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PALAEOCENE—EARLY EOCENE BIOSTRATIGRAPHY IN NAREDA, SOUTHWESTERN KUTCH, WESTERN INDIA

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ABSTRACT

The present investigation has unravelled the presence of Palaeocene—Early Eocene sequence outcropping in the neighbourhood of village Nareda of southwestern Kutch. Micropalaeontological examinaton of the samples from the above sequence has revealed a rich assemblage of larger and smaller benthonic foraminifera and several easily identifiable planktonic foraminiferal taxa. Among planktonic taxa there are a few index species which seem to have significance in biostratigraphy. Aided by these index taxa, four planktonic foraminiferal zones have been recognised in the present succession and have been correlated on regional as well as inter-continental scale.

INTRODUCTION

The Palaeocene—Early Eocene succession under study is exposed in several nala sections near village Nareda (23°34'30" : 68°41'30"), southwestern Kutch. The Deccan Trap in the area forms the basement, over which lie unconformably the Palaeocene rocks. These are in turn disconformably followed by Early Eocene rocks. The shales, clays and marls are the principal constituents of the sequence. Of the total 33.5 m thick succession, the Palaeocene is represented by 15 m thick sequence, whereas the strata representing the Early Eocene are 18.5 m in thickness. The succession as observed in the field is as follows :

Table 1

	Yellow marl (3 m)
	Chocolate clay (2 m)
	Greenish grey, ferruginous marl (1 m)
Early	Brown clay (2.5 m)
Eocene	Glauconitic sandstone (2 m)
	Grey shale (2 m)
	Gypseous clay (3 m)
	Grey clay (3 m)
	———Disconformity———
	Unfossiliferous clay (8 m)
	Venericardia shale (3 m)
	Carbonaceous shale (1 m)
Palaeocene	Pyritic clay (1 m)
	Grey clay (0.5 m)
	Carbonaceous shale (1.5 m)
	Deccan Trap

The purpose of the present paper is to recognize the planktonic foraminiferal taxa and to arrive at a definite biostratigraphic unification, of course local in nature, of the above strata in the present area. The biozones defined here have been briefly described and correlated with other zones at regional level as well as those of the planktonic foraminiferal scheme at inter-continental level. From the historical review as presented below, it is probably true that for this part (Palaeocene—Early Eocene) of Tertiary succession in Kutch, none of the previous works, which were either for the most part the records of some fossil occurrences at respective localities of Kutch or were simply the descriptive accounts of fossils contained therein, ever dealt with biostratigraphic aspect of micropalaeontology.

PREVIOUS WORK

Biswas (1965) recognised Palaeocene of the mainland Kutch as the Madh Series and suggested its age on the basis of pollen and spore assemblage. Later, Biswas and Raju (1973) and Raju (1970) held the view that the Madh Series was constituted mainly by continental deposits. This contention was refuted by a report of some planktonic foraminifera from the Palaeocene rocks by Mathur *et al.* (1970). The occurrence of these planktonic species in the Palaeocene rocks established that these deposits were in part of marine nature and ranged in age from Early to Middle Palaeocene. The occurrence of marine Palaeocene rocks in Kutch was also recorded by Tandon (1971). Mathur (1972) described some nannofossils from Patcham Island and dated them as Palaeocene—Early Eocene. Samanta (1974), while making some biostratigraphic observations on the Palaeocene rocks of the India-Pakistan region, reviewed the earlier works

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on the rocks of this epoch in Kutch.

Tandon (1962) was first to record the presence of Early Eocene as fossiliferous Laki beds from Nareda, Kutch. Biswas (1965) referred to them as Kakdi Stage. Bhatt (1968) reported and described some planktonic foraminifera from these rocks.

