

SOME NEW MIDDLE EOCENE BENTHIC FORAMINIFERA FROM KACHCHH (KUTCH), WESTERN INDIA

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ABSTRACT

The foraminiferal fauna recovered from Middle Eocene exposures around the villages of Vinjhan and Miani, Kachchh, has been studied qualitatively. The associated planktic microfossils, esp. calcareous nannoplankton suggest an age equivalence to zone *D. tani nodifer* (NP₁₆), Bartonian (Late Middle Eocene). Fifteen new species are named and described, and an attempt is made to discuss faunal affinities and the palaeo-ecological factors determining the composition and distribution of the benthic foraminifera in Kachchh. This fauna is similar to the Tethyan carbonate fauna described from the shallow, inner-middle shelf deposits of the Tethys Sea.

INTRODUCTION

The Eocene smaller benthic foraminifera of western India are poorly known, and this work on material from the Vinjhan-Miani section area of Kachchh attempts to improve on existing knowledge. The only previous records of smaller benthic foraminifera from Kachchh are by Tewari, Bhargava and Khanna (1968) who recorded 27 species from the Middle Eocene rocks outcropping around the Waghopadar area and by Jauhri (1991) who described the known species from the present area. Other reports dealing with the Eocene smaller benthic foraminifera are from Rajasthan (Jacob and Sastri, 1950; Bhatia and Khosla, 1970; Habibnia and Mannikeri, 1990) and Pakistan (Haque, 1956, 1960). However, the faunas recorded in these papers have no species in common with the Kachchh fauna presented here. The purpose of this paper is to document and describe the new elements in this fauna, to discuss their affinities with other

species, and to note palaeo-ecological factors determining the faunal composition in the area.

The present foraminiferal study of Middle Eocene rocks in the southwestern Kachchh, western India has resulted in the description and illustration of fifteen species of smaller benthic foraminifera considered new. The material was collected from the Middle Eocene deposits exposed along the Kankawati stream in the vicinity of the villages Vinjhan and Miani, between latitudes 69° 1' 30" N and longitudes 23° 7' E to 23° 6' E. The area is about 82 km SSW of Bhuj (fig. 1). The beds dip at 3°-5° to the southwest, and unconformably overlie the Early Eocene rocks. The sequence has been measured as shown in figs. 2 and 3.

FORAMINIFERAL FAUNA AND BIOCHRONOLOGY

The foraminiferal fauna comprises rich assemblages of larger benthic foraminifera and smaller benthic foraminifera. The larger foraminifera were worked out by Tewari (1952, 1956). The smaller benthic assemblages are dominated by cibicidids, rotaliids and miliolids.

The larger foraminiferal species studied by Tewari (1960) suggest a definite Middle Eocene (Lutetian) age for the fossiliferous rock units in the sequence. Stratigraphically important planktic foraminiferal species recorded by the writer (Jauhri, 1981) indicate that the fossiliferous yellow hard limestone and the dirty white and yellow, soft marl correspond to Bolli's (1957) *Globorotalia lehneri* Zone and *Porticulasphaera mexicana* (= *Orbulinoides beckmanni*) zone respectively. These zones are equivalent to Zones P.12 and P. 13 of Blow's (1969) planktic zonation. Singh (1977, 1980) has described a rich assemblage of calcareous nannoplankton from these

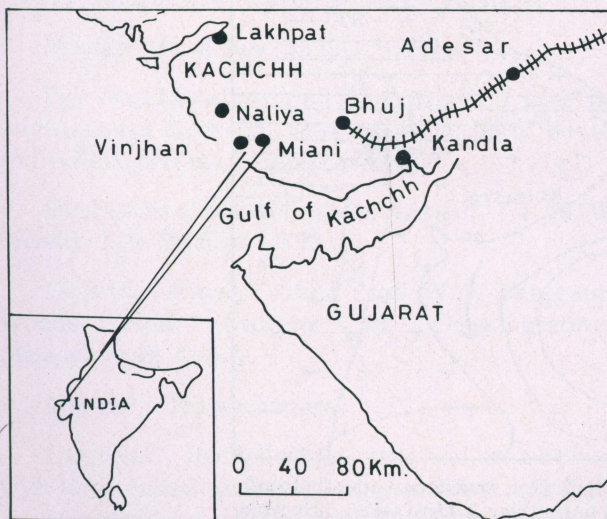


Fig. 1. Location map of the area.

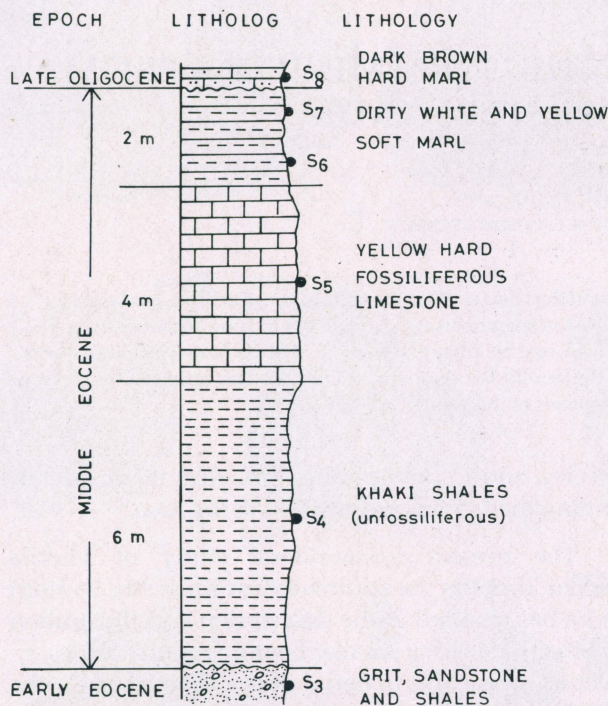


Fig. 2. Lithologic column with relative positions of relevant samples (S₃-S₈).

litho-units. The age assignment based on calcareous nannoplankton precisely suggests an age equivalence to the *D. tani nodifer* Zone (NP16), Bartonian (the Late Middle Eocene).

SYSTEMATIC PALAEOONTOLOGY

The present work follows the new classification of foraminifera proposed by Loeblich and Tappan (1982, 1988), which is the modified version of the classification given by them in Moore's (1964) Treatise on Invertebrate Palaeontology.

Order **Foraminiferida** Eichwald, 1830

Suborder **Miliolina** Delage & Herouard, 1896

Superfamily **Miliolacea** Ehrenberg, 1839

Family **Hauerinidae** Schwager, 1876

Subfamily **Hauerininae** Schwager, 1876

Genus **Triloculina** d'Orbigny, 1826

Triloculina bhujensis n. sp.

(Pl. I, figs. 6-7; Pl. III, fig. 5)

Holotype (Pl. I, figs. 6,7): L.U./Geol./692.

Type locality and horizon : Vinjhan-Miani area, southwestern Kachchh, western India; Dirty white and yellow, soft marl (sample no. S₆; also present in S₇).

