

DISTRIBUTION OF PLANKTONIC FORAMINIFERA IN THE CONTINENTAL SLOPE SEDIMENTS OFF BOMBAY

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ABSTRACT

Three gravity core samples taken from a depth range of 800-2240 m in the slope region off Bombay were studied for their planktonic foraminiferal content. These samples yielded 25 species including a subspecies *Globorotalia menardii flexuosa* (Koch). Among the interesting species encountered were a solitary specimen of *Borbulina bilobata* d'Orbigny, reported for the first time from the Arabian sea and *Globigerina pachyderma* (Ehrenberg). The presence of cold water species of *G. pachyderma* is possibly due to the penetration of cold Antarctic bottom water into the Arabian sea.

INTRODUCTION

A review of the available literature on the distribution of planktonic foraminifera in the deep-sea sediments of the Arabian sea reveals that not much work has been done. However, a number of papers have been published on the distribution of these foraminifera from the waters of the Arabian sea and its sediments from the continental shelf regions. The planktonic foraminifera from the deep-sea sediments of the Arabian sea were studied first by Chapman (1895). From the Laccadive region, Stubbings (1939) gave a list of 18 species in the samples collected during the John Murray Expedition. The studies were again revived during the International Ocean Expedition Programme and Belyaeva (1962, 1964), Zobel (1970), Be and McIntyre (1970), Rao (1971, 1972, 1973), Setty and Guptha (1972), Setty (1972) and Guptha (1972) studied a number of samples.

MATERIALS AND METHODS

During one of the cruises of INS Darshak in 1969, sediment samples were collected from the continental slope off Bombay in the Arabian Sea (text fig. 1). Of the various types of samples collected, three gravity core samples from a depth range of 800-2240 m were chosen for the present investigation on the distributional pattern of planktonic foraminifera.

The top one centimeter of the material from the cores was taken and after sieving and drying one gram of +200 mesh fraction was separated from the material. Since, it contained several thousand specimens of planktonic foraminifera, the sample was divided into a

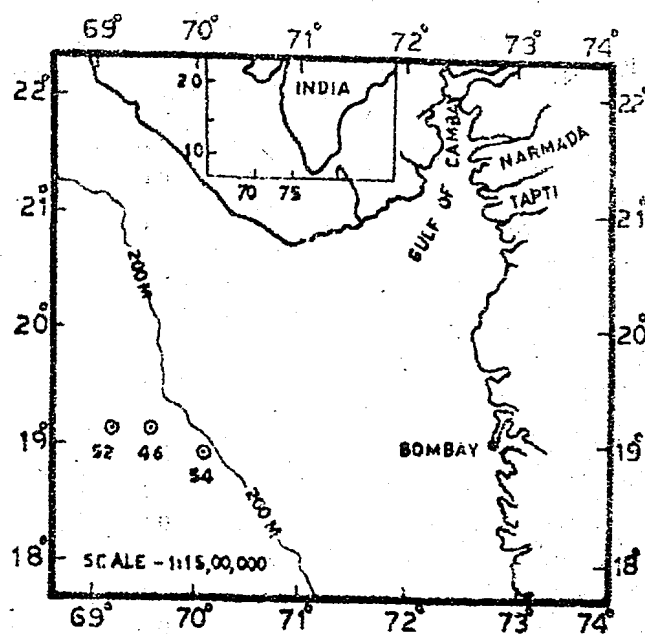


Fig. 1. Showing the Sampling locations.

desired quantity using a microsplitter which was used for the study of planktonic foraminifera and the percentage frequency of each specimen was worked out (Table 1).

RESULTS AND DISCUSSIONS

These samples yielded 25 species including a subspecies. A greater faunal diversity was noticed at station 52 (text Fig. 2). The material largely comprises of planktonic foraminifera except for a few benthonic forms such as *Elphidium*, *Laticarina*, *Ceratobulimina*, *Bulimina*, *Ehrenbergina*, *Bolivina* and *Uvigerina*. The quantitative distribution of planktonic foraminifera populations (Table 1) revealed that the assemblages included an admixture of both cold and warm water fauna, the cold water forms were *Globigerina pachyderma* and *G. bulloides* and the rest were warm water forms.

The assemblage can broadly be divided into two groups as follows:

1. species with a widespread distribution found in all the three cores (Stn. Nos. 52, 46 and 54).

