THE FORAMINIFERAL ASSEMBLAGES IN THE SURFACE SEDIMENTS FROM THE CENTRAL PACIFIC OCEAN

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ABSTRACT

As a result of the quantitative and qualitative analyses of foraminifera from 18 surface sediment samples taken from the Central Pacific Ocean, three assemblages of benthonic foraminifera in different water depths are preliminarily recognized, namely, (i) shelf assemblage of *Amphistegina venosa* (Fichtel and Moll) and *Calcarina hispida* Brady, inhabiting areas with water depths less than 100 m, (ii) bathyal assemblage of *Globocassidulina subglobosa* (Brady) and *Osangularia bengalensis* (Schwager), with water depths ranging from 900 to 4800 m, and (iii) abyssal assemblage of *Cribrostomoides subglobosum* (Sars) and *Cystammina galeata* (Brady), characteristic of water depths greater than 4800 m. However, the assemblage of the planktonic foraminifera in all 18 sediment samples is quite similar and consists mainly of 26 species, such as *Globigerinoides ruber* (d'Orbigny), *G. sacculifer* (Brady), *G. conglobatus* (Brady), *Globoquadrina dutertrei* (d'Orbigny), *Pulleniatina obliquiloculata* (Parker and Jones), etc.

I. INTRODUCTION

Foraminiferal test is an important component of ocean sediments as well as a sensitive indicator of marine sedimentary environments. In the marine geological research, the foraminiferids play an important part in such investigations as geochronology, palaeoclimatology, palaeooceanography, sea-floor spreading, $CaCO_3$ cycle, sea level variations and stratigraphic correlation.

In 1978, a series of ocean bottom samples were collected by National Bureau of Oceanography from the Central Pacific Ocean and Providing a wealth of materials for the study of foraminifera in the Pacific Ocean in our country.

18 surface sediment samples discussed in the paper are from the tropical area of the northern part of South Pacific Ocean (between 171°—178°30′E, 178°—179°30′W and 6°—17°S) (Fig. 1). An average temperature of the surface layer water is about 26°—29°C throughout the year. Sampling depths range from 45 to 5400 m, representing the sedimentary environments from shelf edge to deep sea basin.

The primary purpose of this study is to recognize the distribution of foraminiferal assemblages and their quantity in the surface sediments and to discuss the factors influencing their distribution on the sea bottom.

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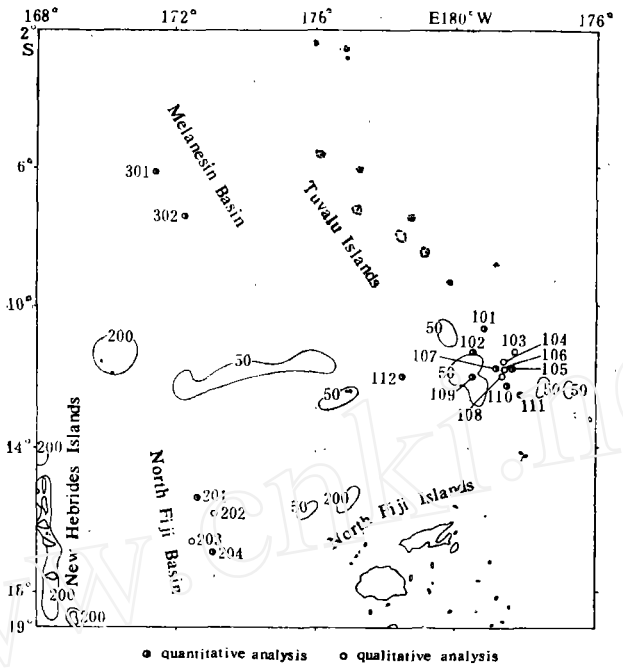

Fig. 1. Sampling sites in the Central Pacific Ocean.

II. PLANKTONIC FORAMINIFERA

The foraminifera found in the surface sediments from the Central Pacific Ocean consists mainly of the following 26 species (ranking of species in order of decreasing number): *Globigerinoides ruber* (d'Orbigny) (Plate I, Figs. 5—8), *G. sacculifer* (Brady) (Plate I, Figs. 9—12), *G. conglobatus* (Brady) (Plate I, Figs. 2—4), *Globoquadrina dutertrei* (d'Orbigny) (Plate II, Figs. 11—12), *Pulleniatina obliquiloculata* (Parker and Jones) (Plate II, Figs. 14—15), *Globigerinita glutinata* (Egger) (Plate I, Figs. 24—25; Plate II, Figs. 7—8), *Globorotalia menardii* (d'Orbigny) (Plate II, Figs. 22—23), *G. tumida* (Brady), *Globigerina rubescens* Hofker (Plate I, Figs. 18—19), *Globigerinella aequilateralis* (Brady) (Plate I, Figs. 26—29), *Globorotalia truncatulinoides* (d'Orbigny) (Plate II, Figs. 20—21), *G. crassaformis* (Galloway and Wissler) (Plate II, Figs. 16—17), *G. scitula* (Brady) (Plate II, Figs. 18—19), *Globigerinoides tenellus* Parker (Plate I, Figs. 14—15), *Globigerina quinqueloba* Natland (Plate II, Figs. 5—6), *Orbulina universa* d'Orbigny (Plate I, Fig. 13), *Candeina nitida* d'Orbigny (Plate II, Fig. 13), *Sphaeroidinella dehiscens* (Parker et Jones) (Plate I, Figs. 16—17), *Globigerina falconensis* Blow (Plate I, Figs. 22—23), *Globorotalia humilis* (Brady) (Plate II, Figs. 1—2), *Globoquadrina hexagona* (Natland), *Globigerinella adamsi* (Banner et Blow) (Plate I, Figs. 20—21), *Globigerina digitata* Brady (Plate I, Fig. 1), *G. bulloides* d'Orbigny (Plate II, Figs. 9—10), *G. pumilio* Parker (Plate II, Figs. 3—4), *Globoquadrina conglomerata* (Schwager), etc.

