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

(VOLUME 4)

SEA AREA OF SOLOMON ISLANDS AND PAPUA NEW GUINEA

March 1994

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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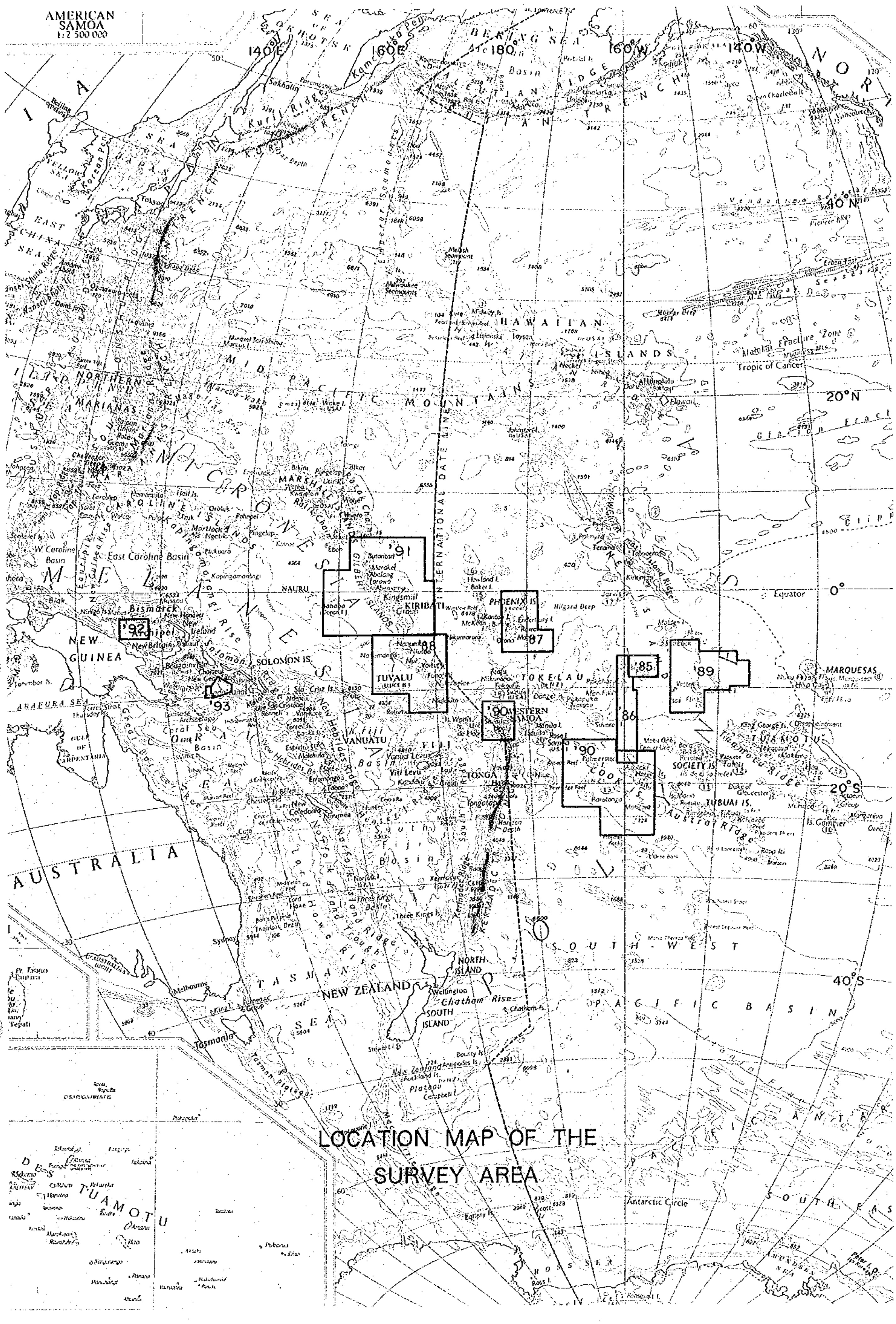
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AUSTRALIA
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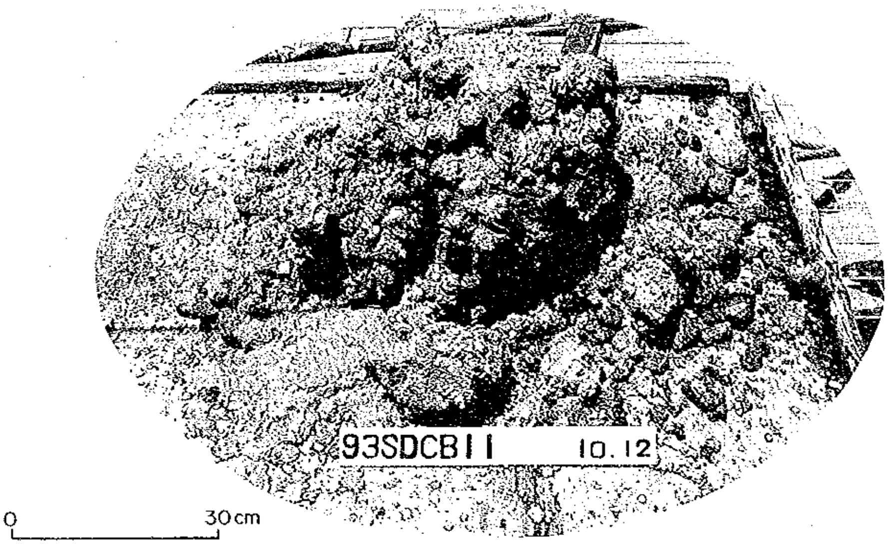
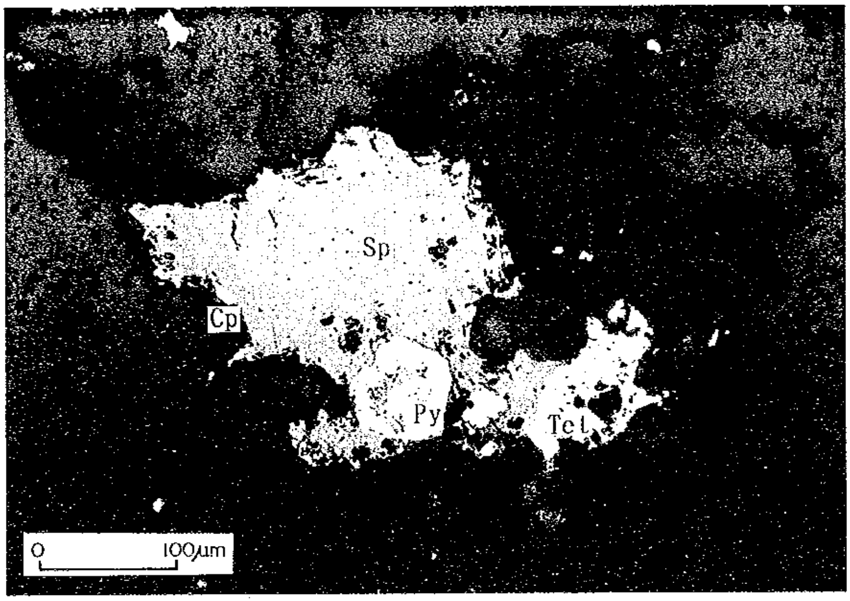
VANUATU
FIJI
TONGA
TOKELAU
MARQUESAS
SOCIETY IS.
TUBUAI IS.
NAURU
HAWAIIAN ISLANDS
MID PACIFIC MOUNTAINS
TASMAN SEA
SOUTH-WEST PACIFIC BASIN
Tropic of Cancer
Antarctic Circle
TUAMOTU
LOCATION MAP OF THE
SURVEY AREA



Hydrothermal sediments (made up of chiefly sericite)
collected from 93SDCB11 dredge



Reflecting microscopic photo of ore minerals collected
from 93SDCB11 dredge

Abbreviation : Tet; tetrahedrite, Cp ; chalcopyrite, Py ; pyrite, Sp ; sphalerite

PREFACE

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

After 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 over a five year period, and started in fiscal 1990. The fourth year of the survey was carried out within an exclusive economic zone of the Solomon Islands and part of Papua New Guinea. The MMAJ dispatched the research vessel HAKUREI MARU No.2, to investigate deep-sea mineral resources at the sites for 68 days from August 18, 1993 to October 24, 1993. The survey was completed on schedule with the cooperation of both the Solomon Islands and Papua New Guinea governments.

This report sums up the results of the fourth year survey.

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

March 1994

Japan International Cooperation Agency
President Kensuke YANAGIYA

Takashi Ishikawa
President
Metal Mining Agency of Japan

ABSTRACT

This is the fourth year of an initial survey for resources development in cooperation with SOPAC member countries, of a planned five years that started in 1990. This year, the survey was conducted over a sea area of about 51,000 km² (the eastern part of the Woodlark Basin), which belongs to the Solomon Islands and in part of Papua New Guinea, from August 18, 1993 to October 24, 1993. The survey period on site was for 42 days, with the target mineral resources being submarine hydrothermal ore deposits.

The survey was composed of topographic cruising, the main purpose of which was for making bathymetric maps, and geochemical survey sampling, which were composed of both regional survey and detailed surveys.

The bathymetric maps result from topographic cruising conducted for every 2.5 miles in Area 1 (the eastern area) and for every 3 miles in Area 2 (the western area). In order to help estimate the geological structure, a magnetic survey was also conducted in conjunction with the topographic cruising. The analytical work of the magnetic survey was done on land. Through this year's survey results, coupled with the previous works, the following information was obtained. The area can be divided into two parts by the Simbo Ridge in the center of the area, where a north-south transform fault is located. The eastern side of the Simbo Ridge differs from that of the western side. The western side is characterized by a combination of a seafloor spreading center (about 4,000 m deep) with an east-west depression and a north-south transform fault, which crosses the spreading center orthogonally. Its magnetic anomaly are readily identifiable, while that of the eastern part, composed of trenches and submarine volcanoes (about 1,000 m deep), are complicated.

Through the regional geochemical prospecting carried out at 24 points over Area 1 in a 21-mile grid, seafloor sediments were collected from 21 of the points. Back on land, multivariate statistics was conducted simultaneously with the chemical analysis, and the secondary principal components of copper, lead and zinc, which indicate hydrothermal deposits, were detected.

As for the detailed survey, FDC (Continuous Deep Sea Camera with Finder) observations were carried out at 9 track lines around the spreading center and the submarine volcanoes in Area 1. Sampling was carried out at 16 points in places where oxidized zones (which are apparent signs of mineralization), were expected. The

chemical analysis, X-ray diffraction and microscopic analysis were all done on land. Rock samples acquired from the seafloor spreading center, which is on the western side of the survey area, belong to the tholeiite rock series, and rock samples acquired from the submarine volcanic chain, belong to the calc-alkali rock series. Furthermore, in light gray clay and siliceous rock, collected from the crest of a submarine volcano (Kana Keoki Seamount) in the above-mentioned submarine volcanic chain, minor amounts of pyrite, gold, and microscopically chalcopyrite, tetrahedrite and sphalerite were observed. Sericite, which is commonly present in hydrothermal deposits as a clay mineral, was also detected. Besides these, very small chimney like structures composed of powdered galena and barite were collected.

Although the scope of the detailed survey was limited to only part of the total sea area, the fact that such oxidized zones were identified by the detailed survey, show a possibility that there have been a number of hydrothermal activities in this area.

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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 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 submarine hydrothermal ore deposits, in the Solomon Islands region of the SOPAC member countries. This survey consists of field surveys, the data analysis and 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 51,000 km^2 formed by joining the following coordinates (Figure1-1). Furthermore, border line of the Solomon Islands and Papua New Guinea in this survey area shows Figure 2-1-1.

Symbol	Latitude	Longitude
A	7°54'S	156°20'E
B	8°40'S	157°53'E
C	8°46'S	158°00'E
D	9°18'S	158°00'E
E	10°00'S	156°00'E
F	9°35'S	155°42'E

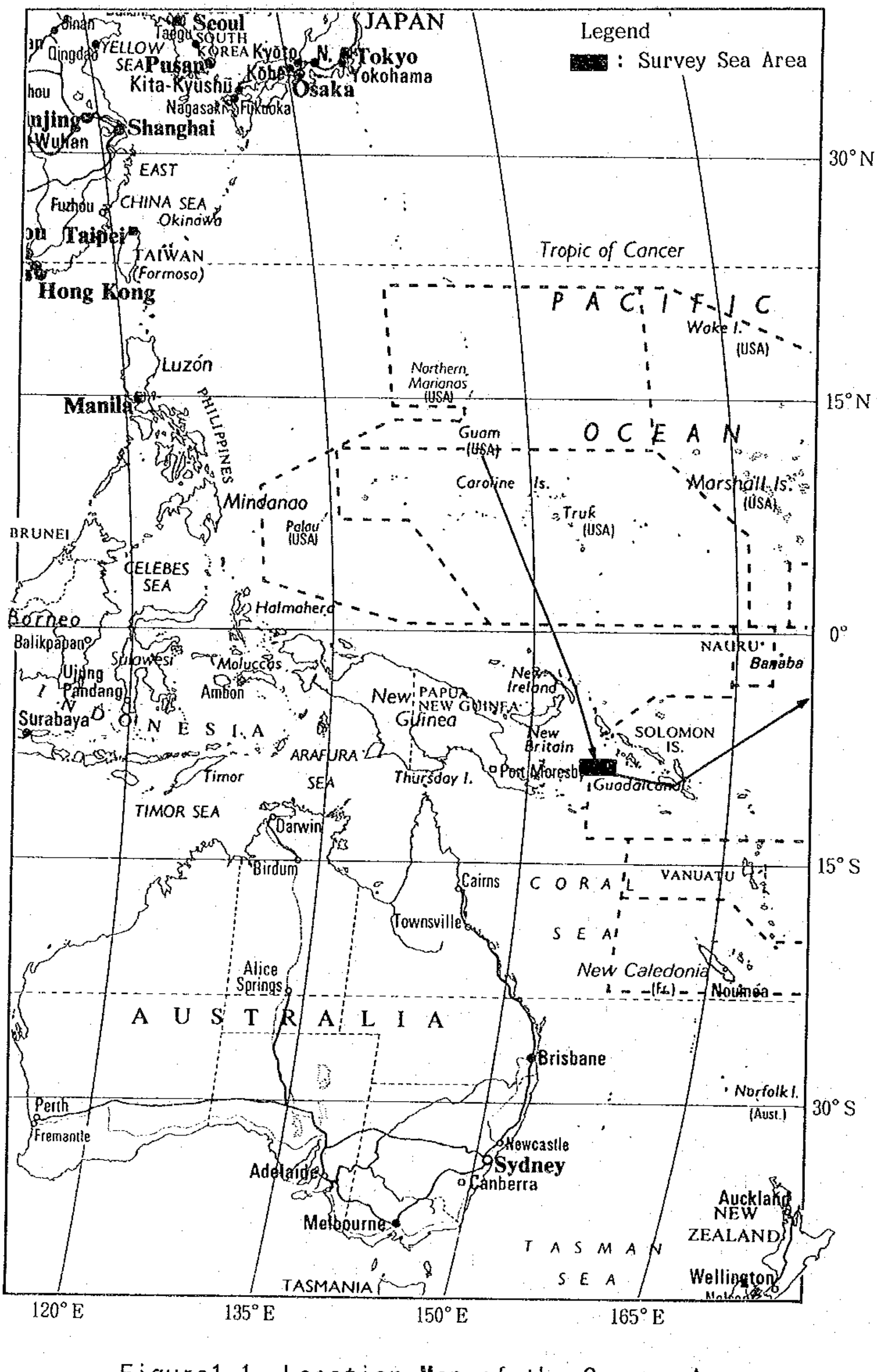


Figure1-1 Location Map of the Survey Area

G	9°00'S	155°42'E
H	9°00'S	154°40'E
I	10°00'S	154°40'E
A	7°54'S	156°20'E

1-4 Duration of the Survey

Survey cruise: From August 18, 1993 to October 24, 1993 (68 days). Analysis and Interpretation (Evaluation): From April 1, 1993 to March 31, 1994.

1-5 Participants of the Survey

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

Negotiators for the agreement:

Ichizo MORIKAWA	(Metal Mining Agency of Japan)
Yoshiaki IGARASHI	(Metal Mining Agency of Japan)
Osamu TSUKAMOTO	(Metal Mining Agency of Japan)
Mr. D.H. TOLIA	(Director, Geology Division Ministry of Natural Resources, Solomon Islands)
Dr. R. ADDISON	(Adviser, Geology Division Ministry of Natural Resources, Solomon Islands)
Dr. D. TIFFIN	(SOPAC)
Dr. Y. KINOSHITA	(SOPAC)

Supervisor

Keita KOUDA (Metal Mining Agency of Japan)
(Sept. 17 to October 24, 1993)

Advisers

Mr. Andrew Mark GOODLIFFE (University of Hawaii)
(Aug. 18 to Sept. 18)

Ms. Sarah Bean SHERMAN (University of Hawaii)
(Sept. 19 to Oct. 23)

Members

Chief of the Survey Party	Taizo MATSUMOTO	(DORD)
Chelf Geologist	Kazunori MATSUI	(DORD)
Geologist	Masatoshi SAKODA	(DORD)
Geologist	Kazuo IKEDA	(DORD)
Geologist	Masahiro NARA	(DORD)
Geologist	Yutaka MATSUURA	(DORD)
Geologist	Atsushi FUTAMADO	(DORD)
Geologist	Kazuhiko TANAKA	(OEDC)
Chief Geophysicist	Shiro OYAMA	(DORD)
Geophysicist	Kiyoshi TONO	(DORD)
Geophysicist	Nadao SAITOH	(DORD)
Geophysicist	Kunio KIMURA	(DORD)
Geophysicist	Hiroyoshi WADA	(DORD)
Geophysicist	Seigo UESAKA	(DORD)
Geophysicist	Kazuhiko KASHIWASE	(DORD)
Geophysicist	Susumu ENDO	(DORD)
Geophysicist	Shinichi KUSAKA	(OEDC)
Geophysicist	Takashi SOEJIMA	(OEDC)

Trainees

Mr. Bobby KELLY (Solomon Islands)
(Aug. 18 to Sept. 18)

Mr. Stanley BASI (Solomon Islands)
(Sept. 18 to Oct. 24)

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 Table1-1.

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	
	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	
		Chain Bucket	CB	
		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
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 survey achievements are listed in Table 1-2 (1), (2), and the records of the survey schedule in Table 1-3.

Table 1-2 Survey Achievements (1)

	Item	Accomplishent
Survey Schedule	Depart Guam Start the Survey Finish the Survey Arrive Honiara Depart Honiara Start the Survey Finish the Survey Arrive Honolulu	Aug. 20 16:00 Aug. 25 20:41 Sep. 16 14:14 Sep. 17 08:40 Sep. 20 16:00 SEp. 21 13:00 Oct. 12 14:41 Oct. 23 08:00
Sampring	Regional Geochemical Sampling Detailed Survey	24 points(GC:22 times, LC: 4 times) 16 points(CB:12 times, FPG: 4 times) (including all trials)
	Weight of Taken Samples	Ligth Gray Clay 154.0kg Rocks 3,636.6kg Total 3,790.6kg
Deep Sea Obser-vation (FDC)	Number of Track lines Total Length of Track lines Acquired Photographs Acquired VTR Tapes	9 track lines 52.0 nautical miles 1,524 sheets No,1 line 204sheets 8.5miles No,2 line 241sheets 8.3miles No,3 line 261sheets 8.7miles No,4 line 261sheets 7.7miles No,5 line 127sheets 6.1miles No,6 line 112sheets 3.5miles No,7 line 104sheets 3.1miles No,8 line 112sheets 3.1miles No,9 line 102sheets 3.0miles 27
Sea Water Physical Proper-ty Survey (CTD)	Vertical Type Towed type	1 point 9 lines(with FDC)
Acoustic Sound-ing	MBES(15.5khz) NBS(30.0khz) SBP(3.5khz)	4,988.9 miles(Area 1), 1,264.8 miles (Area 2), 6,235.7 miles(total) ditto ditto
Magnetic Survey (PGM)	Proton Magnetometer	4,856.0 miles(Area 1), 1,264.8 miles (Area 2), 6,120.8 miles(total)
Deta Processing	MT from Data Processing System(No.5 Labo.) MT from MBES Drawing	1 reel(Off-line) 21 reels(On-line), 7 reels(Off-line) Track Line Map, Bathymetrical Maps, Cross Sections etc.

