

## Major Chemical Compositions of Pelagic Sediments From the Central Pacific Basin

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### Abstract

Samples from the Central Pacific Basin have been investigated to delineate their geochemical characteristics.

Bulk chemical analyses indicate that the sediments in this area have similar concentration in major elements as has been reported for other pelagic areas in the Pacific Ocean except active-ridge regions.

The  $Al/(4Al + Fe + Mn + Ti)$  ratios suggest that the both authigenic fractions and detrital input have been, on an average, relatively constant in this basin since the Miocene, indicating fairly uniform sedimentary environment.

### 1. Introduction

To delineate the geochemical characteristics and origin of manganese nodules in the marine environment it is essential to have a better knowledge of major and minor compositions in the associated sediments on the ocean floor. Though numerous papers as to chemical compositions of normal pelagic or metalliferous sediments were published (GOLDBERG and ARRHENIUS, 1958; EL WAKEEL and RILEY, 1961; TUREKIAN, 1965; TUREKIAN and IMBRIE, 1966; BOSTROM and PETERSÖN, 1969; BOSTRÖM *et al.*, 1969; CHESTER and HUGHES, 1969; CRONAN and TOOMS, 1969; CHESTER and MESSIHA-HANNA, 1970; CRONAN *et al.*, 1972), available data on a relationship between chemical compositions contained in sediments and associated manganese nodules are not abundant (CRONAN and TOOMS, 1969; CHESTER *et al.*, 1973). Hence, it was thought worthwhile to study systematically the distribution of major and minor elements in pelagic sediments in which a number of manganese nodules were distributed at the sediments-seawater interface.

The purpose of this study was to determine the regional variations in the major element contents of pelagic sediments in order to understand the geochemical depositional environment of manganese nodules in the Central Pacific Ocean. The trace element partition and its geochemical behavior between in sediments and in manganese nodules on the Central Pacific Ocean are discussed in detail elsewhere (NOHARA and YOKOTA, 1978).

### 2. Characteristics and Distribution of Sediments

Samples used for this study were recovered during GH74-5 and GH76-1 Cruises, Geological Survey of Japan. Sampling locations and sediment distributions are given in Table 1 and Fig. 1. The descriptions of the samples are taken from ARITA (1975, 1977).

Based on results of compositional analyses, the sediments of this area can be classified into following types, 1) calcareous ooze, 2) siliceous ooze, 3) calcareous-siliceous clay, 4) siliceous clay and 5) deep-sea clay. Fig. 1 shows the horizontal distribution of surface sedimentary facies-types. Calcareous ooze is distributed on and near the seamounts and guyots situated in the northern parts of the surveyed area. The calcareous ooze consists of numerous remains of planktonic foraminifera represented by

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Table 1 Sample Locations and Sediment-types in the Central Pacific Basin.

St. No.	Sample No.	Position		Depth (m)	Sediment-type
		Latitude (N)	Longitude (W)		
117	G40	06°01.7'	166°55.7'	4950	calcareous/siliceous clay
121	G42	08°10.5'	170°27.4'	5450	siliceous ooze
126	G44	09°30.3'	167°03.5'	5010	calcareous/siliceous clay
129	G54	10°00.1'	167°37.0'	5259	siliceous ooze
131	G47	08°52.5'	167°23.0'	5228	siliceous clay
132	G48	07°00.1'	167°49.3'	5164	calcareous/siliceous clay
133	G49	07°16.9'	168°07.3'	5277	siliceous ooze
136	G51	08°29.4'	170°25.5'	5338	siliceous ooze
143	G53	10°00.0'	168°42.1'	5152	calcareous/siliceous clay
144	G54	10°00.3'	168°11.1'	5300	calcareous/siliceous clay
145	G55	09°55.8'	170°40.3'	4930	calcareous/siliceous clay
408	G172	10°00.7'	173°59.7'	5790	deep-sea clay
409	G173	10°00.0'	173°01.3'	5770	deep-sea clay
411	G175	07°58.2'	172°59.8'	5830	deep-sea clay
417	G181	07°01.4'	171°59.7'	5620	deep-sea clay
418	G182	07°59.6'	172°00.3'	5560	siliceous clay
419	G419	09°00.7'	172°00.6'	5480	deep-sea clay
423	G187	07°59.1'	170°59.9'	5420	siliceous clay
426	G190	06°00.2'	169°59.6'	5400	siliceous clay
430	G195	09°59.6'	173°29.9'	5800	deep-sea clay
431	G196	09°28.8'	173°29.9'	5830	deep-sea clay

white coarse-grained foraminiferal sand.

