

PALEOGENE REWORKED FORAMINIFERA IN RECENT SEDIMENTS OFF DAMAN, WESTERN INDIA

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Abstract

The first record of reworked foraminiferal species in the Recent sediments off the coast of Daman is reported. Among others, *Quadriformina advena*, *Uvigerina minuta*, *Gyrogonoides soldani*, *Bulimina aguafrescanensis* and *Alabamina atlantisae* which are characteristic of Paleogene are encountered as earthy coloured, highly polished, rounded grains in well preserved state, and filled with some secondary material. Their ratio to total foraminiferids is highest along the eastern flank of the sand bar which rises abruptly from a depth of 43 m to a height of 7-20 m running parallel to the coast. Based on this ratio, the study area may be divided into four zones. It is considered that the Paleogene of Surat—Broach area is the source for reworking, and the Narmada—Kim—Tapti river complex as the eroding—transporting media.

INTRODUCTION

As part of the oceanographic survey work on the Bombay High region and also the institutional subproject, "Distribution, ecology and significance of foraminiferal fauna on the continental shelf of west coast of India", several surficial samples and cores were collected aboard R. V. *Gaveshani* since 1977. While examining those samples collected from the inner shelf between Bombay and Daman, upto 43 m depth, some unusual and interesting faunal associations were observed. This report is part of a larger study aimed at achieving an understanding of the occurrence of reworked, much older foraminiferal assemblage with the Recent and Near-Recent in situ fauna of the temperate region and their geologic significance. The foraminifera are extremely sensitive to changes in oceanographic conditions and, since such changes reflect in variations in the sediment and faunal properties, the reworked material represents a strong paleo-oceanographic signal. The reworked fauna is an interference composite caused by the interaction of erosion in many fine layers of the sediment column of the nearby Paleogene deposits. Though it is not uncommon for fossil foraminifera to be eroded, transported and deposited in a modern depositional environment, it is for the first time such a situation has been encountered here and this report, though limited in perspective, presents the results of an analysis of the derived fauna in the nearshore region, off Daman, Western India.

STUDY AREA AND SOURCE MATERIAL

Small bands of the Paleogene are exposed in low-lying tracts of Rajasthan (Bikaner and Jaisalmer), Kutch and Surat-Broach area in Gujarat (Krishnan 1960). The smaller outcrops of nearby Kutch and far off Rajasthan

as contributing to the sediment of nearshore Gulf of Cambay is rejected. The shelf region between Kutch out-crops and the study area is bifurcated by the presence of sand bars (Breaker Bank and Eastern Bank) preventing any material to reach this region and give a mixed fauna. Similarly, the distance from Rajasthan and the lack of any transporting media, except atmosphere, is another factor which is prohibiting any mixing from there. Therefore, due to the nearness and the eroding-transporting action of the Narmada-Tapti-Kim rivers alone as plausible, it is assumed that Surat-Broach outliers are the only source for this reworking. The reworked fauna on reaching the sea, seemed to have followed the bathymetric lows and taken the route through the Sutherland Channel to reach the study area. It is possible that this fauna is in greater abundance in the northern portion of this region and more particularly at the mouths of the rivers.

Figure 1 shows the study area on the continental shelf and the Paleogene outcrop area near Surat and Broach north of Daman. Figure 2 is an enlarged map of the Surat-Broach area showing small inliers of Paleogene age occurring within the alluvium. Krishnan (1960) in his book reports the extent of these outcrops which occur between Narmada-Kim-Tapti river complex and mentions the occurrence of characteristic Ranikot nummulites as *N. thalicus*, *N. globulus* (not *N. globosus* as incorrectly reported) and *Discocyclina* aff. *ranikotensis* followed by beds of Kirthar age and upper Eocene (Priabonian) *Pellatispira* beds. These are further overlain by thick Miocene strata. Several workers like Rao (1941), Nagappa (1959) and Raju *et al* (1970) concentrated on the study of larger foraminifera of these beds from what is known as age-diagnostic character. Samanta (1977), after reviewing the various publications based on larger foraminifera studied so far from this region, questioned the authenticity of record of occurrence of Paleocene strata in the region and concluded that it is definitely absent. Data based upon smaller foraminifera is wanting and even if it is available probably through Ph.D. theses, the results of such investigations remain unpublished for a long time.

