JOURNAL OF THE PALAEONTOLOGICAL SOCIETY OF INDIA
VOL. 36, 1991, PP. 67-87

SMALLER BENTHIC FORAMINIFERA FROM THE MIDDLE EOCENE OF KACHCHH (KUTCH), WESTERN INDIA

A.K. JAUHRI
DEPARTMENT OF GEOLOGY, UNIVERSITY OF LUCKNOW, LUCKNOW-226 007.

ABSTRACT

This paper records twenty-nine species of smaller benthic foraminifera from the Middle Eocene rocks of the Vinjhan-Miani area of Kachchh. The accompanying planktic and larger foraminifera and calcareous nannofossils suggest late Middle Eocene age to this assemblage. The assemblage is warm-water in nature and has its elements distributed over a vast geographic area in the Tethyan, American and Indo-Pacific regions. The wide geographic distribution of the assemblage supports the earlier view of wider latitudinal limits of tropical conditions and poor climatic differentiation due to weak pole to equator thermal gradients during Palaeogene. The stratigraphical significance of some species has also been pointed out.

INTRODUCTION

Though Indian micropalaeontologists produced a wealth of data on foraminifera of the Middle Eocene from Kachchh, all relate either to larger foraminifera or the planktic foraminifera. Nothing substantial was published concerning smaller benthic foraminifera from the Kachchh, especially in the light of palaeobiogeographic and biostratigraphic considerations. The present study is a detailed account on smaller foraminifera recorded from the Middle Eocene outcrops at the Vinjhan-Miani area of Kachchh (Fig. 1).

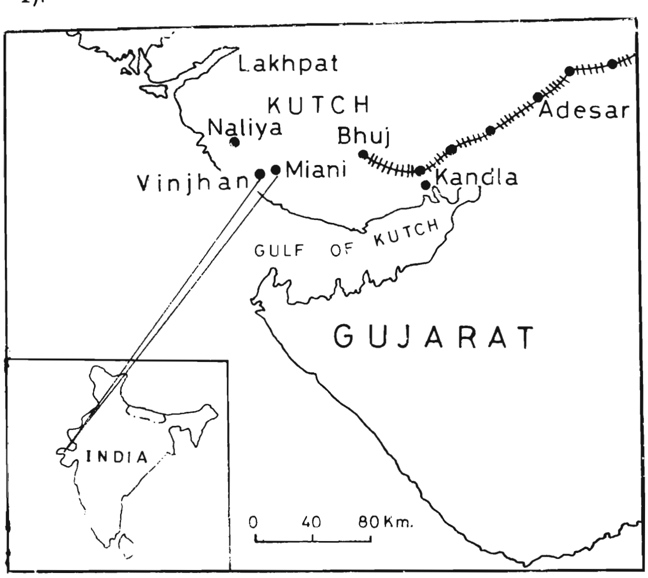


Fig. 1. Location of Kutch.

The purpose of this paper is to record the present foraminiferal assemblage from the studied area; to present observations on their geographic and stratigraphic distribution in the global context; and to discuss their palaeobiogeographic and geologic significance in the light of some recently proposed views on the distribution of larger and smaller benthic foraminifera, chiefly those of Adams (1967, 1983, 1989); Berggren and Phillips (1971); Berggren and Hollister (1974), etc. The Tertiary sequence in the Vinjhan-Miani area is exposed along the Kankawati stream section (Fig. 2). The lowly inclined rocks dip 3^0 to 5^0 towards southwest. The sequence unconformably overlies the Deccan Traps exposed on the eastern side of the village Miani. The Eocene rocks are exposed ENE to Khirasra village.

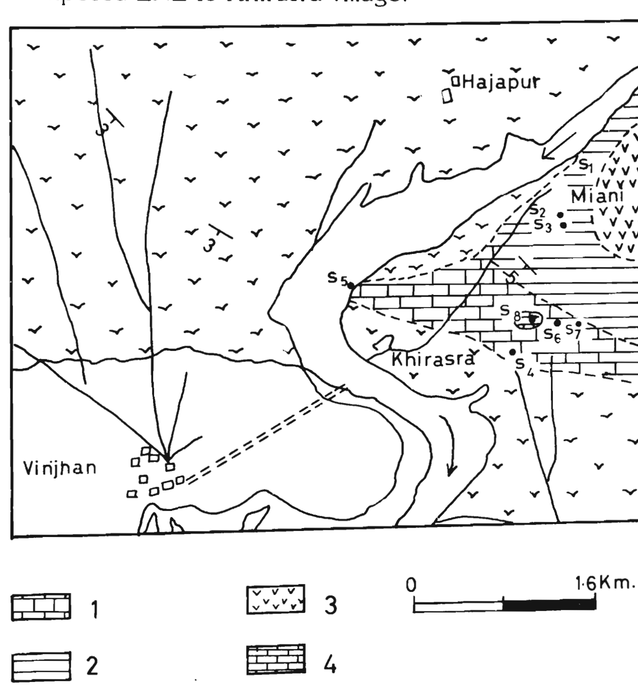


Fig. 2. Geological map of the area.
(1) Deccan Trap, (2) Sandstone and variegated shales, (3) Fossiliferous limestone and marl and (4) Dark brown, hard, fossiliferous marl.

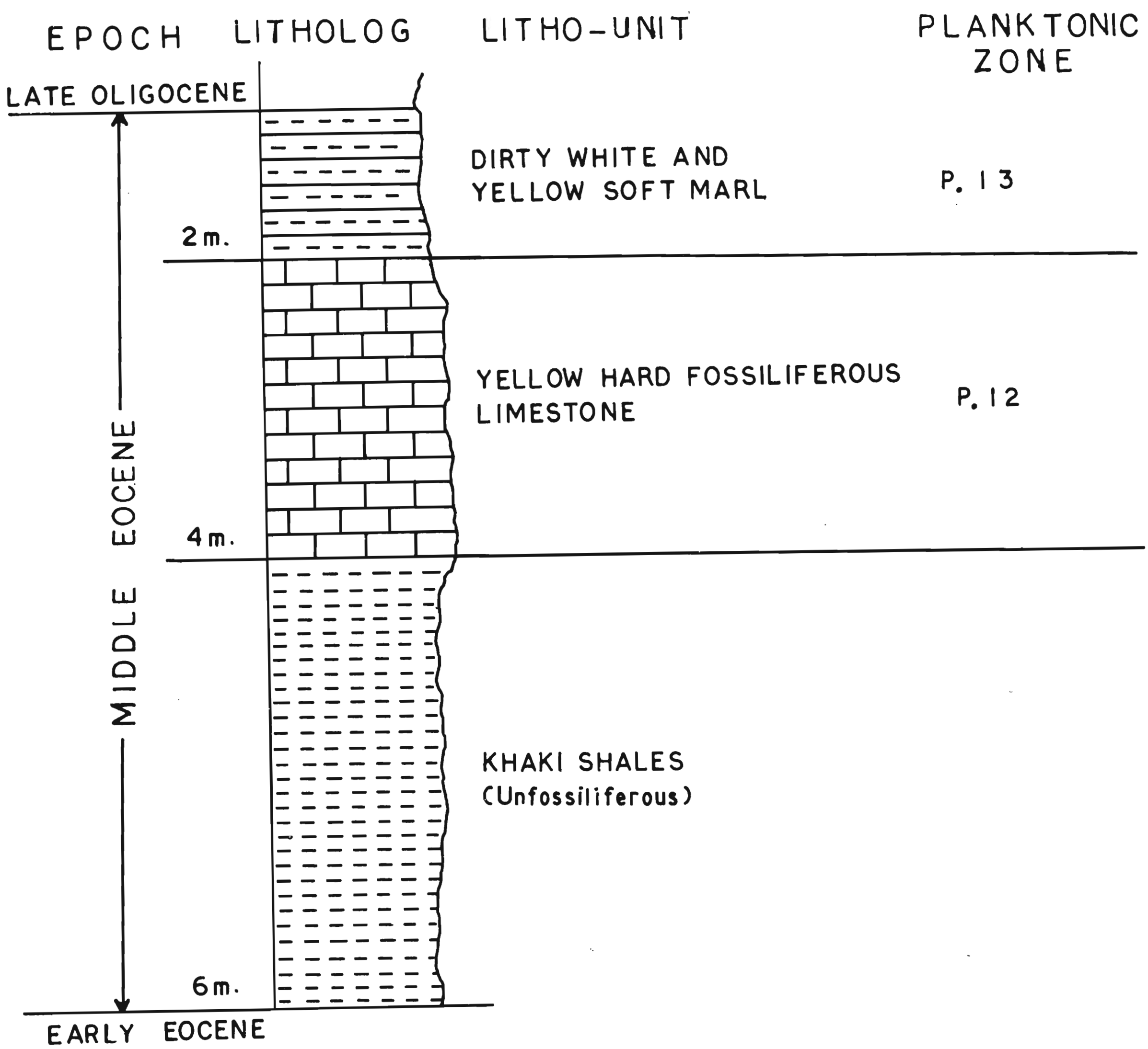


Fig. 3. Stratigraphic column in the studied area.

The rocks doubtfully assignable to the Early Eocene (Ypresian) are devoid of fossils. They are overlain by the Middle Eocene (Lutetian-Bartonian) rocks which include two fossiliferous horizons (Fig. 3). The sequence is reproduced here as follows:

Table 1

	Dirty white and yellow soft, fossiliferous marls (2 m.)
Middle Eocene	Yellow hard, fossiliferous limestone (4 m.)
	Khaki yellow shales (unfossiliferous) (6 m.)
	Grit, sandstone and variegated shales (5 m.)
Early Eocene	Greenish grey smooth clays (3 m.)
	Conglomerate (1 m.)
	Kaolinised clays (1 m.) Deccan Trap
	Deccan Trap

BIOCHRONOLOGY

Samples belonging to yellow, hard, fossiliferous limestone and dirty white and yellow soft marl have yielded a rich assemblage of foraminifera. Tewari (1952, 1956) recorded *Nummulites acutus*, *N. obtusus*, *N. stamineus*, *Alveolina elliptica*, *Assilina cancellata*, *A. exponens*, *A. subcancellata*, *Discocyclina (D.) javana*, *D. (D.) dispansa*, *D.(D.) sowerbyi*, *Dictyoconoides cooki*, *Halkyardia minima*, etc. from these rock units and assigned a Lutetian age to them. The writer has recorded rich assemblages of smaller benthic and planktic foraminifera (Jauhri, 1974, 1981; Jauhri and Vimal, 1978). Planktic foraminifera indicate that these rock units correspond to Bolli's (1957) *Globorotalia lehneri* Zone and *Porticulasphaera mexicana* (= *Or-*

bulinoides beckmanni) Zone respectively. These are equivalent to zones P. 12 and P. 13 of Blow's (1969) planktic zonation (Fig. 3).

Calcareous nannofossil assemblage recorded by Singh (1977, 1980) from these rock units suggests a late Middle Eocene age, equal to *Discoaster tani nodifer* zone (NP 16).