The distribution of siliceous ooze is restricted along the boundary between calcareous-siliceous clay and siliceous clay with small range. The residues (<250 mesh) contain the transparent siliceous organisms or brownish colored-radiolaria. Calcareous-siliceous clays are found in east-northern parts of the surveyed area which are a transitional zone from calcareous ooze to siliceous ooze. The sediments contain the residues, which consist of mixtures of planktonic foraminifera and radiolaria.

Siliceous clay is widely distributed, particularly, in a range from the central to south area. The sediments have the residues up to 20% of fresh radiolaria (Quaternary). Deep-sea clay is distributed in the north-western part of the area with a wedge extending to the southeast. The residues on the 250 mesh sieve consist of the mixtures of fresh radiolarias, brownish stained or silicified radiolarias and shark's scale which may correspond to the Miocene. The Quaternary sediments contain varying amounts of calcareous and siliceous materials and have an assemblage of authigenic clay minerals and non-clay minerals (quartz, feldspar). Irrespective of their mineralogy, the sediments of uppermost (0-20 cm) are dominantly pale brownish to dark brown with small yellowish spots. Detailed information on both the relevant surface sediment samples and cores obtained from the area, can be found in the pertinent cruise reports (ARITA, 1975; 1977).

### 3. Results and Discussion

The bulk chemical analyses of 21 samples are presented on an untreated basis in Table 2. Sediment

samples were obtained from a limited area in the Central Pacific Basin in order to try to detect element distribution in relation to the sediment-types. As can be seen in Table 2, the  $\text{SiO}_2$  contents of sediments are fairly similar except in calcareous-siliceous clay.  $\text{SiO}_2$  contents in calcareous-siliceous clay vary from 30.6% to 43.9%. This variation appears to be related to a proportion of the calcareous fractions. It is suggested from its bulk chemical compositions that deep-sea clay and siliceous clay sediments are essentially composed of the same materials, although they might have been deposited during geologically different ages (ARITA and KINOSHITA, 1976; ARITA, 1977).

The average  $\text{TiO}_2$  contents of siliceous clay and siliceous ooze are 0.46% and 0.48%, respectively (Table 3). Deep-sea clay has slightly greater  $\text{TiO}_2$  contents (0.53%) than those in both siliceous clay and siliceous ooze sediments. The calcareous-siliceous clay gives a bit smaller average (0.41%) which results from the diluting effects as well as Si-contents. CORRENS (1954), GOLDBERG and ARRHENIUS (1958) and ARRHENIUS (1963) have found that euhedral anatase and rutile account for much of the Ti occurring in pelagic sediments of non-volcanic origin.

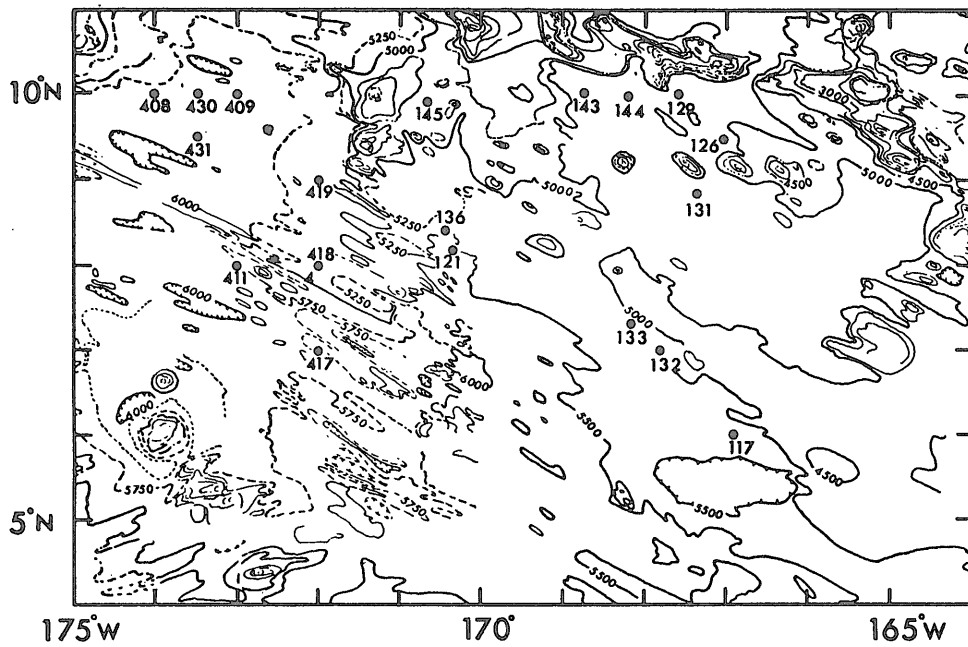
Al contents of calcareous-siliceous sediments vary considerably from 6.2% to 13% with an average of 9.55% as  $\text{Al}_2\text{O}_3$ . On the other hand, Al contents of both siliceous ooze and deep-sea sediments show a variation fairly similar to those of Si and Ti in both sediments. The sediments from the surveyed area contain on average lower  $\text{Al}_2\text{O}_3$  than those of the Atlantic, about 18%, which is attributable to terrigenous matters (EL WAKEEL and RILEY, 1961). Al contents vary linearly with Fe contents throughout the basin except in calcareous ooze (Fig. 2). Possibly this correlation is due to the presence of illite (with some substitution of Al by  $\text{Fe}^{3+}$ ) and montmorillonite (ARITA, 1975), as suggested by HIRST (1962).