TABLE 1. SHOWING FAUNAL COMPOSITION IN PERCENTAGES

Station Numbers and Depth (M)	52 (2240)	46 (1460)	54 (800)
PLANKTONIC NUMBER	16,384	39,168	13,696
(1)	(2)	(3)	(4)
<i>Globigerina bulloides</i>	1.2	2.0	6.5
<i>G. calida</i>	0.8	0.0	0.9
<i>G. rubescens</i>	2.9	4.8	3.3
<i>G. pachyderma</i>	1.6	1.9	2.8
<i>G. quinqueloba</i>	0.4	0.0	0.0
<i>Globigerinella adamsi</i>	0.6	0.7	0.0
<i>Gl. aequilateralis</i>	3.9	3.8	2.1
<i>Globigerinoides conglobatus</i>	2.3	2.5	3.7
<i>G. sacculifer</i>	27.7	28.0	25.5
<i>G. ruber</i>	23.2	32.0	29.4
<i>Orbulina universa</i>	7.4	6.5	0.9
<i>Borbulina bilobata</i>	0.2	0.0	0.0
<i>Pulleniatina obliquiloculata</i>	8.8	6.5	3.1
<i>Sphaeroidinella dehiscens</i>	1.2	0.0	0.0
<i>Globorotalia hirsuta</i>	0.8	0.0	0.0
<i>G. menardii</i>	3.5	2.3	6.5
<i>G. tumida</i>	1.6	1.0	3.5
<i>G. m. flexuosa</i>	0.4	0.8	1.2
<i>G. truncatulinoides</i>	0.2	0.0	0.0
<i>Globoquadrina conglomeraata</i>	2.9	1.1	2.3
<i>G. dutertrei</i>	6.3	3.6	5.4
<i>G. hexagona</i>	0.8	2.0	1.6
<i>Globigerinita glutinaria</i>	0.8	0.8	0.7
<i>G. uvala</i>	0.2	0.0	0.0
<i>Candeina nitida</i>	0.4	0.0	0.5

2. species restricted only to the deepest of the three stations.

Group 1 can be further sub-divided into three sub-groups:

- species of common occurrence,
- species of moderate occurrence,
- species of rare occurrence.

Species of common occurrence — *Globigerinoides sacculifer* and *G. ruber* are the most common species noticed in the material; these two species approximately account for the two thirds of the bulk fauna.

Species of moderate occurrence—*Globigerina rubescens*, *Globigerinoides aequilateralis*, *Globigerinoides conglobatus*, *Orbulina universa*, *Pulleniatina obliquiloculata*, *Globorotalia menardii*, *Globoquadrina conglomeraata* and *G. dutertrei*.

Species of rare occurrence—*Globigerina bulloides*, *G. calida*, *G. pachyderma*, *G. quinqueloba*, *Globigerinella adamsi*, *Borbulina bilobata*, *Sphaeroidinella dehiscens*, *Globorotalia hirsuta*, *G. tumida*, *G. truncatulinoides*, *G. m. flexuosa*, *Globoquadrina hexagona*, *Globigerinita glutinaria*, *G. uvala* and *Candeina nitida*.

The species *Globigerina quinqueloba*, *Borbulina bilobata*, *Sphaeroidinella dehiscens*, *Globorotalia hirsuta*, *G. truncatulinoides* and *Globigerinita uvala*, were noticed only in the deepest station at a depth of 2240 m.

Of the above listed species, a solitary specimen of *Borbulina bilobata* is reported for the first time from the Indian Ocean region in the Recent sediments.

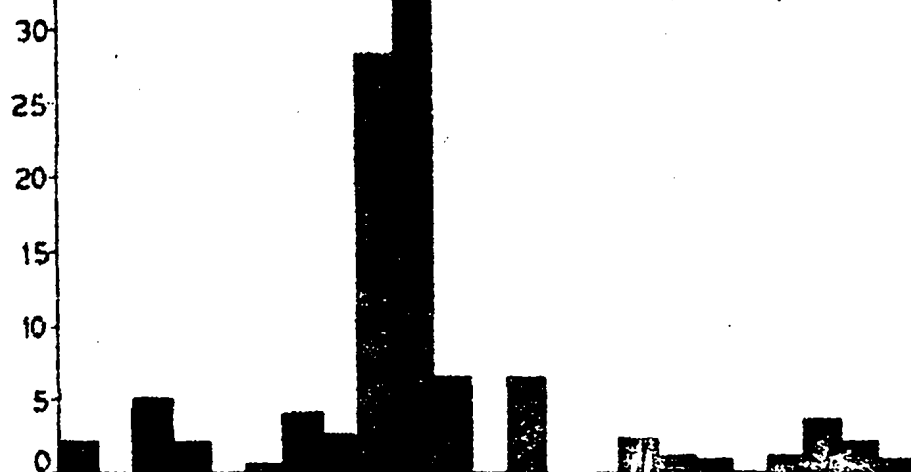
Borbulina bilobata exhibits bilobed test, last two chambers are spherical and almost equal in size, here, penultimate chamber encloses all the preceding chambers unlike in *Orbulina* where the final chamber encloses the preceding chambers. There is a very distinct suture between the last two chambers, aperture multiple, rounded and distributed throughout the test.

