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The Distribution of Amino Acids and Monosaccharides in Deep Sea Sediments from the Japan Trench and Slope Area

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Abstract: Three muddy core samples from the Japan Trench and Slope area were studied for amino acid and monosaccharide geochemistry.

The total carbon content of the cores ranges from 0.86 to 2.16% and shows a decreasing trend in the order of P83(Slope area), P84 (Japan Trench), and P75 (Japan Trench). The highest amount of organic carbon in core P83 may be due to the largest contribution of organic materials and/or good preservation of them.

Amino acids and monosaccharides were separated and identified. Total amino acids are 358–2510 μg/g, and total monosaccharides are 408–2330 μg/g respectively. The vertical distribution of total amino acids and total monosaccharides fluctuates extremely, especially in core P83 (Slope area). These fluctuation may be caused by diagenetic and/or paleoenvironmental changes. Both total amino acids and total monosaccharides contents of core P84 are much higher than those of core P75, though both cores were taken from the Japan Trench. The ratio of D-alloisoleucine to L-isoleucine of all samples from core P84 is less than 0.05 which means that the core sediments are considered to be of recent ages. On the other hand, the ratio of core P75 ranges 0.02–0.38 with an average of 0.17, suggesting the core sediments is older than those of core P84.

Many kinds of amino acids (20) and monosaccharides (8) found in the deep sea sediments suggest that various types of organisms might be source materials of the organic constituents.

Introduction

The survey covered the Japan and southern Kurile Trench and Slope areas has been carried out by the Geological Survey of Japan in 1976 (HONZA *et al.*, 1977). The studies of seismic reflection records and drilling along the Japan Trench transect, a part of Deep Sea Drilling Project, International Phase of Ocean Drilling, have given much geological and geophysical information on the Japan Trench and near shore shelf area (VON HUENE *et al.*, 1978). These abundant data (LUDWING *et al.*, 1966, VON HUENE *et al.*, 1978) have cleared the stratigraphical and geotectonical outlines of the Trench. Very little geochemical information on the sediments in the Japan Trench and Slope areas is, however, available to date.

Protein and carbohydrate in buried sediments may be broken down into component monomers, such as amino acids and monosaccharides, which can be incorporated into the humic substances. Therefore, the understanding of alteration of amino acid and monosaccharides in sediments is important to clarify the factors which control sedimentary environment and the geochemical process of subsequent diagenesis.

The purposes of the present study are: (1) to investigate the distribution of amino acids and monosaccharides in the Japan Trench and Slope are, (2) to clarify the

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behavior of the organic compounds during diagenesis, (3) to understand the environment of sedimentation in the areas by means of organic geochemistry.

Samples and Analytical Method

The location and other descriptions of samples are shown in Figs. 1, 2 and Table 1. The three muddy core samples studied were collected with piston corer from the Japan Trench and Slope area in April–June, 1976. The core samples are mostly composed of clay, intercalating sand and tuff layers. The samples analyzed in this study were only clay layers. The wet muddy sediments were dried at 70°C for 8 h and then, were ground by hand tools to 100 mesh powder.

Amino acids in the pulverized samples were extracted with 6N HCl at 110°C for 24 hours. The amino acid extractes were desalted with a Dowex 50W column, then eluted with 1.5N NH_4OH. Amino acids were analyzed as o-phtalaldehyde derivatives with a LC-3A Shimazu high performance liquid chromatograph fitted with a fluorometer. This method is more sensitive than the standard ninhydrin method, although it does not detect secondary amino acids, such as proline and hydroxy proline. When a marine sediments including a standard amino acids mixture was desalted and concentrated in this way, HPLC analysis showed that the average amino acid recovery was 91%.

Monosaccharides in the powdered samples were extracted with 1N H_2SO_4 at 110°C for 8 houres. Acid extracts were neutralized with $Ba(OH)_2$ and desalted by passing through a set of the three columns (both the upper and the lower column were filled with Dowex 50W and the middle was Duolite A-4, Degens *et al.*, 1963). Monosaccharides were analyzed as monoethanolamine derivatives with a LC-3A Shimazu high performance liquid chromatograph fitted with a fluorometer. D-fructose, L-arabinose and L-fucose derivatives have been quantified together as L-arabinose, because they have overlapping peaks on the chromatogram. When a marine sediment extract including a standard monosaccharide mixture was desalted and concentrated in this way, HPLC analysis showed that the average monosaccharide recovery was 90%.

Total carbon was analyzed by a Kokusai Electric I.R.-Matic C-S VK-III AS analyzer which is a simultaneous carbon-sulfur automatic analyzer.

Manganese and iron were determined by atomic absorption spectrometry using a Nippon Jarrell-Ash AA-781 automatic absorption and flame emission spectrophotometer.

Results and Discussion

The analytical results of the samples from cores P83, P84 and P75 are presented in Table 2 to 7, respectively. Their vertical distributions are shown in Fig. 3 to 10.

Core P83 (Slope area)

The total carbon, total amino acids and total monosaccharides contends of the samples from core P83 had ranges of 1.45–2.16%, 927–2510 μg/g and 526–2330 μg/g respectively. Their vertical distributions fluctuate extremely with the exception of the total carbon. The

Table 1 Sampling locality, water depth, core length, area and sediments.

Station No.	Sample No.	Position Latitude Longitude	Depth (m)	Area	Core length (cm)	Sample
438	P75	36°42.7′N 143°13.0′E	7,300	Japan Trench	475	Clay intercalating sand and tuff layers.
470	P83	40°40.7′N 142°47.0′E	1,650	Off Hachinohe, continental slope	376	Clay intercalating sand layers.
471	P84	40°07.0′N 144°21.9′E	7,330	Off Kuji, Japan Trench	541	Clay intercalating tuffaceous sand and sand layers.

