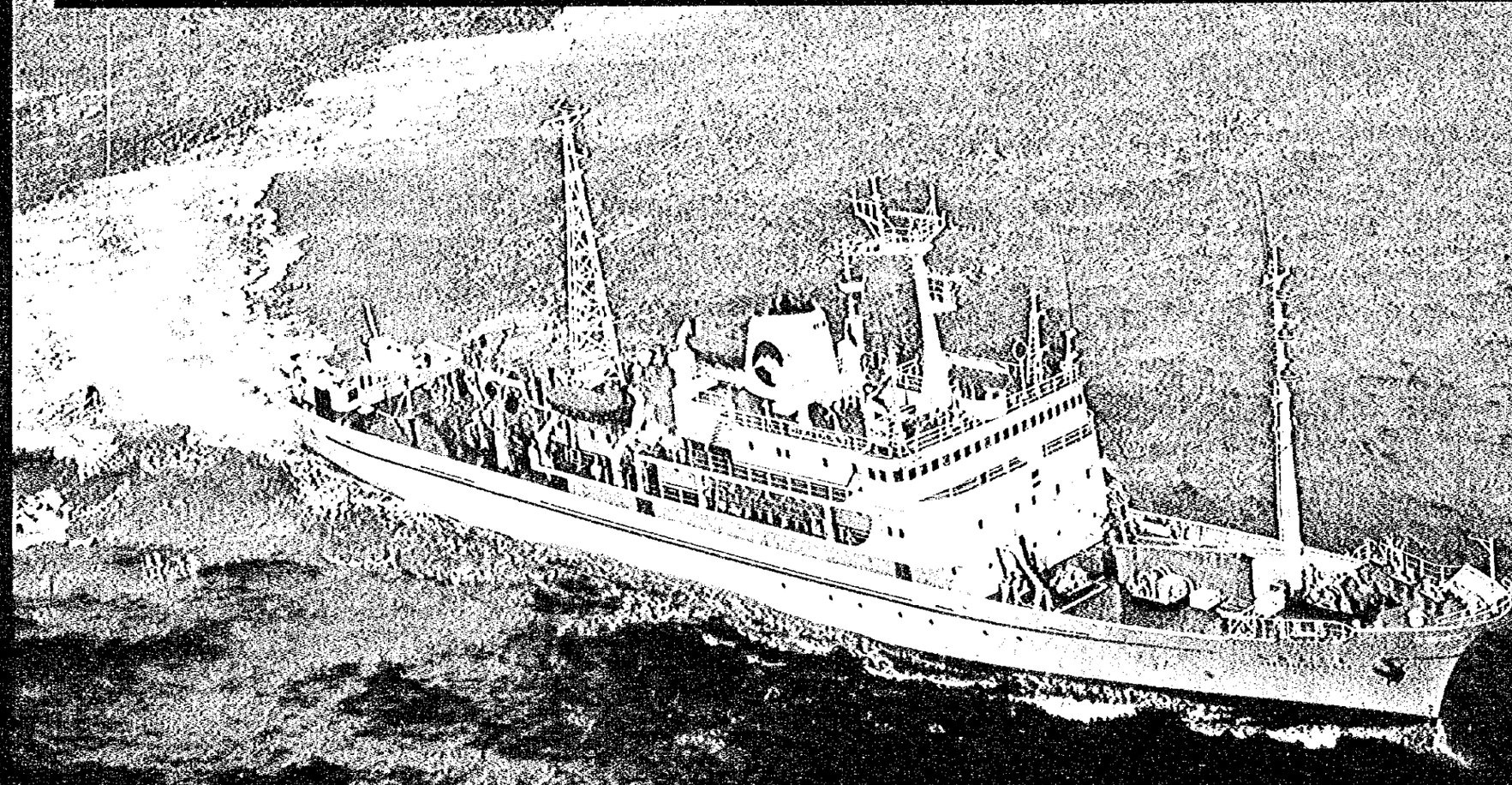
No.17

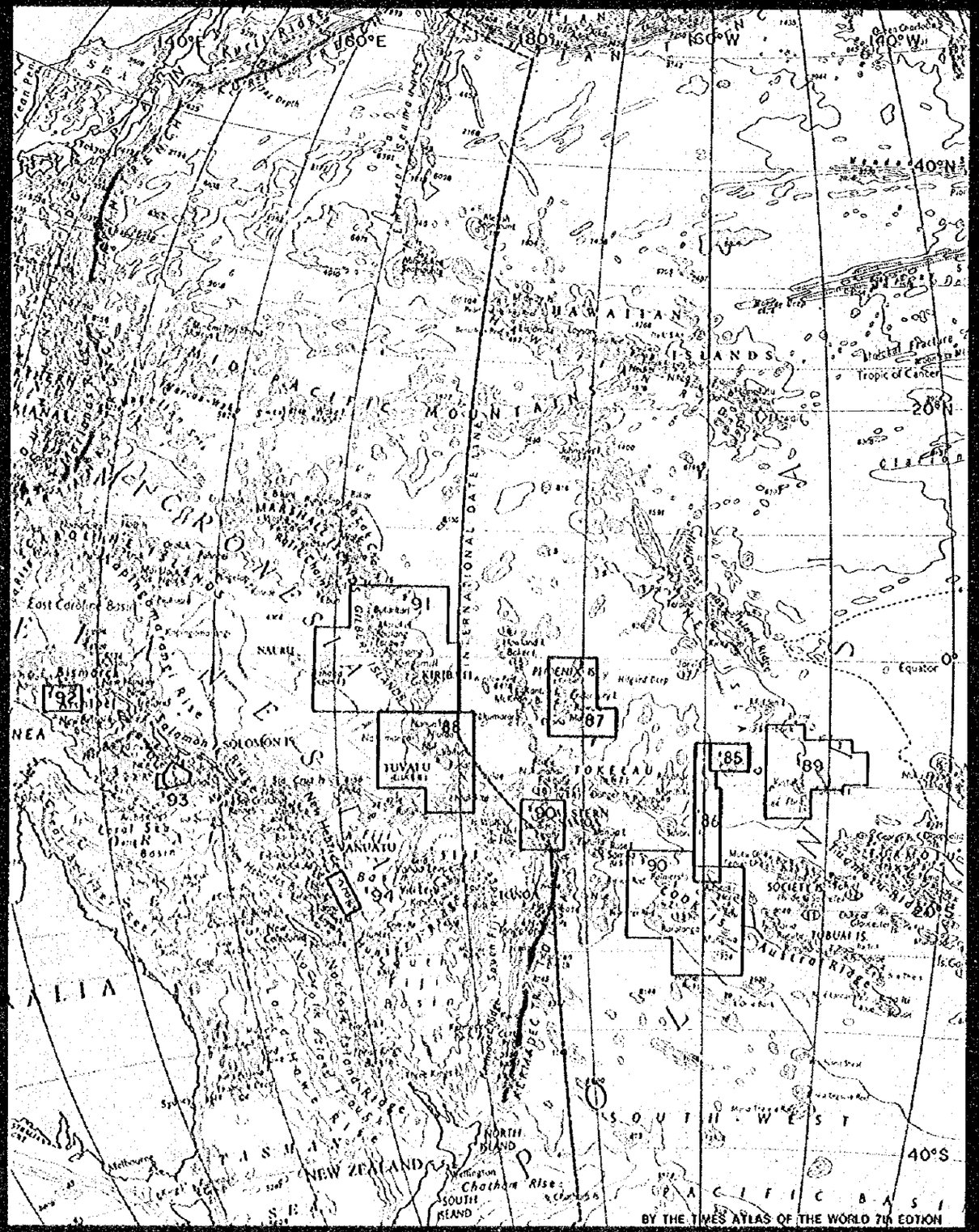
South Pacific Seafloor Atlas



JAPAN-SOPAC COOPERATIVE STUDY
ON DEEP SEA MINERAL RESOURCES
IN THE SOUTH PACIFIC 1985-1994

JICA MMAJ
SOPAC
SOUTH PACIFIC APPLIED GEOSCIENCE COMMISSION

MPN
JR
95 063



BY THE TIMES ATLAS OF THE WORLD 7th EDITION

LOCATION MAP OF THE SURVEY AREA

PREFACE

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

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

The survey was carried out in two stages, the First Stage, for a five-year period from 1985, and the Second Stage, for a five-year period from 1990. The First Stage survey for manganese nodules and cobalt rich crusts was carried out within the exclusive economic zones of the Cook Islands, the Republic of Kiribati and Tuvalu. The Second Stage survey for manganese nodules and cobalt rich crusts was carried out within the exclusive economic zones of Western Samoa, the Cook Islands and the Republic of Kiribati, and the survey for submarine hydrothermal deposits was carried out within the exclusive economic zones of Papua New Guinea, the Solomon Islands and the Republic of Vanuatu. The MMAJ dispatched the Hakurei-Maru No.2, a research vessel for investigating deep-sea mineral resources, to the sites for ten years during the First and Second Stages and implemented the survey with the cooperation of the above mentioned governments.

This Atlas sums up the results of the survey with an emphasis on maps.

We wish to extend our sincere thanks to all the persons concerned, especially for the cooperation given to us by the Secretariat of SOPAC, the Government of the Cook Islands, the Government of the Republic of Kiribati, the Government of Tuvalu, the Government of Western Samoa, the Government of Papua New Guinea, the Government of the Solomon Islands and the Government of the Republic of Vanuatu as well as the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, the Japanese Embassy in Fiji, the Japanese Embassy in Papua New Guinea and the Japanese Embassy in Solomon Islands.