The above-listed 26 species are almost the tropical and subtropical forms, while the

species of the temperate zone, such as *Globigerina bulloides*, are extremely rare. The collecting direction of planktonic foraminiferal tests which indicate the temperate difference of sea water does not change within the area. These are in agreement with the condition that water temperature of the surface layer in the studied ocean region averages over 26°C throughout the year. This shows that the area belongs to the ocean region of the tropical zone under the control of warm current.

The genera and species of planktonic foraminiferal assemblage in all the sediment samples taken from the area are about the same and are dominated by *Globigerinoides ruber*, *G. sacculifer*, *Globoquadrina dutertrei*, *Pulleniatina obliquiloculata* and *Globorotalia menardii*, of which the first two species make up about 60% of the planktonic population. Besides, such species as *Globigerinoides conglobatus*, *Globigerinita glutinata*, *Globorotalia humida*, *Globigerina rubencens*, *Orbulina universa*, *Globigerinella aequilateralis*, *Globigerina quinqueloba*, etc. are also quite common. However, there are some differences in the sediment samples taken from the northern part of the area (i.e., in the Melanesia Basin) where planktonic foraminiferal tests have been intensely subjected to solution, so that the solution-resistant species such as *Pulleniatina obliquiloculata*, *Globorotalia menardii*, *Globoquadrina dutetrei*, appear in great numbers, but the solution-susceptible species like *Globigerinodes ruber*, *G. sacculifer*, etc. are much less or even none.

The numbers of the foraminiferal tests in the surface sediments of the area are mainly controlled by the water depth. The average number of the foraminifera per gram of sediment is only 5 specimens at a depth less than 100 m, 70680 specimens at a depth between 900 and 4800 m, and less than 10 specimens or none at a depth greater than 4800 m (Fig. 2,

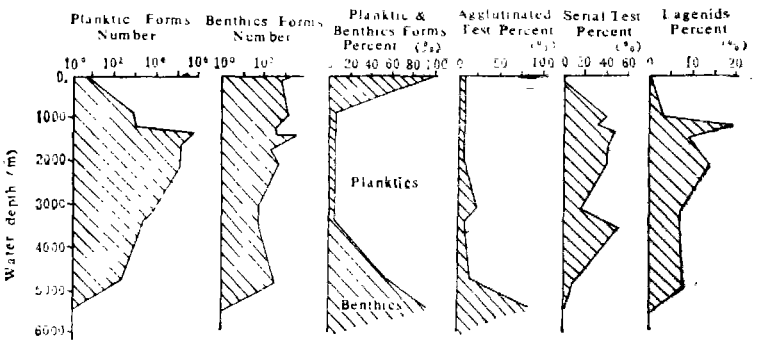

Fig. 2. *Foraminiferal specimens/g and percentage of part of benthonic forms in the different depths.*

Table 1). The low number in shallow water region is due to the coarse deposition materials, high deposition rate, abundant benthonic organisms and a thinner water layer of planktonic foraminifera living, while that in the deep water region is due to the strengthened carbonate dissolution under low temperature and high hydrostatic pressure. That is why the highest content of foraminiferal tests in the surface sediments occurs in sub-deep sea (900—4800 m).

Table 1

The Distribution of the Numbers of Foraminiferal Forms in the Surface Sediments From the Central Pacific Ocean

Site	Depth (m)	Sediment Type	Longitude	Latitude	Number of Planktics per Gram	Number of Benthics per Gram	Planktics Occupies Precentage of the Total Population	Agglutinate		Porcelaneous		Lagenids		Hyaline					
														Serial		Planispira		Trocho-Spiral	
								No.	%*	No.	%*	No.	%*	No.	%*	No.	%*	No.	%*
109	45	coarse sand and gravel	179°29′05″W	12°00′07″S	6	1730	0.4%	16	0.9	104	5.9	2	0.1	30	1.7	144	8.5	1434	82.3
101	51	coarse sand and gravel	179°12′02″W	10°40′06″S	4	533	0.7%	7	1.3	56	10.5	1	0.2	3	0.5	75	14.0	391	73.1
105	910	clay-silty sand	178°26′00″W	11°47′01″S	65300	1219	98.0%	28	2.3	39	3.2	39	3.2	518	42.5	15	1.2	580	47.6
111	1250	silt-sandy clay	178°09′01″W	12°32′00″S	67700	253	99.5%	2	0.79	23	9.1	48	18.9	83	32.8	10	4.0	87	34.3
110	1320	mid fine sand	178°30′09″W	12°18′04″S	118100	284	99.2%	3	1.1	16	5.6	34	11.9	156	54.6	1	0.35	74	25.9
102	1370	silty sand	179°27′08″W	11°18′02″S	226100	2400	98.6%	40	1.6	40	1.6	224	9.4	1136	46.9	40	1.6	920	38.3
112	1680	silty sand	178°30′00″E	12°00′00″S	107700	210	99.1%	2	0.97	10	4.9	24	11.6	82	39.4	14	6.8	78	37.2
107	2000	sand	178°49′06″W	11°46′05″S	117300	444	99.7%	2	0.44	16	3.6	62	14.0	190	42.8	12	2.7	162	36.5
204	3050	fine sand	173°00′00″E	16°56′00″S	7500	42	99.0%	10	23.8	3	7.1	3	7.1	8	19.0	4	9.5	14	33.3
201	3435	sandy silt	172°33′06″E	15°25′09″S	2000	41	98.0%	2	4.8	2	4.8	3	7.2	22	53.4	1	2.4	11	26.9
301	4784	silty clay	171°28′01″E	06°04′00″S	250	256	48.3%	34	13.2	2	0.80	21	8.2	14	5.5	40	16.3	145	56.2
302	5412	silty clay	173°18′08″E	08°01′02″S	1	7	10.4%	6	86.0	1	14.0	0	0	0	0	0	0	0	0

* Precentage of benthonic foraminifera.

