4) Chemical Composition

(1) Five principal components

Fluorescent X-ray analysis for five principal components (Co, Ni, Cu, Mn, Fe) was carried out on the 46 samples out of 52 dredge-samplings from the six seamounts (6 sampling points failed to acquire sample).

The result of the analysis is shown in Appendix Table 2 (The Survey Results of Cobalt Crusts). Geology and Distribution of Cobalt Crust are shown in Annexed Figure 21.

Grade characteristics of cobalt crusts are as follows:

① Behavior of five components

Mean values of all the bulk-samples (Whole shell of each sample was used. Totaling 120 samples) are shown in Table 4-3-8.
Coefficient of Correlation among 5 components is shown in Table 4-3-9. They can be summarized as follows:

(a) Average grade of each component

Co : 0.68%
Ni : 0.61%
Cu : 0.11%
Mn : 23.21%
Fe : 15.76%

(b) There are Co-Ni-Mn series and others. Positive correlation in Co-Ni-Mn series is distinctive. Co shows positive correlation with Mn which is different relation from in case of manganese nodule.

② Crust type and Grade

The relation between crust type and each average grade is shown in Table 4-3-10. The characteristics are as follows:

(a) Crust type and slab type have high Co grade but nodule type has low Co grade.

(b) Slab type and nodule type have high Ni grade.

(c) Every type has similar grade of Cu

(d) Crust type and slab type have high Mn grade.

(e) Crust type and slab type have high Fe grade.

Table 4-3-8 Cobalt Crust Grade from Different Layer

	(n)	Average Thickness (mm)	Co (%)	Ni (%)	Cu (%)	Mn (%)	Fe (%)	Mn/Fe
Bulk	120	27.11	0.68	0.61	0.11	23.21	15.76	1.47
Surface•Outer shell	24	16.67	0.81	0.70	0.10	25.66	14.51	1.77
Surface•Middle shell	18	28.00	0.64	0.71	0.13	22.57	13.54	1.67
Surface•Inner shell	1	8.00	0.55	0.64	0.14	24.92	15.85	1.57
Underside•Outer shell	4	4.25	0.54	0.78	0.12	20.35	14.12	1.44

Table 4-3-9 Correlation Coefficient Table

	Mn	Fe	Ni	Co	Cu
Mn	–	0.099	0.527	0.792	-0.249
Fe	–	–	-0.612	-0.133	0.213
Ni	–	–	–	0.565	-0.029
Co	–	–	–	–	-0.438
Cu	–	–	–	–	–

Table 4-3-10 Cobalt Crust Grade and Types

	(n)	Average Thickness (mm)	Co (%)	Ni (%)	Cu (%)	Mn (%)	Fe (%)	Mn/Fe
Crust	79	18.68	0.71	0.59	0.11	23.55	16.41	1.44
Slab	16	71.31	0.73	0.65	0.13	24.07	15.32	1.57
Cobble	11	27.82	0.59	0.61	0.10	21.35	14.69	1.45
Nodule	12	18.17	0.52	0.66	0.13	21.85	13.40	1.63
Pavement	1	110.00	0.26	0.38	0.20	17.19	18.48	0.93

(f) Nodule type and slab type have relatively high Mn/Fe ratio. Only reference value of pavement type is shown in the Table due to only one sample is available and also, its Mn grade is too low.

③ Substrates and grade

The relation among substrates, type of core and grade of crust are shown in Table 4-3-11.

The phosphorite prominent in limestone is classified into limestone and substrates composed of more than two species are classified into the prominent rocks.

The characteristics are as follows;

(a) Hyaloclastite has the highest grade of Co. Basalt is the second. Phosphorite has the lowest grade of Co.

(b) Phosphorite has high grade of Ni but limestone has low grade of Ni.

(c) Sedimentary rocks have high grade of Cu but phosphorite has low of it.

(d) Hyaloclastite has the highest grade of Mn, sedimentary rocks the second. Tuff breccia has low Mn grade.

(e) Hyaloclastite and limestone have high grade of Fe but phosphorite has low grade of Fe.

(f) Phosphorite has high Mn/Fe ratio.

④ Topography-water depth and grade

The relation between topography and grade is shown in Table 4-3-12. But there are different relation of topography and water depth according to the seamount.

The summit has the highest grade of Co, Ni, Mn and Mn/Fe ratio. The grade decreases along with the water depth deepens. The relation between the water depth and grade is shown in Table 4-3-13 and Figures 4-3-8 to 4-3-11. The relation between topography-depth and grade has same tendency. Co, Ni, Mn and Mn/Fe ratio decrease along with the water depth deepens, while Cu and Fe increases as the water depth deepens.

To study the relation of water depth and principal components (Co, Ni, Cu), triangular diagrams were made as shown in Figure 4-3-12 and Figure 4-3-13.

Table 4-3-11 Cobalt Crust Grade and Substrates

	(n)	Average Thickness (mm)	Co (%)	Ni (%)	Cu (%)	Mn (%)	Fe (%)	Mn/Fe
Basalt	12	15.25	0.67	0.60	0.12	22.62	15.80	1.43
Tuff Breccia	20	26.80	0.59	0.60	0.12	21.58	15.22	1.42
Sedimentary rock	8	104.88	0.61	0.59	0.14	23.54	15.89	1.48
Limestone	20	12.85	0.59	0.55	0.11	22.09	16.61	1.33
Phospholite	2	25.50	0.44	0.65	0.08	22.64	11.05	2.05
Hyaloclastite	19	18.79	0.81	0.61	0.11	24.69	17.07	1.45

Table 4-3-12 Cobalt Crust Grade and Topographic Position of Seamount

	(n)	Average Thickness (mm)	Co (%)	Ni (%)	Cu (%)	Mn (%)	Fe (%)	Mn/Fe
Top	23	27.87	0.88	0.81	0.09	24.84	10.87	2.29
Upper slope	44	32.23	0.76	0.66	0.11	24.32	15.15	1.61
Middle slope	38	20.29	0.56	0.51	0.12	22.11	17.90	1.34
Lower slope	15	28.20	0.43	0.41	0.14	20.27	19.67	1.03

Table 4-3-13 Cobalt Crust Grade and Water Depth

	(n)	Average Thickness (mm)	Co (%)	Ni (%)	Cu (%)	Mn (%)	Fe (%)	Mn/Fe
1,000m ~ 1,500m	12	18.00	1.11	0.86	0.07	27.41	11.14	2.46
1,500 ~ 2,000	28	23.32	0.79	0.70	0.10	24.01	13.62	1.76
2,000 ~ 2,500	53	30.68	0.64	0.61	0.12	23.14	15.92	1.45
2,500 ~ 3,000	21	25.48	0.49	0.44	0.12	21.01	19.61	1.07
3,000 ~ 3,500	6	37.17	0.31	0.38	0.17	19.46	20.25	0.96

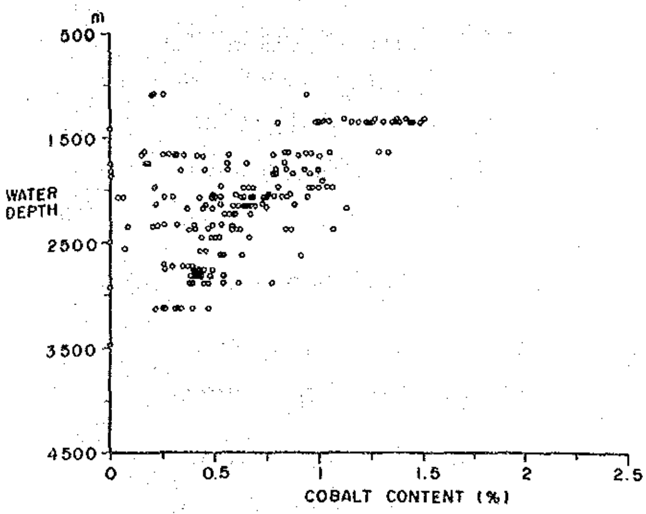

Figure 4-3-8 Co-Water Depth

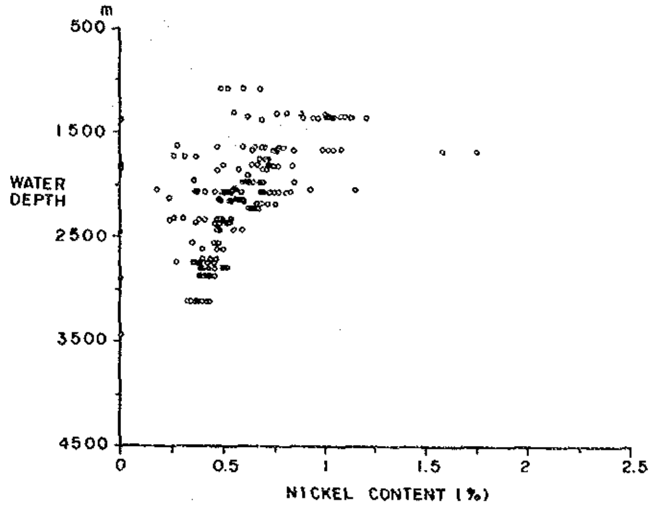

Figure 4-3-9 Ni-Water Depth

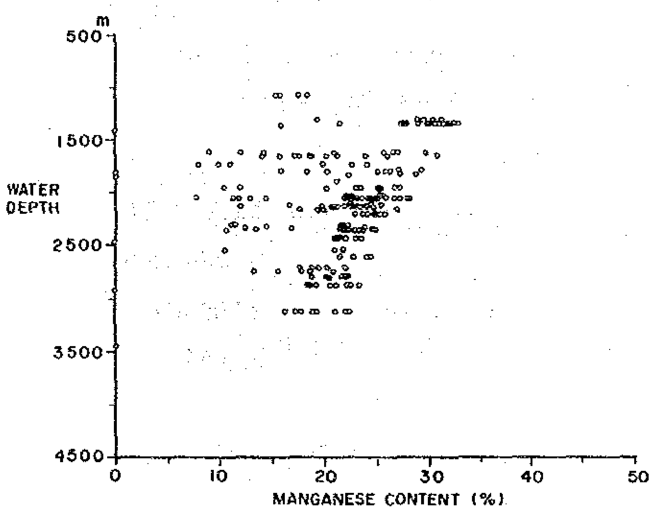

Figure 4-3-10 Mn-Water Depth

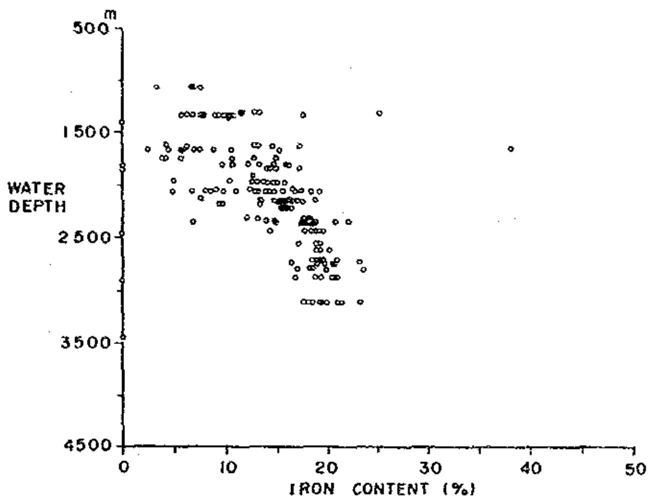

Figure 4-3-11 Fe-Water Depth

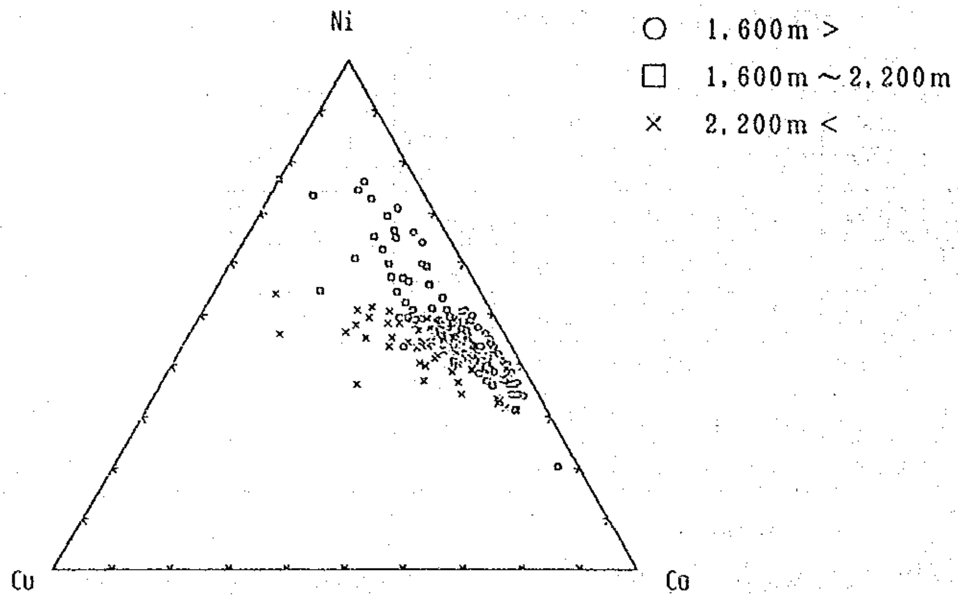

Figure 4-3-12 Triangular Diagram of Co, Ni, Cu

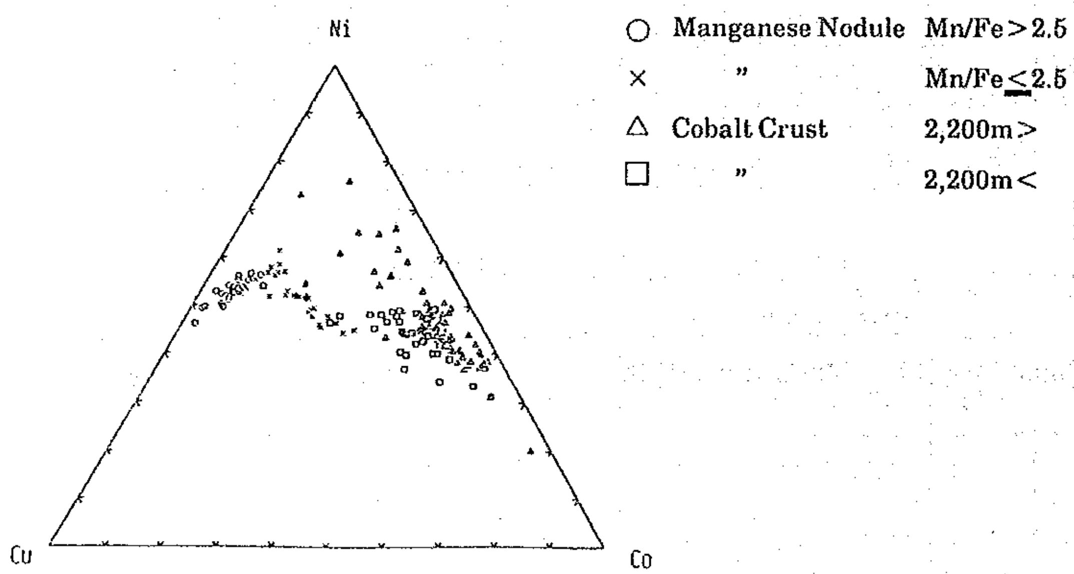

Figure 4-3-13 Triangular Diagram of Co, Ni, Cu

According to the diagrams, percentages of Co grade and Ni grade are high in the shallow water above the depth of 2,200m. This shows the characteristic of normal cobalt crust that has low percentage of Cu grade. But in the deep water (deeper than 2,200m), percentage of Cu grade is as high as the Co rich Type manganese nodule.

⑤ Region and Grade

Average grade of each seamount is shown in Table 4-3-14.
Following features are recognized;

(a) Average Co grade of the six seamount is 0.62%.
Seamount SC02 has the highest value of 0.78%.

(b) Average Ni grade is 0.60%. Seamount SC01 has the highest of 0.65%.

(c) Every seamount has nearly the same values of Cu grade between 0.10% and 0.13%. Average grade is 0.12%.

(d) Average Mn grade is 20.59%. Seamount SC02 has the highest of 24.51%.

(e) Average Fe grade is 13.99%. Seamount SC06 has the highest of 16.40%. Seamount SC01 has the extremely low value of 9.10%.

(f) Average of Mn/Fe ratio is 1.47. Seamount SC01 has the highest of 1.97.

Table 4-3-14 Average Grade of Cobalt Crusts at Each Seamount

	(n)	Average Thickness (mm)	Co (%)	Ni (%)	Cu (%)	Mn (%)	Fe (%)	Mn/Fe
SC01	6	35.4	0.56	0.65	0.11	17.91	9.10	1.97
SC02	7	21.7	0.78	0.64	0.11	24.51	15.28	1.60
SC03	8	15.6	0.54	0.56	0.13	20.85	16.08	1.30
SC04	8	19.0	0.42	0.59	0.13	18.51	14.33	1.29
SC05	8	6.5	0.66	0.53	0.10	17.71	12.76	1.39
SC06	9	18.9	0.76	0.60	0.11	24.02	16.40	1.46
Total average		19.5	0.62	0.60	0.12	20.59	13.99	1.47

⑥ Divided portion and Grade

Among the sampled cobalt crusts, those with relatively thick oxide shells were selected and analyzed according to the classifications of outer shell, inner shell or outer shell, mid shell, inner shell.

The grade of each portion is shown in Table 4-3-8. The result of analysis shows the following features;

(a) Surface outer-shell has the highest Co grade of 0.81%, surface mid-shell has 0.64%, surface inner-shell has 0.55%. It decreases as the layer goes inside.

(b) Underside outer-shell has the highest Ni grade. The grade of Ni decreases in the order of surface mid-shell, surface outer-shell, surface inner-shell.

(c) Surface inner-shell has the highest Cu grade. Surface outer-shell has the lowest Cu grade.

(d) Surface outer-shell has the highest Mn grade. Mn grade decreases in order of surface inner-shell, surface mid-shell underside outer-shell.

(e) Surface inner-shell has the highest Fe grade. It decreases in the order of surface outer-shell, underside outer-shell, surface inner-shell.

(f) surface outer-shell has the highest Mn/Fe ratio. It decreases in the order of surface mid-shell, surface inner-shell, underside outer-shell. However, only one sample of surface inner-shell is available, so it is difficult to judge whether the result reflects the real phase of surface inner-shell.

(2) Auxiliary component

In order to investigate the auxiliary component of cobalt crusts 14 samples were selected from samples undergone the analysis of five principal components on board. Analysis of principal component and trace component was carried out on those 14 samples. The result of this analysis and the result of analysis carried out on boad are shown in Table 4-3-15. Coefficient of correlation among components are shown in Table 4-3-16.

The result shows the following feature;

- Principal components are rich in CaO and P_2O_5, the maximum of P_2O_5 is 20.89% and the average 5.48%.
- Few is ferrous Fe but rich in ferric Fe.
  Outer-shell is rich in Ni, Mn, Fe and Ti than the other portions.
- Among trace components, content of Pb and ΣR_2O_3 is high, average of Pb is 1,093ppm, average of ΣR_2O_3 is 942ppm. Pb is rich in outer-shell and ΣR_2O_3 is rich in inner-shell.
- Average Pt is 0.8ppm and maximum Pt is 1.2ppm.

From the Table 4-3-16, analyzed components can be classified into Co-Ni-Mn system. Cu system and the third system.

① In positive relation with Co, Ni and Mn are:

TiO_2, FeO, Na_2O, K_2O, LOI, Pb, Zn, Sr, V, Mo, (MgO)

② In positive relation with Cu are:

SiO_2, Al_2O_3, Fe_2O_3, B, (Zr), Pt

Table 4-3-16 Correlation Coefficient Table

<Correlation coefficient >

	SiO2	TiO2	Al2O3	Fe2O3	FeO	MnO2	MgO	CaO	BaO	Na2O	K2O	P2O5	LOI	Co	Ni	Cu	Pb	Zn	Sr	V	Mo	B	As	Y	Zr	Pt	T.R.E.
SiO2	1.00	0.08	0.92	0.82	0.15	-0.26	0.17	-0.46	0.47	0.21	-0.69	-0.42	0.15	-0.21	-0.52	0.69	-0.64	-0.24	-0.04	-0.65	-0.58	0.86	-0.10	0.69	0.70	0.62	-0.03
TiO2		1.00	-0.09	0.21	0.52	0.77	0.73	-0.77	0.53	0.55	0.55	-0.77	0.83	0.79	0.57	-0.05	0.49	0.58	0.74	0.47	0.39	0.29	0.43	-0.77	0.40	0.17	-0.92
Al2O3			1.00	0.68	-0.08	-0.43	0.01	-0.24	0.26	0.07	-0.20	-0.19	-0.80	-0.40	-0.54	0.70	-0.72	-0.31	-0.19	-0.24	-0.67	0.72	-0.22	0.35	0.53	0.48	0.14
Fe2O3				1.00	0.27	-0.16	0.44	-0.64	0.68	0.43	-0.18	-0.59	0.27	-0.06	-0.37	0.73	-0.48	-0.11	0.10	0.26	-0.42	0.97	0.23	-0.11	0.90	0.64	-0.16
FeO					1.00	0.62	0.44	-0.66	0.72	0.62	0.55	-0.67	0.61	0.65	0.40	-0.08	0.26	0.52	0.32	0.49	0.39	0.32	-0.10	-0.56	0.49	0.31	-0.59
MnO2						1.00	0.51	-0.69	0.42	0.72	0.85	-0.73	0.88	0.92	0.68	-0.22	0.82	0.83	0.64	0.70	0.86	-0.04	0.35	-0.83	0.11	0.08	-0.86
MgO							1.00	-0.69	0.58	0.51	0.22	-0.67	0.59	0.58	0.30	0.09	0.27	0.35	0.41	0.34	0.15	0.44	0.54	-0.66	0.68	0.07	-0.67
CaO								1.00	-0.80	-0.66	-0.57	0.99	-0.89	-0.68	-0.41	-0.33	-0.27	-0.56	-0.58	-0.67	-0.32	-0.68	-0.39	0.69	-0.74	-0.52	0.81
BaO									1.00	0.71	0.34	-0.79	0.62	0.46	0.23	0.33	-0.07	0.35	0.30	0.53	0.14	0.68	0.19	-0.53	0.60	0.33	-0.62
Na2O										1.00	0.69	-0.88	0.81	0.66	0.62	0.33	0.44	0.69	0.55	0.81	0.57	0.43	0.28	-0.58	0.53	0.35	-0.71
K2O											1.00	-0.62	0.79	0.78	0.80	-0.15	0.78	0.79	0.52	0.53	0.79	-0.11	0.02	-0.63	0.01	0.10	-0.75
P2O5												1.00	-0.92	-0.70	-0.46	-0.35	-0.31	-0.59	-0.61	-0.72	-0.39	-0.63	-0.40	0.72	-0.68	-0.50	0.81
LOI													1.00	0.81	0.72	0.15	0.56	0.74	0.73	0.73	0.61	0.33	0.40	-0.76	0.41	0.26	-0.83
Co														1.00	0.80	-0.21	0.77	0.73	0.60	0.53	0.71	0.00	0.32	-0.82	0.23	-0.00	-0.89
Ni															1.00	-0.29	0.85	0.85	0.52	0.61	0.92	-0.35	0.25	-0.58	-0.17	-0.22	-0.72
Cu																1.00	-0.49	0.10	-0.18	0.21	-0.37	0.65	0.23	0.31	0.49	0.67	0.03
Pb																	1.00	0.65	0.60	0.49	0.88	-0.46	0.31	-0.64	-0.27	-0.24	-0.59
Zn																		1.00	0.34	0.68	0.79	-0.13	0.28	-0.45	-0.02	0.22	-0.72
Sr																			1.00	0.53	0.43	0.17	0.35	-0.71	0.20	0.03	-0.69
V																				1.00	0.69	0.23	0.43	-0.51	0.23	0.38	-0.53
Mo																					1.00	-0.41	0.21	-0.58	-0.27	-0.13	-0.55
B																						1.00	0.14	-0.16	0.90	0.64	-0.22
As																							1.00	-0.48	0.28	0.03	-0.39
Y																								1.00	-0.39	0.05	0.82
Zr																									1.00	0.40	-0.41
Pt																										1.00	-0.12
T.R.E.																											

(n = 14)

Table 4-3-15 Analysis of Major and Minor Elements of Cobalt Crusts (1)

	Sample No.	89SC01 AD03(A)	89SC02 AD05(B)	89SC03AD02(A)			89SC03 AD06(A)	89SC04 AD03(B)
	Location	Upper slope	Upper slope	Upper Slope			Upper slope	Crest
	Water Depth (m)	2,070	2,220	1,750			1,820	1,090
	Morphology	Slab	Crust	Crust			Nodule	Crust
	Analyzed Portion	Inner	Bulk	Outer	Middle	Inner	Bulk	Bulk
	Thickness (cm)	3.0	2.5	1.5	3.5	1.5	0.3	3.8
Major Metal Contents (%)	Co	0.30	0.60	0.56	0	0.18	0.79	0.20
	Ni	0.41	0.66	0.68	0.26	0.31	0.77	0.60
	Cu	0.12	0.11	0.10	0.08	0.08	0.15	0.05
	Mn	12.98	24.07	19.66	7.84	9.78	25.09	18.37
	Fe	8.11	15.56	10.65	4.17	3.88	13.43	6.95
Major Element Contents (%)	SiO_2	4.38	6.38	3.90	2.72	3.32	3.68	0.44
	TiO_2	0.46	1.53	1.60	0.78	0.53	1.37	0.84
	Al_2O_3	0.89	1.56	0.81	0.92	0.77	1.03	0.22
	Fe_2O_3	15.03	21.45	17.01	11.70	11.74	15.30	13.44
	FeO	0.19	0.19	0.19	0.06	0.19	0.32	0.19
	MnO_2	24.29	33.94	37.70	13.09	25.23	35.83	28.66
	MgO	0.41	1.69	1.08	0.96	1.19	1.32	1.26
	CaO	18.94	4.52	7.40	30.06	22.43	9.40	20.98
	BaO	0.27	0.38	0.28	0.22	0.21	0.27	0.26
	Na_2O	1.80	2.02	1.94	1.25	1.51	2.02	1.78
	K_2O	0.45	0.50	0.51	0.26	0.40	0.47	0.32
	P_2O_5	10.68	0.97	3.06	20.89	14.45	4.39	12.13
	Ig-loss	21.28	27.38	25.74	15.67	18.09	26.05	20.99
Minor Element Contents (ppm)	Pb	913	877	1,382	493	913	1,250	1,286
	Zn	536	638	791	408	587	880	510
	Sr	480	560	665	384	268	504	557
	V	418	405	509	253	347	450	475
	Mo	374	352	483	129	357	421	448
	B	178	268	214	150	150	200	162
	As	141	195	178	97	112	156	197
	Y	247	142	184	340	259	267	201
	Zr	5	555	12	12	4	4	4
	Pt	0.7	0.4	1.3	0.2	0.8	1.0	0.2
	ΣR_2O_3	1,373	692	762	1,384	1,506	929	1,422

Table 4-3-15 Analysis of Major and Minor Elements of Cobalt Crusts (2)

	Sample No.	89SC04AD06(C)		89SC05 AD06(D)	89SC06 AD01(B)	89SC06 AD05(A)	89SC06AD09(A)	
Location		Middle slope		Upper slope	Upper slope	Middle slope	Crest	
Water Depth (m)		3,115		1,320	2,370	2,620	1,350	
Morphology		Slab		Crust	Crust	Crust	Slab	
Analyzed Portion		Outer	Inner	Bulk	Bulk	Bulk	Outer	Inner
Thickness (cm)		1.5	8.0	1.8	2.3	2.2	1.5	1.0
Major Metal Contents (%)	Co	0.47	0.22	1.37	0.86	0.91	1.30	1.01
	Ni	0.37	0.38	0.88	0.49	0.47	1.00	1.08
	Cu	0.12	0.22	0.08	0.11	0.10	0.07	0.08
	Mn	22.52	16.19	30.43	22.94	24.28	32.42	27.42
	Fe	19.92	18.21	11.67	17.69	19.34	9.94	6.77
Major Element Contents (%)	SiO_2	7.50	6.56	2.38	5.36	4.60	1.90	1.10
	TiO_2	1.08	0.96	1.59	1.67	1.66	1.61	1.27
	Al_2O_3	1.59	1.46	0.40	0.84	0.72	0.40	0.23
	Fe_2O_3	30.10	35.89	17.01	24.16	25.38	14.65	10.08
	FeO	0.44	0.19	0.25	0.38	0.38	0.38	0.38
	MnO_2	28.04	24.61	43.30	33.94	36.44	45.16	42.66
	MgO	1.28	1.68	1.82	2.08	1.66	1.74	1.27
	CaO	3.45	2.95	3.37	4.52	3.13	3.20	11.00
	BaO	0.45	0.42	0.33	0.41	0.42	0.37	0.42
	Na_2O	2.18	2.23	2.21	1.97	1.82	2.30	2.14
	K_2O	0.45	0.34	0.51	0.44	0.39	0.60	0.56
	P_2O_5	1.23	1.11	0.75	0.75	0.82	0.76	4.74
	Ig-loss	24.00	23.53	26.97	25.51	24.72	27.78	25.62
Minor Element Contents (ppm)	Pb	517	505	1,887	1,046	877	1,959	1,394
	Zn	561	714	753	676	638	918	995
	Sr	506	415	622	636	499	640	448
	V	442	507	497	471	433	454	538
	Mo	288	272	560	331	336	583	667
	B	353	344	219	263	293	174	126
	As	237	268	217	218	234	190	140
	Y	226	260	107	122	105	71	181
	Zr	748	855	461	597	631	373	3
	Pt	1.2	1.3	0.6	0.8	1.0	0.5	0.5
	R_2O_3	1,045	1,073	595	678	703	343	688

③ The third system:

CaO, BaO, P_2O_5, As, Y, ΣR_2O_3

Following components have strong positive relation with each other:

CaO and P_2O_5 are in positive relation of 0.99%.
Fe_2O_3 and B (coefficient of correlation : 0.97).
Fe_2O_3 and Zr (coefficient of correlation : 0.90).
Co and MnO_2 (coefficient of correlation : 0.92).
Co and TiO_2 (coefficient of correlation : 0.79).
Ni and Mo (coefficient of correlation : 0.92).

5) Mineral Composition

In order to investigate the mineralogy and inner structure, powder X-ray diffraction of representative samples was carried out and microscopic observations on polished sections were made. Plural samples totaling 24 were selected from each seamount for identifying the mineral components. As for the crusts sampled from the seamounts 03, 04 and 06, test pieces were selected from different layers. Microscopic observation was also carried out on the test pieces of seamounts 03 and 06.

(1) X-ray diffraction

The result of X-ray diffraction is shown in Table 4-3-17. Typical chart is shown in Figure 4-3-14.

Manganese oxide is mainly composed of δ-MnO_2*1 and only one sample contains 10Å Manganese. Un-identified minerals with broad diffraction of 2.52, 2.56Å and diffraction of 2.71Å are recognised from seven test pieces. They might be manganese oxide of δ-MnO_2 system (birnessite, etc.).

A small amount of goethite is identified from one test piece. Gangue minerals such as apatite, goethite and quartz are identified but the samples are rich in apatite compared with manganese nodules.

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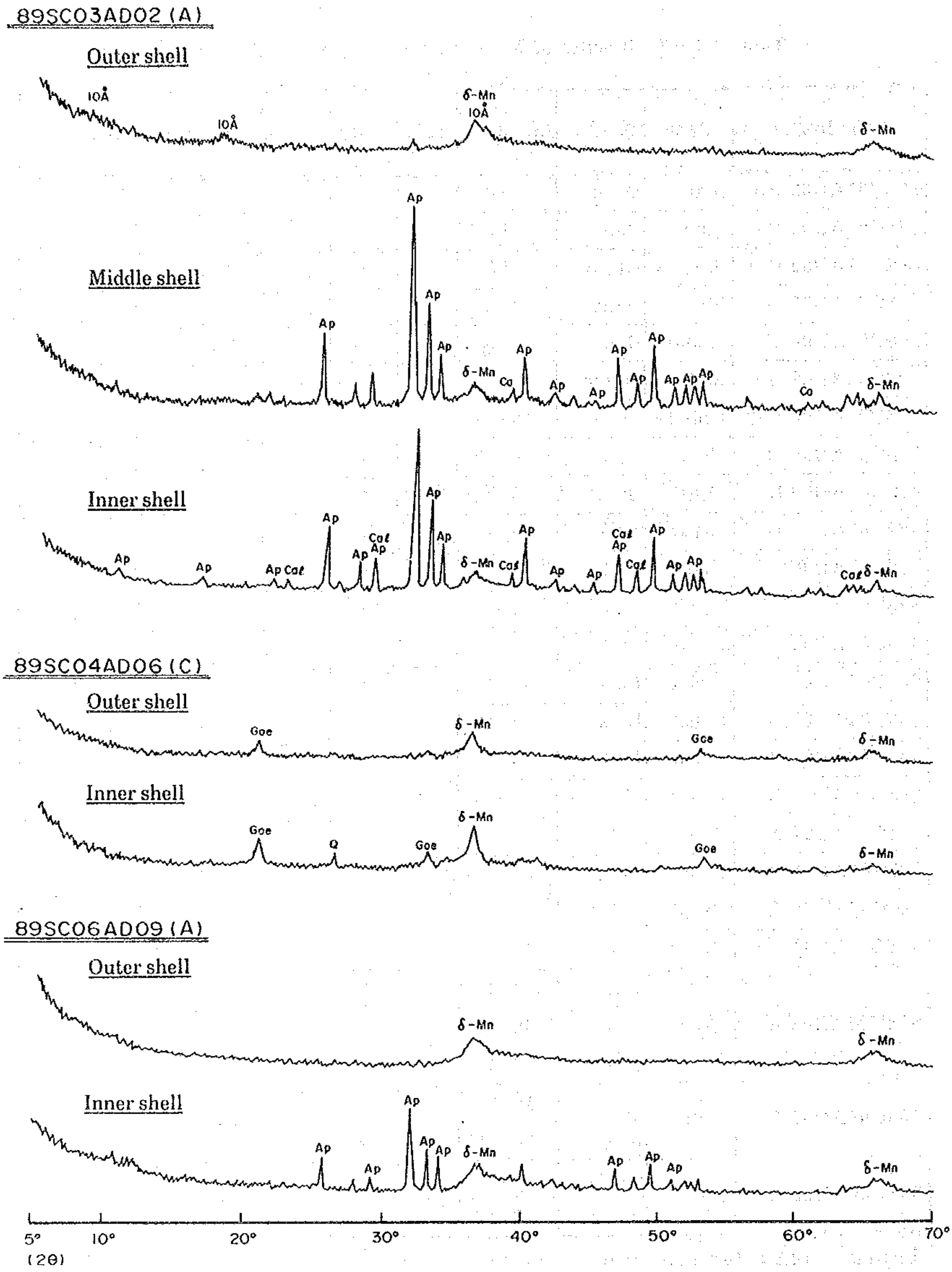
*1 2-line type δ-MnO_2 with broad diffraction of 1.4Å and 2.4Å

Table 4-3-17 Results of X-ray Diffraction of Cobalt Crust

Sample No.	Type	Portion	Crust thickness (mm)	10Å	δ-Mn	Goe	Q	Cal	Ap	X
89SC01AD03 A2	Slab	Outer	30				±		⧺	
89SC01AD03 B	Slab	Bulk	200		⧺					
89SC01AD03 C-1	Slab	Outer	20		+				±	
89SC01AD03 D	Slab	Bulk	190		+				±	
89SC01AD08 C	Nodule	Bulk	50		+		±		⧺	
89SC02AD02 A-2	Slab	Outer	20		+		±	±	⧺	
89SC02AD04 C-2	Cobble	Inner	10~12		±				+	
89SC02AD04 D	Cobble	Bulk	3~20		+			±		
89SC03AD05 B	Crust	Bulk	15~34		±			±		
89SC03AD05 C	Crust	Bulk	10~17		±					+
89SC03AD06 A	Nodule	Bulk	1~25		±					+
89SC03AD09 A	Crust	Bulk	5~15		±				±	
89SC03AD09 D	Nodule	Bulk	1~ 4		+				±	
89SC04AD03 B	Crust	Bulk	32~46		±				⧺	
89SC04AD03 D	Crust	Bulk	5~10		±			±	⧺	
89SC04AD08 B	Crust	Bulk	5~10		±			⧻		
89SC05AD06 E	Crust	Bulk	8~12		±			±		+
89SC06AD01 A	Crust	Bulk	17~27							+
89SC06AD01 B	Crust	Bulk	20~25		±			±		+
89SC06AD05 A	Crust	Bulk	20~24		±					+
89SC06AD06 B	Crust	Bulk	14~20		±			±		+
89SC03AD02 A	Crust	Outer	11~18	±	⧺					
		Middle	30~40		⧺			±	⧻	
		Inner	12~18		±			+	⧻	
89SC04AD06 C	Slab	Outer	10~25		±	+				
		Inner	60~100		±	+	±			
89SC06AD09 A	Slab	Outer	15		⧺					
		Inner	8~12		⧺				⧺	

Legend 10Å : 10Å Manganate δ-Mn : δ-MnO_2 Goe : Goethite
Q : Quartz Ap : Apatite X : Unknown mineral
⧻ : very strong ⧺ : strong
+ : weak ± : very weak, uncertain
Cu-Monochrometer, 45 kV, 20 mA



Legend 10Å : 10Å Manganate δ-Mn : δ-MnO_2 Pl : Plagioclase
Goe : Goethite Q : Quartz Ap : Apatite

Figure 4-3-14 X-ray Diffraction Patterns of Cobalt Crust

(2) Microscopic observation

① 89SC03AD02A (crust type)

Substrate is basalt and intergranular is filled with calcite; the thickness of crust is 5cm - 8cm consisting of inner-shell, mid-shell and outer-shell. Inner-shell is fine-grained and composed of stratified texture of δ-MnO_2, hematite and goethite. Stratified structure (width of 0.01 - 0.1mm) in the inner-shell is most obvious. Mid-shell is composed of δ-MnO_2, 10Å Manganite in the shape of granule (0.5 - 0.1mm); reniform and botryoidal, calcite fills the intergranulars. Outer-shell has manganese oxide in granules and some in elliptic shape. δ-MnO_2 and goethite also compose fine-grained stratification.