Date and Time are shown in Local Time.

Table 1-2 Survey Achievements (2)

F	Track Line No.	93SFDC01	93SFDC02	93SFDC03	93SFDC04	93SFDC05	93SFDC06	93SFDC07	93SFDC08	93SFDC09	Total
	Date	Sep. 23 & 24	Sep. 24 & 25	Sep. 25 & 26	Sep. 26 & 27	Sep. 27 & 28	Oct. 05 & 06	Oct. 06	Oct 06 & 07	Oct. 07	
	Track Line Length (miles):(A)	8.5	8.3	8.7	7.7	6.1	3.5	3.1	3.1	3.0	52.0
	Observing Depth	1,490~2,548m	2,018~2,592m	1,177~2,441m	670~2,113m	1,335~1,952m	2,176~2,760m	2,097~2,911m	2,608~3,138m	2,238~2,635m	670~3,138m
D	Survey Times(hrs.)	08:31	08:45	08:07	08:02	05:38	04:59	04:51	05:17	04:36	58:46
	Equip. Throwing Time	21:06	21:05	20:50	20:55	20:57	20:33	01:58	20:56	02:55	
	Equip. Haul-in time	05:37	05:50	04:57	04:57	02:35	01:32	06:49	02:13	07:31	
C	Observing Time (hrs.):(T)	07:00	06:59	06:54	06:49	04:10	03:12	03:02	03:19	02:54	44:19
	Av. Speed(kn):(A/T)	1.2	1.2	1.3	1.1	1.5	1.1	1.0	0.9	1.0	1.2(AV.)
	Number of Photos	204	241	261	261	127	112	104	112	102	1,524
	Av. Time Interval for each Photo(min.)	2.06	1.74	1.59	1.57	1.97	1.71	1.75	1.78	1.71	1.74(AV.)
	Number of Video Tapes	4	4	4	4	3	2	2	2	2	27

Data and time are shown in GMT.

Table 1-3 Records of Survey Schedule

		Month/Day		Survey Items
01		08/20	Fr	16:00 Departure from Guam
02		08/21	Sa	Sailing(1,521nm between Guam and the survey area)
03		08/22	Su	ditto
04		08/23	Mo	ditto
05		08/24	Tu	ditto
06		08/25	We	20:41 Arrival in the survey area CTD vertical profiling & Bathymetric Survey (Area 1,PGM)
07	01	08/26	Th	Regional Geochemical Sampling(2 point) & Bath. Survey(Area 1, PGM)
08	02	08/27	Fr	Bath. Survey(Area 1, PGM)
09	03	08/28	Sa	Bath. Survey(Area 1, PGM)
10	04	08/29	Su	Re. Geo. Sampling(2) & Bath. Survey(Area 1, PGM)
11	05	08/30	Mo	Re. Geo. Sampling(2) & Bath. Survey(Area 1, PGM)
12	06	08/31	Tu	Re. Geo. Sampling(2) & Bath. Survey(Area 1, PGM)
13	07	09/01	We	Bath. Survey(Area 1, PGM)
14	08	09/02	Th	Bath. Survey(Area 1, PGM)
15	09	09/03	Fr	Re. Geo. Sampling(2) & Bath. Survey(Area 1, PGM)
16	10	09/04	Sa	Bath. Survey(Area 1, PGM)
17	11	09/05	Su	Re. Geo. Sampling(2) & Bath. Survey(Area 1, PGM)
18	12	09/06	Mo	Re. Geo. Sampling(2) & Bath. Survey(Area 1, PGM)
19	13	09/07	Tu	Re. Geo. Sampling(2) & Bath. Survey(Area 1, PGM)
20	14	09/08	We	Bath. Survey(Area 1, PGM)
21	15	09/09	Th	Bath. Survey(Area 1, PGM)
22	16	09/10	Fr	Re. Geo. Sampling(2) & Bath. Survey(Area 1, PGM)
23	17	09/11	Sa	Re. Geo. Sampling(1) & Bath. Survey(Area 1, PGM)
24	18	09/12	Su	Re. Geo. Sampling(3) & Bath. Survey(Area 1, PGM)
25	19	09/13	Mo	Re. Geo. Sampling(2) & Bath. Survey(Area 1, PGM)
26	20	09/14	Tu	Bath. Survey(Area 1, PGM)
27	21	09/15	We	Re. Geo. Sampling(2) & Bath. Survey(Area 1, PGM)
28		09/16	Th	Bath. Survey(Area 1, PGM) 14:14 Departure from the survey area(85.7 nm from the area to Honiara)
29		09/17	Fr	08:40 Arrival in Honiara
30		09/18	Sa	Meeting
31		09/19	Su	Preparation for Sailing

		Month/Day		Survey Items
32		09/20	Mo	16:00 Departure from Honiara(131.0 nm from Honiara to the area)
33		09/21	Tu	13:00 Arrival in the survey area Bath. Survey(Area 1, PGM)
34	22	09/22	We	Bath. Survey(Area 1, PGM)
35	23	09/23	Th	Bath. Survey(Area 1, PGM)
36	24	09/24	Fr	FDC(No.1 line) & Bath. Survey(Area 1, PGM)
37	25	09/25	Sa	FDC(No.2 line) & Bath. Survey(Area 1, PGM)
38	26	09/26	Su	FDC(No.3 line) & Bath. Survey(Area 1)
39	27	09/27	Mo	FDC(No.4 line) & Bath. Survey(Area 1)
40	28	09/28	Tu	FDC(No.5 line) & Bath. Survey(Area 1, PGM)
41	29	09/29	We	Bath. Survey(Area 1, PGM)
42	30	09/30	Th	Bath. Survey(Area 1 & Area 2 PGM)
43	31	10/01	Fr	Bath. Survey(Area 2, PGM)
44	32	10/02	Sa	Bath. Survey(Area 2, PGM)
45	33	10/03	Su	Bath. Survey(Area 2, PGM)
46	34	10/04	Mo	Bath. Survey(Area 2, PGM)
47	35	10/05	Tu	Bath. Survey(Area 2, PGM)
48	36	10/06	We	FDC(No.6 & 7 line) & Bath. Survey(Area 2, PGM)
49	37	10/07	Th	FDC(No.8 & 9 line) & Bath. Survey(Area 2, PGM)
50	38	10/08	Fr	Ore Sampling(3) & Bath. Survey(Area 1)
51	39	10/09	Sa	Ore Sampling(3) & Bath. Survey(Area 1)
52	40	10/10	Su	Ore Sampling(3) & Bath. Survey(Area 1, PGM)
53	41	10/11	Mo	Ore Sampling(4)
54	42	10/12	Tu	Ore Sampling(3) 19:15 Departure from the survey area
55		10/13	We	Sailing
56		10/14	Th	ditto
57		10/15	Fr	ditto
58		10/16	Sa	ditto
59		10/17	Su	ditto
60		10/18	Mo	ditto
61		10/19	Tu	ditto
62		10/20	We	ditto
63		10/21	Th	ditto
64		10/22	Fr	ditto
65		10/23	Sa	08:00 Arrival in Honolulu

Date and Time are shown in Local Time.

Chapter 2. Survey Methods

2-1 Survey Plan

In 1993, the fourth 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 within the exclusive economic zone of the Solomon Islands and a part of Papua New Guinea.

The survey plan was composed of, 24 points for the regional geochemical sampling, as shown in Figure 2-1-1, the detailed survey (SSS or FDC, base-line geochemical survey or sampling), and topographic survey.

The detailed survey took effect practically choice on FDC (7 days) and sampling (5 days).

Principal work for the survey was comprised of the following.

(1) Topographical surveys were carried out at 10 knots using GPS and MBES to identify accurate geographical features. The topographical cruising was carried out at intervals of 2.5 miles in Area 1 (situated on the eastern side and this area was the principal subject of our survey) and at intervals of 3.0 miles in Area 2 (situated on the western side).

(2) In order to estimate the geological structure, magnetic surveys were also carried out in conjunction with the topographical surveys.

(3) Samples for the regional geochemical survey were collected from Area 1 at about 21-mile grid (24 sampling points).

(4) For the purpose of detailed surveys, FDC was carried out at 9 track lines around the seafloor spreading center and submarine volcanoes within Area 1 (7 days).

(5) Sampling for the detailed survey, totaling 16 points, were carried out within Area 1. The sampling points were determined the places where FDC had assumed prospecting values (5 days).

2-2 Numbering

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

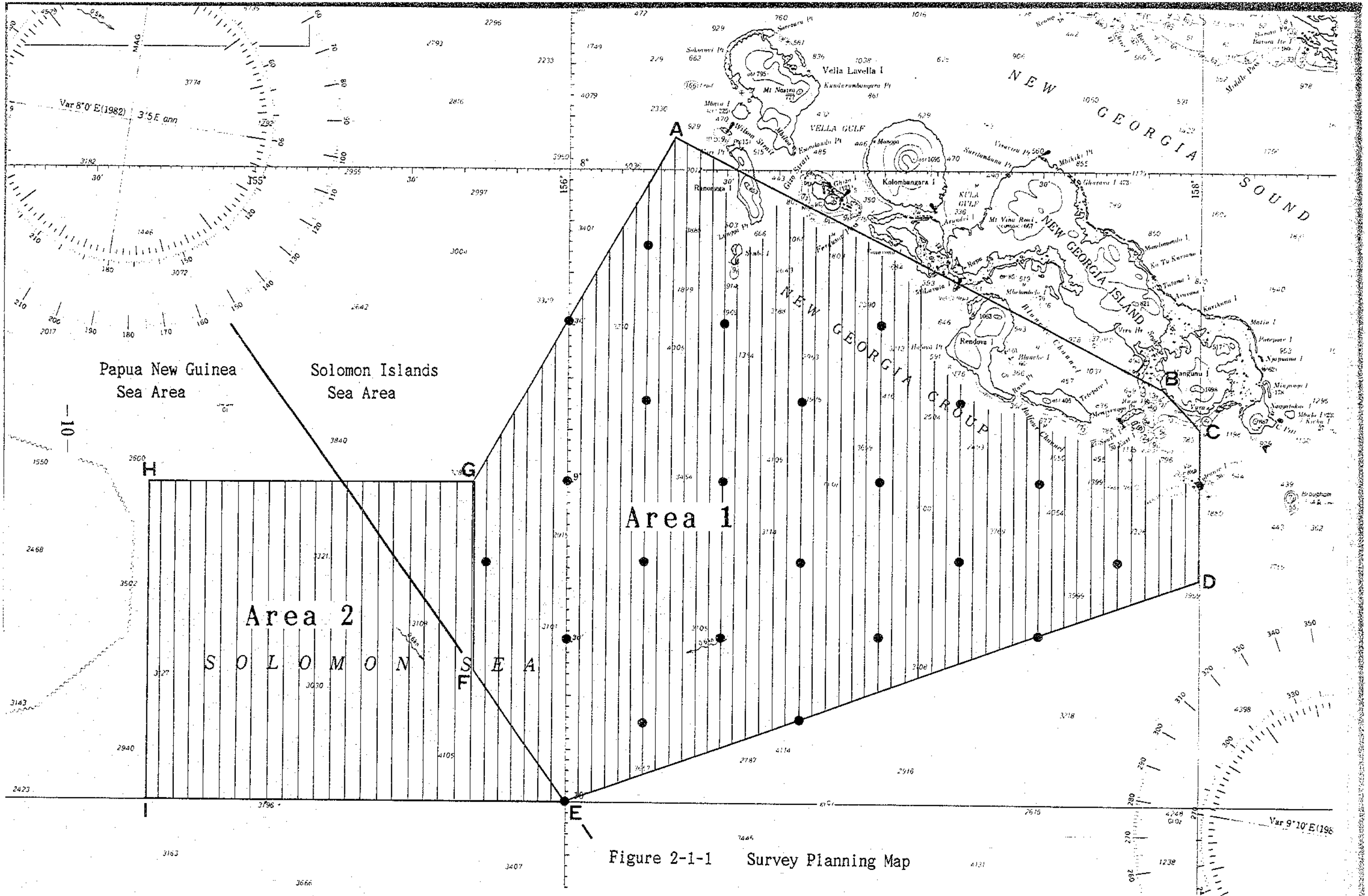


Figure 2-1-1 Survey Planning Map

- For the sampling points of the regional geochemical survey:

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

  Examples: 93SRLC01 (in the case of LC was employed)

  93SRGC01 (in the case of GC was employed)

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

- For the sampling points of the detailed survey:

  Year - S - D - Equipment used (two letters) - No.

  Examples: 93SDPG01 (in the case where FPG was employed)

  93SDCB01 (in the case where CB was employed)

  In these cases, "S" indicates "SOPAC", "D" indicates "detailed" and "No." indicates the serial number.

- For the FDC track lines:

  Year - S - FDC - No.

  Example: 93SFDC01

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

- For the acoustic sounding track lines in Area 1:

  No. - Division - A or C

  Example: 16-0-A

  In this case, "No." indicates the serial number of the track line numbered at intervals of 2.5 miles counting from the western side, and "Division" indicates the divided number of the track line - it applies when a track line is divided into several portions for measuring - and the serial number starts from "0". "A" represents the interval of 2.5 miles in Area 1 and "C" represents the track line at intervals of 1.25 miles in Area 1.

- For the acoustic sounding track lines in Area 2:

  No. - Division - B

  Example: 16-0-B

  In this case, "No." indicates the serial number of the track line numbered at intervals of 3 miles counting from the eastern side, and "Division" indicates the divided number of the track line - it applies when a track line is divided into several portions for measuring - and the serial number starts from "0". "B" represents Area 2.

- For the name of the seamount:

  Year - S - No.

  Example: 93 S01

  In this case, "S" indicates "SOPAC" and "No." indicate serial number represented the named seamount, from west to east.

2-3 Ship and Towed Vehicle Positioning

The position of the ship was measured by the GPS, and the position of the towed vehicle was calculated from the depth by a CTD Sensor, within the towed vehicle and the length of the cable by the Pythagorean formula.

As geodetic coordinates, WGS84 was used. And the 165° E Local Time (GMT + 11 hours) was adopted for on board time.

2-4 Acoustic Soundings

The survey of submarine topography was carried out at intervals of 2.5 miles in Area 1, which was located at the eastern part of this sea area and on the submarine volcano where the depth was more shallow, intervals of 1.25 and 0.625 miles.

The track lines in Area 2, which was located at the western part of the sea area, were set at intervals of 3 miles (see Figure 2-4-1 and Annexed Figure 1-1, Track Line Map).

The bathymetry was made at every 5-10 seconds for MBES and every 8 seconds for NBS at ship speed 10 knots.

2-5 Magnetic Survey (PGM Survey)

Magnetic survey was carrid out simultaneously with the survey of submarine topography in order to investigate the seafloor structure. In order to protect the PGM Sensor from the vessel's magnetism, the PGM Sensor was towed from the stern by a

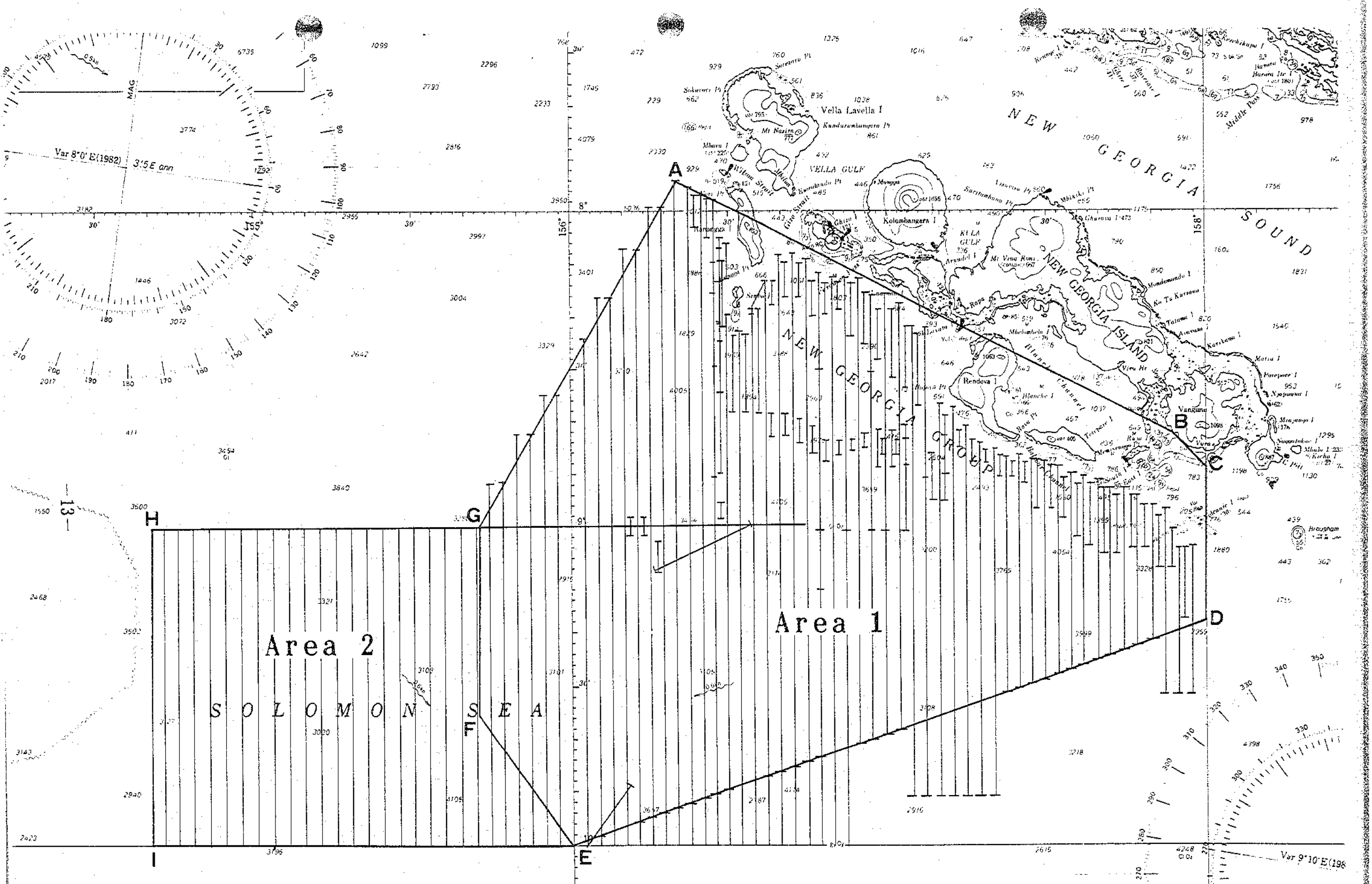


Figure 2-4-1 Location Map of Track Lines

cable and the distance from the stern to the Sensor was set at 750 m. The total magnetic intensity was measured by the Sensor at the senstivity of 0.1 gamma every 6 seconds.

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

2-6 Seafloor Observation and Photographing

Real-time seafloor 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 and the submarine volcano, at the ship speed of about 1 knot, and color photographs were taken at characteristic points. Acquired seafloor images were recorded on video tape. The length of the track lines were set at about 3 - 9 miles. The towing directions were roughly set to NW-SE or W-E (see Figure 5-2-1-1). As the result of the FDC survey, oxidized zones were identified at several points.

2-7 Sampling

The regional geochemical sampling was carried out at 24 points as previously planned (see Figure 2-7-1). As for the equipment for sampling, GC was proved to be effective in the most cases. Sampling was carried out about twice per day on an average. There were, however, some cases in which samples were not callectable like in the case of 93SRGC17. In this case, samples were collected by the second operation (i.e. 93SRGC18). In such case, only the results of the second sampling were indicated in the maps and table of the results of the regional geochemical sampling (Chapter 4 and Table 1 to Appendix).

Sampling for the detailed survey was carried out at places where oxidized zones had been assumed encouraging values through the FDC observation. CB and FPG were appropriately employed to collect samples at the sampling points (see Figure 2-7-2).

