

HOLOCENE PLANKTONIC FORAMINIFERA FROM THE SHELF SEDIMENTS OFF KERALA COAST

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ABSTRACT

Twenty-two planktonic foraminifers were identified from a few samples collected by the author aboard I N S KISTNA at 9°N and 76°E, at 89 metres depth from the bottom sediment-water interface. A few of the more characteristic features of each are described. Some of the species have a geologic range from Miocene to late Pleistocene and Recent also. *Globigerina hexagona* and *Globoquadrina conglomerata* which disappeared from the Atlantic earlier (50,000 to one million years ago) are seen to be living today in the Indian Ocean. A few species are rare and restricted forms.

INTRODUCTION

During the course of cruises with I N S KISTNA along the southwest coast of India in 1964, a few bottom sediment samples (using a snapper) were collected by the author from the continental shelf of the Arabian Sea. The snapper samples represent the sediment taken at the sediment-water interface up to an approximate depth of 5 cm at position 09°00'N and 76°00'E, at a depth of 89 metres, and 36 nautical miles southwest of Alleppy. This represents the outer shelf-upper continental slope region. Therefore, the age of the sediment together with its fossil assemblages may be considered as Recent.

Studies made so far, either on taxonomical, ecological or distributional aspects of the fossil assemblages of the sediments of the continental shelf of the Arabian Sea are very few and far between. However, it may be mentioned here that Stubbings (1939) studied the foraminifera from the sediments collected by the John Murray Expedition of 1933-34. Earlier, Brady had studied the foraminifera from the samples collected by the Challenger Expedition of 1894. Chapman (1895) had given an account of the foraminifera from the Laccadive area. Chaudhury and Biswas (1954), Bhatia (1957), Sethulaxmi Amma (1958), Chatterjee and Gururaja (1967) have recorded the occurrence of foraminifera from some parts of the beaches of the Arabian Sea. Rao (1969) gave a taxonomic account of foraminifera of the shelf sediments of Gulf of Cambay. This paper presents a systematic report on the occurrence of planktonic foraminifera present in the Holocene samples collected off the Kerala Coast with a discussion on their significance. A similar study on the benthonic species will subsequently follow.

LITHOLOGY

The samples, when wet, are greenish in colour, and somewhat sandy but clayey due to the presence of calcareous mud and glauconite. Visual examination also revealed that it is highly fossiliferous. Though it turns greyish on drying and becomes hard and compact, it is friable.

SYSTEMATICS

The generic and suprageneric classification employed here is the one proposed by Loeblich and Tappan (1961). Since many of the species listed here are well known,

their various morphological characters are not included excepting a few characteristic features which are deemed essential wherever necessary.

- Class: RHIZOPODA von Siebold 1845
 Subclass: LOBOSIA Carpenter Parker and Jones 1862
 Order: FORAMINIFERIDA Zborzewski 1834
 Suborder: ROTALIINA Delage and Herouard 1896
 Super-family: GLOBIGERIN^{AEA}~~IDEAE~~ Carpenter Parker and Jones 1862
 Family: GLOBIGERINIDAE Carpenter Parker and Jones 1862
 Subfamily: GLOBIGERINID^N~~AE~~ Carpenter Parker and Jones 1862
 Genus: *Globigerin^{AE}*~~idae~~ d'Orbigny 1826

Globigerina bulloides d'Orbigny

Plate I, Figs. 1-2

1962 *Globigerina bulloides* d'Orbigny, Parker, pl. 1, Figs. 3, 6-7, p. 221.

Typically *G. bulloides* is distinguished in having a large umbilical aperture without a lip and having large spinose spherical chambers in each whorl. Most of the spinose juvenile *G. bulloides* having green protoplasm are found on the surface waters whereas larger and adult forms having white protoplasm with no spines are found at depths (Bé and Hamlin, 1967). This species has a hispid test and is spinose, having very fine, long, and thin spines when living. It is a typical form, and abundant in the subarctic and transitional waters. It is stated that it is practically absent in tropical and subtropical waters south of 40°S; but it is found in the present material (tropical warm waters). This species has a range from Cretaceous to Recent.

