4) Chemical Properties

Analysis was performed on board for 5 principal components of the samples obtained by the 32 dredge samplings. These were selected among the 48 dredge samplings performed in 5 seamounts, excluding those which failed to obtain sample, those which brought only rock, and those which failed to scrape up sample because of too thin crust. The number of analysed samples totaled 98, whereas the number of analysis totaled 125. For the analysis, fluorescent X-ray system was used. Obtained data are given in the tables at the end of this report. The average are given in Tab. 4-3-6. Grade comparison among topographic parts of the seamount is given in Tab. 4-3-7. Grade comparison among different surface appearance of crust is given in Tab. 4-3-8. Grade comparison among different substrate of crust is given in Tab. 4-3-9. Grade comparison among different parts of crust is given in Tab. 4-3-10.

Table 4-3-6 Average Grade of Cobalt Crust at Each Seamount

	SA01	SA02	SA03	SA04	SA05	Total
Number of stations Number of samples	(n=10) (n=34)	(n=1)※1 (n=1)	(n=10) (n=30)	(n= 8) (n=24)	(n=4) (n=9)	(n=33) (n=98)
Co	0.79±0.12 1.01	0.36±0	0.78±0.33 1.38	0.71±0.13 0.86	1.05±0.39 1.38	0.78±0.26 1.38
Ni	0.67±0.17 0.92	0.47±0	0.70±0.24 1.07	0.68±0.24 1.01	0.57±0.19 0.71	0.66±0.21 1.07
Cu	0.13±0.03 0.20	0.12±0	0.10±0.03 0.15	0.09±0.03 0.13	0.07±0.03 0.10	0.11±0.04 0.20
Mn	27.42±2.31 30.71	10.51±0	23.57±6.34 28.76	26.09±2.87 29.05	27.12±5.63 30.98	25.38±5.23 30.98
Fe	15.67±2.51 19.00	12.58±0	12.66±3.29 17.18	14.96±2.95 18.92	15.58±2.15 18.60	14.48±2.91 19.00
Mn/Fe	1.75	0.84	1.86	1.74	1.74	1.75
Average thickness	1.7±1.0 *cm*	0.2±0	1.5±1.1	1.8±1.6	1.9±2.1	1.7±1.3
Average depth	2,490 *m*	2,460	2,170	2,100	1,930	2,250

※ Lower grade is caused by mixture of substrate.

Table 4-3-7 Cobalt Crust Grade and Topographic Position of Seamount

	(n)	Average thickness (cm)	Co (%)	Ni (%)	Cu (%)	Mn (%)	Fe (%)	Mn/Fe
Top	4	1.68	1.12	0.73	0.05	30.39	13.01	2.34
Top-margine	13	2.06	0.87	0.82	0.12	27.93	13.54	2.06
Upper slope	6	1.75	1.08	0.66	0.06	26.56	13.74	1.93
Middle slope	29	1.78	0.71	0.59	0.11	24.68	15.87	1.55
Lower slope	7	1.27	0.68	0.49	0.14	24.21	17.90	1.35

Table 4-3-8 Cobalt Crust Grade and Surface Structure

	(n)	Average thickness (cm)	Co (%)	Ni (%)	Cu (%)	Mn (%)	Fe (%)	Mn/Fe
Botryoidal	27	2.44	0.85	0.69	0.10	27.55	15.06	1.83
Coarse	14	1.09	0.72	0.57	0.11	23.20	16.10	1.44
Smooth	16	1.31	0.86	0.64	0.10	26.39	15.12	1.75

Table 4-3-9 Cobalt Crust Grade and Substrates

	(n)	Average thickness (cm)	Co (%)	Ni (%)	Cu (%)	Mn (%)	Fe (%)	Mn/Fe
Basalt	36	1.72	0.79	0.61	0.10	25.51	15.35	1.66
Clastic rocks	6	1.30	1.00	1.00	0.12	32.46	12.93	2.51
Phospho-rite	8	1.75	0.91	0.68	0.11	26.58	15.32	1.73
Limestone	3	0.93	0.78	0.77	0.10	21.19	10.75	1.97

Table 4-3-10 Grade of Cobalt Crust

			Co (%)	Ni (%)	Cu (%)	Mn (%)	Fe (%)	Mn/Fe
Whole Average								
Upper surface	Outer layer	n=16	1.00	0.74	0.07	30.31	14.82	2.05
	Middle layer	n=5	0.92	0.74	0.10	29.67	14.27	2.08
	Lower layer	n=14	0.79	0.80	0.10	26.67	11.26	2.37
Lower surface		n=4	0.87	0.76	0.09	27.44	13.27	2.07
Individual Samples	SA01 AD12 (A)	Outer	1.01	0.67	0.07	28.73	16.54	1.74
		Middle	0.95	0.83	0.10	30.03	13.59	2.21
		Inner	0.93	0.78	0.10	29.58	14.13	2.09
	SA03 AD01 (A)	Outer	1.07	0.81	0.06	31.39	14.28	2.20
		Inner	0.92	0.89	0.08	30.68	12.19	2.52
	SA03 AD02 (C)	Outer	1.54	0.75	0.05	32.19	13.45	2.39
		Inner	1.11	0.86	0.06	29.97	10.59	2.83
	SA03 CB12 (A)	Outer	0.83	0.67	0.09	29.06	16.04	1.06
		Inner	0.77	0.73	0.11	27.52	14.20	1.94
	SA04 AD02 (A)	Outer	1.37	0.84	0.05	33.16	13.39	2.48
		Inner	0.51	0.90	0.07	23.40	8.05	2.91
	SA04 AD06 (A)	Outer	0.96	0.69	0.04	30.00	14.01	2.14
		Inner	0.85	0.85	0.04	27.77	9.36	2.97
	SA05 AD06 (B)	Outer	1.00	0.82	0.06	32.72	13.84	2.36
		Inner	0.92	0.77	0.06	27.32	11.24	2.43

Table 4-3-11 Analysis of Total and Minor Element from Different Layer of Cobalt Crust

Sample No.		87SA01 CB03(D)	87SA01AD12(A)			S7SA03AD01(B)		S87SA04AD06(A)	
Location		Mid. Slope	Crest	Crest	Crest	Upper Slope	Upper Slope	Crest	Crest
Water Depth (m)		3,000	1,960	1,960	1,960	1,700	1,700	1,200	1,200
Morphology		Cobble	Crust	Crust	Crust	Crust	Crust	Crust	Crust
Analized Portion		Bulk	Outer	Middle	Inner	Outer	Inner	Outer	Inner
Thickness		3 cm	2 cm	2 cm	2 cm	1.5 cm	3.5 cm	1 cm	1.5 cm
Major Metal Contents (%)	Co	0.72	1.01	0.95	0.93	0.92	0.41	0.96	0.85
	Ni	0.57	0.67	0.83	0.78	0.89	0.85	0.69	0.85
	Cu	0.13	0.07	0.10	0.10	0.08	0.09	0.04	0.04
	Mn	24.10	28.73	30.03	29.58	30.68	21.96	30.00	27.77
	Fe	16.19	16.54	13.59	14.13	12.19	7.58	14.01	9.36
Major Chemical Composition (%)	SiO_2	6.99	5.18	4.52	3.20	3.61	1.46	2.74	1.47
	TiO_2	1.74	3.16	1.71	1.85	1.61	1.02	1.31	1.21
	Al_2O_3	1.35	0.90	0.92	0.70	0.54	0.31	0.46	0.25
	Fe_2O_3	22.06	21.42	18.13	15.28	17.86	9.42	18.66	11.69
	FeO	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	MnO_2	30.15	28.33	32.94	29.66	34.49	30.95	33.84	36.28
	MgO	1.81	1.82	1.96	1.77	1.91	1.77	1.87	2.02
	CaO	3.25	3.25	3.27	9.61	3.35	15.49	3.50	7.12
	BaO	0.19	0.16	0.22	0.25	0.21	0.26	0.21	0.27
	Na_2O	2.17	2.11	2.30	2.02	2.21	1.99	2.04	2.08
	K_2O	0.54	0.48	0.58	0.51	0.54	0.54	0.50	0.62
	P_2O_5	0.81	0.98	0.65	4.79	0.69	8.75	0.97	3.25
	LOI	21.08	24.25	23.83	20.99	23.56	19.61	24.15	22.36
	Total	92.15	92.05	91.04	90.64	90.59	91.58	90.26	88.63
Minor Elements (%)	Pb	0.109	0.139	0.137	0.127	0.148	0.124	0.203	0.183
	Zn	0.069	0.067	0.078	0.082	0.080	0.105	0.070	0.110
	Sr	0.157	0.167	0.164	0.181	0.170	0.169	0.187	0.178
	V	0.024	0.018	0.017	0.014	0.017	0.009	0.032	0.010
	Mo	0.044	0.049	0.054	0.054	0.066	0.061	0.078	0.093
	B	0.014	0.014	0.012	0.010	0.012	0.006	0.012	0.008
	As	0.020	0.024	0.020	0.019	0.021	0.011	0.026	0.017
	Y	0.017	0.017	0.012	0.021	0.011	0.022	0.012	0.031
	Zr	0.063	0.053	0.013	0.015	0.022	0.010	0.033	0.018
	Pt	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Σ ReO	0.189	0.154	0.141	0.218	0.141	0.229	0.153	0.274

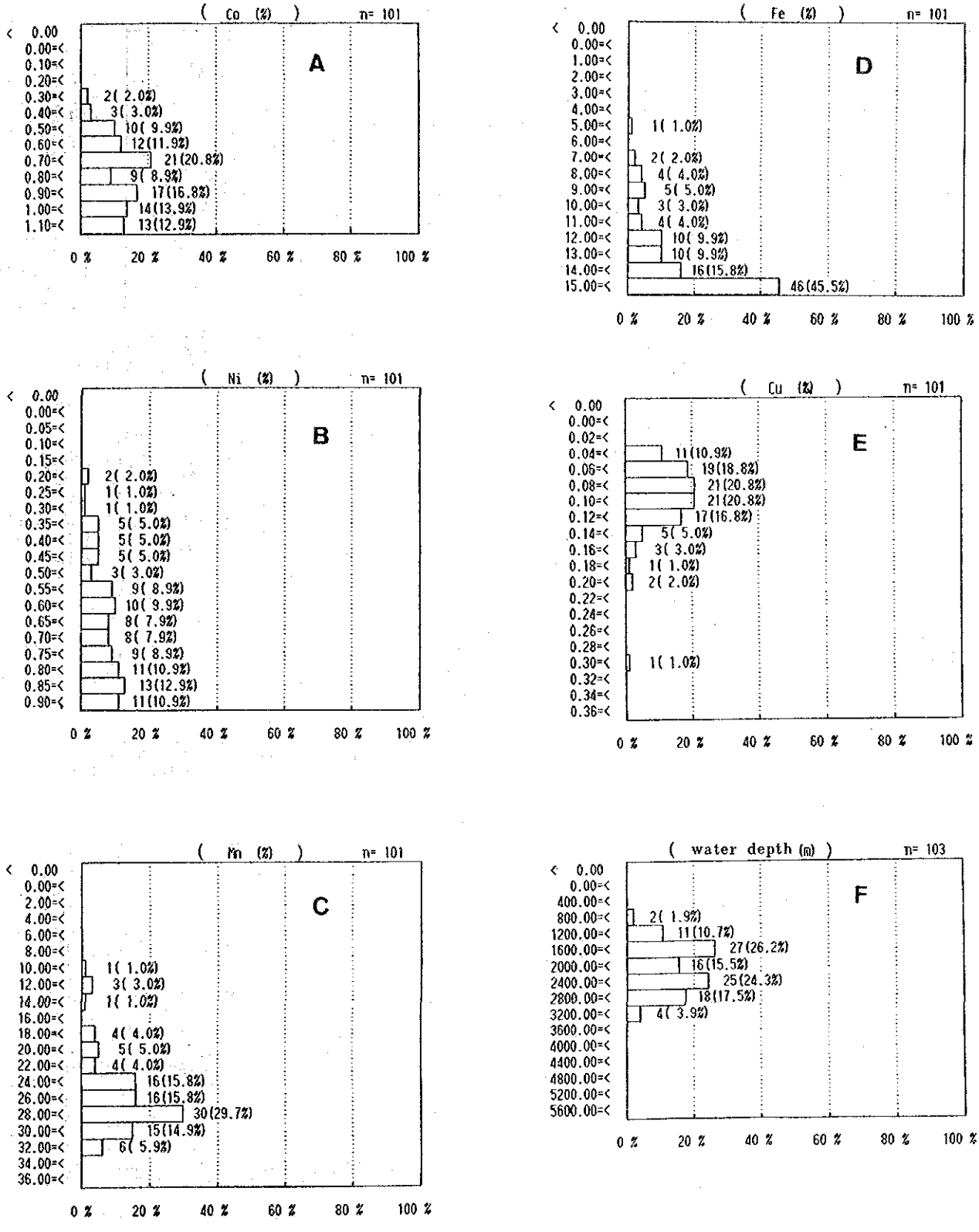


Fig. 4-3-6 Frequency Distribution of Major Five Chemical Components

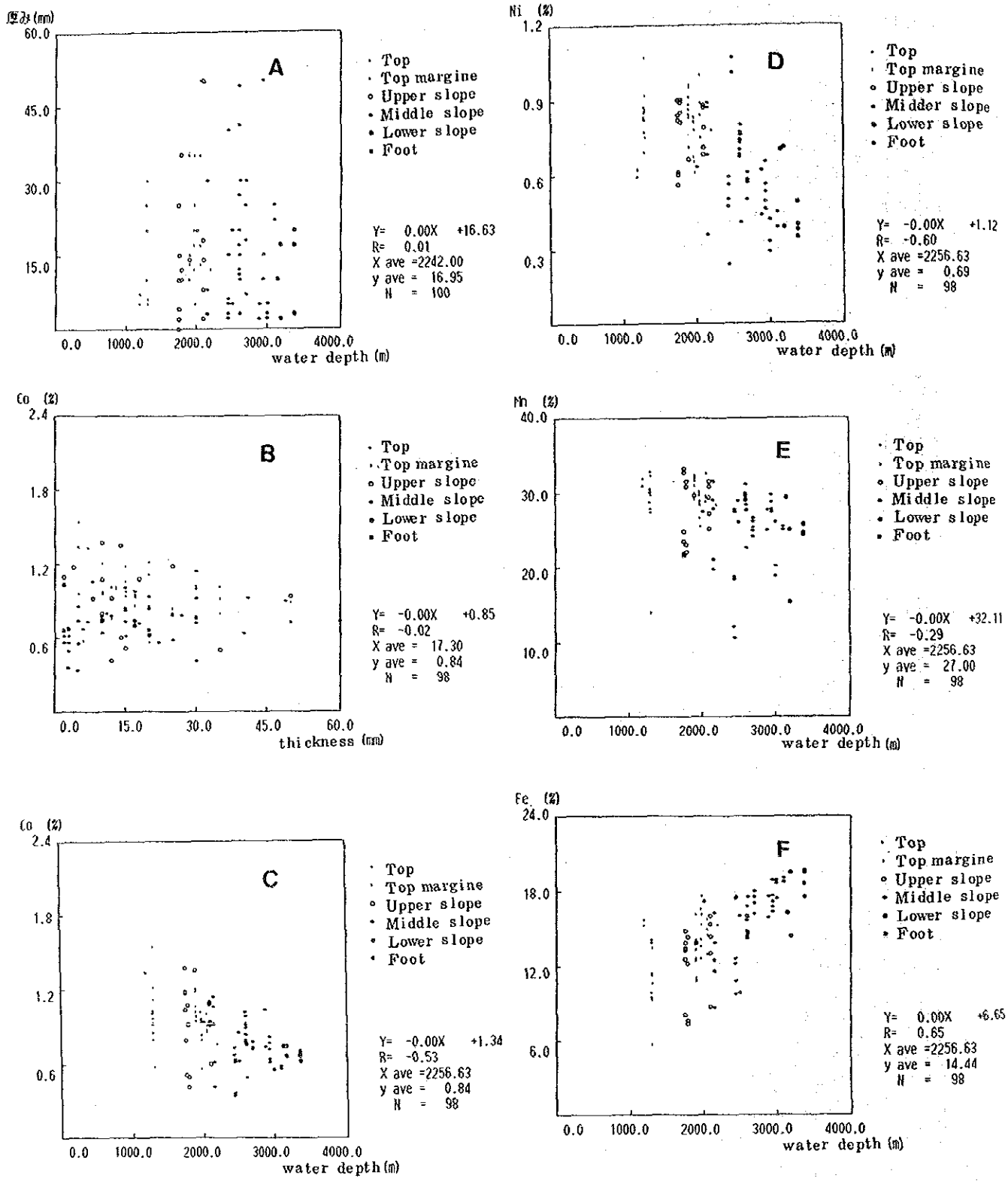


Fig. 4-3-7 Correlative Diagram among Major Chemical Components (1)

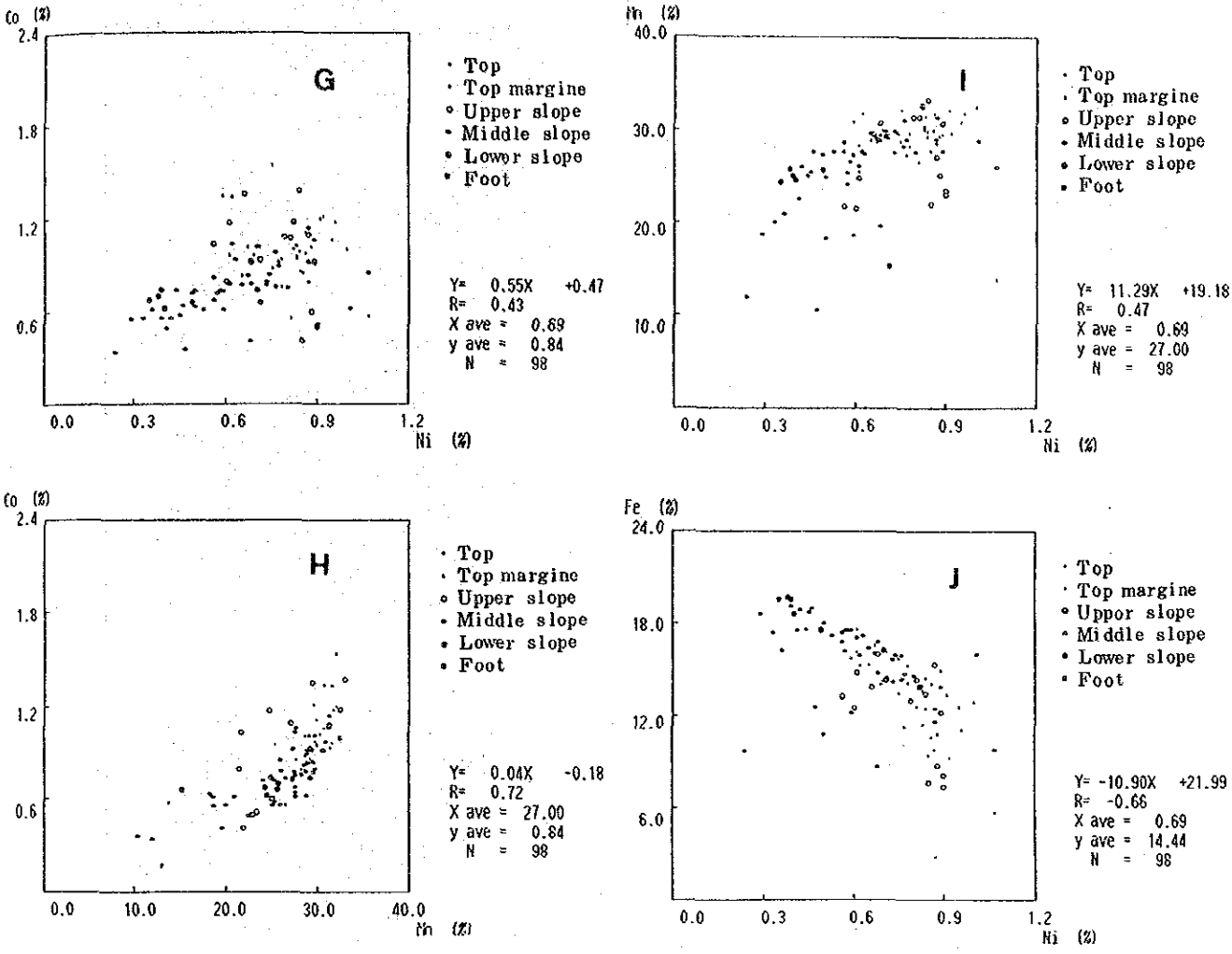


Fig. 4-3-7 Correlative Diagram among Major Chemical Components (2)

Results of total analysis as well as minor element analysis according to the parts of crust are given in Tab. 4-3-11. Furthermore, frequency distribution of 5 principal components (Co, Ni, Cu, Mn, Fe) is given in Fig. 4-3-6. Fig. 4-3-7 and Tab. 4-3-12 show correlation among chemical components, and also relation between each component and crust thickness etc. Photos of samples which were analysed according to their parts are given in Fig. 4-3-8. Based on the above-mentioned data the grade properties of the cobalt crust spread over this area are summarised as follows;

Table 4-3-12 Mutual Relations among Major Chemical Composition of Cobalt Crust

	Water depth	Crust thickness	Co	Ni	Cu	Mn	Fe
Water depth	—	× 0.01	◎ -0.53	◎ -0.60	◎ 0.51	○ -0.29	◎ 0.65
Crust thickness			× -0.02	× 0.15	× 0.11	○ 0.22	× -0.07
Co				◎ 0.43	○ -0.36	◉ 0.72	× -0.07
Ni					× 0.03	◎ 0.47	◎ -0.66
Cu						○ 0.26	× 0.10
Mn							× 0.12
Fe							—

- Numbers are correlation coefficient.
- Strength of relation , ◉ : strong , ◎ : moderate , ○ : weak , × : no relation

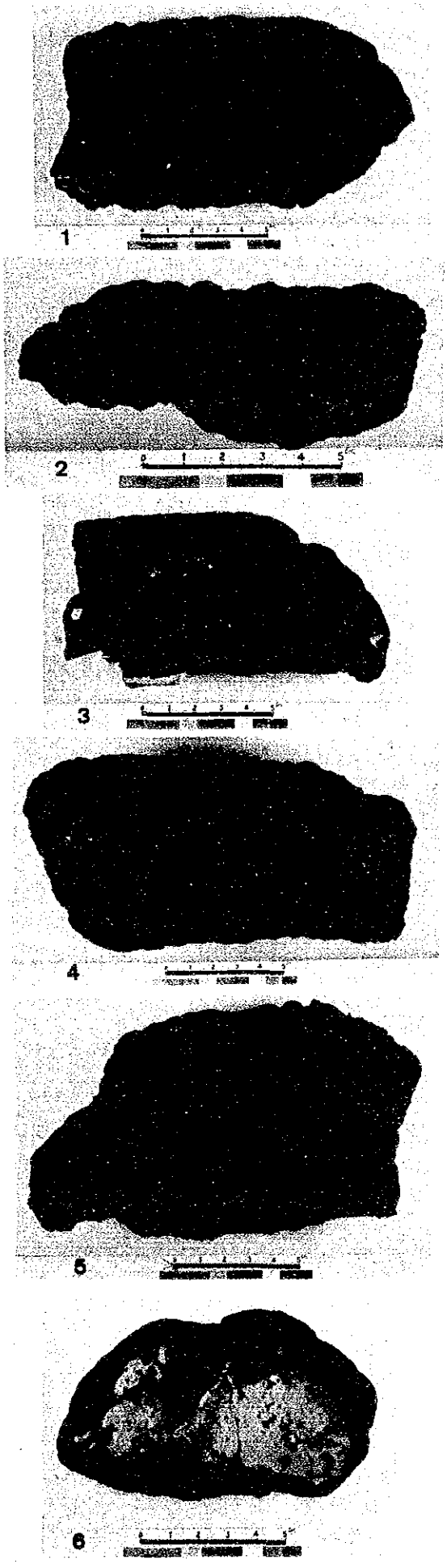
a) Average grade of all 32 observation stations is; Co 0.78%, Ni 0.66% Cu 0.11%, Mn 25.38%, Fe 14.48%, and Mn/Fe ratio 1.75.

b) For your information, average value of all the 98 samples is; Co 0.84%, Ni 0.68%, Cu 0.10%, Mn 27.00%, Fe 14.44%, and Mn/Fe ratio 1.87.

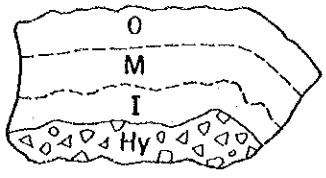
c) Average depth of 32 observation stations is around 2,250m.

d) Comparison of grades according to seamounts is as follows;

Co : SA05 > 01 > 03 > 04 > 02
Ni : SA03 > 04 > 01 > 05 > 02
Cu : SA01 > 03 > 04 > 05 > 02
Mn : SA01 > 05 > 03 > 04 > 02
Mn : SA01 > 05 > 04 > 03 > 02

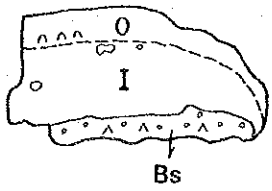


1) SA01AD12(A)

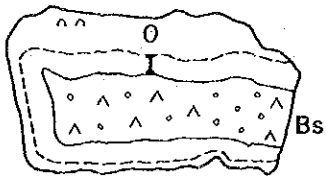


2) SA01AD12(B)

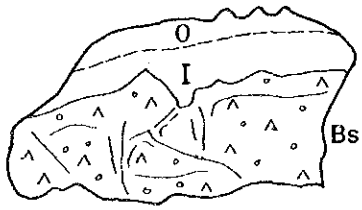
3) SA03AD01(B)



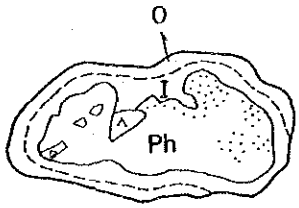
4) SA03CB12(C)



5) SA04AD06(A)



6) SA04AD07(C)



O : Upper
M : Middle
I : Lower

Bs : Basalt
Hy : Hyaloclastite
Ph : Phosphorite

Fig. 4-3-8 Crust Samples Used for Chemical and Mineralogical Analysis

Through this comparison, it can be pointed out that more Co in less deep SA05 (average depth 1,930m) and higher Cu and Fe in deeper SA01 (average depth 2,490m) are in accordance with the observation of correlation which will be discussed later, but no other remarkable tendency is observed.

e) As for the comparison of topographic parts, there is an apparent tendency that in the parts with less water depth such as top, margin and upper slope, grades of Co, Ni, and Mn show high value, whereas those of Cu and Fe low value. Especially, Mn and Fe show systematic change of value in one direction, which is emphasized by taking their ratio.

f) As for the comparison according to the surface appearance, no conspicuous tendency is observed.

g) As for the comparison according to substrate type, high values for Co, Ni and Mn as well as high Mn/Fe ratio are remarked, in hyaloclastite.

h) As for the comparison of the parts of crust, high values for Co, Mn, and Fe as well as low values for Cu and Ni are remarkable in the upper outercrust. In the case of three-layer structure, the above-mentioned tendency does not necessarily appear in one direction but in the double-layer structure the tendency is apparent in most cases.

i) As for the relative correlations, the depth is closely related to each components, but the thickness of crust has no relation to components. Among the components close relation is remarked between Co and Ni, Ni and Mn as well as Ni and Mn.

j) Table 4-3-13 shows the comparison of the average grades of crust in this survey area with those of other sea area or with statistic data obtained by other survey. In general, average of this area shows a value almost same to that of Pacific seamounts with a slight higher ratio of Mn/Fe and in accordance with this tendency, a slight higher value for Co and Ni. It appears that this tendency might be present in the results of De Carlo (1987) who surveyed the area including this area.

Table 4-3-13 Comparison of Cobalt Crust Compositions

	1	2	3	4	5
Element (Wt %)	This Work	Kiribati and Tuvalu Area	Hawaiian Islands Archipelago	Central Pacific Basin Seamounts	Pacific Seamount Average
	n=33 ※	n=50	n=32	n=26~46	n=251~803
Co	0.78	0.945	0.90	0.79	0.73
Ni	0.66	0.650	0.44	0.49	0.47
Cu	0.11	0.095	0.06	0.065	0.16
Mn	25.38	25.69	23.3	24.6	23.1
Fe	14.48	14.73	15.6	14.5	16.1
Mn/Fe	1.75	1.90	1.50	1.70	1.43
Average Depth (m)	2,256	2,189	1,546	2,179	.....

1. This work (1987)
2. De Carlo (1987)
3. De Carlo et.al., (1986)
4. Halbach and Manheim (1984)
5. Manheim (1986)

※ This number represents survey stations. Number of analized samples is 98.

