

RECENT PLANKTONIC FORAMINIFERA FROM THE SEDIMENT OFF KARWAR AND MANGALORE

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Eleven samples collected from the shelf-slope regions off Karwar and Mangalore transects of the Arabian Sea, yielded fifteen planktonic foraminiferal species, which are identified and described. There is a progressive increase in the percentage of planktonic foraminifera from the shore towards the slope, indicative of a regulated sediment discharge and rate of sedimentation in the area. All the species represented are typical warm-water fauna, with one exception. Undoubtedly, though rare, *Globigerina pachyderma* (Ehrenberg) is present in the slope sediment off Mangalore area but not in the Karwar region, which is very significant since it delineates its northern extension beyond the equator.

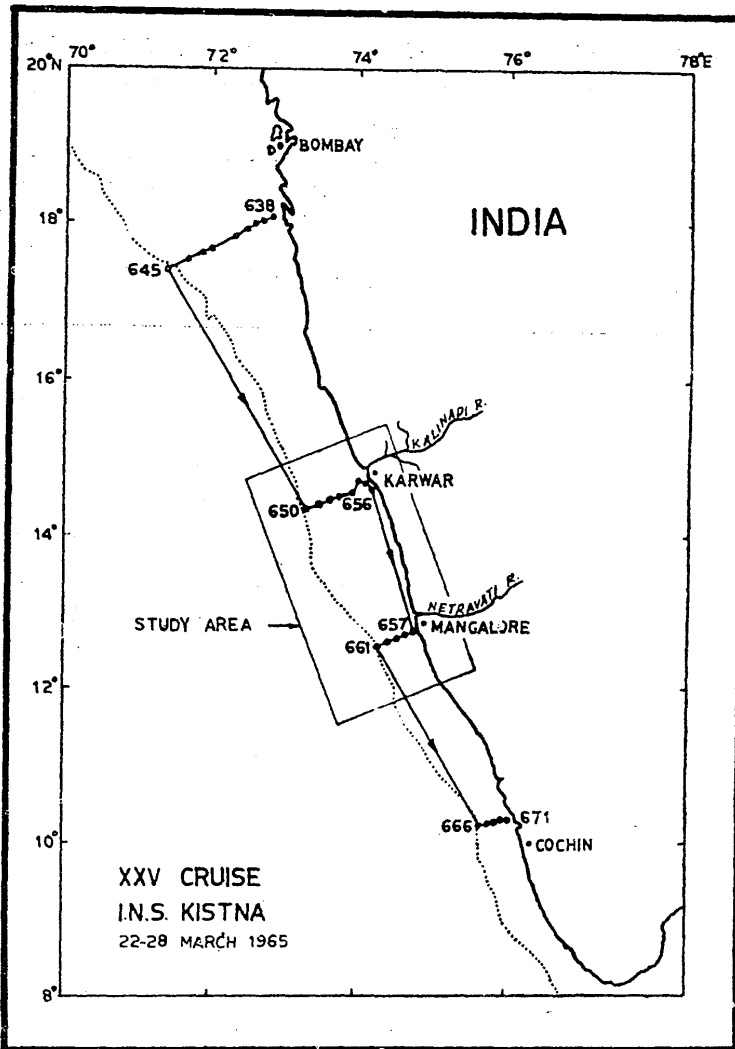
INTRODUCTION

Fifteen planktonic foraminiferal species are identified and described from the shelf sediments of Western India. The eleven samples used for this study were collected during the 25th scientific cruise of INS KISTNA as part of the International Indian Ocean Expedition in 1965, from Karwar (lat. 14° 22.5' N, long. 73° 15' E) and Mangalore (lat. 12° 35' N, long. 74° 16.5' E) regions at positions normal to the coast line. The sampling was done approximately at 5–10 nautical miles interval and, as a result, two samples (Sts. 650 and 661) were collected from the slope (Text Fig. 1).

The size distribution and carbonate content of these sediments were discussed by Nair and Pylee (1968); the organic matter and total phosphorus content by Murty *et al.* (1968, 1969). The present investigation concerns mainly with the planktonic foraminiferal content in the sediment. Among the few notable earlier workers on the foraminiferal assemblages of the bottom sediments of the Arabian Sea are Brady (1884), Chapman (1895) and Stubbings (1939), and recently Rao (1970) and Setty (1972). This paper deals with the planktonic foraminiferal distribution across the continental shelf along two sections; the distance between the two points on land is approximately 232 km. A biometric study of the benthonic population will follow.

PRESENT MATERIAL

The eleven samples collected range in depth from 18 m to 198 m. A unit volume of each sample was wet sieved on a 230 mesh (ASTM) sieve, then dried and concentrated by carbon tetrachloride floatation method; and later the foraminifera



TEXT FIG. 1. Area and track line of XXV Cruise of INS KISTNA

were hand-picked from the residue. Planktonic foraminifera were picked and mounted on faunal slides, at the same time noting their percentage abundance in the concentrated faunal sample. Table I shows percentage frequency of each species recorded at various stations.