Globigerina pachyderma (Ehrenberg)

Plate I, Figs. 3-4

1884 *Globigerina pachyderma* (Ehrenberg) Brady. Rept. Voy. Challenger, Zool. v. 9, pl. 114, Figs. 19-20, p. 600.

It is a right coiling form. As pointed out by Parker (1962, pp. 224-225) this species changes its direction of coiling from left to right northwards from the Antarctic whereas it is definitely a ~~right~~^{left} coiling type there.

Globigerina rubescens Hofker

Plate I, Figs. 5-6

1956 *Globigerina rubescens* Hofker, pl. 35, figs. 18-21, p. 234.

Hofker (1956) refers to this species as having a wall with 'honey-comb' structure. This species is found in the South and North Pacific (Bradshaw, 1959) and also in the sediment samples of the Atlantic (Parker, 1962, p. 226). This species is found in subtropical and tropical surface waters.

Globigerina calida Parker

Plate I, Figs. 7-10

1962 *Globigerina calida* Parker, Parker pl. 1, figs. 9-13, 15, p. 221.

This species differs from *Globigerinella siphonifera* in being less involute in early chambers and less densely hispid. However, it is considered to be an intermediate form between *Globigerinella siphonifera* (= *Globigerinella aequilateralis* (Brady) and *Globigerina bulloides* Bé and Hamlin 1967, p. 101). It also differs from *G. bulloides* in having the apertures appearing as slits and not always clearly visible from the

umbilical side, less hispid and having thinner walls, and also being radially elongated in the last chambers. It is found in subtropical and tropical waters.

Globigerina falconensis Blow
Plate I, Figs. 11-12

1962 *Globigerina falconensis* Blow, Parker, pl. 1, figs. 14, 16-19, p. 224.

This species differs from *G. bulloides* in its more lobulated periphery, in the low arched aperture with a lip, and the final chamber being smaller than the previous one. It is typically a cold temperate and subtropical species, however found in these tropical waters also.

Globigerina quinqueloba Natland
Plate I, Figs. 13-14

1969 *Globigerina quinqueloba* Natland, Boltovskoy, pl. 1, figs. 13-14, p. 250.

It is a left coiling specimen. It has 5 chambers in the initial whorl and five in the last whorl.

Globigerina (Globigerinoides) hexagona Natland
Plate I, Figs. 15-16

1964 *Globigerina (Globigerinoides) hexagona* Natland, Todd, pl. 292, Fig. 3, p. 1080.

This species was originally described from 884 m depth off Southern California from the lower Pliocene of the Los Angeles Basin. It is also found in the mid-Pacific seamounts and Recent sediments from the North Atlantic and Indian Oceans. Thus it is found in the tropical and subtropical regions of the Pacific and Indian Oceans. *Globorotaloides suteri* Bolli which is synonymous with *G. hexagona* is reported as a fossil ranging from the middle Eocene through Miocene of Trinidad.

Genus: *Globigerinoides* Cushman 1927
Globigerinoides ruber (d'Orbigny)
Plate I, Figs. 17-18

1962 *Globigerinoides ruber* (d'Orbigny), Parker, pl. 4, fig. 9, p. 230.

Tests of this species occur in white and pink colours. The pigment (pheopytin) is found within the crystalline shell structure. The colouration is deeper in the earlier chambers fading gradually into the later ones. The fossil specimens retain this colouration (Bé and Hamlin, 1967). *Globigerinoides ruber forma pyramidalis* (Van der Broeck) is the modern variant of *G. ruber*; while the latter is observed since Miocene, the former is restricted to the Recent only. It is common in tropical and subtropical waters.