Its stratigraphic range has been given as Oligo-Miocene of Trinidad and Venezuela, Miocene of Angola, Pliocene of Spain and Italy and Tertiary of Portugal, Spain and Austria (Rocha *et al.*, 1964). The test of the above form very closely resembles that of Rocha's figure of *B. bilobata* (Rocha *et al.*, 1964 pl. XV, fig. 6). The occurrence of this Tertiary form may be due to reworking of microfossils.

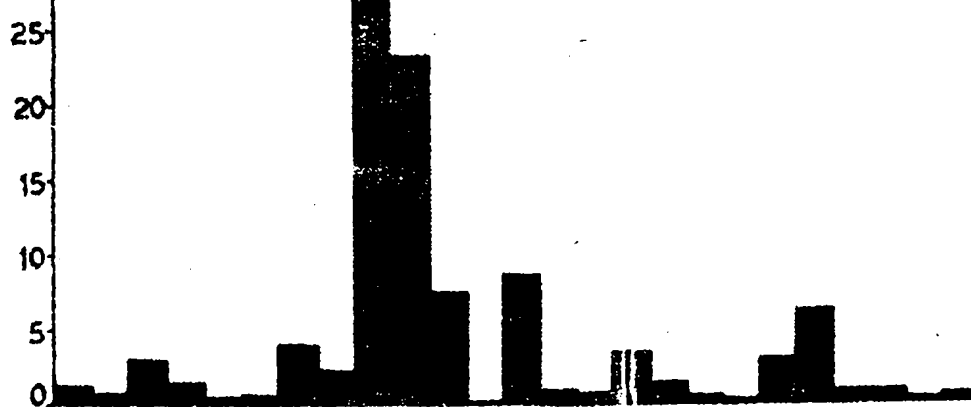
The large concentration of planktonic foraminifera is because that they typically inhabit oceanic waters. The highest concentration of planktonic foraminifera in the samples from greater depths also testifies to the prevailing optimum conditions for living and reproduction of these organisms in the epipelagic region. Thus there is direct relationship between the quantity of living foraminifera in the upper water layers and empty shells in the bottom sediment (Belyaeva, 1962, 1964). Further, these are found in large concentrations in the pelagic offshore regions, because the water is not affected by



STATION NO 54 (800m)



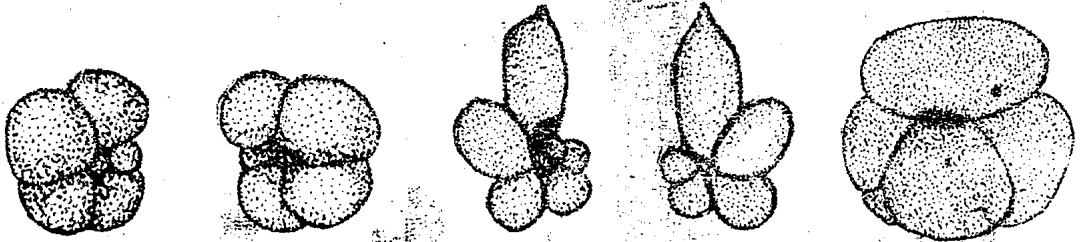
STATION NO 46 (1460m)



STATION NO 52 (2240m)

LOBIGERINA BULLOIDES
 CALIDA
 RUBESCENS
 PACHYDERMA
 QUINQUELOBA
 LOBIGERINELLA ADAMSI
 AEGUALTERALIS
 LOBIGERINOIDES CONGLOBATUS
 SACCULIFER
 RUBER
 TROCHAMMINA UNIVERSA
 TROCHAMMINA BILOBATA
 ELSMOTHERINA OBLIQUOLUCATA
 HAERIDINELLA DEHISCENS
 OBOROTALIA HIRSUTA
 MELANORTHIS
 TUNDIDA
 M. FLEXUOSA
 TRUNCATULINOIDES
 OBOQUADRINA CONGLOMERATA
 DUTERTREI
 HEXAGONA
 GLUTINATA
 GYALIA
 INDEINA NITIDA