March, 1995

Kimio Fujita

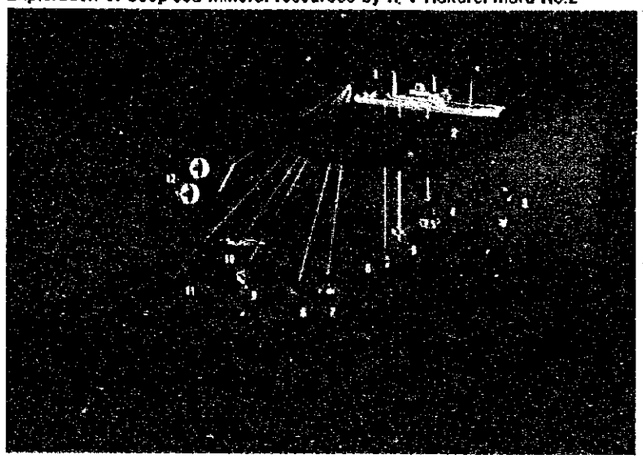
President Kimio FUJITA
Japan International Cooperation Agency

Takashi Ishikawa

President Takashi ISHIKAWA
Metal Mining Agency of Japan

CONTENTS

Exploration of deep-sea mineral resources by R/V Hakurei-maru No.2



Principal Equipment Aboard
HAKUREI MARU NO 2

Navigation System

- GPS : Global Positioning System
- NNSS: Navy Navigation Satellite System
- TPS : Transponder System

Sounding System

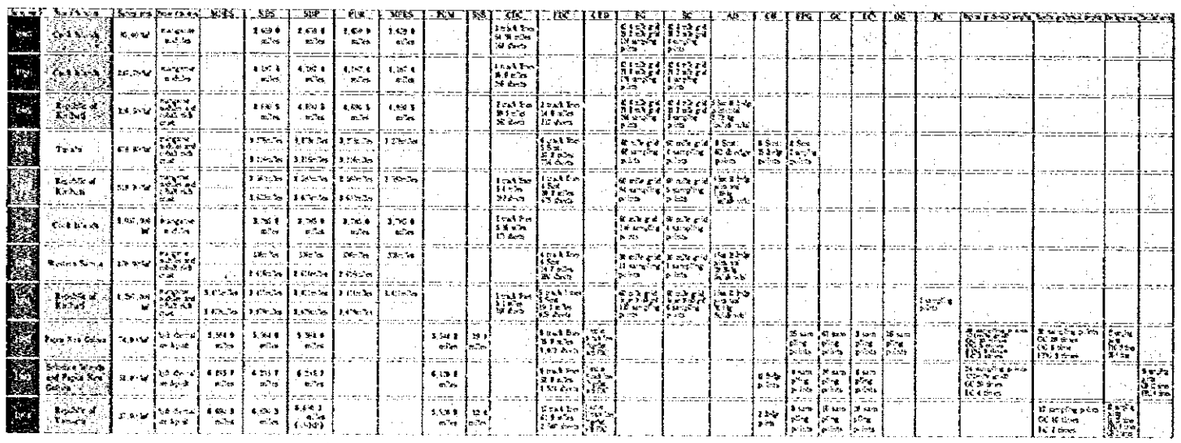
- NBS : Narrow Beam Echo Sounder
- PDR : Precision Depth Recorder
- SBP : Sub-Bottom Profiler
- nSBP: Narrow Beam Sub-Bottom Profiler
- MBES: Multi-narrow Beam Echo Sounder

Sampling

- ❶FG : Free-fall Grab
- ❷CTD : Conductivity-Temperature Depth profiler
- ❸BC : Box Corer (SC, OG)
- ❹GC : Gravity Corer (LC, PC)
- ❺FPG : Finder-installed Power Grab
- ❻FDC : Continuous Deepsea Camera with Finder
- ❼DB : Dredge Bucket (AD, CB)
- ❽SSS : Side Scan Sonar
- ❾CDC : Continuous Deep sea Camera
- ❿PGM: Piston Gravity Meter

(Other)
MFES: Multi Frequency Exploration System

Summary of the survey results within the EEZ of SOPAC menber countries for ten years (1985-1994)



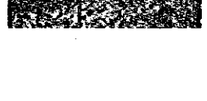
Photos of principal survey equipment

❶FG

❷CTD

❸SC

❹GC



❺FPG

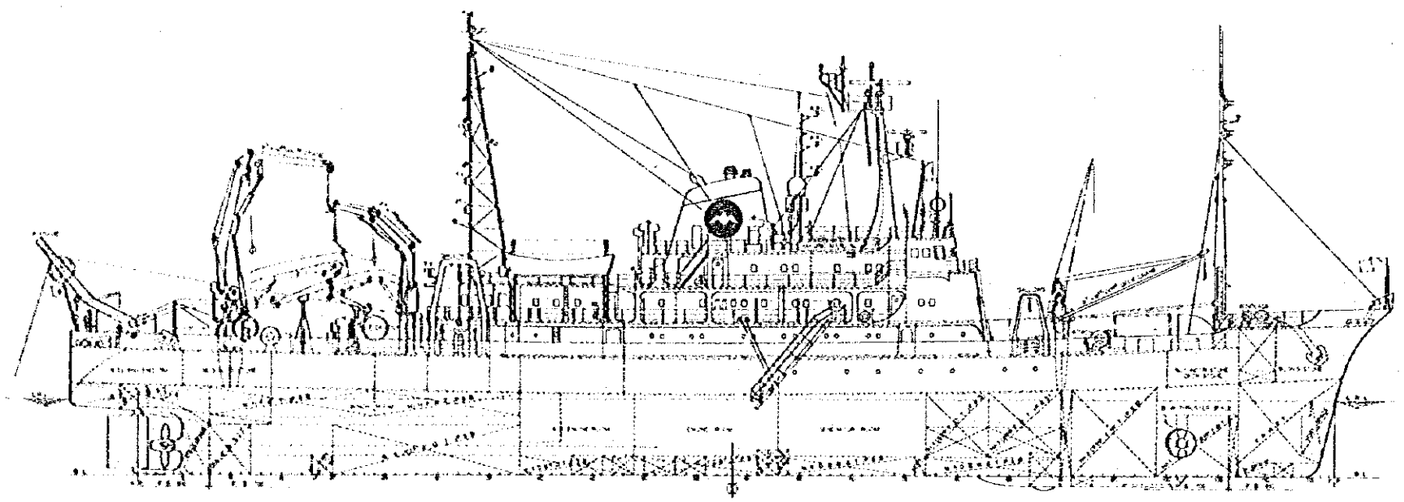
❻FDC

❼AD

❽SSS

❾CDC

❿PGM



Research Vessel

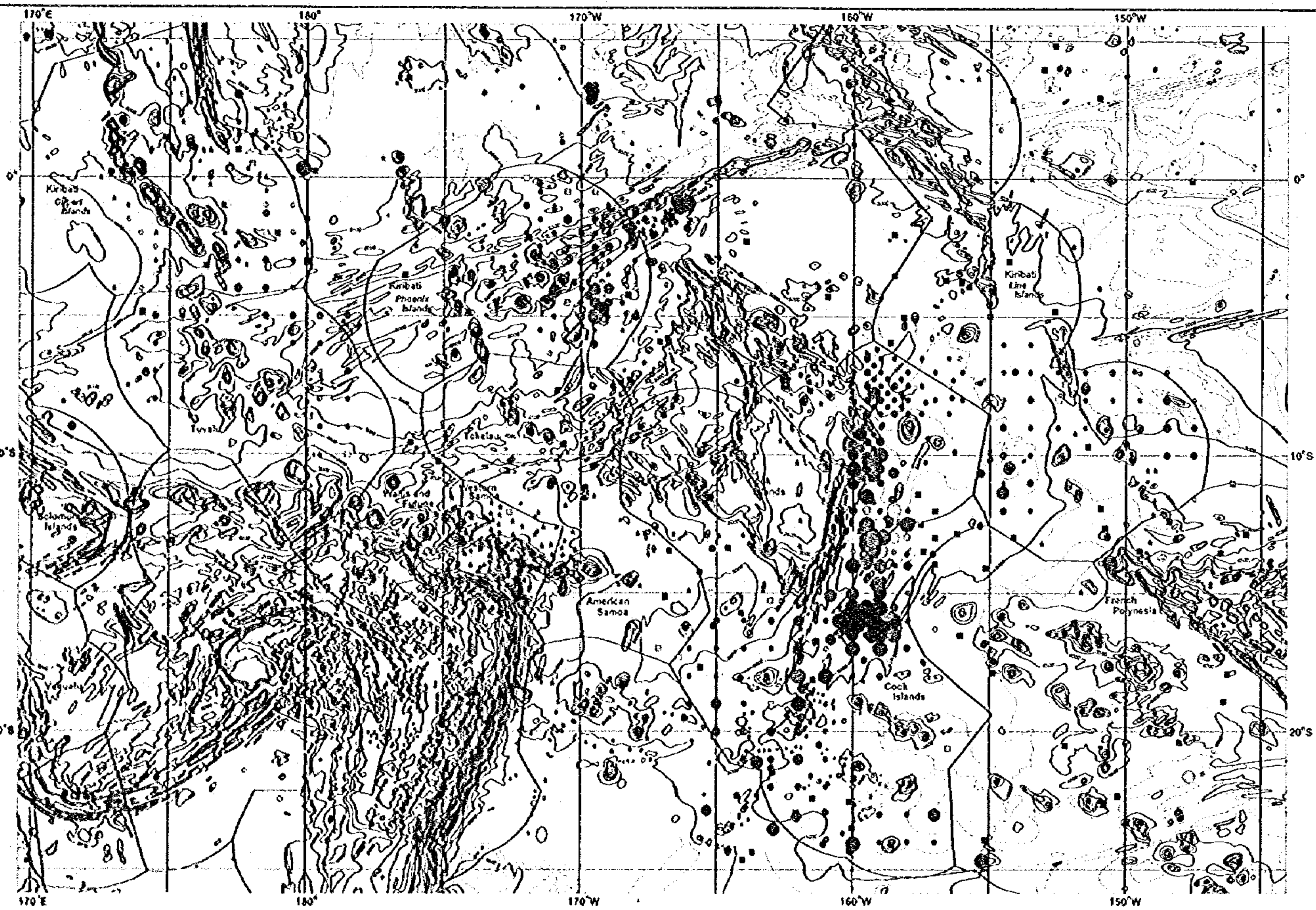
HAKUREI-MARU No.2

SCALE 1/200

JICA/MMAJ/SOPAC ATLAS 1995.
South Pacific Seafloor Atlas, Sheet no.3

DISTRIBUTION OF MANGANESE NODULES SOUTHWEST PACIFIC OCEAN

MAP 1-Ni CONTENT



Nickel Contents

1.50 to 2.23 %	1.25 to 1.50 %	1.00 to 1.25 %
0.75 to 1.00 %	0.50 to 0.75 %	0.25 to 0.50 %
0.01 to 0.25 %	No Chemical Analysis Data	

Abundance

25.0 to 56.4 kg/m²	5.0 to 10.0 kg/m²
20.0 to 25.0 kg/m²	0.01 to 5.0 kg/m²
15.0 to 20.0 kg/m²	0.00 kg/m²
10.0 to 15.0 kg/m²	No Abundance Data

Projection: Mercator (WGS 84)
Scale: 1:10,000,000
For references see back of map

ACKNOWLEDGEMENTS:

Funding by Japan International Cooperation Agency and Metal Mining Agency of Japan.
Bathymetry printed from IHO IOC GEBCO Digital Atlas (GDA) GEBCO 5th Edition.
World Vector Shorelines from DMA, supplied by BODC (UK).
Contours in metres, contour interval 500 metres: 2500, 5000 and 7500 m contours in blue; other contours in black with selected intermediate contours dashed.
200 nautical mile boundaries shown are approximate.
Michel Larue and Phillip Woodward for assistance.