Singh (1972) mentions the occurrence of *Anomalinaella praeanomalinella sureshi* from the upper Eocene, and Bhatia and Mandwal (1957) recorded a few Miocene smaller foraminifera from the Agate Conglomerate (Burdigalion) formation which have a range to the Recent. From Surat and Broach area, Singh (unpublished Ph.D. thesis 1973) listed several species, among which some have a range upto the Recent. He erected *Nonion kimensis* and *Canoris ghalhaensis* as new species of upper Eocene age. Some of the other species of importance which are encountered in the study area are, *Biloculinella lobata*, *Bolivina serrula*, *Discorbis giganticus*, *Glandulina rotunda*, *Marginulina nowei*, *Massilina decorata*, *Quinqueloculina triangularis* and *Rectobolivina* cf. *R. cribrata*. These are found reworked in our material. Thus in this context, this report becomes significant though concerned as reworked and transported fauna it is mixed with the Most Recent *in situ* fauna of the inner neritic shelf.

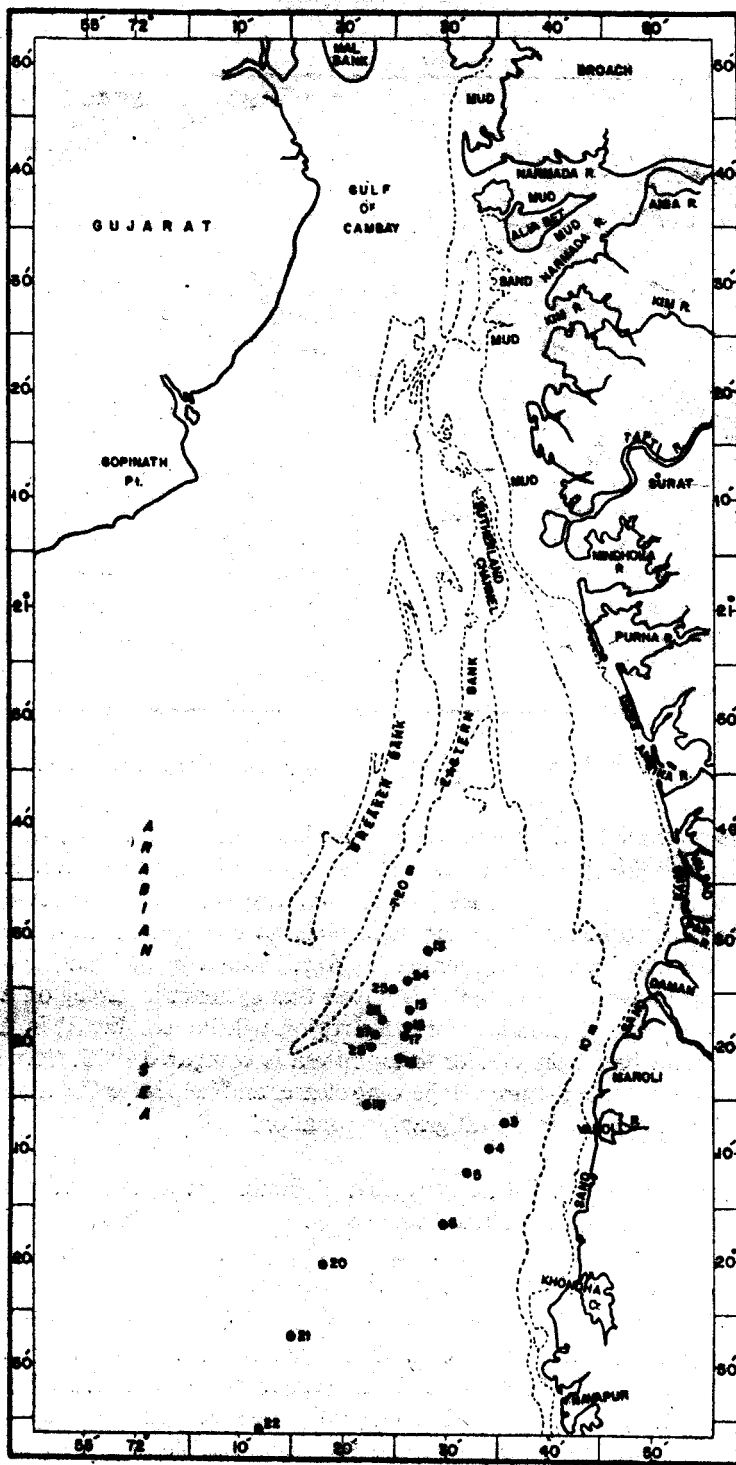


Fig. 1. Map showing location, physiographic conditions on the shelf and Surat-Broach area.