In principle, CB was employed at three sampling points per day. FPG was employed only one day at a shallow water sampling point, where operations were carried out four times.

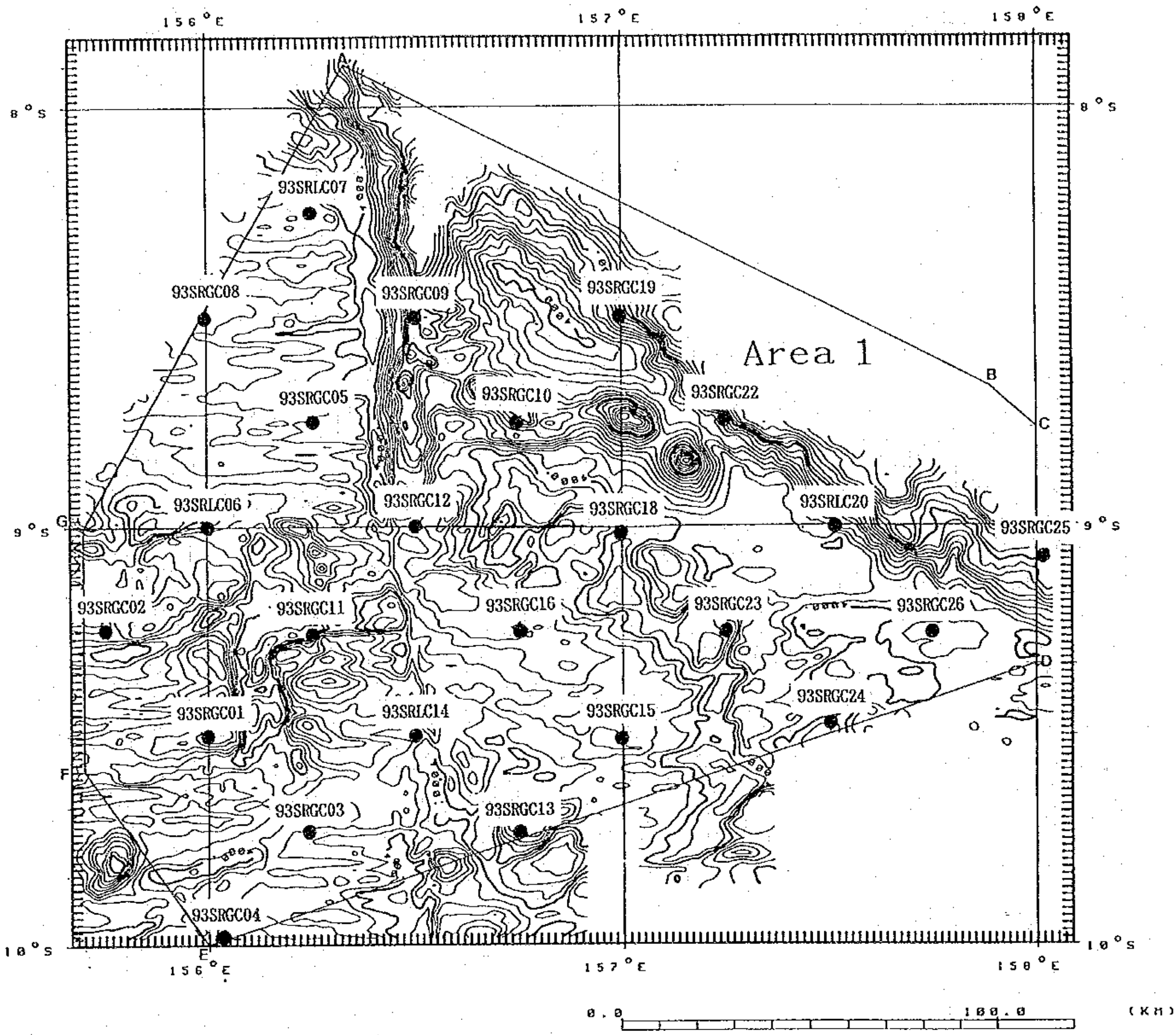


Figure 2-7-1 Location Map of Regional Geochemical Sampling Points

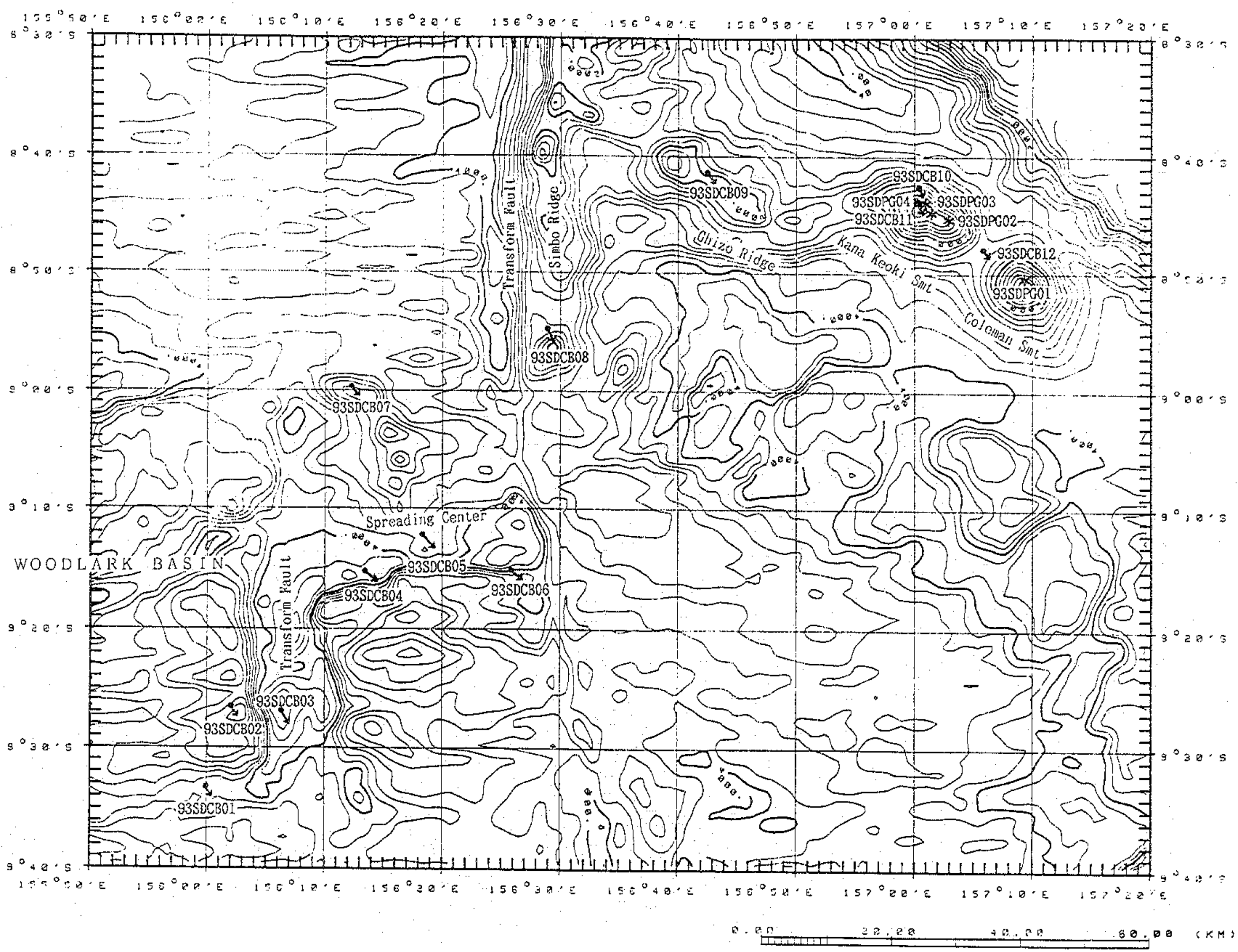


Figure 2-7-2 Location Map of Detailed Survey Sampling Points

2-8 Sea Water Survey (CTD Measurement)

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

Also, in order to survey hydrothermal activity, data on water temperature, salinity and water pressure were collected every 5 seconds by the CTD, which was loaded on the FDC.

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

2-9 Processing and Analysis of the Survey Data

The processing and analysis of the survey data were carried out by the DPS and personal computers as shown in the Data Processing and Analysis Flowsheet (Figure 2-9-1). Fundamental data were processed and analyzed on board and a cruise report was drawn up.

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 seafloor sediments, light gray clay and others obtained by the sampling operations to determine their mineral composition.

Chemical analysis and microscopic observation on rock samples were made to determine their mineral composition and texture.

Chemical analysis and X-ray deffraction on seafloor sediments as well as microfossil identification were carried out.

Equipment employed for the survey and how the equipment was used are shown in Figure 2-9-2.

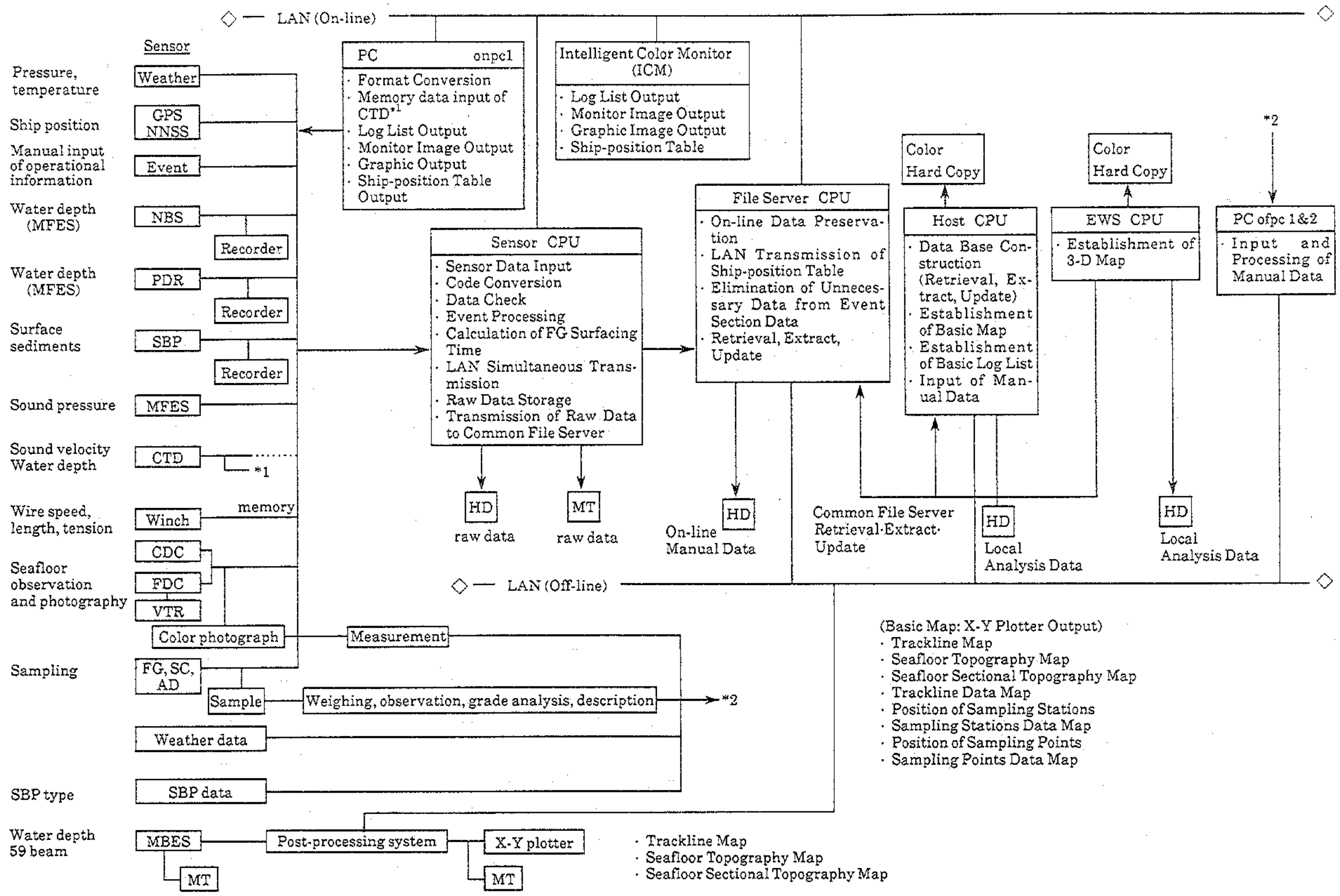
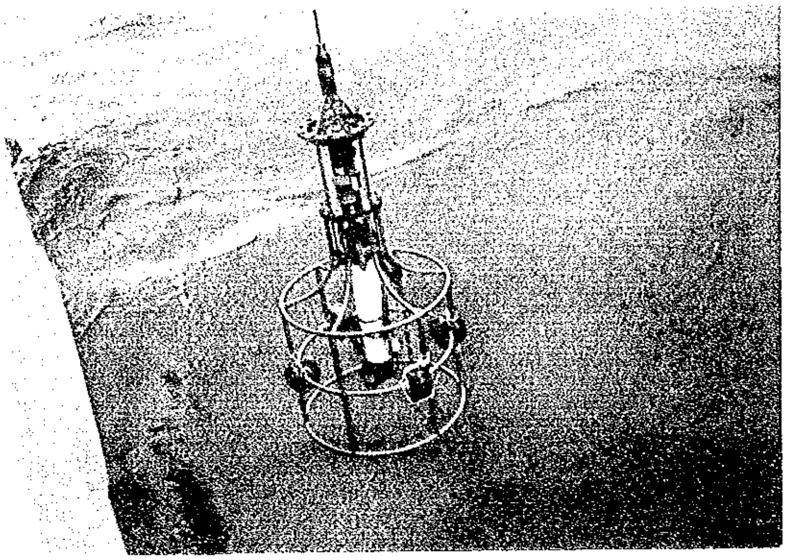
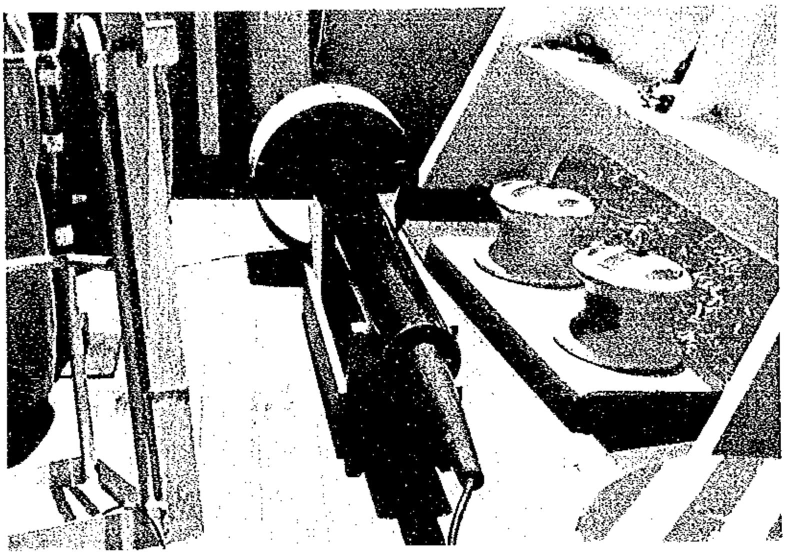


Figure 2-9-1 Data Analysis and Processing Flowsheet

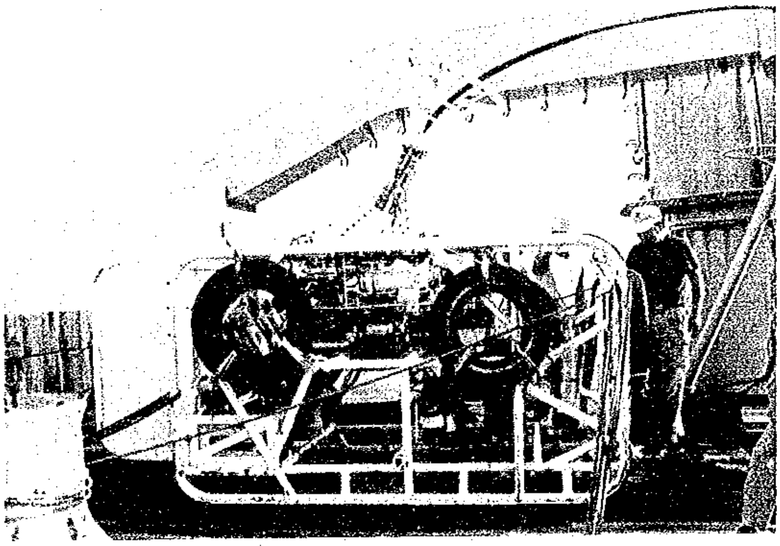


Conductivity Temperature

Depth System



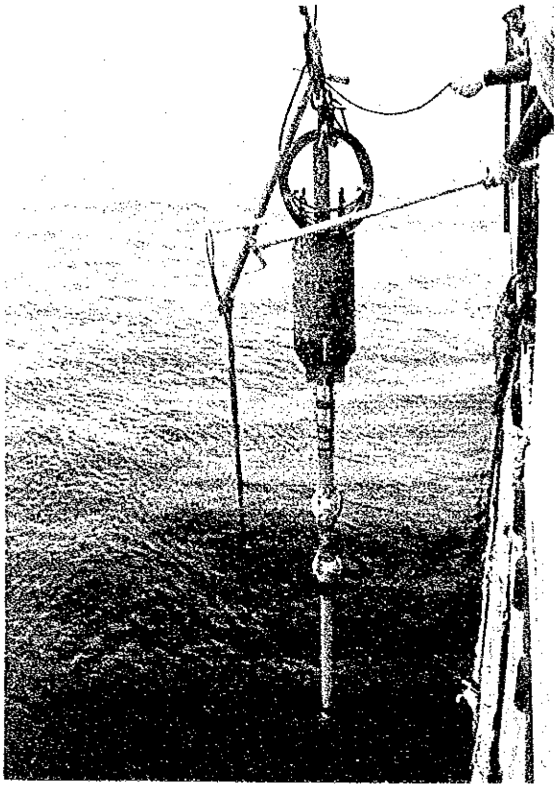
Proton Gradio Mater



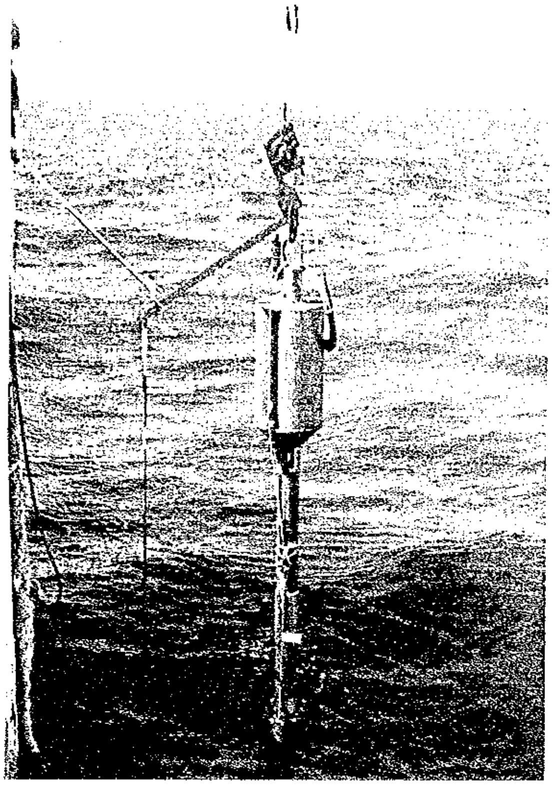
Continuous Deep Sea

Camera with Finder

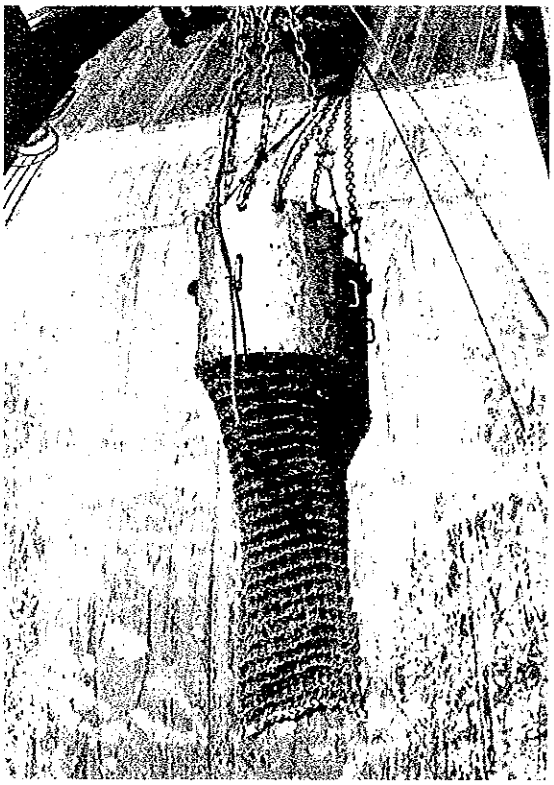
Figure 2-9-2　　Photographs of Survey Equipment and Survey work (1)