5) Mineral Properties

X-ray diffraction analysis and analysis by reflecting microscope and by EPMA were performed in order to determine the mineral properties of the cobalt crust. The number of the analyzed samples is 5 for X-ray diffraction analysis (cf. Fig. 4-3-8), 2 for reflecting microscope and EPMA analysis (cf. Fig. 4-3-8, Fig. 4-2-1). Results are shown in Tab. 4-3-14, Fig. 4-3-9 (X-ray analysis), in Fig. 4-3-10 (reflecting microscope) and in Fig. 4-3-11 (EPMA analysis). Main observation made in these analyses are as follows;

Table 4-3-14 Mineral Assemblage of Cobalt Crust, by X-ray Diffraction Analysis

Sample No.	Morphology	Analized portion	Thick-ness (cm)	10Å	δ-Mn	Q	F-Ap	C-Ap	Others
87SA03AD01(B)	Crust	Outer Inner	1.5 3.5		◎ ◎			○	
87SA04AD06(A)	Crust	Outer Inner	1.0 1.5	○	◎			○	
87SA01AD12(B)	Slub	Outer Inner	1.5 1.2		◎ ◎	●?		○	
87SA03CB12(C)	Massive	Outer Middle Bottom	2.5 1.5 2.0		◎ ◎ ◎				
87SA04AD07(C)	Cobble	Outer Inner	0.7 0.7		◎ ◎		●	○	

Example: 10Å: 10Å Manganite, δ-Mn: δ-MnO_2, Q: Quartz
F-Ap: Fluorapatite, C-Ap: Carbonate-apatite

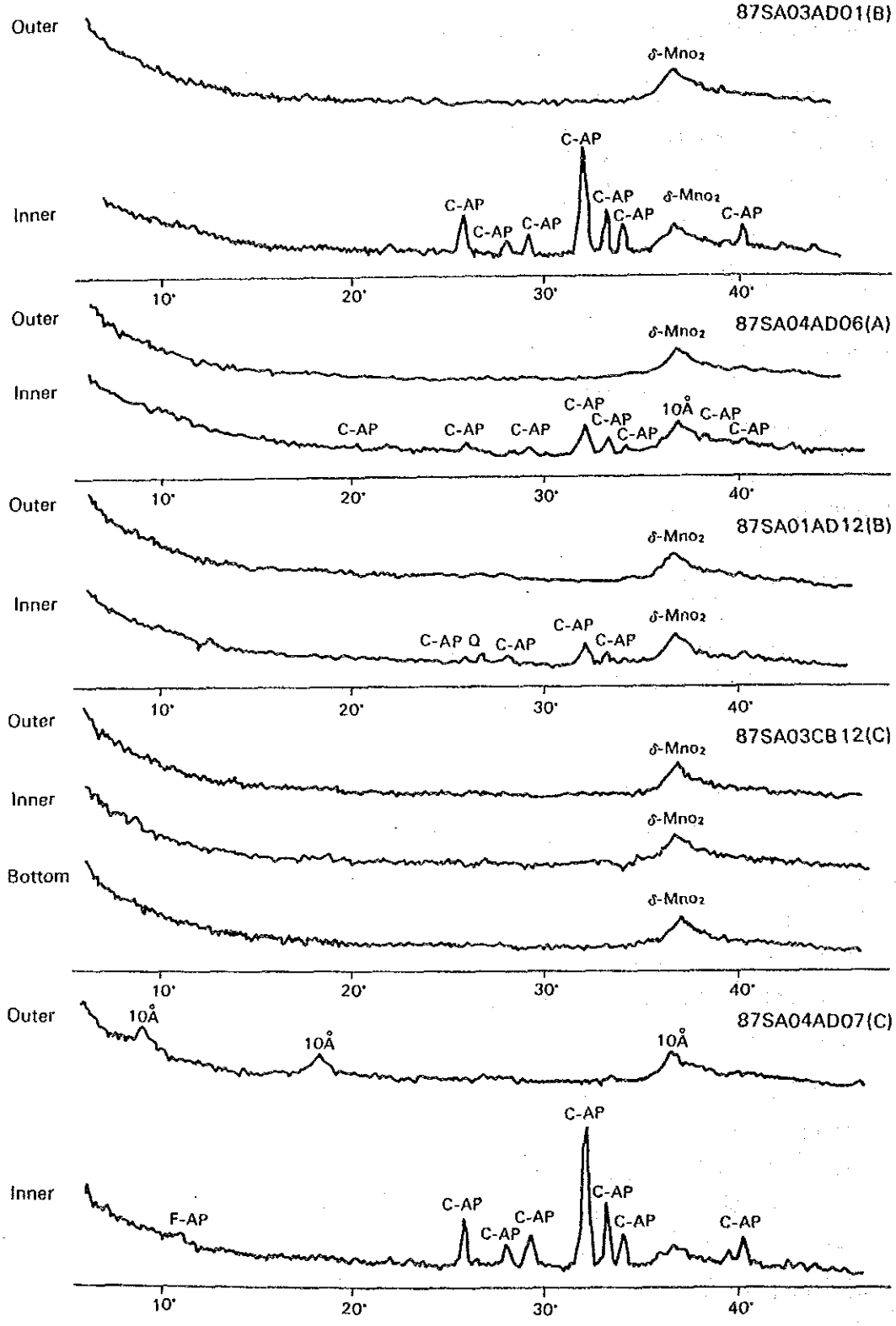
◎: Very high diffraction peaks ○: High diffraction peaks
●: Weak high diffraction peaks ?: Obscure or Uncertain

a) Manganese oxides, major component of the cobalt crusts, are δ - MnO_2 and accompanied by a very small amount of 10Å manganite.

b) As for the crust with double or triple-layer structure, its outer crust (upper layer) is composed of δ - MnO_2 for the most part, while its middle crust (middle layer) and inner crust (lower layer), although mainly composed of δ - MnO_2 contain 10Å manganite in such parts as where the growth banding is disturbed or along the cracks or where the development is discontinuous.

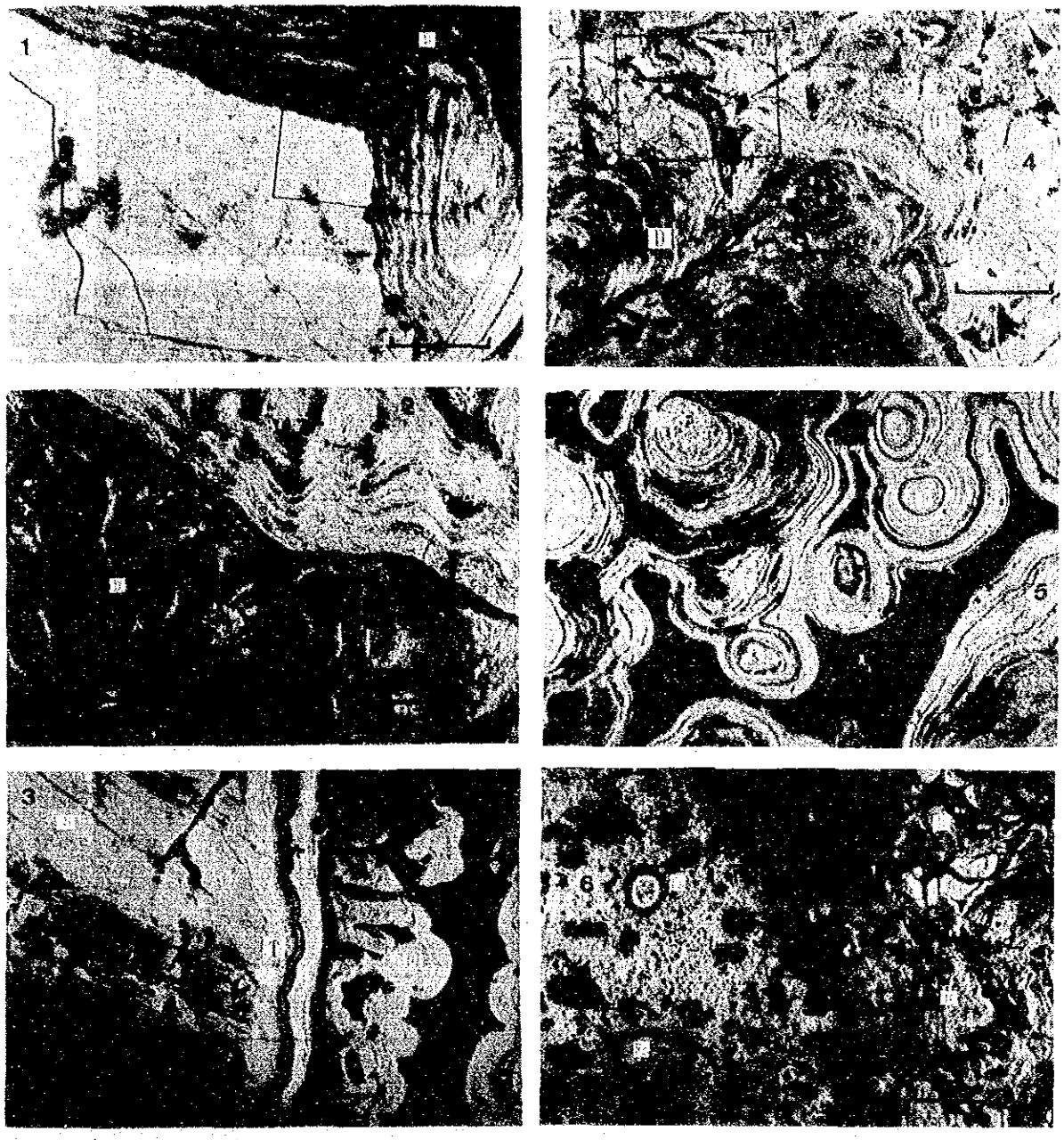
c) As for the features drawn by the observation by naked eyes, it is observed that the inner crust, which is highly glossy, black and dense, is composed of dense δ - MnO_2 with relatively high reflective color. On the other hand, the outer crust, which is less glossy, dark brown and highly porous, is composed of porous δ - MnO_2 in the form of tree branch. Moreover, as in mentioned in b), the cracks and the pores of the glossy inner crust are accompanied by 10Å manganite.

d) The discontinuity of the development structure, already observed by naked eyes among many of samples, becomes more obvious in the observation by microscope.



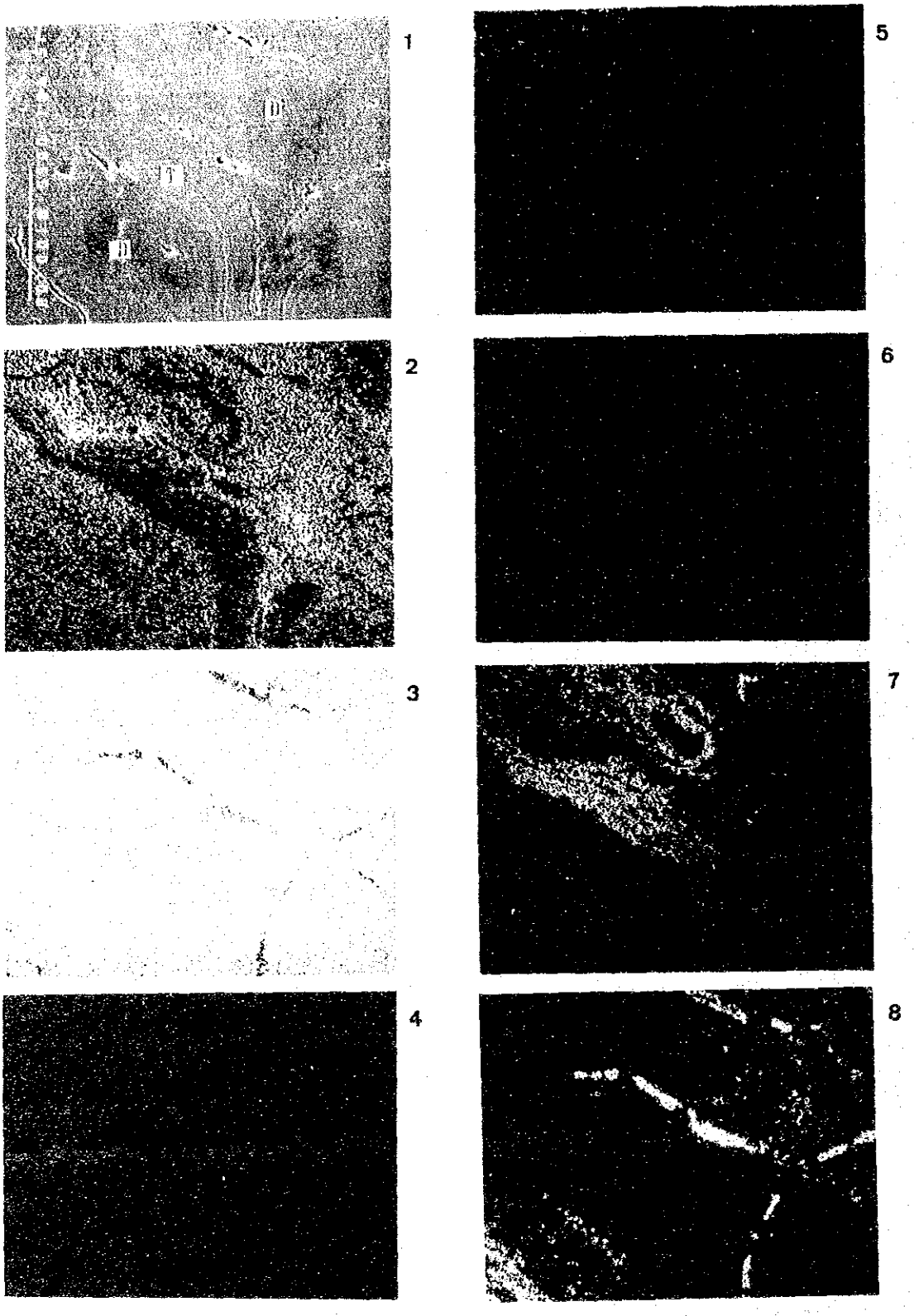
10A : 10Å : 10Å Manganite δ -Mn : δ -MnO_2, Q : Quartz
F-AP : Fluorapatite, C-AP : Carbonate-apatite

Fig. 4-3-9 X-ray Diffraction Patterns of Cobalt Crusts



Sample No : 1, 2, 3 : 87SA03AD01. 4, 5, 6 : 87SA01AD11.
Morphology of the sample is shown in Fig. 4-3-8. T : 10Å manganite, D : δ-MnO_2. 1 : δ-MnO_2 showing different degree of polishing. Sharp boundary denotes historical time gap in the formation of two phases. 2 : Same example as 1. 3 : 10Å manganite obliquely cutting δ-MnO_2 banding. 4 : 10Å manganite intercalatedly develop in the unconformable boundary. Squre area is for EPMA analysis shown in Fig. 4-3-11. 5 : Loose and lusterless outer zone. 6 : Contact zone to substrate (Fs). (Index scale : 0.2mm)

Fig. 4-3-10 Reflective Microscopic photos of Cobalt Crusts



Sample No : 87SA01AD11. Area of the picture is shown in Fig. 4-3-10(d). 1 : SEM image of EPMA, 2 : Fe, 3 : Mn, 4 : Co, 5 : Ni, 6 : Cu, 7 : Al, 8 : P.
T : 10Å manganite, D : δ-MnO_2.

Fig. 4-3-11 EPMA Figures of Cobalt Crusts

e) Through comparison between upper side (side with thicker crust) and lower side (side with thinner crust) of the pebble-type crust (Fig. 4-2-1-8), it is observed that the latter has denser stripes in the growth banding, and contains 10Å manganite in some parts of it.

f) One of the characteristics drawn by the X-ray diffraction analysis is that the inner crust contains quite generally fluorapatite and carbonate-apatite. This feature is also observable in the values of total analysis (Table 4-3-11) mentioned in 4): in all of the 3 samples in the table, the inner crust contains larger amount of P_2O_5 than in the outer crust (and middle crust).

g) Through the EPMA analysis it is observed that there is a clear difference in the distribution density of the main components between δ - MnO_2 phase and 10Å manganite phase, i.e., δ - MnO_2 is high in Fe, Co, Si, Ca and P etc., whereas 10Å manganite is high in Ni and Al. No remarkable difference is observed in Mn, Cu and K etc.

4-4 Considerations

There is no remarkable difference of properties nor of bearing situations of cobalt crust between this area and other areas as far as these features concerned. No remarkable difference is observed, with ordinary crust, in the features such as surface morphology of crust, inner structure, thickness and grade, except for the facts that massive type crust such as pebble-type or nodule-type are very rare because there is almost no flat plain on the summit of all of the surveyed seamounts, and that phosphate rock was frequently seen in the substrate. Nevertheless, it arouse interests to make a comparison among seamounts concerning the bearing conditions of cobalt crust, for the surveyed seamounts include some reef developed islands (atoll) and they are spread widely from north to south. Furthermore, some data concerning the relationship between the inner structure of crust and phosphate rock, of which predominance is discussed above, are obtained.

The two topics is discussed below.

1) Comparison among Seamounts

The seamounts surveyed in the present survey consist of 2 islands and 4 seamounts, SA03 being separated into the eastern island (Phoenix Is.) and western seamount.

The results of the survey are summarized as follows.

a) The slope of the relatively big island (SA02) forming and atoll is covered, almost entirely, with collapsed rolling limestone coffles. These coffles are barren for the most part and only a development of a thin crust coating (< 1mm thickness) on some (around 1 - 10% of total samples) of obtained samples is observed. At a very small part of the eastern slope thin crusts of 0.1 - 0.5cm were observed.

b) At the samll reef island (The island in SA03), the sampling results indicate that the slope is covered almost entirely with limestone debris as deep as about 2,000m. And below this level down to around 3,000m level, basalt, hyaloclastite or phosphate rock get more abundant than limestone. Above the depth of 2,000m, the thickness of crust is 1cm or less, while, below the depth of 2,000m it is more than 1cm and reaches 5cm at maximum (phosphate substrate). Judging from the case of the western adjacent seamount, it is presumed that phosphate rock and basalt are distributed up to a shallow depth, with limestone cobbles covering over them. It is to be noted, although, that, at an island of this scale, the time gap necessary for the crust to develop on the collapsed limestone sill be great, as the developing speed and the amount of reef limestone are smaller than a). Collapsed limestones seem to be supplied in great quantity at the western slope.

c) No difference is observed in the bearing situation among 4 seamounts except islands. Average thickness is almost the same. It could be possible to assume, with more data, that the appearance frequency of phosphate rock gets slightly higher to the northward (in the direction of equator) and, accordingly(?), the double-or triple-structure get slightly frequent. No difference is observed with the directions of slopes: In connection with the depth of water, there's no uniformity; the crust thickness gets < 1cm at less than 3,000m on the sea mounts SA01 or SA05, while, on the sea mount SA04 crust with 4.5cm - 8.0cm thick is observed. It is although to be noteq that crust is developed thicker in a deep water in this area than in an ordinary area. In connection with grade, Cu as well as Mn shows a predominance in southern seamounts. No regularity is observed as for Co, Fe, and Ni. To explain this phenomenon, it is necessary to take into consideration the factors such as the above-mentioned difference of phosphate rock development between north and south, difference of layer structure of crust, average depth of smapling points.

2) Relationship between Inner Structure of Crust and Phosphate Rock

The remarks made by Halback (1984) concerning the relationship are widely known; the cobalt crust in the group of mid-pacific seamounts is divided into superficial, "younger crust" and inner "older crust". Between two crusts, a remarkable difference in Co content and Mn/Fe ratio is observed. Generally, Co is rich in the younger and Mn/Fe ratio is higher in the older. Phosphate content larger in the older crust than in the younger crust. A layer of phosphate often develops in the layer between those two. On the other hand, after having investigated Kiribati-Tuvalu sea area including the area of our survey, De Carlo (1987) reported that no phosphate layer was observed in the crust, but was always observed in the host rock beneath the crust. Concerning these discussions, we obtained the observation results as follows.

i) Most of phosphate rocks develop as substrates of crusts or materials filling up fissures in the host rock (basalt breccias, hyaloclastite, or limestone), or in replaced occurrences.

ii) Nevertheless, development of phosphate materials is observed in the lower layer (inner crust) of the crust having double-or triple layers. In this case, it develops for the most part in a form of fine network.

Total analysis of some of samples shows it, by presenting rather high P_2O_5 in the lower layer.

iii) In the sample with crust contacting phosphate rock, border lines get irregularly entangled, crust components infiltrate in to the phosphate rock in the form of disseminated or concentrated, and crust materials penetrate into the phosphorite as small chips. All of these observation lead us to feel that those structures are generated at nearly same time or almost continuously.

iv) No phosphrite layer is observed, which exist between upper- and lower- layers of crust.

v) As for the grade, the crust in the survey area also shows higher values for Co and Mn/Fe ratio, and lower values for Ni and Cu in the upper layer than in the lower layer.

vi) As for the mineral components, there is a difference that upper layer (outer crust) is composed of δ-MnO_2 for the most part, while lower layer, composed of δ-MnO_2 mainly and contains 10Å manganite, little as it is.

vii) As for features observable by naked eyes, upper layer of crust is slightly coarse and lower layer presents compact and massive structure as in the case of other sea areas.

Judging from the above-mentioned observations, upper and lower layers of the crust classifiable into double layer or triple layer crusts, can be considered to correspond to Halback's "younger crust" and "older crust" respectively. We might also induce that the cause of difference of features is the same as that advocated by Halback, who had treated Mid. Pacific, Johnstone Island and Hawaii Islands as the survey area.

Chapter 5. Summary

5-1 Methods of the Survey

The first half period of the survey was carried out for manganese nodules, and the latter half period of the survey for cobalt crusts. (the total survey period; 40 days, the first half period; 27 days and the latter half period; 13 days).

For the survey of manganese nodules the reconaissance survey (the primary survey) was carried out at first on the survey area as extensive as possible, then the detailed survey (the secondary survey) was carried out only for the high abundance area of manganese nodules. The methods of the survey were mainly acoustic sounding and sampling, and the sea bottom photographing by CDC (Continuous Deep-sea Camera) was partly used during the secondary survey. The acoustic sounding includes sea bottom topographical survey by PDR and NBS, superficial sediments survey by SBP, and exploration for manganese nodules by MFES. Most sampling were carried out by Free Fall Grab, and also partly by Spade Corer. Photographing of the sea bottom was carried out by deep-sea camera mounted on each FG sampling equipment. The number of sampling stations for the primary survey is 35 stations, and the sampling distance is 42.4 mile-grid, while those for the secondary survey are 22 stations and 21.2 mile-grid. 3 samplings were carried out on each sampling station, and the total sampling time is 171 times. During this sampling the sea bottom photographs were successfully taken 162 times. The survey by CDC was carried out on the two track lines being 59.5 miles in total length, where the abundance of manganese nodules are respectively high. The sea bottom photographs obtained are 161 shots, and the grade of 196 sampled manganese nodules were assayed on board.

Five seamounts were selected for the survey of cobalt crusts depending on the various data. Two atolls are included among these five seamounts. Various acoustic sounding for the survey of topography and superficial sediments, and the dredge sampling were mainly carried out, and the sea bottom observation and photographing by FDC (Continuous Deep-sea camera with Finder) were also carried out partly. Total sampling time is 48 times, and its average is 10 times per seamount. Sampling amount is 2,770 kg including substrates. 125 crust samples were assayed on board.

5-2 Topography and Geology

The survey area is on the south fringe of the Central Pacific Ocean Basin. Topographical features have two parts; one is the northern plain, and the other is the southern quasi-plain which is belonging to the North Tokelau Basin. Most of the plain and quasi-plain are in the water depth of 5,200m - 5,600m having several hills (in the depth of 5,800m - 6,000m). The topographical trend is mainly NEE-SWW in parallel with the direction of Nova Canton Trough, and the hilly zone within the southeastern quasi-plain has the direction of NNW-SSE. In the survey area there are about 10 seamounts, and six of them are atolls, known by the name of Canton Island, Enderbury Island, Birnie Island, Phoenix Island, Sydney Island and Hull Island. All other seamounts have steep peaks under sea water whose peaks are in the depth of 1,000m - 1,600m.

The sea bottom geology is described as two characteristics. One is the exposure of basalt and limestone on the surface of the mountainous and seamounts, and the other is the development of the unconsolidated sediments on the plain and the quasi-plain. The kinds of rock are basalt (lava and hyaloclastite), limestone, and phosphorite bearing at the upper half side of seamounts. From the results of acoustic sounding by SBP, it was obtained that the unconsolidated sediments layer has 8 reflection patterns, such as a, b, bc, c, d_1, d_2, ds, and e_1.

The unconsolidated sediment layer becomes thicker in the northern survey area, and its maximum thickness is about 150m. A characteristic distribution of bottom materials on the surface of sediment layer is the different clay in the northern survey area and in the southern survey area, such as silicious clay in the northern area and brown clay in the southern area. CCD (Carbonate Compensation Depth) of the survey area could be estimated 5,200m in the northern area and 5,300m in the southern area according to the distribution of calcareous sediments bearing in the relatively shallow depth zone.

The estimated abundance of manganese nodules in the transparent layer zone is generally low from the results of the survey by MFES carried out as one of the acoustic soundings, and the estimated values by MFES correspond to that of the sampling results.

5-3 Bearing Situation of Manganese Nodules

The distribution continuity of manganese nodules in the survey area is generally poor, and there is only one zone which has a higher abundance. Even in this higher

abundance zone (> 10kg/m ^{2}) its extension is 40 miles in the E-W direction and 60 miles in the N-S direction (the area: about 6,600km^2). Except this zone, there are few places where the abundance shows high values on three sampling points altogether. The degree of the stability of the abundance is rather low according to the results of the survey by CDC. There are several sampling points which have locally more than 20 km/m^2 (35.56 kg/m^2 in maximum) of the high abundance outside the above-mentioned high abundance zone, but all the neighbouring points have zero abundance. The 90% of all the surveyed area has the abundance of less than 1kg/m^2. The average abundance of all the sampling stations is 4.45kg/m^2. (The density of the sampling stations in the primary survey is different from that in the secondary survey.) The average grade of the main components on all the sampling stations (weighted mean) are as the followings: 0.66% Ni, 0.60% Cu, 0.22% Co, 18.74% Mn, and 13.13% Fe. The average content density calculated from the above-mentioned values within the area having more than 20 g/m^2 density is as follows; Ni: 32.1 g/m^2 (in 40,500 km^2), Cu: 30.9 g/m^2 (in 34,500 km^2), and CO: 40.8 g/m^2 (in 11,700 km^2).

The characteristics of manganese nodules varies from the northern sea area to the southern sea area, and there is an transition zone in the central area. In the northern area the surface of the nodules is rough and there are many so-called "r-type" which are rich in Ni and Cu. On the other hand, in the southern area the surface of the nodules is rather smooth and there are many "s-type" which are rich in Co. In the transition zone there are both two types of nodules according to each topography and characteristics of bottom materials. The water depth in the serveyed area which showed high abundance of nodules is generally less than 5,200m up to 5,000m and the depth of more than 5,400m shows almost barren zone. This is closely connected with the fact that the CCD (Carbonate Compensation Depth) is around 5,200m. In conclusion, the abundance of the manganese nodules in the survey area has discontinuity and generally has a poor situation due to the deeper water depth which is more than 5,200m and the various topography with much undulations. Moreover, the characteristics of the manganese nodules are varied by the difference of biological productivity between the northern area and the southern area (Cronan, 1984).

5-4 Bearing Situation of Cobalt Crusts

The four seamounts among five surveyed seamounts (strictly speaking, the four seamount are three seamounts and one island with neighbouring small seamounts) have

some development of crusts which is called to be concentrated as mineral resources. The surveyed water depth is between 570m and 3,400m, and the survey was frequently carried out around the depth of 1,600m - 2,800m. The average surveyed depth is about 2,250m. The total sampled crusts with substrates weighs 2,770 kg. The bearing situation of cobalt crusts by this survey could be described as follows (The general occurrences of cobalt crusts at individual seamount are shown in Tab. 5-1):

a) The confirmed bearing depth is around 1,000m - 3,200m, and the bearing zone would extend further.

b) The crust shapes are mainly crust type, and rarely slab type, massive type, cobble type and nodule type.

c) The surface structure is mostly botryoidal.

d) The inner structure has mainly single layer, but sometimes double or triple layers. The crusts in the deeper zone have more compact characteristics.

e) The composing minerals are mostly δ-MnO_2, and the cores (the lower layer) have of 10Å manganite.

f) The substrates are mainly brecciated basalt (pillow breccia or talus) and hyaloclastite, subsidially limestone and phosporite, and rarely calcareous sandstones.

g) The thickness of crusts varies from less than 1mm of thin coating to 8cm in maximum, and its average value of all the 48 sampling points is 1.6cm. Furthermore, the average value of all the 59 surveyed samples is 1.8cm. The average thickness of crusts on each four seamounts are almost the same, 1.5 - 1.9cm, except that of the seamounts (island) SA02.

h) The coverage on the slope of seamounts varies 20% - 90%, and there are partly barren zones around the top of seamounts. The SA02 island is almost covered with talus of limestone, and the coverage on the SA03 becomes higher in the depth of more than 1,000m.

i) The average grade of the 33 sampling points is 0.78% Co, 0.66% Ni, 0.11 Cu, 25.38% Mn, and 14.48% Fe. There is a positive correlation among the content of Co, Ni and Mn, and there is a negative correlation between the water depth and the content of Co, Ni, and Mn. There is also a positive correlation between the water depth and the content of Fe and Cu.

j) The grade of the confirmed crusts on the seamounts are almost equal to the average grade of the seamounts in the Central Pacific Ocean (Halbach and Menheim, 1984), or the average grade of all the seamounts in the Pacific Ocean (Manheim, 1986), and the thickness and the coverage of the crusts show almost the same values.

k) From the results of this survey it could be estimated that there are bearing potential of the crusts in the appropriate depth on the seamounts which are not yet surveyed, and it could be also expected that the small sized atolls have some potential (Birnie Island), while there are only a few potential on the large sized atolls (Hull Island, Enderbery Island, and Canton Island).