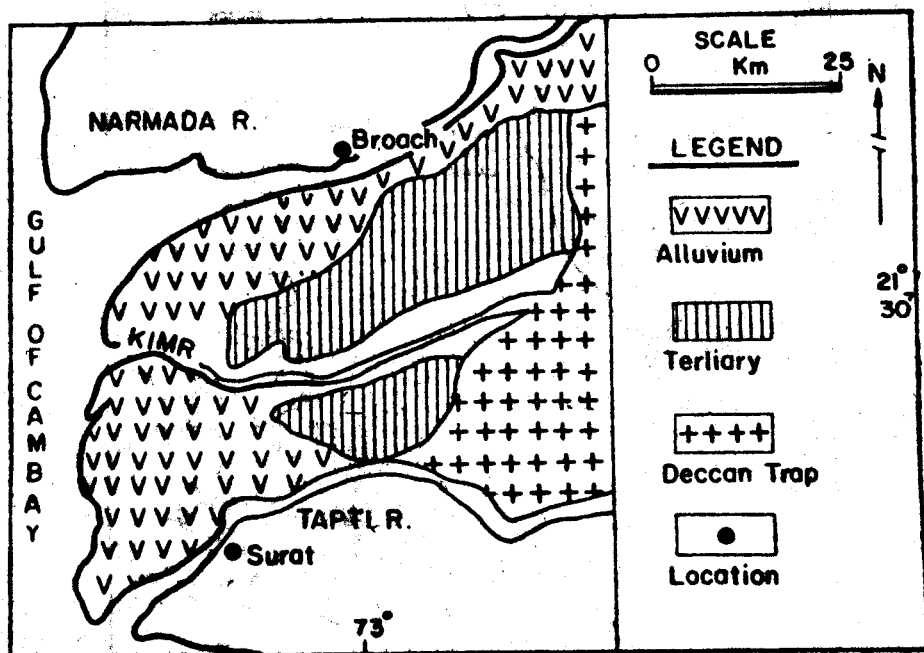


Fig. 2. Enlarged map of Surat-Broach region (the source area).

It is presumed that in view of the proximity of the outcrops of Surat-Broach area and the rivers (Narmada-Kim-Tapti) eroding the strata through which they flow, these reworked foraminifera are considered to have been derived from these beds. Whether these beds have extension into the shelf area and they also have supplemented the foraminifera by submarine/coastal erosion is not known. However, it is hoped that systematic survey on a grid basis and collection of samples from this region will be conducted in future. When such data based on smaller foraminifera is compared with that of the larger foraminifera, the picture will become clearer and help solve the ambiguity of age, and establish correct stratigraphic zonation.

Figure 3 shows a list of reworked foraminifera against each station with data on depth and abundance range of each species. The two components (reworked and Recent fauna) are easily distinguished in all samples. The older fauna is characteristically earthy coloured, highly polished, badly abraded, affecting the suture, periphery, and the shape. The test is smoothly rounded to granular form, and invariably filled with a secondary material. Such forms are preserved in silty-sand substrate and they contrast with fresh, whole, empty and/or rarely filled, complete Recent forms. Specific identification of some of the older forms has not been possible as they lack most morphological features and merge with the grain size of the sediment. The