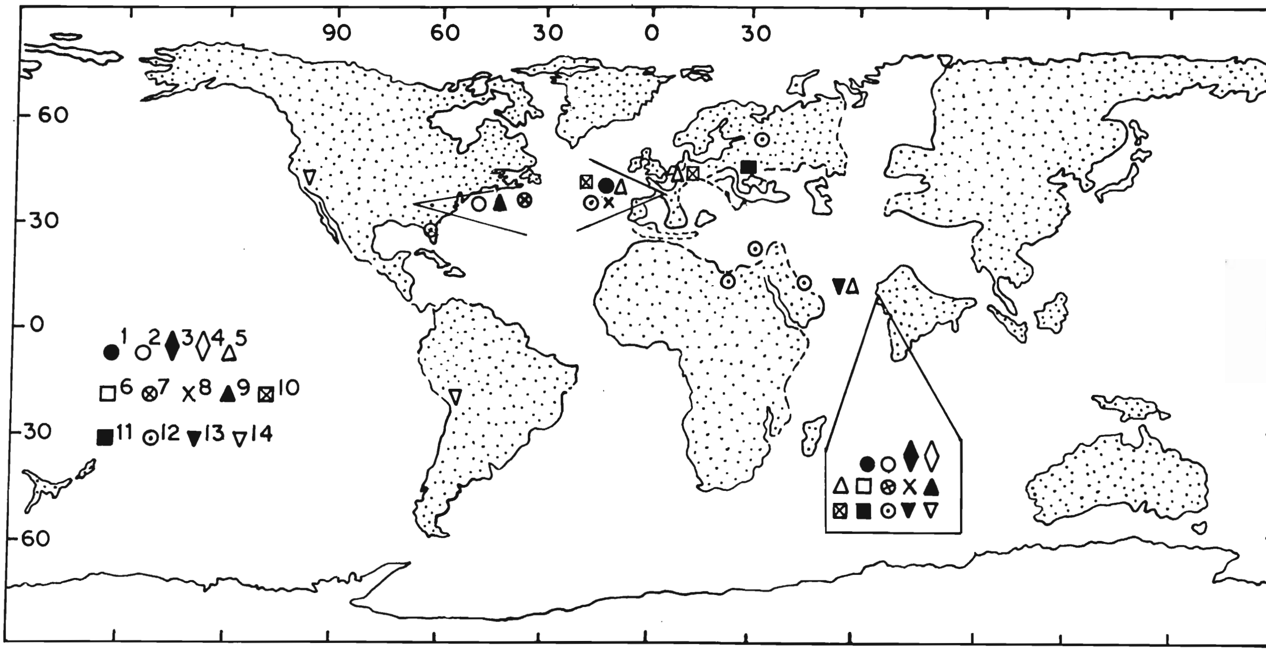


Fig. 4A. Distribution of foraminiferal species recorded in the present study (locations approximate): 1. *Textularia halkyardi*, 2. ***Textularia howei***, 3. ***Textularia kirtharana***, 4. ***Bigenerina singhi***, 5. *Clavulina parisiensis*, 6. *Pseudobolivina kolayatensis*, 7. ***Triloculina architectura***, *8. **Miliola robusta***, 9. *Fissurina crassicarinata*, 10. *Buliminella pulchra*, 11. *Bolvina danvillensis subtilissima*, 12. *Rotalia trochidiformis*, 13. *Valvulineria hillsi*, 14. *Valvulineria chirana*.

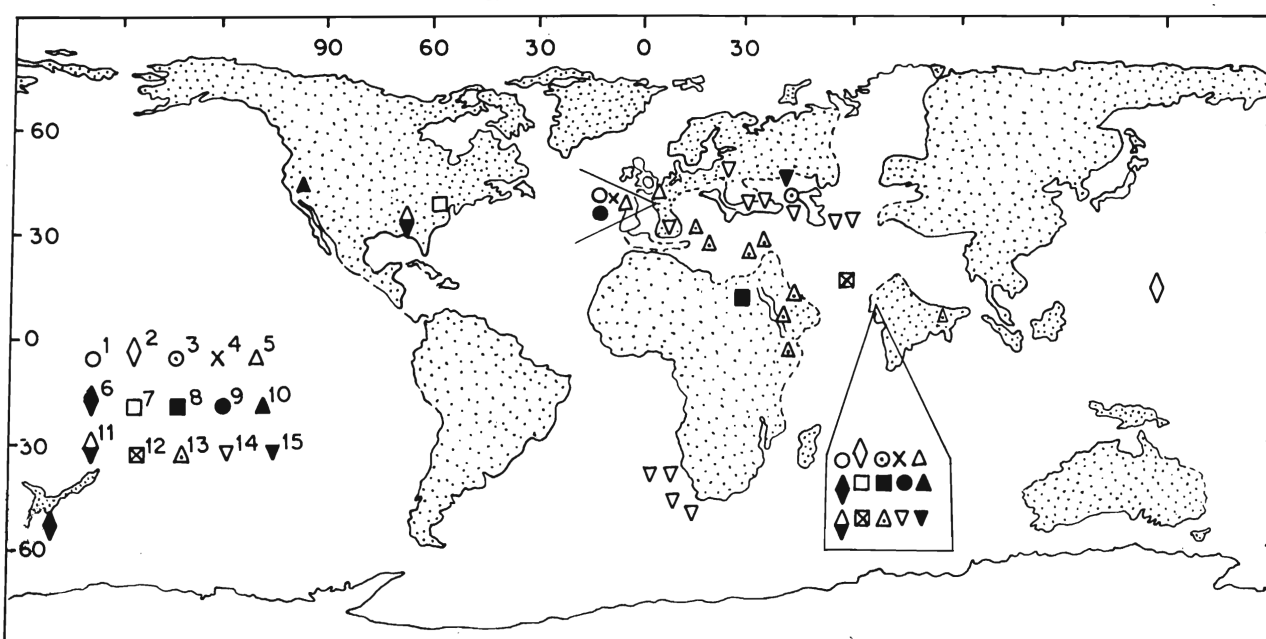


Fig. 4B. Distribution of foraminiferal species recorded in the present study (locations approximate). 1. *Pararotalia inermis*, 2. *Pararotalia floscula*, 3. *Nonion subinsolitum*, 4. *Discorbis pseudodiscoides*, 5. *Discorbis parisiensis*, 6. *Glabratella crassa*, 7. *Cibicides praecipuus*, 8. *Cibicides megaloperforatus*, 9. *Cibicides robusta*, 10. *Cibicides kernensis*, 11. *Cibicides williamsoni*, 12. *Cibicides punjabensis*, 13. *Lockhartia alveolata*, 14. *Heterolepa eocaena*, 15. *Anomalinoides nonioninoides*.

PALAEOBIOGEOGRAPHIC CONSIDERATIONS

The benthic foraminiferal assemblage recovered from the studied area contains species which have previously been cited in the foraminiferal literature. The assemblage, when viewed in terms of palaeobiogeography, seems to be significant as it includes some elements which bear on the relationship of three faunal provinces earlier demarcated on the basis of larger foraminifera (Adams, 1967), and may facilitate correlation of Palaeogene deposits. In order to examine this, a survey has been made of the literature, recording distribution of the species studied in the present paper. And it has been found that most of the species under consideration were those previously recorded from Gulf Coast region, Caribbean-Central American region, northern part of South America, Europe, North Africa, West African region, Middle East, etc. Figs 4A, B and table 2 show geographic distribution of these species. Other details pertaining to stratigraphic and geographic distribution are outlined briefly in the following pages.

EUROPE

Textularia halkyardi was recorded from the Upper Eocene Blue marl exposed near Biarritz, France. The species earlier known from the Middle Eocene of the Paris Basin are *Miliola robusta, Buliminella pulchra, Rotalia trochidiformis, Clavulina parisiensis, Pararotalia inermis, Discorbis pseudodiscoides, Discorbis parisiensis* and *Cibicides robusta. Rotalia trochidiformis* has been reported from the Palaeocene of Belgium, Holland, Germany and Poland (Pozaryska and Szczechura 1968; Van Bellen, 1946). In England, *Pararotalia inermis* is reported from the Middle-Late Eocene of the Hampshire Basin (Murray and Wright, 1974). In addition to the occurrence in the Paris Basin, *Discorbis pseudodiscoides* occurs in the Palaeocene (Montian) of the Netherlands (Van Bellen, 1946) and Palaeocene of Sweden (Hofker, 1966). *Clavulina parisiensis, Buliminella pulchra,* and *Discorbis parisiensis* are also reported from the Eocene of Belgium (Kaasschieter, 1961).

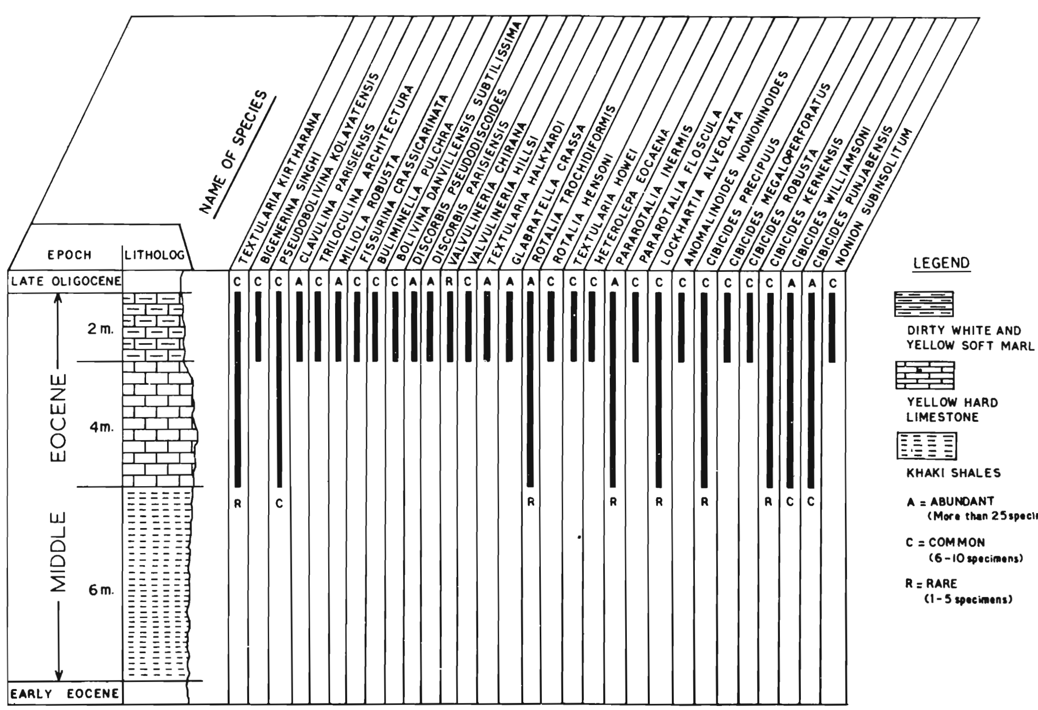


Fig. 5. Frequency distribution of the foraminifera in the studied section.

The species common to the Soviet Tethyan Palaeogene include *Bolivina danvillensis subtilissima* (Oligocene), *Nonion subinsolitum* (Upper Eocene) (Chalilov, 1956), *Heterolepa eocaena* (Eocene) and *Anomalinoides nonioninoides* (Middle and Upper Eocene) (Saperson and Janal, 1980). *Heterolepa eocaena* was previously recorded by Hagn (1956) from the Middle Eocene of Varignano, Italy.

AMERICAN REGION

The species shared with the American region (which includes Gulf Coast region, Caribbean-Central American region and northern part of the South America) are :

Textularia howei (Late Eocene; Lower most parts of Crystal Formation, Ocala group, Jackson stage)

Triloculina architectura (Middle Oligocene; Lower part of Vicksburg group)

Fissurina crassicarinata (Late Eocene; Jackson Formation Little Stave Creek, Clark County, Alabama, USA)

Rotalia trochidiformis (Early Eocene; lower parts of Oldsmar Limestone (Wilcox Group), Florida (Levin, 1957).

Cibicides kernensis (Palaeocene to Early Eocene; California, USA)

Cibicides williamsoni (Middle Eocene; Nanafolia Formation, Camden, Wilcox County, Alabama, USA)

Cibicides praecipuus (Late Eocene; Upper part of Lower to Lower part of Middle Jackson, Castle Hayne Formation, Duplin County, N. Carolina, USA)

Valvulineria chirana (Late Eocene; NW Peru & Lower Tertiary; California Coastal Ranges).

WESTERN PACIFIC REGION

The species shared with this region have been recorded from New Zealand, and Bikini Atoll, the Marshall Islands and are listed below :

Glabratella crassa (described from the Middle Eocene Eyre River Chalks and Late Eocene Kaitan stage, New Zealand, Dorreen, 1948)

Pararotalia floscula (known from the lower Oligocene of Bikini Islands, Bikini Atoll, Marshall Islands).

