

BULIMINIDS FROM THE MIDDLE EOCENE OF RAJASTHAN, INDIA

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ABSTRACT

The present paper embodies the description of the important species of Buliminid foraminifera obtained from the middle Eocene material of Rajasthan. A total number of twelve species are recorded out of which six species and a subspecies are new. Discovery of a new species of the genus *Eowigerina* is significant in view of its restricted occurrence. *Eowigerina* Cushman is considered to be distinct from *Zeawigerina* Finlay.

INTRODUCTION

The present paper records and describes some of the important species of the superfamily Buliminacea present in the Middle Eocene (Kirthar) material of Rajasthan. The exposure of Kirthar beds from which the assemblage was obtained is located about 6 kms west of Shri Kolayatji village, near Fuller's earth quarry in the district of Bikaner, Rajasthan.

The stratigraphy of the area is briefly given in the following Table (After Singh 1969) :

Age		Stratigraphic Subdivisions:	
Post-Lutetian		Jogira formation	
		Unconformity	
		Bikaner stage	<i>Flosculina</i> Zone
Lutetian	Kirthar Series		Discocyclina Zone
		Marh stage	Ferruginous Sandstone
		Unconformity	
		Laki Series	Pelecypoda Zone.
Ypresian		Kolayat stage	Nummulites Zone. Ostracoda Zone.
		Unconformity	
?Palaeocene.		Palana formation.	

The presence of planktonic species in the Bikaner stage has largely helped in assessing its stratigraphic position with reference to standard planktonic zones (Singh and Kalia 1970). The lower *Discocyclina* Zone is characterised by the presence of *Globorotalia lehneri* Cushman and Jarvis and *Globorotalia spinulosa* Cushman. The co-existence of these two important index species provides sufficient grounds to refer this zone as equivalent to the standard *Globorotalia lehneri* (P. 12) Zone. In addition to the above mentioned forms following planktonic forms were also obtained from this zone :

Chiloguemelina vineetae Singh and Kalia,
Pseudogloborotalia lomasha Singh and Kalia and
Inordonatosphaera sp.

Similarly, the upper *Flosculina* zone contains specimens of *Truncorotaloides rohri* Bronnimann and Bermudez. This zone is characterised by the presence of many new forms, both planktonic and benthonic, moreover many species present in the lower zone do not continue to occur in this zone. The important planktonic forms present in this zone are :

Indicola rajasthanensis Singh and Kalia, *Truncorotaloides rohri* Bronnimann and Bermudez *Globigerina tropicalis* Banner and Blow *Globigerina officinalis* Subbotina, *Globigerina frontosa* subbotina, *Globigerina pseudocorpulenta*, Chalilov, *Shastrina udbodhaka* Singh and Kalia.

In Kolayatji, the succession of two Lutetian zones equivalent to *Globorotalia lehneri* (P-12) and *Truncorotaloides rohri* (P-14) zone with the absence of intervening *Porticulusphaera mexicana* (P-13) zone suggests an unconformable junction between the two zones of the Bikaner stage. This is also supported by the overall trends of the faunal assemblages of both larger and smaller foraminifera in the respective zones. It is significant to note in this connection that *P. mexicana* has been reported from the adjoining areas of Kutch (Mohan and Soodan 1967) and Lindi area, East Africa (Banner and Blow, 1962).

All the forms described herein are present throughout the Bikaner stage and the type specimens are deposited with Dr. S. N. Singh in Department of Geology, University of Lucknow, Lucknow, India.

SYSTEMATIC DESCRIPTION

Suborder	Rotaliina Delage and Herouard, 1896.
Superfamily	Buliminacea Jones, 1875.
Family	Turrilinidae Cushman, 1927.
Subfamily	Turrilininae Cushman, 1927.

Genus *Buliminella* Cushman, 1911.

Buliminella aryabhatai Kalia, sp. nov.

(Plate I—1-2)

Description : Test comma shaped with a fine basal spine, consisting of three helicospiral whorls with five chambers per volution ; chamber elongate, inflated ; spiral sutures distinctly depressed, septal sutures curved and flush with the surface. Aperture lateral, situated at the base of the final chamber, broad, loop shaped, almost occupied by the tortuous extension of the internal tooth plate. Wall calcareous, radial in microstructure, finely perforate.

