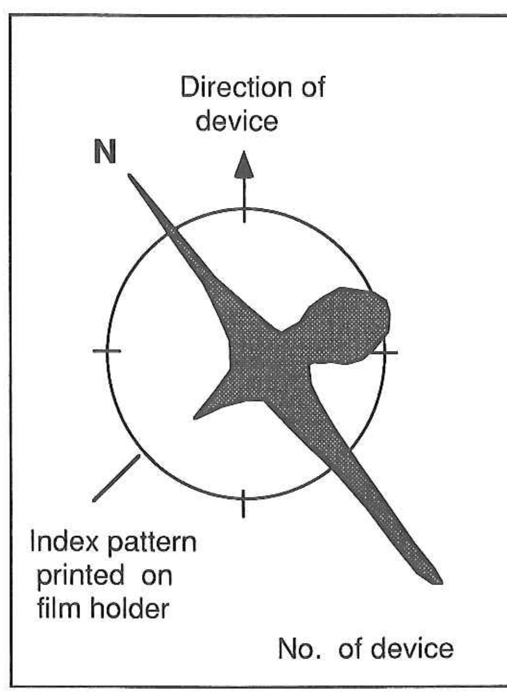


Figure 4-5-3: Actual printed image of compass needle (Left) and its interpretation (Right)

5. BATHYMETRY

5.1 KH92-2 Izu-Ogasawara Arc Sea Beam investigations

A. Klaus, T. Fujiwara, K. Sayanagi, K. Suyehiro, M. Shinohara, K. Fujioka, H. Tokuyama, A. Taira, and F. Yamamoto

Cruise KH92-2 of the Hakuho Maru is part of our continuing studies aimed at determining the origin and evolution of of the Izu-Bonin arc-trench system. We conducted continuous Sea beam mapping during the entire cruise to constrain the surface morphology in support of the primary seismic objectives of this three-ship seismic experiment. Due to cruise logistics, we were also able map two regions across the plate boundary at the Izu-Bonin Trench and a region along the western margin of the arc-trench system on the edge of the Shikoku Basin (Figures. 1, 2, 3, 4). Three-dimensional perspective views of various parts of the trench survey areas are shown in Figures 5, 6, & 7.

Our first two surveys (Figures 2, 3) were aimed at investigating active plate boundary processes, including the formation of serpentinite diapirs, accretion versus tectonic erosion at the toe of the slope, dismemberment and subduction/accretion of seamounts, faulting in the subducting plate due to bending induced extension as the plate subducts.

The first survey (Figure 2), a site survey for Japan Marine Science and Technology Center (JAMSTEC) Shinkai 6500 submersible studies, was conducted near 31°N. This survey covers the inner trench slope, the Torishima Serpentinite Seamount, across the trench axis more than 90 km onto the subducting Pacific Plate. A series of seamounts form a terrace along the Izu-Bonin inner trench slope. At Torishima Seamount, dredging, Ocean Drilling (ODP sites 783,784), and submersible observations (Figure 8) reveal that these seamounts are serpentinite diapirs. An interpretation of the Torishima serpentinite Seamount survey area is shown in Figure 9. Fault offsets forming the horst and grabens on the subducting plate become larger toward the trench form in response to bending induced upper plate extension. The zig-zag pattern of faults show an average trend of N15°W (Figure 10). In contrast to interpretations in the Japan Trench, these faults appear to have no relation whatsoever to the preexisting plate structures which trend ~N45°E in this area.

To the north (~32°40'N), the Aoga Shima Serpentinite and Mogi subducting seamounts survey several features similar to the Torishima survey area including a lower slope serpentinite diapir and a series of horst and grabens forming on the subducting plate (Figures 3, 7, 9). In this area, however, Mogi Seamount is presently being brought into contact with the toe of the slope. The faults forming the horst and graben structures are cutting through and dismembering Mogi Seamount into very thin horsts (Figures 3, 7). Aoga Shima Serpentinite Seamount exhibits a distinct NW-SE elongation (Figures 3) suggesting some type of structural control of serpentinite emplacement. Several much smaller features lower on the slope may also be serpentinite diapirs.

The third survey area covers about 10 seamounts from cross-arc volcanic seamount chains that extend from the edge of the Shikoku Basin to at least the western edge of the active backarc rift basins. Cross-chains are a common feature in many arcs, including the Mariana, Japan, Middle America arcs. They are, however, best developed in the Izu-Bonin Arc where they extend in clearly defined chains for more than 100km (Figure 1). Previous studies the in Izu-Bonin Arc identified the existence of these chains, but recently collected detailed and comprehensive swath-mapping Izanagi Sidescan Sonar (R/V Asia Maru, 1991) and this KH92-2 Hakuho-Maru Sea beam data provides a new view of these enigmatic seamount chains. The region in which the cross-arc seamount chains are present has been termed the Nishi-Shichito Ridge. The Nishi-Shichito Ridge, however, rather than an elongate ridge is considerably more complex than this term suggests (see Fig. 1).

North of 29°-30°N, the backarc is dominated by a series ENE-trending cross-arc seamount chains (Fig. 1). These cross-chains extend westward from western margins of the active backarc rift basins to the edge of the Shikoku Basin. The most prominent cross-chains are Kanei, Manzi, Enpo, and Genroku are spaced at approximately 35-50 km apart. Further to the north, Zenisu Ridge, another large seamount cross-chain, has the added complexity of being the site of recently initiated northward underthrusting.

The seamounts exhibit a wide variety of morphologies from extremely conical, uneroded (young; e.g., Nishi Zyoko Seamount) to eroded, structurally complicated (older; e.g., Kanbun or Nishi Zyoo Seamounts). This suggests that the seamounts may span a variety of ages and there may not be a simple progressive along chain trend in ages. The seamount ages can be constrained by being (1) younger than large inferred early Oligocene extensional structures in the backarc that the seamount chains are built on top of, (2) younger than the earliest Shikoku Basin seafloor crustal accretion (25Ma; Chamot-Rooke, 1989) since the westernmost seamounts may be partially built on the oldest Shikoku Basin oceanic crust, (3) older (at least initially) than the present active rift basins (~1 to 2.Ma) since the seamount chains do not appear to continue across the presently extending rifts There are, however, large volcanic edifices adjacent to and west of the arc volcanoes that segment the rift basins along strike. In some cases, these intra-rift volcanic edifices could be interpreted as the continuation of the seamount chains.

This, therefore, would suggest an age somewhere between 25 and ~2 Ma. The westernmost seamounts probably first started forming earlier (~20-15 Ma) based on undeformed onlap of seismic reflectors. The uneroded surface morphology of some seamount however, suggests that they are quite recent constructs, especially Nishi Zyokyo, Zyoko, and Tenna Seamounts (Figure 4). In fact, age dates for a seamount just to the east of Kanbun Seamount, in the Manzi Seamount chain, yielded an age of 2.2 Ma. Ages of 2.9 and 3.3 have been obtained for the considerably more structurally complex Zenisu Ridge seamount chain to the north near 33°30'N, 138°00'E.

Three-dimensional perspective images of Nishi-Zyoo and Kanbun seamounts (Figure 11) were produced using KH92-2 Hakuho Maru Sea Beam as the digital terrain model and Izanagi sidescan sonar imagery. These images reveal a complex pattern of seamount reflectivity. A large low reflectivity region draped over the western side of Nishi Zyoo and the clearly defined NW structural trend (fault?; Figure 4) suggests a slightly older history for this seamount.

The origin of the seamount remains uncertain. One hypothesis was that they were erupted along extensions of Shikoku basin fracture zones. This is only possibly true for the westernmost seamount in each chain. For example, the topographic high extending to the west of Nishi Zyoo Seamount (Figure 4) may be a Shikoku Basin fracture zone and partially influenced the location of the initial intrusion of this seamount.

Another hypothesis is that there is a relative movement of a magma source relative to the overlying arc crust, similar to a hot spot trace on oceanic crust. The seamount chains do appear to be continuous chains that extend at least to the active backarc rift basins and in one case (Enpo) may connect to presently active arc volcanic front. Furthermore, the spacing between seamount chains is quite similar to that of the frontal arc volcanos. This hypothesis is easily tested since it assumes an along strike age progression within each seamount chain. Presently, however, insufficient data exists to test this hypothesis. Finally, volcanic activity may be contemporaneous along entire seamount chains and that some as yet undefined crustal structure is controlling the chain-like pattern of intrusions.

In summary, there are two plausible hypothesis regarding the cross-arc volcanic seamount chains that can be tested. **Hypothesis 1**-The Izu-Bonin backarc seamount chains represent the relative movement of a magma source relative to the overlying island arc "plate" crust. This implies consistent age progression along each individual seamount chain. **Hypothesis 2**-The Izu-Bonin backarc seamount chains have been erupted along a structural weaknesses in the arc crust. This would imply no consistent age progression along each individual seamount chain.

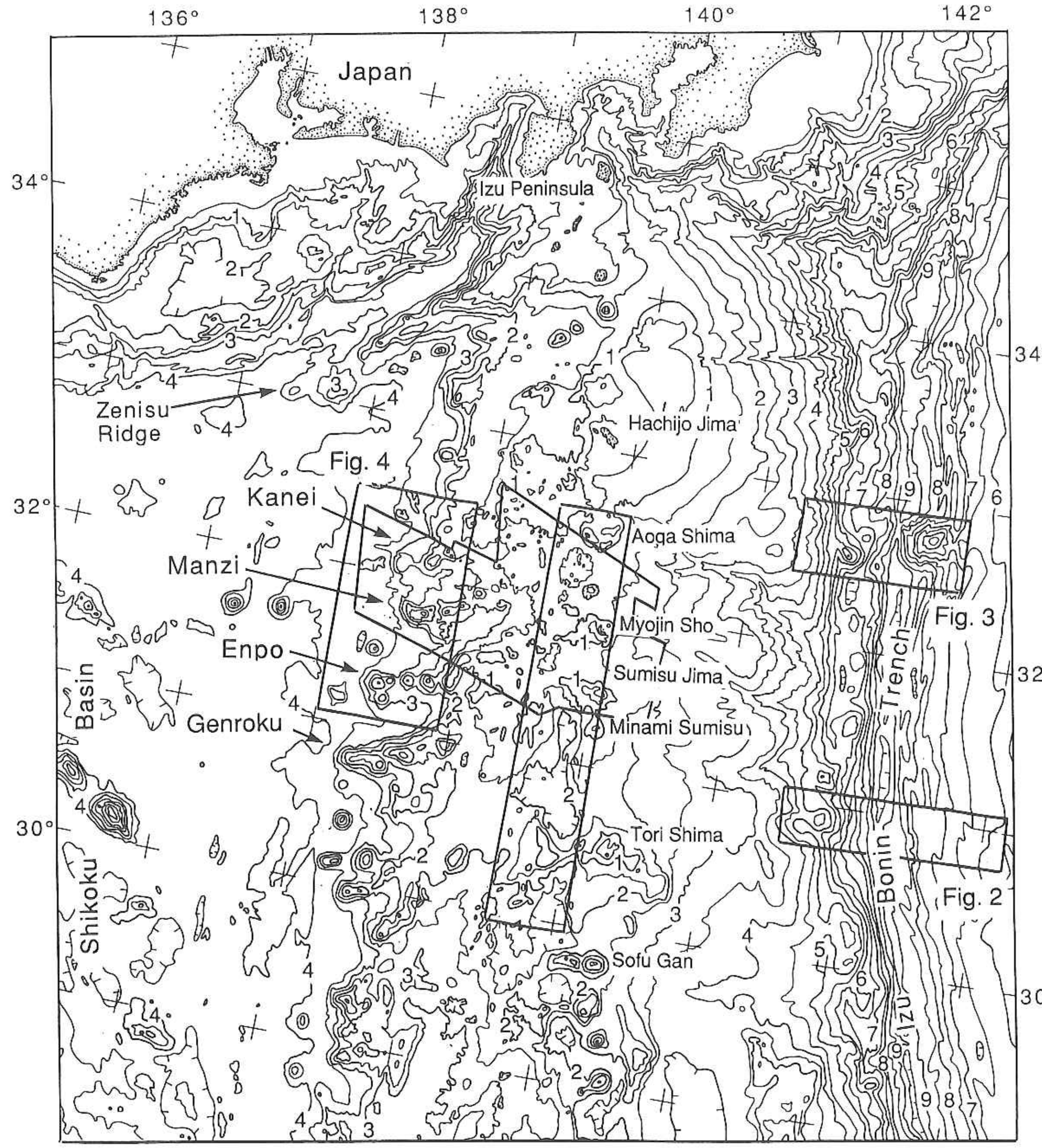


Figure 5-1-1: Sea Beam survey areas collected during Hakuho Maru cruise KH92-2, legs 1 and 2. The labelled boxes locate the areas shown in Figures 2 (Torishima serpentinite seamount),3 (Aoga Shima serpentinite and Mogi seamounts), 4 (backarc cross-arc volcanic seamount chains). The unlabeled boxes show the location of (1) Izu-Bonin backarc rift system Sea Beam coverage, and (2) 1991 Izanagi sidescan sonar survey of the central Izu-Bonin arc-trench system; sidescan sonar data and Hakuho Maru Sea Beam data are combined to produce the three-dimensional images in Figure 5-1-11.

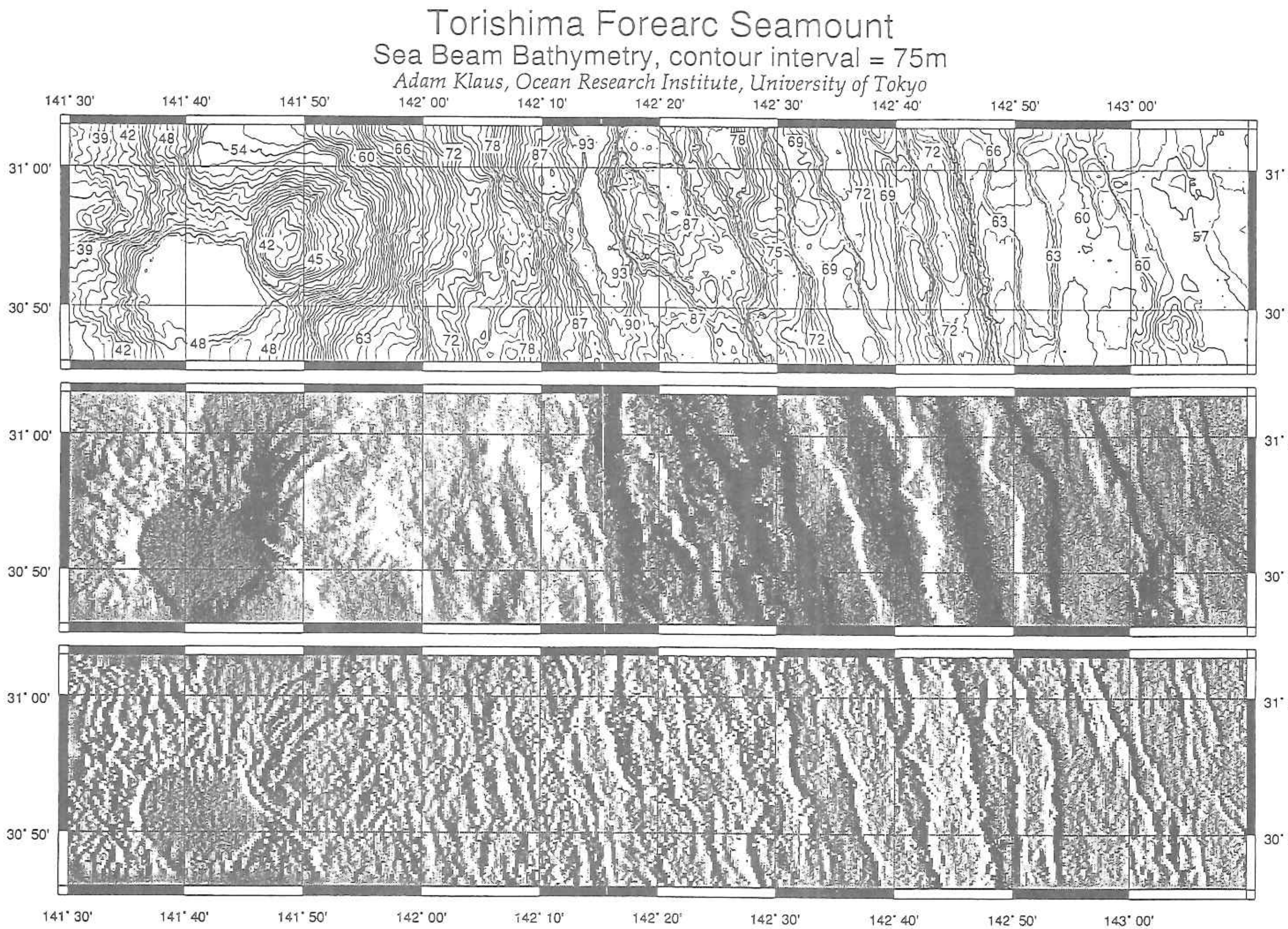


Figure 5-1-2: Sea Beam bathymetry (top), shaded-relief (middle), and "edge map" (bottom) for the Torishima serpentinite seamount, Izu-Bonin trench and subducting Pacific plate survey area. The survey location is shown in Figure 5-1-1. The contour interval is 75m and labelled in hundreds of meters. The shaded-relief map is illuminated from the east.

Adam Klaus, Ocean Research Institute, University of Tokyo

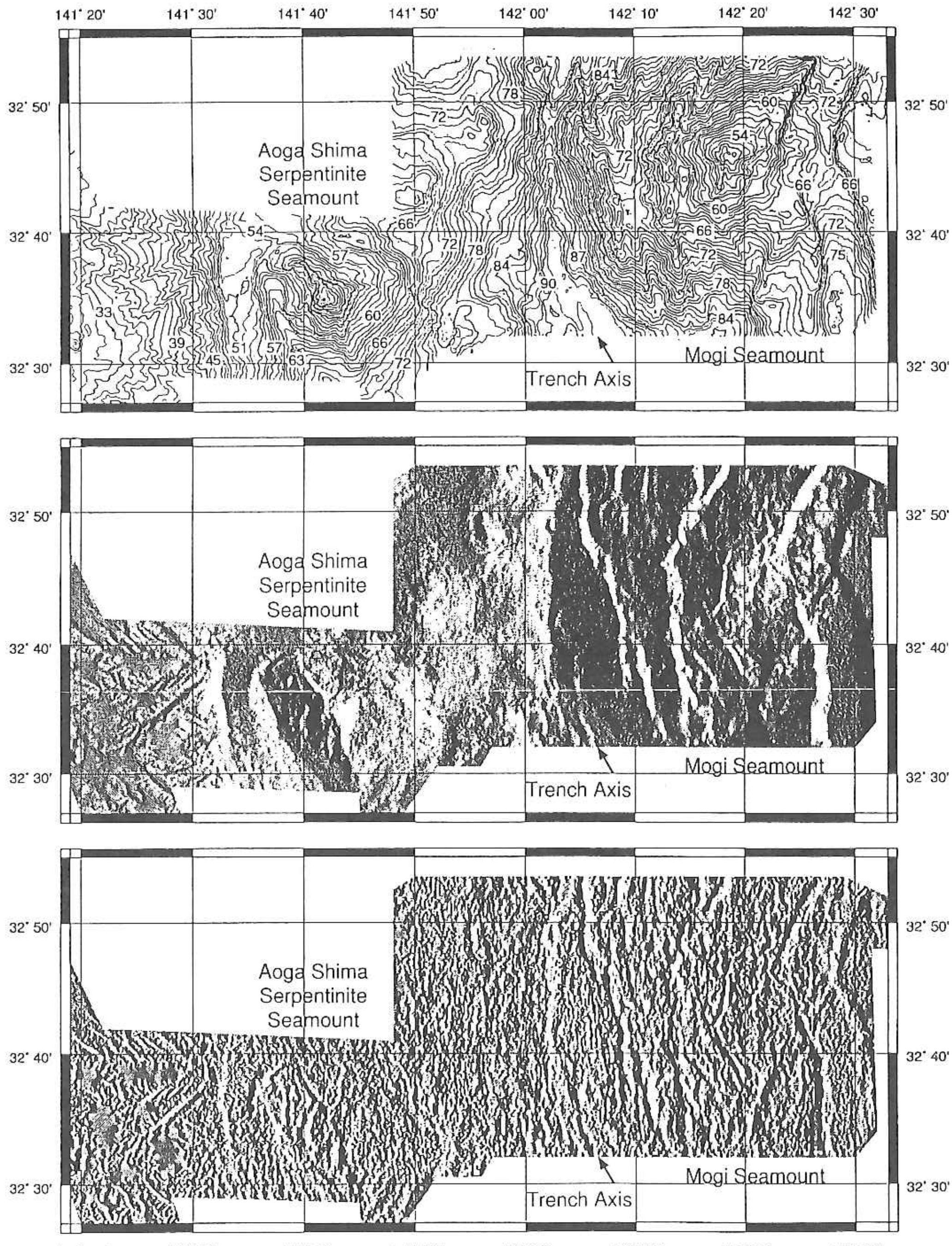


Figure 5-1-3: Sea Beam bathymetry (top), shaded-relief (middle), and "edge map" (bottom) for the Aoga Shima serpentinite and Mogi subducting seamounts survey area. The survey location is shown in Figure 5-1-1. The contour interval is 75m. The shaded-relief map is illuminated from the east.

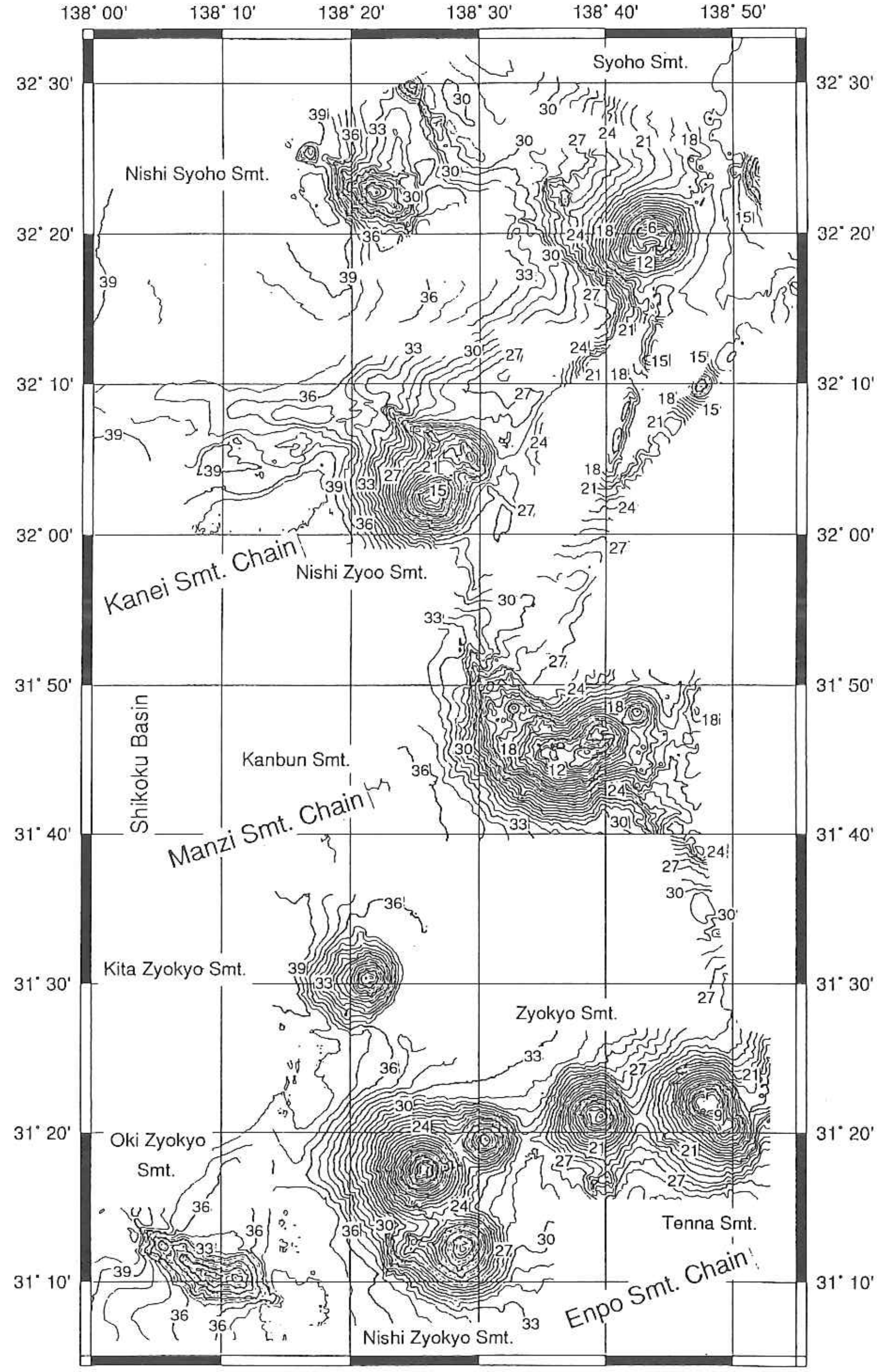


Figure 5-1-4: Sea Beam bathymetric map of the backarc cross-arc volcanic seamount chains survey area. The survey location is shown in Figure 5-1-1. The contour interval is 100m and labelled in hundreds of meters. Sea Beam bathymetry of Nishi Zyoo and Kanbun seamounts is used for the digital terrain model to produce the three-dimensional sidescan sonar data show,n in Figure 5-1-11.