FAUNAL ANALYSIS

The samples from the horizons of above succession were processed by boiling with sodium carbonate for several hours and washing over 50, 70, 100, 120, and 170 mesh sieve. The examination of the dried residue of the samples has brought to light the occurrence of microfossils in some of them. The faunal assemblage so obtained consists of ostracoda, larger and smaller benthonic foraminifera and planktonic foraminifera. The foraminiferal assemblage in the lower most 2 m thick sequence of carbonaceous shales and grey clays is represented by *Globorotalia trinidadensis*, *Globorotalia perclara*, *Globorotalia compressa* and *Globorotalia* spp. and also by several benthonic foraminiferal taxa. The following 2 m thick horizons represented by pyritic clays and carbonaceous shales are barren of microfauna. However, a change in the fauna is observed in the overlying 3 m thick band of shales of varying colours with the appearance of *Globorotalia inconstans* and disappearance of *G. trinidadensis* and *G. compressa*. Practically no microfauna could be recovered from the samples of further 8 m thick sequence of clays lying above the fossiliferous shales. They are rather characterized by pyritic inclusions which testify to the anaerobic conditions during deposition of this unfossiliferous band of clays.

The assemblage in the Early Eocene sequence too is rich in fauna and reveals fairly good number of both benthonic and planktonic foraminiferal taxa. In the lower 3 m thick sequence of sediments, the assemblage is dominated by the foraminiferal taxa like *Globorotalia rex*, *G. wilcoxensis*, *Praeindicola bikanerensis* and several species of *Schackoinella*. The accompanying larger foraminifera worked out by Tandon (1966) include *Nummulites atacicus*, *N. mamilla*, *Assilina daviesi*, *A. spinosa*, and *A. subspinosa*. The overlying 15.5 m thick sequence of beds is characterized by the absence of *G. rex* and presence of *Globorotalia prolata*, *G. esnaensis* and *G. collactea*. Among the larger foraminifera, all species of the underlying portion as mentioned above are present.

FORAMINIFERAL BIOZONATION

The following biozonation of the sequences (Palaeocene—Early Eocene) exposed at Nareda, southwestern Kutch has been proposed mainly based on the distribution of planktonic foraminifera. Four biozones of local nature are recognized, which are described below in ascending order (Table 2).

PALAEOCENE

Two biozones observed in this sequence are given below.

Globorotalia trinidadensis Zone : Thickness—2 m; Lithology—Carbonaceous shales and grey clays.

Characterisation : This zone contains an assemblage marked by *Globorotalia trinidadensis*, *Globorotalia perclara*, *Globorotalia compressa* and *Globorotalia* spp. The top of the zone is marked by the disappearance of *G. trinidadensis* and *G. compressa*. But *G. perclara* continues above.

Age : The zonal taxa and *G. compressa* which are known to occur in the basal part of Palaeocene suggest Early Palaeocene age to this zone.

Overlying the *G. trinidadensis* zone are unfossiliferous horizons of pyritic clays and carbonaceous shales, which are again overlain by fossiliferous grey coloured clays.

Globorotalia inconstans Zone : Thickness — 3 m; Lithology—Shales containing *Venericardia* sp. A.

Characterization : This zone is marked by local range of the zonal taxa which is accompanied by *Globorotalia perclara* of the preceding zone. Both become extinct at the top of this zone.

Age : With the help of the zonal taxa, this zone can be referred to the middle part of Palaeocene.

G. inconstans zone is followed by faunistically barren horizons doubtfully assignable to the later part of Palaeocene on account of their stratigraphic position. Overlying the unfossiliferous horizons is the Early Eocene sequence.

EARLY EOCENE

It is again divisible into two biozones.

Globorotalia rex Zone : Thickness—3 m ; Lithology—Grey coloured plastic clays with a thick clayey limestone band near the base, at places small quantity of gypsum present.

Characterization : This zone is characterized by partial range of the zonal taxa ; other planktonic foraminifera occurring in this zone are *Globorotalia wilcoxensis*, *Globorotalia* spp., *Praeindicola bikanerensis*, *Globigerina* sp. and *Schackoinella* spp., *G. rex* and *G. wilcoxensis* disappear at the top of this zone.

Age : The presence of zonal taxa is indicative of an early part of the Early Eocene.

Globorotalia prolata Zone : Thickness—15.5 m; Lithology—Gypseous brown clay, grey shale, glauconitic sandstone, brown clay, greenish grey marl, chocolate clay, yellow and brown coloured marl with a thin band of limestone at the top.

Characterization : *Globorotalia prolata*, *Globorotalia esnaensis* and *Globorotalia collactea* characterize this zone. *Praeindicola bikanerensis*, *Schackoinella* spp. and *Globigerina* sp. of the preceding zone are also present in this zone.