By Yasumasa Kinoshita and Don Tiffin SOPAC Secretariat

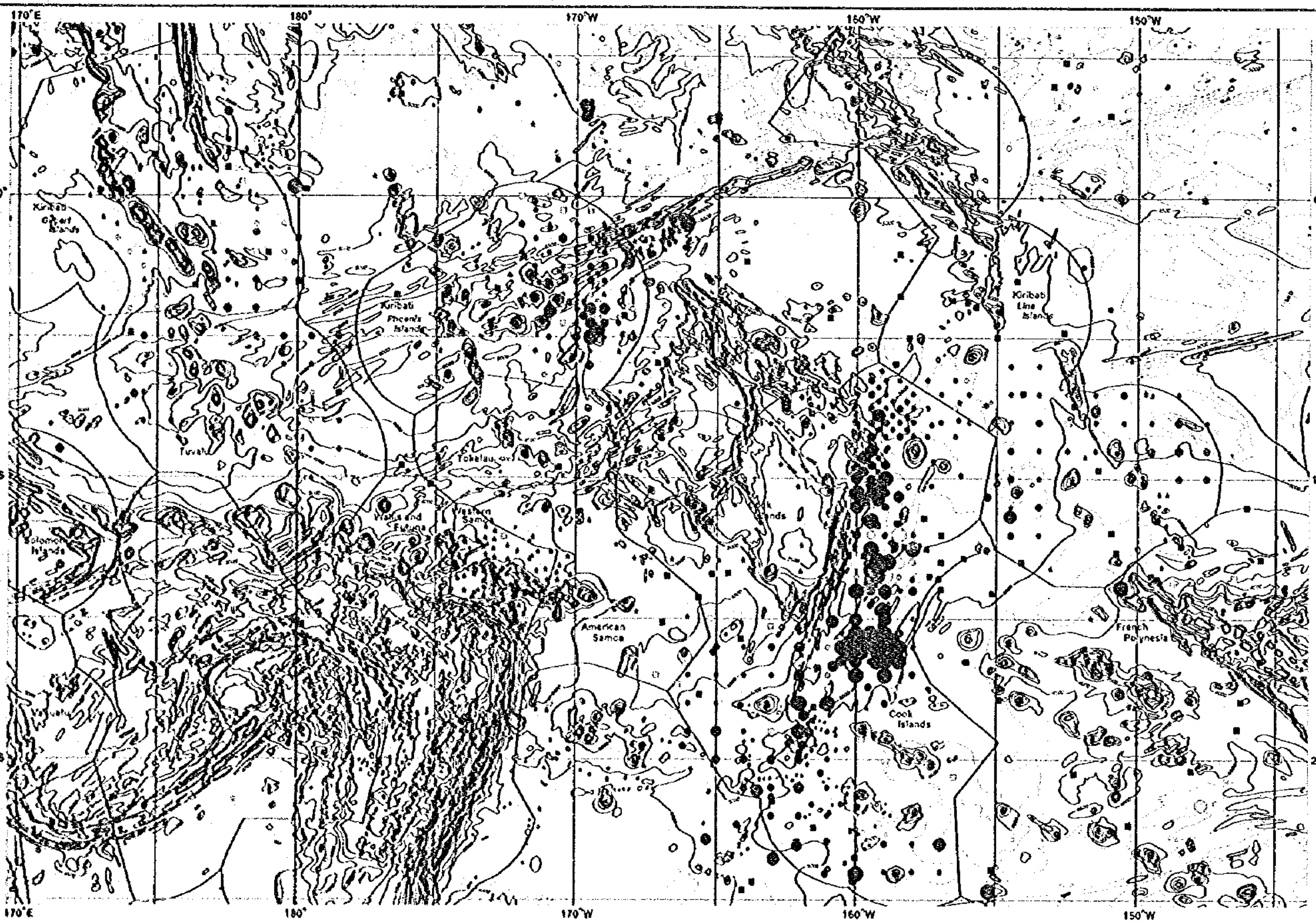
REFERENCES

JICA MMAJ

SOPAC
SOUTH PACIFIC APPLIED GEOSCIENCE COMMISSION

DISTRIBUTION OF MANGANESE NODULES SOUTHWEST PACIFIC OCEAN

MAP 2 - Cu CONTENT



LEGEND

Copper Contents

1.50 to 2.23 %	1.25 to 1.50 %	1.00 to 1.25 %
0.75 to 1.00 %	0.50 to 0.75 %	0.25 to 0.50 %
0.01 to 0.25 %	No Chemical Analysis Data	

Abundance

25.0 to 56.4 kg/m²	5.0 to 10.0 kg/m²
20.0 to 25.0 kg/m²	0.01 to 5.0 kg/m²
15.0 to 20.0 kg/m²	0.0 kg/m²
10.0 to 15.0 kg/m²	No Abundance Data

Projection: Mercator (WGS 84)
Scale: 1:10,000,000
For references see back of map.

ACKNOWLEDGEMENTS:

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200 nautical mile boundaries shown are approximate.
Michel Larue and Phillip Woodward for assistance.

By Yasumasa Kinoshita and Don Tiffin SOPAC Secretariat

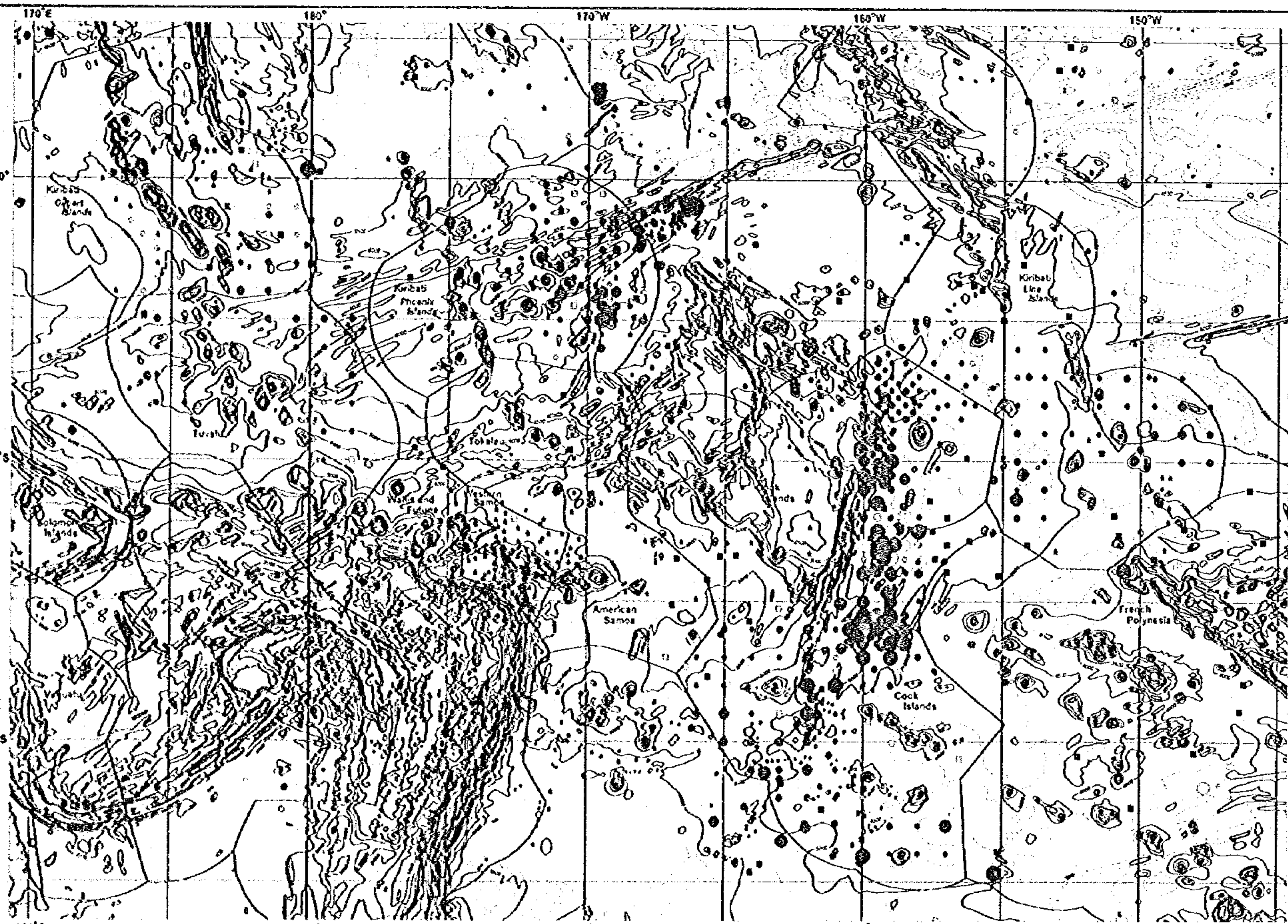
REFERENCES

[illegible]

JICA MMAJ SOPAC
SOUTH PACIFIC APPLIED GEOSCIENCE COMMISSION

DISTRIBUTION OF MANGANESE NODULES SOUTHWEST PACIFIC OCEAN

MAP 3 - Co CONTENT



LEGEND

Cobalt Contents

- 1.50 to 2.23 %
- 1.25 to 1.50 %
- 1.00 to 1.25 %
- 0.75 to 1.00 %
- 0.50 to 0.75 %
- 0.25 to 0.50 %
- 0.01 to 0.25 %
- No Chemical Analysis Data

Abundance

- 25.0 to 56.4 kg/m²
- 20.0 to 25.0 kg/m²
- 15.0 to 20.0 kg/m²
- 10.0 to 15.0 kg/m²
- 5.0 to 10.0 kg/m²
- 0.01 to 5.0 kg/m²
- 0.00 kg/m²
- No Abundance Data

