No. 16

OCEAN RESOURCES INVESTIGATION IN THE SEA AREA OF SOPAC REPORT ON THE JOINT BASIC STUDY FOR THE DEVELOPMENT OF RESOURCES

(VOLUME 3)

SEA AREA OF PAPUA NEW GUINEA

March, 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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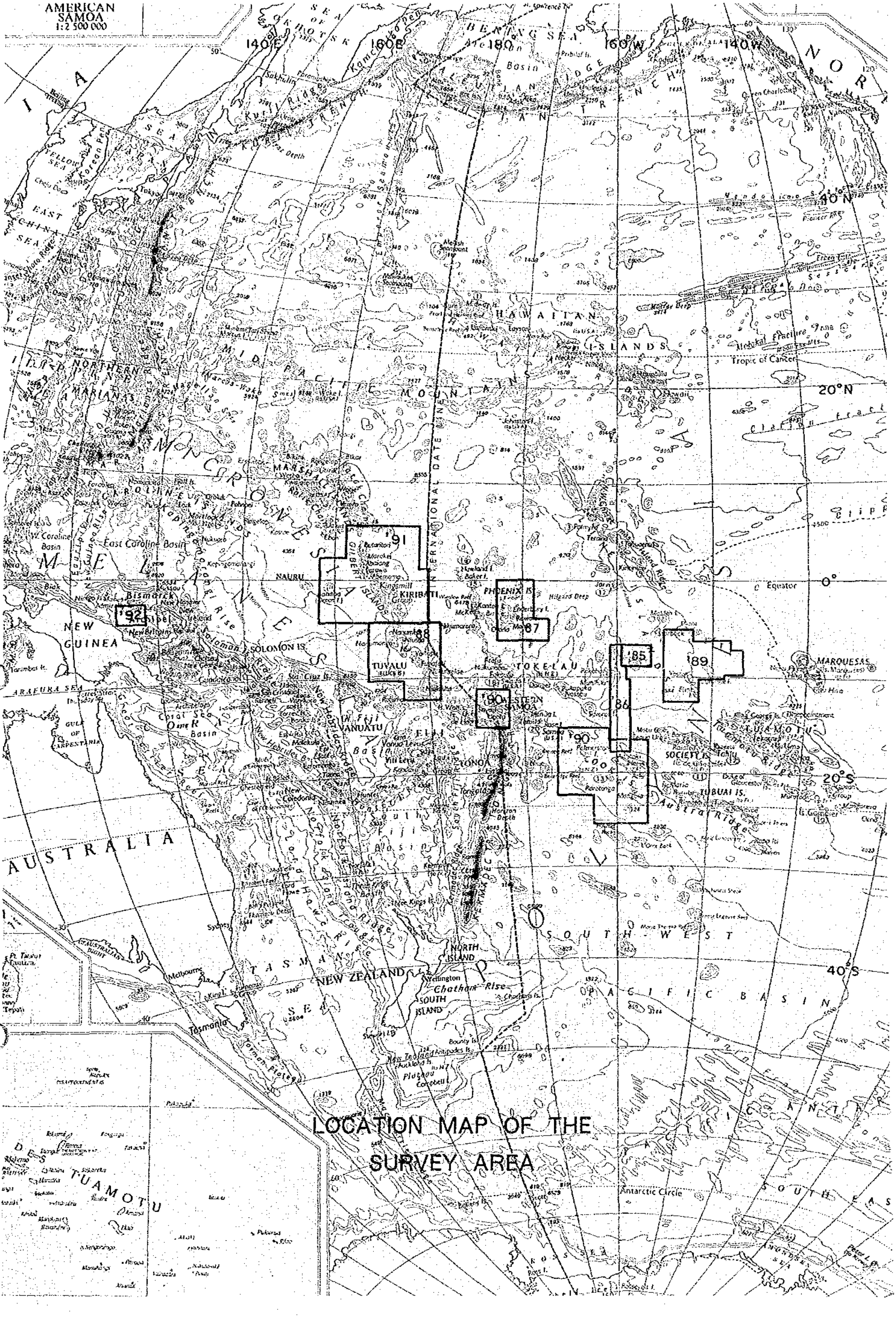
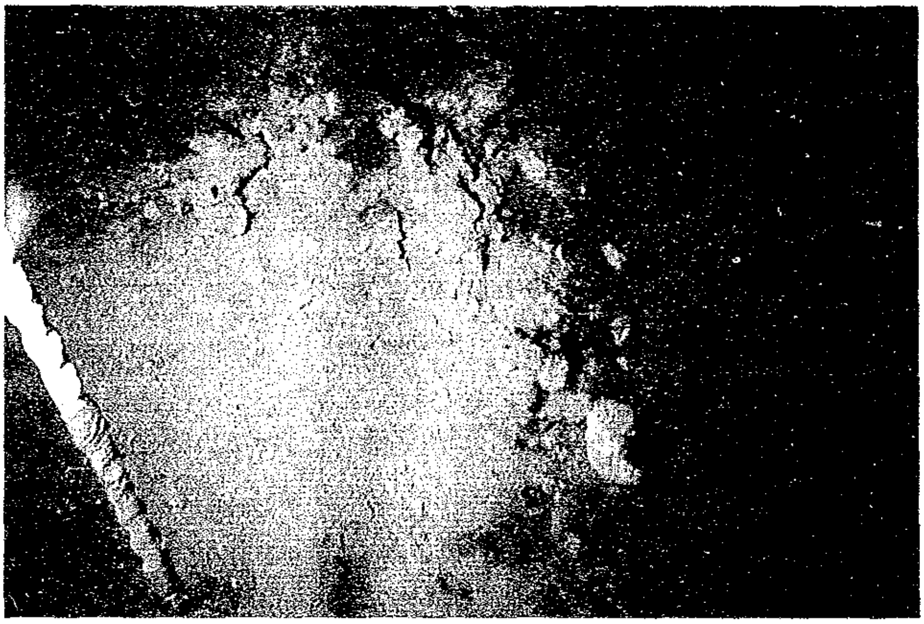


LOCATION MAP OF THE SURVEY AREA

92SFDC07, 3°01.776'S · 147°52.197'E, Water Depth 485 m

Photograph of Hydrothermal oxidized zone taken by Continuous Deep Sea Camera with Finder (FDC).



92SFDC08, 3°05.993'S · 147°45.206'E, Water Depth 947 m

Photograph of Ore indication taken by Continuous Deep Sea Camera with Finder (FDC).

Typical Occurrence of Ore Indication and Oxidized Zone

PREFACE

In response to a request by the South Pacific Applied Geoscience Commission (SOPAC), the Government of Japan has undertaken the studies relating to mineral prospecting such as marine geological surveys to assess mineral resources potential in the deep sea bottom of the offshore regions of SOPAC member countries. Implementation of the survey has been consigned to Japan International Cooperation Agency (JICA).

Considering the technical nature of the geological and mineral prospecting studies, JICA commissioned the Metal Mining Agency of Japan (MMAJ) to execute the survey.

The survey is being undertaken for five a year period starting from fiscal 1990. The third year of the survey was carried out within the exclusive economic zone of Papua New Guinea. MMAJ dispatched the Hakurei Maru No.2, a research vessel for investigating mineral resources in the deep sea bottom, to the sites from August 13, 1992 to October 19, 1992 completing the survey on schedule with the cooperation of Papua New Guinea.

The present report sums up the results of the third year survey.

We wish to extend our sincere thanks to all persons concerned, especially for the cooperation given to us by the Secretariat of SOPAC, the Government of Papua New Guinea as well as the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, and the Japanese Embassy in Papua New Guinea.

March, 1993

Japan International Cooperation Agency
President Kensuke YANAGIYA

Metal Mining Agency of Japan
President Takashi ISHIKAWA

ABSTRACT

The ground survey for resources development cooperation for SOPAC member countries had been decided to be carried out for five years starting from 1990, and this is its third year. This year the survey was made on the sea area of about 74,000km^2 (the western half of the Bismarck Sea) which belongs to Papua New Guinea, from August 13 through October 19, 1992. The survey period on site was 45 days, and the target mineral resource was submarine hydrothermal ore deposits.

The survey was composed of:

(i) topographic cruising, the main purpose of which was making a topographic map,

(ii) geochemical exploratory sampling, mainly for bottom sediments, and

(iii) geological deposit survey, mainly consisting of confirmation of deposits and ore sampling.

The topographic cruising was conducted for every one mile in the eastern area where there are many shallow places, and for every two miles in the western area, and the topographic map was thus made. In order to help estimate the geological structure, a magnetic survey was also conducted for track lines of 2-mile intervals in parallel with the topographic cruising. The analytical work of the magnetic survey was done on land, however. Through this year's survey results coupled with the previous works, it is now proven that the area is composed of the Manus basin (about 2,000m deep) in the east, the Willaumez rise (170-1,500m deep) in the central part and the New Guinea basin in the west. The central part shows complex distribution both in magnetic abnormality and in topography, but as shown in the figure 3-3-1, we have assumed the combination between a transform fault and a seafloor spreading center. While the western area is mainly occupied by the New Guinea basin, the north-western part is full of seamounts of about 600-880m deep and the south-western part is a basin deeper than 2,000m. And we have assumed that a transform fault runs along the boundary between the seamounts and the basin.

The geochemical sampling consists of wide-range regional geochemical sampling and base line geochemical exploration. Through the wide-range geochemical exploration, we have collected bottom sediments at 39 points in a 21-mile grid, over the total area. In the base line geochemical sampling operation, we set two baselines. In their center we put the ore signs which had been discovered during the later-described geological deposit survey. Along the two lines we planned to take a total of 30 samples of bottom

sediments. However, we had to abandon sampling at 3 points where hard rock made sampling impossible. Out of the samples from the 66 points, we have selected 250 samples for chemical analysis and 200 samples for X-ray defraction. Consequently, a small amount of pyrite was identified, but its genetical relation with hydrothermal ore deposits is obscure.

The geological deposit survey consisted of the survey by SSS, seabed observation and sampling. The SSS was conducted on three track lines (19.1 miles in total) in the direction crossing diagonally with the seafloor spreading center which had been estimated through the topographic map, in order to confirm the seafloor spreading center. And then, the seabed observation by FDC was conducted along 8 track lines (35.8 miles in total), and as a result, ore signs were found at 5 places and oxidized zones at 2 places. Although we have observed only a small part of the estimated spreading center, the fact that we could discover so many ore signs and oxidization zones seems to suggest that hydrothermal activities were active in many places within the area. In any case, however, neither hydrothermal living things nor smokers were detected, so we should assume that the hydrothermal activities have largely terminated. We conducted sampling at the five ore sign places and one oxidized zone, and obtained a great amount of oxidized iron and hydroxide iron, but could not confirm any sulfide materials.

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Chapter 1. Outline of the Survey

1-1 Survey Title

"The Cooperative Study Project on the Deep Sea Mineral Resources in selected offshore area of the SOPAC Region around Western Samoa, the Cook Islands, The Republic of Kiribati, Papua New Guinea, the Solomon Islands and the Republic of Vanuatu".

This scope of work was agreed upon among the South Pacific Applied Geoscience Commission (SOPAC), Western Samoa, the Cook Islands, the Republic of Kiribati, Papua New Guinea, the Solomon Islands, the Republic of Vanuatu and the Japan International Cooperation Agency(JICA), the Metal Mining Agency of Japan (MMAJ) on March 13, 1990.

1-2 The Purpose of the Survey

The purpose of the survey is to assess the potential of deep sea mineral resources, especially that of hydrothermal submarine ore deposits, in the marine areas, Papua New Guinea of the SOPAC member countries. This survey consists of field survey, the data analysis and their interpretation.

1-3 The Survey Area

Pursuant to the cooperative study program described in the agreement mentioned above, the Japan International Cooperation Agency and the Metal Mining Agency of Japan (MMAJ) designated the marine survey area, a polygonal area of 74,000 km^2 formed by joining the following coordinates (Figure 1-1).

Point No.	Latitude	Longitude
①	2° 15' S,	148° 15' E
②	4° 15' S,	148° 15' E
③	4° 15' S,	145° 15' E
④	2° 15' S,	145° 15' E

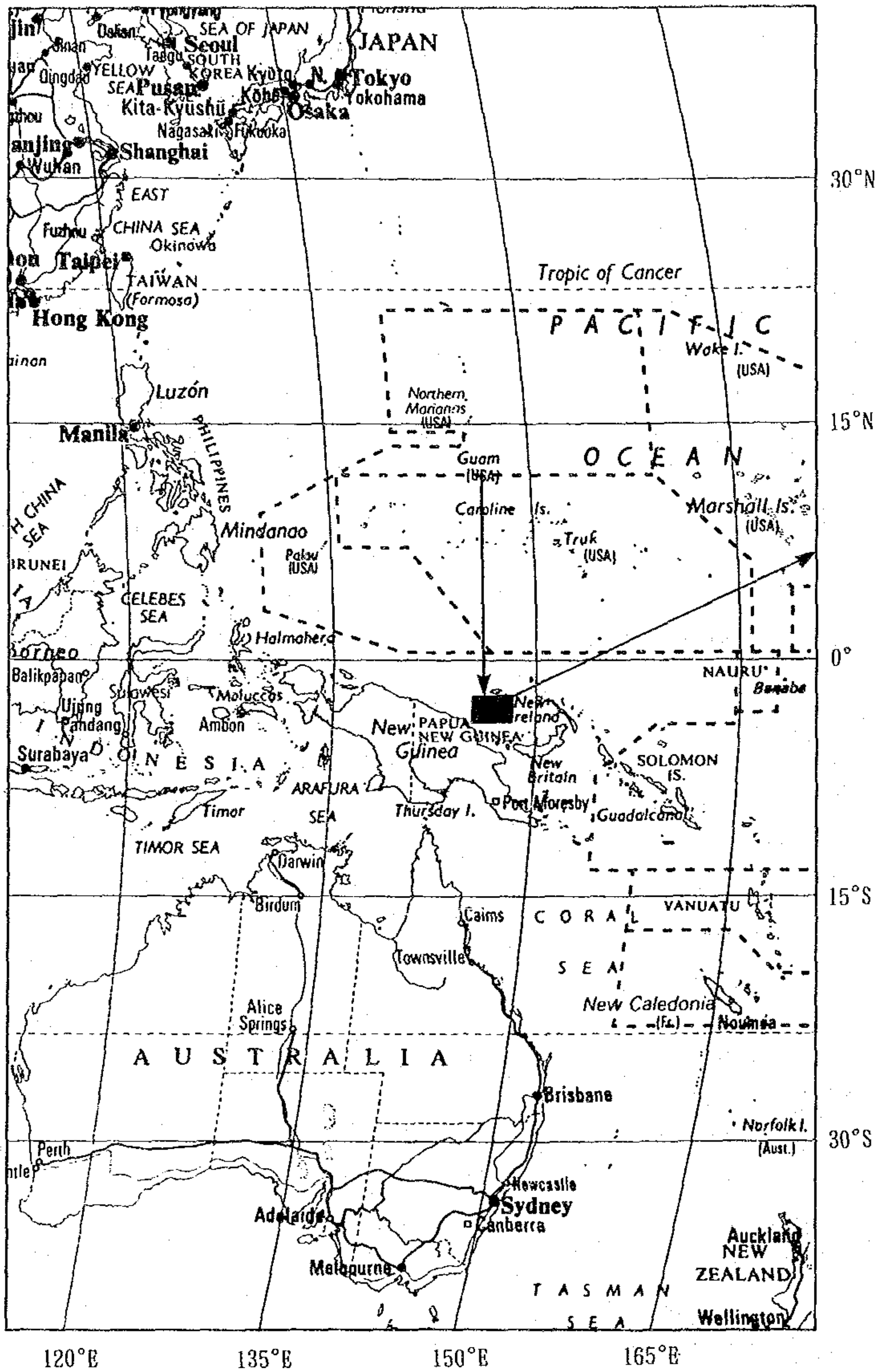


Figure 1-1 Location Map of the Survey Area

① 2° 15' S, 148° 15' E

1-4 Duration of the Survey

Survey cruise:August 13,1992-October 19,1992(68 days).

Analysis and Interpretation (Evaluation): April 1,1992-March 31,1993.

1-5 Participants of the Survey

The staff who participated in the survey cruise were delegated by DORD (Deep Ocean Resources Development) and OEDC (Ocean Engineering and Development Co., Ltd). The members were as follows:

Negotiators for the agreement

Toshio SAKASEGAWA	(Metal Mining Agency of Japan)
Atsuhiko MINOWA	(Metal Mining Agency of Japan)
R. MOAINA	(Chief Government Geologist, Geological Survey of Papua New Guinea)
R. ROGERSON	(Deputy Chief Government Geologist, GS of PNG)
S. NION	(Chief Geologist, GS of PNG)
I. RIPPER	(Principal Seismologist, GS of PNG)
H. DAVIES	(Geology Department, University of PNG)
D. TIFFIN	(SOPAC)
Y. KINOSHITA	(SOPAC)

Supervisors

Kenichi TAKAHASHI (Sept.16-Oct.18)	(Metal Mining Agency of Japan)

Advisor

John A. MADSEN (Aug.12-Sept.14)	(University of Delaware)

Members

Party Chief & Chief Geologist	Jiro DATE	(DORD)
Geologist	Masatoshi SAKOTA	(DORD)
Geologist	Suetaka NAGATE	(DORD)
Geologist	Hitoshi IKEDA	(DORD)
Geologist	Tadayuki ISHIYAMA	(DORD)
Geologist	Yuji NAKATANI	(DORD)
Geologist	Atushi FUTAMADO	(DORD)
Geologist	Yutaka HASHIMOTO	(OEDC)
Chief Geophysicist	Shiro OYAMA	(DORD)
Geophysicist	Nadao SAITOH	(DORD)
Geophysicist	Nobuyuki MURAYAMA	(DORD)
Geophysicist	Kunio KIMURA	(DORD)
Geophysicist	Shintaro KOMAGATA	(DORD)
Geophysicist	Norihiko KASHIWASE	(DORD)
Geophysicist	Takatugu SHIBAHASHI	(DORD)
Geophysicist	Kiminori OKAMOTO	(DORD)
Geophysicist	Takemasa KOBAYASHI	(OEDC)
Geophysicist	Takashi SOEJIMA	(OEDC)

Trainee

Wilfred LUS (Aug.12-Sept.15)	(Papua New Guinea)
Benny KRUMAN (Sept.15-Oct.19)	(Papua New Guinea)

1-6 Apparatus and Equipment for the Survey

The major apparatus and equipment used during the survey and their abbreviation used in this report are listed in Table 1-1.

Table 1-1 Survey Apparatus and Equipment

	Survey Method	Survey Apparatus and System	Abbre-viation	Remarks
Positioning	Satellite Naviga-tion	Global Positioning System	GPS	
		Navy Navigation Satellite System	NNSS	
Sea Bottom Topo-graphy and Geo-logical Survey	Acoustic Sounding Bathymetry	Multi-narrow Beam Echo Sounder	MBES	
		Narrow Beam Echo Sounder	NBS	
		Side Scan Sonar	SSS	
	Subsurface Geolo-gical Structure	Sub Bottom Profiler	SBP	
	Magnetic Survey	Proton Gradio Meter	PGM	Towed Type
	Seawater Survey	Conductivity, Temperature and Pressure Measuring Sys-tem	CTD	Vertical Type and Towed Type
	Sampling	Large Gravity Corer	LC	
		Gravity Corer	GC	
		Okean Grab	OG	
		Finder Mounted Power Grab	FPG	
Sea Bottom Observation	Photograph and TV	Continuous Deep Sea Camera with Finder	FDC	with CTD
	Photograph	Deep Sea Camera		with LC, GC and OG
Data Recording and Processing	On-Line Functions Data Storage Func-tions Off-Line Functions ↓ Track Line Maps Various Plan Maps Cross Sections Data Analysis	Data Processing System Sensor CPU File Server CPU Host CPU Engineering Work Station(EWS) Local Areal Network(LAN) Personal Computer(PC) Intelligent Color Monitor(ICM)	DPS	

1-7 Schedule of the Survey Cruise

The operations, carried out during the cruise are listed in Table 1-2(1), (2) and the itinerary in Table 1-3.