Table 2—Showing Lithounits and Biostratigraphic units of Palaeocene—Early Eocene sequence at Nareda, Southwestern Kutch.

Time Unit: Epoch	Time Unit: Age	Litholog	Lithounit	Biozone
EARLY EOCENE	Ypresian		Yellow Marl (3m)	*Globorotalia prolata* Zone
			Chocolate Clay (2m)	
			Greenish grey ferruginous Marl (1m)	
			Brown Clay (2.5m)	
			Glauconitic Sandstone (2m)	
			Grey Shale (2m)	
			Gypseous Clay (3m)	
			Grey Clay (3m)	*Globorotalia rex* Zone
PALAEOCENE	Landenian		Unfossiliferous Clay (8m)	Faunistically barren Zone
	Heersian		Venericardia Shale (3m)	*Globorotalia inconstans* Zone
	Danian		Carbonaceous Shale (1m)	Faunistically barren Zone
			Pyritic Clay (1m)	
			Grey Clay (0.5m)	*Globorotalia trinidadensis* Zone
			Carbonaceous Shale (1.5m)	

Age : *G. prolata* suggests that this zone is referable to the latter part of Early Eocene.

BIOSTRATIGRAPHIC CORRELATION

Authors have attempted the biostratigraphic correlation of the planktonic zones of the Palaeocene—Early Eocene succession of Nareda, southwestern Kutch with those of Rajasthan, Cambay basin, Cauvery basin, Andaman Islands, etc. in the Indian subcontinent and those of Trinidad, Italy, Egypt, U.S.S.R., etc. in the light of the correlation of Palaeocene foraminiferal zones suggested by Berggren (1971), El-Naggar (1969), Mohan and Pandey (1971) and Mohan *et al.* (1977).

Excepting Cauvery basin, Southern Shillong shelf and Andaman Islands, the biostratigraphic picture of the Palaeocene—Early Eocene is not very encouraging in most of the basins of the Indian subcontinent in view of poorly fossiliferous strata in the succession and lack of continuous sequence. The biostratigraphic correlation of the Palaeocene—Early Eocene strata in the Indian region has been attempted by many workers. The most convincing and pertinent to the present context is that of Raju (1970), Mohan and Pandey (1971) and Mohan *et al.* (1977).

Raju (1970) recognized the Palaeocene/Eocene boundary between *Globorotalia pseudomenardii* and *Globorotalia velascoensis* zones. On the basis of appearance of *Nummulites/Assilina*. According to him, in Cauvery basin where the presence of a seemingly continuous succession of Palaeocene—Eocene is found, *Nummulites/Assilina* appears at the base of *Globorotalia velascoensis* zone and can be taken to mark the onset of Palaeocene at the recommendation of Eocene Colloquium (Paris, 1968 ; Brabb, 1969). Subsequently, Mohan and Pandey (1971) introduced a little change in the boundary placement and suggested that the boundary be placed between *Globorotalia pusilla pusilla* zone and *Globorotalia pseudomenardii* zone on account of the appearance of *Nummulites/Assilina* in lower part of *Globorotalia pseudomenardii* zone in Southern Shillong shelf. However, Mohan *et al.* (1977) share the opinion of Berggren (1971), so far as the placement of Palaeocene/Eocene boundary is concerned. Accordingly, the *Pseudohastigerina* appearance datum which coincides with the top of *G. velascoensis* zone (*G. velascoensis* —*G. subbotinae* zone of Berggren) marks the Palaeocene/Eocene boundary in the Indian basins, especially the Cauvery basin.

The lack of seemingly continuous succession and relatively poorly fossiliferous nature of horizons have actually marred the feasibility of complete biostratigraphy of the Palaeocene—Early Eocene succession in Kutch. However, the sequence at Nareda exposes some fossiliferous horizons, the microfauna of which renders the recognition of a few biostratigraphic zones practically possible. These biostratigraphic zones correlate well with those demarcated elsewhere for the Palaeocene—Early Eocene succession.

