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Grain Size Distribution, Coarse Fraction & Mineralogy of Sediments from Five Areas in the Equatorial & Southwest Pacific

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Preliminary results on the grain size distribution, coarse fraction and mineralogy of a limited number of deep-sea sediments from 4 areas in a N-S transect across the equatorial Pacific (Areas C, D, F and G) and 1 in the southwest Pacific (Area K) are reported. The sediments have been classified according to the Folk classification. Area C sediments are generally mud and in composition siliceous ooze to siliceous mud. The median grain size normally lies between 8.7 and 9.3 φ and the acid soluble ($CaCO_3$) content between 3.1 and 15.9%. Sample 5 KG is a siliceous debris-bearing nanno/foram ooze with a carbonate content of 88.9%. Area D sediments are sandy mud and in composition siliceous debris-bearing nanno/foram ooze with an acid soluble content of 91.2%. The median grain size of these sediments is 8 φ. Area F sediments are sandy silt and in composition siliceous debris-bearing nanno/foram ooze with an acid soluble content of 95.5%. The median grain size of these sediments is 7.25 φ. Area G sediments are mud and in composition siliceous debris-bearing foram/nanno ooze with an acid soluble content of 58.6%. The median grain size of these sediments is 7.75 φ. Area K sediments are mud and in composition nanno/foram bearing red clay with an acid soluble content of 14.4%. The median grain size of these sediments is 8.95 φ. Very poorly sorted sediments are encountered in Areas D and F which lie near to the equatorial high carbonate zone and are characterised by high carbonate contents. The sorting of the sediments improves away from the equatorial region due to lower carbonate contents in the sediments. In the coarse fraction (> 63 μm), radiolaria/siliceous matter predominates in the siliceous ooze sediments from Area C whereas foram/calcareous matter is the dominant constituent of the sediments from Areas D, F and G. Micronodules are the main constituents of the coarse fraction of the red clay sediments from Area K. Fish teeth are observed in sediments from Areas C and K while sediments from Areas D, F and G are devoid of fish teeth. The abundance of fish teeth may be related to carbonate contents of the sediments which acts as a diluent. Mineralogically, Area C sediments are generally characterised by quartz and smectite with lesser amounts of chlorite + kaolinite, illite and plagioclase. Areas D, F and G sediments are dominated by calcite (> 80%) with low percentages of quartz, smectite, chlorite + kaolinite, illite and plagioclase. Area K sediments are dominantly quartz and smectite. Chlorite + kaolinite, plagioclase, illite and calcite are present in moderately high percentages. Quartz, chlorite + kaolinite, illite and feldspar appear to be detrital and eolian in origin. Smectite may be authigenic in origin.

Considerable work has been done on the distribution of manganese nodules, their relation to sediment type and topography in the ocean basins and their chemical characteristics[1-7]. Manganese micronodules have also been studied in detail[8-11] but the grain size distribution, coarse fraction and mineralogy of the associated sediments have received little attention.

Clay mineral distribution in ocean sediments[12,13] and distribution of carbonates in the surface sediments of the Pacific Ocean[14] were described. Halbach *et al.*[15] and Friedrich[8] reported on the grain size of the equatorial Pacific sediments. Krömer[16] studied grain size and mineralogy of a few sediment samples and Hein *et al.*[17] the mineralogy and diagenesis of surface sediments from equatorial Pacific. Meylan[18] described in detail the grain size, coarse fraction and mineralogy of the sediments from the southwest Pacific and Nayudu[19] the mineralogy of sediments from the southern sector of the southwestern Pacific basin.

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Preliminary observations on the grain size distribution, coarse fraction and mineralogy of a limited number of deep-sea sediments from 5 areas in the equatorial north and southwest Pacific are presented here. Chemical composition of these sediments and their associated micronodules has been presented elsewhere[20]. No attempt is made here to discuss variations in sediment type within individual areas as discussed by Stoffers *et al.*[20].