At the same time, the percentage which planktonic foraminifera makes up the number of the total population also changes with depth. The average percentage of planktonic foraminifera is less than 1% in the region with water depth less than 100 m, more than 98% at a depth between 900—4800 m and less than 10% at water depths greater than 4800 m.

III. BENTHONIC FORAMINIFERA

More than 300 species of benthonic foraminifera are found in 18 surface sediment samples from the Central Pacific Ocean. The areas of the most abundant foraminifera are located in the shallow sea and in the upper part of sub-deep sea. And the numbers reduced in deep sea. The average number of benthonic foraminifera per gram of sediment is 1130 at a depth less than 100 m, 445 at a depth between 900 to 4800 m, and about 7 at a depth greater than 4800 m. It is obvious that the number of foraminifera decrease with the increase of water depth.

Three assemblages of benthonic foraminifera were preliminarily established in the area, each representing the environment at different water depths:

(1) A shelf assemblage represented by such species as *Amphistegina venosa* (Fichtel and Moll) (Plate III, Fig. 10), *Calcarina hispida* Brady (Plate III, Figs. 7—8), *Heterostegina suborbicularis* d'Orbigny (Plate III, Fsg. 9), *Schlumbergerina alveoliniformis* (H. B. Brady) (Plate III, Figs. 1—2), *Marginopora vertebralis* Quoy and Gaimard (Plate III, Figs. 5—6), *Triloculina kerimbatic* (Heron-Allen and Earland) (Plate III, Figs. 3—4), *Cymbaloporetta bradyi* (Cushman) (Plate III, Figs. 11—12) and *Anomalinella rostrata* (Brady) (Plate III, Figs. 13—14). Most of them are with greater tests related to coral reefs in the shallow water of the tropical zone and scarcely seen in the deeper water area except for *Cymbaloporetta bradyi*. The assemblage is distributed in the area with a depth less than 100 m.

(2) A bathyal assemblage represented by such species as *Globocassidulina subglobosa* (Brady) (Plate III, Figs. 17—18), *Osangularia bengalensis* (Schwager) (Plate IV, Figs. 11—12) and *Epistominella exigua* (Brady) (Plate IV, Fig. 7), distributed in the sea-floor with a depth ranging from 900 to 4800 m. Three subassemblages may be distinguished:

(i) *Rosalina pacific* (Hofker) (Plate IV, Fig. 6) subassemblage in the region with a water depth of 900 to 1300 m, the common species are *Rosalina pacific*, *Bolivinella folia* (Parker and Jones) (Plate III, Figs. 15—16), *Cymbaloporetta bradyi*, *Fijiella simplex* (Cushman) (Plate III, Figs. 19—20), *Uvigerina asperula* Czjzek (Plate IV, Fig. 1), etc.

(ii) *Gavelinopsis praegeri* (Heron-Allen and Earland) (Plate IV, Figs. 9—10) subassemblage, the common species are *Gavelinopsis praegeri*, *Pullenia bulloides* (d'Orbigny) (Plate IV, Fig. 15), *Uvigerina asperula*, *Fijiella simplex*, *Cibicides wuellerstorfi* (Schwager) (Plate IV, Figs. 4—5), etc. The subassemblage is mainly distributed in the region with water depth of 1300 to 3000 m.

(iii) *Cyclammina bardyi* Cushman (Plate IV, Figs. 13—14) subassemblage, the common species are *Cyclammina bradyi*, *Favocassidulina favus* (Brady) (Plate IV, Figs. 2—3),

Pullenia bulloides, *Melonis pompilioides* (Fichtel and Moll) (Plate IV, Fig. 8), etc. The subassemblage is chiefly distributed in the region with a water depth of 3000 to 4800 m.

(3) An abyssal assemblage of *Cribrostomoides subglobosum* (Sars) (Plate IV, Figs. 16—17) and *Cystammina galeata* (Brady) (Plate IV, Figs. 21—22) characterized by agglutinant foraminifera of deep water, is mainly composed of *Cribrostomoides subglobosum*, *Cystammina galeata*, *Cyclammina bradyi*, *Glomospira* sp. (Plate IV, Fig. 18) and a few of calcareous forms such as *Miliolinella* sp. (Plate IV, Figs. 19—20). The assemblage is distributed in the Melanesia Basin with a water depth greater than 4800 m.

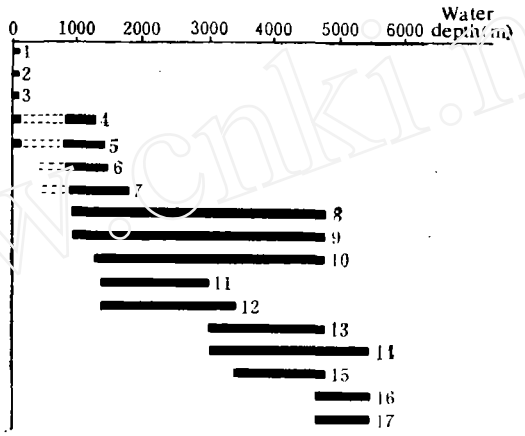

Fig. 3. Water depth distribution of some characteristic species in the Central Pacific Ocean.

1—*Amphistegina venosa*;
2—*Heterostegina suborbicularis*;
3—*Calcarina hispida*;
4—*Bolivinecella folia*;
5—*Cymbaloporetta bradyi*;
6—*Rosalina pacific*;
7—*Uvigerina asperula*;
8—*Osangularia bengalensis*;
9—*Globocassidulina subglobosa*;
10—*Epistominella exigua*
11—*Cibicides wuellenstorfi*;
12—*Gaveliopsis praegeri*;
13—*Favocassidulina favus*,
14—*Cyclammina bradyi*;
15—*Melonis pompiliodes*;
16—*Cystammina galeata*;
17—*Cribrostostomoides subglobosum*.