Table 5-1 General Occurrences of Cobalt Crusts at Individual Seamount

Seamount	SA01	SA02	SA03	SA04	SA05
Position	5°37'S, 170°14'W	4°27'S, 171°15'W	Phoenix Is: 3°43'S, 170°43'W West Seamount: 3°53'S, 170°56'W	0°38'S, 171°00'W	0°36'S, 171°35'W
Survey period	9/25 ~ 28	9/29 ~ 30	10/1 ~ 3	10/14 ~ 16	10/17
Topographic-Survey Dredge Sampling CDC Survey	262 miles 13 stations 10 miles	213 miles 8 stations 0	388 miles 13 stations 5 miles	263 miles 10 stations 0	200 miles 4 stations 0
Surveyed Depth Range	1,700 ~ 3,200 m	980 ~ 3,460 m	570 ~ 3,000 m	1,120 ~ 3,400 m	1,180 ~ 3,000 m
Topographic Feature	Peaked seamount, 37 km x 15 km Depth range: 1,600 ~ 5,000 m Average angle at upper slope: 14° ± 6°	Atoll, 21 km x 19 km 0 ~ 5,000 m 19° ±6°	Atoll (24 km x 19 km) & Peaked seamount (14 km x 9 km) 0 ~ 5,000 m, 1,030 ~ 5,000 m 19° ±6° 20° ± 3°	Peaked seamount, 18 km x 13 km 1,040 ~ 5,000 m 23° ±7°	Peaked seamount, 13 km x 13 km 1,170 ~ 5,000 m 24° ± 6°
Geology	Bs: pillow brc, hyaloclastite lava (vesicular ~ compact) L·S, Calc. S.S, Ripple marks Phosphorite, Foraminifera sands.	Almost entirely covered by coral limestones. Bs: (lava, hyaloclastite) More competent L·S at deeper position.	Prominent phosphorite at west seamount. L·S & phos. at Phoenix Is. Bs: (lava, abundant amigdules) at both mounts · More L·S at western slopes.	Bs: lava, pillow brc, hyaloclastite. Phosporite (rock or matrix of clastites), L·S	Bs: pillow brc, hyaloclastite Phos: matrix of clastites L·S: phosphatized and include chipps of cobalt crusts.
Occurrence of Cobalt Crust *	C, B, M, N, S, single layer, botryoidal. Topographic control and barren zone at top.	Mostly thin coating. 5 mm thick crust at one station of eastern slope.	Prominent crust, S, M, B, with two layer. Phos: intercalated or disseminated.	Prominent crust, B, competent, banded structure platy foliation. Phos: in inner crust.	Only crust, single ~ three layer, platy foliation, botryoidal ~ smooth surface
Coverage of Cobalt Crust	(FDC data) Flat top: 0 (sand cover) Gentle slope: 10~70% Steep slope: 10~100%	Eastern slope < 50%? Other slope: 0 or thin coating only.	(FDC data) West seamount: 10~90% Phoenix Is: 10~70%, nearly 0 at upper slope.	Unestimable. No difference in direction of slopes?	Unestimable. Abundant debris of Bs. and L·S.
Thickness of Cobalt Crust ( ): Average	Thick is C and S. No relation to kind of substrate. 0.1 ~ 7.0 cm (1.7 cm)	Coating < 1 mm Eastern slope: 1 ~ 5 mm (0.2 cm)	0.1 ~ 7.0 cm (1.5 cm) Thick at West seamount (2.0 ±) Phoenix Is: (1.0 ±)	0.1 ~ 8.0 cm (1.8 cm) Maximum thickness 8 cm at 3,000 m depth.	0.1 ~ 6.0 cm (1.9 cm)
Average Grade of Cobalt Crust (%) (*1) ( ): Highest value	Co: 0.79 ± 0.12 (1.01) Ni: 0.67 ± 0.17 (0.92) Cu: 0.13 ± 0.03 (0.20) Mn: 27.42 ± 2.31 (30.71) Fe: 15.67 ± 2.51 (19.00)	0.36 0.47 0.12 10.51 12.58 } Reference analysis, substrate mixed sample.	0.78 ± 0.33 (1.38) 0.70 ± 0.24 (1.07) 0.10 ± 0.03 (0.15) 23.57 ± 6.34 (28.76) 12.66 ± 3.29 (17.18)	0.71 ± 0.13 (0.86) 0.68 ± 0.24 (1.01) 0.09 ± 0.03 (0.13) 26.09 ± 2.87 (29.05) 14.96 ± 2.95 (18.92)	1.05 ± 0.39 (1.38) 0.57 ± 0.19 (0.71) 0.07 ± 0.03 (0.10) 27.12 ± 5.63 (30.98) 15.58 ± 2.15 (18.60)
Evaluation	Best among five seamounts. Some boulder type crusts at top. Eastern slope is more gentle than the west.	Very sparse crust exposure only at the foot slope of eastern side.	West seamount is rich in thick crusts with phosphorite substrate. Phoenix Is. has crusts at middle zone of slopes.	Superior development of crusts and expectable thick crusts at lower slopes. Slopes are steep.	Superior development of crusts and high cobalt content. Slopes are steep.

*1, Calculated from station average value.

Abbreviation: Rock Type { Bs: Basalt, Phos: Phosphorite; L·S: Limestone, Calc: Calcareous; S.S.: Sandstone, Brc: Breccia } * Crust Type { C: Crust, B: Cobble, M: Massive; S: Slub, N: Nodule, }

[References]

1. Aplin A. S and Cronan D. S. (1985): Ferromanganese oxide deposits from the Central Pacific Ocean, II. Nodules and associated sediments. Geochimica et Cosmochimica Acta Vol, 49, pp. 437 - 451.

2. Bischoff J. L., Health G. R., and Leinen M. (1979): Geochemistry of Deep Sea Sediments from the Pacific Manganese Nodule Province: DOMES Sites A, B, and C. Marine Science 9.

3. Cronan D. S. (1984): Criteria for the recognition of areas of potentially economic manganese nodules and encrustations in the CCOP/SOPAC region of the Central and Southwestern Tropical Pacific. South Pacific Marine Geological Notes Vol. 3, No. 1.

4. De Carlo E. H., McMrtry G. M. and Kim K. H. (1986): Geochemistry of ferromanganese crusts from the Hawaiian Archipelago. I, Northern survey areas, Deep Sea Research, in press.

5. De Carlo E. H., Pennywell P. A. and Fraley C. M. (1987): Geochemistry of ferromanganese deposits from the Kiribati and Tuvalu region of the West Central Pacific Ocean. Marine Mining, in press.

6. Exon N. F. (1984): Manganese nodules in the Kiribati region, Equatorial Western Pacific. South Pacific Marine Geological Notes Vol. 2, No. 6.

7. Halbach, P. and Puteanus D. (1984): The influence of the carbonate dissolution rate on the growth and composition of Co-rich ferromanganese crusts from the Central Pacific seamounts area, Earth and Planetary Science Latters. 68, 73-87.

8. Halbach, P. and Manheim, F. T. (1984): Potential of cobalt and other metals in ferromanganese crusts on seamounts of the Central Pacific Basin. Marine Mining, 4 pp 319 - 336.

9. Japan International Cooperation Agency and Metal Mining Agency of Japan (1987): Ocean resources investigation in the sea area of CCOP/SOPAC report on the joint basic study for the development of resources.

10. Keating B. and Bolton B. (1986): Initial report of 1986 R. V. Moana Wave cruise MW-86-02 in the Kiribati/Tuvalu region, Central Pacific Ocean. CCOP/SOPAC Cruise Report No. 121.

11. Manheim, F. T. (1986): Marine cobalt resources, Science, 232: 553-684.

12. Usui A. (1982): X-ray diffraction study of manganese nodules and associated rocks: the Wake to Tahiti Transect. Geological Survey of Japan, Cruise Report No. 18, p. 355 - 369.

13. Usui A., Nishimura A., Tanahashi M., and Terashima S. (1987): Local variability of manganese nodule facies on small abyssal hills of the Central Pacific Basin. Marine Geology, 74, p. 237 - 275.

14. Nishimura A. (1986): Sedimentation in the Deep Sea, and Manganese Nodules. Science, Vol. 8, No. 5.

15. Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (1986 and 1987) Ocean Resources Investigation in the Sea Area of CCOP/SOPAC Report on the Joint Basic Study for the Development of Resources. (Vol. 1 and 2) Sea Area of Cook Islands.

APPENDIX

List of the Survey Results

Data file around the Republic of Kiribati

Sample No. (Station)	Location				Manganese Nodules									XRF Analyses (%)					Geology				
					Size distribution (%)						Abundance	Shape	S.G. wet	H2O (%)						Sediment			T.P.L.*	
	Latitude	Longitude	Depth (m)	Topography	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	(Kg/m2)				Ni	Cu	Co	Mn	Fe		sil%	cal%	type	thick. (m)
87S0172FG01	00° 00.08'N	172° 00.22'W	5,655	(Plain)Flat							0.00	--	---	---	---	---	---	---	---	SC	2	0	bc	0
87S0172FG02	00° 01.11'N	172° 01.33'W	5,666	(Plain)Flat							0.00	--	---	---	---	---	---	---	---	SC	5	0	bc	0
87S0172FG03	00° 01.26'N	171° 59.60'W	5,671	(Plain)Flat							0.00	--	---	---	---	---	---	---	---	SC	8	0	bc	0
(87401) Average			5,664								0.00	--	---	---	---	---	---	---	---					
87S0172FG04	00° 30.02'S	171° 30.27'W	5,545	(Plain)Flat							0.00	--	---	---	---	---	---	---	---	SC	0	0	b	0
87S0172FG05	00° 29.04'S	171° 31.41'W	5,548	(Plain)Flat							0.00	--	---	---	---	---	---	---	---	SC	0	0	b	0
87S0172FG06	00° 29.08'S	171° 29.59'W	5,099	(Plain)Seaknol			100				0.18	E	2.00	30.4	0.63	0.48	0.21	22.41	16.49	-	-	-	dl	0
(87402) Average			5,397				100				0.06	E	2.00	30.4	0.63	0.48	0.21	22.41	16.49					
87S0171FG01	00° 00.04'N	171° 00.01'W	5,670	(Plain)Flat	30	38	9	23			1.70	Ot,Sp	1.89	29.1	1.35	1.23	0.10	24.25	7.34	SC	4	0	b	0
87S0171FG02	00° 00.94'N	171° 01.07'W	5,684	(Plain)Flat	55	23	22				0.24	Ot	1.70	28.6	1.45	1.34	0.10	25.00	7.20	BC	4	0	b	0
87S0171FG03	00° 01.03'N	170° 59.14'W	5,256	(Plain)Seaknol	0	20	60	20			21.19	M ,Sp	2.02	27.0	0.83	0.75	0.18	23.06	12.87	CSC	5	0	dl	0
(87403) Average			5,537		3	22	55	20			7.71	M ,Sp	2.01	27.2	0.88	0.79	0.17	23.16	12.42					
87S0171FG04	00° 30.02'S	170° 30.08'W	5,018	(Plain)Seaknol							0.00	--	---	---	---	---	---	---	---	-	-	-	dl	0
87S0171FG05	00° 29.05'S	170° 31.21'W	5,035	(Plain)Seaknol							0.00	--	---	---	---	---	---	---	---	CSC	0	70	dl	0
87S0171FG06	00° 29.00'S	170° 29.33'W	5,357	(Plain)Seaknol	100						(0.16)	Ot,P	2.00	31.6	0.31	0.32	0.09	3.41	11.19	CSC	0	0	d2	0
(87404) Average			5,137		6						0.00	--	---	---	---	---	---	---	---					
87S0170FG01	00° 00.02'N	169° 59.98'W	5,440	(Plain)Flat	100						0.10	Ot,M	1.86	23.1	1.44	1.42	0.11	24.66	7.06	BC	2	10	a	0
87S0170FG02	00° 00.96'N	170° 01.81'W	5,235	(Plain)Flat	20	80					1.73	M ,Ot	2.00	29.1	1.57	1.66	0.08	26.89	5.99	SCC	2	5	a	0
87S0170FG03	00° 01.04'N	169° 59.02'W	5,268	(Plain)Flat							(0.00)	--	---	---	---	---	---	---	---	-	-	-	ds	0
(87405) Average			5,314		24	76					0.92	M ,Ot	1.99	28.8	1.56	1.65	0.09	26.75	6.06					
87S0170FG04	00° 29.94'S	169° 30.13'W	5,502	(Plain)Flat							0.00	--	---	---	---	---	---	---	---	BC	2	0	b	0
87S0170FG05	00° 28.91'S	169° 31.15'W	5,475	(Plain)Flat	100						0.01	Ef,Ot	---	---	---	---	---	---	---	BC	3	0	b	0
87S0170FG06	00° 28.81'S	169° 29.38'W	5,424	(Plain)Flat	100						0.00	E	---	---	---	---	---	---	---	BC	3	5	b	0
(87406) Average			5,467		100						0.00	Ef,Ot	---	---	---	---	---	---	---					

* sil% ; siliceous fossil % cal% ; calcareous fossil % T.P.L ; Transparent Layer

Data file around the Republic of Kiribati

Sample No. (Station)	Location				Manganese Nodules														Geology				
					Size distribution (%)						Abundance	Shape	S.G. wet	H2O	XRF Analyses (%)					Sediment			T.P.L.*	
	Latitude	Longitude	Depth (m)	Topography	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	(Kg/m2)			(%)	Ni	Cu	Co	Mn	Fe		sil%	cal%	type	thick. (m)
87S0270FG01	01° 30.05'S	169° 29.92'W	5,432	(Plain)Flat		23	67	10			20.79	M	1.97	28.7	0.48	0.39	0.24	20.65	15.62	SC	3	0	ds	0
87S0270FG02	01° 29.20'S	169° 30.99'W	5,461	(Plain)Flat	23	51	26				4.87	M ,Sp	2.02	27.0	1.02	1.04	0.14	24.06	9.05	SC	0	0	ds	0
87S0270FG03	01° 29.12'S	169° 28.99'W	5,364	(Plain)Flat	100						0.02	Pl	---	---	---	---	---	---	---	-	-	-	ds	0
(87407) Average			5,419		4	28	59	8			8.56	M ,Sp	1.98	28.3	0.59	0.52	0.22	21.31	14.35					
87S0270FG04	00° 59.82'S	169° 59.91'W	5,413	(Plain)Flat	17	62	7	14			11.02	Sp,Ef	1.99	24.8	1.34	1.43	0.11	26.71	7.24	SC	2	0	ds	0
87S0270FG05	00° 58.87'S	170° 00.93'W	5,413	(Plain)Flat	100						0.04	Ef	---	---	---	---	---	---	---	SC	2	0	b	0
87S0270SC06	00° 59.06'S	169° 59.78'W	5,371	(Plain)Flat	100						0.21	Ef	1.86	31.3	1.57	1.38	0.10	26.32	6.22	BC	0	0	b	0
(87408) Average			5,399		19	61	7	14			3.76	Sp,Ef	1.99	24.9	1.34	1.43	0.11	26.71	7.23					
87S0271FG01	01° 30.01'S	170° 29.96'W	5,205	(Plain)Seaknol		47	53				20.19	P ,M	2.06	26.6	0.65	0.58	0.21	21.58	13.57	SC /SC	2	0	ds	0
87S0271FG02	01° 29.11'S	170° 31.04'W	4,898	(Plain)Seaknol							0.00	--	---	---	---	---	---	---	---	-	-	-	d1	0
87S0271FG03	01° 29.06'S	170° 28.97'W	5,157	(Plain)Seaknol	1	14	38	37	10		12.07	M ,P	1.99	28.1	0.89	0.78	0.21	23.52	11.44	CSC	2	0	ds	0
(87409) Average			5,087		0	35	47	14	4		10.75	P ,M	2.04	27.2	0.74	0.66	0.21	22.30	12.78					
87S0271FG04	00° 59.98'S	170° 59.75'W	5,757	(Plain)Flat							0.00	--	---	---	---	---	---	---	---	SCC	2	10	e1	0
87S0271FG05	00° 58.93'S	171° 00.70'W	5,751	(Plain)Flat							0.00	--	---	---	---	---	---	---	---	-	-	-	e1	0
87S0271FG06	00° 58.96'S	170° 58.84'W	5,774	(Plain)Flat							0.00	--	---	---	---	---	---	---	---	SCC	2	0	d2	0
(87410) Average			5,761								0.00	--	---	---	---	---	---	---	---					
87S0272FG01	01° 29.99'S	171° 29.94'W	5,519	(Plain)Flat	90	10					2.27	Ef,Ot	1.92	32.2	1.57	1.42	0.08	27.02	5.77	SC	2	5	b	0
87S0272FG02	01° 29.02'S	171° 30.96'W	5,455	(Plain)Flat	3	97					0.13	M	2.00	25.0	1.39	1.51	0.08	26.75	6.20	BC	3	5	b	0
87S0272FG03	01° 28.97'S	171° 28.98'W	5,512	(Plain)Flat	100						0.23	Ef,Sp	2.14	25.0	1.56	1.39	0.09	26.93	5.81	BC	2	0	b	0
(87411) Average			5,495		87	13					0.88	Ef,Ot	1.94	31.2	1.56	1.42	0.08	27.08	5.79					
87S0272FG04	00° 59.64'S	172° 00.22'W	5,474	(Plain)Flat	59	41					5.58	Sp,Ef	1.99	30.1	1.18	1.02	0.13	24.57	8.94	BC	1	0	a	0
87S0272SC05	00° 58.73'S	172° 01.27'W	5,495	(Plain)Flat	49	51					4.31	Sp,Ef	1.96	31.7	1.20	1.04	0.12	24.35	8.67	SC	1	0	a	0
87S0272FG06	00° 58.72'S	171° 59.27'W	5,453	(Plain)Flat	57	43					6.41	Sp,Ot	1.98	30.1	1.11	0.93	0.14	23.89	9.62	BC	1	0	a	0
(87412) Average			5,474		56	44					5.43	Sp,Ef	1.98	30.5	1.16	0.99	0.13	24.17	9.14					

* sil% ; siliceous fossil % cal% ; calcareous fossil % T.P.L ; Transparent Layer

Data file around the Republic of Kiribati

Sample No. (Station)	Location				Manganese Nodules															Geology				
					Size distribution (%)						Abundance	Shape	S.G. wet	H2O (%)	XRF Analyses (%)					Sediment			T.P.L.*	
	Latitude	Longitude	Depth (m)	Topography	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	(Kg/m2)				Ni	Cu	Co	Mn	Fe		sil%	cal%	type	thick. (m)
87S0372FG01	02° 00.05'S	172° 00.01'W	5,427	(Plain)Flat	90	10					0.32	Sp,Ef	2.06	29.0	1.54	1.37	0.10	25.97	6.36	BC	1	0	b	0
87S0372FG02	01° 59.13'S	172° 00.99'W	5,522	(Plain)Flat	100						0.02	Sp	---	---	---	---	---	---	---	BC	1	0	b	0
87S0372FG03	01° 59.11'S	171° 58.94'W	5,428	(Plain)Flat	66	34					0.34	Sp,E	1.88	25.0	1.50	1.36	0.10	25.91	6.43	BC	1	0	b	0
(87413) Average			5,459		78	22					0.23	Sp,E	1.97	27.0	1.52	1.37	0.10	25.94	6.40					
87S0372FG04	02° 29.64'S	171° 30.00'W	5,169	(Mount)Flat	100						0.01	Sp	---	---	---	---	---	---	---	SCO	2	0	d2	0
87S0372FG05	02° 28.61'S	171° 31.05'W	5,156	(Mount)Flat							0.00	--	---	---	---	---	---	---	---	他	3	5	d2	0
87S0372FG06	02° 28.45'S	171° 29.10'W	5,186	(Mount)Flat	100						0.09	P	2.00	25.0	0.53	0.43	0.25	17.63	13.22	他	2	0	d2	0
(87414) Average			5,170		100						0.03	P ,Sp	2.00	25.0	0.53	0.43	0.25	17.63	13.22					
87S0371FG01	02° 00.00'S	171° 00.10'W	5,369	(Plain)Flat	6	48	20	26			2.30	Pt,M	1.90	27.9	0.55	0.42	0.26	20.84	15.29	-	-	-	ds	0
87S0371FG02	01° 58.99'S	171° 00.97'W	5,438	(Plain)Flat							0.00	--	---	---	---	---	---	---	---	SC	3	0	b	0
87S0371FG03	01° 58.91'S	170° 58.95'W	5,464	(Plain)Flat	67	33					0.02	Ot,Sp	---	---	---	---	---	---	---	SC	5	0	d2	0
(87415) Average			5,424		7	48	20	26			0.77	Pt,M	1.90	27.9	0.55	0.42	0.26	20.84	15.29					
87S0371FG04	02° 30.02'S	170° 30.00'W	5,144	(Mount)Seaknol	36	64					1.62	Sp,Ef	2.01	26.8	1.30	1.45	0.09	27.32	5.66	SCC	2	0	ds	0
87S0371FG05	02° 29.09'S	170° 30.93'W	4,855	(Mount)Seaknol							0.00	--	---	---	---	---	---	---	---	-	-	-	d1	0
87S0371FG06	02° 28.99'S	170° 28.92'W	5,196	(Mount)Seaknol	12	74	8	6			10.76	P ,Sp	2.07	21.1	1.05	1.17	0.12	25.52	7.82	SCC	2	0	ds	0
(87416) Average			5,065		15	73	7	5			4.13	P ,Sp	2.07	21.9	1.08	1.21	0.12	25.75	7.55					
87S0370FG01	02° 00.02'S	170° 00.00'W	5,314	(Mount)Flat	74	26					0.36	Sp,Ef	2.01	21.4	1.46	1.52	0.07	27.80	5.39	SC	2	3	b	0
87S0370FG02	01° 59.04'S	170° 00.96'W	5,388	(Mount)Flat	100						0.41	Sp,Ef	2.04	27.6	1.46	1.52	0.08	27.98	5.21	SC	3	5	b	0
87S0370FG03	01° 58.99'S	169° 59.00'W	5,329	(Mount)Flat	73	27					0.65	Sp,Ef	1.96	28.1	1.46	1.52	0.08	27.62	5.60	SC	3	5	b	0
(87417) Average			5,344		81	19					0.47	Sp,Ef	1.99	26.2	1.46	1.52	0.08	27.77	5.43					
87S0370FG04	02° 30.17'S	169° 29.87'W	5,375	(Mount)Seaknol	12	62	16	10			7.28	Sp,Ef	2.08	25.2	1.05	1.13	0.11	24.74	7.61	SC	4	0	ds	0
87S0370FG05	02° 29.26'S	169° 30.88'W	5,288	(Mount)Seaknol	2	73	25				13.63	Ot,P	2.03	38.0	0.40	0.31	0.23	15.61	14.79	SCC	5	0	ds	0
87S0370FG06	02° 29.24'S	169° 28.91'W	5,315	(Mount)Seaknol		48	20	13	19		8.10	Pt,P	2.06	26.6	0.89	0.91	0.15	23.30	9.77	SC	5	0	ds	0
(87418) Average			5,326		4	63	21	6	5		9.67	Ot,P	2.05	27.9	0.71	0.70	0.18	20.17	11.49					

* sil% : siliceous fossil % cal% : calcareous fossil % T.P.L : Transparent Layer

Data file around the Republic of Kiribati

Sample No. (Station)	Location				Manganese Nodules														Geology				
					Size distribution (%)						Abundance	Shape	S.G. wet	H20 (%)	XRF Analyses (%)					Sediment			T.P.L.*	
	Latitude	Longitude	Depth (m)	Topography	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	(Kg/m2)				Ni	Cu	Co	Mn	Fe		sil%	cal%	type	thick. (m)
87S0470FG01	03° 29.98'S	169° 29.96'W	5,759	(Quasi)Hollow	100						0.01	P ,Sp	---	---	---	---	---	---	---	BC	4	0	d2	0
87S0470FG02	03° 29.05'S	169° 30.93'W	5,756	(Quasi)Hollow	75	25					0.03	P ,Pl	---	---	---	---	---	---	---	BC	5	0	d2	0
87S0470FG03	03° 29.01'S	169° 28.90'W	5,938	(Quasi)Hollow	100						0.00	P	---	---	---	---	---	---	---	SC	5	0	b	0
(87419) Average			5,818		81	19					0.01	P ,Pl	---	---	---	---	---	---	---					
87S0470FG04	02° 59.97'S	170° 00.30'W	5,072	(Quasi)Platfor	100						0.04	Ef,P	---	---	---	---	---	---	---	-	-	-	d2	0
87S0470SC05	02° 58.98'S	170° 00.99'W	5,010	(Quasi)Platfor	2	12	16	26	44		9.76	M ,Pl	1.87	29.2	0.73	0.65	0.19	18.92	10.62	SCC	0	0	d2	0
87S0470FG06	02° 58.97'S	169° 59.35'W	5,048	(Quasi)Platfor	62	38					0.10	Sp,P	1.90	15.4	1.21	1.29	0.12	25.56	6.63	SCC	0	0	b	0
(87420) Average			5,043		3	12	16	26	43		3.30	M ,Pl	1.87	29.1	0.74	0.65	0.19	19.00	10.57					
87S0471FG01	03° 30.03'S	170° 30.00'W	5,175	(Mount)Flat							0.00	--	---	---	---	---	---	---	---	BC	4	5	a	0
87S0471FG02	03° 29.07'S	170° 31.00'W	5,175	(Mount)Flat	25	40	35				1.36	Ef,Pt	2.09	27.0	0.93	0.94	0.15	20.50	8.09	SC	2	5	a	0
87S0471FG03	03° 29.16'S	170° 28.90'W	5,197	(Mount)Flat	100						0.05	Sp	---	---	---	---	---	---	---	SC	3	0	a	0
(87421) Average			5,182		28	39	34				0.47	Ef,Pt	2.09	27.0	0.93	0.94	0.15	20.50	8.09					
87S0571FG01	04° 29.99'S	170° 29.97'W	5,663	(Quasi)Platfor							0.00	--	---	---	---	---	---	---	---	SC	3	0	ds	0
87S0571FG02	04° 29.07'S	170° 31.07'W	5,890	(Quasi)Flat	100						0.02	Ef	---	---	---	---	---	---	---	BC	2	5	ds	0
87S0571FG03	04° 28.98'S	170° 29.17'W	5,673	(Quasi)Platfor							0.00	--	---	---	---	---	---	---	---	SC	4	0	ds	0
(87422) Average			5,742		100						0.01	Ef	---	---	---	---	---	---	---					
87S0570FG01	03° 59.85'S	169° 58.98'W	5,622	(Quasi)Flat	24	76					6.28	Ef,P	2.05	25.1	0.55	0.50	0.18	14.51	11.03	SC	0	0	d2	0
87S0570FG02	03° 58.86'S	170° 00.99'W	5,716	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	0	0	el	0
87S0570FG03	03° 58.69'S	169° 59.08'W	5,612	(Quasi)Flat	100						0.08	Ef,Sp	---	---	---	---	---	---	---	BC	3	0	el	0
(87423) Average			5,650		25	75					2.12	Ef,P	2.05	25.1	0.55	0.50	0.18	14.51	11.03					
87S0570FG04	04° 30.05'S	169° 29.93'W	4,972	(Quasi)Seamoun	17	67	16				13.86	P ,M	2.11	19.3	0.21	0.19	0.13	3.90	11.05	CSC	2	0	d1	0
87S0570FG05	04° 29.11'S	169° 30.95'W	5,080	(Quasi)Seamoun		50	50				25.90	Sp	2.03	27.6	0.26	0.19	0.35	16.83	21.11	他	2	0	d1	0
87S0570FG06	04° 29.08'S	169° 28.99'W	4,652	(Quasi)Seamoun	4	87	9				13.74	Sp,P	2.01	29.6	0.31	0.20	0.39	18.90	19.67	SCO	2	0	d1	0
(87424) Average			4,901		5	64	31				17.83	Sp,P	2.05	25.9	0.26	0.19	0.30	13.68	17.92					