Globigerinoides quadrilobatus succulifer (Brady)
Plate I, Figs. 19-20

1962 *Globigerinoides quadrilobatus succulifer* (Brady) Parker, pl. 3, figs. 6-10, p. 229.

This species was originally described from fossil material of New Britain group in Bismark Archipelago, although Brady recognised it in the deep sea dredged samples. It is probably evolved from *G. trilobus* (Reuss) within the Miocene. Typical specimens of *G. succulifer* occur in the Miocene of Jamaica, Equador, and Saipan

and Pliocene of Java. It ranges from Aquitanian to Recent. This is a warm water form.

Globigerinoides tenellus Parker

Plate II, Figs. 1-2

1958 *Globigerinoides tenellus* Parker, Swedish Deep-Sea Expd. pl. 6, figs. 7-11, p. 280.

Parker (1962) reports that this species is found north of Lat. 30°S and is identical with those from eastern Mediterranean.

Globigerinoides conglobatus (Brady)

Plate II, Figs. 3-4

1969 *Globigerinoides conglobatus* (Brady), Boltovskoy, pl. 2, Figs. 6-7, p. 251.

The distinguishing characteristics of this species are, in having two secondary apertures per chamber, the primary aperture resting over three previous chambers and in having a round outline. This species is regarded as a warm water fauna. It is reported from the early Miocene of Dominican Republic and Saipan and occurs in the surface waters.

Genus: *Globoquadrina* Finlay 1947

Globoquadrina dutertrei (d'Orbigny)