PLATE 1



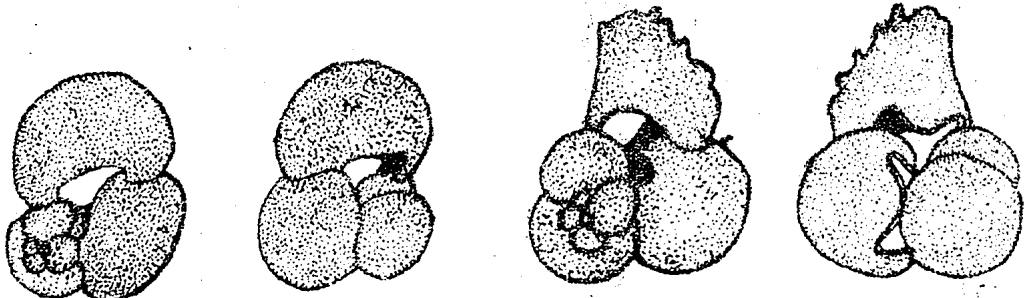
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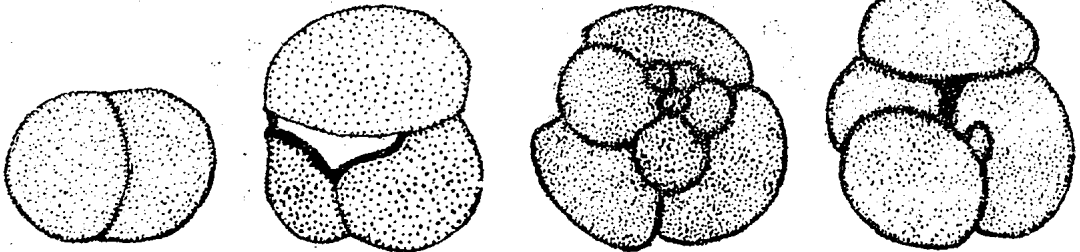


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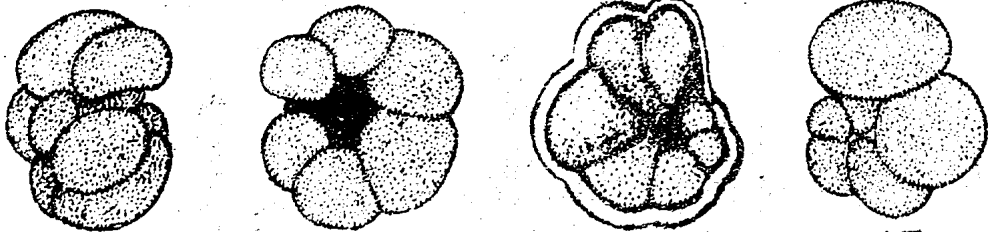


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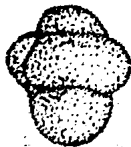


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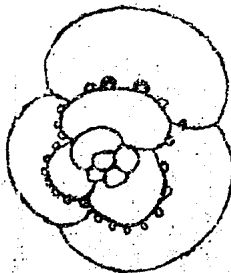
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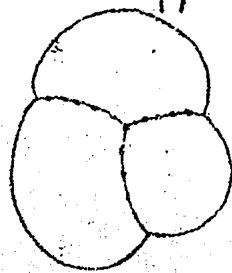
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the influx of fresh water which carry terrigenous matter of the rivers.

In the present planktonic foraminiferal assemblage, two different faunal elements characterising the two different climatic zones, high latitude and mid and low latitudes waters of the present day oceans can be identified.

Globigerina pachyderma is an important climatologic indicator and the only cold water species which is confined to the present day polar regions. Its distribution and ecology in the world oceans has been studied in detail. It has been reported from the sediments of the western continental shelf, extending from Cochin to Bombay (Rao 1973, and Setty 1972, Setty and Gupta 1972 and Rao 1972). In the present assemblage of planktonic foraminifera, it has an average frequency of about 2.1%. Here the test of *G. pachyderma* exhibits an outline with 4-5 thin compact chambers. It has been invariably noticed that the final chamber is smaller than the penultimate chamber, except for a few rare sinistral forms, all were found to be dextral ones.