Projection: Mercator (WGS 84)
Scale: 1:10,000,000
For references see back of map

ACKNOWLEDGEMENTS:

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200 nautical mile boundaries shown are approximate.
Michel Larue and Phillip Woodward for assistance

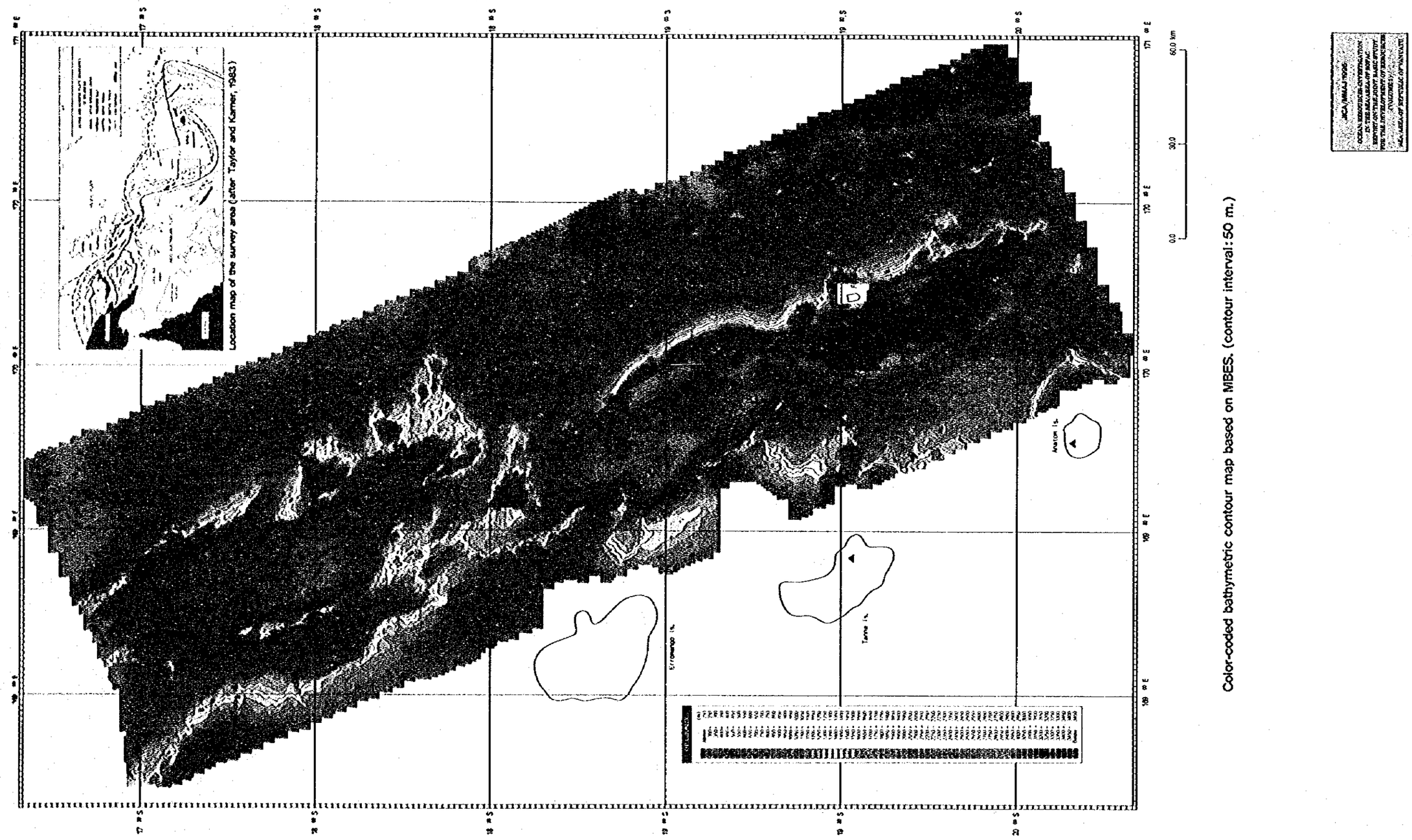
By Yasumasa Kinoshita and Don Tiffin SOPAC Secretariat

REFERENCES

JICA MMAJ SOPAC
SOUTH PACIFIC APPLIED GEOSCIENCE COMMISSION

The Coriolis Troughs of the New Hebrides Backarc Republic of Vanuatu

The Survey of Seafloor Hydrothermal Ore Deposits (1994)

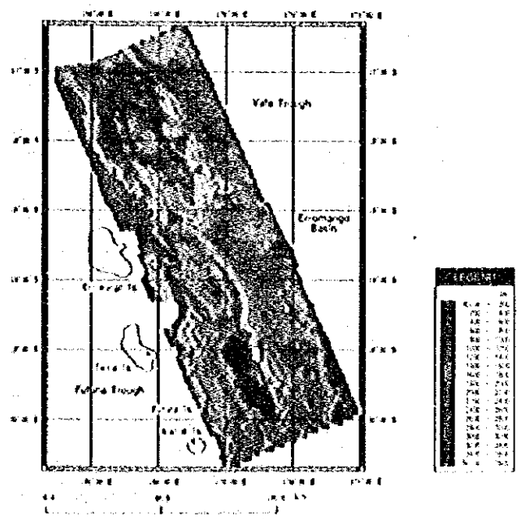


Color-coded bathymetric contour map based on MBES. (contour interval: 50 m.)

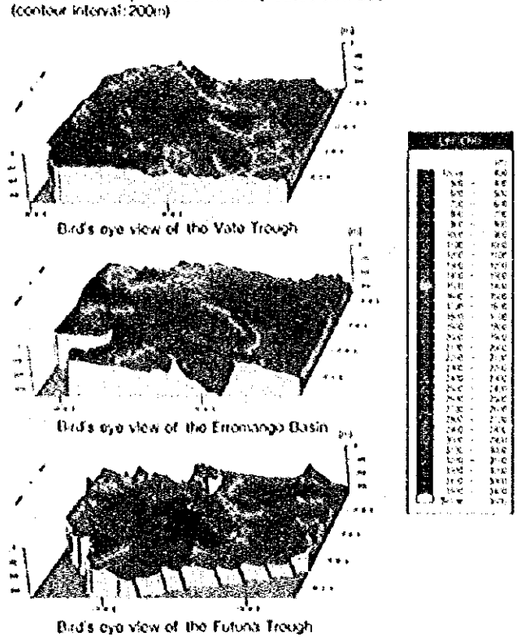
JICA/MMAJ/SOPAC ATLAS 1995. Surveyed by DORD
(DORD: DEEP OCEAN RESOURCES DEVELOPMENT Co.,LTD.)
South Pacific Seafloor Atlas, Sheet no.7

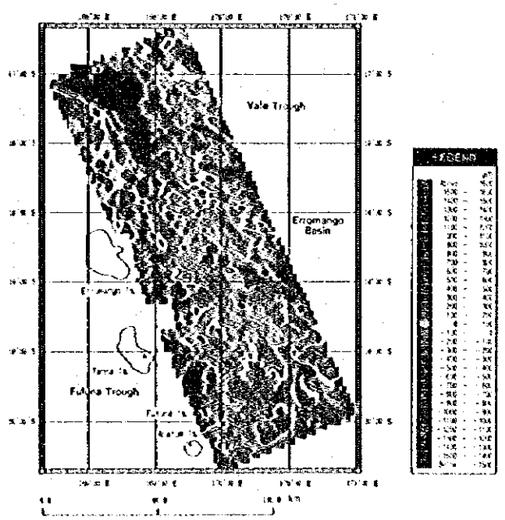
The Coriolis Troughs of the New Hebrides Backarc Republic of Vanuatu

The Survey of Seafloor Hydrothermal Ore Deposits (1994)

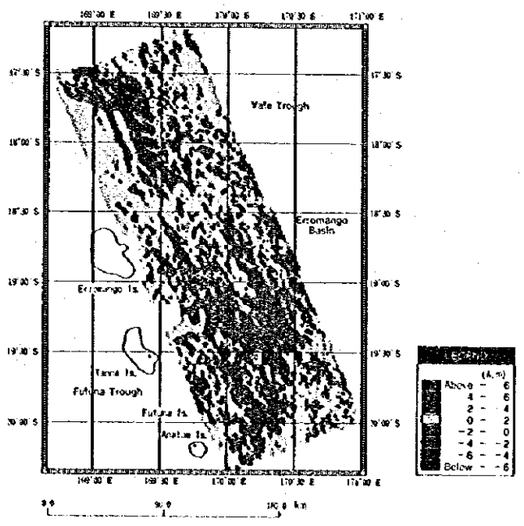


Color-coded bathymetric contour map based on MBES (contour interval: 200m)

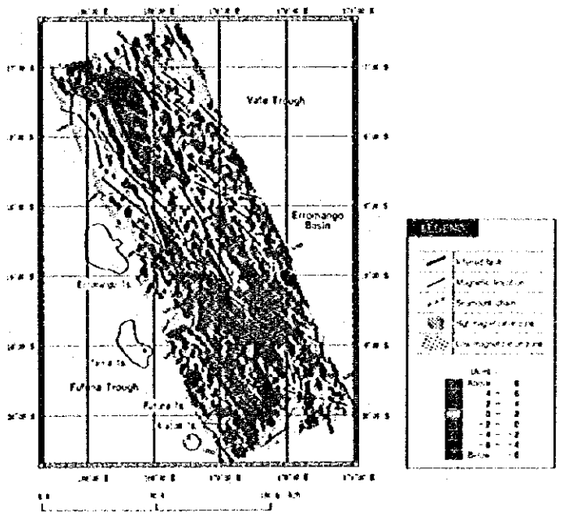




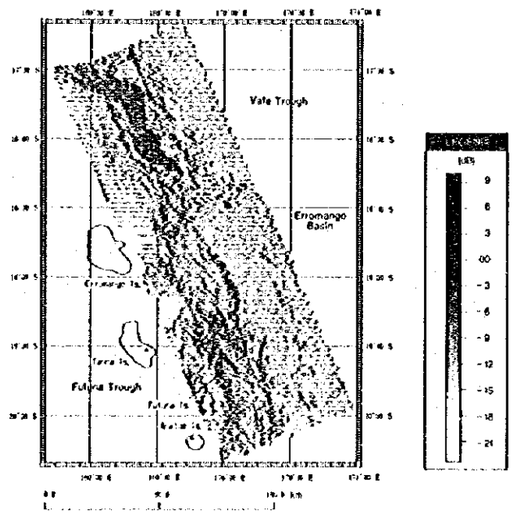
Magnetic anomaly map (contour interval: 200nT)