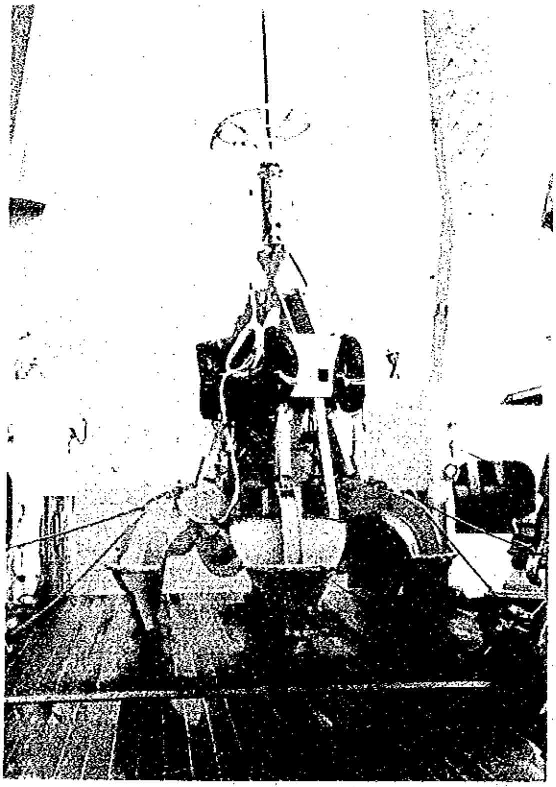
Gravity Corer



Large Corer



Chain Bucket



Finder mounted Power Grab

Figure 2-9-2 Photographs of Survey Equipment and Survey work (2)

Chapter 3. Seafloor Topography and Geological Structure

3-1 Seafloor Topography

1) Outline

Regional Structure of the Solomon-Woodlark Region

The Solomon Islands are comprised of a double chain of stretching for more than 1000 km in a northwestern direction, from the Bougainville Island at the northwestern tip and the San Cristobal Island at the south-eastern tip (from 155° E to 162° E and from 5° S to 11° S). The Bougainville Island, however, belongs to Papua New Guinea. In order to make it clear, sometimes it is called the Solomon Islands - Bougainville Island.

Main islands of double chain are as follows (Figure 3-1-1-1 and Figure 3-1-1-2).

(1) Choiseul Island - Santa Isabel Island - Malaita Island (the Northern Island Arc chain).

(2) New Georgia Island Group - Florida Islands - Guadalcanal Island (the Southern Island Arc chain).

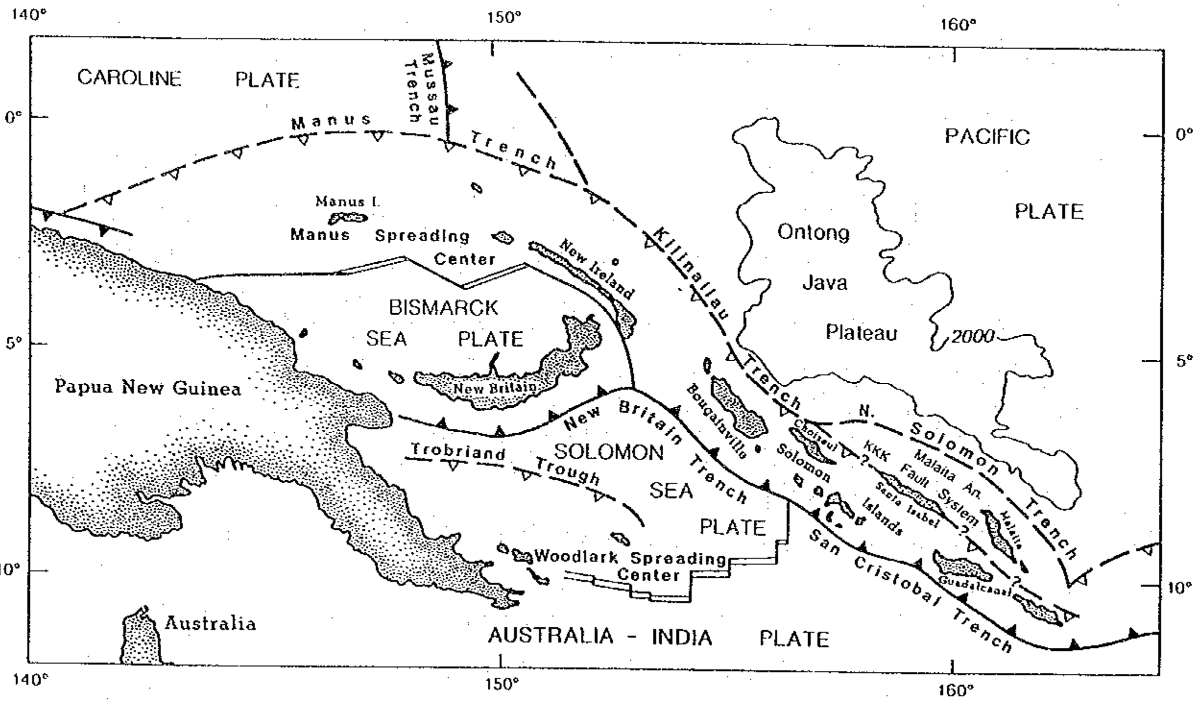
Besides these islands, there are Ontong Java Atoll, Loncador Coral Reef, Reef Islands and Rennel Island around the Solomon Islands.

We describe here the major submarine topography and structure of the Solomon Islands region;

a) The central Solomon Trough (New Georgia sound Basin) which lies between the above-mentioned (1) and (2) is more than 1,800 m deep, and filled with more than 5 km thick sediments.

b) The Kia-Korigole-Kaipito Thrust fault crosses from the northeast of Choiseul Island to Santa Isabel Island in the direction of NW-SE, goes past by the northern tip of Florida Island and passes through the northern tips of Guadalcanal Island and San Cristobal Island.

c) The Kilinailau Trench - North Solomon Trench located in the northeast of the Solomon Islands. These two trenches are normally called the North Solomon Trench by lumping them under the one name. This trench abjoins the Manus Trench on the northwest and the Vitiaz Trench on the southeast.

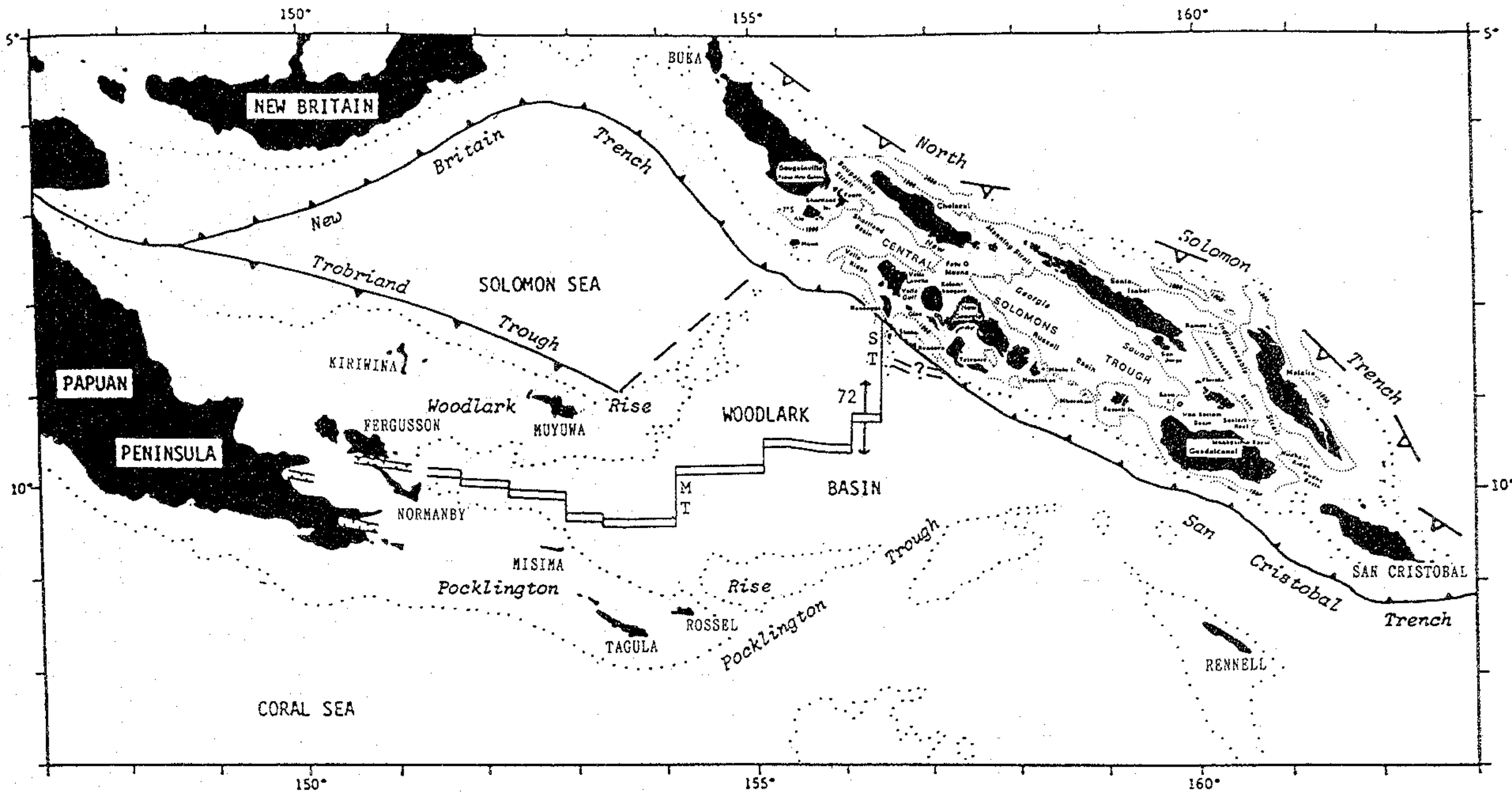


(after T. R. Bruns et al 1989)

LEGEND

- ▽ : active trench
- ▼ : inactive trench
- ═ : spreading ridge
- — : transform faults
- KKK : Kia-Koligo-kaipito-fault systems

Figure 3-1-1-1 Plate boundaries and tectonic features in the Solomons -Woodlark region (after T.R. Bruns et al 1989)



(after B. Taylor et al 1987)

MT:Moresby transform fault

ST:Simbo transform fault

Figure 3-1-1-2 Major physiographic features and active plate boundaries of the Solomons-Woodlark region (after B.Taylor et al 1987)

d) Ontong Java Plateau (depth: more shallow than 2,000 m), composed of 40 km-thick crust is located on the northern margin of the Solomon Islands.

e) The New Britain Trench and the San Cristobal Trench are situated from the west to the southwestern part of the Solomon Islands. The water depth of these two trenches is deeper than 8 km near the Treasure Islands and 7 km in the vicinity of the San Cristobal Island. The San Cristobal Trench, however, Shoal from over 7 km to 3 km along the New Georgia Island Group, which depth are more shallow than typical trenches for example 8,000 m deep.

f) The Solomon Sea is situated in the south of the New Britain Trench and the southwest of the San Cristobal Trench. The Trobriand Trough (depth: 4 km - 5 km) and the Woodlark Basin are located in the Solomon Sea. The Woodlark Rise is located on its south side. By the way, the Woodlark Rise is located on its south side. Subduction along the Trobriand Trough are uncertain (Benes et al, 1992).

The Woodlark Basin

The Woodlark Basin is bounded on the northwest by the Woodlark Rise, on the south by the Pocklington Rise and the Pocklington Trough, on the northeast by the Solomon Islands, and on the west by a Moresby Transform Fault at 154° 10'E. Except the ridges, seamounts, the Woodlark Basin depths are generally between 3 km to 4 km, the basin depths greater than 4 km marked seafloor spreading center and fracture zones.

The seafloor spreading center of the East Woodlark Basin is divided into several segments by N-S trending transform faults and exsists across the middle of the East Woodlark Basin. The its eastern end is the Simbo Transform Fault and the its western tip is the Moresby Transform Fault, which is the boundary of the oceanic crust and the continental crust.

The Woodlark Basin and its surrounding region is composed of the Pacific, India-Australian and Solomon Sea Plate. The point where these three plates intersect is called the triple junction. Grook and Taylor (1993) estimated that this triple junction position Located NNW of the Simbo Island is lat. 8° 07.46'S, long 156° 28.7'E.

The locations of these three plates are as follows:

(1) The Solomon Sea Plate

The area surrounded by the New Britain Trench, the Simbo Transform Fault and the Woodlark seafloor spreading center.

(2) The India-Australian Plate

The area surrounded by the San Cristobal Trench, the Simbo Transform Fault and the Woodlark seafloor spreading center.

(3) The Pacific Plate

The area on the northeastern side of the New Britain Trench and the San Cristobal Trench.

Therefore, the intersecting point of the Simbo Transform Fault, the New Britain Trench and the San Cristobal Trench is the triple junction.

The Woodlark Basin's tectonics

Seafloor spreading in the Woodlark Basin began prior to 5 Ma and propagated progressively westward toward the papuan peninsula, splitting once contiguous Woodlark and Pocklington Rise. Its spreading center is symmetrical, and its rate at the eastern part of the Woodlark Basin is 5.6 - 7.2 cm/y (Taylor, 1987). It is also identified from the magnetic anomalies that there are some places where the seafloor spreading center has jumped (Taylor, 1987).

What differs the Woodlark Basin from other marginal basins is the fact that it has several propagation rifts toward the west and subduction zones with high spreading rates (Benes et al, 1992). Moreover, it is conceivable that the Woodlark Basin is a sea opened as a result of rotation of a microplate and the oblique subduction along the irregular boundary between the India-Australian and Pacific Plate. It, therefore, differs from the ordinary back-arc basins (Benes et al, 1992).

The India-Australian Plate is moving with a rate of about 7.2 cm/y along an azimuth of 15° . The Pacific Plate is moving with a rate of 9.5-10.0 cm/y along an azimuth of 303° - 285° . The India-Australian Plate, therefore, is subducting into the San Cristobal Trench with a rate of about 10.7 cm/y along an azimuth of about 73° (Benes et al, 1992).

The Solomon Sea Plate is subducting, northward and at a rate of more than 15 cm/y, beneath the New Britain Trench (Taylor et al, 1987).

Crook and Taylor (1993) interpret the tectonics to the east of the Simbo Transform Fault as follows;

(1) An area composed of small basins became a spreading segment at about 2 Ma and rearranged to short ESE-trending riftsegments. The spreading rate of this segment was slow, and then ceased spreading at about 0.5 Ma and became a failed rift. Concomitantly, a transform fault propagated from the west end of the failed rift toward the north and formed the present Simbo Transform Fault.

(2) The Simbo Ridge was build by the magmatism along the newly- propagating transform.

(3) As the Pacific plate approached, the eastern area of the Ghizo Ridge tilted towards the north. And the Ghizo Ridge area's crust was dissected and elevated, and intruded by arc-related magmas, forming the Ghizo Ridge. This tectonics and magmatism has continued to the present.

(4) The calc-alkaline magmas, sourced beneath the Pacific Plate, construct the Simbo Ridge, the Kana Keoki and Coleman stratovolcanoes on the Australian Plate. The presently active Kavachi submarine volcano, have formed on the landward slope only 30 km from the trench.

2) Submarine Topography

A color-coded bathymetric-contour map and a bathymetric map of the survey area are shown in Figures 3-1-2-1 and 3-1-2-2 respectively. A three-dimensional representation of the bathymetric map is shown in Figure 3-1-2-3 and a typical bathymetric profile is shown in Figure 3-1-2-4. Characteristics of the major seamounts are shown in Table 3-1-2-1. According to these figures and table, the outline ofthe submarine topography of this survey area is as follows:

(1) The New Britain Trench and San Cristobal Trench are located at the northern marginal part. The water depth of the New Britain trench is about 5,050 m at the north-western side of Simbo Island. The water depths of the San Cristobal

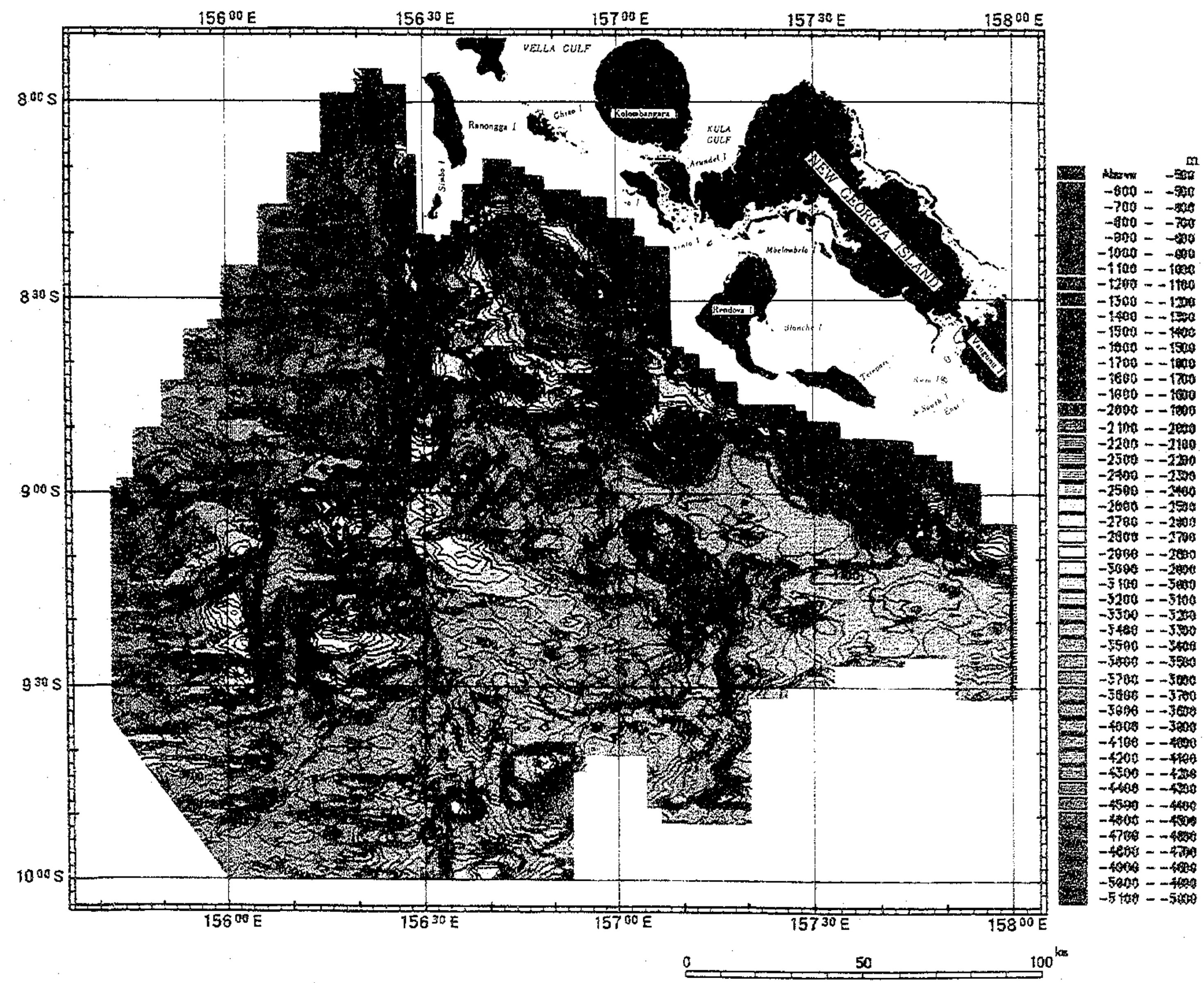


Figure 3-1-2-1 Color-coded bathymetric contour map of area 1 based on MBES. Color change and contour interval is every 100 m