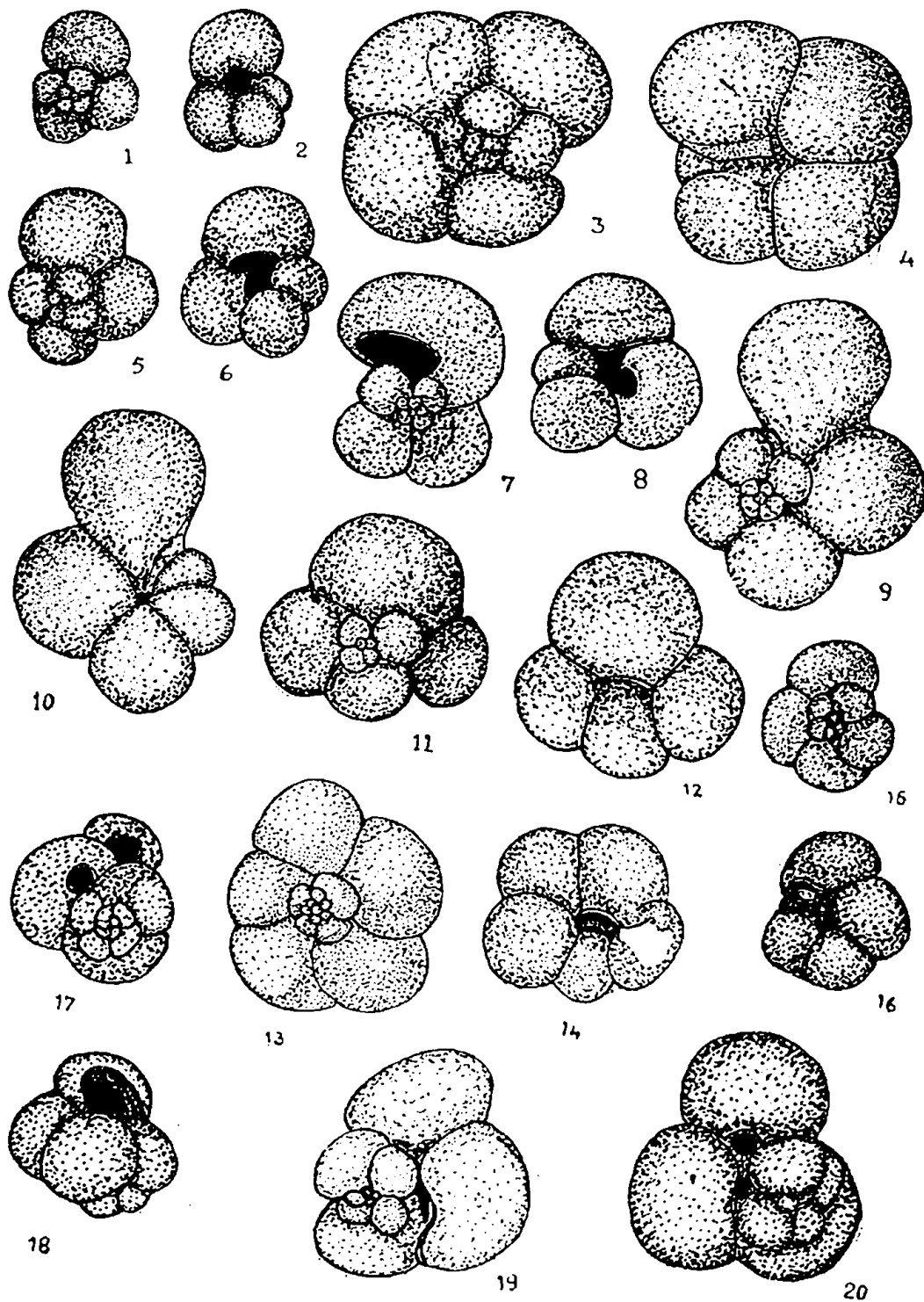
Plate II, Figs. 5-6

1962 *Globoquadrina dutertrei* (d'Orbigny) Parker, pl. 7, Figs. 12-13, pl. 8, Fig. 6, p. 242.