With the exception of the highly calcareous ooze and some of calcareous-siliceous clay, the Fe contents of the pelagic sediments, calculated as  $\text{Fe}_2\text{O}_3$ , are surprisingly uniform. This is particularly true of siliceous ooze sediments, which contain an average concentration of 5.4% total  $\text{Fe}_2\text{O}_3$ . The mean Fe content of the sediments from this area is somewhat lower than the results for Pacific sediments (about 8.8% as total  $\text{Fe}_2\text{O}_3$ ) by EL WAKEEL and RILEY (1961). A ferrous ion is present in all the sediments examined, usually less than 0.3% FeO, but it is present in slightly larger concentrations in calcareous-siliceous clay and siliceous ooze.

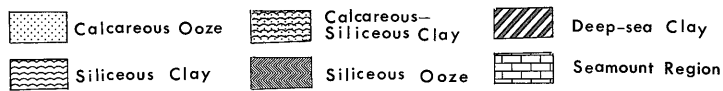
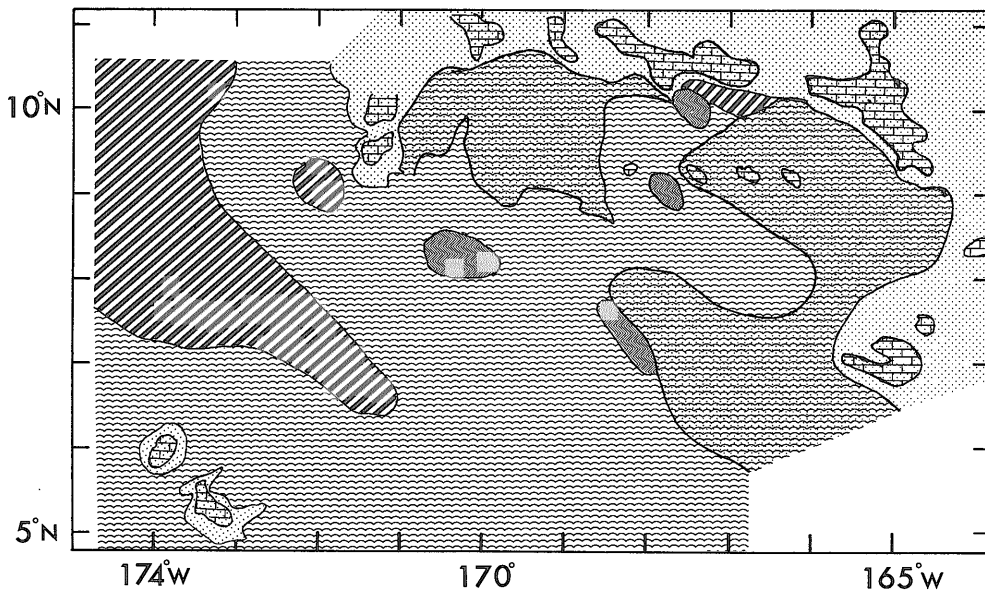
A linear relationship exists between the  $\text{TiO}_2$  contents of the sediments and total Fe contents as  $\text{Fe}_2\text{O}_3$  (Fig. 3), expressed as  $\text{TiO}_2 = -0.01 + 0.09\text{Fe}_2\text{O}_3$ . This relationship seems to hold regardless of the type of sediment in the ocean from which it originated. Similar correlations have been previously observed by REVELLE (1944) and EL WAKEEL and RILEY (1961) for deep-sea sediments.

Although the average Mn contents of all sediment-types are similar (siliceous ooze and calcareous-siliceous clay: 0.58%, siliceous clay: 0.68%, deep-sea clay: 0.67%, respectively), the Mn contents of the individual sample are remarkably variable, ranging from 0.25% to 1.14%  $\text{MnO}_2$ . This variation, which is much greater than that of any of the other major constituents, is probably caused by the fact that in the sediments most of the Mn is an adventitious impurity and occurs mainly as discrete manganese minerals (EL WAKEEL and RILEY, 1961; CRONAN, 1969). Indeed, the elevated MnO contents in stations 417 and 418 samples appear to be due to sampling technique for analysis because that another analytical results (NOHARA and YOKOTA, 1978), and also microscopic observation reveal the existence of trace manganese nodules in the both samples.