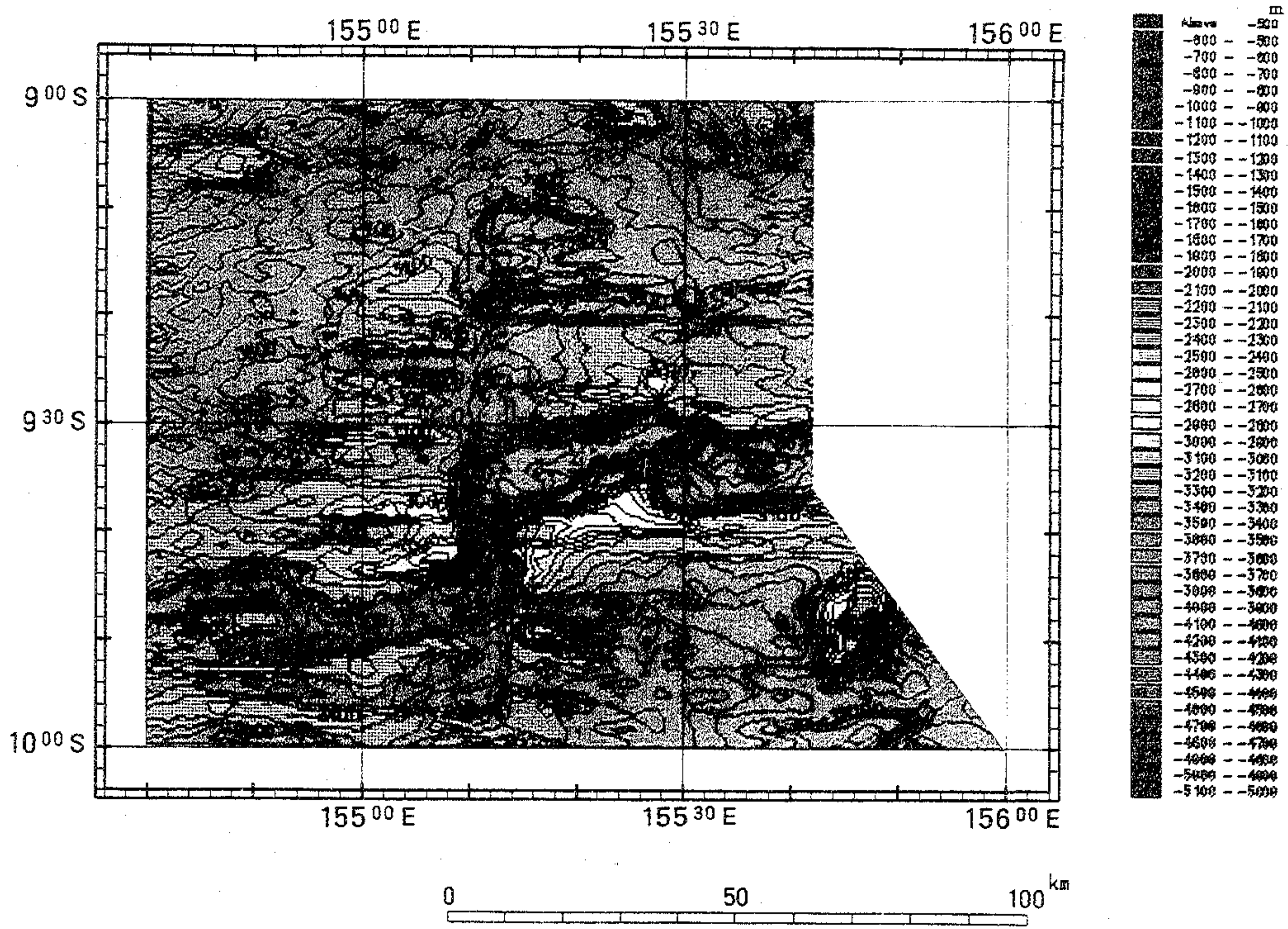


Figure 3-1-2-1 Color-coded bathymetric contour map of area 2 based on MBES.
Color change and contour interval is every 100 m

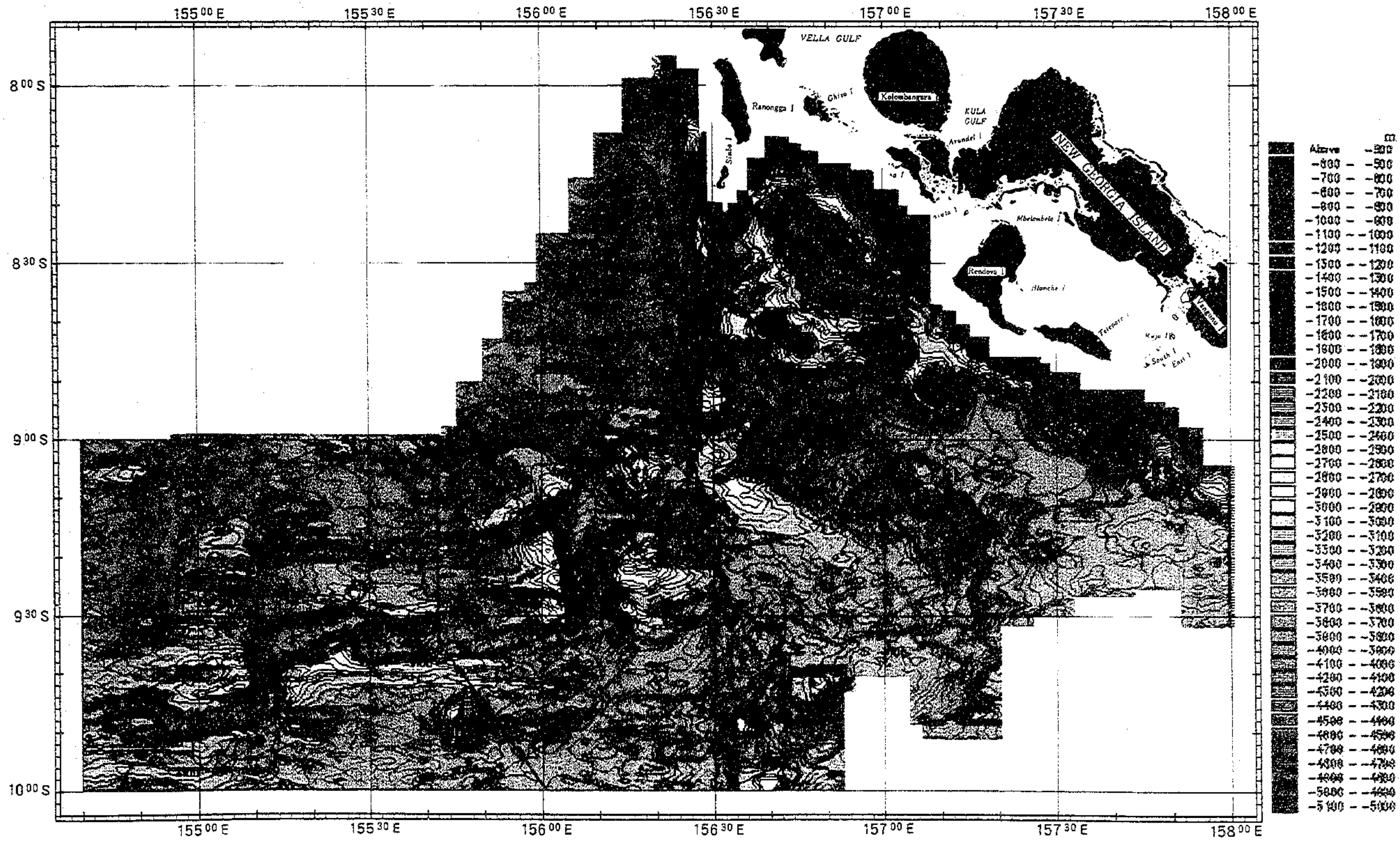


Figure 3-1-2-1 Color-coded bathymetric contour map of area 1+2 based on MBES. Color change and contour interval is every 100 m

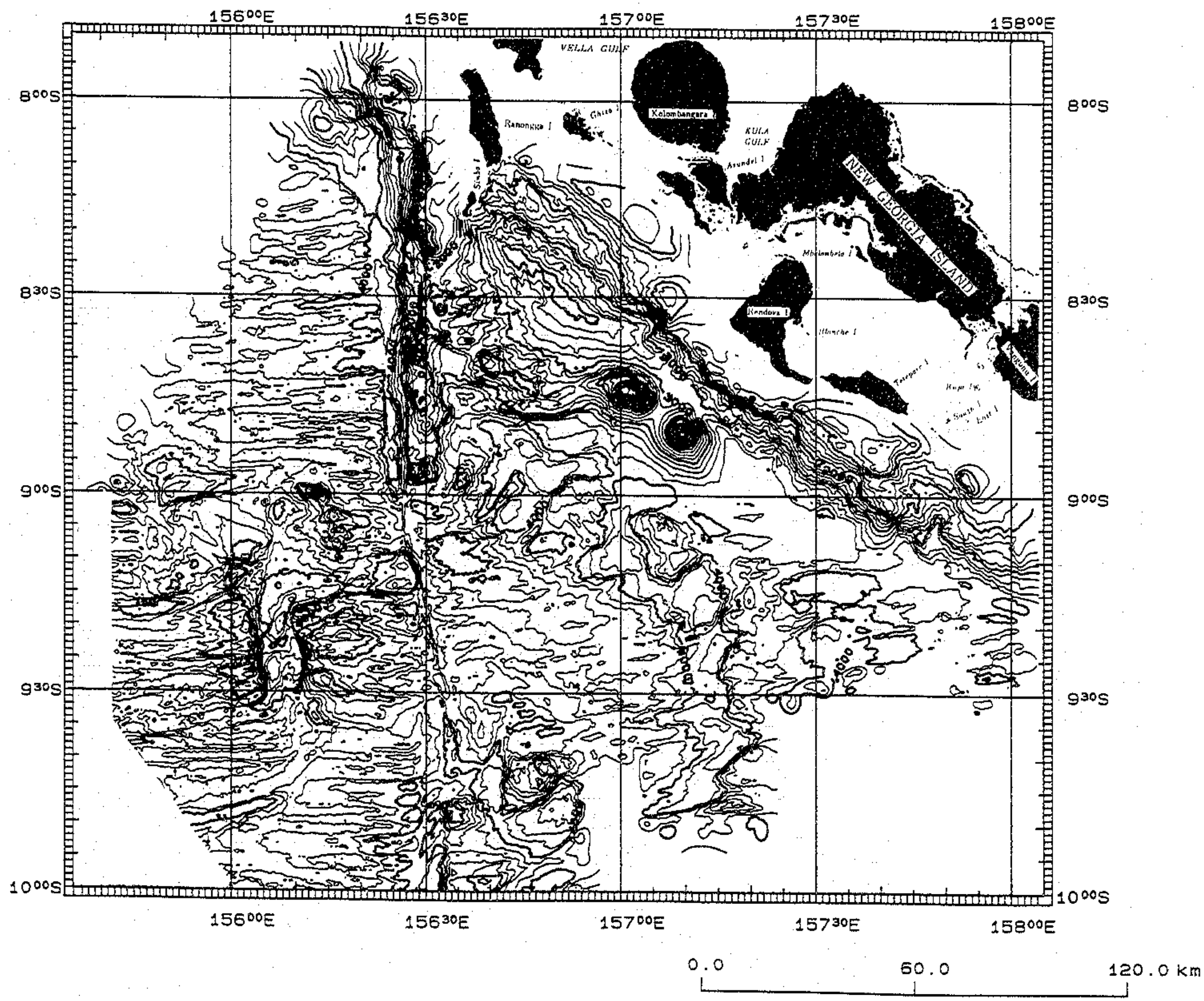


Figure 3-1-2-2 Bathymetric map of area 1 based on MBES. MBES data are gridded at an about 0.5-km spacing. Contour interval is 200 m

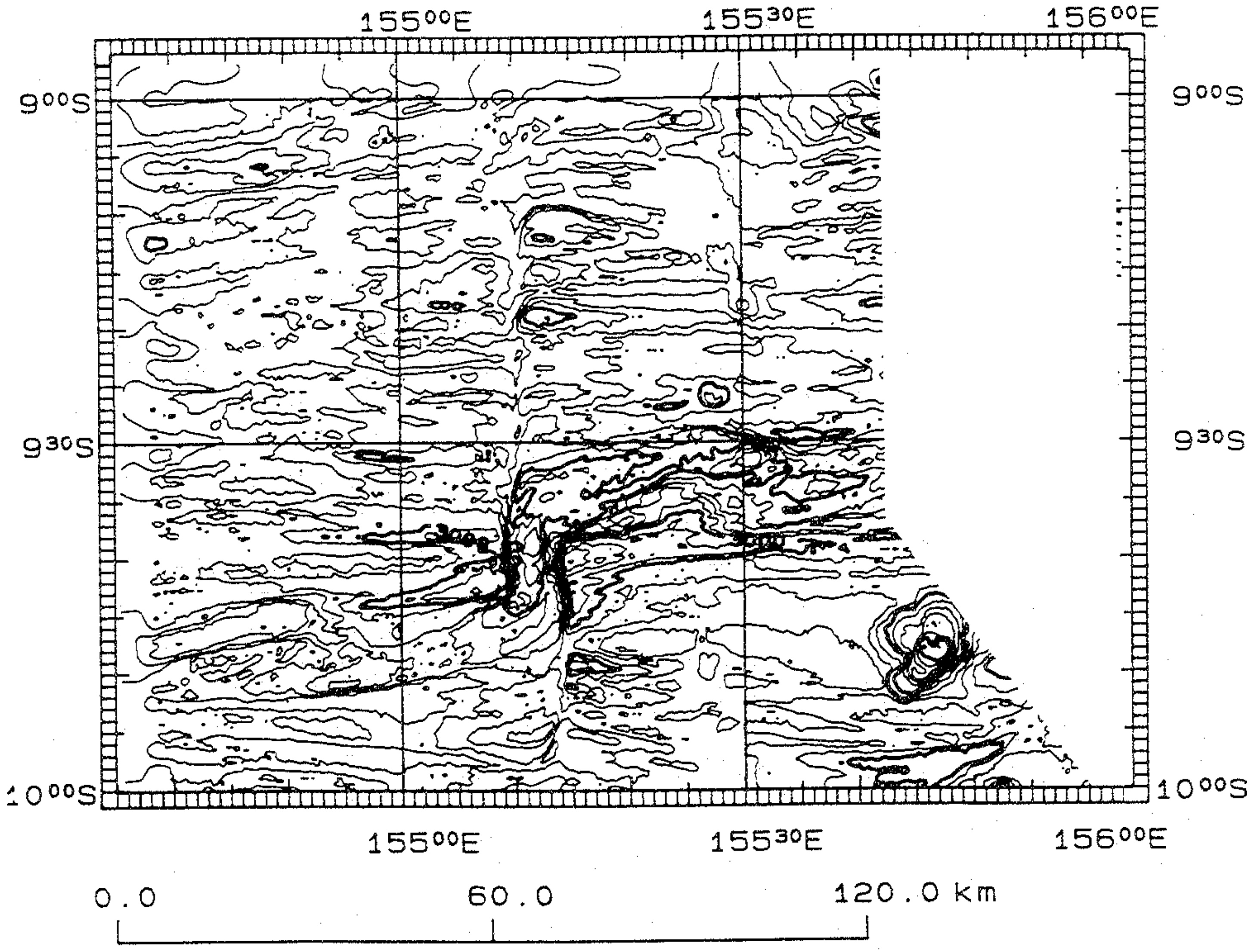


Figure 3-1-2-2 Bathymetric map of area 2 based on MBES. MBES data are gridded at an about 0.5-km spacing. Contour interval is 200 m