PALAEOCENE

Globorotalia trinidadensis zone of the present succession can be correlated with *Globorotalia compressa/Globigerina daubjergensis* zone of El-Naggar (1969), *Globorotalia trinidadensis* zone of Bolli (1957), *Globorotalia trivalis* subzone of Subbotina (1953, 1960), *Globorotalia trinidadensis* zone of Luterbacher (1964) and latter part of *Globorotalia daubjergensis-Globigerina pseudobulloides* zone of Berggren (1971) Fig. 2. This zone is referable to the latest part of the Danian Stage (Early Palaeocene). The Indian equivalents have been shown in Fig. 1. *G. trinidadensis* zone is followed by a faunistically barren zone which is again overlain by *Globorotalia inconstans* zone.

Globorotalia inconstans zone of the present succession correlates well with *Globorotalia pusilla* subzone (of *Globorotalia angulata* zone) of El-Naggar (1969), *Globorotalia*

AGE		RAJASTHAN (Sigal & Singh; Unpub. in Mohan & Pandey, 1971)		CAMBAY BASIN (Dutta et al, 1969)	CAUVERY BASIN (Raju, 1970)	ASSAM HIMALAYA (Mohan & Pandey, 1971)	ANDAMAN ISLAND (Mohan & Pandey, 1971)	KUTCH (Raju, 1970)		KUTCH (Present Work)
EARLY EOCENE	Ypresian		N atacicus-A granulosa Ass	Data Not Conclusive	G palmerae Z	N. atacicus Ass	Data not Conclusive	Data not Conclusive		G prolata Z
		G aragonensis Z			G aragonensis Z		G aragonensis Ass	Data not Conclusive	N atacicus A granulosa Ass	
		G formosa-formosa Z			G formosa formosa-G subbotinae Z		G formosa formosa Ass			
					G subbotinae-G aequa Z		Data not Conclusive	G rex Ass		G rex Z
PALAEOCENE	Up. Palaeocene (Landenian)	G velascoensis Z		Nummulites Ass. Z	G velascoensis Z			Data not Conclusive		Faunistically barren
		G pseudomenardii Z			G pseudomenardii Z	Nummulites-Discocyclina-M miscella Ass	M miscella Ass			
	Md. Palaeocene (Heersian)	G pusilla-pusilla Z			G angulata Z	F primaeva-M miscella Ass	Data not Conclusive			G inconstans Z
		Data Not Conclusive		G pseudobulloides Ass	G uncinata Z	Data not Conclusive				Faunistically barren
	L. Palaeocene (Danian)				G trinidadensis Z	G pseudobulloides	G pseudobulloides-S triloculinoides-Ass			G trinidadensis Z
				Data not Conclusive	Data not Conclusive	S triloculinoides-Ass				

Abbreviations—Ass.-Assemblage, A.-*Assilina*, F.-*Fasciolites*, G.-*Globorotalia*, M.-*Miscellanea*, N.-*Nummulites*, S.-*Subbotina* and Z.-Zone.

Fig. 1—Showing Inter-regional correlation of Palaeocene—Early Eocene rocks in India.

AGE		Bolli (1957)	El-Naggar (1969)		Subbotina (1953,60)		Luterbracher (1964)	Berggren (1971)	Present Work
EARLY EOCENE	Ypresian	G. palmerae Zone	Not studied		Zone of conical Globorotaliids		G. bullbrooki Zone	A. densa Zone	G. prolata Zone
		G. aragonensis Zone					G. aragonensis Zone	G aragonensis Zone	
		G. formosa formosa Zone					G. formosa formosa/	G formosa Zone	
		G. rex Zone	G. wilcoxensis Zone		b & C (Zone of compressed globorotaliids)	C. G. marginodentata subzone	G. subbotinae Zone	G. subbotinae – P. wilcoxensis Zone	G. rex Zone
							G. aequa Zone		
PALAEOCENE	Up. Palaeocene (Landenian)	G. velascoensis Zone	G. velascoensis Zone	G. aequa – G esnaensis subzone		b G. crassata/A intermedia subzone	G. velascoensis Zone	G. velascoensis-G. subbotinae Zone	Faunistically barren
								G. velascoensis Zone	
		G. pseudomenardii Zone		G. pseudomenardii subzone			G. pseudomenardii Zone	G. pseudomenardii Zone	
	Mid. Palaeocene (Heersian)	G. pusilla pusilla Zone	G. angulata Zone	G. pusilla subzone	a (Zone of rotaliid-like globorotaliids)	G. inconstans subzone	G. pusilla pusilla Zone	G. pusilla-G. angulata Zone	G. inconstans Zone
		G. uncinata Zone		G. uncinata subzone			G. uncinata Zone	G. uncinata-G. spiralis Zone	Faunistically barren
	Lr. Palaeocene (Danian)	G. trinidadensis Zone	G. compressa/Gl. daubjergensis Zone			G. trivialis subzone	G. trinidadensis Zone	Gl. daubjergensis - Gl. pseudobulloides Zone	G. trinidadensis Zone
		Rzehakina epigona Zonule					Gl. pseudobulloides/Gl. daubjergensis Zone		
							Gl. eugubina Zone		