LITHOLOGY

The material of the eleven samples from the coast towards the slope varies from grey to greenish grey colour having medium to fine texture. At 18-31 m the substrate is mostly clayey and silty but at 42-201 m it is sandy and medium grained. At 77-201 m it is mostly a calcareous sediment. This is due to the high content of foraminiferal tests and fragmented shell debris in the sediment. Station locations and sedimentary unit types are shown in Table II

The sedimentology of the present material corresponds to the facies zonation as proposed by Schott (1968) for the Western India-Pakistan shelf.

TABLE I
Distribution chart of planktonic foraminifera from Karwar and Mangalore regions

Species	Karwar Region						Mangalore Region				
	Inner Neritic			Outer Slope Neritic			Inner Neritic		Outer Slope Neritic		
	656	655	654	652	651	650	657	658	659	660	661
<i>Globigerina bulloides</i> [d'Orbigny]			4	2	4	4		4	4	4	4
<i>G. calida</i> Parker					1	1			1	1	
<i>G. quinqueloba</i> [Natland]						1					1
<i>G. rubescens</i> [Hofker]						1					1
<i>G. pachyderma</i> [Ehrenberg]						1					1
<i>Globigerinella aequilateralis</i> [Brady]		2	1	1	1	1	2	2	2	2	2
<i>Globigerinoides ruber</i> [d'Orbigny]		4	3	4	4	4	4	4	4	4	4
<i>G. conglobatus</i> [Brady]		2	1	1	1	1	2		1	1	
<i>G. sacculifer</i> [Brady]		4	2	2	2	2	4	3	2	2	
<i>Orbulina universa</i> [d'Orbigny]				1	1	1					1
<i>Globoquadrina dutertrei</i> [d'Orbigny]		2	1	2	2	2	2	2	2	2	3
<i>G. conglomerata</i> [Schwager]					1	1					
<i>G. hexagona</i> [Natland]						1					1
<i>Pulleniatina obliquiloculata</i> [Parker & Jones]		2	2	1	1	1	3	1	2	2	
<i>Globorotalia menardii</i> [d'Orbigny]		2	2	1	1	1	2	2	2	2	

1, 0-5% [rare]; 2, 5-10% [frequent]; 3, 10-20% [common]; 4, >20% [abundant]

Temperature, salinity and oxygen content of the overlying water mass in the area of sampling and the date of sampling are presented in Table III. The temperature variation either at the surface or at the bottom is very marginal, but it is lowest (almost half) at the shelf edge (Sts. 650 and 661).

In the Karwar region, the salinity varies from 33.288°/00 at 195 m to 36.032°/00 at 50 m (on the day the samples were collected). Again, the salinity value appears to increase from 35.633°/00 at 16 m depth to 36.032°/00 at 50 m and 36.284°/00 at the edge of the shelf. It seems to be very nearly uniform at Mangalore region from the coast to the edge of the shelf.

The oxygen content of the water (0.22 and 0.64 ml/l.) at the shelf edge (Sts. 650 and 661) is very low, but highest (4.17 and 4.52 ml/l.) at stations 652 and 659 at 75 and 40 m depths, respectively. This may be due to the mixing of fresh water brought in by the two rivers (Kalinadi and Netravati) at Karwar and Mangalore areas. Therefore, near the coast, even at 18-22 m depth, the faunal content in the sediment is very poor and hence negligible. Thus, the variation in temperature, salinity and

TABLE II

Station locations and sedimentary unit types of the sediment collected

Station Numbers	Depth (m)	Location		Sediment unit	C _a CO ₃ %			Total sample
		Latitude	Longitude		Sand	Silt	Clay	
Karwar Region								
650	201	14° 25.2'N	73°15.0'E	Silty sand	48.0	30.0	21.0	56.0
651	101	14°28.0'N	73°24.2'E	„ „	72.7	17.0	10.3	51.0
652	77	14°30.5'N	73°34.0'E	„ „	75.6	13.3	10.1	47.0
654	46	14°35.2'N	73°53.5'E	„ „	91.0	13.0	5.0	43.0
655	22	14°47.5'N	73°59.8'E	Clayey silt	8.3	60.6	31.1	6.0
656	18	14°40.3'N	74°09.2'E	„ „	9.4	75.6	15.0	3.5
Mangalore Region								
657	18	12°49.0'N	74°45.8'E	Clayey silt	3.2	63.4	33.0	7.0
658	31	12°46.7'N	74°41.0'E	„ „	7.6	80.1	12.3	13.0
659	42	12°43.5'N	74°31.2'E	Silty sand	51.0	35.0	14.0	28.0
660	79	12°38.5'N	74°21.0'E	Clayey silt	—	—	—	—
661	192	12°35.0'N	74°16.5'E	Silty sand	75.0	19.0	6.0	57.0