CaO and MgO are fairly uniformly distributed in the four groups of sediment. MgO is approxi-



(A)



(B)

Fig. 1 Sampling locations (A) and distribution of sediments (B) in the Central Pacific Basin (from ARITA, 1975, 1977).

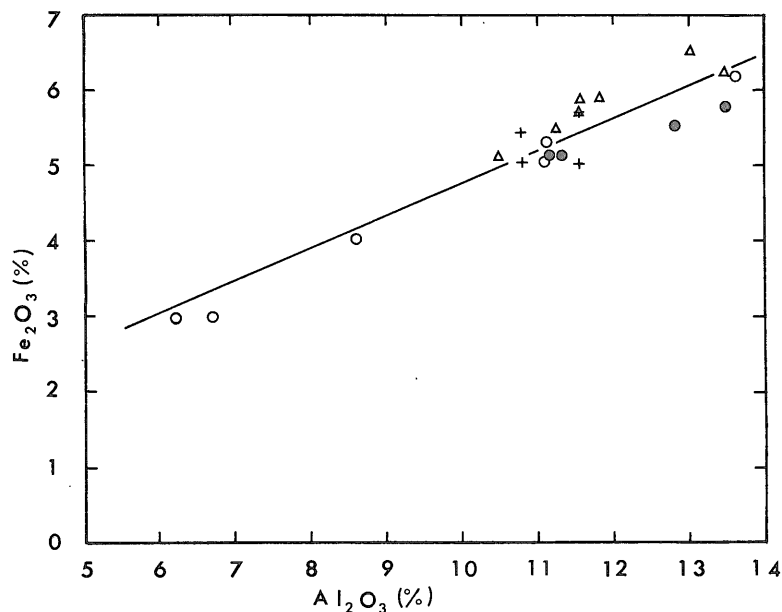


Fig. 2 Relationship between Al<sub>2</sub>O<sub>3</sub> and total Fe (as Fe<sub>2</sub>O<sub>3</sub>) in pelagic sediments from the Central Pacific Basin.

The regression line is  $Fe_2O_3 = 0.49 + 0.43 Al_2O_3$ , correlation coefficient,  $r: 0.93$ .

● : Siliceous ooze, ○ : Calcareous/siliceous clay, + : Siliceous clay, Δ : Deep-sea clay

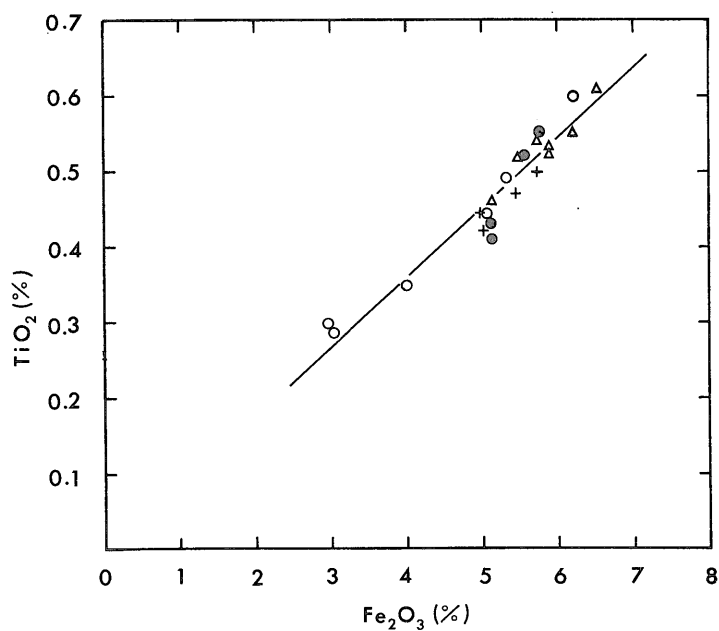


Fig. 3 Relationship between TiO<sub>2</sub> and total Fe (as Fe<sub>2</sub>O<sub>3</sub>) in pelagic sediments from the Central Pacific Basin.

The regression line is  $TiO_2 = -0.01 + 0.09 Fe_2O_3$ , correlation coefficient,  $r: 0.93$ .

For symbols see the legend in Fig. 2.