② 89SC06AD09A (slab type)

The core is composed of rock flakes, fragments of plagioclase, clay minerals, calcite and hematite. Two layers of manganese nodules form inner-shell and outer-shell. Inner-shell is mainly composed of δ-MnO_2 accompanied with goethite forming compositional banding. Outer-shell is composed of δ-MnO_2 forming irregular massive and has plenty of cracks smaller than 0.01mm.

6) Result of FDC Survey

FDC survey was carried out at seamounts SC02, SC03, SC04 and SC05 (Flint Island). Sea bottom observation by FDC was carried out at four track lines totaling 20.2 miles. Observation was also recorded by video tape, and 675 photographs were taken.

FDC route map (occurrence of crusts and coverage were entered on the chart) is shown in Figure 4-3-15. Examples of FDC continuous photograph are shown in figure 4-3-16.
Sea bottom photographs of cobalt crust occurrence are shown in Figure 4-3-13. The result of observation are shown in Table 4-3-18.

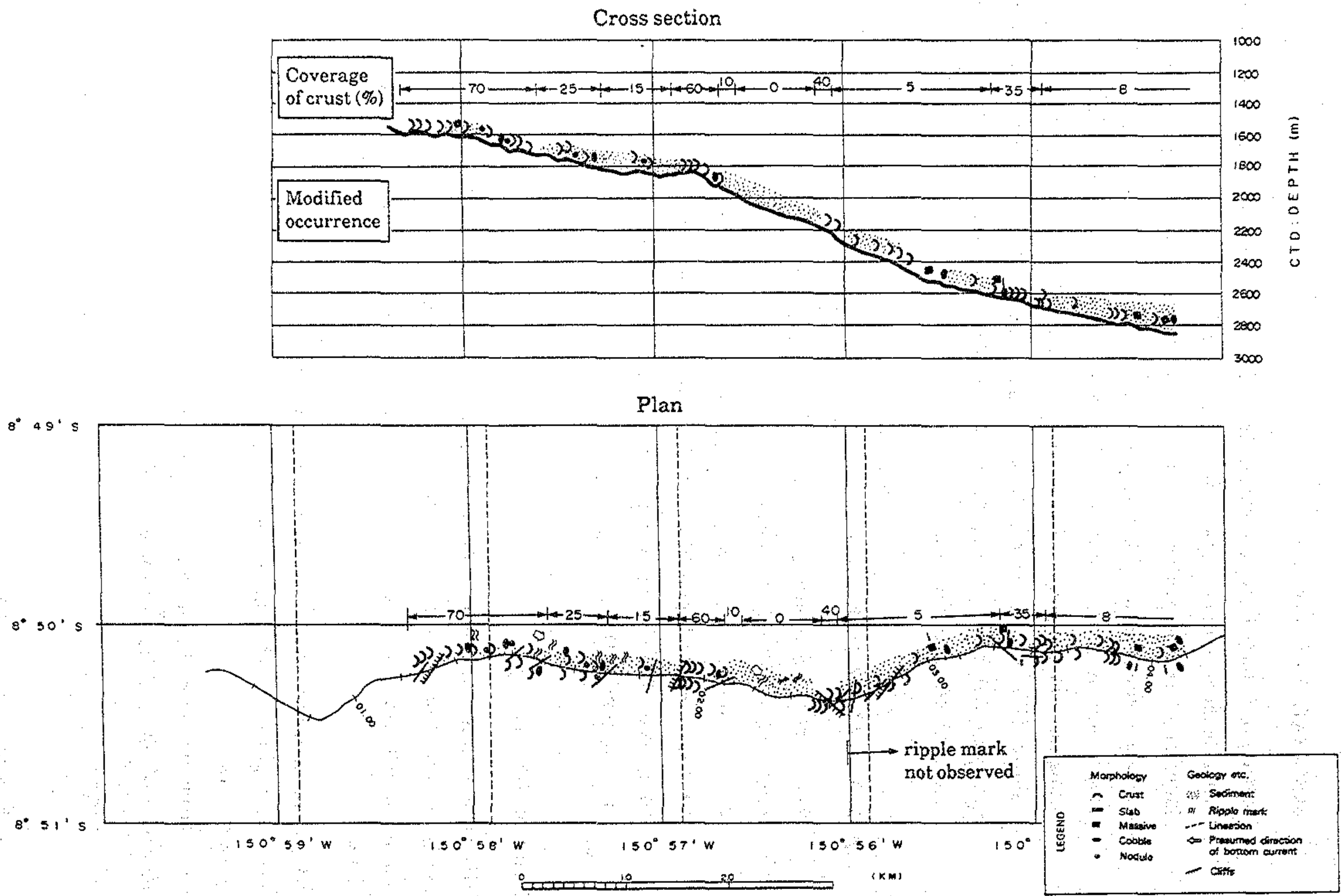


Figure 4-3-15 FDC Route Map (Line No. 89SC02FDC01) (1)

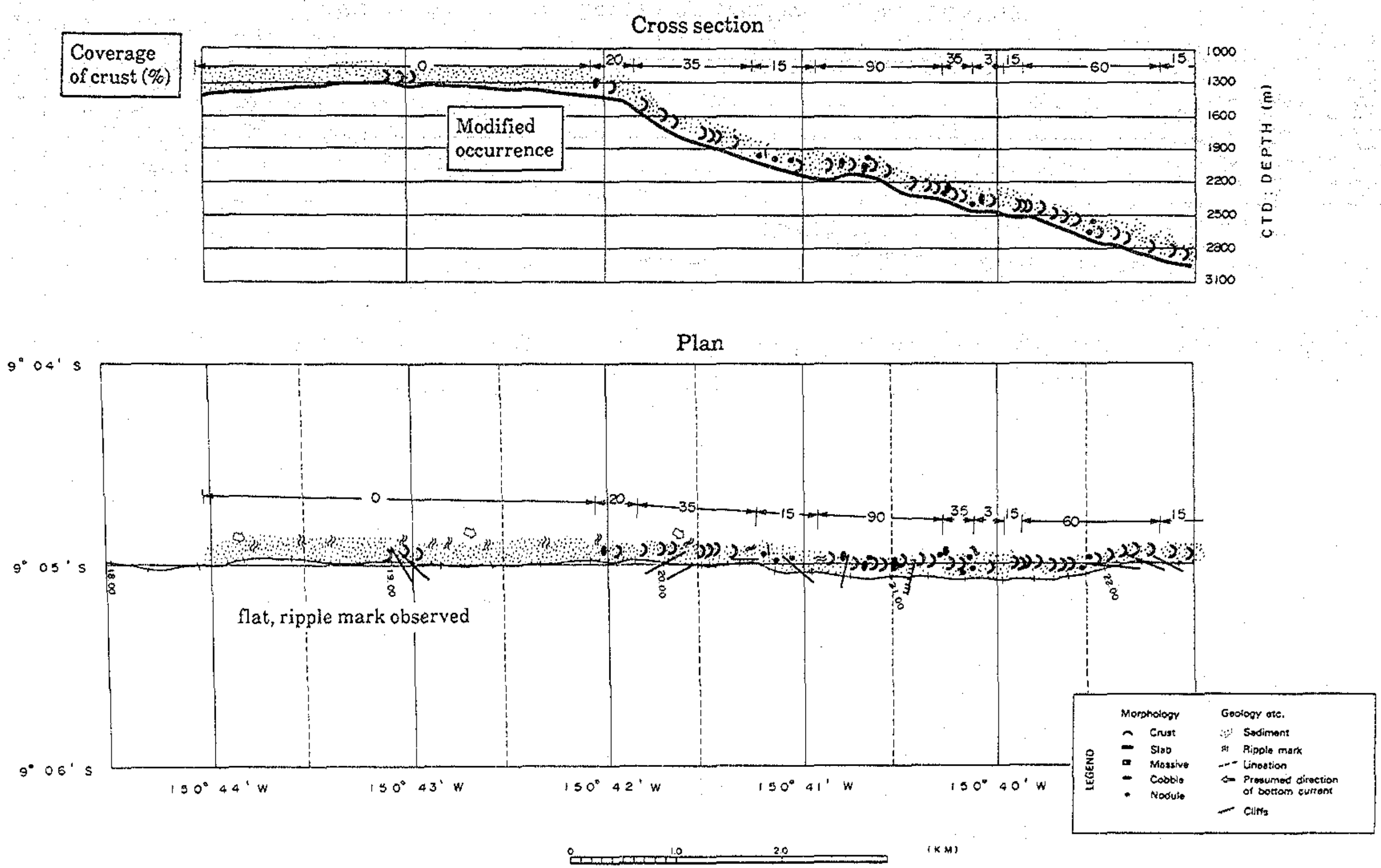


Figure 4-3-15 FDC Route Map (Line No. 89SC03FDC02) (2)

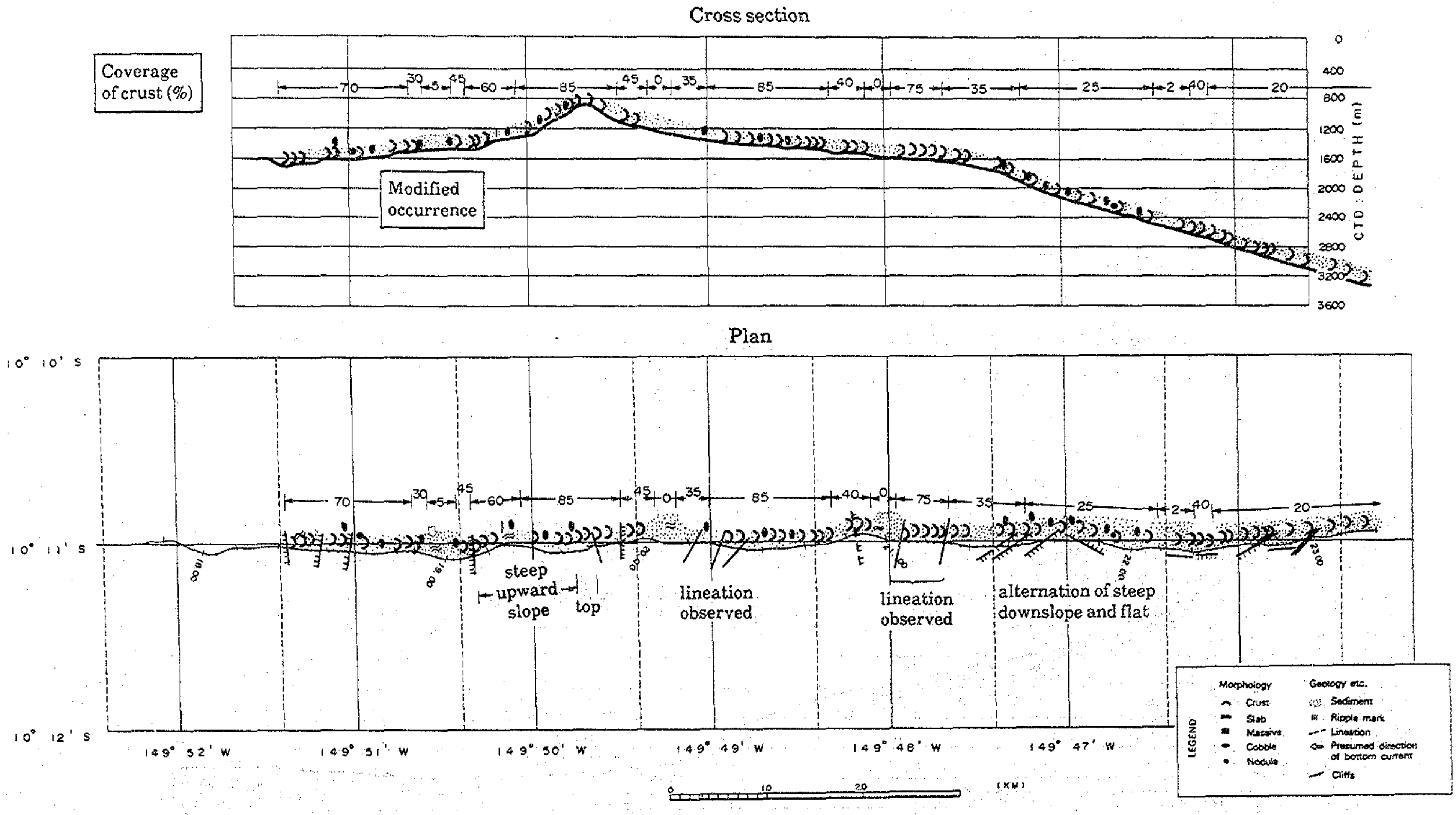


Figure 4-3-15　FDC Route Map (Line No. 89SC04FDC03) (3)

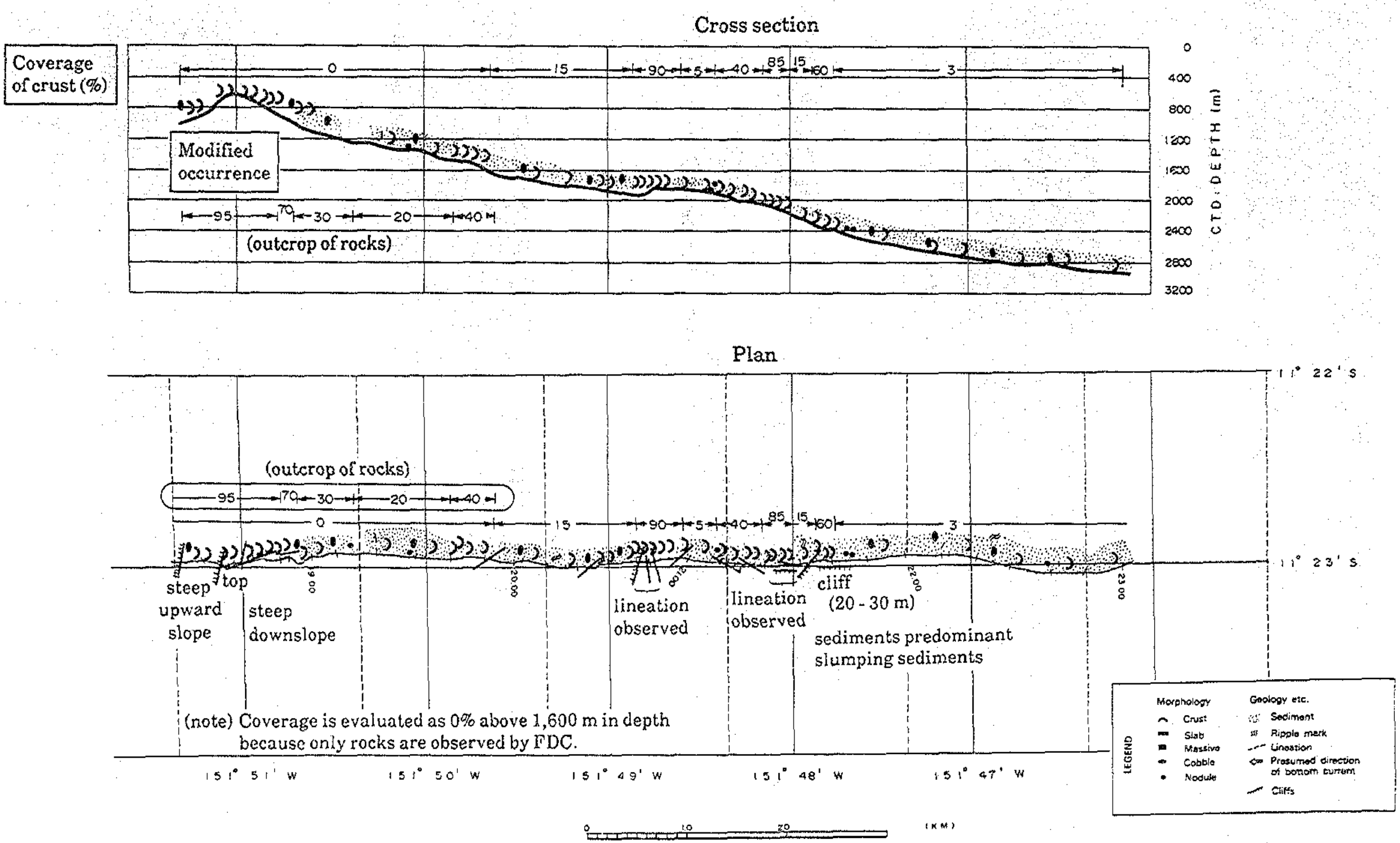
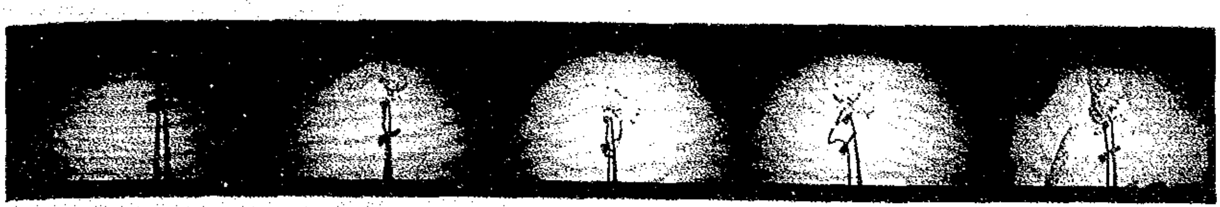
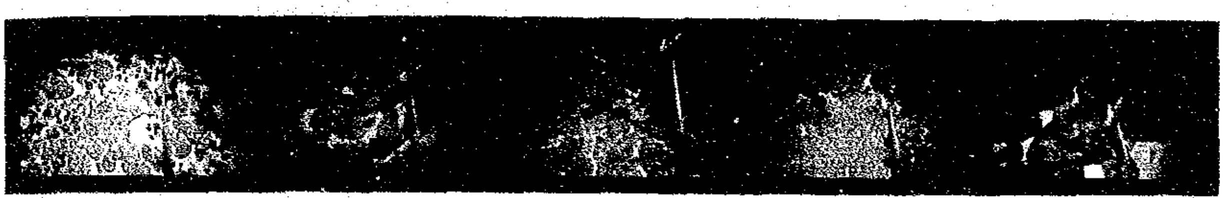


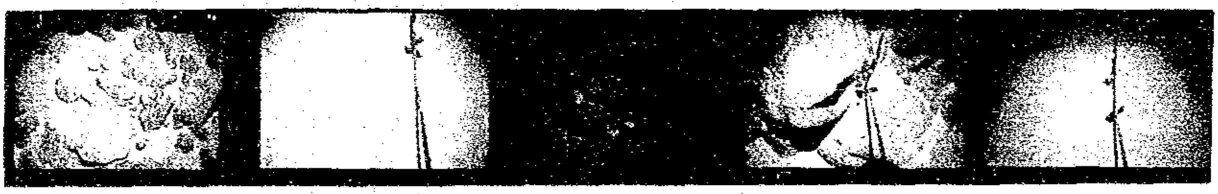
Figure 4-3-15 FDC Route Map (Line No. 89SC05FDC04) (4)



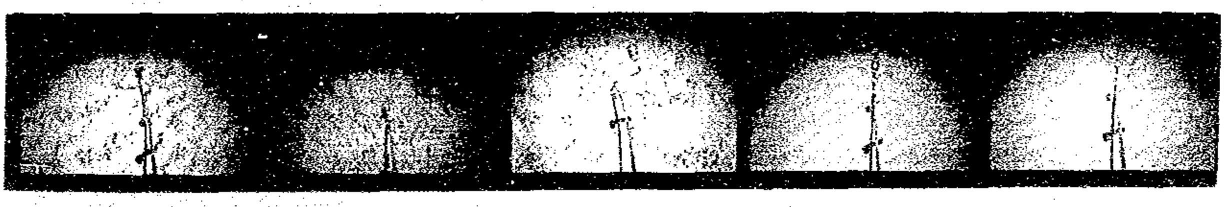
A: Line No. 89SC02FDC02, SC03 Flat Top (Depth 1,401m~1,438m)



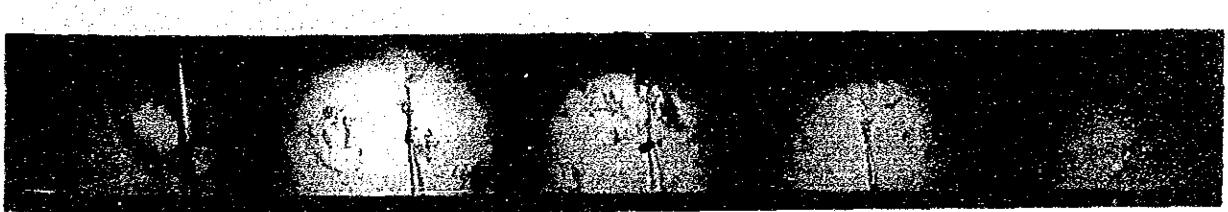
B: Line No. 89SC04FDC03, SC04 Top (Depth 1,400m~1,413m)



C: Line No. 89SC04FDC03, SC04 Top (Depth 1,627m~1,670m)



D: Line No. 89SC03FDC02, SC03 Upper Slope (Depth 2,448m~2,456m)



E: Line No. 89SC04FDC03, SC04 Middle Slope (Depth 3,084m~3,151m)

Figure 4-3-16 Examples of FDC Continuous Photographs

Table 4-3-18 FDC Observation of Cobalt Crust

Track No.	Occurrence
SC02 FDC01	Observed from upper to lower slope. Steep in places at upper slope. Crust coverage is better at shallow depth. Crust type is predominant, cobble and nodule types are abundant too on uncongealed sediments. Due to gentle slope at middle slope, crust coverage is worse than upper part. Crust type distributed with small amount of cobble, massive and slab type. Ripple mark observed on uncongealed sediments at upper slope indicates bottom water current of NW→SE direction.
SC03 FDC02	Observed from top to middle slope. Flat, uncongealed sediments predominant and barren at top of the seamount. Small amount of crust, slab, nodule types distributed. Slope and terrace consist the upper part and crust type developed at slope but sediments predominant at terrace with small amount of crust, cobble and nodule types. At middle part, same with upper part, slope and terrace developed. Due to gentle slope, sediments are predominant. Estimated bottom water current direction is WNW→ESE and NW→SE by ripple mark observation.
SC04 FDC03	Observed from top to middle slope. Crust type covered basement rocks and cobble, nodules types distributed on sediments at central part of the top. Slope and terrace consist the upper and middle part. Uncongealed sediments predominant at terrace with small amount of crust, cobble and nodule types. Lineation of sediments runs from NE to SW and from N to S. Bottom water current was estimated as from N to S and from NNW to SSE by ripple mark direction.
SC05 FDC04	Observed from upper to middle slope of Flint Island. Both slopes consist of slope and terrace. Less than 1,600m in depth, basement rock exposed widely at slope but photographs and samples indicate almost no development of cobalt crust. Below 1,600m in depth, crust observed and crust type covered on the slope. Uncongealed sediments predominant at terrace with small amount of crust, cobble, nodule and slab types. Below 2,400m in depth, due to gentle slope, uncongealed sediments predominant with decrease of crust coverage.

(1) Distribution

As the result of FDC survey, distribution of cobalt crust in the four seamounts was identified. The occurrence was observed from the summit to the middle slopes of the seamounts at the water depth ranging from 990-3,270m.

Topography of the seamounts are classified into summit and slope (upper part, middle part, lower part) and the features were as follows:

① Summit

Observation of summit was made at the seamounts SC03 and SC04. The summits show gentle inclination compared with the slopes of seamounts.

SC03 : Flat summit, prominent in unskeletal sediments, ripple marks of 20 - 30cm cycles on the sediments, distribution of small amount of cobble type cobalt crust.

SC04 : Peak on the center of summit, steep topography around the peak. Widely covered by rocks. Away from the peak is gentle slope covered by unskeletal sediments. Crust type is prominent around the peak with small amount of cobble type, slab type and nodule type. Away from the peak, crust type, cobble type and nodule type are distributed between sediments as well as on the surface. But the coverage is low.

② Upper part of the slope (depth range is shown in Table 4-3-19.)

Upper part consists of slope and terrace. Inclination of slope is generally steep and, elliptic rocks presumed to be pillow lava and platy rocks are exposed on the surface of slope. On the other hand, terrace is covered by unskeletal sediments, and some place has exposed rocks. Ripple marks on the sediments are observed in the shallow water but as the depth deepens the ripple marks are not observed.

Crust type is prominent on the slope but a small amount of cobble type and slab type are found on sunken places and border between rocks.

Unskeletal sediments are prominent on the terrace but a small amount of crust type, cobble type and slab type are observed.

SC05 (Flint Island) has steep topography around the ridge and has wide-ranging exposed rocks. From the sea bottom photographs, it is presumed that the occurrence of cobalt crust is very poor until the water depth of 1,600m.

⑧ Middle part of the slope (depth range is shown in Table 4-3-19)
FDC observation was made as deep as 3,290m.
(Track line 89SC04FDC03, Seamount SC04)
Middle part of the slope is composed of terrace. Inclination of the slope is sharp with undulations. There are some cliffs of a few meters high around the border with the upper part. The terrace is covered by slumping sediments but there are some exposed rocks under the sediments. Inclination is gentle in the deep sea and all of the slopes in the deep sea are covered by sediments. Exposed rocks are rarely seen below the depth of 2,500m. Crust type is prominent at the slope but a small amount of cobble type and slab type are observed. Crust type and a small amount of slab type, cobble type, nodule type and massive type are recognized.

Table 4-3-19 Average Coverage of Cobalt Crust by FDC

Line No.	Topographic Position	Average Coverage (%)
SC02 FDC01	Upper slope (1,500~2,500m)*1	30
	Middle slope (2,500~3,500m)	10
SC03 FDC02	Top (0~1,500m)	2
	Upper slope (1,500~2,500m)	50
	Middle slope (2,500~3,500m)	45
SC04 FDC03	Top (0~1,700m)	60
	Upper slope (1,700~2,500m)	25
	Middle slope (2,500~3,500m)	20
SC05 FDC04	Upper slope (500~2,000m)	30*2
	Middle slope (2,000~3,500m)	15

*1 Water depth in ( ) corresponds to topographic feature of individual seamount.

*2 Average coverage of upper slope of line 89SC05FDC04 shows the coverage below the depth 1,600m.

(2) Coverage

Coverage of crust is calculated by following method;

① Occurrence of crust, its amount ratio, surface structure, coverage were read from the sea bottom photographs and plotted on the trackline map (scale: 1/30,000).

② When the interval of photographing time was long, a coverage of crust was tentatively calculated by referring to photographs taken previously and afterward as well as FDC observation field notes.

③ Each track line's regional coverage was calculated by the distance adding method.

The FDC route map is shown in Figure 4-3-15.
Average coverage of crusts is shown by FDC in Table 4-3-19.
The Following features are observed:

① Coverage of crust is influenced by topography. When the topography is steep with sharp slopes, crust type cobalt crusts cover the rocks, and the coverage will be high as 90%. But at the places where the topography is gentle on the summit or slopes, foraminifera sand and ooze are prominent and the coverage of crusts will be as low as 0 - 3%.

② Coverage at the upper part of slope is higher than that of the middle part.

③ At the middle parts of the slope, the inclination of slope becomes gentler as the depth deepens and sediments become prominent. Also the thickness of crust becomes thinner.

④ On seamount SC05 (Flint Island). inclination of slope is sharp as deep as 1,600m and exposed rocks appear widely. However, coverage of crust is not observed.

4-4 Discussions

1) Morphologically, crust type is prominent, followed by slab type, nodule type and cobble type. They are distributed around summits and on the slopes with irregular exposed rocks. On the contrary, places like flat summit, slope terraces, middle and lower parts of slopes are covered by slumping sediments. At the latter places, crust occurrence is not good. (Refer Figure 4-4-1)

2) Cobalt crusts of slab type and crust type, hyaloclastite substrate are rich in Co grade. The regions from the seamount summit to the lower part of the slopes located in the depth range of 1,000m - 1,500m have the highest grade Co. As the depth deepens the grade of Co decreases. Co grade is in positive relation with Ni grade and Mn grade but in negative relation with Fe. The portion of the crust like surface outer-shell which directly touches sea water has the highest grade but the portions like mid-shell and inner-shell have lower grade.

3) Slab type has excellent thickness of crust. Substrates composed of sedimentary rocks and pyroclastics have average thickness of more than 27mm, but substrates composed of basalt and limestone have average thickness of less than 15mm. Places deeper than 1,500m have good thickness.

4) Average Co grade at seamounts SC02 and SC06 is 0.76%. Average thickness of crust at seamounts SC01 and SC02 is thicker than 20mm. Occurrence of crust at the seamounts located in the sea areas of northern and western parts of the Line Islands proved to be excellent. Tendency of excellent distribution at seamounts formed in earlier age is observed. (Refer Table 4-4-1).

5) Cobalt crusts were classified into following three categories according to the Ni-Cu-Co grade and species of substrate. (Refer Figure 4-4-2).

	Grade	Substrate
①	Ni rich	Tuff, Tuff breccia
②	Ni/Co	Sedimentary rock (Sandstone, Phosphorite)
③	Co rich	Basalt, Hyaloclastite, Limestone

In shallower sea area, differences of grade according to the species of substrate are obvious, but in deeper sea areas the grade becomes medium of Ni-Co and gradually, grade of Ni and Co both decreases to inferior levels. Finally there is a similarity to Co rich type manganese nodules. From above points, the fact that grade variation of Cobalt Crust and Manganese Nodules are influenced by the factors of water depth and species of substrate can be ascertained.

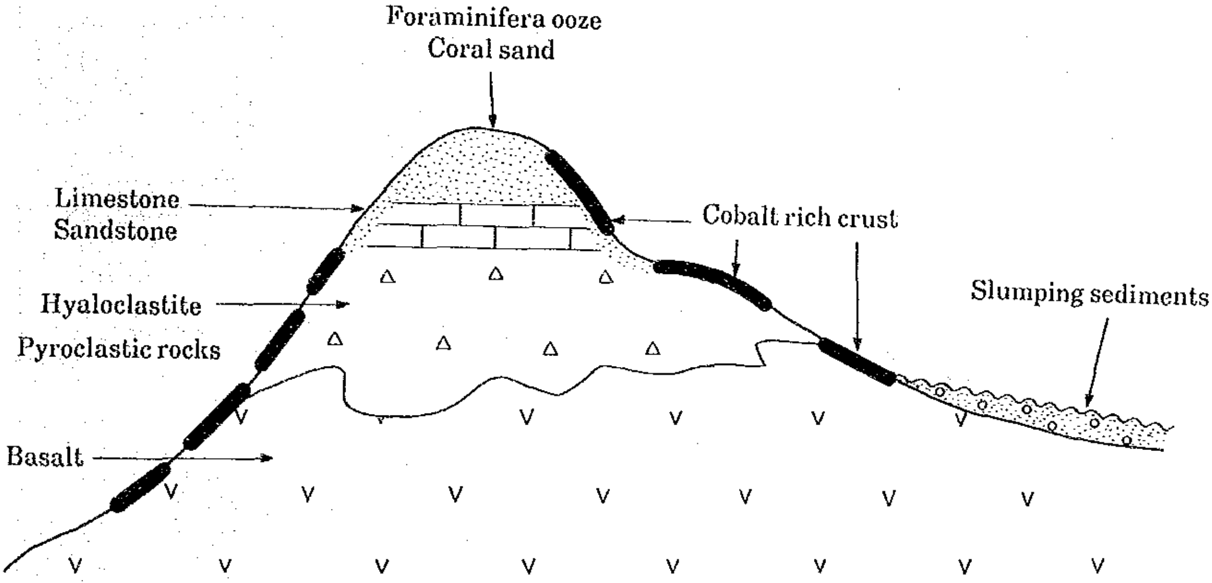


Figure 4-4-1 General Occurrence of Cobalt Rich Crust

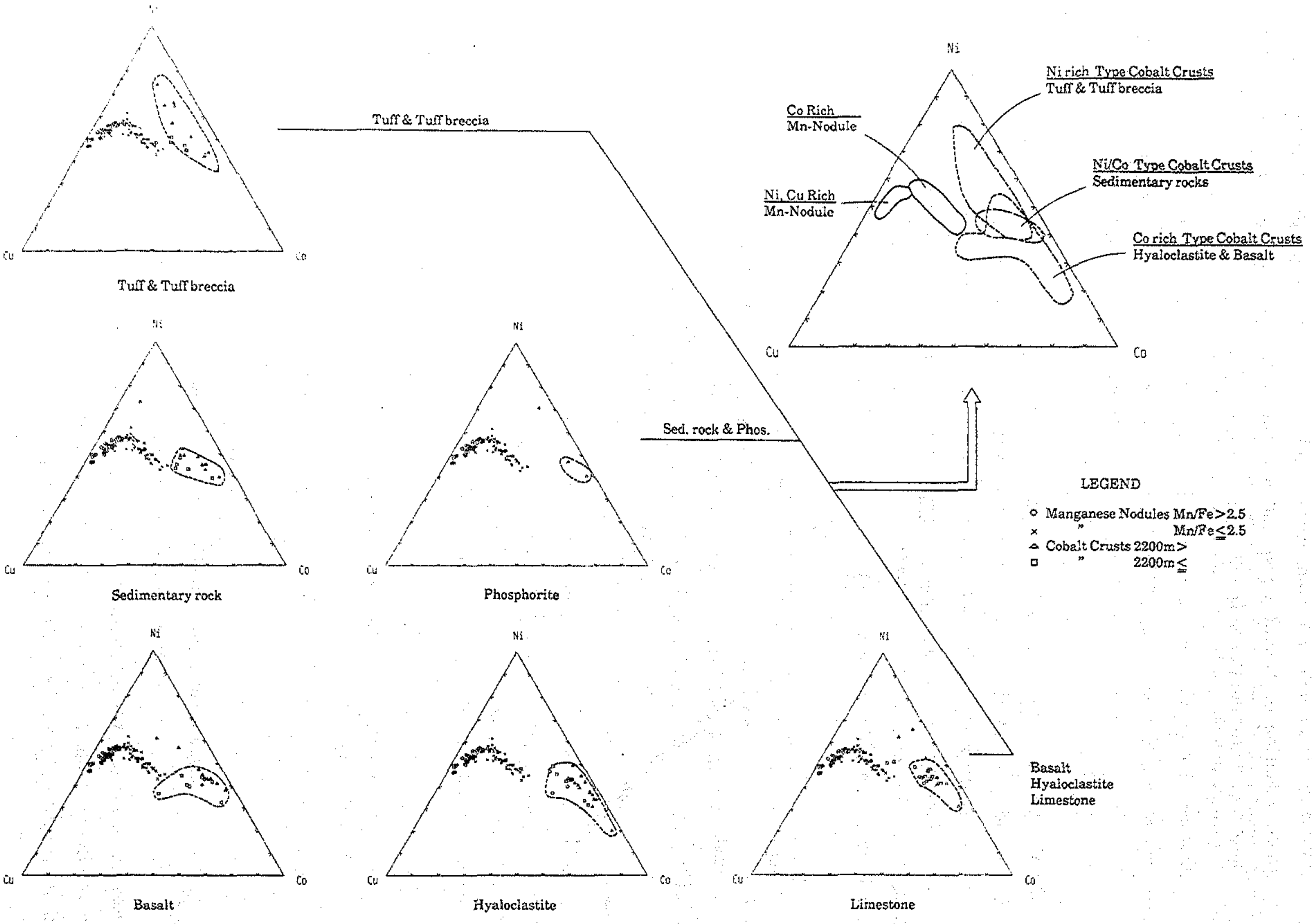


Figure 4-4-2 Relation of Co-Ni-Cu Grade and Substrate of Cobalt Crust

Table 4-4-1 General Occurrences of Cobalt Crusts at Individual Seamount

Seamount	SC-01	SC-02	SC-03	SC-04	SC-05	SC-06
Position*1	(N) 7°20' S, 151°52' W, (S) 7°33' S, 151°32' W	8°52' S, 150°57.5' W	9°05' S, 150°43' W	10°11' S, 149°49' W	11°25' S, 151°50.0' W	10°30' S, 154°12' W
Survey Period	Sept. 27 ~ 28 (2 days)	Sept. 29 ~ Oct. 2 (4 days)	Oct. 03 ~ 06 (4 days)	Oct. 07 ~ 10 (4 days)	Oct. 12 ~ 15 (4 days)	Oct. 17 ~ 19 (3 days)
Topographic Survey	450 miles	500 miles	410 miles	400 miles	421 miles	304 miles
Dredge Sampling	7 points, 471.74 kg	9 points, 219.44 kg	9 points, 616.83 kg	9 points, 325.23 kg	9 points, 30.20 kg	9 points, 167.06 kg
Photography (FDC)	-	1 line, 4.1 miles, 137 photographs	1 line, 5.0 miles, 192 photographs	1 line, 6.0 miles, 180 photographs	1 line, 5.1 miles, 166 photographs	-
Survey Depth Range						
Sampling	1,260m ~ 2,180m	1,300m ~ 2,720m	1,540m ~ 2,920m	890m ~ 3,115m	1,090m ~ 2,745m	1,140m ~ 2,880m
FDC	-	1,646m ~ 2,882m	1,253m ~ 3,110m	818m ~ 3,446m	539m ~ 3,098m	-
Topographic Feature of Seamount						
Type	Peaked top; Peaked top	Peaked top	Peaked top	Peaked top	Table reef	Peaked top
Size (km)	16 × 47; 17 × 42	10 × 24	15 × 15	18 × 15	28 × 10	15 × 12
Water Depth Range (m)	1,590~5,000; 1,200~5,000	1,040~4,000	1,140~4,500	805~4,500	0~4,500	1,130~4,700
Area of Top (km)	5 × 5; 5 × 5	5 × 5	4 × 4	1 × 1	4 × 1	2 × 2
Average inclination of slope (upper/middle/lower)*2	11°/9°/5°; 13°/10°/6°	14°/12°/6°	14°/12°/6°	18°/16°/7°	17°/13°/4°	18°/17°/4°
Area of above 2400m depth (km²)	141; 179	217	219	145	253	58
Top (km²)	62; 97	25	18	62	1	6
Slope (km²)	79; 82	192	201	83	252	52
Geology	Basalt contains hornblende phenocryst. Hyaloclastite is basaltic composition and replaced by phosphorite in matrix. Limestone is composed of hermatic sediments and contains foraminifera and bivalves fossils.	Basalt shows amygdaloidal texture. Hyaloclastite is basaltic in composition and matrix is replaced by phosphorite. Limestone is composed of hermatic sediments with foraminifera fossils. Basalt is predominant at west side of seamount.	Limestone is composed of hermatic sediments with foraminifera, bivalves fossils and phosphatized. Basalt shows two types: aphyric and pyroxene bearing basalt. Amygdaloidal basaltic boulders are sampled from south slope at 2,000m depth.	Limestone is composed of hermatic sediments with foraminifera, bivalves fossils and phosphatized. Only limestone is collected from top above 1,700m in depth. Laminated tuff is collected from west and east slope. Fine grained sandstone is collected from south-west and north slope.	Limestone is composed of hermatic sediments with foraminifera, bivalves fossils. Phosphatized, porous limestone is observed. Basalt shows amygdaloidal texture.	Basalt shows amygdaloidal texture. Basalt, hyaloclastite collected from west slope contain large pyroxene phenocrysts (max. about 1cm). Limestone is composed of hermatic sediments with foraminifera fossils. Limestone is dominant compared with other seamounts.
Cobalt Crust — Occurrence	Cobble type is predominant with slab, crust type.	Crust type is predominant with slab, cobble, nodule type.	Crust type is predominant with nodule, cobble type.	Crust type is predominant with cobble, slab and nodule type	Crust develops poor, coating type is predominant (<1mm).	Crust type is predominant with slab type.
Cobalt Crust — Substrate	Basalt, hyaloclastite are predominant with limestone and sediments.	Basalt, hyaloclastite are predominant with limestone and sediments.	Limestone is predominant with hyaloclastite, basalt and sediments.	Limestone is predominant with basalt, hyaloclastite and sediments.	Limestone is predominant with basalt, hyaloclastite and sediments.	Basalt, hyaloclastite are predominant with limestone and sediments.
Thickness — Average (mm)	35.4	21.7	15.6	19.0	6.5	18.9
Thickness — Range (mm)*4	1~200	3~85	1~80	0~130	1~20	1~85
Thickness — Number*3	7	7	9	8	8	9
Average Grade*5 — Co (%)	0.56 0.16~ 1.01	0.78 0.34~ 1.48	0.54 0.28~ 0.68	0.42 0.28~ 0.61	0.66 0.34~ 1.33	0.76 0.54~ 1.25
Average Grade*5 — Ni (%)	0.65 0.47~ 0.87	0.64 0.43~ 0.89	0.56 0.37~ 0.80	0.59 0.38~ 1.26	0.53 0.36~ 0.80	0.60 0.42~ 1.04
Average Grade*5 — Cu (%)	0.11 0.07~ 0.14	0.11 0.06~ 0.15	0.13 0.10~ 0.18	0.13 0.05~ 0.17	0.10 0.06~ 0.15	0.11 0.07~ 0.14
Average Grade*5 — Mn (%)	17.91 8.99~24.71	24.51 19.48~31.38	20.85 17.47~23.88	18.51 11.87~23.34	17.71 10.60~27.87	24.02 20.82~30.72
Average Grade*5 — Fe (%)	9.10 4.29~12.83	15.28 10.16~19.55	16.08 11.13~21.46	14.33 6.19~20.57	12.76 6.86~16.37	16.40 8.87~19.43
Average Grade*5 — Number*3	6	7	8	8	8	9
Estimated Coverage*6 (FDC)	FDC not operated	Top unknown Upper slope 30% Middle slope 10%	Top 0~5% (calcareous ooze predominant) Upper slope 50% Middle slope 45%	Top 60% Upper slope 25% Middle slope 20%	Cobalt crust not developed from top to 1,600m depth. Upper slope 30% Middle slope 15%	FDC not operated
Evaluation	Crust thickness is favorable.	Co grade, thickness are favorable.	Coverage of upper slope is favorable.	Coverage of tops is favorable.	Poor	Co grade is favorable but thickness is ordinary.