The distribution of the above-mentioned foraminiferal assemblages and a few of major species (Fig. 3) clearly shows that the distribution of benthonic foraminifera has a distinct zonality of water depth (Table 2). Another marked feature of its distribution in the area is that the ranging pattern of benthonic foraminiferal chambers and the composition of the foraminiferal tests are distinct in the different water depths, that is, the area with water depth less than 100 m is dominated by the trochospiral and planispiral tests, accounting for about 89% of the total benthonic foraminifera in the sediments on an average; the region between 900 and 4800 m is dominated by the serial and trochospiral forms, averaging up to about 74%; and the region of water depths greater than 4800 m is dominated by the agglutinant forms, making up about 86% on the average. It is to be noted that the distribution areas of

the three forms of benthonic foraminifera in the different water depths are just those of the three types of the different sediments (i.e., coarse sand and gravel, silty sand and fine sand silty clay).

Table 2

The Distribution of the Water Depth of Benthonic Foraminiferal Assemblages and the Content of Foraminifera (Average Number/g) in the Surface Sediments From the Central Pacific Ocean

Water Depth (m)		Foraminiferal Assemblages		Foraminiferal Content (Average) Individual/g		
				Planktonic	Benthic	Planktonic (%)
<100		*Amphistegina venosa*–*Calcarina hispida*		5	1130	<1
900–4800	900–1300	*Globocassidulina subglobosa*–*Osangularia bengalensis*	*Rosalina particle*	70,680	445	>95
	1300–3000		*Gavelinopsis praegeri*			
	3000–4800		*Cyclammina bradyi*			
>4800		***Cribrostomoides subglobosum*–*Cystammina galeata***		1	7	<10

In the deep sea sediments, the percentages of agglutinant and calcareous tests of benthonic foraminifera are very important. Their distribution are closely related to the water depth. In general, calcareous tests tend to predominate on plateaus, rises, ridges and upper slopes, while agglutinant tests predominate in the sediments of deep basins. The boundary between calcareous and agglutinant foraminifera in the most deep sea sediments is located closely to the carbonate compensation depth (CCD) (Echols, 1971). The percentage of calcareous tests in the studied area is about 86% near the water depth of 4800 m, while in the region with a water depth greater than 4800 m, it suddenly decreases to about 14% and that of agglutinant forms rapidly increases to about 86%. The boundary of sudden change is just located closely to the CCD of the area. It may be seen that fluctuations in the contents of calcareous and agglutinant foraminifera can be applied to reflect the sedimentary environments in the deep sea.

IV. FACTORS CONTROLLING DISTRIBUTION OF FORAMINIFERA

Since the temperature and salinity through the year show no distinct variation within the area, the major factors controlling the distribution of foraminiferal assemblages are water depth, sediments typeary and carbonata dissolution. In fact, the above-mentioned three assemblages of benthonic foraminifera in the sediments are just reflected in the three kinds of different sediment environments in the area. These environmental factors have controlled the distribution of foraminifera and also determined the different types of sediments. They are as follows:

1. *Coral and Sand Gravel of Shallow Sea* (< 100 m)

This region belongs to the shallow water environment with thriving benthonic organisms and strong hydrodynamic action. The sediments sampled from the region are composed of organic skeletons and their fragments. The species of benthonic foraminifera make up more than 99% of the total foraminiferal population and are predominantly with coral symbiotic larger calcareous foraminifera restricted to shallow sea of the tropical zone, in which the number of three dominant species as *Amphistegina venosa*, *Calcarina hispida* and *Heterostegina suborbiculatris* make up 73% of the total population (Fig. 4). Here, the foraminiferal tests are generally large, but the majority of them were destroyed. A part of foraminifera tests were subjected to violentl wearing. For example, the walls of *Schlumbergerina alveoliniformis* were worn into holes. It is obvious that the region represents the environment with stronger water powers.

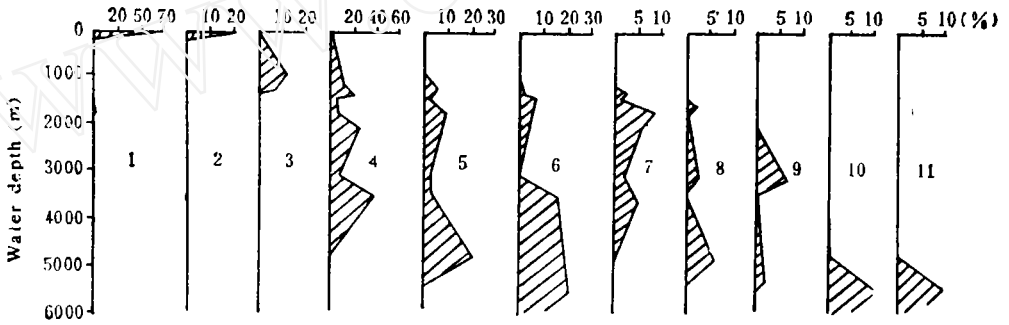

Fig. 4. Percentage of part characteristic species in the Central Pacific Ocean.

1—*Amphistegina venosa*; 2—*Calcarina hispida*;
3—*Rosalina pacific*; 4—*Globocassidulina subglobosa*;
5—*Osangularia bengalensis*; 6—*Epistominella exigua*;
7—*Gavelinopsis praegeri*; 8—*Melonis pompiliodes*;
9—*Cyclammina bradyi*; 10—*Cribrostomoides subglobosum*;
11—*Cystammina galeata*.