Table 2 The analytical results of pelagic sediments from the Central Pacific Basin (in wt.%)

	SiO <sub>2</sub>	TiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	FeO	MnO	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>
117-G40*	30.61	0.29	6.70	3.03	0.01	0.44	2.04	21.83	3.99	1.48	—
121-G42*	49.84	0.52	12.28	5.35	0.18	0.59	3.50	1.08	5.84	2.55	—
126-G44*	49.31	0.44	11.08	4.83	0.22	0.57	3.09	9.10	5.10	2.56	—
129-G45	52.43	0.56	13.47	5.59	0.14	0.64	3.59	1.33	5.79	2.83	—
131-G47*	50.93	0.42	11.52	4.83	0.18	0.57	3.36	2.82	6.33	2.38	—
132-G48*	38.33	0.35	8.60	3.87	0.11	0.50	2.56	13.16	5.09	1.73	—
133-G49*	48.23	0.41	11.27	5.11	0.01	0.64	3.37	1.32	5.97	2.40	—
136-G51*	49.49	0.43	11.15	4.87	0.18	0.46	3.60	1.08	6.68	2.72	—
143-G53*	42.57	0.49	11.11	5.15	0.14	0.64	3.08	7.80	4.82	2.56	—
144-G54*	47.82	0.60	13.59	6.19	0.01	1.06	3.80	1.61	4.83	3.08	—
145-G55*	43.25	0.29	6.20	2.75	0.22	0.25	2.27	11.20	5.63	2.16	—
408-G172**	48.59	0.61	13.01	6.45	0.06	0.66	3.26	1.14	6.30	2.59	0.25
409-G173**	47.75	0.52	11.24	5.33	0.14	0.48	3.15	1.11	8.00	2.36	0.25
411-G175**	48.33	0.52	11.55	5.85	0.04	0.69	3.11	1.22	7.00	2.25	0.37
417-G181**	47.59	0.46	10.48	5.10	0.02	1.14	3.00	1.22	7.85	2.13	0.35
418-G182**	48.15	0.47	10.78	5.42	0.03	0.88	3.11	1.34	7.40	2.21	0.44
419-G183**	49.03	0.53	11.80	5.85	0.04	0.63	3.17	1.31	6.60	2.44	0.40
423-G187**	49.32	0.50	11.54	5.58	0.15	0.47	3.13	1.33	6.75	2.30	0.46
426-G190**	47.54	0.44	10.79	4.93	0.10	0.79	2.95	1.51	7.70	2.08	0.57
430-G195**	48.05	0.55	13.42	6.13	0.06	0.66	3.24	1.32	6.05	2.64	0.43
431-G196**	50.26	0.54	11.54	5.50	0.20	0.45	3.07	1.01	6.80	2.43	0.22

\* analyzed by Tokyo Coal Mineral Institute

\*\* analyzed by K. KATO

Table 3 Average major compositions of pelagic sediments from the Central Pacific Basin (calcareous ooze were not analyzed for major constituents).

	siliceous ooze	calcareous/siliceous clay	siliceous clay	deep-sea clay
SiO <sub>2</sub>	50.00	41.08	48.99	48.51
TiO <sub>2</sub>	0.48	0.41	0.46	0.53
Al <sub>2</sub> O <sub>3</sub>	12.04	9.55	11.16	11.86
Fe <sub>2</sub> O <sub>3</sub>	5.23	4.30	5.19	5.74
FeO	0.13	0.12	0.12	0.08
MnO	0.58	0.58	0.68	0.67
MgO	3.52	2.81	3.14	3.14
CaO	2.35	10.78	1.75	1.19
Na <sub>2</sub> O	6.07	4.91	7.05	6.94
K <sub>2</sub> O	2.63	2.26	2.24	2.41
P <sub>2</sub> O <sub>5</sub>	—	—	0.49	0.32

mately three times as abundant as CaO except calcareous-siliceous clay which has an elevated average CaO content. The sediments from this area are considerably richer in the both Mg and Ca than those of the Atlantic (Table 3).

The distribution of alkaline metals in the samples is similar to that in sediments in general, in which Na<sub>2</sub>O preponderates over K<sub>2</sub>O. This observation is in contrary to the results of EL WAKEEL and RILEY

(1961) who reported that  $K_2O$  contents were greater than those of  $Na_2O$  in Atlantic, Indian and Pacific Oceans.

The siliceous clay, on an average, contains approximately twice as much  $P_2O_5$  as deep-sea clay samples. In general  $P_2O_5$  is of biological origin (EL WAKEEL and RILEY, 1961; HIRST, 1962). There is, however, no correlation between the  $P_2O_5$  and the nature of biogenic sediments. The  $P_2O_5$  contents are greater in siliceous clay and deep-sea clay sediments than in calcareous sediments. This does not necessarily preclude a biological origin, since Ca-phosphate and apatite are considerably less soluble than  $CaCO_3$  in water containing  $CO_2$ , and would dissolve less readily during the process of sedimentation.