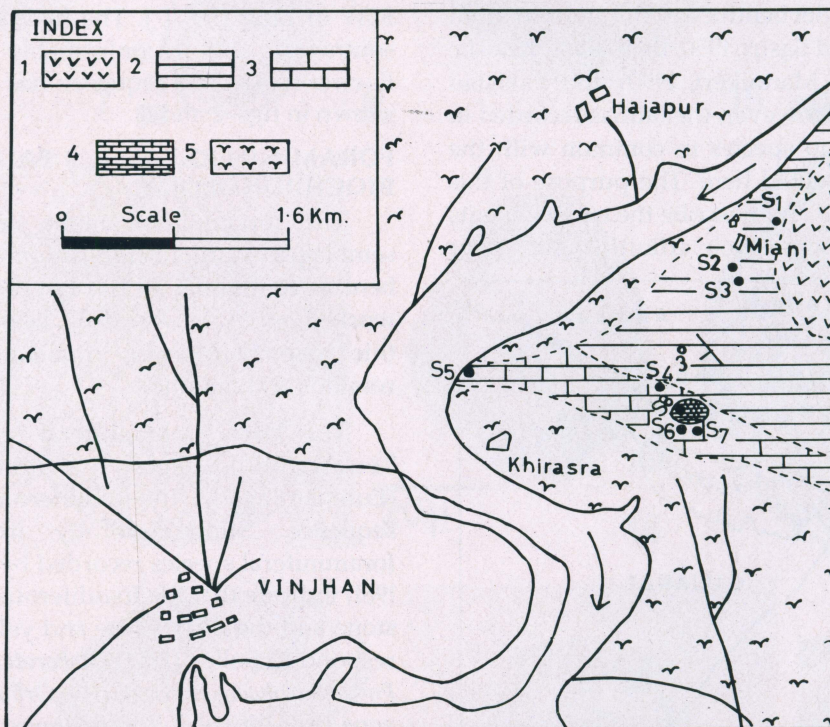


Fig. 3. Geological Map of the area. 1. Deccan Trap; 2. Grit, sandstone, variegated shale, Greenish grey clay, conglomerate and kaolinized clay; 3. Khaki shales, Dirty white and yellow, soft marl and yellow, hard limestone; 4. Dark brown, fossiliferous marl; 5. Alluvium.

Dimensions of holotype in mm :

Diameter 0.42; thickness 0.40.

Derivation of name : After the district head-quarters, Bhuj, 82 km NNE of the area of study.

Material : Fifteen specimens. This species also occurs in the dark brown, fossiliferous marl (Late Oligocene) of the present area.

Diagnosis : Test small, with equal length and breadth, chambers inflated, embracing, periphery subrounded, aperture rounded with a T-shaped bifid tooth.

Description : Test small, length and breadth equal, periphery subrounded, chambers strongly inflated, embracing, only three visible externally; sutures distinct, strongly depressed; with a layer of adventitious material; aperture terminal, nearly rounded; with a curved T-shaped bifid tooth; triangular in cross-section.

Remarks : The species closely resembles *Triloculina collinsi* Carter reported from the Middle Miocene of the Fossil beach of Port Phillips Bay, Victoria, Australia (Carter, 1964, Victoria, *Geol. Survey Mem.*, no. 23, pp. 59-60) in its appearance, but is distinguished by its relatively smaller size, highly inflated chambers, and rounded aperture with a curved T-shaped bifid tooth.

Subfamily Siphonapertinae Saidova, 1975

Genus Ammomassilina Cushman, 1933

Ammomassilina berggreni n. sp.

(Pl. II, fig. 13; Pl. VI, figs. 7-8; Pl. VIII, fig. 6)

Holotype (Pl. II, fig. 13): L.U./Geol./704.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India; Dirty white and yellow, soft marl (Sample no. S₆).

Dimensions of holotype in mm : Length 0.70; Breadth 0.45; Thickness 0.15.

Derivation of name : After Prof. W.A. Berggren, Woods Hole Institute of Oceanography, Massachusetts, U.S.A.

Material : Ten specimens.

Diagnosis : Test elongate, elliptical in outline, with large coiled early portion, periphery rounded, aperture terminal, with trematophore, bordered by a thin rim.

Description : Test elongate, elliptical in outline, with narrow tubular chambers, two to a whorl, arranged about a long axis, earlier ones irregularly coiled about this axis in different planes but later ones added in a single plane; periphery rounded; aperture terminal, with trematophore, bordered by a thin, rim-like structure.

Remarks : This species resembles *Ammomassilina prisca* (d'Orbigny), a species described from the Middle Eocene of the Paris Basin. *A. berggreni* n. sp. is more elliptical in shape, with a larger coiled early portion. The new form is less elongate and lacks extensive development of adventitious material seen in *A. prisca*. *A. alveoliniformis* (Millet) described from the Recent sediments is larger in size and has adventitious particles prominently raised above the surface.

Family Miliolidae Ehrenberg, 1839

Subfamily Miliolinae Ehrenberg, 1839

Genus Miliola Lamarck, 1804

Miliola ashoki n. sp.

(Pl. IV, figs. 5-6; Pl. III, fig. 4)

Holotype (Pl. IV, fig. 5): L.U./Geol./701.

Type locality and horizon : Vinjhan-Miani area, southwestern Kachchh, western India; Dirty White and yellow, soft marl (sample no. S₆; also present in S₇).

Dimensions of holotype in mm : Length 0.85; Breadth 0.30; Thickness 0.20.

Derivation of name : After Prof. Ashok Sahni, Geology Department, Panjab University, Chandigarh.

Material : Twenty specimens.

Diagnosis : Test elongate, fusiform, surface with a layer of adventitious material, chambers tubular, aperture terminal, rounded, situated on obliquely elongate neck.

Description : Test elongate, fusiform, longer than wide, chambers quinqueloculine in arrangement, elongate, tubular, distinct, rounded in cross-section; sutures distinct, depressed; wall porcelaneous, imperforate, with an external layer of adventitious material composed of sand particles; aperture terminal, rounded, situated on obliquely elongate neck, with trematophore, provided with a very thin, rim-like structure around the border.