SOUTHEAST ATLANTIC DSDP LEG 40 SITES
(WEST AFRICAN OFFSHORE REGION)

Only one species of the present assemblage is known from the West African offshore region. *Heterolepa eocaena,* frequently appearing in the Eocene of the Soviet Tethyan Palaeogene and the Middle Eocene of Varignano (Italy), has been recorded from the DSDP Leg 40 sites 360, 361, 362 A and 363 in Southeast Atlantic where it occurs in association with Velasco type assemblage (Proto Decima and Bolli, 1978).

THE MIDDLE EAST, SOMALILAND AND THE INDIAN SUBCONTINENT

The elements common to the Middle East and adjoining areas are listed below :

Cibicides megaloperforatus (reported from the Early Palaeocene of northern Sinai, Egypt).

Rotalia trochidiformis (recorded from the Palaeocene, Early Eocene of Qatar; and Early Eocene of Iraq and Palaeocene to Middle Eocene of Libya).

Lockhartia alveolata (described from the Early Eocene of Qatar, Iran, Middle Eocene of Iraq, Saudi Arabia; Early-Middle Eocene of Somaliland; and Early Eocene of Turkey) (see Al-Hashimi, 1974; Jauhri, 1985).

The species shared within the subcontinent (including Pakistan) are

Textularia kirtharana (recorded from the Middle
Pseudobolivina kolayatensis Eocene of Rajasthan (Kalia, 1971).

Bigenerina singhi (recorded from the Middle Eocene of Rajasthan (as *Bifarina singhi,* Bhatia and Khosla, 1970 and Early Eocene of Salt Range, Pakistan (as *Ectogumbelina* sp., Haque, 1956).

Clavulina parisiensis (recorded from the Early Eocene of Salt Range (Haque, 1956), the Middle Eocene of Bikaner, Rajasthan (as *Clavulina* sp. (Bhatia and Khosla, 1970), and Early Eocene of Jaisalmer, Rajasthan (Habibnia and Mannikeri, 1990).

Valvulineria hillsi (described from the Early Eocene of Salt Range, Pakistan, Haque, 1956).

Cibicides punjabensis (recorded from the Middle Eocene of Quetta District, Pakistan, Haque, 1960).

Lockhartia alveolata (reported from the Eocene of Kashmir, Western India, Assam (Singh, 1970; Jauhri, 1985; Pandey and Dwarikanath, 1977; Samanta, 1968).

The above survey demonstrates that the species recorded herein are mostly from the deposits located round the continental margins and are spread over a vast geographic area within the limits of three faunal provinces, namely, American, Tethyan and Indo-Pacific. The provinces are longitudinally separated and currently cover a circumglobal latitudinal zone over 60^0 wide. There is thus an indication that like larger foraminifera (as suggested by Adams, 1983), the warm-water smaller benthic foraminifera had extended far and wide latitudinally during Lower Tertiary times (record of *Asterocyclina* north to Latitude 54^0, Dobson *et al.,* 1976). It is now accepted that tropical conditions extended northward up to the Paris Basin and even beyond during the Palaeogene (Palaeocene to Middle Eocene) (Adams, 1967, 1983, 1989; Berggren and Phillips, 1971; Berggren and Hollister, 1974; Savin *et al.,* 1975. Durham, 1950, 1952). Such a broad latitudinal distribution of warm water conditions in early Tertiary times, according to Savin *et al.* (1975), was the result of poor development of latitudinal climatic belts due to smaller Equator to Pole thermal gradients. The faunal distribution in response to this equable thermal conditions would largely be independent of latitudinal control and there would be remarkable cosmopolitanism among marine faunas. The geographic distribution of the present foraminiferal assemblage supports this. The distribution of *Heterolepa eocaena,* a form known from European Tethys to as far south as DSDP Leg 40 sites 360, 361, 362 and 363 in southeast Atlantic, in particular, favours the idea of weak thermocline in the Palaeogene seas, as earlier suggested by Saperson and Janal (1980).

Yet despite the cosmopolitan nature of marine fauna over a wide latitudinal zone, some faunal segregation among Palaeogene benthic foraminifera has been suggested by Berggren (1974) and Berggren and Aubert (1975). Attributing this differentiation to depth and lithotope, they distinguished 3 distinct assemblages of benthic foraminifera during Palaeocene: (a) Tethyan Carbonate Fauna (TCF) includes the assemblage characteristic of shallow, warm water, inner to middle shelf, carbonate environment in the Tethys. It is characterized by distinct smaller foraminifera such as cibicidids, nonionids, rotaliids, discorbids, etc. and the larger foraminifera such as *Nummulites, Lockhartia, Alveolina, Discocyclina,* etc.; (b) Midway-Type Fauna (MF) is the middle to outer shelf assemblage deposited in shale-marl environment; (c) Velasco-type Fauna (VF) is represented by continental slope and abyssal plain assemblage. Though mainly Tethyan carbonate in character, the present assemblage also includes some elements from Midway-type and Velasco type Fauna. In this context, the mention is made of the occurrence of *Textularia howei, Heterolepa eocaena and Anomalinoides nonioninoides,* which have previously been recorded from the Midway-type and the Velasco type assemblages (Proto Decima and Bolli, 1978; Saperson and Janal, 1980). It is suggested that influx of detrital clays and silts brought into the carbonate deposition sites by rivers draining Jurassic, Cretaceous sediments and Deccan Trap in Kachchh may have resulted in the colonisation of some of these elements.

The data presented in Table 2 indicate that the present assemblage has more elements in common with the Tethyan or the Mediterranean region than with the remaining two provinces. The poor representation of the assemblage in the latter case may be due either to lack of data from these regions or to the fact that these species exist under different names because of subjective assessment of taxa. Whatever may be the reason, it is quite obvious that Kachchh faunas as recorded herein were shared to the maximum with the Tethyan region; and that the Western Indian region and the Mediterranean region supported a relatively common foraminiferal fauna. This similarity of foraminiferal fauna seems to bear out the belief that the Tethyan and Western Indian part formed a somewhat 'uniform Zoogeographic Province' during the Palaeogene. It is likely that the Western Indian region, the West Asian regions east of Iraq and Iran, and northeast Africa constituted a sort of transition zone between the Tethyan and the Indo-Pacific during the Palaeogene.

The widespread geographic distribution of benthic foraminifera have earlier been discussed in the light of dispersal through migration (Adams, 1967; Berggren and Phillips, 1971; Berggren and Aubert, 1975). The presence here of several species known previously from Europe and America throws light on the dispersal of benthic foraminifera in the Palaeogene seas (Fig. 6). Recent data on benthic invertebrates provide positive evidence for their larval transport for long distances. Based on studies of the geographic distribution of the larvae of stratigraphically important invertebrate groups in the open Atlantic Ocean, Scheltema (1977) suggested the possibility of long-distance larval transport across present ocean basins. Taking present-day evidence as analogy, he concludes that pelagic larvae of benthic invertebrates must have travelled for long distances during the Cretaceous and Early Cenozoic. The observations in the Gulf of Elat support passive transport of larger and smaller benthic

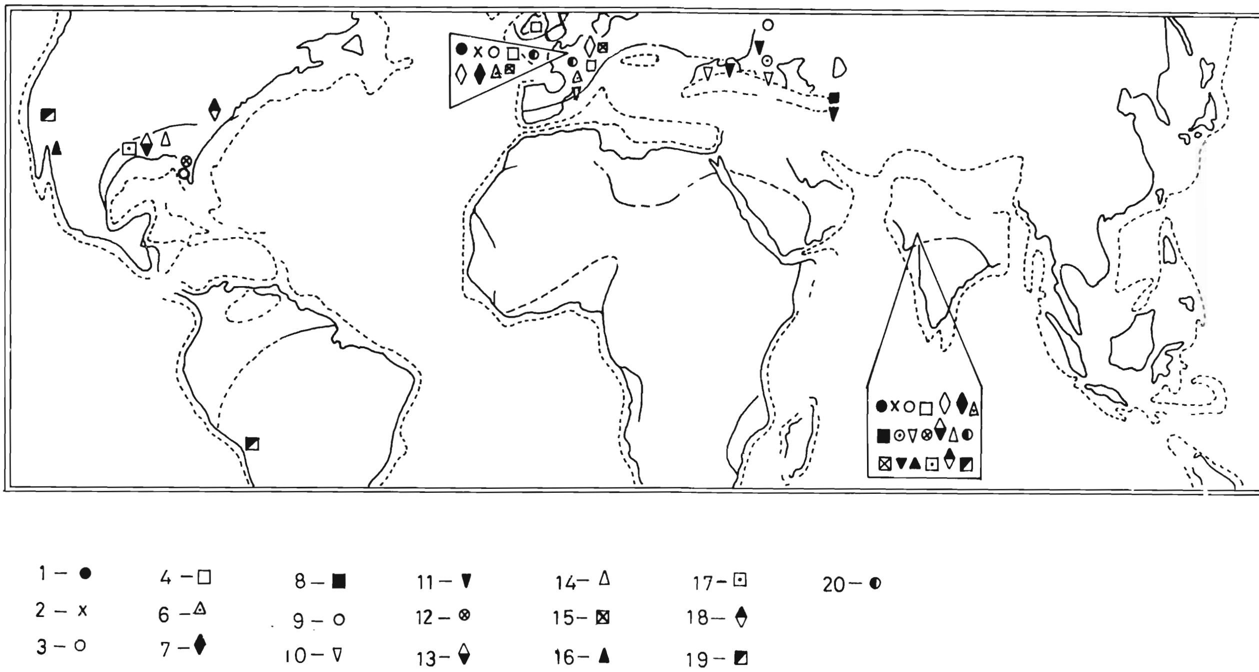


Fig. 6. Some Kachchh foraminifera common to European and American Regions (After Owen, 1983; and Fleury *et al.*, 1985) (Locations approximate).
1. *Textularia halkyardi*, 2. *Miliola robusta*, 3. *Rotalia trochidiformis*, 4. *Pararotalia inermis*, 5. *Discorbis pseudodiscoides*, 6. *Discorbis parisiensis*, 7. *Cibicides robusta*, 8. *Bolivina danvillensis subtilissima*, 9. *Nonion subinsolitum*, 10. *Heterolepa eocaena*, 11. *Anomalinoides nonioninoides*, 12. *Textularia howei*, 13. *Triloculina architectura*, 14. *Fissurina crassicarinata*, 15. *Buliminella pulchra*, 16. *Cibicides kernensis*, 17. *Cibicides williamsoni*, 18. *Cibicides praecipuus*, 19. *Valvulineria chirana*, 20. *Clavulina parisiensis*.