The relations between the major elements Al, Fe and Mn are shown in the ternary diagram in Fig. 4. Si is not included in the graph since it co-varies with Al, except in the areas of high biological productivity. Fig. 4 shows that the Al-Fe-Mn relations in the sediments differ from those in volcanic matter on crest of East Pacific Rise. Particularly, the sediments from this area surveyed are exceptionally poor in Mn compared with that in active-ridge or volcanic origin sediments. However, the sediments from this area have similarity in Al, Fe, Mn-contents to other Pacific sediments, judging from investigations by POLDERVAART (1955), GOLDBERG and ARRHENIUS (1958), EL WAKEEL and RILEY (1961), TUREKIAN and WEDEPOHL (1961), HIRST (1962) and LANDERGREN (1964). The normal pelagic sediments scatter around 60% Al, 5% Mn and 38% Fe. On the other hand, sediments from active-ridge fall in extreme cases around 0.1–5% Al, 13–28% Mn and 73–80% Fe. Thus, the major compositions of the sediments from this area are similar to those for normal pelagic sediments from the rest of the Pacific Ocean, but markedly different from those of active-ridge sediments where hydrothermal solutions including volcanic emanations have remarkably affected their chemical compositions (BOSTRÖM and PETERSON, 1969; BOSTRÖM *et al.*, 1969; HOROWITZ, 1970; CRONAN and GARRETT, 1973; PIPER, 1973). Therefore, it appears to be the most reasonable that there are not any significant

Fig. 4 Relative variation in the contents of Al, Fe and Mn in pelagic sediments and active-ridge sediments, recalculated on the mass basis  $Al+Fe+Mn=100\%$ .

- A: high heat flow area on the active-ridge.
- B: average to low heat flow area on the active-ridge.
- C: normal Pacific pelagic sediment-area.
- from BOSTRÖM *et al.* (1969), BOSTRÖM and PETERSON (1969).
- ⊙ from GOLDBERG and ARRHENIUS (1958), EL-WAKEEL and RILEY (1961).
- + this work.

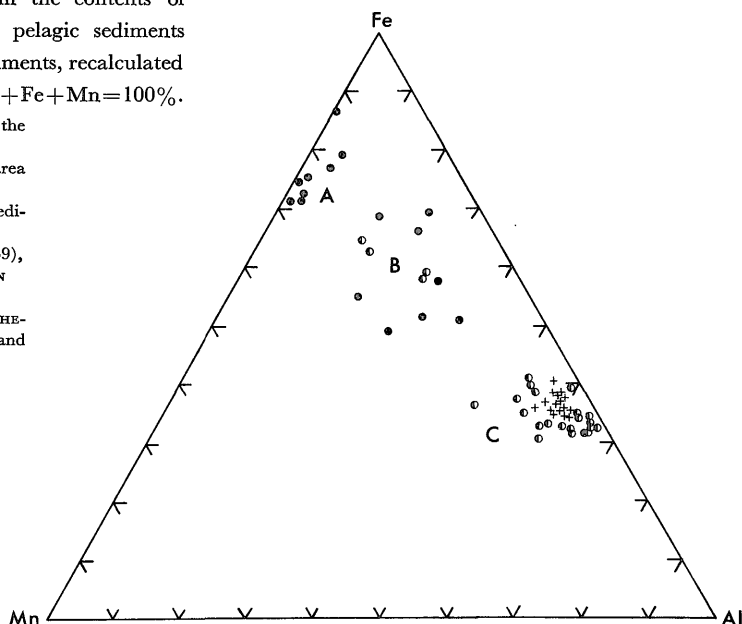


Table 4 Al/(4Al + Fe + Mn + Ti) ratios for pelagic sediments and active-ridge sediments.

Sediments	Ti (%)	Al (%)	Fe (%)	Mn (%)	R*
Siliceous ooze (this work)	0.29	6.37	3.76	0.45	0.21
Calcareous-siliceous clay (this work)	0.25	5.05	3.10	0.45	0.21
Siliceous clay (this work)	0.28	5.90	3.72	0.53	0.21
Deep-sea clay (this work)	0.32	6.27	4.07	0.52	0.21
Pacific pelagic clay (GOLDBERG and ARRHENIUS, 1958)	0.73	9.2	6.5	1.25	0.20
Pacific red clay (EL WAKEEL and RILEY, 1961)	0.40	9.55	6.15	0.74	0.21
Pacific pelagic clay (LANDERGREN, 1964)	0.34	8.3	5.15	1.83	0.21
Active-ridge sediments from East Pacific Rise (BOSTRÖM and PETERSON, 1969; BOSTRÖM <i>et al.</i> , 1969)	0.02 <sup>a</sup>	0.50	18.0	6.0	0.02
Active-ridge sediments from Reykjanes Ridge (HOROWITZ, 1974)	0.20 <sup>b</sup>	3.5	12.3	3.9	0.12
	1.30	5.32	10.77	0.11	0.16

R\* = Al/(4Al + Fe + Mn + Ti) ratio

a: area of high heat flow on the crest.

b: area of average to low heat flow on the crest.

contributions to the chemical compositions of the sediments from submarine hydrothermal solutions or volcanic emanations enriched in some elements by alteration of basalt.