*1: Position shows the center of top.
*2: According to the definition of Table 4-1-3.
*3: Number shows dredging with sample.
*4: Cobalt crust thickness of each samples.
*5: Average grade of each seamount is calculated by arithmetic mean.
*6: Coverage is estimated from sample data and FDC data.

Chapter 5. Summary

5-1 Survey Methods

The survey of Manganese Nodules (duration of survey in the sea area: 18 days) was carried out during the first half of the entire survey (total duration was 65 days and duration of survey was 42 days), and the survey of Cobalt Crusts (duration of survey in the sea area: 24 days) was carried out during the second half of the survey.

During the survey of Manganese Nodules, manganese nodules were sampled at intervals of 60-mile-grid in the whole survey area, and at the same time, sea bottom photographs were taken to identify the occurrence, grade, bottom materials, etc. At the transition between sampling points, various acoustic sounding surveys were carried out for the purpose of making a sea bottom topography map and investigating surficial sediments. Survey of manganese nodules abundance by MFES was carried out simultaneously. Survey data was recorded and processed by the computer system installed on the survey vessel. Various kinds of figures and tables were also made out by the same system.

Based on these data, survey by Continuous Deep Sea Camera System (CDC) was carried out in the most favorable sea area.

Analyses, X-ray diffraction, microscopic observation, identification of fossil, etc., were carried out on shore on part of the samples collected so as to make comprehensive analysis.

For the survey of Cobalt Crusts, six seamounts were selected for the topographical survey by acoustic sounding and survey of surficial sediments. Based on above surveys, sampling points were selected and average of nine dredgings per seamount were carried out. Such elements as water depth, topography of slopes, state of sediments, tide, wind direction, etc., were considered while selecting the sampling points. For seamounts that had been observed by FDC, those data of photographs and images were also referred to. Type, thickness, specific gravity, grade, etc. of the samples were investigated on board and the coverage of Cobalt Crusts was calculated from photographic data. Based on all of the aforesaid data, occurrence of Cobalt Crusts at each seamount was obtained.

Analyses, X-ray diffraction, microscopic observation, age determination, etc. were made on shore on part of the samples collected, and comprehensive analyses including major and minor elements and mineral components were made.

Main items of survey carried out on board are as follows:

1) Manganese Nodule

Sampling points:	33 stations. Samples collected from each sampling station: 3 samples. Total samples collected: 99 samples
Sampling equipment:	Free Fall Grab, Total operation: 94 Spade Corer. Total operation: 5
Interval of sampling points:	60 mile grid
Acoustic sounding:	PDR, NBS (Topographic survey) SBP (Surficial sediments) MFES (Survey of estimated abundance)
Number of analyses:	205×5 components (Ni, Cu, Co, Mn, Fe)
CDC observation:	1 track-line, 5.4 miles, 188 photographs

2) Cobalt Crusts

Number of seamount:	Six seamounts (including one table reef).
Sampling equipment:	Arm Dredger.
Number of dredgings:	52 (7 ~ 9/seamount)
Sample collected:	2,356 kg (including rocks)
Number of analyses:	180×5 components (Ni, Cu, Co, Mn, Fe)
Acoustic soundings:	PDR, NBS (Topographic survey) SBP (Surficial sediments)
FDC observation:	4 track-lines, totaling 20.2 miles, 675 photographs, Video tape (black and white) 11 reels.

5-2 Topography and Geology

The Line Islands cross the central part of the sea area in the direction of NW-SE dividing the area into two parts. The western part belongs to the North Penrhyn Basin and the eastern part belongs to the Northeast Pacific Basin. There is Plain zone at the

North Penrhyn Basin at depths of 5,200 - 5,400m and Quasi-plain zone at the Northeast Pacific Basin at depths of 5,000 - 5,200 m.

The Line Islands line consists of two series in the direction of NW-SE, the western part is composed of knolls and the eastern part of mountains. The seamounts SC01-SC04 are included in the eastern series and the seamount SC05 is included in the western series. The seamount SC06 is included in the North Penrhyn Basin.

All of the target seamounts for Cobalt Crusts are peaked seamounts, and the seamount SC05 is table reef. The depth of seamount summits ranges from 805m to 1,590m, it deepens to the northward.

Mountainous regions and seamounts are mainly composed of exposed rocks of basalt, hyaloclastite and limestone accompanied with pyroclastic and paleo-sediments; gaps in between rocks are filled with unskeletal sediments. Brown clay is distributed in wide range at Plain and Quasi-plain but calcareous sediments are also distributed in parts of these zones. The carbonate compensation depth is estimated as about 5,000m.

The thickness of un-skeletal sediments estimated by SBP at the North Penrhyn Basin is about 10m but, in the aggregate, it is thin. Even on the summit of seamounts SC01 - SC06, transparent layers are recognized only locally. Accordingly, unskeletal sediments in this area are considered to be inferior.

5-3 Mode of Manganese Nodule Occurrence

Mode of manganese nodule occurrence in this area can be summarized as follows:

(1) Pebble type is prominent (about 50%), plenty of massive type at the western part of the sea area and pebble thin type at the eastern part of the area are also observed, but very few of ellipsoidal type (3%). Massive type has high abundance (8.65kg/m^2) but pebble type (4.75kg/m^2) and pebble thin type (5.34kg/m^2) have medium abundance.

(2) Rich in small size manganese nodules. About 49% are in the category of 2 - 4cm in diameter.

(3) Average abundance is as low as 4.37kg/m^2. About 68% of the sampling points are barren, with less than 2.5kg/m^2, while only 8% are rich with more than 10kg/m^2.

(4) High abundance of more than $10kg/m^2$ occurs at the eastern part of the area and medium abundance of more than $5kg/m^2$ occurs at the western part and other places. Average abundance of 60 sampling points in the western side is $2.94kg/m^2$ while for 39 sampling points in the eastern side the average is $6.56kg/m^2$.

(5) Abundance of more than $10kg/m^2$ in the eastern side is in the Sea knolls of 4,700m - 5,100m deep. Abundance of more than $5kg/m^2$ in the western side is in the Plain of 5,300m - 5,500m deep.

(6) High abundance in the sea area with calcareous sediments.

Sediments	Average abundance
Calcareous sediments	$7.76kg/m^2$
Brown clay	$3.72kg/m^2$

(7) Two type of manganese nodules are identified by the classification of Mn/Fe

Ni-Cu rich type	(Mn/Fe $>$ 2.5)
Co rich type	(Mn/Fe $\leqq$ 2.5)

(8) Ni-Cu rich type has low abundance (Average of $2.7kg/m^2$). This type occurs in the depth of slightly below CCD (depth of 5,000m - 5,200m) and is accompanied by Brown clay. Most are ellipsoidal type, pebble thin type and spheroidal type.

	Grade	Percentage (Ni, Cu, Co/Ni+Cu+Co)
Ni	1.08%	54%
Cu	0.78%	39%
Co	0.13%	7%

Manganese nodules have tendency of

10Å Manganite $>$ δ-MnO_2

(9) Co rich type has high abundance (Average of $7.5kg/m^2$), accordingly the potentiality is high as it shows high metal content. It occurs at the southeastern part of the sea area (7 sampling points, area of $25,000km^2$) right above and right below the CCD. Usually it is accompanied by calcareous sediments. Mostly pebble type, massive type and plate type.

	Grade	Percentage (Ni, Cu, Co/Ni+Cu+Co)
Ni	0.61%	50%
Cu	0.35%	29%
Co	0.26%	21%

Manganese nodules have tendency of

δ-MnO_2 > 10Å Manganite

(10) Mode of occurrence was surveyed by CDC for the distance of 5.4 miles. Relations among average abundance (about $8kg/m^2$), morphology and topography are obtained Fine-grained manganese nodules are prominent in the zones of knolls and rocks and decrease of abundance is seen locally.

(11) Estimated abundance made by MFES is consistent with the result of sampling except at Seamounts and Sea knolls.

(12) Most part of the survey area have distribution of Ni-Co rich type, so, in the aggregate, the abundance is low, but some parts with high abundance are observed in the sea area with Co rich type.

5-4 Mode of Cobalt Crust Occurrence

Sampling by arm-dredger and sea bottom observation by FDC were carried out at six seamounts. The result of the surveys are summarized in Table 4-4-1.

The features are as follows:

(1) Crust type is prominent (67%), slab type, nodule type and cobble type are also observed.

(2) At the places such as steep slopes and pinnacles where sediments are difficult to settle, the development of crust is excellent, but at basins, gentle slopes and the lower part of slopes covered by slumping sediments the mode of occurrence is not so good.

(3) Average grades of crust at six seamounts are

Co	0.62%
Ni	0.60%
Cu	0.12%

Seamounts SC02 and SC06 have excellent grade. The summit and the upper part of slopes of seamounts in depths of 1,000m - 1,500m have the highest grade. Co grade decreases as the depth deepens. Analysis of sectional samples shows that the outer-shell that directly touches the sea water is high grade, decreasing in the order of mid-shell, inner-shell. Statistically processed data show that the Co grade and the Ni, Mn grade are in positive correlation while the Co grade is in negative correlation with Fe.

(4) Thickness of crust is good in depths below 1,500m. Seamounts SC01 and SC02 have the thickness of 22 - 35mm, but the average of six seamounts is 19.5mm. Substrates composed of sedimentary rocks or pyroclastics have the thickness of more than 27mm but substrate of basalt or limestone have average of less than 15mm. Slab type has the thickest crust (average of 71mm).

(5) From the view points of grade and thickness of crust, the seamounts SC01, SC02, SC06 are excellent. In this sea area, seamounts of older age show good occurrence.

(6) Analyzed grade plotted on the Ni-Cu-Co Triangular diagram reveals significant differences originated with substrates as follows:

① Tuff, Tuff Breccia
② Sedimentary Rock
③ Basalt, Hyaloclastite, Limestone

Above categories are obviously identified in shallow depths but as the depth deepens Ni and Co approach the same amount and Cu will increase slightly. Finally it continues to Co rich manganese module.

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【 Appendix 】

1. List of the Survey Results of Manganese Nodules

2. List of the Survey Results of Cobalt Crusts

3. List of the Survey Results by FDC

4. Weather and Sea-state Data

1. List of the Survey Results of Manganese Nodules

Data file around Kiribati (No. 1)

Sample No. (Station)	Location: Latitude	Longitude	Depth (m)	Topography	Manganese Nodules: Size distribution (%) 0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	Abundance (Kg/m2)	Shape	S.G wet	H2O (%)	XRF Analyses (%) Ni	Cu	Co	Mn	Fe	Geology: Sediment	sil%	cal%	T.P.L.* type	thick (m)
89S0741FG01	6° 0.02'S	154° 29.96'W	5.054	(Plain) Flat	64	36					2.17	P.Sp	2.20	21.5	0.81	0.53	0.13	12.40	6.30	BC	8	0	d1	0
89S0741FG02	5° 59.3'S	154° 31.3'W	4.955	(Plain) Seaknol	22	78					0.52	P.Pl	2.00	22.4	0.91	0.52	0.19	16.52	7.07	SCC	4	0	ds	0
89S0741FG03	5° 58.99'S	154° 29.01'W	4.977	(Plain) Seaknol	18	82					0.50	Ot.P	1.91	21.0	0.56	0.32	0.12	8.07	7.66	SCC	4	7	ds	0
(89401) Average			4.995		50	50					1.06	P.Sp	2.12	21.6	0.79	0.49	0.14	12.38	6.64					
89S0841FG01	7° 0.01'S	154° 29.92'W	5.040	(Plain) Seaknol	88	12					0.06	P	—	—	—	—	—	—	—	BC	3	0		0
89S0841FG02	6° 59.10'S	154° 30.99'W	5.010	(Plain) Seaknol							0.00	—	—	—	—	—	—	—	—	-	-	-	ds	0
89S0841FG03	6° 59.07'S	154° 28.96'W	4.800	(Plain) Seaknol	63	37					0.73	P.Ot	2.11	22.6	0.80	0.41	0.16	12.00	7.94	CC	2	30	ds	0
(89402) Average			4.950		65	35					0.26	P.Ot	2.11	22.6	0.80	0.41	0.16	12.00	7.94					
89S0941FG01	7° 59.99'S	154° 29.96'W	5.180	(Plain) Flat	33	35	17		15		5.43	P.M	2.02	25.7	0.72	0.36	0.25	18.24	9.70	BC	8	0	ts	10
89S0941FG02	7° 59.01'S	154° 31.02'W	5.160	(Plain) Flat	46	54					2.58	P.Pt	2.01	25.6	0.88	0.47	0.23	19.91	8.70	BC	3	0	el	10
89S0941FG03	7° 58.99'S	154° 29.05'W	5.210	(Plain) Flat	58	42					3.05	P.Pt	2.06	33.4	0.91	0.48	0.21	18.13	8.77	BC	3	0	el	10
(89403) Average			5.183		43	41	8		7		3.70	P.M	2.03	27.8	0.81	0.42	0.23	18.61	9.22					
89S1041FG01	8° 59.92'S	154° 29.87'W	5.350	(Plain) Flat	13	49	11	27			11.30	P.M	2.04	27.2	0.54	0.30	0.29	18.46	11.85	BC	5	0	d2	0
89S1041FG02	8° 58.85'S	154° 30.86'W	5.370	(Plain) Flat	82	18					0.71	Sp.P	1.98	27.2	0.96	0.56	0.20	18.54	8.30	SC	15	0	el	10
89S1041FG03	8° 58.71'S	154° 28.83'W	5.340	(Plain) Flat	12	33	12	22	21		16.54	M.P	2.00	28.2	0.51	0.29	0.31	19.09	12.02	BC	5	0	d2	0
(89404) Average			5.353		14	39	11	23	12		9.68	M.P	2.02	27.8	0.54	0.30	0.30	18.82	11.86					
89S1141FG01	9° 59.99'S	154° 29.98'W	5.550	(Plain) Flat	3	30	34	20	13		12.35	M.P	2.06	26.5	0.63	0.36	0.24	16.42	10.09	BC	3	0	ds	0
89S1141FG02	9° 59.01'S	154° 31.02'W	5.560	(Plain) Flat	57	39	4				3.38	Sp.P	2.03	26.8	1.11	0.70	0.19	23.54	7.68	BC	3	0	c	0
89S1141FG03	9° 59.03'S	154° 29.00'W	5.560	(Plain) Flat	53	47					1.12	Sp.P	2.07	26.6	1.18	0.80	0.16	25.91	6.91	BC	3	0	b	40
(89405) Average			5.557		17	33	26	15	10		5.62	P.M	2.05	26.5	0.76	0.45	0.23	18.48	9.40					
89S1241FG01	10° 59.89'S	154° 30.02'W	5.480	(Plain) Flat							0.00	—	—	—	—	—	—	—	—	BC	2	0	el	10
89S1241FG02	10° 58.83'S	154° 31.10'W	5.490	(Plain) Flat							0.00	—	—	—	—	—	—	—	—	BC	2	0	el	0
89S1241FG03	10° 58.62'S	154° 29.03'W	5.530	(Plain) Flat							0.00	—	—	—	—	—	—	—	—	BC	2	0	el	10
(89406) Average			5.500								0.00	—	—	—	—	—	—	—	—					

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

Data file around Kiribati

(No. 2)

Sample No. (Station)	Location				Manganese Nodules															Geology				
					Size distribution (%)						Abun-dance	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)
89S1341SC01	12° 1.27'S	154° 29.99'W	5.310	(Plain)Flat	40	44	16				4.99	P.Sp	1.99	28.4	0.85	0.50	0.25	21.53	10.25	BC	2	0	el	10
89S1341FG02	11° 58.98'S	154° 31.04'W	5.370	(Plain)Flat	11	15	25		49		5.08	M.P	1.97	34.6	0.60	0.33	0.29	19.87	11.30	BC	4	0	el	10
89S1341FG03	11° 58.99'S	154° 29.00'W	5.250	(Plain)Platfor	10	23	20		47		9.02	M.Ot	1.98	30.5	0.42	0.22	0.30	15.61	12.82	BC	2	0	c	0
(89407) Average			5.310		18	26	20		35		6.36	M.P	1.98	31.1	0.58	0.32	0.28	18.29	11.74					
89S1342FG01	12° 0.22'S	153° 30.11'W	5.270	(Plain)Flat	38	62					0.25	P.Sp	2.00	28.1	1.08	0.66	0.17	23.49	8.21	BC	2	0	a	20
89S1342FG02	11° 59.28'S	153° 31.20'W	5.270	(Plain)Flat	52	48					0.16	Sp.P	2.00	19.1	1.16	0.72	0.15	23.56	7.45	BC	4	0	a	20
89S1342FG03	11° 59.34'S	153° 29.26'W	5.250	(Plain)Flat	7	44	49				0.96	M.P	2.00	27.8	0.67	0.38	0.24	19.33	10.31	BC	4	0	el	20
(89408) Average			5.263		18	48	34				0.46	M.P	2.00	26.8	0.81	0.48	0.22	20.63	9.56					
89S1242FG01	10° 59.99'S	153° 30.00'W	5.290	(Plain)Flat							0.00	—	—	—	—	—	—	—	—	-	-	-	ts	40
89S1242FG02	10° 59.00'S	153° 31.05'W	5.310	(Plain)Flat	27	59	14				2.75	Sp.P	2.02	27.4	1.04	0.61	0.19	20.69	8.31	BC	0	0	el	10
89S1242FG03	10° 59.02'S	153° 29.00'W	5.240	(Plain)Flat	1	22	36	13	28		13.28	Pl.Ot	1.97	32.5	0.58	0.31	0.28	19.38	11.76	BC	2	0	el	10
(89409) Average			5.280		6	28	32	11	23		5.34	Pl.Ot	1.98	31.6	0.66	0.36	0.26	19.62	11.13					
89S1142FG01	10° 0.16'S	153° 29.90'W	5.340	(Plain)Flat	46	54					0.77	P.Sp	2.04	28.5	1.17	0.74	0.15	24.11	6.96	BC	3	10	el	20
89S1142FG02	9° 59.24'S	153° 30.97'W	5.320	(Plain)Flat	4	9	26	36	25		3.15	M.Ot	1.92	30.0	0.71	0.41	0.25	20.95	10.36	BC	3	0	el	10
89S1142FG03	9° 59.24'S	153° 28.84'W	5.340	(Plain)Flat	4	9	10	33	44		6.68	M.P	1.98	30.1	0.69	0.40	0.26	20.03	10.19	BC	4	0	el	10
(89410) Average			5.333		7	12	14	32	35		3.53	M.P	1.97	30.0	0.73	0.43	0.25	20.61	10.00					
89S1042FG01	9° 0.02'S	153° 29.98'W	4.660	(Hilly)Seaknol							0.00	—	—	—	—	—	—	—	—	-	-	-	ds	0
89S1042FG02	8° 58.99'S	153° 31.05'W	4.980	(Hilly)Seaknol							0.00	—	—	—	—	—	—	—	—	-	-	-	ds	0
89S1042FG03	8° 58.98'S	153° 28.99'W	4.980	(Hilly)Seaknol	16	72	12				10.16	P.M	2.04	26.0	0.71	0.38	0.27	19.93	11.26	CSC	5	3	ds	0
(89411) Average			4.873		16	72	12				3.39	P.M	2.04	26.0	0.71	0.38	0.27	19.93	11.26					
89S0942FG01	7° 59.99'S	153° 30.14'W	4.860	(Hilly)Seaknol	4	82	14				14.92	P.M	2.04	26.7	0.52	0.28	0.29	19.30	12.24	SCC	5	8	ds	0
89S0942FG02	7° 59.05'S	153° 31.16'W	5.010	(Hilly)Seaknol	50	45	5				6.11	P.Pl	2.04	17.1	0.76	0.42	0.14	10.68	6.32	BC	3	0	ds	0
89S0942FG03	7° 59.02'S	153° 29.16'W	5.060	(Hilly)Flat	67	31		2			0.85	Sp.P	2.02	26.4	1.14	0.75	0.13	18.49	5.79	BC	3	0	ds	0
(89412) Average			4.977		19	70	11	0			7.29	P.M	2.03	24.0	0.62	0.34	0.24	16.65	10.19					

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

Data file around Kiribati

(No. 3)

Sample No. (Station)	Location				Manganese Nodules															Geology				
	Latitude	Longitude	Depth (m)	Topography	Size distribution (%)						Abun-dance (Kg/m2)	Shape	S.G. wet	H2O (%)	XRF Analyses (%)					Sediment			T.P.L.*	
					0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm					Ni	Cu	Co	Mn	Fe		sil%	cal%	type	thick (m)
89S0842SC01	7° 0.22'S	153° 30.40'W	5.170	(Plain)Flat	8	60	32				1.99	E.P	2.00	28.5	1.17	0.95	0.12	23.00	5.42	BC	4	0	el	10
89S0842FG02	6° 58.99'S	153° 31.01'W	5.150	(Plain)Flat	33	64	3				3.50	Pt.Sp	1.99	28.9	1.24	0.88	0.13	24.05	5.63	BC	3	0	el	10
89S0842FG03	6° 59.00'S	153° 28.98'W	5.030	(Plain)Seaknol	7	93					2.20	Pt.P	2.01	27.7	1.19	0.96	0.12	23.57	5.51	BC	5	0	el	10
(89413) Average			5.117		19	71	10				2.56	Pt.E	2.00	28.5	1.21	0.92	0.12	26.64	5.54					
89S0742FG01	6° 0.12'S	153° 29.87'W	5.100	(Plain)Flat	100						0.02	Sp	—	—	—	—	—	—	—	BC	8	0	b	50
89S0742FG02	5° 59.22'S	153° 30.82'W	5.110	(Plain)Flat	100						0.10	P.Ot	2.00	23.1	1.34	1.04	0.09	28.70	4.94	BC	10	0	ds	0
89S0742FG03	5° 59.33'S	153° 28.66'W	5.065	(Plain)Flat	2	1	44	53			2.29	E	2.07	26.0	1.00	0.89	0.10	31.07	5.36	BC	10	0	b	40
(89414) Average			5.092		7	1	42	50			0.80	E.P	2.07	25.8	1.02	0.90	0.10	30.97	5.35					
89S0743FG01	6° 0.07'S	152° 30.09'W	3.850	(Mount)Seamoun							0.00	—	—	—	—	—	—	—	—	-	-	-	ds	0
89S0743FG02	5° 59.00'S	152° 31.02'W	3.700	(Mount)Seamoun							0.00	—	—	—	—	—	—	—	—	FO	0	90	ds	0
89S0743FG03	5° 59.02'S	152° 29.01'W	4.230	(Mount)Seamoun	100						0.01	P	—	—	—	—	—	—	—	-	-	-	ds	0
(89415) Average			3.927		100						0.00	P	—	—	—	—	—	—	—					
89S0843FG01	6° 59.89'S	152° 30.11'W	5.300	(Mount)Flat	39	61					0.14	P	0.00	30.8	1.16	0.97	0.06	23.52	4.09	BC	8	0	b	30
89S0843FG02	6° 58.86'S	152° 31.23'W	5.380	(Mount)Flat	100						0.02	P	—	—	—	—	—	—	—	BC	8	0	c	0
89S0843FG03	6° 58.70'S	152° 29.32'W	5.320	(Mount)Flat	100						0.01	P	—	—	—	—	—	—	—	BC	8	0	c	0
(89416) Average			5.333		50	50					0.06	P	0.00	30.8	1.16	0.97	0.06	23.52	4.09					
89S0943FG01	8° 0.00'S	152° 30.02'W	5.040	(Mount)Seaknol							0.00	—	—	—	—	—	—	—	—	-	-	-	dl	0
89S0943FG02	7° 59.00'S	152° 30.97'W	5.160	(Mount)Seaknol	100						0.00	Sp	—	—	—	—	—	—	—	BC	4	0	ds	0
89S0943FG03	7° 58.99'S	152° 29.00'W	5.260	(Mount)Flat	100						0.01	P	—	—	—	—	—	—	—	BC	2	0	c	0
(89417) Average			5.153		100						0.00	P	—	—	—	—	—	—	—					
89S1043FG01	9° 0.01'S	152° 30.01'W	4.885	(Hilly)Flat	55	45					5.54	P.Sp	2.02	23.8	0.86	0.47	0.18	14.94	7.41	SCC	2	8	el	10
89S1043FG02	8° 59.04'S	152° 31.08'W	4.900	(Hilly)Flat	37	60	3				8.82	P	2.02	24.8	0.78	0.42	0.22	16.02	8.79	SCC	2	10	el	10
89S1043FG03	8° 58.95'S	152° 29.12'W	4.870	(Hilly)Flat	64	36					0.64	Sp.P	2.05	31.9	1.30	0.84	0.16	23.79	6.44	SCC	3	4	ds	0
(89418) Average			4.885		45	53	2				5.00	P.Sp	2.02	24.7	0.83	0.46	0.20	15.92	8.18					

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

Data file around Kiribati

(No. 4)

Sample No. (Station)	Location: Latitude	Longitude	Depth (m)	Topography	Size distribution (%) 0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	Abundance (Kg/m2)	Shape	S.G. wet	H2O (%)	XRF Analyses (%) Ni	Cu	Co	Mn	Fe	Sediment	sil%	cal%	T.P.L.* type	thick (m)
89S1044FG01	9° 0.03'S	151° 29.97'W	5.000	(Mount) Flat	35	22	43				0.61	E.Sp	2.05	26.1	1.19	0.99	0.11	25.04	5.84	BC	4	0	c	0
89S1044FG02	8° 59.01'S	151° 31.01'W	5.030	(Mount) Flat	42	58					5.59	P	1.98	28.9	0.67	0.40	0.25	18.05	11.82	BC	2	0	c	0
89S1044FG03	8° 59.05'S	151° 29.01'W	5.010	(Mount) Flat	80	20					0.35	Sp.Pt	2.00	27.8	1.30	1.00	0.11	25.74	5.62	BC	3	0	c	0
(89419) Average			5.013		43	53	4				2.18	P.Sp	1.99	28.6	0.75	0.49	0.23	19.13	10.91					
89S0944FG01	8° 0.05'S	151° 30.08'W	5.165	(Mount) Flat	39	61					0.49	Pt.P	2.03	33.4	1.23	0.84	0.12	21.57	6.68	BC	3	0	el	10
89S0944FG02	7° 59.10'S	151° 31.17'W	5.170	(Mount) Flat	9	81	10				2.95	Pt.P	2.08	27.0	1.21	0.93	0.14	27.00	6.40	BC	5	0	c	0
89S0944FG03	7° 59.11'S	151° 29.23'W	5.040	(Mount) Seaknol	53	32	15				1.14	Pt.P	2.00	28.2	0.76	0.52	0.19	16.89	10.28	CSC	8	2	d1	0
(89420) Average			5.125		23	67	10				1.53	Pt.P	2.05	28.0	1.10	0.82	0.15	23.95	7.39					
89S0844FG01	7° 0.01'S	151° 30.04'W	4.850	(Mount) Seaknol							0.00	—	—	—	—	—	—	—	—	-	-	-	ds	0
89S0844FG02	6° 58.95'S	151° 31.00'W	5.100	(Mount) Seaknol							0.00	—	—	—	—	—	—	—	—	-	-	-	ds	0
89S0844FG03	6° 58.99'S	151° 29.00'W	4.600	(Mount) Seaknol	10	87	3				8.16	Pt.M	2.04	30.6	0.44	0.25	0.30	19.33	14.49	FO	0	90	ds	0
(89421) Average			4.850		10	87	3				2.72	Pt.M	2.04	30.6	0.44	0.25	0.30	19.33	14.49					
89S0845FG01	6° 59.98'S	150° 30.14'W	5.190	(Quasi) Flat	31	23	36	10			6.54	M.P	2.01	23.4	0.76	0.54	0.11	12.83	7.11	BC	10	0	d2	0
89S0845FG02	6° 58.97'S	150° 31.17'W	5.100	(Quasi) Seaknol	8	19	22	6	45		10.69	M.Pt	1.98	26.8	0.87	0.65	0.12	17.12	6.48	BC	8	0	ds	0
89S0845FG03	6° 58.93'S	150° 29.19'W	5.240	(Quasi) Flat	73	27					1.77	P.Sp	2.07	22.3	0.77	0.59	0.11	12.41	8.06	BC	10	0	ds	0
(89422) Average			5.177		22	21	25	7	25		6.33	M.P	2.00	25.2	0.82	0.61	0.11	15.15	6.85					
89S0846SC01	7° 0.92'S	149° 29.90'W	5.270	(Quasi) Flat	14	79	7				4.74	P.Pt	2.05	27.5	1.15	0.90	0.14	28.82	6.07	BC	10	0	el	10
89S0846FG02	6° 59.02'S	149° 31.02'W	5.340	(Quasi) Channel	25	63	12				2.32	P.Pl	2.01	21.9	0.68	0.52	0.12	11.80	10.30	BC	12	0	c	0
89S0846FG03	6° 58.97'S	149° 29.01'W	5.230	(Quasi) Flat	60	32	8				4.32	P.Pt	2.04	25.7	0.98	0.72	0.13	19.64	7.68	BC	10	0	d2	0
(89423) Average			5.280		34	58	8				3.79	P.Pt	2.04	25.7	0.98	0.75	0.13	22.10	7.59					
89S0847FG01	6° 59.95'S	148° 29.94'W	5.190	(Quasi) Seaknol	71	29					0.45	P.E	2.07	29.6	1.15	1.11	0.05	29.02	4.70	BC	10	0	ds	0
89S0847FG02	6° 58.94'S	148° 31.07'W	5.220	(Quasi) Flat	100						0.02	Sp	—	—	—	—	—	—	—	BC	8	0	b	30
89S0847FG03	6° 58.87'S	148° 29.05'W	5.100	(Quasi) Seaknol	39	61					0.14	Sp	0.00	22.2	1.13	1.16	0.04	30.80	4.14	BC	10	0	b	30
(89424) Average			5.170		65	35					0.20	P.Sp	2.07	27.8	1.15	1.12	0.05	29.48	4.56					

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

Data file around Kiribati

(No. 5)

Sample No. (Station)	Location: Latitude	Longitude	Depth (m)	Topography	Manganese Nodules: Size distribution (%) 0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	Abundance (Kg/m2)	Shape	S.G. wet	H2O (%)	XRF Analyses (%) Ni	Cu	Co	Mn	Fe	Geology: Sediment	sil%	cal%	T.P.L.* type	thick (m)
89S0947FG01	8° 0.02'S	148° 30.00'W	5.110	(Quasi) Seaknol	16	56	28				21.13	P.Pt	2.02	28.5	0.57	0.36	0.27	19.99	12.92	BC	8	0	dl	0
89S0947FG02	7° 58.98'S	148° 31.05'W	5.100	(Quasi) Seaknol	47	44	9				1.32	P.Ot	2.06	25.2	0.72	0.44	0.22	18.43	11.30	BC	10	0	dl	0
89S0947FG03	7° 59.00'S	148° 28.99'W	4.815	(Quasi) Seaknol	9	20	43	28			20.90	Sp.P	1.99	29.6	0.40	0.25	0.28	19.03	14.31	SCO	25	15	dl	0
(89425) Average			5.008		14	38	35	14			14.45	Sp.P	2.01	28.9	0.50	0.31	0.27	19.48	13.53					
89S1047FG01	8° 59.99'S	148° 29.82'W	4.850	(Quasi) Seaknol	7	68	25				11.95	P.Pt	2.03	27.7	0.64	0.39	0.25	18.30	12.61	SCC	6	50	ds	0
89S1047FG02	8° 59.01'S	148° 30.77'W	4.770	(Quasi) Seaknol	25	75					11.26	P	2.03	26.0	0.56	0.35	0.27	20.09	13.73	CSC	5	10	ds	0
89S1047FG03	8° 59.01'S	148° 28.65'W	4.870	(Quasi) Flat	8	82	10				11.58	P.Pt	2.00	27.1	0.54	0.32	0.27	19.29	13.31	SCC	6	3	ds	0
(89426) Average			4.830		13	75	12				11.60	P.Pt	2.02	27.0	0.58	0.35	0.26	19.22	13.21					
89S1046SC01	9° 1.26'S	149° 30.32'W	5.030	(Quasi) Flat	—	—	—	—	—	—	(—)	—	1.98	25.3	1.20	0.93	0.13	27.47	5.91	—	4	-	el	10
89S1046FG02	8° 59.00'S	149° 31.02'W	4.990	(Quasi) Flat	—	—	—	—	—	—	(—)	—	0.00	26.1	1.23	0.92	0.15	27.38	6.57	—	5	3	el	10
89S1046FG03	8° 58.99'S	149° 29.00'W	4.980	(Quasi) Flat	6	51	29	14			13.02	Pt.M	2.01	28.9	0.49	0.31	0.27	18.80	13.91	BC	4	0	d2	0
(89427) Average			5.000		6	51	29	14			13.02	Pt.M	2.01	28.9	0.49	0.31	0.27	18.80	13.91					
89S1147FG01	10° 0.04'S	148° 29.66'W	4.810	(Quasi) Flat	28	64	8				4.70	P.Pt	2.04	25.9	1.05	0.66	0.17	19.73	7.71	SCC	8	2	c	0
89S1147FG02	9° 59.01'S	148° 30.99'W	4.730	(Quasi) Flat	—	—	—	—	—	—	(—)	—	—	—	—	—	—	—	—	—	6	4	c	0
89S1147FG03	9° 58.98'S	148° 29.03'W	4.790	(Quasi) Flat	8	33	31	8	20		14.61	M.P	1.98	30.0	0.57	0.33	0.26	18.41	12.48	CSC	3	10	cl	10
(89428) Average			4.777		13	41	25	6	15		9.86	P.M	1.99	29.0	0.69	0.41	0.24	18.75	11.27					
89S1148FG01	9° 59.88'S	147° 29.99'W	4.760	(Quasi) Seaknol	57	22	21				4.92	P.Pt	2.05	26.2	0.86	0.45	0.15	13.67	9.88	CSC	2	5	ds	0
89S1148FG02	9° 58.82'S	147° 30.97'W	4.700	(Quasi) Seaknol	42	54	4				8.42	P.Pt	2.00	27.5	0.56	0.31	0.27	17.28	13.65	CSC	4	20	ds	0
89S1148FG03	9° 58.63'S	147° 28.93'W	4.900	(Quasi) Flat	13	77	10				15.73	P.Pt	2.01	28.2	0.60	0.35	0.27	19.39	14.42	CSC	8	20	ds	0
(89429) Average			4.787		29	61	10				9.69	P.Pt	2.02	27.7	0.65	0.36	0.25	17.79	13.41					
89S1048SC01	9° 0.03'S	147° 29.96'W	5.170	(Quasi) Flat	—	—	—	—	—	—	(—)	—	—	—	—	—	—	—	—	—	-	-	b	30
89S1048FG02	8° 59.01'S	147° 31.01'W	5.020	(Quasi) Seaknol	8	67	17	8			8.15	Pt.P	2.01	27.8	1.07	0.95	0.12	26.83	6.74	BC	10	0	ds	0
89S1048FG03	8° 58.99'S	147° 28.99'W	5.200	(Quasi) Flat	20	66	14				5.22	Pt.P	2.01	28.2	1.16	0.88	0.14	23.94	7.00	BC	10	0	ds	0
(89430) Average			5.130		13	67	16	5			6.68	Pt.P	2.01	27.9	1.10	0.93	0.13	25.71	6.84					