Measurements in mm :

	Length	Breadth	Thickness
Holotype	0.55	0.225	0.225
Average	0.52	0.22	0.22

Comparison and Remarks :

The present new species is comparable to *B. basistriata* Cushman & Jarsis described from the upper eocene Mt. Moriah beds of Trinidad but it does not possess the basal striations characteristic of *B. basistriata*. The new species *B. aryabhatai* is distinguishable from all the known species of *Buliminella* by the presence of the basal spine and comma shaped test composed of inflated and curved chambers. Abundant throughout the Bikaner stage. (Holotype No. SFKIY/42, Paratype Assemblage. Slide no. SFKLY/42-1).

Etymology : The new species is named in memory of Aryabhata, the ancient Indian Astronomer and Mathematician.

Bulimnella pulchra (Terquem) 1882

(Pl. I—3)

1882. *Bulimina pulchra* Terquem, Mem. Soc. Geol. France, Ser. 3, T. 11, P-115. Pl. XII, fig. 16
 1882. *Bulimina intorta* Terquem, Mem. Soc. Geol. France, Ser. 3, T. 11, P. 115. Pl. XII, fig. 15
 1947. *Buliminella pulchra* (Terquem) Cushman and Parker in *Bulimina* and related foraminiferal genera, Geol. Surv. Prof. paper 210-D p. 61, pl. 16, figs. 5-6.
 1949. *Buliminella pulchra* Le Calvez. Revision des foraminifères Lutitians du Bassin de Paris. III, Polymorphinidae, Buliminidae, Nonionidae. Cat Geol. Detaillee France, Mem., P-33 pl. 11, Fig. 31-32.

Remarks

The present specimens of *B. pulchra* compares well in all the characters with the description of the original type. Abundant throughout the Bikaner stage (Hypotype no. SFKLY/43 and Paratype assemblage slide no. : SFKLY/43-1.

Genus *Buliminoides* Cushman, 1911

Buliminoides eocenica Kalia sp. nov.

(Pl. I—4, 5)

Description : Test elongate, tapering at both the ends, consisting of 7-8 closely coiled whorls, chambers of the earlier 3-4 whorls are oval, inflated and obliquely placed ; in the later 3-4 whorls chambers are more broad and high, almost quadrangular in outline, septal sutures distinct. Aperture basal, situated at the centre of the convex apertural end, wall densely and coarsely perforate, surface smooth, microstructure calcareous radial.

Measurement in mm

	Length	Diameter
Holotype	0.4	0.15
Paratypes	0.45	0.15
	0.425	0.15

Comparison and Remarks : The new species *B. eocenica* resembles *Buliminoides challonensis* (Finlay) described from the lower oligocene of New Zealand in the elongate outline and smooth surface of the test but differs in having a broader and cylindrical test with inflated chambers.

Fairly common in the Bikaner stage. (holotype No. : SFKLY/44, Paratype assemblage slide No. SFKLY/44-1)

Family Eouvigernidae Cushman, 1927

Genus *Eouwigerina* Cushman, 1926

Eouwigerina indica Kalia sp. nov.

Description : Test elongate, twisted, biserial, becoming uniserial in the final stage. Initial 2-3 biserial set of reniform chambers are compressed and overlapping, later chambers loosely appressed and alternatingly placed, subrhomboidal in shape, bearing a strong median angulation which imparts a characteristic many angled profile to the test. The ultimate chamber centrally placed, quadrangular in cross section. Sutures distinct in the considerably depressed area formed by the slopes from the median angulations of the adjacent chambers. Aperture terminal, subrhomboidal in shape, provided with a distinctly raised phialine lip and negligible neck, occupied almost half with the extension of the internal columnar process. Wall finely perforate densely hispid, microstructure calcitic-radial.

Measurement in mm :

	Length	Breadth	Thickness
Holotype (micro-spheric)	0.5	0.15	0.1
Paratype (i)	0.325	0.125	0.1
(ii)	0.4	0.15	0.1
Hypotype (megalospheric)	0.325	0.175	0.125
Paratype (i)	0.275	0.125	0.075
(ii)	0.14	0.125	0.125

Comparison and Remarks : The new species *Eowigerina indica* is comparable and closest to the type species of the genus *E. americana* Cushman, described from the Taylor Marl (Upper Cretaceous) but it differs in possessing a centrally situated final chamber, absence of prominent chamber carinae and a shorter, almost negligible apertural neck.