Location and Geological Setting

The *FS Sonne* cruise 'Hawaii-Tahiti-Transect' (Fig. 1) took place during Aug.-Oct. 1978 as part of the International Cooperative Investigations of Manganese Nodules Environments (ICIME) Project jointly undertaken by the Technische Hochschule, Aachen, CNEXO, Brest, University of Hawaii, New Zealand Oceanographic Institute and Imperial College, London, to collect more information on the genesis of the manganese nodules and the factors responsible for the enrichment of elements such as Ni, Cu, and Co in them. The areas surveyed by *FS Sonne* were traversed by major east-west fracture zones and bounded by the east Pacific Rise to the east (Fig. 1). The

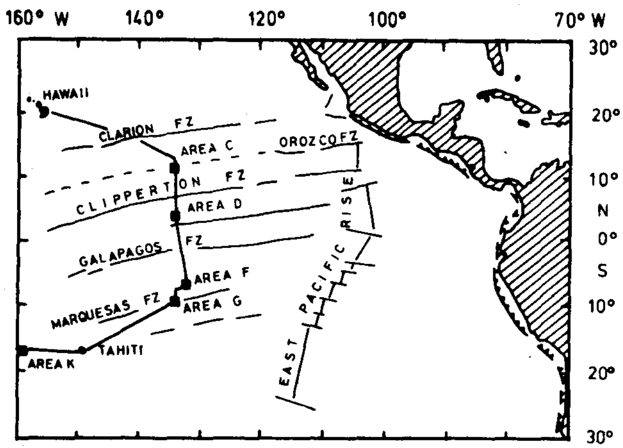

Fig. 1—Locations of sampling areas

manganese nodule distribution and geochemistry as well as bathymetry and topography of these areas were described[7].

Area C—Area C lies between the extension of the Orozco Fracture Zone and the Clipperton Fracture Zone (11°-11°50'N; 134°-135° W). Generally, the area is characterised by the north - south valleys and hills with water depths in the range 4750 to 4950 m. The western part of the area is dominated by a steep seamount having relief of nearly 600 m between the top of the seamount (4338 m) and the adjacent basin (4942 m).

Area D—No detailed bathymetric surveys were carried out during the *Sonne* cruise. The area lies south of the Clipperton Fracture Zone (4°20'N: 134°W).

Area F—This area is characterised by north-south trending valleys, hills and seamounts separated by 5-18 km with water depths in the range 3993 to 4923 m. The area lies between Galapagos and Marquesas Fracture Zones (6°50'-7°10'S: 132°15' W).

Area G—The area lies between 9°-10°30'S and 134°-134°15'W in the vicinity of the Marquesas Fracture Zone. The topography of the northern part is characterised by NW - SE trending features varying in depth from 4680 to 3726 m. Two seamounts with elevations of 3206 and 3655 m and a wide valley further south are the main features of the area.

Area K—Area K lies in the Aitutaki Passage, northwest of Rarotonga, at 15°S and 160°W. The sediments are thin within the Passage, and thicken into the basins to the northeast and the southwest as revealed by the reflection profiles.

Berger *et al.*[14] observed that equatorial north Pacific sediments are poor in carbonates due to predominance of sea floor at or below the calcite compensation depth (CCD) compared to the equatorial south Pacific sediments which are rich in carbonate due to the shallower depth. The influence of the equatorial high productivity zone of the carbonate contents of the sediments has been dealt with in detail by Stoffers *et al.*[20].

Materials and Methods

The details of the samples collected by spade and box corers are given in Table 1. Samples were prepared for the grain size, coarse fraction and mineralogical studies by removing salts from the sediments by filtering with warm distilled water ($<50°C$). When the filtrate showed no sign of chloride with silver nitrate solution, the samples were dried at room temperature.