Magnetization distribution map



Interpretative magnetic structure map



Acoustic reflection image based on MBES

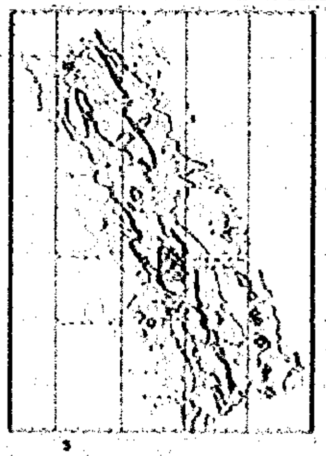
JICA/MMAJ/SOPAC ATLAS 1995. Surveyed by DORO

South Pacific Seafloor Atlas, Sheet no.8

The Coriolis Troughs of the New Hebrides Backarc
Republic of Vanuatu

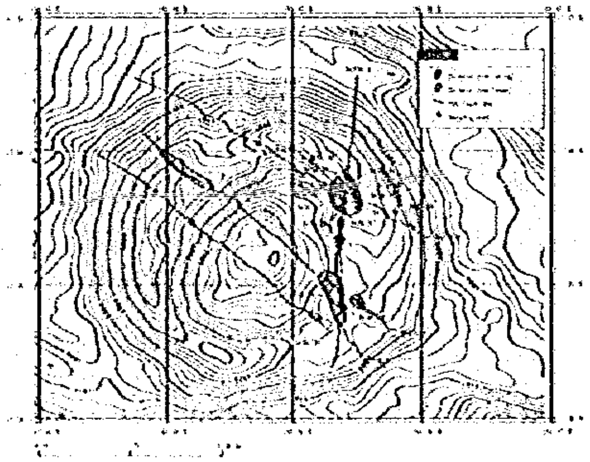
The Survey of Seafloor Hydrothermal Ore Deposits (1994)

Coriolis Troughs

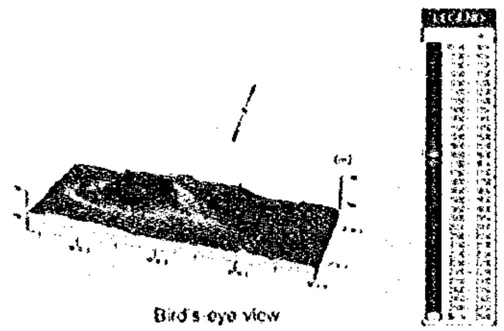


Promising sites of hydrothermal activities in the survey area

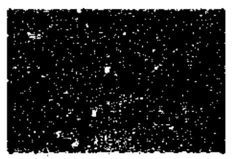
94S01 Seamount



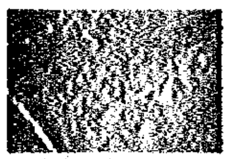
Ore indication map



Bird's-eye view



Bacteria vent communities (94SFDC12)



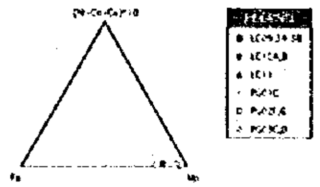
Reddish brown oxides (94SFDC12)

Seafloor photographs taken by FDC

The sample photograph of basaltic rocks (94SOPD07)

Central part of the Erromango Basin

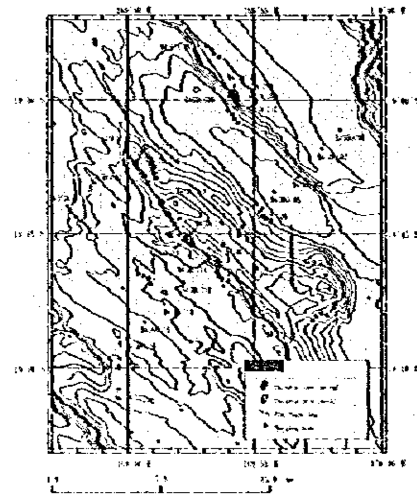
Schematic drawings of sampling results obtained from the Baseline Geochemical Survey.



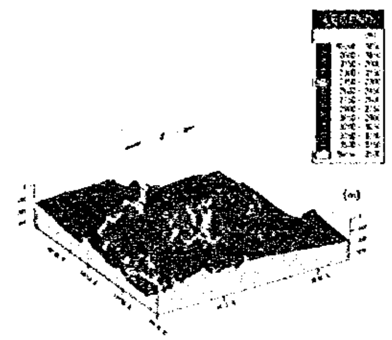
Mn-Fe-(Ni+Co+Cu)X10 diagram for manganese oxides

Results of chemical analysis for manganese oxides

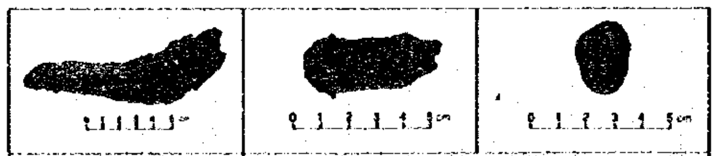
Sample No.	Ni(ppm)	Co(ppm)	Cu(ppm)	Fe(%)	Mn(%)
LC05	94	553	115	3.46	26.53
LC10A	32	65	30	1.11	32.20
LC10B	54	145	47	1.74	27.61
LC11	133	218	290	6.13	29.51
PG01C	193	213	193	3.37	36.55
PG02F	41	203	90	1.35	21.38
PG03D	67	223	135	8.54	14.01
PG0?C	30	76	13	8.20	51.09
PG02D	41	9	55	2.36	25.54



Ore indication map

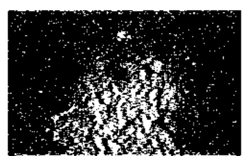


Bird's-eye view



Manganese oxide (Section 94SOPD03)

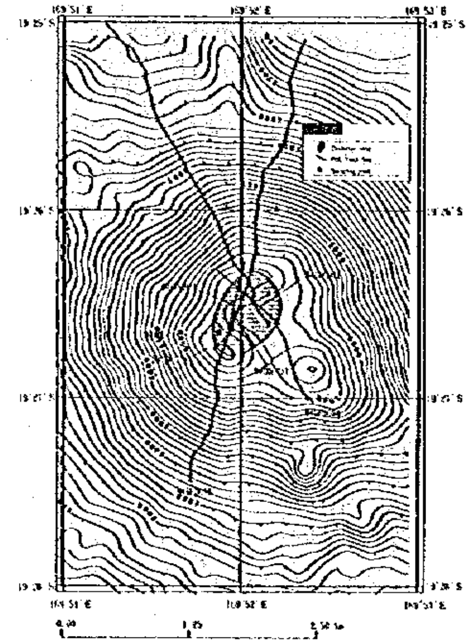
Manganese chimney (whole view, 94SDLC08)



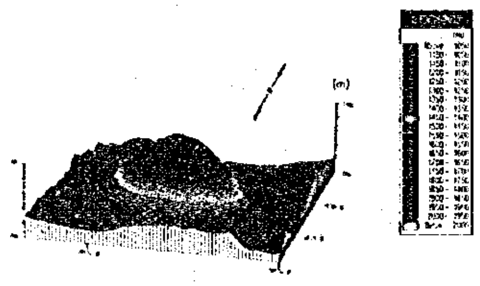
Seafloor photograph of brown and black colored deposit (94SFDC01)

The sample photograph of manganese oxides (94SOPD03)

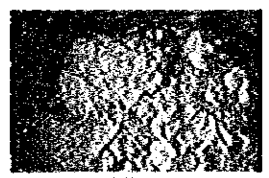
94S02 Seamount



Ore indication map



Bird's-eye view

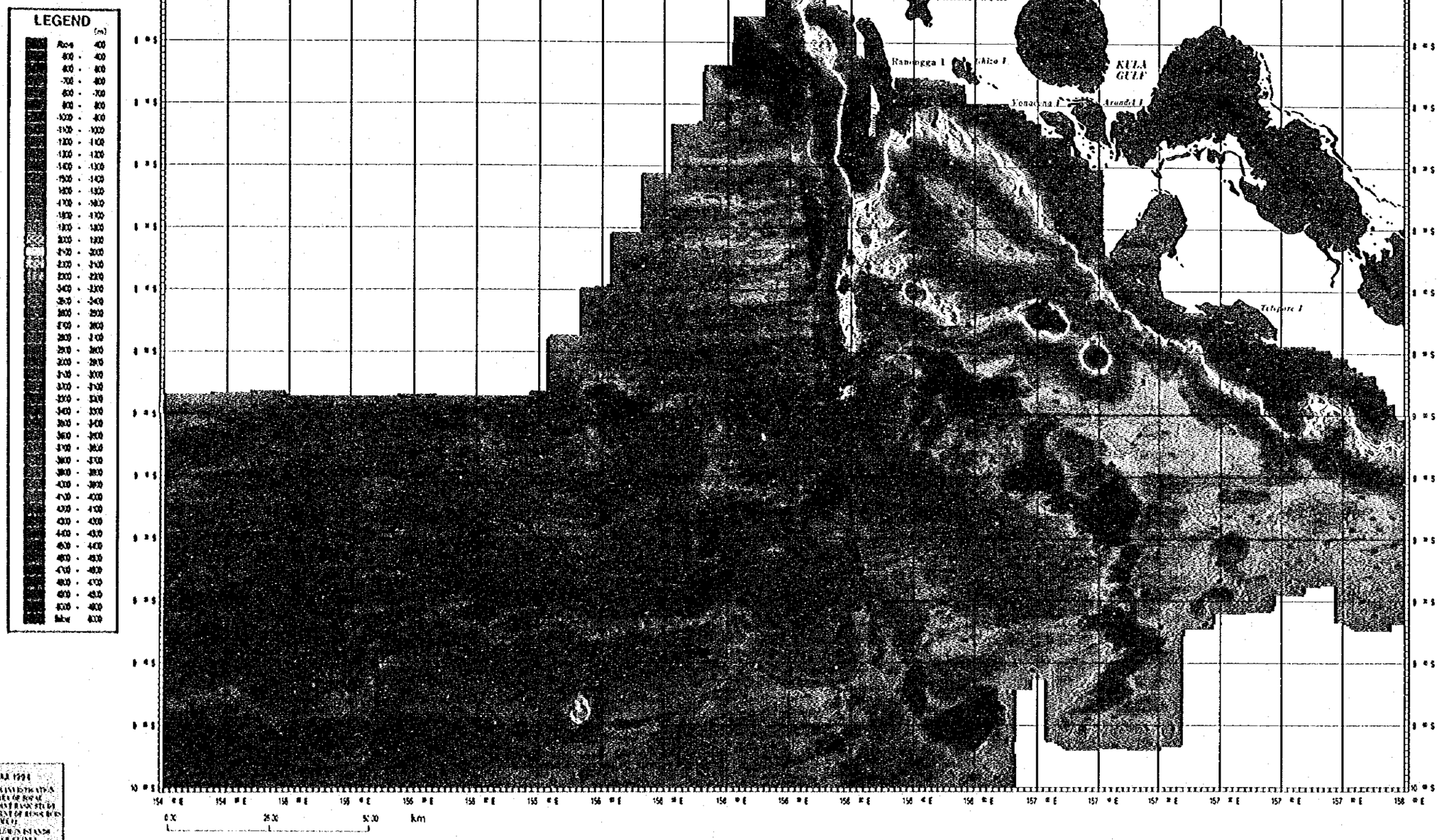


Seafloor photograph of brown colored deposit (94SFDC05)