* sil% ; siliceous fossil % cal% ; calcareous fossil % T.P.L ; Transparent Layer

Data file around the Republic of Kiribati

Sample No. (Station)	Location				Manganese Nodules														Geology				
					Size distribution (%)						Abundance	Shape	S.G. wet	H20 (%)	XRF Analyses (%)					Sediment			T.P.L.*	
	Latitude	Longitude	Depth (m)	Topography	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	(Kg/m2)				Ni	Cu	Co	Mn	Fe		sil%	cal%	type	thick. (m)
87S0569FG01	03° 59.90'S	168° 59.98'W	5,147	(Quasi)Flat		22	72	6			29.81	M ,Sp	2.03	26.8	0.33	0.23	0.34	18.49	17.77	CSC	2	5	ei	0
87S0569FG02	03° 58.90'S	169° 00.93'W	5,094	(Quasi)Flat	45	41	14				4.49	Ot	1.97	26.3	0.27	0.23	0.12	4.15	11.60	SCC	2	0	d2	0
87S0569FG03	03° 58.76'S	168° 58.95'W	4,813	(Quasi)Seaknol	--	--	--	--	--	--	(---)	----	---	---	---	---	---	---	---	--	-	-	d1	0
(87425) Average			5,018		6	25	64	5			17.15	M ,Ot	2.02	26.7	0.32	0.23	0.31	16.61	16.96					
87S0569FG04	04° 29.99'S	168° 30.03'W	5,544	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	2	0	d1	0
87S0569FG05	04° 29.02'S	168° 31.11'W	5,534	(Quasi)Flat	100						0.03	Sp,P	---	---	---	---	---	---	---	BC	2	0	d1	0
87S0569FG06	04° 28.92'S	168° 29.10'W	5,367	(Quasi)Platfor	100						0.08	Ef,Sp	2.00	20.0	1.02	0.98	0.11	25.20	6.95	BC	2	0	b	0
(87426) Average			5,482		100						0.04	Sp,Ef	2.00	20.0	1.02	0.98	0.11	25.20	6.95					
87S0568FG01	04° 00.38'S	168° 00.09'W	5,646	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	2	0	bc	0
87S0568FG02	03° 59.50'S	168° 01.10'W	5,618	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	0	0	bc	0
87S0568FG03	03° 59.52'S	167° 59.21'W	5,606	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	SC	0	0	bc	0
(87427) Average			5,623								0.00	--	---	---	---	---	---	---	---					
87S0668FG01	04° 59.99'S	168° 00.04'W	5,356	(Quasi)Flat		37	42	21			8.69	M ,P	1.99	24.1	0.56	0.45	0.28	20.18	12.17	SC	1	0	ds	0
87S0668SC02	04° 58.99'S	168° 01.08'W	5,340	(Quasi)Flat	2	63	31	4			19.00	M ,P	1.98	27.7	0.41	0.26	0.34	18.51	14.88	BC	0	0	b	0
87S0668FG03	04° 58.97'S	167° 59.03'W	5,355	(Quasi)Flat		16	65	9	10		(8.28)	M ,Ot	2.02	28.6	0.28	0.19	0.40	18.81	18.98	SC	1	0	b	0
(87428) Average			5,350		1	55	35	9	0		13.84	M ,P	1.99	26.6	0.46	0.32	0.32	19.85	14.00					
87S0669FG01	05° 30.13'S	168° 29.30'W	5,612	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	0	50	b	0
87S0669FG02	05° 29.19'S	168° 30.23'W	5,619	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	0	60	b	0
87S0669FG03	05° 29.18'S	168° 28.13'W	5,602	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	0	40	b	0
(87429) Average			5,611								0.00	--	---	---	---	---	---	---	---					
87S0669FG04	04° 59.95'S	169° 00.00'W	5,611	(Quasi)Flat							(0.00)	--	---	---	---	---	---	---	---	BC	1	0	b	0
87S0669FG05	04° 59.01'S	169° 01.03'W	5,586	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	1	0	b	0
87S0669FG06	04° 58.96'S	168° 59.08'W	5,562	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	-	-	-	b	0
(87430) Average			5,586								0.00	--	---	---	---	---	---	---	---					

* sil% ; siliceous fossil % cal% ; calcareous fossil % T.P.L ; Transparent Layer

Sample No. (Station)	Location				Manganese Nodules															Geology				
					Size distribution (%)						Abundance	Shape	S.G. wet	H2O	XRF Analyses (%)					Sediment			T.P.L.*	
	Latitude	Longitude	Depth (m)	Topography	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16~ cm	(Kg/m2)			(%)	Ni	Cu	Co	Mn	Fe		sil%	cal%	type	thick. (m)
87S0670PG01	05° 29.96'S	169° 29.93'W	5,593	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	1	3	el	0
87S0670PG02	05° 29.01'S	169° 30.83'W	5,645	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	1	5	el	0
87S0670PG03	05° 28.92'S	169° 28.86'W	5,590	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	1	6	el	0
(87431) Average			5,609								0.00	--	---	---	---	---	---	---	---					
87S0670PG04	05° 00.02'S	170° 00.13'W	5,381	(Quasi)Flat	9	73	16	2			13.82	P ,M	2.09	24.2	0.32	0.21	0.25	12.75	19.93	BC	0	0	d2	0
87S0670SC05	04° 59.03'S	170° 01.14'W	5,370	(Quasi)Flat					100		6.49	Pl	1.90	23.8	0.15	0.16	0.10	1.21	16.37	BC /BC	2	8	d2	0
87S0670PG06	04° 59.01'S	169° 59.14'W	5,389	(Quasi)Flat	--	--	--	--	--	--	(---)	-----	---	---	---	---	---	---	---	---	-	-	d2	0
(87432) Average			5,380		6	50	11	1	32		10.16	P ,Pl	2.03	24.1	0.26	0.19	0.20	9.05	18.79					
87S0671PG01	05° 30.27'S	170° 29.71'W	5,551	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	0	0	d2	0
87S0671PG02	05° 29.39'S	170° 30.59'W	5,544	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	-	-	-	d2	0
87S0671PG03	05° 29.41'S	170° 28.51'W	5,362	(Quasi)Seaknol							0.00	--	---	---	---	---	---	---	---	-	-	-	d1	0
(87433) Average			5,486								0.00	--	---	---	---	---	---	---	---					
87S0671PG04	05° 00.03'S	171° 00.00'W	5,627	(Quasi)Flat	100						0.01	Ef	---	---	---	---	---	---	---	BC	1	0	el	0
87S0671PG05	04° 59.04'S	171° 01.02'W	5,636	(Quasi)Flat		100					0.04	P	2.09	20.0	0.29	0.20	0.23	11.70	19.91	SC	0	0	el	0
87S0671PG06	04° 59.00'S	170° 59.02'W	5,581	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	1	5	el	0
(87434) Average			5,615		20	80					0.02	P ,Ef	2.00	20.0	0.29	0.20	0.23	11.70	19.91					
87S0672PG01	05° 29.85'S	171° 29.87'W	5,632	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	1	0	bc	0
87S0672PG02	05° 28.77'S	171° 30.81'W	5,605	(Quasi)Flat	21	79					0.22	Ef,Ot	2.09	23.5	0.86	0.90	0.14	21.70	7.60	BC	2	0	a	0
87S0672PG03	05° 28.65'S	171° 28.78'W	5,661	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	1	0	bc	0
(87435) Average			5,633		21	79					0.07	Ef,Ot	2.09	23.5	0.86	0.90	0.14	21.70	7.60					
87S0470PG07	03° 29.98'S	169° 59.96'W	4,938	(Quasi)Seaknol							0.00	--	---	---	---	---	---	---	---	-	-	-	d2	0
87S0470PG08	03° 28.96'S	170° 00.96'W	5,228	(Quasi)Seaknol	28	72					0.14	E ,P	2.03	30.8	1.06	1.04	0.14	21.72	7.50	BC	1	3	d2	0
87S0470PG09	03° 28.91'S	169° 58.97'W	5,203	(Quasi)Seaknol	9	41	18	32			14.68	M ,P	2.05	24.2	0.44	0.37	0.20	12.37	14.44	SCC	1	0	d2	0
(87436) Average			5,123		9	41	18	32			4.94	M ,P	2.05	24.2	0.44	0.38	0.20	12.45	14.38					

* sil% ; siliceous fossil % cal% ; calcareous fossil % T.P.L ; Transparent Layer

Data file around the Republic of Kiribati

(No. 7)

Sample No. (Station)	Location				Manganese Nodules														Geology				
					Size distribution (%)						Abundance	Shape	S.G. wet	H20 (%)	XRF Analyses (%)					Sediment			T.P.L.*	
	Latitude	Longitude	Depth (m)	Topography	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	(Kg/m2)				Ni	Cu	Co	Mn	Fe		sil%	cal%	type	thick. (m)
87S0470FG10	03° 44.95'S	169° 44.97'W	5,435	(Quasi)Flat	17	17	66				0.14	Ot	2.00	16.7	0.52	0.39	0.12	8.22	8.35	BC	1	0	c	0
87S0470FG11	03° 43.96'S	169° 46.06'W	5,422	(Quasi)Flat		100					0.92	Ot	---	---	---	---	---	---	---	BC	1	0	el	0
87S0470FG12	03° 43.93'S	169° 44.00'W	5,468	(Quasi)Flat	15	32		53			(1.26)	Ot	2.16	26.7	0.39	0.35	0.12	6.90	12.48	BC	1	0	el	0
(87437) Average			5,442		15	27	58	0			0.08	Ot	2.00	16.7	0.52	0.39	0.12	8.22	8.35					
87S0570FG07	03° 59.53'S	169° 30.20'W	5,191	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	-	-	-	ds	0
87S0570FG08	03° 58.51'S	169° 31.23'W	5,224	(Quasi)Flat	9	85	6				13.80	P	2.05	23.8	0.30	0.22	0.27	14.15	17.12	SCC	1	0	d2	0
87S0570FG09	03° 58.56'S	169° 29.24'W	5,299	(Quasi)Flat	1	10	66	23			19.78	M	2.00	27.1	0.23	0.15	0.38	18.21	19.52	SCC	1	0	ds	0
(87438) Average			5,238		4	41	41	14			11.19	M,P	2.02	25.8	0.26	0.18	0.33	16.50	18.51					
87S0570FG10	04° 14.97'S	169° 44.93'W	5,382	(Quasi)Flat	100						0.03	E,P	---	---	---	---	---	---	---	SC	0	90	el	0
87S0570FG11	04° 14.02'S	169° 45.95'W	5,291	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	-	-	-	ds	0
87S0570FG12	04° 14.01'S	169° 43.95'W	5,393	(Quasi)Flat		15	82	3			32.51	M,Sp	2.03	29.3	0.33	0.22	0.38	19.50	16.70	SC	0	90	ts	0
(87439) Average			5,355		0	15	82	3			10.85	M,Sp	2.03	29.3	0.33	0.22	0.38	19.50	16.70					
87S0570FG13	04° 30.22'S	170° 00.41'W	5,481	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	-	-	-	d2	0
87S0570FG14	04° 29.21'S	170° 01.46'W	5,347	(Quasi)Flat	7	69	17		7		11.76	Pl,P	1.94	22.4	0.12	0.13	0.11	0.83	12.84	BC	2	0	d2	0
87S0570FG15	04° 29.21'S	169° 59.45'W	5,519	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	-	-	-	d2	0
(87440) Average			5,449		7	69	17		7		3.92	Pl,P	1.94	22.4	0.12	0.13	0.11	0.83	12.84					
87S0570FG16	04° 45.00'S	169° 45.07'W	5,304	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	1	0	ds	0
87S0570FG17	04° 44.02'S	169° 46.11'W	5,208	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	-	-	-	ds	0
87S0570FG18	04° 43.99'S	169° 44.05'W	5,203	(Quasi)Flat		100					(0.06)	Ot	1.78	50.0	0.16	0.14	0.23	9.65	17.82	-	-	-	ds	0
(87441) Average			5,238			0					0.00	--	---	---	---	---	---	---	---					
87S0670FG07	05° 00.09'S	169° 29.98'W	5,257	(Quasi)Flat	1	11	69	16	3		24.82	M,Sp	2.01	27.5	0.24	0.14	0.39	17.90	20.32	BC	1	0	d2	0
87S0670FG08	04° 59.06'S	169° 31.03'W	5,273	(Quasi)Flat		7	87	6			44.03	M,Sp	2.00	28.2	0.26	0.14	0.43	19.69	19.56	BC	0	0	el	0
87S0670FG09	04° 59.06'S	169° 28.97'W	5,267	(Quasi)Flat	1	15	77	7			18.98	M	1.91	29.7	0.27	0.17	0.36	17.34	20.01	BC	1	0	d2	0
(87442) Average			5,266		1	10	80	9	1		29.28	M,Sp	1.98	28.3	0.26	0.15	0.41	18.68	19.87					

* sil% ; siliceous fossil % cal% ; calcareous fossil % T.P.L ; Transparent Layer

Data file around the Republic of Kiribati

Sample No. (Station)	Location				Manganese Nodules										XRF Analyses (%)					Geology				
					Size distribution (%)						Abundance	Shape	S.G. wet	H2O (%)						Sediment			T.P.L.*	
	Latitude	Longitude	Depth (m)	Topography	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	(Kg/m2)				Ni	Cu	Co	Mn	Fe		sil%	cal%	type	thick. (m)
87S0570FG19	04° 45.11'S	169° 15.01'W	5,229	(Quasi)Flat		5	55	40			39.95	M,Sp	1.99	23.9	0.23	0.13	0.39	18.39	19.77	-	-	-	d2	0
87S0570FG20	04° 44.21'S	169° 16.07'W	5,194	(Quasi)Flat		16	42	42			(2.04)	M,Bf	2.05	26.1	0.22	0.11	0.44	19.18	28.31	-	-	-	ds	0
87S0570FG21	04° 44.11'S	169° 14.06'W	4,992	(Quasi)Flat	3	36	61				29.52	M,P	2.05	30.7	0.23	0.15	0.36	16.16	26.75	CSC	0	0	d2	0
(87443) Average			5,138		1	18	58	23			34.74	M,Sp	2.02	26.8	0.23	0.13	0.38	17.49	20.16					
87S0569FG07	04° 30.41'S	169° 00.28'W	5,267	(Quasi)Platfor		45	52	3			28.36	M,P	2.09	26.2	0.28	0.20	0.30	15.97	19.31	BC	1	0	d1	0
87S0569FG08	04° 29.49'S	169° 01.39'W	5,229	(Quasi)Platfor							0.00	--	---	---	---	---	---	---	---	-	-	-	d1	0
87S0569FG09	04° 29.32'S	168° 59.28'W	5,554	(Quasi)Platfor	4		96				(0.38)	M	2.14	29.8	0.32	0.19	0.38	18.08	18.67	-	-	-	d1	0
(87444) Average			5,350		0	45	52	3			14.18	M,P	2.09	26.2	0.28	0.20	0.30	15.97	19.31					
87S0570FG22	04° 15.00'S	169° 15.02'W	5,530	(Quasi)Channel							0.00	--	---	---	---	---	---	---	---	-	-	-	ds	0
87S0570FG23	04° 14.00'S	169° 16.08'W	5,195	(Quasi)Channel							0.00	--	---	---	---	---	---	---	---	-	-	-	ds	0
87S0570FG24	04° 13.97'S	169° 14.08'W	5,321	(Quasi)Channel		13	51	36			(25.74)	M,Sp	2.01	28.1	0.21	0.13	0.39	17.72	20.09	-	-	-	ds	0
(87445) Average			5,349			0	0	0			0.00	--	---	---	---	---	---	---	---					
87S0470FG13	03° 44.80'S	169° 15.11'W	5,370	(Quasi)Channel	100						0.01	P	---	---	---	---	---	---	---	BC	1	0	d2	0
87S0470FG14	03° 43.80'S	169° 16.24'W	5,367	(Quasi)Channel	100						0.01	P	---	---	---	---	---	---	---	BC	2	0	d2	0
87S0470FG15	03° 43.85'S	169° 14.16'W	5,240	(Quasi)Channel							0.00	--	---	---	---	---	---	---	---	-	-	-	d1	0
(87446) Average			5,326		100						0.01	P	---	---	---	---	---	---	---					
87S0469FG01	03° 29.85'S	169° 00.07'W	5,821	(Quasi)Channel							0.00	--	---	---	---	---	---	---	---	BC	5	1	d2	0
87S0469FG02	03° 28.76'S	169° 01.15'W	5,750	(Quasi)Channel							0.00	--	---	---	---	---	---	---	---	BC	2	0	d2	0
87S0469FG03	03° 28.83'S	168° 59.13'W	6,031	(Quasi)Channel							0.00	--	---	---	---	---	---	---	---	BC	2	40	d2	0
(87447) Average			5,867								0.00	--	---	---	---	---	---	---	---					
87S0470FG16	03° 14.87'S	169° 14.98'W	4,003	(Quasi)Seaknol							0.00	--	---	---	---	---	---	---	---	CC	0	0	ds	0
87S0470FG17	03° 13.81'S	169° 16.00'W	3,913	(Quasi)Seaknol							0.00	--	---	---	---	---	---	---	---	-	-	-	ds	0
87S0470FG18	03° 13.86'S	169° 13.99'W	3,888	(Quasi)Seaknol							0.00	--	---	---	---	---	---	---	---	-	-	-	d1	0
(87448) Average			3,935								0.00	--	---	---	---	---	---	---	---					

* sil% ; siliceous fossil % cal% ; calcareous fossil % T.P.L ; Transparent Layer

Data file around the Republic of Kiribati

Sample No. (Station)	Location				Manganese Nodules										Geology									
					Size distribution (%)						Abundance	Shape	S.G. wet	H2O (%)	XRF Analyses (%)					Sediment			T.P.L.*	
	Latitude	Longitude	Depth (m)	Topography	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	(Kg/m2)				Ni	Cu	Co	Mn	Fe		sil%	cal%	type	thick. (m)
87S0470FG19	02° 59.93'S	169° 29.81'W	5,222	(Quasi)Flat	1	30	63	6			24.51	M ,Sp	2.00	29.3	0.27	0.20	0.35	18.47	20.71	-	-	-	d1	0
87S0470FG20	02° 58.89'S	169° 30.86'W	5,191	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	-	-	-	d2	0
87S0470FG21	02° 58.92'S	169° 28.90'W	4,871	(Quasi)Seaknol							0.00	--	---	---	---	---	---	---	---	-	-	-	d2	0
(87449) Average			5,095		1	30	63	6			8.17	Sp,M	2.00	29.3	0.27	0.20	0.35	18.47	20.71					
87S0370FG07	02° 44.94'S	169° 15.02'W	5,399	(Quasi)Flat	50	50					0.08	P ,E	2.00	30.0	1.14	1.01	0.12	23.65	8.51	BC	0	0	b	0
87S0370FG08	02° 44.00'S	169° 16.10'W	5,309	(Quasi)Flat	100						0.25	Sp,Bf	2.00	31.3	1.31	1.18	0.09	25.90	6.50	BC	0	0	b	0
87S0370FG09	02° 43.88'S	169° 14.12'W	5,370	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	0	90	b	0
(87450) Average			5,359		88	12					0.11	Sp,Bf	2.00	31.0	1.27	1.14	0.10	25.35	6.99					
87S0469FG04	03° 00.33'S	169° 00.15'W	5,335	(Quasi)Flat	100						0.06	Ot,E	2.00	25.0	0.87	0.57	0.16	15.58	7.20	SC	0	70	b	0
87S0469FG05	02° 59.38'S	169° 01.28'W	5,273	(Quasi)Flat	100						0.02	E	---	---	---	---	---	---	---	SC	2	60	b	0
87S0469FG06	02° 59.34'S	168° 59.23'W	5,308	(Quasi)Flat							0.00	--	---	---	---	---	---	---	---	BC	5	60	b	0
(87451) Average			5,305		100						0.03	Ot,E	2.00	25.0	0.87	0.57	0.16	15.58	7.20					
87S0369FG01	02° 29.84'S	168° 59.75'W	4,884	(Quasi)Platfor	1	61	38				12.39	P ,M	2.04	28.3	0.44	0.30	0.26	18.73	16.91	CC	3	70	d1	0
87S0369FG02	02° 28.84'S	169° 00.74'W	5,085	(Quasi)Platfor	4	32	32	20	12		10.92	M ,P	2.10	28.8	0.61	0.52	0.16	15.40	11.14	SCC	1	80	e1	0
87S0369FG03	02° 28.78'S	168° 58.77'W	5,245	(Quasi)Platfor	1	69	30				12.87	P ,Pt	2.04	28.3	0.49	0.38	0.22	17.17	15.50	CSC	0	0	d1	0
(87452) Average			5,071		2	55	33	6	4		12.06	P ,M	2.06	28.4	0.51	0.39	0.22	17.18	14.67					
87S0370FG10	02° 14.85'S	169° 15.12'W	5,689	(Mount)Flat							0.00	--	---	---	---	---	---	---	---	SC	0	0	b	0
87S0370FG11	02° 13.94'S	169° 16.22'W	5,601	(Mount)Flat							0.00	--	---	---	---	---	---	---	---	SC	0	0	b	0
87S0370FG12	02° 13.90'S	169° 14.12'W	5,608	(Mount)Flat	100						0.03	Sp,Pt	---	---	---	---	---	---	---	BC	0	0	b	0
(87453) Average			5,633		100						0.01	Sp,Pt	---	---	---	---	---	---	---					
87S0370FG13	02° 00.21'S	169° 29.93'W	4,720	(Mount)Seamoun		100					0.05	P	0.00	28.6	0.40	0.37	0.33	18.75	15.67	FO	5	0	d1	0
87S0370FG14	01° 59.26'S	169° 31.04'W	3,717	(Mount)Seamoun							0.00	--	---	---	---	---	---	---	---	-	-	-	d1	0
87S0370FG15	01° 59.21'S	169° 28.97'W	4,426	(Mount)Seamoun							0.00	--	---	---	---	---	---	---	---	-	-	-	d1	0
(87454) Average			4,288			100					0.02	P	0.00	28.6	0.40	0.37	0.33	18.75	15.67					

* sil% ; siliceous fossil % cal% ; calcareous fossil % T.P.L ; Transparent Layer

Data file around the Republic of Kiribati

Sample No. (Station)	Location				Manganese								Nodules								Geology				
					Size distribution (%)						Abundance	Shape	S.G. wet	H2O (%)	XRF Analyses (%)					Sediment			T.P.L.*	
	Latitude	Longitude	Depth (m)	Topography	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	(Kg/m2)				Ni	Cu	Co	Mn	Fe		sil%	cal%	type	thick. (m)
87S0369FG04	01° 59.98'S	168° 59.97'W	4,959	(Mount)Platfor	2	33	41	24			(5.07)	M ,P	1.98	28.9	0.42	0.30	0.23	17.47	16.92	CSC	0	0	ts	0
87S0369FG05	01° 59.00'S	169° 01.00'W	5,009	(Mount)Platfor							0.00	--	---	---	---	---	---	---	---	-	-	-	d2	0
87S0369FG06	01° 58.97'S	168° 59.02'W	5,118	(Mount)Platfor	8	58	34				1.85	Sp,E	2.04	24.5	1.21	1.37	0.10	26.71	6.40	SC	0	0	b	0
(87455) Average			5,029		8	58	34	0			0.93	Sp,E	2.04	24.5	1.21	1.37	0.10	26.71	6.40					
87S0270FG07	01° 44.80'S	169° 14.86'W	4,855	(Mount)Seamoun	58	36	6				3.36	P	2.08	22.2	0.34	0.26	0.24	13.75	14.18	CSC	0	0	d1	0
87S0270FG08	01° 43.83'S	169° 15.94'W	4,515	(Mount)Seamoun		100					0.04	E	---	---	---	---	---	---	---	FO	0	0	d1	0
87S0270FG09	01° 43.87'S	169° 13.94'W	5,307	(Mount)Seamoun							0.00	--	---	---	---	---	---	---	---	-	-	-	d1	0
(87456) Average			4,892		57	37	6				1.13	P	2.08	22.2	0.34	0.26	0.24	13.75	14.18					
87S0269FG01	01° 29.54'S	168° 59.68'W	5,653	(Mount)Channel	49	51					1.82	Sp,Ot	2.05	28.1	1.46	1.43	0.09	27.18	6.03	SC	3	0	d1	0
87S0269FG02	01° 28.51'S	169° 00.67'W	6,263	(Mount)Channel	4	20	12	46	18		8.11	Ot	1.92	28.6	0.65	0.56	0.14	15.07	9.91	SO	15	0	d1	0
87S0269FG03	01° 28.56'S	168° 58.73'W	5,907	(Mount)Channel			100				0.39	Ot	2.04	30.3	0.43	0.32	0.30	16.64	14.65	-	-	-	d1	0
(87457) Average			5,941		12	25	13	36	14		3.44	Ot,Sp	1.95	28.5	0.78	0.78	0.14	17.27	9.48					

* sil% ; siliceous fossil % cal% ; calcareous fossil % T.P.L ; Transparent Layer

Data file around the Republic of Kiribati (Cobalt rich Crust)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analysis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
87SA01AD01	05° 37.82′S	170° 12.39′W	2,060	Smt	112	20	1.86	33.1	0.90	0.86	0.13	29.68	14.55	Bulk
					3.00	17	1.98	31.4	0.86	0.84	0.13	29.23	14.45	A. Cubble
					1.51	50	1.86	34.6	0.88	0.75	0.12	28.75	15.69	B. Crust
					0.52	35	1.80	36.0	0.91	0.89	0.12	29.46	14.87	C. Slub
					0.38	13	2.06	30.6	1.00	1.00	0.12	32.46	12.93	D. Nodule
										—				
87SA01AD02	05° 31.10′S	170° 12.30′W	2,515	Smt(Mrg)	0	—	—	—	—	—	—	—	—	
87SA01CB03	05° 26.14′S	170° 12.27′W	2,700	Slp(Md)	188	30	1.90	35.1	0.73	0.55	0.13	25.69	17.60	Bulk
					1.72	25	1.88	33.0	0.78	0.61	0.10	26.08	17.04	A Crust
					4.45	60	1.96	32.5	0.73	0.58	0.13	26.50	17.49	B. Slub
					3.40	7	2.00	34.3	0.73	0.50	0.09	24.84	17.98	C. Massive
					1.80	30	1.90	34.4	0.72	0.57	0.13	24.10	16.19	D. Cobble
					0.80	18	2.00	32.8	0.72	0.57	0.15	25.29	17.53	E. Nodule
87SA01CB04	05° 44.96′S	170° 11.99′W	3,380	Slp(Lw)	15	1	—	—	—	—	—	—	—	
					0.006	3	—	44.4	0.67	0.35	0.09	24.27	19.53	A. Crust

Data file around the Republic of Kiribati (Cobalt rich Crust)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analysis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
87SA01CB05	05°41.17′ S	170°07.92′ W	3,380	Slp(Lw)	107	10	1.93	37.0	0.67	0.48	0.16	23.93	16.95	Bulk
					2.40	20	2.00	35.9	0.66	0.49	0.18	25.60	17.47	A. Crust
					1.29	17	1.90	47.4	0.70	0.38	0.09	25.69	19.66	B. Slub
					2.20	20	2.00	33.3	0.62	0.40	0.13	24.53	18.60	C. Massive
87SA01AD06	05°42.00′ S	170°15.22′ W	1,980	Smt(Crt)	8.50	25	2.05	33.3	0.86	0.66	0.12	28.4	15.5	Bulk
					0.40	35	1.93	34.5	0.79	0.61	0.10	28.3	16.1	A. Crust
					0.30	25	2.07	28.6	0.83	0.65	0.11	28.8	15.3	B. Slub
					0.10	5	—	44.4	0.96	0.61	0.11	25.4	17.6	C. Cobble
87SA01AD07	05°46.31′ S	170°17.32′ W	3,150	Slp(Lw)	16	10	—	—	—	—	—	—	—	
					0.38	10	—	36.1	0.74	0.70	0.17	29.23	16.20	A. Crust
87SA01AD08	05°29.78′ S	170°14.40′ W	2,890	Slp(Md)	15	2	—	33.3	0.82	0.51	0.12	25.09	16.57	Bulk
					2.90	5	—	38.6	0.74	0.44	0.13	24.89	17.54	A. Slub
					1.50	2	—	31.6	1.03	0.62	0.06	27.60	15.87	B. Massive

Data file around the Republic of Kiribati (Cobalt rich Crust)

(No. 3)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analysis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
87SA01AD09	05°34.37′S	170°13.86′W	2,210	Smt(Crt)	1.6	12	—	—	—	—	—	—	—	
					0.362	12	2.04	32.6	0.76	0.78	0.20	28.25	15.22	A. Slub
87SA01CB10	05°34.89′S	170°09.41′W	3,100	Slp(Md)	75	10	2.06	20.8	0.59	0.42	0.11	25.27	19.00	Bulk
					1.50	22	2.00	31.5	0.56	0.39	0.11	25.00	19.05	A. Crust
					0.90	25	2.05	34.2	0.58	0.45	0.12	25.44	18.73	B. Crust
87SA01AD11	05°35.84′S	170°13.66′W	1,910	Smt(Crt)	116	20	2.00	37.9	1.01	0.92	0.09	30.71	11.35	Bulk
					2.25	15	1.93	32.1	0.98	0.84	0.09	29.82	12.45	A. Slub(Up)
					2.25	10	2.14	32.6	1.20	0.91	0.09	32.17	13.28	A. 〃 (Lw)
					1.30	13	1.86	41.2	1.01	0.71	0.07	29.04	16.09	B. Crust(Up)
					1.30	35	2.00	32.3	1.01	0.88	0.10	29.23	10.80	B. 〃 (Lw)
					1.26	10	1.98	37.7	0.97	0.86	0.09	31.67	14.03	C. Cobble(Up)
					1.26	15	2.04	32.1	1.18	0.96	0.09	31.79	11.04	C. 〃 (Lw)
					0.70	15	1.88	24.7	0.94	0.83	0.09	31.52	13.87	D. Cobble
					0.106	15	2.08	32.0	1.06	0.95	0.12	30.83	12.55	E. Nodule

Data file around the Republic of Kiribati (Cobalt rich Crust)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analysis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
87SA01AD12	05°39.66′S	170°14.27′W	1,970	Smt(Crt)	37	35	1.83	35.53	0.79	0.79	0.10	28.19	13.74	Bulk
					1.96	12	1.91	31.82	1.01	0.67	0.07	28.73	16.54	A. Slub(Up)
					1.96	17	2.06	32.79	0.95	0.83	0.10	30.03	13.59	A. 〃 (Md)
					1.96	17	2.05	37.50	0.93	0.78	0.10	29.58	14.13	A. 〃 (Lw)
							2.00	35.14	0.77	0.77	0.10	26.90	12.35	A. 〃 (Bulk)
					0.70	20	2.05	36.84	0.56	0.81	0.11	26.52	12.54	B. Slub
87SA01CB13	05°37.50′S	170°16.25′W	3,300	Slp(Lw)	27	0.001	—	—	—	—	—	—	—	rock
87SA02CB01	04°24.59′S	170°11.68′W	2,800	Slp(Lw)	0.1	—	—	—	—	—	—	—	—	Coral , Shell
87SA02AD02	04°24.23′S	170°15.21′W	1,960	Slp(Up)	0.48	0.1	—	—	—	—	—	—	—	rock
87AS02AD03	04°25.69′S	170°15.55′W	1,140	Slp(Up)	500	—	—	—	—	—	—	—	—	Coral
87SA02AD04	04°23.88′S	170°18.56′W	2,835	Slp(Md)	28	—	—	—	—	—	—	—	—	Coral
		W												
87SA02AD05	04°32.00′S	170°18.01′W	3,460	Slp(Lw)	31	—	—	—	—	—	—	—	—	Coral