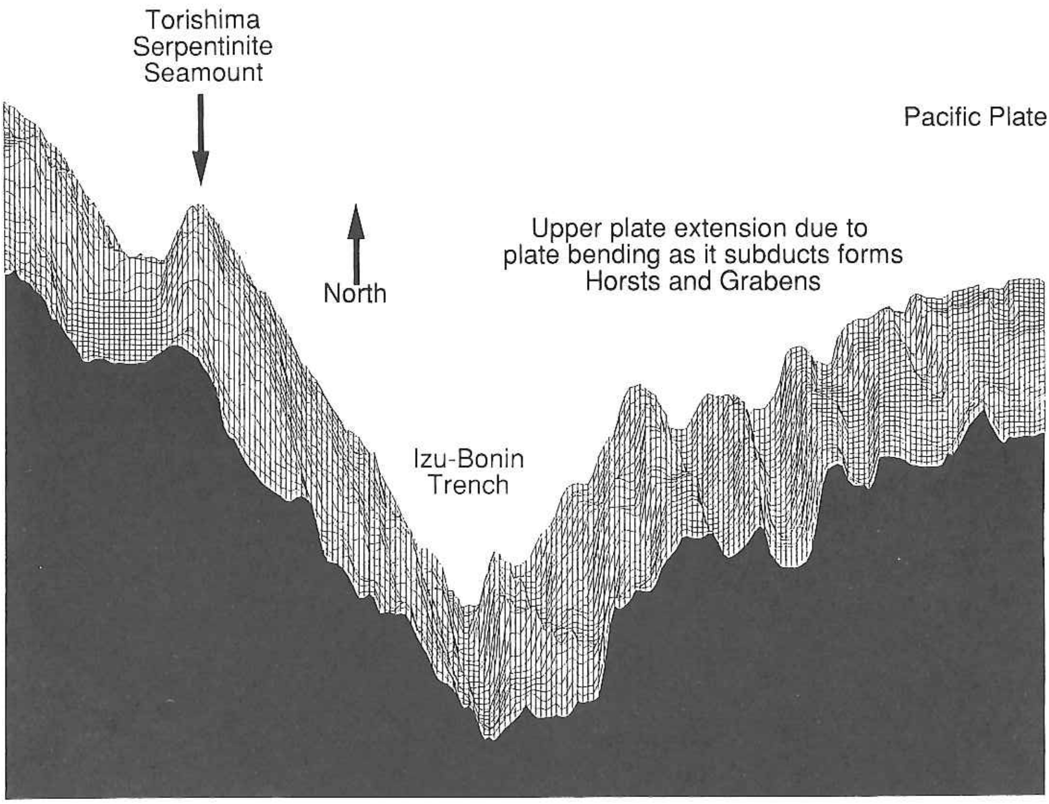


Figure 5-1-5: Whales-eye view (45° elevation, N0°W) of the Torishima serpentinite seamount survey area. Area displayed is the same as shown in Figures 5-1-1 and -2).

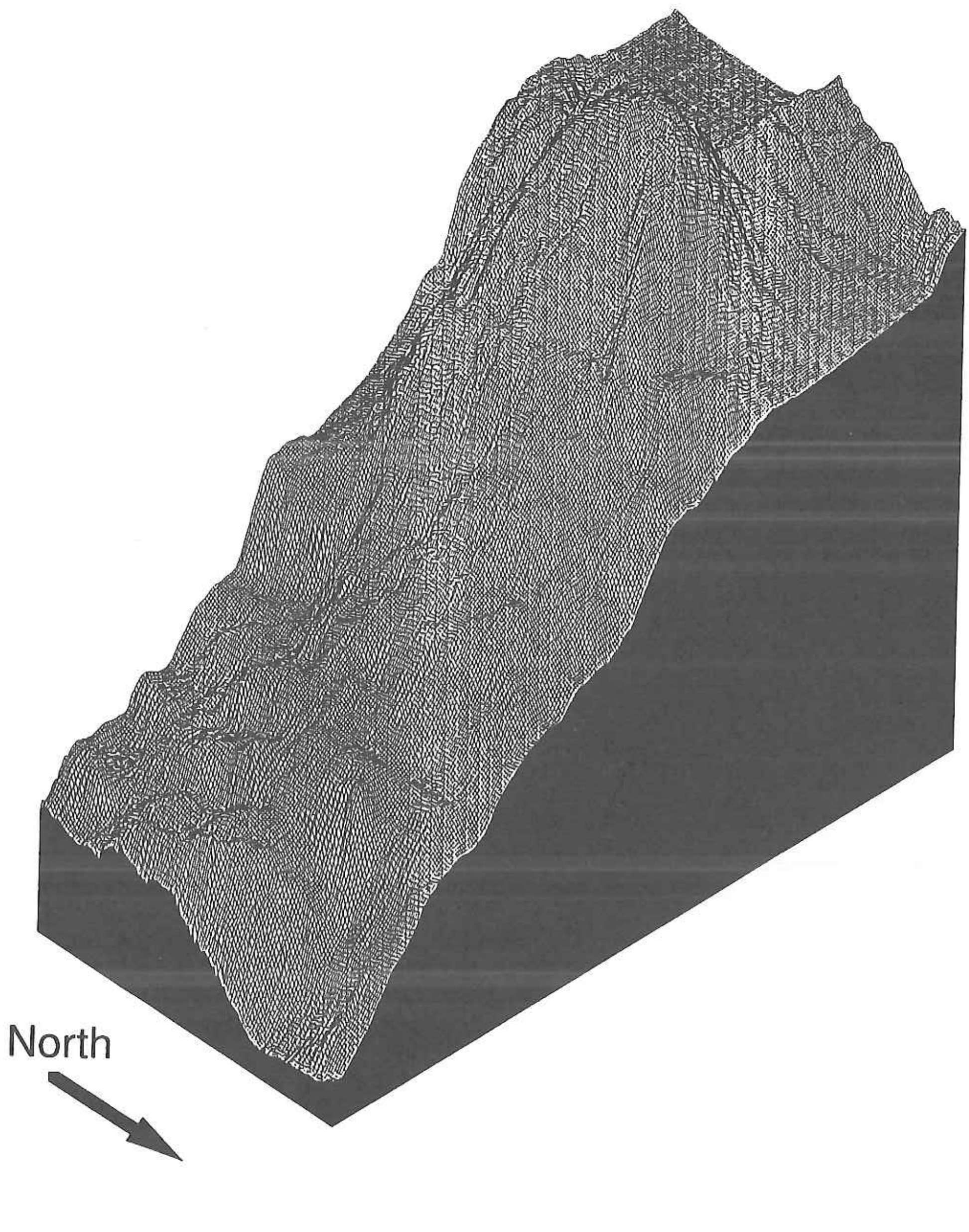


Figure 5-1-6: Whales-eye view (65° elevation, N135°W) of the Torishima serpentinite seamount and lowermost inner trench slope.

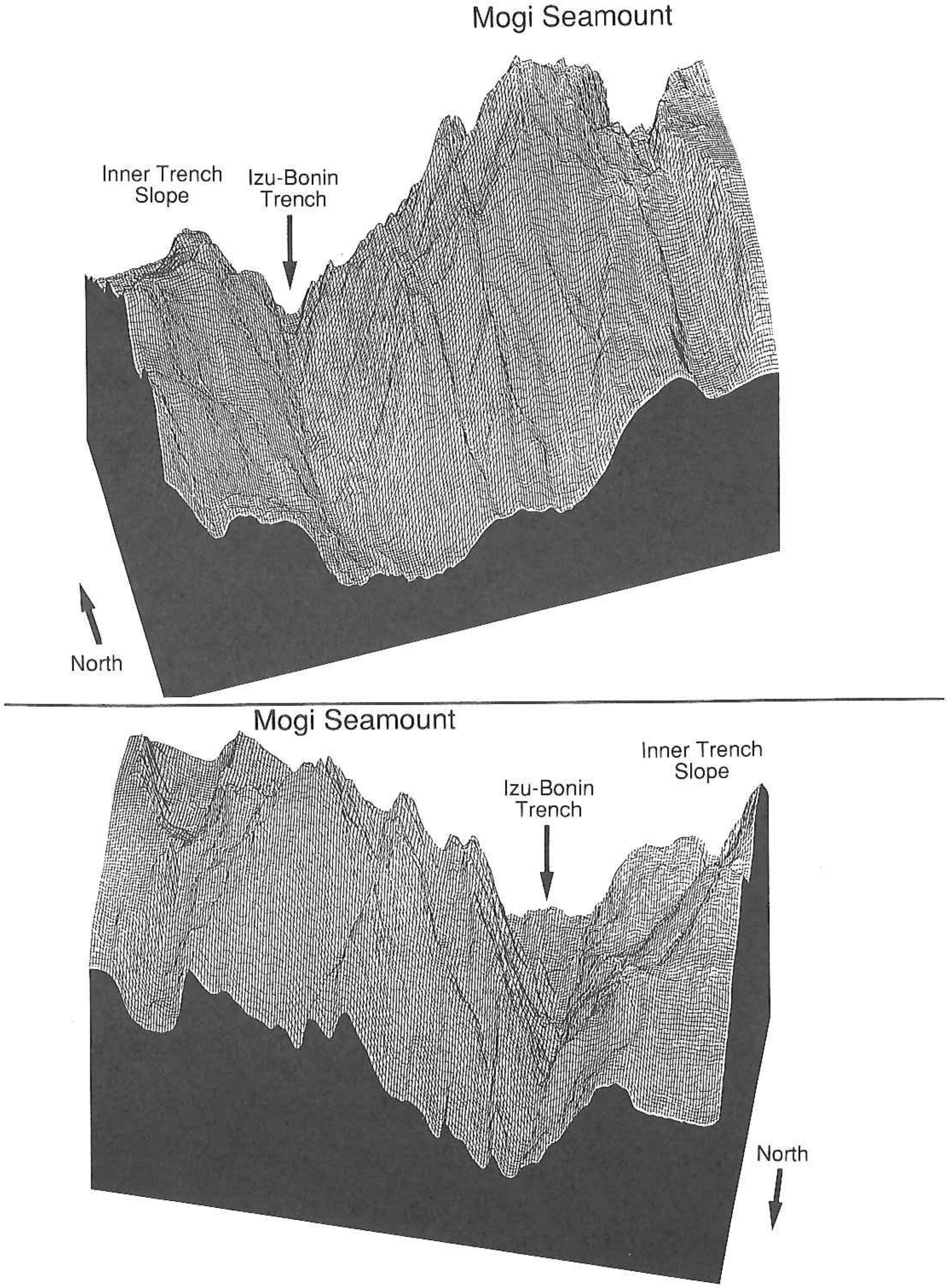


Figure 5-1-7: Two whales-eye views of the the dismembering, subducting Mogi Seamount and lowermost inner trench slope.(top: 50° elevation, N10°E; bottom: 50° elevation, N170°W)

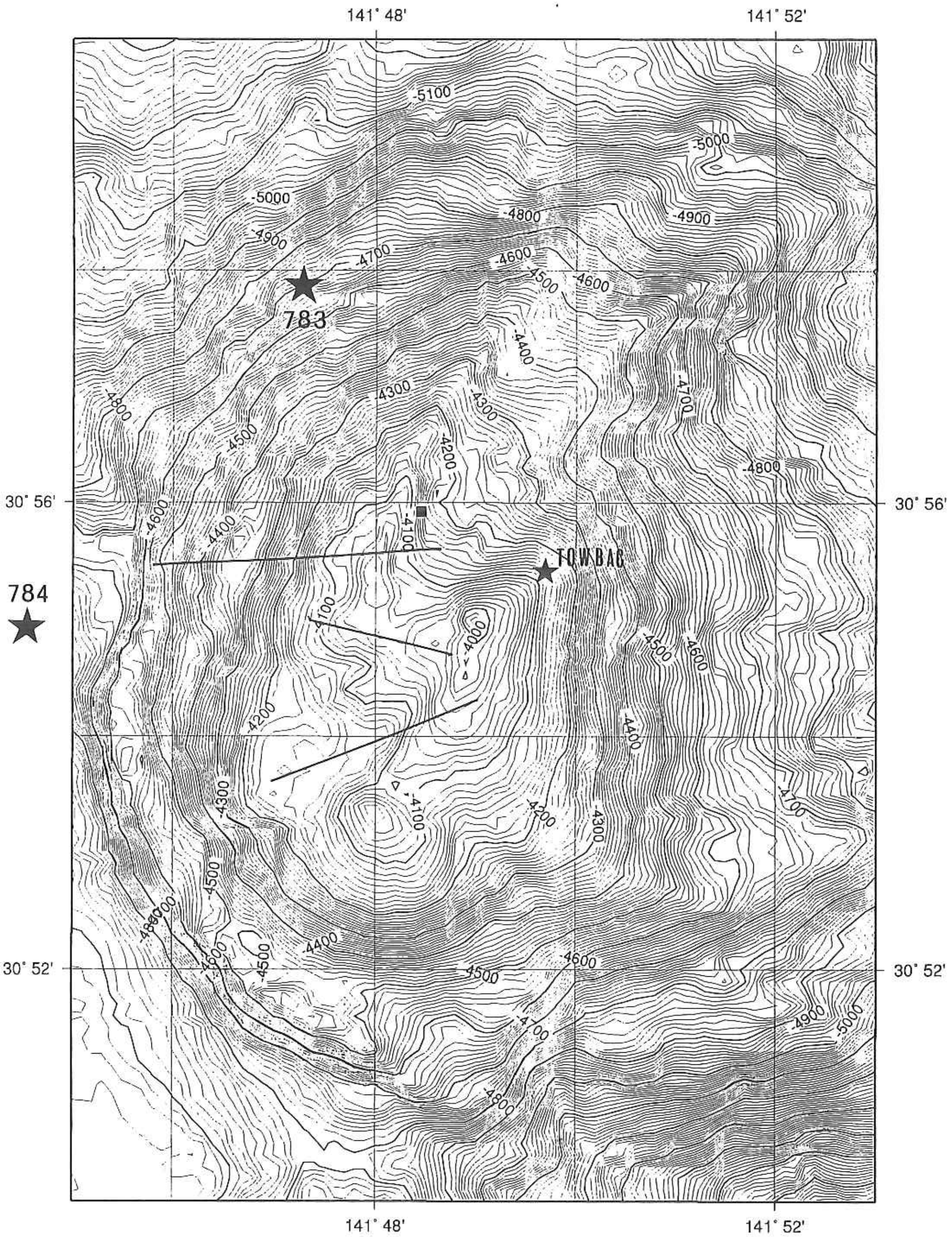
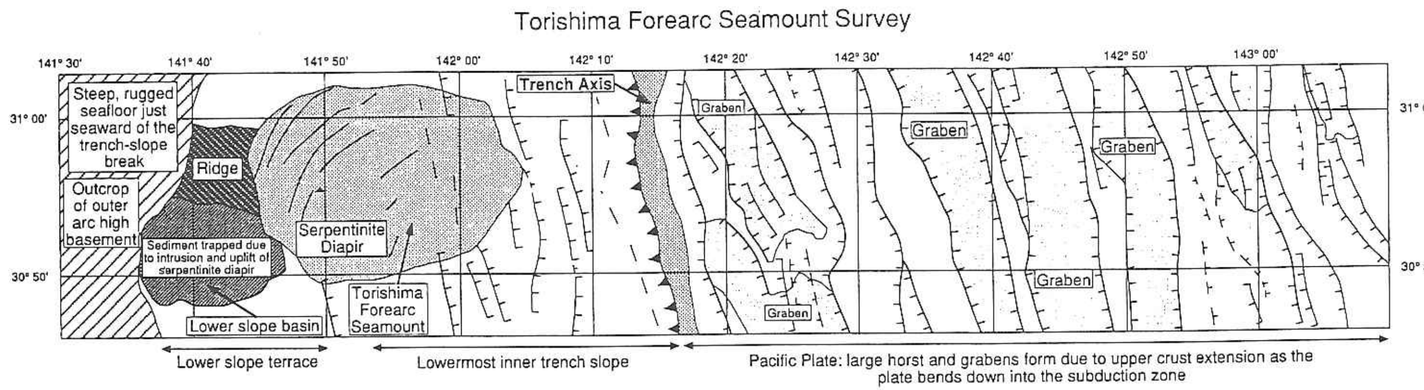


Figure 5-1-8: Sea Beam bathymetric map of the Torishima serpentinite seamount. The large stars locate ODP leg 125 sites 783 and 784. The small star and the square locates the Torishima whale bone animal community (TOWBAC) and outcrops of serpentinite recently discovered during Shinkai 6500 submersible observations, and the lines show dredge locations . The contour interval is 10m.



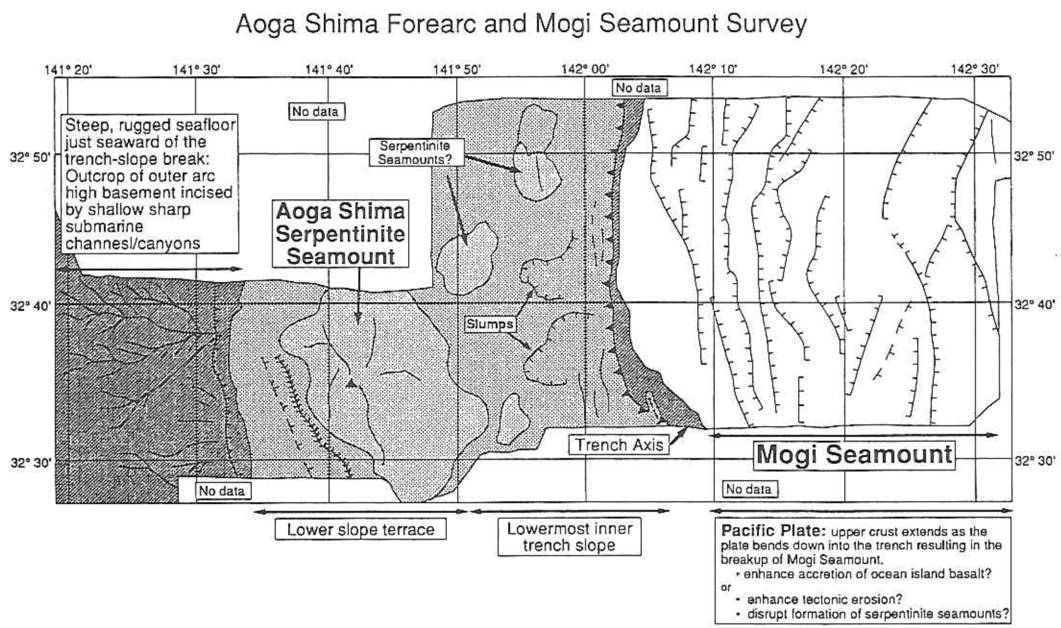


Figure 5-1-9: Interpretation of the Torishima serpentinite seamount (top) and Aoga Shima serpentinite and Mogi seamount (bottom) survey areas shown in Figures 5-1-2 and -3, respectively.

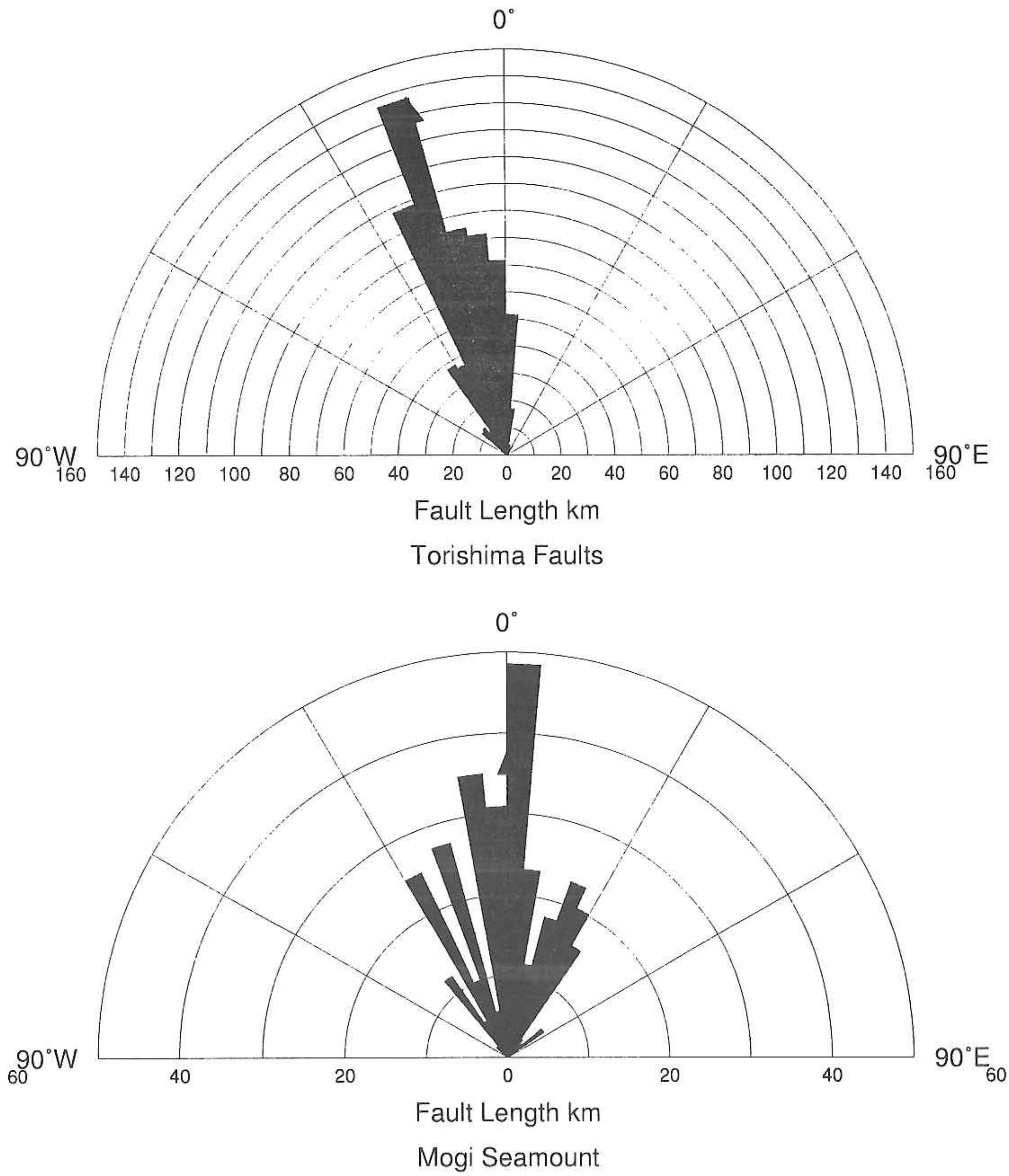


Figure 5-1-10: Polar histograms of faults on the subducting plate (cumulative fault length vs. azimuth) for the Torishima serpentinite seamount (top) and Aoga Shima serpentinite/Mogi subducting seamount (bottom) survey areas. Arrows show the mean faults strike. This demonstrates that the subduction induced faulting has no relation to the preexisting spreading fabric which is oriented N45°E in the region.