The sample photograph of iron oxides (94SOCD01)

The Woodlark Basin
Solomon Islands and Papua New Guinea

The Survey of Seafloor Hydrothermal Ore Deposits (1993)



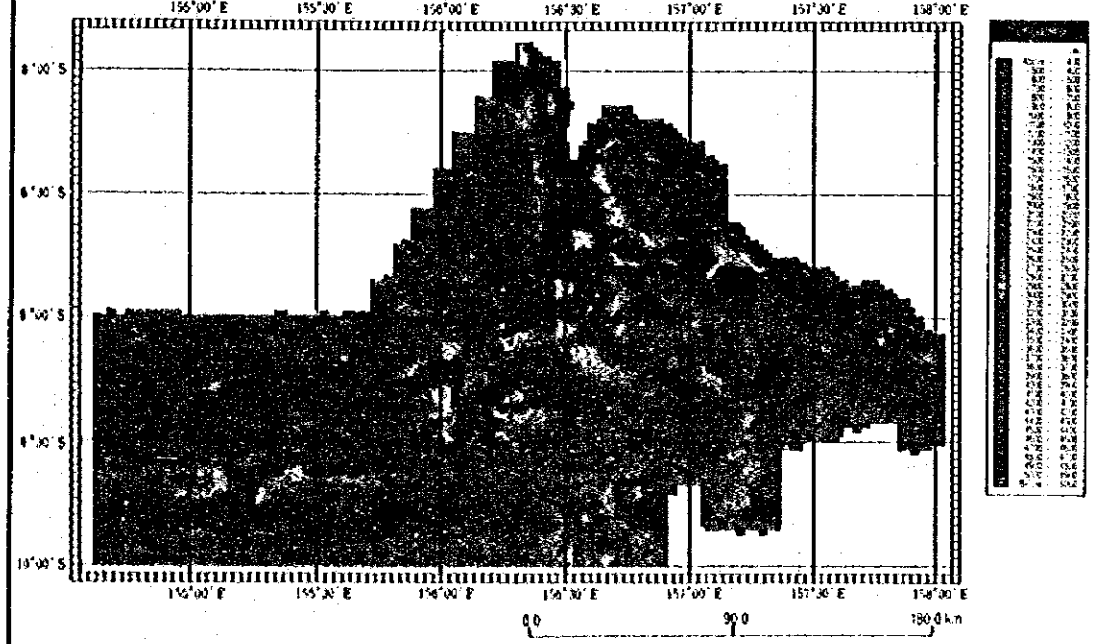
Color-coded bathymetric contour map based on MBES (contour interval : 100 m)

JICA/MMAJ/SOPAC ATLAS 1995. Surveyed by DORD

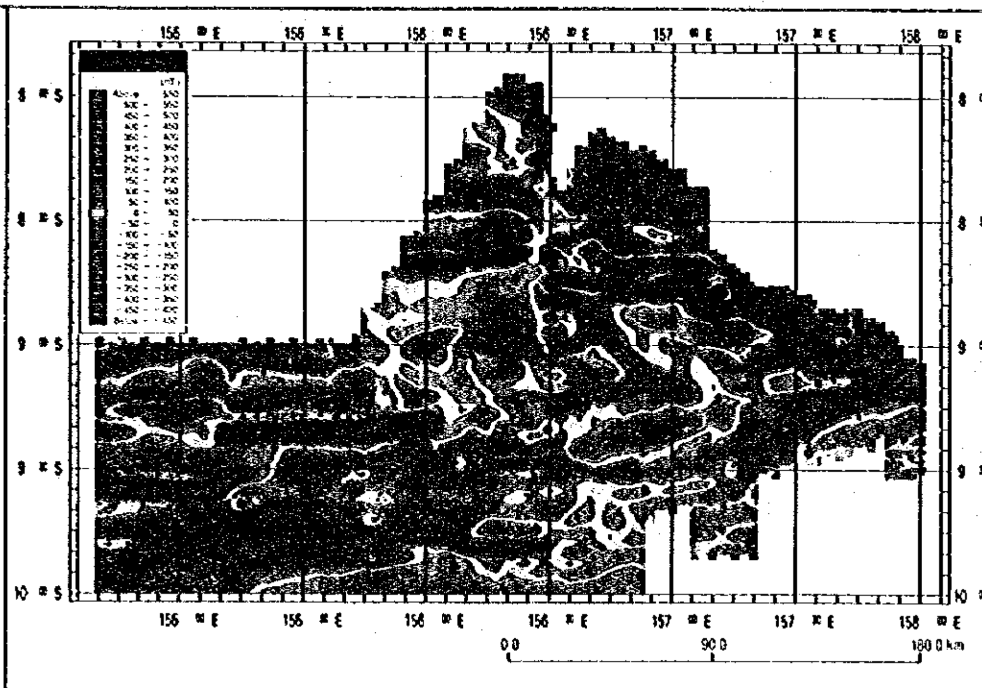
South Pacific Seafloor Atlas, Sheet no.10

The Woodlark Basin
Solomon Islands and Papua New Guinea

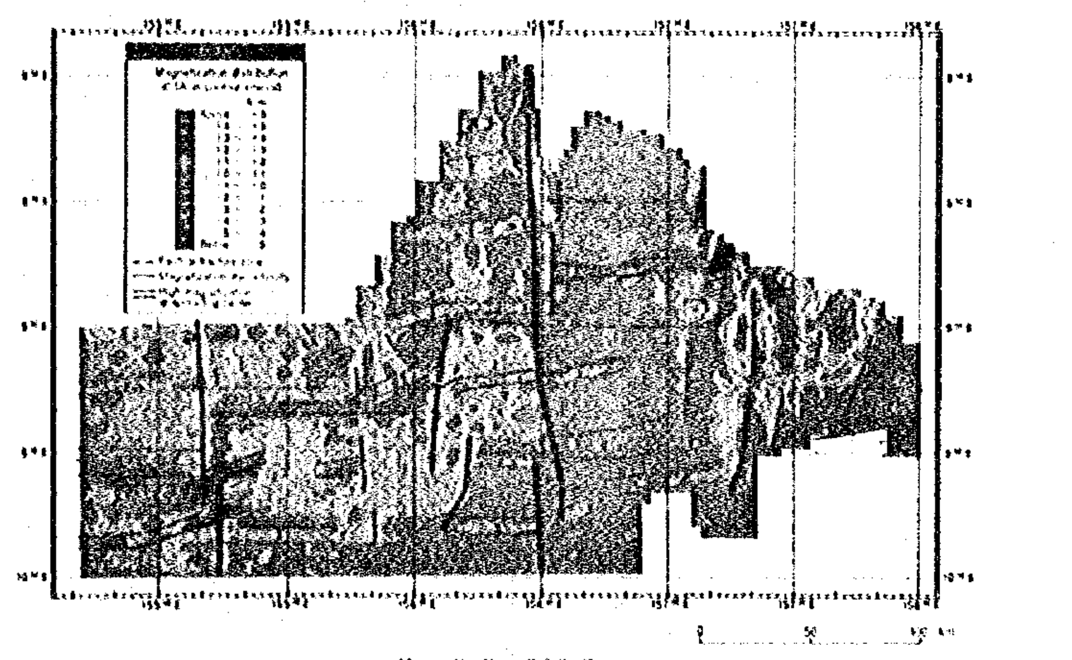
The Survey of Seafloor Hydrothermal Ore Deposits (1993)



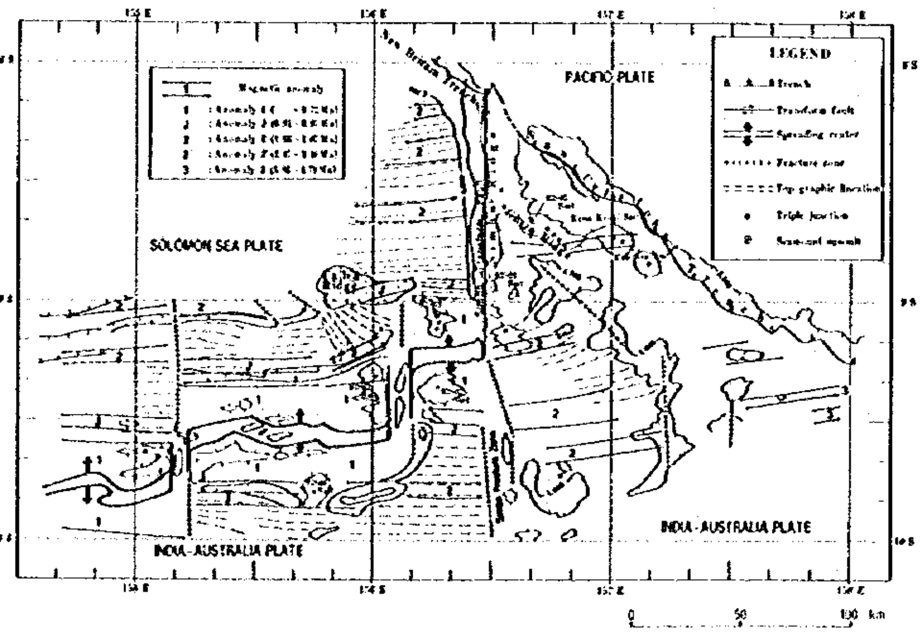
Color-coded bathymetric contour map based on MBES (contour interval: 100 m)