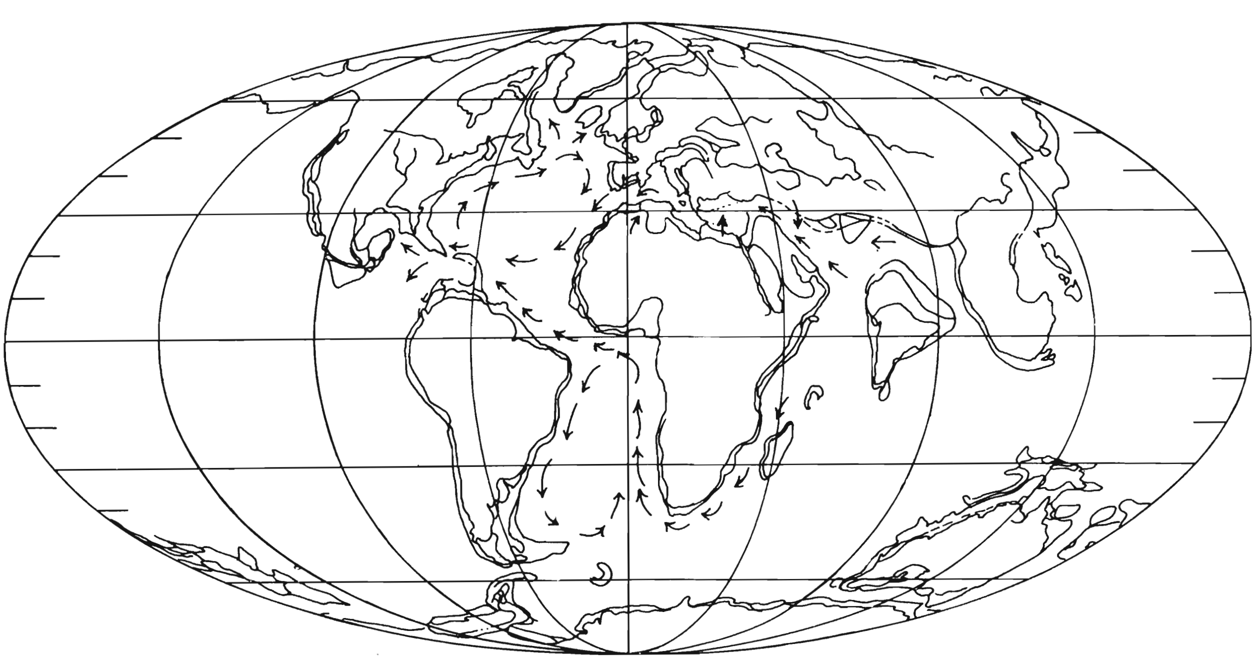


Fig. 7. World palaeogeography and inferred palaeocirculation during Palaeogene (Middle Eocene) (After Ziegler *et al.*, 1982; Berggren and Hollister, 1974).

Table 2 Geographic distribution of foraminiferal species studied in the present investigation.

Name of Species / Areas of Distribution	England	France	The Netherlands	Belgium	Italy	Crimea	Poland	Turkmenia	Lithuania	Caucasus	Carpathian	Soviet Russia	Turkey	Iraq	Iran	Saudi Arabia	Qatar	Libya	Egypt	Somaliland	America (N)	Peru	Marshall Islands	New Zealand	DSDP Sites (West African Coast)	Pakistan	India
Textularia halkyardia		●																									●
Textularia howei																					●						●
Textularia kirtharana																											●
Bigenerina singhi																											●
Pseudobolivina kolayatensis																											●
Clavulina parisiensis		●		●																						●	●
Triloculina architectura																					●						●
Miliola robusta		●																									●
Fissurina crassicarinata																					●						●
Buliminella pulchra		●		●																							●
Bolivina danvillensis subtilissima								●	●	●	●	●															●
Discorbis pseudodiscoides		●	●																								●
Discorbis parisiensis		●		●																							●
Valvulineria hillsi																										●	●
Valvulineria chirana																					●	●					●
Glabratella crassa																								●			●
Rotalia trochidiformis		●	●	●			●							●			●	●			●						●
Pararotalia inermis	●	●																									●
Pararotalia floscula																							●				●
Lockhartia alveolata													●	●	●	●	●			●							●
Cibicides megaloperforatus																			●								●
Cibicides precipuus																					●						●
Cibicides robustus		●																									●
Cibicides kernensis																					●						●
Cibicides willamsoni																					●						●
Cibicides punjabensis																										●	●
Nonion subinsolitum								●	●	●	●	●															●
Heterolepa eocaena					●	●		●	●	●	●	●													●		●
Anomalinoides nonioninoides						●		●	●	●																	●

foraminifera on filamentous green algae over great distances (Hottinger, 1977).

Very well discussed by Berggren and Aubert (1975), the effectiveness of dispersal of smaller benthic foraminifera in the Palaeogene seas seems to be in conformity with the information on global configuration, palaeocirculation and palaeotemperature. The palaeocirculation studies by Berggren and Hollister (1974) indicate that two main currents analogous to present Gulf stream and North Equatorial current existed in the Atlantic during Early Cenozoic. These were the chief agents transporting various foraminiferal elements from the Tethys and neighbouring region to America and vice versa. The Palaeogene palaeogeographic reconstructions of Owen (1983) and Ziegler *et al.* (1982) suggest that the progressively widening Atlantic was lesser than its present size during the Eocene; the Tethyan and American regions were not so widely separated longitudinally as today; and an open seaway existed from the Atlantic through the Mediterranean to the Indo-Pacific region (see Fig. 7). The palaeotemperature studies by Savin *et al.* (1975) indicate that uniform climatic conditions over long distances in the Tethyan, the American and the Indo-Pacific areas have provided the benthic forms with suitable neritic biotopes during the Palaeogene (Palaeocene to Eocene).

To sum up, the Palaeogene palaeocirculation studies, palaeotemperature analysis and palaeogeographic reconstructions all favour the idea of long distance dispersal of benthic foraminifera during their larval stages. The data presented in the present study seem compatible with the above palaeogeographic setting and the benthic foraminiferal migration during the Middle Eocene. However, it is emphasized that much specific palaeobiogeographic information on the Middle Eocene smaller benthic foraminifera is not possible until more detailed distributional studies such as those by Adams (1967) and Berggren and Aubert (1975) have been carried out from other areas in the three provinces.

STRATIGRAPHIC SIGNIFICANCE

The constituent members of the present assemblage in general are long ranging and therefore have no stratigraphic significance. But there are some which could be put to use for broad stratigraphic correlation in the absence of age-diagnostic forms. *Miliola robusta, Pararotalia inermis, Buliminella pulchra* and *Cibicides robusta* can be regarded as reliable Middle Eocene species since they also occur in the same stage in the Paris Basin. *P. inermis* is also known from the Middle - Late Eocene of Southern England. *Rotalia trochidiformis* in the wide sense, though known from the Middle Eocene of the Paris Basin and India, is a long-ranging species in Qatar, Libya, Iraq and Poland. It is also reported from the Early Eocene of Florida. In this respect, *Discorbis parisiensis* also seems to be significant in view of its occurrence in the Eocene of the Paris and Belgian Basins. *Discorbis pseudodiscoides,* and *Cibicides williamsoni* could be regarded as good Middle Eocene forms in view of their restricted occurrence in the same stage in the Paris Basin and Alabama respectively. However, in the Netherlands, *D. pseudodiscoides* occurs in the beds of Montian age (Palaeocene). *Glabratella crassa,* with its range from the Middle to Upper Eocene in New Zealand, may prove to be of some value in the Eocene stratigraphy. Of much stratigraphic interest would be *Lockhartia alveolata,* a species which is characteristic of the Eocene of Northern Somaliland, Qatar, Turkey, Iraq, Iran, Saudi Arabia and India. *Anomalinoides nonioninoides* and *Heterolepa eocaena* are also important in this respect. The former is distributed in the Middle and Upper Eocene of Crimea, northern Caucasus, Western Turkmenia, etc., and can be used as a Middle to Upper Eocene marker. *Heterolepa eocaena,* though continuing into higher stratigraphic levels in the DSDP Leg 40 sites (360, 361, 362A and 363), is restricted in the Eocene of Crimea, northern Caucasus, Turkmenia, Lithuania, Belorussia, Italy, etc. and could be considered as a good Eocene marker in Europe and Asia.

There are certain species in the assemblage which seem to be useful in local correlation within the subcontinent. *Textularia kirtharana, Pseudobolivina kolayatensis,* and *Bigenerina singhi* would possibly be good Middle Eocene species in Western India, since they are found in the same stratigraphic stage in Rajasthan. *Cibicides punjabensis,* also known from the Middle Eocene of Pakistan (Quetta), may be considered as a distinct Middle Eocene species. With its distribution in the Eocene of Rajasthan and Kachchh (Middle), and Pakistan (Lower), and Paris and Belgian Basins, *Clavulina parisiensis,* could be regarded as a species of some correlative value in the Eocene stratigraphy.

SYSTEMATIC PALAEONTOLOGY

As the taxonomic consideration is important to distributional studies of fossil species, the author's observations on the species from the studied sequence (Fig.5) are presented in this section. However, a detailed taxonomic discussion including a comprehensive synonymic listing of the present species is beyond the scope of this study. These species, in fact, refer to the broad specific categories relevant in the context of their geographic distribution.

Genus *Textularia* DEFRANCE in DE BLAINVILLE, 1824

Textularia halkyardi LALICKER
(Plate I — 1)

Textularia halkyardi Lalicker, 1963, *contrib. Cushman Lab Foram. Res. Sharon, Mass.,* Vol. 11, pt. 2, p. 45, pl. 7, fig. 5a-c.

Remarks : The present specimens are referable to *Textularia halkyardi* Lalicker on the basis of small tapering, compressed test, broadly oval distal end and low, arched aperture at the base of the last chamber.

Dimensions : Length 0.40 mm; Breadth varies between 0.25 mm and 0.27 mm; Thickness varies between 0.15 mm and 0.20 mm.

Horizon : Dirty white and yellow, soft marl.

Textularia howei PURI
(Plate I —2)

Textularia howei Puri, 1957, *Geol. Surv. Bull. Tallahassee, Florida,* no. 28, p. 100, pl. 1, fig. 4a-b.

Remarks : The present specimens compare favourably with *Textularia howei* Puri in their small, compressed test, rounded periphery, much broader apertural end, arched aperture at the inner margin of the final chamber.

Dimensions : Length 0.50 mm; Breadth ranges between 0.35 mm and 0.40 mm. Thickness 0.30mm.

Horizon : Dirty white and yellow, soft marl.

Textularia kirtharana KALIA
(Plate I — 3)

Textularia kirtharana Kalia, 1971, *Jour. Pal. Soc. India,* Vol.16, p. 58, pl. 2, figs. 1-4.

Remarks : Though much smaller than the type specimens, the present specimens are referable to *Textularia kirtharana* Kalia.

Dimensions : Length varies between 0.25 mm and 0.50 mm; Breadth varies between 0.22 mm and 0.30 mm; Thickness lies between 0.15 mm and 0.25 mm.

Horizon : Dirty white and yellow, soft marl; and yellow, hard limestone.

Genus *Bigenerina* D'ORBIGNY, 1826

Bigenerina singhi (BHATIA AND KHOSLA)
(Plate II — 5)

Bifarina singhi Bhatia and Khosla, 1970, University of Roorkee Research Journal, vol. XII, nos. 1 & 2, p. 6, pl.1, fig. 20a-b.

Remarks : The present specimens are identified as the Kutch representatives of *Bigenerina singhi* (Bhatia and Khosla) known previously from Kirthar beds (Middle Eocene) of Rajasthan.

Dimensions : Length, between 0.32 mm and 0.40 mm; Breadth, 0.15 mm; thickness, 0.12 mm.

Horizon : Dirty white and yellow, soft marl.

Genus *Pseudobolivina* WIESNER, 1931

Pseudobolivina kolayatensis KALIA
(Plate I — 6)

Pseudobolivina kolayatensis Kalia, 1971, *Jour. Pal. Soc. India,* vol. 16, pp. 60-61, pl. 3, figs. 1-12.

Remarks : *Pseudobolivina kolayatensis* in the present material is conspicuous by its elongate test with twisted axis and lobulate margins, early biserial stage, later uniserial stage, and terminal, slit-like aperture.

Dimensions : Length varies between 0.35 mm and 0.75 mm; Breadth ranges between 0.22 mm and 0.35 mm; thickness varies between 0.20 mm and 0.25 mm.

Horizon : Dirty white and yellow, soft marl; and yellow, hard limestone.

Genus *Clavulina* D'ORBIGNY, 1826

Clavulina parisiensis D'ORBIGNY
(Plate I — 8)

Clavulina parisiensis d'Orbigny, 1826, *Ann. Sci. Nat.,* vol.7, p.268, no. 3, modele no. 66 (Lutetian, Paris basin); Terquem, 1882, *Mem. Soc. Geol.* France, Ser. 3, vol. 2, p. 121, pl. 12, f. 34; Cushman, 1937, *Cush Lab. Foram. Res. Spec. Publ.* No. 8, p.18, pl. 2, f. 22-26; Y. Le Calvez, 1952, Mem. Expl. Carte Geol. det France, pt. 4, p. 15.