Abbreviations—A.-*Acarinina*, G.-*Globorotalia*, Gl.-*Globigerina* and P.-*Pseudohastigerina*.

Fig. 2. Showing Inter-continental biostratigraphic correlation of Palaeocene-Eocene Epochs.

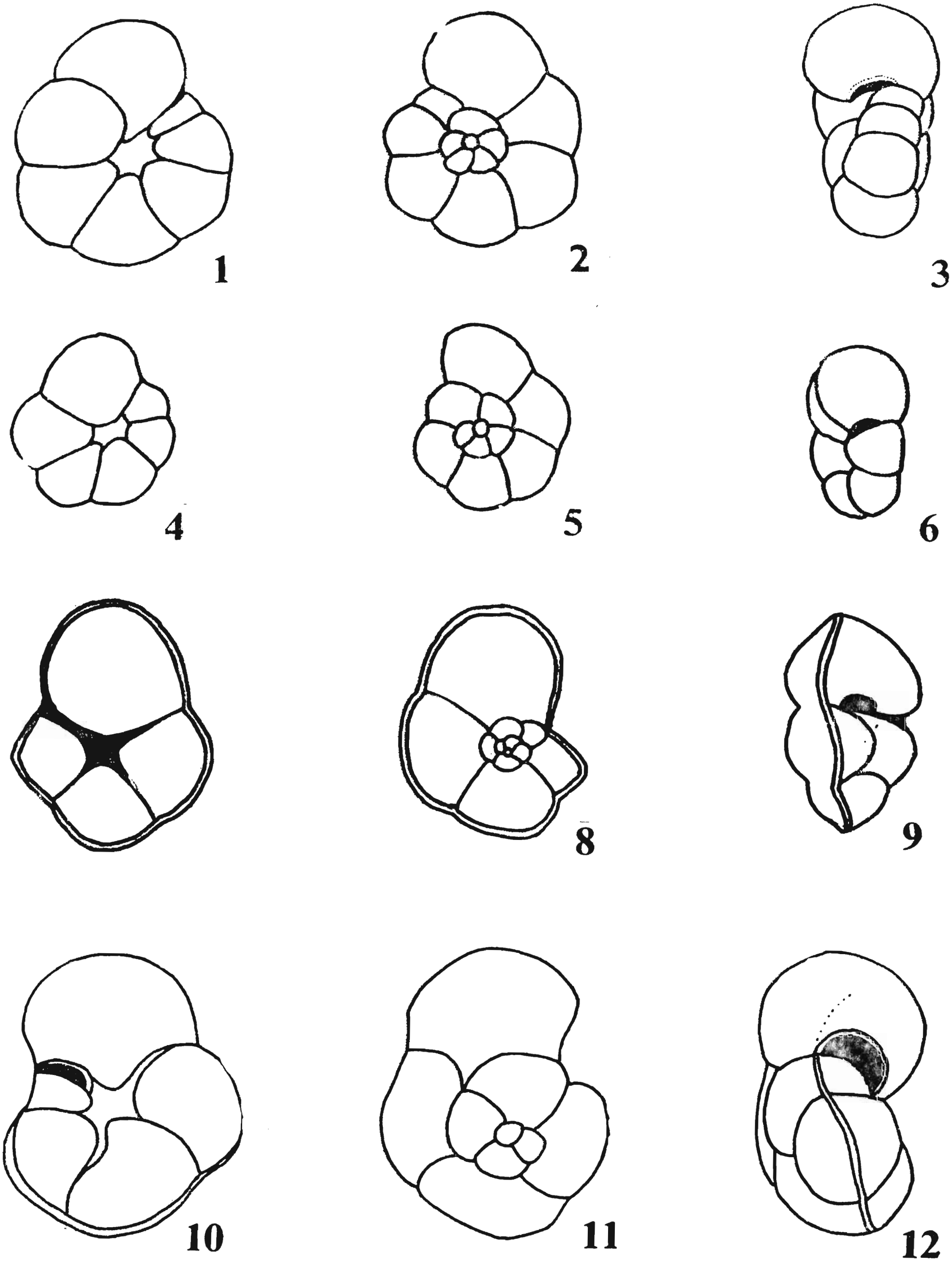
pusilla pusilla zone of Bolli (1957), latter part of *Globorotalia inconstans* subzone of Subbotina (1953, 1960), *Globorotalia pusilla pusilla* zone of Luterbacher (1964) and *Globoratalia pusilla*--*Globorotalia angulata* zone of Berggren (1971) Fig. 2. The biostratigraphic position of this zone suggests that it is referable to the latter part of Heersian (Montian) stage (latter part of the Middle Palaeocene). Its Indian equivalents have been shown in Fig.1. The horizons overlying this zone have been found to be faunistically barren and are in turn overlain by horizons showing the presence of *Globorotalia rex*, an Early Eocene index species. The faunistically barren horizons may possibly be assigned to the Late Palaeocene by way of it being intermediate in stratigraphic position between Middle Palaeocene zone and Early Eocene zone.