Table 1-2 List of Survey Achievements (1)

	Item	Accomplishment
Survey Schedule	Depart Guam Start the Survey Finish the Survey Arrive Rabaul Depart Rabaul Start the Survey Finish the Survey Arrive Honolulu	Aug. 15 16:30 Aug. 18 16:20 Sep. 13 00:34 Sep. 14 08:30 Sep. 17 16:00 Sep. 18 18:24 Oct. 06 15:00 Oct. 18 08:00
Sampling	Regional Geochemical Sampling Baseline Geochemical Sampling Ore Deposits Survey	39 points(GC 33 times, FPG 3 times, OG 3 times, LC 3 times) 30 points(GC 28 times, FPG 3 times, OG 5 times) 27 points(FPG 19 times, OG 8 times) (including all trials)
	Weight of Taken Samples	Hydrothermal Precipitates 3,242.0kg Rocks 2,200.0kg Muddy Sediments 6,720.9kg Total 12,162.9kg
Deep Sea Observation(FDC)	Number of Track lines Total Length of Track Lines Acquired Photographs Acquired VTR Tapes	8 track lines 35.8 nautical miles 1,073 sheets No.1 line 210sheets 7.9miles No.2 line 171sheets 7.2miles No.3 line 81sheete 3.2miles No.4 line 81sheets 3.0miles No.5 line 37sheets 0.9miles No.6 line 194sheets 6.5miles No.7 line 161sheets 3.4miles No.8 line 138sheets 3.7miles 20
Physical Property Survey	CTD(Vertical Type) (Towed Type) Magnetic Survey(PGM)	1 point 8 lines(with FDC) 2,174.8 miles(A area), 1,369.4 miles (B area), 3,544.2 miles(total)
Acoustic Sounding	MBES(15.5khz) NBS(30.0khz) SBP(3.5khz) SSS(59.5khz)	4,194.6 miles(A area), 1,369.4 miles (B area), 5,564.0 miles(total) ditto ditto 19.1 miles(3 lines in A area)
Data Processing	MT from Data Processing System(No.5 Labo.) MT from MBES Drawing	1 reel(Off-Line) 18 reels(On-Line), 10 reels(Off-Line) Track Line Map, Bathymetrical Maps, Cross Sections etc.

Date and Time are shown in Local Time.

Table 1-2 List of Survey Achievements (2)

	Track Line No.	92SFDC01	92SFDC02	92SFDC03	92SFDC04	92SFDC05	92SFDC06	92SFDC07	92SFDC08	Total(or Average)
	Date	Sep. 07	Sep. 07 & 08	Sep. 08 & 09	Sep. 09	Sep. 09	Sep. 10	Sep. 10 & 11	Sep. 11	
	Angle with Spreading Center	Parallel	Parallel	Perpendicu-lar	Perpendicu-lar	Parallel	Parallel	Parallel	Parallel	
F	Track Line Length (miles)(A)	7.9	7.2	3.2	3.0	0.9	6.5	3.4	3.7	35.8
	Observing Depth	1,510~1,840m	1,750~1,830m	1,020~1,160m	970~1,130m	890~1,010m	1,000~1,190m	360~ 540m	590~ 970m	360~1,840m
	Survey Times(hrs.)	08:17	07:39	03:48	03:40	03:48	06:33	03:39	04:18	41:42
	Equip. Throwing Time	00:06	22:08	22:14	02:45	22:05	00:46	21:59	02:18	
D	Equip. Haul-in Time	08:23	05:47	02:02	06:25	23:50	07:19	01:38	06:36	
	Observing Time (hrs.)(T)	07:04	06:23	02:43	02:42	00:52	05:40	03:03	03:31	32:03
	Av. Speed(kn)(A/T)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	(1.1)
C	Number of Photos	210	171	81	81	37	194	161	138	1,073
	Av. Time Interval for each Photo(min.)	2.02	2.24	2.07	2.00	1.41	1.75	1.14	1.53	(1.79)
	Number of Video Tapes	4	4	2	2	1	3	2	2	20

Date and Time are shown in GMT.

Table 1-3 Records of Survey Schedule

		Month/Day		Survey Items
01		08/15	Sa	16:30 Departure from Guam
02		08/16	Su	Sailing(980nm between Guam and the survey area)
03		08/17	Mo	ditto
04	01	08/18	Tu	16:20 Arrival in the area Regional Geochemical Sampling(1 point) & Bathymetric Survey(A area)
05	02	08/19	We	Re. Geo. Sampling(1) & Bath. Survey(A area)
06	03	08/20	Th	Re. Geo. Sampling(2) & Bath. Survey(A area)
07	04	08/21	Fr	Re. Geo. Sampling(2) & Bath. Survey(A area)
08	05	08/22	Sa	Bath. Survey(A area)
09	06	08/23	Su	Re. Geo. Sampling(2) & Bath. Survey(A area)
10	07	08/24	Mo	Re. Geo. Sampling(1) & Bath. Survey(A area, PGM)
11	08	08/25	Tu	Re. Geo. Sampling(2) & Bath. Survey(A area, PGM)
12	09	08/26	We	Re. Geo. Sampling(2) & Bath. Survey(A area, PGM)
13	10	08/27	Th	Re. Geo. Sampling(2) & Bath. Survey(A area, PGM)
14	11	08/28	Fr	Re. Geo. Sampling(2) & Bath. Survey(A area, PGM)
15	12	08/29	Sa	Re. Geo. Sampling(1) & Bath. Survey(A area, PGM)
16	13	08/30	Su	Bath. Survey(A area, with PGM)
17	14	08/31	Mo	Bath. Survey(A area, with PGM)
18	15	09/01	Tu	Bath. Survey(A area, with PGM)
19	16	09/02	We	Bath. Survey(A area, with PGM)
20	17	09/03	Th	Re. Geo. Sampling(3) & Bath. Survey(B area, PGM)
21	18	09/04	Fr	Re. Geo. Sampling(3 points)
22	19	09/05	Sa	Re. Geo. Sampling(3) & Bath. Survey(A area)
23	20	09/06	Su	SSS(3 lines) & Bath. Survey(A area)
24	21	09/07	Mo	FDC(No.1 line) & Bath. Survey(A area)
25	22	09/08	Tu	FDC(No.2 line) & Bath. Survey(A area)
26	23	09/09	We	FDC(Nos.3 & 4 lines) & Bath. Survey(A area)
27	24	09/10	Th	FDC(Nos.5 & 6 lines) & Bath. Survey(A area)
28	25	09/11	Fr	FDC(Nos.7 & 8 lines) & Bath. Survey(A area) 5 Ore Indications & 2 Oxidation Zones were discovered by FDC.
29	26	09/12	Sa	Ore Sampling(No.3→No.5→No.4 ore indication)
30		09/13	Su	00:34 Departure from the area(290nm from the area to Rabaul)
31		09/14	Mo	08:30 Arrival in Rabaul
32		09/15	Tu	Meeting
33		09/16	We	Preparation for Sailing
34		09/17	Th	16:00 Departure from Rabaul(320nm from Rabaul to the area)
35	27	09/18	Fr	12:30 Arrival in the area Bath. Survey(B area, with PGM)
36	28	09/19	Sa	Bath. Survey(B area, with PGM)
37	29	09/20	Su	Re. Geo. Sampling(2) & Bath. Survey(A area, PGM)
38	30	09/21	Mo	Baseline Geo. Sampling(5) & Bath. Survey(A, PGM)
39	31	09/22	Tu	Baseline Geo. Sampling(4) & Bath. Survey(A area)
40	32	09/23	We	Baseline Geo. Sampling(4) & Bath. Survey(A area)
41	33	09/24	Th	Baseline Geo. Sampling(3), Ore Sampling(No.5 ore indication) & Bath. Survey(A area)
42	34	09/25	Fr	Ore Sampling(No.5 ore indication) & Bath. Sur.(A)
43	35	09/26	Sa	Ore Sampling(No.4 ore indi.) & Bath. Sur.(A, PGM)
44	36	09/27	Su	Ore Sampling(No.3 ore indi.) & Bath. Sur.(A, PGM)
45	37	09/28	Mo	Ore Sampling(No.2 ore indi.) & Bath. Sur.(B, PGM)
46	38	09/29	Tu	Ore Sampling(No.1 ore indi.) & Bath. Sur.(B, PGM)
47	39	09/30	We	Baseline Geo. Sampling(5) & Bath. Sur.(B, PGM)
48	40	10/01	Th	Baseline Geo. Sampling(5) & Bath. Sur.(B, PGM)
49	41	10/02	Fr	Baseline Geo. Sanpling(4) & Bath. Sur.(B, PGM)
50	42	10/03	Sa	Re. Geo. Sampling(4) & Bath. Survey(B area, PGM)
51	43	10/04	Su	Re. Geo. Sampling(2) & Bath. Survey(B area, PGM)
52	44	10/05	Mo	Re. Geo. Sampling(4) & Bath. Survey(B area, PGM)
53	45	10/06	Tu	Bath. Survey(B area, with PGM)
54		10/07	We	00:34 Departure from the area
55		10/08	Th	Sailing
56		10/09	Fr	ditto
57		10/10	Sa	ditto
58		10/11	Su	ditto
59		10/12	Mo	ditto
60		10/13	Tu	ditto
61		10/14	We	ditto
62		10/15	Th	ditto
63		10/16	Fr	ditto
64		10/17	Sa	ditto
65		10/18	Su	08:00 Arrival in Honolulu

Date and Time are shown in Local Time.

Chapter 2. Survey Methods

2-1 Survey Plan

In 1992, the third fiscal year of the second phase of the five-year SOPAC program, a survey on submarine hydrothermal ore deposits and their related bathymetry was carried out, as previously arranged, in the Bismarck Sea within the exclusive economic zone of Papua New Guinea.

The survey plan was composed of, as shown in Figure 2-1-1, 39 points for the regional geochemical sampling, 30 points for the base-line geochemical sampling, geological surveys on ore deposits (SSS, FDC and sampling) and topographical cruising. The survey plan was carried out practically as stated, though a part of the topographical cruising was changed to the surveys on ore deposits. Principal work for the survey was comprised of the following;

(1) Topographical surveys were carried out at 10 knots by employing GPS and MBES to identify geographical features accurately. The topographical cruising was carried out at intervals of one mile in the A area (situated in the eastern part of the surveyed waters and was the principal subject of our investigation) and at intervals of two miles in the B area (the western part.)

(2) Magnetic surveys at intervals of two miles were also carried out sim ultaneously with the topographical surveys to estimate the geological structure.

(3) Samples were collected for the regional geochemical survey at about 21-mile grid (39 sampling points) from the entire waters.

(4) SSS was carried out at three track lines to identify the spreading center.

(5) For the purpose of geological surveys on ore deposits, FDC was carried out at eight track lines selected in the areas where the spreading center was supposed to exist. As a result, ore signs or indications were discovered at five places and oxidation zones at two places.

(6) Two base-lines were established around the discovered ore signs, and samples for the geochemical survey were collected at 30 places. Among which, however, no sediments were collected from 3 places.

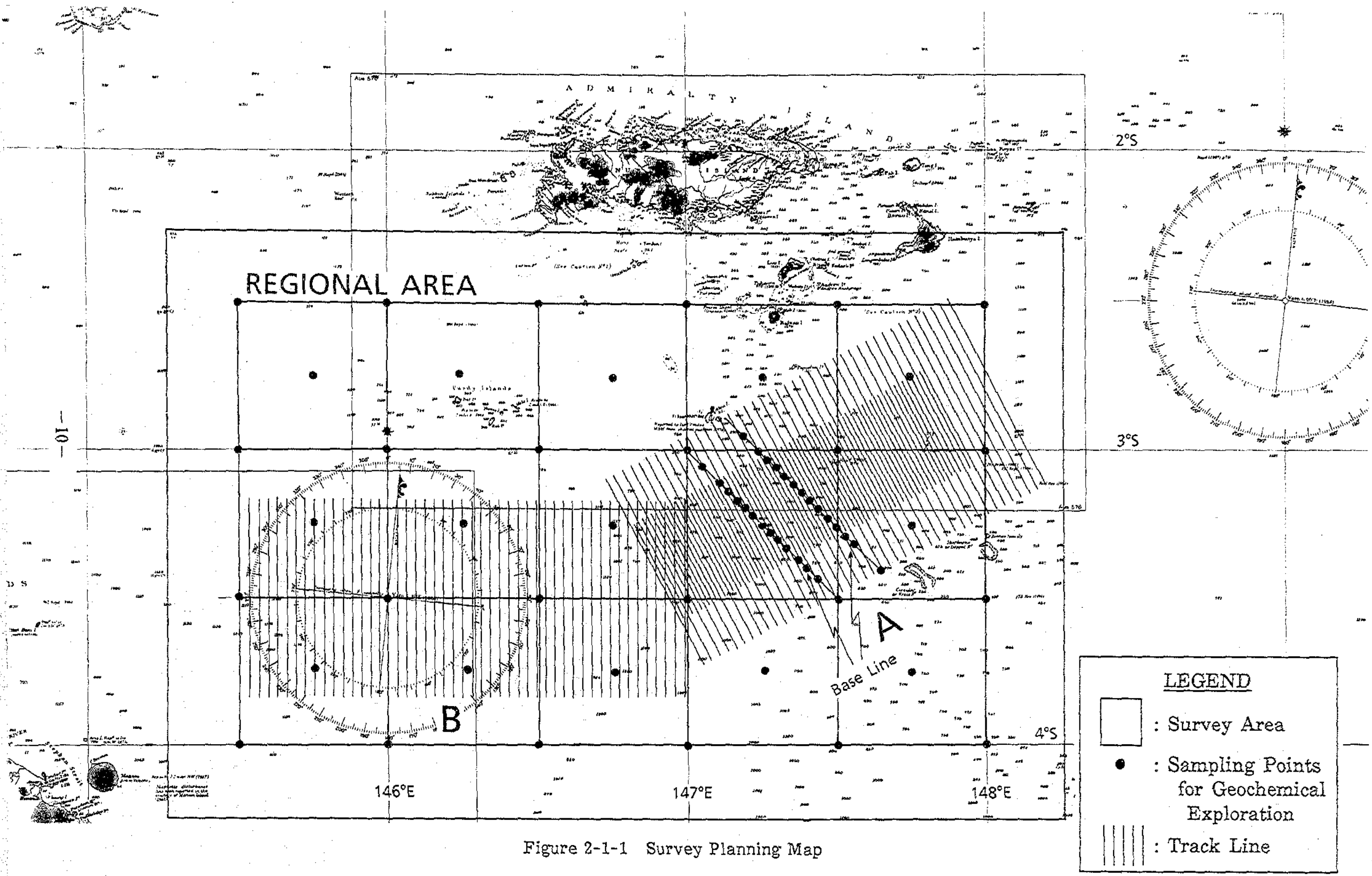


Figure 2-1-1 Survey Planning Map

2-2 Numbering

Sampling points, track lines and SSS were numbered in the following ways;

- For the sampling points of the regional geochemical survey:

Year - R - Equipment used (two letters)- No.

Examples: 92RLC01 (in the case where an LC was employed)

92RPG02 (in the case where an FPG was employed)

In these cases, "R" indicates the regional and the "No." indicates the serial number.

- For the sampling points of the base-line geochemical survey:

Year - B - Equipment used (two letters) - No.

Examples: 92BGC01 (in the case where a GC was employed)

92BPG02 (in the case where an FPG was employed)

In these cases, "B" indicates the base-line and the "No." indicates the serial number.

- For the sampling points of the survey on ore deposits:

Year - H - Equipment used (two letters)- No.

Examples: 92HPG01 (in the case where an FPG was employed)

92GOG01 (in the case where an OG was employed)

In these cases, "H" indicates the hydrothermal ore deposits surveyed and the "No." indicates the serial number.

- For the FDC track lines:

Year - S - FDC - No.

Example: 92SFDC01

In this case, "S" indicates the executing organization (SOPAC) and the "No." is the serial number starting from 01.

- For the acoustic sounding track lines in the A area:

Year - S - No. - O or 1 - A

Example: 92S01-1A

In this case, "S" represents "SOPAC", "No." indicates the serial number of the track line which is numbered at intervals of 2 miles counting from the eastern side, "0" in the "0 or 1" indicates an interval of 2 miles and "1" indicates the track line within such interval (an interval of 1 mile). "A" represents the name of the waters.

- For the acoustic sounding track lines in the B area:

Year - S - No. - B

Example: 92S01B

In this case, "S" represents "SOPAC", "No." indicates the serial number of the track line which is numbered at intervals of 2 miles counting from the eastern side and "B" represents the name of the waters. Acoustic soundings at intervals of one mile were not carried out in the B area.

- For SSS:

Year - S - SSS - No.

Example: 92SSSS01

In this case, "S" represents "SOPAC" and "No." indicates the serial number.

2-3 Ship Positioning and Positions of Towed Vehicle

The ship positions were measured by the GPS, and the positions of the towed vehicle were calculated from the depth sounded by a CTD Sensor which was loaded on the towed vehicle and the length of the cable by employing the Pythagorean formula.

As for the system of geodetic coordinates, WGS84 was used.And the 150 E Local Time (GMT + 10 hours) was used for the inboard time.

2-4 Acoustic Soundings

The survey of the submarine topography was carried out at intervals of 1 mile as there were shoals in the A area, which was located in the eastern part of the target waters and was the principal subject of the survey. Furthermore, there were extremely shallow areas in which cruising at intervals of 0.5 miles was adopted. The track lines in the B area, the western part of the waters, were established at intervals of 2 miles (see Figure 2-4-1 and Annexed Figure 1, Track Line Map).

The bathymetry was made at every 5~10 seconds for MBES and every 8 seconds for NBS while the vessel was cruising at 10 knots.