TABLE III

Salinity, temperature and oxygen ratio of water masses in sampled localities

Station Numbers	Depth (m)	Temperature °C		Salinity %	Oxygen ml/l	Date of Sampling
		Surface	Bottom			
650	195	28.30	15.29	33.288	0.22	25-3-65
651	115	28.40	22.32	35.685	1.29	„
652	75	28.40	27.77	36.28+	4.17	„
654	50	29.10	28.02	36.032	3.32	„
655	20	29.50	27.77	35.790	3.16	„
656	16	29.40	27.86	35.633	3.96	„
657	20	28.90	28.22	35.066	3.40	26-3-65
658	30	28.90	27.75	35.099	3.94	„
659	40	28.90	27.70	34.228	4.52	„
660	81	29.00	24.20	35.728	—	„
661	196	28.95	14.31	35.232	0.64	„

oxygen content of the overlying water has a profound effect on the foraminifera as controlling parameters of the environment in which they live.

The generic and suprageneric classification followed here is the one proposed in the Treatise on Invertebrate Palaeontology (Moore 1964).

Superfamily : Globigerinaceae Carpenter, Parker and Jones 1862

Family : Globigerinidae Carpenter, Parker and Jones 1862

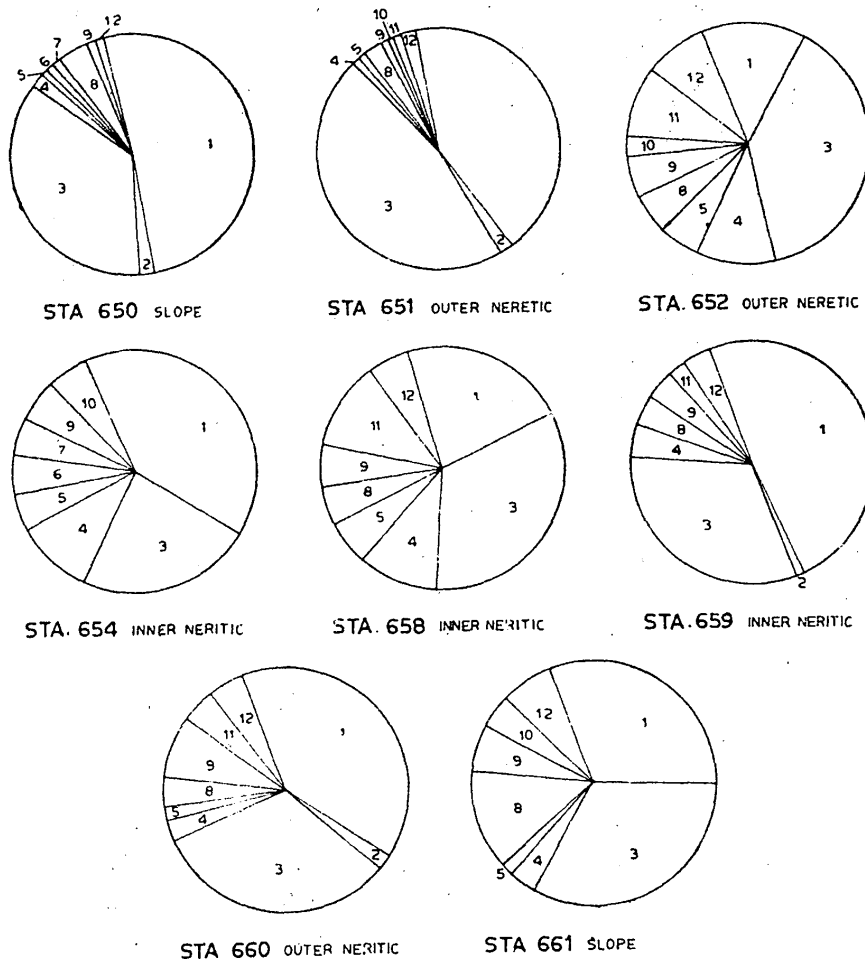
Subfamily : Globigerininae Carpenter, Parker and Jones 1862