Data file around the Republic of Kiribati (Cobalt rich Crust)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analysis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
87SA02AD06	04° 27.88′ S	171° 16.45′W	1,120	Slp(Up)	54	0.1	—	—	—	—	—	—	—	Coral
									0.18	—	0.02	4.18	2.89	A.
87SA02AD07	04° 30.03′ S	171° 13.96′W	1,990	Slp(Up)	160	< 1	—	—	—	—	—	—	—	Coral
									0.19	—	0.02	4.98	3.11	A. Crust Coating
87SA02AD08	04° 27.79′ S	171° 10.26′W	2,450	Slp(Md)	0.118	2								
					0.05	3	2.13	23.5	0.36	0.47	0.12	10.51	12.58	A. Crust Coating
87SA03AD01	03° 54.14′ S	170° 57.28′W	1,790	Slp(Up)	115	30	2.11	39.47	0.61	0.86	0.08	23.88	9.04	Bulk
					3.57	10	1.89	37.50	1.07	0.81	0.06	31.39	14.28	A. Crust(Up)
					3.57	12	1.96	28.00	0.41	0.85	0.09	21.96	7.58	A. 〃 (Lw)
					1.225	12	2.00	32.7	0.92	0.89	0.08	30.68	12.19	B. Crust(Up)
					1.225	35	2.14	32.1	0.50	0.90	0.09	22.92	7.30	B. 〃 (Lw)

Data file around the Republic of Kiribati (Cobalt rich Crust)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analysis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
87SA03AD02	03° 52.82′ S	170° 55.60′W	1,310	Smt(Crt)	147	20	2.00	43.75	1.38	1.00	0.09	28.76	9.30	Bulk
					1.13	6	2.25	24.2	0.57	1.07	0.16	13.85	5.66	A.Crust
					2.60	20	2.03	20.0	1.21	0.92	0.06	29.65	9.23	B. 〃
					0.745	5	2.10	33.3	1.54	0.75	0.05	32.19	13.45	C.Crust(Up)
					0.745	20	2.00	40.0	1.11	0.86	0.06	29.97	10.59	C. 〃 (Lw)
87SA03AD03	03° 56.07′ S	170° 54.78′W	2,700	Slp(Md)	—	—	—	—	—	—	—	—	—	
87SA03AD04	03° 56.00′ S	170° 55.02′W	2,450	Slp(Md)	29	30	2.00	37.3	0.77	0.65	0.12	25.59	14.55	Bulk
					4.60	15	2.05	31.8	0.73	0.59	0.10	27.29	17.52	A.Crust(Up)
					4.60	40	2.19	27.6	0.63	0.50	0.13	18.31	10.80	A. 〃 (Lw)
					3.05	6	2.10	33.3	0.67	0.56	0.07	27.56	17.38	B. Slub
					0.82	5	2.15	34.6	0.34	0.24	0.09	12.00	9.68	C.Crust
					0.24	2	2.14	37.3	0.61	0.59	0.10	18.66	12.15	D.Cobble
87SA03OB05	03° 53.20′ S	170° 52.02′W	3,000	Slp(Md)	9	2	2.08	43.5	0.36	0.26	0.10	13.84	14.24	Bulk
					5.7	3	2.00	30.8	0.56	0.42	0.10	25.90	18.82	A.Crust
					0.47	2	2.05	33.3	0.56	0.33	0.08	20.05	17.37	B.Crust

Data file around the Republic of Kiribati (Cobalt rich Crust)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analysis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
87SA03CB06	03° 43.58′ S	170° 47.91′ W	2,620	Slp(Md)	2.2	20	1.94	33.00	0.75	0.75	0.14	27.88	15.35	Bulk
					0.68	10	2.00	38.5	0.75	0.80	0.15	27.58	14.57	A. Slub
					1.50	30	1.94	30.00	0.76	0.76	0.12	28.28	15.92	B. Slub
87SA03AD07	03° 43.67′ S	170° 39.93′ W	1,760	Slp(Up)	40	2	—	—	—	—	—	—	—	
					0.66	4	—	33.3	1.17	0.61	0.07	24.77	14.77	A. Crust
					1.10	2	—	36.4	1.03	0.56	0.05	21.76	13.23	B. Crust
									—					
87SA03AD08	03° 47.24′ S	170° 42.98′ W	2,500	Slp(Md)	0.5	5	—	—	—	—	—	—	—	
					0.375	5	2.25	28.6	0.85	1.07	0.15	25.92	9.75	A. Crust
87SA03AD09	03° 52.06′ S	170° 54.57′ W	2,010	Smt(Mrg)	16	4	—	—	—	—	—	—	—	
					5.25	4	—	23.1	0.25	0.47	0.13	10.50	7.93	A. Crust
87SA03JD10	03° 40.06′ S	170° 45.18′ W	2,020	Slp(Md)	6	20	—	—	—	—	—	—	—	
					0.88	20	—	35.8	0.93	0.63	0.07	27.36	17.18	A. Crust

Data file around the Republic of Kiribati (Cobalt rich Crust)

(No. 8)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analysis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
87SA03CB11	03°40.84′S	170°38.38′W	3,060	Slp(Md)	0	—	—	—	—	—	—	—	—	
87SA03CB12	03°44.63′S	170°37.18′W	2,600	Slp(Md)	49	20	1.96	35.3	0.81	0.74	0.10	28.73	15.27	Bulk
					3.00	20	2.00	31.8	0.83	0.67	0.09	29.06	16.04	A.Cobble(Up)
					3.00	12	1.91	30.2	0.77	0.73	0.11	27.52	14.20	A. 〃 (Md)
					3.00	17	1.91	33.3	0.98	0.76	0.11	31.01	14.35	A. 〃 (Lw)
					2.10	27	1.88	27.57	0.78	0.68	0.08	28.84	16.74	B.Crust
					4.50	15	1.95	40.5	0.84	0.74	0.09	29.59	15.93	C.Cobble(Up)
					4.50	15	2.00	33.3	1.01	0.70	0.15	29.84	14.24	C. 〃 (Md)
					4.50	11	1.91	33.3	0.79	0.73	0.10	29.79	15.64	C. 〃 (Lw)
							2.00	32.9	0.89	0.77	0.11	28.93	14.71	A.Bulk
							—	28.6	0.92	0.68	0.12	29.40	14.75	C.Bulk
87SA03AD13	03°42.71′S	170°44.30′W	810	Smt(Mrg)	0.76	< 1	—	—	—	—	—	—	—	rock
87SA04AD01	00°35.71′S	170°58.49′W	2,620	Slp (Md)	51	2	—	—	—	—	—	—	—	
					1.00	3	—	23.5	0.49	0.41	0.07	22.46	17.48	A.Crust

Data file around the Republic of Kiribati (Cobalt rich Crust)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analysis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
87SA04AD02	00° 36.24′ S	171° 02.29′ W	1,760	Slp(Up)	53	15	2.28	35.0	0.86	0.76	0.05	29.05	13.25	Bulk
					3.8	10	1.80	39.3	1.37	0.84	0.05	33.16	13.39	A. Crust(Up)
					3.8	15	2.20	37.5	0.51	0.90	0.07	23.40	8.05	A. 〃 (Lw)
					3.8		2.09	37.0	1.18	0.82	0.05	32.61	13.83	A. 〃 (Bulk)
					2.5	10	1.90	36.8	0.79	0.60	0.05	21.46	12.51	B.
87SA04AD03	00° 38.15′ S	170° 54.91′ W	2,950	Slp(Md)	2.3	50	1.88	36.7	0.72	0.49	0.11	27.28	17.65	Bulk
						10	2.00	39.1	0.64	0.46	0.07	27.56	18.89	A. Crust(Up)
						10	1.87	35.7	0.77	0.65	0.09	29.59	16.38	A. 〃 (Md)
						15	1.95	33.3	0.82	0.56	0.11	28.64	16.75	A. 〃 (Lw1)
						15	1.94	36.5	0.61	0.53	0.14	27.57	17.20	A. 〃 (Lw2)
87SA04AD04	00° 39.67′ S	170° 58.97′ W	2,500	Slp(Md)	21	5	—	—	—	—	—	—	—	
					0.36	20	2.00	38.2	0.62	1.01	0.11	28.80	15.97	A. Crust
87SA04AD05	00° 39.79′ S	171° 02.34′ W	2,550	Slp(Md)	0	—	—	—	—	—	—	—	—	

Data file around the Republic of Kiribati (Cobalt rich Crust)

(No. 10)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analysis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
87SA04AD06	00° 38.13′ S	171° 00.82′ W	1,290	Smt(Crt)	350	15	2.09	26.9	0.81	0.86	0.06	28.18	11.48	Bulk
					3.0	25	1.96	32.8	0.79	0.87	0.04	28.64	9.78	A. Crust(Bulk)
					3.0	10	1.95	28.4	0.96	0.69	0.04	30.00	14.01	A. 〃 (Up)
					3.0	20	2.12	29.2	0.85	0.85	0.04	27.77	9.36	A. 〃 (Lw)
					1.5	30	2.13	29.4	1.02	0.83	0.06	30.41	11.35	B. Crust(Bulk)
					1.5		2.13	31.4	1.00	0.82	0.06	32.72	13.84	B. 〃 (Up)
					1.5		2.08	26.9	0.92	0.77	0.06	27.32	11.24	B. 〃 (Lw)
87SA04AD07	00° 37.45′ S	170° 57.66′ W	2,160	Slp(Md)	8.4	15	2.00	31.3	0.82	0.82	0.10	26.70	11.23	Bulk
					0.49	3	1.83	33.3	0.61	0.36	0.06	20.92	16.22	A. Crust
					2.10	30	1.85	36.4	0.92	0.87	0.12	28.96	11.57	B. Cobble(Bulk)
					2.10	30	2.00	36.4	1.14	0.87	0.09	31.40	12.42	B. 〃 (Up)
					2.10	30	1.87	30.8	0.41	0.68	0.12	19.58	8.66	B. 〃 (Lw)
					0.70	8	1.89	40.0	1.06	0.89	0.13	27.76	13.85	C. Cobble
87SA04CB08	00° 33.76′ S	171° 00.31′ W	3,400	Slp(Lw)	0	—	—	—	—	—	—	—	—	

Data file around the Republic of Kiribati (Cobalt rich Crust)

(No. 11)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analksis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
87SA04CB09	00°37.53′S	171°03.76′W	3,000	Slp(Md)	72	30	1.84	40.0	0.75	0.76	013	24.60	13.69	Bulk
						25	1.97	34.2	0.93	0.44	0.08	29.62	15.65	A. Crust
						40	2.33	22.2	0.51	1.28	0.16	23.00	8.69	B. Crust
						25	1.70	45.0	1.12	0.23	0.31	12.33	1415	C. Crust
87SA04AD10	00°42.07′S	170°59.97′W	3,190	Slp(Lw)	60	10	—	32.6	0.58	0.35	0.09	21.64	18.92	Bulk
					2.9	17	1.91	37.10	0.74	0.39	0.08	24.92	19.50	A. Massive
					0.88	2	—	44.4	0.66	0.71	0.21	15.24	14.34	B. Massive
87SA05AD01	00°35.90′S	170°35.17′W	1,195	Smt	120	7	1.96	36.2	1.38	0.61	0.04	30.98	15.62	Bulk
					0.50	7	1.94	36.4	1.33	0.62	0.04	31.71	15.24	A. Crust
					1.50	5	2.00	34.2	1.34	0.59	0.04	30.79	15.67	B. Crust
87SA05AD02	00°35.81′S	170°32.96′W	2,110	Slp(Up)	66	50								
					3.5	50	1.93	35.0	0.93	0.71	0.06	29.24	14.27	A. Crust(Bulk)
						8	1.96	40.0	0.92	0.68	0.05	30.73	15.97	A. 〃 (Up)
						18	2.00	34.6	1.08	0.79	0.06	31.36	12.96	A. 〃 (Md)

Data file around the Republic of Kiribati (Cobalt rich Crust)

Sample No.	Latitude	Longitude	Depth (m)	Topography	Weight (kg)	Thickness (mm)	S.G.wet	H_2O	XRF Analysis (%)					Ramarks
									Co	Ni	Cu	Mn	Fe	
						14	1.97	35.3	0.60	0.88	0.08	25.03	8.70	A. Crust(Lw)
						2	1.79	33.3	1.09	0.87	0.10	27.11	15.28	A. 〃 (Under)
87SA05AD03	00° 36.08′ S	170° 31.17′ W	3,000	Slp(Md)	1.4	5	—	—	—	—	—	—	—	
					1.16	5	1.91	40.0	0.55	0.29	0.06	18.75	18.60	A. Crust
87SA05AD04	00° 34.89′ S	170° 35.21′ W	1,900	Slp(Up)	63	14		—	—	—	—	—	—	
					34	14	2.00	32.4	1.35	0.66	0.10	29.50	13.83	A. Crust

Monthly Frequency Distribution of Wind Velocity in 1987

(W.V : m/sec)

W.V / Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
September	12	32	68	54	61	90	52	43	48	35	38	13	3	3	1		553
%	2.18	5.79	12.30	9.76	11.03	16.27	9.40	7.78	8.68	6.33	6.87	2.35	0.54	0.54	0.18		
October	1	10	9	36	47	113	71	55	36	25	15	11	2	0	0	2	433
%	0.23	2.31	2.08	8.31	10.85	26.10	16.40	12.70	8.31	5.77	3.46	2.54	0.47	0	0	0.47	

Monthly Frequency Distribution of Wind Direction in 1987

W.D / Month	CALM	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
September	12	3	21	32	56	123	127	57	32	31	16	15	10	8	2	6	12	553
%	2.17	0.54	3.80	5.79	10.13	22.24	22.97	10.31	5.79	5.61	2.89	2.71	1.81	1.45	0.36	1.08	2.17	
October	1	7	21	52	63	140	59	63	14	2	0	0	0	0	0	8	3	433
%	0.23	1.62	4.85	12.01	14.55	32.33	13.63	14.55	3.23	0.46	0	0	0	0	0	1.85	0.69	

Monthly Frequency Distribution of Weather in 1987

Weather / Month	Fine	Cloudy	Rain	Total	Light rain
September	17	5	1	23	15
%	73.91	21.74	4.35		(65.22)
October	11	7	0	18	9
%	61.11	38.89	0		(50.00)

Monthly Frequency Distribution of Atmospheric Pressure (daily average) in 1987

(A.P : mb)

A.P / Month	1007.1 ~ 1008.0	1008.1 ~ 1009.0	1009.1 ~ 1010.0	1010.1 ~ 1011.0	1011.1 ~ 1012.0	1012.1 ~ 1013.0	1013.1 ~ 1014.0	1014.1 ~ 1015.0	1015.1 ~ 1016.0	1016.1 ~ 1017.0	1017.1 ~ 1018.0	1018.1 ~ 1019.0	Total
September		21	75	103	106	124	65	40	14	5			553
%		3.80	13.56	18.63	19.17	22.42	11.75	7.23	2.53	0.90			
October	5	42	83	98	95	63	24	16	7				433
%	1.15	9.70	19.17	22.63	21.94	14.55	5.54	3.70	1.62				

Monthly Frequency Distribution of Swell Direction in 1987

S.D / Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	NSW	W	NNW	NW	NNW	Not clear	Total
September				2	8	21	18	6	14								70	139
%				1.44	5.76	15.11	12.95	4.32	10.07								50.36	
October	2	2	2	4	8	7	15	11	1						1	1	55	109
%	1.83	1.83	1.83	3.67	7.34	6.42	13.76	10.09	0.92						0.92	0.92	50.46	

Monthly Frequency Distribution of Swell Cycle in 1987

(S.C : sec)

S.C / Month	5	6	7	8	9	10	11	12	13	14	15	Not clear	Total
September		2	27	34	6							70	139
%		1.44	19.42	24.46	4.32							50.36	
October		2	7	17	6	20	1	1				55	109
%		1.83	6.42	15.60	5.50	18.35	0.92	0.92				50.46	

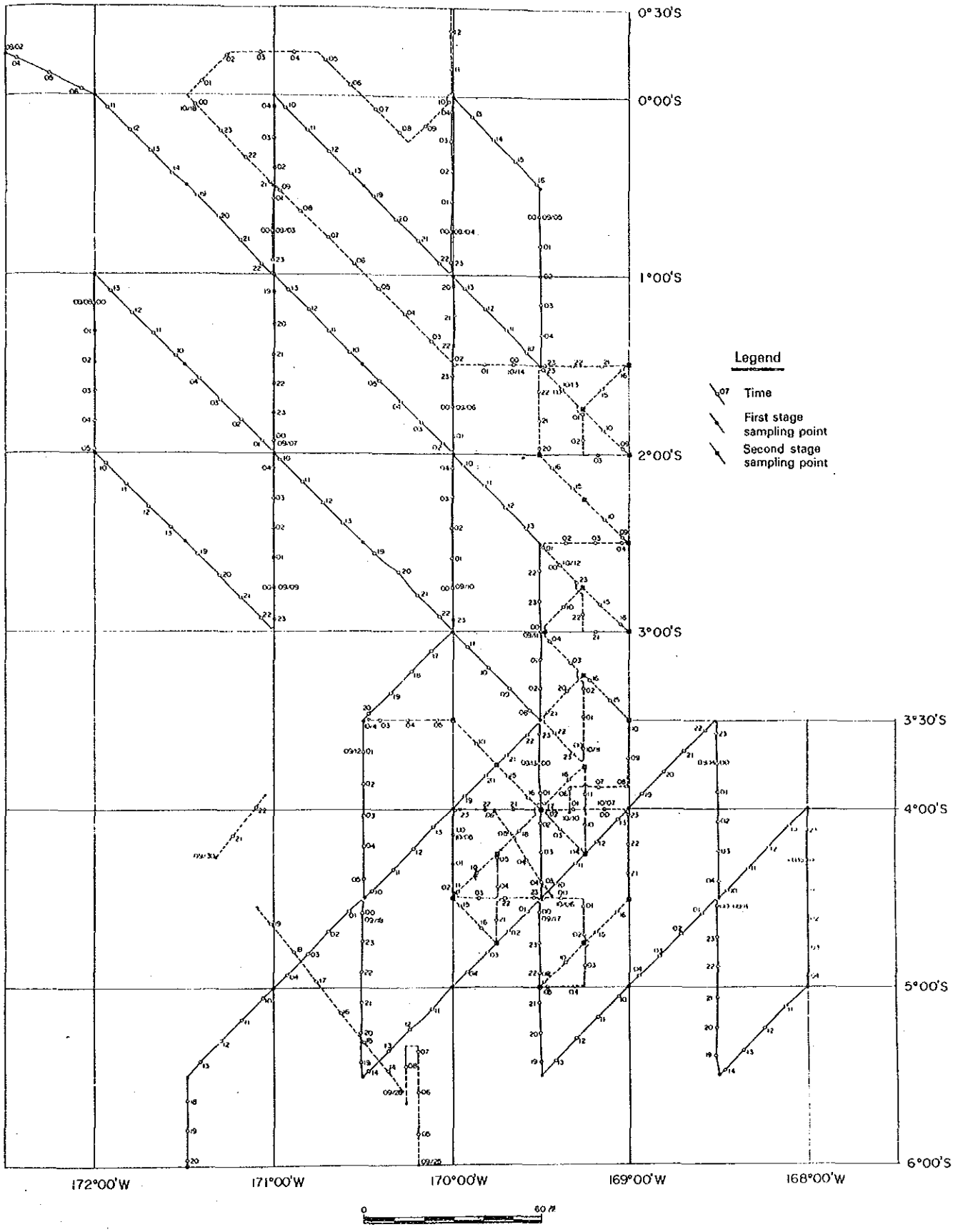
Monthly Frequency Distribution of Swell Height in 1987

(S.H : m)

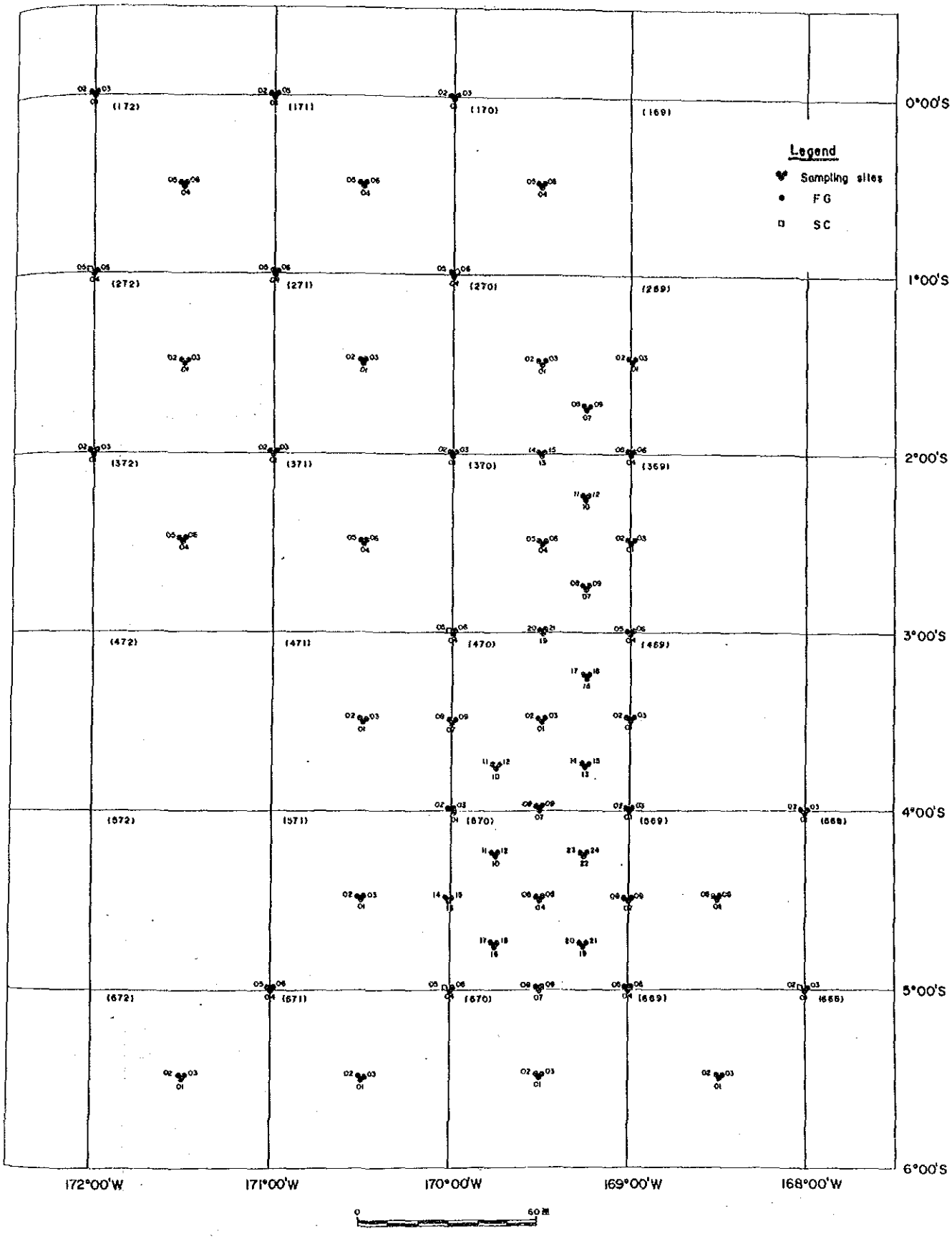
S.H / Month	1	2	3	4	5	Not clear	Total
September	6	40	21	1	1	70	139
%	4.32	28.78	15.11	0.72	0.72	50.36	
October		11	38	4	1	55	109
%		5.26	34.86	3.67	0.92	50.46	

Monthly Frequency Distribution of Degree of Cloudiness in 1987

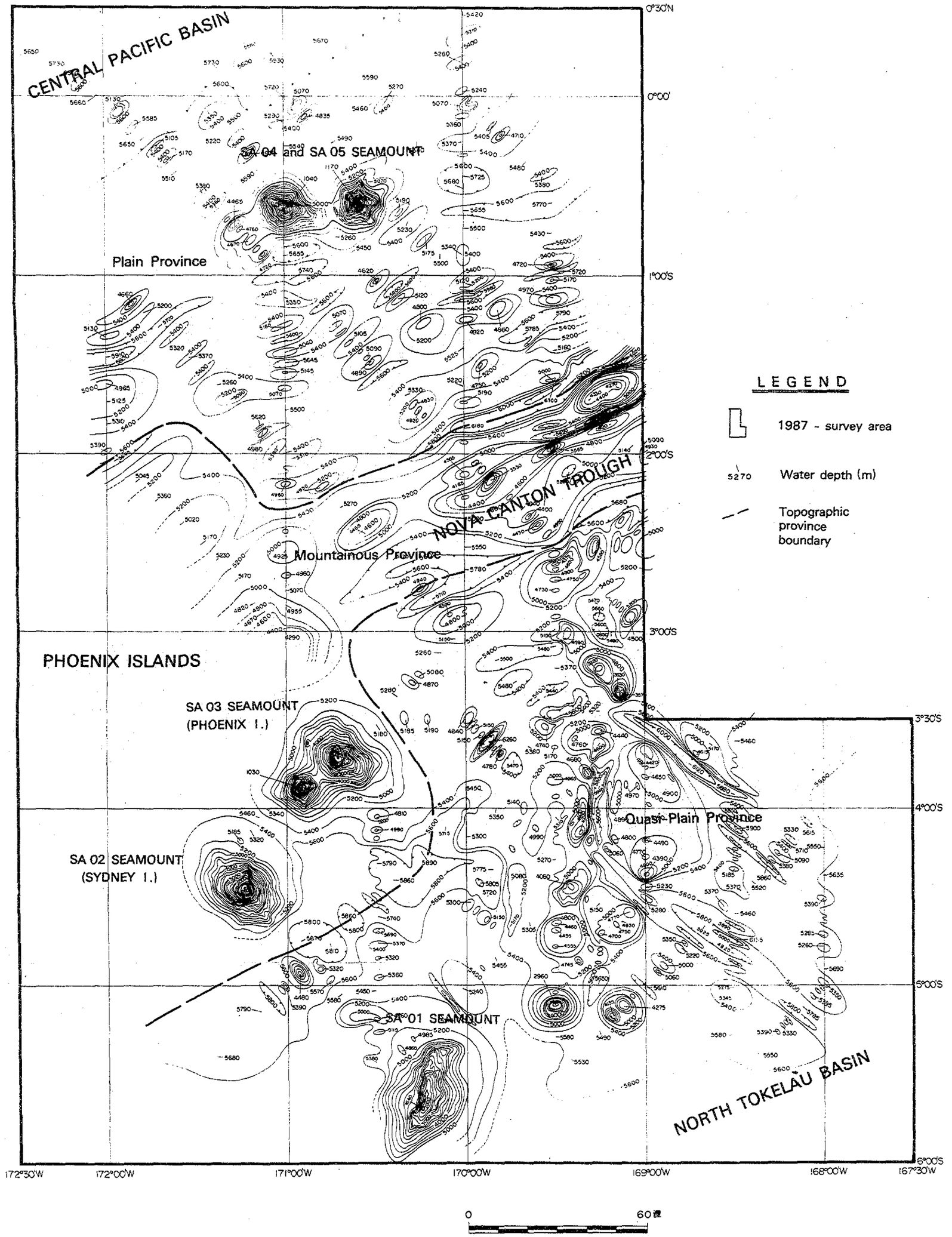
D.C / Month	0	1	2	3	4	5	6	7	8	9	Total
September		9	57	123	83	92	108	41	40		553
%		16.27	10.31	22.24	15.01	16.64	19.53	7.41	7.23		
October		1	34	68	51	69	95	53	62		433
%		0.23	7.85	15.70	11.78	15.94	21.94	12.24	14.32		