Normal sieving and pipetting method[21] was followed for grain size analysis. Ammonia (0.01 *N*) was used as the dispersing agent. The coarse fraction (>63 μm) was separated from the bulk sediment samples by sieving about 1000 g of the wet material through 300, 150 and 63 μm plastic sieves. The retained fractions were dried at room temperature and the weight percentages of each fraction in the bulk sediment were determined.

About 5 g of dried samples were heated at 105°C for 24 hr. About 1 g from this was treated with 2 *N* HCl and the acid was removed by washing with distilled water. The sample was again dried at 105°C for 24 hr and weighed. The difference in weights is taken as the acid soluble fraction ($CaCO_3$) in the sediment sample.

Dried samples were made as thin pastes with spirit in a agate mortar and slides prepared for X-ray diffraction analysis. The fraction (<2 μm) separated from each sample during the pipette analysis was also dried in air at room temperature and slides prepared for the X-ray diffraction analysis as described above. Glycolation and heat treatments were carried out to help differentiate between individual clay minerals. Mineralogy of the sediments was studied with Siemens diffractometer using Cu K_α radiation.

Results and Discussion

Grain size distribution—The grain size of 9 selected deep-sea sediments was determined (Table 1). The sediments are classified[22] as silt, sandy silt, sandy mud and mud. The sand, silt and clay ratios are shown in Fig. 2. Grain size distribution of some of the sediment samples from the areas has previously been reported by Stoffers *et al.*[20]. Sand, silt and clay ratios of the sediments were determined by them using Atterberg method. The samples 45 KG and 179 KG fall under sandy silt and mud respectively which correspond to our analysis.

The grain size parameters of each sample were calculated using Folk[22] formulae and are given in Table 2.

In Area C, the median of the sediments varies between 5 and 9.3 φ. Sample 5 KG has a value of 5.1 φ which is different from the other samples in the area and reflects a contribution from Miocene carbonate-rich sediments[20]. The sample analysed was white in colour with specks of brown material. The acid soluble ($CaCO_3$) for this sample is 88.9% suggesting mixing of 2 different facies. The acid soluble for the other samples in the area varies between 3.1 and 15.9% (Table 2).

Area F is characterised by the coarsest sediments (Table 2) and sediments become finer towards Areas D and C in the north, and Areas G and K in the south. The sediments of Area C are finer than Area K.

The mèdian (Md) of siliceous sediments from the central Pacific was found by Halbach *et al.*[15] to be between 1.88 and 2.10 μm; and of marl oozes to be 3.1 μm which corresponds to our observations.

The sediments are poorly to very poorly sorted (Table 2) which is in agreement with the observations of Friedrich[8] and Halbach *et al.*[15] for the central Pacific sediments.

The sediments from Areas D and F are very poorly sorted; these sediments lie near to equatorial high productivity zone and are characterised by high carbonate contents. The sorting of the sediments improves away from the equatorial region due to the lower rate of sedimentation and lower carbonate contents of the sediments.