STATION NUMBER	3	4	5	6	13	15	16	17	18	19	20	21	22	24	25	26	27	28	
DEPTH (m)	24	27	31	34	31	40	40	44	47	43	53	32	31	34	30	29	29	38	
FORAMINIFERIDS																			
1 <i>Alabammina atomifera</i> (Cushman)												F	R		R	F	R	R	
2 <i>Ammonia amoretana</i> (Parker & Jones)															A	A		R	
3 <i>Biloculinella lobata</i> (Reuss)																	R	R	
4 <i>Bolivina ferrata</i> (Sandy)		F	R	R		F	R	F	F	F	R	R		R				R	
5 <i>B. edvaxa</i> var. <i>elongata</i> Pilger		R	R	F		R	R	R	F	R	R	A		R	R	R		R	
6 <i>Bolivina apofrascoensis</i> Todd & Kakei						R	R	R		R		R						R	
7 <i>Cancris maurylea</i> Cushman & Reay																R		R	
8 <i>C. philoensis</i> Singh												R			R	R		R	
9 <i>Cibicides americanus</i> (Cushman)				R	R		R									R	R	R	
10 <i>C. portulacis</i> Nettel												R		R	R	R	R	R	
11 <i>C. pseudogurjanovi</i> (Cushman)		R	F	F	R				R			A	R	A	R	A	R	A	
12 <i>Cibicides</i> sp.			R															R	
13 <i>Dicorbis giganteus</i> Singh																R	F	A	
14 <i>Ephidium crispus</i> (Linnaeus)		R	R	R		R	R	R		R		R		R	R		R	R	
15 <i>E. minutum</i> (Reuss)												R		R	R		R	F	
16 <i>Ephidium</i> sp.						R						F		R		R	R	R	
17 <i>Eponides</i> sp.			R					R	R					R	R	R	F	R	
18 <i>Fibrosites</i> sp.							R												
19 <i>Floresta acutum</i> (Fichtel & Moll)													R	R	R	R	R	F	
20 <i>Standane rotundata</i> Reuss									R			R					R		
21 <i>S. ovata</i> Cushman & Applin						R			R										
22 <i>Stobigera</i> cf. <i>S. triloculoides</i> Plummer							R		R		R		R	R	R	R	R	R	
23 <i>Stridaria soldanii</i> Orbiay		R	R	F	R	F	F	F	F	R	R	F	R	F	R	F	R	R	
24 <i>Marginalina nana</i> Garret & Billie													R						
25 <i>Marginalina decorata</i> Cushman										R		R							
26 <i>Nonion lineosus</i> Singh							R		F			A		F			A	R	
27 <i>Narquemianum</i> Cushman							R					F			R	F		F	
28 <i>Nonionella</i> sp.																	R	R	
29 <i>Oranulites brachicaulis</i> Todd & Kakei															R	R	F	R	
30 <i>Parvulinella marinoi</i> (Tarasov)												F		R	F	F	A	R	
31 <i>Quadrangulites edvaxa</i> (Cushman & Sigsbee)							R	R											
32 <i>Quadrangulites edvaxa</i> Hussey			F	R		R	F	R	A	F	F	F	A	R	R	A	F		
33 <i>Q. orbiculatus</i> Cushman		R	R		F	F	R	R	R	R	F		F	A	F	F	F	R	
34 <i>Q. imperialis</i> G. D. & M.A. Howe		R	R	R		R	R	F	R	F	R	R	A	A	A	F	F		
35 <i>Quadrangulites</i> D'Orbiay			R		R	R	R				R		R	R	R	F	R		
36 <i>Revolvinella cribrata</i> Singh							R												
37 <i>Spiraloculina</i> sp.							R	R	R		R	F		F	F	A	A	R	
38 <i>Spiraloculina edvaxa</i> Lottner							R		R		R							R	
39 <i>Taxularia</i> sp.															R	R			
40 <i>Trochammina notchkeana</i> Howe																		R	
41 <i>Trochammina</i> (Bredy)																R	R		
42 <i>Trochammina</i> D'Orbiay																R	R		
43 <i>Uvigerina minuta</i> Cushman & Stone												R			R		R	R	

A = Abundant

F = Frequent

R = Rare

Fig. 3. The relative abundance chart of reworked foraminifera.

fauna recorded here is estimated to represent about 90 percent of the total reworked fauna. Comparison with other known species and their stratigraphic range helped in fixing the age of the derived fauna.

DISCUSSION

Quantitative estimates of relative and absolute abundance of species was not possible as the foraminiferal tests had been abraded severely as a result of wave and current action in a medium of highly energised coarse grain sediment. Only semiquantitative estimates based on visual observation of the

dominant taxa was feasible and these are taken in demarking the zonations. The sporadic occurrence of species in a given sample is roughly proportional to the sample size.

Approximately 42 species have been recorded but not all the Paleogene species are represented here. Of these 10 are typical Eocene forms. *Cibicides americanus* (Cushman) and *Quinqueloculina imperialis* range to Miocene, while *Cibicides perlucides* has a range upto Oligocene. *Quadriformina advena*, *Uvigerina minuta*, *Gyroidinoides soldani*, *Bulimina aguafrescanensis* and *Alabama atlantisae* are characteristic of Paleogene sediments, and occur as earthy coloured, highly polished, rounded grains filled with some secondary material.