In order to directly compare sediments of different area it is necessary to remove the effects of biogenic carbonate, silicate, dried sea salt and organic matter. To accomplish this, the data was normalized according to the procedures outlined by BOSTRÖM *et al.* (1972). As can be seen from Table 4, the ratios for sediments from this area are remarkably uniform. Also these values are exactly the same as those of normal pelagic sediments from the rest of the Pacific Ocean. The values for the sediments from this area, however, differ from those in active-ridge sediments in which these values are significantly lower (0.21 compared to either 0.02 or 0.12–0.16). Consequently, this finding would indicate that the major compositions of the sediments from this basin, including trace elements, are hardly influenced by sub-marine hot spring or sub-marine volcanism, as pointed out by NOHARA and YOKOTA (1978). With the exception of the calcareous sediments, the sediments appear to be fairly uniform geochemically on the basis of the Al/(4Al + Fe + Mn + Ti) ratios. This would suggest that both authigenic deposition and detrital input have been, on an average, relatively constant in this area since the Miocene, indicating no remarkable changes in sedimentary environments.

#### 4. Summary and Conclusions

The uppermost surface sediments from the Central Pacific Ocean are analyzed for the major elements as a clue to elucidate the geochemical characteristics and a relationship between sediments and associated manganese nodules. SiO<sub>2</sub> contents vary from 30% to 52%. SiO<sub>2</sub> contents in each sediment-type except for calcareous ooze, however, show no remarkable variations. TiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> are also variable in each sediment-type. These elements are somewhat low in calcareous-siliceous clay. This will be resulted from dilution by calcareous fractions which are usually depleted in these elements. The sediments from this basin have similar concentration in these elements, on an average, to those



from other areas in the Pacific Ocean excluding active-ridge sediments. Similarly, Fe and Mn contents show fairly uniform distributions in all sediment-types except in calcareous ooze.

With the exception of calcareous sediments, the uppermost sediments in the Central Pacific Basin appear to be remarkably uniform geochemically on the basis of the  $Al/(4Al + Fe + Mn + Ti)$  ratios. This would indicate that both authigenic fraction and detrital input have been, on an average, relatively constant in this area since the Miocene at the latest. That is, most of elements in the sediments from this basin have never been supplied from sources other than the overlying seawater-mass, such as submarine volcanism or hydrothermal solutions which must give rise to a drastic change of sedimentary environment in the sea-floor.

### 5. Acknowledgements

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### Reference

- ARITA, M. (1975) Bottom sediments. in MIZUNO, A. and CHUJO, J., ed., *Geol. Surv. Japan Cruise Report*, no. 4, p. 62-70.
- (1977) Bottom sediments. in MIZUNO, A. and MORITANI, T., ed., *Ibid.*, no. 8, p. 94-117.
- and KINOSHITA, Y. (1976) On the sediments recovered from GH76-1 surveyed area. *Mar. Sci.*, vol. 8, p. 856-860 (in Japanese with English abstract).
- ARRHENIUS, G. O. S. (1963) Pelagic sediments. in HILL, M. H., ed., *The Sea*, vol. 3, p. 655-727, Interscience, New York, N.Y.
- BOSTRÖM, K., JOENSUU, O., VALDÉS, S. and RIERA, M. (1972) Geochemical history of south Atlantic Ocean sediments since Late Cretaceous. *Mar. Geol.*, vol. 12, p. 85-121.
- , PETERSON, M. N. A. (1969) The origin of aluminum poor ferromanganoan sediments in areas of high heat flow on the East Pacific Rise. *Ibid.*, vol. 7, p. 427-447.
- , ———, JOENSUU, O. and FISHER, D. E. (1969) Aluminum-poor ferromanganoan sediments on active oceanic ridges. *Jour. Geophys. Res.*, vol. 74, p. 3261-3270.
- CHESTER, R. and HUGHES, M. J. (1969) The trace-element geochemistry of a North Pacific pelagic clay core. *Deep-Sea Res.*, vol. 16, p. 639-654.
- and MESSIHA-HANNA, R. G. (1970) Trace element partition patterns in North Atlantic deep-sea sediments. *Geochim. Cosmochim. Acta*, vol. 34, p. 1121-1128.
- and JOHNSON, L. R., MESSIHA-HANNA, R. G. and PADGHAM, R. C. (1973) Similarities between Mn, Ni, and Co contents of deep-sea clays and manganese nodules from the South-West region of the North Atlantic. *Mar. Geol.*, vol. 14, p. M15-M20.
- CORRENS, C. W. (1954) Titan in Tiefseesedimenten. *Deep-Sea Res.*, vol. 1, p. 78-85.
- CRONAN, D. S. (1969) Average abundances of Mn, Fe, Ni, Co, Cu, Pb, Mo, V, Cr, Ti, and P in Pacific pelagic clays. *Geochim. Cosmochim. Acta*, vol. 33, p. 1562-1564.
- and GARRETT, D. (1973) The distribution of elements in metalliferous Pacific sediments collected during the D.S.D.P. *Nature Phys. Sci.*, vol. 242, p. 88-89.
- and TOOMS, J. S. (1969) The geochemistry of manganese nodules and associated pelagic deposits from the Pacific and Indian Oceans. *Deep-Sea Res.*, vol. 16, p. 335-359.
- , VAN ANDEL, T., HEALH, G., DINKLEMAN, M., BENNETT, R., BUKRY, D., CHARLESTON, S., KNAPPS, A., RODOLFO, K. and YEATS, R. (1972) Iron-rich basal sediments from the eastern equatorial Pacific: Leg XVI, D.S.D.P. *Science*, vol. 175, p. 61-63.