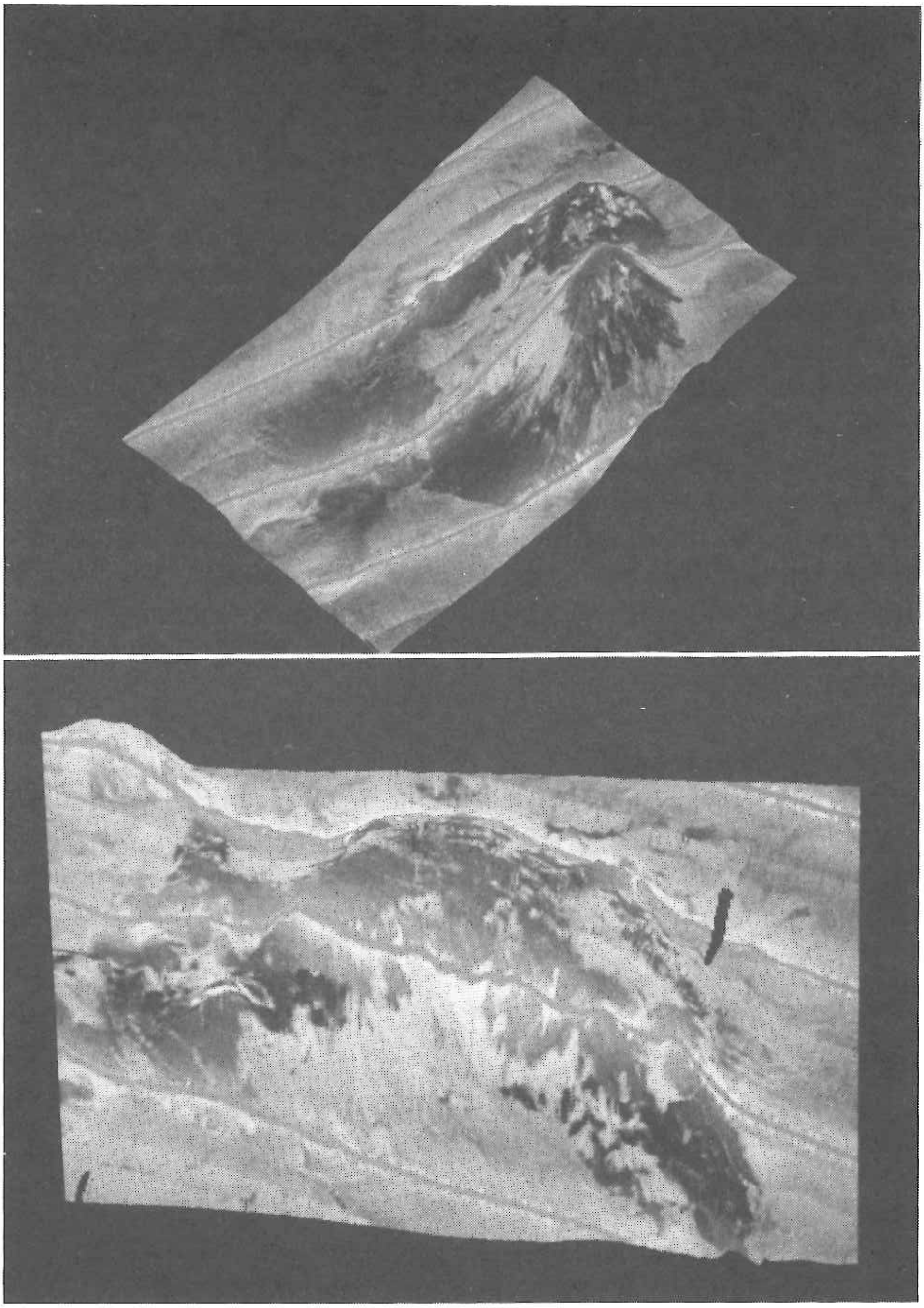


Figure 5-1-11: Three-dimensional Izanagi sidescan sonar perspective view of Nishi Zyoo (top) and Kanbun (bottom) seamounts which are part of the Kanei and Manzi cross-arc seamount chains, respectively. See Figures 5-1-1 and -4 for location of seamounts. The Hakuho-maru Sea Beam data is used for the digital terrain model onto which the sidescan imagery data is draped.

6. GRAVITY

6.1 Gravity Field Measurement on the KH92-2 Cruise

T. Fujiwara, K. Sayanagi and H. Toh

Introduction

On the KH92-2 cruise of the *R/V Hakuho Maru,* gravity field measurement was carried out. The objectives of the measurement are investigations the density structure and the isostatic balance of the northern Izu - Ogasawara Arc - Trench system, seamounts in the Izu - Ogasawara Arc and serpentine diapir seamounts near the Izu - Ogasawara Trench.

The data are valuable for the comparative investigation of Arc - Trench system. We have investigated the structure of Arc - Trench system using gravity field data. Gravity field measurement were done at the Japan Trench (39°N) on the KH90-1 cruise, at the Mariana Trench (18°N) on the KH92-1 cruise (Figure 1). Furthermore the measurement is going to be done at the Kuril Trench (42°N) on the KH92-3 cruise for that purpose.

Gravity field measurement

Gravity field was measured with the seasurface gravitymeter NIPR-ORI - 2 attached on the *R/V Hakuho Maru.* Gravity data were logged every 1 minute. Gravity data were collected throughout the ship track. In the leg 1 of the cruise, the system of the gravitymeter has to be restarted at sea, therefore gravity data on Leg 1 of the cruise could not be tied to the gravity data at Harumi, Tokyo.

Gravity tie-in

Measured seasurface gravity data were tied to gravity data measured at ports to remove effects of drift and biases.

Operator : T. Fujiwara
Gravity meter : Lacoste - Romburg model G-124
Reference value and point : 979774.8 mgal at Harumi, Tokyo.

Port : Harumi, Tokyo
Date : 12:38 (JST), May 20, 1992
Gravity value of L & R : 979774.8 mgal
Gravity value of NIPR-ORI : 979979.4 mgal

Port : Shinko, Yokosuka
Date : 14:25 (JST), June 3, 1992
Gravity value of L & R : 979767.2 mgal
Gravity value of NIPR-ORI : 979958.5 mgal

Port : Shinko, Yokosuka
Date : 12:31 (JST), June 9, 1992
Gravity value of L & R : 979767.3 mgal
Gravity value of NIPR-ORI : 979956.9 mgal

Port : Harumi, Tokyo
Date : 11:03 (JST), June 26, 1992
Gravity value of L & R : 979774.6 mgal
Gravity value of NIPR-ORI : 979964.3 mgal

The difference between gravity value of L & R and NIPR-ORI did not change throughout Leg 2 of the cruise. The NIPR-ORI gravimeter is almost no drifted.

Final data

Observed, Eötvös and Free air anomaly value at each minute were stored in the form of MGD77. Free air gravity anomaly was calculated using reference gravity field 1967. The data are administered by the submarine geophysics division of ORI.

Results

The profiles of free air gravity anomaly and topography along the ship track across the Izu - Ogasawara Arc - Trench system at 32°20'N are shown in Figure 2.

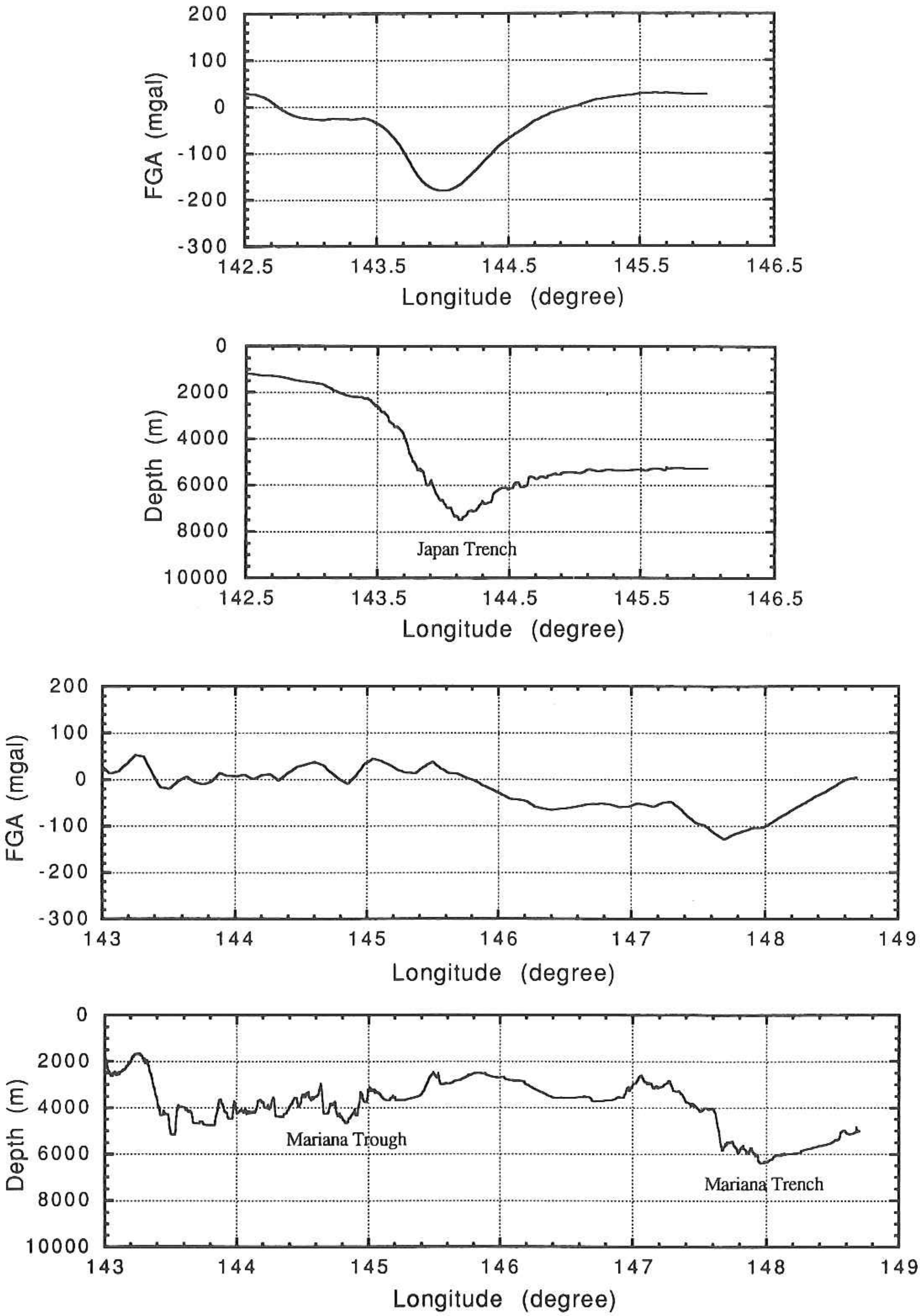


Figure 6-1-1: The profiles of free air gravity anomaly (FGA) (upper) and topography (lower). (a) is the Japan Trench and (b) is the Mariana Trench.

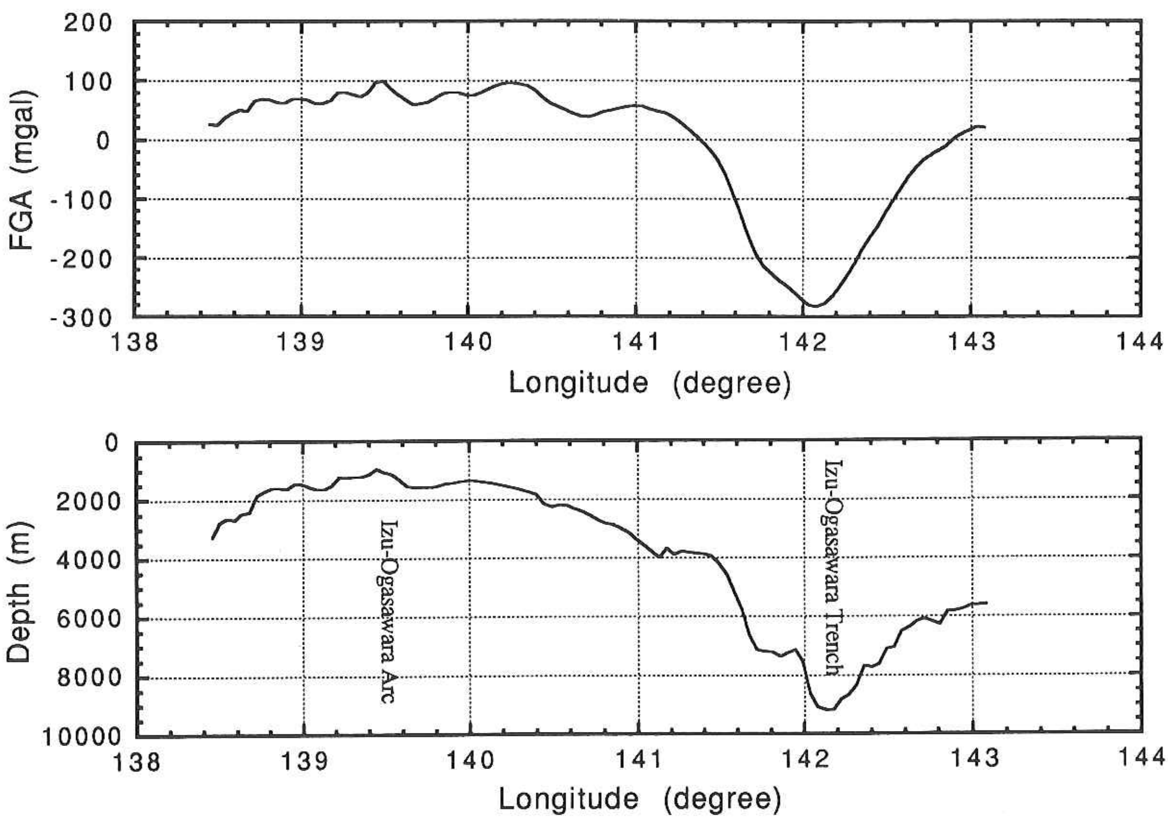


Figure 6-1-2: The profiles of free air gravity anomaly (FGA) (upper) and topography (lower) obtained on this cruise.

7. GEOMAGNETISM

7.1 Seafloor Ultra Low Frequency Magnetotelluric Measurements

H. Toh and A. Kitahara

Introduction

Electromagnetic (EM) waves originating in the ionosphere rapidly decay in the ocean due to the high conductivity of seawater (mean value of 3.3 S/m). Since the skin depth, d [km], of a semi-infinite homogeneous media of a conductivity, s [S/m], at which the amplitudes of injected EM waves become 1/e, is given by the following formula,

$$d = \frac{1}{2\pi}\sqrt{\frac{10T}{\sigma}},$$

where T denotes the period in seconds, most of the EM waves with periods shorter than 5 minutes are severely attenuated at the bottom of the ocean. Thus, it is usually very difficult to determine EM response functions for the periods shorter than 5 minutes at the deep seafloor because of low signal to noise ratios. This, however, does not necessarily mean that it is impossible to measure natural high frequency EM signals in shallower ocean depths. Skin depths of EM variations with periods longer than one minute in a semi-infinite ocean are larger than 2000m. This fact enables us to observe geomagnetic micropulsations in the ultra low frequency (ULF) band (periods ranging from 1 to 500s with typical signal peaks such as Pc3 and Pc5) even at the seafloor using a somewhat higher than usual sampling rate. This is the reason why we deployed an ocean bottom magnetometer (OBM) and an ocean bottom electrometer (OBE) during this cruise.

The OBM and OBE were installed on the fore-arc basin within a few nautical miles (n.m.) of each other to carry out ULF-MT (magnetotelluric) measurements. Since ULF signals can penetrate all crustal depths, we expect to be able to estimate the detailed one-dimensional (1D) crustal conductivity structure of the western margin of the fore-arc basin provided that the observed signals consist of many different frequencies. Moreover, we can make a direct comparison of the EM 1D structure with the structure determined by a variety of seismic methods utilized during this cruise, including 3.5 kHz subbottom, multichannel, constant offset and expanding spread seismic profiling using Airgun-OBS arrays. In this context, our EM measurements are analogous to natural micro-earthquake observation using OBS's.

Instrumentation

We deployed an ocean bottom magnetometer (model OBM-C3) in this experiment to measure the three components of the geomagnetic field at the seafloor. Its sensor consists of three orthogonal flux-gate type ring-cores made of a high-m permalloy metal with a resolution of 0.1 nT each.

As for electric field measurements, we used an ocean bottom electrometer (model OBE-ORI) deployed near the OBM site to record the two components of the horizontal electric field every second. Its electrodes are sintered-type silver-silver chloride electrodes separated by 4.5m at each of the four tips of the two orthogonal arms of the electrometer. This span length results in a resolution of approximately 70 nV/m, which is sensitive enough to record the minute changes in the horizontal electric field at the seafloor induced by even strongly attenuated ULF signals.

Each instrument is equipped with an acoustic transponder, a 43.528 MHz beacon and a flasher for release and recovery of the instruments which will occur in late June during the Tansei-maru cruise, KT92-9. Figures 1(a) and 1(b) show the outer views of OBM and OBE just before launch, respectively.

Instrument Deployment

OBE-ORI and OBM-C3 were installed at (31°59.73'N, 140°12.49'E, 1750m) on 25/MAY/1992 01:51JST and at (31°59.93'N, 140°11.01'E, 1717m) on 25/MAY/1992 02:17JST, respectively. The OBE site is 1.5 n.m. away from the OBM site, a little farther than we had desired, due to strong (2-3 knots) ESE ocean currents at the time of deployment. The installation data are summarized in Table 1. 'Code' in Table 1 denotes the call sign of the acoustic transponder.

The OBE and OBM installation sites and the location of the expanding spread seismic profile, ESP#5, is shown in Fig. 2. The 1D seismic velocity structure under the common mid-point (CMP) of the two ship expanding spread profile (ESP) will be precisely determined using both the reflection and refraction seismic data. Since the OBM and OBE were deployed about 10 n.m. south of the ESP#5 CMP, a direct comparison of the EM 1D conductivity structure with the seismic counterpart may be quite feasible.

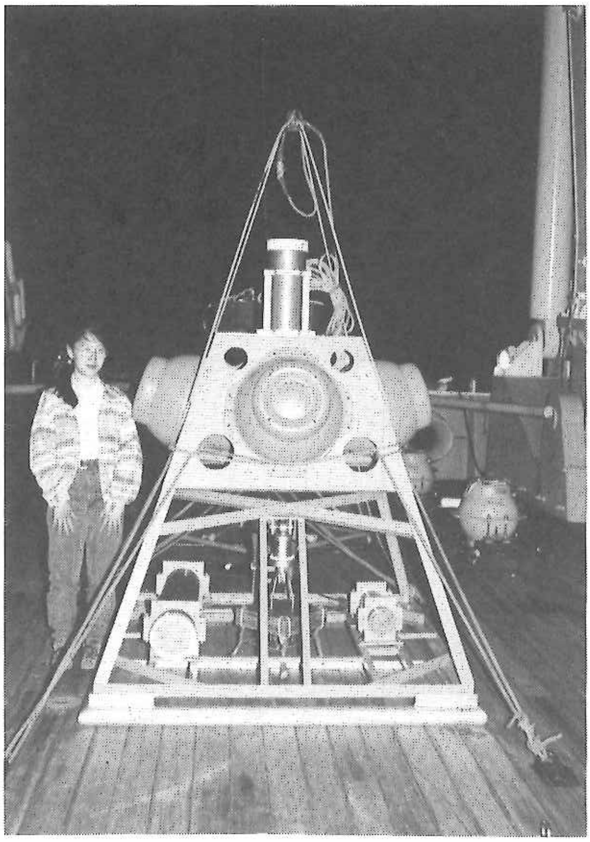
Data and 1D Modeling

The OBE and OBM were successfully retrieved during the Tansei-maru cruise, KT92-9. Figure 3 shows observed EM variations at the seafloor. Unfortunately, one component of horizontal electric fields could not be recorded due to stuck bits in ROM memories. According to the geomagnetic compass attached to the OBE, the other electric component lied in almost east-west direction (5° east by south) and hence it should have good correspondence with geomagnetic north-south component (C3-H in Fig. 3), which is not very clear in Fig. 3. Moreover, few natural geomagnetic disturbances were occurred during the observation terms (as long as three days), which resulted in the low power and multi-coherence level of the EM fields at the seafloor for all the observed frequencies as shown in Fig. 4.

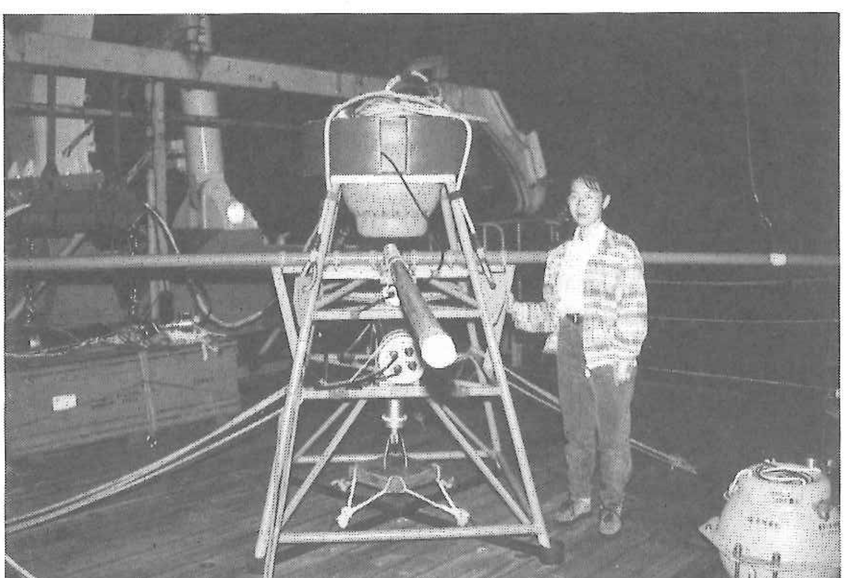
In spite of poor quality of the data, 1D modeling for the electrical conductivity structure below the observation site was performed to fit the amplitudes and phases of the apparent resistivity for five frequencies resolved, which yielded the shallower 1D structure as shown in Fig. 5. This structure might be interpreted as consisting of a relatively thick conductor at the top, a resistive crustal layer as thick as 20 km in the middle and a deep conductive layer at the bottom corresponding to the mantle conductor. The conductor at the top could be regarded as the sedimentary layer of the fore-arc basin. However, we should say this result is weak even if it gives a seemingly reasonable structure because of the insufficient number of the resolved frequencies and lack of the other horizontal component of the observed electric field. The latter disables the examination of the validity of 1D approximation and overestimation of the conductivities of each layer appeared in the model shown in Fig. 5 might at least occur in the course of the 1D modeling because the observation site were located at the western margin of the fore-arc basin where previous MT observations for longer periods showed conspicuous two-dimensionality which originated from the almost north-south geological strike of the arc.

Table 1. Summary of deployment

Site	Apparatus	Latitude	Longitude	Depth	Code	Set time	Start time
JK31A	OBE-ORI	31° 59.73'N	140° 12.49'E	1750 m	3H	25/May/92 01:51 JST	25/May/92 18:00 JST
JK31B	OBM-C3	31° 59.93'N	140° 11.01'E	1717 m	1B	25/May/92 02:17 JST	25/May/92 18:00 JST



(a)



(b)

Figure 7-1-1: Photographs of OBM-C3 (a) and OBE-ORI (b) on board and one of the authors (A. K.).

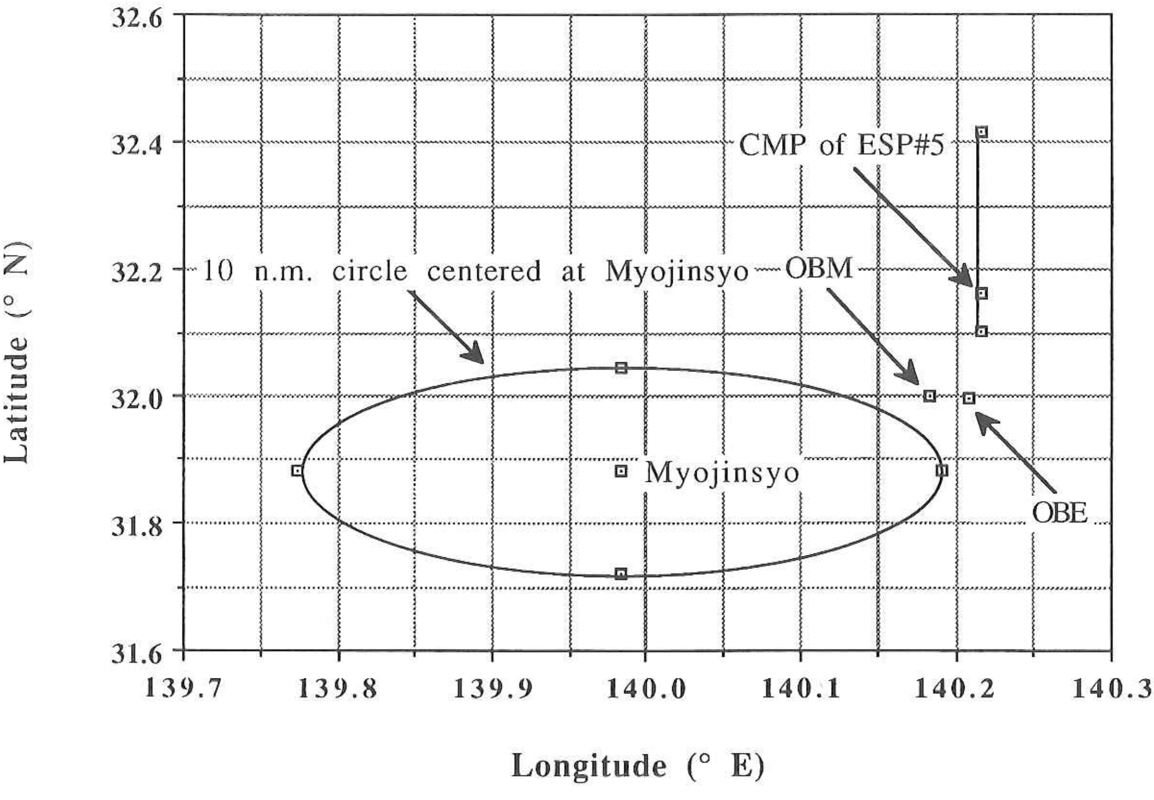


Figure 7-1-2: A map showing the locations of the installation sites of OBE and OBM in addition to the nearest profile of the seismic experiment (ESP#5).