2. *Bathyal Fine Sand And Silty Sand* (900—4800 m)

The bathyal sediments represent the sedimentary environment short of terrigenous debris and are mainly made of foraminiferal tests and remains of other organisms, except those parts which are rich with volcanic debris. Therefore, there is a large number of foraminiferal tests in the region. The number of foraminiferal tests per gram of surface sediment may generally exceed several ten thousand specimens or reach more than 200,000. Only samples collected from the northern Fiji Basin (2500—4000 m) which contains a great number of volcanic debris have several thousand specimens of foraminifera tests. The planktonic foraminifera predominates in the foraminiferal population and accounts for over 98% of the total forminiferal population. The species of planktonic population are dominated by *Globigerinoides ruber*, *G.*

sacculifer, *G. conglobatus*, etc. which live in the tropical and subtropical zones. Benthonic foraminiferal population is dominated by calcareous serial and trochospiral tests of bathyal region. The species are various without distinct dominant species, in which the genus and species like *Globocassidulina*, *Cassidulina*, *Epistominella*, *Osangularia*, *Cibicides*, *Melonis*, etc., are common in the region, showing the features of foraminiferal assemblage in the bathyal region. In addition, the complete foraminiferal tests within the area are well preserved in the surface sediments below the water depth less than 3000 m, but a lot of dissolved tests of planktonic foraminifera and solution-resistant species of benthonic foraminifera, such as *Osangularia bengalensis*, *Epistominella exiga*, have been found in the region with water depths between 4000 and 4800 m.

3. *Deep Sea Red Clay* (> 4800 m)

This is the sediments located below the carbonate compensation depth. Since the tests of calcareous organisms in the sediments have been strongly subjected to solution, the number of foraminifera and their species are largely reduced. For example, in the south of the Melanesia Basin of the studied area, only 8 specimens of foraminiferal tests per gram of sediment were found. The foraminifera of non-calcareous agglutinant tests of deep water, such as *Cribrostomoides subglobosum*, *Cystammina galeata*, *Cyclammina bradyi*, develop in the sediments (i. e., red clay). Calcareous foraminiferal tests disappear nearly (except for *Miliolinella* sp.) in the region of water depths greater than 4800 m. Therefore, the foraminifera in the deep sea bottom is fundamentally made of benthonic foraminifera of deep water agglutinant tests. In addition, there is a greater number of radiolaria in the surface sediments. This shows clearly that the deep sea solution contributes much to the transformation of foraminiferal assemblage.

To sum up, water depth is the main factor controlling the foraminiferal distribution in the surface sediments. It is closely related to the ecological environments which determine the distribution patterns of species, and alters the thanatocoenosis of foraminifera in deep sea sediments through the effect of carbonate dissolution. However, the type of sediments is also an influencing factor. For example, the number of foraminiferal species and their tests decrease rapidly in the region developed with volcanic debris. Moreover, the redeposition of the foraminiferal fossils in the older sediments also influences foraminiferal assemblages. For example, the mixed yellowish-brown redeposited fossils such as *Globigerinoides fistulosus* (Schubert) (Plate I, Figs. 30—31) and *Globorotalia multicamerata* Cushman at Tarvis (Plate II, Figs. 24—25) which are brown Pliocene index fossils, are found in the surface sediment of 112 sites from the nothern area of Fiji Island. Therefore, the mixing of the young-old fauna is also a common factor influencing the distribution of foraminiferal assemblages in the sea floor sediments.

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Explanation of Plates

Plate I

Fig. 1. *Globigerina digitata* Brady, ×50.

Figs. 2—4. *Globigerinoides conglobatus* (Brady). (2), ×35; (3—4), ×80.

Figs. 5—8. *Globigerinoides ruber* (d'Orbigny). (5—6), ×55; (7—8), ×75.

Figs. 9—12. *Globigerinoides sacculifer* (Brady). (9—10), ×45; (11—12), ×50.

Fig. 13. *Orbulina universa* d'Orbigny, ×30.

Figs. 14—15. *Globigerinoides tenellus* Parker, ×145.

Figs. 16—17. *Sphaeroidinella dehiscens* (Parker and Jones), ×40.

Figs. 18—19. *Globigerina rubescens* Hofker, ×130.

Figs. 20—21. *Globigerinella adamsi* (Banner et Blow). (20), ×35; (21), ×40.

Figs. 22—23. *Globigerina falconensis* Blow, ×125.

Figs. 24—25. *Globigerinita glutinata* (Egger). (24), ×175; (25), ×165.

Figs. 26—29. *Globigerinella aequilateralis* (Brady). (26), ×95; (27), ×100; (28—29), ×45.

Figs. 30—31. *Globigerinoides fistulosus* (Schubert). (30), ×35; (31), ×30.

Plate II

Figs. 1—2. *Globorotalia humilis* (Brady), ×175.

Figs. 3—4. *Globigerina pumilio* Parker, ×235.

Figs. 5—6. *Globigerina quinqueloba* Natland, ×205.

Figs. 7—8. *Globigerinita glutinata* (Egger), ×135.

Figs. 9—10. *Globigerina bulloides* d'Orbigny. (9), ×90; (10), ×95.

Figs. 11—12. *Globoquadrina dutertrei* (d'Orbigny), ×15.

Fig. 13. *Candeina nitida* d'Orqigny, ×55.

Figs. 14—15. *Pulleniatina obliquiloculata* (Parker and Jones), ×40.

Figs. 16—17. *Globorotalia crassaformis* (Galloway and Wissler), ×60.

Figs. 18—19. *Globorotalia scitula* (Brady), (18), ×50; (19), ×55.

Figs. 20—21. *Globorotalia truncatulinoides* (d'Orbigny), ×45.

Figs. 22—23. *Globorotalia menardii* (d'Orbigny), ×25.

Figs. 24—25. *Globorotalia multicamerata* Cushman et Tarvis, ×55.

Plate III

Figs. 1—2. *Schlumbergerina alveoliniformis* (Brady), ×20.