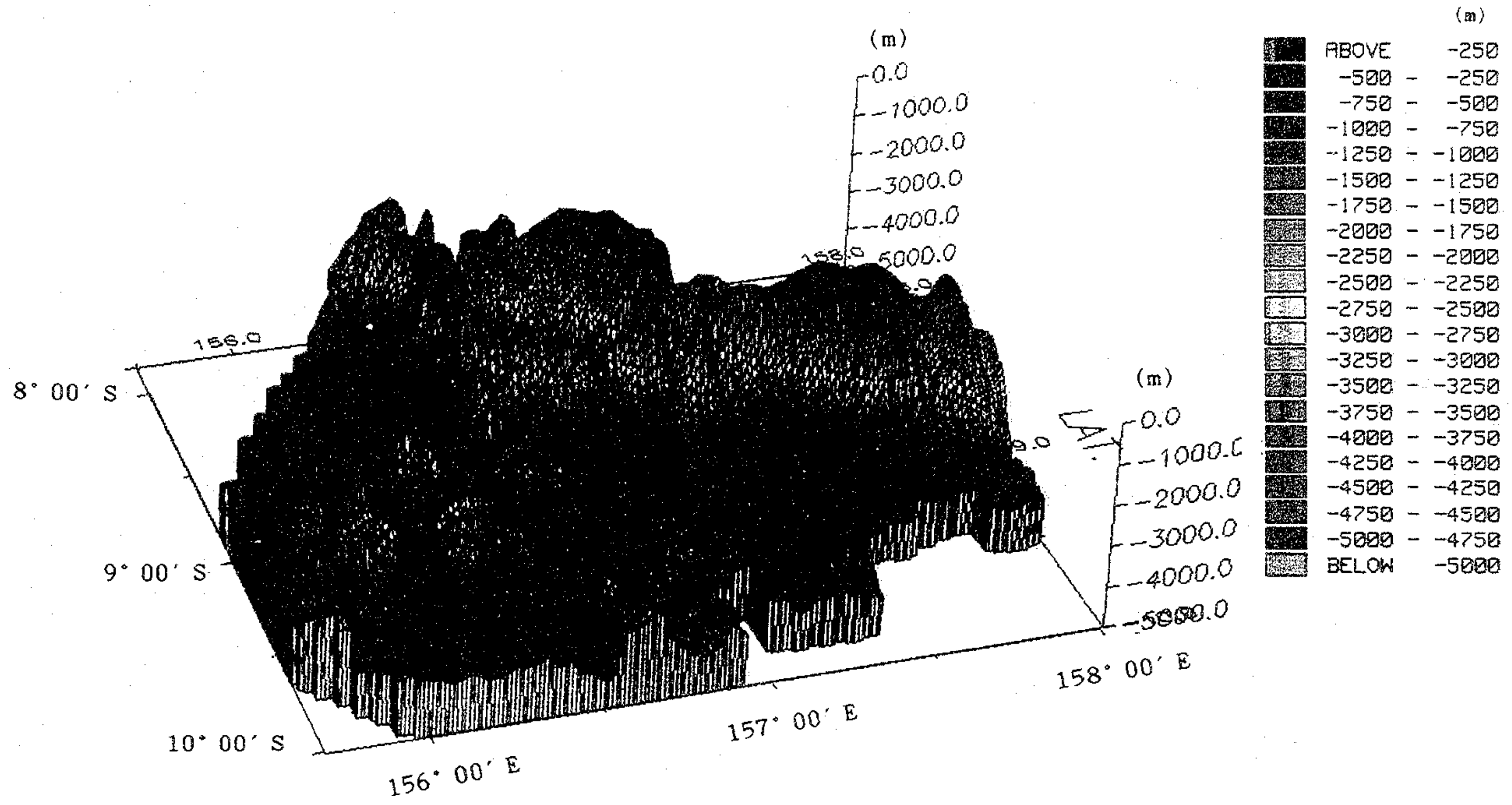


Figure 3-1-2-3 Three-dimensional representation of bathymetric map of area 1

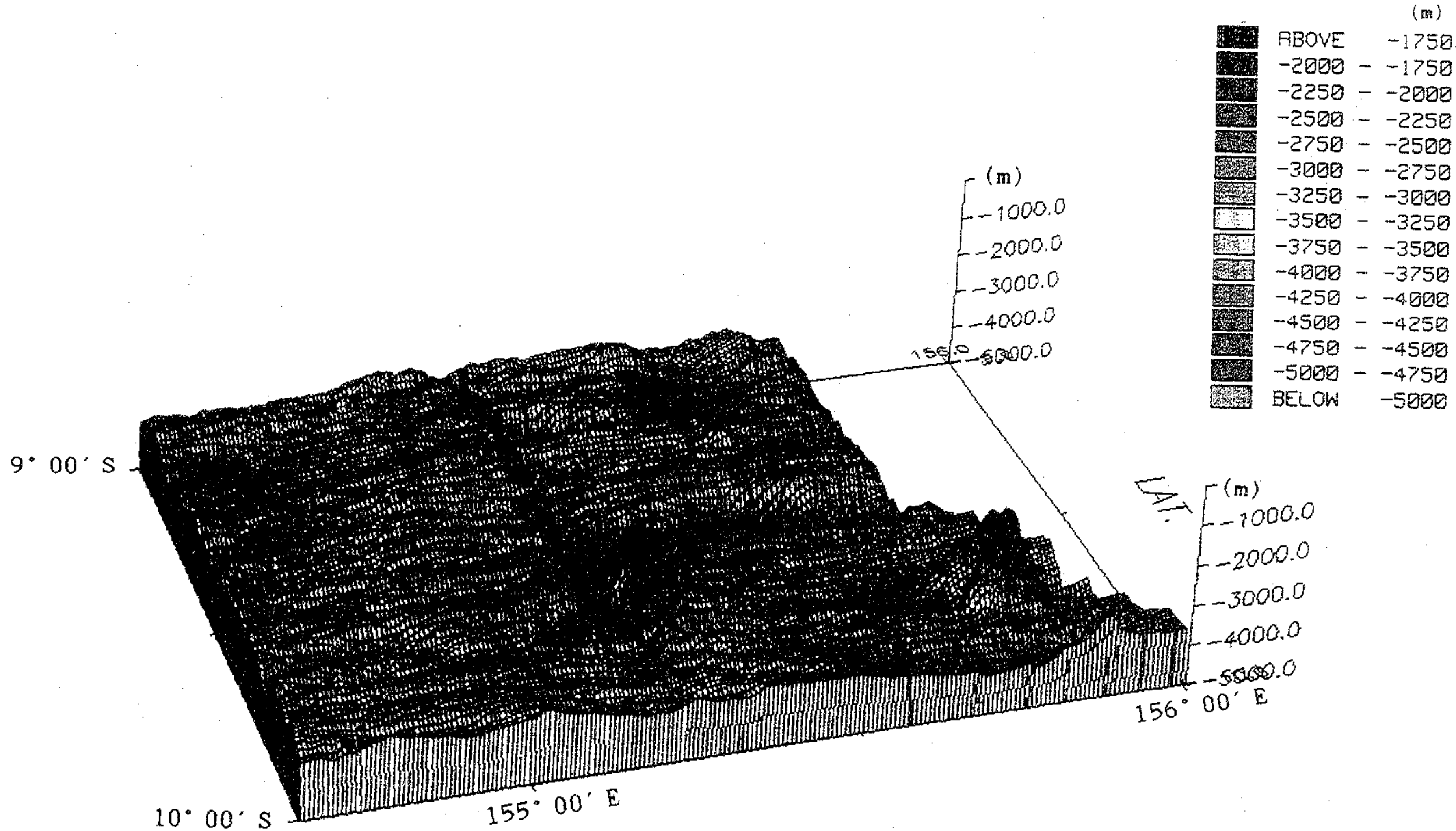


Figure 3-1-2-3 Three-dimensional representation of bathymetric map of area 2

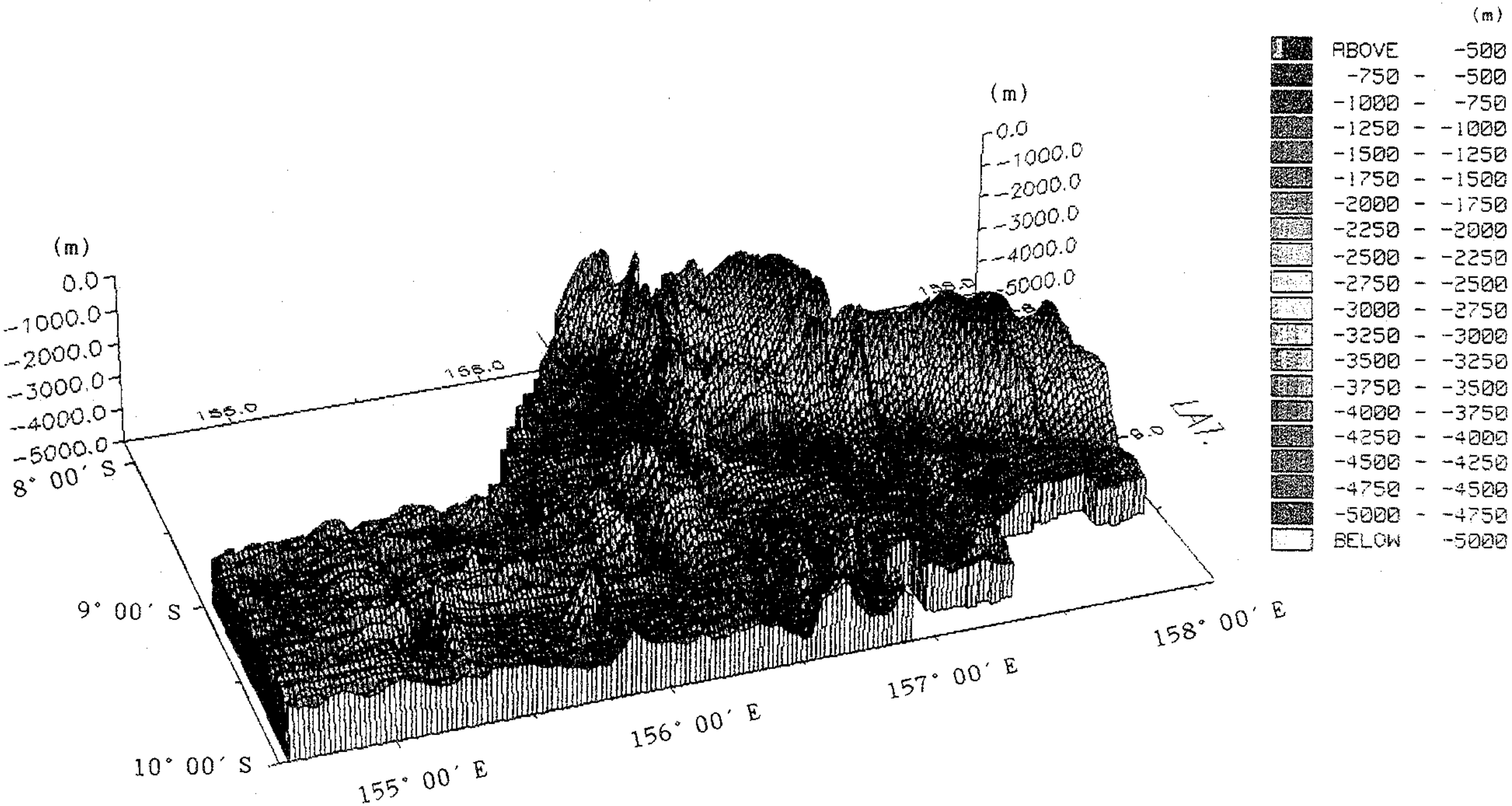


Figure 3-1-2-3 Three-dimensional representation of bathymetric map of area 1+2

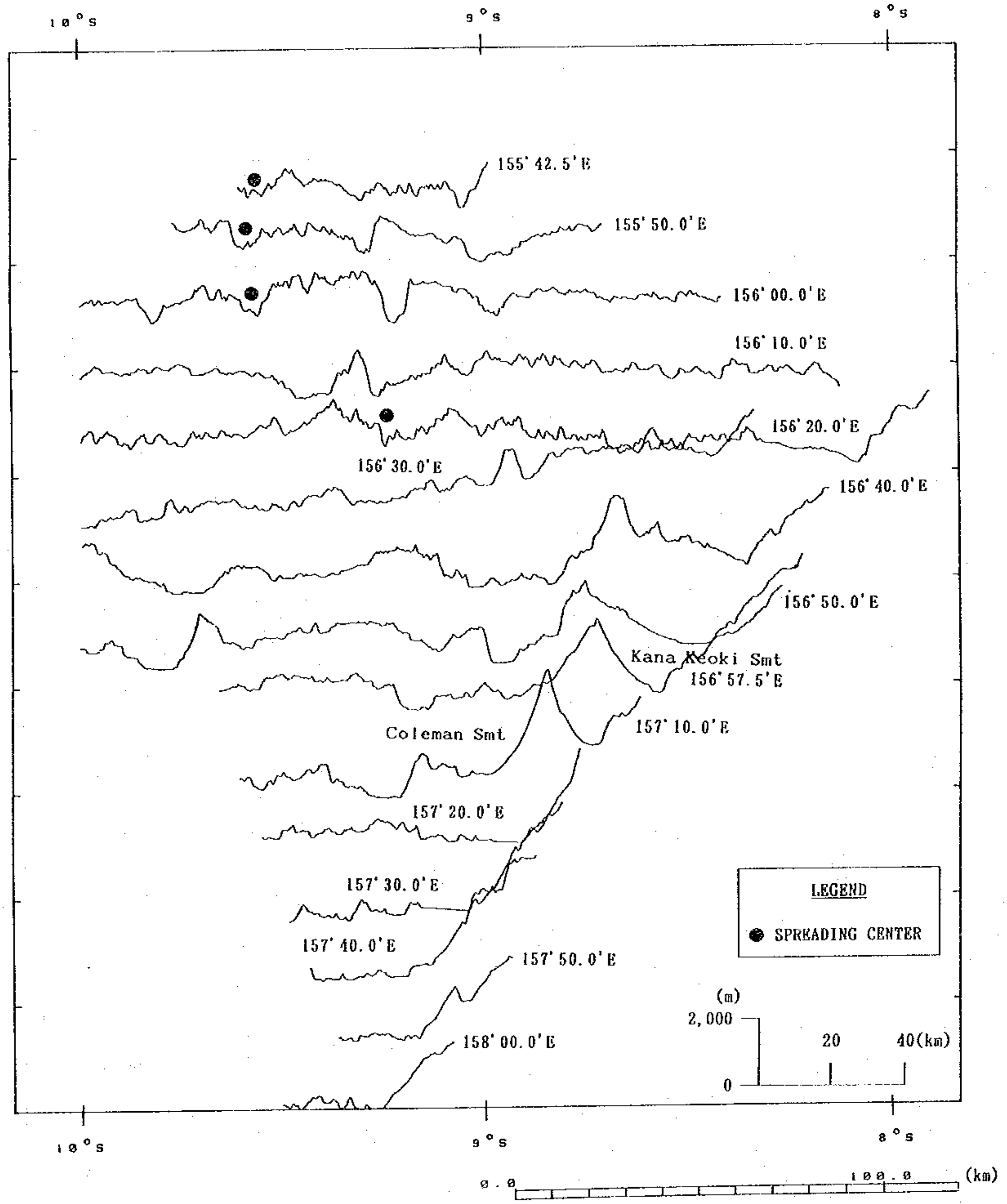


Figure 3-1-2-4 Bathymetric profiles of area 1 based on MBES

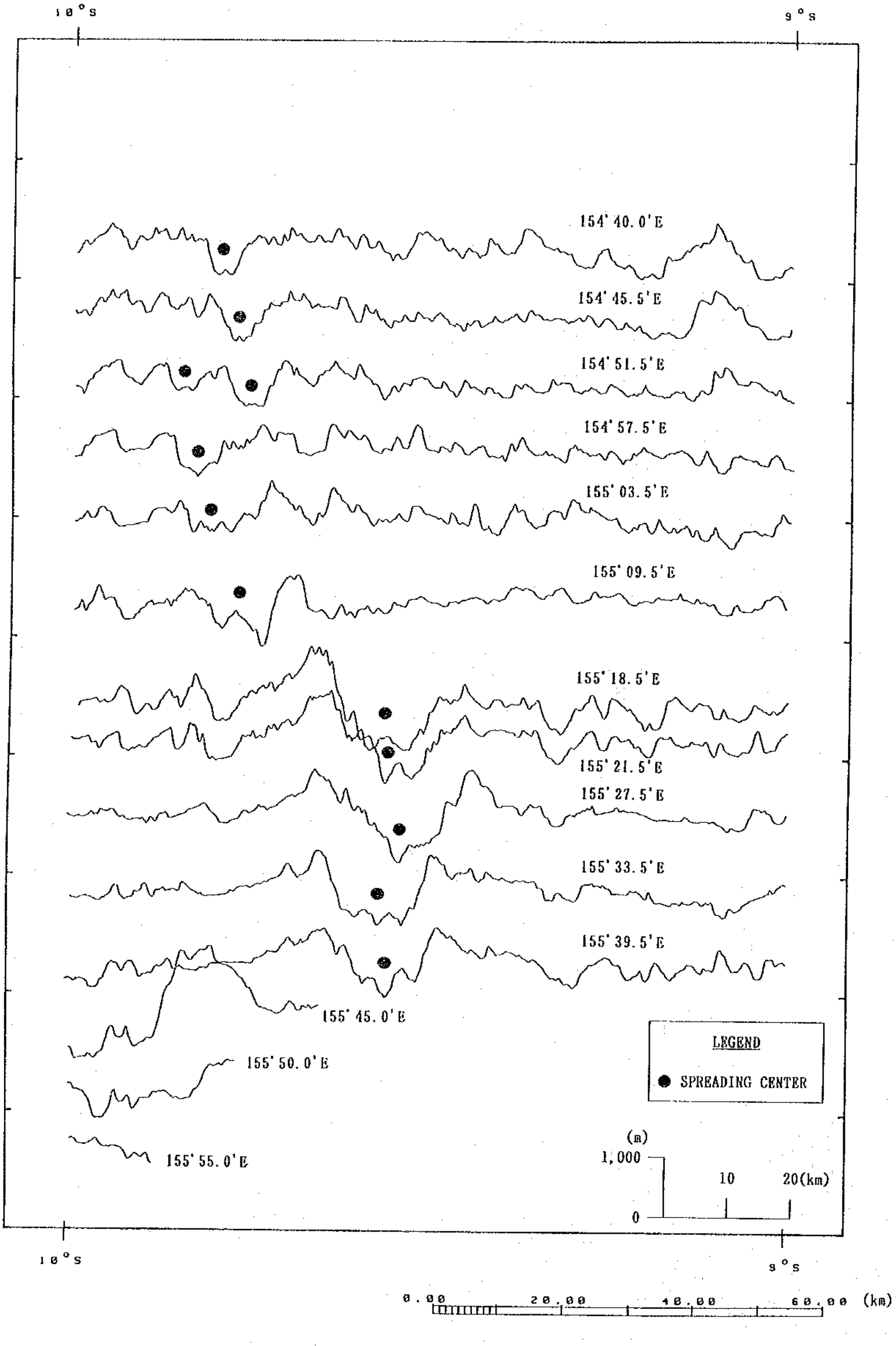


Figure 3-1-2-4 Bathymetric profiles of area 2 based on MBES

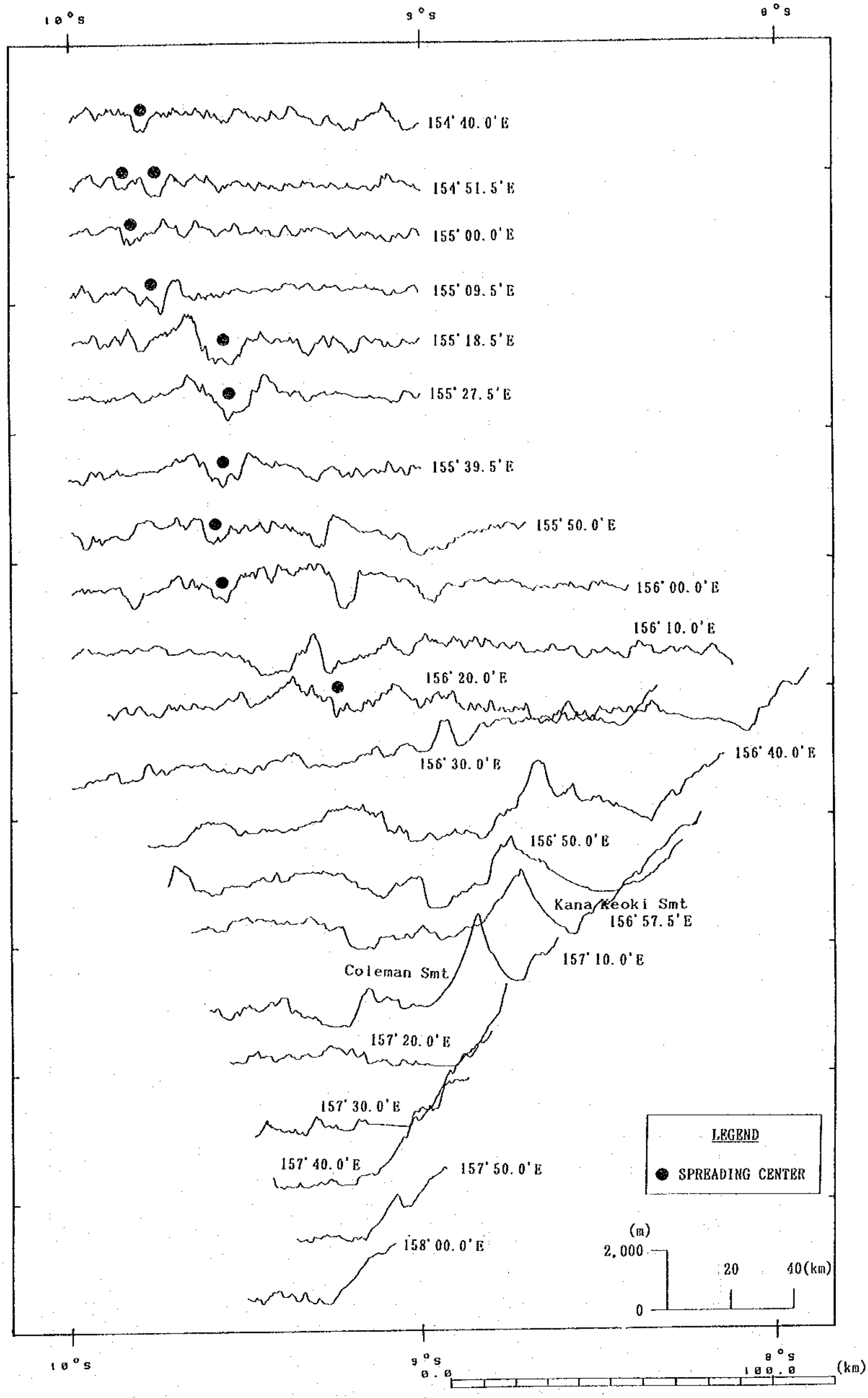


Figure 3-1-2-4 Bathymetric profiles of area 1+2 based on MBES

Table 3-1-2-1 Features of Major Seamounts

Seamount	Location	Minimum Water Depth (m)	Basal Water Depth (m)	Basal diameter (km)	Slope	Shape	Relief (m)	Topographic Features
Coleman Smt.	8°50.8' S 157°09.5' E	550	3,000	17.0	17°	Round Shape	2,800	Located at the western area of the Ghizo Ridge. The crest has a horseshoe-shaped peak opening to the west. The basal water depth is deeper in the south and shallower in the north.
Kana Keoki Smt.	8°44.5' S 157°01.0' E	650	3,000	Major Axis 25 Minor Axis 16	15°	Oval	2,500	Located in the north-west of Coleman Smt. It is an elliptical shape with trend NW-SE. It has two peaks and there are three small peaks on the north-western crest. There are a N72°E trending ridge extending from the north-western flank of the seamount.
93S01 Smt.	9°25.0' S 156°00.0' E	2,500	3,500	North-South 30 East-West 19	—	Comb shape	1,000	It adjoins to the west of the Transform Fault at 156°10' E. A comb-shaped ridge is extending toward the west.
93S02 Smt.	9°22.0' S 156°18.0' E	2,250	3,000	North-South 13 East-West 31	—	—	800	It adjoins to the east of the Transform Fault at 156°10' E. It has a trend E-W.
93S03 Smt.	9°05.0' S 156°15.0' E	2,200	3,000	North-South 19 East-West 20	—	Rhomb shape	800	Located to the south-west of the Simbo Ridge. there are four small peak. The crest is extending in the direction E-W.
93S04 Smt.	8°56.0' S 156°29.5' E	1,800	3,000	North-South 9 East-West 9	—	Rhomb shape	1,200	Located at southern end of the Simbo Ridge. There are two parastic volcanoes on the eastern part of the seamount.
93S05 Smt.	8°40.0' S 156°40.0' E	1,500	3,000	Major Axis 28	—	Oval	1,500	Located on the central part of the Ghizo Ridge. It is an elliptical shape with trend NW-SE.