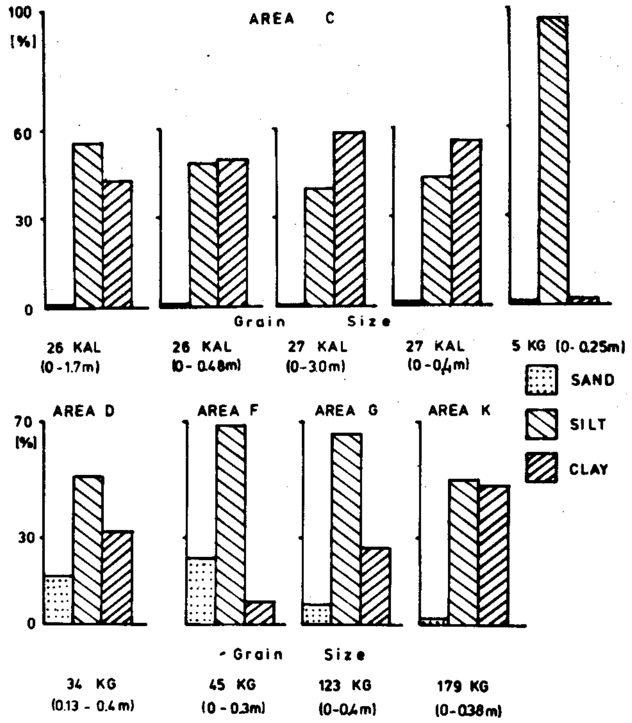

Fig. 2—Grain size distribution (% sand, silt and clay) in sediments from the sampling areas [Sand refers to > 63 μm, silt 63-2 μm and clay < 2 μm]

Table 1—Description of Sediment Samples Studied

Area	Sample No.	Sediment classification	Co-ordinates	Depth (m)	Description
C	26 KAL (0-1.7 m)	1	11°30′ N 133°49′ W	4779	Light yellowish brown (10 YR 6/4) muddy siliceous ooze passing down to a greyish brown (10YR 6/3) siliceous mud
	26 KAL (0-0.48 m)	1	do	do	do
	27 KAL (0-3.0 m)	1	11°34′ N 133°44′ W	4881	do
	27 KAL (0-0.6 m)	1	do	do	do
	5 KG (0-0.25 m)	2	11°31′ N 133°47′ W	4774	Brown (10 YR 5/3) calcareous nanno-plankton bearing siliceous ooze, passing through a sharp contact to white (10 YR 8/2) calcareous nanno ooze (Lower Miocene). The sediment sample analysed was white with specks of brown material
D	34 KG (0.13-0.4 m)	3	4°03′ N 134°06′ W		Light greyish brown (10 YR 5/3) siliceous microfossils rich foram/nanno marl, grading down to a very pale brown (10 YR 7/3) siliceous microfossils bearing foram/nanno ooze.
F	45 KG (0-0.3 m)	4	7°00′ S 131°52′ W	4321	Light yellowish brown (10 YR 6/4) siliceous debris-bearing nanno/foram ooze
G	123 KG (0-0.4 m)	1	9°50′ S 133°59′ W	4557	Hydroxide and siliceous debris-bearing foram/nanno ooze
K	179 KG (0-0.38 m)	1	19°21′ S 133°16′ W	4616	Nanno/foram bearing brown dark reddish brown pelagic clay

KG = Spade core sample
KAL = Box core sample
Sediment classification—1, mud; 2, silt; 3, sandy mud; 4, sandy silt

Table 2—Grain Size Parameters and Acid Soluble ($CaCO_3$) Contents of Sediments

Area	Sample No.	Median (Md) φ	Mean (Mz) φ	Inclusive graphic SD φ	Inclusive graphic skewness SK_1	Graphic kurtosis K_G	Acid soluble ($CaCO_3$) %
C	26KAL (0-1.7 m)	8.71	8.32	1.43	−0.48	0.87	10.9
	26KAL (0-0.48m)	9.0	8.62	1.18	−0.58	1.13	15.9
	27KAL (0-3.0m)	9.3	8.88	1.15	−0.65	1.15	3.1
	27KAL (0-0.4m)	9.15	8.72	1.04	−0.65	1.04	11.2
	5KG (0-0.25m)	5.1	5.42	1.23	+0.52	1.13	88.9
D	34KG (0.13-0.4m)	8.0	7.15	2.53	−0.47	0.78	99.2
F	45KG (0-0.3m)	7.25	6.35	2.59	−0.49	0.78	95.5
G	123KG (0-0.4m)	7.75	7.72	1.8	−0.21	0.101	58.6
K	179KG (0-0.38m)	8.95	8.5	1.36	−0.60	1.31	14.4

The sediments in all the areas studied are coarse to strongly coarse skewed except sample 5 KG from Area C which is strongly fine skewed. Sample 5 KG is carbonate rich and, therefore, from a different sediment facies to other sediments in the area. The skewness values are given in Table 2.