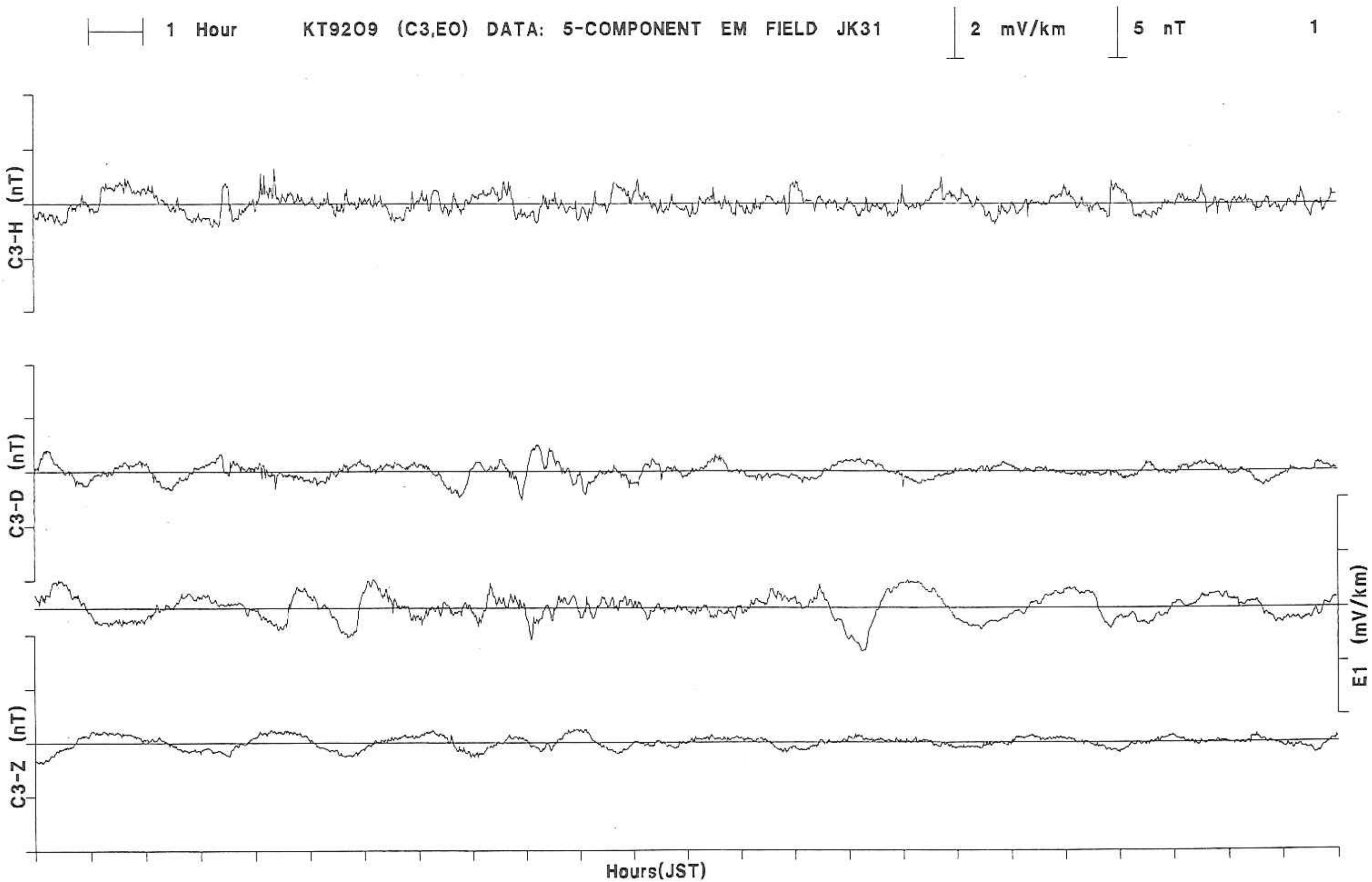


Figure 7-1-3: Observed EM fields at the seafloor from 18:00JST 25/MAY/'92 to 18:00JST 26/MAY/'92. The electric field (E1) lies in N95°E.

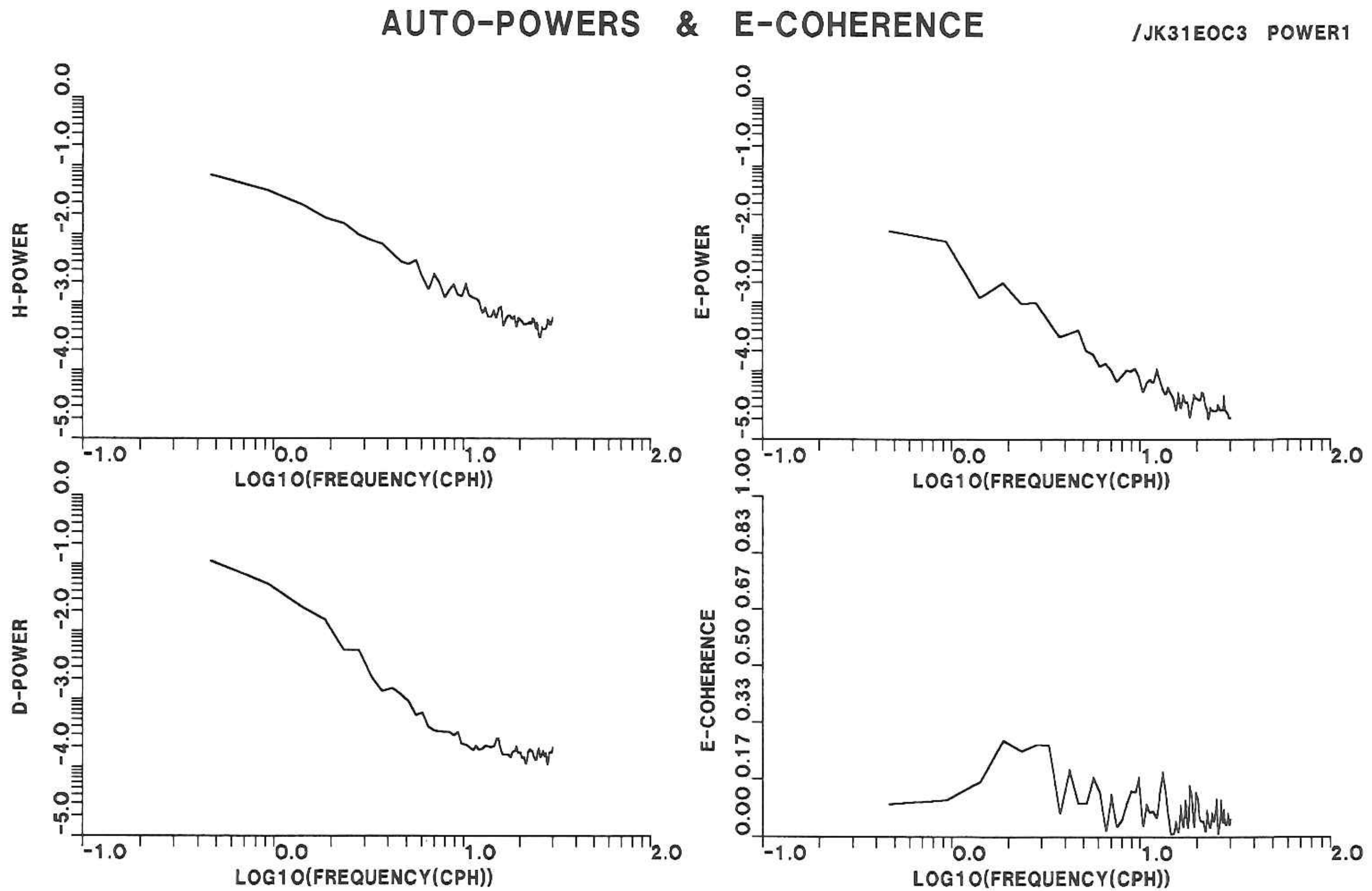


Figure 7-1-4: Auto power spectra of the horizontal geomagnetic components (H, D) and electric field (E). The coherence is a multi-coherence between the electric field and the horizontal geomagnetic field.

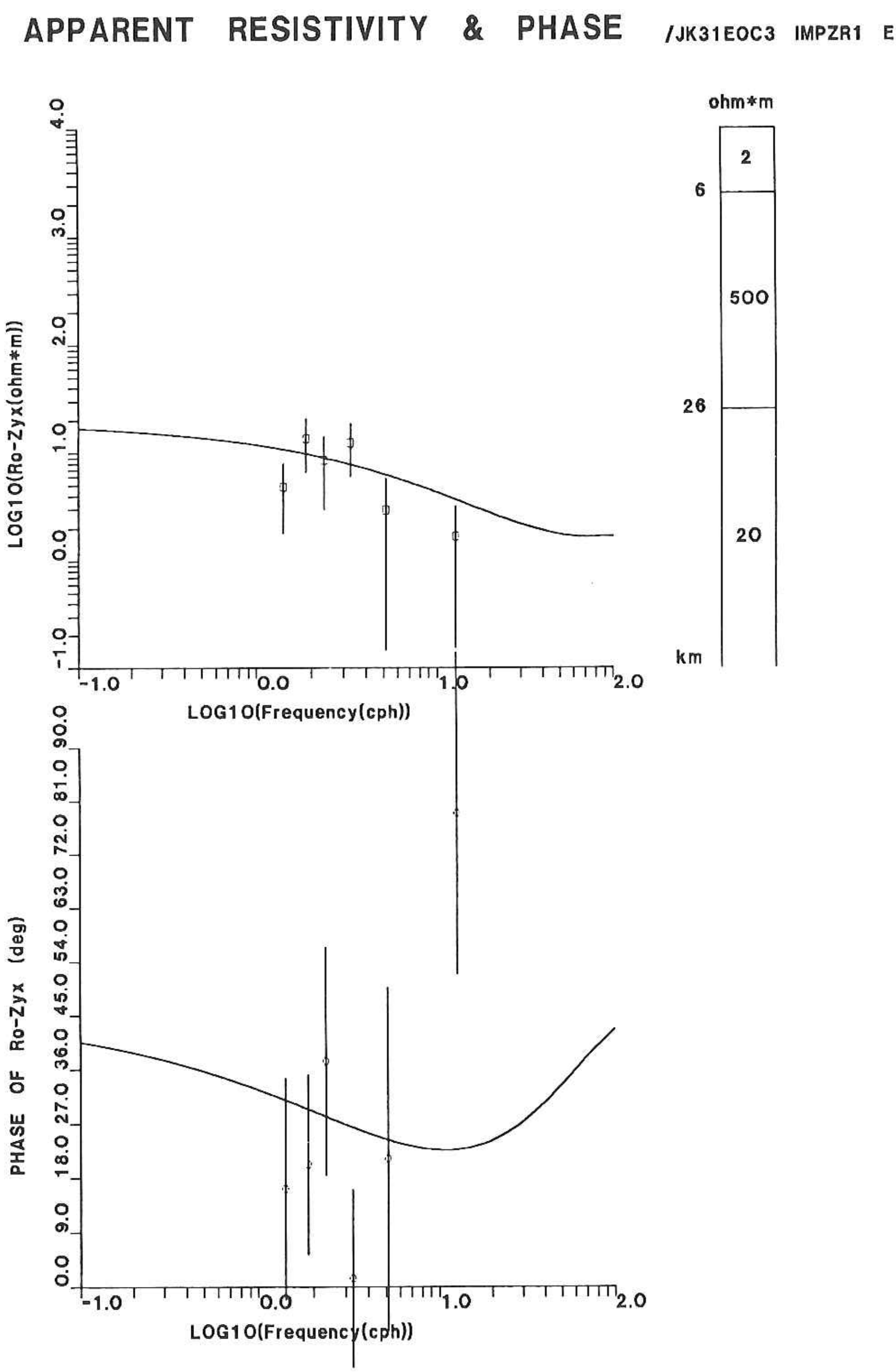


Figure 7-1-5: The observed amplitude (upper) and phase (lower) of apparent resistivity (symbols with error bars) and theoretical curves (solid lines) calculated from the 1D model shown on the right of the upper (amplitude) diagram.

7.2 Measurement of three-component and total intensity of geomagnetic field in the Izu-Ogasawara Arc-Trench system area

A. Kitahara, T. Fujiwara, K. Sayanagi and H. Toh

Introduction

In the KH92-2 cruise, three components and total intensity of geomagnetic field were measured using the ORI's STCM (Shipboard Three-Component Magnetometer ; Isezaki *et al.*, 1981) system and a proton precession magnetometer. The objectives of geomagnetic measurement in this cruise are investigations of the magnetic structure of the Izu-Ogasawara Arc-Trench system and seamounts in the Izu-Ogasawara Arc.

The STCM has been used to get the three component geomagnetic field at sea. Analysis of three component geomagnetic anomaly has many advantages compare with that of total intensity anomaly. The advantages are as follows (e.g. Isezaki *et al.*, 1981; Isezaki, 1986; Seama *et al.*, 1993).

1) Whether the magnetic source body is two or three dimensional structure can be determined by even a single measurement line.

2) The dip and strike of two dimensional source body can be determined directly (without any assumption).

3) The three component geomagnetic anomaly is not affected by ambient geomagnetic field and the trend of geomagnetic anomaly lineation. The three component geomagnetic anomaly can be detected even at the geomagnetic equatorial area, while the total intensity anomaly becomes very small at the equatorial area, moreover the magnetic lineation trends NS.

4) The bottom depth of the two dimensional source body can be estimated directly.

The system of STCM and proton precession magnetometer

The STCM system of the R/V Hakuho-maru is shown in Figure 1. The system was controlled by a personal computer in Lab. 1. The personal computer also collected data of magnetic field, ship's condition and navigation. The three components of geomagnetic field were measured by three axial fluxgate-type sensor. The sensor of the magnetometer was mounted on the pole on the upper deck. The pole was newly built up from this cruise. The ship's heading, rolling and pitching angles were measured by the precise gyrocompass (SGC-1) in Lab.9. The data were sent to Lab.1 through the LAN (Local Area Network) system of the R/V Hakuho-maru using RS232-C interface. These data were stored in a hard disk every 1 second. Position, depth, speed, gravity and temperature data were also obtained through the LAN system via RS232-C. These data were stored in the hard disk every 1 minute.

The total intensity of geomagnetic field were measured by the ORI type of proton precession magnetometer. The system was composed of a personal computer, a main magnetometer unit, a condenser box, an oscilloscope, a pen recorder and a sensor with a cable length of 250m (Figure 2). The system was controlled by the personal computer in Lab.3. The position and time data were obtained through the LAN system. These data were stored in floppy disks every 30 seconds.

The geomagnetic data were collected during the entire period of the cruise.

Results

Three component geomagnetic field obtained from observed data according to the method of Isezaki (1986). To get the true X (north), Y (east) and Z (vertical-down) components of geomagnetic field, we must know 12 constants for translating from observed field to geomagnetic field. To get these constants, the ship sailed along an '8' shape track at seven different places in this cruise. The location where these operations were done and the final 12 constants are shown in Table 1.

Vector geomagnetic anomalies were obtained using IGRF-90 field (IAGA Division V Working Group 8, 1991). The three component geomagnetic anomalies along the all tracks in the Izu-Ogasawara Arc is shown in Figure 3-(a), (b) and (c). The total intensity anomaly along the all tracks is shown in Figure 4.

The [A] area is the Izu-Ogasawara Trench. Two strike angles of the geomagnetic anomaly lineations are obtained. First, the strike angle of the direction of NE-SW is caused by geomagnetic anomaly lineations of the Pacific plate. Then, the direction of N-S is caused by the characteristic of Trench bathymetry as the horst-glaben-structure. The [B] area is the back arc area. The NE-SW strike angle of two dimensional magnetic source body can be obtained in this area. This direction may be caused by the seamount-chain aligned in echelon on the Izu-Ogasawara back arc area.

References

[1] N. Isezaki , J. Matsuda , H. Inokuchi and K. Yaskawa , Shipboard Measurement of Geomagnetic Field , J. Geomag. Geoelectr. , 33 , 329-334 , 1981

[2] N.Isezaki , A new shipboard three component magnetometer , Geophys. , 51 , 1992-1998 , 1986

[3] N. Seama , Y. Nogi and N. Isezaki , A new method for precise determination of the position and strike of magnetic boundaries using vector data of the geomagnetic anomaly field , Geophys. J. Int. , 1993 (in press)

[4] IAGA Division V, Working group 8, International Geomagnetic Reference Field, 1991 Revision, J. Geomag. Geoelectr., 43 , 1007-1012, 1991

Table 1 Locations of '8' shape sailings (a) and the final 12 constants (b).

(a)					
Station No.	Date	Latitude(°)	(')	Longitude(°)	(')
KH92-2.R1	92. 5.21	N 34	4.78	E 139	54.25
KH92-2.R2	92. 5.22	N 30	48.04	E 143	10.83
KH92-2.R3	92. 5.24	N 31	1.28	E 141	31.61
KH92-2.R4	92. 5.25	N 32	15.80	E 138	58.69
KH92-2.R5	92. 5.26	N 32	31.65	E 138	26.61
KH92-6.R6	92. 6. 9	N33	4.00	E139	20.80
KH92-2.R7	92. 6.15	N31	18.20	E138	15.65
(b)					
B(1,1)	0.224	B(1,1)	1.032	B(1,1)	0.549
B(1,2)	-1.153	B(1,2)	0.500	B(1,2)	-0.657
B(1,3)	0.405	B(1,3)	0.630	B(1,3)	0.661
Hph	-683	Hps	-1299	Hpv	3121

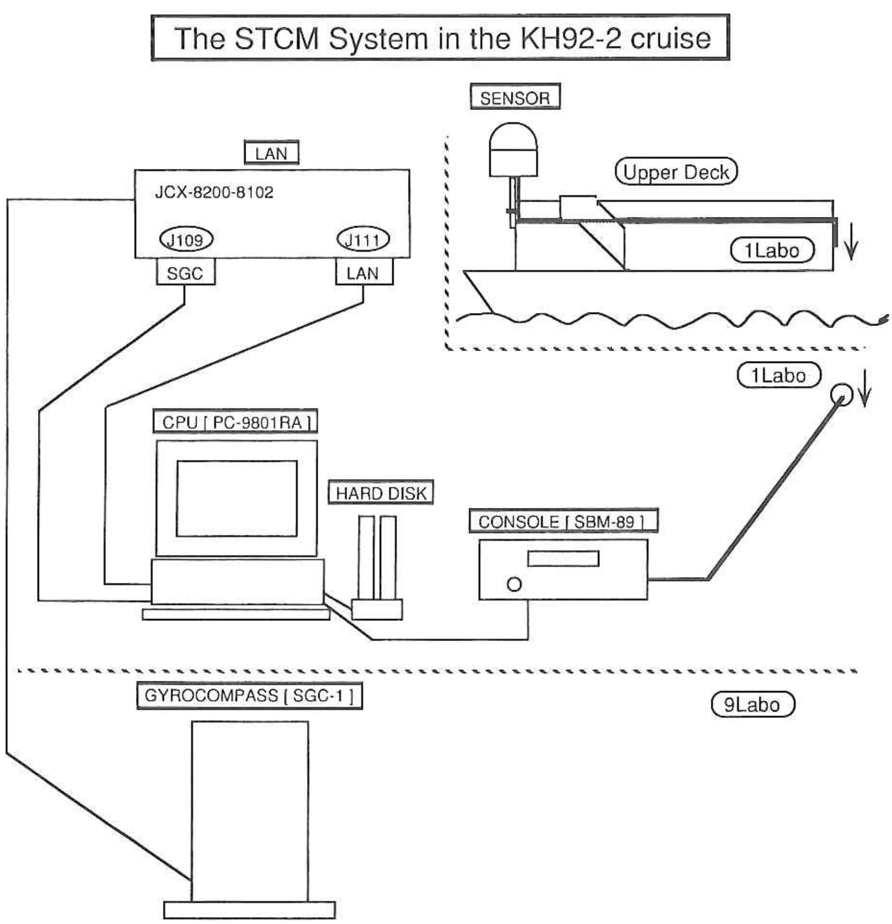


Figure 7-2-1: The system of Shipboard Three Component Magnetometer in the KH92-2 cruise. The sensor of the magnetometer was set up to the pole fixed on the upper deck.

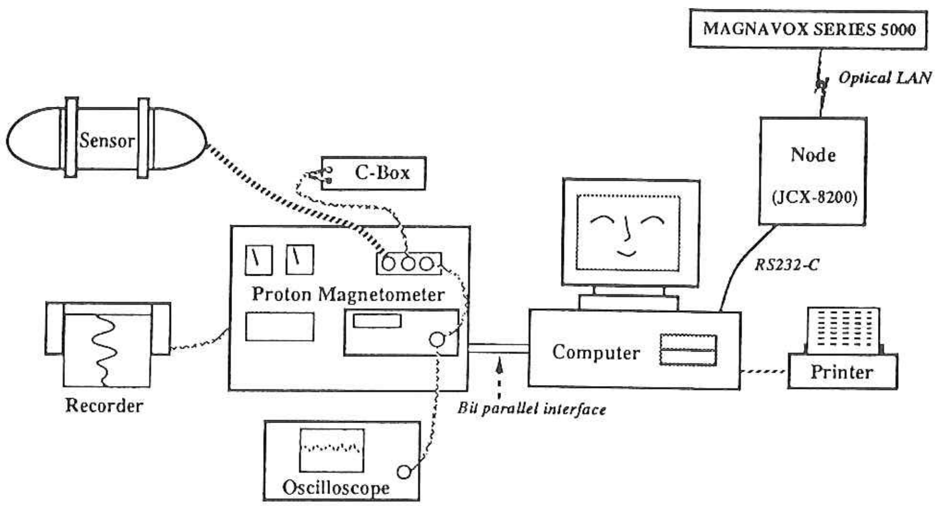


Figure 7-2-2: The system of proton precession magnetometer.

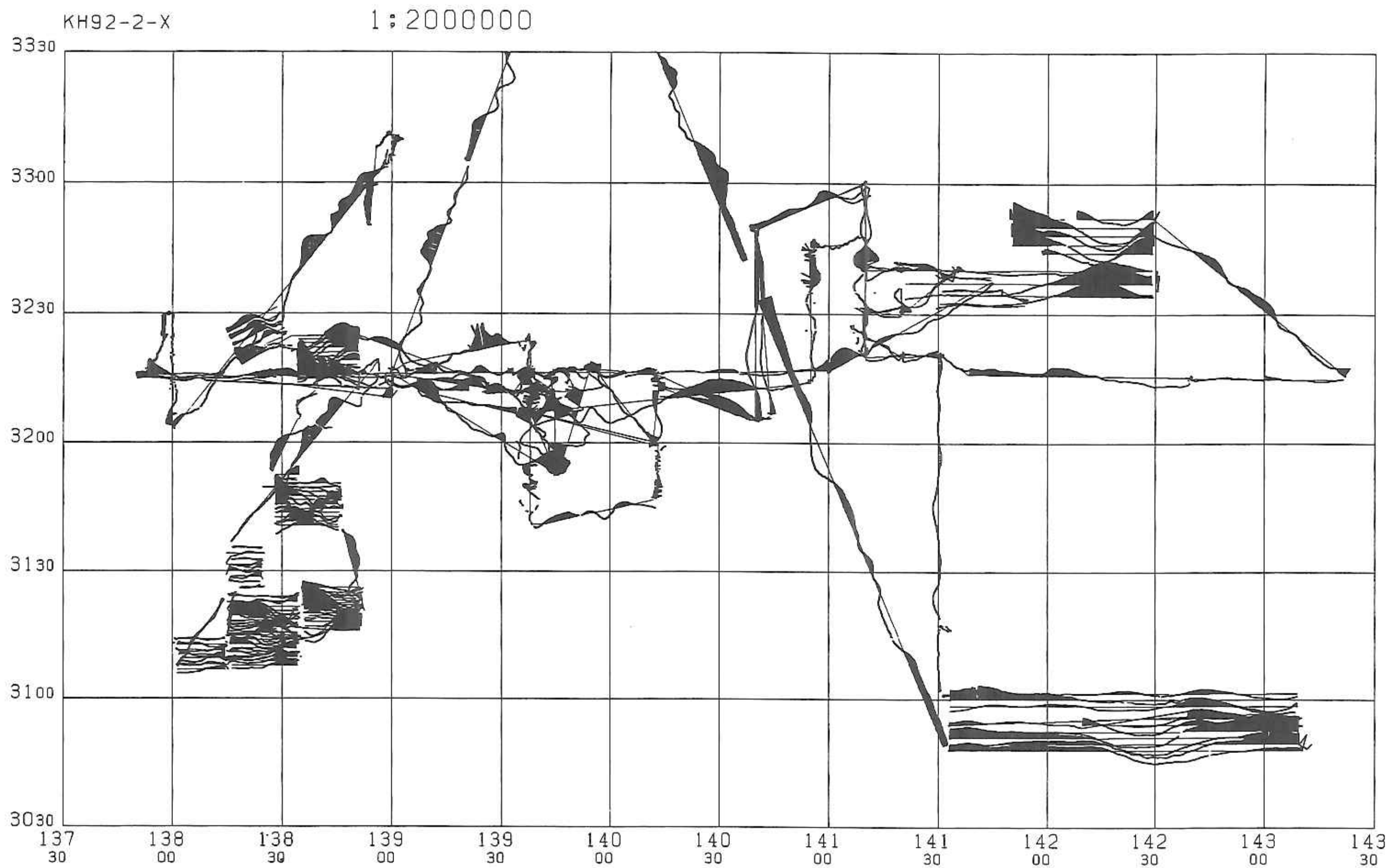


Figure 7-2-3: The three component anomaly profiles of geomagnetic field referred to IGRF90 field along the all tracks in the KH92-2 cruise in the Izu-Ogasawara Arc area. The positive anomalies are shaded. (a): X (north) component.