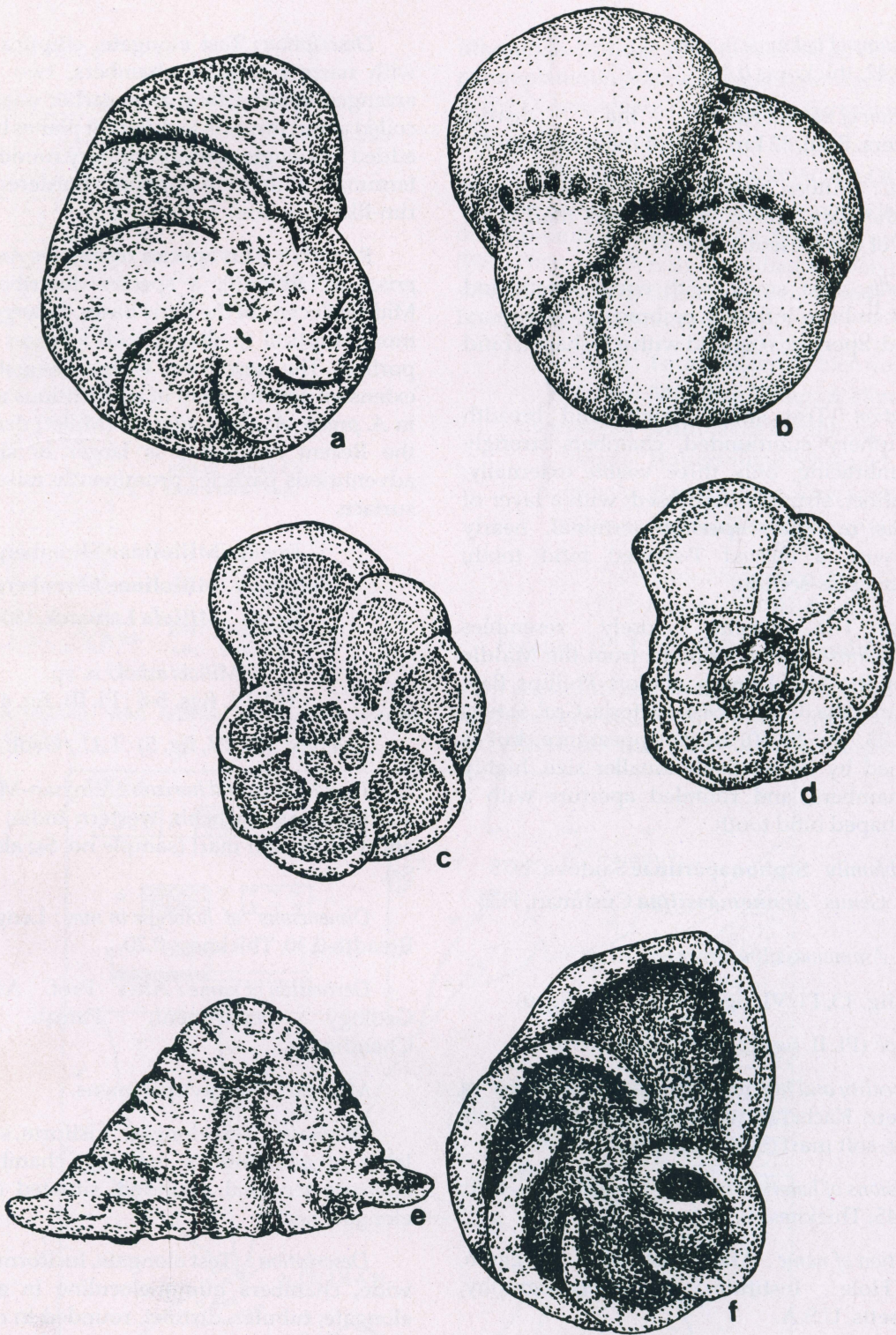


Fig. 4. Sketches based on light photomicrographs and specimens to show features not clear in the photographs of some species presented in the plates. a, f. *Epistomaria talukdari* n. sp., a, dorsal side, holotype (L.U./Geol./773), X 100; f, equatorial section showing radially perforate walls and thick septa (Thin section (L.U./Geol./116) x 90). b. *Elphidium bhattacharyai* n. sp., side view showing chambers, sutures and septal pits and multiple apertures at the base of apertural face, paratype (L.U./Geol./800), x 325. c-d. *Planulinoides vimalae* n. sp., opposite sides, c, partially evolute ventral side, holotype (L.U./Geol.748) x 150; d, evolute dorsal side, paratype (L.U./Geol./749), x 150. e. *Biapertorbis svaroopi* n. sp., axial section showing radial, calcitic wall and a thick umbilical pillar (Thin section (L.U./Geol./112), x 110).

Remarks: *Miliola ashoki* is close to *M. rostrata* (Terquem) emend. Le Calvez (1947) and *M. saxorum* (Lamarck) from the Middle Eocene of the Paris Basin, but differs in its aperture situated on obliquely elongate neck, much agglutinated nature of the surface, and an elongate and fusiform shape.

Suborder **Lagenina** Delage & Herouard, 1896

Family **Ellipsolagenidae** A. Silvestri, 1923

Subfamily **Oolininae** Loeblich & Tappan, 1961

Genus **Oolina** d'Orbigny, 1839

Oolina oblonga n. sp.

(Pl. I, fig. 9; Pl. III, figs. 7-8)

Holotype (Pl. I, fig. 9; Pl. III, fig. 8) : L.U./Geol./716.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India; Dirty white and yellow, soft marl (sample no. S₆; also present in S₇).

Dimensions of holotype in mm : Diameter 0.6; Thickness 0.40.

Derivation of name : After the oblong shape of the test.

Material : Fifteen specimens.

Diagnosis : Test ovate in shape, elongate along oral-aboral axis, both ends pointed, surface smooth, aperture with numerous, radiating grooves.

Description : Test oblong, elongate along oral-aboral axis, rounded in cross-section, both oral and aboral ends broadly 'V' shaped, giving the whole test an ellipsoidal appearance; surface smooth, perforate; aperture terminal, with numerous prominent, radiating grooves.

Remarks : In its aperture, this species closely resembles *O. simplex lacrima* White recorded from the Upper Cretaceous of Tampico Embayment, Mexico, and *O. simplex* Reuss known from the Tertiary of west Galicia, Poland, but differs from these species in its ovate shape. *Oolina reussi* Said and Kenawy from the Upper Maastrichtian of northern Sinai, Egypt is similar in shape, but differs in its non-radiate, rounded, aperture.

Suborder **Rotaliina** Delage & Herouard, 1896

Superfamily **Buliminacea** Jones, 1875

Family **Buliminellidae** Hofker, 1951

Genus **Buliminella** Cushman, 1911

Buliminella elongata n. sp.

(Pl. III, fig. 6)

Holotype : L.U./Geol./723.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India; Dirty white and yellow, soft marl (sample no. S₆; also present in S₇).

Dimensions of holotype in mm : Length 0.47; Breadth 0.17; Thickness 0.20.

Derivation of name : After the elongate character of the test.

Material : Fifteen specimens.

Diagnosis : Test elongate, twisted, initial portion narrow, subrounded to acute, later portion high, broad, twisted around a longitudinal axis, aperture wide, in the middle of the concave apertural face.

Description : Test elongate, twisted, with early chambers low-trochospirally coiled, in later stages spire rapidly grows in height around an open axis; initial portion subrounded to acute, apertural portion broad; broadly rounded periphery; numerous chambers to a whorl, chambers longer than wide; sutures distinct, depressed, curved, spiral sutures at right angles to intercameral sutures; Wall finely perforate, smooth; apertural face usually broad, sharp angled; aperture loop shaped, medium sized, in the middle of concave apertural face.

Remarks : The twisted test with a high spire coiled around an open umbilicus, wide, concave apertural face and elongate chambers are the distinguishing features of this species. It is close to *Buliminella colonensis africana* de Klasz, Magne, and Rerat, a form from the Upper Cretaceous Pointe Clairette Field, Nigeria, but differs in its broadly rounded periphery, loop-shaped aperture and more elongate test. As figured by Bhatia (1955) from the Oligocene of Wight, *B. elegantissima* (d'Orbigny), a cosmopolitan species ranging from the Eocene to Recent, is different in shape and has long apertural face. *B. pulchra* (Terquem) described from the Eocene of the Paris and Belgian Basins also occurs in the Middle Eocene of the studied area (Jauhri, 1991) but is much smaller in size and can be distinguished from the present species.

Superfamily **Bolivinacea** Glaessner, 1937

Family **Bolivinoidea** Loeblich & Tappan, 1984

Genus **Bolivinoidea** Cushman, 1927

Bolivinoidea pratapi n. sp.

(Pl. I, fig. 3; Pl. IV, fig. 3; Pl. VII, fig. 2)

Holotype (Pl. I, fig. 3; Pl. VII, fig. 2) : L.U./Geol./740.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India; Dirty white and yellow, soft marl (sample no. S6).

Dimensions of holotype in mm : Length 0.27; Breadth 0.20; Thickness 0.15.

Derivation of name : After Dr. Pratap Singh, Chief Geologist, O.N.G.C., Baroda, India.

Material : rare (two specimens).

Diagnosis : Test rhomboidal, compressed, flaring, initial end flat, rounded and tapering, later portion broader, thickened distally, periphery acute with a fine keel, surface ornamented by raised, rounded lobes which fade near the apertural end.

Description : Test rhomboidal, considerably flaring, compressed, initial end flat, bluntly rounded and tapering, later portion broader, slightly compressed, thickened near distal end; periphery acute, with a fine, nonperforate keel, slightly lobulate; chambers biserially arranged, in about 6-7 pairs; sutures curved near initial end, but obscured by strong ornamentation at later-formed portion; surface with raised, broadly circular to elongate lobes, the portion near apertural end less ornamented; aperture terminal, elongate, slit-like, with thin, rim-like borders.

Remarks : A highly distinctive species, recognized by its compressed, flaring test, acute periphery and surface sculpture, *B. pratapi* resembles *Bolivinoidea shatai* Ansary and Emara recovered from the Late Cretaceous (Early Senonian) of northern Sinai, Egypt, but differs in its bluntly rounded initial end and raised, broadly rounded lobes on the surface. Its characteristic ornamentation also distinguishes it from *Bolivinoidea decorata australis* Edgell, a form reported from the Late Cretaceous (Late Campanian) of northwest Australia. The latter shows numerous nodes or tubercles on the surface which tend to coalesce to form costae in the early portion and short ribs in later part of the test.

Superfamily **Discorbinellacea** Sigal, 1952

Family **Planulinoididae** Saidova, 1981

Genus **Planulinoides** Parr, 1941

Planulinoides vimlae n. sp.