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

Data file around Kiribati

(No. 8)

Sample No. (Station)	Location: Latitude	Longitude	Depth (m)	Topography	Manganese Nodules: Size distribution (%) 0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-16 cm	16- cm	Abundance (Kg/m2)	Shape	S.G. wet	H2O (%)	XRF Analyses (%) Ni	Cu	Co	Mn	Fe	Geology: Sediment	sil%	cal%	T.P.L.* type	thick (m)
89S0948FG01	8° 0.69'S	147° 30.02'W	5.290	(Quasi) Flat	100						0.08	Sp	—	—	—	—	—	—	—	BC	6	0	b	50
89S0948FG02	7° 59.74'S	147° 31.08'W	5.170	(Quasi) Seaknol			49	51			3.34	E.Ef	2.06	26.6	0.97	1.04	0.06	30.81	5.34	BC	10	0	b	10
89S0948FG03	7° 59.77'S	147° 29.07'W	5.230	(Quasi) Flat	4		15		81		2.94	E.Ef	2.07	27.4	0.97	1.08	0.05	30.79	5.03	BC	6	0	b	30
(89431) Average			5.230		3		33	27	37		2.12	E.Ef	2.08	27.0	0.97	1.06	0.06	30.80	5.20					
89S0946FG01	8° 0.02'S	149° 29.95'W	5.025	(Quasi) Flat	15	76	9				6.19	P.Sp	2.07	27.1	1.19	0.93	0.14	27.73	6.27	BC	10	0	el	10
89S0946FG02	7° 58.95'S	149° 31.05'W	4.840	(Quasi) Seaknol	100						0.01	P	—	—	—	—	—	—	—	-	-	-	dl	0
89S0946FG03	7° 58.98'S	149° 28.94'W	5.030	(Quasi) Flat	4	57	33	6			8.57	Pt.E	1.99	26.9	1.12	0.96	0.12	29.28	6.24	BC	10	0	c	0
(89432) Average			4.965		9	65	23	4			4.92	Pt.P	2.02	27.0	1.15	0.95	0.12	28.63	6.25					
89S0945FG01	8° 0.11'S	150° 29.78'W	5.180	(Quasi) Flat	100						0.02	P	—	—	—	—	—	—	—	-	-	-	ds	0
89S0945FG02	7° 59.18'S	150° 30.83'W	5.170	(Quasi) Flat	52	48					0.40	Sp.P	2.04	26.9	1.19	1.00	0.09	27.51	5.38	BC	12	0	b	10
89S0945FG03	7° 59.16'S	150° 28.78'W	5.090	(Quasi) Flat	100						0.03	P	—	—	—	—	—	—	—	BC	10	0	b	50
(89433) Average			5.147		57	43					0.15	Sp.P	2.04	26.9	1.19	1.00	0.09	27.51	5.38					

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

2. List of the Survey Results of Cobalt Crusts

Data List around Kiribati (Cobalt rich Crust)

(P. 1)

Sample No.	Sampling Position Latitude	Sampling Position Longitude	Depth (m)	Topo-graphy	Weight (Kg)	Thick-ness (mm)	S.G. wet	H2O (%)	X. R. F. Analysis (%) Co	Ni	Cu	Mn	Fe	Chip Code	Crust Type	Substra-te or Core	Surface Texture	Sample Part
89SC01AD01	7° 21.063'S	151° 54.022'W	2,180	Smt(Ctr)	0.183	25.0	2.000	27.27	0.49	0.69	0.18	20.13	9.57	A0	Nodule	Tuf.bre	—	Bulk
89SC01AD01	7° 21.063'S	151° 54.022'W	2,180	Smt(Ctr)	0.104	15.0	2.000	33.33	0.44	0.76	0.15	19.43	9.70	B0	Nodule	Tuf.bre	—	Bulk
89SC01AD01	7° 21.063'S	151° 54.022'W	2,180	Smt(Ctr)	0.068	15.0	2.000	27.78	0.37	0.67	0.14	17.79	9.35	C0	Nodule	Basalt	Rough	Bulk
89SC01AD01	7° 21.063'S	151° 54.022'W	2,180	Smt(Ctr)	0.030	5.0	1.850	33.33	1.12	0.72	0.09	27.04	13.37	D0	Slub	—	Rough	Bulk
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	127.000	20.0	1.750	38.10	0.74	0.73	0.13	26.81	14.47	A1	Slub	Sedim't	—	Outer
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	127.000	30.0	2.000	23.53	0.30	0.41	0.12	12.98	8.11	A2	Slub	Sedim't	—	Middle
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	127.000	50.0	2.090	20.00	0.06	0.18	0.09	7.71	4.88	A3	Slub	Sedim't	—	Inner
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	127.000	200.0	1.800	35.80	0.74	0.75	0.16	27.31	13.30	A0	Slub	Sedim't	—	Bulk
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	105.000	200.0	2.050	24.39	0.04	0.38	0.10	11.37	8.64	B1	Nodule	Sedim't	—	
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	105.000	200.0	1.760	36.66	0.82	0.81	0.16	27.98	13.17	B0	Slub	Sedim't	—	Bulk
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	55.000	20.0	1.890	34.78	0.64	0.75	0.15	24.24	11.06	C1	Slub	Sedim't	—	Outer
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	55.000	170.0	2.060	22.31	0.26	0.37	0.12	11.94	6.75	C2	Slub	Sedim't	—	
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	55.000	190.0	1.890	34.78	0.64	0.75	0.15	24.24	11.06	C0	Slub	Sedim't	—	Bulk
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	38.000	190.0	1.790	35.20	0.75	0.69	0.15	24.73	14.10	D0	Slub	Sedim't	—	Bulk
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	6.000	5.0	1.910	34.86	0.78	0.83	0.10	28.22	14.03	E0	Nodule	Tuf.bre	—	Bulk
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	86.000	5.0	2.040	26.60	0.30	0.46	0.12	14.52	9.94	F0	Cobble	Sedim't	—	Bulk
89SC01AD03	7° 29.738'S	151° 35.808'W	2,070	Slp (Up)	33.000	3.0	1.760	38.53	0.67	0.77	0.12	25.98	14.18	G0	Crust	—	—	Bulk
89SC01AD04	7° 33.581'S	151° 33.488'W	1,640	Slp (Up)	0.044	30.0	2.200	13.64	0.16	0.47	0.09	8.99	4.29	A0	Nodule	Tuf.bre	—	Bulk
89SC01AD05	7° 30.169'S	151° 30.874'W	1,860	Slp (Up)	0.005	2.0	0.000	0.00	0.00	0.00	0.00	0.00	0.00	A0	Crust	—	—	Bulk
89SC01AD06	7° 29.802'S	151° 33.313'W	1,910	Slp (Up)	0.138	3.0	1.940	33.33	1.01	0.62	0.07	21.21	12.73	A0	Crust	Tuf.bre	—	Bulk
89SC01AD07	7° 31.613'S	151° 36.162'W	2,140	Slp (Md)	0.011	5.0	0.000	18.18	0.46	0.48	0.11	11.97	7.69	A0	Crust	Tuf.bre	—	Bulk
89SC01AD08	7° 35.010'S	151° 31.705'W	1,670	Smt(Ctr)	1.800	15.0	2.000	27.69	0.90	1.02	0.10	23.75	8.85	A1	Cobble	Tuf.bre	—	Outer
89SC01AD08	7° 35.010'S	151° 31.705'W	1,670	Smt(Ctr)	1.800	30.0	2.090	21.88	0.26	0.65	0.09	17.62	7.51	A2	Cobble	Tuf.bre	—	Middle
89SC01AD08	7° 35.010'S	151° 31.705'W	1,670	Smt(Ctr)	1.800	40.0	2.130	19.00	0.15	0.75	0.11	14.02	4.54	A3	Cobble	Tuf.bre	—	Lw-Mid
89SC01AD08	7° 35.010'S	151° 31.705'W	1,670	Smt(Ctr)	1.800	10.0	2.140	23.40	0.31	1.58	0.19	18.77	2.47	A4	Cobble	Tuf.bre	—	Lw-Out
89SC01AD08	7° 35.010'S	151° 31.705'W	1,670	Smt(Ctr)	1.800	100.0	2.100	21.74	0.32	0.85	0.11	17.19	5.94	A0	Cobble	Tuf.bre	—	Bulk
89SC01AD08	7° 35.010'S	151° 31.705'W	1,670	Smt(Ctr)	1.200	10.0	1.980	33.33	1.00	1.04	0.09	30.73	10.56	B1	Cobble	—	—	Outer
89SC01AD08	7° 35.010'S	151° 31.705'W	1,670	Smt(Ctr)	1.200	80.0	2.030	20.45	0.35	1.08	0.13	18.56	5.65	B2	Cobble	—	—	Middle
89SC01AD08	7° 35.010'S	151° 31.705'W	1,670	Smt(Ctr)	1.200	90.0	2.010	33.77	0.57	0.99	0.11	21.09	6.85	B0	Cobble	—	—	Bulk
89SC01AD08	7° 35.010'S	151° 31.705'W	1,670	Smt(Ctr)	1.100	50.0	2.150	28.57	0.42	0.76	0.09	20.07	6.92	C0	Nodule	—	—	Bulk
89SC02AD01	8° 52.939'S	151° 1.712'W	2,160	Slp (Md)	0.500	15.0	1.870	32.64	0.69	0.60	0.12	21.97	15.22	A0	Crust	Tuf.bre	—	Bulk
89SC02AD01	8° 52.939'S	151° 1.712'W	2,160	Slp (Md)	0.235	15.0	1.860	35.90	0.74	0.53	0.11	23.40	17.64	B0	Crust	—	—	Bulk
89SC02AD01	8° 52.939'S	151° 1.712'W	2,160	Slp (Md)	0.186	13.0	1.920	32.00	0.66	0.54	0.11	24.68	17.68	C0	Crust	Limest.	Rough	Bulk
89SC02AD02	8° 49.905'S	150° 58.774'W	1,810	Smt(Mrg)	55.000	20.0	1.820	32.54	0.99	0.84	0.10	29.21	12.35	A1	Slub	Tuf.bre	—	Outer
89SC02AD02	8° 49.905'S	150° 58.774'W	1,810	Smt(Mrg)	55.000	40.0	2.100	27.62	0.34	0.67	0.16	15.79	9.70	A2	Slub	Tuf.bre	—	Middle

Data List around Kiribati (Cobalt rich Crust)

Sample No.	Sampling Position		Depth	Topo-graphy	Weight	Thick-ness	S.G.	H2O	X. R. F. Analysis (%)					Chip	Crust	Substra-te or Core	Surface	Sample
	Latitude	Longitude	(m)		(Kg)	(mm)	wet	(%)	Co	Ni	Cu	Mn	Fe	Code	Type		Texture	Part
89SC02AD02	8° 49.905'S	150° 58.774'W	1,810	Smt(Mrg)	55.000	40.0	2.010	29.26	0.56	0.73	0.14	20.26	10.58	A0	Slub	Tuf.bre	—	Bulk
89SC02AD02	8° 49.905'S	150° 58.774'W	1,810	Smt(Mrg)	20.000	60.0	1.910	35.35	0.84	0.74	0.11	26.35	13.32	B0	Slub	Tuf.bre	—	Bulk
89SC02AD02	8° 49.905'S	150° 58.774'W	1,810	Smt(Mrg)	8.000	10.0	1.900	36.36	0.93	0.72	0.09	27.12	14.77	C0	Cobble	Basalt	—	Bulk
89SC02AD02	8° 49.905'S	150° 58.774'W	1,810	Smt(Mrg)	2.000	15.0	1.860	35.19	0.93	0.64	0.09	25.84	16.01	D0	Crust	Tuf.bre	—	Bulk
89SC02AD03	8° 48.158'S	150° 59.155'W	2,480	Slp (Lw)	0.000	0.0	0.000	0.00	0.00	0.00	0.00	0.00	0.00	A0	—	—	—	—
89SC02AD04	8° 43.758'S	150° 58.278'W	2,145	Slp (Up)	3.000	18.0	1.890	36.11	0.67	0.53	0.10	21.87	17.24	A1	Crust	Tuf.bre	—	Outer
89SC02AD04	8° 43.758'S	150° 58.278'W	2,145	Slp (Up)	3.000	23.0	1.860	30.77	0.64	0.60	0.13	23.10	15.93	A2	Crust	Tuf.bre	—	Middle
89SC02AD04	8° 43.758'S	150° 58.278'W	2,145	Slp (Up)	3.000	30.0	1.870	33.11	0.65	0.57	0.12	22.56	16.51	A0	Crust	Tuf.bre	—	Bulk
89SC02AD04	8° 43.758'S	150° 58.278'W	2,145	Slp (Up)	3.300	8.0	1.950	35.14	0.64	0.49	0.07	19.77	15.98	B0	Cobble	Tuf.bre	—	Bulk
89SC02AD04	8° 43.758'S	150° 58.278'W	2,145	Slp (Up)	3.600	22.0	1.770	37.27	0.59	0.55	0.11	20.78	15.42	C1	Cobble	Basalt	—	Outer
89SC02AD04	8° 43.758'S	150° 58.278'W	2,145	Slp (Up)	3.600	11.0	2.000	34.21	0.64	0.54	0.15	21.08	13.46	C2	Cobble	Basalt	—	Middle
89SC02AD04	8° 43.758'S	150° 58.278'W	2,145	Slp (Up)	3.600	33.0	1.850	36.25	0.61	0.55	0.12	20.88	14.77	C0	Cobble	Basalt	—	Bulk
89SC02AD04	8° 43.758'S	150° 58.278'W	2,145	Slp (Up)	1.600	10.0	1.930	35.34	0.69	0.61	0.11	24.12	16.55	D0	Cobble	Basalt	—	Bulk
89SC02AD05	8° 47.779'S	150° 56.499'W	2,220	Slp (Up)	0.740	25.0	1.790	36.00	0.60	0.66	0.11	24.07	15.56	A0	Crust	Limest.	Rough	Bulk
89SC02AD05	8° 47.779'S	150° 56.499'W	2,220	Slp (Up)	2.200	30.0	1.950	37.21	0.59	0.64	0.12	23.59	15.92	B0	Crust	Limest.	Rough	Bulk
89SC02AD05	8° 47.779'S	150° 56.499'W	2,220	Slp (Up)	1.560	12.0	1.860	34.15	0.67	0.63	0.09	25.44	16.27	C1	Crust	—	—	Outer
89SC02AD05	8° 47.779'S	150° 56.499'W	2,220	Slp (Up)	1.560	15.0	1.790	37.70	0.57	0.67	0.14	23.96	15.38	C2	Crust	—	—	Middle
89SC02AD05	8° 47.779'S	150° 56.499'W	2,220	Slp (Up)	1.560	8.0	1.590	45.01	0.55	0.64	0.14	24.92	15.85	C3	Crust	—	—	Inner
89SC02AD05	8° 47.779'S	150° 56.499'W	2,220	Slp (Up)	1.560	35.0	1.770	38.15	0.60	0.65	0.12	24.69	15.79	C0	Crust	—	—	Bulk
89SC02AD05	8° 47.779'S	150° 56.499'W	2,220	Slp (Up)	3.000	20.0	1.920	34.78	0.57	0.63	0.09	22.94	15.84	D0	Nodule	—	Rough	Bulk
89SC02AD05	8° 47.779'S	150° 56.499'W	2,220	Slp (Up)	2.000	15.0	2.050	32.56	0.60	0.67	0.09	25.69	16.24	E0	Nodule	—	—	Bulk
89SC02AD06	8° 49.947'S	150° 54.130'W	2,720	Slp (Md)	4.700	35.0	1.820	38.03	0.37	0.40	0.13	18.89	19.34	A0	Crust	Tuf.bre	—	Bulk
89SC02AD06	8° 49.947'S	150° 54.130'W	2,720	Slp (Md)	2.200	40.0	1.740	36.00	0.30	0.47	0.16	20.15	19.04	B0	Crust	Tuf.bre	—	Bulk
89SC02AD06	8° 49.947'S	150° 54.130'W	2,720	Slp (Md)	2.400	12.0	1.850	34.43	0.35	0.44	0.13	21.95	19.41	C1	Crust	Tuf.bre	—	Outer
89SC02AD06	8° 49.947'S	150° 54.130'W	2,720	Slp (Md)	2.400	17.0	1.890	36.36	0.26	0.44	0.19	17.73	18.39	C2	Crust	Tuf.bre	—	Middle
89SC02AD06	8° 49.947'S	150° 54.130'W	2,720	Slp (Md)	2.400	33.0	1.870	35.56	0.30	0.44	0.17	19.48	18.81	C0	Crust	Tuf.bre	—	Bulk
89SC02AD06	8° 49.947'S	150° 54.130'W	2,720	Slp (Md)	1.200	20.0	1.720	38.81	0.39	0.40	0.13	19.38	21.00	D0	Crust	Tuf.bre	—	Bulk
89SC02AD07	8° 53.304'S	150° 58.888'W	1,410	Smt(Mrg)	0.000	0.0	0.000	0.00	0.00	0.00	0.00	0.00	0.00	A0	—	—	—	—
89SC02AD08	8° 54.615'S	150° 57.410'W	1,980	Slp (Up)	3.000	12.0	1.930	36.47	1.06	0.60	0.08	25.06	15.79	A1	Crust	Tuf.bre	—	Outer
89SC02AD08	8° 54.615'S	150° 57.410'W	1,980	Slp (Up)	3.000	28.0	2.000	37.93	0.96	0.64	0.13	25.39	14.06	A2	Crust	Tuf.bre	—	Middle
89SC02AD08	8° 54.615'S	150° 57.410'W	1,980	Slp (Up)	3.000	40.0	1.980	37.49	0.99	0.63	0.12	25.29	14.58	A0	Crust	Tuf.bre	—	Bulk
89SC02AD08	8° 54.615'S	150° 57.410'W	1,980	Slp (Up)	0.870	13.0	1.980	32.77	0.68	0.69	0.10	26.91	15.14	B0	Crust	Calc.rk	Rough	Bulk
89SC02AD08	8° 54.615'S	150° 57.410'W	1,980	Slp (Up)	0.152	15.0	1.970	39.24	0.95	0.68	0.10	27.19	15.02	C0	Crust	—	Rough	Bulk
89SC02AD09	8° 53.072'S	150° 58.911'W	1,360	Smt(Mrg)	0.014	7.0	1.840	40.47	1.48	0.89	0.06	31.38	10.16	A0	Crust	—	—	Bulk
89SC03AD01	9° 5.047'S	150° 40.865'W	1,970	Slp (Md)	1.230	10.0	1.880	30.00	0.64	0.85	0.11	23.40	13.19	A0	Crust	Limest.	Smooth	Bulk

Data List around Kiribati (Cobalt rich Crust)

Sample No.	Sampling Position Latitude	Sampling Position Longitude	Depth (m)	Topo-graphy	Weight (Kg)	Thick-ness (mm)	S.G. wet	H2O (%)	X. R. F. Analysis (%) Co	Ni	Cu	Mn	Fe	Chip Code	Crust Type	Substra-te or Core	Surface Texture	Sample Part
89SC03AD01	9° 5.047'S	150° 40.865'W	1,970	Slp (Md)	3.500	2.0	0.000	36.36	0.80	0.63	0.07	22.95	12.77	B0	Crust	Limest.	—	Bulk
89SC03AD01	9° 5.047'S	150° 40.865'W	1,970	Slp (Md)	0.260	2.0	0.000	30.00	1.03	0.68	0.06	25.17	13.81	C0	Crust	Basalt	—	Bulk
89SC03AD01	9° 5.047'S	150° 40.865'W	1,970	Slp (Md)	0.320	2.0	0.000	37.50	0.66	0.60	0.09	20.19	12.74	D0	Crust	Limest.	—	Bulk
89SC03AD01	9° 5.047'S	150° 40.865'W	1,970	Slp (Md)	0.550	8.0	2.000	25.00	0.21	0.61	0.18	10.36	4.98	E0	Cobble	Basalt	—	Bulk
89SC03AD02	9° 5.196'S	150° 44.236'W	1,750	Slp (Up)	0.045	15.0	1.960	31.11	0.56	0.68	0.10	19.66	10.65	A1	Crust	Tuf.bre	Rough	Outer
89SC03AD02	9° 5.196'S	150° 44.236'W	1,750	Slp (Up)	0.100	35.0	2.380	18.00	0.00	0.26	0.08	7.84	4.17	A2	Crust	Tuf.bre	Rough	Middle
89SC03AD02	9° 5.196'S	150° 44.236'W	1,750	Slp (Up)	0.029	15.0	2.230	24.14	0.18	0.31	0.08	9.78	3.88	A3	Crust	Tuf.bre	Rough	Inner
89SC03AD02	9° 5.196'S	150° 44.236'W	1,750	Slp (Up)	90.000	20.0	2.250	22.44	0.17	0.37	0.08	11.02	5.60	A0	Crust	Tuf.bre	Rough	Bulk
89SC03AD02	9° 5.196'S	150° 44.236'W	1,750	Slp (Up)	40.000	6.0	0.000	31.25	0.65	0.71	0.11	22.46	12.93	B0	Crust	Limest.	Smooth	Bulk
89SC03AD02	9° 5.196'S	150° 44.236'W	1,750	Slp (Up)	10.000	10.0	2.050	35.56	0.83	0.72	0.10	24.02	14.87	C0	Cobble	Tuf.bre	Rough	Bulk
89SC03AD03	9° 3.928'S	150° 46.774'W	2,750	Slp (Md)	0.047	18.0	1.680	38.30	0.49	0.46	0.10	20.80	18.86	A1	Crust	Basalt	—	Outer
89SC03AD03	9° 3.928'S	150° 46.774'W	2,750	Slp (Md)	0.054	35.0	1.740	40.74	0.43	0.39	0.16	18.58	20.47	A2	Crust	Basalt	—	Middle
89SC03AD03	9° 3.928'S	150° 46.774'W	2,750	Slp (Md)	0.045	18.0	1.960	33.33	0.26	0.28	0.23	13.18	23.09	A3	Crust	Basalt	—	Inner
89SC03AD03	9° 3.928'S	150° 46.774'W	2,750	Slp (Md)	5.100	70.0	1.780	38.24	0.40	0.38	0.16	17.77	20.73	A0	Crust	Basalt	—	Bulk
89SC03AD03	9° 3.928'S	150° 46.774'W	2,750	Slp (Md)	1.000	10.0	1.810	41.38	0.45	0.43	0.11	20.93	19.74	B0	Crust	Tuf.bre	—	Bulk
89SC03AD04	9° 3.072'S	150° 44.667'W	2,140	Slp (Md)	0.192	24.0	1.930	36.54	0.73	0.58	0.11	24.46	17.06	A0	Crust	—	Rough	Bulk
89SC03AD04	9° 3.072'S	150° 44.667'W	2,140	Slp (Md)	0.130	25.0	1.960	32.65	0.53	0.56	0.13	22.43	16.72	B0	Crust	—	Smooth	Bulk
89SC03AD04	9° 3.072'S	150° 44.667'W	2,140	Slp (Md)	0.086	24.0	1.960	32.56	0.88	0.60	0.11	25.39	16.33	C0	Crust	—	Rough	Bulk
89SC03AD04	9° 3.072'S	150° 44.667'W	2,140	Slp (Md)	0.020	12.0	1.760	33.33	0.21	0.24	0.10	16.70	18.77	D0	Nodule	—	Smooth	Bulk
89SC03AD05	9° 1.142'S	150° 44.572'W	2,435	Slp (Md)	0.049	17.0	1.820	36.73	0.49	0.47	0.11	21.00	17.83	A1	Crust	Limest.	Smooth	Outer
89SC03AD05	9° 1.142'S	150° 44.572'W	2,435	Slp (Md)	0.040	20.0	1.740	42.50	0.50	0.47	0.15	21.41	19.61	A2	Crust	Limest.	Smooth	Middle
89SC03AD05	9° 1.142'S	150° 44.572'W	2,435	Slp (Md)	2.900	37.0	1.780	39.85	0.50	0.47	0.13	21.22	18.79	A0	Crust	Limest.	Smooth	Bulk
89SC03AD05	9° 1.142'S	150° 44.572'W	2,435	Slp (Md)	0.035	25.0	1.670	42.86	0.66	0.55	0.10	23.39	18.35	B0	Crust	Limest.	Rough	Bulk
89SC03AD05	9° 1.142'S	150° 44.572'W	2,435	Slp (Md)	0.045	14.0	1.880	33.33	0.44	0.48	0.09	23.08	19.08	C0	Crust	Limest.	—	Bulk
89SC03AD06	9° 2.963'S	150° 41.419'W	1,820	Slp (Up)	0.416	3.0	1.910	38.64	0.79	0.77	0.15	25.09	13.43	A0	Nodule	Basalt	Smooth	Bulk
89SC03AD06	9° 2.963'S	150° 41.419'W	1,820	Slp (Up)	0.132	7.0	1.900	40.00	0.45	0.50	0.11	18.33	16.33	B0	Crust	Tuf.bre	Rough	Bulk
89SC03AD07	9° 4.973'S	150° 38.568'W	2,920	Slp (Lw)	0.008	8.0	0.000	0.00	0.00	0.00	0.00	0.00	0.00	A0	Crust	—	—	Bulk
89SC03AD08	9° 7.213'S	150° 41.017'W	2,350	Slp (Md)	0.144	20.0	1.710	39.84	0.08	0.24	0.20	13.44	22.12	A0	Nodule	—	Rough	Bulk
89SC03AD08	9° 7.213'S	150° 41.017'W	2,350	Slp (Md)	0.046	7.0	1.860	36.59	0.47	0.50	0.16	21.49	20.79	B0	Crust	Tuf.bre	Rough	Bulk
89SC03AD09	9° 7.089'S	150° 43.078'W	2,050	Slp (Up)	3.550	10.0	1.980	32.26	0.60	0.56	0.09	22.46	15.69	A0	Crust	Limest.	—	Bulk
89SC03AD09	9° 7.089'S	150° 43.078'W	2,050	Slp (Up)	0.250	1.0	0.000	36.36	0.86	0.93	0.17	25.17	12.54	B0	Nodule	Basalt	Smooth	Bulk
89SC03AD09	9° 7.089'S	150° 43.078'W	2,050	Slp (Up)	0.110	27.0	1.850	33.33	0.49	0.55	0.11	22.18	16.70	C0	Nodule	—	—	Bulk
89SC03AD09	9° 7.089'S	150° 43.078'W	2,050	Slp (Up)	0.061	2.0	0.000	50.00	0.75	1.15	0.16	25.72	9.07	D0	Nodule	—	—	Bulk
89SC04AD01	10° 11.171'S	149° 46.319'W	2,560	Slp (Md)	2.050	20.0	1.850	40.00	0.46	0.48	0.14	21.68	19.15	A0	Crust	Limest.	—	Bulk
89SC04AD01	10° 11.171'S	149° 46.319'W	2,560	Slp (Md)	1.100	35.0	1.850	36.51	0.43	0.46	0.14	20.97	18.91	B0	Crust	Limest.	—	Bulk

Data List around Kiribati (Cobalt rich Crust)

Sample No.	Sampling Position		Depth	Topo-graphy	Weight	Thick-ness	S.G.	H2O	X. R. F. Analysis (%)					Chip	Crust	Substra-te or Core	Surface	Sample
	Latitude	Longitude	(m)		(Kg)	(mm)	wet	(%)	Co	Ni	Cu	Mn	Fe	Code	Type		Texture	Part
89SC04AD01	10° 11.171'S	149° 46.319'W	2,560	Slp (Md)	0.350	27.0	1.920	30.43	0.07	0.35	0.23	10.64	17.17	C0	Crust	—	—	Bulk
89SC04AD02	10° 10.968'S	149° 47.528'W	1,650	Slp (Up)	0.034	4.0	2.050	28.36	0.28	0.70	0.14	11.87	6.28	A0	Crust	Limest.	—	Bulk
89SC04AD03	10° 11.180'S	149° 50.008'W	1,090	Smt(Mrg)	43.000	3.0	0.000	22.22	0.94	0.68	0.05	15.43	3.42	A0	Crust	Calc.rk	Smooth	Bulk
89SC04AD03	10° 11.180'S	149° 50.008'W	1,090	Smt(Mrg)	2.600	38.0	2.290	29.17	0.20	0.60	0.05	18.37	6.95	B0	Crust	Calc.rk	Smooth	Bulk
89SC04AD03	10° 11.180'S	149° 50.008'W	1,090	Smt(Mrg)	0.253	20.0	2.190	22.86	0.21	0.49	0.04	15.67	6.77	C0	Crust	Limest.	Smooth	Bulk
89SC04AD03	10° 11.180'S	149° 50.008'W	1,090	Smt(Mrg)	4.700	7.0	2.140	25.33	0.25	0.52	0.04	17.63	7.62	D0	Crust	—	Smooth	Bulk
89SC04AD04	10° 10.575'S	149° 54.564'W	3,450	Slp (Lw)	0.000	0.0	0.000	0.00	0.00	0.00	0.00	0.00	0.00	A0	—	—	—	—
89SC04AD05	10° 9.062'S	149° 50.520'W	2,330	Slp (Md)	1.852	1.0	0.000	36.36	0.32	0.26	0.07	11.07	12.07	A0	Crust	Hyaloc.	Rough	Bulk
89SC04AD05	10° 9.062'S	149° 50.520'W	2,330	Slp (Md)	1.260	70.0	1.660	38.24	0.53	0.49	0.17	21.45	17.70	B0	Crust	—	Rough	Bulk
89SC04AD05	10° 9.062'S	149° 50.520'W	2,330	Slp (Md)	0.820	6.0	2.030	50.82	0.49	0.47	0.11	21.79	18.28	C0	Crust	Limest.	Rough	Bulk
89SC04AD05	10° 9.062'S	149° 50.520'W	2,330	Slp (Md)	0.840	5.0	2.090	31.34	0.25	0.30	0.09	11.46	13.08	D0	Crust	Tuf.bre	Rough	Bulk
89SC04AD05	10° 9.062'S	149° 50.520'W	2,330	Slp (Md)	0.600	32.0	1.820	37.10	0.41	0.54	0.16	22.19	18.08	E0	Crust	—	Rough	Bulk
89SC04AD06	10° 13.164'S	149° 54.924'W	3,115	Slp (Lw)	39.000	8.0	1.800	33.91	0.33	0.35	0.13	21.18	21.07	A0	Crust	Sedim't	Rough	Bulk
89SC04AD06	10° 13.164'S	149° 54.924'W	3,115	Slp (Lw)	14.000	30.0	1.850	35.29	0.25	0.43	0.22	18.82	17.74	B0	Nodule	Hyaloc.	Rough	Bulk
89SC04AD06	10° 13.164'S	149° 54.924'W	3,115	Slp (Lw)	28.000	15.0	1.760	37.84	0.47	0.37	0.12	22.52	19.92	C1	Pavem't	—	Smooth	Outer
89SC04AD06	10° 13.164'S	149° 54.924'W	3,115	Slp (Lw)	28.090	80.0	1.670	49.09	0.22	0.38	0.22	16.19	18.21	C2	Pavem't	—	—	Middle
89SC04AD06	10° 13.164'S	149° 54.924'W	3,115	Slp (Lw)	28.000	110.0	1.680	47.31	0.26	0.38	0.20	17.19	18.48	C0	Pavem't	—	Smooth	Bulk
89SC04AD06	10° 13.164'S	149° 54.924'W	3,115	Slp (Lw)	18.000	25.0	1.830	33.33	0.40	0.33	0.16	19.24	23.34	D0	Slub	Hyaloc.	Rough	Bulk
89SC04AD06	10° 13.164'S	149° 54.924'W	3,115	Slp (Lw)	20.000	10.0	1.970	33.80	0.32	0.37	0.14	21.10	21.42	E0	Crust	Basalt	Smooth	Bulk
89SC04AD06	10° 13.164'S	149° 54.924'W	3,115	Slp (Lw)	5.000	25.0	1.910	32.89	0.32	0.44	0.15	22.00	19.98	F1	Cobble	Sedim't	Rough	Outer
89SC04AD06	10° 13.164'S	149° 54.924'W	3,115	Slp (Lw)	5.000	50.0	1.880	42.86	0.31	0.38	0.18	17.82	19.15	F2	Cobble	Sedim't	Rough	Middle
89SC04AD06	10° 13.164'S	149° 54.924'W	3,115	Slp (Lw)	5.000	40.0	1.890	39.54	0.31	0.40	0.17	19.21	19.43	F0	Cobble	Sedim't	Rough	Bulk
89SC04AD07	10° 15.097'S	149° 52.145'W	2,810	Slp (Lw)	3.650	4.0	0.000	30.00	0.48	0.43	0.10	21.97	19.84	A0	Slub	Hyaloc.	—	Bulk
89SC04AD07	10° 15.097'S	149° 52.145'W	2,810	Slp (Lw)	0.720	2.0	0.000	45.00	0.39	0.40	0.10	18.91	18.28	B0	Cobble	Limest.	—	Bulk
89SC04AD07	10° 15.097'S	149° 52.145'W	2,810	Slp (Lw)	0.061	25.0	1.690	44.26	0.54	0.39	0.13	20.38	23.60	C0	Crust	—	Rough	Bulk
89SC04AD08	10° 13.462'S	149° 50.980'W	1,680	Slp (Up)	0.250	20.0	2.000	34.62	0.78	0.77	0.10	25.94	15.15	A0	Crust	—	Botry'd	Bulk
89SC04AD08	10° 13.462'S	149° 50.980'W	1,680	Slp (Up)	0.070	8.0	2.000	40.91	0.44	1.75	0.23	15.71	2.54	B0	Crust	—	Smooth	Bulk
89SC04AD09	10° 14.244'S	149° 48.128'W	2,070	Slp (Md)	53.000	8.0	1.790	34.00	0.68	0.59	0.09	24.29	16.88	A0	Crust	Basalt	Botry'd	Bulk
89SC04AD09	10° 14.244'S	149° 48.128'W	2,070	Slp (Md)	2.450	13.0	2.000	39.29	0.53	0.51	0.10	24.14	18.58	B1	Crust	—	Botry'd	Outer
89SC04AD09	10° 14.244'S	149° 48.128'W	2,070	Slp (Md)	2.450	10.0	1.810	36.73	0.43	0.55	0.14	23.13	18.42	B2	Crust	—	Botry'd	Middle
89SC04AD09	10° 14.244'S	149° 48.128'W	2,070	Slp (Md)	2.450	23.0	1.920	38.18	0.49	0.53	0.12	23.70	18.51	B0	Crust	—	Botry'd	Bulk
89SC04AD09	10° 14.244'S	149° 48.128'W	2,070	Slp (Md)	1.040	30.0	1.960	45.45	0.51	0.50	0.13	22.03	19.42	C0	Crust	—	Botry'd	Bulk
89SC05AD01	11° 22.836'S	151° 47.576'W	2,450	Slp (Lw)	0.066	7.0	0.000	40.00	0.52	0.60	0.15	21.95	14.42	A0	Crust	—	Smooth	Bulk
89SC05AD02	11° 22.724'S	151° 50.050'W	1,370	Slp (Up)	0.017	6.0	0.000	29.41	0.80	0.69	0.11	15.85	10.42	A0	Crust	—	Smooth	Bulk
89SC05AD03	11° 22.961'S	151° 53.531'W	2,340	Slp (Md)	0.360	12.0	1.880	36.67	0.20	0.38	0.17	12.44	13.94	A0	Crust	Limest.	Rough	Bulk

Data List around Kiribati (Cobalt rich Crust)