Furthermore, the survey of SSS was carried out at 3 track lines in the oblique direction to the spreading center. (see Figure 2-4-1)

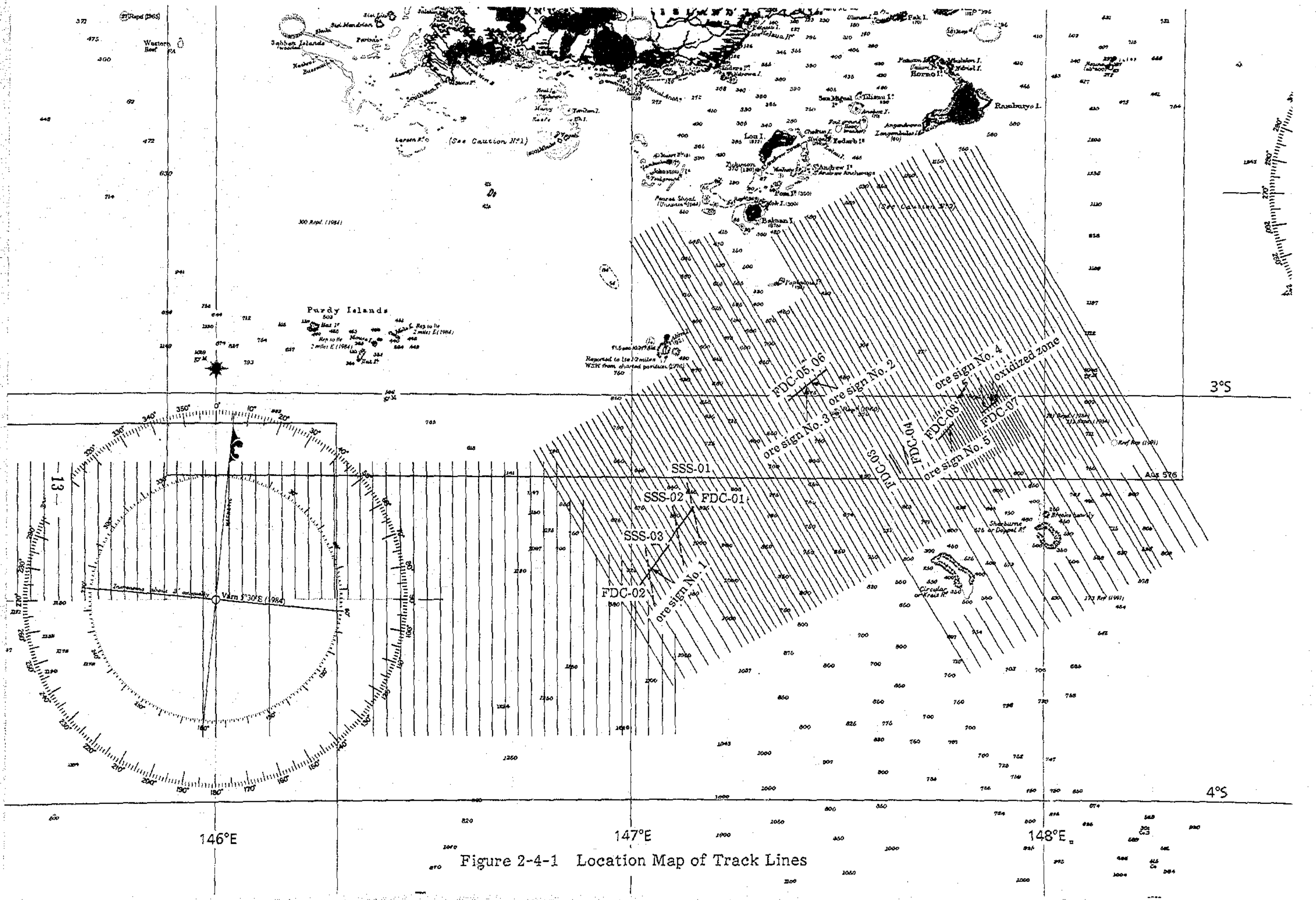


Figure 2-4-1 Location Map of Track Lines

2-5 Magnetic Survey (PGM Survey)

Magnetic survey was carried out simultaneously with the survey of submarine topography in the hope that the magnetic survey might be of some help toward the elucidation of the geological structure. However, the magnetic data was collected while cruising at intervals of 2 miles.

In order to protect the PGM Sensor from the magnetism in the vessel, the PGM Sensor was towed from the stern by a cable and the distance from the stern to the Sensor was set at 750 m. As the synchronizing signals were not updated for the measurement of the total magnetic force, so, magnetic force was measured by the Sensor at the sensitivity of 0.1 gamma every 6 seconds.

Measured data was on-line recorded in the DPS every 10 seconds before the data was processed.

2-6 Seafloor Observation and Photographing

Real-time sea-floor observation was made through color images by towing the FDC on which, a still camera, a TV camera and a CTD were loaded around the spreading center at the cruising speed of about 1 knot, and color photographs were taken at characteristic points. Seafloor images were videotaped.

The length of the track lines were set at about 3-7 miles when they ran parallel with the spreading center and at about 3 miles when they ran orthogonally with the spreading center.

The towing directions were set to NE -> SW or N -> S. As the equipment went wrong when the track line 92SFDC05 had been observed at about 1 mile, the equipment was hauled in once and the observation was carried out again by changing the number of the track line to 92SFDC06 (see Figure 2-4-1).

2-7 Sampling

The regional geochemical sampling was carried out at 39 points as previously planned. (Figure 2-7-1). Various kinds of equipment were tried and the GC was proved to be effective in the most cases. Sampling was carried out about five times per day on average, but the number of times varied according to the depth. However, there were cases in which samples were not collectable like in the case of 92RGC15. In this case,

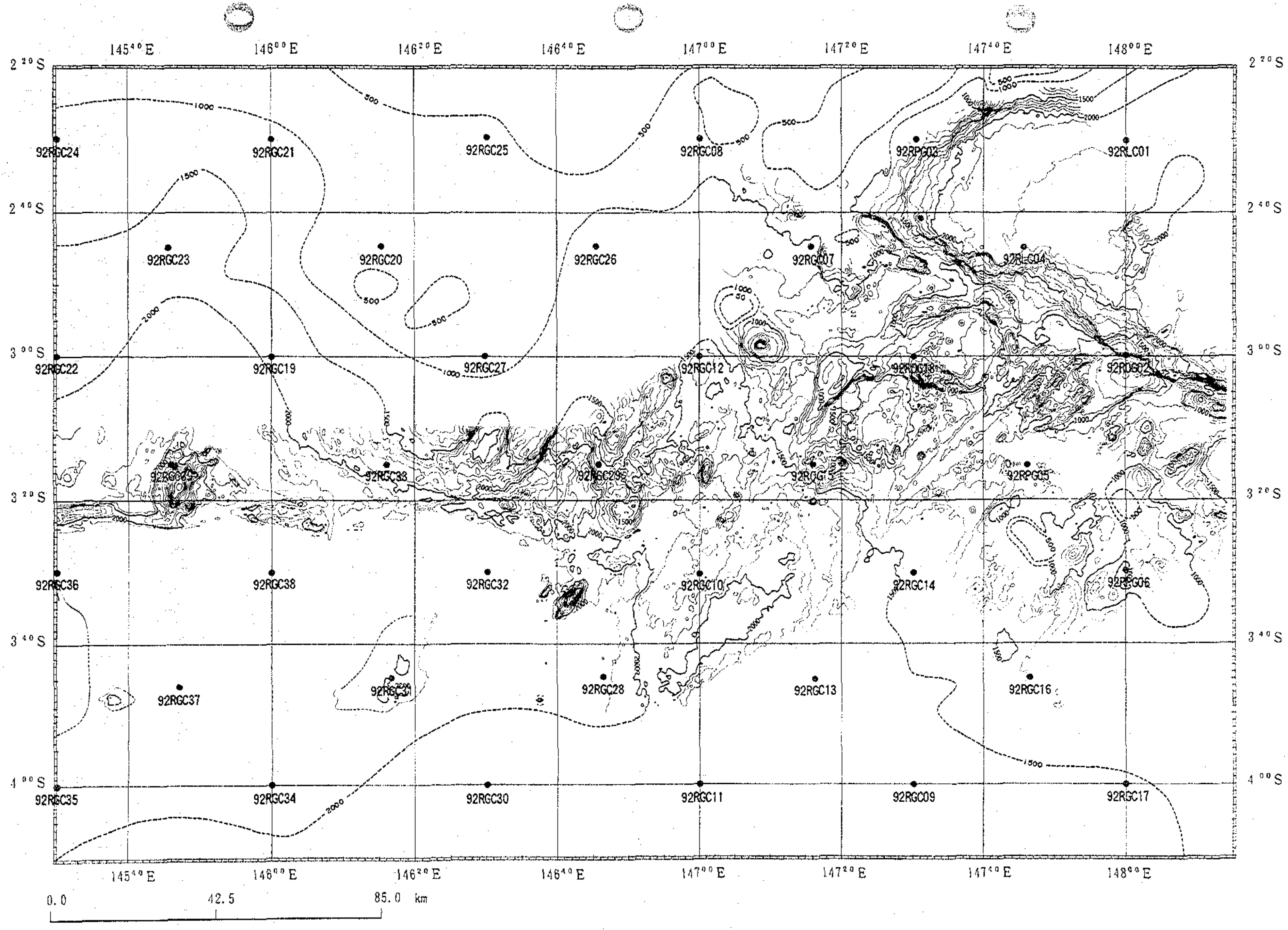


Figure 2-7-1 Location Map of Regional Geochemical Sampling Points

samples were collected by the second operation (i.e. 92ROG15.) In such case, only the results of the second sampling were indicated in the maps and tables of the results of the regional geochemical sampling (Chapter 4 and Table 1 to Appendix). The base-line geochemical sampling was carried out at 30 points. As ore signs or indications were discovered by the FDC observation, base-lines passing through ore signs or indications were established first and then the points where the sampling points for the survey of hydrothermal ore deposits overlapped were excluded. As for the type of the sampler, GC was employed in many cases like in the cases of the regional geochemical sampling. But still, samples were not collected from 3 points. These 3 points are shown in the map (Fig.2-7-2) as the end-use samplers, but they are treated as missing numbers in the results of the base-line geochemical sampling (Chapter 4 and Table 2 to Appendix).

Sampling for the survey of hydrothermal ore deposits was carried out at six places where ore signs (or indications) and an oxidation zone had been discovered in advance through the FDC observation. At these six sampling points, FPG and OG were appropriately employed to collect samples. As a general rule, FPG was employed at 3 sampling points per day and, in the course of them, OG was employed at 2 sampling points. Every FPG operation was numbered even when the equipment was hauled in the middle of the operation due toa breakdown of the equipment or due to afailure of discovering a suitable place for sampling. Such numbers are treated as missing numbers in the maps and tables. Color FPG images were used for this year's operation.

2-8 Survey on Sea Water (CTD Measurement)

As the MBES requires values of sound velocity versus depth, a vertical CTD survey was carried out once.

Also, in order to identify the signs of hydrothermal activity, data on water temperature and water pressure were collected every 5 seconds by the CTD, which was loaded on the FDC, for analysis.

Furthermore, depth data which was calculated from the CTD, loaded on the FDC, was utilized to calculate the location of the towed vehicle.

2-9 Processing and Analysis of Survey Data

The processing and analysis of the survey data were carried out by the DPS and personal computers as shown in Data Processing and Analysis Flowsheet (Figure 2-9-1).

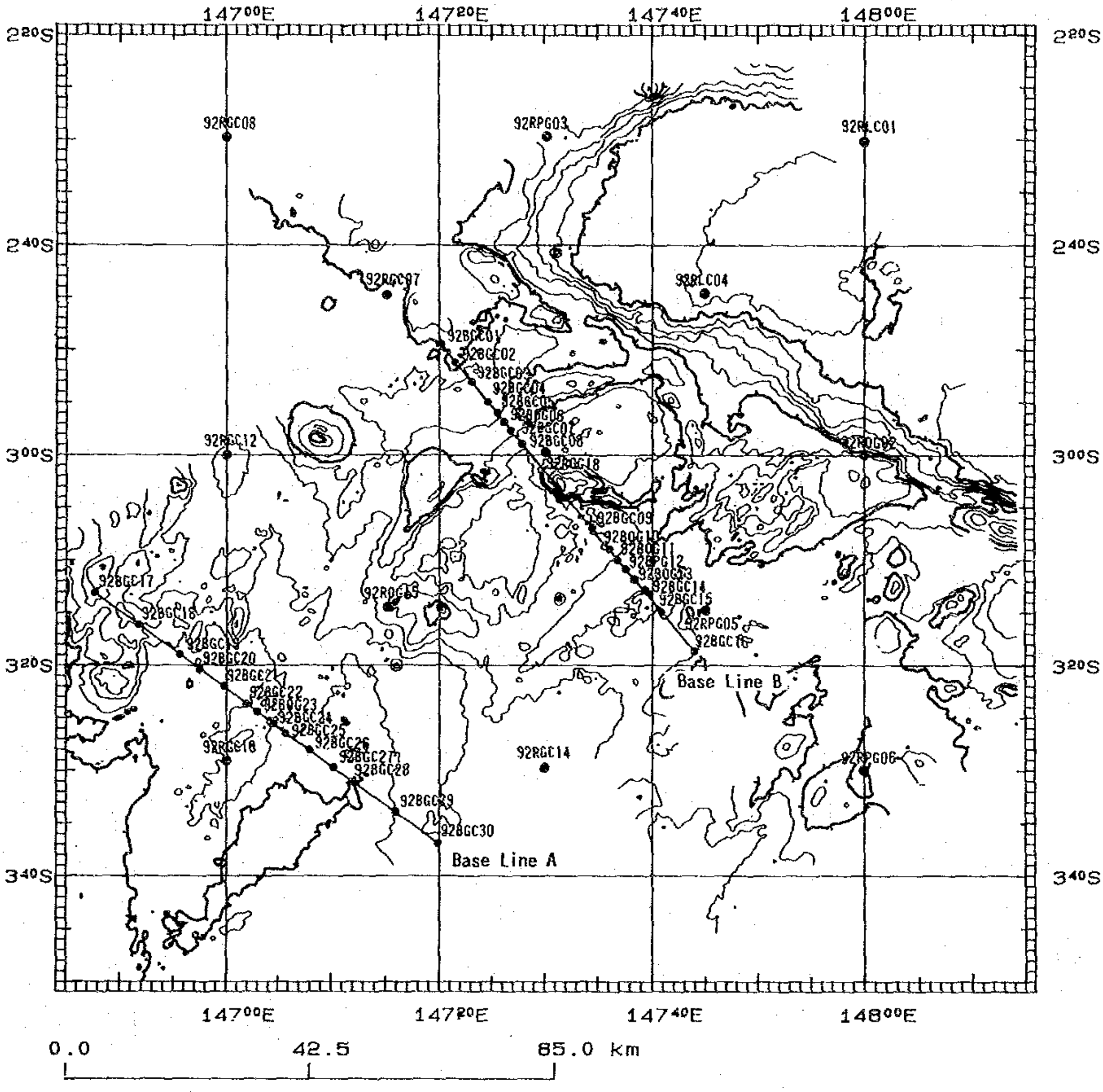


Figure 2-7-2 Location Map of Base Line Geochemical Sampling Points

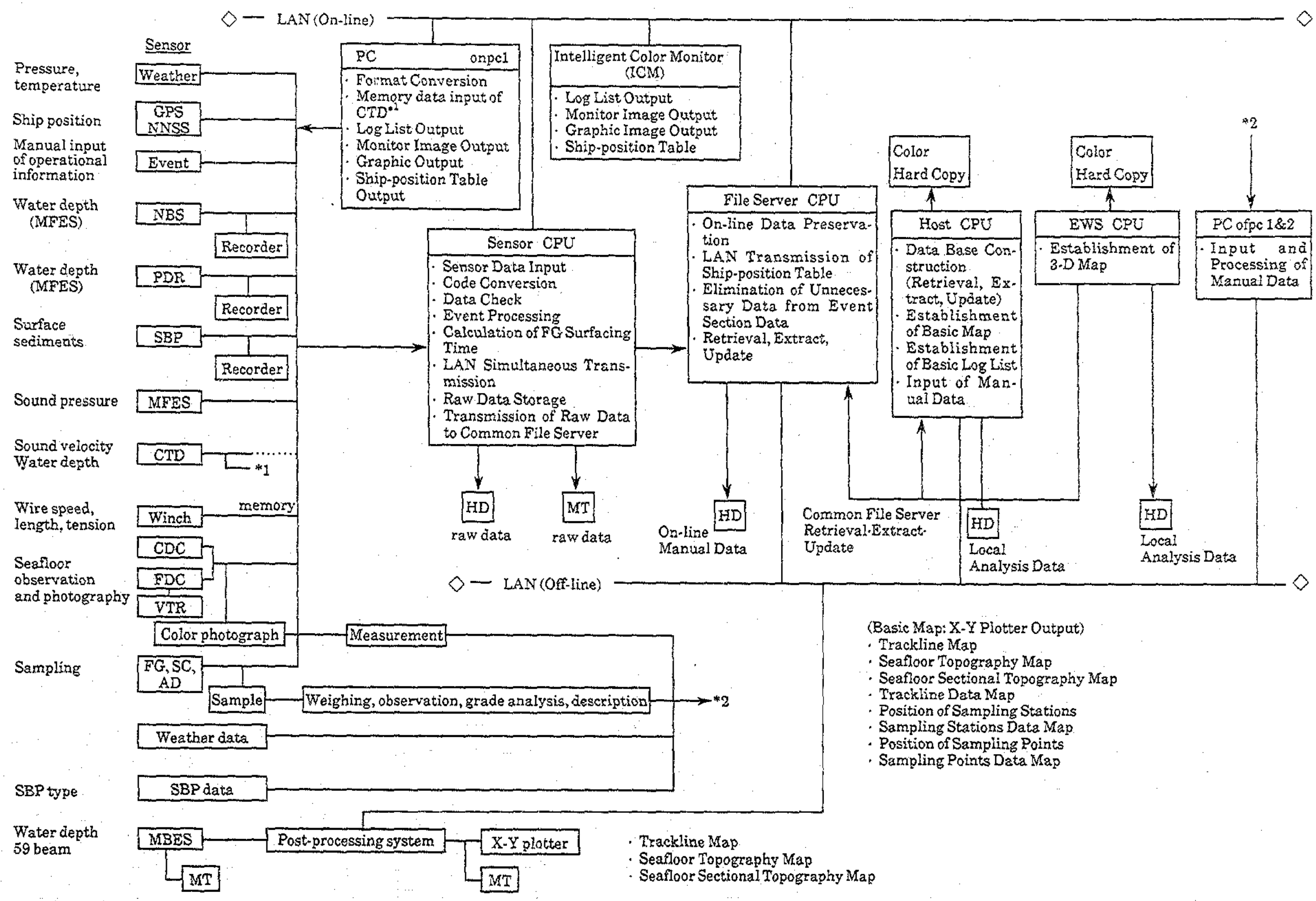
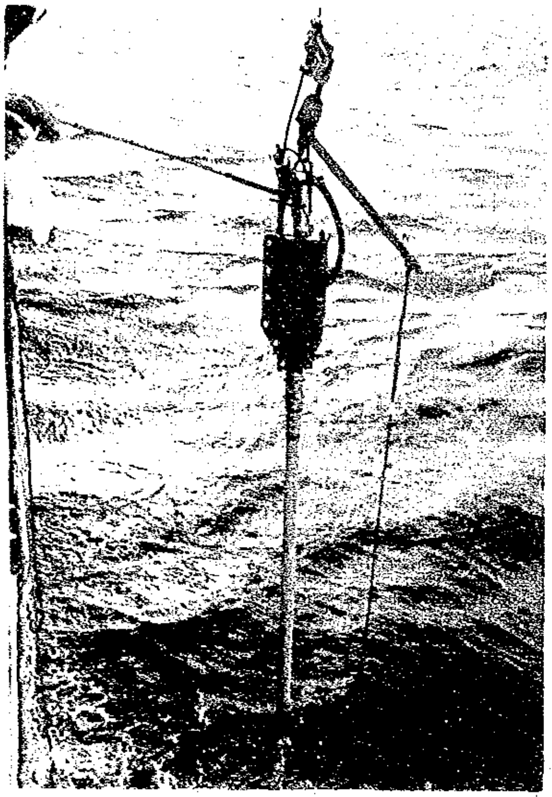


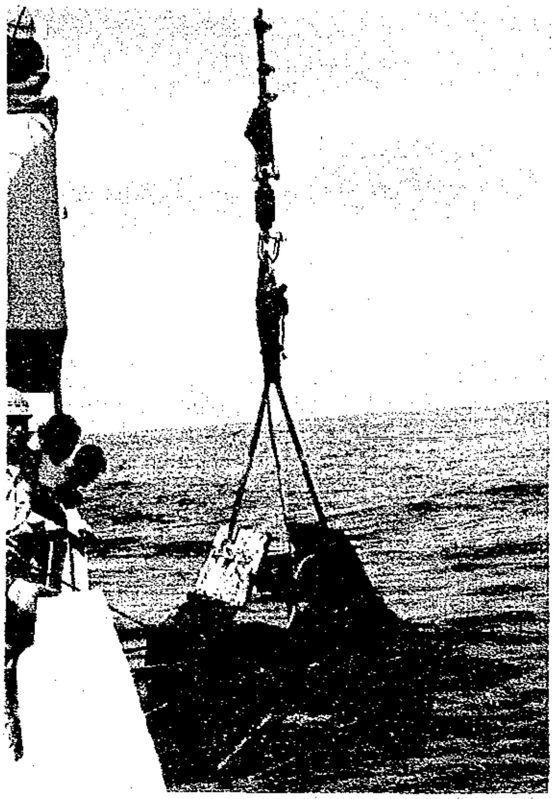
Figure 2-9-1 Data Analysis and Processing Flowsheet

Fundamental data were processed and analyzed on board and a cruise report was written. Later, various tests, studies and analyses were made on shore and the present report was drawn up by putting both results together, i.e. grade analysis and X-ray diffraction on hydrothermal sediments were made and the mineral composition was determined, chemical analysis and microscopic observation on rock samples were made and their mineral composition and texture were determined, and chemical analysis and X-ray diffraction were done on sediments. Furthermore, microfossil samples were extracted from a certain part of the sediments samples and the survey on fossils was done on these microfossil samples.