Both the micro- and megalospheric generations of *E. indica* occur abundantly throughout the Bikaner stage. The microspheric specimens are represented by the slender and elongate forms while the megalospheric forms possess a smaller, broader and stout test, with a marked twisting along the median line imparting an apparent triseriarity to the later portion of the Test, moreover the chamber angulations are perceived right from the earliest stage in these forms.

Eowigerina was considered till recently an index genus restricted to upper Cretaceous. Except for the record of two species *E. loxistoma* Loeblich and Tappan, 1964, from the lower Cretaceous and *E. excavata* Cushman, 1946, from the lower Eocene, all the known species of this genus were reported from the upper Cretaceous. In 1957 *E. excavata* was put under the synonymy of the newly proposed genus *Tappanina* by Montenegro Gallitelli, who regarded *E. excavata* to be conspecific with *Bolivina selmensis* Cushman, 1933, the type species of the genus *Tappanina*, saying :

“The holotype of *Eowigerina excavata* Cushman consists of a specimen of *T. selmensis* with the last chamber broken and simulating a neck. This confirms the doubt of Brotzen 1948 about the validity of the species ‘*excavata*’ (p. 147, U. S. N. Hist. Bull. 215, 1957).”

The rejection of the validity of the Eocene species *E. excavata* by Gallitelli, again brought down the upper age limit of the genus *Eowigerina* to upper Cretaceous. Loeblich and Tappan (Treatise. C556) consider the upper and Middle Eocene genus *Zeawigerina* Finlay as synonym of *Eowigerina* Cushman. In the opinion of the present author *Eowigerina* has a distinct morphology and *Zeawigerina* should not be included as its synonym. The undoubted presence of this species of *Eowigerina* s. s. in the Lutetian (Kirthar) material from Rajasthan is perhaps the only record of its occurrence in the post Cretaceous formations of the world.

Common throughout the Bikaner stage

(holotype No. SPKLY/45, Paratype assemblage slide No. SFKLY/45-1).

Family Bolivinitidae, Cushman 1927

Genus *Brizalina* Costa, 1856

Brizalina kanadi Kalia sp. nov.

(Pl. I—12-13)

Description : Test lanceolate, with convex sides and acute carinate periphery, chambers biserially arranged,

cuneate, broad, gradually becoming as high as broad, closely appressed. Sutures distinctly depressed. Aperture terminal an illiptical slit surrounded by thick border, which is continuous with the marginal carina. Periphery lobulate, carinate, thus appearing bluntly spinose at the chamber sutures. Wall coarsely perforate and densely punctate, microstructure calcareous radial.

Measurement in mm :

	Length	Breadth	Thickness
Holotype	0.35	0.175	0.125

Comparison and Remarks :

Loeblich and Tappan in the Treatise consider the genus *Bolivina* as restricted to include only the biserial forms with chamber-retral processes or overlaps, while the species without chamber overlaps, commonly keeled and strongly compressed form, are placed under the genus *Brizalina*.

The new species *brizalina Kanadi* Kalia differs from *Bolivina antigressa* Subboitna, 1953, described from the upper Eocene of Southern U.S.S.R. in having a smooth, rather than a striated test surface. It is also similar to *Bolivina dilatata* Reuss in general appearance but it possesses greater number of chambers and differently shaped aperture. Fairly common in the material (Holotype No. : SFKLY/46, paratype assemblage slide No. : SFKLY/46-1).

Etymology : The species has been named in memory of ‘Kanad’ the Ancient Indian Sage.

Family Buliminidae Janes 1875

Subfamily Pavononinae Kimer and Tickert 1899.