Figs. 3—4. *Triloculina kerimbatica* (Heron-Allen and Earland), ×35.

Figs. 5—6. *Marginopora vertebralis* Quoy and Gaimard, ×20.

Figs. 7—8. *Calcarina hispida* Brady, ×25.

Fig. 9. *Heterostegina suborbicularis* d'Orbigny, ×20.

Figr 10. *Amphistegina venosa* (Fichtel and Moll), ×35.

Figs. 11—12. *Cymbaloporetta bradyi* (Cushman). (11), ×65; (12), ×70.

Figs. 13—14. *Anomalinella rostrata* (Brady), ×35.

Figs. 15—16. *Bolivinella folia* (Parker and Jones). (15), ×100; (16), ×95.

Figs. 17—18. *Globocassidulina subglobosa* (Brady), ×85.

Figs. 19—20. *Fijiella simplex* (Cushman), ×100.

Plate IV

Fig. 1. *Uvigerina asperula* Czjzek, ×65.

Figs. 2—3. *Favocassidulina favus* (Brady), ×80.

Figs. 4—5. *Cibicides wuellerstorfi* (Schwager), ×45.

Fig. 6. *Rosalina pacific* (Hofker), ×155.

Fig. 7. *Epistomininella exigua* (Brady), ×180.

Fig. 8. *Melonis pompilioides* (Fichtel and Moll), ×45.

Figs. 9—10. *Gavelinopsis praegeri* (Heron-Allen and Earland), ×120.

Fsig. 11—12. *Osangularia bengalensis* (Schwager). (11), ×105; (12), ×90.

Figs. 13—14. *Cyclammina bradyi* Cushman, ×60.

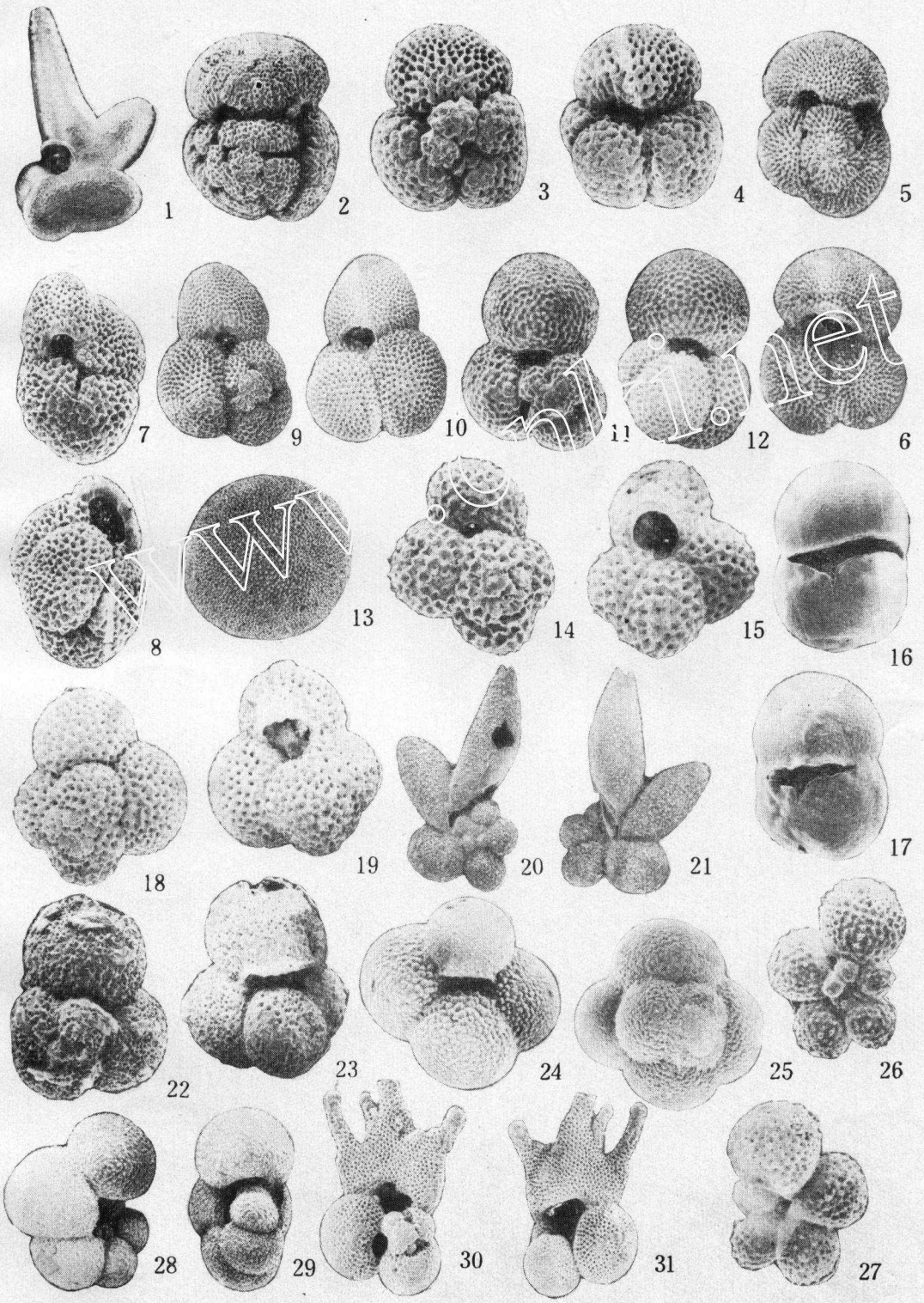
Fig. 15. *Pullenia bulloides* (d'Orbigny), ×150.