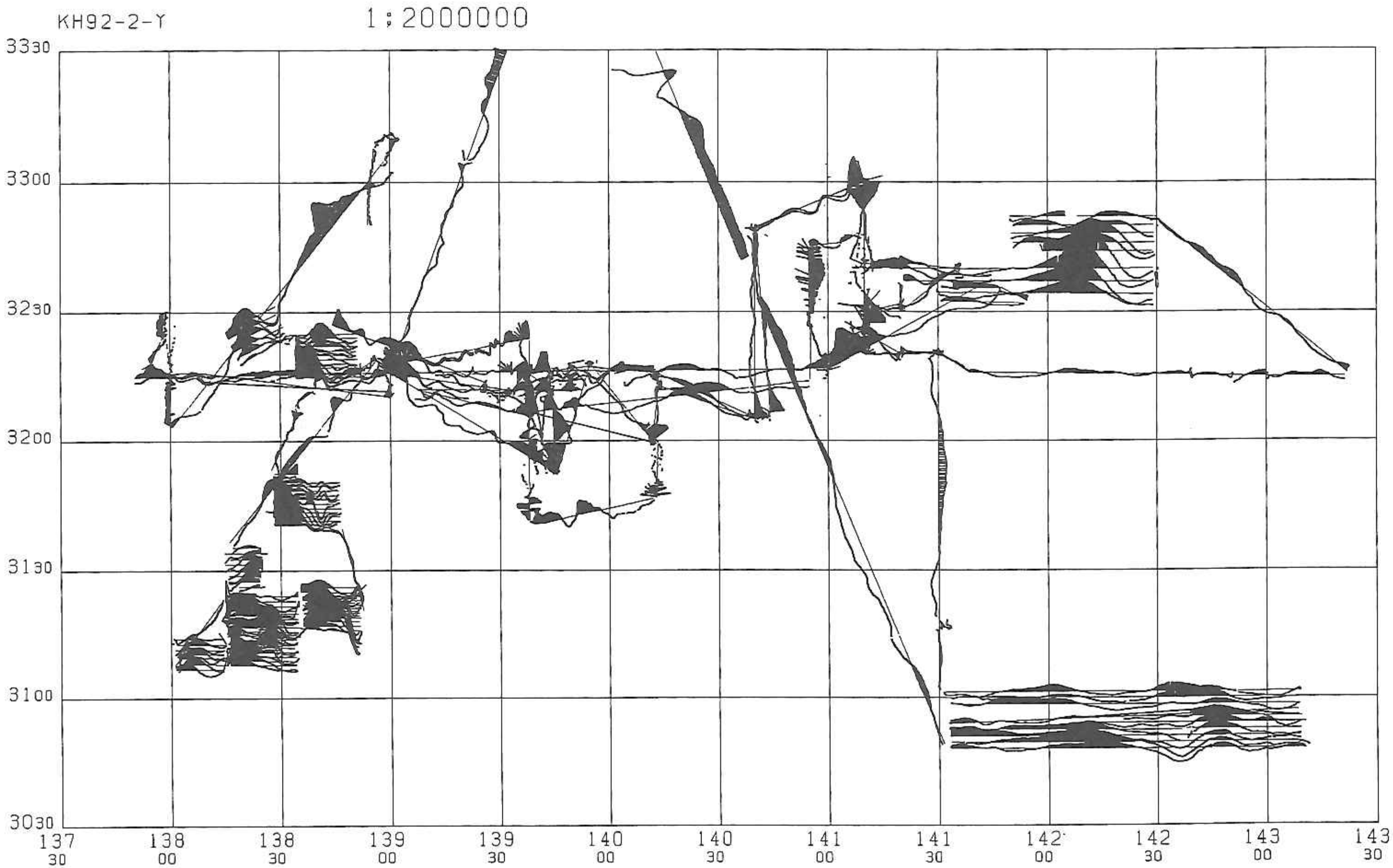


Figure 7-2-3 (cont) : The three component anomaly profiles of geomagnetic field referred to IGRF90 field along the all tracks in the KH92-2 cruise in the Izu-Ogasawara Arc area. The positive anomalies are shaded. (b): Y (east) component.

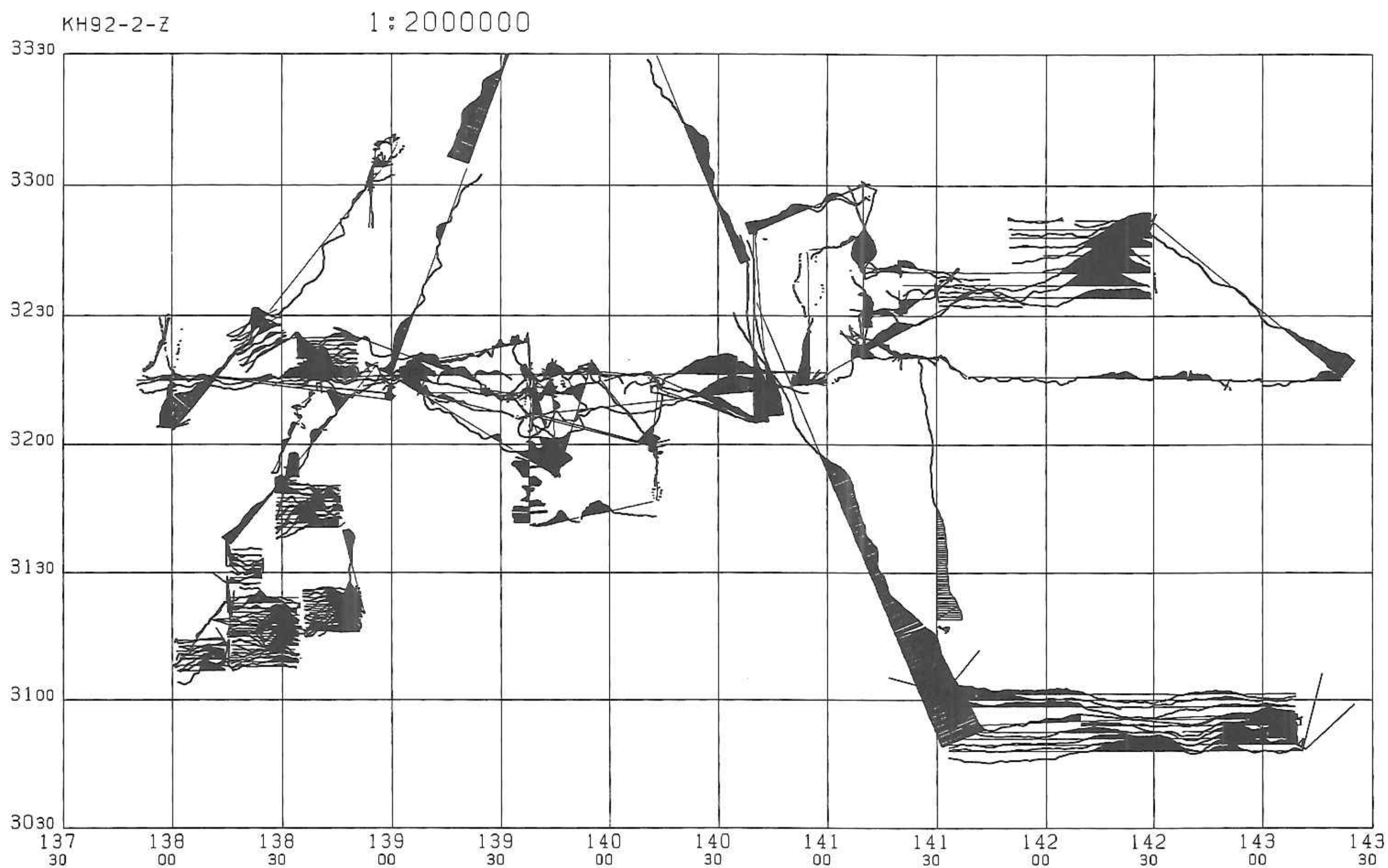


Figure 7-2-3 (cont) : The three component anomaly profiles of geomagnetic field referred to IGRF90 field along the all tracks in the KH92-2 cruise in the Izu-Ogasawara Arc area. The positive anomalies are shaded. (c): Z (vertical-down) component.

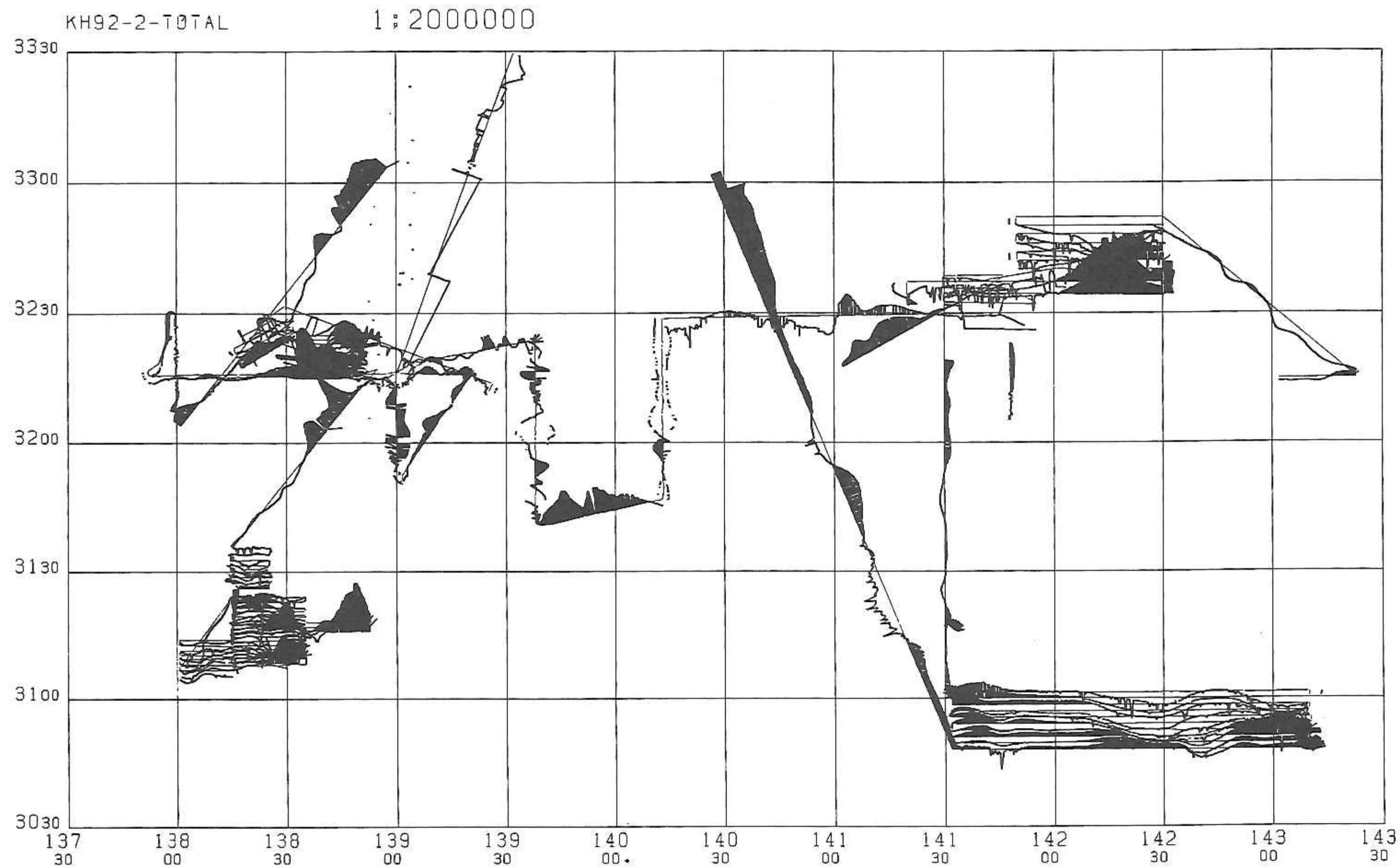


Figure 7-2-4: The total intensity anomaly profiles of geomagnetic field referred to IGRF90 field along the tracks over the seamounts in the KH92-2 cruise. The positive anomalies are shaded.

8. ACOUSTICS

8.1 Measurement of current–velocity with IES

A. Kubo and K. Ogura

Introduction

Our IES (inverted echo sounder) system is designed to measure the horizontal current-velocity integrated from sea surface to the IES's depth. It is used in the set of at least 3 units to obtain the vector of current-velocity. Each of them is moored to the ocean bottom, then transmits and receives acoustic signal in programmed schedule.

IES system

Our system uses the acoustic signal modified by M-sequence. One IES opens the window (gate) at programmed time and receives the signals, which traveled different path. Then, IES calculates the quadrature correlation of received waveform with that of original one, and records the position (arrival time) of several largest peaks (in this case, 6 peaks for redundance). The peaks should include the direct arrival and sea surface reflected one, necessary to obtain the current velocity. The block diagram of the processing in IES is shown in Fig. 1.

After the whole operation is over, we take back the moored system and read data from memory chip. Then, we do off-line processing to obtain the current-velocity along the axis which connects some 2 units. The current-velocity is calculated from 4 values: the traveltime of direct arrival and reflected one from sea surface, in both reciprocal direction between the 2 units.

Operation on Hakuho-maru (KH-92-2)

In this cruise, we have deployed 3 units on May 21 at the points below.

	deployment	depth
unit A	33° 59.63′ N, 139° 51.06′ E	1155 m
unit B	34° 04.66′ N, 139° 54.10′ E	1161 m
unit C	33° 59.88′ N, 139° 57.75′ E	1108 m

And, at the same time, we measured the sound-velocity profile with XBT after each deployment at the same area. The moored system is shown in Fig. 2. The system will be recovered by *Tansei Maru* cruise KT-92-8.

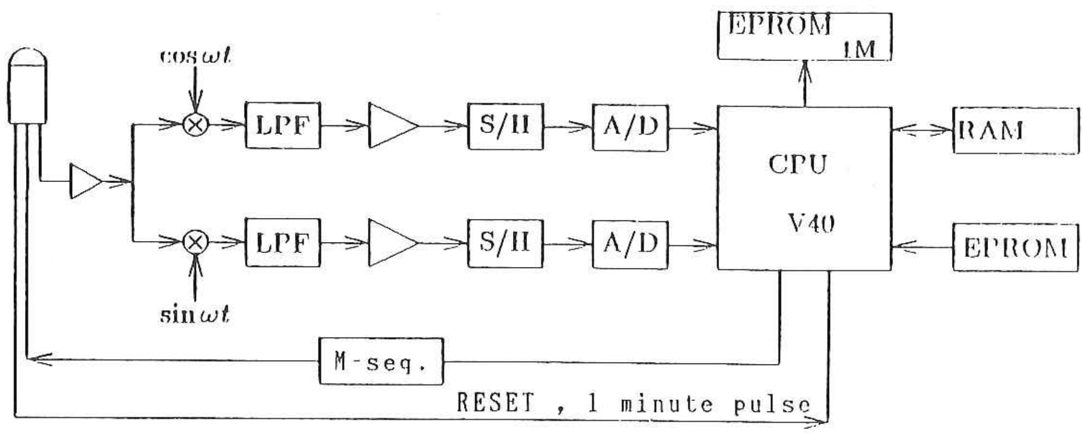


Figure 8-1-1: Block diagram of processing in IES

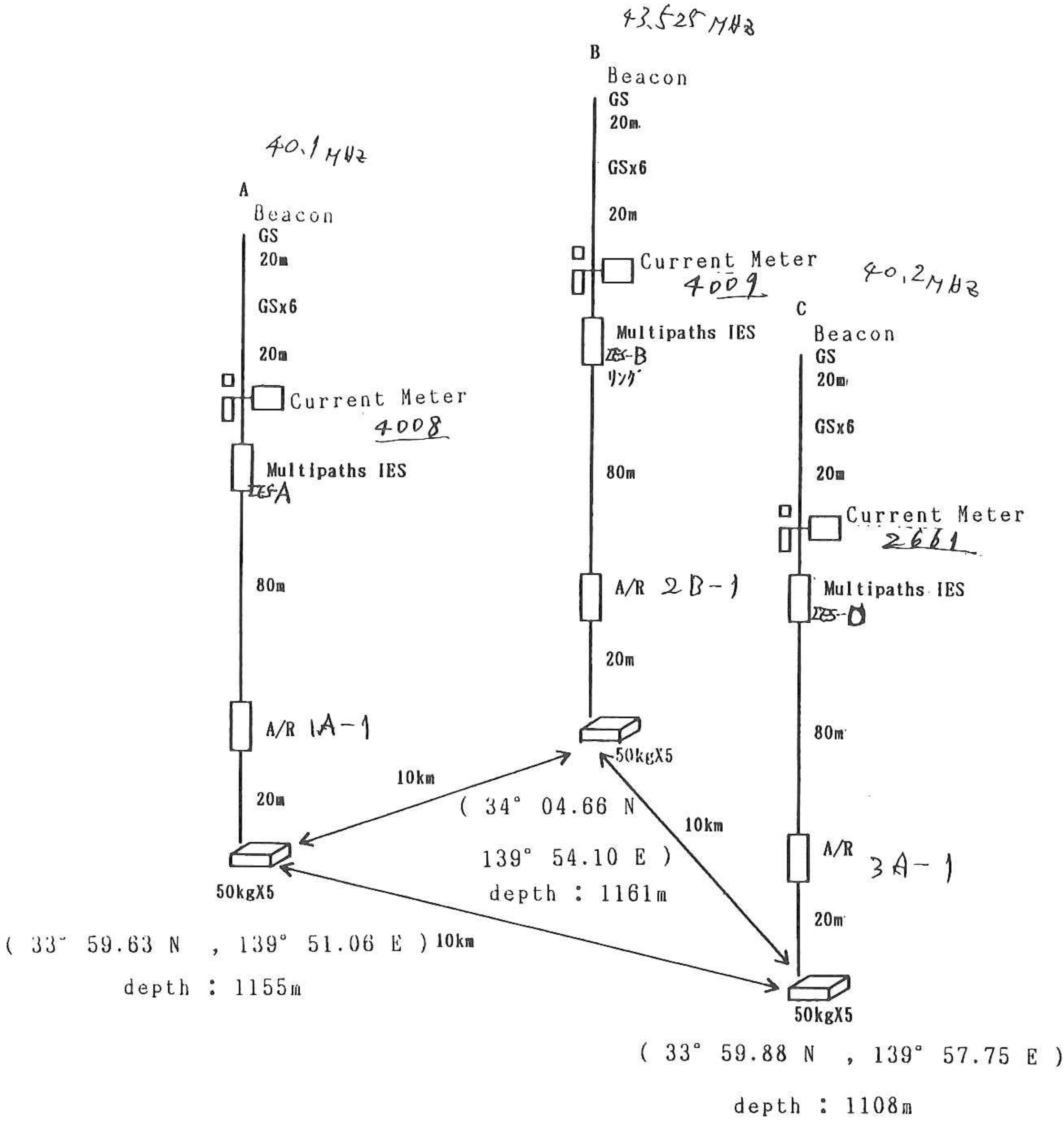


Figure 8-1-2: Deployment of IES

APPENDIX

Station and work log KH 92-2 (excerpt from log tape)

Leg 1: Tokyo (May 20) to Yokosuka (June 3) [JST=UT + 9]

M D	H M	Latitude	Longitude	Depth (m)	HDG (deg)	SPD (kt)	Remarks
0520	0323	35°38.510N	139° 46.740E	0	141	0.1	KH 92-2 LEG 1 TKY - YKSK
0520	0457	35°38.610N	139° 46.470E	0	184	0.1	UP & DOWN ANCHOR
0520	0501	35°38.200N	139° 46.160E	0	215	9.5	FULL AHEAD ENG
0520	0529	35°34.500N	139° 48.260E	0	135	3.7	PILOT LEFT Ship
0520	0530	35°34.470N	139° 48.350E	0	134	4.5	TANDEM MOTION
0520	0626	35°24.460N	139° 43.410E	0	229	16.5	A/CO TO 208
0520	0633	35°22.940N	139° 42.910E	0	185	16.5	A/CO TO 177
0520	0646	35°19.420N	139° 43.000E	3	143	11.0	Entered Uraga Suido Co.Var'ly Full Ahd
0520	0725	35°12.620N	139° 46.430E	6	196	13.9	Cleared out of Uraga Suido traffic route
0520	0725	35°12.550N	139° 46.410E	6	195	14.2	s/co on 195°
0520	0821	34°57.580N	139° 41.720E	26	194	16.4	a/co to 180°
0520	0834	34°54.085N	139° 41.880E	330	180	16.4	a/co to 168°
0520	0900	34°46.840N	139° 43.200E	306	168	16.2	SLOW AHEAD ENG
0520	0904	34°46.120N	139° 43.400E	170	168	5.8	**PROTON SURVEY START**
0520	0918	34°43.720N	139° 43.990E	77	168	15.5	RUNG UP ENGINES
0520	1036	34°22.937N	139° 48.245E	296	229	16.4	a/co to 230°
0520	1056	34°20.527N	139° 42.224E	83	238	16.2	a/co to 238°
0520	1111	34°18.280N	139° 37.780E	855	238	15.7	a/co to 240°
0520	1325	34°00.110N	139° 00.430E	190	249	15.8	a/co to 360°
0520	1327	34°00.290N	139° 00.080E	139	002	13.6	s/co on 360°
0520	1404	34°09.800N	139° 00.020E	209	356	16.4	USED ENGINES VARIOUSLY
0520	1423	34°13.130N	139° 00.020E	495	355	15.7	RUNG UP ENGINES
0520	1429	34°14.750N	138° 59.980E	149	355	16.4	a/co to 270°
0520	1436	34°14.920N	138° 57.830E	867	266	15.8	a/co to 180°
0520	1545	33°55.360N	138° 57.490E	173	181	15.8	a/co to 81 °
0520	1559	33°55.670N	139° 02.090E	147	065	16.2	a/co to 270°
0520	1626	33°55.560N	138° 55.190E	39	304	14.0	a/co to 000°
0520	1701	34°04.590N	138° 55.140E	255	351	16.1	9a/co to 103°
0520	1711	34°04.560N	138° 56.200E	93	097	16.4	CURRENT DATA BAD 5/20 1700 GMT
0520	1845	33°59.110N	139° 27.480E	584	106	16.1	a/co to 81 °
0520	1902	33°59.730N	139° 32.990E	732	082	16.4	a/co to 74 °
0520	2005	34°04.590N	139° 53.720E	1154	072	15.0	HALF AHEAD ENG
0520	2010	34°04.860N	139° 54.690E	1169	084	9.1	**8-SHAPE ROTATION** right turn
0520	2025	34°04.870N	139° 54.200E	1162	071	9.0	8-SHAPE ROTATION left turn
0520	2042	34°04.960N	139° 55.160E	1174	069	7.0	8-SHAPE ROTATION END
0520	2045	34°05.070N	139° 55.580E	1179	070	5.9	**PROTON SURVEY END**
0520	2109	34°04.600N	139° 54.230E	1164	312	1.4	LAUNCH **CURRENT METER #1**
0520	2114	34°04.660N	139° 54.100E	1161	313	2.6	END LAUNCH CURRENT METER #1
0520	2125	34°04.730N	139° 54.150E	1163	213	5.1	s/co on 210°
0520	2154	33°59.770N	139° 50.970E	1152	167	0.4	LAUNCH **CURRENT METER #2**
0520	2159	33°59.630N	139° 51.060E	1155	141	1.9	Finish launchCURRENT METER #2
0520	2240	33°59.940N	139° 57.750E	1110	167	0.5	LAUNCH **CURRENT METER #3**
0520	2244	33°59.880N	139° 57.750E	1108	161	1.2	Finish launch CURRENT METER #3
0520	2255	33°59.920N	139° 57.670E	1110	151	0.0	SLOW AHEAD ENG
0520	2257	33°59.790N	139° 57.760E	1102	157	5.4	**PROTON SURVEY START**