Sample No.	Sampling Position Latitude	Sampling Position Longitude	Depth (m)	Topo-graphy	Weight (Kg)	Thick-ness (mm)	S.G. wet	H2O (%)	X. R. F. Analysis (%) Co	Ni	Cu	Mn	Fe	Chip Code	Crust Type	Substra-te or Core	Surface Texture	Sample Part
89SC05AD03	11° 22.961'S	151° 53.531'W	2,340	Slp (Md)	2.800	2.0	1.880	36.67	0.58	0.55	0.12	23.80	17.73	B0	Crust	Limest.	Botry'd	Bulk
89SC05AD03	11° 22.961'S	151° 53.531'W	2,340	Slp (Md)	0.610	2.0	1.880	30.00	0.23	0.41	0.16	14.42	14.83	C0	Crust	Limest.	Rough	Bulk
89SC05AD04	11° 25.242'S	151° 51.786'W	1,820	Slp (Up)	0.000	0.0	0.000	0.00	0.00	0.00	0.00	0.00	0.00	A0	—	—	—	Bulk
89SC05AD05	11° 27.132'S	151° 52.376'W	2,745	Slp (Md)	0.050	5.0	2.000	37.04	0.42	0.36	0.08	15.51	16.37	A0	Crust	—	Smooth	Bulk
89SC05AD06	11° 21.043'S	151° 51.836'W	1,320	Smt(Mrg)	6.800	8.0	1.890	30.61	1.41	0.76	0.06	29.53	12.91	A0	Crust	Hyaloc.	Rough	Bulk
89SC05AD06	11° 21.043'S	151° 51.836'W	1,320	Smt(Mrg)	2.800	10.0	2.080	26.00	1.11	0.55	0.10	19.32	25.21	B0	Crust	Hyaloc.	Rough	Bulk
89SC05AD06	11° 21.043'S	151° 51.836'W	1,320	Smt(Mrg)	2.100	6.0	2.000	33.33	1.26	0.81	0.07	28.91	13.46	C0	Crust	Hyaloc.	Rough	Bulk
89SC05AD06	11° 21.043'S	151° 51.836'W	1,320	Smt(Mrg)	0.420	18.0	2.000	35.71	1.37	0.88	0.08	30.43	11.67	D0	Crust	—	Rough	Bulk
89SC05AD06	11° 21.043'S	151° 51.836'W	1,320	Smt(Mrg)	0.068	10.0	2.000	39.39	1.50	1.00	0.08	31.15	11.48	E0	Crust	—	Rough	Bulk
89SC05AD07	11° 26.096'S	151° 45.768'W	2,365	Slp (Md)	4.950	1.0	2.000	33.33	0.38	0.37	0.07	10.60	6.86	A0	Crust	Limest.	Rough	Bulk
89SC05AD08	11° 28.355'S	151° 46.654'W	1,640	Slp (Up)	0.037	12.0	1.850	29.73	0.96	0.60	0.07	20.95	13.22	A0	Crust	—	Rough	Bulk
89SC05AD09	11° 28.806'S	151° 49.893'W	1,970	Slp (Md)	0.015	6.0	1.880	26.67	0.53	0.36	0.06	12.04	10.37	A0	Crust	—	Rough	Bulk
89SC06AD01	10° 28.967'S	154° 15.363'W	2,370	Slp (Up)	0.135	20.0	1.810	41.38	0.84	0.46	0.11	22.19	18.56	A0	Crust	Basalt	Rough	Bulk
89SC06AD01	10° 28.967'S	154° 15.363'W	2,370	Slp (Up)	0.194	23.0	1.770	40.00	0.86	0.49	0.11	22.94	17.69	B0	Crust	Hyaloc.	Rough	Bulk
89SC06AD01	10° 28.967'S	154° 15.363'W	2,370	Slp (Up)	0.055	10.0	1.810	41.38	0.58	0.52	0.11	23.17	18.17	C0	Crust	—	Rough	Bulk
89SC06AD01	10° 28.967'S	154° 15.363'W	2,370	Slp (Up)	0.142	18.0	1.670	40.00	1.06	0.52	0.09	24.90	18.03	D0	Crust	—	Rough	Bulk
89SC06AD01	10° 28.967'S	154° 15.363'W	2,370	Slp (Up)	0.340	2.0	1.810	51.72	0.60	0.49	0.08	21.81	17.37	E0	Cobble	Limest.	Rough	Bulk
89SC06AD02	10° 31.063'S	154° 15.679'W	2,880	Slp (Lw)	0.021	7.0	1.750	38.10	0.47	0.39	0.11	22.14	20.44	A1	Slub	—	—	Outer
89SC06AD02	10° 31.063'S	154° 15.679'W	2,880	Slp (Lw)	0.054	55.0	1.740	44.44	0.38	0.41	0.14	18.73	20.35	A2	Slub	—	—	Middle
89SC06AD02	10° 31.063'S	154° 15.679'W	2,880	Slp (Lw)	0.032	4.0	1.680	43.75	0.45	0.46	0.11	21.02	19.41	A3	Slub	—	—	Lw-Out
89SC06AD02	10° 31.063'S	154° 15.679'W	2,880	Slp (Lw)	4.500	75.0	1.740	43.73	0.39	0.41	0.14	19.23	20.30	A0	Slub	—	—	Bulk
89SC06AD02	10° 31.063'S	154° 15.679'W	2,880	Slp (Lw)	0.950	38.0	1.590	37.10	0.39	0.43	0.14	18.46	18.74	B0	Slub	Tuf.bre	Rough	Bulk
89SC06AD02	10° 31.063'S	154° 15.679'W	2,880	Slp (Lw)	0.580	1.0	0.000	40.00	0.54	0.44	0.07	20.74	16.80	C0	Cobble	Basalt	Rough	Bulk
89SC06AD02	10° 31.063'S	154° 15.679'W	2,880	Slp (Lw)	0.280	40.0	1.900	40.00	0.61	0.40	0.15	22.43	20.90	D0	Crust	—	Rough	Bulk
89SC06AD02	10° 31.063'S	154° 15.679'W	2,880	Slp (Lw)	0.077	8.0	1.670	52.00	0.77	0.43	0.09	23.22	20.65	E0	Crust	—	Rough	Bulk
89SC06AD03	10° 31.259'S	154° 13.731'W	2,360	Slp (Md)	4.900	20.0	1.800	37.04	0.61	0.54	0.10	23.68	18.78	A0	Crust	Hyaloc.	Rough	Bulk
89SC06AD03	10° 31.259'S	154° 13.731'W	2,360	Slp (Md)	1.440	6.0	2.000	38.46	0.60	0.53	0.09	24.51	18.26	B0	Crust	Hyaloc.	Rough	Bulk
89SC06AD03	10° 31.259'S	154° 13.731'W	2,360	Slp (Md)	1.920	5.0	1.690	37.04	0.41	0.53	0.14	16.81	14.92	C0	Crust	Limest.	Rough	Bulk
89SC06AD04	10° 31.027'S	154° 12.052'W	1,850	Slp (Up)	1.500	4.0	0.000	34.62	0.79	0.58	0.09	22.30	14.79	A0	Slub	Sedim't	Rough	Bulk
89SC06AD04	10° 31.027'S	154° 12.052'W	1,850	Slp (Up)	0.310	30.0	1.910	31.25	0.78	0.69	0.13	27.30	14.26	B0	Crust	Hyaloc.	Rough	Bulk
89SC06AD04	10° 31.027'S	154° 12.052'W	1,850	Slp (Up)	0.300	27.0	2.000	36.11	0.87	0.71	0.12	28.65	14.06	C0	Crust	Hyaloc.	Rough	Bulk
89SC06AD04	10° 31.027'S	154° 12.052'W	1,850	Slp (Up)	0.051	6.0	2.000	33.33	0.95	0.47	0.08	22.22	17.28	D0	Crust	Limest.	Rough	Bulk
89SC06AD05	10° 27.035'S	154° 12.864'W	2,620	Slp (Md)	0.272	22.0	1.670	47.13	0.91	0.47	0.10	24.28	19.34	A0	Crust	Hyaloc.	Rough	Bulk
89SC06AD05	10° 27.035'S	154° 12.864'W	2,620	Slp (Md)	0.041	20.0	1.800	39.24	0.54	0.50	0.10	23.98	18.97	B0	Crust	—	Smooth	Bulk
89SC06AD05	10° 27.035'S	154° 12.864'W	2,620	Slp (Md)	0.020	7.0	2.100	42.86	0.53	0.40	0.09	21.38	20.20	C0	Crust	Sedim't	Rough	Bulk

Data List around Kiribati (Cobalt rich Crust)

Sample No.	Sampling Position		Depth	Topo-graphy	Weight	Thick-ness	S.G.	H2O	X. R. F. Analysis (%)					Chip	Crust	Substra-te or Core	Surface	Sample
	Latitude	Longitude	(m)		(Kg)	(mm)	wet	(%)	Co	Ni	Cu	Mn	Fe	Code	Type		Texture	Part
89SC06AD05	10° 27.035'S	154° 12.864'W	2,620	Slp (Md)	0.035	21.0	1.760	43.28	0.63	0.47	0.11	22.80	19.28	D0	Crust	—	Rough	Bulk
89SC06AD06	10° 29.080'S	154° 12.681'W	1,640	Slp (Up)	0.041	20.0	1.950	46.94	1.33	0.80	0.07	29.76	12.88	A1	Slub	Hyaloc.	—	Outer
89SC06AD06	10° 29.080'S	154° 12.681'W	1,640	Slp (Up)	0.034	4.0	2.130	23.53	1.05	0.28	0.05	14.15	38.09	A2	Slub	Hyaloc.	—	Lw-Out
89SC06AD06	10° 29.080'S	154° 12.681'W	1,640	Slp (Up)	42.000	20.0	1.980	43.04	1.28	0.71	0.07	27.16	17.08	A0	Slub	Hyaloc.	—	Bulk
89SC06AD06	10° 29.080'S	154° 12.681'W	1,640	Slp (Up)	20.000	16.0	1.890	21.05	0.85	0.66	0.10	25.66	17.20	B0	Crust	Hyaloc.	Rough	Bulk
89SC06AD06	10° 29.080'S	154° 12.681'W	1,640	Slp (Up)	5.100	25.0	1.930	34.62	0.84	0.77	0.15	26.66	14.64	C0	Slub	Hyaloc.	Rough	Bulk
89SC06AD06	10° 29.080'S	154° 12.681'W	1,640	Slp (Up)	6.000	18.0	1.940	35.05	0.94	0.69	0.11	26.63	14.53	D0	Crust	Hyaloc.	Rough	Bulk
89SC06AD07	10° 28.927'S	154° 11.552'W	2,070	Slp (Up)	20.000	5.0	1.880	31.25	0.63	0.52	0.11	22.28	17.47	A0	Crust	Limest.	—	Bulk
89SC06AD07	10° 28.927'S	154° 11.552'W	2,070	Slp (Up)	0.053	16.0	2.040	33.33	0.85	0.70	0.13	22.93	13.04	B0	Crust	Tuf.bre	Rough	Bulk
89SC06AD07	10° 28.927'S	154° 11.552'W	2,070	Slp (Up)	0.085	18.0	1.930	37.50	0.94	0.77	0.14	24.90	14.76	C0	Crust	—	Rough	Bulk
89SC06AD08	10° 28.939'S	154° 9.910'W	2,800	Slp (Md)	0.081	40.0	1.840	35.80	0.42	0.50	0.15	22.22	18.57	A1	Slub	Hyaloc.	Rough	Outer
89SC06AD08	10° 28.939'S	154° 9.910'W	2,800	Slp (Md)	0.019	2.0	1.850	35.14	0.43	0.46	0.12	20.22	17.02	A2	Slub	Hyaloc.	Rough	Lw-Out
89SC06AD08	10° 28.939'S	154° 9.910'W	2,800	Slp (Md)	5.000	40.0	1.840	35.77	0.42	0.50	0.15	22.12	18.50	A0	Slub	Hyaloc.	Rough	Bulk
89SC06AD08	10° 28.939'S	154° 9.910'W	2,800	Slp (Md)	0.082	2.0	0.000	33.33	0.41	0.51	0.12	21.63	18.40	B0	Crust	Hyaloc.	Rough	Bulk
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.041	15.0	1.950	39.02	1.30	1.00	0.07	32.42	9.94	A1	Slub	Hyaloc.	Rough	Outer
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.042	10.0	2.100	26.19	1.01	1.08	0.08	27.42	6.77	A2	Slub	Hyaloc.	—	Middle
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.014	1.0	0.000	28.57	0.98	0.62	0.06	21.38	17.59	A3	Slub	Hyaloc.	—	Lw-Out
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	11.000	25.0	2.010	33.68	1.18	1.02	0.07	30.07	9.02	A0	Slub	Hyaloc.	Rough	Bulk
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.035	15.0	1.940	40.00	1.43	0.94	0.06	32.12	10.52	B1	Crust	—	Rough	Outer
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.031	10.0	1.990	31.15	1.25	1.00	0.08	29.03	10.91	B2	Crust	—	Rough	Middle
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	4.000	25.0	1.960	36.46	1.36	0.96	0.07	30.88	10.68	B0	Crust	—	Rough	Bulk
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.040	15.0	1.880	36.71	1.37	0.96	0.06	32.47	10.20	C1	Crust	—	Rough	Outer
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.033	10.0	2.060	30.30	1.00	1.13	0.10	27.66	7.47	C2	Crust	—	Rough	Middle
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	3.500	25.0	1.950	34.15	1.22	1.03	0.08	30.55	9.11	C0	Crust	—	Rough	Bulk
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.045	11.0	1.780	39.33	1.44	1.04	0.07	32.84	9.43	D1	Crust	—	Rough	Outer
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.026	10.0	2.040	41.18	1.24	1.20	0.10	31.43	5.75	D2	Crust	—	Rough	Middle
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	1.200	21.0	1.900	40.21	1.34	1.12	0.08	32.17	7.68	D0	Crust	—	Rough	Bulk
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.057	13.0	1.970	35.09	1.24	1.01	0.07	31.81	9.04	E1	Crust	—	Rough	Outer
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.023	10.0	2.140	34.78	1.04	1.10	0.08	27.48	6.30	E2	Crust	—	Rough	Middle
89SC06AD09	10° 29.953'S	154° 13.157'W	1,350	Smt(Mrg)	0.640	23.0	2.040	34.96	1.15	1.05	0.07	29.93	7.85	E0	Crust	—	Rough	Bulk

3. List of the Survey Results by FDC

Date	Track Line No.	a Throwing Time b On sea-floor c Off sea-floor d Haul-in time	Location		Depth (m)	Survey Duration (hrs) (a ~ d)	Observation duration (hrs) (b ~ c)	Observation length (mile)	Number of photos (acquired)
			Latitude	Longitude					
10/02	SC02FDC01	a 14:31				4:30	3:00	4.1	137
		b 15:11	8° 50.25' S	150° 57.43' W	1,579				
		c 18:11	8° 50.14' S	150° 53.29' W	2,792				
		d 19:01							
10/04	SC03FDC02	a 07:52				5:21	4:01	5.0	192
		b 08:23	9° 05.00' S	150° 43.47' W	1,430				
		c 12:24	9° 05.01' S	150° 38.45' W	2,890				
		d 13:13							
10/08	SC04FDC03	a 07:43				6:38	4:01	6.0	180
		b 08:22	10° 11.02' S	149° 50.95' W	1,697				
		c 13:18	10° 10.95' S	149° 44.83' W	3,286				
		d 14:21							
10/13	SC05FDC04	a 07:42				6:16	4:47	5.1	166
		b 08:14	11° 22.98' S	151° 50.97' W	989				
		c 13:01	11° 23.00' S	151° 45.77' W	2,942				
		d 13:58							

Notes) 1. Location of 「on sea-floor」 and 「off sea-floor」 showned by ship position.
2. Depth was surveyed by CTD.

4. Weather and Sea-state Data

Monthly Frequency Distribution of Wind Velocity in 1989

(W.V : m/sec)

Month \ W.V	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total
September	4	8	5	12	15	31	49	38	49	42	46	46	45	25	26	17	16	12	4	3	493
%	0.81	1.62	1.01	2.43	3.04	6.29	9.94	7.72	9.94	8.52	9.33	9.33	9.13	5.07	5.27	3.45	3.25	2.43	0.81	0.61	100
October	2	14	29	23	24	21	27	37	42	41	35	33	38	29	21	21	15	3	2		457
%	0.44	3.05	6.34	5.03	5.25	4.60	5.91	8.10	9.19	8.97	7.66	7.22	8.31	6.35	4.60	4.60	3.28	0.66	0.44		100

Monthly Frequency Distribution of Wind Direction in 1989

Month \ W.D	CALM	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
September	29	29	70	53	31	15	16	10	5	12	10	12	16	44	40	42	59	493
%	5.88	5.88	14.20	10.75	6.29	3.04	3.25	2.03	1.01	2.43	2.03	2.43	3.25	8.92	8.11	8.52	11.98	100
October	61	53	44	52	18	10	9	16	13	24	15	9	5	10	23	37	58	457
%	13.35	11.60	9.63	11.38	3.94	2.19	1.97	3.50	2.84	5.25	3.28	1.97	1.09	2.19	5.03	8.10	12.69	100

Montly Frequency Distribution of Weather in 1989

Month \ Weather	Fine	Cloudy	Rain	Total	Light rain
September	24			24	12
%	100.00			100	50.00
October	21			21	9
%	100.00			100	42.86

Montly Frequency Distribution of Atmospheric Pressure (daily average) in 1989

(A.P : mb)

Month \ A.P	1005.1 ~ 1006.0	1006.1 ~ 1007.0	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	1019.1 ~ 1020.0	Total
September			3	18	30	33	35	12	4	1					1	137
%			2.19	13.14	21.90	24.09	25.54	8.76	2.92	0.73					0.73	100
October			6	7	22	24	28	19	12	2						120
%			5.00	5.83	18.33	20.0	23.33	15.83	10.0	1.68						100

Monthly Frequency Distribution of Swell Direction in 1989

S.D / Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Not Clear	Total
September			8	52	161	58											274	553
%			1.45	9.40	29.11	10.49											49.55	100
October				126	122												235	483
%				26.09	25.26												48.65	100

Monthly Frequency Distribution of Swell Cycle in 1989

(S.C : sec)

S.C / Month	5	6	7	8	9	10	11	12	13	14	15	Not Clear	Total
September		8		271								264	543
%		1.47		49.91								48.62	100
October		36		212								235	483
%		7.46		43.89								48.65	100

Monthly Frequecny Distribution of Swell Height in 1989

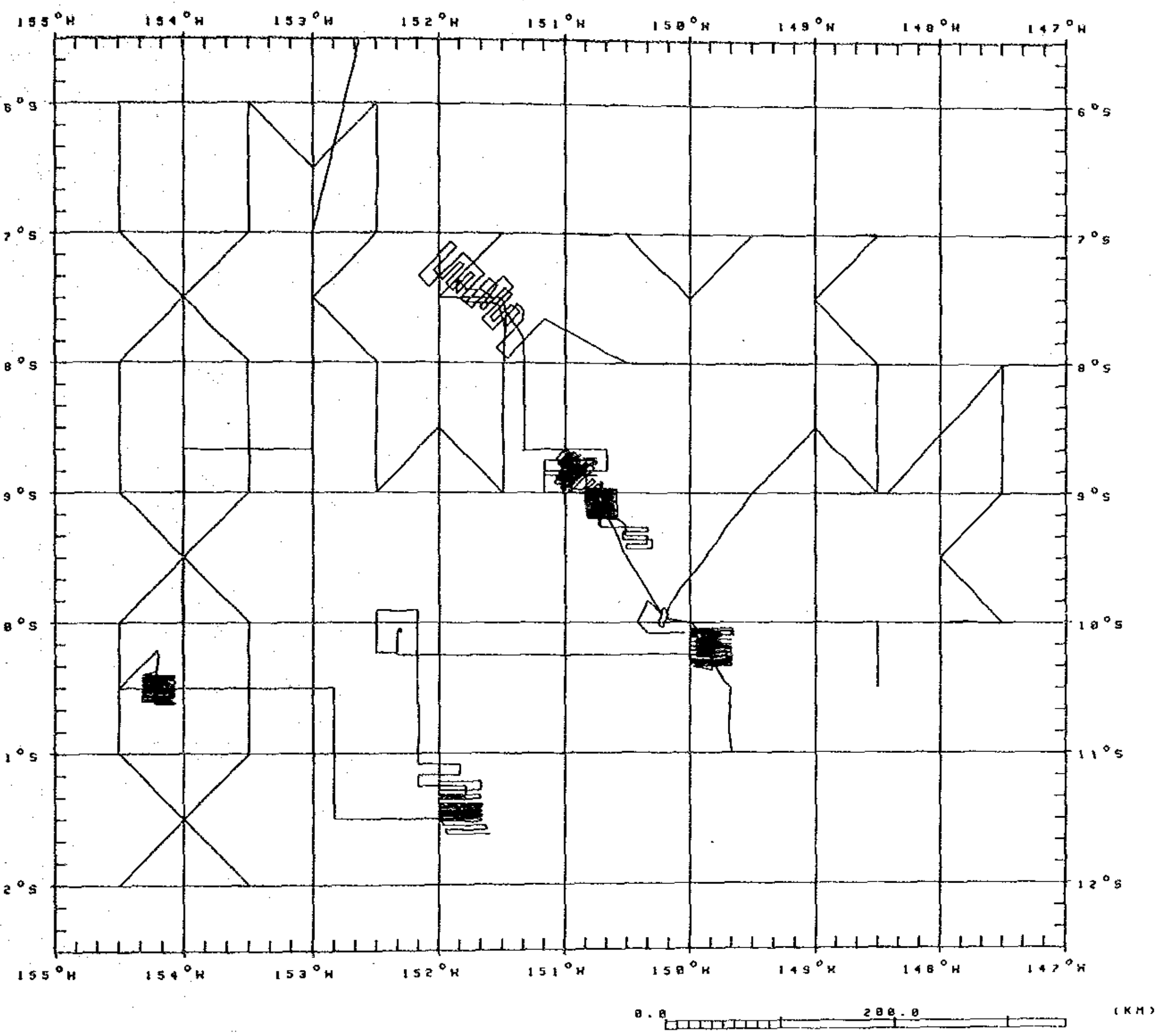
(S.H : m)

S.H / Month	1	2	3	4	5	6	Not Clear	Total
September		15	25	80	118	41	264	543
%		2.76	4.61	14.73	21.73	7.55	48.62	100
October			36	164	47		235	482
%			7.47	34.02	9.75		48.76	100

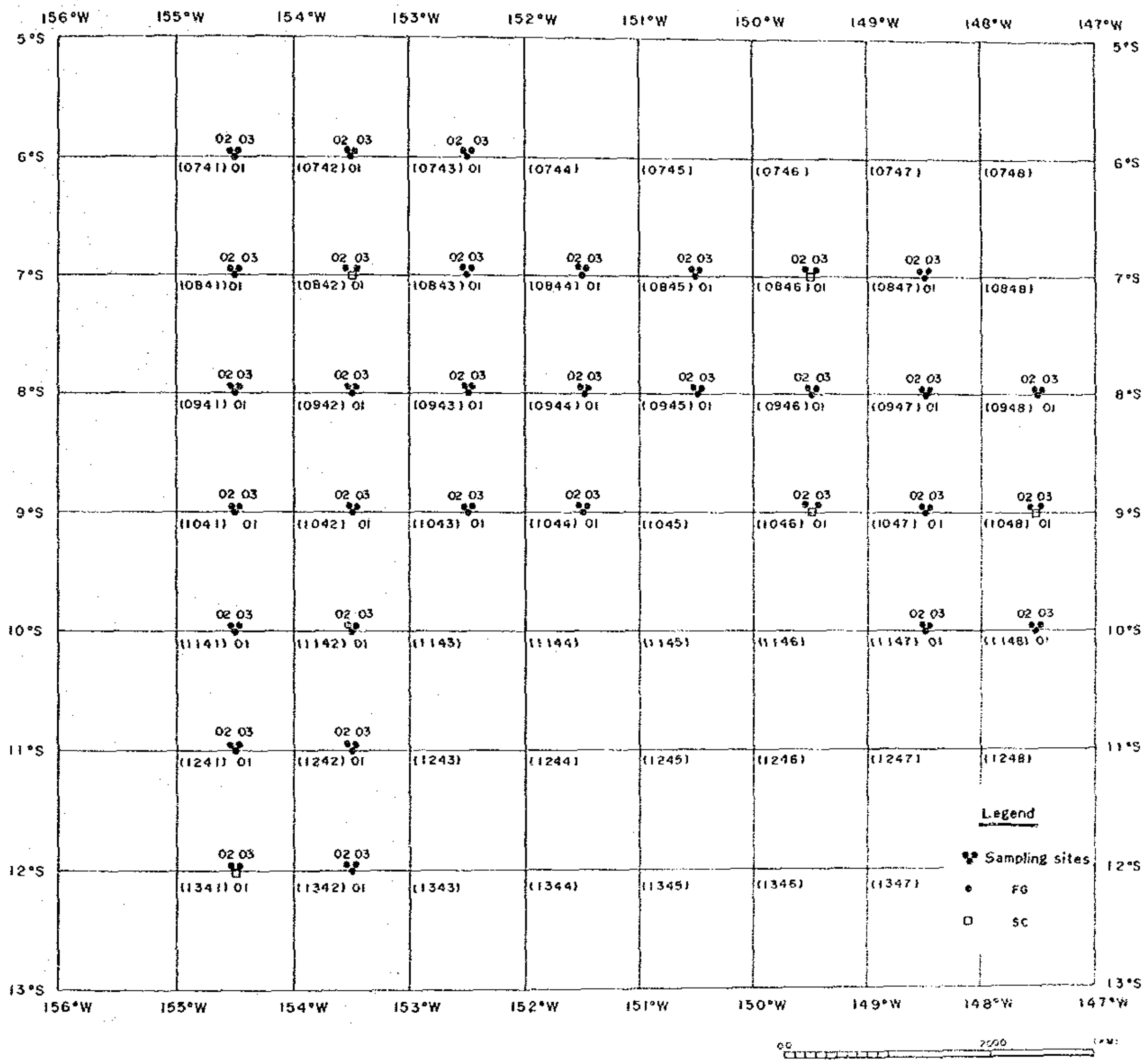
Monthly Frequency Distribution of Degree of Cloudiness in 1989

D.C / Month	0	1	2	3	4	5	6	7	8	9	Total
September		45	45	110	183	101	27	20	9	3	543
%		8.29	8.29	20.26	33.70	18.60	4.97	3.68	1.66	0.55	100
October		26	29	103	162	112	33	13	3	2	483
%		5.38	6.00	21.33	33.54	23.19	6.83	2.69	0.62	0.42	100

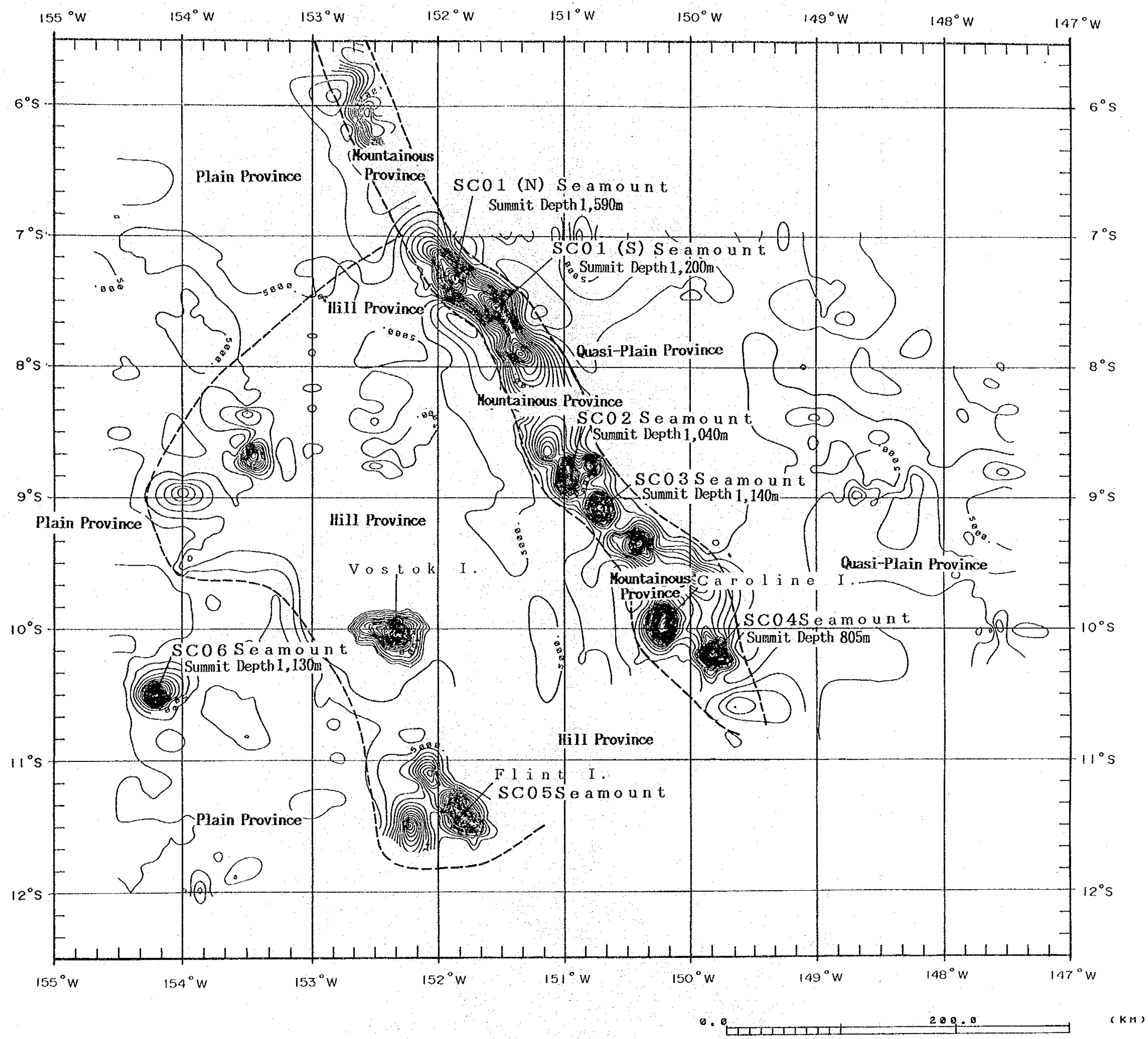
(List of Annexed Figures)



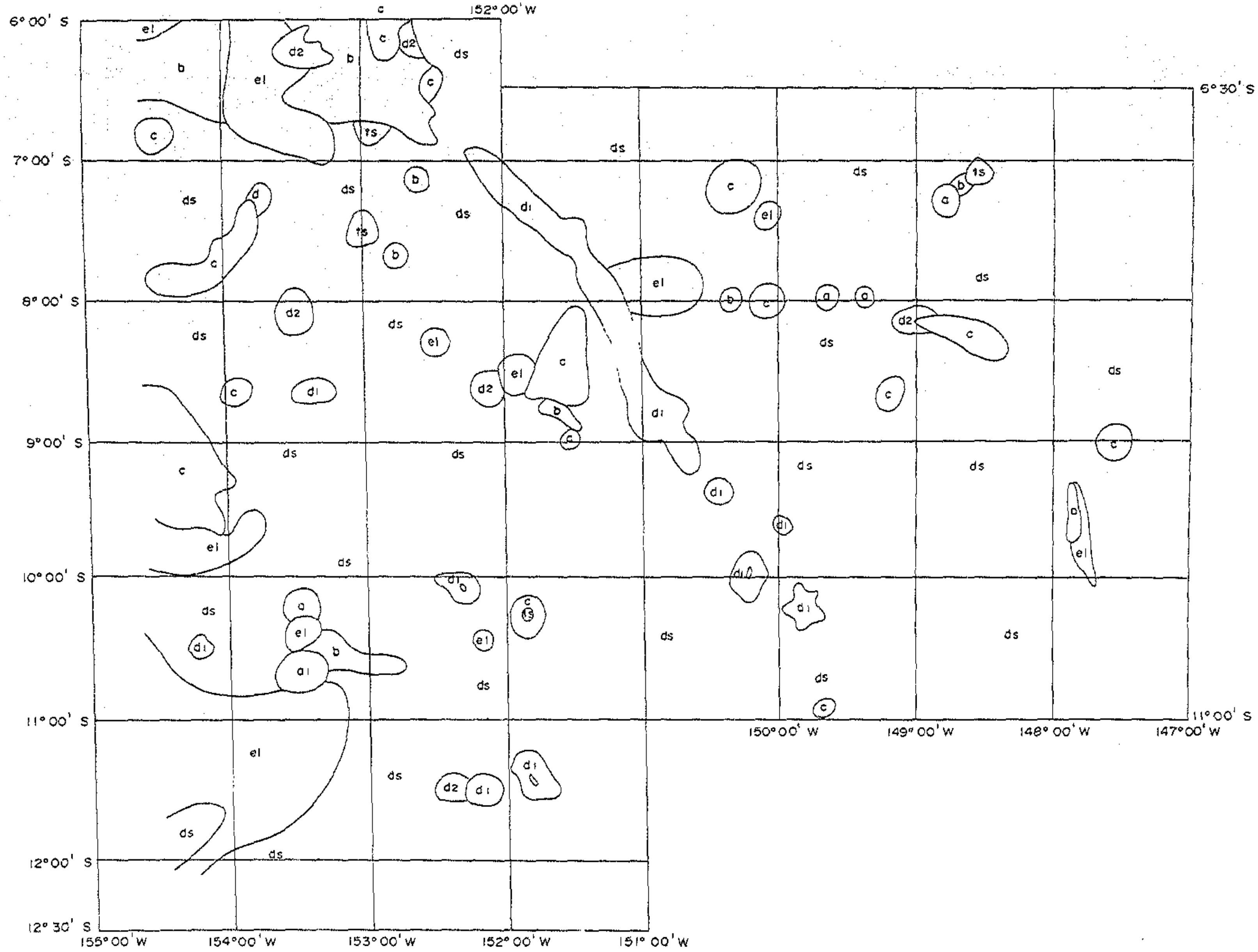
Annexed Figure 1   Trackline Map



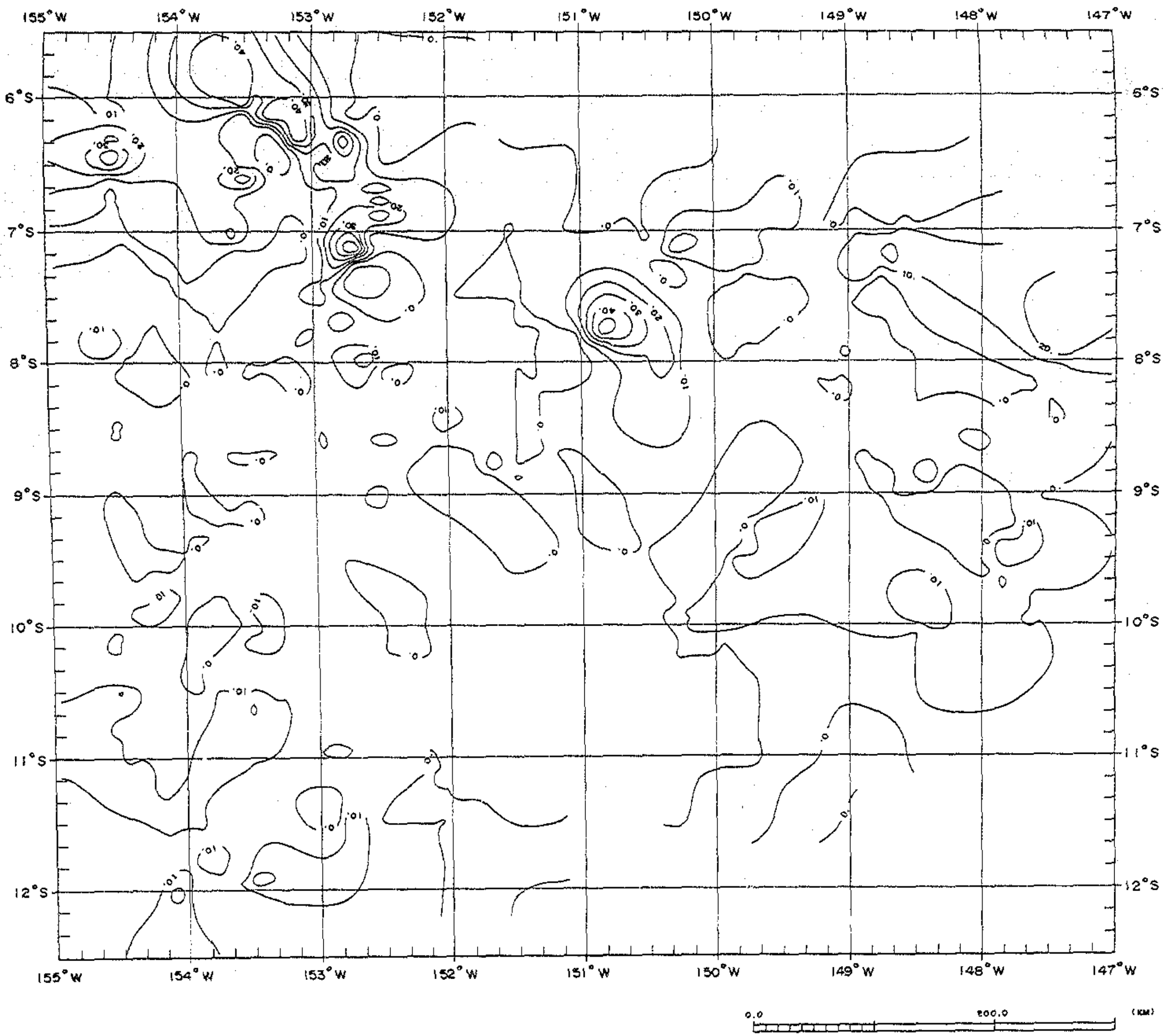
Annexed Figure 2 Positions of Sampling Points