Trench are more than 4,050 m at the north-western part of the Ghizo Ridge, more than 3,050 m at the northwestern part of the Ghizo Ridge, more than 3,050 m around the Coleman Seamount and more than 4,050 m in the southern part of Kavachi Volcano. The trench landward slope is 5° -12° , and has several terraces with one or two steps as well as sea knoll with 400 to 600 m of relief. Most of the trench basinward slope is less than 5° . The San Cristobal Trench near the New Georgia Island gruop is not well developed.

(2) There is a N-S trending depression with over 4,000 m deep along the line of 156° 25'E, between 8° S and 9° S and it width becomes narrower as it runs from the north to the south. This bathmetric dipression is distributed discontinuously 10° S.

(3) West of area (2) displays series of parallel ridge and valley topography with trending east-west. Conspicuous seamounts and ridges is a few. Among the E-W trending valley, the one offsetting stepwise from the central part to the south toward the west is the seafloor spreading center, whose depth is deeper than 4 km and whose width is about 5 - 15 km. The N-S trending depressions, crossing this seafloor spreading center, is composed of transform faults. Seamounts and ridges are located in the margin of the transform faults zone and the seafloor spreading center. They are characterized by the crest's depths of about 1,800 - 2,400 m, and their spines and rilles extending in the direction east - west.

(4) As for the submarine topography of the area east of (2), we can point out the following features.

a) The N-S trending Simbo Ridge lies between about 8° S and 8° 40'S. The depth of the crests is more shallow than 2,300 m. The depth of the foot of the ridge is about 3,500 m.

b) The NW-SE trending Ghizo Ridge, exists from around the southern part of the Simbo Ridge. The depth of the crests of the Ghizo Ridge is 1,600 - 2,100 m and the basal depth is about 3,500 m. The Kana Keoki Seamount and the Coleman Seamount are located at the sourtheastern end of the Ghizo Ridge. The Kana Keoki Seamount is oval with two peaks. One of the peaks has three small peaks. The depth of the summit is 650 m and has the ESE elongation of the summit of

Kana Keoki ediface. The northern flank of the Kana Keoki Seamount slips laterally.

The Coleman Seamount has a very uniformly developed cone. The minimum water depth encountered was 550 m. The summit part has a horseshoe-shaped peak.

c) The southwestern part and southern part are mainly composed of the ENE-WSW trending finger-like topography.

d) Small basins with the depths between 4,200 to 4,700 m are intermittently distributed from the southern tip of the Shimbo Ridge to the Ghizo Ridge. This group of basins becomes a N-S trending furrow at around 9° 10'S·157° 15'E.

e) There is a group of small furrows (irregular depression) of deeper than 4 km on the south of the Ghizo Ridge, Coleman Seamount and Kana Keoki Seamount.

f) A flat seafloor is observed on the south of the eastern trench.

3-2 Magnetic Survey (PGM Survey)

The magnetic survey was carried out with the objective of investigating the geological structure and ages of the seafloor crust.

1) Total Magnetic Force

Total magnetic force was measured in conjunction with the bathymetric survey. Influence of magnetic storms were not found during the survey. We did not correct the secular and diurnal variation of the geomagnetic field. A remeasurement was carried out along the same track line in order to check a accuracy if data were uncertain. A total magnetic force map (Figure 3-2-1-1) was produced by gridding the measured values of the total magnetic force at 2-km spacing. The total magnetic force is within the range from 41,000 to 43,000nT (nanotesla) and its value is generally low at the north and high at the south. These trends are consistent with the trends of the global geomagnetic field.

2) Magnetic Anomalies

The International Geomagnetic Reference Field are removed from the measured total magnetic force. Then we create a magnetic anomaly map (Figure 3-2-2-1). Profiles of magnetic anomaly is shown in Figure 3-2-2-2.

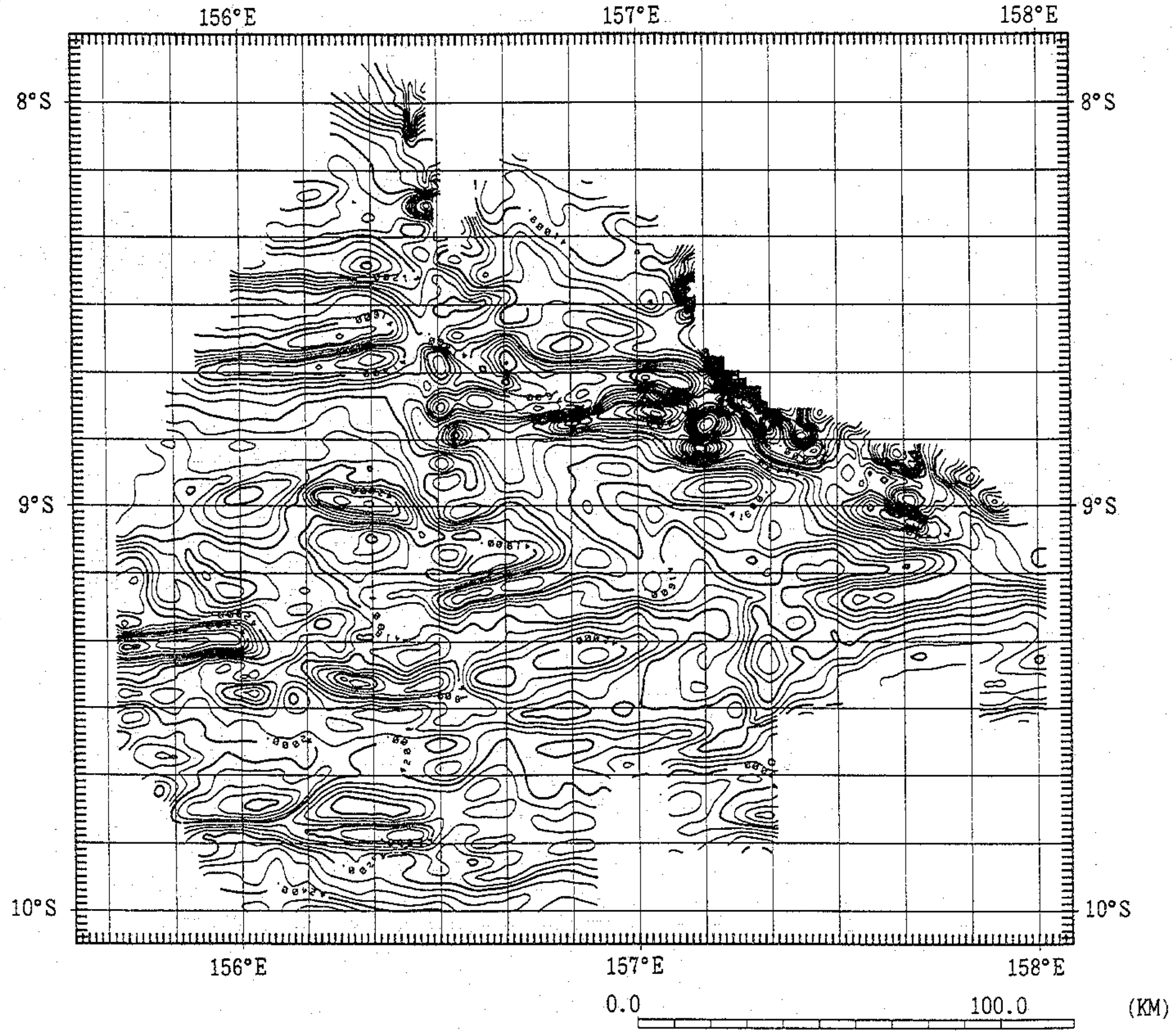


Figure 3-2-1-1　Total magnetic force map of area 1 produced from the data of measured total magnetic force value gridded at a 2-km spacing. Contour labels are in nanoteslas(nT), and contour interval is 50 nT

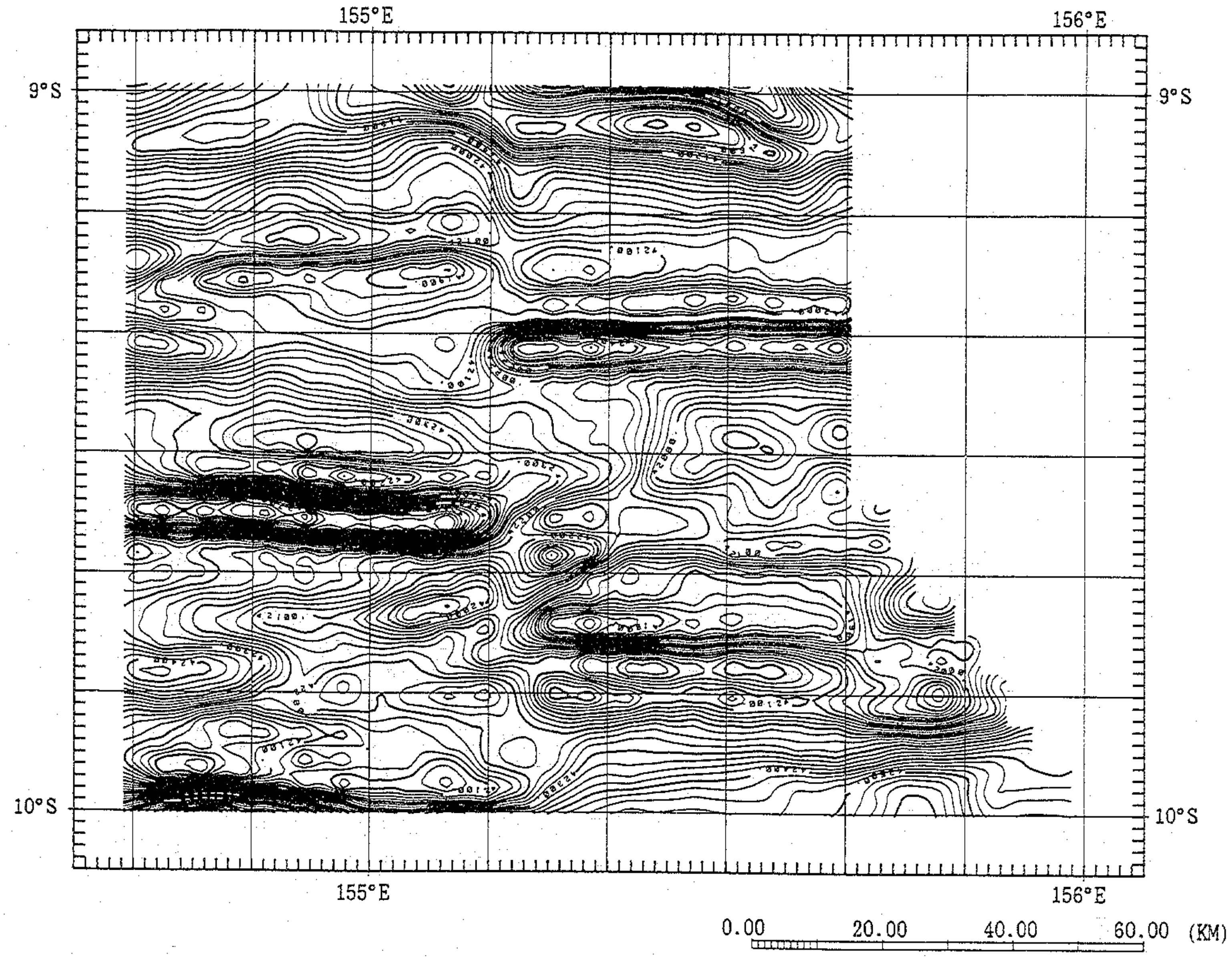


Figure 3-2-1-1 Total magnetic force map of area 2 produced from the data of measured total magnetic force value gridded at a 2-km spacing. Contour labels are in nanoteslas(nT), and contour interval is 25 nT

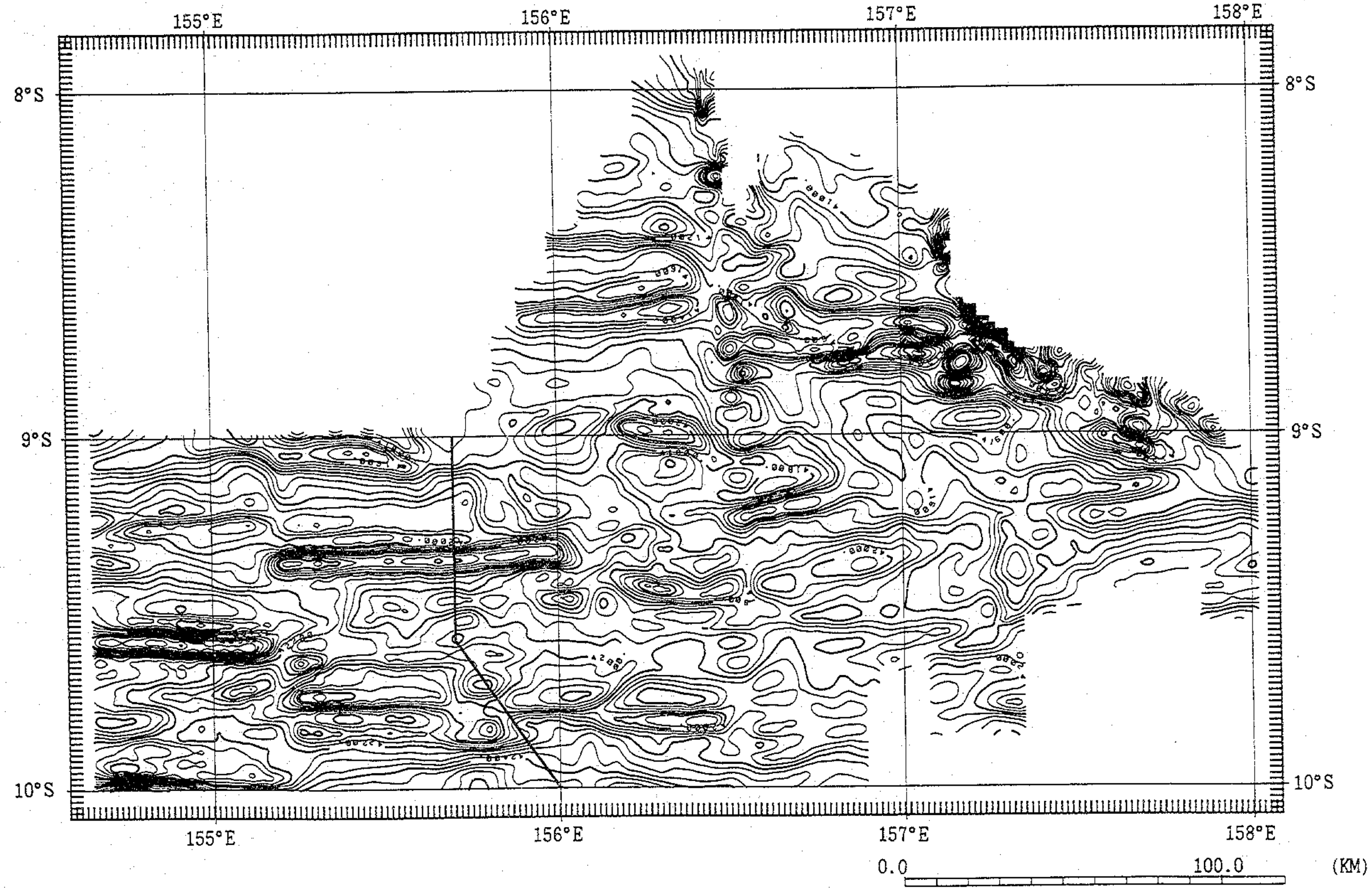


Figure 3-2-1-1 Total magnetic force map of area 1+2 produced from the data of measured total magnetic force value gridded at a 2-km spacing. Contour labels are in nanoteslas(nT), and contour interval is 50 nT

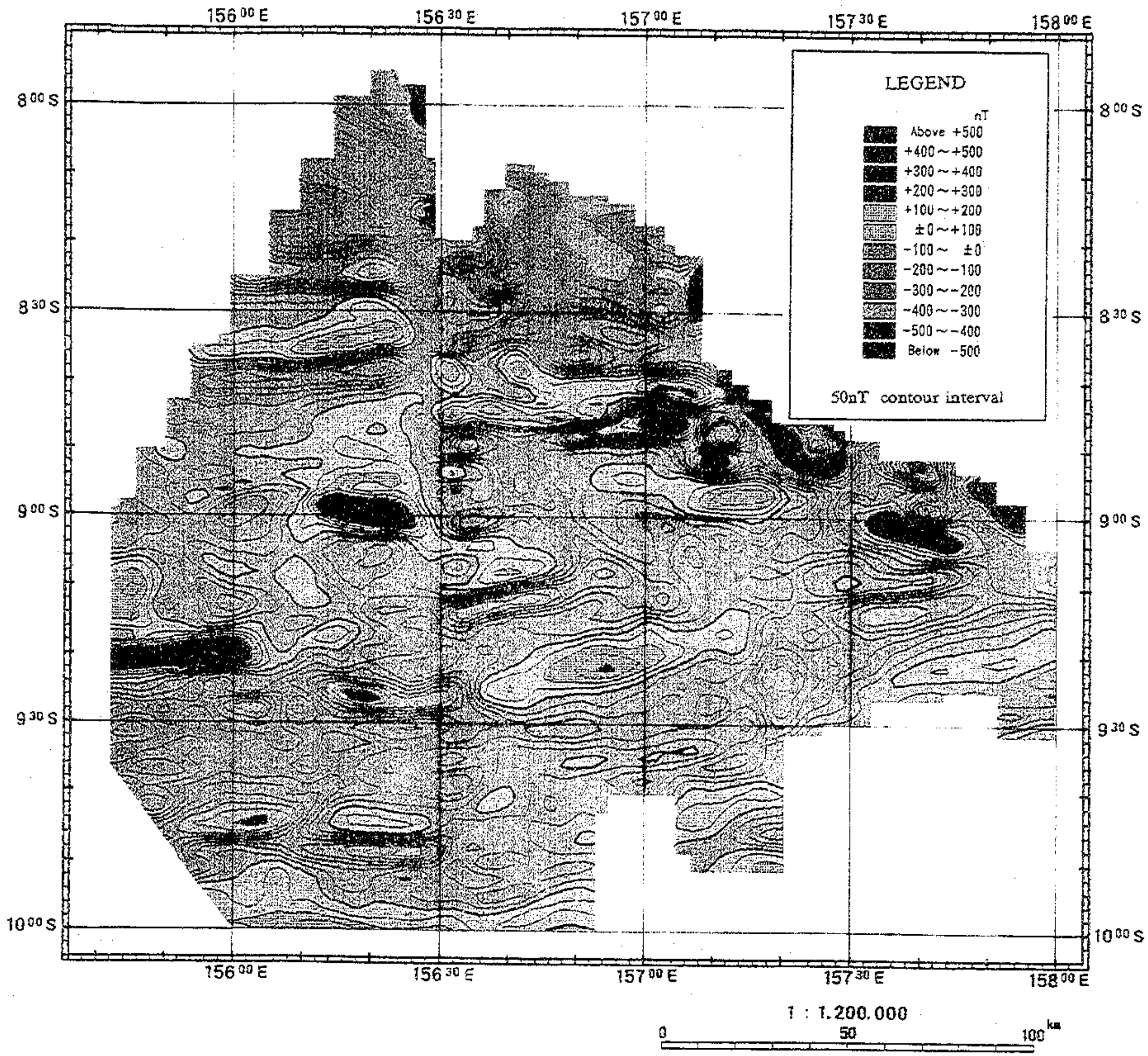


Figure 3-2-2-1 Magnetic anomaly map of area 1 produced from the data gridded at a 2-km spacing. Contour interval is 50 nT