Although many workers have reported *G. pachyderma* in the sediments of the Arabian Sea, it may not be specific to this region as area of present investigation falls in the tropical zone of Bradshaw (1959.) These species in the sediments of the slope off Bombay might have been brought by the cold Antarctic bottom water currents which probably penetrate into this region. The general frequency distribution of these two cold water species *G. pachyderma* and *G. bulloides* in the material may directly be proportional to the distance they might have been drifted from the areas of their origin from the Antarctic and Sub-Antarctic respectively. Zobel (1970), Be and Toldlund (1971), and Rao (1973) in their study of living planktonic foraminifera from the surface waters of the Arabian sea and from the tropical and subtropical Indian Ocean did not find any *G. pachyderma*.

According to Blair (1965), *G. pachyderma* is the only foraminifera species of the Antarctic which gradually decreases in number towards the north. Jenkins (1967) found that *G. pachyderma* has a dominantly dextral coiling in Recent sediments around New Zealand. Bandy (1960) revealed that *G. pachyderma* gradually changes

the Antarctic. The occurrence of these species in the present area may be because that *G. pachyderma* is essentially restricted to water masses as far as 25°N in the northern hemisphere. On the basis of the direction of coiling, these species have been differentiated into two categories; sinistrally coiled cold water species and dextrally coiled warm water type, the former is restricted to the higher latitudes and the latter to the midlatitudes (Ericson 1959 and Bandy 1960). Bandy (1967) has concluded that the variation from the existing polar planktonic fauna of *G. pachyderma* to the tropical planktonic foraminiferal faunas reflects the changes in water temperature from less than 2°C to more than 23°C. He also mentioned the extension of polar planktonic foraminifera into temperate areas such as southern California, New Zealand and parts of Japan. Bhatt (1969) has reported the presence of *G. pachyderma* from the outer shelf regions off Visakhapatnam in the Bay of Bengal, and has concluded that its presence indicates the "relict" nature of the sediment in that region. He also stresses that the recorded assemblage corresponds to the latest stage or sub-stage of the Pleistocene glaciation.

In the present investigation, the meagre percentage occurrence (average 2.1%) of *G. pachyderma* does not suggest that they originated during the Pleistocene. However, the presence of *G. pachyderma* may possibly be due to the following factors :

1. it might have been brought by the cold Antarctic bottom water currents,
2. possibly, its presence may be as a result of bioturbation carried by the burrowing organisms from the sites of Pleistocene outcrops, if any, in the vicinity,
3. similarly, the slumping of the sediments might have played a role in transportation of these species from the Pleistocene deposits of the outer shelf.

Since the mixing processes play a prominent role in the assemblage of planktonic foraminifera, the presence of *G. pachyderma* elsewhere other than the regions of higher latitudes, may be attributed to the oceanic currents.

In view of the paucity of *Globigerina pachyderma* in the present area, it is suggested that

other two factors mentioned above. Moreover, the additional evidence supporting the above hypothesis is the fact that the tests of the accompanying planktonic and benthonic forms show no indication of their transportation by the turbidity currents.

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EXPLANATION OF PLATE I

- 1- 2. *Globigerina pachyderma* (Ehrenberg), 1-dorsal, 2-ventral, hypotype, dextral, X20.
- 3- 4. *Globigerinella adamsi* (Banner and Blow), 3-dorsal, 4 ventral, hypotype, X20.
5. *Globigerinoides conglobatus* (Brady), 5-ventral, hypotype, X20.
- 6- 9. *Globigerinoides sacculifer* (Brady), 6 and 8 dorsal, 7 and 9-ventral, hypotype, X20.
10. *Borbulina bilobata* d'Orbigny, 10 sutural, hypotype, X20.
11. *Sphaeroidinella dehiscens* Parker and Jones, 11-apertural, hypotype, X20.
- 12-13. *Globoquadrina conglomerata* (Schwager), 12-dorsal, 13-ventral, hypotype, X20.
- 14-15. *Globoquadrina duterrei* (D'Orbigny), 14-peripheral, 15-apertural, hypotype, X20.
16. *Globorotalia menardii flexuosa* (Koch), 16-ventral hypotype, X20.
17. *Globoquadrina hexagona* Natland, 17-peripheral hypotype, X20.
18. *Globigerinita glutinata* (Egger), 18-ventral, hypotype X20.
- 19-20. *Candeiina nitida* D'Orbigny, 19-dorsal, 20-ventral, hypotype, X20.