Remarks : The specimens referable to *Clavulina parisiensis* d'Orbigny are rare in the material. An important Eocene species of the Paris Basin (d'-Orbigny, 1826) and Belgian Basin (Kaaschieter, 1961), it is known from the Laki beds of Salt Range (Haque, 1956), Middle Eocene of Bikaner district of Rajasthan (Bhatia and Khosla, 1970) and the Lower Eocene of Jaisalmer district (Habibnia and Mannikeri, 1990).

Dimensions : Length 1.10 mm; Breadth, 0.35 mm and 0.45 mm and thickness, between 0.30 and 0.35 mm.

Horizon : Dirty white and yellow, soft marl.

Genus *Fissurina* REUSS, 1850

Fissurina crassicarinata BANDY 1949
(Plate I —12-13)

Fissurina crassicarinata Bandy, 1949, *Bull. Amer. Pal.* Ithaca, N.Y. vol. 32, no. 131, p. 64, pl. 9, fig. 6a-b.

Remarks : The present specimens agree well with the type description of *Fissurina crassicarinata* Bandy.

Dimensions : Diameter varies between 0.15 mm and 0.20 mm.

Horizon : Dirty white and yellow, soft marl.

Genus *Buliminella* CUSHMAN, 1911

Buliminella pulchra (TERQUEM)
(Plate II — 4)

Bulimina pulchra Terquem, 1882. *Mem Soc. Geol.* France ser. 3, vol. 2, p. 114, pl. 12, fig. 9-12.
Buliminella pulchra (Terquem), Cushman and Parker, 1947, U.S.G.S. Prof. Paper 210-D, p.61, pl. 16, fig. 5-6; Le Calvez, 1950, *Mem. Expl. Carte Geol.* det. France, pt. 3, p. 33, pl.2, fig. 21, 22; Kaasschieter, 1961. *Mem. Inst. Roy. Sci. Nat.* Belgique No. 147, p. 189, pl. 9, fig. 2,77.

Remarks : The present specimens compare closely with *Buliminella pulchra* (Terquem) in overall morphology. They seem to be much closer to the figures of Kaasschieter (1961) in shape, large relative size of the last whorl having long and narrow chambers, and concave apertural face with terminal aperture.

Dimensions : Length varies between 0.20 mm. and 0.225 mm and breadth between 0.125 mm and 0.15 mm.

Horizon : Dirty white and yellow, soft marl.

Genus *Triloculina* D'ORBIGNY, 1826

Triloculina architectura TODD
(Plate I — 5)

Triloculina architectura Todd, 1952, *U.S. Geol. Survey Prof. Paper*, Washington, D.C. no. 241, p. 10, pl. 1, fig. 23a,b.

Remarks : *Triloculina architectura* Todd in the Kachchh material is characterized by oval test, rounded, periphery, rapidly enlarging chambers, faintly costate surface, and rounded aperture with thin lip.

Dimensions : Length, 0.27 mm; Breadth, 0.15 mm; Thickness, 0.10 mm.

Horizon : Dirty white and yellow, soft marl.

Genus *Miliola* LAMARCK, 1804

Miliola cf. *Miliola robusta* LE CALVEZ
(Plate II —15)

Miliola robusta Le Calvez, 1947, France, *Service Caste Geol. Mem.* Paris, p. 34, pl. 3, figs. 58-60.

Remarks : The present specimens are similar to *Miliola robusta* in ovate, flat test with thin, compressed chambers, and rounded, sieve-like aperture. It differs from *M. prisca* (d'Orbigny) in its acute periphery.

Dimensions : Length, between 0.30 mm and 0.35 mm; breadth, between 0.20 mm and 0.25 mm; thickness, 0.15 mm.

Horizon : Dirty white and yellow soft, marl.

Genus *Bolivina* D'ORBIGNY, 1839

Bolivina danvillensis subtilissima MYATLIUK
(Plate II — 13)

Bolivina danvillensis subtillissma Myatliuk, 1950, Stratigraphy of the Flysch sediments of the North Carpathian Mountains in the the light of the foraminiferal fauna: Vses Neft. nauchnoissled. Geol. nauchnoissled. Geol. Razved. (VNIGRI), Microfauna of the U.S.S.R. Trudy, sbornik, 4 n.s. vypusk, 51, p.247, pl. 3, fig. 3a-b.

Remarks : The present specimens conform to the type description of *Bolivina danvillensis subtilissima*.

Dimensions : Length lies between 0.20 mm and 0.35 mm; Breadth, between 0.10 mm and 0.15 mm; and thickness between 0.05 mm and 0.10 mm.

Horizon : Dirty white and yellow, soft marl.

Genus *Discorbis* LAMARCK, 1804

Discorbis cf. *Discorbis pseudodiscoides* VAN BELLEN
(Plate II — 1)

Discorbis pseudodiscoides van Bellen, 1946, *Netherlands Geol. Stiching. Meded.* Harrlem, Ser. C.vol. 5, no. 4, p. 53, pl. 6, figs. 10-15.
Rotalia discoides (d'Orbigny) - Terquem, 1882, *Mem. Soc., Geol.*, France 3, 2, p. 82, pl. 16, fig. 9.

Remarks : Because of insufficient number of specimens, the forms are provisionally compared with *Discorbis pseudodiscoides* van Bellen. The features common to type species are the planoconvex test, flat umbilical side, strongly convex spiral side, almost straight, depressed, radial sutures on umbilical side, and closed umbilicus. Like *D. vesicularis* (Lamarck) described by Kaasschieter (1961), they have narrow projections of chambers extending to the central depressed area on umbilical side, but are characterised by the absence of calcareous plate of the former.

Dimensions : Diameter 0.25 mm.

Horizon : Dry white and yellow, soft marl.

Discorbis parisiensis (D'ORBIGNY)
(Plate II — 12-14 & Plate III — 4)

Rosalina parisiensis d'Orbigny', 1865, in Parker, Jones and Brady, *Ann. Mag. Nat. Hist.* vol. 16, ser. 3, pl.2, fig. 70 (Eocene, Paris

Basin); Terquem, 1882, *Mem. Soc. Geol.* France, Ser. 3, vol.2, p. 99, pl. 10, fig. 15-17.
Discorbis parisiensis (d'Orbigny), Cushman, 1927, *Contrib. Cush. Lab. Foram. Res.* vol. 3, p. 142; Le Calvez, 1949, *Mem. Expl. Carte Geol. det.* France pt. 2, p. 16; Kaasschieter, 1961, *Mem. Inst. Roy. Sci. Nat. Belgique.* No. 147, p. 208, pl.11, fig. 9,10.

Remarks : The present forms seem to be close to *Discorbis parisiensis* (d'Orbigny) originally described from the Middle Eocene of Paris Basin. Their distinguishing features are planoconvex, compressed test, convex spiral side, concave umbilical side, distinct, arcuate, eight to nine chambers on spiral side, and an interiomarginal, low-arched, peripheral aperture with a distinct thin lip.

Dimensions : Diameter 0.25 mm.

Horizon : Dirty white and yellow, soft marl.

Genus *Valvulineria* CUSHMAN, 1926

Valvulineria hillsi HAQUE
(Plate II — 6,10)

Valvulineria hillsi Haque, 1956, The foraminifera of the Ranikot and Laki of the Nammal Gorge, Salt Range, *Mem. Geol. Geol. Surv., Pakistan, Pal. Pakistanica,* vol. 1, p.161, pl.12, fig. 1a-b.

Remarks : These specimens conform to the type description of *Valvulineria hillsi* Haque.

Dimensions : Diameter varies between 0.125 and 0.25 mm.

Horizon : Dirty white and yellow, soft marl.

Valvulineria cf. *Valvulineria chirana* CUSHMAN AND STONE
(Plate I —18)

Valvulineria chirana Cushman and Stone, 1947, *Cushman Lab. Foram. Spec. Publ.* Sharon, Mass No. 20, p. 22, pl. 3, fig. 3a-c. - Mallory, 1959. *Bull. Assoc. Petroleum Geologists, Tulsa, Okla.* p. 230, pl. 37, fig. 8a-c.

Remarks : Because of limited number of specimens, these forms are provisionally compared with *Valvulineria chirana* Cushman and Stone. The present specimens differ in having flattened spiral side and in lacking the apertural lip.

Dimensions : Diameter varies between 0.15 mm and 0.20 mm.

Horizon : Dirty white and yellow, soft marl.

Genus *Glabratella* DORREEN, 1948]

Glabratella crassa DORREEN
(Plate I — 16)

Glabratella crassa Dorreen, 1948. *Jour. Pal.* Tulsa Okla, p. 294, pl. 39, fig. 1a-b.

Remarks : The Kachchh specimens agree with the type description in having globose, hemispherical test, inflated chambers, and rounded umbilical aperture with fine striae radiating outwards from it.

Dimensions : Diameter varies between 0.15 mm and 0.175 mm.

Horizon : Dirty white and yellow, soft marl.

Genus *Rotalia* LAMARCK, 1804

Rotalia trochidiformis (LAMARCK) *Sensu lato*
(Plate I — 14 & Plate III — 1,5)

Rotalites trochidiformis Lamarck, 1804, *Ann. Mus.* vol. 5, 184, pl. 62, fig. 3.
Rotalia trochidiformis (Lamarck) - Davies, 132, Roy. Soc. no.13, p.416, pl.2, figs. 1, 3-13, pl.4, figs. 3-6, 9-11.
Rotalia trochidiformis Lamarck var. *hautevillensis* Davies, 1932, *Roy. Soc. Edinburgh Trans.* Edin., vol. 57, (1934), pt. 2, no. 13, p. 418, pl. 4, fig. 1,2,7,8, tf. 7.
Rotalia trochidiformis (Lamarck) - Smout, 1954, Lower Tertiary foraminifera of the Qatar peninsula. London, *Brit. Mus. Nat His.*, p. 43, pl. 1, figs. 1-6. - Levin, 1957, Micropal. vol. 3, no.2, p.144-145, pl. 3, figs. 1-4.
— Haynes, 1962, *Contrib. Cushm. Found. Foram. Res.*, vol. 8, pt. 3, pl. 91.
— Pozaryska and Szczechura, 1968, *Palaeontol. Polon.*, no. 20, p.62, pl. 17, figs. 5-8.
— Cole, 1971, *Jour. Foram. Res.*, vol. 1 no. 1, p. 32, pl.1, fig. 11, pl. 2, figs. 8, 14, 16.
— Parvati, 1971, Konikal Nederal - *Akademie von Waterns chappen* - fig. 1-4.
— Al-Hashimi, 1974, *Jour. Geol. Soc. Iraq*, vol. II, pp. 59-60, pl. 2, figs. 1,2.

Remarks : The present forms seem to represent a variation of *Rotalia trochidiformis.* The important characters are trochospiral, lenticular to hemispherical test; convex spiral side; flattened to convex umbilical side; acute, carinate periphery; and granulated umbilical disc, the granules being separated by fissures.

Dimensions : Diameter ranges between 0.325 mm and 0.35 mm; much smaller than types (Haynes, Pers. Comm.).

Horizon : Dirty white and yellow, soft marl; and yellow hard limestone.

Genus *Pararotalia* LE CALVEZ, 1949

Pararotalia inermis (TERQUEM) emend. LE CALVEZ
(Plate II — 7-8)

Pararotalia inermis (Terquem) emend Le Calvez, 1949, France, *Service Carte. Geol. Mem.* Paris, p. 32, pl. 3, figs. 54-56.- Loeblich and Tappan, 1957. *Smithsonian Inst. Misc. Coll.* Washington, D.C. vol. 135 (Publ. 4303), p.14, pl.1, figs. 2-3; p.9, tfs. 4-5.

Remarks : The present forms compare favourably with *Pararotalia inermis* (Terquem) in their acute, strongly keeled periphery, inflated umbilical chambers, an interiomarginal, extraumbilical- umbilical aperture with lip, and an areal aperture. The figured specimen shows proximally directed secondary apertures.

Dimensions : Diameter ranges between 0.60 mm and 0.65 mm.