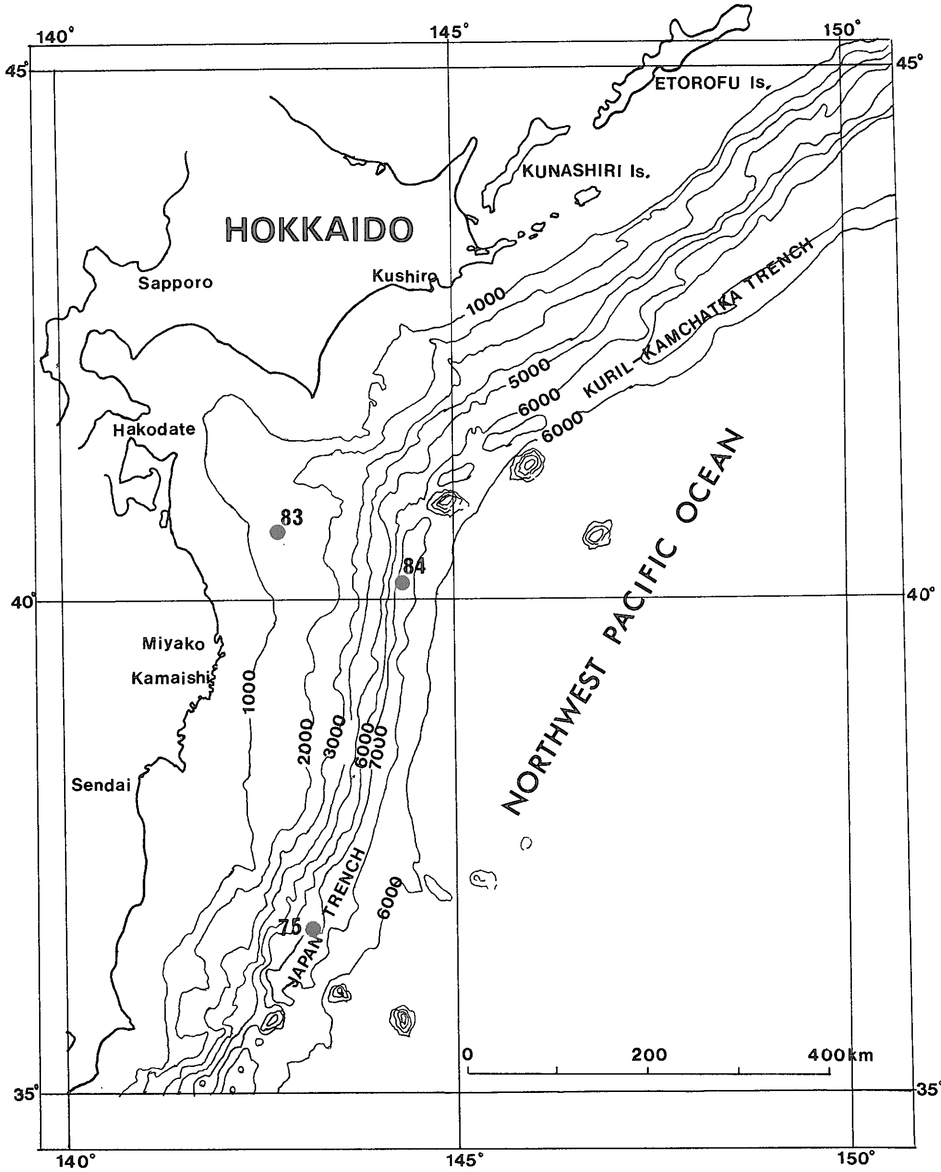

Fig. 1 Sampling locality map.

total amino acids decrease gradually, but irregularly with depth of burial. The wide fluctuation in the concentration of organic constituents is likely to indicates the qualitative variation of the supplied organic matter. On the other hand, the smaller fluctuation of total carbon may indicate the supply of constant amounts organic materials. The highest concentration of these organic constituents in core P83 show a large supply and/or good preservation of organic materials.

The weight percentage of acidic amino acids in the total amino acid mixture decreases sharply from the core top to 160 cm depth. Aspartic acid levels in particulur decrease sharply from 13.2% at the top of the core to 0.4% at 160 cm depth, and remain low (1.7 to 0.4%) at greater depths (Table 3). It is likely that the remarkable low concentration of aspartic acid at depth in core P83 suggests

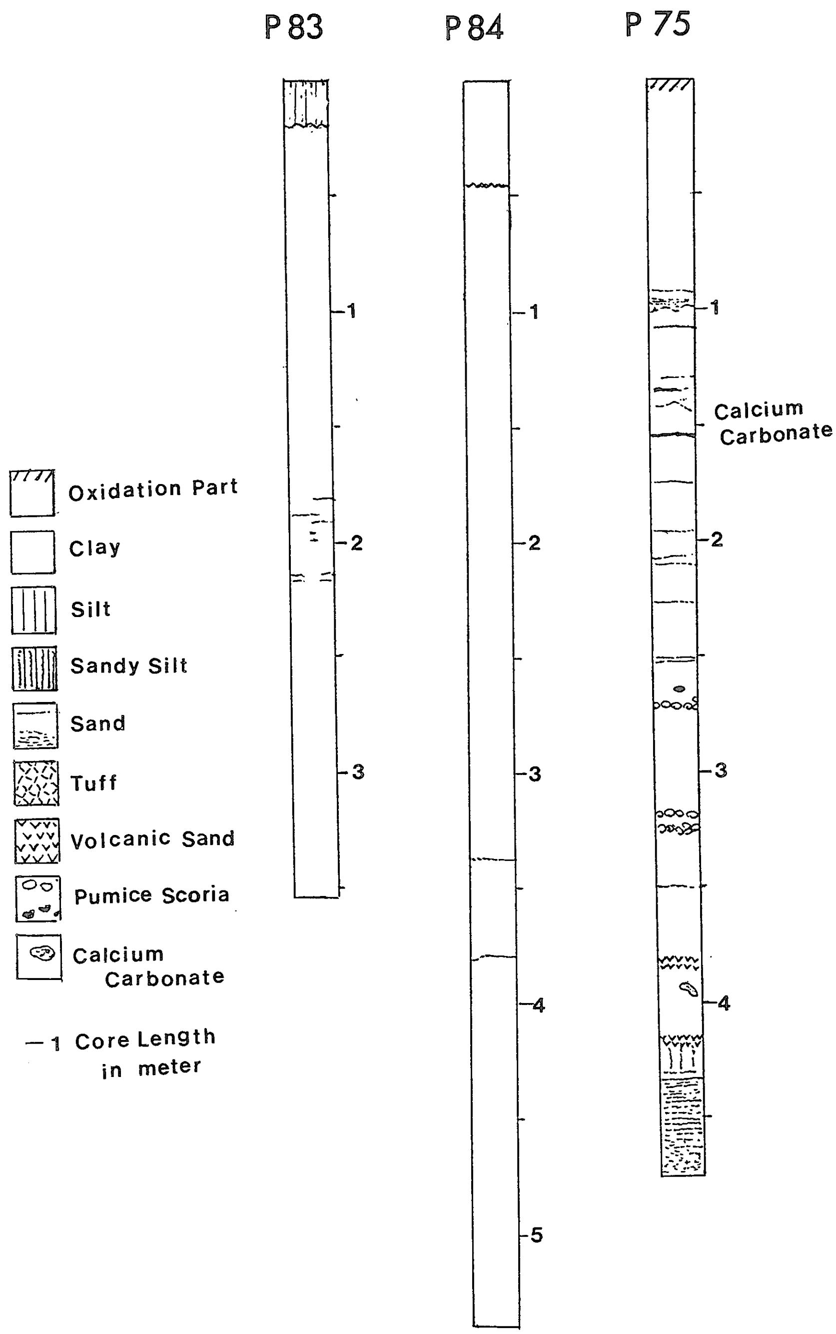

Fig. 2 Columnar section of piston cores.

environmental changes such as Eh condition. Because it has been reported that the acidic amino acids degrade more rapidly under oxidizing conditions (NISSENBAUM *et al.*, 1972, SASAKI, 1973), the lower concentration of aspartic acid in the Slope area indicates that the sediments of core P83 were deposited under oxidizing conditions. The minimum concentration of acidic amino acids at 160 cm depth coincides with those of total amino

Table 2 Amino acid composition, total carbon and Mn/Fe in core P83.