Sample 26 KAL (0-1.7 m) from Area C and samples 34 KG and 45 KG from Areas D and F are platykurtic. Strongly platykurtic sediments are in general, bimodal.

Coarse fraction—The coarse fraction (>63 μm) retained on the 300, 150 and 63 μm sieves were studied for their different constituents.

The weight percentage of the coarse fraction is given in Table 3. Sediments from Areas D and F have higher percentage of coarse fraction due to higher contents of carbonate microfossils. Within the coarse fraction, 150-63 μm size class is dominant in Area C whereas >300 μm size class predominates in Areas D, F, G and K.

The coarse fraction constituents such as foraminifera, calcareous matter, radiolaria, siliceous matter, diatoms, sponges, siliceous spicules, fish teeth, manganese micronodules, minerals (quartz, feldspar and mica) and others were differentiated. Both planktonic and benthic foraminifera were present. The calcareous matter includes mainly fragments of foraminifera and other shells. Radiolarian and diatom fragments were included under siliceous matter.

A small proportion from each size class of the coarse fraction (>63 μm) was taken after coning and quartering and the above constituents were counted under the binocular microscope. The larger grains from the >300 μm size class were separated prior to coning and quartering to facilitate representative sampling. About 400-600 grains were counted from each size class of the coarse fraction and grain percentage calculated. The grain percentage of the coarse fraction constituents is given in Table 4.

When all the 3 size classes of the coarse fraction (>63 μm) are considered together, foram/calcareous fragments dominate in Areas D, F and G, and radiolaria/siliceous matter in Area C (Fig. 3). Micronodules are the dominant constituent of the coarse fraction (>63 μm) from Area K.

Table 3—Weight Percentage of the Sediments in Different Size Classes of the Coarse Fraction (>63 μm)

Area	Sample No.	Wt percentage of sediments in the size		
		>300 μm	300-150 μm	150-63μm
C	26 KAL (0-1.7 m)	0.009	0.019	0.141
C	26 KAL (0-0.48 m)	0.190	0.053	0.081
C	27 KAL (0-3.0 m)	0.002	0.013	0.128
C	27 KAL (0-0.6 m)	0.024	0.034	0.173
C	5 KG (0-0.25 m)	0.031	0.112	1.185
D	34 KG (0.13-0.4 m)	7.008	2.675	3.751
F	45 KG (0-0.3 m)	12.327	2.674	4.629
G	123 KG (0-0.4 m)	1.528	0.364	0.946
K	179 KG (0-0.38 m)	0.829	0.275	0.159

There appears to be a correlation between sediment type and presence of fish teeth. Fish teeth have been observed in sediments from Areas C and K which are rich in radiolaria/siliceous matter and micronodules. These were not observed in foram/nanno ooze rich sediments from Areas D, F and G apparently due to dilution by calcareous sediment. Within Area C, they are abundant in the 300-150 μm size class except for sample 5 KG where they are more abundant in the >300 μm size class. In Area K, their abundance is higher in the finer size classes (150-63 μm) of the coarse fraction. Hein *et al.*[17] also observed that fish debris forms a major part of the coarse fraction in some samples of the siliceous ooze from equatorial N. Pacific.

Manganese micronodules are abundant in red clays (Area K) and siliceous ooze/mud (Area C). They are absent or very poor in calcareous ooze sediments (Areas D, F and G). They are more abundant in the coarser size class (>300 μm) of the coarse fraction from the siliceous ooze area than in that of the red clays

Table 4—Percentage of Different Constituents of the Coarse Fraction (> 63 μm) of Sediments