0520	2257	33°59.780N	139° 57.760E	1102	157	5.5	s/co on 157°
0520	2300	33°59.520N	139° 57.910E	1087	159	6.6	STOP'D NO.3 M/E
0520	2313	33°57.630N	139° 58.890E	991	158	9.5	REPAIRED NO.3 M/E
0520	2323	33°55.590N	139° 59.890E	879	159	15.9	RUNG UP ENGINES
0521	0400	32°51.970N	140° 31.430E	1441	159	16.5	COM`CED BOAT STATION DRILL
0521	0430	32°45.500N	140° 34.620E	1739	159	16.5	FINISHED DOING IT
0521	1228	30°48.160N	141° 31.930E	3934	157	16.1	a/co to 90 ° **SEABEAM SURVEY START**
0521	1720	30°48.030N	143° 09.840E	5712	089	15.7	SLOW AHEAD ENG
0521	1722	30°48.060N	143° 10.570E	5693	089	9.6	**8-SHAPE ROTATION** right turn
0521	1738	30°48.010N	143° 11.000E	5692	090	9.6	8-SHAPE ROTATION left turn
0521	1753	30°47.870N	143° 11.370E	5678	088	10.1	8-SHAPE ROTATION FINISH
0521	1800	30°48.690N	143° 11.170E	5636	310	15.7	RUNG UP ENGINES
0521	1805	30°49.510N	143° 09.950E	5720	268	14.3	s/co on 270°
0521	2332	30°49.510N	141° 32.250E	4144	273	15.5	a/co to 360°
0521	2337	30°50.770N	141° 32.060E	4156	001	15.7	a/co to 90 °
0522	0401	30°51.070N	142° 59.180E	6109	090	15.8	COM`CED FIRE STATION DRILL
0522	0436	30°51.030N	143° 09.990E	5635	092	15.7	a/co to 000°
0522	0441	30°52.240N	143° 10.320E	5610	357	16.2	a/co to 270°
0522	1001	30°52.460N	141° 32.230E	3978	268	16.8	a/co to 360°
0522	1006	30°53.760N	141° 31.950E	4001	001	16.4	a/co to 090°
0522	1457	30°54.010N	143° 10.080E	5581	088	15.9	a/co to 360°
0522	1502	30°55.240N	143° 10.450E	5552	354	15.9	a/co to 270°
0522	1516	30°55.510N	143° 06.400E	5691	270	16.4	CURRENT DATA BAD 5/22 1300 GMT
0522	2036	30°55.430N	141° 32.200E	3514	275	16.5	a/co to 360°
0522	2042	30°56.810N	141° 32.050E	3452	354	16.1	a/co to 090°
0523	0131	30°57.030N	143° 09.710E	5586	090	15.7	a/co to 360°
0523	0150	30°58.500N	143° 05.800E	5701	271	16.1	A/CO TO 270
0523	0400	30°58.510N	142° 26.420E	7829	269	16.8	COM`CED LEAK DRILL
0523	0430	30°58.510N	142° 17.290E	8471	267	16.1	DISMISSED LEAK DRILL
0523	0704	30°58.400N	141° 32.190E	3605	282	15.8	a/co to 360°
0523	0710	30°59.830N	141° 31.940E	3852	357	16.5	a/co to 090°
0523	0950	31°00.020N	142° 26.900E	7931	091	15.0	HALF AHEAD ENG
0523	1034	31°00.020N	142° 38.300E	6919	091	11.5	REPAIRED NO.3 M/E
0523	1043	30°59.990N	142° 40.890E	6793	090	13.2	FULL AHEAD ENG
0523	1048	30°59.980N	142° 42.180E	7230	089	14.9	RUNG UP ENGINES
0523	1208	31°00.010N	143° 09.670E	5659	088	15.8	a/co to 360°
0523	1213	31°01.310N	143° 10.010E	5680	346	16.5	a/co to 270°
0523	1744	31°01.420N	141° 31.960E	3862	275	16.5	**F/W Seabeam survey** and slow down engs
0523	1746	31°01.380N	141° 31.390E	3818	264	10.2	**8-SHAPE ROTATION** right turn
0523	1803	31°01.090N	141° 31.540E	3840	266	9.8	8-SHAPE ROTATION left turn
0523	1818	31°00.860N	141° 31.890E	3851	265	9.6	8-SHAPE ROTATION FINISH
0523	1827	31°01.670N	141° 30.260E	3685	355	14.8	RUNG UP ENGINES & s/co on 360°
0523	1920	31°15.480N	141° 30.110E	4570	359	15.0	HALF AHEAD ENG
0523	2017	31°15.950N	141° 33.630E	4618	188	6.0	Finished checking STEERING GEARS
0523	2021	31°15.990N	141° 33.090E	4605	294	9.7	FULL AHEAD ENG
0523	2028	31°16.790N	141° 31.740E	4696	314	15.5	RUNG UP ENGINES
0523	2036	31°18.470N	141° 30.070E	4617	357	16.1	CO 360

0524	0015	32°17.990N	141° 29.970E	4443	001	15.9	SLOW AHEAD ENG
0524	0023	32°19.030N	141° 30.010E	4380	359	3.1	**PROTON SURVEY END**
0524	0034	32°20.050N	141° 29.980E	4403	025	2.2	FINISH LAUNCH **OBS#1**
0524	0127	32°20.040N	141° 20.050E	3641	223	0.8	FINISH LAUNCH **OBS#2**
0524	0214	32°20.100N	141° 10.000E	3388	235	0.7	FINISH LAUNCH **OBS#3**
0524	0300	32°30.000N	141° 09.980E	2552	046	0.1	FINISH LAUNCH **OBS#4**
0524	0347	32°30.080N	141° 20.020E	3116	090	0.8	FINISH LAUNCH **OBS#5**
0524	0502	32°40.010N	141° 34.930E	5349	049	1.1	FINISH LAUNCH **OBS#6**
0524	0606	32°40.070N	141° 20.160E	3172	236	0.6	FINISH LAUNCH **OBS#7**
0524	0653	32°40.140N	141° 10.040E	2553	227	0.6	FINISH LAUNCH **OBS#8**
0524	0818	33°00.170N	141° 10.030E	2909	272	0.1	FINISH LAUNCH **OBS #9**
0524	1018	32°49.110N	140° 39.790E	1872	079	0.6	LAUNCH **OBS #10**
0524	1332	32°05.020N	140° 40.060E	2620	148	1.0	FINISH LAUNCH **OBS#11**
0524	1534	32°15.800N	140° 13.110E	1554	318	1.2	FINISH LAUNCH **OBS#12**
0524	1652	31°59.720N	140° 12.500E	1750	149	1.0	FINISH LAUNCH **OBE ORI**
0524	1655	31°59.610N	140° 12.730E	1760	159	1.6	COM`CED SHIFTING TO OBM C2
0524	1718	31°59.940N	140° 11.050E	1718	328	1.6	FINISH LAUNCH **OBM-C2**
0524	2018	32°17.860N	139° 54.920E	1338	183	0.5	FINISH LAUNCH **OBS #13**
0524	2131	32°15.800N	139° 37.900E	1580	107	0.2	FINISH LAUNCH **OBS #14**
0524	2205	32°11.880N	139° 44.050E	1576	301	0.7	FINISH LAUNCH **OBS #15**
0524	2239	32°11.930N	139° 38.000E	1597	341	0.6	FINISH LAUNCH **OBS #16**
0524	2311	32°12.040N	139° 31.980E	1263	226	0.6	FINISH LAUNCH **OBS#17**
0524	2346	32°06.990N	139° 37.960E	1440	176	0.9	FINISH LAUNCH **OBS#18**

0525	0051	31°52.930N	139° 45.110E	1366	119	0.7	FINISH LAUNCH **OBS#19**
0525	0402	32°15.930N	138° 59.960E	1483	289	1.4	FINISH LAUNCH **OBS #20**
0525	0409	32°15.880N	138° 59.900E	1473	270	1.9	Slow ahd ENG soon used ENG co varly
0525	0412	32°15.860N	138° 59.620E	1439	269	5.6	**PROTON SURVEY START**
0525	0418	32°15.820N	138° 58.720E	1481	270	10.1	**8-SHAPE ROTATION** right turn
0525	0433	32°15.660N	138° 58.670E	1509	269	9.8	8-SHAPE ROTATION left turn
0525	0449	32°15.510N	138° 58.660E	1534	261	10.1	8-SHAPE ROTATION FINISH
0525	0452	32°15.260N	138° 57.790E	1583	260	12.7	s/co on 266°
0525	0456	32°15.149N	138° 56.694E	1516	264	15.7	RUNG UP ENGINES
0525	0511	32°14.930N	138° 52.170E	1625	270	16.4	a/co to 270° **SEABEAM Survey START**
0525	0612	32°14.940N	138° 33.050E	3137	273	15.9	a/co to 360°
0525	0616	32°15.760N	138° 32.890E	3253	002	15.9	a/co to 90 °
0525	0713	32°16.000N	138° 51.970E	1600	065	15.8	a/co to 360°
0525	0717	32°16.930N	138° 52.090E	1566	339	15.8	a/co to 270°
0525	0819	32°16.950N	138° 33.230E	3312	275	15.8	a/co to 360°
0525	0823	32°17.790N	138° 32.990E	3351	354	16.4	a/co to 090°
0525	0919	32°18.110N	138° 52.060E	1529	032	14.4	a/co to 356°
0525	0923	32°18.850N	138° 52.100E	1510	347	16.1	a/co to 270°
0525	1026	32°18.950N	138° 33.030E	3212	296	14.3	a/co to 360°
0525	1030	32°19.820N	138° 32.970E	3203	356	16.2	5a/co to 090°
0525	1125	32°20.000N	138° 51.720E	1453	083	16.4	a/co to 360°
0525	1129	32°20.780N	138° 51.970E	1416	353	16.4	a/co to 270°
0525	1231	32°20.980N	138° 33.210E	3073	274	16.5	a/co to 360°
0525	1235	32°21.800N	138° 33.010E	3077	358	15.8	a/co to 90 °
0525	1331	32°22.050N	138° 51.760E	1395	078	16.8	a/co to 360°
0525	1334	32°22.830N	138° 51.930E	962	344	16.2	a/co to 270°
0525	1436	32°22.950N	138° 33.240E	3030	278	15.5	a/co to 360°
0525	1440	32°23.810N	138° 32.970E	3010	356	15.8	a/co to 90 °

0525	1537	32°24.020N	138° 51.940E	550	087	16.4	a/co to 360°
0525	1541	32°24.790N	138° 52.270E	509	349	15.8	a/co to 270°
0525	1644	32°24.940N	138° 33.090E	2946	274	16.2	a/co to 240°
0525	1740	32°17.480N	138° 18.000E	3939	250	15.5	a/co to 336°
0525	1747	32°18.820N	138° 17.100E	3962	005	14.6	a/co to 63 °
0525	1839	32°25.470N	138° 32.190E	3034	058	15.8	a/co to 336°
0525	1845	32°26.930N	138° 31.760E	3083	328	16.2	a/co to 240°
0525	1942	32°20.570N	138° 16.340E	3984	315	13.2	a/co to 336°
0525	1949	32°22.030N	138° 15.760E	3982	042	14.0	a/co to 063°
0525	2039	32°28.470N	138° 30.390E	3091	049	16.5	a/co to 336°
0525	2045	32°29.900N	138° 29.880E	3102	302	14.3	a/co to 243°
0525	2138	32°23.520N	138° 15.020E	3963	257	15.4	a/co to 336°
0525	2144	32°24.820N	138° 14.130E	3975	338	15.5	a/co to 063°
0525	2236	32°31.560N	138° 29.030E	3173	060	15.0	Finished Seabeam survey & half SP'D
0525	2238	32°31.720N	138° 29.430E	3219	082	10.2	a/co to 110°
0525	2240	32°31.650N	138° 29.760E	3240	111	10.1	8-SHAPE ROTATION right turn
0525	2255	32°31.550N	138° 29.950E	3242	106	10.2	8-SHAPE ROTATION left turn
0525	2310	32°31.480N	138° 29.950E	3232	102	9.5	8-SHAPE ROTATION FINISH
0525	2311	32°31.390N	138° 30.230E	3238	110	10.9	s/co on 110°
0525	2317	32°30.940N	138° 31.660E	3214	109	16.5	RUNG UP ENGINES

0526	0220	32°14.100N	139° 25.360E	1143	110	15.0	SLOW AHEAD ENG
0526	0224	32°13.830N	139° 26.040E	1045	128	3.3	PROTON SURVEY END
0526	0231	32°13.620N	139° 26.250E	1030	166	0.9	Changed prop to ELECTRIC MOTORS
0526	0341	32°11.360N	139° 26.860E	1051	067	3.9	AIR-GUN STARTED
0526	0350	32°11.500N	139° 27.440E	1040	064	3.7	LAUNCH OF STREAMER CABLE
0526	0450	32°12.040N	139° 32.005E	1262	086	4.4	START OF SEISMIC SURVEY
0526	0930	32°16.910N	139° 45.280E	1543	285	6.2	AIR-GUN STARTED
0526	0944	32°17.010N	139° 44.020E	1541	290	5.6	SET AIR-GUN SYSTEM
0526	0954	32°16.520N	139° 43.480E	1431	186	4.3	s/co on 174°
0526	1059	32°11.290N	139° 44.860E	1569	034	4.7	a/co to 270°
0526	1119	32°11.790N	139° 44.280E	1574	289	5.6	s/co on 270°
0526	1123	32°11.850N	139° 43.990E	1576	288	5.3	PASSED OBS#15
0526	1226	32°12.020N	139° 38.000E	1599	280	5.7	PASSED OBS#16
0526	1326	32°12.060N	139° 31.980E	1261	277	5.9	PASSED OBS#17
0526	1337	32°12.040N	139° 30.820E	1252	276	3.9	END OF SEISMIC SURVEY
0526	1434	32°11.730N	139° 27.380E	1020	275	3.4	AIR-GUN ENDED
0526	1436	32°11.740N	139° 27.260E	1017	283	4.4	a/co to 320°
0526	2156	32°41.130N	138° 55.860E	1783	313	6.3	AIR-GUN STARTED
0526	2235	32°43.860N	138° 52.910E	1796	356	5.8	a/co to 006°

0527	0326	33°07.550N	138° 55.720E	1832	350	5.2	END OF SEISMIC SURVEY
0527	0338	33°08.480N	138° 56.460E	1865	035	5.1	HOVE UP AIR-GUN
0527	0451	33°09.350N	139° 01.480E	1801	217	5.1	STREAMER WINCH TROUBLE
0527	0529	33°06.626N	138° 59.806E	1783	221	4.0	ResumedHEAVING streamer winch
0527	0636	33°04.180N	138° 57.920E	1848	243	0.6	RECOVERY OF STREAMER CABLE
0527	0643	33°04.200N	138° 58.000E	1846	276	0.4	Changed prop to DIESEL ENGINES
0527	0644	33°04.200N	138° 58.040E	1845	281	0.4	SLOW AHEAD ENG
0527	0648	33°04.180N	138° 57.960E	1849	219	5.1	s/co on 220°
0527	0650	33°04.000N	138° 57.860E	1850	220	6.3	PROTON SURVEY START
0527	0702	33°02.490N	138° 56.510E	1870	220	14.8	RUNG UP ENGINES
0527	0748	32°53.700N	138° 47.470E	1751	217	15.5	a/co to 217°

0527	0955	32°27.300N 138° 24.060E	3165	223	16.1	a/co to 220°
0527	1151	32°04.100N 138° 01.100E	3950	223	16.4	SLOW AHEAD ENG
0527	1158	32°03.460N 138° 00.430E	3939	250	2.5	**PROTON SURVEY FINISH**
0527	1158	32°03.460N 138° 00.420E	3938	248	2.3	STOP ENG
0527	1201	32°03.450N 138° 00.410E	3938	224	0.9	Changed prop to ELECTRIC MOTORS
0527	1236	32°05.760N 138° 00.030E	3964	348	5.3	**AIR-GUN STARTED**
0527	1250	32°06.940N137 59.990E	3815	349	5.2	**LAUNCH OF STREAMER CABLE**
0527	1254	32°07.240N137 59.960E	3823	349	5.5	**PROTON SURVEY START**
0527	1727	32°29.510N137 59.900E	3971	346	5.5	END OF SEISMIC SURVEY **ESP-2**
0527	1729	32°29.740N137 59.900E	3978	332	5.1	A/CO TO VAR'LY
0527	1803	32°29.350N137 58.060E	3973	195	4.9	s/co on 180°
0527	2048	32°16.770N137 52.260E	4041	220	5.2	USED CO VAR'LY
0527	2110	32°15.680N137 53.770E	4044	085	5.8	s/co on 090°
0527	2230	32°15.960N 138° 02.140E	3865	087	3.9	Com'ced **airgun survey** at 32-16N 138-02E
0528	1348	32°15.880N 139° 20.000E	1279	078	4.0	END SEISMIC SURVEY ON **COP-1**
0528	1402	32°15.140N 139° 20.140E	1284	241	4.8	a/co to 215°
0528	1940	31°52.020N 139° 01.540E	1939	190	4.8	a/co to 190°
0528	1953	31°51.050N 139° 01.150E	1870	280	3.7	a/co to 280°
0528	2006	31°51.140N 139° 00.230E	1837	352	4.4	a/co to 360°
0528	2030	31°52.860N 139° 00.040E	1664	358	4.2	Com'ced **AIR GUN survey** by TWO SHIP
0528	2208	32°00.830N 139° 00.310E	1945	353	5.9	PASSED TANSEI MARU
0529	0110	32°16.040N 138° 59.930E	1486	356	5.4	**END** SEISMIC SURVEY ON **EPS-3**
0529	0120	32°16.710N 139° 00.600E	1212	061	5.9	s/co on 77 °
0529	0155	32°18.330N 139° 03.820E	1419	064	5.8	a/co to 79 °
0529	0736	32°22.000N 139° 37.990E	1390	181	3.0	Com'ced **AIR GUN survey** by 2-ship
0529	0932	32°12.620N 139° 38.110E	1597	184	3.7	Passed TANSEIMARU on STBD SIDE
0529	1557	31°41.920N 139° 38.040E	1434	188	4.5	END SEISMIC SURVEY of LINE **ESP-4**
0529	1557	31°41.880N 139° 38.040E	1433	186	4.6	a/co to 80 °
0529	2042	31°46.950N 140° 12.890E	1959	345	5.4	s/co on 360°
0530	0137	32°06.000N 140° 12.890E	1645	337	6.3	**START** OF SEISMIC SURVEY ON **ESP-5**
0530	0240	32°09.740N 140° 13.220E	1614	339	6.0	Passed TANSEI MARU ON PORT SIDE
0530	0759	32°25.270N 140° 12.960E	1608	360	6.1	END SEISMIC SURVEY of LINE **ESP-5**
0530	0759	32°25.270N 140° 12.960E	1607	359	6.1	**PROTON SURVEY END**
0530	0815	32°25.920N 140° 12.880E	1590	000	4.4	**AIR-GUN ENDED**
0530	0833	32°26.450N 140° 12.750E	1565	360	4.4	**AIR GUN STARTED TEST**
0530	0927	32°28.240N 140° 13.040E	1482	011	4.7	**AIR-GUN ENDED (TEST)**
0530	0942	32°28.280N 140° 12.980E	1476	315	0.8	RECOVERY OF STREAMER CABLE
0530	0944	32°28.260N 140° 12.950E	1479	310	0.9	Changed prop to DIESEL ENGINES
0530	0944	32°28.260N 140° 12.950E	1479	310	0.9	SLOW AHEAD ENG
0530	0947	32°28.290N 140° 12.940E	1476	020	5.2	**PROTON SURVEY START**
0530	0954	32°28.720N 140° 13.180E	1485	083	8.0	s/co on 093°
0530	1002	32°28.740N 140° 15.040E	1556	082	14.3	RUNG UP ENGINES
0530	1022	32°28.520N 140° 21.100E	2294	085	15.9	a/co to 089°
0530	1454	32°30.030N 141° 46.530E	6837	092	16.1	SLOW AHEAD ENG
0530	1459	32°30.060N 141° 47.300E	6958	098	2.5	**PROTON SURVEY FINISH**
0530	1500	32°30.060N 141° 47.320E	6957	096	2.4	STOP ENG
0530	1504	32°30.110N 141° 47.300E	6962	128	0.9	Changed prop to ELECTRIC MOTORS
0530	1635	32°29.280N 141° 47.720E	7068	209	3.9	LAUNCH STREAMER CABLE OF **ESP-6**
0530	1653	32°28.570N 141° 47.080E	7036	206	3.5	AIR-GUN STARTED OF NO-1

0530	1708	32°27.800N	141° 46.610E	7130	195	3.5	AIR-GUN STARTED OF NO-4
0530	1802	32°23.340N	141° 47.950E	7468	180	5.8	PROTON SURVEY START
0530	1830	32°20.690N	141° 48.010E	7458	179	6.0	START OF SEISMIC SURVEY OF ESP-6
0530	2028	32°11.210N	141° 48.190E	6311	196	3.5	Passed TANSEI MARU on STBD SIDE
0531	0100	31°49.980N	141° 47.870E	6788	195	4.2	END OF SEISMIC SURVEY ON ESP-6
0531	0111	31°49.320N	141° 47.840E	6792	195	2.5	PROTON SURVEY END
0531	0126	31°48.380N	141° 47.810E	6790	191	2.9	AIR-GUN ENDED
0531	0219	31°45.580N	141° 47.920E	6789	192	1.8	RECOVERY OF STREAMER CABLE
0531	0227	31°45.500N	141° 48.010E	6789	254	0.3	Changed prop to DIESEL ENGINES
0531	0227	31°45.500N	141° 48.010E	6785	257	0.3	SLOW AHEAD ENG
0531	0230	31°45.630N	141° 47.890E	6786	331	5.8	s/co on 338°
0531	0232	31°45.820N	141° 47.800E	6787	332	6.1	PROTON SURVEY START
0531	0247	31°48.580N	141° 46.500E	6770	334	16.2	RUNG UP ENGINES
0531	0825	33°14.995N	141° 04.787E	2828	339	16.7	HALF AHEAD ENG
0531	0832	33°15.910N	141° 04.370E	2873	320	2.2	PROTON SURVEY END
0531	0833	33°15.930N	141° 04.350E	2876	317	1.0	STOP ENG
0531	0837	33°16.110N	141° 04.350E	2892	299	0.9	Changed prop to ELECTRIC MOTORS
0531	0843	33°16.170N	141° 04.180E	2899	212	1.8	LAUNCH OF STREAMER CABLE
0531	0854	33°15.910N	141° 04.330E	2863	156	4.7	s/co on 164°
0531	0858	33°15.740N	141° 04.490E	2832	162	4.6	AIR-GUN STARTED
0531	0908	33°15.170N	141° 04.720E	2823	170	5.0	OTHER AIR-GUN STARTED
0531	0916	33°14.610N	141° 04.880E	2838	170	4.8	PROTON SURVEY START
0531	1000	33°11.660N	141° 05.870E	2737	168	5.6	START OF SEISMIC SURVEY
0531	1217	33°00.570N	141° 09.990E	2887	165	4.4	PASSED TANSEI MARU
0531	1847	32°31.120N	141° 21.020E	3157	175	5.4	END OF SEISMIC SURVEY OF ESP-7
0531	1847	32°31.050N	141° 21.020E	3164	183	5.4	a/co to 185°
0531	2056	32°20.000N	141° 20.050E	3641	189	6.1	Passed over OBS-2 & USED CO VAR'LY
0531	2104	32°19.640N	141° 19.320E	3621	270	5.9	s/co on 270°
0531	2224	32°20.000N	141° 09.900E	3411	295	4.2	PASSED OVER OBS-3
0531	2253	32°22.410N	141° 10.020E	3198	007	3.5	s/co on 360°
0531	2300	32°23.040N	141° 09.970E	3186	015	3.4	START OF SEISMIC SURVEY
0601	0035	32°30.740N	141° 09.970E	2501	012	4.0	MET WITH TANSEI MANU
0601	0355	32°47.020N	141° 10.050E	2457	011	4.9	END OF SEISMIC SURVEY OF ESP-8
0601	0356	32°47.170N	141° 10.060E	2462	004	4.9	a/co to 241°
0601	0455	32°46.580N	141° 05.210E	2432	244	4.0	a/co to 247°
0601	0623	32°45.140N	140° 55.470E	2479	250	3.9	a/co to 180°
0601	0800	32°38.310N	140° 55.040E	2644	162	6.3	START OF SEISMIC SURVEY
0601	0951	32°30.290N	140° 55.080E	2796	160	6.4	PassedTANSEI MARU on STBD SIDE
0601	1300	32°15.680N	140° 55.120E	3074	182	5.5	END OF SEISMIC SURVEY ON ESP-9
0601	1305	32°15.300N	140° 55.100E	3096	181	3.4	PROTON SURVEY END
0601	1321	32°14.760N	140° 55.050E	3123	180	3.1	AIR-GUN ENDED
0601	1358	32°13.980N	140° 55.060E	3125	181	1.6	RECOVERY OF STREAMER CABLE
0601	1403	32°13.930N	140° 55.090E	3129	192	1.0	Changed prop to DIESEL ENGINES
0601	1406	32°13.940N	140° 55.030E	3129	231	1.7	SLOW AHEAD ENG
0601	1410	32°13.920N	140° 54.630E	3129	264	6.2	PROTON SURVEY START
0601	1424	32°13.790N	140° 51.820E	3129	260	11.5	USED ENGINES VARIOUSLY
0601	1646	32°10.730N	140° 21.040E	1790	272	11.3	Current data are usable after 6/1 15H
0601	1936	32°07.290N	139° 41.770E	1515	270	11.3	HALF AHEAD ENG
0601	2001	32°06.850N	139° 37.470E	1468	273	6.0	PROTON SURVEY END
0601	2006	32°06.770N	139° 37.150E	1425	281	0.8	STOP ENG