Horizon : Dirty white and yellow, soft marl; and yellow, hard limestone.

Pararotalia floscula (TODD AND POST)
(Plate III — 2,6,8)

Rotalia floscula Todd and Post, 1954, *U.S. Geol. Survey, Prof.* Papers, Washington, D.C. no. 260 N, p. 561.

Remarks : The Kachchh specimens agree with *P. floscula* in their trochospiral, biconvex test, knob-like umbilical plug with a groove round it, and spinose periphery. They can be distinguished from *P. inermis* (Terquem) by their elongate, pointed spines at the periphery and less prominent carinate character. It differs from *P. audouini* (d'Orbigny) in its indistinct but depressed sutures, larger number of chambers in the last whorl and in having a boss on each chamber near the umbilical portion; and from *P. spinigera* (Le Calvez) in having larger number of chambers in the last whorl and few, thick, elongate peripheral spines. (See Murray *et al.,* 1989; Le Calvez, 1970).

Dimensions : Diameter 0.60 mm.

Horizon : Dirty white and yellow, soft marl.

Genus *Lockhartia* DAVIES, 1932

Lockhartia alveolata SILVERSTRI
(Plate I—4)

Lockhartia alveolata Silvestri 1932, *Palaeont. Italica. Siena* Italy, vol. 32, suppl. 3, pp. 49-89, pl. 11 (9), fig. 4; Also Silvestri, 1939 ibid suppl. 4, pl. 8 (18), fig. 8.

Remarks : The present specimens agree well with *Lockhartia alveolata* Silvestri. The species is common in the material and shows considerable variation in its dimensions (Jauhri, 1985).

Horizon : Dirty white and yellow, soft marl; and yellow, hard limestone.

Genus *Cibicides* DE MONTFORT, 1808

Cibicides megaloperforatus SAID AND KENAWAY
(Plate II —2)

Cibicides megaloperforatus Said and Kenaway, 1956. *Micropaleont.* vol.2, no.2, pl. 155, pl. 7, fig. 13a-c.

Remarks : Though rarely represented in the present material, this species is characterized by buckled test, acute, lobulate periphery, curved, depressed sutures, large last chamber, and slit-like, arched aperture.

Dimension : Diameter ranges betewwn 0.30 mm and 0.45 mm.

Horizon : Dirty white and yellow, soft marl.

Cibicides robusta LE CALVEZ
(Plate I—1)

Cibicides robusta Le Calvez, 1949, *Cart. Geol. Mem.,* Paris, p. 47.

Remarks : These specimens bear marked resemblance with *Cibicides robusta* Le Calvez but differ in their large number of chambers in the last whorl and high-arched aperture extending on to spiral side.

Dimensions : Diameter ranges between 0.50 mm and 0.52 mm.

Horizon : Dirty white and yellow, soft marl.

Cibicides praecipuus COPELAND
(Plate II —3)

Cibicides praecipuus Copeland 1964, *Bull. Amer. Pal.* Ithaca, N.Y. vol. 47, no. 215, pl. 32, fig. 2a-c.

Remarks : The present specimens are referable to *Cibicides praecipuus* Copeland.

Horizon : Dirty white and yellow, soft marl; and yellow, hard limestone.

Cibicides aff. *Cibicides kernensis* COOK
(Plate I—17)

Cibicides kernensis Cook, 1959 in Mallory, Lower Tertiary Biostratigraphy of the California Coast Ranges, Tulsa, Okla. *Amer. Assoc. Petroleum Geologists,* p. 266, pl. 24, fig. 2a-c; pl. 35, fig. 6a-c.

Remarks : The present specimens are close to *Cibicides kernensis* Cook in their strongly convex umbilical side and slightly depressed spiral side, acute, strongly lobulate, periphery and a low-arched aperture with a lip.

Dimensions : Diameter ranges between 0.40 mm and 0.45 mm.

Horizon : Dirty white and yellow, soft marl; and yellow, hard limestone.

Cibicides punjabensis HAQUE
(Plate I—7)

Cibicides punjabensis Haque, 1960, *Pakistan, Geol. Surv. Mem. Pal. Pakistanica,* Pakistan, vol. 2, pt. 2, p. 42.

Remarks : The Kachchh specimens are characterized by less number of chambers in the last whorl and a high-arched aperture extending from the periphery to near umblicus. Although it looks similar to *Cibicides refulgens* Montfort and the allied species such as *C. westi* Howe and *C. vortex* Dorreen in general appearance, it is distinguishable on account of its conical umbilical side, closed umbilicus and elongate slit-like aperture extending from periphery to near the closed umbilicus. See Murray *et al.* (1989) and Kaasschieter (1961).

Dimensions : Diameter varies between 0.65 mm and 0.85 mm.

Horizon : Dirty white and yellow, soft marl; and yellow, hard limestone.

Cibicides williamsoni GARRETT
(Plate II—9,11)

Cibicides williamsoni Garrett, 1944. *Jour. Pal.* Tulsa Okla; vol. 15, p. 156, pl. 26. fig. 15a-c.

Remarks : Cibicides williamsoni Garrett is abundant in the present material and is mainly characterized by 8-9 chambers in the last whorl, plug-like structure on both sides, and low-arched, peripheral aperture with lip. It differs from *Cibicides tenellus* (Reuss) in its less strongly convex umbilical side and subacute periphery; and from *Cibicides lobatulus* (Walker and Jacob) in having the subacute periphery, inflated last chamber, and central plug-like structure on both sides.

Dimensions : Diameter ranges between 0.32 mm and 0.60 mm.

Horizon : Dirty white and yellow, soft marl; and yellow, hard limestone.

Genus *Nonion* DE MONTFORT, 1808

Nonion subinsolitum CHALILOV
(Plate I—9)

Nonion subinsolitum Chaliov, 1956 (Russian) *Akad. Nauk.* S.S.R., *Inst. Geol.* Baku, Trudy, vol. 18, pl. 13, pl. 2, fig. 6a-b.

Remarks : These forms are referable to *Nonion subinsolitum* Chalilov on the basis of small planispiral, slightly compressed test, rounded periphery, 5-8 gradually enlarging chambers in the last whorl, deep umbilicus, and a series of pores at the base of the last-formed chamber.

Dimensions : Diameter lies between 0.15 mm and 0.20 mm.

Horizon : Dirty white and yellow, soft marl; and yellow, hard limestone.

Genus *Anomalinoides* BROTZEN, 1942

Anomalinoides nonioninoides FURSENKO AND FURSENKO
(Plate I— 10, 15)

Anomalina (Anomalina) nonioninoides Fursenko and Fursenko, 1961, *Pal. Strat.* BSSR Sbormik 3, p. 290, pl. 6, fig. 7a-b.

Remarks : The Kachchh specimens compare favourably with this species in having planispiral, biconvex test, 8-9 chambers in last whorl, thin depressed sutures, narrow umbilicus, rounded periphery and slit-like aperture.

Dimensions : Diameter varies between 0.20 mm and 0.225 mm.

Horizon : Dirty white and yellow, soft marl; and yellow, hard limestone.

Genus *Heterolepa* FRANZENAU, 1884

Heterolepa eocaena (GÜMBEL)
(Plate III — 3,7)

Rotalia eocaena Gumbel, 1968, *K. Bayer, Akad. Wiss. Munchen Math.-Phys. Cl. Abh.,*10 (1870), (2), pp. 650, 651, pl. 2, fig, 8a-b.

Remarks : The present specimens compare favourably with *Heterolepa eocaena* (Gümbel).

Dimensions : Diameter ranges between 0.25 mm and 0.325 mm.

Horizon : Dirty white and yellow, soft marl.

ACKNOWLEDGEMENTS

The author is grateful to Prof. S.K. Singh, Head of the Geology Department, Lucknow University, for facilities. He is indebted to Dr. Pratap Singh, Chief

Geologist, O.N.G.C., Jodhpur, for sustained help in the preparation of this work. He has a debt of gratitude to all those scientists of Palaeontological Laboratory of K.D.M.I.P.E., O.N.G.C., who encouraged and helped him during the course of this work in their laboratory. The author expresses his gratefulness to Prof. F.T. Banner, Department of Geology, University College, London, Prof. G. Bignot, Universite Pierre Et Marie Curie (Paris VI), Prof. J.R. Haynes, Department of Geology, University College of Wales, Aberystwyth, U.K. for reading the manuscript and giving helpful suggestions and to Dr. J.P. Beckmann, Geological Institute, ZÜrich for advice and literature. Sincere thanks are expressed to the Director, B.S.I.P., Lucknow for the kind permission to use S.E.M. facilities. Funds for this research were obtained from State Council of Science and Technology, Lucknow, (vide grant no. SCST/1883/LKO (45)/72) and C.S.I.R., New Delhi (vide grant no. 24 (174)/86 EMR-II).

REFERENCES

ADAMS, C.G. 1967. Tertiary foraminifera in the Tethyan, American and Indo-Pacific provinces : Aspects of Tethyan Palaeobiogeography. *Syst. Assoc. Publ.* 7: 195-219.

ADAMS, C.G. 1983. Speciation, Phylogenesis, Tectonism, Climate and Eustasy : Factors in the Evolution of Cenozoic Larger Foraminiferal Bioprovinces : In Sims, R.W., Price, J.H. & Whalley, P.E.S. (Eds), *Evolution, Time and Space : The Emergence of Biosphere. Spl. Vol. Syst. Asoc.* 23 : 255-287.

ADAMS, C.G. 1989. Foraminifera as indicators of geological events. *Proc. Geol. Assoc.* 100 (3): 297-311.

AL-HASHIMI, HISHAM, A.J., 1974. Alveolinidae and Rotallidae from the Eocene Dammam Formation of S.W. Iraq. *Geol. Soc. Iraq* 7: 51- 74.

BERGGREN, W.A. 1974. Palaeocene benthonic foraminiferal biostratigraphy, biogeography and Palaeoecology of Libya and Mali. *Micropal.* **20**: 449-465

BERGGREN, W.A. & PHILLIPS, J.D. 1971. The influence of continental drift on the distribution of Cenozoic benthonic foraminif era in the Mediterranean and Caribbean-Gulf coast regions. *In: Symposium on Geology of Libya* (Tripoli, 1969). *Proc.* Beirut, 263-299, Catholic Press.

BERGGREN, W. A. & HOLLISTER, C.D. 1974. Palaeogeography, Palaeobiogeography and History of circulation in the Atlantic Ocean. In: Hay, W.W. *Studies in Palaeogeography. Soc. Econ. Palaeont. Mineral. Spl. Publ.* No. 24: 126-186.

BERGGREN, W.A. & AUBERT, J. 1975. Palaeocene benthonic foraminiferal biostratigraphy, palaeobiogeography, and palaeoecology of Atlantic Tethyan region: Midway-Type Fauna. *Palaeog. Palaeochim. Palaeoecol.* 18 : 73-192.

BHATIA, S.B. & KHOSLA, S.C. 1970. Some smaller forminifera from the Kirthar Beds near Mudh, District Bikaner, Rajasthan. *Res. Jour- University of Roorkee* 12: 1-13,

BANDY, O.L. 1949. Eocene and Oligocene forminifera from Little Stave Creek, Clarke County, Alabama. *Bull. Amer. Pal.* 32: 1-211.

BIGNOT, G., BLONDEAU, A., GUER NET, C., PERREAU, M., POIGNANT, A., RENARD, M., RIVELINE, J., GRAUS, C., DUDICH, E., & KAZMER, M. 1985. Age and characteristics of the Eocene Transgression at Gant (Vertes Mts, Transdanubia Hungary). *Acta Geol. Hung.* 28: 29-48.

BLOW, W.H., 1969. Late Middle Eocene to recent planktonic foraminiferal biostratigraphy. *Proc. First Int. Conf. Plankt. Microf.* 1: 199-422.

BOLLI, H.M. 1957. Planktonic foraminifera from the Eocene Navet and San Fernando Formations of Trinindad. B.W.I. *U.S. Nat. Mus. Bull.* 215: 155-172.