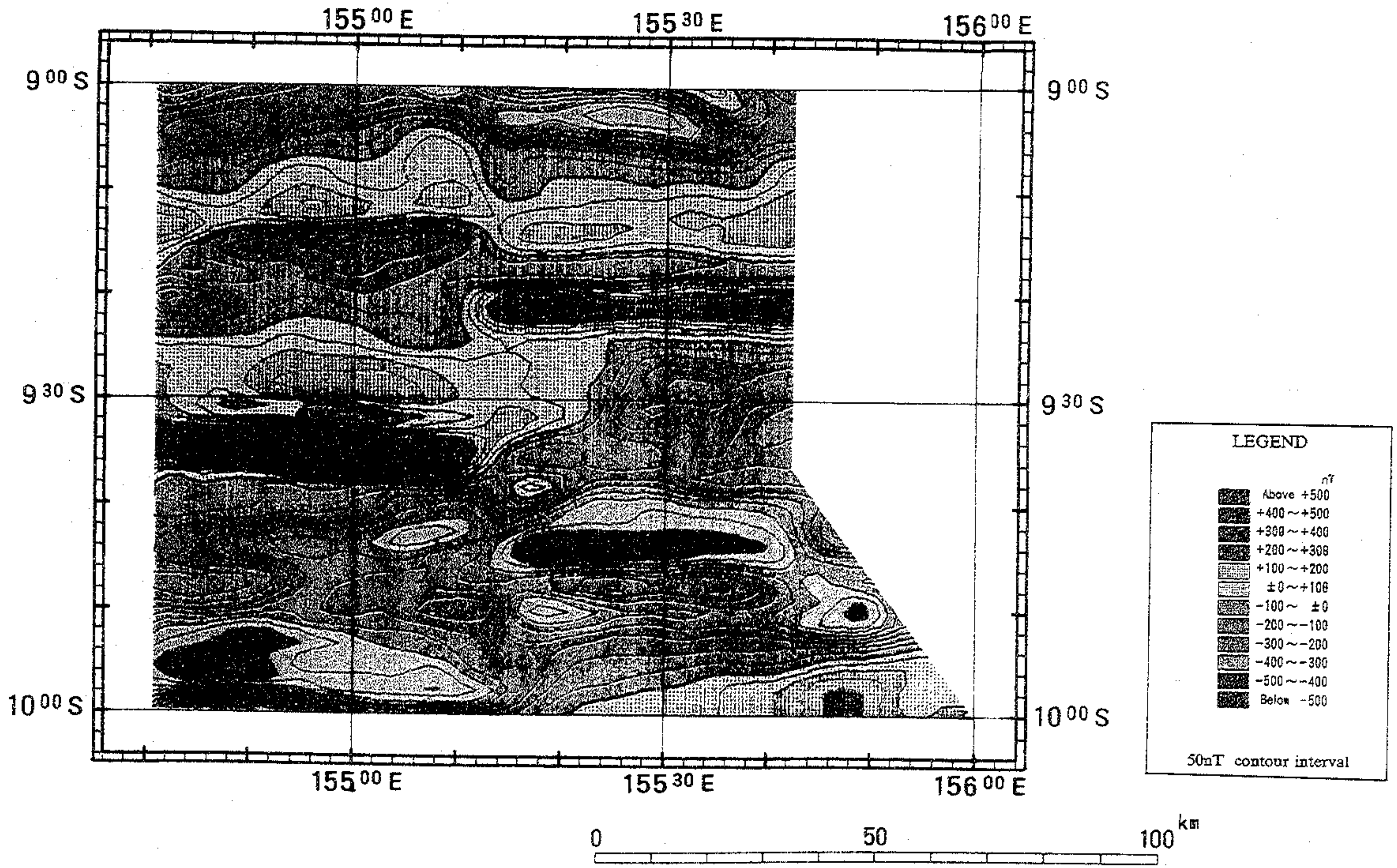


Figure 3-2-2-1 Magnetic anomaly map of area 2 produced from the data gridded at a 2-km spacing. Contour interval is 50 nT

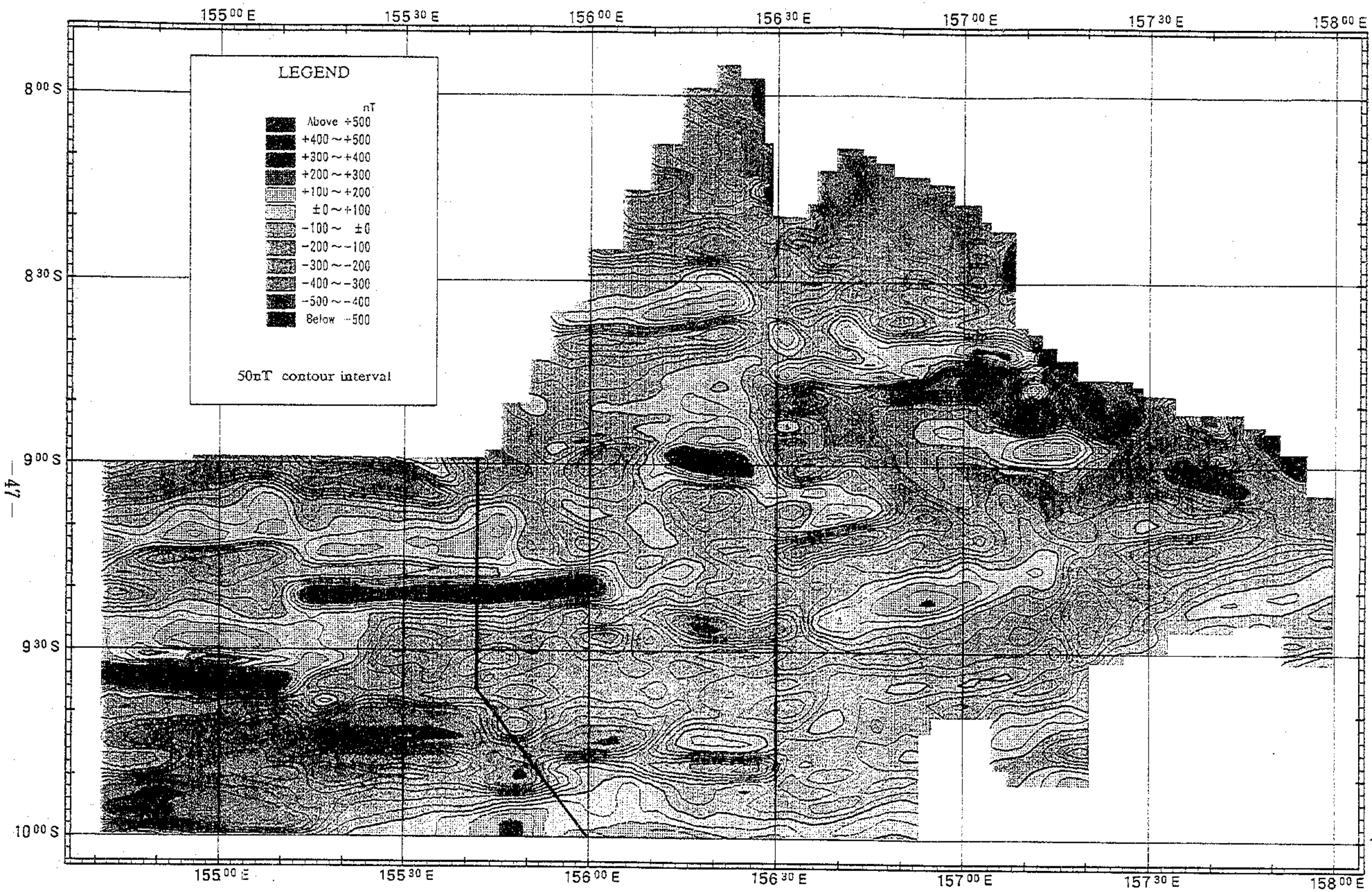
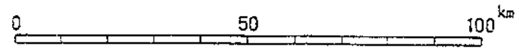


Figure 3-2-2-1 Magnetic anomaly map of area 1+2 produced from the data gridded at a 2-km spacing. Contour interval is 50 nT.



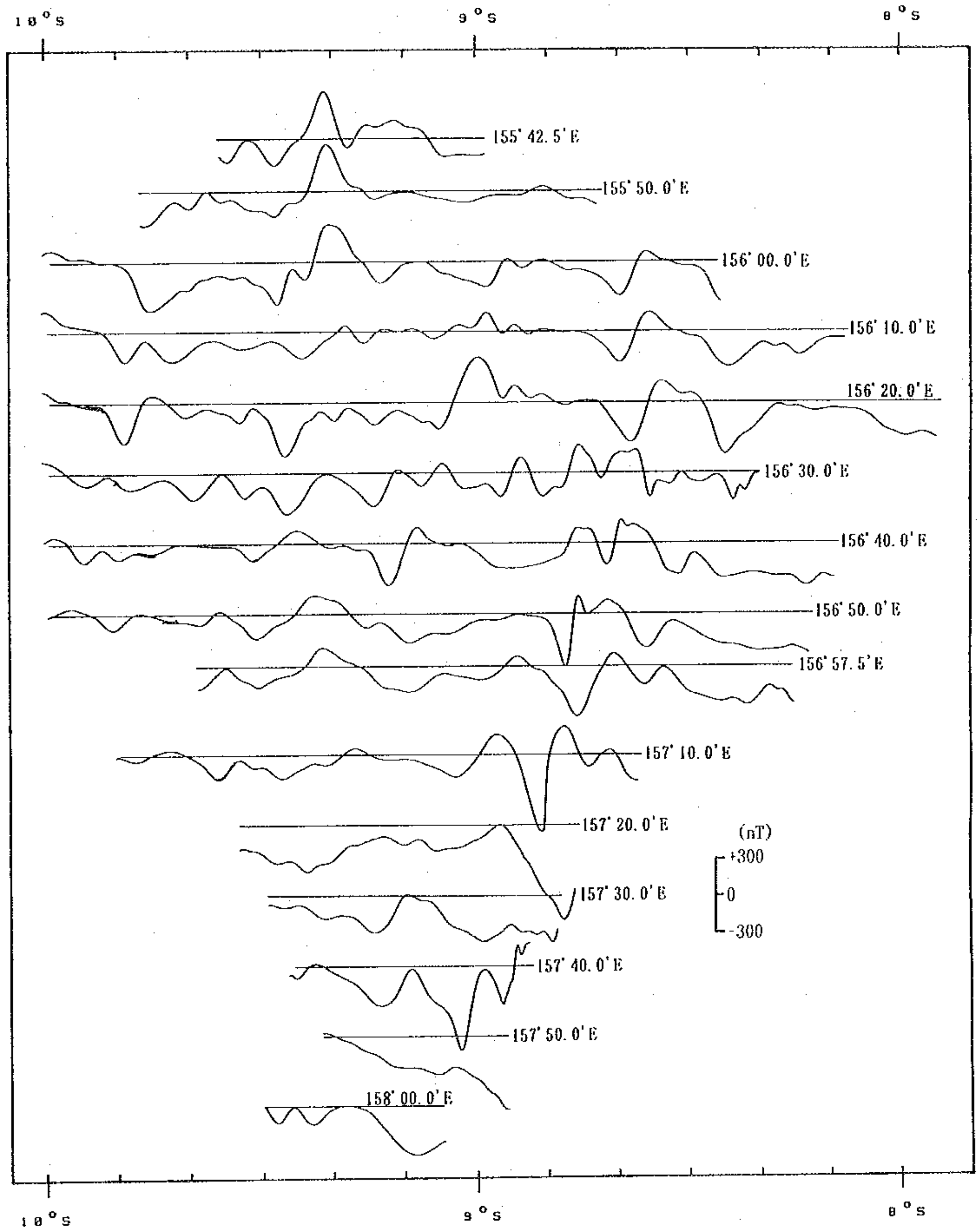


Figure 3-2-2-2 Magnetic anomaly profiles of area 1

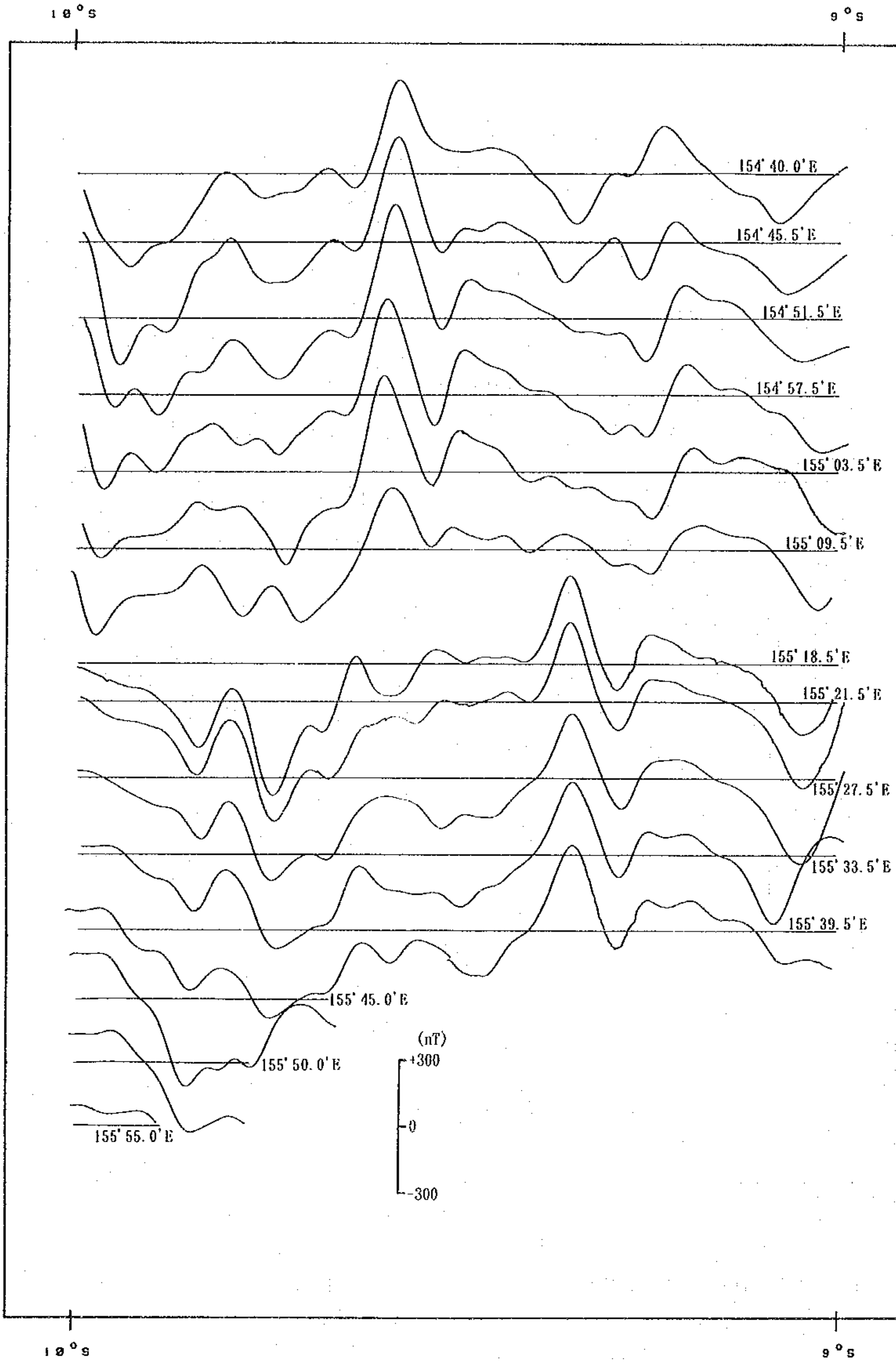


Figure 3-2-2-2 Magnetic anomaly profiles of area 2

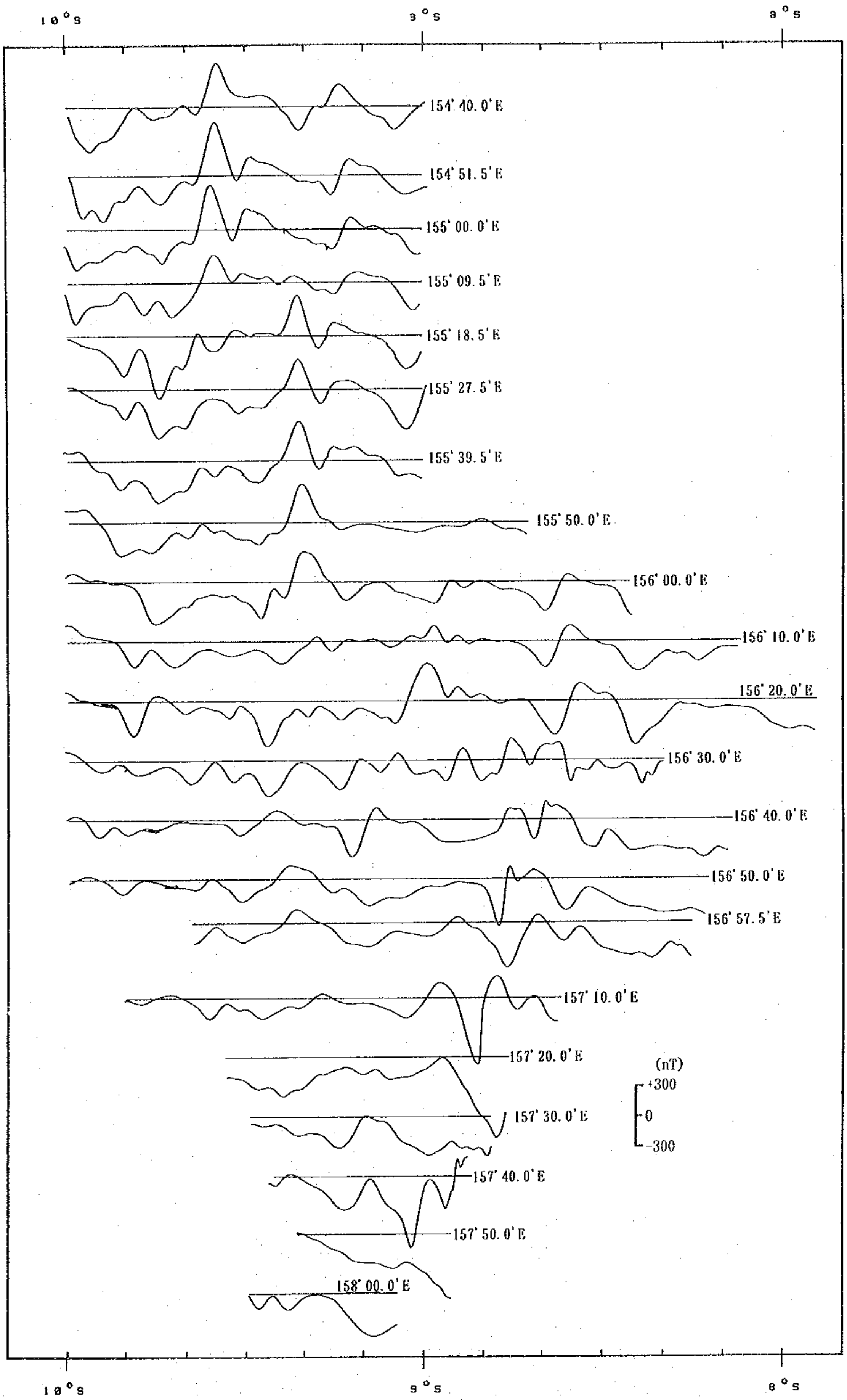


Figure 3-2-2-2 Magnetic anomaly profiles of area 1+2