(Pl. II, fig. 8; Pl. III, fig. 2; Pl. IV, fig. 8; Pl. VII, figs., 7-8; fig. 4 c-d)

Holotype (Pl. II, fig. 8; fig. 4c) : L.U./Geol./748.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India. Dirty white and yellow, soft marl; and yellow, hard limestone (sample no. S6; also present in S5 & S7).

Dimensions of holotype in mm : Diameter 0.30; thickness 0.10.

Derivation of name : After the writer's maternal aunt, the late Mrs. Vimla Srivastava, w/o Dr. Ram P. Srivastava.

Material : Thirty specimens.

Diagnosis : Test biconcave, low trochospirally coiled, evolute on dorsal side, less so on ventral side, nearly circular in outline, periphery broadly truncated with double keels and a groove, chambers initially sub-rectangular, later becoming radially elongate, sutures thickened, curved, aperture areal, equatorial, a small opening at the base of the apertural face.

Description : Test biconcave, low trochospiral, evolute on dorsal side, less so on ventral side, equatorial periphery weakly lobulate, axial periphery broadly truncated, with imperforate double keels and a groove; chambers initially sub-rectangular, later becoming more radially elongate, increasing gradually in size; sutures distinct, thickened, slightly curved, commonly raised but sometimes flush; primary aperture areal, equatorial, obliquely quadrangular opening at the base of the apertural face, with thin, often indistinct, rim-like borders; in many cases the aperture is reduced to a small equatorial arch or an oval-shaped opening; supplementary apertures consist of few small openings at the inner margins of the chambers, not clearly visible in the present forms. Wall perforate, granular in appearance.

Remarks : *Planulinoides vimlae* bears some resemblance to *Saraswati kapilae* and *S. noettingi* but differs in lacking the subperipheral sigmoidal sutural apertures (Singh and Kalia, 1972). Moreover, the test in *P. vimlae* has compressed chambers and a partially

evolute ventral side. It is also distinct from *P. biconcava* (Jones and Parker), a Recent and fossil species from South Australia, which is more concave on the ventral side than on the dorsal, and shows highly thickened, raised sutures.

Family **Pseudoparrellidae** Voloshinova, 1952

Subfamily **Pseudoparrellinae** Voloshinova, 1952

Genus **Epistominella** Husezima, and Maruhasi, 1944

Epistominella vinjhanensis n. sp.

(Pl. III, figs. 1,3; Pl. IV, figs. 4, 7; Pl. V, figs. 1-4; Pl. VIII, figs. 9-10)

Holotype (Pl. V, figs. 1-4) : L.U./Geol./767.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India; Dirty white and yellow, soft marl (sample no. S₆; also present in S₇).

Dimensions of holotype in mm : Diameter 0.32; Thickness 0.16.

Derivation of name : After the village Vinjhan, southwestern Kachchh, India.

Material : Forty specimens.

Diagnosis : Test trochospiral, unequally biconvex, tightly coiled, periphery acute, carinate, chambers 5-6 in the last whorl, flush with the surface, surface smooth, prominently perforate near periphery, umbilicus closed, aperture an elongate, marginal slit in the last chamber.

Description : Test trochospiral, unequally biconvex, tightly coiled, dorsal side slightly evolute, less convex, ventral side more convex, involute; in equatorial profile nearly circular, equatorial periphery entire, carinate; axial periphery acute; chambers weakly distinct on dorsal side, distinct on ventral side, about 5 - 6 in the last whorl, flush with the surface; sutures distinct near margins only, oblique, curved on dorsal side, radial, depressed on ventral side. Wall smooth, perforate, perforations prominent near periphery, small, rounded pores seen in irregular fashion on both sides along the sutures; umbilicus closed, with very fine perforations. Aperture an elongate slit extending all along the face of the last chamber just beneath the periphery on ventral side, nearly parallel to the periphery, straight

to arched, in some specimens extending to the umbilicus.

Remarks : *Epistominella vinjhanensis* is close to *E. acutimargo* (Halkyard) recorded from the Eocene of France, Belgium and England but differs in its highly perforated peripheral region and less thickened sutures and keel. It can also be distinguished from *E. pulchella* Husezima and Maruhasi described from the Pliocene of Niigata Prefecture, Japan in being less convex on the ventral side and in having less number of chambers in the final whorl.

Superfamily **Glabratellacea** Loeblich & Tappan, 1964

Family **Glabratellidae** Loeblich & Tappan, 1964

Genus **Glabratella** Dorreen, 1948

Glabratella maheshwarii n. sp.

(Pl. II, figs. 3, 6; Pl. VII, fig. 1)

Holotype (Pl. II, fig.3; Pl. VII, fig.1) : L.U./Geol./762.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India; Dirty white and yellow, soft marl (sample no. S₆).

Dimensions of holotype in mm : Diameter 0.20; thickness 0.12.

Derivation of name : After the late Prof P.N. Maheshwari, F.R.S., Botany Department, Delhi University.

Material : Six specimens.

Diagnosis : Test hemispherical, trochospiral, ventral side concave, dorsal side convex with prominent spire, periphery subrounded, finely crenulated, aperture a low interio-marginal slit.

Description : Test hemispherical, trochospiral; ventral side concave, dorsal side pronouncedly convex, spire in some specimens obscured by ornamentation consisting of pustules; few thickened costae and fine striae seen radiating from the apex; in some forms, where ornamentation is weak, spire is prominent and raised above the surface; periphery subrounded, ornamented with crenulations throughout (these are the continuations of radiating striae on concave side); chambers on dorsal side are few, elongate, closely arranged, oblique, longer than wide, the three visible on ventral side, are indistinct because of strong striae; aperture a low interio-marginal slit.

Remarks: This species is comparable to *G. distincta* (McCulloch) known from the Recent sediments of Pacific, off Seymour Island, Galapagos, but differs in its concavo-convex test, subrounded periphery with fine radiating grooves, and ornamented dorsal side. *G. pulvinata* (Brady) (= *Discorbina pulvinata* Brady), a Recent species from the Admiralty Islands, is relatively larger in diameter and has subglobular test with inflated chambers and low spire. *G. crassa* Dorreen, which also occurs in the Kachchh Middle Eocene assemblage (Jauhri, 1991), has globose test and inflated chambers and does not have the high spire characteristic of this species.

Superfamily **Asterigerinacea** d'Orbigny, 1839

Family **Epistomariidae** Hofker, 1954

Subfamily **Epistomariinae** Hofker, 1954

Genus **Epistomaria** Galloway, 1933

Epistomaria talukdari n. sp.

(Pl. I, fig. 8; Pl. V, fig. 10; Pl. VI, figs. 1-3; Pl. VIII, figs. 5, 7; fig. 4 a, f)

Holotype (Pl. I, fig. 8; Pl. V, fig. 10, fig. 4a) : L.U./Geol./ 773.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India. Yellow, hard limestone; and dirty white and yellow, soft marl (sample Nos. S₆; also present in S₅, S₇).

Dimensions of holotype in mm : Diameter 0.55; Thickness 0.35.

Derivation of name : After Mr. S.N. Talukdar, a retired scientist, K.D.M.I.P.E., O.N.G.C., Dehra Dun, India.

Material : Thirty specimens.

Diagnosis : Test trochospiral, elongate, gently convex on dorsal side, strongly convex on ventral side, periphery rounded, sutures straight on ventral side, wall radially perforate with thick septa, primary aperture a narrow interio-marginal slit, secondary aperture a low slit at right angles to periphery, accessory apertures along the periphery and sutures present on ventral side.

Description : Test slightly elongate, trochospiral, biconvex, ventral side strongly convex, dorsal side less so, evolute on dorsal side, involute on ventral side, in equatorial profile subcircular, equatorial periphery weakly lobulate, axial periphery rounded; chambers gradually increasing in size, on dorsal side indistinct, elongate, rectangular, flaring near

periphery and becoming narrow towards spire, those on ventral side triangular with alar projections completely masking the umbilicus, about 5-6 in the last whorl; sutures distinct, depressed, curved, on dorsal side, but straight on ventral side; wall coarsely perforate; primary aperture a narrow, interio-marginal slit bordered by thin rim-like lip extending from periphery to near umbilicus; secondary aperture a low slit in the last chamber almost at right angles to the periphery; slit-like accessory apertures parallel to periphery and perpendicular to sutures present on ventral side; additional supplementary apertures along sutures also observed.