0601	2009	32°06.700N	139° 37.000E	1426	308	0.9	Changed prop to ELECTRIC MOTORS
0601	2035	32°06.680N	139° 38.140E	1446	152	0.1	RELEASE FOR OBS-18
0601	2120	32°06.640N	139° 37.690E	1399	153	0.3	POPPING UP OF OBS-18
0601	2138	32°06.290N	139° 37.910E	1440	125	0.9	FINISH **RETREIVE OBS-18**
0601	2143	32°06.160N	139° 37.870E	1404	134	0.7	Changed prop to DIESEL ENGINES
0601	2143	32°06.140N	139° 37.870E	1404	138	2.2	SLOW AHEAD ENG
0601	2147	32°05.960N	139° 37.680E	1412	290	7.2	s/co on 284°
0601	2156	32°06.350N	139° 35.490E	1364	290	15.3	RUNG UP ENGINES
0601	2304	32°11.170N	139° 13.490E	1403	277	16.5	a/co to 277°
0601	2323	32°11.690N	139° 07.280E	1663	298	14.3	SLOW AHEAD ENG
0601	2327	32°11.970N	139° 07.240E	1643	108	1.2	STOP ENG
0601	2333	32°11.830N	139° 07.330E	1635	104	2.3	Changed prop to ELECTRIC MOTORS
0601	2350	32°12.000N	139° 08.460E	1604	080	4.2	**AIR-GUN STARTED**
0602	0008	32°12.040N	139° 10.190E	1593	084	4.7	s/co on 90 °
0602	0025	32°11.950N	139° 11.780E	1428	082	4.0	LAUNCH OF STREAMER CABLE
0602	0026	32°11.940N	139° 11.850E	1423	082	4.3	**PROTON SURVEY START**
0602	0026	32°11.940N	139° 11.860E	1423	082	4.2	**START OF SEISMIC SURVEY**
0602	1110	32°12.010N	140° 10.310E	1549	066	5.0	**END OF SEISMIC SURVEY**
0602	1116	32°11.970N	140° 10.720E	1555	067	3.4	**PROTON SURVEY END**
0602	1125	32°11.890N	140° 11.250E	1560	069	2.6	**AIR-GUN ENDED**
0602	1218	32°11.560N	140° 13.350E	1591	078	0.7	Changed prop to DIESEL ENGINES
0602	1219	32°11.540N	140° 13.350E	1592	081	1.1	RECOVERY OF STREAMER CABLE
0602	1219	32°11.520N	140° 13.350E	1593	075	1.0	SLOW AHEAD ENG & s/co on 346°
0602	1235	32°13.550N	140° 12.620E	1570	351	15.5	RUNG UP ENGINES
0602	2155	34°42.900N	139° 30.360E	705	342	15.4	FULL AHEAD ENG
0602	2201	34°43.620N	139° 30.050E	705	287	0.9	STOP ENG
0602	2203	34°43.690N	139° 30.090E	705	254	0.5	CHANGED ENG TO S/M
0602	2350	34°44.800N	139° 29.640E	705	311	2.0	SLOW AHEAD ENG
0602	2350	34°44.800N	139° 29.630E	705	313	2.0	a/co to 37 °
0603	0114	34°58.200N	139° 41.670E	705	029	12.2	a/co to 17 °
0603	0205	35°07.590N	139° 45.800E	705	020	11.0	USED COURSE VARIOUSLY
0603	0236	35°12.610N	139° 46.900E	705	359	11.7	EnteredUraga Suido traffic route
0603	0322	35°18.780N	139° 42.450E	705	234	1.7	PILOT CAME ON BOARD
0603	0359	35°16.700N	139° 40.940E	705	004	0.2	LET GO ANCHOR
0603	0401	35°16.700N	139° 40.900E	705	004	0.1	SENT SHORE LINES
0603	0421	35°16.700N	139° 40.900E	705	017	0.1	PILOT LEFT SHIP
0603	0430	35°16.700N	139° 40.920E	705	017	0.0	Made Ship fast to Yokosuka Shinko #2

Leg 2: Yokosuka (June 9) to Tokyo (June 26) [JST=UT + 9]

M D	H M	Latitude	Longitude	Depth (m)	HDG (deg)	SPD (kt)	Remarks
0609	0438	35°16.660N	139°40.890E	0	018	0.1	PILOT CAME ON BOARD
0609	0451	35°16.690N	139°40.910E	0	019	0.2	COMMENCED TO HEAVE UP ANCHOR
0609	0457	35°16.690N	139°40.950E	0	028	0.2	UP & DOWN ANCHOR
0609	0457	35°16.690N	139°40.950E	0	027	0.2	SLOW AHEAD ENG
0609	0508	35°17.330N	139°42.020E	0	060	4.5	PILOT LEFT Ship
0609	0550	35°12.520N	139°46.520E	406	184	12.0	Cleared out Uraga Suido traffic route
0609	0550	35°12.460N	139°46.500E	406	185	12.0	s/co on 195°
0609	0558	35°10.460N	139°45.930E	552	195	14.1	RUNG UP ENGINES
0609	0654	34°55.520N	139°41.520E	494	189	17.1	a/co to 180°
0609	0730	34°44.790N	139°41.990E	694	184	16.7	FULL AHEAD ENG
0609	0732	34°44.430N	139°41.940E	461	188	15.8	PROTON SURVEY START
0609	0744	34°42.650N	139°41.930E	466	182	11.1	RUNG UP ENGINES
0609	1058	33°52.060N	139°41.950E	1024	190	14.5	a/co to 200°
0609	1408	33°05.070N	139°21.250E	1265	200	16.8	Half ahead ENG & used ENG VARIOUSL
0609	1411	33°04.410N	139°20.960E	1262	203	15.8	8-SHAPE ROTATION RIGHT TURNING
0609	1426	33°04.300N	139°21.000E	1261	201	4.3	8-SHAPE ROTATION LEFT TURNING
0609	1441	33°04.230N	139°20.870E	1260	20	2.2	8-SHAPE ROTATION FINISH
0609	1444	33°03.630N	139°20.620E	1251	200	4.7	s/co on 200°
0609	1754	32°16.070N	138°59.940E	1488	259	10.0	PROTON SURVEY END
0609	1824	32°16.300N	138°59.860E	1471	354	0.3	RELEASE OBS-20
0609	1929	32°16.130N	138°59.920E	1479	268	1.1	POPPING UP OF OBS#20
0609	1949	32°15.780N	139°00.260E	1433	136	1.3	FINISH RETREIVE OBS#20
0609	2145	32°11.950N	139°32.130E	1265	007	7.8	RELEASE OBS#17
0609	2159	32°11.810N	139°32.500E	1264	121	2.6	RELEASE OBS#17
0609	2225	32°11.750N	139°32.400E	1270	314	1.6	POPPING UP OF OBS#17
0609	2247	32°11.320N	139°32.650E	1272	083	1.9	FINISH RETREIVE OBS#17
0609	2334	32°16.970N	139°38.170E	1420	001	4.4	RELEASE OBS#14
0610	0018	32°15.540N	139°38.040E	1567	175	1.9	POPPING UP OF OBS#14
0610	0029	32°15.270N	139°38.080E	1588	145	1.7	FINISH RETREIVE OBS#14
0610	0116	32°12.160N	139°38.100E	1604	137	0.9	RELEASE OBS#16
0610	0212	32°11.380N	139°38.000E	1607	155	1.8	POPPING UP OF OBS#16
0610	0220	32°11.010N	139°38.090E	1608	107	2.5	FINISH RETREIVE OBS#16
0610	0301	32°11.540N	139°42.630E	1589	026	3.0	RELEASE OBS#15
0610	0355	32°11.920N	139°44.030E	1581	355	0.9	POPPING UP OF OBS #15
0610	0400	32°11.800N	139°44.180E	1579	134	0.7	COM`CED BOAT DRILL
0610	0415	32°10.960N	139°44.390E	1574	154	2.6	FINISH RETREIVE OBS#15
0610	0541	31°52.700N	139°45.000E	1398	205	6.9	RELEASE OBS-19
0610	0633	31°52.390N	139°45.340E	1443	131	2.8	FINISH RETREIVE OBS#19
0610	0900	32°18.480N	139°54.660E	1330	098	0.2	RELEASE OBS#13
0610	0954	32°17.250N	139°54.840E	1444	128	2.4	FINISH RETREIVE OBS#13
0610	1107	32°15.780N	140°12.200E	1543	086	7.5	RELEASE OBS#12
0610	1151	32°16.000N	140°12.990E	1554	358	4.2	POPPING UP OF OBS#12
0610	1228	32°13.510N	140°13.290E	1581	137	3.7	FINISH RETREIVE OBS#12
0610	1429	32°05.480N	140°39.370E	2630	078	2.1	RELEASE OBS#11
0610	1505	32°05.640N	140°40.390E	2662	217	1.4	POPPING UP OF OBS#11

0610	1522	32°05.120N	140°40.970E	2668	203	1.9	FINISH RETREIVE **OBS #11**
0610	2018	32°49.160N	140°39.410E	1876	064	1.3	RELEASE OBS#10
0610	2051	32°49.120N	140°39.550E	1864	100	2.2	POPPING UP OF OBS#10
0610	2112	32°49.210N	140°38.740E	1834	224	2.0	FINISH RETREIVE **OBS#10**
0610	2321	33°00.020N	141°10.070E	2918	054	6.8	RELEASE OBS#9
0611	0049	33°00.520N	141°09.980E	2913	227	1.2	FINISH RETREIVE **OBS #9**
0611	0229	32°41.560N	141°09.830E	2541	086	1.5	RELEASE OBS#8
0611	0337	32°40.340N	141°09.870E	2556	118	0.3	POPPING UP OF OBS #8
0611	0350	32°40.800N	141°09.330E	2533	240	2.7	FINISH RETREIVE **OBS#8**
0611	0448	32°40.150N	141°20.050E	3184	118	6.6	RELEASE OBS #7
0611	0605	32°40.420N	141°20.100E	3233	123	1.3	POPPING UP OF OBS #7
0611	0728	32°41.500N	141°19.390E	3146	109	0.7	FINISH RETREIVE **OBS #7**
0611	0851	32°40.150N	141°35.020E	5372	122	1.2	RELEASE OBS #6
0611	1036	32°40.740N	141°36.190E	5488	126	0.5	POPPING UP OF OBS#6
0611	1124	32°39.830N	141°34.570E	5327	259	1.8	FINISH RETREIVE **OBS#6**
0611	1132	32°39.910N	141°34.590E	5326	308	0.6	CHANGED TO T/M
0611	1146	32°39.960N	141°36.700E	5439	096	7.5	**PROTON SURVEY START**
0611	1156	32°39.950N	141°38.620E	5533	088	9.7	RUNG UP ENGINES
0611	1433	32°39.980N	142°29.740E	7207	091	16.7	a/co to 180°
0611	1444	32°37.220N	142°29.980E	7482	188	12.8	a/co to 270°
0611	1819	32°37.050N	141°20.060E	3167	261	16.2	a/co to 180°
0611	1843	32°31.140N	141°19.990E	3102	179	14.1	SLOW AHEAD ENG
0611	1851	32°30.200N	141°19.960E	3134	225	9.5	**PROTON SURVEY END**
0611	1949	32°30.350N	141°20.360E	3155	334	1.3	RELEASE OBS#5 AT 0446
0611	2050	32°30.080N	141°20.000E	3129	314	2.9	POPPING UP OF OBS#5
0611	2139	32°31.560N	141°19.750E	2893	330	1.6	**START** TO RETRIEVE OF **OBS#5**
0611	2245	32°30.490N	141°09.680E	2520	341	1.9	RELEASE OBS#4 AT 0743
0611	2339	32°30.450N	141°09.890E	2514	340	0.2	POPPING UP OF OBS#4
0611	2349	32°30.670N	141°09.610E	2540	321	1.4	FINISH RETREIVE **OBS#4**
0612	0055	32°20.460N	141°10.080E	3344	331	3.8	RELEASE FOR OBS#3
0612	0408	32°24.440N	141°08.110E	2976	352	4.6	LET GO BUOY (Survey)
0612	0525	32°24.890N	141°06.830E	2868	294	1.7	FINISH RETREIVE **OBS-3**
0612	0722	32°20.540N	141°20.210E	3636	142	1.5	RELEASE OBS#2
0612	0833	32°20.510N	141°20.290E	3645	156	1.1	POPPING UP OF OBS#2
0612	0857	32°21.020N	141°19.900E	3546	001	1.4	FINISH RETREIVE **OBS#2**
0612	0940	32°19.950N	141°30.000E	4459	143	9.3	Com'ed DRIFTING
0612	1002	32°20.260N	141°30.390E	4516	148	1.5	RELEASE OBS#1
0612	1136	32°20.260N	141°30.180E	4467	149	0.8	POPPING UP OF OBS#1
0612	1150	32°20.390N	141°29.870E	4400	286	1.2	FINISH RETREIVE **OBS#1**
0612	1556	32°15.310N	142°39.430E	6259	149	3.8	LAUNCH OF **OBS-3A**
0612	1654	32°15.150N	142°50.730E	5850	073	5.4	FINISH TO LAUNCH OF **OBS-2A**
0612	1744	32°14.990N	142°59.920E	5655	107	8.0	FINISH TO LAUNCH OF **OBS-1A**
0612	1750	32°14.950N	142°59.930E	5656	139	3.8	SLOW AHEAD ENG
0612	1753	32°14.880N	143°00.040E	5660	090	3.2	s/co on 90 °
0612	1800	32°14.820N	143°00.630E	5655	086	3.6	**PROTON SURVEY START**
0612	1814	32°14.950N	143°03.450E	5597	089	10.4	RUNG UP ENG; **SEABEAM survey**
0612	1918	32°15.170N	143°22.710E	5560	002	15.5	a/co to 310°AT END OF LINE 1
0612	2245	32°52.050N	142°29.830E	7322	271	17.1	a/co to 270°& ENTERED IN LINE #1
0613	0049	32°52.000N	141°49.930E	7723	270	16.0	a/co to 180°

0613	0058	32°50.000N	141°50.010E	7327	088	10.9	a/co to 90 °& ENTERED LINE #2
0613	0302	32°50.010N	142°30.030E	6636	091	16.3	a/co to 180°
0613	0310	32°48.280N	142°30.320E	6567	181	11.1	a/co to 270°
0613	0400	32°48.010N	142°14.280E	6479	269	16.5	COM`CED LEAK DRILL
0613	0430	32°47.990N	142°04.790E	7487	270	16.3	FINISH WITH LEAK DRILL
0613	0516	32°48.010N	141°49.950E	7063	269	16.2	a/co to 180°
0613	0523	32°46.240N	141°49.600E	6733	178	11.6	a/co to 90 °
0613	0728	32°46.000N	142°29.810E	6413	099	16.2	a/co to 180°
0613	0735	32°44.240N	142°30.020E	6335	181	11.7	a/co to 270°
0613	0937	32°44.000N	141°50.220E	6323	265	16.6	a/co to 180°
0613	0944	32°42.220N	141°49.860E	6218	175	11.8	a/co to 090°
0613	1149	32°41.950N	142°30.060E	6894	097	16.1	a/co to 180°
0613	1219	32°33.940N	142°29.950E	7657	271	16.1	a/co to 270°
0613	1406	32°34.000N	141°55.090E	7834	270	16.5	a/co to 271°
0613	1525	32°34.540N	141°29.960E	4248	270	15.9	a/co to 180°
0613	1533	32°32.730N	141°29.680E	4163	175	11.1	a/co to 90 °
0613	1648	32°32.020N	141°55.190E	7719	075	17.2	a/co to 297°
0613	1717	32°35.480N	141°47.450E	6005	294	15.3	a/co to 270°
0613	1813	32°35.530N	141°29.930E	4134	270	16.0	a/co to 360°
0613	1823	32°38.300N	141°29.740E	4489	011	12.5	a/co to 90 °
0613	1912	32°38.460N	141°46.130E	5997	135	17.2	a/co to 240°
0613	2203	32°17.380N	141°01.690E	3471	229	9.0	SEABEAM/Proton SURVEY END
0613	2220	32°16.470N	140°59.960E	3416	215	5.3	Finish launch OBS-10A
0613	2359	32°16.360N	140°35.130E	2226	231	6.6	Finish launch OBS-12A
0614	0117	32°16.390N	140°14.550E	1584	255	12.1	Finish launch OBS-14A
0614	0225	32°16.360N	140°04.130E	1393	325	1.4	Finish launch OBS-15A
0614	0310	32°16.360N	139°53.780E	1451	238	11.8	LAUNCH OBS 16A
0614	0355	32°16.350N	139°43.480E	1484	274	11.4	Finish launch OBS 17A
0614	0441	32°16.280N	139°33.060E	1154	258	11.5	Finish launch OBS 18A
0614	0528	32°16.220N	139°22.810E	1183	272	10.1	Finish launch OBS 19A
0614	0615	32°16.100N	139°12.390E	1429	258	11.2	Finish launch OBS 20A
0614	0705	32°16.000N	139°02.120E	1548	250	10.5	Finish launch OBS-21A
0614	0811	32°15.870N	138°51.860E	1611	112	2.4	Finish launch OBS-22A
0614	0900	32°15.700N	138°41.400E	2291	146	9.3	Finish launch OBS-23A
0614	1002	32°15.550N	138°27.550E	3508	174	8.8	Finish launch OBS-24A
0614	1059	32°15.370N	138°13.730E	3786	003	11.7	Finish launch OBS-25A
0614	1156	32°15.000N	138°00.110E	3915	233	10.6	Finish launch OBS-26A
0614	1245	32°15.030N	137° 50.070E	4075	226	6.9	Changed prop to ELECTRIC MOTORS
0614	1333	32°15.090N	137° 54.630E	4042	096	5.4	AIR-GUN STARTED
0614	1340	32°15.060N	137° 55.430E	4035	097	5.4	LAUNCH OF STREAMER CABLE
0614	1340	32°15.060N	137° 55.440E	4034	096	5.4	START OF SEISMIC SURVEY
0614	2201	32°15.700N	138°43.590E	1788	098	5.1	END OF SEISMIC SURVEY
0614	2340	32°17.630N	138°53.250E	1597	026	4.7	AIR-GUN ENDED
0615	0028	32°19.010N	138°56.090E	1365	021	3.3	RECOVERY OF STREAMER CABLE
0615	0035	32°19.150N	138°56.460E	1325	332	2.9	Changed prop to DIESEL ENGINES
0615	0037	32°19.190N	138°56.510E	1324	312	2.9	SLOW AHEAD ENG
0615	0042	32°19.040N	138°56.400E	1327	218	0.9	s/co on 219°;PROTON SURVEY START
0615	0055	32°17.080N	138°54.700E	1584	225	9.4	RUNG UP ENGINES
0615	0416	31°35.930N	138°15.350E	3878	222	16.7	a/co to 90 °COM`CED SEABEAM SURVEY
0615	0447	31°35.520N	138°25.030E	3611	088	16.2	a/co to 180°

0615	0453	31°34.270N	138°25.470E	3611	188	12.2	a/co to 270°
0615	0528	31°34.010N	138°14.970E	3924	275	15.5	a/co to 180°
0615	0533	31°32.900N	138°14.600E	3930	181	12.1	a/co to 90 °
0615	0606	31°32.700N	138°25.000E	3509	089	16.3	a/co to 180°
0615	0610	31°31.680N	138°25.360E	3521	180	12.8	a/co to 270°
0615	0645	31°31.420N	138°14.920E	3934	271	15.5	a/co to 180°
0615	0650	31°30.370N	138°14.620E	3931	183	11.8	a/co to 90 °
0615	0723	31°30.050N	138°25.030E	3555	064	16.1	a/co to 360°
0615	0725	31°30.420N	138°25.250E	3550	008	14.8	a/co to 270°
0615	0747	31°30.610N	138°18.690E	3121	263	13.5	a/co to 180°
0615	0752	31°29.560N	138°18.530E	3116	135	10.5	a/co to 090°
0615	0812	31°29.570N	138°24.820E	3565	095	14.1	a/co to 180°
0615	0815	31°28.950N	138°25.150E	3566	171	12.5	a/co to 270°
0615	0848	31°28.750N	138°15.120E	3924	272	15.6	a/co to 180°
0615	0853	31°27.650N	138°14.810E	3893	175	12.1	a/co to 090°
0615	0925	31°27.470N	138°24.810E	3527	088	15.7	a/co to 180°
0615	0930	31°26.340N	138°25.140E	3534	181	12.3	a/co to 270°
0615	0955	31°26.090N	138°17.270E	3812	271	15.1	a/co to 188°
0615	1020	31°19.360N	138°16.010E	3776	190	16.4	HALF AHEAD ENG
0615	1025	31°18.410N	138°15.800E	3724	195	14.2	**8-SHAPE ROTATION** RIGHT TURNING
0615	1040	31°18.210N	138°15.680E	3716	193	3.9	8-SHAPE ROTATION LEFT TURNING
0615	1055	31°17.990N	138°15.520E	3691	188	2.6	8-SHAPE ROTATION FINISH
0615	1100	31°16.950N	138°15.360E	3653	189	7.2	RUNG UP ENGINES
0615	1110	31°14.000N	138°15.050E	3794	253	14.1	a/co to 270°
0615	1154	31°14.040N	138°00.950E	4063	269	16.8	a/co to 180°
0615	1200	31°12.640N	138°00.770E	4067	094	12.1	a/co to 90 °
0615	1246	31°12.540N	138°15.020E	3795	095	16.4	a/co to 180°
0615	1251	31°11.360N	138°15.110E	3787	267	11.8	a/co to 270°
0615	1335	31°11.430N	138°00.960E	3964	263	16.5	a/co to 180°
0615	1340	31°10.430N	138°00.900E	3886	095	11.5	a/co to 90 °
0615	1425	31°10.350N	138°15.015E	3805	092	16.2	a/co to 180°
0615	1429	31°09.420N	138°15.150E	3814	260	12.9	a/co to 270°
0615	1515	31°09.420N	138°00.940E	3838	264	15.9	a/co to 180°
0615	1519	31°08.470N	138°00.640E	3847	181	12.7	a/co to 90 °
0615	1606	31°08.050N	138°15.060E	3815	094	16.3	a/co to 180°
0615	1611	31°07.030N	138°15.430E	3807	180	11.8	a/co to 270°
0615	1700	31°06.720N	138°00.920E	3844	266	14.4	a/co to 35 °
0615	1700	31°06.720N	138°00.920E	3844	266	14.4	a/co to 35 °
0615	1711	31°08.980N	138°01.930E	3781	034	9.9	Current data unusable due to strong wind
0615	1712	31°09.310N	138°02.190E	3784	035	10.6	from 6/16 1400 - 1700 GMT
0615	1816	31°23.790N	138°14.870E	3807	039	16.9	a/co to 90 °
0615	1916	31°23.990N	138°34.850E	3236	100	17.1	a/co to 180°
0615	1921	31°23.020N	138°35.110E	3178	187	12.5	a/co to 270°
0615	2031	31°22.750N	138°15.110E	3806	257	14.8	a/co to 180°
0615	2035	31°21.775N	138°14.910E	3799	171	11.0	a/co to 090°
0615	2139	31°20.830N	138°35.110E	2887	187	13.4	a/co to 270°
0615	2249	31°20.570N	138°15.090E	3782	263	14.4	a/co to 180°
0615	2253	31°19.790N	138°14.780E	3743	178	11.8	a/co to 090°
0615	2355	31°19.550N	138°35.000E	2762	085	16.9	USED COURSE VARIOUSLY
0615	2359	31°19.940N	138°34.700E	2830	275	9.9	a/co to 270°