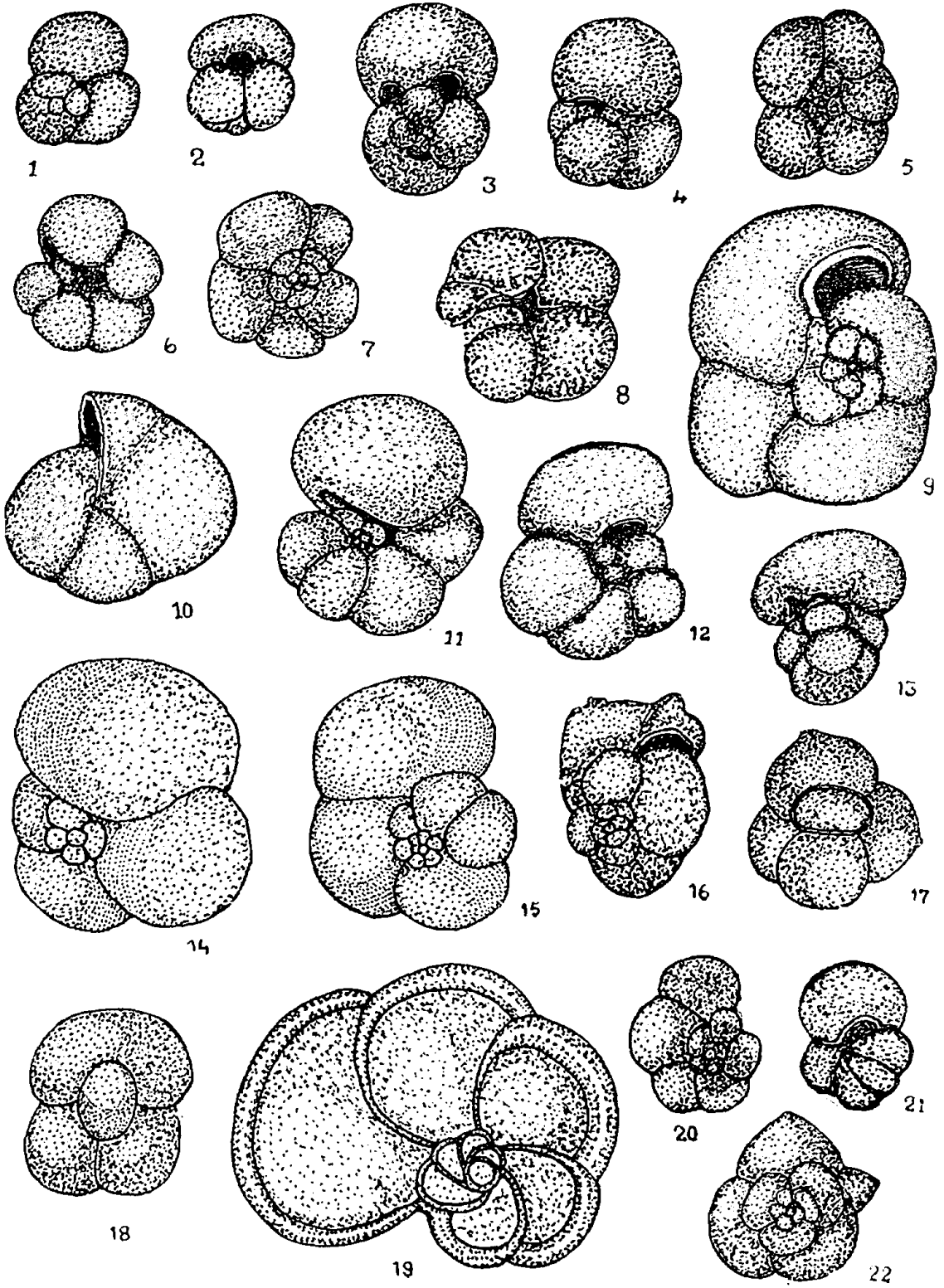
This species has a massive structure characteristic of other species of *Globoquadrina*. According to Parker (1962, p. 242) the assemblages of *G. dutertrei* vary to some extent in various parts of the Atlantic and the Pacific but this specimen seems to be very nearly similar to those of Pacific fauna. The resultant variants of this species are *Globigerina rotundata* (d'Orbigny), *G. eggeri* Rhumbler, *G. subarcticae* Lamarck which are synonymous. *G. dutertrei* appears to be closely related to *G. altispira* (Cushman and Jarvis) and the 'subspecies' *globosa* of Bolli. This species is found in tropical, subtropical and transitional waters but abundant in the transitional zone.

EXPLANATION OF PLATE I

- 1-2 *Globigerina bulloides* d'Orbigny. Hypotype, × 20.
- 3-4 *Globigerina pachyderma* (Ehrenberg). Hypotype, × 40.
- 5-6 *Globigerina rubescens* Hofker, Hypotype, × 20.
- 7-10 *Globigerina calida* Parker, Hypotype, 7-8
Two different specimen × 20; 9-10, another specimen × 25.
- 11-12 *Globigerina falconensis* Blow. Hypotype × 40.
- 13-14 *Globigerina quinqueloba* Natland. Hypotype, × 40.
- 15-16 *Globigerina* (*Globigerinoides*) *hexagona* Natland. Hypotype, × 20.
- 17-18 *Globigerinoides ruber* (d'Orbigny). Hypotype, × 20.
- 19-20 *Globigerinoides quadrilobatus succulifer* (Brady).
Hypotype, 19, sinistral × 20; 20, dextral specimen × 25.



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Globoquadrina conglomerata (Schwager)

Plate II, Figs. 7-8

1962 *Globoquadrina conglomerata* (Schwager), Parker pl. 6, Figs. 11-18. p. 240.

This species was first described from the Neogene of Kar Nicobar in the Andaman-Nicobar group of islands in the Bay of Bengal as *Globigerina conglomerata*. Bradshaw (1959) obtained these specimens in planktonic forms in the Pacific. This species is also reported from the Recent sediments from off Bikini and Phillippines. However, this species is reported from the Miocene of North Atlantic deep sea cores and Miocene strata of Trinidad and Saipan, and Oligocene of Venezuela.

