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XIII. MINOR CHEMICAL COMPOSITION OF DEEP-SEA SEDIMENTS FROM THE GH81-4 AREA IN THE CENTRAL PACIFIC BASIN

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Introduction

The contents of several metal elements and moisture were determined for 76 samples collected from the GH81-4 survey area of the Central Pacific Basin. The elements determined were Mn, Fe, Co, Ni, Zn and Pb. The sample comprises 18 surface sediment samples, 2 outcropped clay stones, and 56 core segment samples, whose maximum depth below the bottom surface attains to about 8 meters. From the result, general distribution of metal contents are described for surficial and core segment samples.

Sample preparation and analytical method

The methods of sample preparation and analysis were the same as those in our preceding work (MITA *et al.*, 1982). The outline of them are as follows.

The samples which contain sea water were dried in air enough. After grinding, the sample was weighed out into the platinum dish and then mixed with nitric acid, hydrofluoric acid and perchloric acid. The dish was heated to dryness. The salts were dissolved with hydrochloric acid and the acidity of HCl was adjusted to 0.3N. Then the contents of Mn, Fe, Co, Ni, Cu, Zn and Pb in the samples were determined by atomic absorption spectrometry. The analytical values were converted to the dry basis comparing with the moisture contents determined at 110° C for another aliquot.

Results and discussions

The dry basis contents of Mn, Fe, Co, Ni, Cu, Zn and Pb in the 76 samples are shown in Table XIII-1. The averages, minimums, maximums and standard deviations for each element in 2 principal type of the sediments are shown in Table XIII-2. The samples analysed are divided into following five groups based on sediment facies or rock name.

(a) siliceous clay (abbreviated as SC)
(b) siliceous ooze (abbreviated as SO)
(c) siliceous ooze contains manganese micronodules (abbreviated as SON)
(d) siliceous-calcareous ooze (abbreviated as SCO)
(e) clay stone (abbreviated as CLS)

The number of samples are 48 for SC, 23 for SO, 2 each for SON and CLS, and one for SCO. So the statistical discussions are only carried out for SC and SO.

On previous cruise, GH80-1, it has been noted that the sediment in the Penrhyn Basin is extraordinary rich in metal elements, such as those mentioned above. Maximum contents were 2.22% for Mn, 8.81% for Fe and 1134 ppm for Cu, for examples (MITA *et al.*, 1982). On the other hand, on the GH80-5 cruise, maximum contents of them were 1.74% (Mn), 5.9% (Fe) and 903 ppm (Cu) (MITA and NAKAO, 1984).

Table XIII-1 Minor chemical composition of bottom sediments in the GH81-4 area (in dry basis).