Thin section shows radially perforate walls with thick septa.

Remarks : The new species is comparable to *Epistomaria rimosa* (Parker and Jones) (as figured by Loeblich and Tappan, 1964 in Treatise on Invertebrate Palaeontology (part C, Protista 2), a species from the Middle Eocene of England and the Eocene of the Paris Basin (Murray *et al.*, 1989). However, it differs from *E. rimosa* in its longer than broad test with strongly convex umbilical side, raised, sharply delimited chambers and deeply depressed sutures. *E. separans* Le Calvez from the Middle Eocene of the Paris Basin differs in convex spiral side and flat umbilical side, shape of chambers and highly incised sutures between chambers of final whorl. The variations shown by *E. talukdari*, n. sp. are mainly those of the size of the test, number of accessory apertures and number of chambers in the last whorl (5-6) and appear to be of ontogenetic nature.

Family **Asterigerinidae** d'Orbigny, 1839

Genus **Asterigerina** d'Orbigny, 1839

Asterigerina umbonata n. sp.

(Pl. II, figs. 5, 7; Pl. III, figs. 9-10; Pl. V, figs. 5-6; Pl. VI, figs. 4-5; Pl. VIII, fig. 3,8)

Holotype (Pl. V, figs. 5-6) : L.U./Geol./803.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India: Dirty white and yellow, soft marl (sample no. S₆; also present in S₇).

Dimensions of holotype in mm : Diameter 0.40; Thickness 0.20.

Derivation of name : After the umbonate character.

Material : Ten specimens.

Diagnosis : Test unequally biconvex, ventral side more convex than dorsal side, with prominent umbilical boss, periphery acute, carinate, secondary chambers faintly developed, obscured by umbonal boss, aperture a slit at the base of the last chamber near the periphery, with a prominent lip and granules below.

Description : Test unequally biconvex, less convex to nearly flattened dorsal side, strongly convex ventral side, with prominent umbilical boss, equatorial profile circular, equatorial periphery smooth and almost entire, axial periphery acute, distinctly carinate; chambers numerous, gradually increasing in size, 7-8 in the last whorl, only those of last whorl visible on the dorsal side, earlier ones obscured by clear shell material, chambers square-shaped on dorsal side, longer than broad on ventral side; secondary chambers faintly developed, obscured by the shell material of umbonal boss; wall finely perforate, smooth, but ventral side with dense, small granules in front of the aperture. Sutures obscured by clear shell material, but, when visible, are curved, depressed, radial on dorsal side, strongly curved, flush, on ventral side; central area on ventral side with a prominent umbo. Aperture a slit-like opening with a prominent lip, situated near the periphery at the base of the last chamber on ventral side.

Remarks : This species is similar to *Asterigerina bartoniana* (Ten Dam) known from the Eocene of the Netherlands, Paris Basin, Belgian Basin and England, but differs in its square-shaped chambers on the dorsal side, prominent umbonal boss obscuring secondary chamberlets, weakly lobulate periphery at later part of the test, and prominent apertural lip. *Asterigerina carinata* d'Orbigny which is similar in shape of the test and granulation of the apertural area, differs in having oblique and thickened sutures on the dorsal side, prominent carina, and distinct stellate pattern of secondary chamberlets on the ventral side.

Family **Discorbinellidae** Sigal, 1952

Subfamily **Discorbinellinae** Sigal, 1952

Genus **Biapertorbis** Pokorný, 1956

Biapertorbis swaroopi n. sp.

(Pl. II, figs. 10-12; Pl. V, figs. 7-9; Pl. VII, figs. 5-6, 9; fig. 4 e)

Holotype (Pl. V, figs. 7-8) : L.U./Geol./810.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India: Dirty white and yellow, soft marl (sample no. S₆; also present in S₇).

Dimensions of holotype in mm : Diameter 0.40; Thickness 0.22.

Derivation of name : After the late Mr. Shanti Swaroop, the writer's brother-in-law.

Material : Twenty specimens.

Diagnosis : Test trochospiral, planoconvex with exceptionally high spire, strongly convex dorsal side, flattened ventral side, periphery acute, carinate, lobulate, chambers arcuate on dorsal side, broadly triangular on ventral side, oblique, thickened sutures on dorsal side, coarsely perforate on dorsal side, prominent umbilical plug, and primary aperture a rounded opening at the base of the last chamber.

Description : Test trochospiral, planoconvex, high-spined, flattened ventral side, strongly convex dorsal side, circular in equatorial outline, equatorial periphery slightly lobulate, roughly conical in axial profile, axial periphery acute, carinate; chambers numerous, arcuate on dorsal side, gradually increasing in size, uniformly shaped on ventral side, 5-7 chambers in the last whorl, last chamber inflated, large in size, occupying in some forms a considerable portion of the test; sutures on dorsal side thickened, curved, imperforate, oblique, flush (also raised above the surface in some), and those on ventral side radial, depressed, thickened near umbilicus; wall coarsely perforate, perforations on dorsal side coarser than those on ventral side; ventral side with a distinct umbilical plug. Primary aperture at the base of apertural face, a rounded opening near the margin, secondary umbilical opening also present.

Thin section shows primary double septa with intraseptal passages and a prominent pillar. The wall is made up of radially fibrous calcite, having coarse perforations.

Remarks : *Biapertorbis swaroopi* is quite distinct in its exceptionally high spire, oblique, thickened, imperforate sutures on dorsal side, completely flattened ventral side, a prominent umbilical plug, coarsely perforate wall on dorsal side and a large last chamber. The primary aperture is a lowly to highly arched slit. The wall perforations do not show uniformity in size. The dimensions of the species also vary considerably.

This species is closely comparable to the type species of the genus, *Biapertorbis biaperturata* Pokorný' recorded from the Late Eocene of Moravia, Czechoslovakia (Pokorný', 1956), but differs in having fewer chambers in the last whorl, a lobulate periphery, thin keel, and coarsely perforate wall on the dorsal side. Pokorný's (1956) figured specimens as well as those described by Butt (1966, as *Discorbis biaperturata* (Pokorný')) show a finely perforate wall on the dorsal side.

Superfamily Planorbulinacea Schwager, 1877

Family Planorbulinidae Schwager, 1877

Subfamily Planorbulininae Schwager, 1877

Genus Planorbulinella Cushman, 1927

Planorbulinella sp.

(Pl. II, figs. 2, 4, 9; Pl. VII, fig. 3; Pl. VIII, fig. 4)

The locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India; Dirty white and yellow, soft marl (Sample no. S₆).

Dimensions of Specimen (No. L.U./Geol/740) in mm : Diameter 0.65; Thickness 0.30.

Material : Rare (two specimens)

Description : Test discoidal, compressed, early chambers spirally arranged, later ones added in a ring-like manner, equatorial profile circular, equatorial periphery lobulate, axial periphery broadly rounded; due to lamellar thickening chambers of only last annulus visible and central part thickened on one side, chambers inflated and arranged in a regular series, on the opposite side they are slightly inflated and irregular in appearance; surface coarsely perforate; aperture two interio-marginal slits per chamber, one on each side with a narrow bordering lip; few supplementary apertures present on the dorsal side.

Remarks : *Planorbulinella* sp. is comparable to *P. larvata* (Parker & Jones) from Recent sediments, but differs in being much smaller than the latter and shows less coarse perforations and irregular thickening of the wall in major portion of the test. Similar forms have also been recorded by Butt (1966) from the Late Oligocene of Escornebeou (France). The test in the present forms is, however, biconvex in vertical section. Like the European fossil forms which seem to represent a new species (Butt, 1966), the present material also needs to be differentiated from *P. larvata*. However, it is not possible to create a new

species with insufficient number of specimens in the present case.