Genus *Reusella* Galloway 1933

Reusella elongata (Terquem) Cushman, 1945

(Pl. I—14-15)

1882. Mem. Soc. Geol. France, Ser. 3; Tom. 11; p. 106; pl. XI; fig. 13.

Verneuilina elongata Terquem,

1909. Heron-Allen and Earland, Jour. Roy. Micr. Soc., p-326.

1945. Cushman, Contr. Cushman Lab. Foram. Res., Vol. 21; pt. 2; p. 27; pl. 5; figs. 10-11.

Reusella elongata (Terquem),

1947. Le Calvez, Revision des foraminifères Lutetiens du Bassin de Paris, 111, Polymorphinidae, Buliminidae Nonionidae. Carte. Geol. Detaille, France, Mem., p-46; pl. 111, figs. 45-46.

Remarks

The present specimens correspond in all the aspects to *R. elongata* Cushman, except having a slightly broader test outline. (Hypotype slide No. : SFKLY/47).

Measurements in mm (average) :

Length	Breadth (of each lateral chamber face)
0.375	0.225
0.4	0.225

Reusella nagarjuni Kalia sp. nov.
(Pl. II—1-2)

Description : Test triangular, triserial throughout with carinate, slightly spinose angles ; chambers gradually enlarge, resulting in a broader and thicker test; lateral faces of the test flat, with a slight curved depression near the angles, sutures not distinct, flushed with the surface. Aperture, basal in the final chamber, roughly triangular in shape without any border with an internal tooth-plate, apertural end truncated. Wall finely end densely perforate.

Measurement in mm :

	Length	Breadth (of each lateral chamber face)
Holotype	0.35	0.275
Average	0.3	0.25

Comparison and Remarks :

Reusella nagarjuni n. sp. differs with *R. elongata* Cushman, 1945 in having a less elongate, broader, spinose-angled test with truncated apertural end and almost flat lateral sides. *R. nagarjuni* n. sp. occurs abundantly in the material and shows very little variation in size.

Repository : Holotype No. : SFKLY/48 and Paratype assemblage slide No. : SFKLY/48-1.

Rtymology : The new species is named after 'Nagarjuna' the ancient Indian Geochemist.

Reusella recurvata (Halkyard)
(Pl. II—3-4)

1918. *Verneuilina recurvata* : Halkyard, E., The fossil foraminifera of the Blue marl of the Cote des Basques, Biarritz Edited with additions by E. Heron-Allen and A. Earland, Manchester Lit. Phil. Soc. 1918, Vol. 62; pt. 2; No. 6; P. 43; Pl. 3; 7a-b, Middle Eocene.

Comparison and Remarks :

The present specimens of *R. recurvata* (Halkyard) exactly resemble with the original type. Fairly common in the material (Slide Nos.: SFKLY/49 and SFKLY/49-1).

Measurements in mm (average) :

Length	Breadth (of each chamber face)
0.175	0.25

Genus *Tubulogenerina* Cushman, 1929.

Tubulogenerina tubulifera (Parker and Jones)

1863. *Textularia (Bigenerina) tubulifera* Parker and Jones, On the nomenclature of the foraminifera, pt. 8, Textularia, Ser. 3; Vol. 11; p. 94; fig. 2.
1882. *Clavulina eocenica* Terquene (on Guembel) Mem. Soc. Geol. Paris., Ser. 3; tome 11; p. 121; pl. XII; fig. 35-6.
1909. *Bigenerina eonica* Heron-Allen and Earland, Jour. Roy. Micr. Soc., p. 329; pl. XIV; fig. 1.
1927. *Tubulogenerina tubulifera* (Parker and Jones) Cushman, some new genera of foraminifera; contr. Cushman Lab. foram. Res. Vol. 2; pl. 4; p. 78.
1950. *Tubulogenerina tubulifera* (Parker and Jones) Le Calvez, Rev. Foraminiferaes, Lutetian due basin, Paris, pt. III, p. 46. (Mem. Carte. Geol. Detaille).

Remarks

Few specimens of *T. Tubulifera* Cushman described from the Lutetian of France are encountered in the present material. Both the young (with entirely triserial tests) and the adult with later Uniserial stages are present. (Slide Nos.: SFKLY/50 and SFKLY/50-1).

Measurement in mm (average) :

Length	Diameter
0.25	0.15

Family Uvigeriniæ Haeckel, 1894.

Genus *Sagrina* D'orbigny, 1839.