Anal. No.	Sample No.	Sample type	Mn (%)	Fe (%)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	Pb (ppm)
1	D496 (1)	CLS	.04	3.76	12	50	241	162	19
2	D496 (2)	CLS	.67	2.62	58	523	654	232	15
3	B60 5-10	SO	.58	3.41	58	233	607	191	12
4	B60 15-20	SO	.57	3.57	69	185	431	164	20
5	B63 8-13	SO	.34	3.57	67	204	341	126	24
6	B63 23-28	SCO	.04	3.18	21	85	179	96	32
7	B63 39-44	SC	.44	3.70	67	105	328	95	28
8	B64 10-15	SC	.76	4.23	99	285	453	141	32
9	B64 33-37	SO	.51	3.17	68	237	419	138	10
10	B57	SO	.56	3.84	82	140	359	101	27
11	B58	SC	.29	3.90	84	149	362	103	21
12	B59	SC	.59	3.39	82	174	364	101	26
13	B60	SC	.58	3.43	83	166	368	102	23
14	B61	SC	.56	3.89	81	147	351	107	34
15	B63	SC	.51	3.56	77	189	371	103	13
16	B64	SC	.67	3.85	92	216	430	114	12
17	B65	SC	.70	3.70	90	234	413	105	39
18	B66	SC	.61	3.82	89	177	371	102	3
19	B67	SC	.61	4.25	78	153	356	106	32
20	B68	SC	.58	3.81	82	147	354	110	32
21	P218 41- 46	SON	30.68	1.53	37	1.44%	668	222	1
22	P218 72- 77	SON	5.35	3.07	118	793	847	89	0
23	P218 127-132	SO	.86	3.21	85	272	430	156	28
24	P218 172-177	SO	.66	3.02	60	258	379	111	7
25	P218 227-232	SO	.93	2.82	80	316	364	82	0
26	P218 277-282	SO	.65	2.70	65	228	301	69	0
27	P218 327-332	SO	.35	2.48	40	162	242	63	0
28	P218 377-382	SO	.60	2.32	41	266	253	57	29
29	P218 427-432	SO	.79	2.60	49	283	265	68	17
30	P218 447-482	SO	.84	2.39	45	326	257	62	18
31	P218 527-532	SO	1.80	2.49	46	701	369	69	48
32	P224 5- 10	SC	.63	4.33	85	150	342	128	50
33	P224 45- 50	SC	.64	4.38	83	153	365	113	36
34	P224 95-100	SC	.63	4.42	83	138	378	111	34
35	P224 145-150	SC	.65	4.35	85	178	364	118	27
36	P224 178-183	SC	.57	3.80	65	204	373	117	32
37	P224 228-233	SO	.26	1.84	19	85	255	70	22
38	P224 294-299	SO	.23	1.64	14	49	208	56	11
39	P224 344-349	SO	.23	1.63	16	55	191	45	20
40	P224 384-389	SO	.17	1.32	14	51	144	31	15

Table XIII-1 (continued)

Anal. No.	Sample No.		Sample type	Mn (%)	Fe (%)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	Pb (ppm)
41	P224	439-444	SO	.18	1.20	14	96	126	25	16
42	P224	589-594	SO	.31	2.22	30	115	279	70	32
43	P224	639-644	SO	.31	2.04	27	102	225	57	23
44	P224	694-699	SO	.34	2.28	29	135	228	58	8
45	P224	744-749	SO	.33	2.16	27	116	252	63	22
46	P226	9- 14	SC	.52	4.51	78	108	302	75	19
47	P226	29- 34	SC	.57	4.45	79	145	343	81	38
48	P226	76- 81	SC	.69	4.52	86	155	330	77	27
49	P226	126-131	SC	.69	4.43	87	179	332	83	29
50	P226	176-181	SC	.68	4.37	79	164	369	85	30
51	P226	226-231	SC	.61	4.56	82	144	350	76	38
52	P226	276-281	SC	.70	4.53	85	140	326	83	50
53	P226	326-331	SC	.68	4.51	87	163	374	83	40
54	P226	376-381	SC	.69	4.44	87	160	341	82	38
55	P226	426-431	SC	.66	4.27	81	153	339	82	31
56	P226	476-481	SC	.74	4.31	86	175	332	75	26
57	P226	536-531	SC	.72	4.29	81	182	333	81	29
58	P226	606-611	SC	.97	4.53	91	276	353	76	28
59	P226	626-631	SC	.66	4.41	89	173	318	72	35
60	P226	675-680	SC	.74	4.58	95	170	372	77	39
61	P226	725-730	SC	.83	4.91	108	201	392	86	34
62	P228	8- 13	SC	.74	4.29	83	188	331	79	29
63	P228	66- 71	SC	.65	4.51	92	152	380	79	36
64	P228	126-131	SC	.70	4.54	93	183	369	70	41
65	P228	175-180	SC	.57	4.38	93	156	316	72	41
66	P228	225-230	SC	.72	4.51	86	195	316	71	34
67	P228	275-280	SC	.79	4.38	88	217	331	81	30
68	P228	325-330	SC	.75	4.54	91	196	347	80	25
69	P228	372-377	SC	.80	4.81	105	179	383	94	31
70	P228	422-427	SC	.77	4.82	102	177	400	84	35
71	P228	472-477	SC	.93	4.94	113	299	434	98	35
72	P228	522-527	SC	.78	4.52	97	228	361	99	19
73	P228	572-577	SC	.69	4.08	84	181	370	84	33
74	P228	622-627	SC	.65	3.83	79	141	351	73	32
75	P228	672-673	SC	.50	3.82	85	87	325	70	48
76	P228	722-727	SC	.96	3.73	84	256	433	82	23