CHALIOV, D.M. 1956. New species of Nonion from the Palaeogene of Azerbaidzhan (Russian). *Akad. Nauk, Azerb. SSR., Int. Geol. Baku, Trudy,* 18: 5-32.

DAVIES, L.M. 1932. The Genera *Dictyoconoides*. Nuttall, *Lockhartia* sp. nov. and *Rotalia* Lamarck. *Trans. Roy. Soc. Edin.* 57: 397-428.

D'ORBIGNY, A 1826. Tableau methodique szczechura de la classe des Foraminifers. Ann. Sci. Nat, **7** : 245-314.

DOBSON, M.R. GARRETT, P., HAYNES, J.R., JENKINS, D.G. & MEDANI, A.H. 1976. Upper Cretaceous and Cenozoic carbonates from the margins of Rockall N. Atlantic. *J. Geol Soc. Lond.* 132: 611-621.

DORREEN, J.M. 1948. A foraminiferal fauna from the Kaitan stage (Upper Eocene) of New Zealand. *Jour. Pal.* 22: 281-300.

DURHAM, J.W. 1980 Cenozoic marine climates of the Pacific coast. *Geol. Soc. Amer. Bull.* 61: 1243-1264.

DURHAM, J.W. 1952. Early Tertiary marine faunas and continental drift. *Am. Jour. Sci.* 250: 320-343.

FLEURY, JEAN-JACQOUES, BIGNOT, G., BLONDEAU, A. & POIGNAT, A. 1985. Biogeographie de Foraminiferes benthiques tethysiens du Senonien a 1' Eocene superieur (Biogeography of some Senonian to Upper Eocene benthic Foraminifera in the Tethyan region). *Bull. Soc. Geol,* France (8), 5: 757-770.

GALLOWAY, J.J. & MORREY, M. 1929. A lower Tertiary foraminiferal fauna from Manta, Ecaudor. *Bull. Amer. Pal.* 15 (55). 1-56.

HABIBNIA, B.A. & MANNIKERI, M.S. 1990. Smaller Foraminifera from Eocene beds of Jaisalmer district, Western Rajasthan. *Jour. Pal. Soc. India* 35: 1-15.

HAQUE, A.F.M.M. 1956. The foraminifera of the Ranikot and the Laki of Nammal Gorge, Salt Range. *Geol. Survey Pakistan, Palaeont. Pakistanica* 1: 1-300.

HAQUE, A.F.M.M. 1960. Some Middle to Late Eocene smaller foraminifera from the Sor Range, Quetta. *Mem., Pal. Pakistanica,* Karachi, Pakistan, 2 (1959) (2) : 1-79.

HAGN, H. 1956. Geologische and Palaeontologische untersuchungen in Tertiar des Monte Brione and seiner umgabung (Gardasee, Oberiaalien). *Palaeontographica Abt.* A, 107: 67-210.

HAYNES, J.R. 1962. *Operculina* and associated foraminifera from the Palaeocene of the N.E. Fezzan, Libya. *Contrib. Cushm. Found. Foram. Res.*, 18: 90-97.

HOFKER, J. 1966. Maestrichtian, Danian and Paleocene Foraminfera. *Palaeontograph. Suppl.* 10: 1-376.

HOTTINGER, L. 1977 Distribution of larger Peneroplidae, *Borelis,* and Nummulitidae in the Gulf of Elat, Red. Sea. *Utrecht Micropal. Bull,* 15: 35-109.

JAUHRI, A.K. 1974. Occurrence of *Indicola rajasthanensis* in the Lutetian rocks of Vinjhan-Mani area, Southwestern Kutch, Gujarat. *Curr. Sci.* 43: 582-583.

JAUHRI, A.K. 1981. Observations on Morphotypes, Taxonomy and biostratigraphic correlation of the Middle Eocene planktonic foraminifera from the Vinjhan-Miani area of Kutch, Western India. *Geosci. Jour.* 2: 177-212.

JAUHRI, A.K. 1985. On the foraminifer *Lockhartia alveolata* Silvestri. *Jour. Pal. Soc. India.* 30: 30-34.

JAUHRI, A.K. & VIMAL, K.P. 1978. Some observations on the foraminifera from the Tertiary rocks of the Vinjhan-Miani area, Kutch. *Jour. Geol. Sco. India*, 19:154-159.

KAASSCHIETER, J.P.H. 1961. Foraminifera of the Eocene of Belgium. *Mem. Instit. Roy. Sci. Nat. Belgique,* 147: 1-271.

KALIA, P. 1971. Arenaceous foraminiferal assemblage from Middle Eocene of Shri Kolayatji, Bikaner, Rajasthan. *Jour. Pal. Soc. India*, 16: 60-61.

LE CALVEZ, Y. 1970. Contribution a l'etude des foraminiferes paleogenes du Bassin de Paris, Paris. *Centre Nat. Rech. Sci. Cahier Palaeont.* p. 326.

LEVIN, H.L. 1957. Micropaleontology of the Oldsmar Limestone (Eocene) of Florida. *Micropal.* 3: 139-154.

LOEBLICH, A.R. & TAPPAN, H. 1964. Sarcodina, chiefly "thecomoebians" and foraminiferida. *In Moore, Treatise Invertebrate Palaeontology*, New York. *Geol. Soc. Amer.* Pt. C. Protista 2, vols.1-2.

MURRAY, J.W. & WRIGHT, C.A., 1974. Palaeogene Foraminiferids and Palaeoecology, Hamsphire and Paris Basins and the English Channel. *Spec. Pap. Palaeont.* 14: 1-171.

MURRAY, J.W., CURRY, D., HAYNES, J.R. & KING, C. 1989. Palaeogene. In: Stratigraphic Atlas of Fossil Foraminifera (eds.D.G. Jenkins and J.W. Murray). *Brit. Micropal. Soc. Series:* 228-267.

OWENS. H.G. 1983. Atlas of continental displacement from 200 million years to present. *Cambridge. Earth Science Series* 159 p. 76 cartes.

D'ORBIGNY, A. 1826. Tableau methodique de la classe des cephalopode, III order, Foraminiferes. *Ann. Sci. Nat.* Ser. 1, 7: 245-314.

PANDEY, J. & DWARIKANATH, 1977. Larger forminiferal Zonation and Biofacies in the Palaeogene of Cambay Basin. *Proc. 4 th Colloq. Indian Micropal & Strat.* 45-33.

PARVATI, S. 1971. A study of some *Rotaliid* foraminifera. *Konikal Nederal-Akademie* von *Wetensehappen*-Amsterdam, Ser. B, 74 (1): 1- 26.

PROTO DECIMA, F. & BOLLI, H.M. 1978. Southeast Atlantic DSDP Leg 40 Palaeogene benthonic foraminifera. Initial Reports of the Deep Sea Drilling Project 40: 783-810. Washington, D.C. U.S. Govt. Printing Office.

POZARYSKA, K. & SZCZECHURA, J. 1968. Foraminifera from the Palaeocene of Poland, their ecological and biostratigraphical meaning. *Palaeontological Polonica.* 20: 1-107.

SAMANTA, B.K. 1968. The Eocene succession of Garo Hills, Assam, India, *Geol. Mag.* London, 105: 124-135.

SAPERSON, E. & JANAL, M. 1980. Biostratigraphy of the Anomalinidae and Cibicididae in the Soviet Tethyan Palaeogene. *Micropaleont.* 29: 392-413.

SAVIN, S.M., DOUGLAS, R.C. & STEHLI, F.G. 1975. Tertiary marine palaeotemperatures. *Geol. Soc. America,* 86: 1499-1510.

SCHELTEMA, RUDOLF S. 1977. Dispersal of marine Invertebrate Organisms : Paleobiogeographic and Biostratigraphic Implications. In : *Concepts and Methods of Biostratigraphy* (Eds., Kauffman and Hazel), Dowden, Hutchinson & Ross, Inc., Stroudsberg, Pennsylvania : 73-108.

SINGH, P. 1970. Lager foraminifera from the Subathus, Beragua-Jangalgali area, Jammu and Kashmir State. *Jour. Geol. Soc. India,* 11: 34-44.

SINGH, P. 1977. A note on the Late Middle Eocene nannofossils from the Vinjhan-Miani area, Kutch. *Curr. Sci.* 47: 53-54.

SINGH, P. 1980. Late Middle Eocene calcareous nannoplankton and palaeogeographic remarks on Vinjhan-Miani area, Kutch, Gujarat, *Geosci. Jour.* 1: 5-29.

SMOUT, A.H. 1954. Lower Tertiary foraminifera of the Qatar Peninsula. *British Mus. Nat. Hist.* 196: pls. 1-15.

TEWARI, B.S. 1952. The Tertiary beds of Vinjhan-Miani area, Southwestern Cutch, India. *Curr. Sci.* 21: 217-218.

TEWARI, B.S. 1956. The genus *Halkyardia* from Kutch, Wester n India. *Jour. Pal. Soc. India*, 1: 172-175.

VAN BELLEN, R.C. 946. Foraminifera from the Middle Eocene in the southern part of the Netherlands province of Limburg. *Meded. Geol. Sticht. Ser.* C-V, 4: 144.

ZIEGLER, A.M., SCOTESE, C.R. & BARRETT, S.F. 1982. Mesozoic and Cenozoic paleogeographic maps. In: *Tidal Friction and Early Rotation II,* (Eds. Brosche, F. & Sundermann, J.), Springer-Verlag, Berlin : 240-252.

EXPLANATION OF PLATES

PLATE I

1. *Textularia halkyardi* Lalicker, side view x 114.
2. *Textularia howei* Puri, side view, x 80.
3. *Textularia kirtharana* Kalia, side view, x 160.
4. *Lockhartia alveolata* Silvestri, aperatural view, x 114.
5. *Triloculina architectura* Todd, side view, x 140.
6. *Pseudobolivina kolayatensis* Kalia, side view, x 150.
7. *Cibicides punjabensis* Haque, umbilical view, x 80.
8. *Clavulina parisiensis,* (d'Orbigny), side view x 45.
9. *Nonion subinsolitum* Chalilov, side view, x 300.

10, 15. *Anomalinoides nonioninoides* (Fursenko and Fursenko), 10 apertural view, 15 side view, x 114.

11. *Cibicides robusta* Le Calvez, side view, x 85.

12, 13. *Fissurina crassicarinata* Bandy, 12 side view, 13, apertural view, x 56.

14. *Rotalia trochidiformis* (Lamarck), apertural view, x 130.

16. *Glabratella crassa* Dorreen, umbilical view, x 300.

17. *Cibicides* aff. *C. kernensis* Cook, side view, x 114.

18. *Valvulineria* cf. *V.chirana* Cushman and Stone, side view, x 300.

PLATE II

1. *Discorbis* cf. *D.pseudodiscoides* van Bellen, umbilical view, x 300.
2. *Cibicides megaloperforatus* Said and Kenaway, umbilical view, x 190.
3. *Cibicides praecipuus* Copeland, spiral view, x 135.
4. *Buliminella pulchra* (Terquem) side view showing aperture, x 300.
5. *Bigenerina singhi* (Bhatia and Khosla), side view, x 190.

6, 10. *Valvulineria hillsi* Haque, 6 side view, 10 apertural view, x 430.

7-8. *Pararotalia inermis* (Terquem), 7 apertural view, 8 umbilical view, x 114.

9, 11. *Cibicides williamsoni* Garrett, 9 side view, 11 apertural view, x 180.

12, 14. *Discorbis parisiensis* (d'Orbigny), 12 umbilical view, 14 spiral view, x 160.

13. *Bolivina danvillensis subtilissima* Myatliuk, side view, x 170.

15. *Miliola* cf. *M. robusta* Le Calvez, side view, showing aperture, x 114.

PLATE III

1,5. *Rotalia trochidiformis* Lamarck, 1 spiral view, 5 umbilical view, x 250.

2. *Pararotalia floscula* (Todd and Post), umbilical view, x 50.

3. *Heterolepa eocaena* (Gumbel), spiral view, x 200.