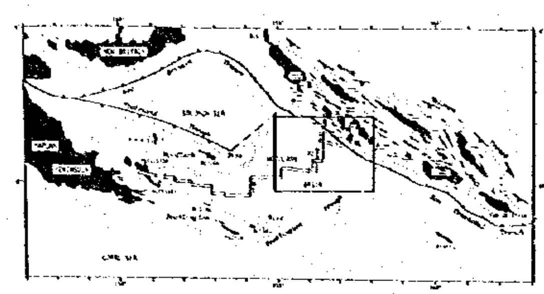
Magnetic anomaly map (contour interval: 50 nT)



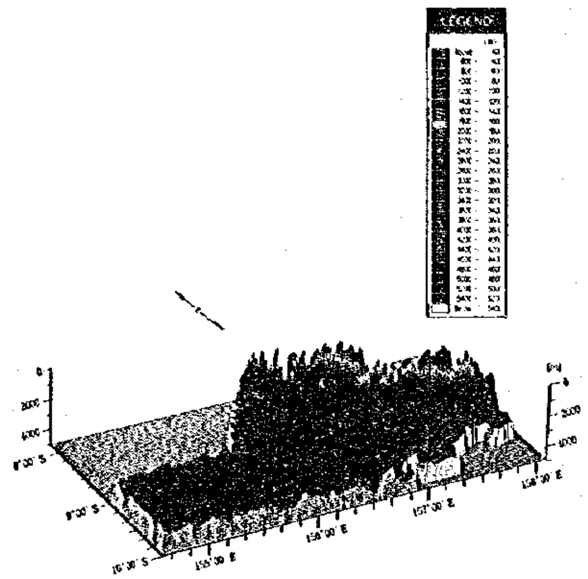
Magnetization distribution map



Interpretative geological structure map



Location map of the survey area (after Taylor, 1987). [ ]: survey site.



Bird's-eye view

According to Taylor (1987), seafloor spreading in the easternmost Woodlark Basin began prior to 5 Ma and propagated progressively westward toward the Papuan Peninsula, splitting formerly continuous Woodlark and Pocklington Rise. Magnetic lineations identify a symmetrical spreading history in the eastern basin, except for the spreading center jumps to south in the past. The total opening rates have varied spatially and temporally between 36 and 77 mm/yr.

The survey area (the East Woodlark Basin) is divided into eastern and western parts by the Simbo Transform Fault and Fracture Zone running through its middle area from north to south.

West of the Simbo Fracture Zone, is characterized by a presence of the active spreading center, which is east-west trending rift valleys (about 4 km deep, 5 ~ 10 km wide) and by the north-south trending transform fault, which is also valleys (locally over 4 km deep). Equivalently, magnetic lineations are arrayed symmetrically both sides of the seafloor spreading center in chronological order except the spreading center jumps occurred. These lineations identify anomaly 1, anomaly J, anomaly 2 and anomaly 2' in this region.

Topographically, west of the Simbo Fracture Zone is characterized by a family of rift valley-parallel horst and graben-like structure.

East of the Simbo Fracture Zone, is characterized by the absence of the spreading center, which is presumably already subducted beneath the Solomon Island (Taylor, 1987). It is easily understood from the fact that magnetic lineations are not arrayed symmetrically, i.e. anomaly 2, anomaly 2' and anomaly 3 are found there but no anomaly J. These anomalies, which display east-west trending lineations are broken into small belts by several north-south trending transform faults and are shifted to north and south. There is an E-W trend lineation with positive magnetization on the southside of the Ghizo Ridge. This lineation is enough to be envisioned the reactivated ocean-basic zone.

Topographically, east of the Simbo Fracture Zone is characterized by shallow trench, the N-S trending Simbo Ridge and E-W trending Ghizo Ridge, the Kana Keoki and Coleman Seamounts (stratovolcano), several N-S trending short depression (about 4,700 m deep) and curvilinear horst and graben-like structures started from Simbo Fracture Zone.

Reference

Taylor, B., 1987: A geophysical survey of the Woodlark-Solomons region. Circum-Pacific Council for Energy and Mineral Resources, Earth Sci. Ser. 7, 25-48.

The Woodlark Basin
Solomon Islands

Regional Survey of Hydrothermal Ore Deposits (1993)

Through the regional geochemical prospecting carried out at 24 points over Area 1 in a 21 mile grid, seafloor sediments were collected from 21 points. Multivariate statistics was conducted simultaneously with the chemical analysis.

(With regard to Muddy Substances)

The muddy substances of this survey area are composed of clastic minerals forming basic or intermediate igneous rocks, and organic fossils mainly composed of foraminifera. They have sedimented at the rate of more than 2 ~ 3 mm/1,000 years. Only a trace of clay minerals are contained in the muddy substances, and it is presumed that these clay minerals were generated from clastic mafic minerals through alteration, and the possibility of being the products of hydrothermal activities or diagenesis is low.

The color tones of the muddy substances can be classified into the brown series and olive series. Nearly always the former exists on the upper position of the latter. From the chemical composition, we can presume that the former is a sample under an oxidized environment and rich in foraminiferous fossils, and the latter is a sample in a reducing environment and rich in clastic minerals.

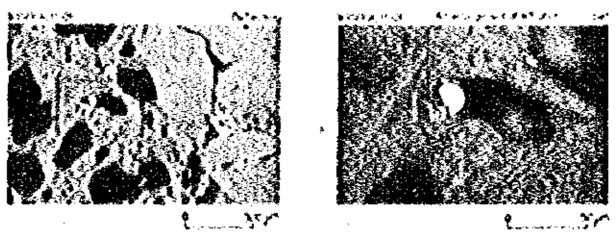
Samples abundantly rich in foraminiferous fossils are identified in the southeastern half of the survey area and samples abundantly rich in clastic minerals are identified in the northwestern half of the survey area.

(Multivariate Analysis)

On the first principal component, SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, Na_2O, Ni, Co, P, Cr and V control its factor positively and CaO, CO_2, LOI and Sr control it negatively. From the combination of these components and elements, this principal component is presumed to expressing the amount of clastic minerals in the positive direction and the amount of foraminiferous fossils in the negative direction.

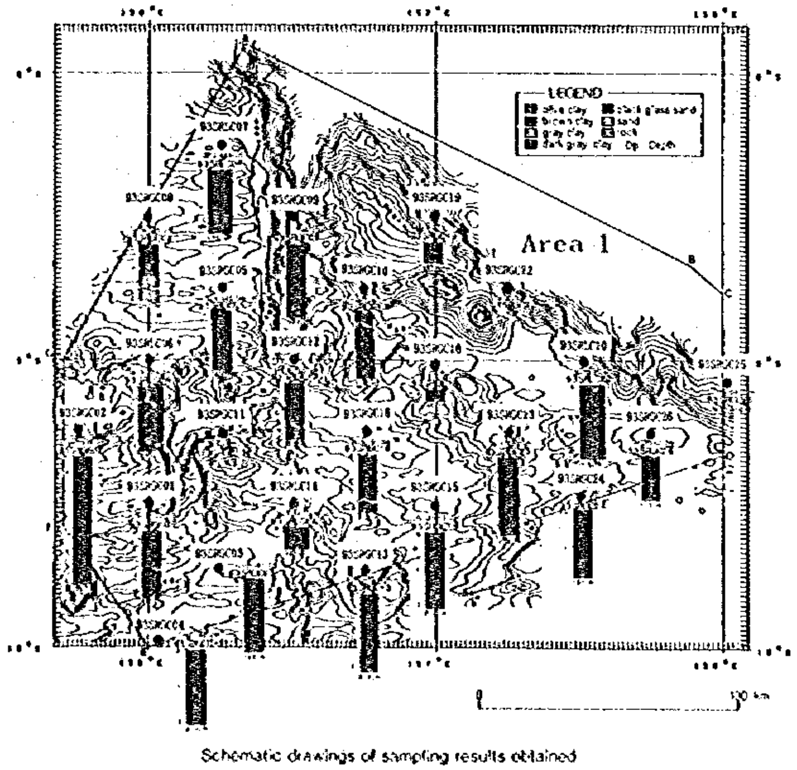
On the second principal component, Cu, Pb, Zn, As, Ba, SO_4, B and Li control its factor positively but factors controlling it negatively are weak. Cu, Pb and Zn are the principal ore elements produced by the already known submarine hydrothermal activities. As and Ba are also the elements showing high abnormality in hot spring activities. B and Li are also the elements contained more abundantly in hydrothermal solution erupted from the seafloor than in sea water. Accordingly, this principal component is presumed as indicating a seafloor hydrothermal activity in the positive direction.

It is considered that the parameters indicating hydrothermal ore deposits in the muddy substances are shown by the values of Al/(Al+Fe+Mn) and the second principal component from the principal component analysis. Anomalous values of them are always appeared in the vicinity of the south-eastern tip of the survey area.



Microscopic photos of olivine basalt on regional survey

Abbreviation
Py: Pyrite Sp: Spinel Ol: Olivine



Schematic drawings of sampling results obtained from regional geochemical survey

Mean, standard deviation, minimum and maximum of chemical component in sediments

Entire population

Component	Geometric mean	σ*1	Minimum	Maximum	Unit
SiO_2	33.458	1.328	17.18	42.40	%
TiO_2	0.413	1.318	0.22	0.79	%
Al_2O_3	10.356	1.361	1.64	16.54	%
Fe_2O_3	2.475	1.275	1.26	6.84	%
FeO	1.052	1.962	0.13	4.19	%
MnO	0.154	1.768	0.06	1.40	%
MgO	2.674	1.281	1.15	5.56	%
CaO	19.362	1.481	6.15	35.75	%
BaO	0.0415	1.0643	0.013	0.074	%
Na_2O	3.152	1.165	2.19	4.56	%
K_2O	1.061	1.361	0.45	2.56	%
P_2O_5	0.143	1.225	0.08	0.37	%
CO_2	10.43	2.72	0.1	27.1	%
LOI	19.543	1.726	2.32	33.29	%
Ag	0.026	1.092	0.01	0.22	ppm
Cu	64.49	1.38	24.0	130.5	ppm
Pb	5.93	1.45	0.5	15.5	ppm
Zn	82.3	1.2	37	130	ppm
Mn	1172.6	1.8	470	2600	ppm
S	0.0405	1.3664	0.025	0.451	%
Cd	0.08	1.50	0.05	0.5	ppm
Ni	34.7	1.4	[illegible]	108	ppm
Co	15.8	1.4	4	30	ppm
As	2.15	1.69	0.1	15.0	ppm
Sb	0.11	1.46	0.1	1.0	ppm
Hg	65.9	1.4	40	170	ppb
Ba	315.2	1.4	130	670	ppm
Sr	701.8	1.2	270	1920	ppm
Cl	15151.0	1.4	1650	29070	ppm
P	520.2	1.2	470	1160	ppm
SO_4	0.1263	1.7605	0.005	0.426	%
Cr	53.1	1.4	10	132	ppm
V	136.4	1.4	60	340	ppm
Tl	0.35	1.08	0.25	2.0	ppm
B	31.6	1.5	5	55	ppm
Li	12.1	1.4	8	25	ppm
Rb	13.1	1.6	1.5	50	ppm
U	0.45	1.93	0.1	2.0	ppm

*1 log(σ) is standard deviation of log(X), where X is concentration of each component.