Table XIII-2 Averages, minimums, maximums, and standard deviations of the metal contents in 2 principal sediment facies.

(a) ***Siliceous ooze*** (n=23)

	Mn(%)	Fe(%)	Co(ppm)	Ni(ppm)	Cu(ppm)	Zn(ppm)	Pb(ppm)
Ave	0.54	2.46	44	203	298	83	17
Min	0.17	1.20	14	49	126	25	0
Max	1.80	3.57	85	701	607	191	48
SD	0.36	0.67	22	139	108	43	11

(b) ***Siliceous clay*** (n=48)

	Mn(%)	Fe(%)	Co(ppm)	Ni(ppm)	Cu(ppm)	Zn(ppm)	Pb(ppm)
Ave	0.67	4.25	87	177	360	91	31
Min	0.29	3.39	65	87	302	70	3
Max	0.97	4.94	113	299	453	141	50
SD	0.12	0.38	9	42	37	17	9

On this cruise, furthermore, maximum content of them are 1.80% for Mn, 4.94% for Fe, 607 ppm for Cu in SO and SC. On the other hand, in SON, one sample which is from so-called micro nodule layer contains 30.68% for Mn, 1.44% for Ni and 668 ppm for Cu.

Vertical distribution of the metallic elements

Vertical distributions of the elements in four sediment cores are shown in Fig. XIII-1. In the core P218, especially, the vertical distribution of Mn content is very similar with that of Ni. Around 40 cm and 60 cm deep, near the top of the core (siliceous ooze), very high concentration of them are observed. It is considered as described above, that these high values are reflected the existing of the manganese micronodules. Pb shows abrupt vertical changes compared to others.

In the core P224, abrupt decreasing or increasing of the contents is observed for all 7 elements, around the 2 portions, near 170 cm and 440 cm deep. All elements show the similar tendency of the distribution in this core. The core P224 consists of the following three layers, based on the concentration of the elements.

(a) Upper layer (ca. 0–170 cm deep, SC)
(b) Middle layer (ca. 170–440 cm deep, SO)
(c) Lower layer (ca. 440 cm deep to the bottom, SO)

In general, the highest value appears in the layer(a). On the other hand, the lowest value appears in the layer(b) and the medium one does in the layer(c). However, only Pb in the layer(c) shows thoroughly different distribution pattern from others. The deeper in the layer(c), the lower the Pb concentration gradually, while the cencentrations of other elements in this layer are rather constant. The contents of every element are depleted in the lower part (SO) compared to these in the upper part (SC) of this core. It shows that siliceous organic remaines have a diluting effect for the metal elements.