4. *Discorbis parisiensis* (d'Orbigny), umbilical view, x 300.

6. *Pararotalia floscula* (Todda and Post), enlarged umbilical view, of fig. 2 above, x 100.

7. *Heterolepa eocaena* (Gumbel), 7 apertural view, x 200.

8. *Parorotalia floscula* (Todd and Post), spiral view, x 50.

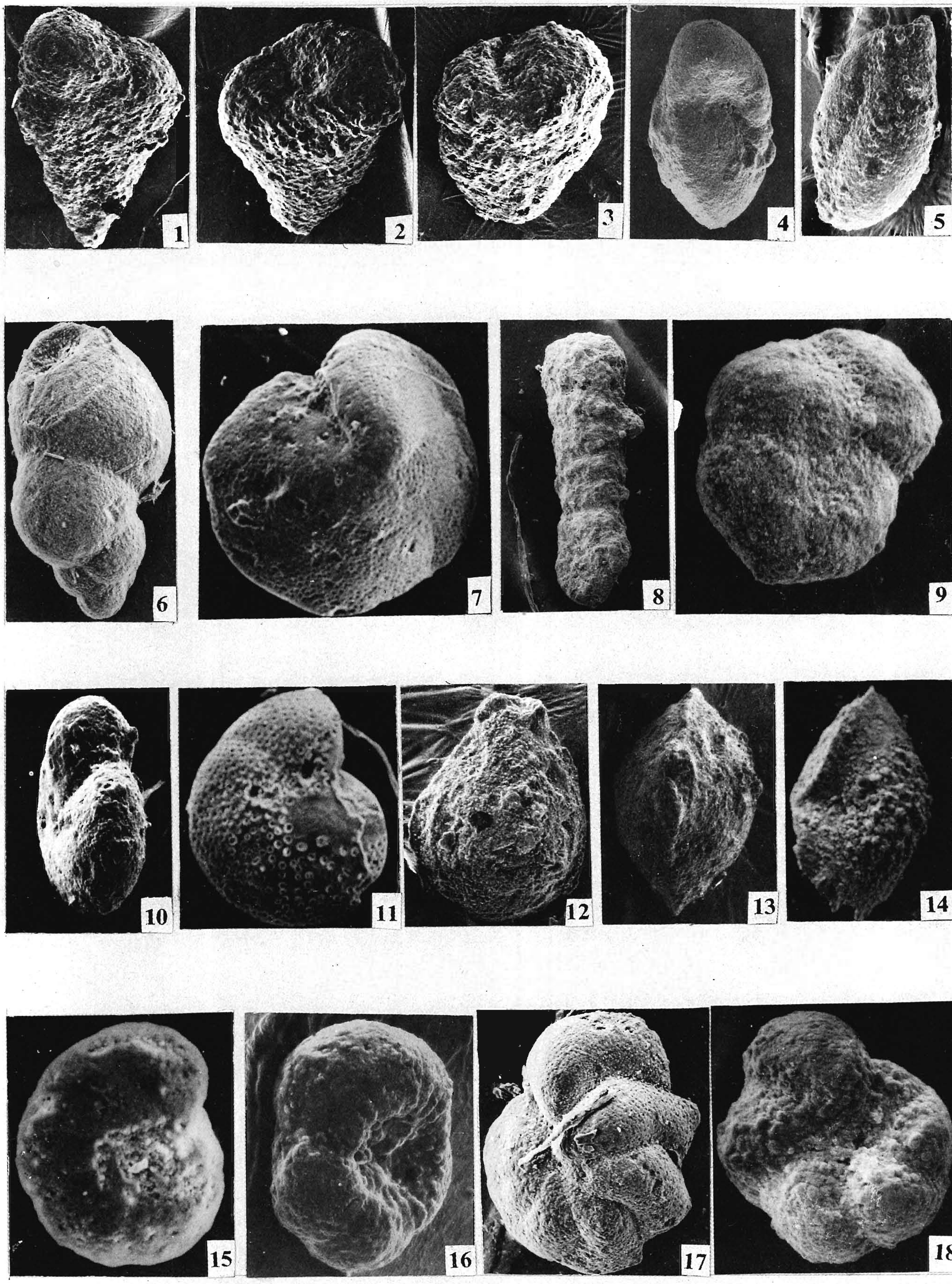
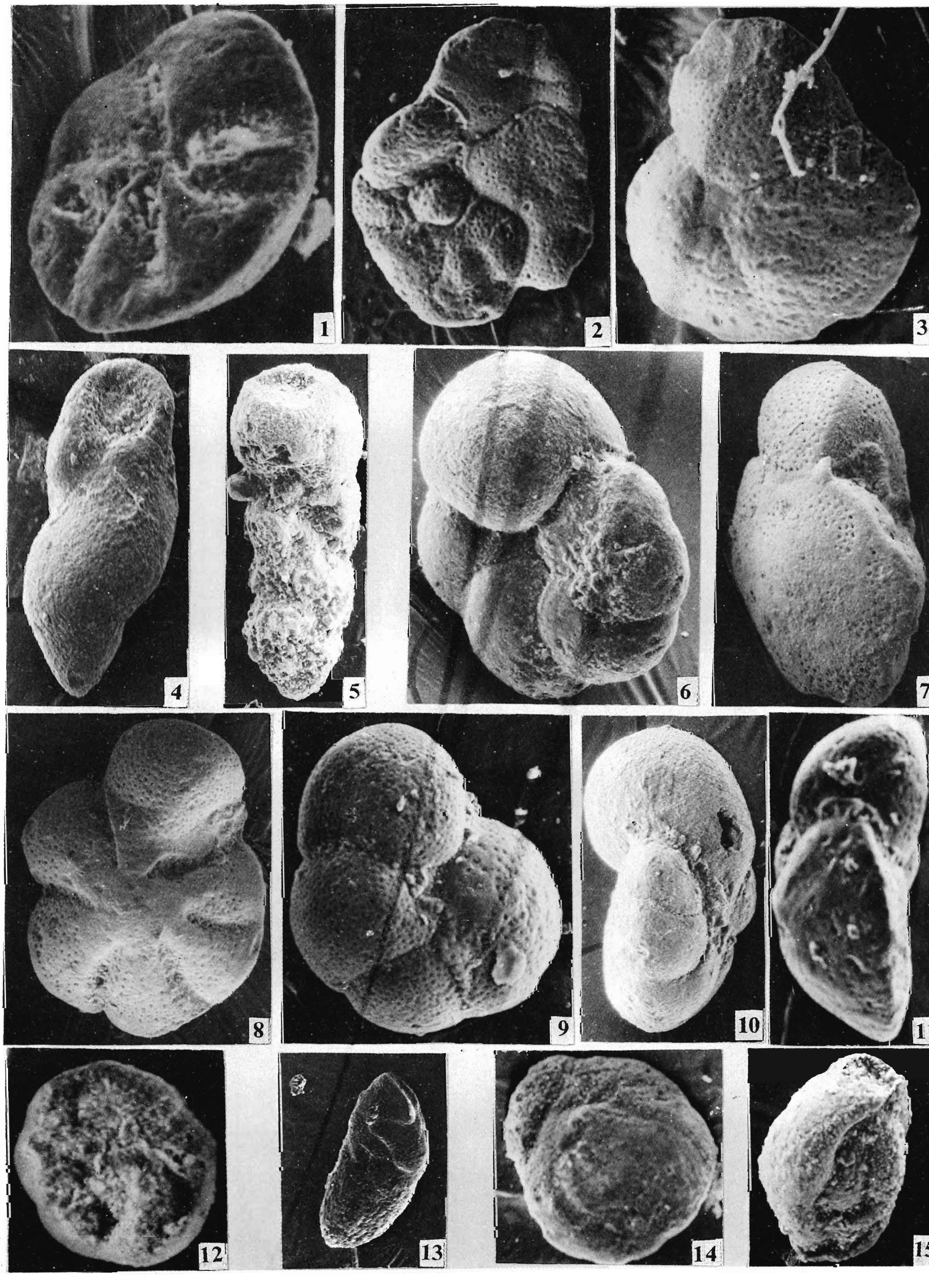
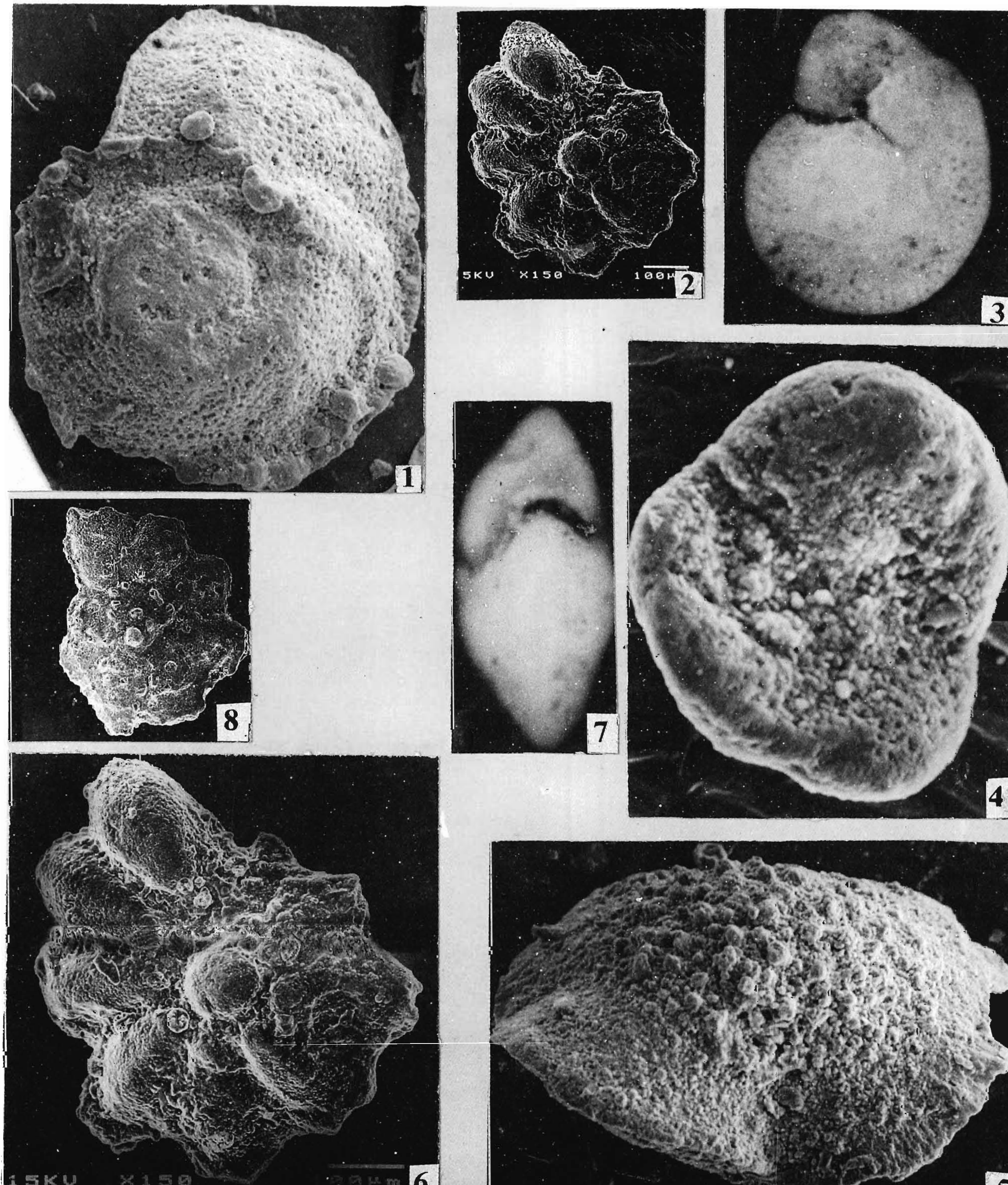

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Plate II



JAUHRI


1
5KV X150
2
3
7
8
4
15KV X150
6
5