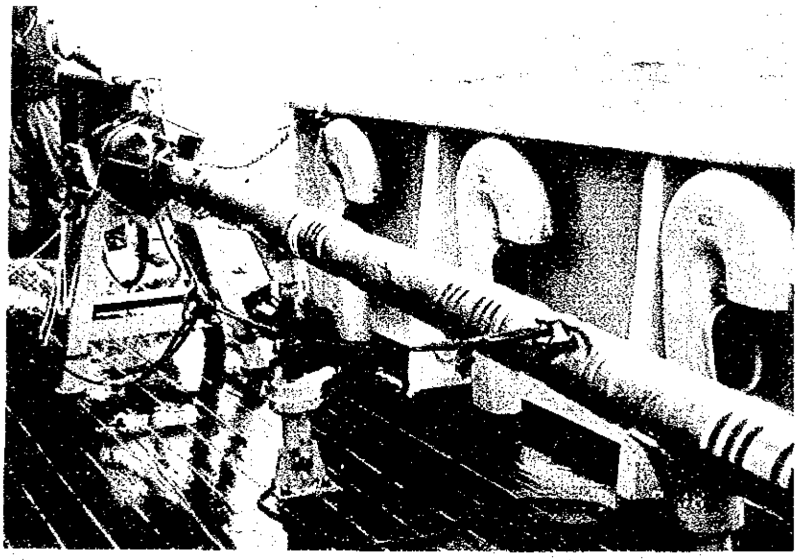
Equipment employed for the survey and how the equipment was used are shown in Figure 2-9-2 (1) ~ (3).



Gravity Corer (GC)

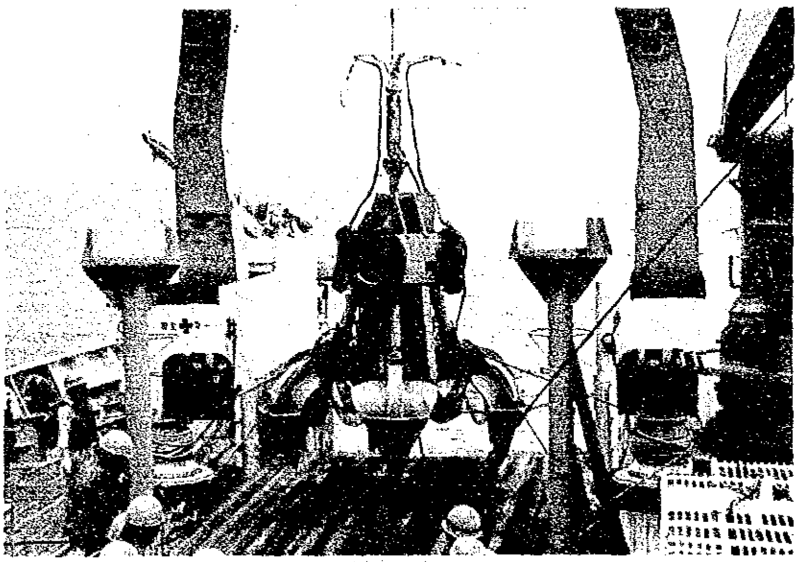


Okean Grab (OG)

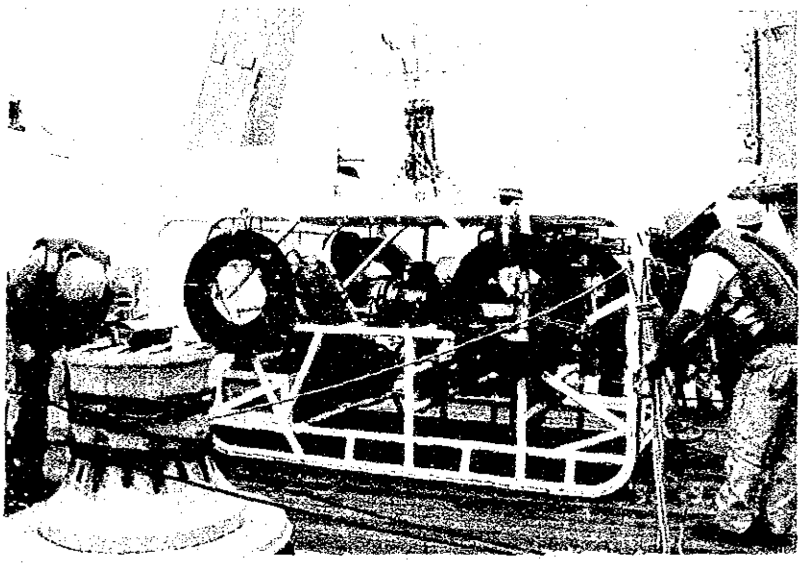


Large Corer (LC)

Figure 2-9-2 Survey Apparatus and Equipment (1)

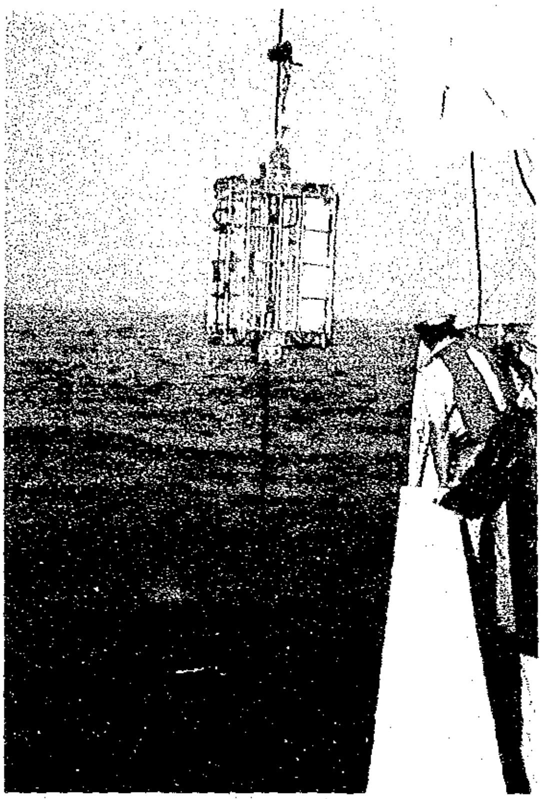


Fider mounted Power Grab (FPG)

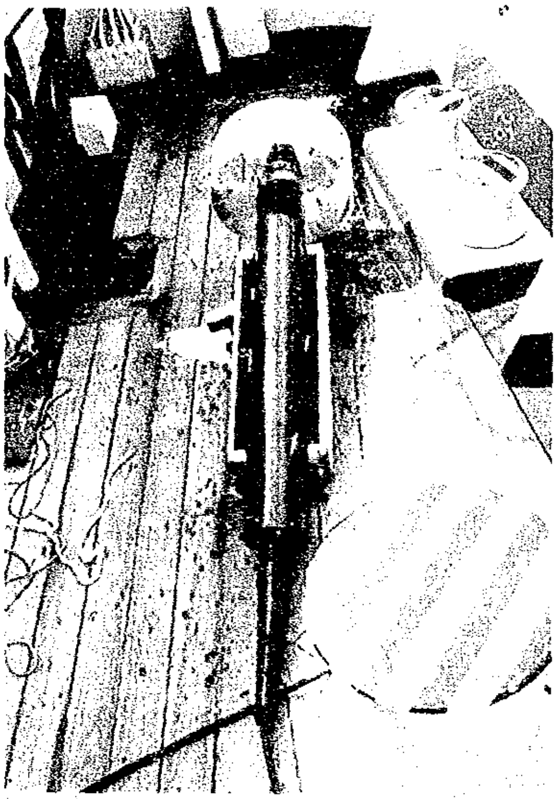


Continuous Deep sea Camera with Finder (FDC)

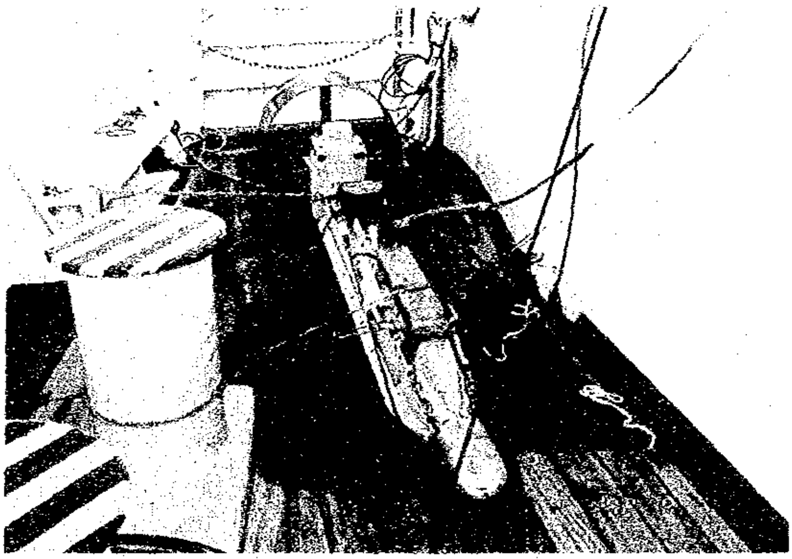
Figure 2-9-2 Survey Apparatus and Equipment (2)



Conductivity Temperature Depth System (CTD)



Proton Gradio Meter (PGM)



Side Scan Sonor (SSS)

Figure 2-9-2 Survey Apparatus and Equipment (3)

Chapter 3. Seafloor Topography and Geological Structure

3-1 Seafloor Topography

1) Previous Works (The Topography and Geological Structure of the Bismarck Sea)

A tectonic setting map of the Bismarck Sea area (after Taylor et al., 1991) is shown in Figure 3-1-1.

The Bismarck Sea is a sea area bounded by New Guinea in the southwestern part, New Britain Island in the south-southeastern part, New Ireland Island and Manus Island in the east-northern part. This sea area is divided into two parts by the Willaumez rise(*1) running in the direction of northwest-southeast. The eastern part is the Manus Basin and the western part the New Guinea Basin.

The Bismarck Sea is considered to be divided into northern and southern parts by the sea-floor spreading system composed of the spreading center - transform fault - spreading center. The plate lying between this sea-floor spreading system and the New Britain Trench, in the southern part, is called the Bismarck Plate. The plate lying between this sea-floor spreading system and the Manus Trench (West Melanesia Trench) is named by Eguchi (1989) as the Manus Plate.

The Manus Trench has a length of 1,100 km, a width of 60 km and a depth of 6,540 m at its deepest bottom. It is an old trench. Manus Islands (Admiralty Islands) are presumed to be an island arc corresponding to the Manus Trench. The New Britain Trench has a length of 750 km, a width of 40 km and a depth of 8,320 m at its deepest bottom. It is an active trench and its island arc is New Britain Island (Tomoda 1972). For the above reasons, the Bismarck Sea is presumed to be a back-arc basin in the New Britain Trench area (marginal sea)(*2). There is also an active trench, the New Guinea Trench, running parallel to the Papua New Guinea Peninsula at the western extremity of the Manus Trench.

(*1): The water depth of the Willaumez rise is shallower than 1,500 m and this rise stretches for over 400 km from Manus Island to the Willaumez Peninsula situated on the north of New Britain Island (Johnson 1979).

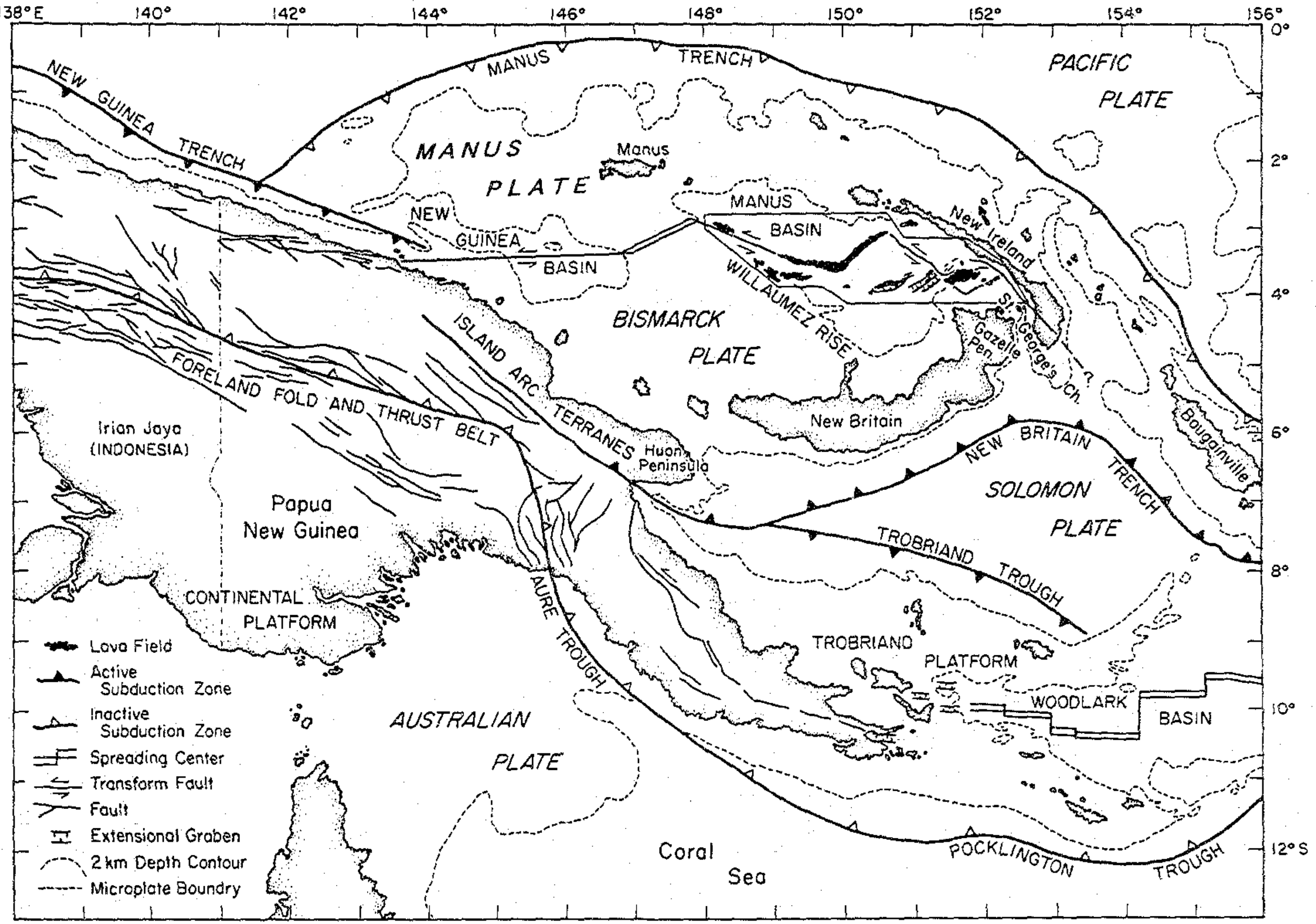


Figure 3-1-1 Tectonic Setting Map (after Taylor et al. 1991)

The major sea-floor spreading system of the Bismarck Sea as shown in Figure 3-1-1 is composed of two spreading centers called Manus spreading center in latter chapters and three transform faults. They are

(1) a spreading center roughly stretching from 3°40'S, 150°E to 3°S, 150°30'E in the direction of northeast~southwest and traversing the Manus Basin,

(2) a spreading center running in the direction of northeast-southwest and traversing the Willaumez rise, which lies between the Manus Basin and the New Guinea Basin, and two transform faults running in the direction of northwest-southeast and linking the above two seafloor spreading centers, and a transform fault running from east to west and traversing the New Guinea Basin.

According to the teleseismic data (Eguchi 1989), the locations of these sea-floor spreading systems correspond roughly to the 30~40 km wide shallow earthquake zone (which is shallower than 60 km), of the Bismarck Sea. However, the 30~40 km wide shallow earthquake zone is presumed to be considerably wide when compared with the width of one sea-floor spreading system, and also, all of the earthquake focal mechanism solutions are strike-slip type. Based on these, Taylor (1979) interpreted that the sea-floor spreading center is not formed by one segment but broken by small transform faults.

As the accuracy of the locations obtained from the teleseismic data was not so high, Eguchi (1989) performed a seismic observation of micro-earthquake by employing eight sets of self-floating type seabottom seismometers and interpreted that the spreading centers running from east to west were arranged in echelon between the transform faults which run in the direction of northwest-southeast roughly from 148°30'E to 149°30'E.

(*2): A distinguishing characteristic of a marginal sea when viewing from the gravity anomaly is that the free-air anomaly of it is composed of positive anomaly alone, i.e. a seafloor in which isostasy may not be retained (Tomoda 1972). Actually, at 148°E and eastward of the Bismarck Sea, the free-air anomaly of gravity is composed of positive anomaly only (Taylor et al. 1991). Incidentally, only fragmented data on gravity is available for the part westward from 148°E.

Based on the geomagnetic data of the Manus Basin, Taylor (1979) calculated that the above mentioned Manus spreading center started to spread from three and a half million years ago in the average direction of N60°W at average opening rates of 7.4 cm/y on the north side, 5.8 cm/y on the south side and 13.2 cm/y in the aggregate and regarded it as an asymmetric seafloor spreading.

Based on the results of the survey made by Both et al. (1986), Tufar (1991) collected a large quantity of submarine hydrothermal sulfides and discovered hydrothermal life, smokers etc. at the Manus spreading center (between 3°15'S, 150°08'E and 3°05'S, 150°25'E). Also, Crook et al. (1990) discovered a submarine hydrothermal oxidation zone in the vicinity of 3°06.79'S, 150°21.18'E).

Binns et al. (1991) discovered submarine hydrothermal ore deposits around the Paul ridge at 3°4'S, 151°40'E.

Sakai (1991) discovered sulfide minerals at a cauldron around 3°41'S, 151°52'E.

Volcanoes or volcanic clusters of the Quaternary period adjoining these survey waters include

(1) Volcanic clusters surrounding the St. Andrew Strait situated on the south of Manus Island - such volcanoes as Tuluman Islands (erupted during 1953 and 1957), Lou Island, Pom Island and Fedarb Islands.

(2) Vitu Islands situated to the north of New Britain Island.

(3) Active volcanoes of Manam Island and Karkara Island.
Both islands run along the Papua New Guinea Peninsula situated in the south of the survey area. Major islands and reefs adjoining the survey waters are as follows;

① Northern part: Purdy Islands, Alim Island and Papialou Islands.

② Southern part: Circular reef and Sherburne reef.