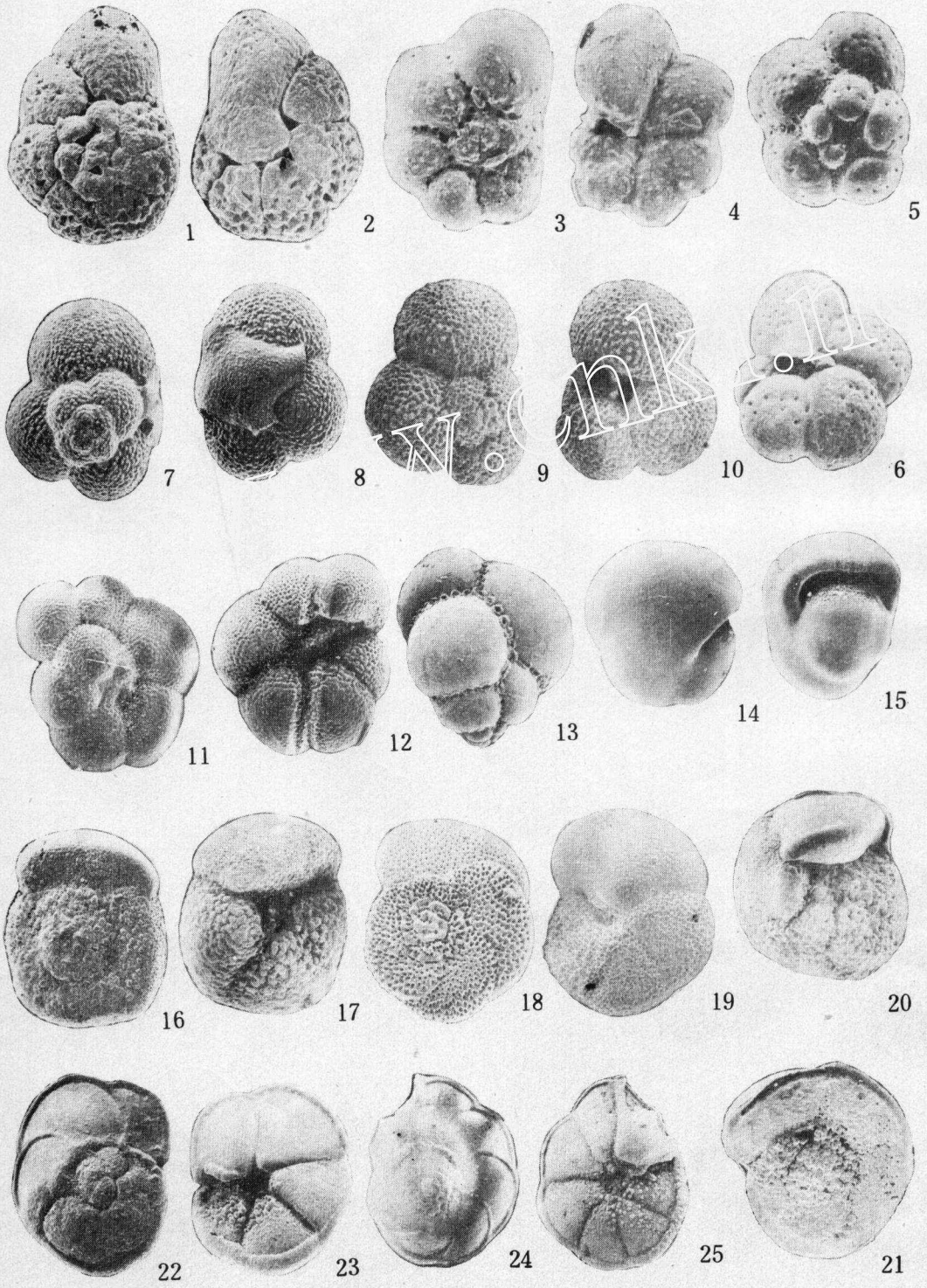
Figs. 16—17. *Cribrostomoides subglobosum* (Sars), ×55.

Fig. 18. *Glomospira* sp. ×210.

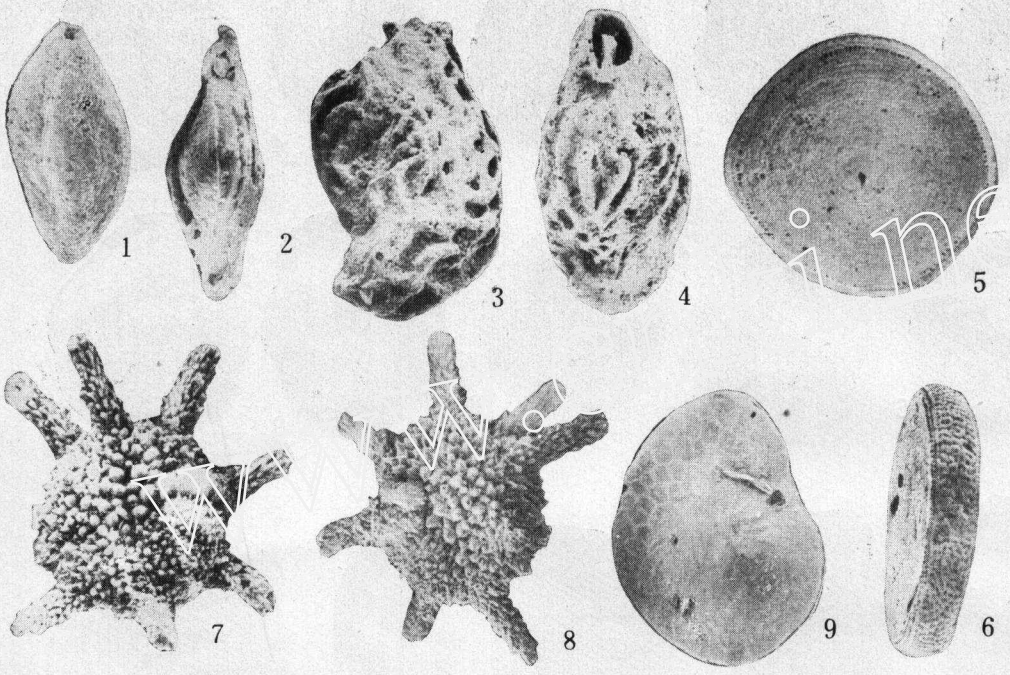
Figs. 19—20. *Miliolinella* sp. (19), ×50; (20), ×60.