Superfamily Rotaliacea Ehrenberg, 1939

Family Elphidiidae Galloway, 1933

Subfamily Elphidiinae Galloway, 1933

Genus Elphidium de Montfort, 1808

Elphidium bhattacharyai n. sp.

(Pl. II, fig. 1; Pl. VI, fig. 6; fig. 4 b)

Holotype (Pl. II, fig. 1) : L.U./Geol./798.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India. Dirty white and yellow, soft marl (sample no. S₆).

Dimensions of holotype in mm : Diameter 0.22; Thickness 0.15.

Derivation of name : After Dr. A.R. Bhattacharya, Reader in Geology, University of Lucknow, Lucknow.

Material : Rare (six specimens).

Diagnosis : Test involute, bilaterally symmetrical, circular in outline, periphery rounded, chambers strongly inflated, triangular, last chamber much large, sutures depressed with septal pits only, umbilicus narrow, almost covered by the umbilical ends of chambers, aperture multiple, at the base of broad apertural face.

Description : Test bilaterally symmetrical, involute, nearly circular in equatorial profile, equatorial periphery lobulate, oval in axial profile, axial periphery broadly rounded; chambers strongly inflated, roughly triangular, gradually increasing in size, about six in the last-formed whorl, with numerous minute septal pits all along the length of sutures, last chamber exceptionally large and inflated, occupying about one third of the whole test; sutures distinct, depressed, radially curved; umbilicus very narrow, deep, almost completely covered by the pointed ends of the chambers of the last whorl, without any umbilical plug. Wall smooth, finely perforate. Apertural face broad, covering the multiple aperture; aperture consisting of several rounded pores at the base of the apertural face.

Remarks : *Elphidium bhattacharyai*, n. sp. is distinguished by its turgid test and septal pits. It resembles *E. hiltermanni* Hagn, a species from the Eocene to Middle Oligocene of Europe, but differs in less number of chambers in the last whorl and the

presence of septal pits only. *E. latidorsatum* (Reuss), another comparable species, which is known from the Paris Basin (Late Eocene to Oligocene) and Belgian Basin (Early to Late Eocene), is less inflated and has flush sutures with numerous small retral processes. The last chamber of the latter species is not as enlarged as in the present species.

Superfamily **Nonionacea** Schultze, 1854

Family **Nonionidae** Schultze, 1854

Subfamily **Nonioninae** Schultze, 1854

Genus **Nonion** de Montfort, 1808.

Nonion sastrii n. sp.

(Pl. I, figs. 1-2)

Holotype (Pl. I, fig. 1) : L.U./Geol./842.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India. Dirty white and yellow, soft marl (sample no. S₆; also present in S₅, S₇).

Dimensions of holotype in mm : Length 0.35;
Breadth 0.25; Thickness 0.20.

Derivation of name : After Mr. V.V. Sastri, a retired scientist of O.N.G.C., Dehra Dun, India.

Material : Thirty specimens.

Diagnosis : Test involute, longer than broad, periphery subacute, chambers low, increasing rapidly in length, 10-12 in the last whorl, last chamber large, more elongate than the rest, broadly triangular in apertural view, sutures straight to curved, radial, deeply depressed near umbilicus, umbilicus depressed, with granular shell material, part of which also extends into the sutures, aperture equatorial, small slit at the base of the last chamber.

Description : Test involute on both sides, longer than broad, oval in equatorial profile, equatorial periphery smooth, elliptical in axial profile, axial periphery subacute; chambers low, increasing rapidly in length, excepting for few earlier ones usually longer than broad, about 10-12 in the last-formed whorl, last chamber broadly triangular in apertural view; first few chambers fused at their umbilical ends, the pointed ends of chambers appear to be projecting into the umbilical depression; sutures straight to curved, radial, more distinct and depressed near umbilicus; umbilicus depressed on both sides, filled with granular shell substance which also extends into the deeply incised sutures; wall finely perforate; aperture peripheral, a small curved

slit situated at the base of the last-formed, large, flaring chamber which partly obscures it.

Remarks : This species, when compared with *Nonion scaphum* (Fichtel and Moll) as figured in Kaasschieter (1961), is distinct in the larger number of chambers in the last whorl, elongate, depressed, radial sutures, and more elongate, flaring last chamber that overhangs the early part. *Nonion indica* (Jacob and Sastri) emend. Habibnia and Mannikeri (1990), a species from the Middle Eocene of Rajasthan, is similar to the present form in the longer than broad, flaring test having broad and low chambers, but the latter is distinguished by an elongate last chamber which is of triangular outline in apertural view. This species is also close to *Nonion longicamerata* (Bandy) recorded from the Middle Eocene of the American region (Claiborne, Cook Mountain Formation of Louisiana), but differs in its completely involute test, 10-12 chambers in the last whorl, and triangular, flattened apertural face.

Superfamily **Chilostomellacea** Brady, 1881

Family **Gavelinellidae** Hofker, 1956

Subfamily **Gavelinellinae** Hofker, 1956

Genus **Gavelinella** Brotzen, 1942

Gavelinella eicheri n. sp.

(Pl. I, figs. 4-5; Pl. IV, figs. 1-2; Pl. V, figs. 11-13; Pl. VII, fig. 4; Pl. VIII, figs. 1-2)

Holotype (Pl. V, figs. 11-13) : L.U./Geol./852.

Type locality and horizon : Vinjhan-Miani area of southwestern Kachchh, western India: Dirty white and yellow, soft marl (sample no. S₆; also present in S₇).

Dimensions of holotype in mm : Diameter 0.40;
Thickness, 0.30.

Derivation of name : After Prof. Don L. Eicher, Department of Geological Sciences, Colorado University, Boulder, Colorado, U.S.A.

Material : Thirty five specimens.

Diagnosis : Test biconvex with flattened, evolute dorsal side and strongly convex, involute ventral side, periphery subrounded, chambers about eight in the last whorl, expanding gradually in size, last chamber markedly inflated, sutures distinct, depressed, umbilicus deep with granular substance, aperture an arched, interio-marginal slit extending from near periphery to umbilicus and marked by a

prominent lip, a series of pustules present on apertural borders.

Description: Test biconvex, dorsal side evolute, slightly flattened, ventral side involute, strongly convex, equatorial profile nearly circular, equatorial periphery smooth to very slightly lobulate, axial profile ellipsoidal to ovoid, axial periphery subrounded; chambers, on dorsal side elongate, longer than broad, approaching a rectangular shape, on ventral side almost equal in length and breadth, about eight in the last-formed whorl, gradually increasing in size, last chamber markedly inflated and considerably drawn out over the ventral side; sutures curved, depressed, radial: umbilicus small, deep; aperture an arched-slit, interio-marginal, umbilical-extraumbilical, bordered with a marked lip extending throughout the apertural length and continuing on the dorsal side, often with a distinct umbilical flap; a series of pustules present on apertural borders; umbilical region covered with granular substance; wall perforate. (Though superficially similar to *Gyroidina*, the present specimens lack typical features of the latter, such as the bluntly angled periphery, closed umbilicus and extraumbilical aperture).

Remarks: This species closely resembles the Kaasschieter's (1961) figures of "*Gyroidinoides*" *octocamerata* (Cushman and Hanna) from the Eocene of the Belgian Basin. The latter, however, is distinguished by oblique sutures on the dorsal side, aperture without lip and absence of granules near the apertural borders and umbilicus. *Gavelinella lellingensis* Brotzen, a species reported from the Palaeocene of Denmark (Brotzen, 1948) and Tunisia (Aubert and Berggren, 1976), is similar to this species, but has larger umbilicus without granular shell material, rounded periphery, coarsely perforate wall and thickened, raised sutures. *Gavelinella calymene* (Gümbel) (= *Rosalina calymene* Gümbel, 1868; see Berggren and Aubert, 1975) reported from the Early Eocene of Bavarian Alpine, Germany is readily distinguishable from the present species in the larger dimensions, equally biconvex, compressed test, rounded periphery, larger number of chambers in the last whorl and elevated, thick sutures. Moreover, the inflated last chamber in *G. calymene* overhangs the aperture on both the sides symmetrically. The species varies mainly in the size of the test and inflation of the last chamber.