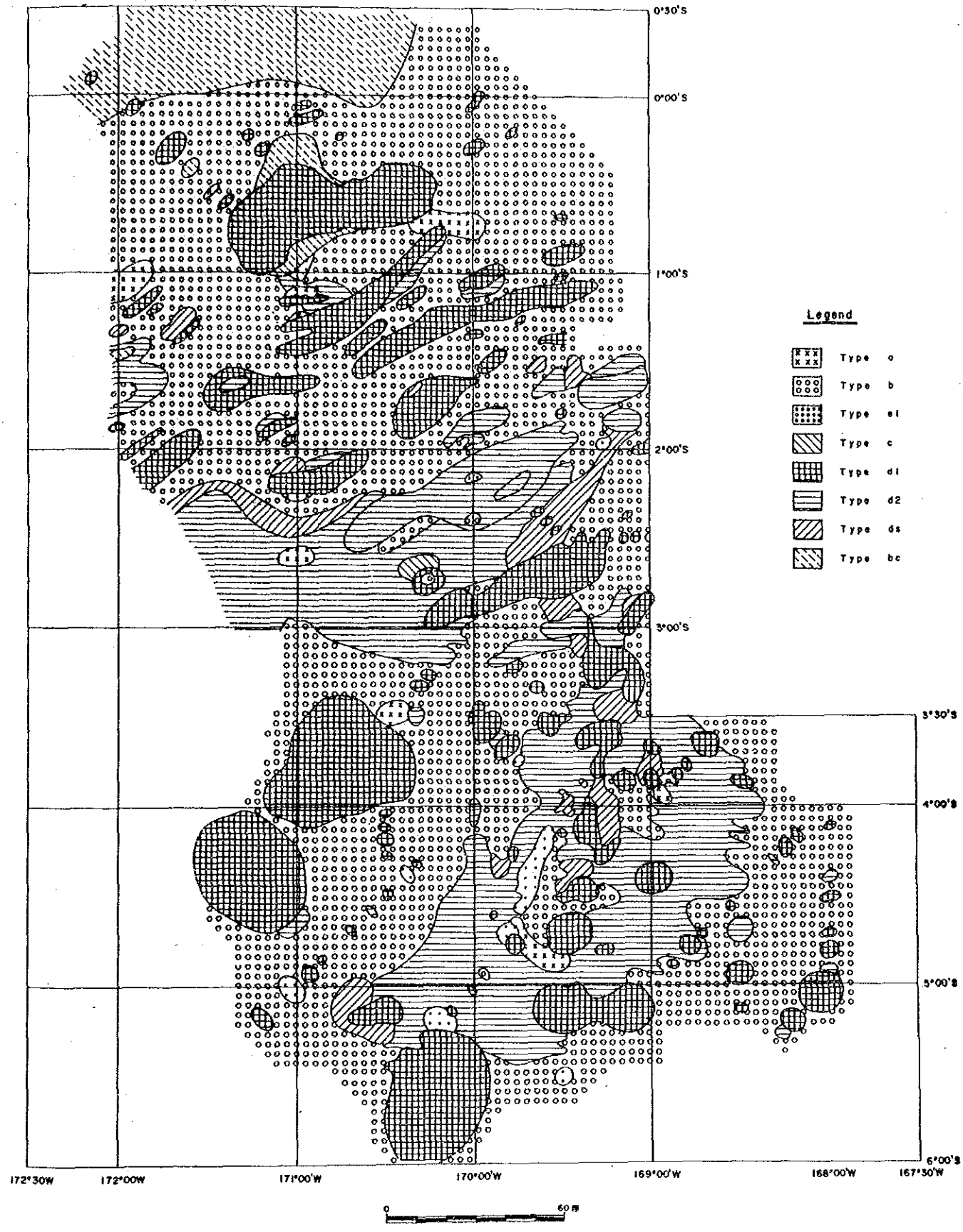
Annexed Figure 1 Trackline Map



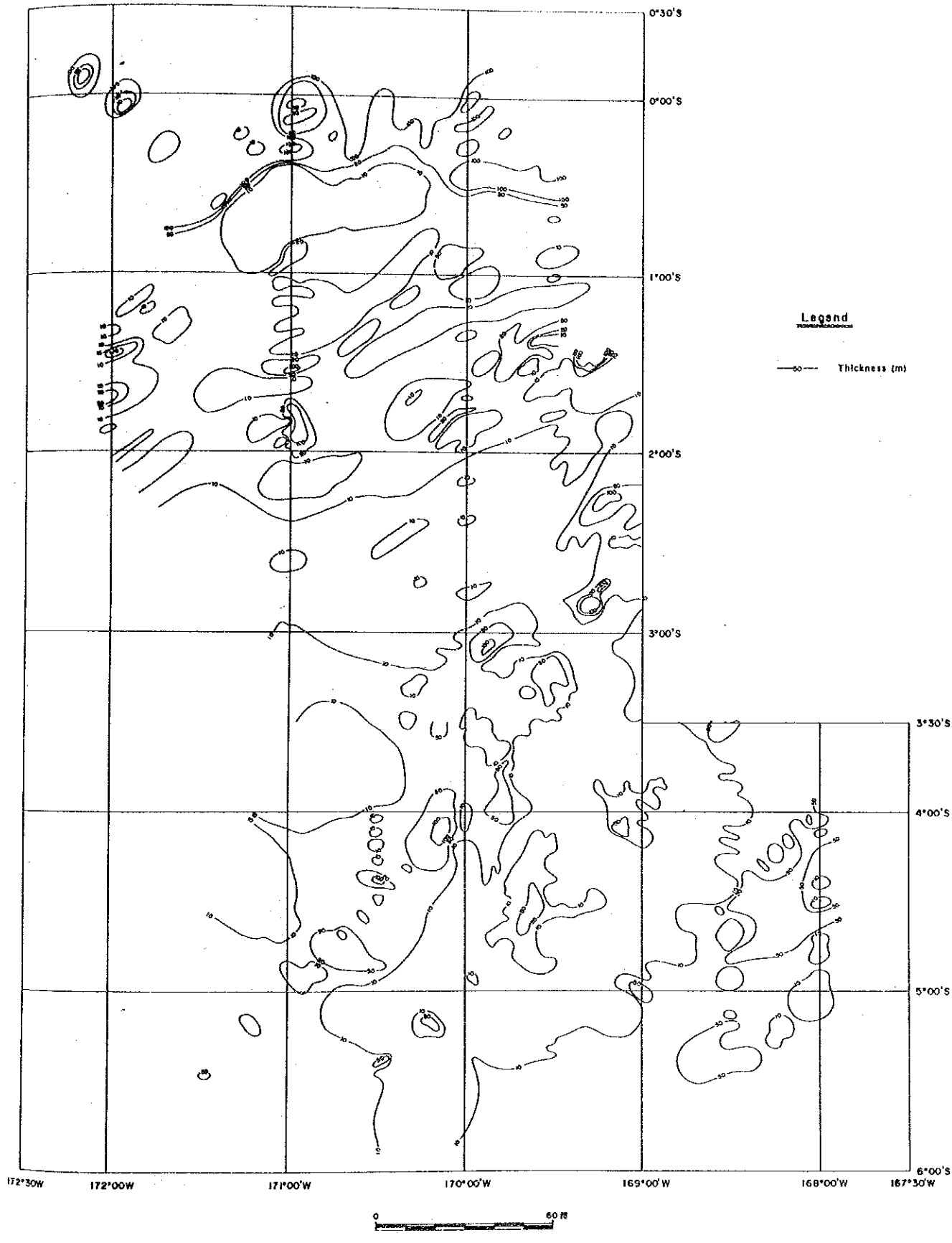
Annexed Figure 2 Positions of Sampling Points



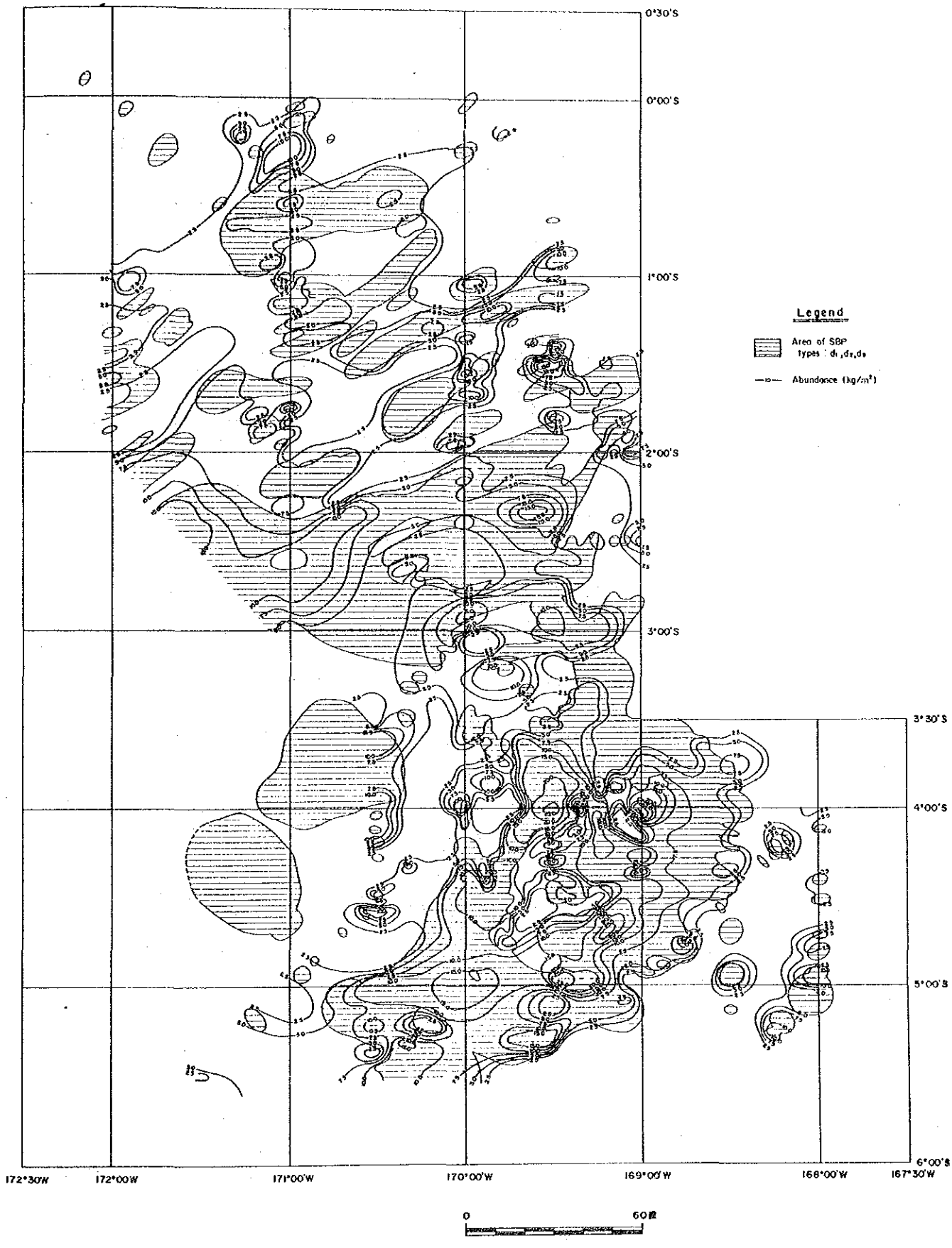
Annexed Figure 3 Sea Floor Topography



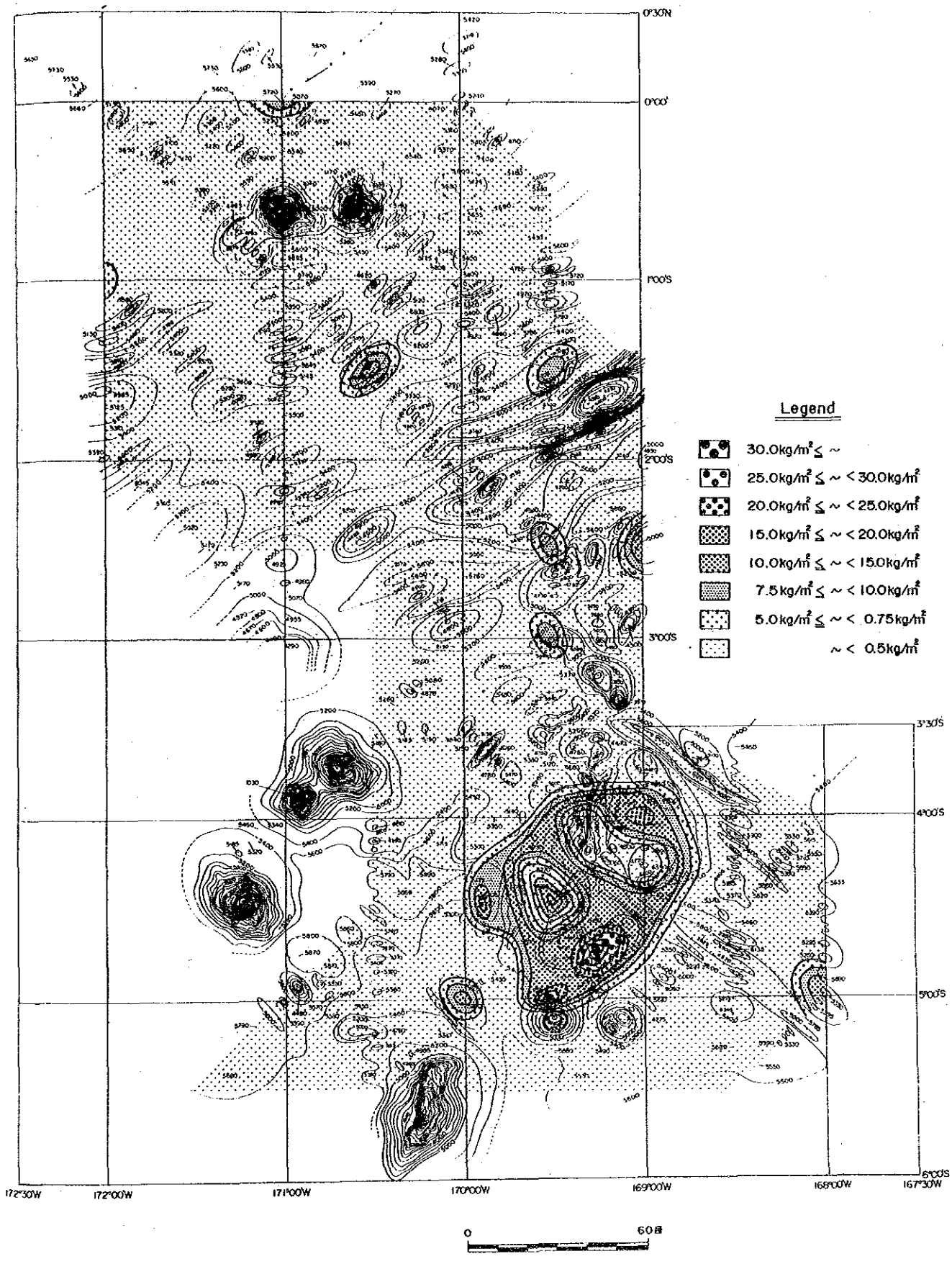
Annexed Figure 4 Distribution of SBP Types



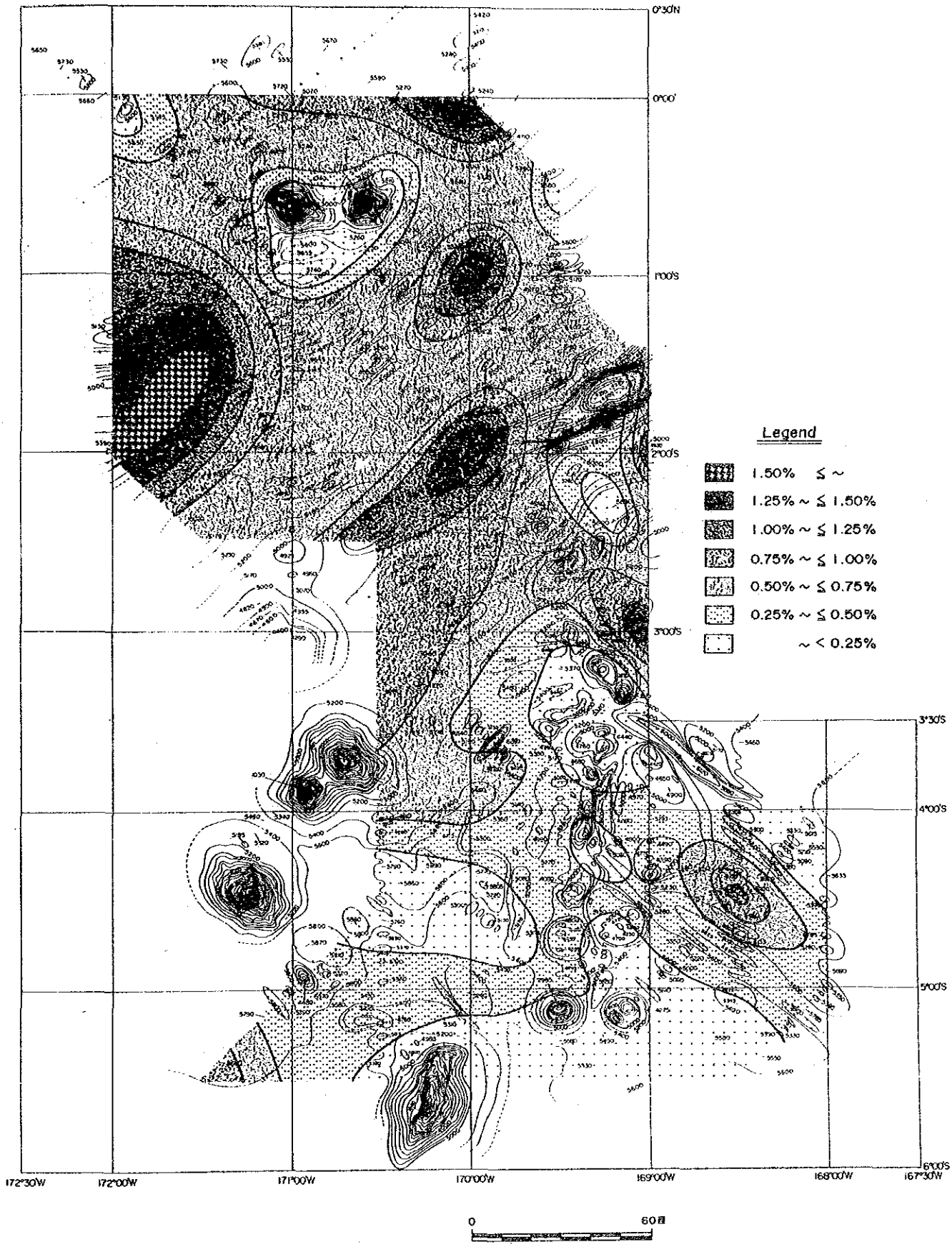
Annexed Figure 5 Acoustic Thickness of Upper Transparent Layers Obtained by SBP Survey



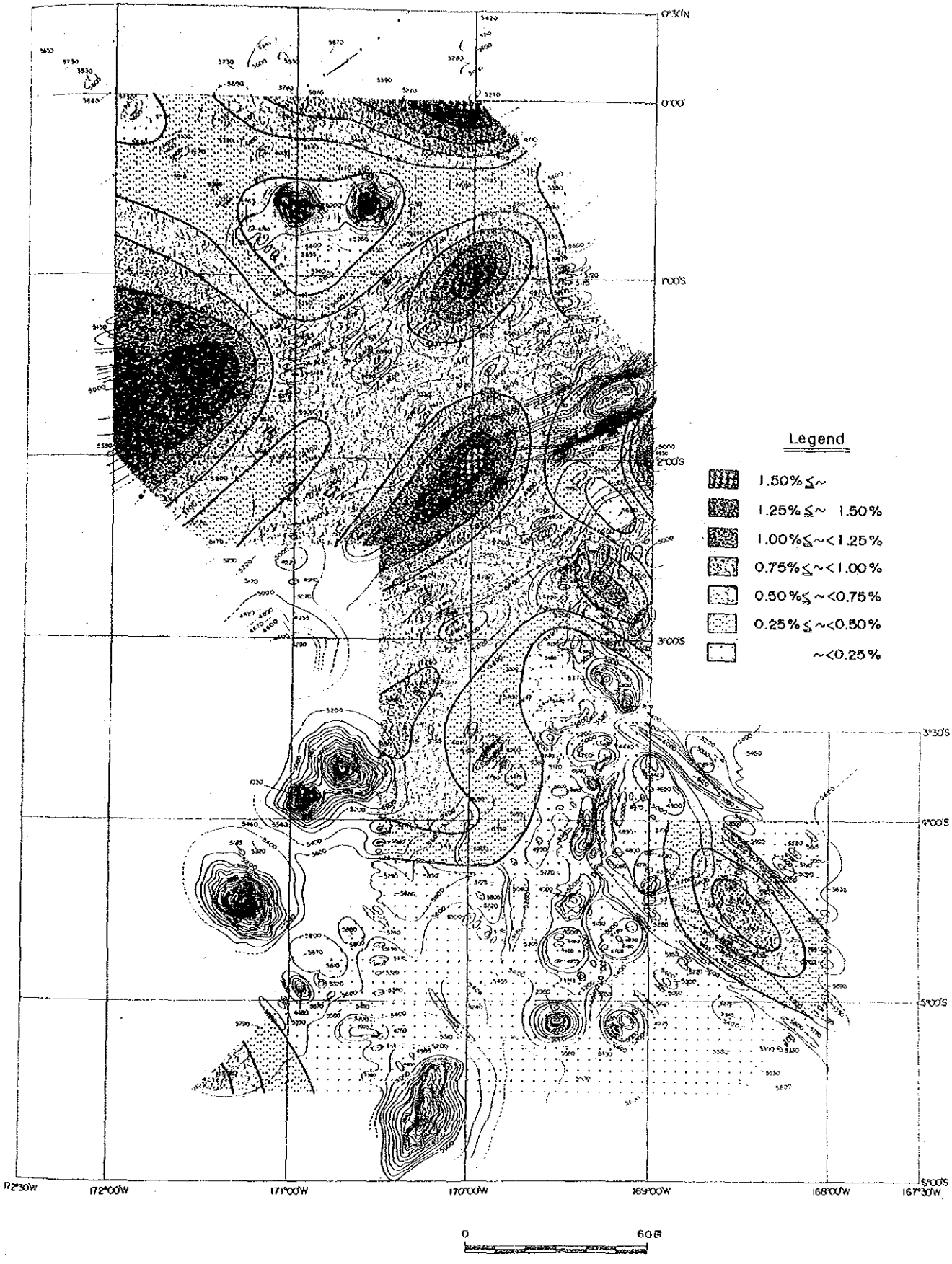
Annexed Figure 6 Estimated Abundance Map of Manganese Nodules by MFES



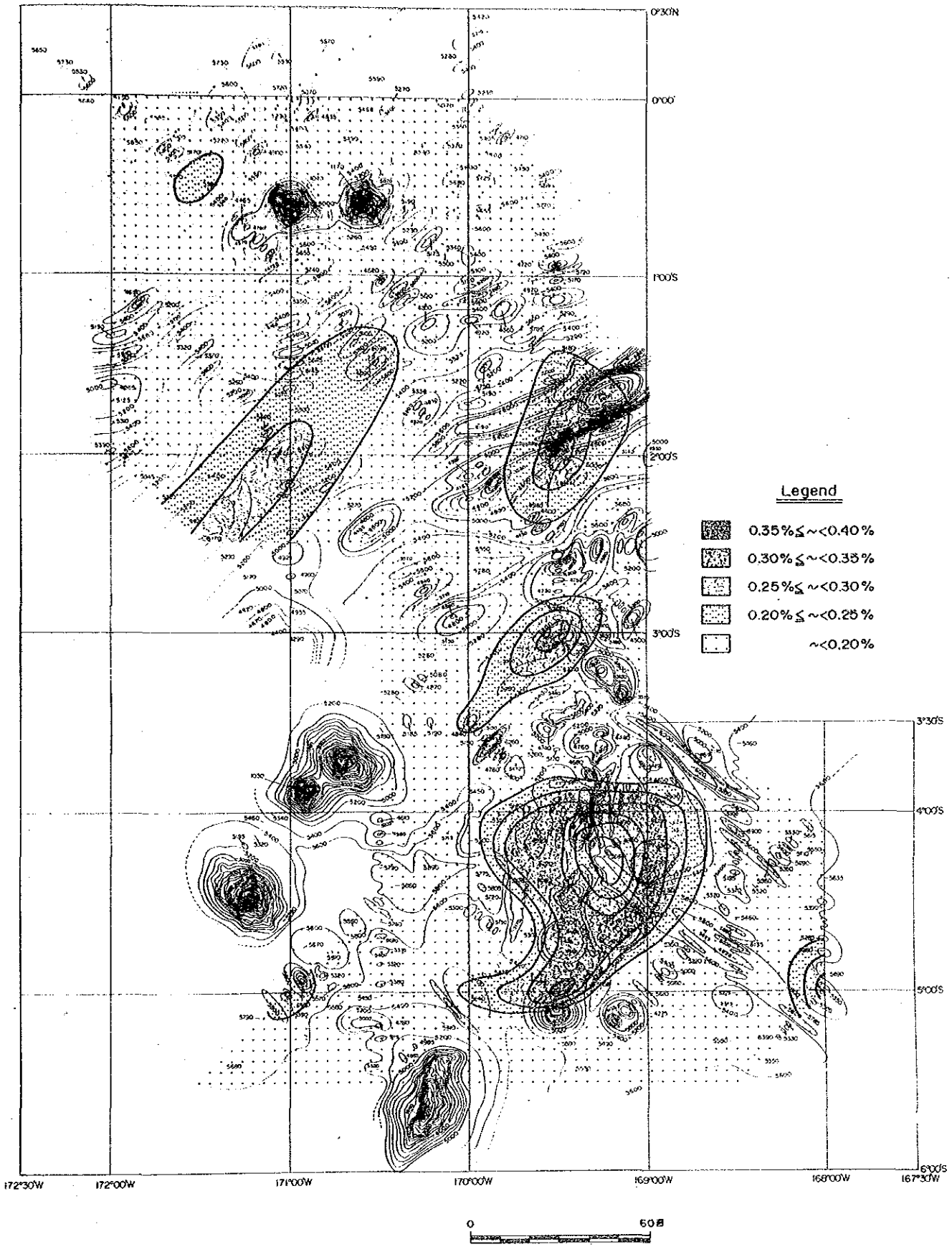
Annexed Figure 7　Abundance Map of Manganese Nodules



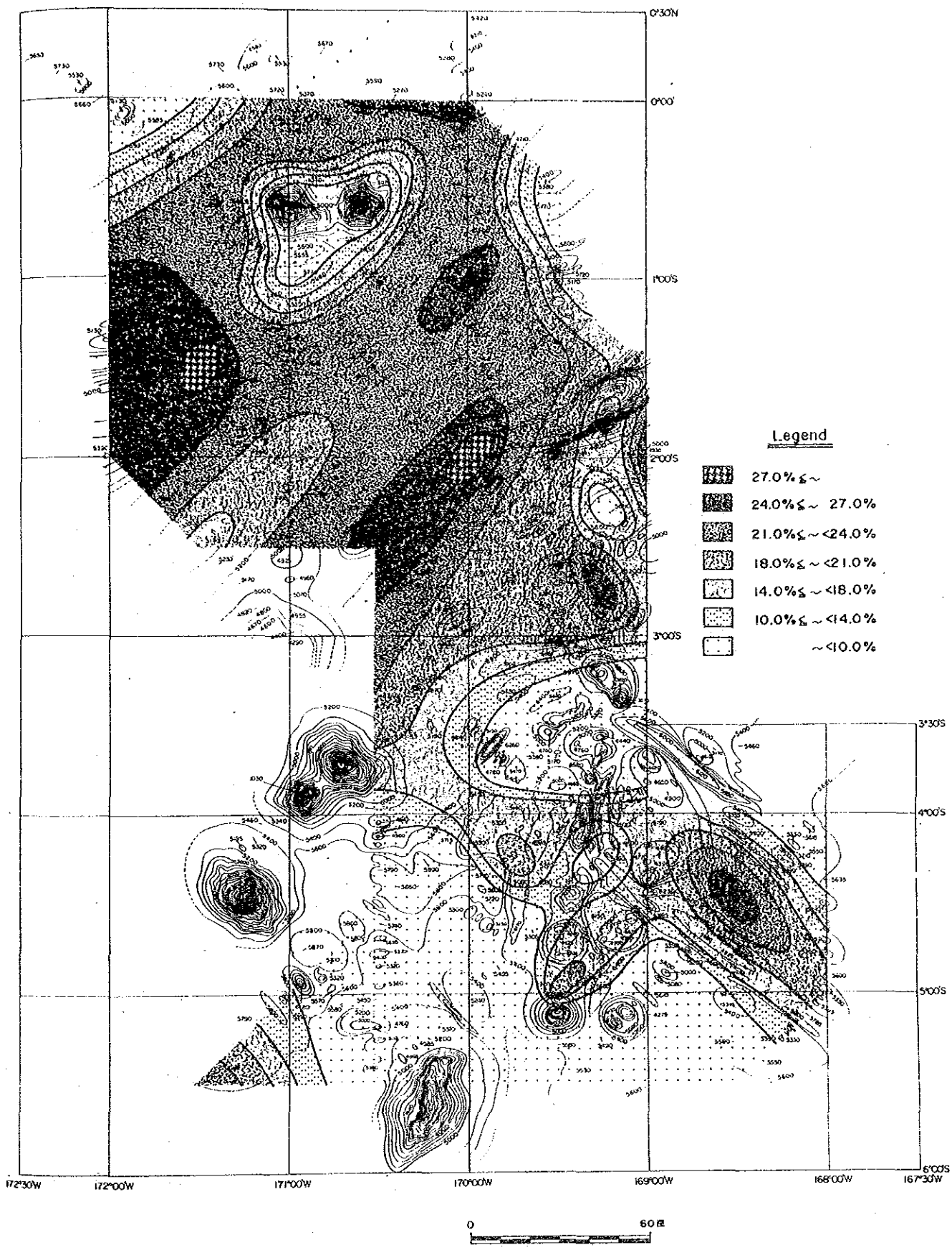
Annexed Figure 8 Ni Grade Map of Manganese Nodules