Genus : *Globigerina* d'Orbigny 1826

Globigerina bulloides d'Orbigny 1826

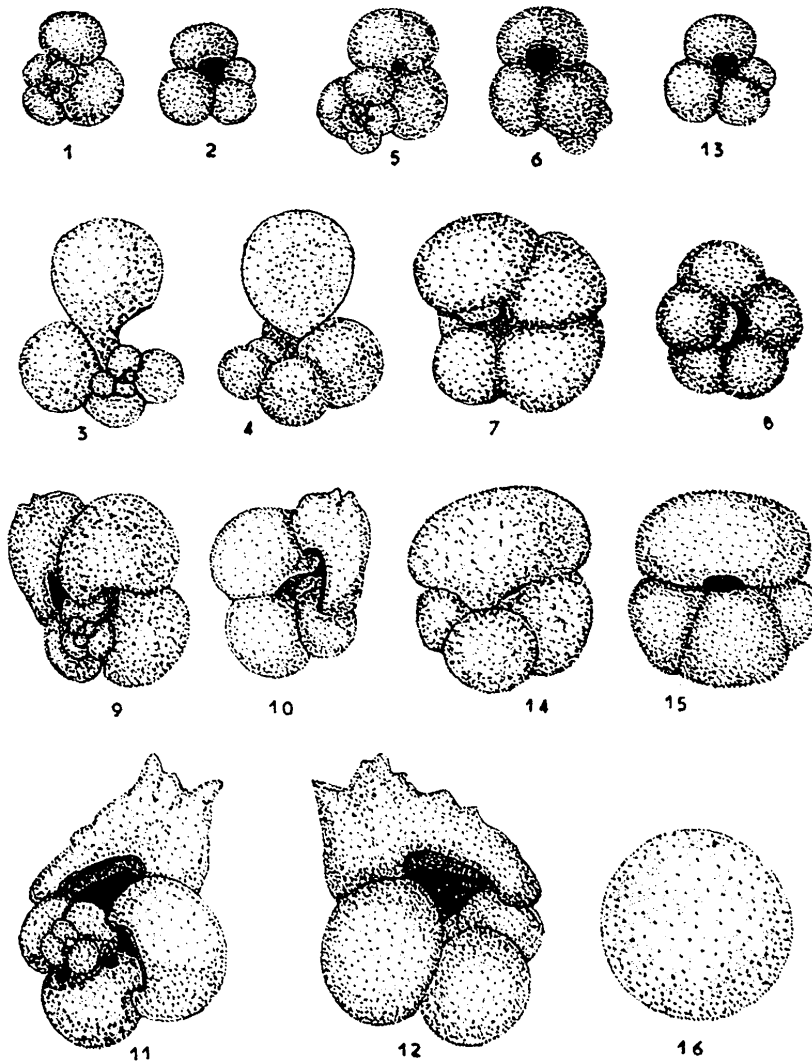
(Pl. XXII, Figs. 1, 2)

1962 *Globigerina bulloides* Parker, *Micropalaeontology*, 8 (2), 122 Figs. 1-8.



TEXT FIG. 2. Percentage circular diagrams showing the pattern of distribution and population control of species in samples from shelf/slope regions : 1, *Globigerina bulloides* [d'Orbigny]; 2, *G. calida* Parker; 3, *Globigerinoides ruber* [d'Orbigny]; 4, *Globigerinoides sacculifer* [Brady]; 5, *G. conglobatus* [Brady]; 6, *Globoquadrina hexagona* [Natland]; 7, *G. conglomerata* [Schwager]; 8, *G. dutertrei* [d'Orbigny]; 9, *Globigerinella aequilateralis* [Brady]; 10, *Orbulina universa* [d'Orbigny]; 11, *Pulleniatina obliquiloculata* [Parker & Jones]; 12, *Globorotalia menardii* [d'Orbigny]

This is a cosmopolitan form, present in the subarctic, transitional, and equatorial waters but practically absent south of 40° . *G. bulloides* is abundant in these samples, and especially in the outer neritic zones of Karwar and Mangalore; however, it is poorly represented in the near shore. Age—upper Cretaceous to Recent.