2) Submarine Topography

A bathymetric map and typical bathymetric profiles are shown in Figures 3-1-2 and 3-1-3(1), (2), respectively. Three-dimensional representations of bathymetric maps are shown in Figures 3-1-4(1)~(3). In order to make the submarine topography of this area clearly understandable, a color-coded bathymetric-contour map is shown in Figure 3-1-5.

Purdy Islands, Alim Island, Papialou Island, Baluan Island, Tulman Island (erupted from 1953 to 1957), St. Andrew Islands, Lou Island and Rambutyo Island are studded

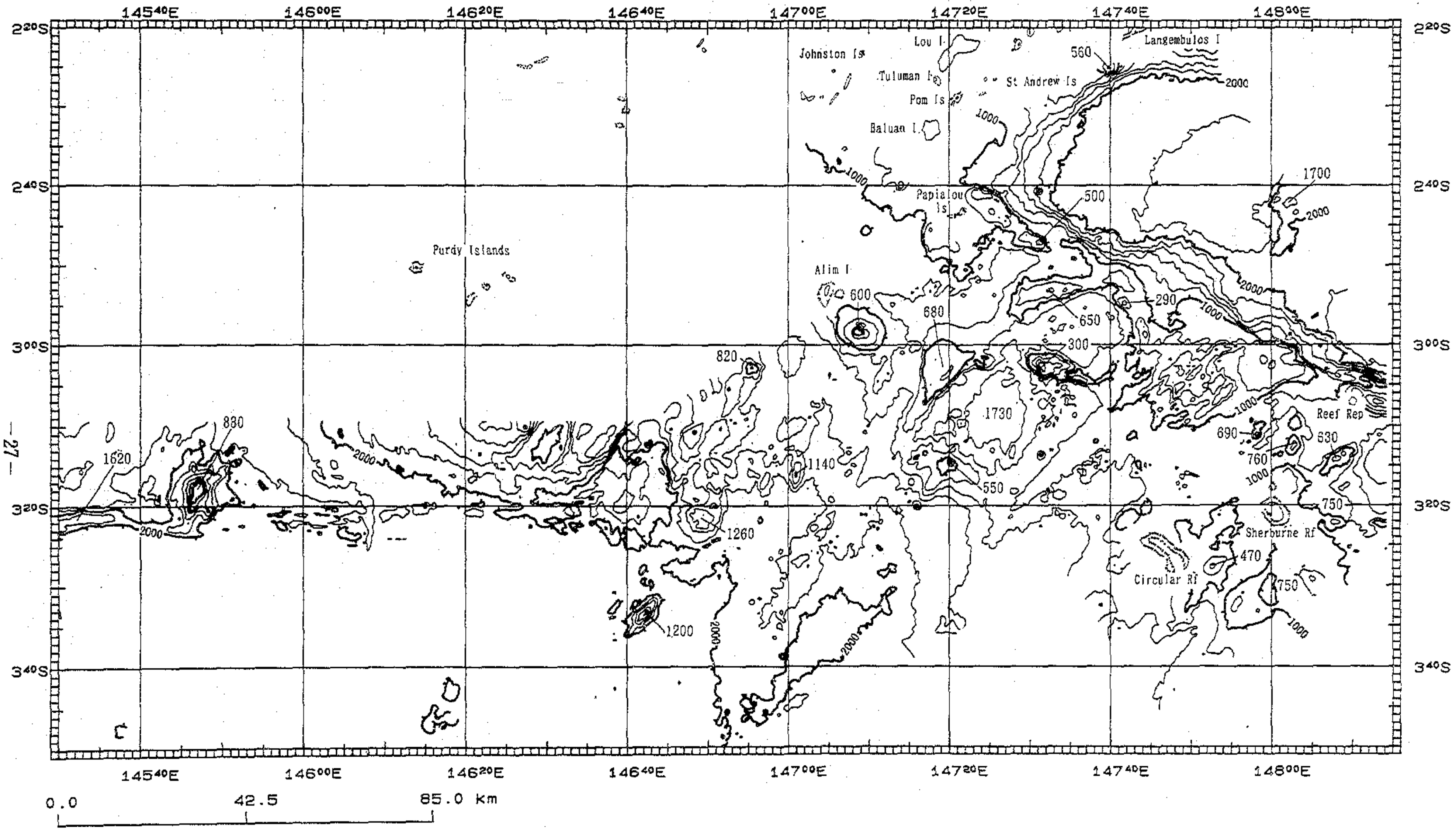


Figure 3-1-2 Bathymetric Map Based on MBES. MBES data are gridded at an about 0.7-km spacing. Contour interval is 200 m.

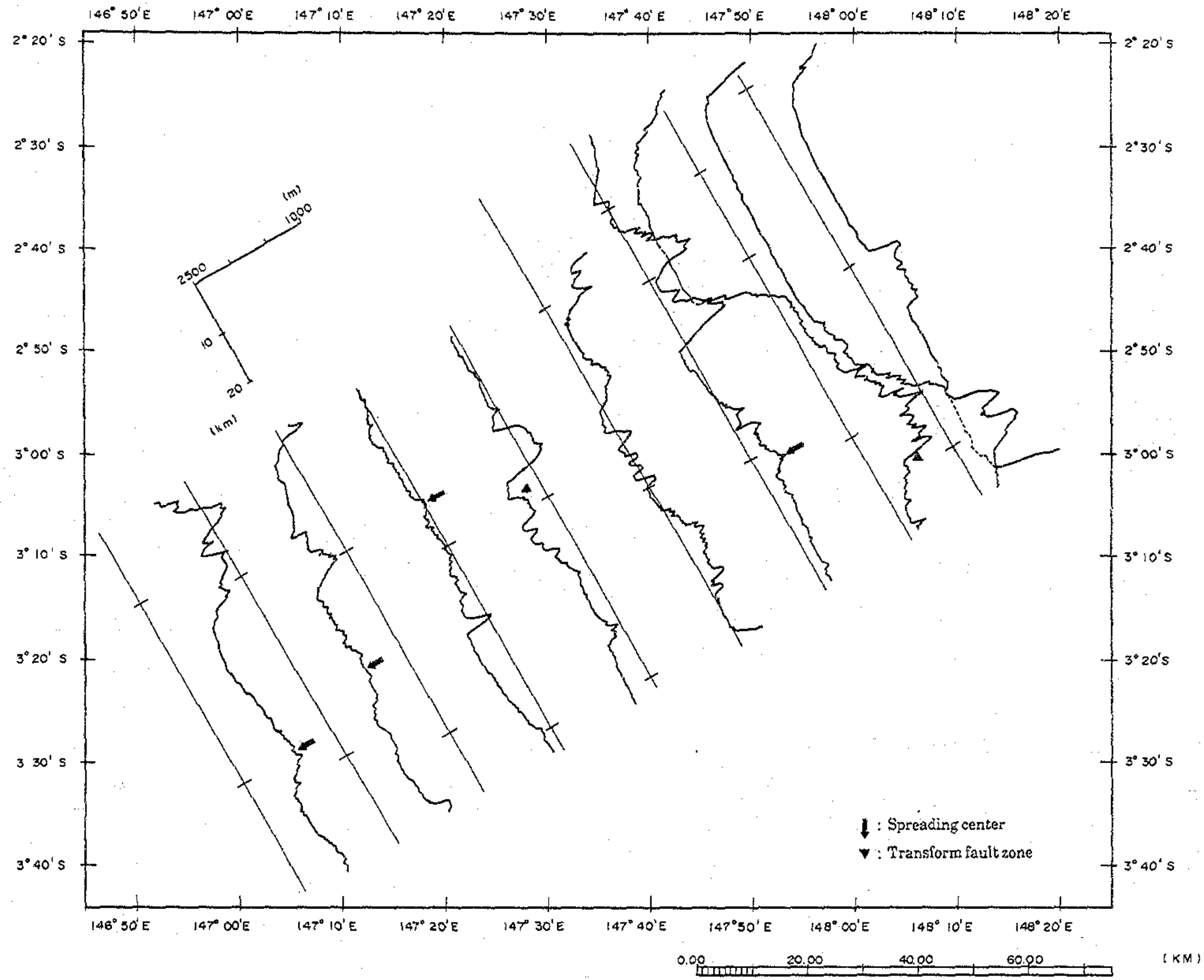


Figure 3-1-3 Bathymetric Profiles of A Area Based on MBES. (1)

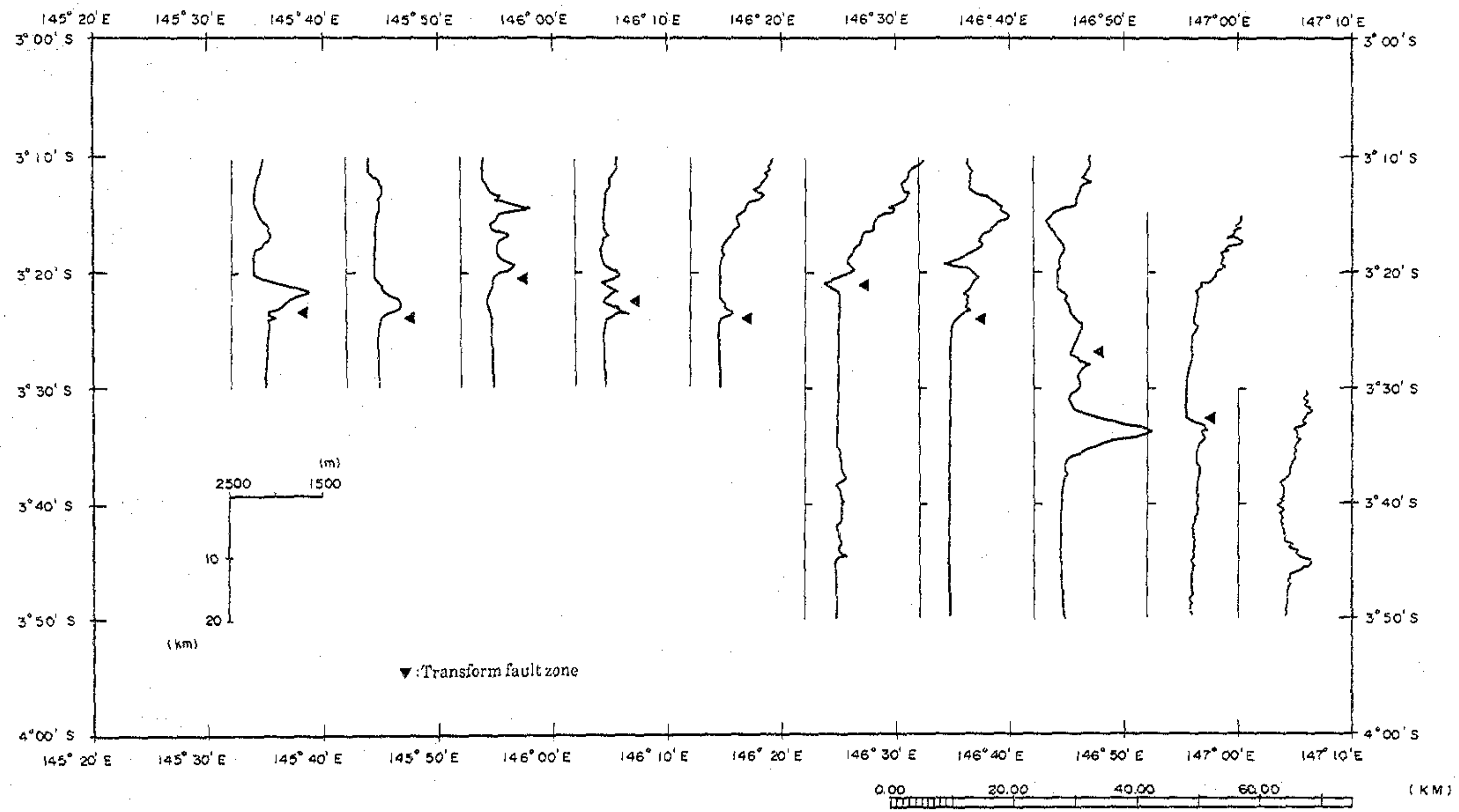


Figure 3-1-3 Bathymetric Profiles of A Area Based on MBES. (2)

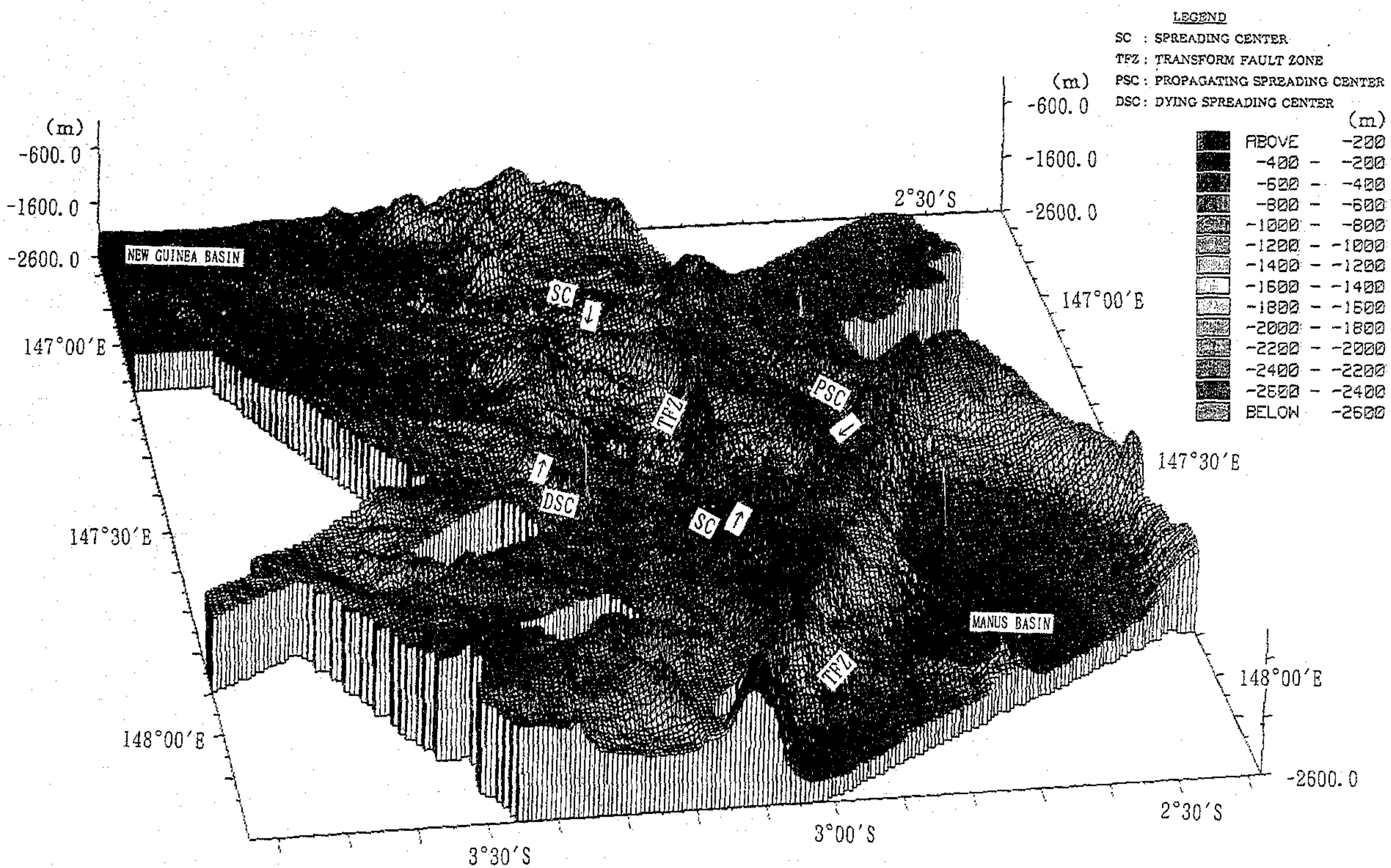


Figure 3-1-4 Three-dimensional Representation of Bathymetric Map of A Area. (1)

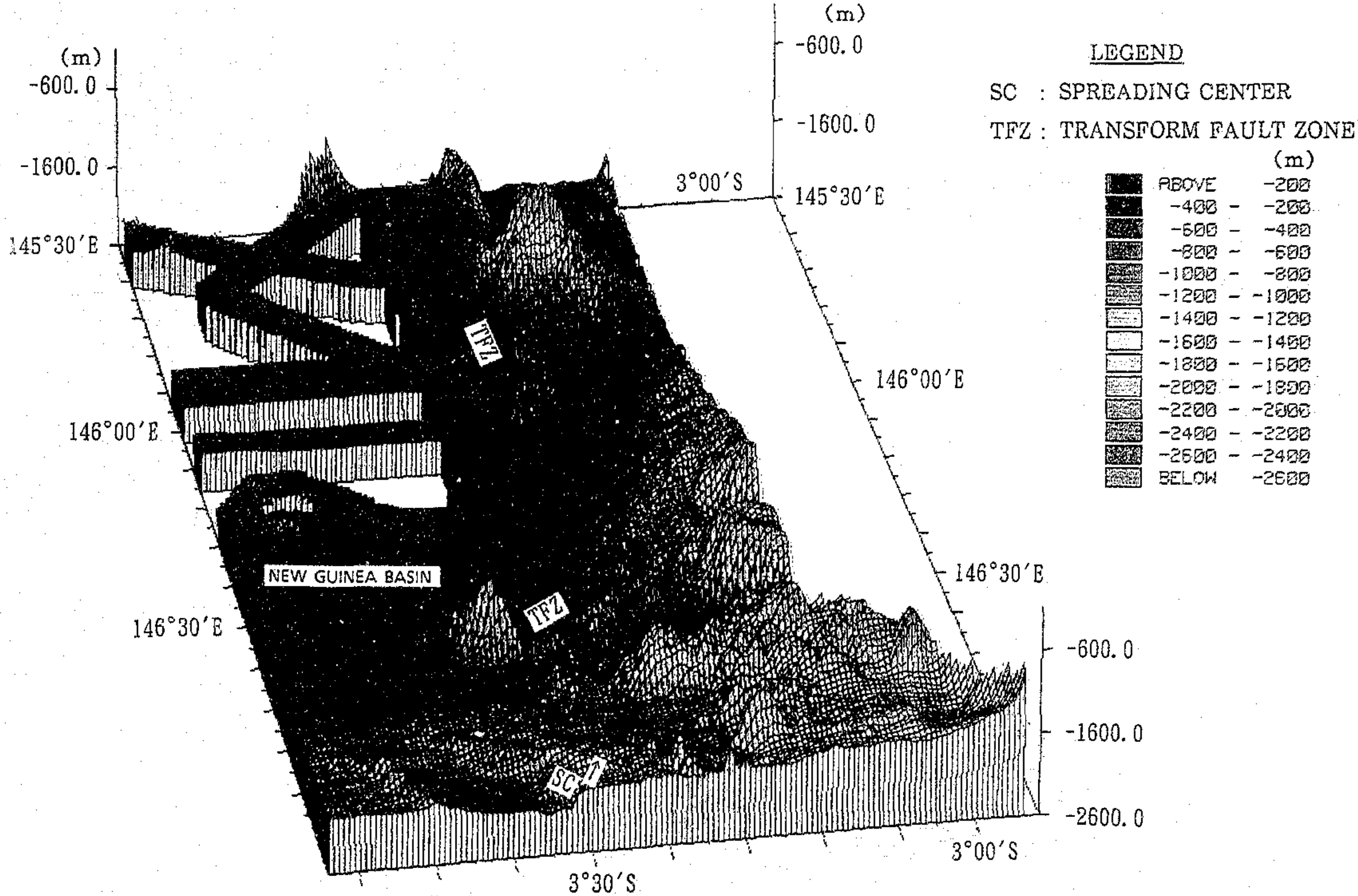


Figure 3-1-4 Three-dimensional Representation of Bathymetric Map of B Area. (2)