DISCUSSION AND CONCLUSIONS

The species proposed in this study bear some

resemblance to those previously described from the Anglo-Paris Basin, Germany, America, Australia, Japan, Admiralty Islands and Egypt. Among these species, those having affinity with the European Eocene species outnumber others. Some of these are cited here. *Miliola ashoki* is comparable to *M. rostrata* (Terquem) and *M. saxorum* (Lamarck), both of which are described from the Middle Eocene of the Paris Basin. *Asterigerina umbonata* has affinities with *A. bartoniana* described from the Eocene of Europe. *Ammomassilina berggreni* is close to *A. prisca* (d'Orbigny), also known from the Middle Eocene of the Paris Basin. Other species which are closely similar to the Eocene species of Europe are *Gavelinella eicheri* (resembling "*Gyroidinoides*" *octocamerata* (Cushman and Hanna) from the Belgian Basin); *Biapertorbis swaroopi* (similar to *B. biaperturata* Pokorny' from Czechoslovakia and also from the Oligocene of France; *Epistomaria talukdari* (similar to *E. rimosa* (Parker and Jones) and *E. separans* Le Calvez); and *Elphidium bhattacharyai* (close to *E. hiltermanni* Hagn and *E. latidorsatum* (Reuss)). *Nonion sastrii* has affinities with both *Nonion scaphum* (Fichtel and Moll) of Europe and *N. longicamerata* (Bandy) of America. *Epistominella vinjhanensis*, on the other hand, seems related with both *Epistominella acutimargo* (Halkyard) of Europe and *E. pulchella* Husezima and Maruhasi of the Pacific region. Other forms are comparable with stratigraphically younger or older species from different areas of the world and presently seem to have little stratigraphic value among the Kachchh Eocene benthic assemblage.

Palaeo-ecologically, the Kachchh benthic foraminiferal fauna is characteristic of a warm, shallow water, inner-middle shelf environment. The diverse larger foraminifera, abundant *Miliolina*, and *Clavulina angularis* type (represented by *C. parisiensis* in the Kachchh assemblage, Jauhri, 1991) are good indicators of warm (subtropical) water conditions (Murray, 1987). *Cibicides* and members of *Rotaliidae* which form an important part of the Kachchh fauna (Jauhri, 1980) are characteristic of mid-continental shelf environment in the Gulf of Mexico (Lowmann, 1949). The ecological data on *Anomalinoidea*, *Gavelinella*, *Epistominella*, and *Nonion* present in large numbers reinforce this interpretation and indicate presence of some clastic material in the environment of deposition (Berggren and Aubert, 1975). The clastic material seems to have been supplied by the rivers draining the Deccan Trap and older sediments in western India. However, the influence of clastic content on the faunal development was very limited owing to low

sediment input because of the extensive carbonate province that existed during the Middle Eocene times in Kachchh and other neighbouring areas (possibly associated with the Khirthar transgression; see McGowran, 1991). This is well indicated by the occurrence in abundance of larger foraminifera such as *Nummulites*, *Assilina*, *Discocyclusina*, *Alveolina* and *Lockhartia* in the samples examined. The presence of the rich assemblages of planktic foraminifera and nanoplankton suggests the influence of open sea conditions.

Other ecologically significant genera present as the major components of the studied benthic assemblage are *Pararotalia*, *Asterigerina*, *Biapertorbis* and *Epistomaria*. In modern seas, these forms or their analogues are associated with the seagrass-covered coarse substrates of sands and shell sands under conditions of high water energy at shallower depths (between 20m and 60m), characterized by presence of attached genera such as *Cibicides* and *Planorbulinella* (Reiss and Hottinger, 1984; Edwards, 1982). The closely comparable faunas described from the Middle Eocene of the Paris Basin and the Western Approaches are characterized by abundance of the members of *Rotaliina* and *Miliolina* in association with diverse larger foraminifera. Wright and Murray (1972) interpreted this faunal association as indicative of a hypersaline (30‰-40‰) environment of high water energy with a seagrass cover and firm substrates at depths less than 35m.

Thus, the environment of deposition in the area of study was essentially a shallow shelf (< 35m) carbonate environment of high energy, with some access to open marine conditions. The foraminiferal fauna which evolved in response to this environment is generically most similar to the Tethyan Carbonate Fauna (TCF) of the Palaeogene sediments deposited in the carbonate environment of the Tethys sea, such as those found in the Caribbean region, the Middle East, Somaliland, Pakistan, Southern Europe, etc. (Berggren, 1974; Berggren and Aubert, 1975; Miller, 1982). However, in Kachchh, this fauna is associated with some elements of the Midway type assemblage, e.g., *Epistominella*, *Gavelinella*, *Anomalinoidea* and *Heterolepa* (the last two being represented by *A. nonioninoidea* and *H. eoacena*, respectively; Jauhri, 1991). The presence of these elements in the TCF-dominated assemblage seems to be the result of a small influx of clastic material at the site of deposition.

As the present species have been found only in Kachchh, they appear to be local in character and quite different from those of the European, Caribbean and other areas of the Tethyan region. At this stage, it is difficult to explain this assemblage in a palaeogeographic framework used to explain the cosmopolitan elements recorded in Kachchh (Jauhri, 1991). Among the Kachchh elements, the restricted distribution has also been noted in the case of many species of *Nummulites* (Samanta *et al.*, 1990) and the rotaliid *Lockhartia* (Jauhri, 1985; Samanta and Bandyopadhyay, 1994). Some kind of ecological constraint may be thought of as a possible reason for the restricted dispersal of these species. The hypothesis of non-availability of ecological niches to the species migrating from the Eastern Tethys (India, Pakistan, Himalaya) appears sound in the light of widely distributed shallow shelf conditions suitable for the development of shallow marine faunas (see Samanta *et al.*, 1990). It is believed that during the Late Middle Eocene the shallow marine regimes in the European Tethys allowed rapid evolution which resulted in high-diversity assemblages of foraminifera occupying almost all the available ecological niches. The absence of vacant ecological niches may have proved a deterrent to the dispersal of species migrating from the Indian region.

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EXPLANATION OF PLATE

Plate I

- 1-2. *Nonion sastrii* n. sp., 1, holotype (L.U./Geol./841), side view X 175; (Sample No. S₆) 2, paratype (L.U./Geol./842), apertural view X 175 (Sample No. S₆).
3. *Bolivinooides pratapi* n. sp., holotype (L.U./ Geol./ 740). side view, X 270 (Sample No. S₆).
- 4-5. *Gavelinella eicheri* n. sp., 4, paratype (L.U./Geol./853), apertural view, x 125; (Sample No. S₆) 5, paratype (L.U./Geol./854), ventral view, x 125 (Sample No. S₆).
- 6-7. *Triloculina bhujensis* n. sp., holotype (L.U./Geol./ 692), 6, apertural view, 7, side view, x 150 (Sample No. S₆).
8. *Epistomaria talukdari* n. sp., holotype (L.U./ Geol./773), ventral view, X 100 (Sample No. S₆).
9. *Oolina oblonga* n. sp., holotype (L.U./Geol./716), top view showing radiate aperture, x 100 (Sample No. S₆).

Plate II

1. *Elphidium bhattacharyai* n. sp., holotype (L.U./Geol./797), side view, x 175 (Sample No. S₆).
- 2,4,9. *Planorbulinella* sp., 2, 4 specimen (L.U./Geol/ 832), side views, x 70 (Sample No. S₆) ; 9, specimen (L.U./Geol/ 833), side view, x 130 (Sample No. S₆)
13. *Ammomassilina berggreni* n. sp., holotype, (L.U./Geol./ 704), side view, x 70 (Sample No. S₆).
- 3, 6. *Glabrattella maheshwarii* n. sp., 3, holotype (L.U./ Geol./ 762), ventral view, x 310 (Sample No. S₆); 6, paratype (L.U./Geol./763), dorsal view, X 200 (Sample No. S₆).
- 5,7. *Asterigerina umbonata* n. sp., 5, paratype (L.U./Geol./ 805), ventral view, x 100. (Sample No. S₆)7, paratype (L.U./Geol./ 804), dorsal view, x 100 (Sample No. S₆).
8. *Planulinoides vimalae* n. sp., holotype (L.U./ Geol./ 748), apertural view, x 120 (Sample No. S₆).
- 10-12. *Biapertorbis swaroopi* n. sp., 10, paratype (L.U./ Geol./ 811), dorsal view, x 60; 11, paratype (L.U./ Geol./ 813), ventral view, showing umbilical plug, x 85; 12, paratype (L.U./ Geol./812), dorsal view, x 60 (Sample No. S₆).