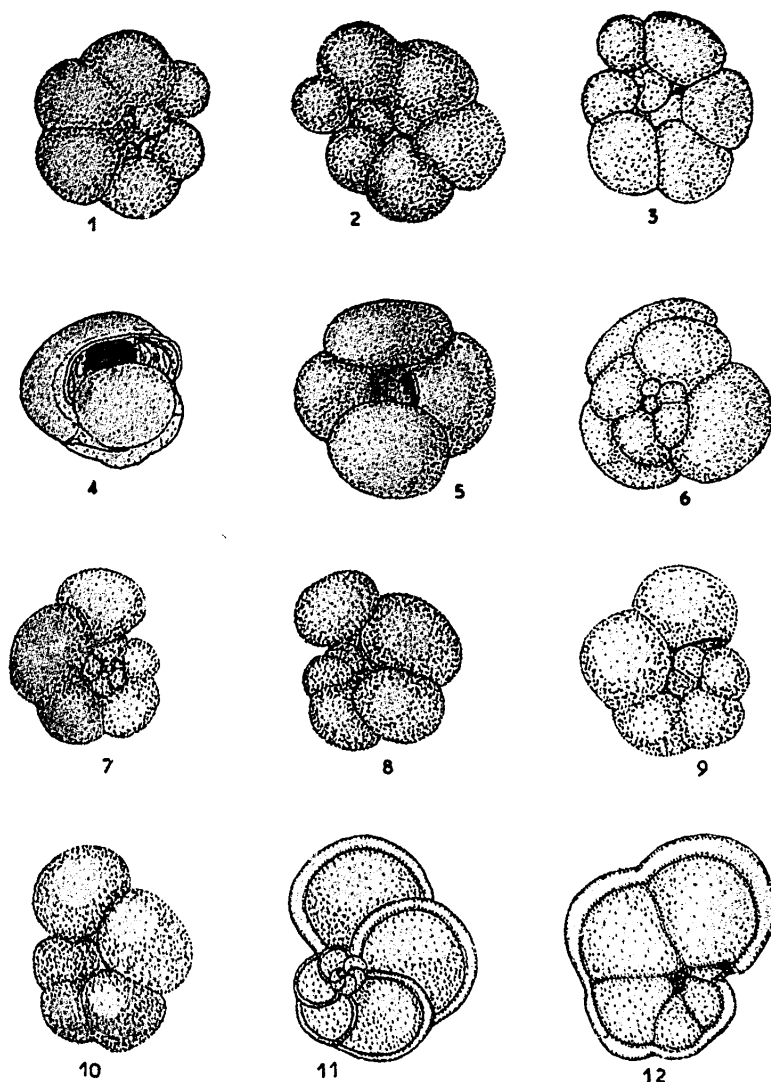
FIGS. 1, 2, *Globigerina bulloides* (d'Orbigny), 1-dorsal, 2-ventral, hypotype, St. No. 661., $\times 30$; 3, 4, *Globigerina calida* Parker, 3-dorsal, 4-ventral, hypotype; St. No. 650., $\times 30$; 5, 6, *Globigerinoides ruber* (d'Orbigny), 5-dorsal, 6-ventral, hypotype, St. No. 661., $\times 30$; 7, *Globigerina pachyderma*, ventral view, hypotype, $\times 30$; 8, *Globigerina quinqueloba*, ventral view, hypotype, $\times 30$; 9-12, *Globigerinoides sacculifer* (Brady), 9 and 11-dorsal, 10 and 12-ventral, hypotype, St. Nos. 651, 658., $\times 30$; 13, *Globigerina rubescens* (Hofker), ventral view, hypotype, St. No. 661., $\times 30$; 14, 15, *Globigerinoides conglobatus* (Brady), 14-dorsal, 15-apertural, hypotype, St. No. 661., $\times 20$; 16, *Orbulina universa* d'Orbigny, Hypotype, St. No. 650., $\times 30$.

Globigerina calida Parker

(Pl. XXII, Figs. 3, 4)

1962 *Globigerina calida* Parker, *Micropalaeontology*, 8, (2), 221 Pl. 1, Figs. 9-13, 15.

This is particularly a very rare species in the present material, occurring at depths of more than 42 m. In both the regions, it has a distinct increase in



FIGS. 1-3, *Globoquadrina dutertrei* (d'Orbigny), 1-dorsal, 2-and 3-apertural hypotype, St. No. 652., $\times 30$; 4, *Pulleniatina obliquiloculata* (Parker and Jones), 4-apertural, hypotype, St. No. 658., $\times 30$; 5, 6, *Globoquadrina conglomerata* (Schwager), 5-ventral, 6-dorsal, hypotype, St. No. 650. $\times 30$; 7, 8, *Globoquadrina hexagona* (Natland), 7-dorsal, 8-ventral, hypotype, St. No. 650. $\times 30$; 9, 10, *Globigerinella aequilateralis* (Brady); 9, 10-peripheral, hypotype, St. No. 651., $\times 30$; 11, 12, *Globorotalia menardii* (d'Orbigny), 11-dorsal, 12-ventral, hypotype, Sta. No. 651., $\times 30$.

abundance with depth, indicating the deeper water habitat. It is found in subtropical, tropical, and also equatorial waters.

Globigerina pachyderma (Ehrenberg)

(Pl. XXII, Fig. 7)

1884 *Globigerina pachyderma* (Ehrenberg) Brady, *Rep. Voy. Challenger, Zool.*, **9**, 600; Pl. 114, Figs. 19-20.

1962 *Globigerina pachyderma* (Ehrenberg) Parker, *Micropalaeontology*, **8** (2), 224; Pl. 1, Figs. 26-35; Pl. 2, Figs. 1-6.

Test trochospiral, coarse, final whorl composed of globular chambers with a large aperture; lobate periphery and a distinct lip.