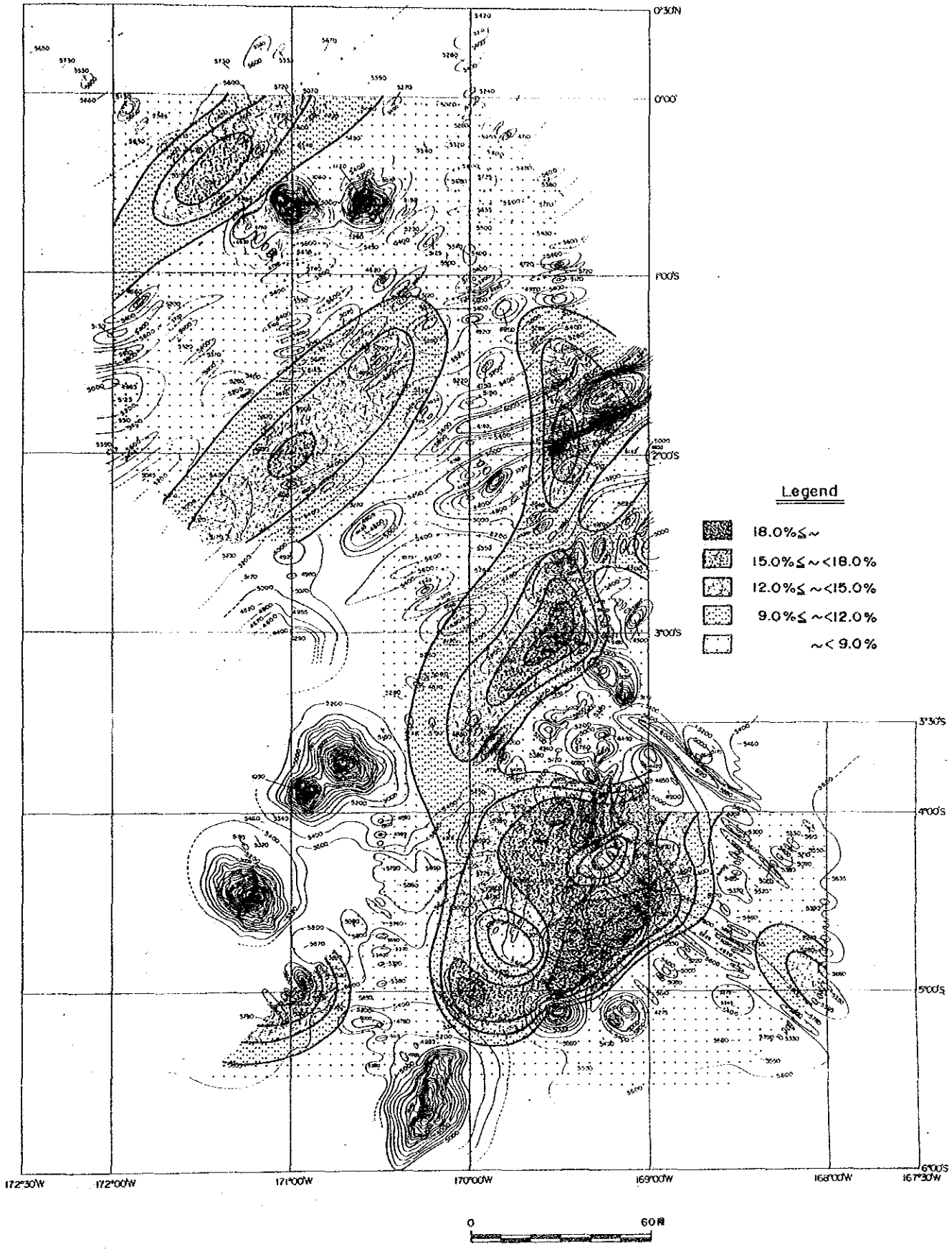
Annexed Figure 9 Cu Grade Map of Manganese Nodules



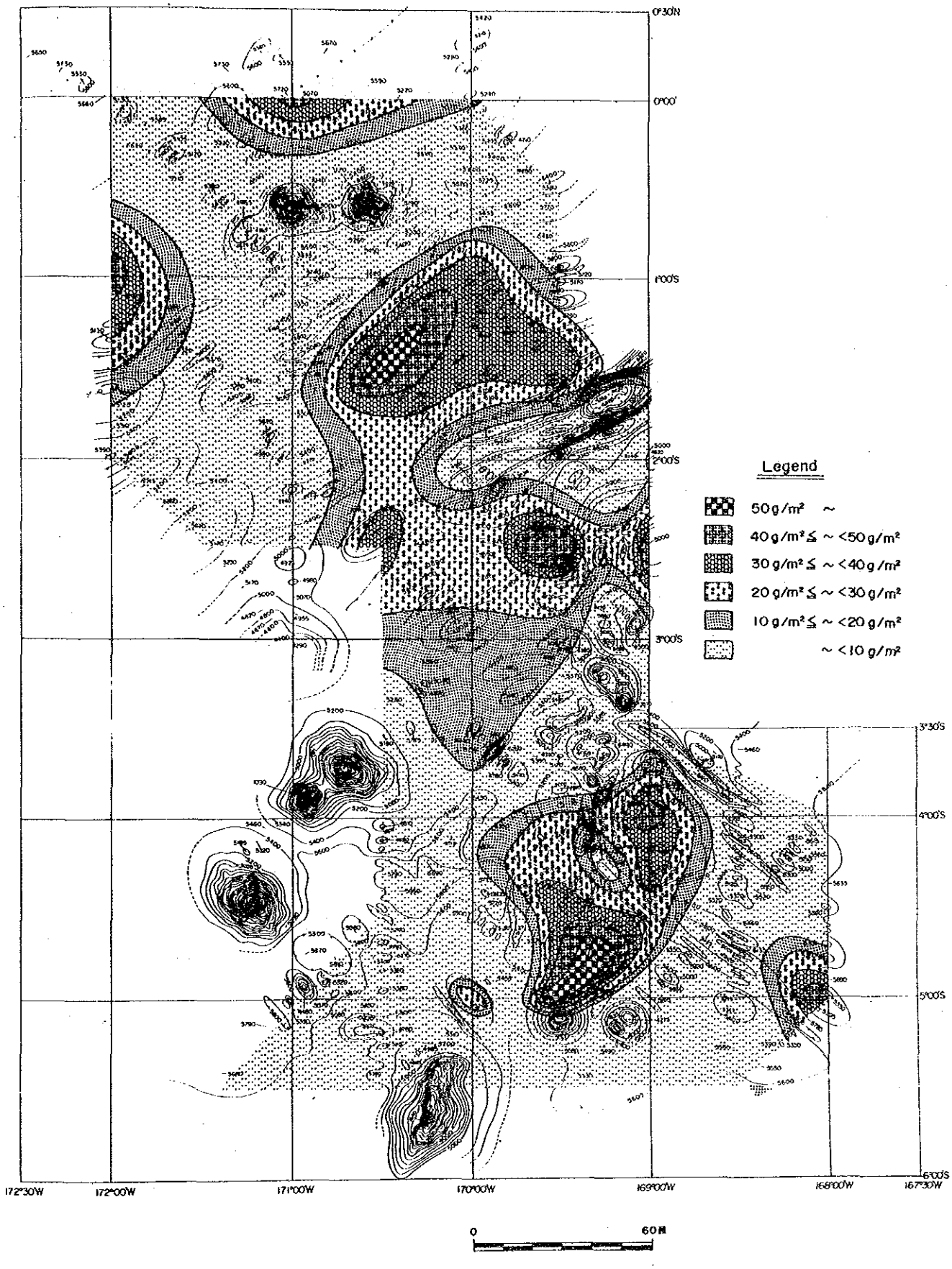
Annexed Figure 10 Co Grade Map of Manganese Nodules



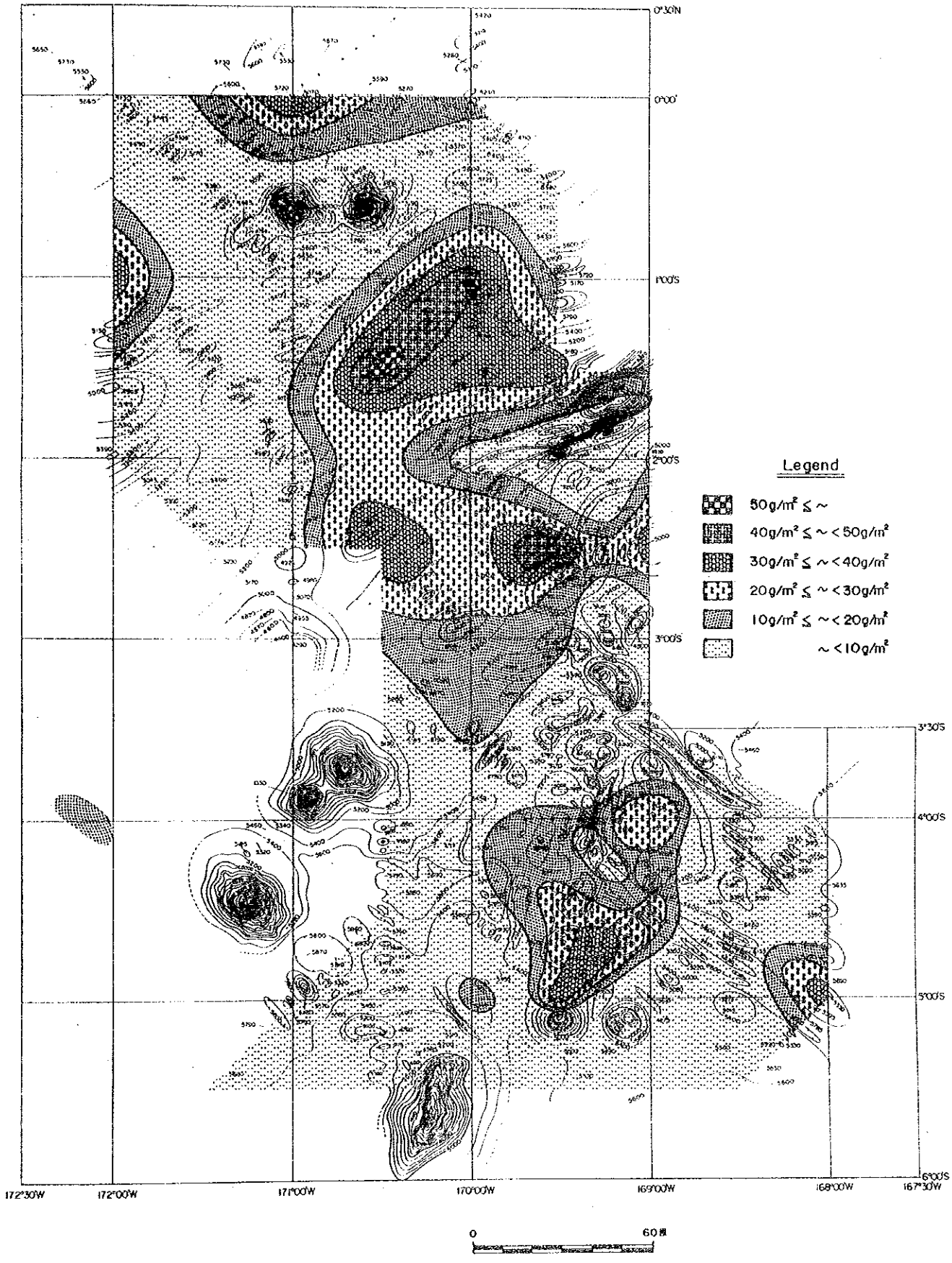
Annexed Figure 11 Mn Grade Map of Manganese Nodules



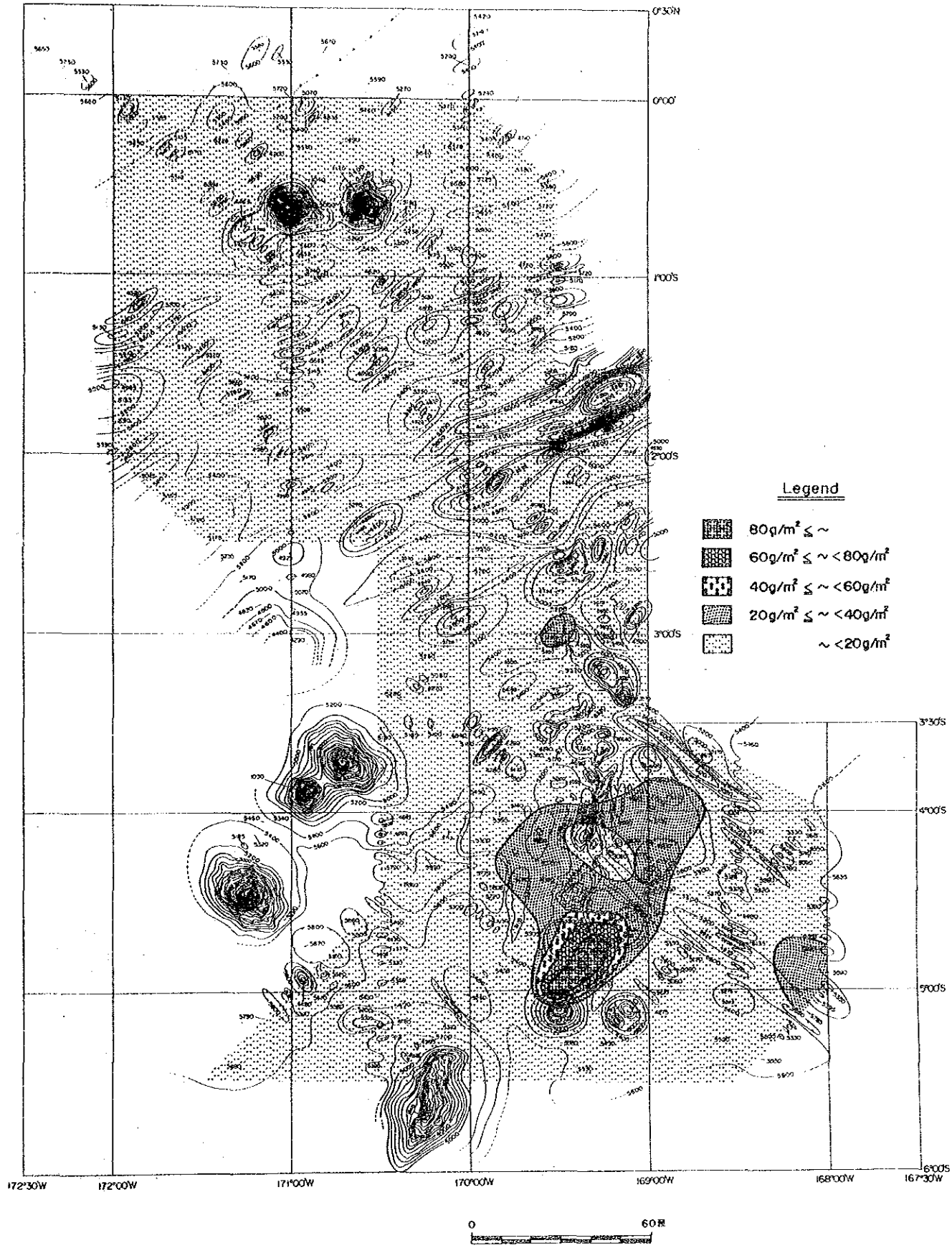
Annexed Figure 12 Fe Grade Map of Manganese Nodules



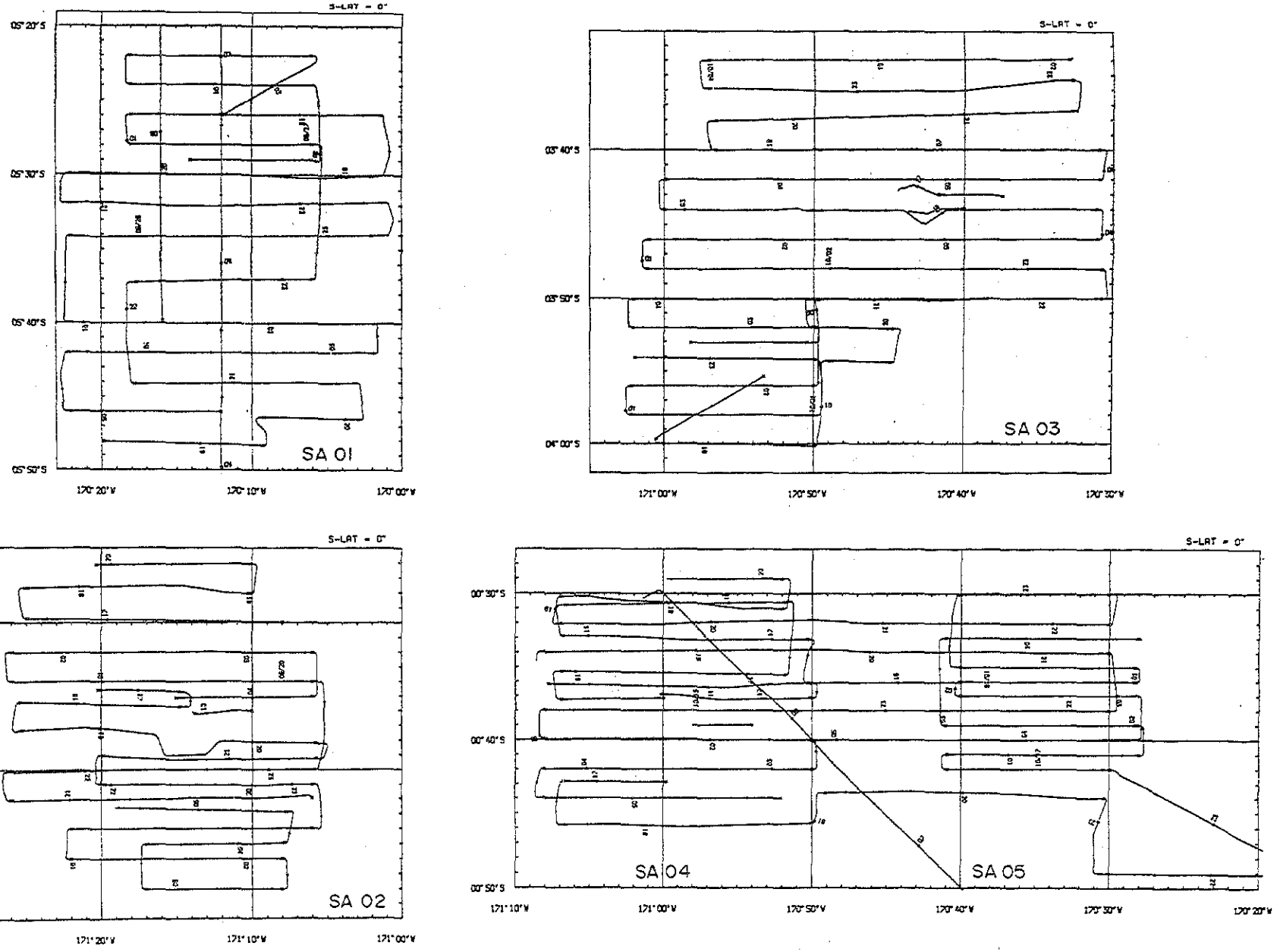
Annexed Figure 13 Ni Metal Quantity Map



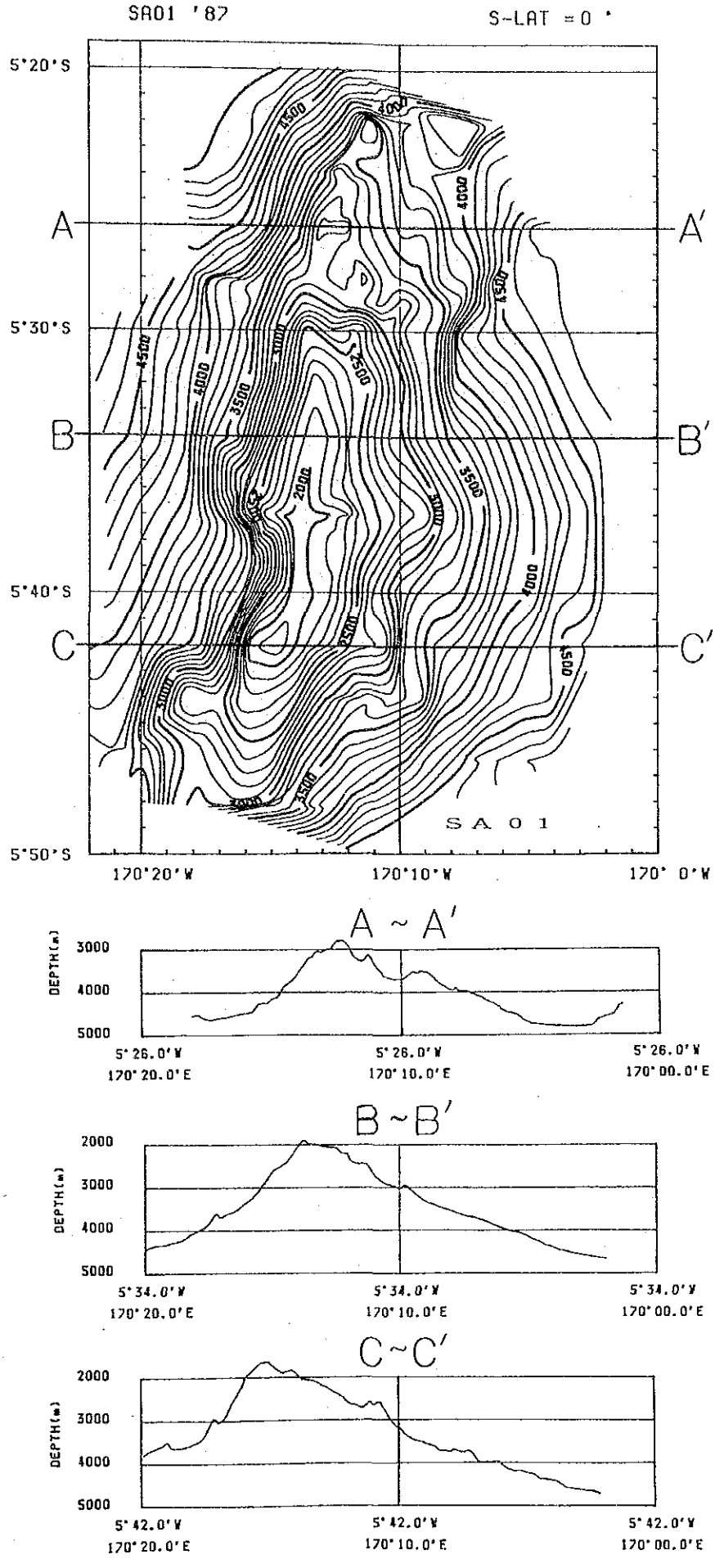
Annexed Figure 14 Cu Metal Quantity Map



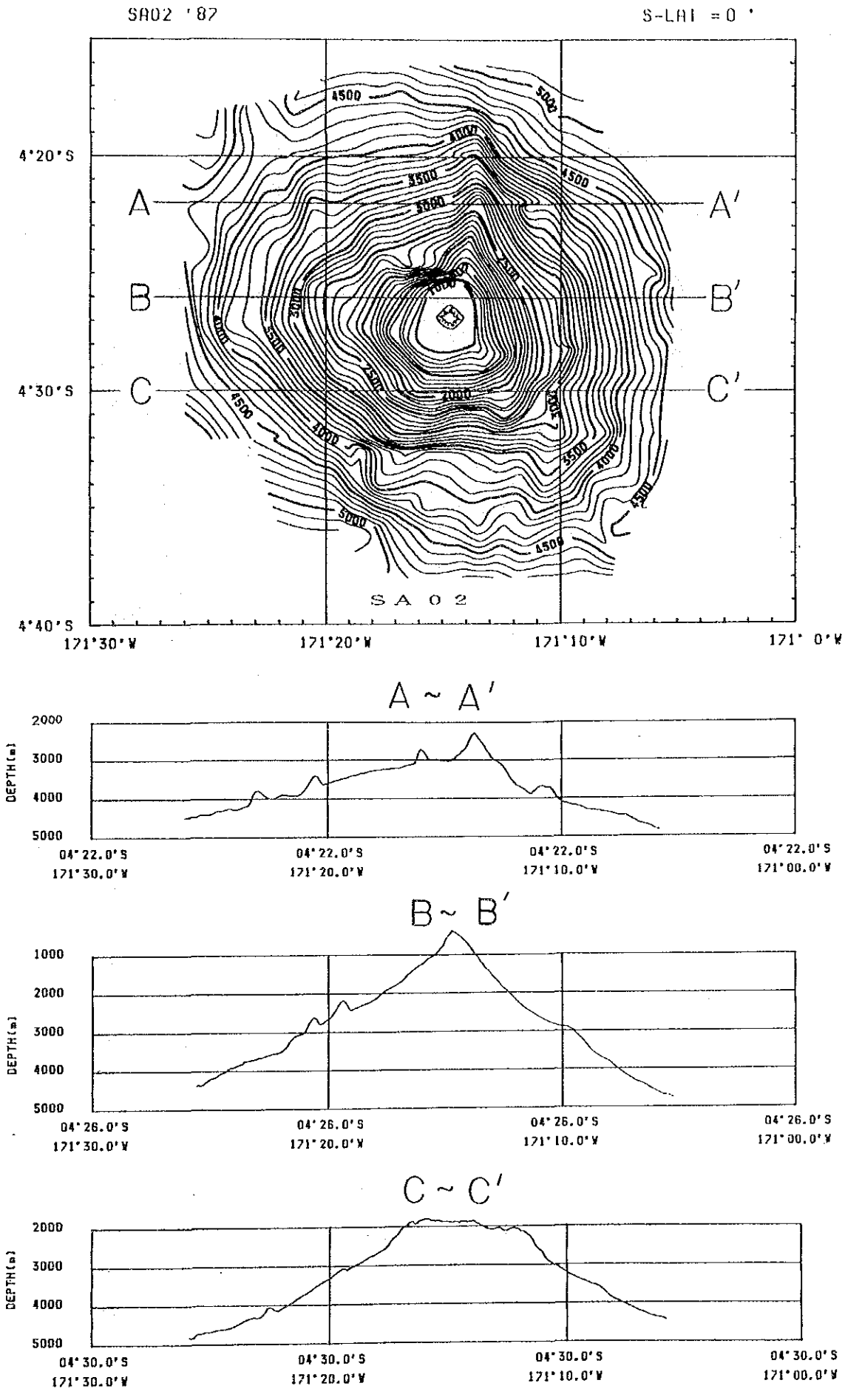
Annexed Figure 15 Co Metal Quantity Map



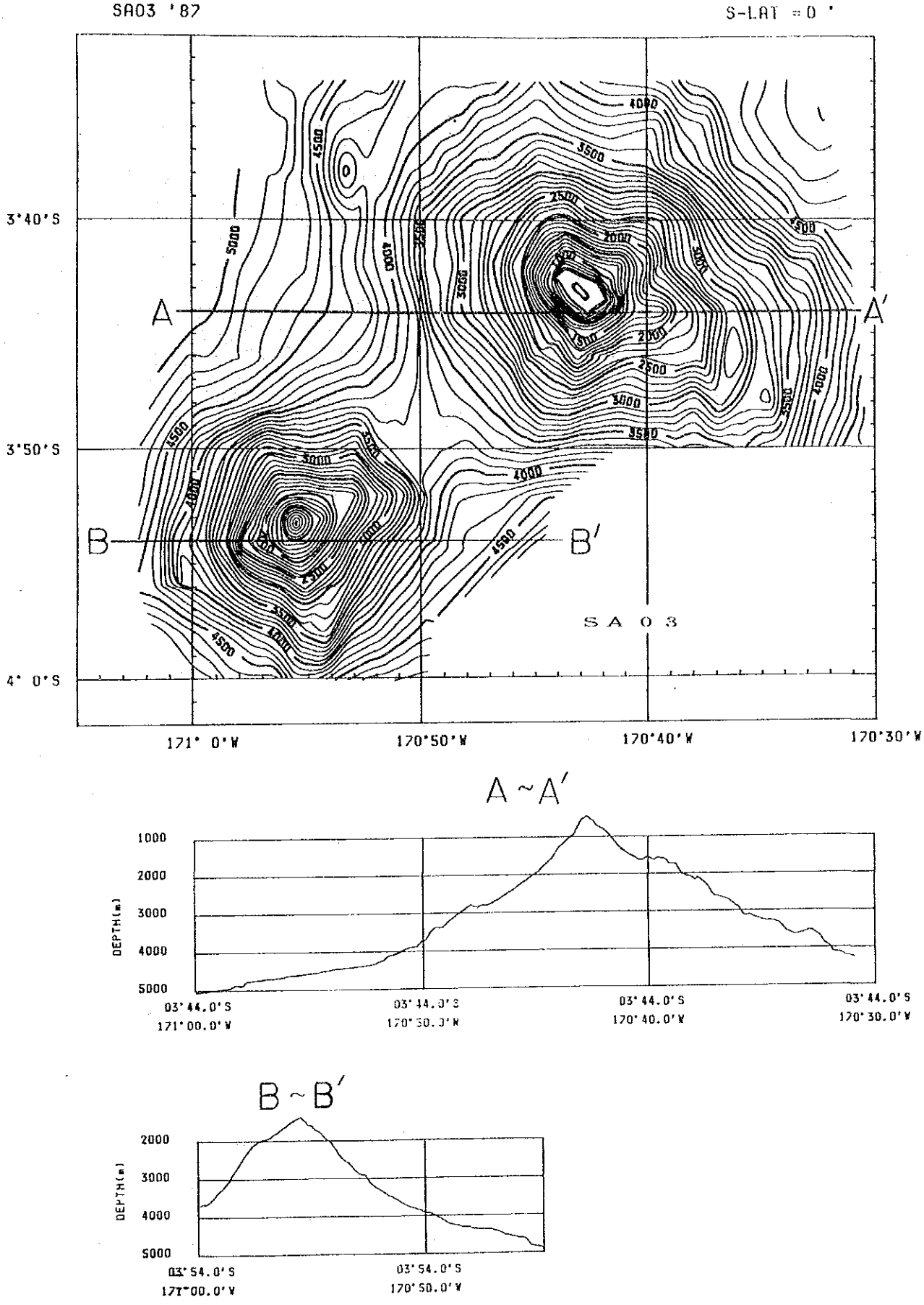
Annexed Figure 16 Trackline Map of Individual Seamounts