Area	Sample No.	Size class	Foram.	Cal. F.	Radio.	Sil. F.	Diatom	Spg.	Sil. Sp	F. th.	Micr.	Min.	Oth.
C	26 KAL (0-1.7 m)	a	2.7	24.7	27.0	0.5	1.2	8.9	1.4	0.2	29.0	2.4	1.4
		b	0.2	1.1	67.1	6.1	5.1	3.5	5.2	0.4	6.6	4.4	—
		c	—	0.3	84.0	6.5	2.1	1.5	0.5	—	1.5	3.5	—
	26 KAL (0-0.48 m)	a	—	2.9	8.9	3.8	0.6	4.0	—	—	78.6	0.6	0.2
		b	—	0.3	71.8	8.8	9.4	0.8	—	0.1	7.8	0.9	—
		c	—	1.8	55.4	19.9	1.8	7.6	0.1	—	3.9	9.1	—
	27 KAL (0-3.0 m)	a	—	43.1	6.4	10.6	—	7.5	—	0.3	6.1	25.7	—
		b	0.6	22.7	41.9	15.1	1.5	6.9	—	0.6	2.4	7.5	0.3
		c	—	4.9	49.1	10.4	0.2	8.5	0.4	—	2.3	23.8	—
	27 KAL (0-0.60 m)	a	3.3	22.8	28.6	14.4	0.9	13.2	—	—	7.8	8.1	0.6
		b	—	1.1	77.5	8.5	5.1	3.7	—	0.2	0.4	3.2	—
		c	—	0.3	52.2	22.1	2.1	5.6	0.6	—	—	8.8	0.5
C	5 KG (0-0.25 m)	a	20.1	59.6	0.5	4.3	—	0.7	—	1.5	6.8	3.8	2.2
		b	4.5	18.0	57.5	9.5	0.1	3.7	—	0.1	3.3	2.2	0.5
		c	1.1	2.8	59.4	27.2	0.1	3.2	0.3	—	1.4	2.1	0.1
D	34 KG (0.13-0.4 m)	a	60.4	39.2	—	—	—	—	—	—	—	—	0.3
		b	18.6	81.3	—	—	—	—	—	—	—	—	—
		c	5.9	90.4	2.1	1.1	—	—	—	—	—	—	—
F	45 KG (0-0.3 m)	a	68.8	29.9	—	—	—	—	—	—	—	—	0.8
		b	16.6	80.1	1.2	—	0.1	—	—	—	0.4	0.8	0.4
		c	7.2	89.6	0.3	0.9	—	—	—	—	0.1	0.9	0.3
G	123 KG (0-0.4 m)	a	53.2	45.9	—	0.1	—	—	—	—	0.3	0.1	0.1
		b	8.2	88.9	0.1	0.1	—	—	0.1	—	1.1	0.9	0.1
		c	6.8	83.9	2.4	2.2	0.7	0.5	0.4	—	0.7	1.7	0.2
K	179 KG (0-0.38 m)	a	5.7	11.2	0.2	—	—	0.2	—	1.2	80.9	0.6	0.2
		b	3.7	7.6	0.1	0.3	—	0.1	0.1	0.9	85.2	1.4	—
		c	7.1	9.6	0.2	0.6	—	0.1	—	1.4	66.9	13.6	—

Size class—a = > 300 μm; b = 300-150 μm and c = 150-63 μm
Foram. = foraminifera, Sil. Sp. = siliceous spicules,
Cal. F. = calcareous fragments, F. Th. = fish teeth,
Radio. = radiolaria, Micr. = manganese micronodules,
Sil. F. = siliceous fragments, Min. = minerals,
Diatom = diatoms, Oth. = others.
Spg. = sponges,

or calcareous ooze areas where they are more in the middle fraction (300-150 μm) of the coarse fraction. The distribution and description of the micronodules have been dealt with in greater detail elsewhere[20].