It is a right coiling type. It is already reported that it occurs in the sediments off Kerala coast (Setty 1972). According to Boltovskoy (1969) two forms of *G. pachyderma* can be distinguished depending on their direction of coiling. They are (1) *forma dextralis* and (2) *forma sinistralis*. It is very rare in these samples.

Globigerina quinqueloba Natland

(Pl. XXII, Fig. 8)

1938 *Globigerina quinqueloba* Natland. *Bull. Scripps Instn. Oceanogr. tech. Ser.*, **4** (5), 149; Pl. 6, Fig. 7.

1969 *Globigerina quinqueloba* Natland, Boltovskoy, *Micropalaeontology*, **15** (2), 250; Pl. 1, Figs. 13-14.

Test as in *Globigerina* but there are five chambers in the initial whorl and five in the last whorl; aperture is large and umbilical and sometimes modified into infralaminar apertures with gentle thin lip. It is considered to belong to *G. pachyderma* sensu lato. This species is abundant in the surface waters but very rare in the present samples.

Globigerina rubescens Hofker

(Pl. XXII, Fig. 13)

1956 *Globigerina rubescens* Hofker, Copenhagen Univ. Zool. Mus., *Spolia*, **15**, 234, Pl. 35, Figs. 18-21.

1962 *Globigerina rubescens* Hofker, Parker, *Micropaleontology*, **8**, (2) 226, Figs. 17, 18.

This species is usually recognised by its pink or orange colour. Only very rare specimens are found in the present material. This species is found in subtropical and tropical surface waters.

Genus *Globigerinoides* Cushman 1927

Globigerinoides ruber (d'Orbigny)

(Pl. XXII, Figs. 5, 6)

1962 *Globigerinoides ruber* (d'Orbigny) Parker, *Micropalaeontology*, **8** (2), 230; Pl. 4, Fig. 9.

It is a cosmopolitan globigerinal form with its characteristic supplementary apertures found around the margin of the last chamber. It is common in tropical and subtropical waters.

G. ruber is equal or next in abundance to *G. bulloides* in the entire neritic zone. It is primarily a near-surface living form.

Globigerinoides sacculifer (Brady)

(Pl. XXII, Figs. 9-12)

1964 *Globigerinoides sacculifer* (Brady) Todd, *Prof. Pap. U.S. geol. Surv.*, No 260-CC, 1083; Pl. 290, Figs. 7-8.

1967 *Globigerinoides sacculifer* (Brady) Parker, *Bull. Am. Palaeont.*, 52 (235), 156; Pl. 21, Figs. 2-4, Text Fig. 5.

This species is typically trochospiral, thick-shelled, hispid form usually occurring with two types of final chambers; one with an elongated final chamber and the other with globose chamber having large accessory apertures. It is rather rare but less so in the inner neritic than in the outer neritic and slope regions. This species is a warm water form.

Globigerinoides conglobatus (Brady)

(Pl. XXII, Figs. 14, 15)

1959 *Globigerinoides conglobata* Brady, Bradshaw, *Contr. Cushman Fdn. Foramin. Res.* 10 (2), 40, Pl. 7, Figs. 5-6.

1969 *Globigerinoides conglobatus* (Brady), Boltovskoy, *Micropalaeontology*, 15 (2), 251, Pl. 2, Figs. 6-7.

As in other species of *Globigerinoides*, here the chambers increase gradually in size and wall grows thicker. Characteristically, there are two secondary apertures per chamber and the primary aperture rests over three previous chambers.

The species is widely distributed and is considered as a warm water fauna. It occurs in the surface waters of North Atlantic, Pacific, and the Indian Oceans.

Subfamily Orbulininae Schultze 1854

Genus *Orbulina* d'Orbigny 1839*Orbulina universa* d'Orbigny 1839

(Pl. XXII, Fig. 16)

1839 *Orbulina universa* d'Orbigny in de la Sagra *Hist. Phys. Pol. Natn. Cuba. Foraminiferes*, 8, Pl. 1, Fig. 1.

This is a very widespread and common species occurring in tropical, subtropical, and transitional waters. It ranges from Tertiary to Recent.

Its distribution in these two regions is very poor, but it is not found in the inner neritic zone at all.

Genus *Globoquadrina* Finlay 1947*Globoquadrina dutertrei* (d'Orbigny)

(Pl. XXIII, Figs. 1-3)

1960 *Globigerina eggeri* Rhumbler, Banner and Blow, *Contr. Cushman Fdn. Foramin. Res.*, 11, 11; Pl. 2, Fig. 1 (lectotype).

1962 *Globoquadrina eggeri* (d'Orbigny) Parker, *Micropalaeontology*, 8 (2), 242; Pl. 7, Figs. 12, 13; Pl. 8, Fig. 6.