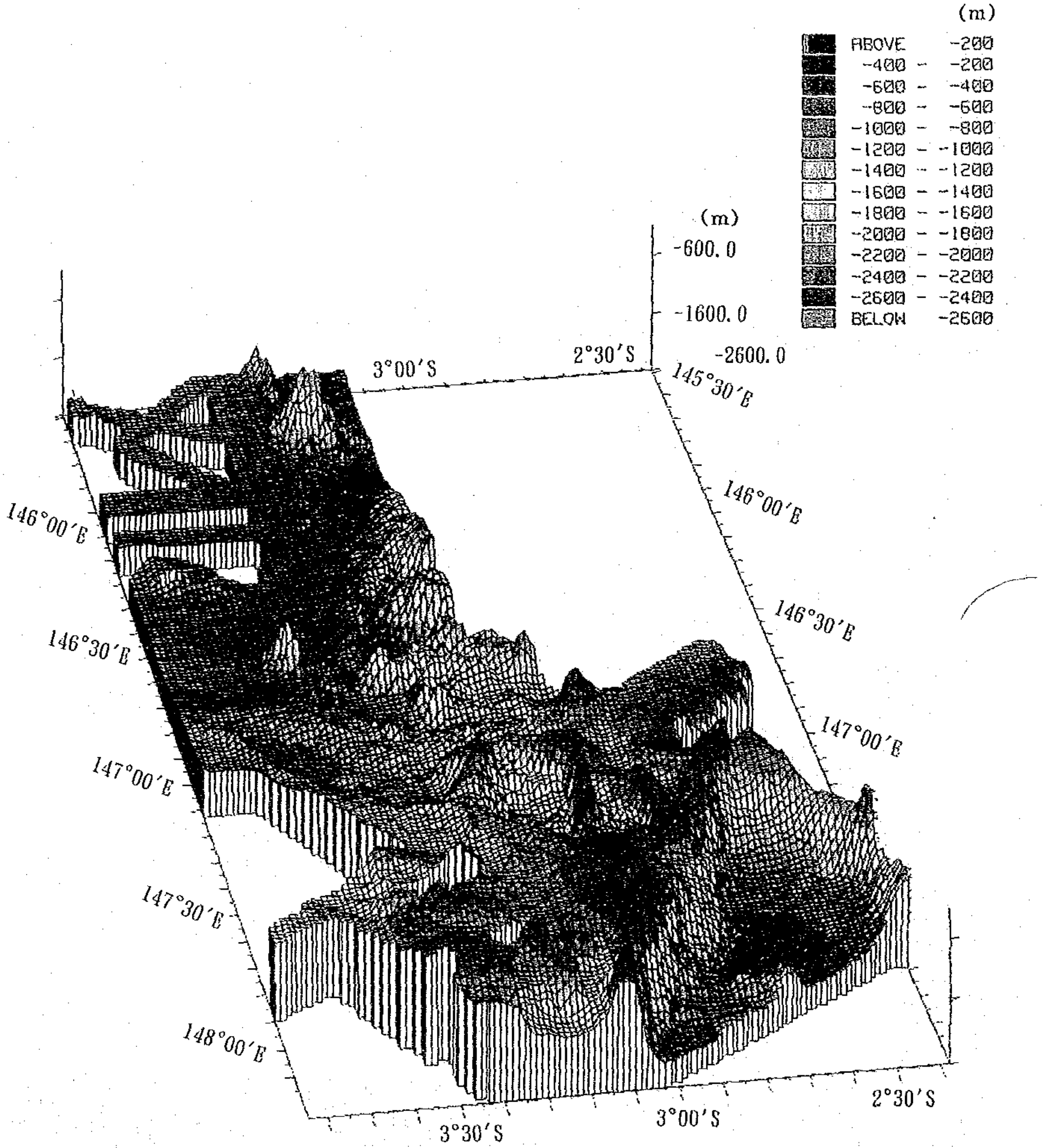


Figure 3-1-4 Three-dimensional Representation of Bathymetric Map of A+B Area. (3)

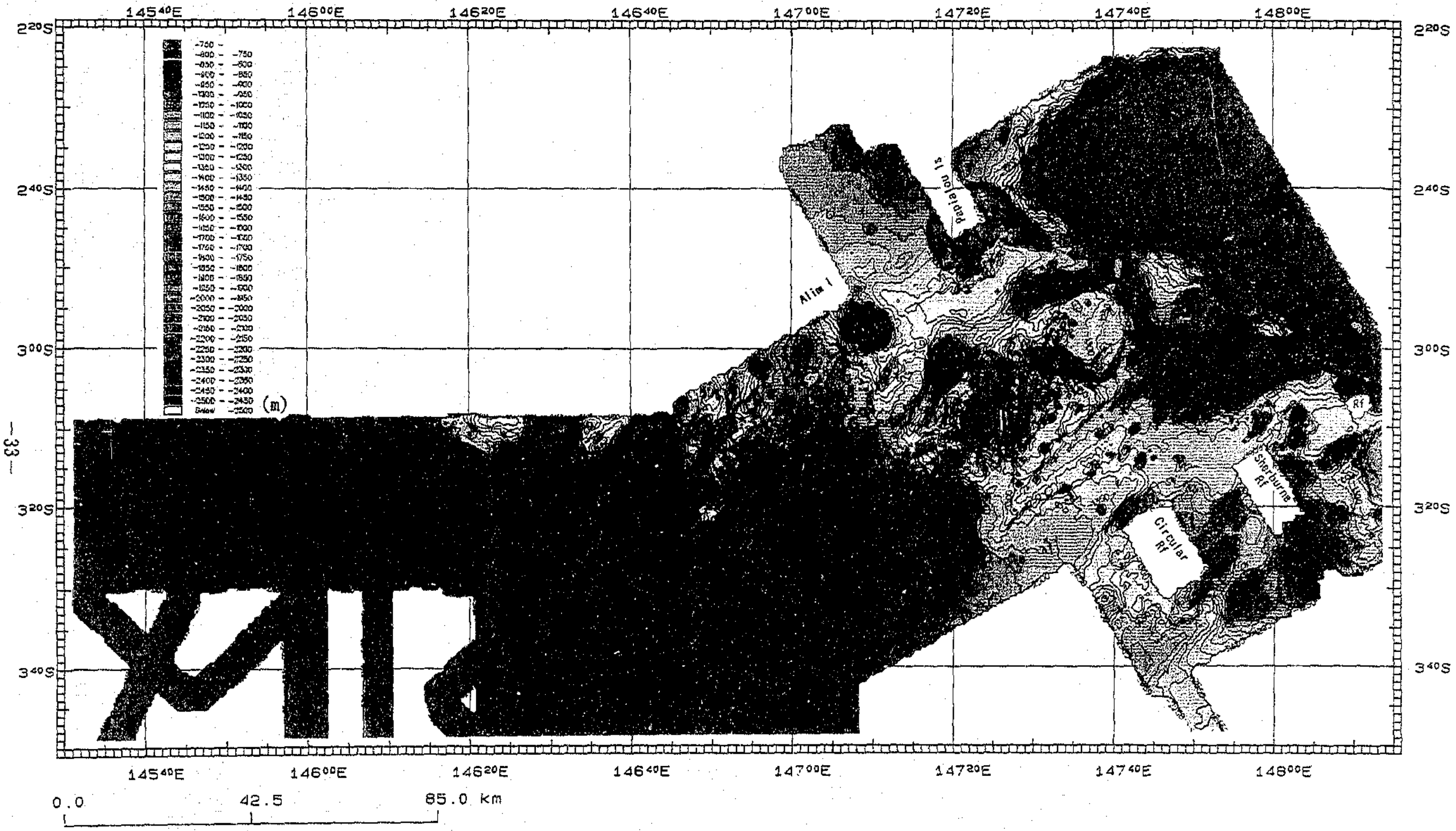


Figure 3-1-5 Color-coded Bathymetric Contour Map Based on MBES. Contour level is 50 m and color changes at every 50 m.

from northwest to east on the north of the survey area. There are Circular reef, Sherburne reef and small shoals on the southeastern part of the survey area.

The survey area is divided into two by the 60~70 km wide Willaumez rise in the northwest direction. The eastern part of it consits of the Manus Basin and the western part consits chiefly of the New Guinea Basin. We describe the characteristics of the seafloor morphology of the survey area in three parts, i.e. the Willaumez rise, the Manus Basin and the New Guinea Basin area.

<Willaumez rise>

(1) The eastern margin of the Willaumez rise, shaped like a cliff, forms the boundary with Manus Basin. Its relative height is at least 1,000 m. The western boundary is considered to be a northwest line that links Alim Island with Circular reef. Three prominent seamounts are distributed on this line. The width of the rise is 60~70 km and the direction of the summit is northwest.

The water depths of the rise are within the range of 170~1,500 m and numerous seamounts and ridges of shallower than 700 m are distributed on the rise. Also, islands and reefs are distributed on it. It is an undulating rise.

(2) There is a large scale Bank in the neighborhood of 3°02'S, 147°5'E. Numerous summits are recognized within this Bank and the shallowest part of these summits is at a water depth of 170 m. Among them, we estimated that the two summit lines with S35°W strike should be the spreading center.

(3) There is ridge extending in the direction of about S35°W from a seamount at 2°52'S, 147°32'E (at a water depth of 650 m) and disappearing in the vicinity of 3°40'S, 146°55'E.

Also there is an opinion to estimate the ridge on the southwestern side of 3°02'S, 147°20'E (the eastern flank of the seamount at a water depth of 680 m) as a spreading center and the northeastern side as a Propagating spreading center.

(4) There is ridge roughly paralleling the above mentioned ridge (paragraph (3)), getting sharp-pointed like a spear from the Bank mentioned in paragraph (2) and extending to the neighborhood of 3°20'S, 147°30'E. This ridge disappears at this point. There is an opinion to consider this ridge as a Dying spreading center.

(5) There is a seamount (the water depth of its summit is 300 m, at 3°02'S, 147°33'E) lying between the above mentioned two ridges (the ridges mentioned in paragraphs (3) and (4)). There is a furrow on the southwestern side of the seamount and another furrow on the northeastern side of the seamount. The water depth of these two furrows are 1,730 m and 1,370 m, respectively (refer to Figure 3-3-1).

<Manus Basin>

The northwestern tip of the Manus Basin lies on the north-eastern part of the survey area.

The western marginal part of the Manus Basin is a cliff with a relative height of about 1,000 m. The northern boundary of the Basin also shows cliff-shaped topography.

The Manus Basin is, on the whole, flat but there is a small elevated part of the water depth of about 1,700 m in the neighborhood of 2°40'S, 148°E.

<New Guinea Basin Area>

(1) The topography of the eastern part of the New Guinea Basin is complicated with a spreading center (submarine ridge) extending from the Willaumez rise, a chain of seamounts stretching out from the north and a small furrow at a depth of about 2,000 m.

(2) Along the 3°20'S line in the west of 146°30'E is mainly composed of chain of seamounts and the southern part of 3°20'S is a very smooth seafloor surface.

(3) The sea area deeper than the 2,000 m isobathmetric line at 146°50'E and westward is a flat plain (refer to the above paragraph (2)). But there is a seamount in the neighborhood of 3°35'S, 146°40'E, the depth of its summit is about 1,200 m.

(4) The deepest part - deeper than 2,400 m - is located in the neighborhood of 3°20'S, 146°40'E. This deepest part shows an ellipse in shape.

(5) A plateau extending from Purdy Islands stretches in semicircular shape in the western part of the depression mentioned in the above paragraph (4).

(6) There is a seamount in the neighborhood of 3°18'S, 145°48'E. The water depth of its summit is about 880 m.

(7) The circumference of the plateau mentioned in paragraph (5) and the seamount mentioned in paragraph (6) is an area with a water depth of more than 2,200 m. The New Guinea Basin has a tendency to spreading out northward from this region.

3-2 Magnetic Anomalies

The magnetometry was carried out with the object of finding out the geological structure, age of the seafloor (Vine-Mathews magnetic lineation) and so forth.

Data processing and drawing up of figures were performed by DPS in the following order.

(1) Obtain the total magnetic force value of each grid point at 1,000 m intervals by interpolating the measured value of the total magnetic force.

(2) Obtain the primary trend from the total magnetic force value of each grid point and then, calculate back to the total magnetic force of each grid point from this primary trend.

(3) Define the magnetic anomaly of each grid point as (1) minus (2) (the residual).

(4) Draw a total magnetic field map (Figure 3-2-1) based on the data of the paragraph (1), a magnetic anomaly map (Figure 3-2-2) and a three-dimensional representation of magnetic anomalies superimposed on bathymetric data (Figure 3-2-3) based on the data of the paragragraph (2). Residual magnetic anomaly profiles (Figure 3-2-4 (1), (2)) were drawn from the data of track line's magnetic anomaly obtained by subtracting the primary trend values from the measured magnetic values.

(5) The values of magnetic anomalies at grid points were filtered by 5-point weight moving average, then the results were converted to a single magnetic anomaly value, which is a value obtained by moving the positive/negative anomaly pair to the north pole and is called reduction to the pole anomaly value. Then reduction to the pole anomaly map (Figure 3-2-5) was drawn.

(6) Magnetization distribution (Figure 3-2-6) and a magnetic structural map (Figure 3-2-7) were drawn by an inversion solution (which is a solution to create automatically a model that will be consistent with reduction to the pole anomaly value).

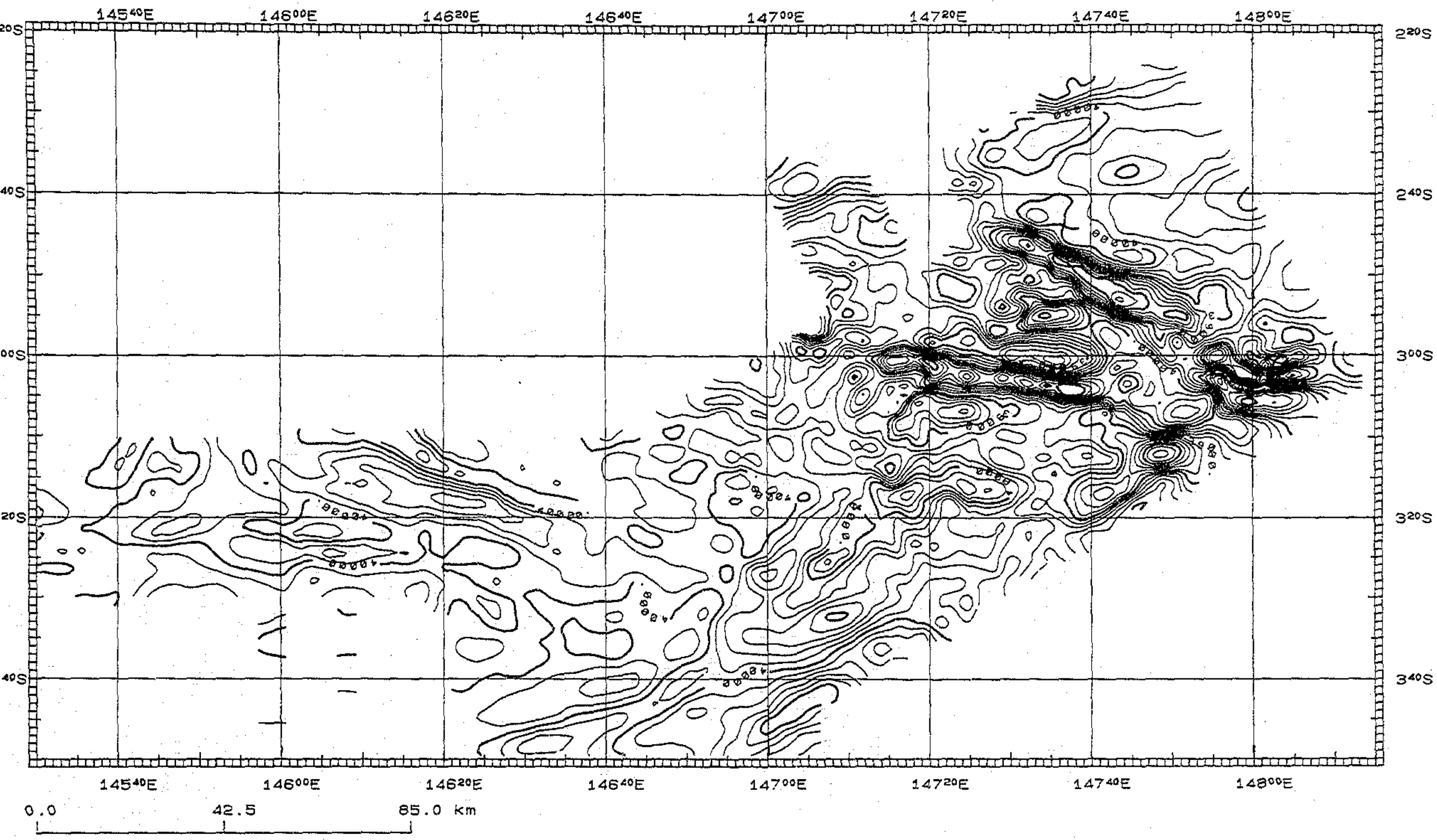


Figure 3-2-1 Total Magnetic Force Map Produced from the Data of the Measured Total Magnetic Force Value Gridded at a 1-km Spacing. Contour labels are in nanoteslas, and contour interval is 200 nT.

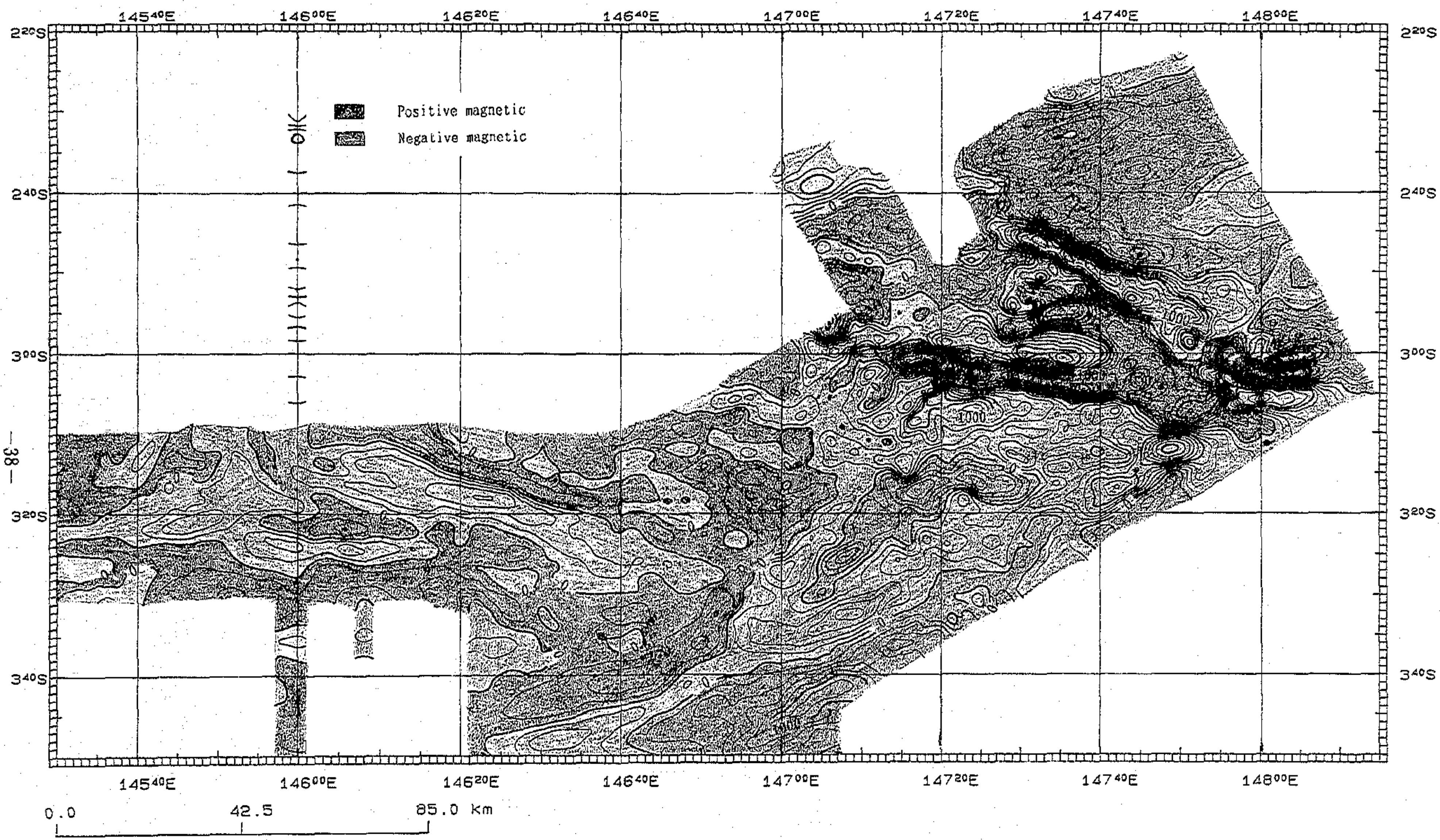


Figure 3-2-2 Magnetic Anomaly Map Produced from the Data Gridded at a 1-km Spacing. Contour interval is 200 nT.