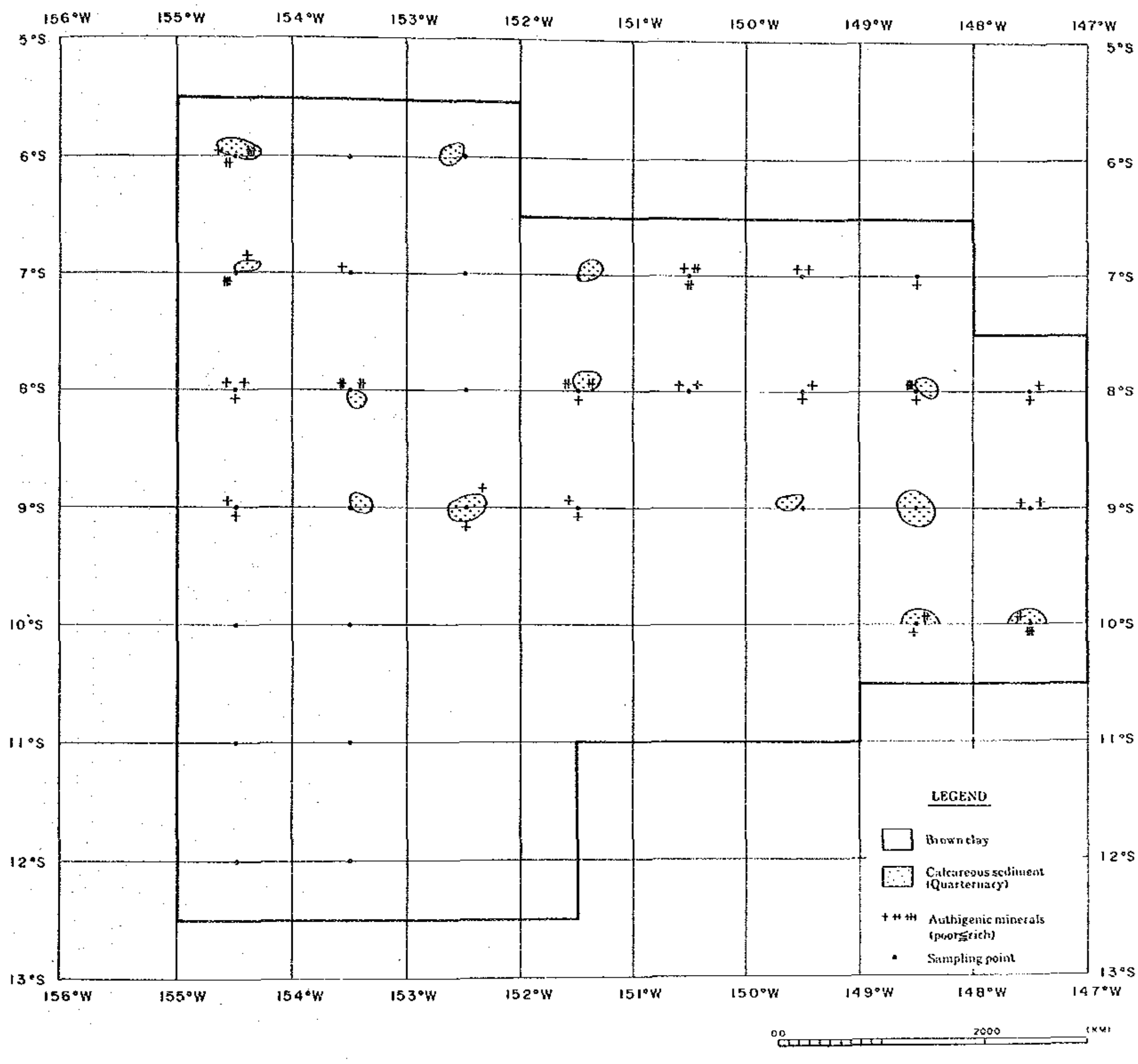
Annexed Figure 3 Sea Floor Topography



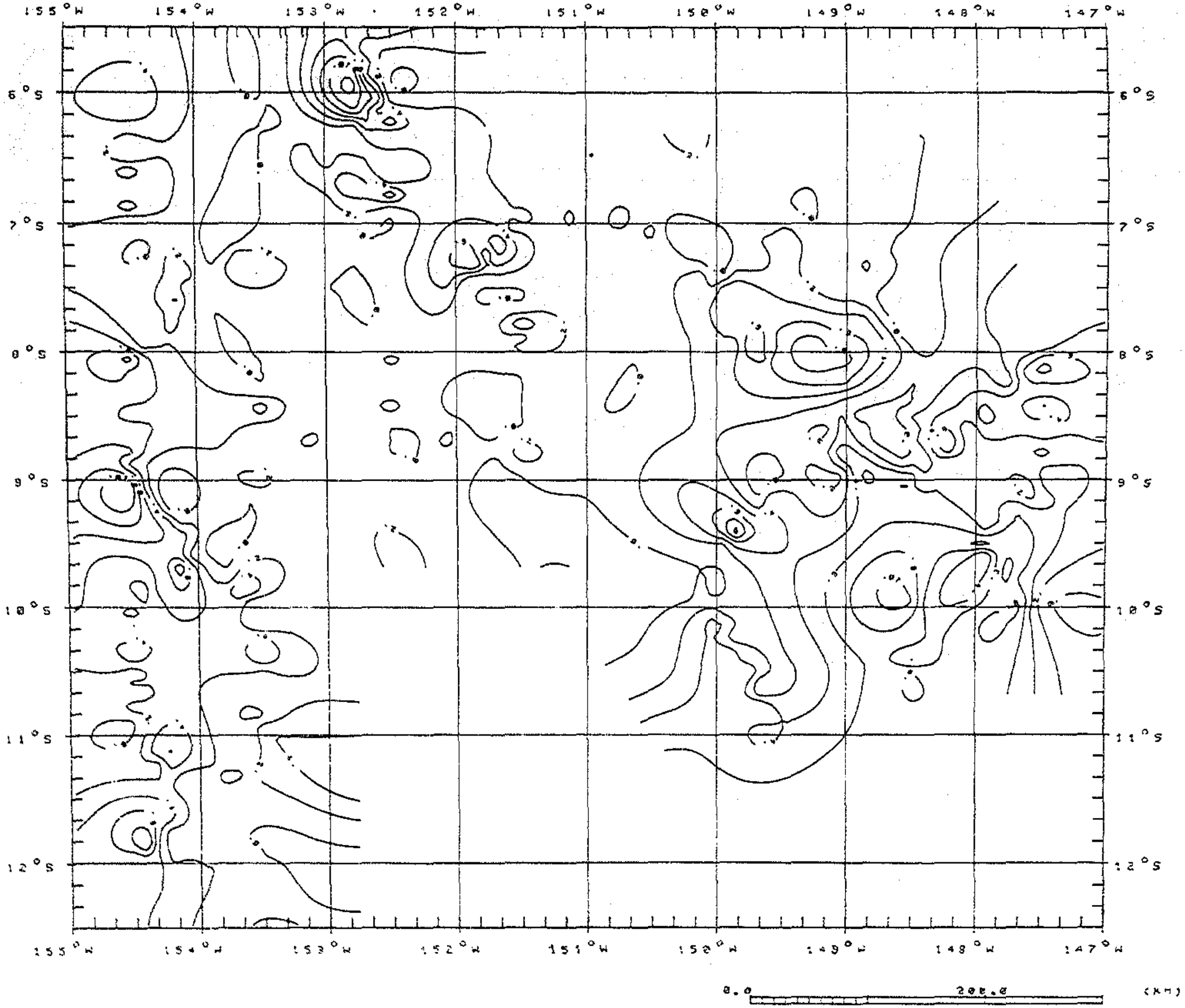
Annexed Figure 4 . Distribution of SBP Types



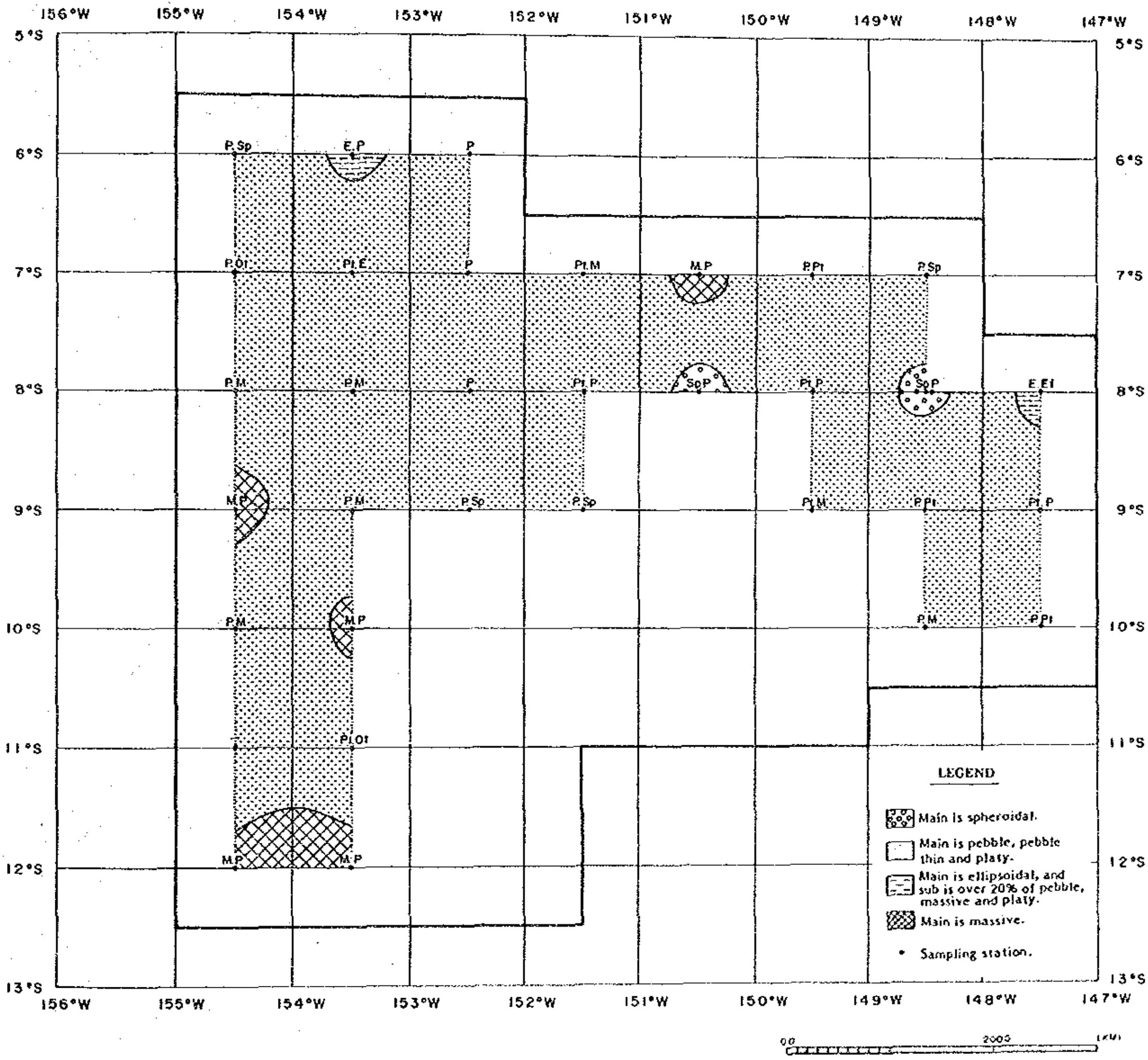
Annexed Figure 5 Acoustic Thickness of Upper Transparent Layers Obtained by SBP Survey



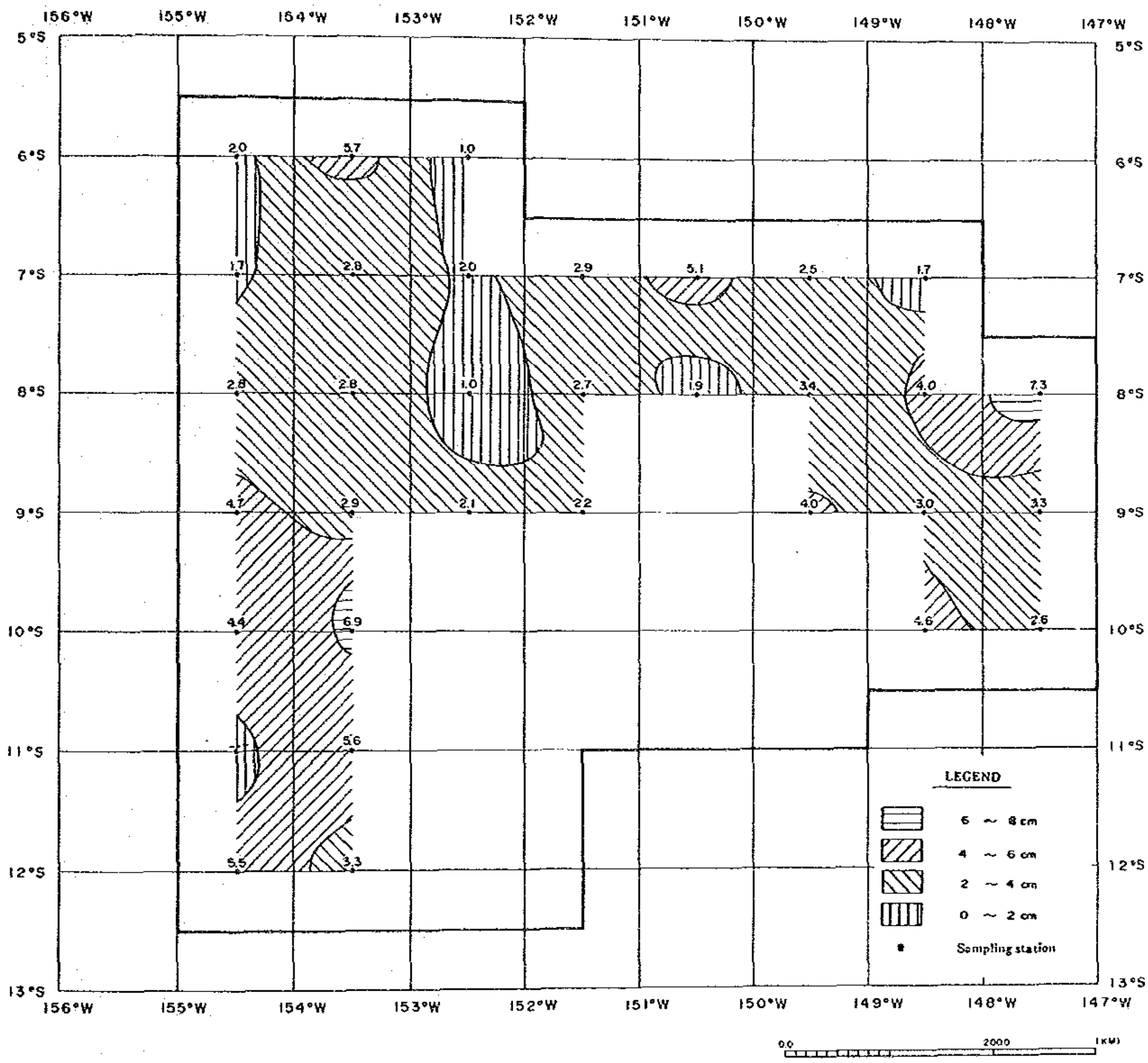
Annexed Figure 6 Distribution of Bottom Materials



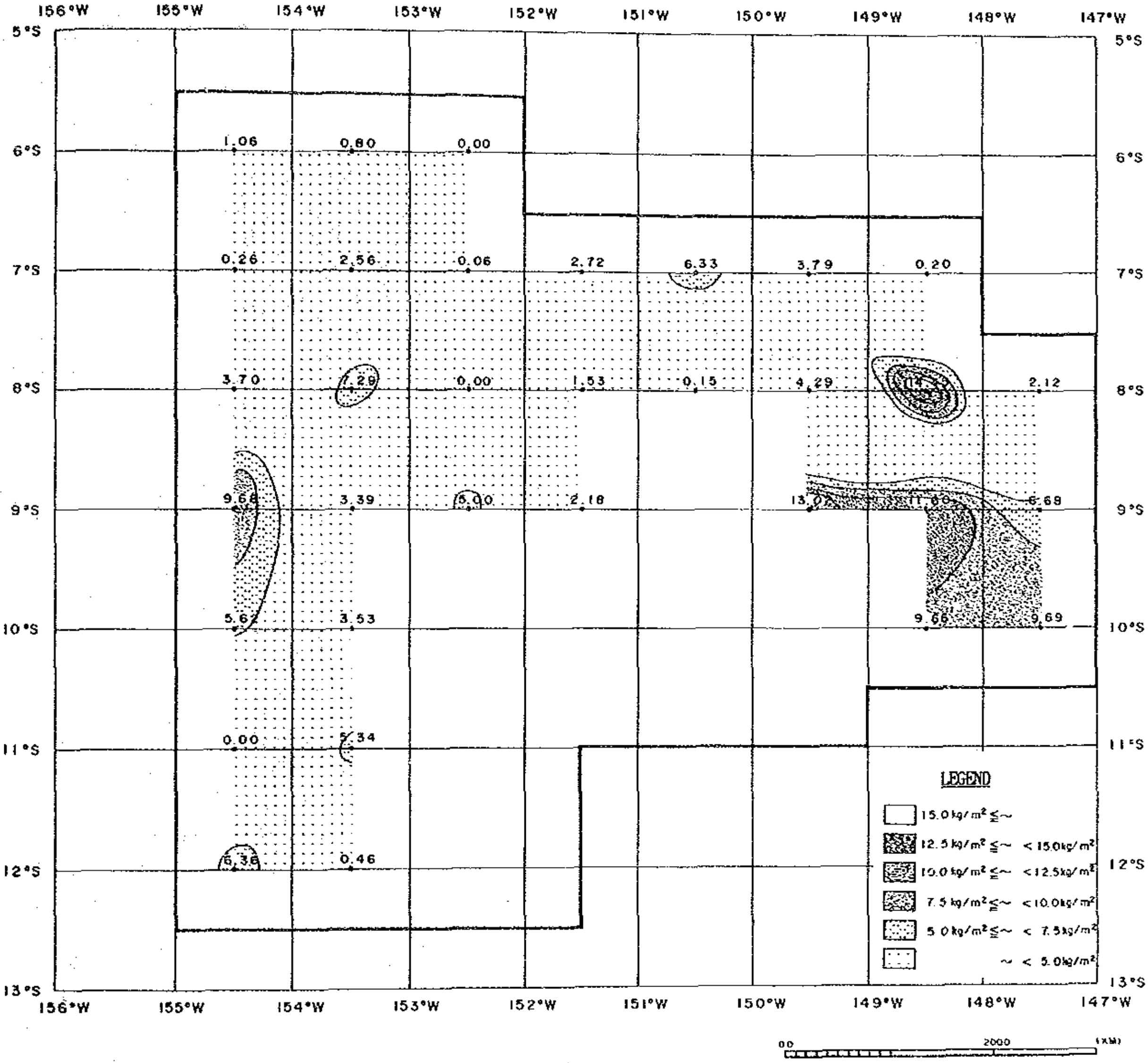
Annexed Figure 7 Estimated Abundance Map of Manganese Nodules by MFES



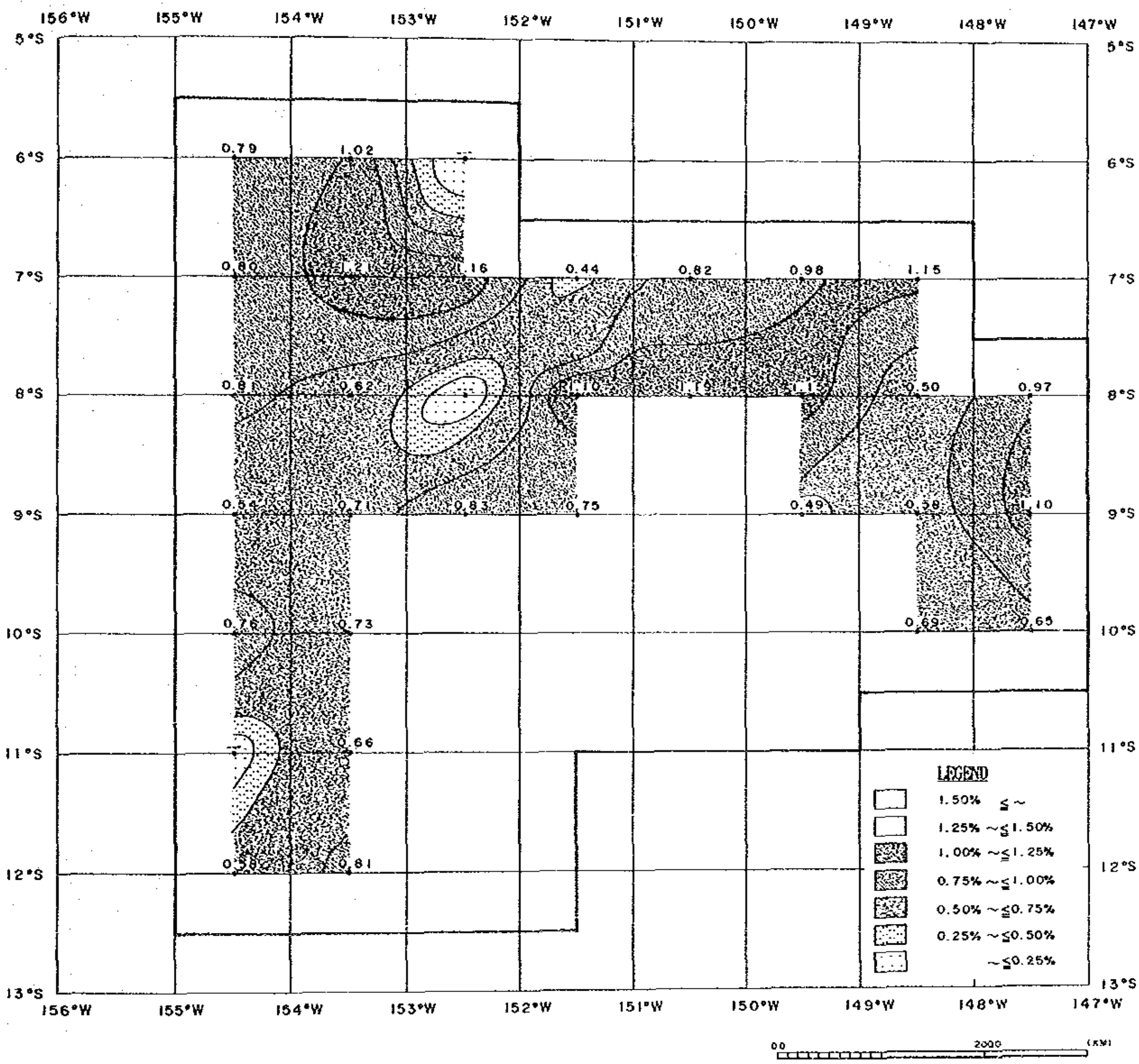
Annexed Figure 8 Morphology Distribution of Manganese Nodules



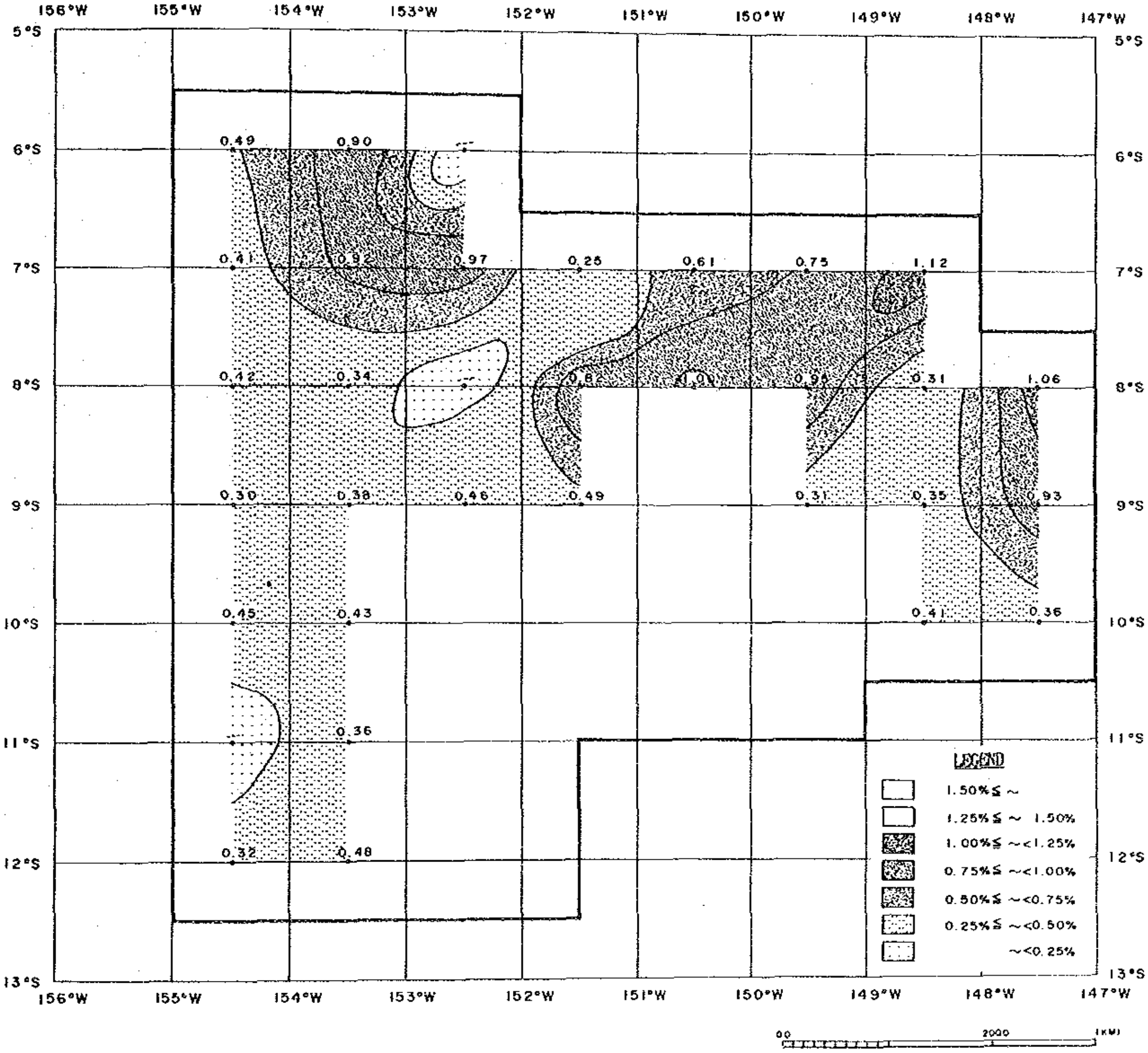
Annexed Figure 9 Size Distribution of Manganese Nodules



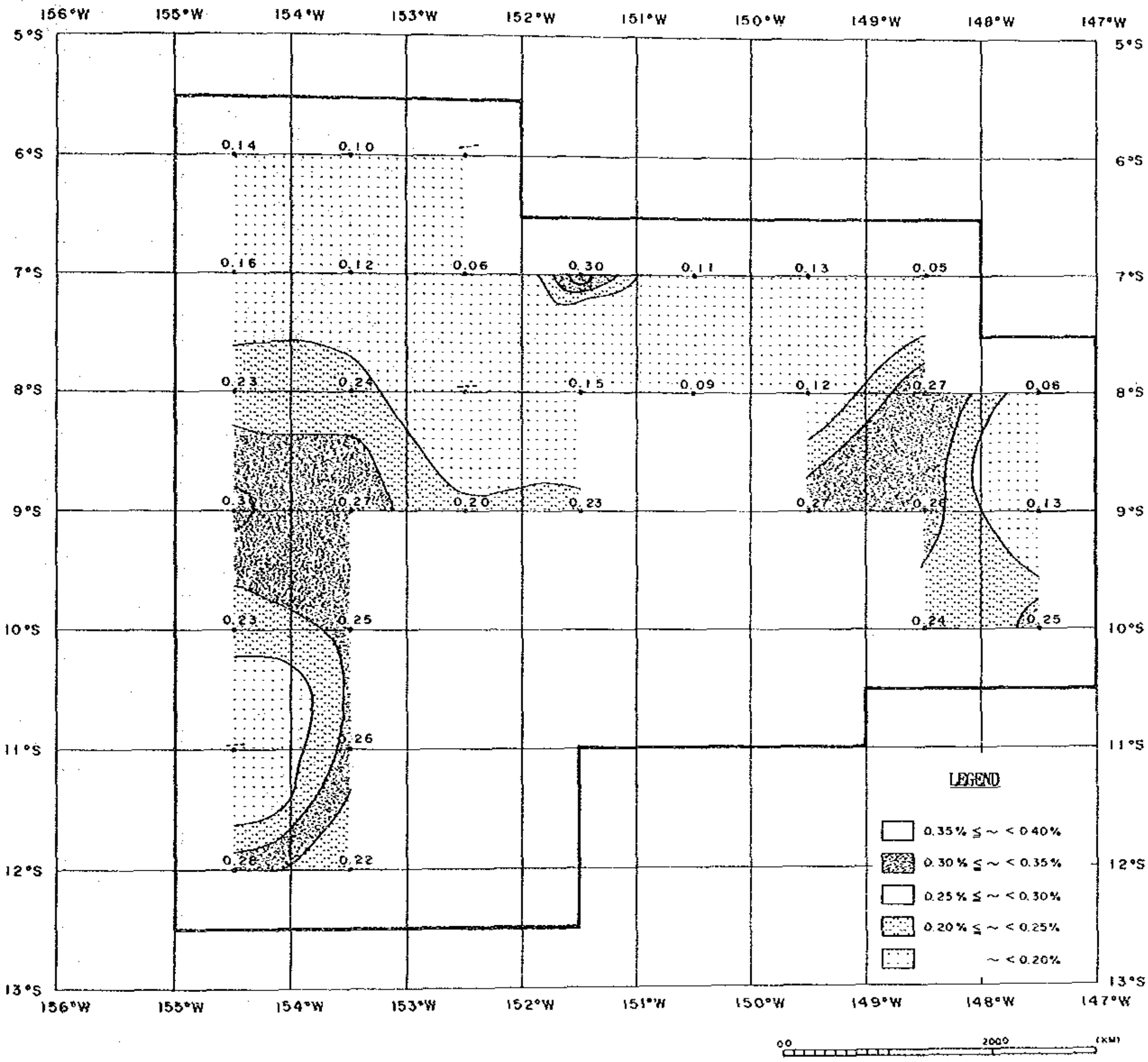
Annexed Figure 10 Abundance Map of Manganese Nodules



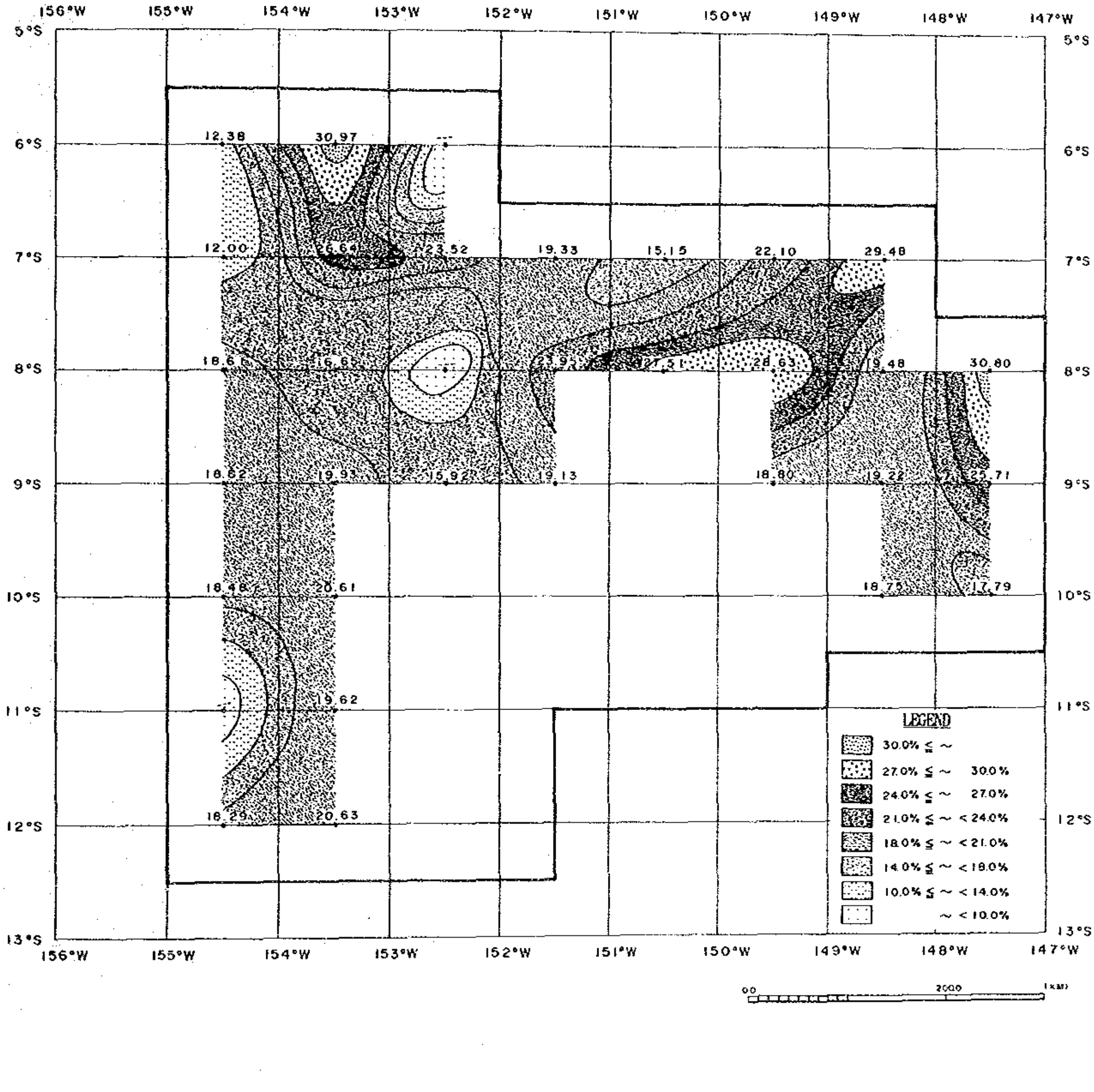
Annexed Figure 11 Ni Grade Map of Manganese Nodules



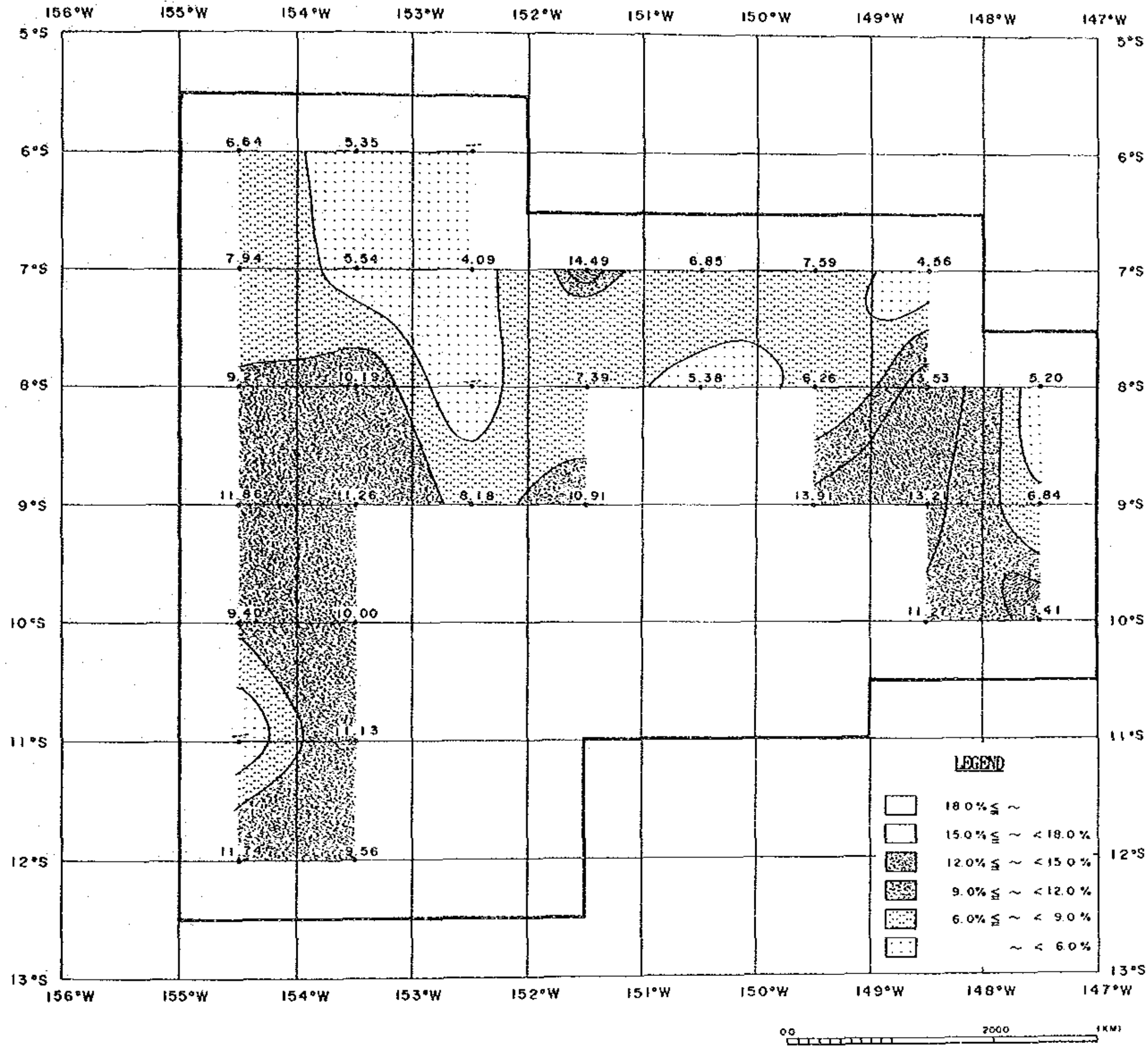
Annexed Figure 12 Cu Grade Map of Manganese Nodules



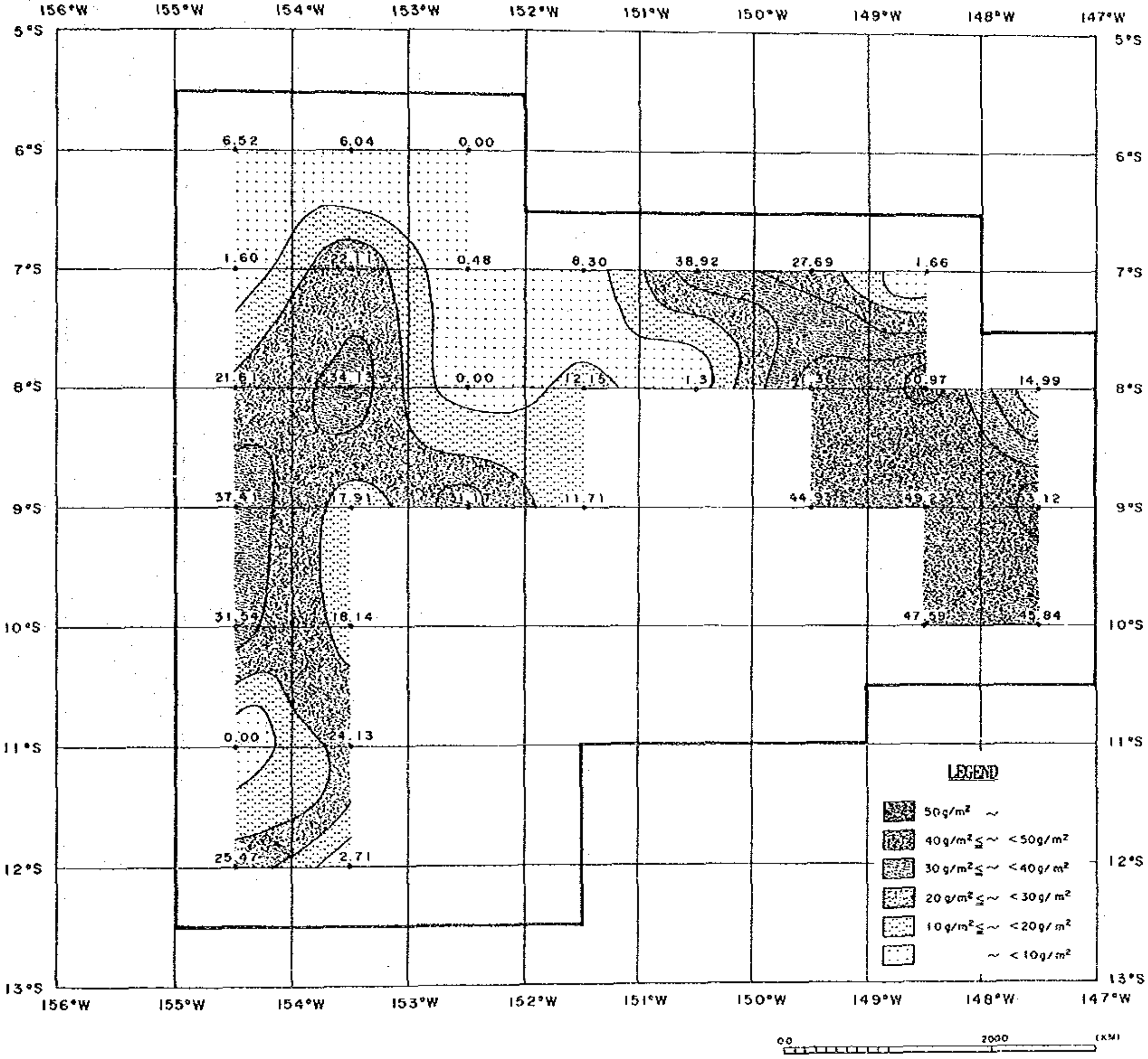
Annexed Figure 13 Co Grade Map of Manganese Nodules