This reworked assemblage contains faunal elements in common with those described from the Paleogene of Surat-Broach (Singh, 1972), Subathu subgroup (Dutta and Banerji, 1972), and wide spread geographic areas such as Kreyenhagen shale of California (Cushman and Siegfus, 1942), Verdun formation of Peru (Cushman and Stone, 1949) and Agua Fresca Shale of southernmost Chile (Todd and Kniker, 1952). Several species are common in these assemblages. In general, individual species values are between 1-5% only. At several stations (21, 25, 26 and 27) the relative percentage increase is by individual species only (see also fig. 3). The percentage increase of these species occurs in the middle and lower part of the sampled area (13-41 m depth). The percentage increase of species like *Bolivina serrula*, *Nonion kimensis*, *Pararotalia inermis*, *Quinqueloculina acuta*, *Q. alabamensis*, and *Q. imperialis*, occur with the interval transitional to 7 to 20 m on the eastern flank of the sand bar which rises abruptly from a depth of 43 m to a height of 7-20 m running parallel to the coast.

Thus as a first approximation, based upon relatively high percentages of these species compared (ratio) to the total foraminiferal number (TFN) which includes the Recent forms and the percentage distribution of the dominant forms are considered to be suggestive of four zones (zones 1 to 4, Fig. 4).

It is difficult to distinguish the true stratigraphic range of individual taxa of these derived species to their respective lithologic stages (such as members and formations) on land. Several other foraminiferal species of Paleogene of Surat and Broach are missing or not represented in these samples. It appears very strange to note as to the total absence of larger foraminifera, which have been described in detail earlier (Rao, 1941; Raju *et al.*; 1970) and even some of the other smaller foraminifera including the planktonics described by Singh (1972) and some others. It is possible, but more likely that many of them must have been fragmented and destroyed by attrition during saltation due to high wave and current action in the region. Vora *et al.* (in press) reported extensive sand wave action in this region and attributed this to the coarse sediment transported by the Narmada and Tapi

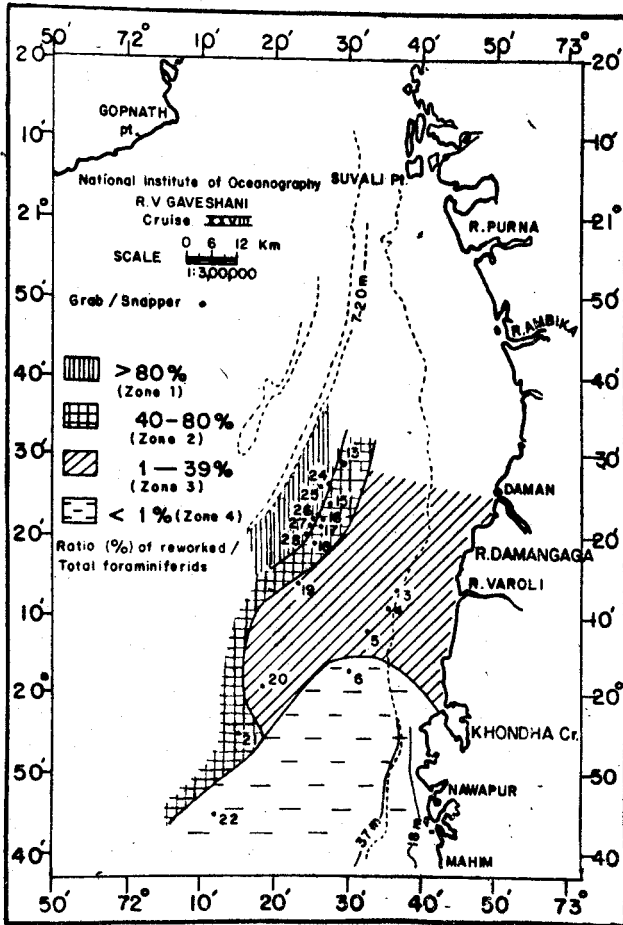


Fig. 4. Zonation (1-4) of reworked fauna based on the ratio of reworked to total foraminiferids in the study area.

river complex. It is, therefore, considered that the Paleogene of Surat-Broach area is the source for reworking, and the Narmada-Tapti-Kim river complex as the eroding-transporting media.

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