LEGEND

SC : SPREADING CENTER

TFZ : TRANSFORM FAULT ZONE

PSC : PROPAGATING SPREADING CENTER

DSC : DYING SPREADING CENTER

Positive magnetic anomaly

Negative magnetic anomaly

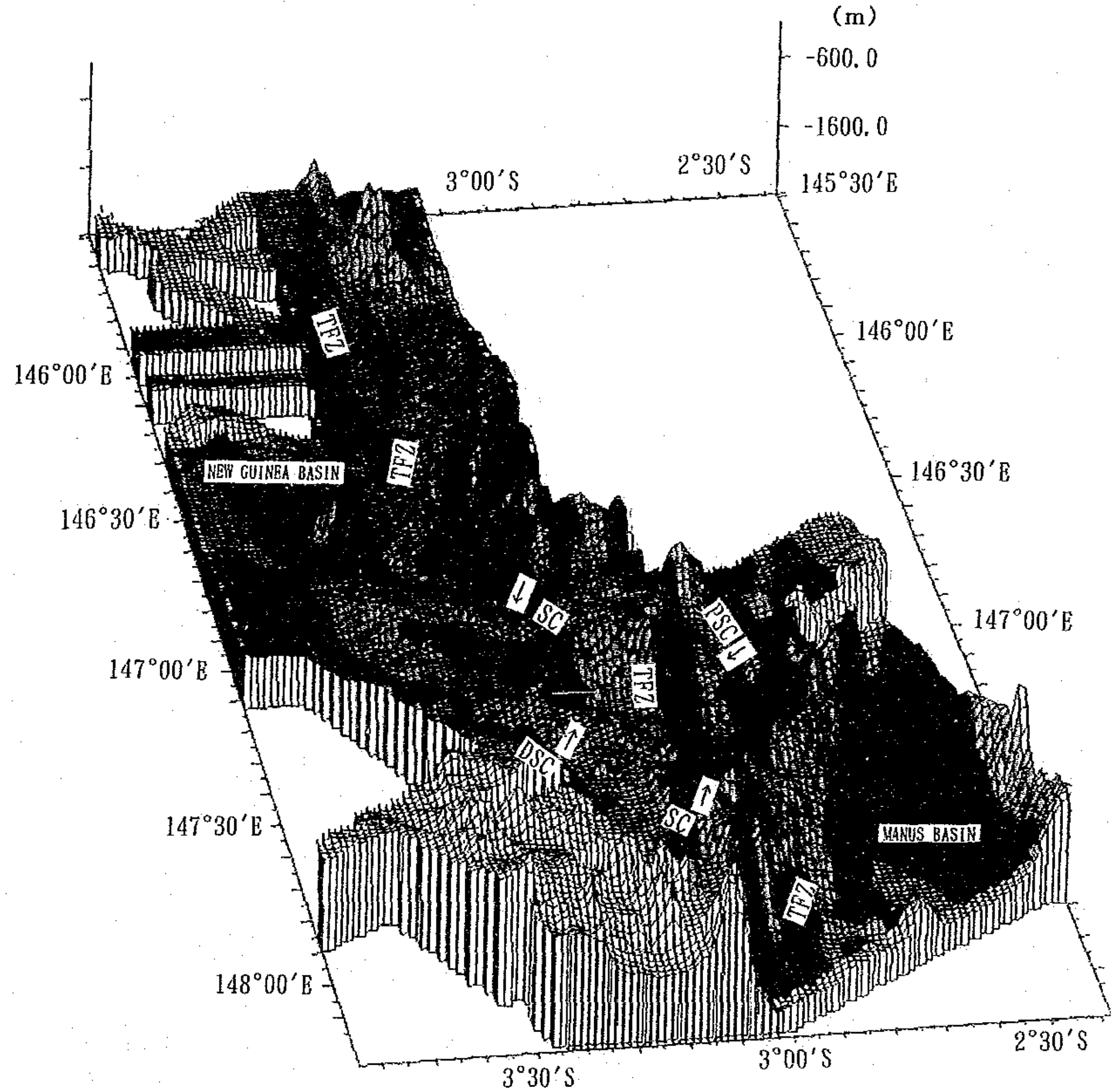


Figure 3-2-3 Three-dimensional Representation Map of Magnetic Anomaly Superimposed on Bathymetric Data. Contour labels are in meter, and positive magnetic anomaly is in red color and negative magnetic anomaly in green color.

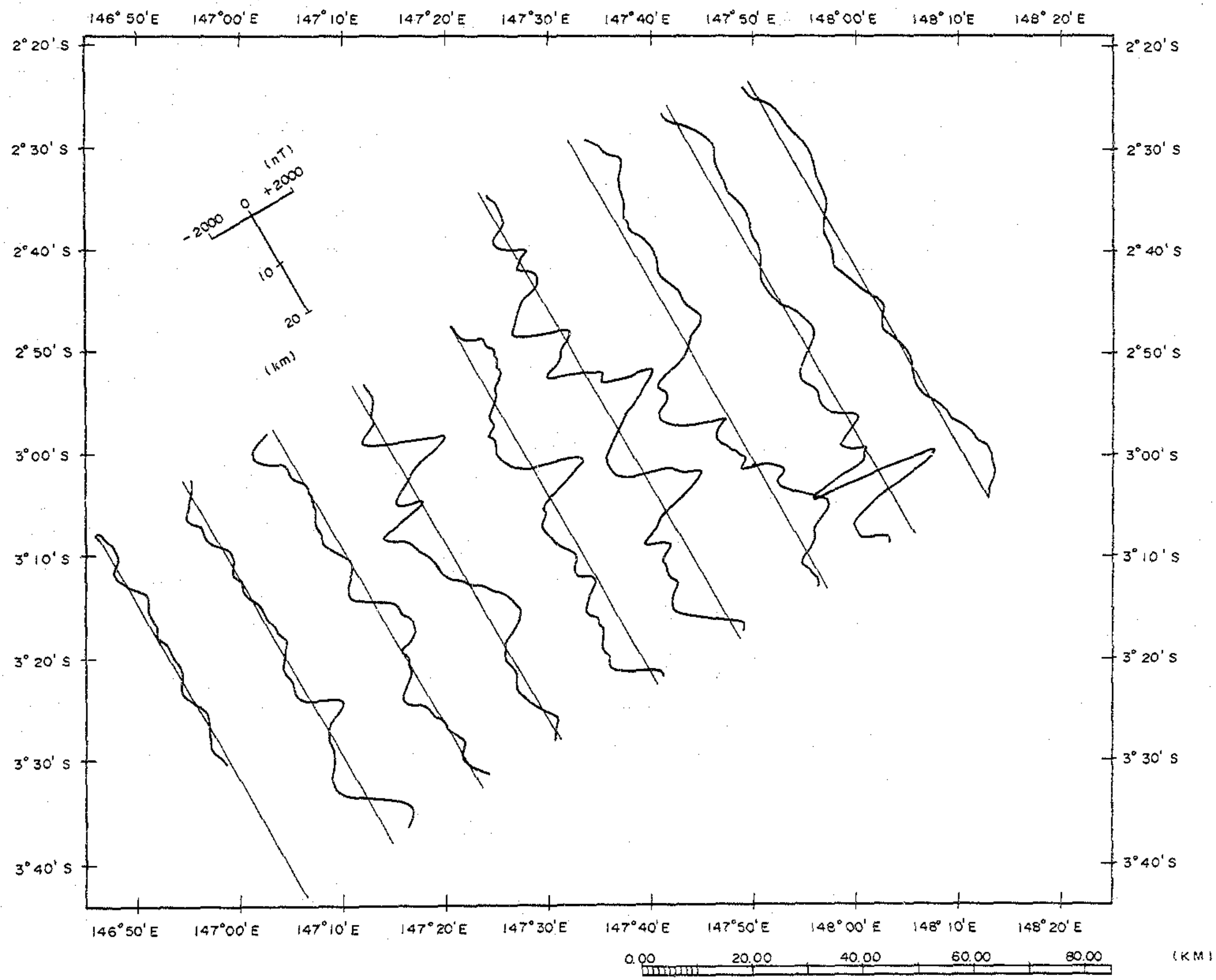


Figure 3-2-4 Residual Magnetic Anomaly Profiles of A Area. (1)

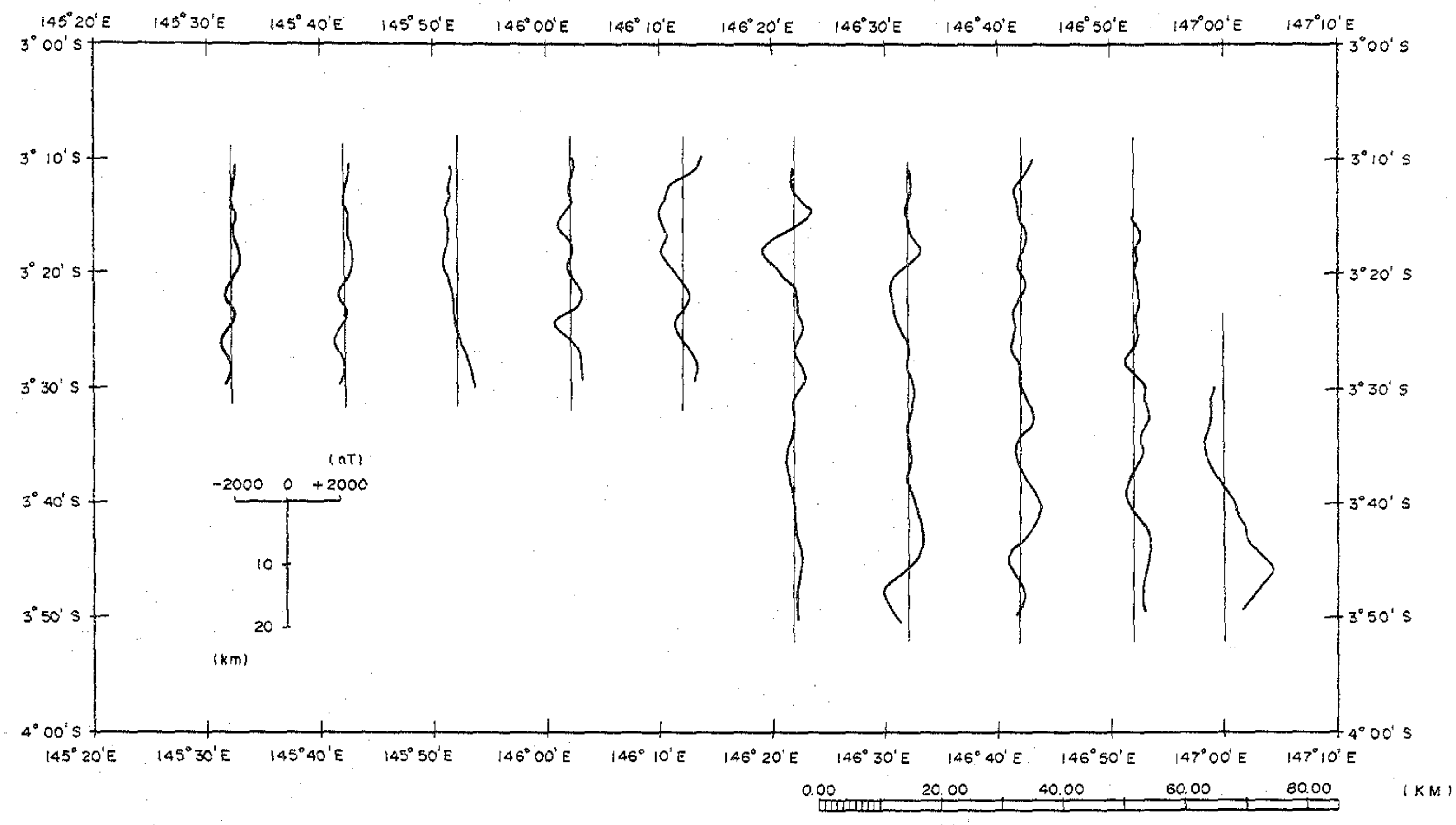


Figure 3-2-4 Residual Magnetic Anomaly Profiles of B Area. (2)

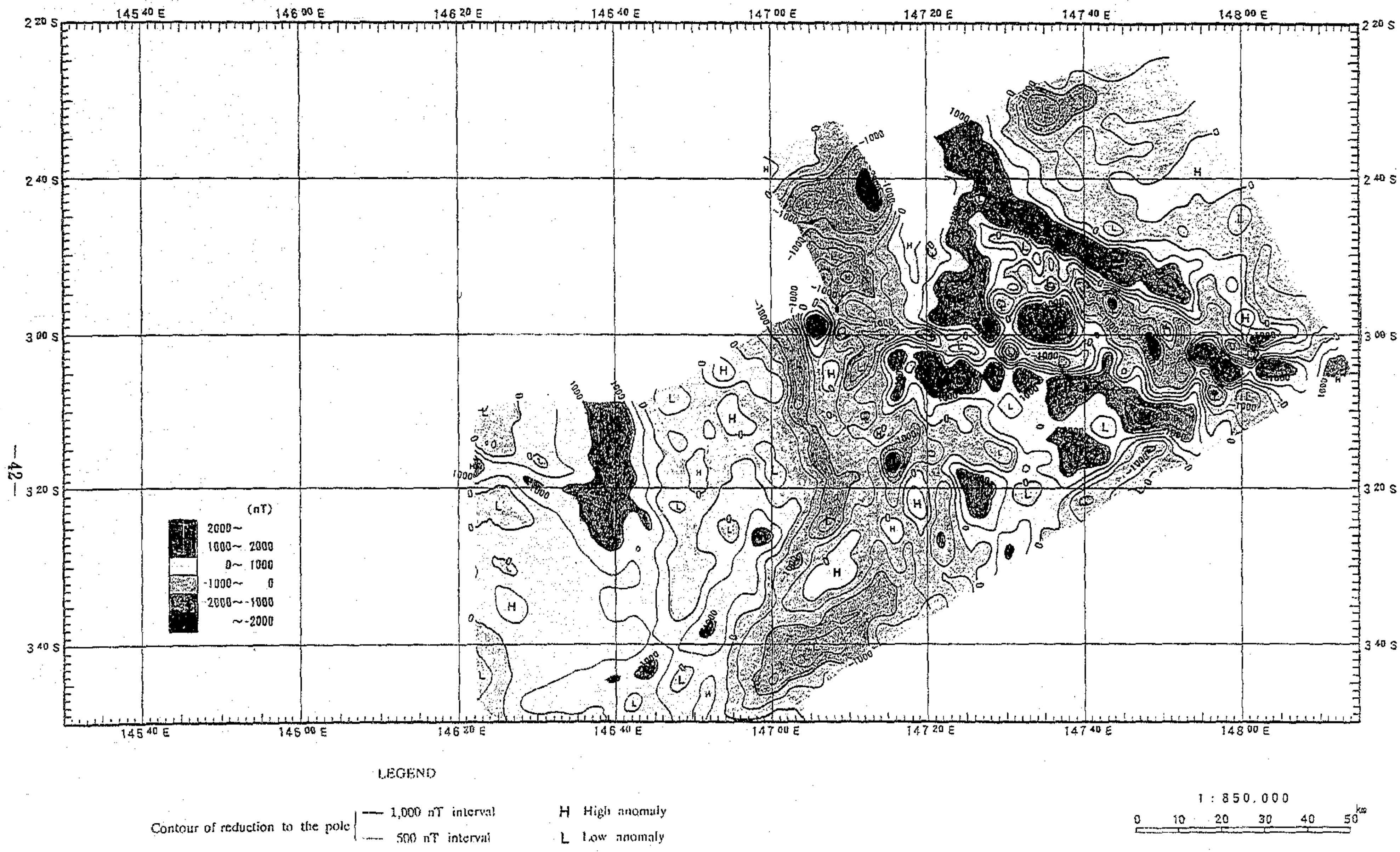


Figure 3-2-5 Reduction to the Pole Anomaly Map Derived from the Total Magnetic Force Value

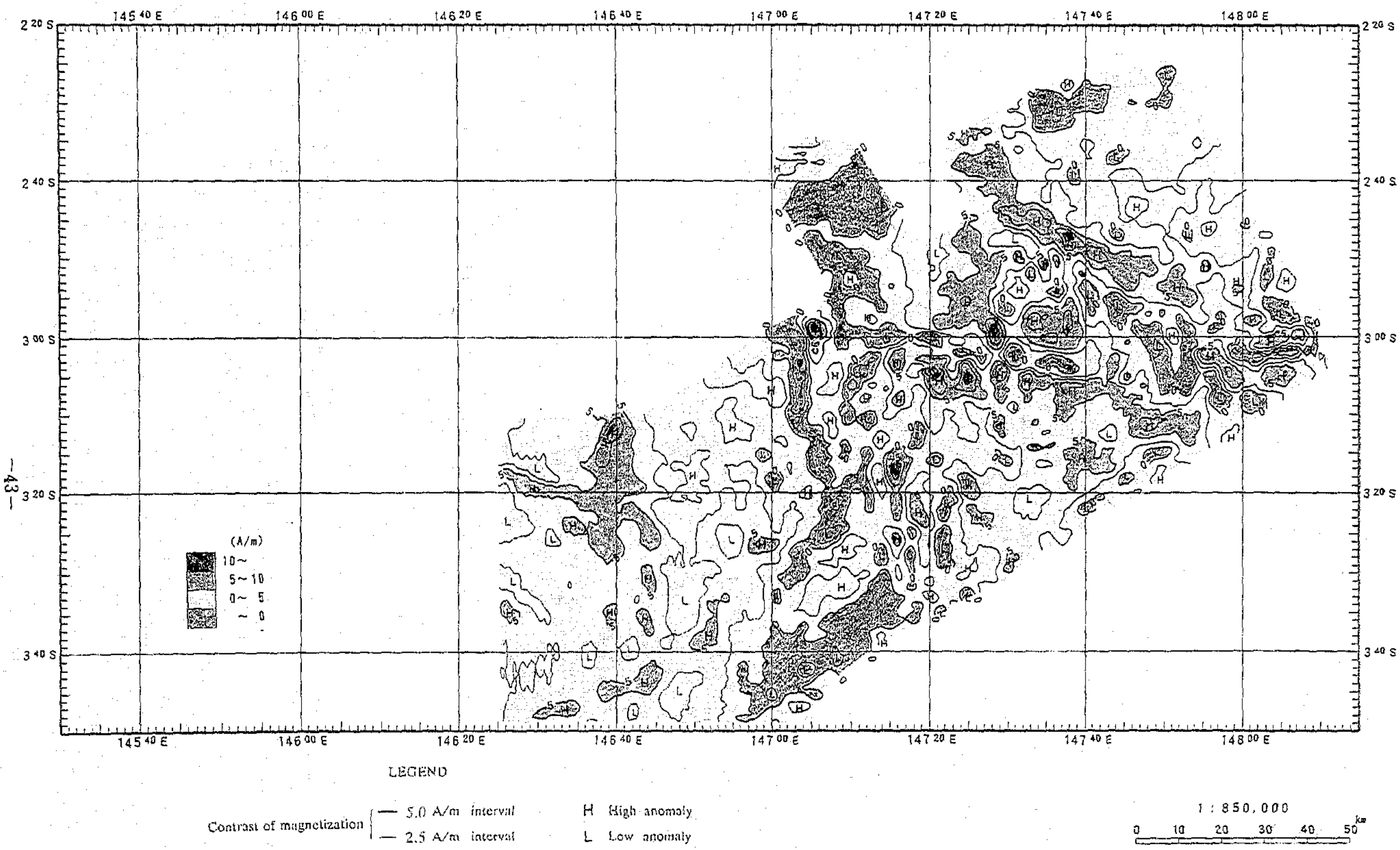


Figure 3-2-6 Magnetization Distribution Map from Three-dimensional Inversion Solution of Magnetic Anomaly Data Based on Gridded Bathymetric Data. Contour interval is 2.5 A/m.