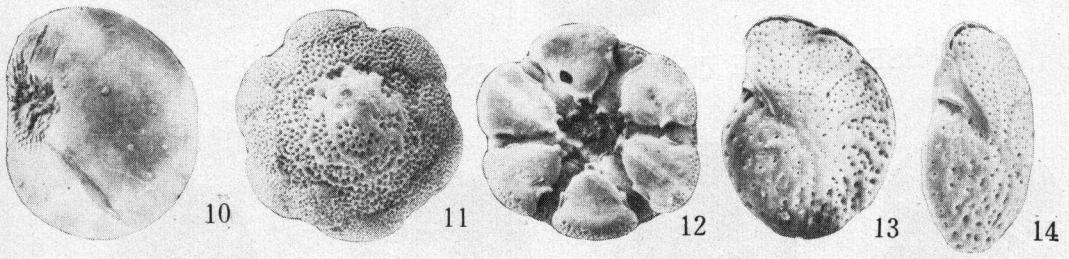
Figs. 21—22. *Cystammina galeata* (Brady), ×55.



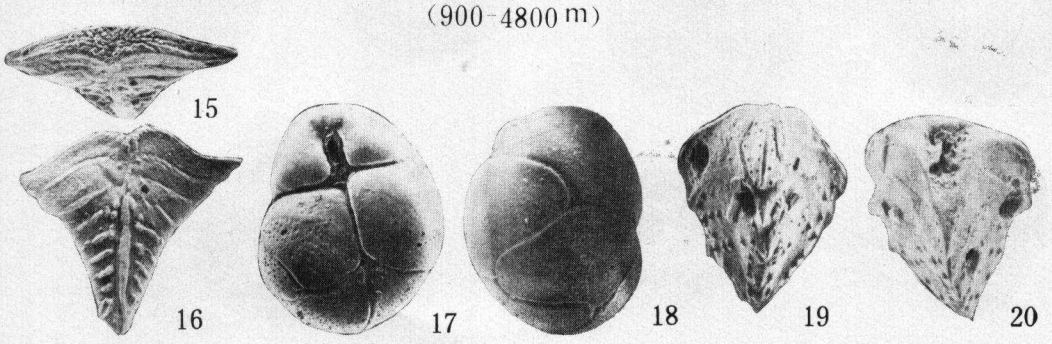


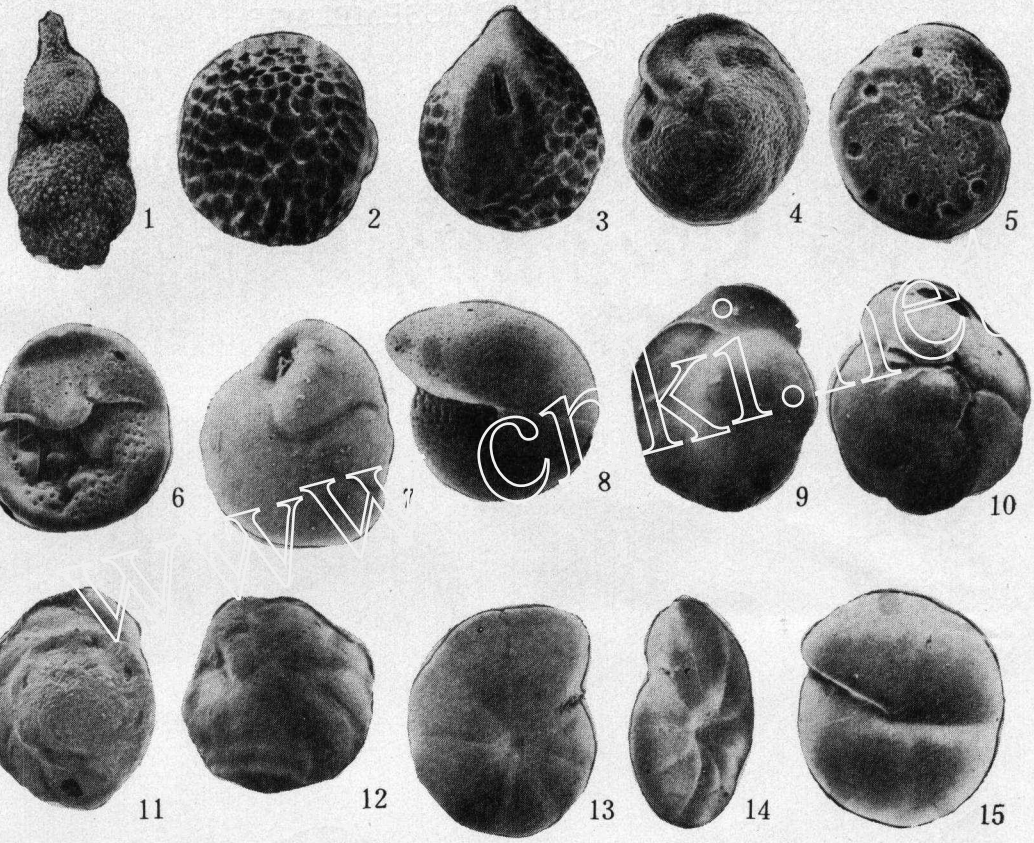
ASSEMBLAGE I -SHELF ASSEMBLAGE
(<100 m)





ASSEMBLAGE II -BATHYAI ASSEMBLAGE
(900-4800 m)





ASSEMBLAGE III - ABYSSAL ASSEMBLAGE

(>4800 m)