Sagrina mauricensis (Howe)
(Pl. II—7-8)

1839. *Bitubulogenerina mauricensis* Howe, Louisiana Cook Mountain Eocene Foraminifera, Louisiana Geol. Surv. Bull. 14.
1962. *Sagrina mauricensis* (Howe) Treatise on Invertebrate Palaeontology : Part C (Protista) p. c569, fig. 448, 7-11.

Remarks

The present specimens exhibit similar characters as *S. mauricensis* (Howe), the only difference exists in the size of the aperture. Rare in the material. (Hypotype No. : SFKLY/51).

Measurement in mm (average) :

Length	Diameter
0.3	0.25

Genus *Trifarina* Cushman, 1926

Trifarina advena rajasthanensis Kalia subsp. nov.
(Pl. II—9-12)

Comparison and Remarks :

The new subspecies resembles *T. advena* var. *californica* in general appearance but differs in possessing a bigger Test and in the absence of an apertural neck. Fairly common in the material. (Holotype No. : SFKLY/52)

Measurement in mm :

Length	Breadth
0.3	0.1

Trifarina sushrutai Kalia sp. nov.
(Pl. II—13, 14)

Description : Test triserial, triangular in cross section, elongate, with moderately tapering ends, exhibiting a tendency to become Uniserial in the adult stage. Margins keeled angle bluntly spinose, Chambers triangular, as high as broad, sutures distinct, obliquely running. Aperture at the base of the final chamber, situated laterally, a high arched loop, surrounded on all sides by a thick poreless border, which is continuous with the keeled angles. Lateral faces of the Triangled test characteristically flat. Wall coarsely perforate, except on the keeled angles of the test.

Measurement in mm :

	Length	Breadth
Holotype	0.775	0.2
Average	0.625	0.2

Comparison and Remarks :

The new species *Trifarina sushrutai* is nearest to the Recent, Indopacific species *T. Bradyi* Cushman, 1923, but differs in having both ends tapering and a subquadrate laterally placed aperture. Abundant in the material. (Holotype no. SFKLY/53, Paratype assemblage slide (No. : SFKLY/53-1)).

Etymology : The species has been named after the famous ancient Indian Surgeon 'Sushrut'.

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EXPLANATION OF PLATES

PLATE I.

- 1-2. *Buliminella aryabhatai* Kalia, n. sp., Holotype 1. Lateral view, 2 Latero-apertural view. $\times 120$.
3. *Buliminella pulchra* (Terquem), Latero-apertural view $\times 120$.
- 4-5. *Bulminoides eocenica* Kalia, n. sp. Holotype 4 Lateral view, 5. apertural view. $\times 120$,
- 6-11. *Eouwigerina Indica* Kalia, n. sp. 6-9 Holotype (Microspheric form)—6 & 8—Lateral views 7, apertural view. 9, apertural view slightly tilted showing penultimate chamber also 10-11 Paratype (Megalospheric form) 10 Lateral view 11. apertural view. (all figs. $\times 90$).
- 12-13. *Brizalina Kanadi* Kalia n. sp. Holotype. 12. Lateral view. 13. apertural view $\times 120$.
- 14-15. *Reussella elongata* (Terquem) Cushman. 14. apertural view—15. Lateral view $\times 120$.

PLATE II.

- 1-2. *Reusella nagarjunai*. Kalia, n. sp. Holotype. 1. Lateral view. 2. Apertural view— $\times 120$.
- 3-4. *Reusella recurvata* (Halkyard). $\times 120$. 3. Lateral view. 4. Apertural view.
- 5-6. *Tubulogenerina tubulifera* (Parker & Jones) $\times 180$. 5. Lateral view. 6. Apertural view.
- 7-8. *Sagrina mauricensis* (Howe $\times 90$). 7. Lateral view. 8. Apertural view.
- 9-12. *Trifarina adriana rajasthanensis* n. sub. sp 9-10. Holotype. 9. Latero-apertural view. 10. Lateral view. 11-12. Paratype 11. Apertural view. 12. Lateral view $\times 90$.
- 13-14. *Trifarina sushrutai*. Kalia, n. sp. Holotype 13. Lateral view. 14. Latero-apertural view $\times 90$.