Mineralogy—Mineralogy of the bulk sample and the clay fraction (<2 μm) of the 9 sediment samples was determined by X-ray diffraction (Table 5). The semiquantitative percentage of each mineral identified is based on the relative intensities of their principal XRD peaks. There appears to be not much difference in the mineralogical composition and relative abundance of each mineral in the bulk sample and <2 μm fraction of the same sample. The clay mineral content was, however, slightly higher in <2 μm fraction than in the bulk sample.

Area C sediments are characterised by quartz and smectite (montmorillonite) with lesser amounts of chlorite + kaolinite, illite and feldspar (plagioclase) except for sample 5 KG where calcite forms more than 80% of the total sample with illite, quartz, feldspar and chlorite in low percentages (Table 3). This difference in mineralogy within Area C reflects the different facies of the sediments. Krömer[16] reported quartz, mica, feldspar, chlorite, illite and siderite from equatorial N. Pacific sediments. Mica may be illite. Hein *et al.*[17] reported smectite as the dominant constituent of clay mineral from their Areas A and B in the equatorial N. Pacific sediments. Area C of the present study is close to their Area B and our findings are in agreement with their observations.

Calcite is the dominant mineral and constitutes over 80% of the sediments from Areas D, F and G. Quartz, smectite, chlorite + kaolinite, illite and plagioclase are present in small amounts (<5%) in the sediments from these areas (Table 5) and minor amounts of magnetite. The magnetite is a reflection of the presence of volcanoclastic material in Area K sediments.

The mineralogy of Area K sediment is characterised by quartz and smectite with moderately high percentages of chlorite + kaolinite, feldspar, illite and calcite. Meylan[18] reported quartz, feldspar and calcite as non-clay minerals and montmorillonite, illite,

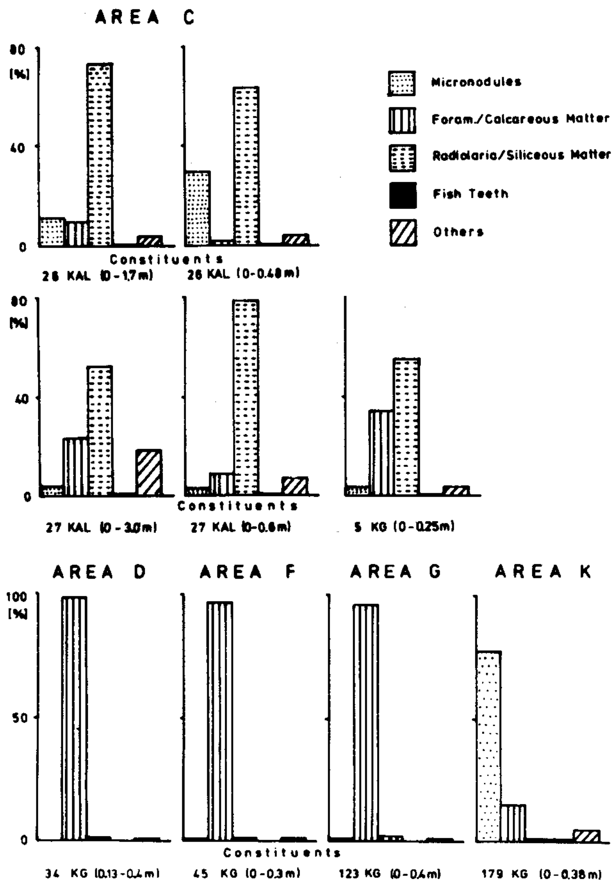

Fig. 3—Frequency distribution of different constituents in the coarse fraction (>63 μm) of sediments from sampling areas

chlorite and kaolinite as clay minerals from southwest Pacific sediments. No zeolite (as reported by Nayudu[19] from southwestern Pacific basin brown clays) was observed.

A big "hump" of amorphous material was observed in the X-ray diffraction patterns of sediments from Areas C and F. This may be due to volcanic glass or biogenic silica in the sediments. Melguen[23] described the composition of these sediment samples based on the smear slide studies and did not observe volcanic glass in these sediments. This suggests that the amorphous material in the sediment is of biogenic origin.