Genus: *Pulleniatina* Cushman 1927*Pulleniatina obliqueloculata* (Parker and Jones)

Plate II, Figs. 9-10

1962 *Pulleniatina obliqueloculata* (Parker and Jones) Parker pl. 4, Figs. 13-16, 19-22, p. 234.

The specimen has 5 chambers in the initial whorl and up to 13 in all. This is a warm water species.

Subfamily: ORBULININAE Schutze 1854

Genus: *Orbulina* d'Orbigny 1839*Orbulina universa* d'Orbigny 18391839 *Orbulina universa* d'Orbigny, in de la Sagra Hist. Phys. Pol. Nat. Cuba 'Foraminiferes', v. 8, pl. 1, Fig. 1.

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

Genus: *Globigerinella* Cushman 1927*Globigerinella aequilateralis* (d'Orbigny) 1839

Plate II, Figs. 11-13

1959 *Globigerinella aequilateralis* (Brady) Bradshaw, pl. 7, figs. 1-2, p. 38.

This is primarily a tropical species. The author agrees with Parker (1962) that

EXPLANATION OF PLATE II

- 1-2 *Globigerinoides tenellus*, Parker. Hypotype, $\times 20$.
 3-4 *Globigerinoides conglobatus* (Brady). Hypotype, $\times 20$.
 5-6 *Globoquadrina dutertrei* (d'Orbigny). Hypotype.
 7-8 *Globoquadrina conglomerata* (Schwager). Hypotype $\times 20$.
 9-10 *Pulleniatina obliqueloculata* Parker and Jones.
 Hypotype, 24, 25. juvenile specimen $\times 20$;
 11-13 *Globigerinella aequilateralis* (d'Orbigny), Hypotype,
 11. dextral $\times 20$; 12. sinistral $\times 15$; 13. juvenile specimen $\times 20$.
 14-15 *Globigerinella iota* Parker. Hypotype, 14. sinistral and 15 dextral specimen—all $\times 40$.
 16-17 *Globigerinella glutinata* Eggr. Hypotype, $\times 40$.
 18 *Globigerinella uvala* (Ehrenberg). Hypotype, $\times 40$.
 19 *Globorotalia menardii* (d'Orbigny). Hypotype, $\times 20$.
 20-22 *Globorotalia pumilio* Parker. Hypotype, $\times 40$.

the species *G. siphonifera* is trochospiral in the juvenile stages but planispiral in the adult; hence that *G. siphonifera* is synonymous with *G. aequilateralis*.

Genus: *Globigerinita* Bronnimanna 1951 emended

Globigerinita iota Parker

Plate II, Figs. 14-15

1962 *Globigerinita iota* Parker, pl. 10, Figs. 30, p. 250.

This species is very much similar to *Globigerina radians* Eggar; however, Parker has erected it into a new species. The specimen described here agrees with Parker's described form.

Globigerinita glutinata (Eggar)

Plate II, Figs. 16-17

1962 *Globigerinita glutinata* (Eggar) Parker, pl. 9, fig. 9, p. 246.

This specimen is very similar to that described by Parker. According to Blow (1959) *G. glutinata* is synonymous with *G. napparimanse incrusta* Akers in having bullae with apertures at the surface of the previous chambers only. This is a well known and cosmopolitan eurythermal species having a wide geographical distribution.

Globigerinita uvala (Ehrenberg)

Plate II, Figs. 18

1962 *Globigerinita uvala* (Ehrenberg) Parker, pl. 8, figs. 14-26, p. 252.

Globigerinoides minuta Natland appears to be a phenotype of *Globigerinita uvala*, but *Globigerina bradyi* Weisner is definitely synonymous with this species. It is found more commonly in the warmer waters.