EARLY EOCENE

Globorotalia rex zone of the present study seems correlatable with *Globorotalia wilcoxensis* zone of El-Naggar (1969), *Globorotalia marginodentata* zone (C) of Subbotina (1953), combined *Globorotalia aequa* and early part of *Globorotalia formosa formosa*—*Globorotalia subbotinae* zones of Luterbacher (1964) and *Globorotalia subbotinae*—*Pseudohastigerina wilcoxensis* zone of Berggren (1971) Fig. 2. It refers to the early half of Ypresian stage (early part of Early Eocene). The equivalents of the Indian subcontinent are shown in Fig. 1.

Globorotalia prolata zone at the top of the presen succession under study appears to be in correspondenc with the combined *Globorotalia formosa formosa*, *Globorotalia aragonensis* and *Globorotalia palmerae* zones of Bol (1957), lower part of the zone of conical *Globorotalia* (Sul botina, 1960), combined latter part of *Globorotalia formo formosa*—*Globorotalia subbotinae*, *Globorotalia aragonens* and early part of *Globorotalia bullbrooki* zones of Lute bacher (1964) and the combined *Globorotalia formo Globorotalia aragonensis* and *Acarinina densa* zones of Berggr (1971) Fig. 2. Its other Indian equivalents are shown Fig 1. The overlying horizons are unfossiliferous and a assignable to the early part of the Middle Eocene becau of their conformable position underneath the fossiliferc Middle Eocene strata.

The present study of the planktonic foraminif from Palaeocene—Early Eocene at Nareda, southwest Kutch suggests the possibility of the presence of f planktonic foraminiferal zones : *Globorotolia trinidade* zone, *Globorotalia inconstans* zone, *Globorotalia rex* zc and *Globorotalia prolata* zone. The biostratigraphic lir of these zones have led us to conclude that the Pala cene—Early Eocene succession under study contains sediments belonging to the Upper Danian, Heer (Montian), Landenian and Ypresian Stages (Fig. 2).



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EXPLANATION OF PLATE

PLATE I

1—3. *Globorotalia trinidadensis* 1. Umbilical view; 2. Spiral view; 3. Apertural view, ×150.

4—6. *Globorotalia inconstans* 4. Umbilical view; 5. Spiral view; 6. Apertural view, ×150.

7—9. *Globorotalia rex* 7. Umbslical view; 8. Spiral view; 9. Apertural view, ×150.

10—12. *Globorotalia prolata* 10. Umbilical view; 11. Spiral view; 12. Apertural view, ×150.