Sample	1	2	3	4	5	6	7	8	9	10	11
Depth (cm)	12	45	82	115	160	195	232	278	315	358	388
Amino acid, basic(wt%)											
Lysine	1.4	7.0	5.9	6.4	1.9	7.1	6.9	8.4	8.4	8.2	9.0
Ornithine	1.3	6.3	0.7	1.8	0.8	0.8	1.9	2.4	2.3	2.2	1.5
Histidine	4.1	1.8	2.4	2.5	3.1	2.9	2.5	2.6	3.6	2.6	2.5
Arginine	8.4	2.9	7.5	8.1	9.7	9.3	10.8	8.1	8.3	7.9	8.2
Acidic											
Aspartic acid	13.2	7.6	4.2	1.0	0.4	1.7	0.6	0.6	0.6	0.4	0.4
Glutamic acid	12.3	12.4	14.2	10.7	9.5	9.8	13.7	10.9	14.2	15.1	11.3
Hydroxy											
Threonine	7.3	7.0	7.8	8.3	8.7	7.5	7.5	7.3	7.7	6.6	6.9
Serine	7.1	5.9	7.3	4.9	3.9	4.0	5.8	6.1	5.9	5.6	5.0
Neutral											
Glysine	7.3	7.4	8.9	11.9	11.0	9.6	7.5	10.8	7.0	9.4	9.6
Alanine	7.6	7.8	9.1	8.9	7.9	7.7	8.2	9.0	9.0	9.0	8.7
Valine	6.6	7.0	7.8	9.1	10.7	9.5	8.2	7.6	7.9	7.9	8.6
Isoleucine	5.1	5.1	5.7	6.3	7.8	6.6	6.4	5.6	5.8	5.7	6.4
Leucine	6.4	6.9	7.6	8.3	10.5	8.7	8.3	7.5	7.7	7.8	8.8
Sulfur											
Methionine	0.4	0.3	0.3	0.9	0.4	0.4	0.2	1.0	0.6	+	0.1
Aromatic											
Tyrosine	2.6	2.2	2.5	3.2	3.6	4.8	2.4	2.2	2.3	2.3	2.5
Phenylalanine	5.3	10.2	5.6	5.2	7.8	6.6	6.2	5.4	3.2	5.3	6.0
Non-protein											
α-aminobutyric acid	0.1	—	—	—	—	—	—	—	—	—	—
β-alanine	1.3	1.0	1.2	1.1	0.8	1.1	1.2	1.8	2.3	1.8	1.8
γ-aminobutyric acid	1.9	1.1	1.3	1.3	1.5	1.8	1.7	2.5	3.2	2.2	2.6
D-alloisoleucine	0.3	+	—	—	—	0.1	—	0.1	—	—	0.1
Total (μg/g)	2460	2510	2340	2050	1340	1700	927	978	1310	1200	1130
(μM/g)	20.1	20.5	19.5	17.3	11.2	13.9	7.52	8.25	10.8	10.1	9.47
D-alloisoleucine/L-isoleucine	—	—	—	—	—	—	—	—	—	—	—
Total carbon (%)	1.88	2.16	2.14	2.08	1.81	1.45	1.77	1.69	2.03	2.10	2.11
Mn/Fe	0.012	0.011	0.011	0.011	0.012	0.015	0.012	0.012	0.012	0.011	0.11

Table 3 Amino acid composition, total carbon and Mn/Fe in core P84.

Sample Depth (cm)	1 7	2 50	3 95	4 130	5 145	6 187	7 227	8 267	9 307	10 347	11 387	12 427	13 477
Amino acid, basic (wt%)													
Lys	9.3	9.0	8.6	8.7	4.0	8.5	7.8	8.1	8.0	10.4	8.7	9.3	9.0
Orn	1.2	3.7	1.0	1.5	1.5	3.0	2.6	2.1	1.3	1.4	2.4	2.7	1.6
His	2.2	2.2	2.1	2.0	2.9	2.1	2.8	2.2	2.1	2.4	2.2	2.4	2.5
Arg	8.4	9.7	7.7	7.9	10.4	8.6	10.2	9.2	8.5	0.6	14.3	9.8	10.5
Acidic													
Asp	0.3	6.3	0.2	4.7	1.6	0.9	5.1	11.2	10.8	7.7	6.1	7.9	4.7
Glu	14.0	10.6	11.6	11.4	13.6	12.1	10.8	11.0	11.7	12.7	8.4	9.7	9.7
Hydroxy													
Thr	8.7	7.3	7.8	7.5	8.2	8.0	6.8	6.5	6.5	8.0	6.7	7.0	7.3
Ser	8.4	5.3	6.0	6.2	6.3	5.1	7.5	5.4	6.4	6.2	5.6	4.8	5.0
Neutral													
Gly	5.9	7.5	14.5	12.5	10.1	8.8	9.3	9.1	8.5	6.5	7.7	6.4	7.5
Ala	8.9	7.1	9.6	8.9	9.4	8.4	6.1	7.0	7.5	9.4	7.7	8.1	8.8
Val	7.3	7.3	7.1	6.7	7.5	7.7	6.3	5.7	5.7	7.0	5.9	6.4	6.8
Ileu	5.5	5.4	5.0	4.7	5.3	5.5	4.9	4.4	4.3	5.3	4.7	4.9	5.0
Leu	7.6	7.3	6.9	6.4	7.4	7.5	7.8	7.2	7.3	8.1	7.4	8.0	8.1
Sulfur													
Met	0.9	1.3	0.6	0.6	0.1	1.1	1.2	1.1	1.2	1.5	1.3	1.2	0.9
Aromatic													
Tyr	2.2	1.9	2.0	1.9	2.1	2.1	1.9	1.8	1.8	2.0	1.8	1.7	1.8
Phe	5.7	5.2	5.0	4.6	5.5	5.5	4.7	4.3	4.3	5.5	4.4	4.8	4.9
Non-protein													
α-ABA	—	—	—	—	—	—	—	—	—	—	—	—	—
β-Ala	1.7	1.3	2.3	2.1	2.1	2.9	1.8	1.6	1.9	2.3	2.0	1.9	2.7
γ-ABA	1.8	1.4	1.9	1.7	2.0	2.1	2.4	2.1	2.2	3.0	2.6	2.9	3.2
Alleu	—	—	—	—	—	—	—	—	—	—	—	—	—
Total (μg/g)	1310	608	1150	1070	783	1220	1190	1070	1200	805	757	728	654
(μM/g)	10.7	4.94	10.1	9.20	6.60	10.0	10.0	8.81	9.92	6.76	5.89	5.93	5.41
Alleu/Ileu	—	—	—	—	—	—	—	—	—	—	—	—	—
Total C. (%)	1.35	1.00	1.26	1.26	1.16	1.18	1.19	1.20	1.56	1.31	1.20	1.17	1.05
Mn/Fe	0.012	0.013	0.013	0.011	0.012	0.012	0.012	0.012	0.012	0.013	0.013	0.013	0.014

Table 4 Amino acid composition, total carbon and Mn/Fe in core P75.