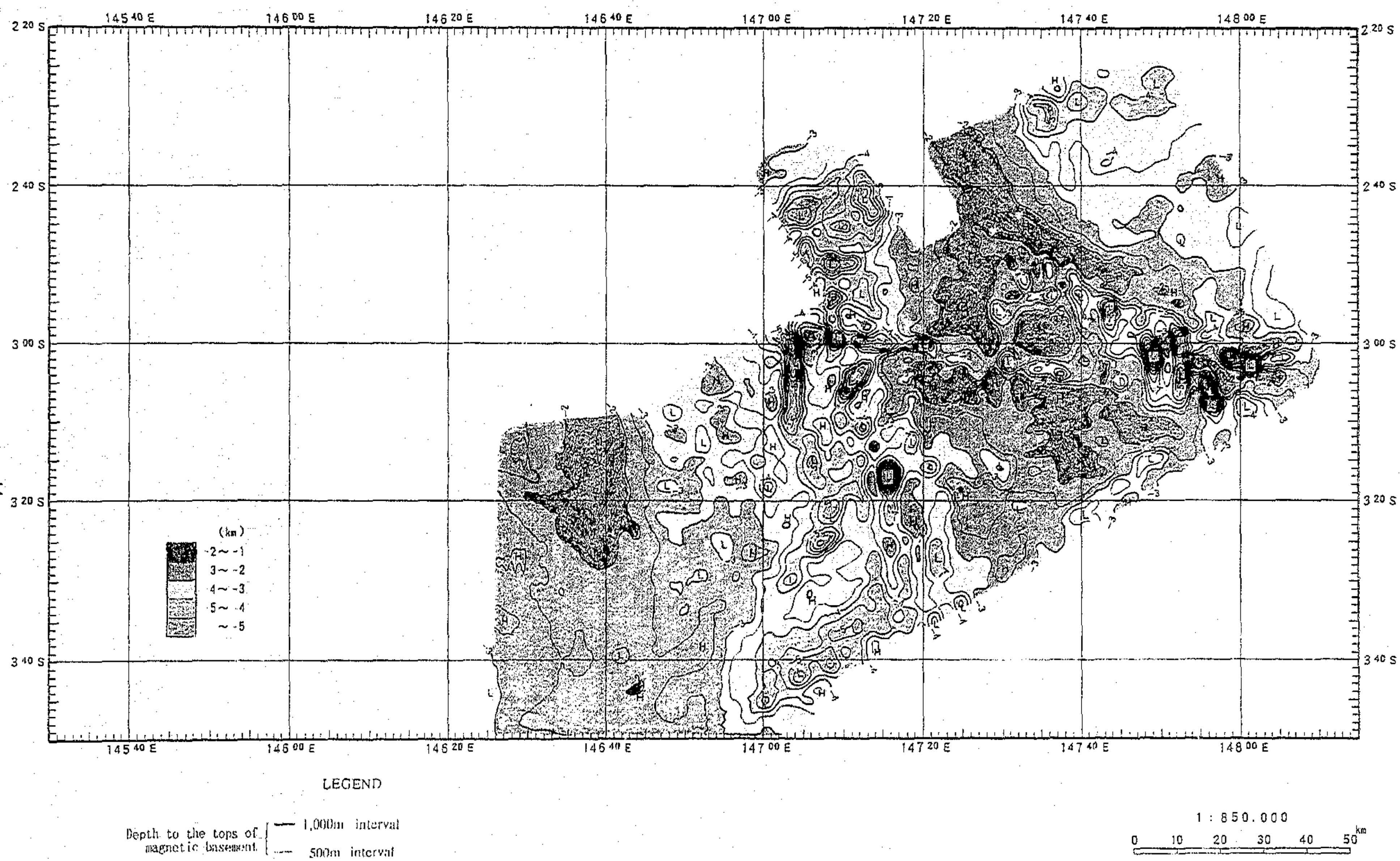


Figure 3-2-7 Magnetic Structural Map from Three-dimensional Inversion Solution of Magnetic Anomaly Data Based on Gridded Bathymetric Data. Contour labels represent the top depth of the magnetic basement. Contour interval is 500 m.

The measured total magnetic force values of the survey area is within the scope of 39,000~40,000 nT. No correction is made to the secular variation and daily variation of the geomagnetism.

The magnetic anomaly map, reduction to the pole anomaly map, magnetization distribution map and magnetic structural map are described hereunder.

As for the relation with the seafloor spreading system, referto Subchapter 3-3.

1) The Outline of the Magnetic Anomaly Map

A total magnetic field map and a magnetic anomaly map of the survey area are shown in Figures 3-2-1 and 3-2-2, respectively. Also, a three-dimensional representation of magnetic anomalies superimposed on bathymetric data and residual magnetic anomaly profiles are shown in Figures 3-2-3 and 3-2-4, respectively.

The characteristics of magnetic anomalies in the survey area are as follows (Figure 3-2-2);

(1) As the Vine-Mathews magnetic lineation in the survey area was not identified, it was impossible to specify the seafloor age.

(2) When comparing with the Willaumez rise (see the paragraph mentioned later), it is seen that the zone within the Manus Basin of the survey area is, on the whole, a magnetically smooth zone.

(3) The Willaumez rise is composed of two magnetic anomaly zone. One is the NNW trending anomaly zone and the other is EW trending anomaly zone. The amplitude of magnetic anomalies exceeds 1,000 nT, which value is very high as compared with the magnetic anomalies of the Manus Basin and the New Guinea Basin. The reasons of which can be adduced as that the magnetic substances of the Willaumez rise are younger than those of the Manus Basin and the New Guinea Basin, and that the magnetic substances are thicker because the water depth of the Willaumez rise is shallower.

(4) Negative magnetic anomalies presumed to be ranging roughly from east and to west - it may be magnetized reversely -are recognized in the Manus Basin and on the northern tip of the Willaumez rise.

(5) The New Guinea Basin is, on the whole, a magnetically smooth zone in comparison with the Willaumez rise but it has, as mentioned below, two characteristic magnetic anomalies;

- A positive high magnetic anomaly is distributed from 3°15'S, 147°30'E to 3°30'S, 147°05'E in the shape of an island. The negative magnetic anomaly distributed on the north side and south side of the above anomaly merges in the neighborhood of 3°30'S, 147°05'E and has a tendency to stretch in the direction of WSW.
- A negative anomaly extending in the direction of roughly northwest from approximately 3°30'S, 146°50'E and changing in the direction of west in the neighborhood of 3°10'S, 146°30'E is distributed. However, the negative anomaly has a tendency to expand in the northern part in the neighborhood of 3°10'S, 146°00'E.

(6) The magnetic amplitude of the seamount located in the vicinity of 3°35'S, 146°40'E is small but it is magnetized normally.

The seamount located in the vicinity of 3°18'S, 145°48'E is within the negative anomaly zone.

2) Magnetization Distribution and Magnetic Structure

The calculation of magnetization distribution and magnetic structure based on three-dimensional magnetic inversion solution was carried out only for the sea area with magnetic measurement track lines of 40 miles.

(1) Inversion Solution

Total magnetic force anomalies made up of positive/negative anomaly pair can be represented as a single anomaly by converting them[*3], i.e. the top of the normally magnetized magnetic substance becomes the center of positive reduction to the pole anomaly and the top of the reversely magnetized magnetic substance becomes the center of negative reduction to the pole anomaly.

(*3) This is a method to convert total magnetic force anomalies into the magnetic anomalies which would be shown by magnetic substances when they are moved to the north or south magnetic pole. Accordingly, this conversion is expressed as reduction to the pole conversion and its anomaly is expressed as reduction to the pole anomaly.

Accordingly, the comparison with seafloor topography and the interpretation to distribution of magnetic substances can be easily made by converting the magnetic anomaly map into a reduction to the pole anomaly map. Furthermore, the three-dimensional inversion solution, which enables one to identify the magnetization distribution and magnetic structure, will be easier. Reduction to the pole anomaly map is shown in Figure 3-2-5.

Magnetization was calculated by presuming a two-layer model (approximated by a partitioned prism) composed of a flat plane at the bottom and a seafloor plane at the top.

A magnetization distribution map is shown in Figure 3-2-6.

Magnetic structure is calculated by presuming uniform magnetization contrast and three-dimensional magnetic 2-layer model, i.e. make the sum total of the magnetic force within the region of 50 km × 50 km as the reduction to the pole anomaly value of each grid point of any 1 km × 1 km semi-infinite length prism. Then, compare these values with reduction to the pole anomaly data and increase or decrease the depth of each prism based on excess or deficiency of the reduction to the pole anomaly values.

We repeated this operation and calculation until the calculated values roughly coincided with the reduction to the pole anomaly data. The isoplethic depth map of the prism's top face of the entire grid points was adopted as a three-dimensional magnetic structure map.

Actually, we constructed the magnetic structure based on three kinds of magnetization, i.e. 10, 20 and 30 A/m, and then compared the results with the bathymetric map and magnetization distribution map. As a result of such operation, we found that the magnetic structural map based on 20 A/m harmonized most with the bathymetric map and magnetization distribution map. So we drew a magnetic structural map based on 20 A/m as shown in Figure 3-2-7.

(2) The outline of Reduction to the Pole anomaly Map

Characteristics of reduction to the pole anomaly map (Figure 3-2-5) as compared with the magnetic anomaly map (Figure 3-2-2) are as follows;

① On the whole, positive and negative magnetic anomalies are converted into low (negative) and high (positive) reduction to the pole anomalies, respectively(*4). In this survey area, it will be better to interpret the low (negative) reduction to the pole anomaly area as an area in which magnetic substances have low magnetization rather than to consider this area as an reversely magnetized area.

② The area at about 147°20'E and westward is composed of a low reduction to the pole anomaly and a high reduction to the pole anomaly trending northsouth, which is not clearly seen from the magnetic anomaly map. As an example of the former, we can cite a belt-shaped negative reduction to the pole anomaly distributed along the 147°05'E line and as an example of the latter, we can cite a positive reduction to the pole anomaly distributed along the 147°40'E line.

③ On the whole, many seamounts indicate low magnetic anomalies.

(3) Magnetization Distribution

As the magnetic anomaly is in inverse proportion to the cube of the depth of three-dimensional magnetic substances, we can consider that the magnetization distribution map may reflects the magnetization of the relatively shallow part beneath the seafloor.

The outline of the magnetization distribution map (figure 3-2-6) is as follows;

① Magnetization is distributed within the scope of 10 A/m ~ -5 A/m, and the maximum value is about 20 A/m. On the whole, the positive magnetization is prominent.

② Prominently high magnetized zones of more than 5 A/m are distributed on the Willaumez rise and the New Guinea Basin in the neighborhood of 146°30'E. It is inferred that magnetic substances are latent or partially exposed in these high magnetized zones.

③ Conspicuously low magnetization distribution of less than 0A/m is prominently running in the direction of east-west in the Willaumez rise and in the direction of south-north in the sea area between 147°00'E~ 147°20'E. The former roughly corresponds to the seamounts and we presume it is mainly caused by the hydrothermal alteration. As for the latter, we consider it is caused by the magnetic substances with low magnetization.

(*4): Magnetic anomalies tend to excel in the east-west trend in the equatorial region.

④ When we examine microscopically the positional relation between the negative magnetization distribution and seamounts, the summits of the seamounts are not necessarily consistent with the peaks of the negative magnetization distribution. Rather, the centers of the negative magnetization tend to locate in the circumference of the summits of the seamounts. We presume that this is not because the negative magnetization is reversely magnetized but because of the disappearance of magnetism due to some other reasons.

(4) Magnetic Structure

We consider that the patterns of isoplethic depth curves of the magnetic substances represent rough geological structure of this sea area although the reliability is poor at the places where the 2-layer structure is not realized (e.g. places with multi-layer substances, inclined magnetic substances or negatively magnetized substances) and the depth of magnetic substances shifts locally when assumptive magnetization varies at every district (low magnetization zones are calculated deeper and high magnetization zones are calculated shallower).

Based on the depth of magnetic basement(*5), we can classify the magnetic structure of this survey area into the following four districts (Figure 3-2-7).

① The Manus Basin is a district with magnetic basement depths of more than 3,000 m.

② The Willaumez rise is a horst district with the magnetic basement depths of less than 3,000 m.

③ The area between 147°00'E~147°20'E is a district with the magnetic basement depths of more than 3,000 m.

④ The area at 147°00'E and westward (the New Guinea Basin) is a horst district with the magnetic basement depth of less than 3,000 m.

(*5): Hereinafter the depth of magnetic substances from the sea level is expressed as the magnetic basement depth.

On the whole, the magnetic basement depth of the district of paragraph ② sandwiched between the district ① and ③ is generally shallow, i.e., means 1,500 m with horst structure. Also, the magnetic basement in the area ③ is mainly occupied by the district at the magnetic basement depths of 3,000~5,000 m and it may form a large-scale magnetic structural zone of the east-west system. One of the reason for the deeper magnetic basement is low magnetization, so, rock species or the content of FeTi may differ at the districts ② and ③.

Furthermore, the places at the northern tips of the ① and ③ indicated as having their magnetic basement depths of more than 4,000 m may be magnetized reversely and if they are actually magnetized reversely, the magnetic basement depth in the circumference of these places will be shallower.

Also, in the district along the 146°40'E line as mentioned in paragraph ④, the result of structural calculation shows that the magnetic basement depth projects from the sea-surface plane. The reason of which may be attributed to the presupposed values of magnetization being larger than the actual values.

However, we can presume that fresh rocks exist at about 30°20'S, 146°40'E (at depths deeper than 2,400 m, the deepest place, in the survey area).

3-3 Geological Structure

<Concerning the Seafloor Spreading System>

Based on the results obtained from the seafloor topography and magnetic surveys we estimated that the seafloor spreading system of the survey area is composed of two spreading centers and three transform fault zones. We also presented some spreading centers presumed to be propagating spreading centers and dying spreading centers. Estimated locations of their setting are shown in Figure 3-3-1.

(1) The spreading center estimated in the south-eastern trends about S45°W, has a length of about 19 km, a width of about 5 km and depths about 500~1,000 m. Topographically it is composed of a series of summit~valley~summit.

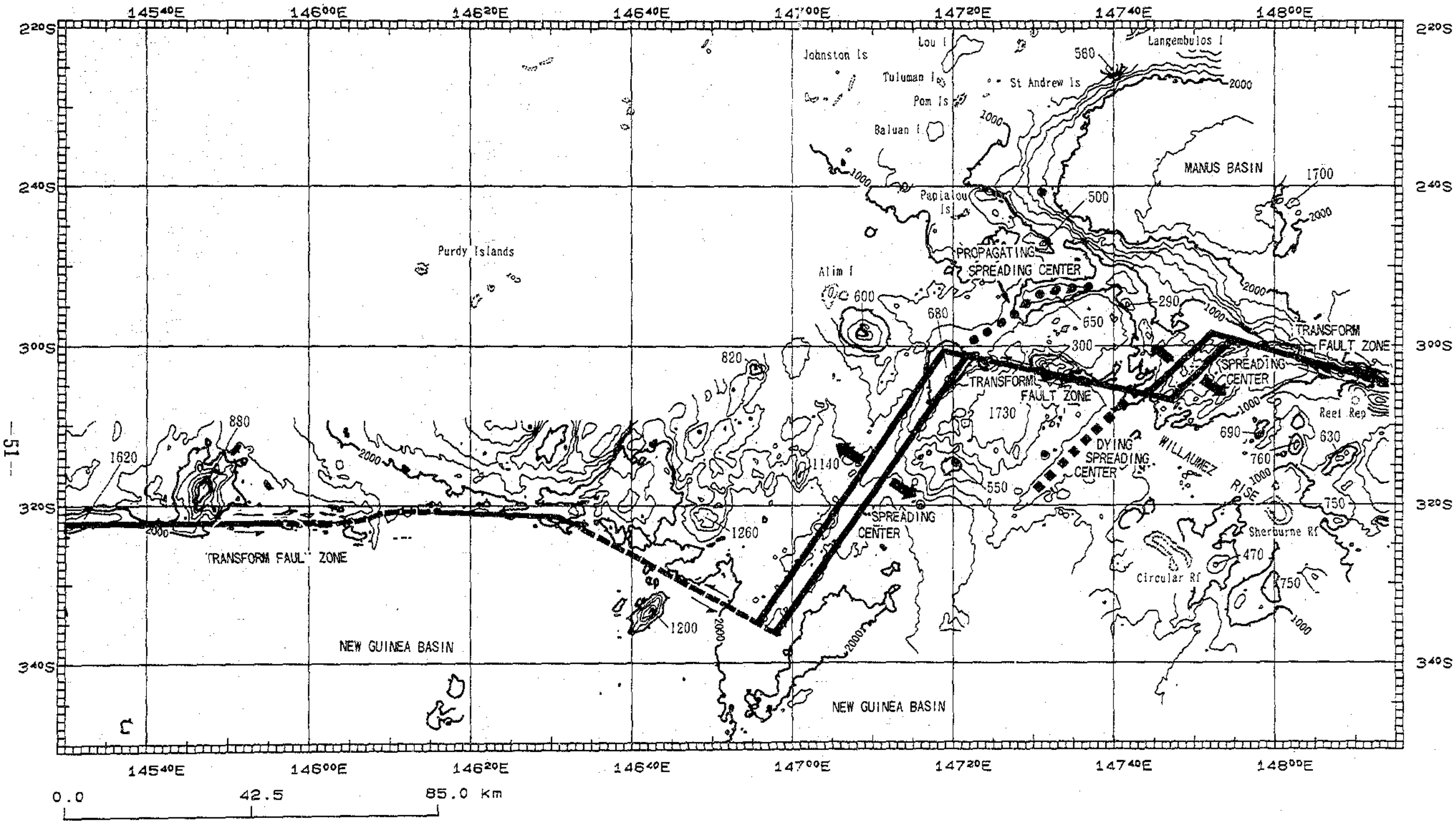


Figure 3-3-1 Geological Structural Map