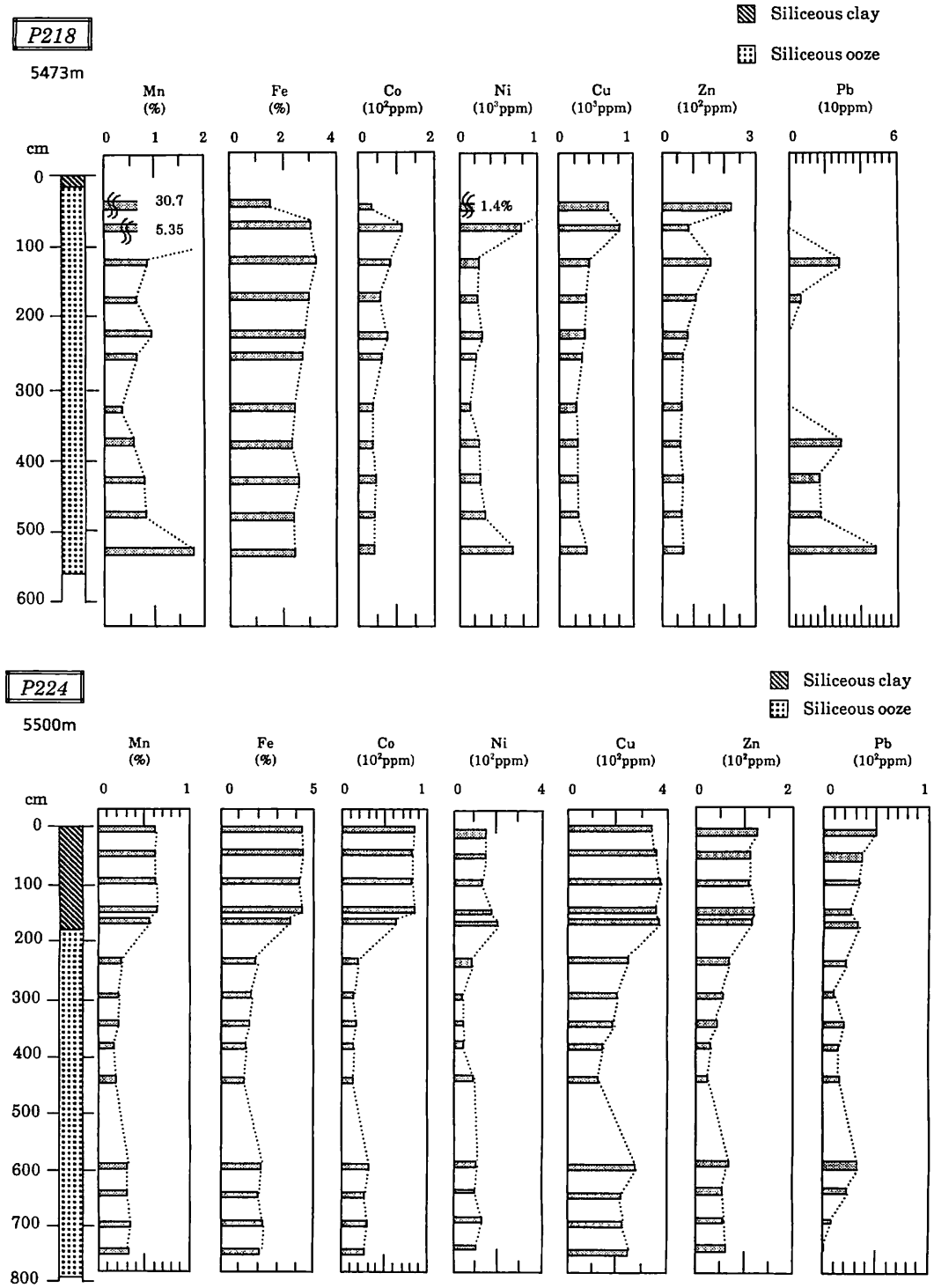

Fig. XIII-1(1)

Fig. XIII-1 Vertical distribution of metal contents in the cores.