Sample	1	2	3	4	5	6	7	8	9	10
Depth (cm)	8	38	72	106	140	188	230	278	308	436
Amino acid, basic (wt%)										
Lys	7.8	8.2	8.0	6.9	8.2	6.9	7.0	7.8	11.0	8.1
Orn	1.4	1.6	1.7	1.2	2.2	2.3	1.8	1.6	1.5	2.2
His	1.9	1.8	1.9	1.7	2.1	1.7	1.6	1.6	1.5	1.7
Arg	6.1	4.1	8.5	3.9	5.4	5.3	5.8	4.5	6.8	6.1
Acidic										
Asp	9.5	3.7	2.4	1.1	6.6	2.8	9.9	7.0	2.4	9.6
Glu	12.2	14.4	11.4	13.7	12.2	15.0	10.8	10.2	4.5	12.1
Hydroxy										
Thr	7.8	7.7	8.2	6.3	6.8	7.7	6.0	6.6	6.7	6.5
Ser	5.0	4.9	4.0	5.2	3.6	4.4	4.5	3.8	2.0	4.3
Neutral										
Gly	5.6	5.8	6.2	8.2	3.9	4.6	5.9	4.1	6.3	3.4
Ala	8.3	9.7	7.7	7.0	6.6	8.0	8.0	6.8	5.8	7.0
Val	8.5	9.1	9.9	8.5	7.4	8.1	6.1	7.7	9.9	7.4
Ileu	5.4	7.1	7.1	7.2	7.3	6.4	6.2	8.1	9.1	6.9
Leu	8.0	9.7	10.4	10.3	11.0	10.1	6.7	9.2	10.9	8.4
Sulfur										
Met	0.2	0.2	0.3	5.5	0.5	0.5	0.5	0.2	—	0.3
Aromatic										
Tyr	2.0	1.6	1.5	1.4	2.8	1.4	3.0	5.5	5.3	2.7
Phe	5.7	4.5	6.0	5.4	5.5	5.6	6.3	7.3	9.0	6.9
Non-protein										
α-ABA	—	—	—	—	0.3	1.7	0.6	0.1	—	—
β-Ala	2.1	2.5	2.0	2.3	2.1	2.5	3.6	2.7	2.7	2.5
γ-ABA	2.4	2.8	2.6	3.4	3.5	4.1	3.3	2.7	2.6	2.6
Alleu	0.1	0.6	0.2	0.8	1.9	0.8	2.3	2.5	1.9	1.3
Total (μg/g)	485	751	507	457	702	537	391	713	358	408
(μM/g)	3.96	6.22	4.13	3.79	5.60	4.37	3.20	5.68	2.86	3.24
Alleu/Ileu	0.021	0.085	0.022	0.114	0.261	0.127	0.372	0.304	0.207	0.195
Total C.(%)	1.20	1.13	1.20	1.13	1.10	0.96	0.86	0.97	0.97	0.99
Mn/Fe	0.018	0.014	0.016	0.016	0.017	0.014	0.015	0.016	0.014	0.014

acids and also those of total monosaccharides. Conversely, the ratio of neutral amino acids to total amino acids shows a increasing trend from the sediment surface to 160 cm depth.

The weight percentage of Xylose in the total monosaccharide mixture of core P83 is higher than those in the other cores. The vertical distribution of individual monosaccharide in core P83, especially galactose and glucose shows irregular variation. This fact seems to suggest that change of organic source materials and/or diagenetic changes occurred in this area.

Core P84 (**Japan Trench**)

The total carbon, total amino acids and total monosaccharides in core P84 have

Table 5 Monosaccharide composition in core P83.

Sample Depth (cm)	1 12	2 45	3 82	4 115	5 160	6 195	7 232	8 278	9 315	10 358	11 388
Monosaccharides(wt%)											
Rhamnose	7.2	6.9	9.2	9.5	4.2	8.1	9.9	8.7	9.4	10.9	7.6
Ribose	1.3	1.2	2.3	2.4	2.6	1.3	4.7	4.0	+	1.4	1.2
Mannose	12.0	12.1	9.2	9.9	5.6	11.6	11.2	13.0	10.2	10.1	12.1
Arabinose	16.6	18.2	19.9	19.4	22.8	19.0	19.8	18.2	14.8	16.9	17.1
Galactose	31.3	24.5	33.6	31.0	40.8	35.0	29.4	29.9	32.5	35.7	31.0
Xylose	15.6	13.9	14.5	14.5	17.9	11.3	14.1	12.6	13.1	12.4	12.6
Glucose	16.0	23.2	11.3	13.3	6.1	13.7	10.9	13.6	20.0	12.6	18.5
Total (μg/g)	2330	762	1150	1190	526	1560	2305	1780	808	1040	735

Table 6 Monosaccharide composition in core P84.

Sample Depth (cm)	1 7	2 50	3 95	4 130	5 145	6 187	7 227	8 267	9 307	10 347	11 387	12 427	13 477
Monosaccharides(wt%)													
Rhamnose	12.2	5.0	7.6	8.9	8.6	8.9	9.2	9.1	8.6	9.2	8.8	9.1	7.9
Ribose	0.9	1.2	+	1.4	1.1	1.1	1.7	4.4	3.5	3.4	3.8	3.1	2.9
Mannose	12.0	11.2	11.2	12.9	10.1	10.3	12.8	13.0	12.5	11.6	14.1	12.2	11.6
Arabinose	17.5	22.8	16.0	20.8	19.0	17.3	20.7	20.8	21.8	20.2	20.4	22.0	24.2
Galactose	29.7	32.2	27.1	29.5	31.8	31.9	29.4	25.2	27.4	26.6	26.9	27.0	27.3
Xylose	14.7	11.0	10.6	9.5	11.2	12.0	7.7	11.4	11.7	12.8	10.8	11.7	11.5
Glucose	13.0	16.4	27.5	17.0	18.2	18.4	18.4	16.1	14.5	16.2	15.2	14.9	14.6
Total (μg/g)	775	593	408	1120	1200	1190	901	1320	1120	798	1540	1100	951

Table 7 Monosaccharide composition in core P75.

Sample Depth (cm)	1 8	2 38	3 72	4 106	5 140	6 188	7 230	8 278	9 308	10 346
Monosaccharides (wt%)										
Rhamnose	6.8	5.2	2.6	7.3	9.1	7.4	8.8	7.4	11.6	10.6
Ribose	1.3	0.9	0.9	+	0.6	0.9	2.2	1.7	2.0	2.0
Mannose	12.3	10.4	10.7	9.4	9.3	9.8	10.4	9.4	10.2	11.9
Arabinose	15.9	19.1	19.7	17.7	15.7	15.0	27.0	25.2	26.1	27.0
Galactose	28.6	32.5	30.3	29.1	27.2	35.6	22.7	31.2	24.5	21.9
Xylose	10.3	9.8	9.8	11.4	11.4	8.8	11.2	8.2	11.4	10.4
Glucose	24.7	22.1	25.9	25.1	26.7	22.4	17.7	16.9	14.1	16.1
Total (μg/g)	682	504	497	518	421	551	619	947	874	879

ranges of 1.00–1.56%. 608–1310 μg/g and 408–1540 μg/g, respectively. The concentration of total carbon in core P84 are almost one-half of those in core P83. Both total amino acids and total monosaccharides in core P84 are higher than reported for deep sea sediments (Degens *et al.*, 1964, Aizenshtat *et al.*, 1973).