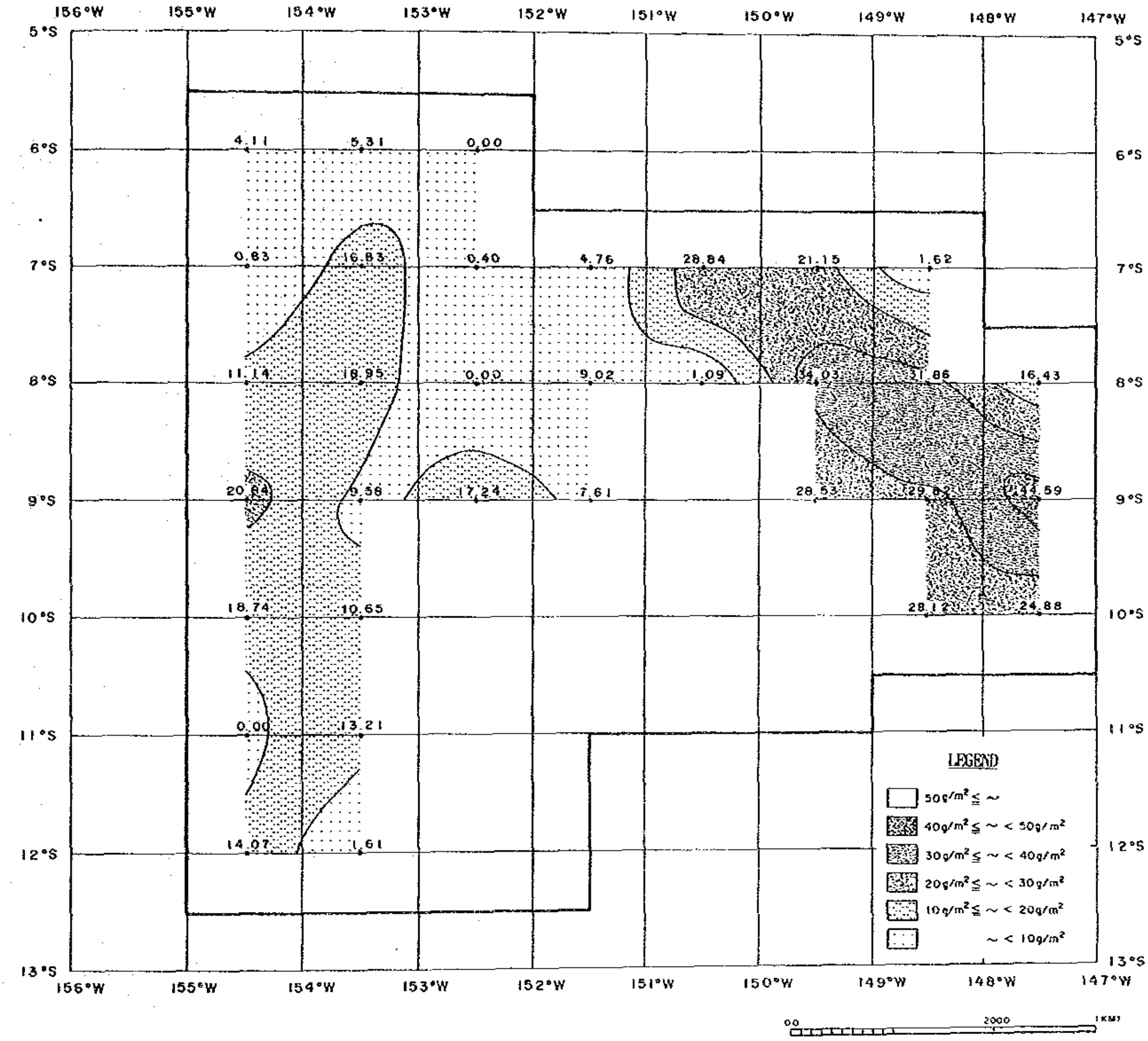
Annexed Figure 14 Mn Grade Map of Manganese Nodules



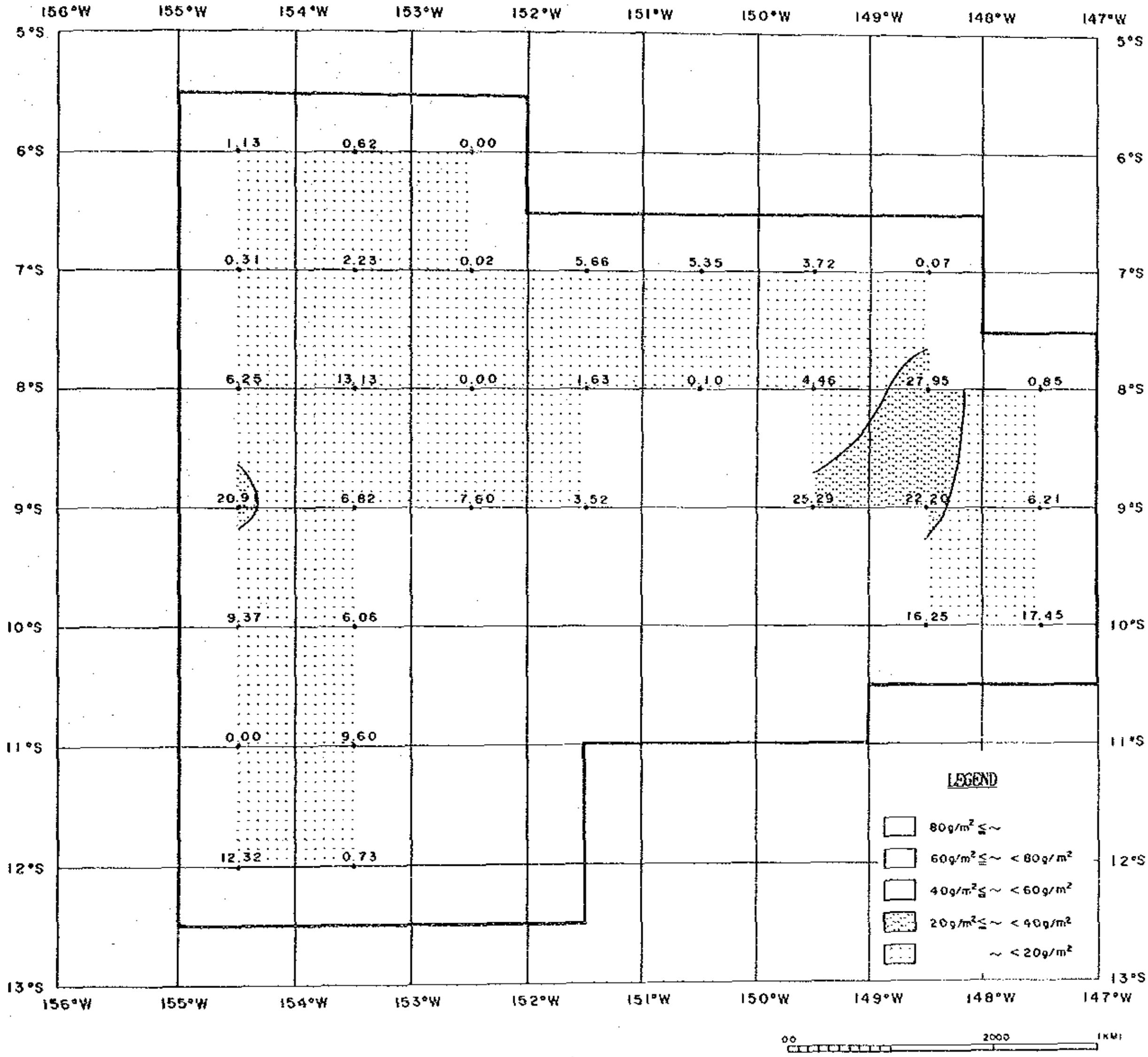
Annexed Figure 15 Fe Grade Map of Manganese Nodules



Annexed Figure 16 Ni Metal Quantity Map

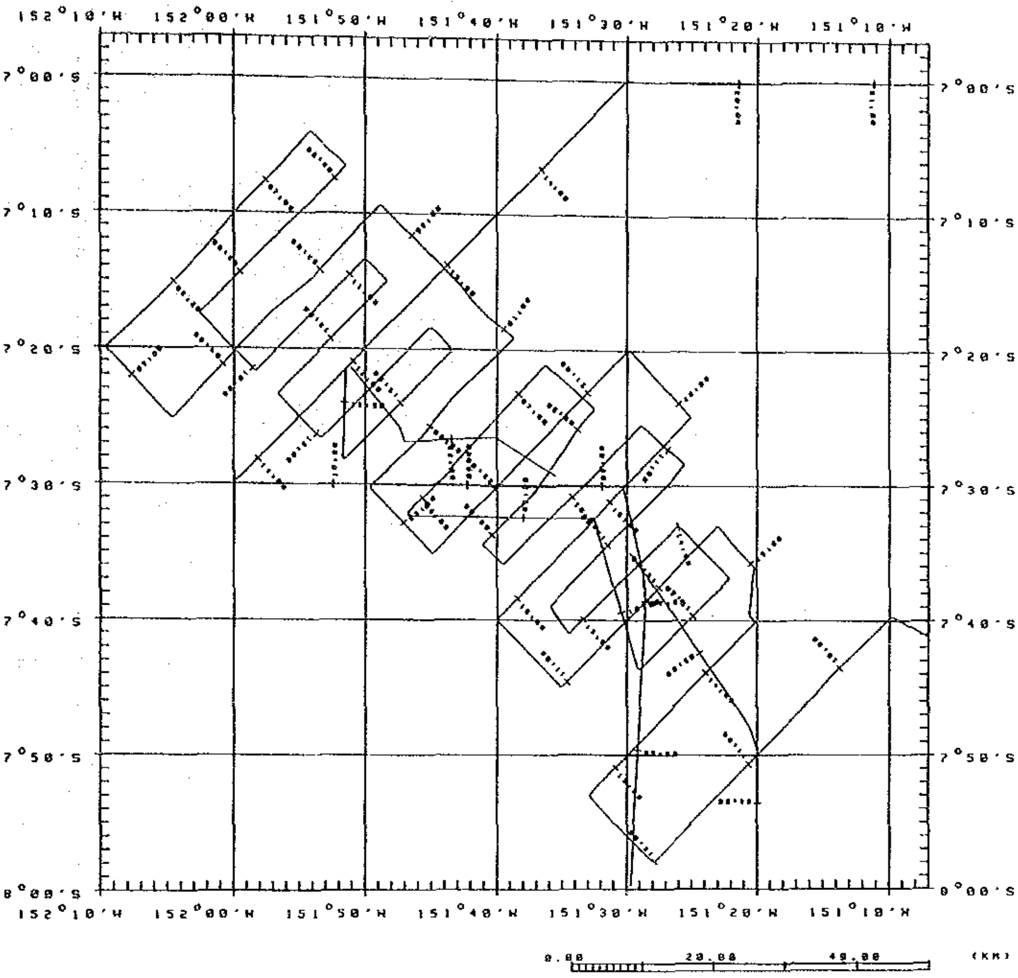


Annexed Figure 17 Cu Metal Quantity Map

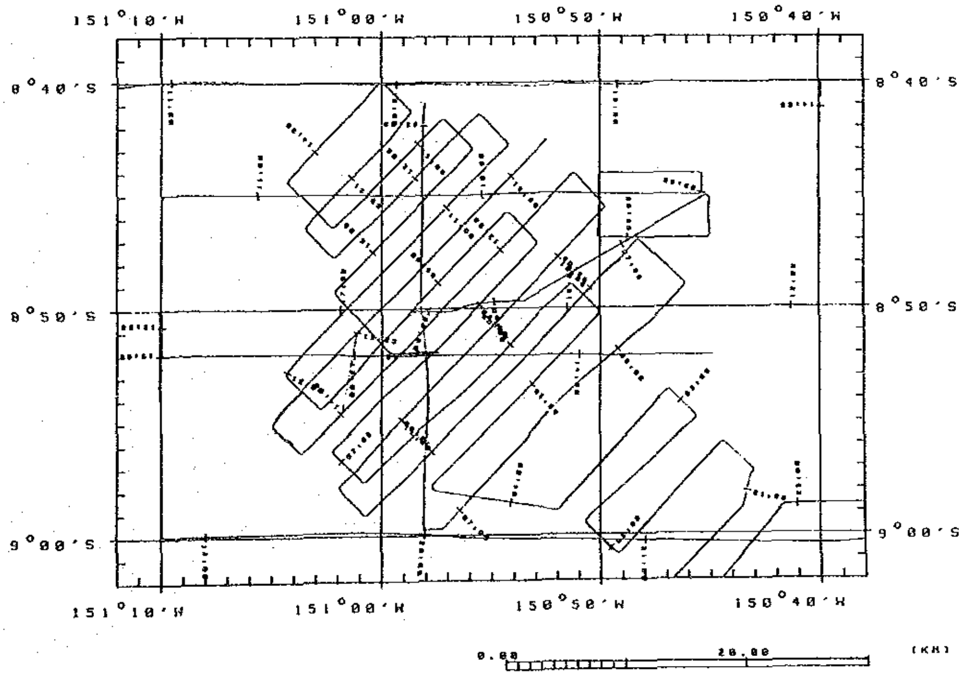


Annexed Figure 18 Co Metal Quantity Map

S C O 1

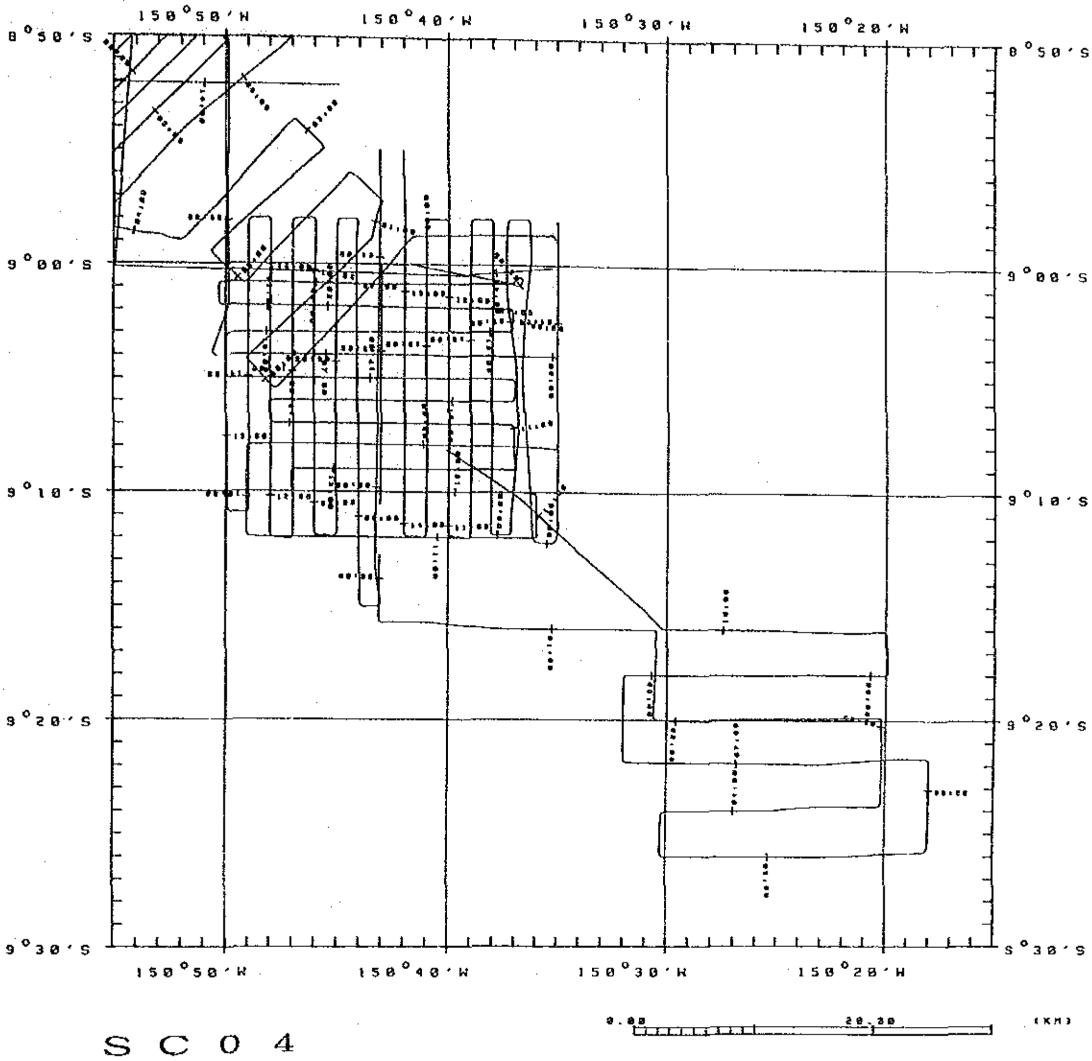


S C O 2

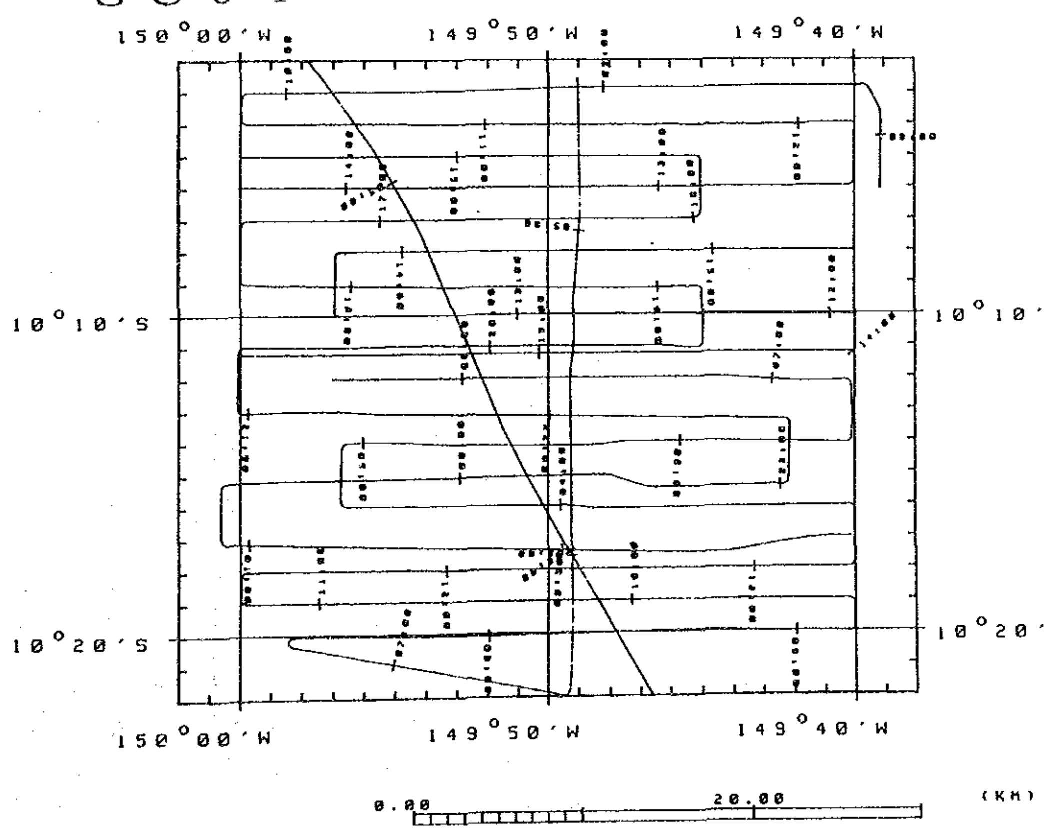


Annexed Figure 19 Trackline Maps of Individual Seamount (1)

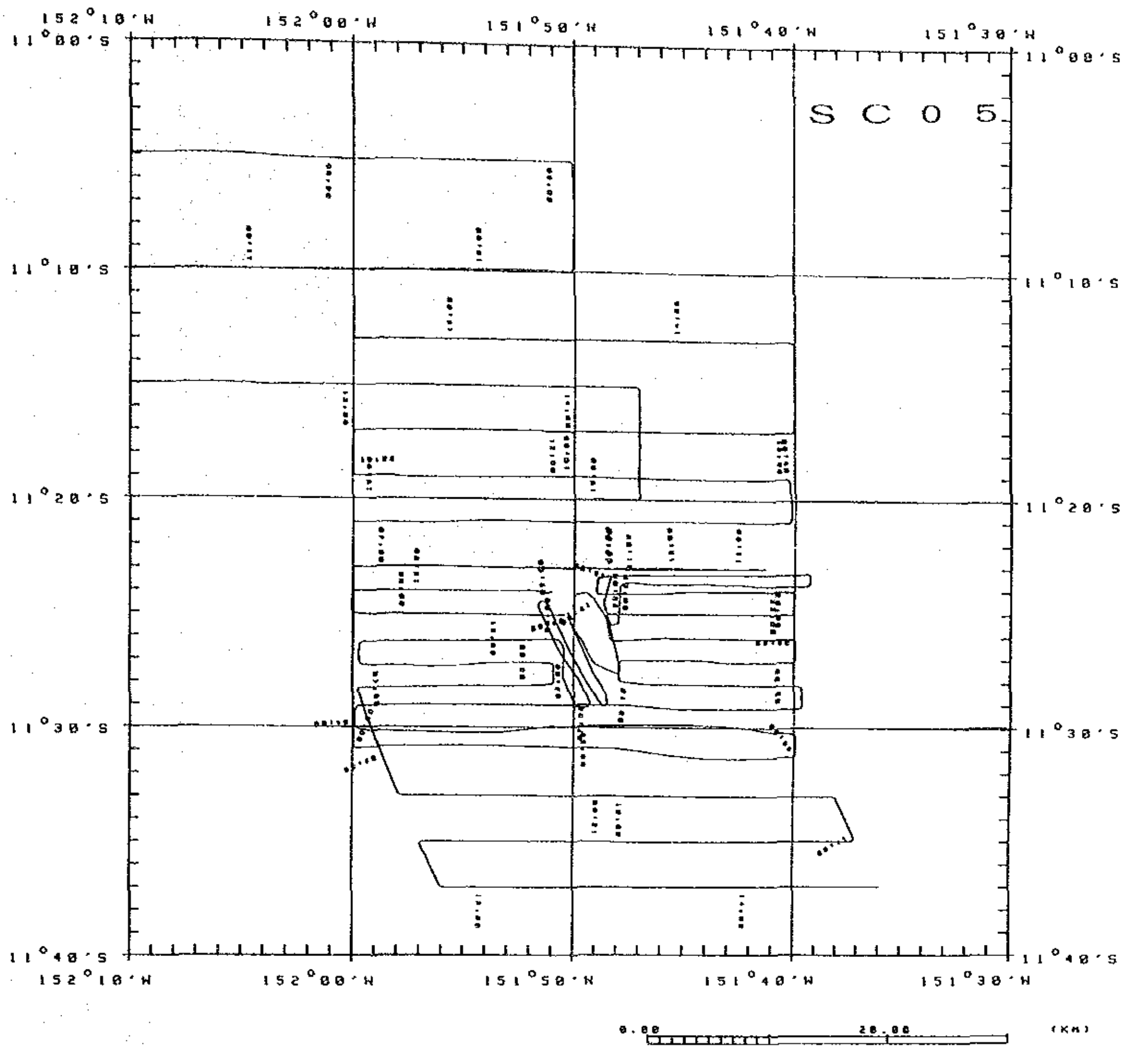
SC03

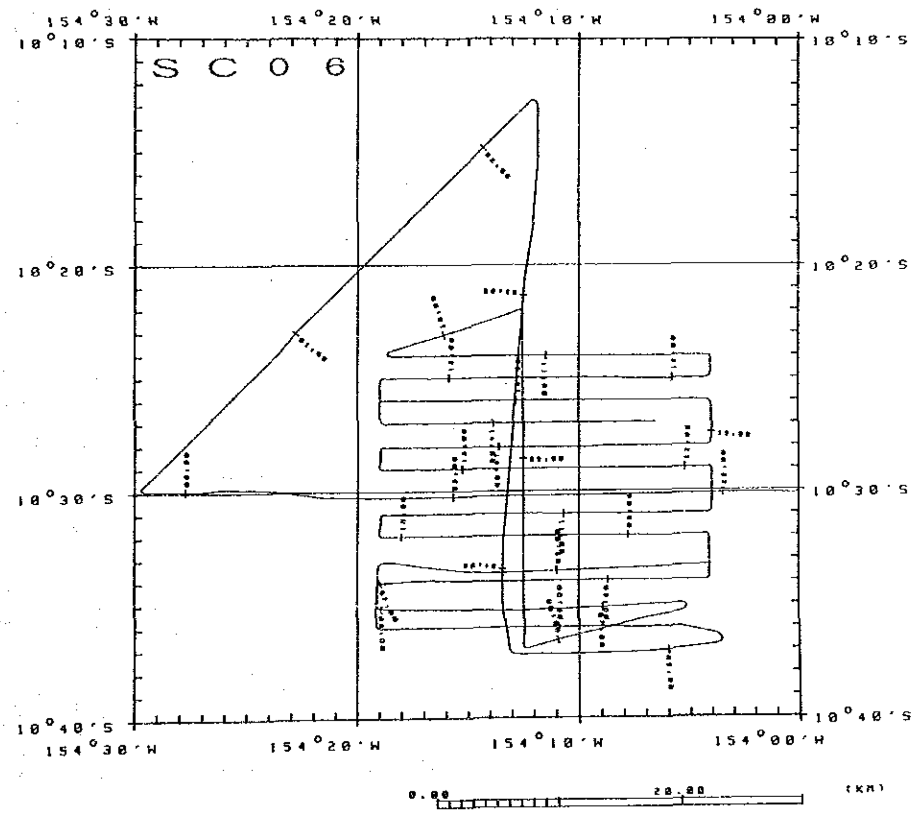


SC04

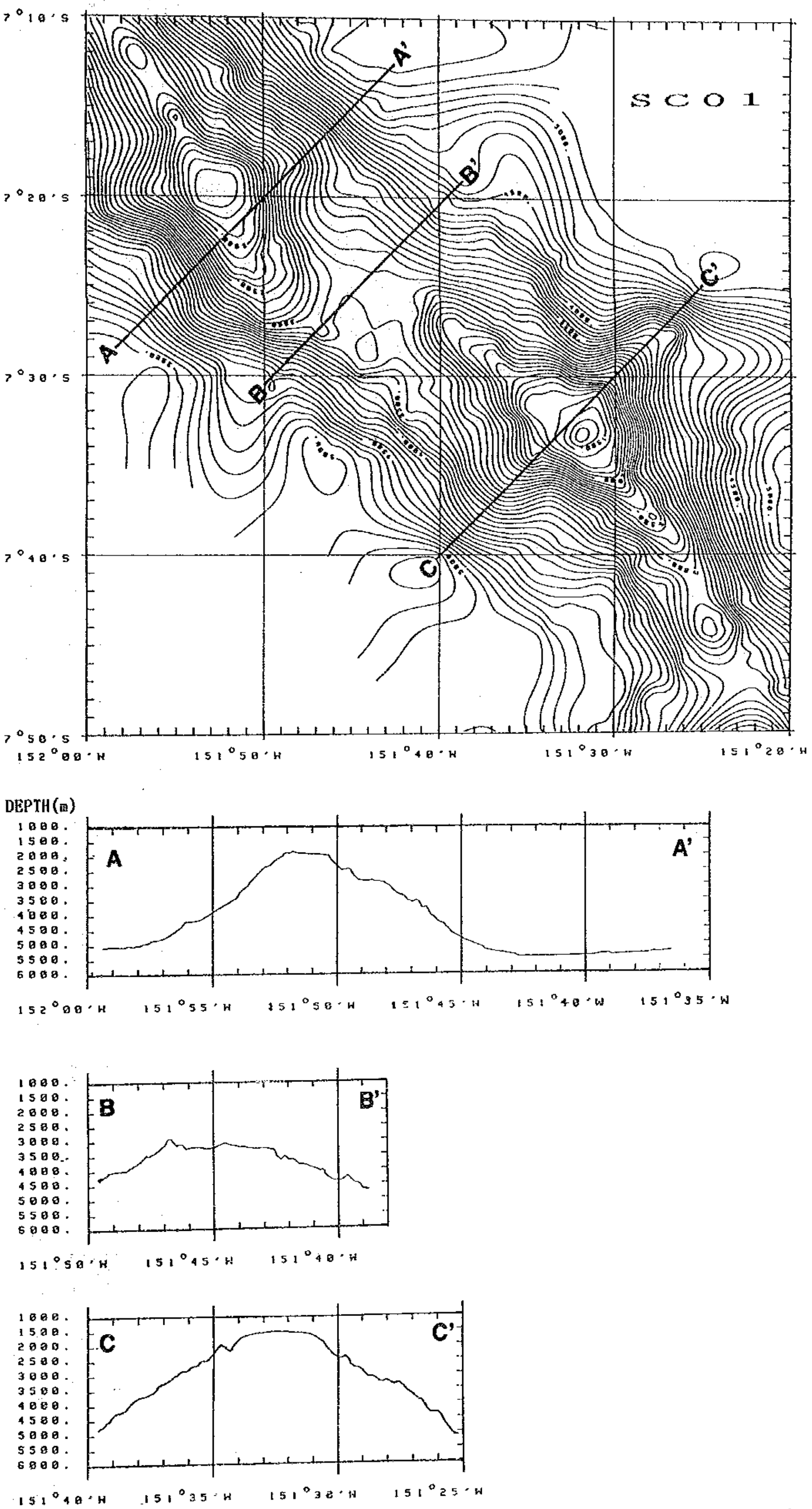


Annexed Figure 19 Trackline Maps of Individual Seamount (2)

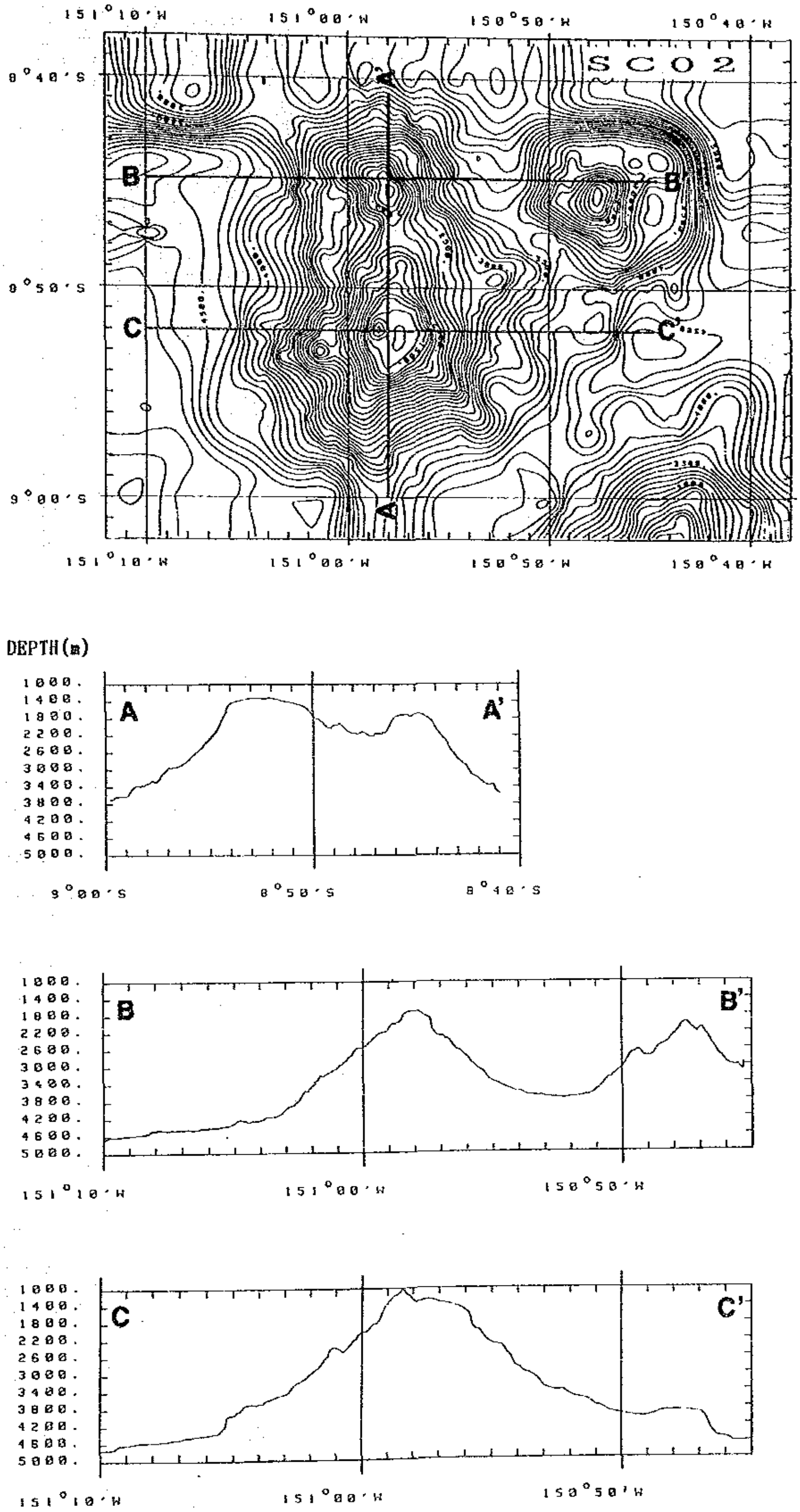




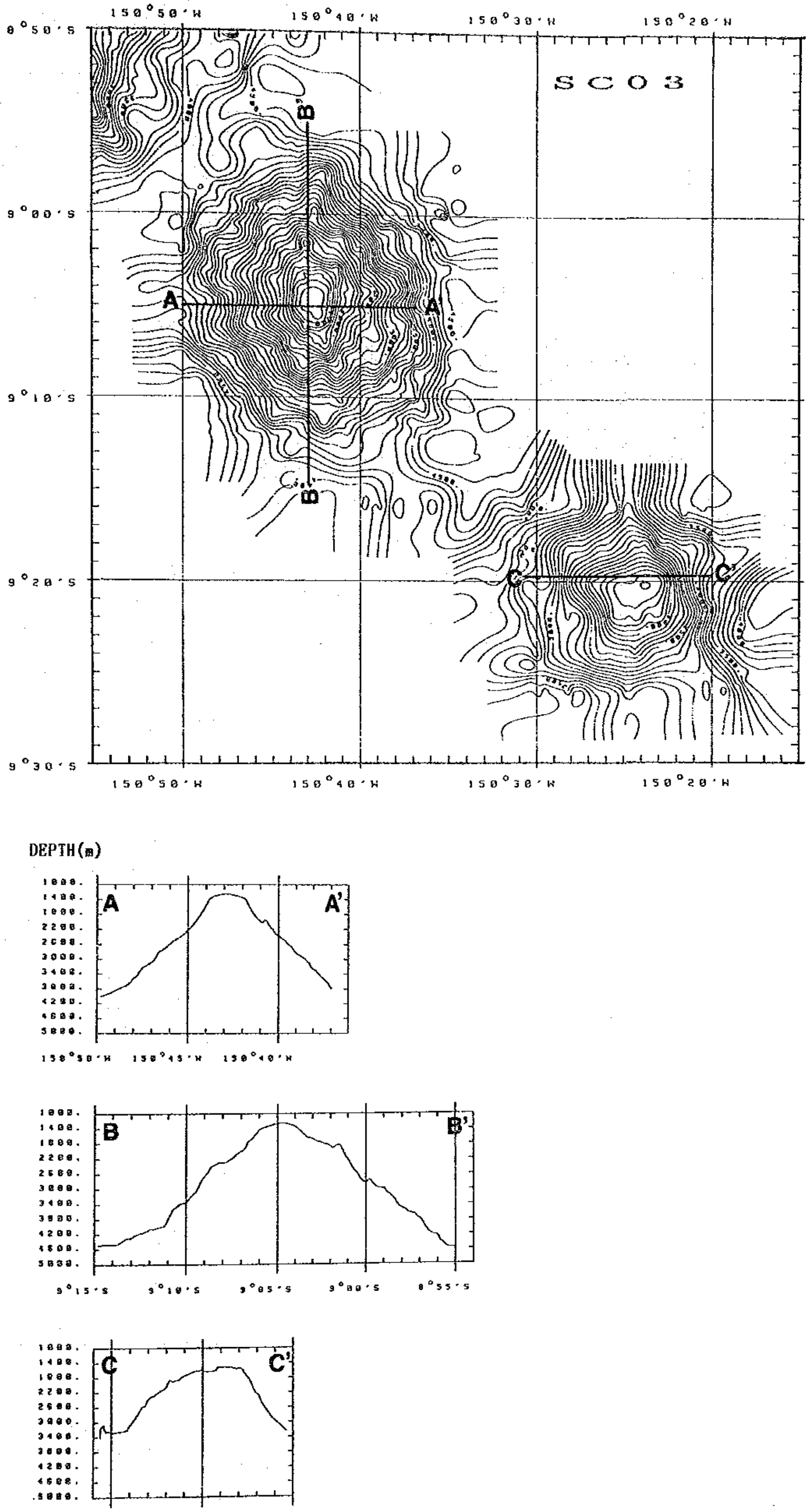
Annexed Figure 19 Trackline Maps of Individual Seamount (3)