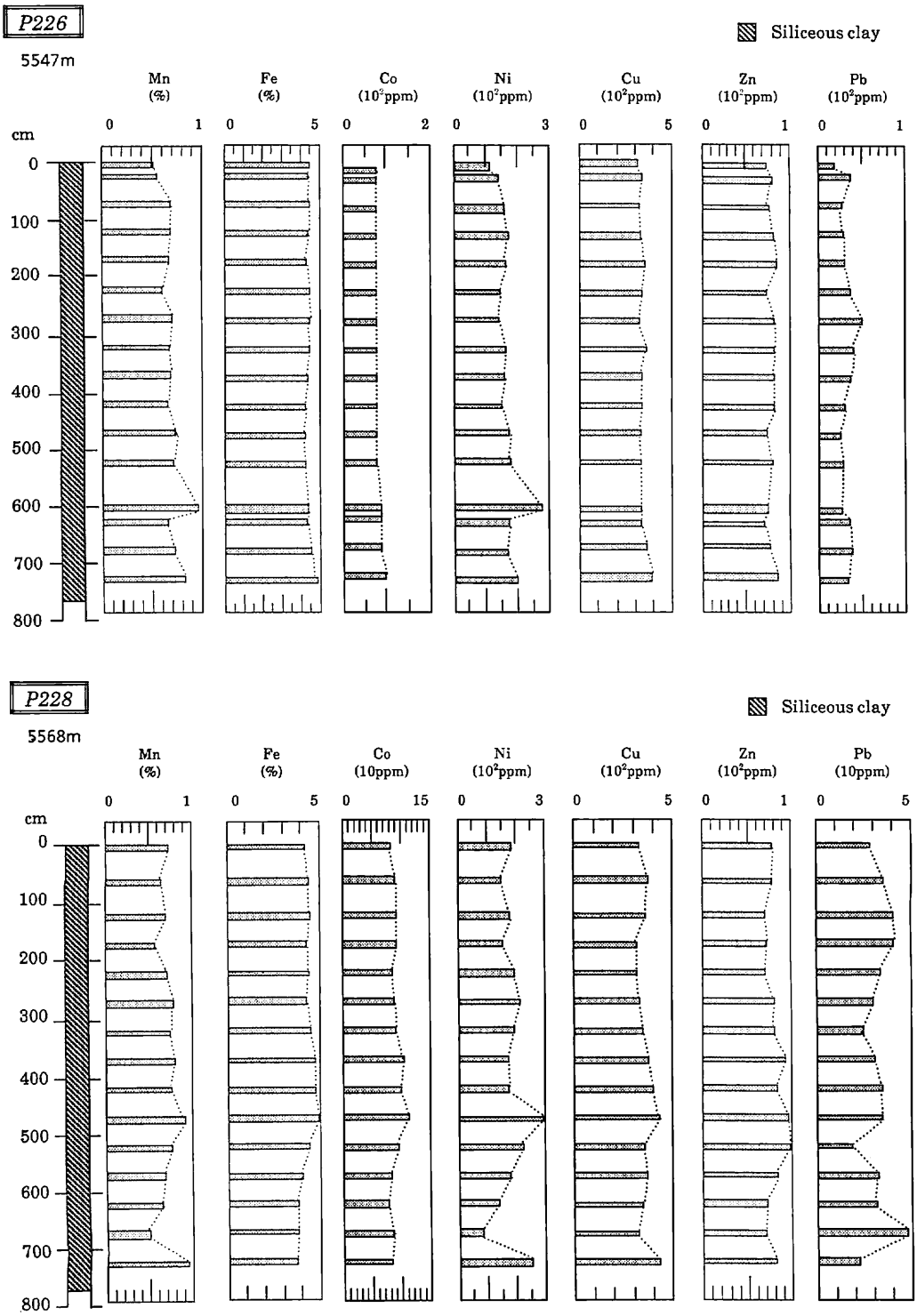
P226
5547m
Siliceous clay
Mn (%)
Fe (%)
Co (10^2ppm)
Ni (10^2ppm)
Cu (10^2ppm)
Zn (10^2ppm)
Pb (10^2ppm)
cm
0
100
200
300
400
500
600
700
800
P228
5568m
Siliceous clay
Mn (%)
Fe (%)
Co (10ppm)
Ni (10^2ppm)
Cu (10^2ppm)
Zn (10^2ppm)
Pb (10ppm)

Fig. XIII-1(2)