Plate III

- 1.3. *Epistominella vinjhanensis* n. sp., 1, paratype (L.U./Geol./771), dorsal view, x 340 (Sample No. S₆); 3, paratype (L.U./Geol./770), ventral side showing an elongate aperture just below the margin, x 260 (Sample No. S₆).
2. *Planulinoides vimalae* n. sp., paratype (L.U./ Geol./ 750), side view, x 340 (Sample No. S₆).
4. *Miliola ashoki* n. sp., paratype (L.U./ Geol./ 702), apertural end showing trematophore and a very thin rim around the apertural margin, x 60 (Sample No. S₇).
5. *Triloculina bhujensis* n. sp., paratype (L.U./Geol./ 693), apertural view, showing rounded terminal aperture with curved 'T'-like bifid tooth, x 50.
6. *Buliminella elongata* n. sp., holotype (L.U./Geol./748), apertural view, x 120 (Sample No. S₆).
- 7-8. *Oolina oblonga* n. sp., 7, paratype (L.U./Geol./717), side view, x 70 (Sample No. S₆), 8, holotype (L.U./ Geol./716), side view, x 75 (Sample No. S₆).
- 9-10. *Asterigerina umbonata* n. sp., paratype (L.U./Geol./ 806), ventral view, with enlarged apertural portion showing apertural lip and granules in large numbers (Fig. 9, x 225 and Fig. 10, x 450) (Sample No. S₆).

Plate IV

- 1-2. *Gavelinella eicheri* n. sp., 1, paratype (L.U./Geol/855), dorsal view, X 400 (Sample No. S₆), 2, paratype (L.U./ Geol./ 856), dorsal view, x 170 (Sample No. S₆).
3. *Bolivinooides pratapi* n. sp., 3, paratype (L.U./ Geol./ 742), side views X 170 (Sample No. S₆).
- 4, 7. *Epistominella vinjhanensis* n. sp., 4, paratype (L.U./ Geol./768), apertural view, X 175; 7, ventral view, x 175 (Sample No. S₆).
- 5-6. *Miliola ashoki* n. sp., 5, holotype (L.U./Geol./701), side view, x 60 (Sample No. S₆); 6, paratype (L.U./Geol./702), side view, x 100 (Sample No. S₆).
8. *Planulinoides vimalae* n. sp., paratype (L.U./Geol./749), side view, x 250 (Sample No. S₆).

Plate V

(All figures are light, photomicrographs)

- 1-4. *Epistominella vinjhanensis* n. sp., holotype (L.U./Geol./767), 1, dorsal view, 2, ventral view, 3, apertural view, X 100 (Sample No. S₆) ; 4, paratype (L.U./Geol./769), dorsal view, X 100 (Sample No. S₆).
- 5-6. *Asterigerina umbonata* n. sp., holotype (L.U./Geol./803), 5, dorsal view; 6, ventral view, X 100 (Sample No. S₆).
- 7-9. *Biapertorbis swaroopi* n. sp. 7 and 8 holotype (L.U./Geol./810), 7, ventral view, 8, dorsal view, x 60 (Sample No. S₆) ; 9, paratype (L.U./Geol./112), axial section showing radially fibrous calcitic wall and prominent pillar, x 110 (Sample No. S₆).
10. *Epistomaria talukdari* n. sp., holotype (L.U./Geol./773), dorsal view, X 100 (Sample No. S₆).
- 11-13. *Gavelinella eicheri* s. sp., holotype (L.U./Geol./ 852), 11, dorsal view, 12, ventral view, 13, apertural view, X 50 (Sample No. S₆).

Plate VI

- 1-3. *Epistomaria talukdari* n. sp., 1, paratype (L.U./Geol./774), peripheral view, x 290 (Sample No. S₆); 2, paratype (L.U./Geol./774), dorsal view, x 230 (Sample No. S₆); 3, paratype (L.U./Geol./775), ventral view, x 145 (Sample No. S₆).
- 4-5. *Asterigerina umbonata* n. sp., 4, paratype (L.U./Geol./807), peripheral view, x 125 (Sample No. S₆); 5, paratype (L.U./Geol./806), peripheral view, x 180 (Sample No. S₆).
6. *Elphidium bhattacharyai* n. sp. paratype (L.U./Geol./799), side view, x 250 (Sample No. S₆).
- 7-8. *Ammomassilina berggreni* n. sp., 7, paratype (L.U./Geol./705), showing aperture and its enlargement 7_a x 310, 7_b x 62 (Sample no. S₆); 8, same specimen, side view, x 100 (Sample no. S₆).

Plate VII

1. *Glabratella maheshwarii* n. sp., holotype (L.U./Geol./762), peripheral view, x 375 (Sample No. S₆).
2. *Bolivoides pratapi* n. sp., holotype (L.U./Geol./740), showing aperture, x 230 (Sample No. S₆).
3. *Planorbulinella* sp., specimen no. (L.U./Geol./832), dorsal view showing supplementary apertures, x 85 (Sample No. S₆).
4. *Gavelinella eicheri* n. sp. paratype (L.U./Geol./857), peripheral view, x 190 (Sample No. S₆).
- 5-6, 9. *Biapertorbis swaroopi* n. sp., 5, paratype (L.U./Geol./814), ventral view showing the umbilical plug and deeply depressed sutures near the umbilicus, x 175 (Sample No. S₆); 6, same specimen, slightly tilted to show periphery, x 205; 9, enlarged ventral view of the same specimen showing umbilical plug and secondary opening near umbilicus, x 300 (Sample no. S₆).
- 7-8. *Planulinoides vimalae* n. sp., 7, paratype (L.U./Geol./751), ventral view, x 270 (Sample No. S₆); 8, paratype (L.U./Geol./752), peripheral view showing the equatorial aperture, x 290 (Sample no. S₆).

Plate VIII

- 1-2. *Gavelinella eicheri* n. sp. 1, paratype (L.U./Geol./857), ventral view (1a) with enlarged umbilical portion showing prominent lip surrounded by numerous pustules (1b), 1a x 115, 1b x 460; 2 (same specimen), peripheral view, x 130 (Sample no. S₆).
- 3, 8. *Asterigerina umbonata* n. sp., paratype (L.U./Geol./807), ventral view, with slit-like aperture near periphery, prominent lip and pustules in front of aperture, x 110; 8, paratype (L.U./Geol./808) ventral view of a broken specimen showing secondary chamberlets and dense, small pustules in front of aperture x 160 (Sample No. S₆).
4. *Planorbulinella* sp., specimen no. (L.U./Geol./832), dorsal view, x 110 (Sample No. S₆).
- 5, 7. *Epistomaria talukdari* n. sp., 5, paratype (L.U./Geol./776), ventral view showing slit-like accessory apertures parallel to periphery, x 190 (sample no. S₆); 7, paratype (L.U./Geol./775), ventral view, x 180 (Sample No. S₆).
6. *Ammomassilina berggreni* n. sp., 6, paratype (L.U./Geol./705), side view, x 85. (Sample No. S₆).
- 9-10. *Epistominella vinjhanensis* n. sp., paratype (L.U./Geol./772), 9 dorsal view showing oblique sutures and perforations near periphery, x 300 (Sample No. S₆); 10, ventral view showing and elongate aperture nearly parallel to the periphery, x 300 (Sample No. S₆).