Family: GLOBOROTALIIDAE Cushman 1927

Subfamily: GLOBOROTALI^NAE Cushman 1927

Genus: *Globorotalia* Cushman 1927

Globorotalia menardii (d'Orbigny)

Plate II, Fig. 19

1969 *Globorotalia menardii*, Boltovskoy, pl. 3, figs. 2-3, p. 253.

This species, as a redeposited fossil material, was first described from the Adriatic near Rimini in the Mediterranean; Parker, Jones and Brady recorded it from the Recent sediments from the Isle of Man.

G. menardii is a widespread warm water species occurring in North Atlantic, Pacific, and the Indian Ocean; the tests appear to be larger in the deeper waters. Its range is from Miocene to Recent. It grades into several subspecies giving rise to transitional forms connecting *G. menardii* with *G. tumida*. Boltovskoy differentiates *G. menardii* into three characteristic forms—(i) *forma typica*, (ii) *forma tumida* and (iii) *forma fimbriata*.

Globorotalia hirsuta (d'Orbigny)

1959 *Globorotalia hirsuta* (d'Orbigny) Bradshaw, pl. 8, figs. 1-2, p. 44.

This specimen is typically left-coiling but according to some authors it is mostly dextral. The sinistral types are noticed in the eastern part of the South Pacific between Lat. 15-35°S.

Globorotalia pumilio Parker

Plate II, Figs. 20-22

1962 *Globorotalia pumilio* Parker, pl. 6, fig. 3, p. 238.

This species is reported throughout the Pacific and north of Lat. 30°S.

DISCUSSION

Planktonic foraminifera have frequently been used in interpreting recent and palaeo environments. Foraminifera, when entombed in ancient sediments, are frequently used as stratigraphic guides. Such studies have been carried out with the notion that planktonic forms are subject to wide and relatively rapid dispersal by ocean currents. In view of this, it is very essential to know the ecology and phylogeny of living forms.

Amongst the twenty-two characteristic planktonic foraminifers described here, *Globigerina bulloides*, *G. quinqueloba*, *Globigerinoides ruber*, *G. quadrilobatus* ^{Succulifer} ~~succulifer~~, *Orbulina universa*, *Globigerinita glutinata* and *Globorotalia menardii* have a geologic range from Miocene to late Pleistocene (having abundant populations) and in the Recent also.

However, the most abundant species found in these sediments are *Globigerina bulloides*, *Globoquadrina dutertrei*, and *Globigerinoides ruber*; but *Globigerinella aequilateralis*, *Globigerinoides quadrilobatus succulifer*, and *Globorotalia menardii* are common. *Globigerina pachyderma* is rare. *Globorotalia menardii* is the major species of the family Globorotaliidae. The total population of foraminiferal assemblage (planktonic and benthonic) is in fairly good proportion with the sediment which indicates that the temperature, depth, salinity and nutrients had been favourable for the growth and development of the microfauna in a favoured and relatively stable environment.

Globigerian hexagona (Natland) disappeared from the Atlantic at the end of the Last interglacial or of interstadial of the last Glaciation (approx. 50,000 to 12,000 years ago) but it can be considered that it may be slowly dying out. *Globoquadrina conglomerata* (Schwager) apparently developed from *G. venezuelana* (Hedberg) during Pliocene disappeared from the Atlantic earlier than *G. hexagona* (approx. one million years ago) but it is found to be living in the Pacific and Indian Oceans even today.

The other typical tropical species which occur in this assemblage are, *Globigerinoides conglobatus* (Brady), *G. quadrilobatus succulifer* (Brady), *Pulleniatina obliqueloculata* (Parker and Jones), *Globoquadrina dutertrei*, *Orbulina universa* (d'Orbigny), *Globigerinella aequilateralis* and *Globorotalia menardii* (d'Orbigny). However, the significant feature of this faunal assemblage is in the presence of *Globigerina bulloides* (considered to be cold temperate) in abundance and *G. pachyderma* (considered to be cold water fauna)—ecologically significant species found to exist in an otherwise tropical environment with typical warm water species. Does this suggest an instance of faunal mixing? It needs further examination. A detailed account of the significance is dealt with separately.