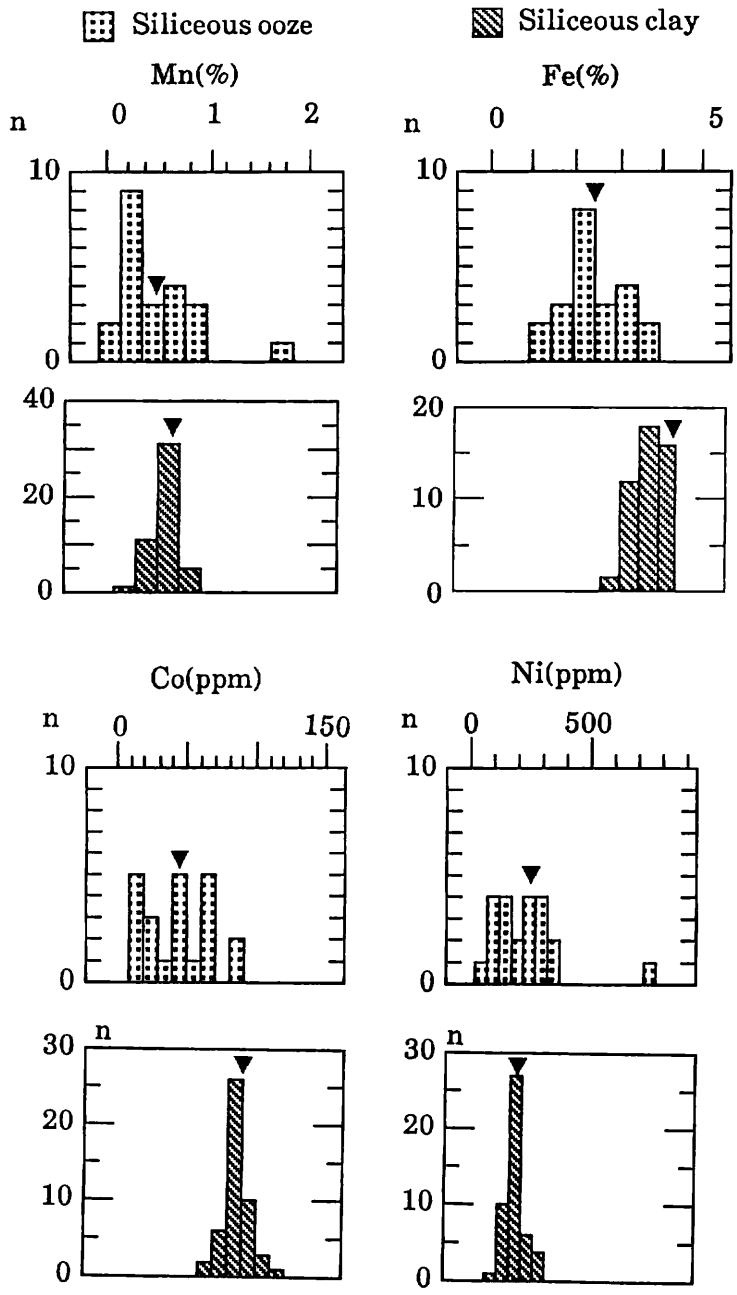

Fig. XIII-2(1)

Fig. XIII-2 Histograms of the concentration of metal contents in each sediment facies.