Calcite in the sediments is mainly foraminifera and nanno fossils.

Griffin *et al.*[12], Windom[13] and Rateev *et al.*[24] described the distribution of clay minerals in the world oceans. Chlorite, montmorillonite, illite and kaolinite are present in varying amounts in the surface sediments of the Pacific. They argued for the continental source for these minerals. Montmorillonite may form *in situ*.

Considerable amount of kaolinite + chlorite and illite are present in the sediments from Areas C and K in the < 2 μm size class. These minerals are also present in small amounts (< 5%) in the < 2 μm size class of sediments from Areas D, F and G. The high calcite peaks have suppressed the clay mineral peaks in these sediments.

Kaolinite and illite have not been reported in the

Table 5—Semiquantitative Distribution of Different Minerals in Sediments Based on the Relative Intensities of Principal XRD Peaks

Area	Sample No.	Fraction	Q	S	Ch+K	I	P	C	R
C	26KAL (0-1.7m)	Bulk	+++	+++	++	++	++		+ ML
		< 2μm	++	+++	+++	+++	+		++ ML
	26KAL (0-0.48m)	Bulk	+++	+++	++	++	++		+ Si
		< 2μm	+++	+++	+++	+++	++		+ ML
	27KAL (0-3.0m)	Bulk	+++	+++	++	++	++		+ Si
		< 2μm	++	+++	+++	+++	+		+ Si
	27KAL (0-0.4m)	Bulk	+++	+++	+++	++	++		
		< 2μm	++	+++	+++	+++	+		
	5KG (0-0.25m)	Bulk	+	+	+	+	+	++++	
		< 2μm	+	+	+	+	+	++++	
D	34KG (0.13-0.4m)	Bulk	+	+				++++	
		< 2μm	+	+	+	+	+	++++	
F	45KG (0-0.3m)	Bulk	+	+	+	+	+	++++	
		< 2μm	+	+	+	+	+	++++	
G	123KG (0-0.4m)	Bulk	+	+	+	+	+	++++	
		< 2μm	+	+	+	+	+	++++	
K	179KG (0-0.38m)	Bulk	+++	+++	+++	++	+++	++	
		< 2μm	+++	+++	+++	++	++	++	

Q — quartz,
S — smectite.
Ch + K — chlorite + kaolinite,
I — illite,
P — plagioclase,
R — rest (ML-mixed layer; Si-SiO_2 amorphous),

++++ — dominant (> 80%),
+++ — major (21-40%),
++ — considerable (5-20%)
\+ — Trace (< 5%).

ocean sediments. Chlorite, sometimes, is reported to have formed *in situ*[25] but, in general, it is terrigenous in origin. The presence of kaolinite, illite and chlorite in varying amounts in the clay fraction (<2 μm) of these sediments suggests a terrigenous source. Hein *et al.*[17] reported that quartz, feldspar, illite and chlorite +kaolinite in the equatorial N. Pacific sediments are terrigenous and aeolian in origin. The presence of quartz in the <2 μm size class sediment samples studied indicates a continental source. Heath[26] showed that quartz and feldspar are of aeolian origin in north equatorial Pacific sediments. Meylan[18] and Thiede[27] suggested an aeolian origin for quartz in southwest Pacific sediments.

The presence of smectite and feldspar (plagioclase) in these sediments suggests some volcanic contribution but smectite may also form in marine environments and may be authigenic in origin[17]. No volcanic glass and zeolites were reported from these samples[23]. X-ray diffractogram also do not show presence of zeolites in these sediments. Smectite in these sediments might, therefore, be authigenic in origin as reported by Hein *et al.*[17] for equatorial N. Pacific sediments. The feldspar (plagioclase) appears to be acidic in nature which suggests a terrigenous and aeolian origin as reported by Heath[26] from equatorial N. Pacific sediments.

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