0616	0041	31°19.990N	138°22.480E	2627	269	14.9	USED COURSE VARIOUSLY

0616	0052	31°18.750N	138°20.020E	3088	077	12.1	a/co to 90 °
0616	0138	31°18.770N	138°35.040E	2890	088	16.7	a/co to 180°
0616	0143	31°17.800N	138°35.030E	2894	272	11.8	a/co to 270°
0616	0250	31°17.720N	138°14.974E	3656	272	15.6	a/co to 180°
0616	0255	31°16.810N	138°14.940E	3657	090	12.0	a/co to 90 °
0616	0358	31°16.750N	138°35.030E	2892	084	16.4	a/co to 180°
0616	0401	31°15.990N	138°35.310E	2916	198	13.2	a/co to 270°
0616	0507	31°15.810N	138°15.000E	3745	274	16.2	a/co to 180°
0616	0513	31°14.730N	138°15.190E	3791	091	9.6	a/co to 90 °
0616	0618	31°14.830N	138°35.030E	2970	089	15.7	a/co to 180°
0616	0623	31°13.830N	138°35.000E	2981	274	10.3	a/co to 270°
0616	0723	31°13.770N	138°15.020E	3793	243	17.2	a/co to 180°
0616	0836	31°12.810N	138°34.910E	2944	089	15.1	a/co to 180°
0616	0839	31°12.020N	138°35.160E	2993	188	11.9	a/co to 270°
0616	0939	31°11.830N	138°15.180E	3796	267	17.4	a/co to 180°
0616	0943	31°11.050N	138°14.840E	3781	174	13.9	a/co to 090°
0616	1054	31°10.770N	138°35.050E	3135	111	14.8	a/co to 180°
0616	1058	31°09.790N	138°35.120E	3204	225	11.5	a/co to 270°
0616	1159	31°09.840N	138°14.970E	3815	267	17.0	a/co to 180°
0616	1204	31°08.890N	138°15.010E	3815	097	11.6	a/co to 90 °
0616	1312	31°08.800N	138°35.040E	3239	093	15.2	a/co to 180°
0616	1317	31°07.830N	138°34.970E	3239	271	10.5	a/co to 270°
0616	1419	31°07.800N	138°14.920E	3815	270	16.6	a/co to 70 °
0616	1459	31°11.400N	138°25.830E	2507	073	15.6	a/co to 90 °
0616	1517	31°11.440N	138°31.330E	2618	077	15.4	a/co to 45 °
0616	1521	31°12.020N	138°32.020E	2790	046	14.7	a/co to 270°
0616	1544	31°12.280N	138°24.840E	2298	275	14.6	a/co to 360°
0616	1549	31°13.270N	138°25.000E	2547	094	9.6	a/co to 90 °
0616	1612	31°13.190N	138°32.060E	2803	093	14.5	a/co to 320°
0616	1619	31°14.240N	138°31.130E	2750	266	6.2	a/co to 270°
0616	1638	31°14.180N	138°24.790E	2524	267	14.8	a/co to 303°
0616	1645	31°15.010N	138°22.870E	2611	302	15.1	a/co to 90 °
0616	1707	31°15.350N	138°29.200E	2537	094	13.7	a/co to 38 °
0616	1714	31°16.520N	138°29.780E	2588	266	11.2	a/co to 270°
0616	1737	31°16.390N	138°22.410E	2412	272	15.1	a/co to 360°
0616	1741	31°17.370N	138°22.430E	2414	091	11.9	a/co to 90 °
0616	1807	31°17.340N	138°30.380E	2590	094	14.9	a/co to 60 °
0616	1816	31°18.510N	138°32.010E	2433	266	12.9	a/co to 270°
0616	1910	31°18.290N	138°14.680E	3663	262	16.4	a/co to 098°
0616	2018	31°16.030N	138°35.090E	2913	098	16.3	a/co to 090°
0616	2113	31°16.010N	138°52.320E	2752	093	16.1	a/co to 360°
0616	2116	31°16.850N	138°52.630E	2668	354	13.4	a/co to 270°
0616	2212	31°16.960N	138°35.180E	2871	274	16.0	a/co to 360°
0616	2216	31°17.740N	138°34.910E	2900	001	12.7	a/co to 090°
0616	2257	31°18.010N	138°48.160E	2187	091	16.4	FULL AHEAD ENG
0616	2305	31°18.020N	138°50.080E	2159	090	14.3	RUNG UP ENGINES
0616	2312	31°17.990N	138°52.540E	2586	089	15.6	a/co to 360°
0616	2318	31°19.020N	138°52.580E	2482	267	10.6	a/co to 270°
0617	0015	31°18.960N	138°34.910E	2878	278	15.9	a/co to 360°
0617	0020	31°19.910N	138°35.050E	2792	083	9.5	a/co to 90 °
0617	0113	31°20.010N	138°52.550E	2256	086	17.2	a/co to 360°

0617	0118	31°21.020N	138°52.510E	2035	270	11.3	a/co to 270°
0617	0215	31°20.970N	138°34.930E	2945	275	16.0	a/co to 360°
0617	0220	31°21.940N	138°35.010E	3083	090	9.5	a/co to 90 °
0617	0313	31°22.010N	138°52.550E	1798	089	16.8	a/co to 360°
0617	0317	31°22.745N	138°52.959E	1785	354	13.4	a/co to 270°
0617	0416	31°23.010N	138°34.950E	3183	272	15.9	a/co to 360°
0617	0421	31°23.930N	138°34.940E	3230	091	11.6	a/co to 90 °
0617	0514	31°23.970N	138°52.560E	1947	087	16.9	a/co to 360°
0617	0520	31°24.930N	138°52.510E	1968	268	10.3	a/co to 270°
0617	0616	31°25.030N	138°34.950E	3264	272	16.3	a/co to 360°
0617	0621	31°25.990N	138°34.980E	3305	090	10.5	a/co to 90 °
0617	0715	31°25.980N	138°52.500E	2105	096	16.6	a/co to 251°
0617	0747	31°23.370N	138°43.860E	2307	091	13.5	a/co to 090°
0617	0806	31°23.450N	138°50.140E	1945	100	13.9	a/co to 136°
0617	0811	31°22.660N	138°51.370E	1911	151	14.4	a/co to 270°
0617	0858	31°22.520N	138°36.580E	2602	250	16.6	a/co to 180°
0617	0902	31°21.710N	138°36.360E	2623	170	12.9	a/co to 090°
0617	0952	31°21.470N	138°51.960E	1833	101	16.3	a/co to 180°
0617	0956	31°20.520N	138°51.890E	2025	272	11.9	a/co to 270°
0617	1046	31°20.510N	138°35.970E	2573	223	16.6	a/co to 159°
0617	1050	31°19.660N	138°36.130E	2492	159	11.1	a/co to 090°
0617	1143	31°19.470N	138°52.570E	2383	083	16.3	a/co to 346°
0617	1302	31°40.530N	138°46.480E	2154	269	16.8	a/co to 270°
0617	1407	31°40.480N	138°27.420E	3587	269	14.9	a/co to 360°
0617	1412	31°41.480N	138°27.480E	3574	094	9.4	a/co to 90 °
0617	1508	31°41.480N	138°46.610E	2228	093	17.6	a/co to 360°
0617	1514	31°42.530N	138°46.500E	2089	265	8.8	a/co to 270°
0617	1522	31°42.520N	138°44.330E	2288	267	6.2	FULL AHEAD ENG
0617	1536	31°42.529N	138°40.674E	2625	265	11.9	Current data unusable from 6/17 08H GM
0617	1536	31°42.530N	138°40.610E	2612	265	11.9	due to strong wind
0617	1628	31°42.500N	138°27.460E	3541	267	13.0	a/co to 360°
0617	1630	31°42.740N	138°27.010E	3560	331	13.0	RUNG UP ENGINES
0617	1634	31°43.510N	138°27.450E	3474	095	8.9	a/co to 90 °
0617	1729	31°43.490N	138°46.630E	2058	092	17.9	a/co to 360°
0617	1736	31°44.430N	138°46.530E	1980	269	9.0	a/co to 270°& FULL AHEAD ENG
0617	1902	31°44.480N	138°27.610E	3433	268	11.0	a/co to 360°
0617	1907	31°45.290N	138°27.270E	3405	012	8.7	a/co to 090°
0617	2007	31°45.510N	138°46.510E	2027	079	16.5	a/co to 360°
0617	2010	31°46.100N	138°46.860E	1906	350	13.4	a/co to 270°
0617	2137	31°46.490N	138°27.670E	3301	280	11.8	a/co to 360°
0617	2141	31°47.200N	138°27.340E	3381	007	9.9	a/co to 090°
0617	2241	31°47.480N	138°46.400E	1923	079	16.2	a/co to 360°
0617	2245	31°48.320N	138°46.820E	1778	345	13.2	a/co to 270°

0618	0004	31°48.530N	138°27.450E	3335	272	12.8	a/co to 360°
0618	0010	31°49.430N	138°27.510E	3256	092	8.4	a/co to 90 °
0618	0113	31°49.490N	138°46.550E	1898	088	15.4	a/co to 360°
0618	0124	31°50.500N	138°45.370E	2031	271	3.5	a/co to 270°
0618	0240	31°50.520N	138°27.480E	3250	268	12.0	a/co to 360°
0618	0247	31°51.490N	138°27.400E	3270	092	7.8	a/co to 90 °
0618	0314	31°51.550N	138°35.050E	2729	095	14.2	a/co to 360°
0618	0320	31° 52.410N	138°35.020E	2786	275	7.7	a/co to 270°
0618	0353	31° 52.450N	138°27.420E	3330	271	11.6	a/co to 25 ° **F/W SEABEAM**

0618	0518	32°06.610N	138°34.660E	2413	341	4.7	Sea became rough & HEAVED TO
0618	0621	32°14.320N	138°39.710E	2717	061	10.3	STOP ENG
0618	0624	32°14.270N	138°39.710E	2717	100	7.1	PROTON SURVEY END
0618	0627	32°14.190N	138°39.720E	2714	112	4.3	Changed prop to ELECTRIC MOTORS
0618	0652	32°14.490N	138°40.960E	2429	049	2.6	AIR-GUN STARTED
0618	0720	32°15.340N	138°43.030E	1841	060	4.6	PROTON SURVEY START
0618	0724	32°15.440N	138°43.320E	1819	062	4.5	Current data unusable to O600 GMT
0618	0745	32°15.740N	138°45.310E	1739	075	4.7	ENTERED IN AIR-GUN SURVEY LINE
0618	2256	32°16.410N	140°13.430E	1562	071	4.1	PICKED UP ONE OF AIR-GUNS

0619	0014	32°16.560N	140°20.930E	1742	086	4.8	SET ONE AIRGUN AGAIN
0619	0931	32°16.460N	141°12.790E	3969	104	5.0	a/co to 091°

0620	0349	32°14.960N	142°59.970E	5659	098	5.4	END OF SEISMIC SURVEY
0620	0402	32°14.950N	143°01.140E	5654	097	4.7	AIR-GUN ENDED
0620	0407	32°14.930N	143°01.550E	5651	099	4.4	PROTON SURVEY FINISH
0620	0456	32°15.280N	143°04.690E	5603	053	2.9	RECOVERY OF STREAMER CABLE
0620	0602	32°15.080N	143°00.130E	5653	266	1.3	RELEASE OBS 1A

0621	2048	32°16.590N	141°00.290E	3449	229	0.4	POPPING UP OBS-10A
0621	2103	32°16.920N	140°59.070E	3376	308	3.3	FINISH RETREIVE OBS-10A
0621	2202	32°16.320N	140°47.610E	2755	189	3.1	RELEASE OBS-11A
0621	2250	32°16.500N	140°47.600E	2793	104	0.9	POPPING UP OBS-11A

0622	0036	32°16.700N	140°43.780E	2578	170	3.5	FINISH RETREIVE OBS-11A
0622	0122	32°16.230N	140°34.930E	2212	166	6.5	RELEASE OBS-12A
0622	0221	32°16.610N	140°34.290E	2195	021	3.9	POPPING UP OBS-12A
0622	0241	32°16.400N	140°34.550E	2201	299	0.5	FINISH RETREIVE OBS-12A
0622	0331	32°16.370N	140°24.890E	1870	296	6.1	RELEASE OBS-13A
0622	0419	32°16.050N	140°24.810E	1865	275	0.7	POPPING UP OBS-13A
0622	0424	32°15.980N	140°24.680E	1859	299	1.0	RELEASE OBS-13A
0622	0427	32°15.930N	140°24.660E	1856	282	0.9	PROCEEDED TO OBS-14A
0622	0517	32°16.330N	140°14.690E	1586	268	8.1	ARRIVED TO OBS-14A
0622	0520	32°16.290N	140°14.690E	1586	287	5.6	RELEASE OBS-14A
0622	0605	32°16.070N	140°14.600E	1584	330	1.0	POPPING UP OBS-14A
0622	0617	32°15.720N	140°14.770E	1590	296	1.2	FINISH RETREIVE OBS-14A
0622	0620	32°15.660N	140°14.830E	1592	326	1.3	PROCEEDED TO OBS-15A
0622	0650	32°16.090N	140°08.960E	1468	280	11.2	CURRENT USABLE 6/22 O700 GMT
0622	0728	32°16.030N	140°04.190E	1397	164	1.2	RELEASE OBS 15A
0622	0814	32°15.660N	140°04.420E	1404	245	2.1	FINISH RETREIVE OBS-15A
0622	1015	32°15.910N	139°54.020E	1448	232	1.2	POPPING UP OF OBS-16A
0622	1025	32°16.000N	139°54.080E	1450	333	0.4	FINISH RETREIVE OBS-16A
0622	1117	32°16.200N	139°43.370E	1503	179	6.3	RELEASE OBS-17A
0622	1201	32°16.030N	139°43.230E	1537	051	1.2	POPPING UP OF OBS-17A
0622	1215	32°15.710N	139°43.420E	1548	026	1.0	FINISH RETREIVE OBS-17A
0622	2038	32°16.160N	139°32.540E	1591	078	0.2	RELEASE OBS-18A
0622	2101	32°16.270N	139°33.150E	1170	043	1.5	POPPING UP OBS-18A
0622	2115	32°15.900N	139°33.310E	1179	264	1.6	FINISH RETREIVE OBS-18A
0622	2215	32°16.250N	139°23.320E	1173	057	1.6	RELEASE OBS-19A
0622	2237	32°15.910N	139°22.860E	1194	122	2.8	POPPING UP OBS-19A
0622	2248	32°15.820N	139°23.010E	1199	241	1.0	FINISH RETREIVE OBS-19A

0622	2337	32°16.010N	139°12.470E	1433	268	6.2	RELEASE OBS-20A
0623	0021	32°15.840N	139°12.310E	1448	022	0.2	POPPING UP OBS-20A
0623	0031	32°15.660N	139°12.530E	1440	231	1.0	FINISH RETREIVE **OBS-20A**
0623	0120	32°16.140N	139°02.200E	1532	259	5.8	RELEASE OBS-21A
0623	0201	32°15.960N	139°02.300E	1559	211	0.5	POPPING UP OBS-21A
0623	0211	32°15.560N	139°02.440E	1655	172	2.3	FINISH RETREIVE **OBS-21A**
0623	0259	32°15.840N	138°51.860E	1619	203	8.5	RELEASE OBS-22A
0623	0352	32°15.600N	138°52.330E	1607	346	2.0	POPPING UP OBS-22A
0623	0401	32°15.330N	138°52.190E	1612	175	1.1	FINISH RETREIVE **OBS 22A**
0623	0500	32°15.760N	138°41.340E	2305	215	5.8	RELEASE OBS-23
0623	0558	32°15.680N	138°41.360E	2320	208	1.3	POPPING UP OBS-23A
0623	0610	32°15.560N	138°41.610E	2221	187	1.7	FINISH RETREIVE **OBS-23A**
0623	0731	32°15.920N	138°27.380E	3546	226	2.6	RELEASE OBS-24A
0623	0839	32°15.170N	138°27.940E	3452	211	1.8	POPPING UP OBS-24A
0623	0907	32°15.830N	138°28.150E	3497	211	1.2	FINISH RETREIVE **OBS-24A**
0623	0915	32°15.920N	138°28.060E	3511	167	0.8	**PROTON/SEABEAM SURVEY START**
0623	0916	32°15.820N	138°28.130E	3503	138	0.1	s/co on 140°
0623	0925	32°14.960N	138°29.100E	3400	140	5.8	RUNG UP ENGINES
0623	0952	32°10.940N	138°31.880E	2610	249	10.0	a/co to 270°
0623	1143	32°11.030N	138°07.960E	3761	259	10.6	a/co to 180°
0623	1153	32°09.730N	138°08.000E	3672	104	6.5	a/co to 90 °
0623	1330	32°09.710N	138°32.060E	2660	097	12.5	a/co to 180°
0623	1341	32°08.510N	138°32.020E	2688	261	5.3	a/co to 270°
0623	1513	32°08.510N	138°14.310E	3555	263	9.3	WIND STRONG
0623	1550	32°08.510N	138°07.970E	3724	263	8.7	a/co to 180°
0623	1558	32°07.490N	138°07.810E	3786	196	6.2	a/co to 90 °
0623	1735	32°07.240N	138°32.030E	2692	095	12.8	a/co to 180°
0623	1745	32°06.070N	138°32.220E	2701	252	6.1	a/co to 270°
0623	1835	32°06.020N	138°24.380E	2812	264	8.1	HALF AHEAD ENG
0623	2045	32°06.000N	138°08.150E	3746	243	6.6	a/co to 180°
0623	2054	32°04.980N	138°08.250E	3875	173	5.0	a/co to 090°
0623	2100	32°04.720N	138°09.370E	3916	091	5.2	RUNG UP ENGINES
0623	2230	32°04.830N	138°31.930E	2561	097	12.7	a/co to 180°
0623	2237	32°03.700N	138°32.270E	2612	188	8.6	a/co to 270°
0624	0113	32°03.530N	138°07.980E	3885	269	8.4	a/co to 180°
0624	0124	32°02.100N	138°08.000E	3942	057	6.0	a/co to 90 °
0624	0304	32°02.220N	138°32.010E	2711	088	12.0	a/co to 180°
0624	0313	32°01.030N	138°32.080E	2679	270	6.7	a/co to 270°
0624	0411	32°01.010N	138°21.580E	1998	275	9.3	CURRENT UNUSABLE TO 6/24 0300 GMT
0624	0519	32°01.030N	138°07.970E	3979	270	10.2	**F/W SEABEAM** a/co to 333°
0624	0520	32°01.040N	138°07.800E	3970	304	10.2	SLOW AHEAD ENG
0624	0525	32°01.500N	138°07.560E	3950	356	7.4	Changed ENG to T/M HALF AHEAD ENG
0624	0531	32°02.200N	138°07.860E	3931	019	5.2	a/co to 20 °
0624	0632	32°14.990N	138°13.570E	3780	021	11.5	CHANGED ENG TO S/M
0624	0633	32°15.090N	138°13.630E	3779	021	10.8	**PROTON SURVEY END**
0624	0644	32°15.480N	138°13.780E	3785	023	4.0	RELEASE OBS-25A
0624	0813	32°15.320N	138°14.200E	3787	018	0.4	POPPING UP OBS-25A
0624	0819	32°15.420N	138°14.290E	3788	034	0.8	FINISH RETRIEVE **OBS-25A**
0624	0934	32°15.240N	137° 59.790E	3928	025	2.6	RELEASE OBS-26A
0624	1055	32°14.810N	138°00.300E	3912	346	0.3	POPPING UP OBS-26A

0624	1115	32°15.440N	138°00.520E	3911	005	1.6	FINISH RETREIVE **OBS-26A**
0624	1122	32°15.550N	138°00.520E	3913	027	1.3	CHANGED ENG TO T/M
0624	1122	32°15.550N	138°00.520E	3912	027	1.3	SLOW AHEAD ENG & s/co on 111°
0624	1127	32°15.600N	138°00.780E	3911	111	1.6	**PROTON SURVEY START**
0624	1136	32°15.260N	138°02.200E	3872	112	6.2	**8-SHAPE ROTATION** RIGHT TURNING
0624	1151	32°15.510N	138°02.090E	3876	111	3.1	8-SHAPE ROTATION LEFT TURNING
0624	1207	32°15.670N	138°02.230E	3873	102	1.5	8-SHAPE ROTATION FINISH
0624	1208	32°15.610N	138°02.530E	3867	108	2.3	s/co on 115° **SEABEAM survey**
0624	1211	32°15.370N	138°03.390E	3855	119	5.8	RUNG UP ENGINES
0624	1215	32°14.900N	138°04.450E	3835	120	9.6	a/co to 115°
0624	1329	32°06.470N	138°26.050E	2162	109	16.1	a/co to 90 °
0624	1341	32°06.490N	138°29.890E	2368	095	16.0	a/co to 218°
0624	1347	32°05.500N	138°29.130E	1666	245	7.3	a/co to 265°
0624	1348	32°05.490N	138°29.070E	1617	263	6.4	a/co to 270°
0624	1358	32°05.400N	138°26.170E	2093	264	9.8	a/co to 215°
0624	1405	32°04.200N	138°25.070E	2285	118	10.6	a/co to 90 °
0624	1433	32°03.160N	138°28.750E	2240	239	5.9	A/C TO 243
0624	1435	32°02.930N	138°28.110E	1969	267	7.8	a/co to 270°
0624	1452	32°02.910N	138°23.220E	2475	261	13.8	a/co to 180°
0624	1459	32°01.590N	138°23.540E	2618	091	8.7	a/co to 90 °
0624	1515	32°01.580N	138°28.700E	2357	095	13.6	a/co to 180°
0624	1519	32°01.010N	138°28.870E	2562	257	11.3	a/co to 270°
0624	1548	32°00.860N	138°20.280E	3744	223	14.1	a/co to 225°
0624	1555	31°59.670N	138°19.530E	3929	094	11.6	a/co to 90 °
0624	1621	31°59.790N	138°28.030E	2729	097	15.3	a/co to 163°
0624	1720	31°45.040N	138°33.140E	1597	099	15.9	a/co to 90 °
0624	1740	31°44.970N	138°39.890E	1246	086	16.0	a/co to 41 °
0624	1749	31°46.780N	138°41.900E	1509	040	15.4	a/co to 270°
0624	1819	31°46.960N	138°33.310E	1805	270	14.5	a/co to 180°
0624	1823	31°46.130N	138°33.000E	1723	179	12.1	a/co to 90 °
0624	1848	31°45.930N	138°40.910E	1046	075	15.5	a/co to 300°
0624	1851	31°46.431N	138°40.744E	1073	280	12.0	a/co to 270°
0624	1911	31°46.520N	138°34.840E	1412	326	13.0	**Finished SEABEAM survey** & a/co to 016°
0624	2258	32°49.640N	138°55.430E	1784	018	17.9	Current data is not useable at 23:00

0625	0148	33°29.680N	139°18.050E	1915	016	19.1	UPDATE TO THE GPS POSITION
0625	0203	33°33.830N	139°19.660E	1871	019	15.5	A/C TO 16°
0625	0220	33°38.320N	139°21.650E	1364	025	16.9	A/C TO 21°
0625	0320	33°54.160N	139°30.080E	1634	045	16.6	s/co on 45 °
0625	0358	34°03.150N	139°36.760E	592	014	16.8	a/co to 5 °
0625	0529	34°28.720N	139°38.970E	1010	005	17.3	POSITION WAS DR 6/24 2016 - 6/25 0139
0625	0630	34°46.090N	139°40.740E	1123	006	16.3	SLOW AHEAD ENG
0625	0636	34°46.840N	139°40.770E	1144	007	11.8	**PROTON SURVEY END**
0625	0816	35°12.480N	139°46.940E	183	000	16.5	Fullahd ENG & entered in URAGASUIDO
0625	0850	35°18.680N	139°44.180E	183	018	11.9	Clr'd out Uraga Suido & entered in NA
0625	0918	35°24.150N	139° 46.670E	28	042	12.7	CLEARED OUT NAKANOSE ROUTE
0625	0919	35°24.340N	139° 46.900E	56	043	12.9	RUNG UP ENGINES
0625	0948	35°30.540N	139° 52.730E	27	322	15.7	a/co to 328°
0625	1000	35°33.260N	139° 50.140E	6	322	14.9	HALF AHEAD ENG
0625	1002	35°33.570N	139°49.900E	6	324	14.6	USED ENGINES VARIOUSLY
0625	1016	35°34.460N	139° 49.910E	3	276	5.0	LET GO ANCHOR