The vertical distribution of basic amino acids and acidic amino acids changes abruptly. Especially, the weight percentage of aspartic acid is relatively low and fluctuates from 0.2 to 6.3% in the upper half of the core. From these data poor preservation of aspartic acid

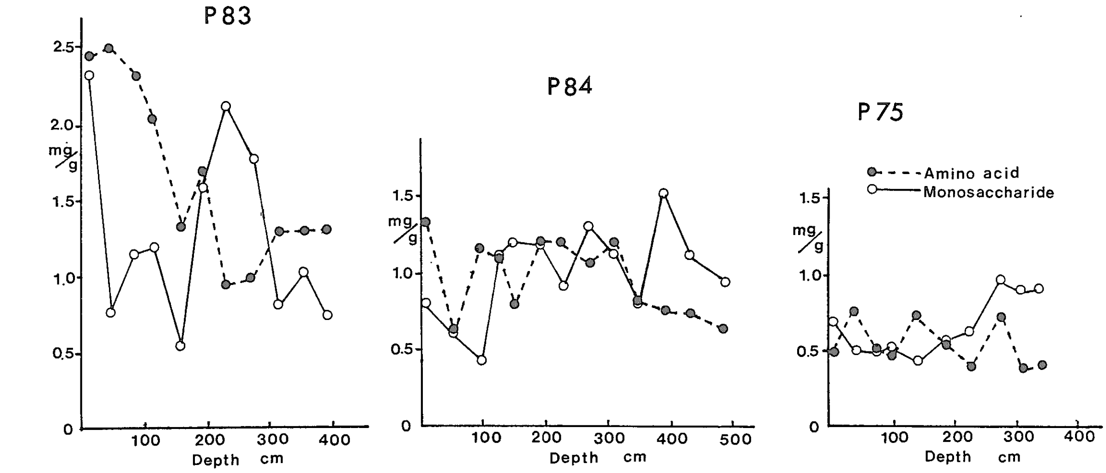

Fig. 3 Vertical distribution of total amino acids and total monosaccharides.

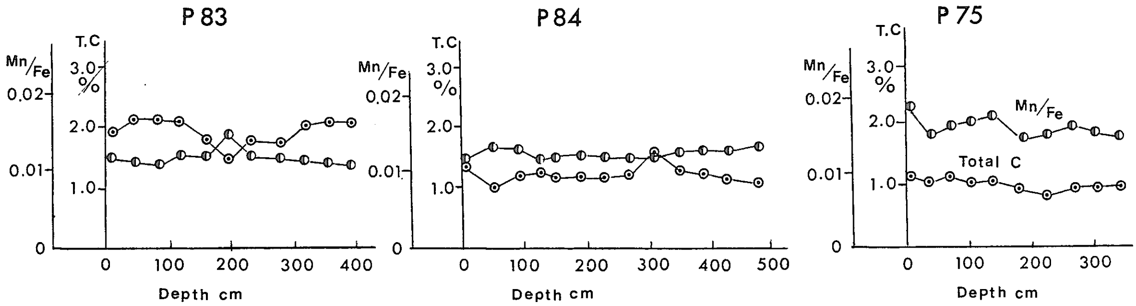

Fig. 4 Vertical distribution of total carbon and Mn/Fe.

is expected under an aerobic condition.

The weight percentage of galactose in the total monosaccharides in core P84 is lower than those found in core P83. Glucose shows extremely high values at 100 cm depth of burial.

Core P75 (Japan Trench)

The total carbon, total amino acids and total monosaccharides in core P75 have ranges of 0.86–1.20%, 358–751 μg/g and 421–947 μg/g respectively. These values are the lowest among the three cores. Such low values may be due to: (a) a small amount of organic material was supplied, because the site of the core was situated in the outside of the Japan Trench, (b) a large part of the original amino acids at the time of sedimentation might have been lost during diagenesis. The total amino acids in core P75 fluctuate considerably, but show a decreasing trend with depth. On the other hand, the total monosaccharides increase with depth, resulting in the reverse relation of the total amino acids to the total monosaccharides between upper and lower part of the core (Fig. 3).

As shown in Table 4, amino acid composition of core P75 is characterized by a fairly low concentration of basic amino acids and a little higher concentration of acidic amino acids, when compared with other cores Furthermore, the weight percentage of aspartic acid in the total amino acids fluctuate extremely. Aromatic amino acids shows a progressive increasing trend with depth. Hydroxy amino acids decreases slightly with depth. The weight percentage of non-protein amino acids in the total amino acids in core P75 is twice as great as in the other cores. Non-protein amino acids which have been found in deep sea core sediments are α-alanine,

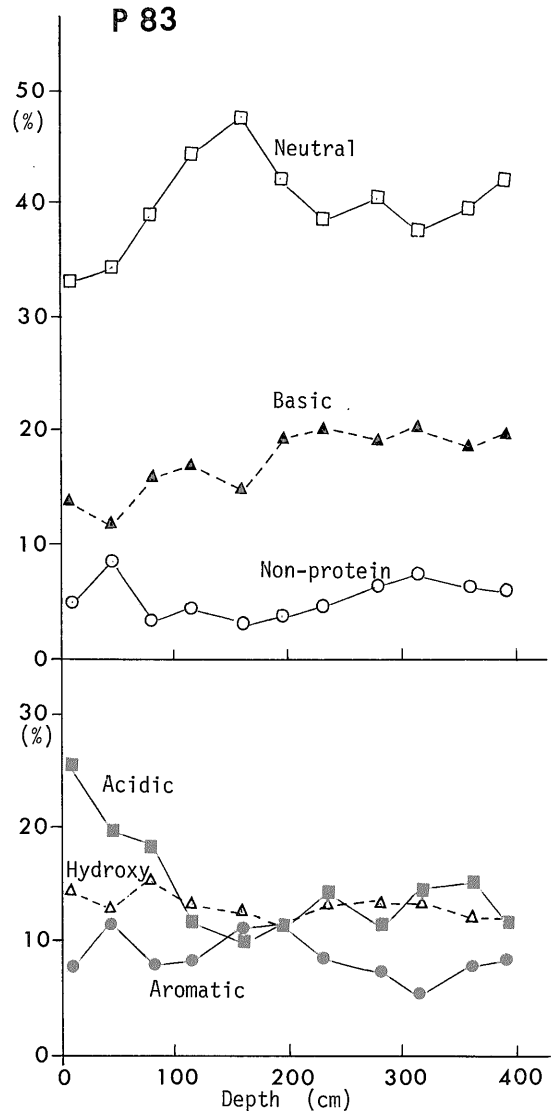

Fig. 5 Vertical distribution of amino acids in core P83.

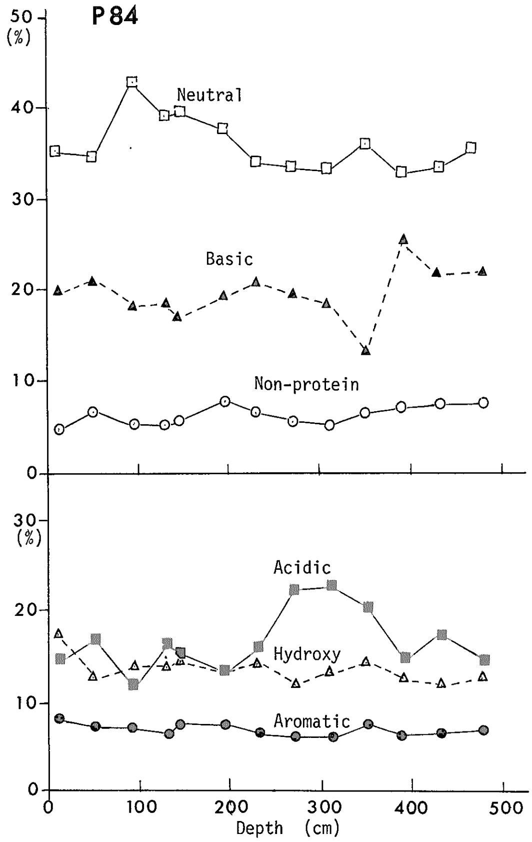

Fig. 6 Vertical distribution of amino acids in core P84.