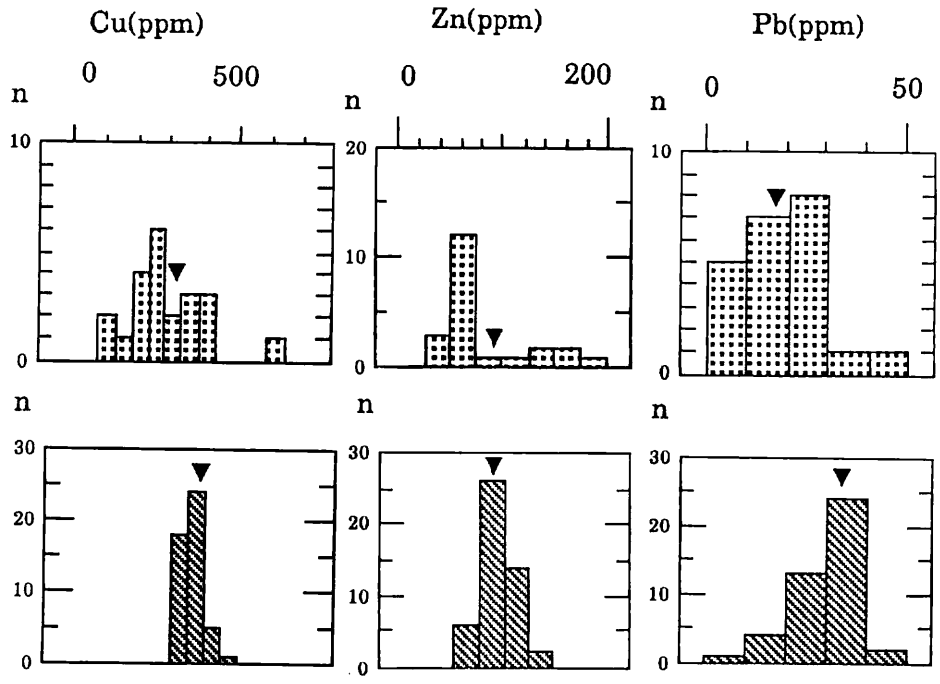

Fig. XIII-2(2)

In the core P226, all parts consist of siliceous clay. It is observed that the distribution patterns of Mn and Ni are almost same. The concentrations of them at the depth of about 35 cm in this core are the lowest. On the other hand, the highest values are observed at the depth of about 600 cm. For Fe, Co, Cu and Zn, each element shows little vertical variation. For Pb, the lowest concentration is observed at the depth of about 15 cm in this core, and the highest one about 380 cm. This distribution pattern is rather different comparing with those of other elements. The concentrations of each element in this core are little variable and these are near the same in siliceous clay part of the core P224.

In the core P228, it is analogous to the case of the core P226. The concentrations of each element show rather little variations and near the same with those in the core P226. Particularly, a similar tendency of the vertical distribution is seen among Mn and Ni. Their highest concentrations appear at the depth of 480 cm and 730 cm and the lowest ones at 670 cm in this core. Fe and Co also show mutually analogous distribution. On the other hand, vertical distribution of Pb is very different from those of others. The highest concentration of Pb is seen at the depth where Mn and Ni contents are the lowest.

From the facts mentioned above, it is summarized that the vertical variations of each element content are rather little in siliceous clay, but great in siliceous ooze. Dilution of the metal contents by siliceous organic remains which has been already clarified in previous cruise reports (MITA *et al.*, 1982; MITA and NAKAO, 1984), are confirmed through this study.

Table XIII-3 Coefficient of correlations among the metal contents in 2 sediment facies.

(b) *Siliceous clay* (n=48)

Mn						
.49	Fe					
.60	.59	Co				
.73	.13	.52	Ni			
.39	-.07	.46	.64	Cu		
.19	-.33	-.06	.23	.51	Zn	
.07	.35	-.09	-.23	-.16	-.18	Pb

(a) *Siliceous ooze* (n=23)

Mn						
.41	Fe					
.53	.90	Co				
.98	.44	.53	Ni			
.46	.87	.78	.46	Cu		
.23	.88	.75	.23	.93	Zn	
.34	-.06	-.14	.34	.02	-.01	Pb