Result of t-test

	Arithmetic Mean (M) and Standard Deviation (σ): Brown M (σ)	Olive M (σ)	Result of t-test (2-tail)
$logSiO_2$	1.4920(.122)	1.5751(.034)	**
$logTiO_2$	-.3760(.115)	-.3276(.115)	=
$logAl_2O_3$	.9851(.142)	1.0614(.048)	**
$logFe_2O_3$	.3918(.100)	.3695(.124)	=
logFeO	-.0519(.251)	.3549(.392)	**
logMnO	-.7200(.236)	-.9409(.116)	**
logMgO	.4051(.120)	.4187(.143)	=
logCaO	1.3252(.132)	1.2160(.171)	**
logBaO	-1.3718(.116)	-1.3968(.151)	=
$logNa_2O$	.4930(.025)	.5240(.026)	**
$logK_2O$	-.0060(.125)	.1950(.128)	**
$logP_2O_5$	-.7421(.117)	-.7168(.116)	=
$logCO_2$	1.1039(.267)	.9560(.295)	**
logLOI	1.3219(.164)	1.2210(.177)	**
logAg	-1.9060(.120)	-1.4953(.339)	**
logCu	1.8190(.101)	1.8024(.162)	=
logPb	.8255(.163)	.7170(.212)	**
logZn	1.7227(.105)	1.7340(.129)	=
logMn	3.1335(.249)	2.8707(.119)	**
logS	-1.1156(.137)	-1.1778(.138)	=
logCd	-1.0649(.152)	-1.0429(.206)	=
logNi	1.5189(.141)	1.5439(.361)	=
logCo	1.2029(.122)	1.1661(.177)	=
logAs	.3700(.172)	.4058(.182)	**
logSb	-.9615(.154)	-.9220(.290)	=
logHg	1.8159(.114)	1.8298(.157)	**
logBa	2.5411(.112)	2.5709(.163)	=
logSr	2.9713(.080)	2.8191(.092)	**
logCl	4.2829(.123)	4.2520(.119)	=
logP	2.8076(.080)	2.9251(.167)	=
$logSO_4$	-.8745(.426)	-.8977(.400)	=
logCr	1.7129(.137)	1.7169(.150)	=
logV	2.1090(.133)	2.1566(.140)	=
logTl	-.4058(.300)	-.3995(.215)	*
logB	1.5167(.132)	1.5158(.109)	=
logLi	1.0780(.125)	1.0767(.115)	**
logRb	1.1631(.198)	1.2569(.170)	*
logU	-.3406(.290)	-.3522(.366)	*

* 2-tail prob. < 0.05 ** 2-tail prob. < 0.01

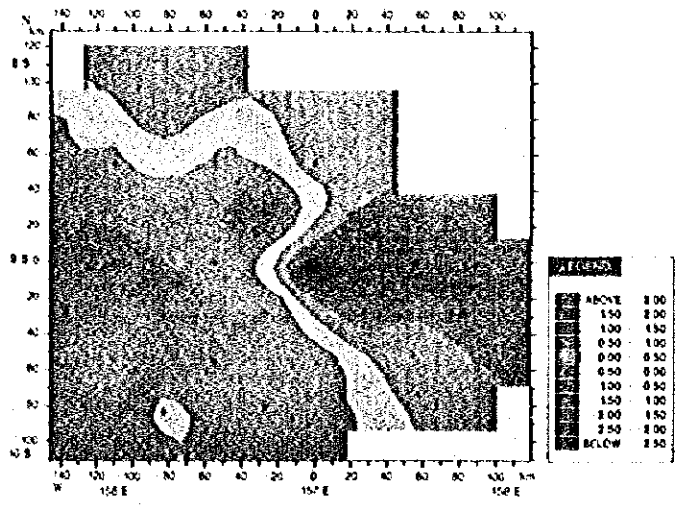
Factor loading pattern

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
$logSiO_2$	[.87161]	-.12400	.39953	.02753	-.12131	-.06244
$logTiO_2$	[.95136]	.12562	-.13735	-.02791	-.03224	.11525
$logAl_2O_3$	[.87657]	-.02562	.21083	.01373	-.06718	.00062
$logFe_2O_3$	.66494	.35545	-.24201	-.21497	.06713	-.06928
logFeO	[.77242]	-.34089	.02779	.26314	.14094	.28545
logMgO	[.93516]	-.09761	-.17439	.08534	.11342	.06497
logCaO	[-.91358]	.10417	-.27776	-.06796	.08274	.06136
$logNa_2O$	.62182	.35544	.47147	.01735	.01695	-.05741
$logK_2O$	.39919	.13534	.05334	-.11191	-.09670	.08579
$logP_2O_5$	.68922	-.11153	.31016	-.32367	.53905	-.21175
$logCO_2$	[-.86829]	.31536	-.03677	-.13652	.07319	.13070
logLOI	[-.87781]	.16962	-.02423	-.04264	.12547	.11755
logCu	.45336	.55410	-.30125	-.04509	.08169	.22579
logPb	-.30619	[.75305]	.06049	-.13272	-.05298	-.06918
logZn	.25694	[.86098]	-.13675	-.07790	-.03123	.24036
logMn	.42965	.37153	-.35527	-.30452	-.34004	-.26153
logS	-.16190	.42106	-.13550	.56710	.25232	-.22913
logNi	.55040	.54719	-.18529	.12537	-.09668	-.90019
logCo	.65429	.29707	-.39184	-.01925	-.08675	.00422
logAs	-.07510	[.76099]	-.12224	-.11062	.25621	-.21363
logHg	-.06736	.42307	.17536	.52434	.30292	-.00954
logBa	-.26651	[.70750]	.32216	.07528	-.29664	-.32911
logSr	[-.83789]	.32743	-.04012	-.24421	.10312	.22583
logP	.63294	.22240	.01626	-.34345	.01490	.19900
$logSO_4$	-.25576	.49156	-.16597	.45917	-.01992	.26136
logCr	.65551	.14545	-.29571	.16739	.01929	-.30035
logV	[.91773]	-.07361	-.30016	.07597	.09794	.06420
logB	-.31740	.59911	.34452	-.16274	.39747	-.03142
logLi	.06496	[.84136]	.31554	.10029	-.07291	.15126
logRb	.45574	.36320	.32540	-.22634	-.34550	.01337
logU	.04254	.32658	.45365	.35306	.41862	-.19158
Eigenvalue	11.3257	6.3605	3.4578	1.6041	1.1767	.9496
Pct of Var	37.8	20.3	11.2	5.3	3.8	3.0
Cumulative Pct of Var	37.8	58.1	69.4	74.9	78.7	81.8

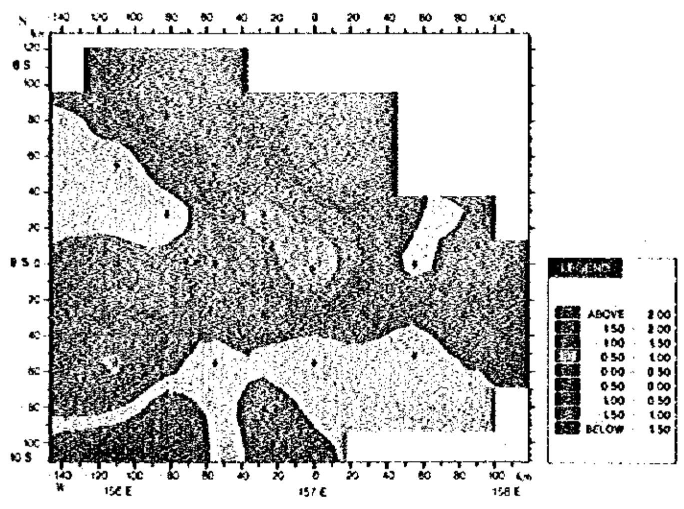
[ ]: factor loading > 0.7 or < -0.7

PC: Principal component; Pct of Var: Percent of variability explained

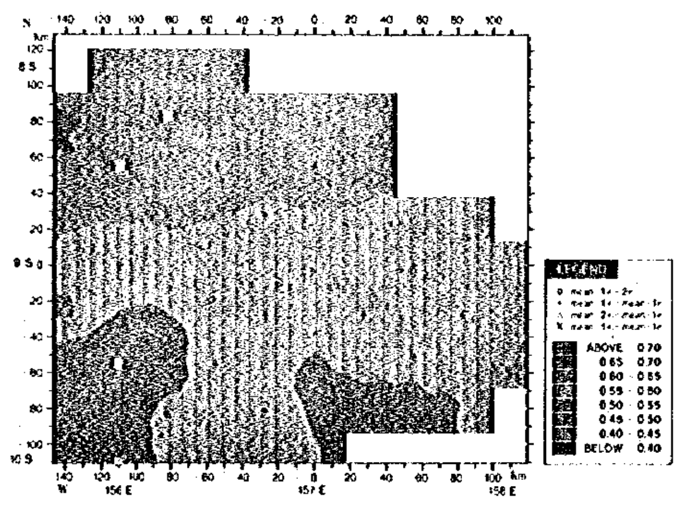
Matrix analyzed by the statistics was correlation matrix of the following components: SiO_2 - LOI (log %), Ag - As & Ba - U (log ppm), Hg (log ppb).



Distribution of the factor score of principal component 1



Distribution of the factor score of principal component 2



Distribution of Al/(Al+Fe+Mn)