β-alanine, *α*-aminobutyric acid, *γ*-aminobutyric acid and D-alloisoleucine. Different sources for non-protein amino acids have been considered including: terrestrial organic materials (SASAKI, 1973), microbial metabolic products (DEGENS *et al.*, 1964, ITIHARA, 1972) and diagenetic product (VALLENTINE, 1964). It has been reported that D-alloisoleucine is diagenetic product of L-isoleucine (VALLENTINE, 1964). D-alloisoleucine in core P75 is more concentrated than that in the other cores. As shown in Fig. 11, the ratio of D-alloisoleucine to L-isoleucine in core P75 shows a pronounced increasing trend from the surface to 230 cm depth. This trend suggests that diagenesic production of D-alloisoleucine from L-isoleucine has occurred.

The weight percentage of arabinose (plus fructose and fucose) in the total monosaccharides increases sharply at 230 cm depth of core P75 and remains high to bottom of the core. The weight percentage of glucose in the total monosaccharides in core P75 is higher than that in other cores and decreases gradually from 188 cm depth to the bottom of the core. The relatively high concentration of glucose in this core may be partly due to a large supply of such organic material and partly due to slow degradation of glucose.

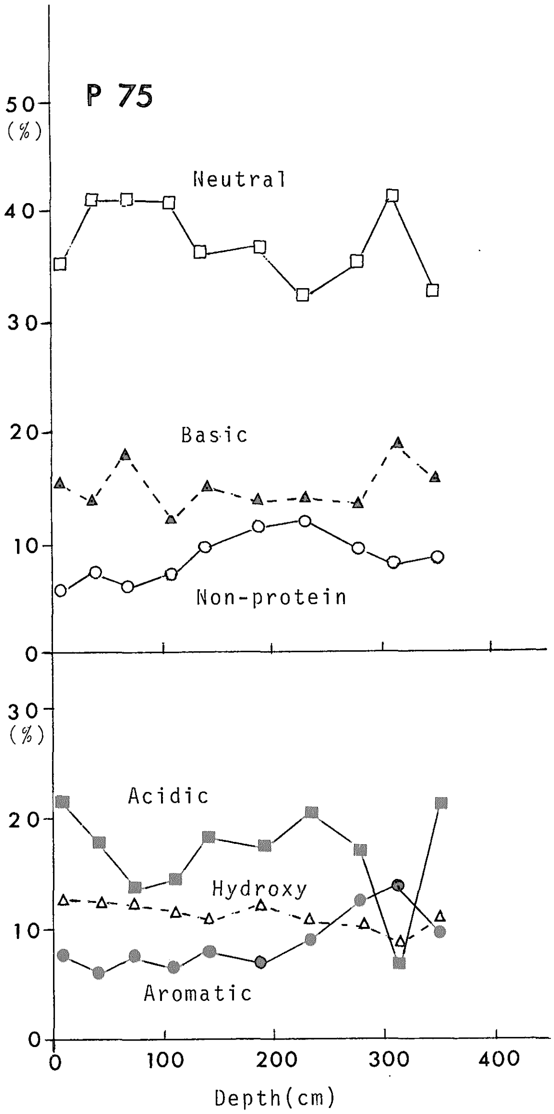

Fig. 7 Vertical distribution of amino acids in core P75.

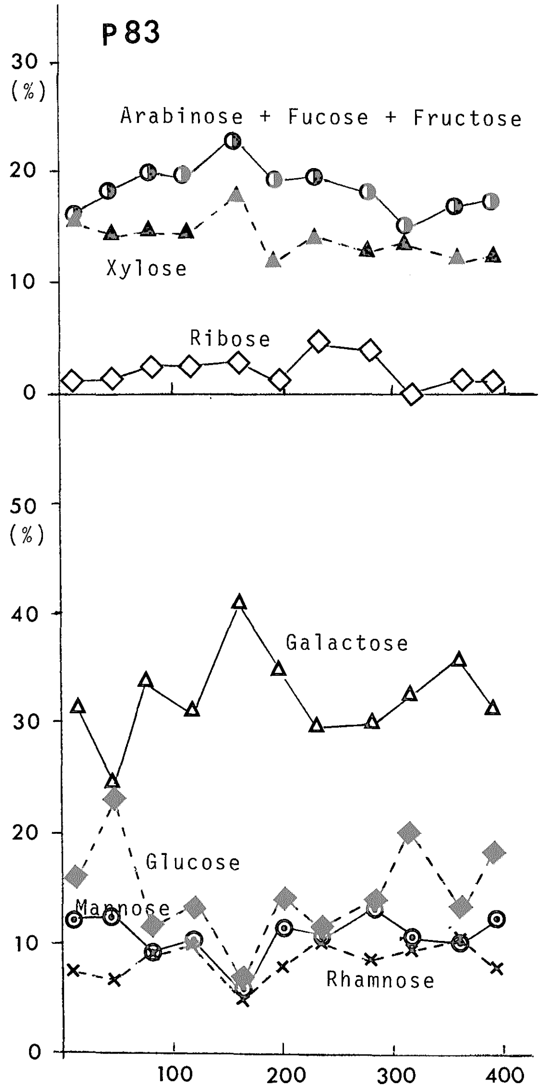

Fig. 8 Vertical distribution of monosaccharides in core P83.

Environment of deposition and accumulation

The concentration of total carbon, total amino acids and total monosaccharides decrease from core P83 (Slope area), to core P84 (Japan Trench) to core P75 (Japan Trench). As mentioned before, the highest level of total carbon in core P83 may be due to a large quantity of organic materials supplied. Among the core from the Japan Trench, core P84 showed generally higher total carbon content than core P75. Water depth at the drilling sites of P84 and P75 (7300 and 7330 m respectively) was not appreciably different. Site P84 is located at the inner side of the Japan Trench, while site P75 situated at the outside of it (Fig. 1).