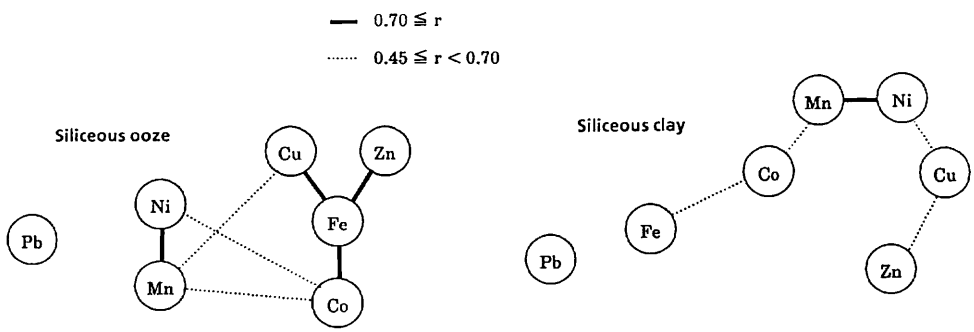

Fig. XIII-3 The strength patterns of the correlations among the elements in the bottom sediments.

Sediment facies and concentrations of the elements

Figure XIII-2 shows histograms of the elements for each 2 major sediment types, i.e. siliceous clay and siliceous ooze. The elements, Mn, Fe, Co, Cu, Zn and Pb, have a common tendency, namely average concentrations of those in siliceous clay are higher than those in siliceous ooze. In the case of Ni, average content for siliceous ooze is rather high than that for siliceous clay. Even after rejecting the highest value for Ni in siliceous ooze (around 530 cm, P218), they are almost same. At this portion Mn content is higher than those in other portions just like Ni, suggesting the mere coexsistance of them in the manganese micronodules.

Taking a general view of the concentration of each element in the sediment facies, systematic distributions of them are observed in siliceous clay. However, it is observed remarkably that each metal except Pb show rather irregular or polymodal feature in siliceous ooze. Considering the dilution effect mentioned above, it is assumed that these irregular feature in siliceous ooze are caused by various amounts of the skeletons of siliceous planktons.

Correlation among the elements

Coefficients of correlations among the elements in the two sediment facies are shown in Table XIII-3. The strength patterns of the correlations are shown Fig. XIII-3.

1) Correlations in siliceous ooze

The metal elements are classified into the following three groups based on the coefficients of the correlation among them.

Group A (Fe, Co, Cu, and Zn): strong correlationships are observed among these four element in each other.

Group B (Mn and Ni): a strong correlationships is observed between Mn and Ni.

Group C (Pb) is considerably independent against other six elements. This tendency is apparently different from that of previous cruise, GH80-1 (MITA *et al.*, 1982) on which the strong correlationships ($r \geqq 0.70$) have been observed between Pb and Mn, Fe, Co in all samples. Furthermore, strong correlationship has been observed between Pb and Zn in siliceous fossil rich clay facies on another cruise, GH80-5 (MITA and NAKAO, 1984).

In addition to the three groups mentioned above, it is pointed out that medium correlationships ($0.45 \leqq r < 0.70$) are observed between Mn and Co or Cu, and that medium correlationships are observed between Ni and Co.

2) Correlations in siliceous clay

Vivid classification like as mentioned above in siliceous ooze can not be observed in this sediment facies. The tendency of correlations are as follows.

(a) A strong correlationship is observed between Mn and Ni.
(b) Medium correlationships are observed between Co and Mn or Fe.
(c) Medium correlationships are observed between Cu and Ni or Zn.
(d) Tendency of Pb is the same with that of siliceous ooze.

References

MITA, N., NAKAO, S. and KATO, K. (1982) Minor chemical composition of bottom sediments from the Central Pacific Wake-Tahiti Transect. *Geol. Surv. Japan Cruise Rept.*, no. 18, p. 313-338.

MITA, N. and NAKAO, S. (1984) Minor chemical composition of deep-sea sediments from the GH80-5 area in the Central Pacific Basin. *Geol. Surv. Japan Cruise Rept.*, no. 20, p. 215-226.