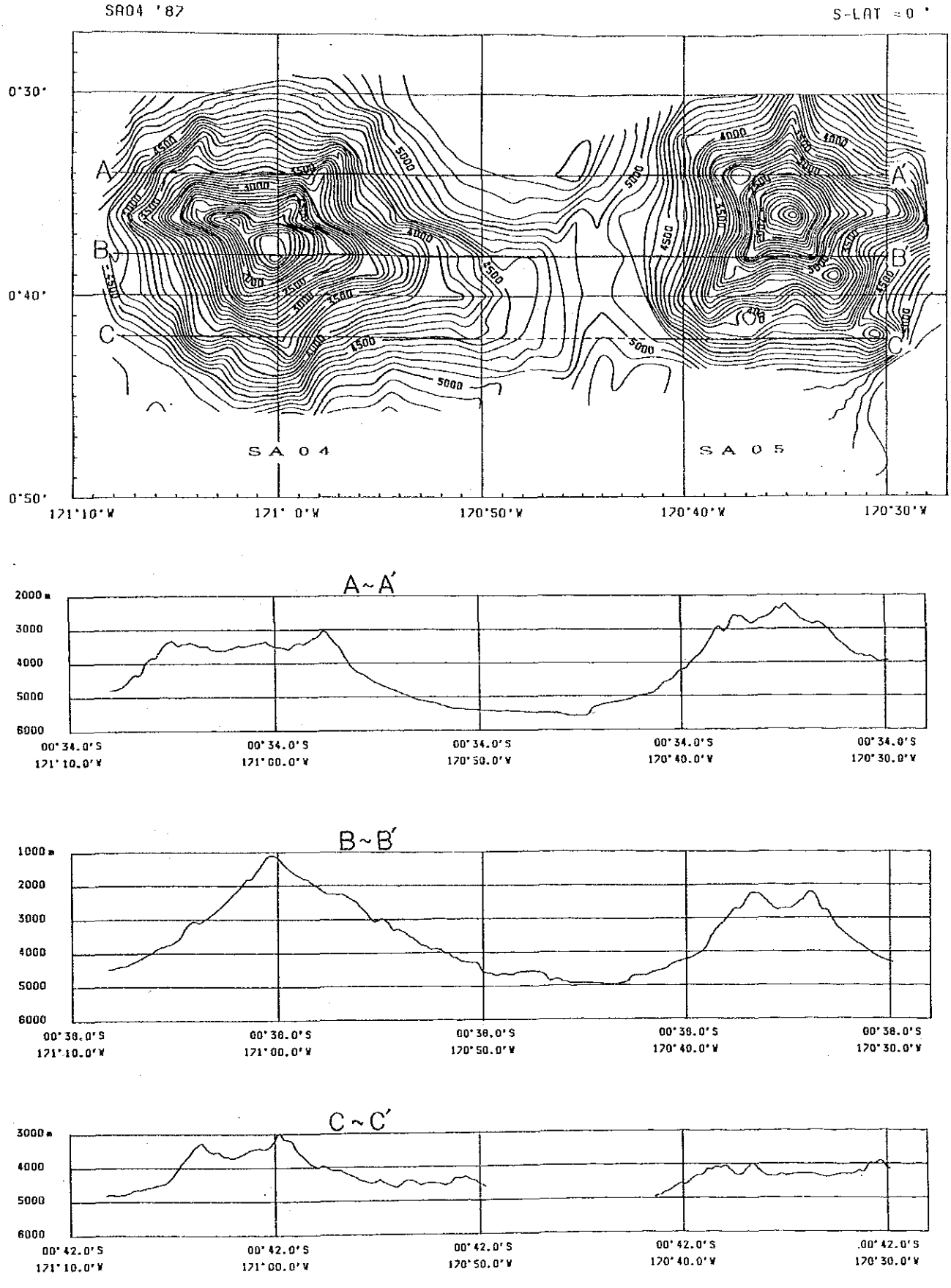
Annexed Figure 17 Topographic Planes and Sections of Individual Seamounts (1)



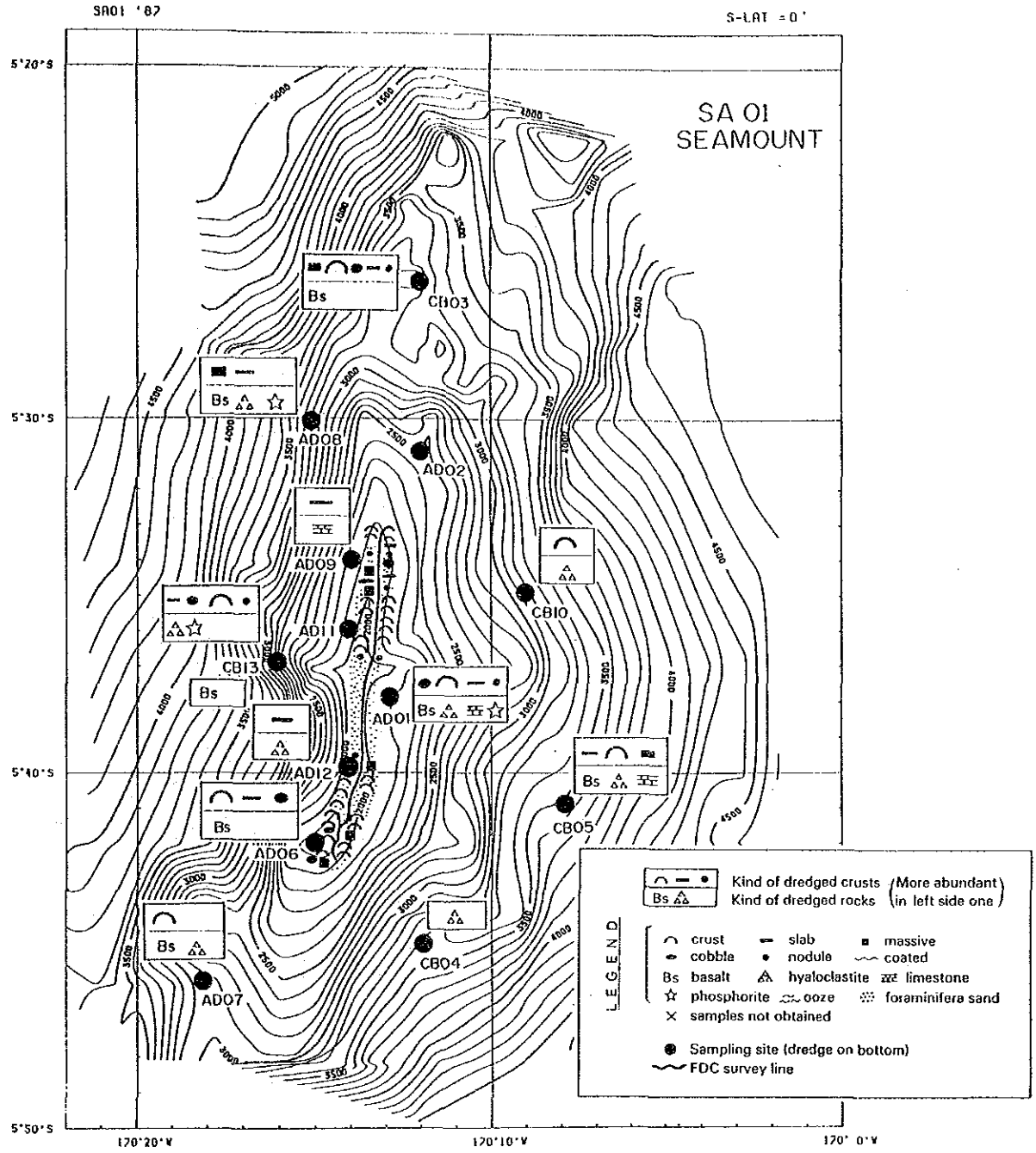
Annexed Figure 17 Topographic Planes and Sections of Individual Seamounts (2)



Annexed Figure 17 Topographic Planes and Sections of Individual Seamounts (3)

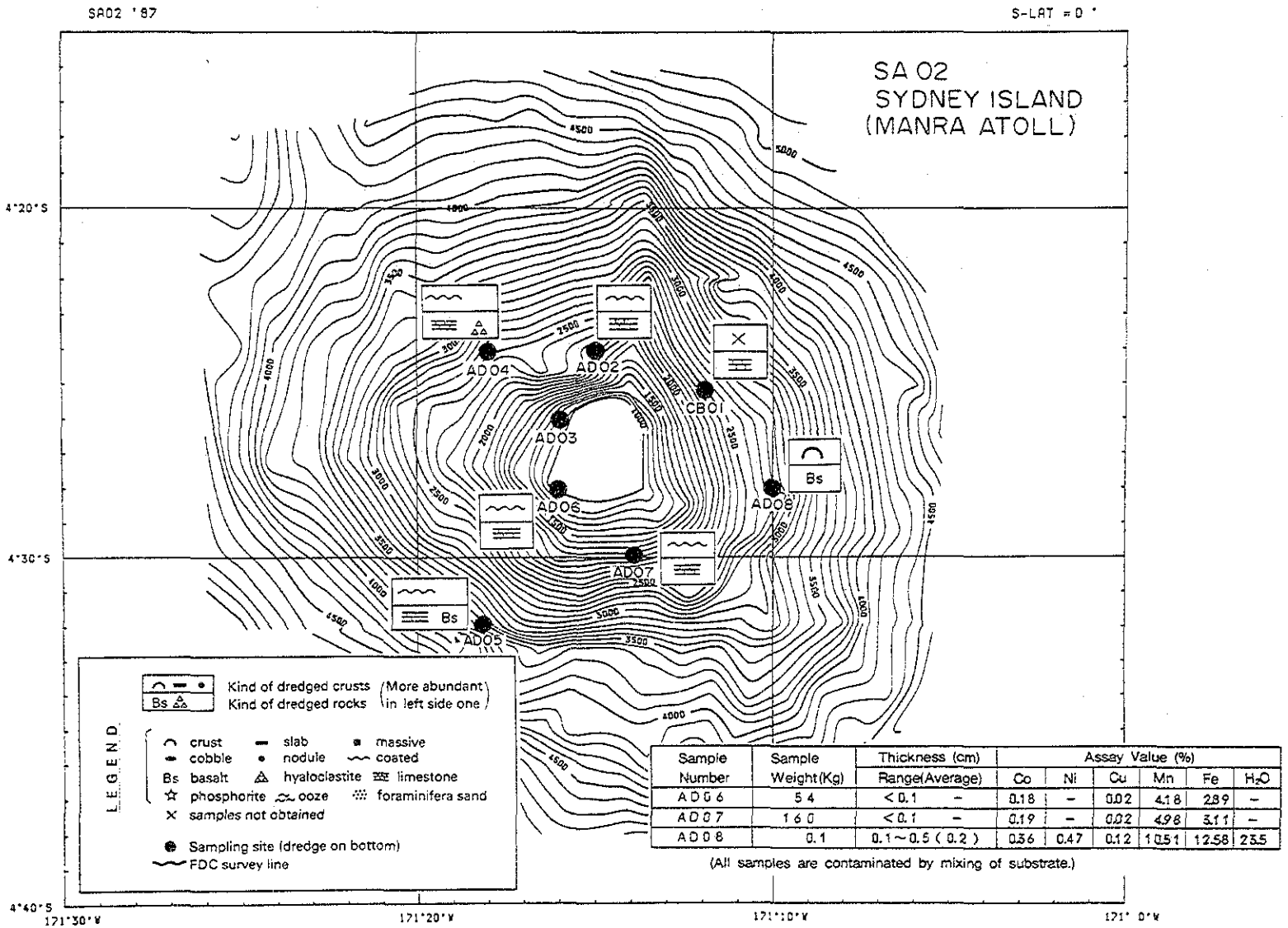


Annexed Figure 17 Topographic Planes and Sections of Individual Seamounts (4)



Sample Number	Sample Weight (Kg)	Thickness (cm) Range (Average)	Assay Value (%) Co	Ni	Cu	Mn	Fe
AD01	112	0.1～5.5 (2.0)	0.90	0.86	0.13	29.68	14.55
CB03	188	0.5～7.0 (3.0)	0.73	0.55	0.13	25.69	17.60
CB05	107	0.2～4.0 (1.0)	0.67	0.48	0.16	23.73	16.95
AD06	9	0.3～4.0 (2.5)	0.86	0.66	0.12	28.40	15.50
AD07	16	0.7～1.2 (1.0)	0.74	0.70	0.17	29.23	16.20
AD08	15	0.1～0.8 (0.2)	0.82	0.51	0.12	25.09	16.57
AD09	2	1.0～1.5 (1.2)	0.76	0.78	0.20	28.25	15.22
CB10	75	0.2～3.0 (1.0)	0.59	0.42	0.11	25.27	19.00
AD11	116	0.5～7.0 (2.0)	1.01	0.92	0.09	30.71	11.35
AD12	37	1.5～5.5 (3.5)	0.79	0.79	0.10	28.19	13.74

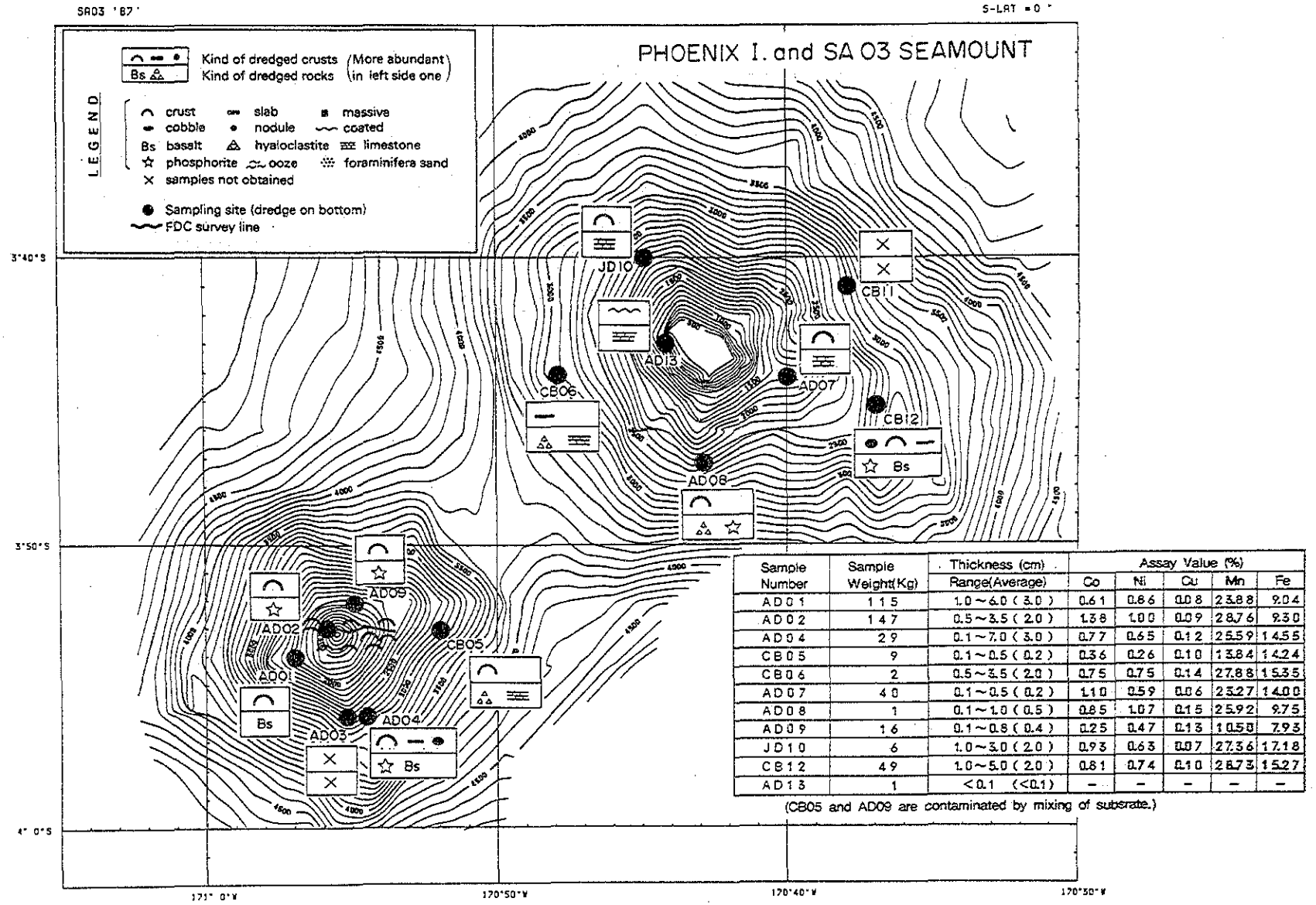
Annexed Figure 18 Geology and Distribution of Cobalt Crusts of Individual Seamounts (1)



Sample Number	Sample Weight(Kg)	Thickness (cm) Range(Average)	Assay Value (%) Co	Ni	Cu	Mn	Fe	H_2O
AD06	5.4	< 0.1 –	0.18	–	0.02	4.18	2.89	–
AD07	16.0	< 0.1 –	0.19	–	0.02	4.98	3.11	–
AD08	0.1	0.1 ~ 0.5 (0.2)	0.36	0.47	0.12	10.51	12.58	23.5

(All samples are contaminated by mixing of substrate.)

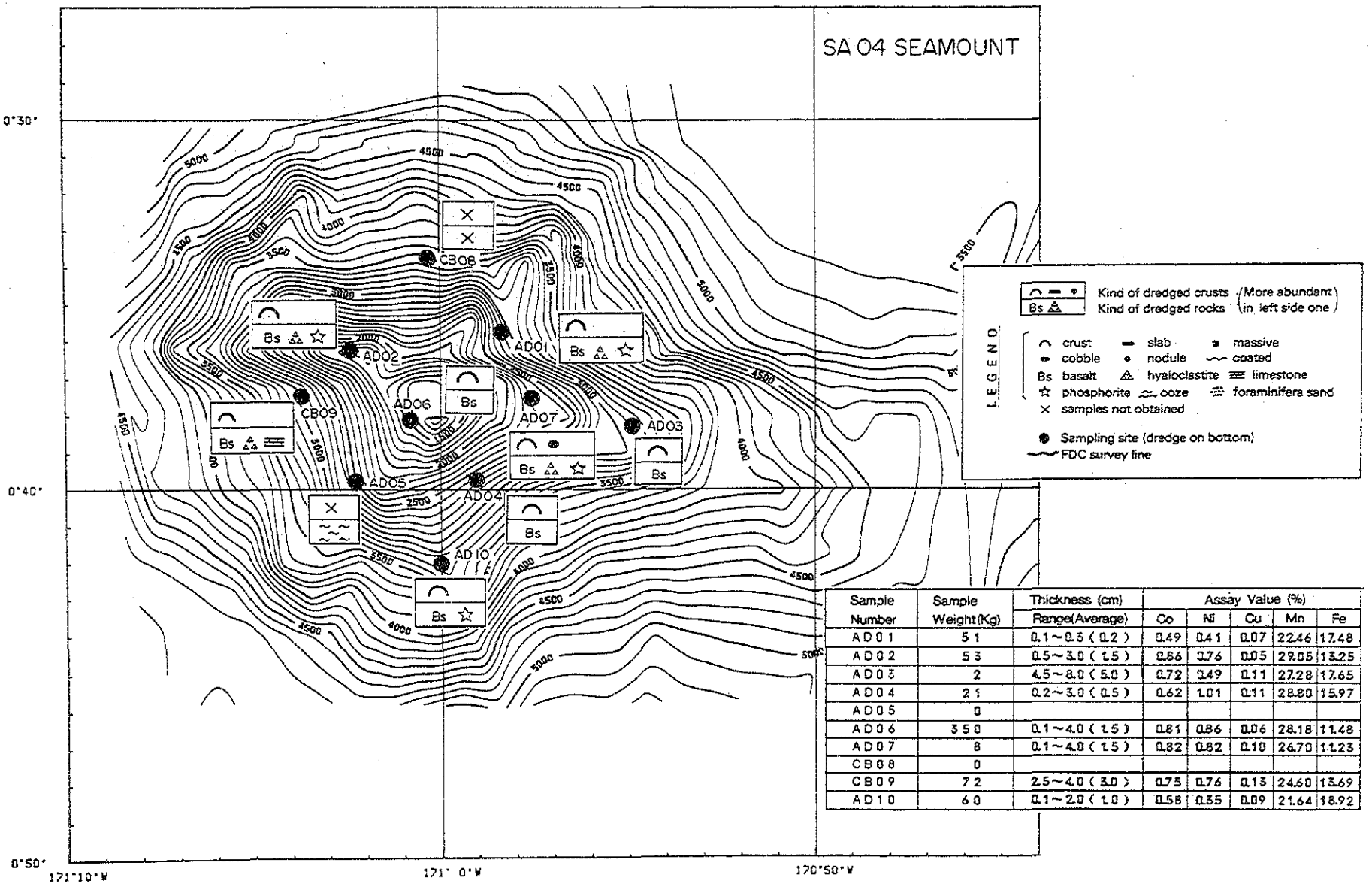
Annexed Figure 18 Geology and Distribution of Cobalt Crusts of Individual Seamounts (2)



Sample Number	Sample Weight(Kg)	Thickness (cm) Range(Average)	Assay Value (%) Co	Ni	Cu	Mn	Fe
AD01	115	1.0～6.0 (3.0)	0.61	0.86	0.08	23.88	9.04
AD02	147	0.5～3.5 (2.0)	1.38	1.00	0.09	28.76	9.30
AD04	29	0.1～7.0 (3.0)	0.77	0.65	0.12	25.59	14.55
CB05	9	0.1～0.5 (0.2)	0.36	0.26	0.10	13.84	14.24
CB06	2	0.5～3.5 (2.0)	0.75	0.75	0.14	27.88	15.35
AD07	40	0.1～0.5 (0.2)	1.10	0.59	0.06	23.27	14.00
AD08	1	0.1～1.0 (0.5)	0.85	1.07	0.15	25.92	9.75
AD09	16	0.1～0.8 (0.4)	0.25	0.47	0.13	10.50	7.93
JD10	6	1.0～3.0 (2.0)	0.93	0.63	0.07	27.36	17.18
CB12	49	1.0～5.0 (2.0)	0.81	0.74	0.10	28.73	15.27
AD13	1	<0.1 (<0.1)	-	-	-	-	-

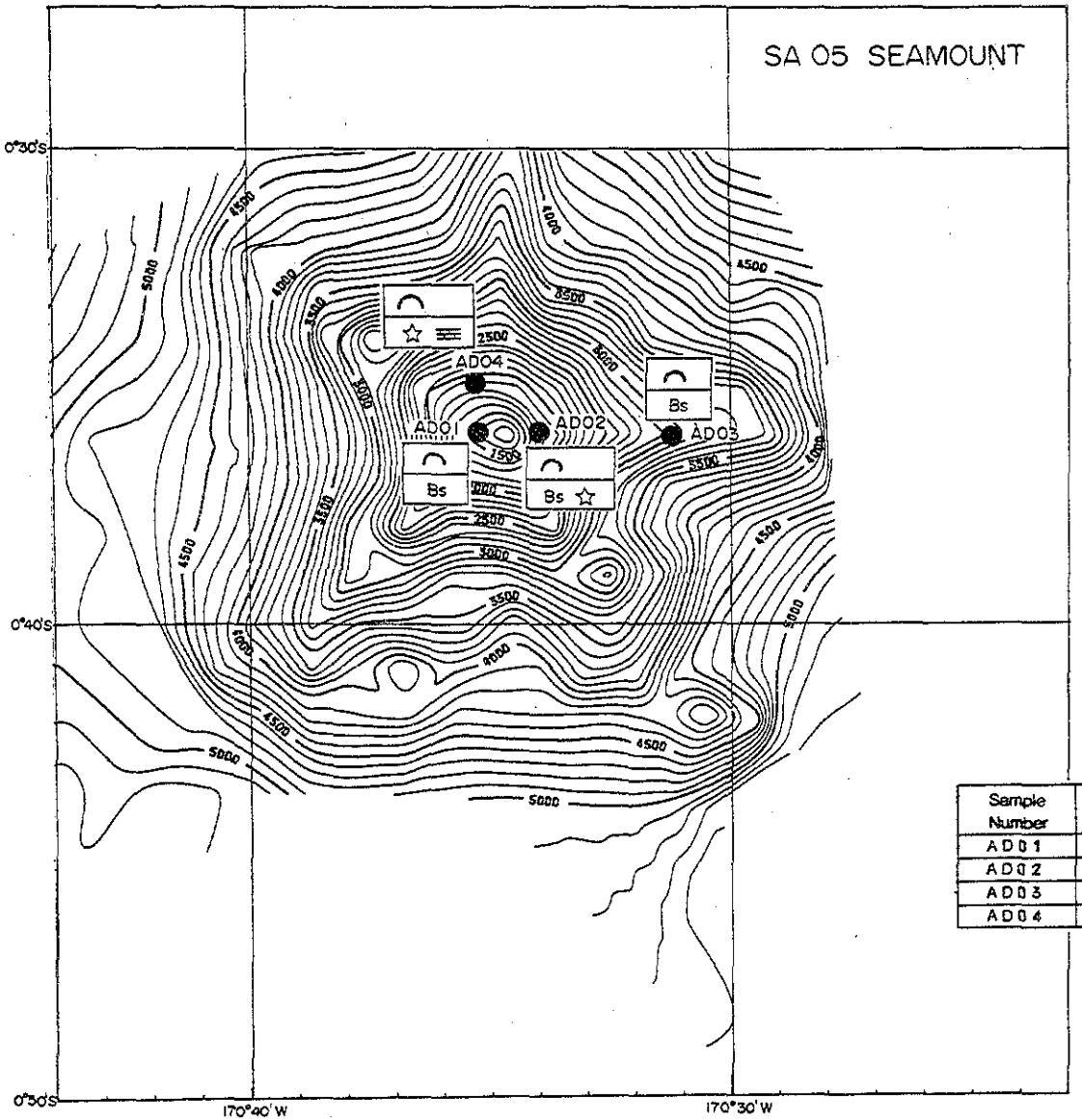
(CB05 and AD09 are contaminated by mixing of substrate.)

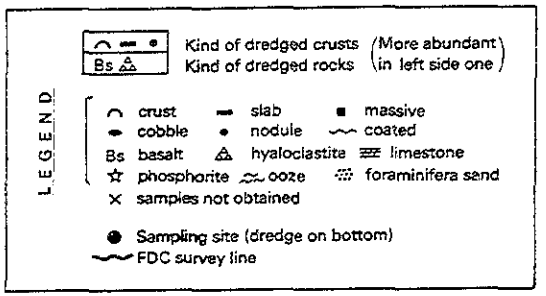
Annexed Figure 18 Geology and Distribution of Cobalt Crusts of Individual Seamounts (3)



Sample Number	Sample Weight(Kg)	Thickness (cm) Range(Average)	Assay Value (%) Co	Ni	Cu	Mn	Fe
AD01	51	0.1~0.5 (0.2)	0.49	0.41	0.07	22.46	17.48
AD02	53	0.5~3.0 (1.5)	0.66	0.76	0.05	29.05	13.25
AD03	2	4.5~8.0 (5.0)	0.72	0.49	0.11	27.28	17.65
AD04	21	0.2~3.0 (0.5)	0.62	1.01	0.11	28.80	15.97
AD05	0						
AD06	350	0.1~4.0 (1.5)	0.81	0.86	0.06	28.18	11.48
AD07	8	0.1~4.0 (1.5)	0.82	0.82	0.10	26.70	11.23
CB08	0						
CB09	72	2.5~4.0 (3.0)	0.75	0.76	0.13	24.60	13.69
AD10	60	0.1~2.0 (1.0)	0.58	0.35	0.09	21.64	18.92

Annexed Figure 18 Geology and Distribution of Cobalt Crusts of Individual Seamounts (4)





Sample Number	Sample Weight(Kg)	Thickness (cm) Range(Average)	Assay Value (%) Co	Ni	Cu	Mn	Fe
AD01	120	0.5～1.0 (0.7)	1.38	0.61	0.04	30.98	15.62
AD02	66	4.0～6.0 (5.0)	0.93	0.71	0.06	29.24	14.27
AD03	1	0.1～0.7 (0.5)	0.55	0.29	0.06	18.75	18.60
AD04	63	1.0～1.5 (1.4)	1.35	0.66	0.10	29.50	13.83

Annexed Figure 18 Geology and Distribution of Cobalt Crusts of Individual Seamounts (5)

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