As shown in Fig. 4 and Table 2 to 4, the ratio of Mn to Fe(Mn/Fe) in cores P75, P83 and P84 varied in the ranges of 0.014–0.018, 0.011–0.015 and 0.011–0.014 respectively. The ratio of Mn to Fe in core P75 was the highest

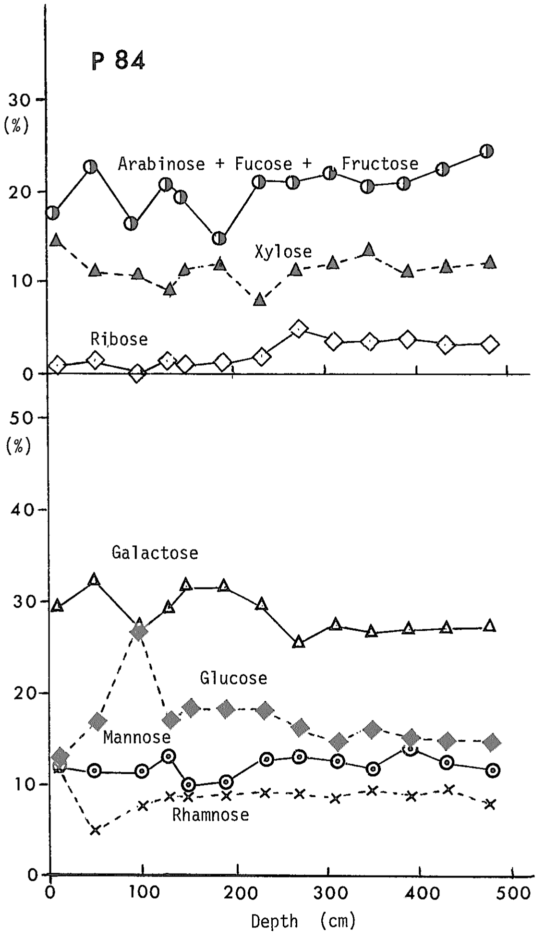

Fig. 9 Vertical distribution of monosaccharides in core P84.

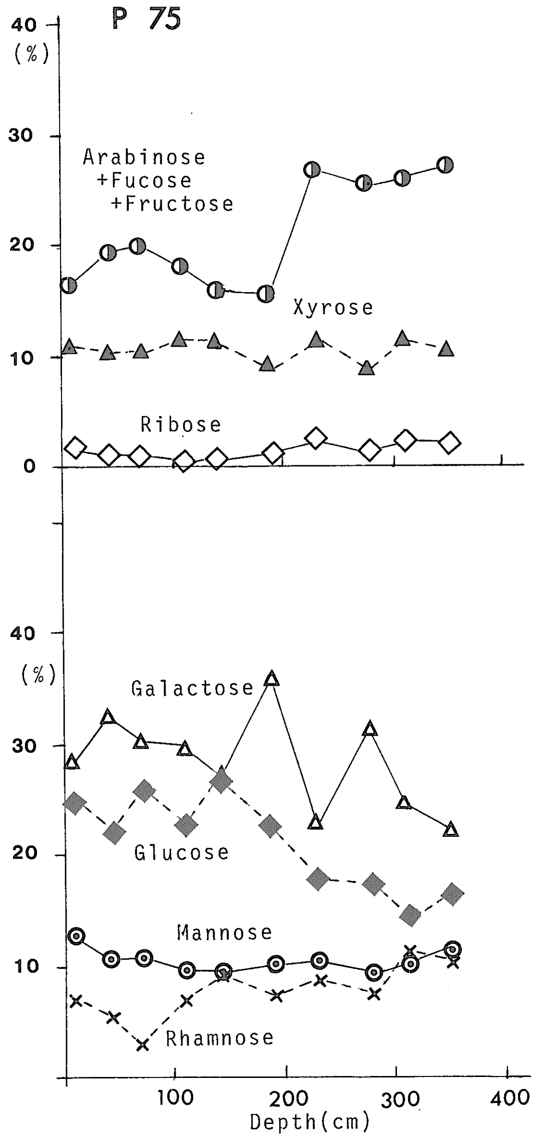

Fig. 10 Vertical distribution of monosaccharides in core P75.

in average among the three cores, the mean value of the ratio in core P83 was similar to that of P84. According to Keith and Degens (1959) Mn/Fe is usefull as a criterion to distinguish marine sediments from fresh ones. Sugisaki (1980) determined Mn content in the marine sediments from the shelf of the Japan Islands and concluded that Mn content increases with increasing distance from land. The relation of Mn/Fe to the distance of sampling site from land seems to be supported by the geological observation that core P75 contains a larger amount of pelagic sediments than core P84.

As mentioned latter, it is conceivable that the sediments in core P75 may be older than at a corresponding depth in core P84, as suggested by the D-alloisoleucine and L-isoleucine data. The main reasons for the low total organic content of core P75 compared to core P84 are considered to be; a large part of the original organic materials deposited at the time of sedimentation might be lost during diagenesis.

The vertical distributions of total amino acids, total monosaccharides, individual amino

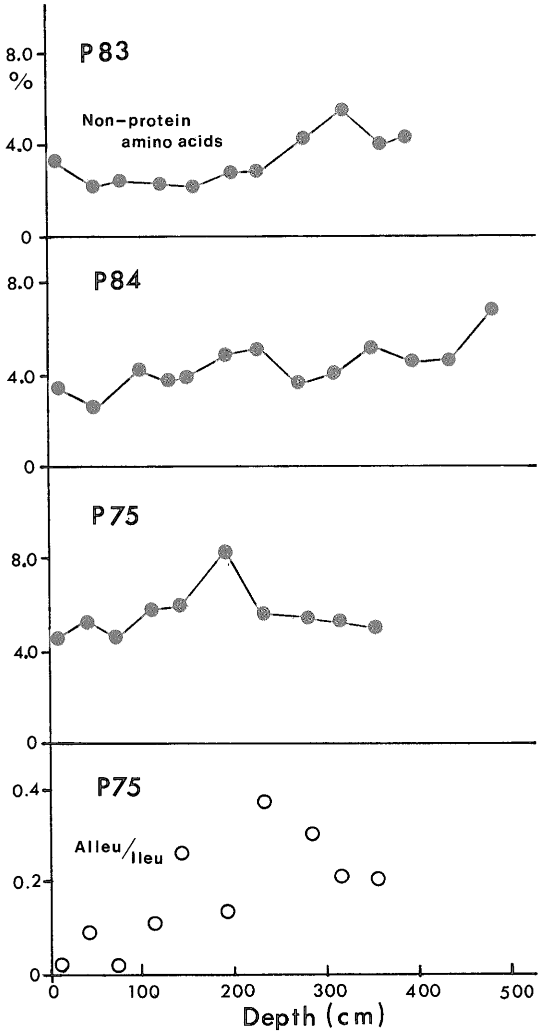

Fig. 11 Vertical distribution of non-protein amino acids and Alleu/Ileu.

acid and monosaccharide fluctuate extremely. In particular, the fluctuation of aspartic acid may be due to a change of sedimentary environment, because the amino acid is likely to be sensitive to oxidizing conditions. Among these three cores the vertical distributions of total amino acids and total monosaccharides change most irregularly in core P83. As shown in Fig. 3, the fluctuation of total amino acids does not coincide with that of total monosaccharides. The large fluctuation with depth and the different manner in the fluctuation of amino acids and monosaccharides seem to suggest a significant variation in the supplied organic materials which might be caused by the changes on physical conditions such as sea level, local current, incline of sea bottom and so on.

In the lowermost sections of cores from the Japan Trench, total monosaccharides were more abundant than total amino acids, suggesting the stability of monosaccharides when compared with amino acids. HANDA (1974) has studied the 200 m drilling core from Biwa Lake and calculated the decomposition constant of amino acids and monosaccharides as 0.48×10^{-6}/y and 0.36×10^{-6}/y, respectively. According to these data, the increasing trend in the ratio of monosaccharides to amino acids with depth could be interpreted in terms of ageing of sediments and the relative stability of the organic species. However, one could not deny a possibility that monosaccharides were originally supplied more abundant than amino acids.