This species conforms with the genus *Globoquadrina* having a pitted surface, secondary spines being present near the umbilical area, generally non-spinose, and aperture being umbilical in the adult with umbilical teeth. Its distribution in the

present material is frequent and not remarkably different in the shelf. This species is typical of tropical, subtropical, and transitional waters.

Globoquadrina conglomerata (Schwager)

(Pl. XXIII, Figs. 5-6)

1959 *Globigerina conglomerata* Schwager, Bradshaw, *Contr. Cushman Fdn. Foramin. Res.*, **10**, 33, Pl. 6, Figs. 6-7.

1962 *Globoquadrina conglomerata* (Schwager) Parker, *Micropaleontology*, **8** (2), 240; Pl. 6, Figs. 11-18.

Parker (1962) refers to this species as a *Globoquadrina* instead of a *Globigerina*. Undoubted specimens of *G. conglomerata* are present in the outer neritic-slope region material; rather very rare.

Globoquadrina hexagona (Natland)

(Pl. XXIII, Figs. 7-8)

1938 *Globigerina hexagona* Natland, *Bull. Scripps Instn. Oceanogr. tech. Ser.*, **4** (5), 149; Pl. 7, Fig. 1.

1962 *Globoquadrina hexagona* (Natland) Parker, *Micropaleontology*, **8** (2), 244; Pl. 8, Figs. 5-13.

This species is referred to as *Globigerina* (Parker 1962). It is also characterised by a flat dorsal surface and coarsely cancellated wall having a hexagonal form. It is found in the tropical and subtropical waters of the Pacific and the Indian Oceans. It is very rare in the present material.

Genus *Globigerinella* Cushman 1927

Globigerinella aequilateralis (d'Orbigny)

(Pl. XXIII, Figs. 9-10)

1959 *Globigerinella aequilateralis* (Brady) Bradshaw, *Contr. Cushman Fdn. Foramin. Res.*, **10**, 38; Pl. 7, Figs. 1-2.

1962 *Globigerinella aequilateralis* (d'Orbigny) Parker, *Micropalaeontology*, **8** (2), 228; Pl. 2, Figs. 22-28.

Test trochospiral, becoming planispiral having bilateral symmetry, loosely coiled, chambers globular, inflated and increasing in size in the last whorl, finely hispid, aperture broad, semicircular in the umbilical face of the chamber.

It is primarily a tropical species living in a temperature range of 15-27°C. *Globigerinella siphonifera* and *Hastigerina (Hastigerina) siphonifera* are considered to be synonymous with this species. This species is uniformly found in the present material but somewhat less so in the Karwar region.

Genus *Pulleniatina* Cushman 1927

Pulleniatina obliquiloculata (Parker and Jones)

(Pl. XXIII, Fig. 4)

1960 *Pullenia sphaeroides* (d'Orbigny) var. *obliquiloculata* Parker and Jones, Banner and Blow, *Contr. Cushman Fdn. Foramin. Res.*, **11**, 25; Pl. 7, Fig. 4 (lectotype).

1969 *Pulleniatina obliquiloculata* (Parker and Jones) Boltovskoy, *Micropalaeontology*, **15** (2), 252; Pl. 3, Figs. 6-8.

Test as in *Globigerina*, perforate, involute. last chamber forming the last whorl, aperture elongate, arched, and located at the base of the chamber. It is a warm water species. It is quite common in the present material.

Family Globorotaliidae Cushman 1927

Subfamily Globorotaliinae Cushman 1927

Genus *Globorotalia* Cushman 1927

Globorotalia menardii (d'Orbigny)

(Pl. XXIII, Figs. 11-12)

1960 *Rotalia menardii* d'Orbigny, Banner and Blow, *Contr. Cushman Fdn. Foramin. Res.*, **11**, 31; Pl. 6, Fig. 2 (lectotype).

1962 *Globorotalia cultrata* d'Orbigny, Parker, *Micropalaeontology*, **8**(2), 235; Pl. 5, Figs. 3-5.

1969 *Globorotalia menardii* d'Orbigny, s. l., Boltovskoy, *Micropalaeontology*, **15**(2), 253; Pl. 3, Figs. 2-3.

This species is a widespread warm water (tropical) fauna occurring in North Atlantic, Pacific and the Indian Oceans. It grades into several subspecies. Very few good specimens are found in the present material.

DISCUSSION

Table I shows a general increase in the percentage of planktonic foraminifera from the shore towards the outer shelf and upper continental slope. Very few species occur in depths less than 18 m (10 fathoms) but they seem to increase progressively with increased depth. The scarcity of species in very shallow regions may be attributed to factors such as fragmentation of tests by off-shore transportation by currents; winter storms and summer winds (monsoonic conditions) in the area, fresh water influx through the rivers and consequent lowering of salinity, resulting in the destruction of tests.