- EL WAKEEL, S. K. and RILEY, J. P. (1961) Chemical and mineralogical studies of deep-sea sediments. *Geochim. Cosmochim. Acta*, vol. 25, p. 110-146.
- GOLDBERG, E. D. and ARRHENIUS, G. O. S. (1958) Chemistry of Pacific pelagic sediments. *Ibid.*, vol. 13, p. 153-212.
- HIRST, D. M. (1962) The geochemistry of modern sediments from the Gulf of Paria-1. The relationship between the mineralogy and distribution of major elements. *Ibid.*, vol. 26, p. 309-334.
- HOROWITZ, A. (1970) The distribution of Pb, Ag, Sn, Tl, and Zn in sediments on active oceanic ridges. *Mar. Geol.*, vol. 9, p. 241-259.
- (1974) The geochemistry of sediments from the Northern Reykjans Ridge and the Iceland-Faroes Ridge. *Ibid.*, vol. 17, p. 103-122.
- LANDERGREN, S. (1964) On the geochemistry of deep-sea sediments. *Rept. Swedish Deep-Sea Expedition, X, Special Investigation no. 5*, 154 pp.
- NOHARA, M. and YOKOTA, S. (1978) The geochemistry of trace elements in pelagic sediments from the Central Pacific Basin. *Jour. Geol. Soc. Japan*, vol. 84, p. 165-175.
- PIPER, D. (1973) Origin of metalliferous sediments from the East Pacific Rise. *Earth Planet. Sci. Lett.*, vol. 19, p. 75-82.
- POLDERVAART, A. (1955) Chemistry of the earth's crust. In POLDERVAART, A., ed., *Crust of the Earth*, Geol. Soc. Am., Spec. Papers, vol. 62, p. 119-144.
- REVELLE, R. R. (1944) Marine bottom samples collected in the Pacific by the "Carnegie" on its seventh cruise. *Carnegie Inst. Wash., Publ.*, no. 556, p. 1-180.
- TUREKIAN, K. K. (1965) Some aspects of the geochemistry of marine sediments. in RILEY J. P. and SKIRROW, G., ed., *Chemical Oceanography*, vol. 2, p. 81-126, Academic press, London.
- and IMBRIE, J. (1966) The distribution of trace elements in deep-sea sediments of the Atlantic Ocean. *Earth planet. Sci. Lett.*, vol. 1, p. 161-168.
- and WEDEPOHL, K. H. (1961) Distribution of the elements in some major units of the earth's crust. *Bull. Geol. Soc. Am.*, vol. 72, p. 175-192.

## 中央太平洋海盆域深海堆積物の化学組成

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### 要 旨

中央太平洋海盆域から採取された堆積物の地球化学的特性および、随伴するマンガンノジュールとの関係を明らかにする目的で、その化学組成について検討した。SiO<sub>2</sub> は 30% から 50% まで変化するが、石灰質軟泥を除いた、石灰質-珪質粘土、珪質軟泥、珪質粘土および深海粘土では、その平均値に著しい変動は認められない。TiO<sub>2</sub> と Al<sub>2</sub>O<sub>3</sub> も各堆積物中で変化に富み、石灰質軟泥を除いた他の堆積物中では、石灰質-珪質粘土でいくらか低い値を示す。これは Ti や Al 含有量の少ない石灰質部分に希釈された結果であろう。Fe や Mn は石灰質軟泥を除いて、各堆積物中でかなり均質な分布を示す。

石灰質軟泥を除いた、各種堆積物中の Al/(4Al+Fe+Mn+Ti) 比は極めて一定である。このことは、当海域において、自生的成分と碎屑性成分の堆積フラックスが、少なくとも Miocene 以降、定常的であったことを示す。すなわち、海水以外の他の因子、例えば、堆積環境条件を著しく変化させるような海底火山、温泉水を含む熱水溶液からの元素の供給はほとんどなかった。

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