Among others, *Globigerina falconensis*, *G. quinqueloba*, *Globigerinella aequilateralis*, *Globigerinoides ruber*, *G. conglobatus*, and *Globoquadrina dutertrei* appeared for the first time in the Pliocene sediments off Baja California, but many of these species appeared first in the Miocene in various parts of the world. Similarly, *G.*

pachyderma was noticed in the upper Pliocene (Mohnian stage) of California (Parker, 1964, p. 622).

According to Ericson *et al* (1963) in the case of *Globorotalia menardii* (1) the change in the coiling direction from dextral to sinistral, (2) increase in the average diameter in the tests, and (3) reduction in the number with respect to total assemblage marks the boundary between *Pliocene-Pleistocene*. In New Zealand *G. menardii* is rare in Pliocene rocks, absent in Pleistocene but appears as a warm water fauna in the Recent marine sediments (Jenkins, 1964).

In general these species exhibit long ranges in time. A few species are, nevertheless, geographically restricted, and for the most part are rare forms.

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REFERENCES

- BHATIA, S. B., (1957) Recent foraminifera from shore sands of Western India. *Cushman Found. Foram. Res. Contri.*, v. 7, pp. 15-24.
- BRADSHAW, J. S., (1959) Ecology of living, planktonic foraminifera in the north and equatorial Pacific. *Cushman Found. Foram. Res. Contri.*, v. 10, pt. 2, pp. 25-64, pls. 6-8.
- CHAPMAN, F., (1895) On some foraminifera obtained by the Royal Indian Survey ship s. s. INVESTIGATOR from the Arabian Sea. *Proc. Zool. Soc.*, 55 pp.
- CHATTERJEE, B. P. and GURURAJA, M. N., (1967) Foraminifera off Mangalore Coast, South India. Proc. Symp. Indian Ocean. *Bull. Nat. Inst. Sci. India*. No. 38, Pt. I, Sec. II, pp. 393-397.
- CHAUDHURY, A. and BISWAS, B., (1954) Recent perforate foraminifera from Juhu beach, Bombay, *Micropaleontologist*, v. 8, No. 4, pp. 30-32.
- HOFKER, J., (1956) Foraminifera Dentata. Foraminifera of Santa Cruz and Thatch Island, Virginia Archipelago, West Indies. Copenhagen, Univ., Zool. Mns., *Spolia*, v. 15, p. a-237, pls. 1-35.
- LOEBLICH, A., JR. and TAPPAN, H., (1961) Suprageneric classification of the Rhizopoda, *Jour. Paleo.*, v. 35, No. 2, pp. 245-330.
- PARKER, F., (1962) Planktonic foraminiferal species in Pacific sediments. *Micropaleontology*, v. 8, No. 2, p. 219-254, 4 tables, 10 pls.
- RAO, K. K., (1969) Foraminifera of the Gulf of Cambay. *Jour. Bombay Nat. Hist. Soc.*, v. 66, No. 3, pp. 584-596, pls. 3.
- SETHULAKSHMI AMMA, J., (1958) Foraminifera of the Travancore Coast. *Bull. Res. Instt. Univ. Kerala*, v. 6, No. 1, pp. 1-88.
- STUBBINGS, H. G., (1939) The marine deposits of the Arabian Sea: An investigation into their distribution and Biology. John Murray Expd., 1933-34, *Scientific Reports*, v. 3, No. 2, p. 158, pls. I-IV, Charts I-IV.

P. 5: Some of the references ~~present~~ ^{quoted} in the above paper are not found listed under 'References' which is, unfortunately, due to printer's mistake. The omission is regretted.

- Author.