The most abundant species are *Globigerina bulloides*, and *Globigerinoides ruber*; these are followed by *Globoquadrina dutertrei*, *Pulleniatina obliquiloculata*, *Globigerinella aequilateralis* and *Globorotalia menardii*. This repeated sequence of species indicates a consistency in the distribution of the population along these traverses. This may be related to a comparatively stable shelf having a highly regulated or controlled sediment discharge and a steady rate of sedimentation in the region.

The other species recorded are *Globigerinoides conglobatus*, *G. succulifer* which are typically warm water fauna but their number decreases in the inner neritic region.

Orbulina universa is very frequently found in the outer neritic region of Karwar area but significantly rare in the traverses of the Mangalore region. However, *Globigerina calida*, *G. rubescens*, *Globoquadrina hexagona* and *G. conglomerata* are very rare in the samples.

Globorotalia menardii is the lone species representing the family Globorotaliidae. It is not clear why this family is very poorly represented.

One special characteristic feature is in the occurrence of *Globigerina pachyderma*, a restricted bipolar, cooler water species in the sediment sample (Sta. 661) from the slope area of Mangalore region. Earlier, the presence of this species was reported from the region south of this area, (Setty 1972). The continued occu-

rence of this species further north in this region is very significant, since it delineates its northern extension beyond Kerala coast and also north of the equator upto Mangalore region.

The percentage circular diagrams (Text Fig. 2) give the pattern of distribution and population control of the different species composing each sample. Foraminifera are totally absent in stations 655, 656 and 657 which are very close to the shore and hence are influenced by the fresh water and river laden sediment discharge in the region. Table I and Text Fig. 2 show the progressive increase in abundance of the planktonic fauna from a depth of 18 meters towards the slope (to 201 m) along both the traverses. It may be observed further that the planktonic species are richer in the Mangalore section than in the Karwar section.

Further, it is noted that the increase in the offshore distribution of species by depth suggests that some species have a higher frequency of occurrence within a specific depth range even though they may be present at other depths.

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REFERENCES

- Barker, R. W. (1960). Taxonomic notes on the species figured by H. B. Brady in his report on the Foraminifera dredged by H. M. S. *Challenger*, during the years 1873-1876. Accompanied by a reproduction of Brady's plates. *Spec. Publs. Soc. econ. Palaeont. Miner. Tulsa* **9**, 1-238.
- Betjeman, K. J. (1969). Recent foraminifera from the western continental shelf of Western Australia. *Contr. Cushman Fdn. Foramin. Res.*, **20**, Pt. 4, 119-138.
- Brady, H. B. (1877). Supplementary note on the foraminifera of the Chalk of the New Britain Group. *Geol. Mag. Ser. 2*, **4**, 534-536.
- (1879). Notes on some of the Reticularian Rhizopoda of the *Challenger* Exped. *Q. Jl. microsc. Sci.*, **19**, 20-63, 261-269.
- (1884). Report on the foraminifera dredged by H. M. S. *Challenger* during the years 1873-1876. *Rep. scient. Results Challenger Exped. Zool.* **9**, 1-814.
- Chapman, F. (1906). On some foraminifera and Ostracoda obtained off Great Barrier Island, New Zealand. *Trans. Proc. New Zealand Inst.*, **38**, 77-112.
- (1909). Report on the foraminifera from the Sub-Antarctic Islands of New Zealand. **1**, 312-371. *Phil. Inst. Centerbuty, Christchurch*, **2**.
- Moore, R. C. (1964). Treatise on Invertebrate Palaeontology. (Ed. 6) Part. C., Protista 2, Vol. 1 and 2, Geol. Soc. Am. and Univ. Kansas Press.
- Murthy, P. S. N., Reddy, C. V. G., and Varadachari, V. V. R. (1968). Distribution of total Phosphorus in the shelf sediments off the west coast of India. *Proc. natn. Inst. Sci. India.*, **34B**, 134-141.
- (1969). Distribution of organic matter in the marine sediments off the west coast of India. *Proc. natn. Inst. Sci. India*, **35B**, 377-384.

- Nair, R. R. and Pylee, A. (1968). Size distribution and carbonate content of the sediments of the western shelf of India. *Bull. natn. Inst. Sci. India*, No. 38, Pt. 2, 411-419.
- Rao, K. Kameswara (1970). Foraminifera of the Gulf of Cambay. *J. Bombay. nat. Hist. Soc.* 66 (3), Pl. 1-3. 584-596
- Schott, Wolfgang (1968). Recent sedimentation in the Indian Ocean : First Results of "Meteor", Indian Ocean Expedition. *Bull. natn. Inst. Sci. India*, No. 38, Pt. 1, 424-427.
- Setty, M. G. Anantha P. (1972). Holocene planktonic foraminifera from the shelf sediments off Kerala coast. *J. geol. Soc. India*, 13, 131-138.