Source of organic materials

About 20 kinds of amino acids and 8 kinds of monosaccharides were universally detected from the core sediments of deep sea drillings, indicating that source materials of such organic constituents are various and complicated. Usually protein amino acids are ubiquitous in all sorts of living materials. Conversely polysaccharides are usually composed of a few types of monosaccharides (for example, cellulose is mainly composed of glucose, galactan is chiefly composed galactose). Therefore, it was expected that the different monosaccharide composition would be observed between the Japan Trench and Slope area, and that major source for monosaccharides in deep sea sediments could be estimated from the composition of monosaccharides. However, the compositions of monosaccharides at the two deep sea sites were similar as shown in Figs. 8–10, suggesting that many kinds of source materials for the monosaccharides would be considered. Furthermore, the activity of microorganisms cannot be ignored, ROGERS (1969) concluded that the variety and amount of polysaccharides demonstrate the importances of microorganisms in altering the polysaccharide fraction prior to stabilization and preservation within the sediments. Appreciable amounts of non-protein amino acids were present in the deep sea core sediments, indicating that micro-organisms play an important role in decomposition of organic materials, because β-alanine, γ-aminobutyric acid and ornithine may be microbial metabolic products (DEGENS *et al.*, 1964, ITIHARA, 1972).

Glucose was one of a abundant monosaccharide throughout the three cores. It is well known that glucose is a main constituent of cellulose and laminaran. According to several investigations SWAIN and BRATT, 1972, HANDA and MIZUNO, 1973), glucose is the most prominent constituent in the monosaccharides which found in the recent sediments. In the sediments from the Japan Trench and slope area, glucose was not the most abundant monosaccharide. The data of this study cannot be compared with the data of other deep sea sediments, because of little information on the monosaccharides in pelagic or semipelagic sediments. However, the monosaccharide composition in the sediments of the Japan Trench and Slope area are characterized by the highest concentration of galactose. Galactose is a prominent component of the algal polysaccahrides, agar and calagenan. Fructose has been found in the storage polysaccharides of cereals. It has not been known whether fructose exists as a component of structural polysaccharides or not. Arabinose has been found in the hemicellulose of land plant and gums and mucilaginous polysaccharides. Fucose is a component of fucoisine in the brown algae. BOHM *et al.* (1980) have reported that fucose is a prominent component in the brown algea and coral. Therefore, fucose and arabinose are probably present in the deep sea sediments.

The ratio of D-alloisoleucine to L-isoleucine

WHEMILLER & HARE (1971) have investigated calcareous deep sea sediments in drilling cores, in which the ratio of D-alloisoleucine to L-isoleucine increased steadily with depth of burial. The ratio of about 0.25 was calculated to be correspond to approximately 400,000 years at a temperature range of 2.2 to 4.0 °C.

As shown in Table 2 and 3, in the sediments of cores P83 and P84 the ratio was usually less than 0.05, while the ratio in the sediments of the core P75 were relatively high (0.37—0.02) and increased with depth (see Table 4 and Fig. 11). The highest values (0.37) of the ratio at the 230 cm depth from surface of the P75 site would suggest that the sediment below that depth may be older than 400,000 years if the environmental conditions of core P75 were similar to those of calcareous deep sea sediments studied by WEHMILLER & HARE.

Conclution

The study was performed to examine the distribution and nature of total carbon, amino acids, monosaccharides, Mn and Fe in the deep sea sediments of the Japan Trench and Slope area. The results are summerized as follows.

(1) The amounts of total carbon, total amino acids and total monosaccharides increase in the order cores P75, P84 (Japan Trench) core P83 (Slope area). The high amount of organic materials in core P83 may be due to input of a large amount of organic supply, because the situation of core P83 is the nearest to land among the three cores. By comparison the organic constituents, Mn/Fe ratio and D-alleu/L-iso ratio between two Japan Trench cores, there are the following differences: (a) the sediments of core P84 which is located in the inner side of the Japan Trench contain a larger amount of organic materials than those of core P75, and are of recent age, (b) on the contrary, the sediments of core P75 which is situated in the outer side of the Japan Trench are pelagic sediments and older than those of core P84, therefore a large part of the original organic materials deposited at the time of sedimentation might have been lost during diagenesis.

(2) Generally, the vertical distribution of total carbon, total amino acids, and total monosaccharides fluctuate extremely. Espe-

cially, this tendancy is observed in core P83 (Slope area), and also in the composition of some amino acids and monosaccharides. This fact seems to suggest that some significant change affected the organic compositions have occured in this area, especially in the Slope area.

(3) Many kinds of amino acids and monosaccharides have been found in the deep sea sediments. This fact seems to suggest that sources of organic constituents in the deep sea sediments are from various organisms. On the other hand, the role of bacteria should not be overlooked, because of existing appreciable amounts of non-protein amino acids which are probably produced by microbial metabolisms.

Galactose is the most abundant monosaccharide throughout the core sediments of the Japan Trench and Slope area. Concerning monosaccharides, we need the more information about the distribution and behaviour in various environments.

(4) In the Japan Trench the ratio of D-alloisoleucine to L-isoleucine in core P75 indicates relatively high values, but the ratio in core P84 does not show such high values. These observations make it possible to suggest that the sediments of core P75 are older than those of core P84 which are of recent age. Judging from the distribution of organic constituents and Mn/Fe, it is conceivable that the sediments of core P75 and P84 in the Japan Trench have been subjected to be different from each other diagenetically and environmentally.

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日本海溝とその周辺大陸斜面の深海堆積物中のアミノ酸と単糖類の分布

寺島美南子

要　旨

日本海溝とその周辺大陸斜面より採取した3本の泥質柱状試料について，アミノ酸と単糖類の有機地球化学的研究を行った.

コアの全炭素含有量は0.86-2.16％の範囲に分布していて，P83(大陸斜面),P84(日本海溝),P75(日本海溝)の順で減少する傾向を示している．コア P83 における最も高い炭素含有量は，有機物の供給が最も多かったためか，または有機物の保存が良かったためと思われる.

各種のアミノ酸と単糖類が分離され同定された．全アミノ酸は 358-2510 μg/g, 全単糖類は 408-2330 μg/g の間にそれぞれ分布している．全アミノ酸と全単糖類の鉛直分布は非常に変動しており，特に，コア P83 (大陸斜面)において変動が大きい．これらの変動は続成作用とあるいは古環境の変化によって起こされたものと思われる．P84 と P75 の 2 つのコアは日本海溝から採取されたものであるが，全アミノ酸と全単糖類はともに，コア P84の方が P75 よりも高い含有量を示す．コア P84 の試料中のL-イソロイシンに対するD-アロイソロイシン比がすべて0.05以下の値を示すことは，これらの柱状堆積物が現世のものであることを意味している．他方，コア P75 のこの比は 0.02-0.38 の範囲にあり，平均 0.17 で，コア P84 よりも古い堆積物であることを示している.

多くの種類のアミノ酸(20)と単糖類(8)が深海堆積物より検出されたが，種々のタイプの生物体が深海堆積物の有機成分の根源物質である可能性を示している.

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