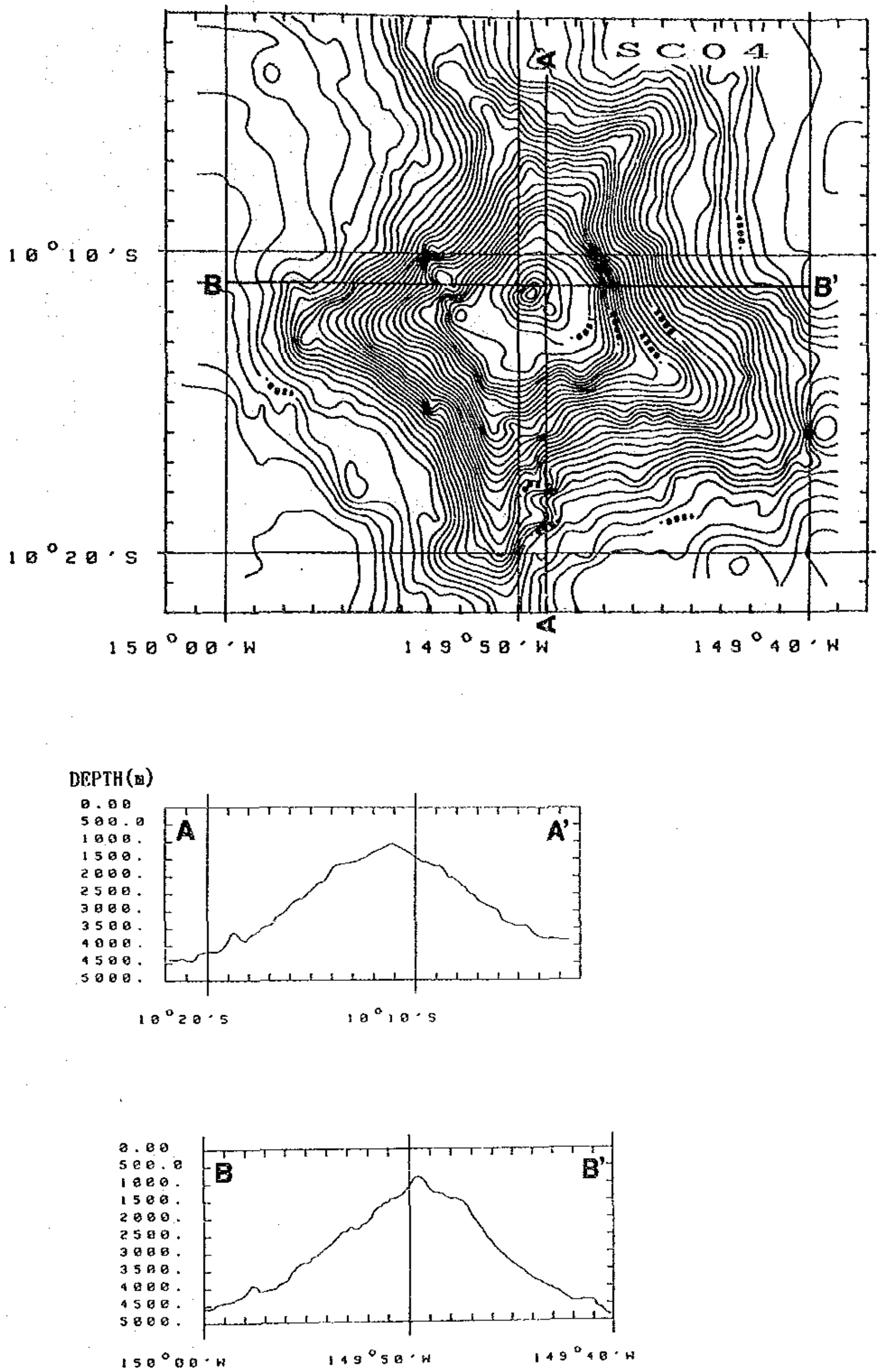
Annexed Figure 20 Topographic Plans and Sections of Individual Seamount (1)



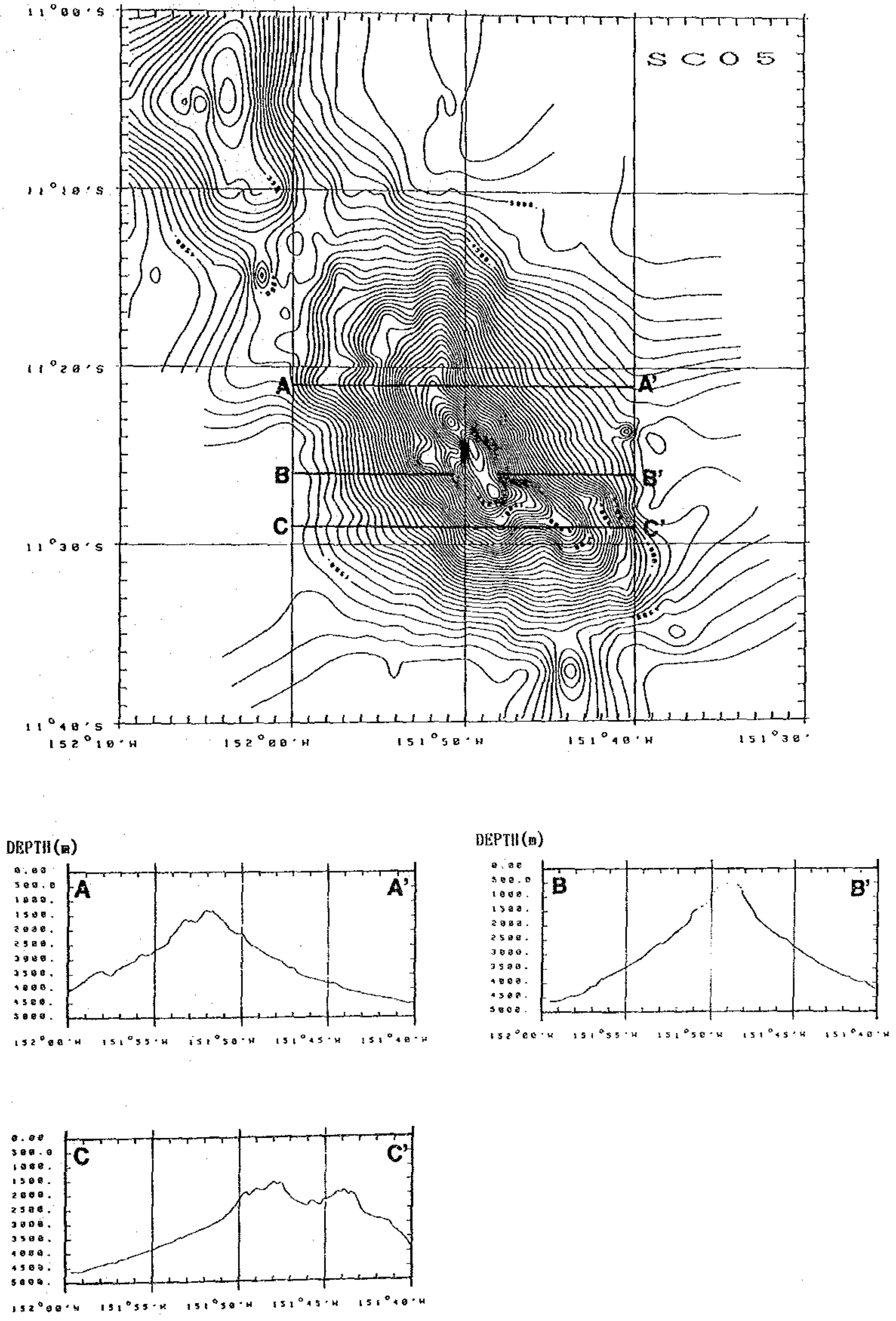
Annexed Figure 20 Topographic Plans and Sections of Individual Seamount (2)



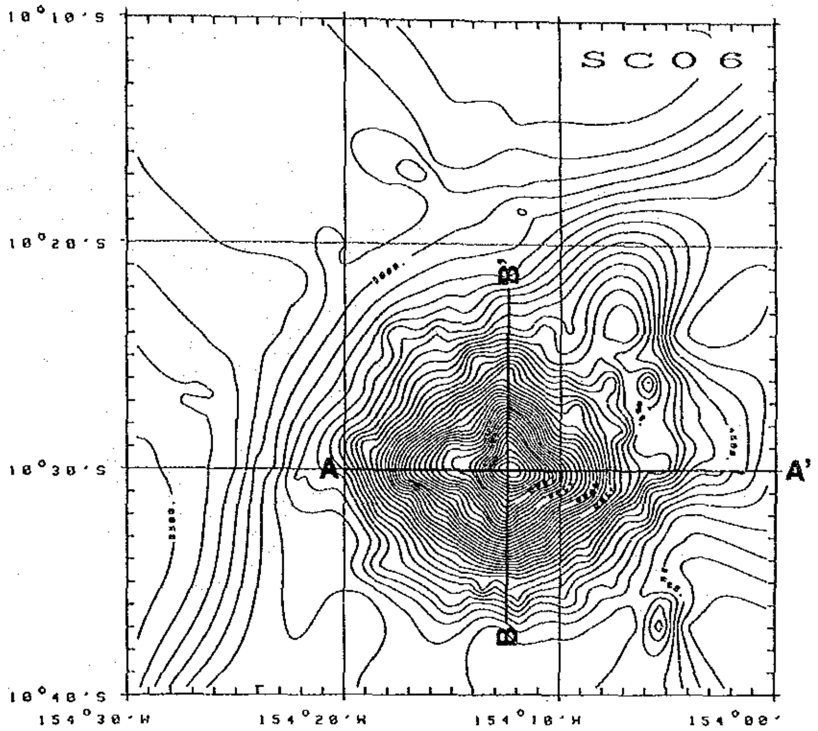
Annexed Figure 20 Topographic Plans and Sections of Individual Seamount (3)

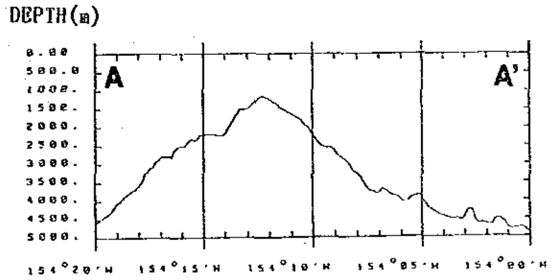


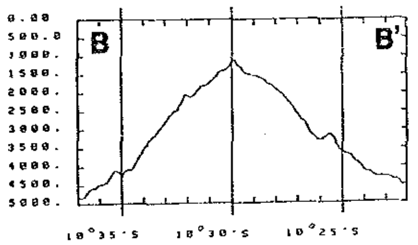
Annexed Figure 20 Topographic Plans and Sections of Individual Seamount (4)



Annexed Figure 20 Topographic Plans and Sections of Individual Seamount (5)

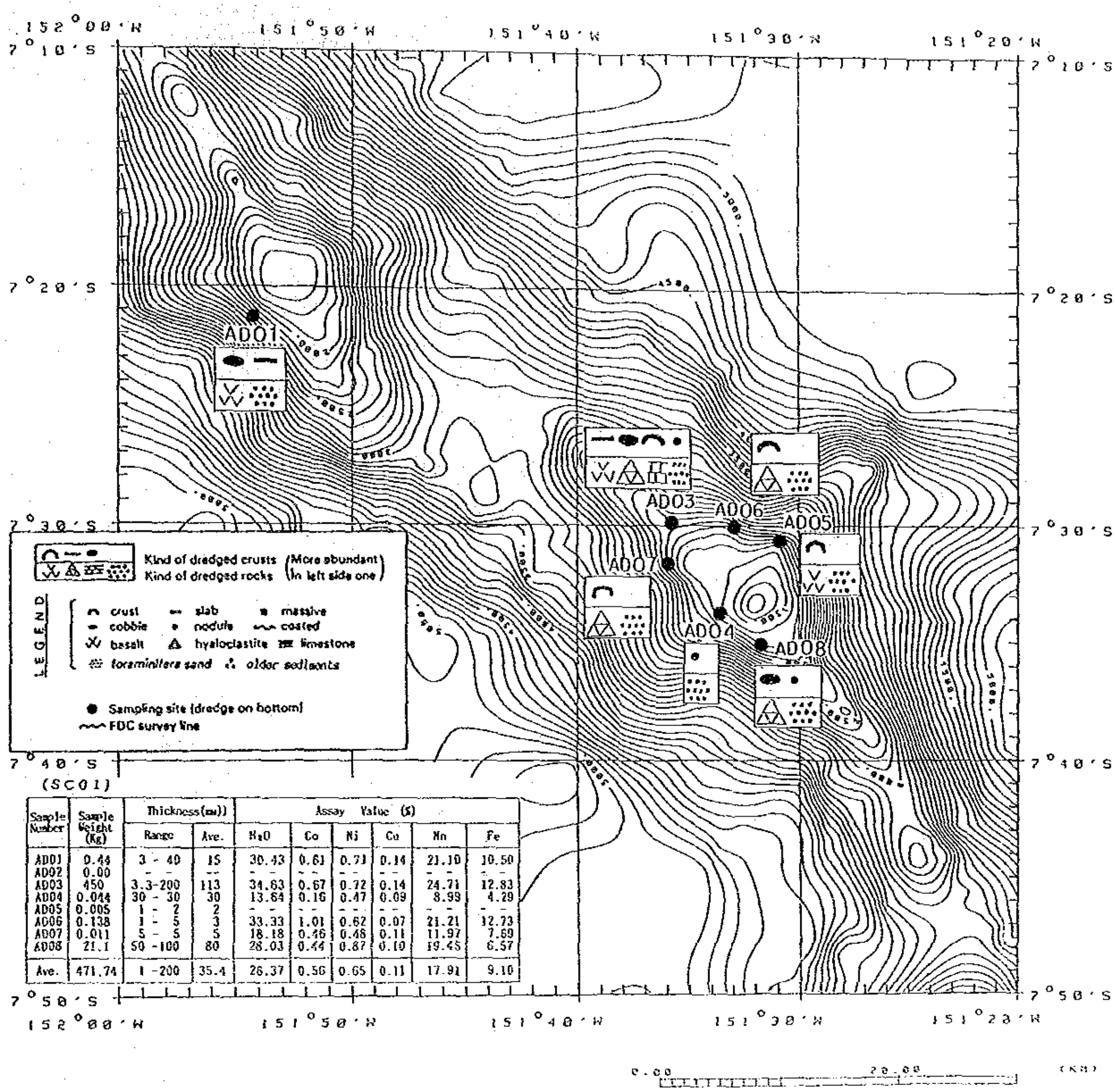






Annexed Figure 20 Topographic Plans and Sections of Individual Seamount (6)

SC01 Seamount

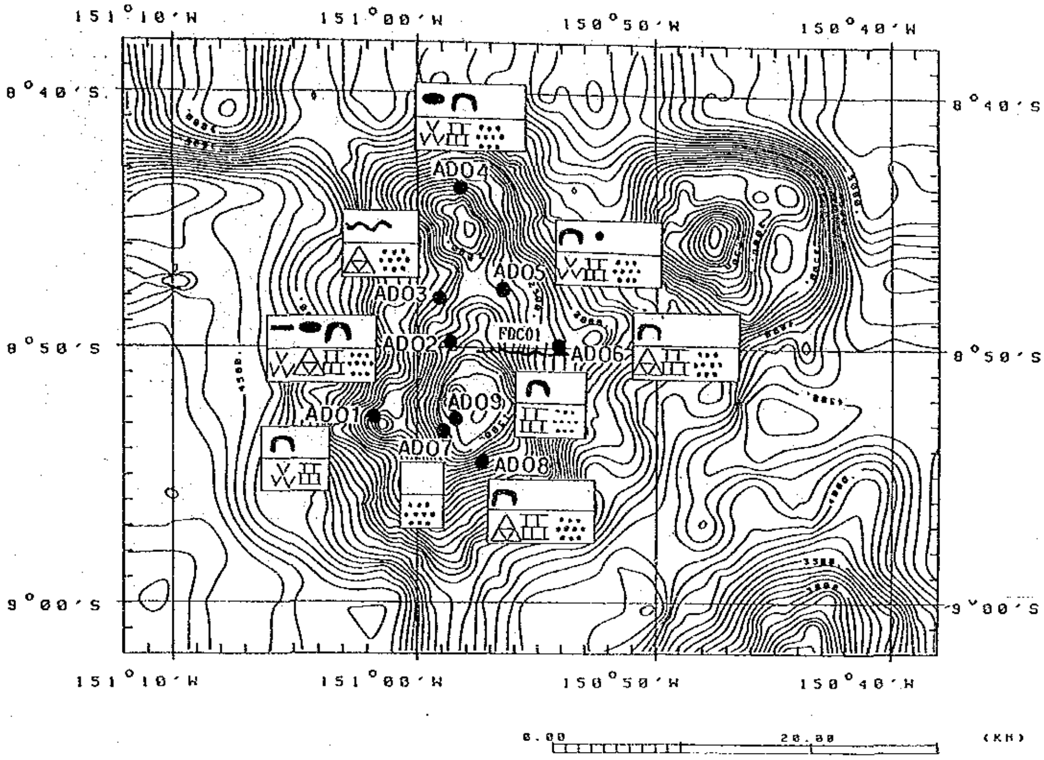


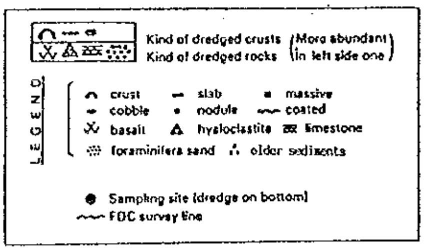
(SC01)

Sample Number	Sample Weight (Kg)	Thickness(mm)		Assay Value (%)					
		Range	Ave.	H_2O	Co	Ni	Cu	Mn	Fe
AD01	0.44	3 - 40	15	30.43	0.61	0.71	0.14	21.10	10.50
AD02	0.00	- -	--	- -	- -	- -	- -	- -	- -
AD03	450	3.3-200	113	34.63	0.67	0.72	0.14	24.71	12.83
AD04	0.044	30 - 30	30	13.64	0.16	0.47	0.09	8.99	4.29
AD05	0.005	1 - 2	2	- -	- -	- -	- -	- -	- -
AD06	0.138	1 - 5	3	33.33	1.01	0.62	0.07	21.21	12.73
AD07	0.011	5 - 5	5	18.18	0.46	0.46	0.11	11.97	7.69
AD08	21.1	50 -100	80	28.03	0.44	0.87	0.10	19.45	6.57
Ave.	471.74	1 -200	35.4	26.37	0.56	0.65	0.11	17.91	9.10

Annexed Figure 21 Geology and Distribution of Cobalt Crusts of Individual Seamount (1)

SC02 Seamount



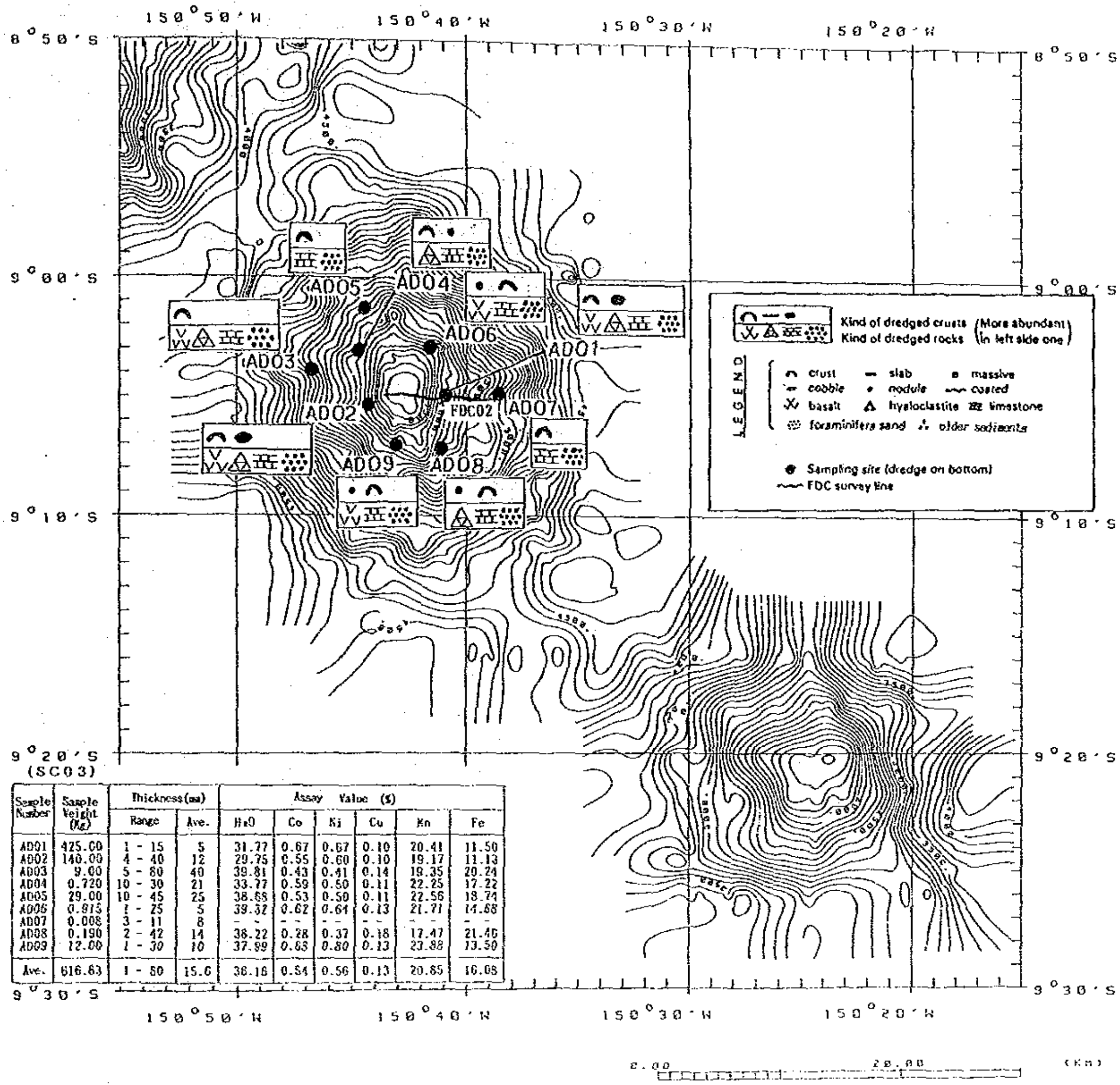


(SC02)

Sample Number	Sample Weight (Kg)	Thickness(mm)		Assay Value (%)					
		Range	Ave.	H_2O	Co	Ni	Cu	Mn	Fe
AD01	3.00	10 - 22	14	33.51	0.70	0.56	0.11	23.35	16.65
AD02	89.00	5 - 80	31	34.04	0.82	0.71	0.11	24.89	13.67
AD03	0.00	- -	--	- -	- -	- -	- -	- -	- -
AD04	47.00	3 - 45	20	34.96	0.65	0.55	0.11	21.83	15.95
AD05	60.00	10 - 40	25	35.74	0.59	0.65	0.11	24.20	15.87
AD06	15.00	5 - 45	32	37.10	0.34	0.43	0.15	19.48	19.55
AD07	0.00	- -	--	- -	- -	- -	- -	- -	- -
AD08	5.43	6 - 85	23	36.50	0.87	0.67	0.11	26.46	14.91
AD09	0.014	5 - 9	7	40.47	1.46	0.89	0.06	31.38	10.16
Ave.	219.44	3 - 85	21.7	36.05	0.78	0.64	0.11	24.51	15.26

Annexed Figure 21 Geology and Distribution of Cobalt Crusts of Individual Seamount (2)

SC03 Seamount

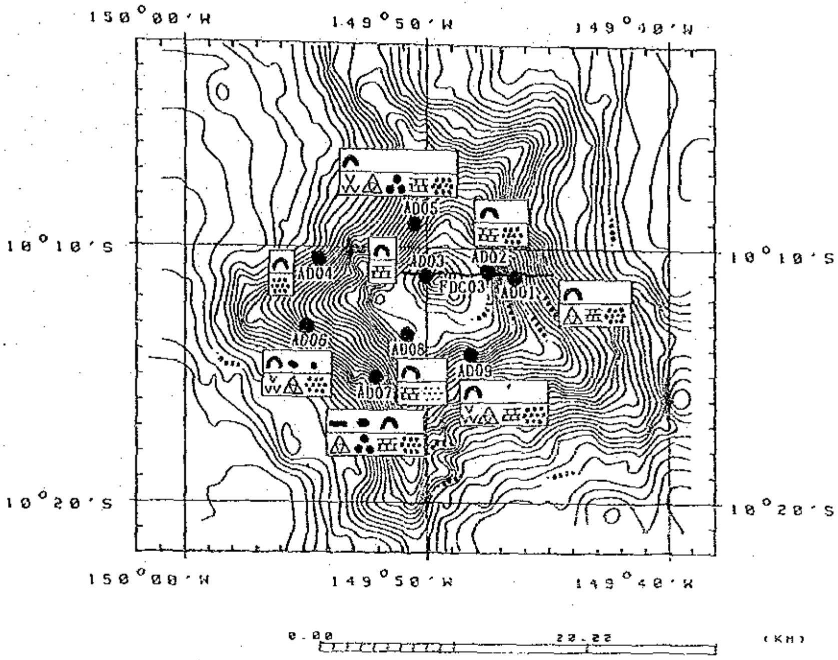


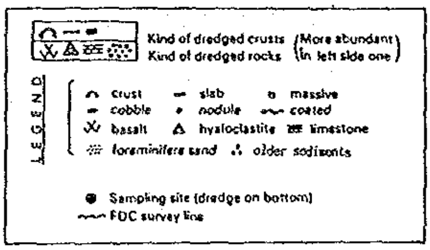
(SC03)

Sample Number	Sample Weight (Kg)	Thickness (mm)		Assay Value (%)					
		Range	Ave.	H_2O	Co	Ni	Cu	Mn	Fe
AD01	425.00	1 - 15	5	31.77	0.67	0.67	0.10	20.41	11.50
AD02	140.00	4 - 40	12	29.75	0.55	0.60	0.10	19.17	11.13
AD03	9.00	5 - 80	40	39.81	0.43	0.41	0.14	19.35	20.24
AD04	0.720	10 - 30	21	33.77	0.59	0.50	0.11	22.25	17.22
AD05	29.00	10 - 45	25	38.65	0.53	0.50	0.11	22.56	18.74
AD06	0.913	1 - 25	5	39.32	0.62	0.64	0.13	21.71	14.68
AD07	0.008	3 - 11	8	- -	- -	- -	- -	- -	- -
AD08	0.190	2 - 42	14	36.22	0.28	0.37	0.18	17.47	21.40
AD09	12.00	1 - 30	10	37.99	0.63	0.80	0.13	23.88	13.50
Ave.	616.83	1 - 80	15.6	36.16	0.54	0.56	0.13	20.85	16.08

Annexed Figure 21 Geology and Distribution of Cobalt Crusts of Individual Seamount (3)

SC04 Seamount



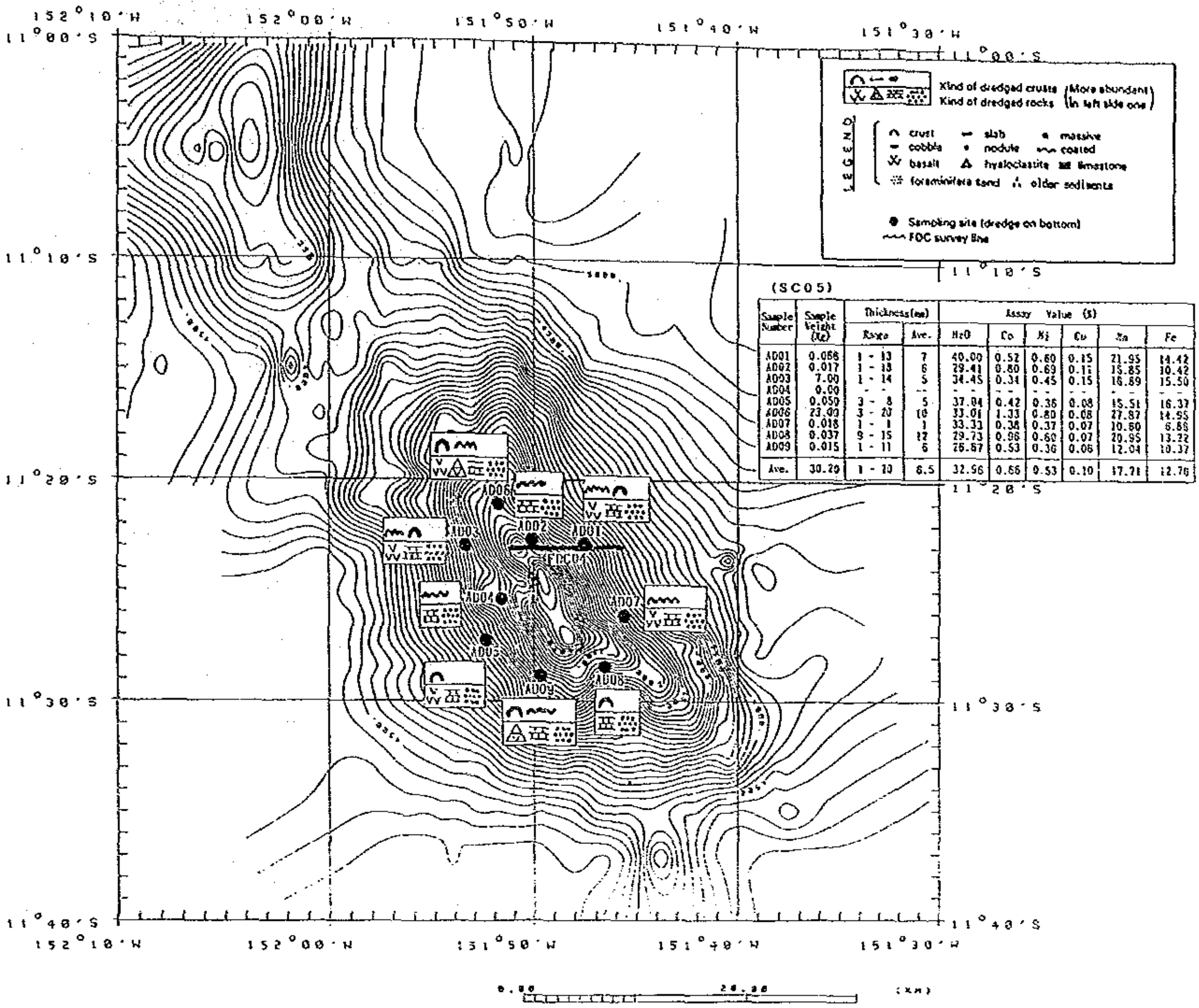


(SC04)

Sample Number	Sample Weight (Kg)	Thickness (mm)		Assay Value (%)					
		Range	Ave.	H_2O	Co	Ni	Cu	Mn	Fe
AD01	22.00	1 - 40	27	35.65	0.32	0.43	0.17	17.76	18.41
AD02	0.044	3 - 5	4	28.36	0.28	0.70	0.14	11.87	6.28
AD03	50.60	0 - 46	17	24.90	0.40	0.57	0.05	16.78	6.19
AD04	0.00	- -	—	- -	- -	- -	- -	- -	- -
AD05	20.00	1 - 85	23	38.77	0.40	0.41	0.12	17.59	15.84
AD06	141.00	1 -130	37	37.20	0.31	0.38	0.17	19.46	20.25
AD07	7.05	1 - 27	10	39.75	0.47	0.41	0.11	20.42	20.57
AD08	0.540	5 - 24	14	37.77	0.61	1.26	0.17	20.83	5.85
AD09	84.00	5 - 35	20	39.21	0.56	0.54	0.11	23.34	18.27
Ave.	325.23	0 -130	19.0	35.20	0.42	0.59	0.13	18.51	14.33

Annexed Figure 21 Geology and Distribution of Cobalt Crusts of Individual Seamount (4)

SC05 Seamount

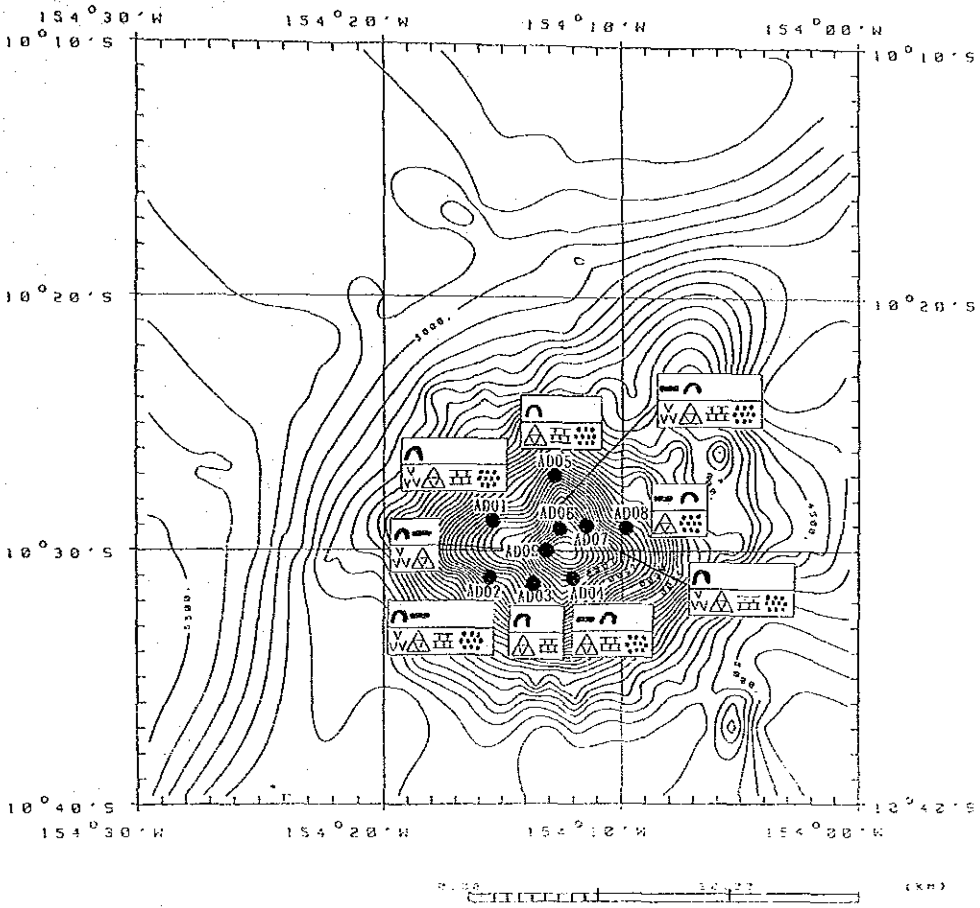


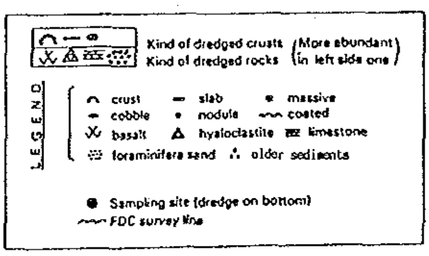
(SC05)

Sample Number	Sample Weight (Kg)	Thickness (mm)		Assay Value (%)					
		Range	Ave.	H2O	Co	Ni	Cu	Mn	Fe
AD01	0.066	1 - 13	7	40.00	0.52	0.60	0.15	21.95	14.42
AD02	0.017	1 - 18	6	29.41	0.80	0.69	0.11	15.85	10.42
AD03	7.00	1 - 14	5	34.45	0.34	0.45	0.15	16.89	15.50
AD04	0.00	- -	--	- -	- -	- -	- -	- -	- -
AD05	0.050	3 - 8	5	37.04	0.42	0.36	0.08	15.51	16.37
AD06	23.00	3 - 20	10	33.01	1.33	0.80	0.08	27.87	14.95
AD07	0.018	1 - 1	1	33.33	0.36	0.37	0.07	10.60	6.66
AD08	0.037	9 - 15	12	29.73	0.96	0.60	0.07	20.95	13.22
AD09	0.015	1 - 11	6	26.67	0.53	0.30	0.06	12.04	10.37
Ave.	30.20	1 - 20	6.5	32.96	0.66	0.53	0.10	17.71	12.76

Annexed Figure 21　Geology and Distribution of Cobalt Crusts of Individual Seamount (5)

SC06 Seamount





(SC06)

Sample Number	Sample Weight (Kg)	Thickness(mm)		Assay Value (%)					
		Range	Ave.	H₂O	Co	Ni	Cu	Mn	Fe
AD01	2.00	1 - 27	15	42.90	0.79	0.50	0.10	23.00	17.96
AD02	9.40	1 - 85	32	42.57	0.54	0.42	0.12	20.82	19.48
AD03	8.00	1 - 30	10	37.51	0.54	0.53	0.11	21.67	17.32
AD04	3.00	3 - 35	17	33.83	0.85	0.61	0.11	25.12	15.10
AD05	0.660	7 - 24	18	43.13	0.65	0.46	0.10	23.11	19.45
AD06	76.00	3 - 35	20	33.44	0.98	0.71	0.11	26.53	15.86
AD07	24.00	2 - 23	13	34.03	0.81	0.65	0.13	23.37	15.09
AD08	17.00	1 - 55	21	34.55	0.42	0.51	0.14	21.88	16.45
AD09	27.00	15 - 45	24	35.89	1.25	1.04	0.07	30.72	8.67
Ave.	167.06	1 - 85	18.9	37.54	0.76	0.60	0.11	24.02	16.40

Annexed Figure 21 Geology and Distribution of Cobalt Crusts of Individual Seamount (6)

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