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CRETACEOUS FORAMINIFERA OF UM SOHRYNGKEW RIVER SECTION, MEGHALAYA

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ABSTRACT

Twelve species of benthonic and thirty six species of planktonic foraminifrea, restricted to the Cretaceous section of Mahadeo Formation, are described and figured from the Um Sohryngkew River section near village Therria (25° 11' N : 91° 45' E). The recorded assemblage is divisible into two distinct biozones which, together, are correlated with the Maastrichtian of Europe.

The rich planktonic assemblage includes several cosmopolitan species, but some local characteristics are also observed. These include absence of dicarinate *Globotruncana*, a second record of genus *Guembelitriella* after Santonian, a very rare occurrence of *Planomalina* ex. gr. *buxtorfi* which is believed to be extinct much before Maastrichtian and a rare record of Campanian form *Globotruncanella coarctata*.

INTRODUCTION

In the southern part of Meghalaya, comprising of southerly areas of Shillong Plateau and its rapidly descending slopes near Bangladesh border, Cretaceous and Tertiary strata occur overlying a Pre-Cambrian granitic basement or, occasionally, the Sylhet Basalts ('trap') of presumably Jurassic age. One of the earliest explored segments of these strata occurs around Cherrapunji (25° 16'N : 91°45' E ; Figure-1, insets 1,3.)

Although the first account of the Cheera sedimentary succession was presented by Oldham (1858) ; it was Medlicott (1869) who introduced a formal classification for the sediments underlying the famous Sylhet Limestone of Tertiary age. He grouped the infra-Sylhet strata around Cherrapunji into the Mahadeo, Langpar and Cherra 'bands' ; and, on the megafaunal evidence compared the Mahadeo 'band' with the Cretaceous 'Ariyaloor' beds of Trichinopoly.

An account of Cretaceous foraminifer occurrence from the Mahadeo 'band' of Medlicott was given, for the first time, by Nagappa (1959 ; Mahadeo and Mahadek lithotopes are synonymous ; Mahadeo, being the current and Medlicott's spelling of the locality, is adopted here). This was followed by enumeration of several planktonic foraminifera of Cretaceous age by this author (1974) from the Um Sohryngkew River section near village Therria (25° 11'N : 91°45'E), about twelve kilometres south of Cherrapunji. It was also brought out in this report, that the Creatceous/Teritiary boundary falls in the continuously marine section of the Mahadeo Formation—the terminal and initial events of the Cretaceous and Paleocene respectively, being the disappearance of *Globotrancana-Heterohetix* suite, and appearance of *Turborotalia sabina* assemblage.

The present paper figures and describes such species of foraminifera that are essentially restricted to the Cretaceous section of the Mahadeo Formation in the Um Sohryngkew River section barring one species which occurs in the Paleocene. All the Paleocene species of foraminifera or those stradling the Cretaceous/Tertiary boundary in the Um Sohryngkew River section have been included in Paleocene (Pandey, 1978).

LITHOLOGIC SUCCESSION AROUND THERRIA

Medlicott (1869) recognised five principal litho-units in the Cherrapunji-Therria area below the Nummulitics or the Sylhet Limestone. These units, all comprising of clastics, exhibit the following order of superposition in the Cherrapunji area :

Sylhet Limestone

Conformable boundary.....

Cherra band :	Whitish or reddish medium to coarse sandstones.
Langpar band :	Gray and greenish gray calcareous shales and limestones.
Mahadeo band :	Greenish gray sandstones
Great Bottom Sandstone	Coarse arkosic sandstones.
Basal Conglomerate:	Conglomerates and sandstones

.....Unconformity.....

Sylhet Trap or Precambrian Complex.

While mapping in the Therria area(Fig. 1, inset 2) the author conveniently modified the above scheme considering gross geological history of Cherra-Therria area. Thus, the Basal Conglomerate and Great Bottom Sandstone—mostly nonmarine arkosic sandstones were mapped as a single litho-unit : the Um Sohryngkew Formation. The Mahadeo 'band' of Medlicott was mapped as the Mahadeo Formation between the first major transgressive event indicated by a shell limestone (30 cm. thick) at the base and a distinct unconformity/regression at the top.

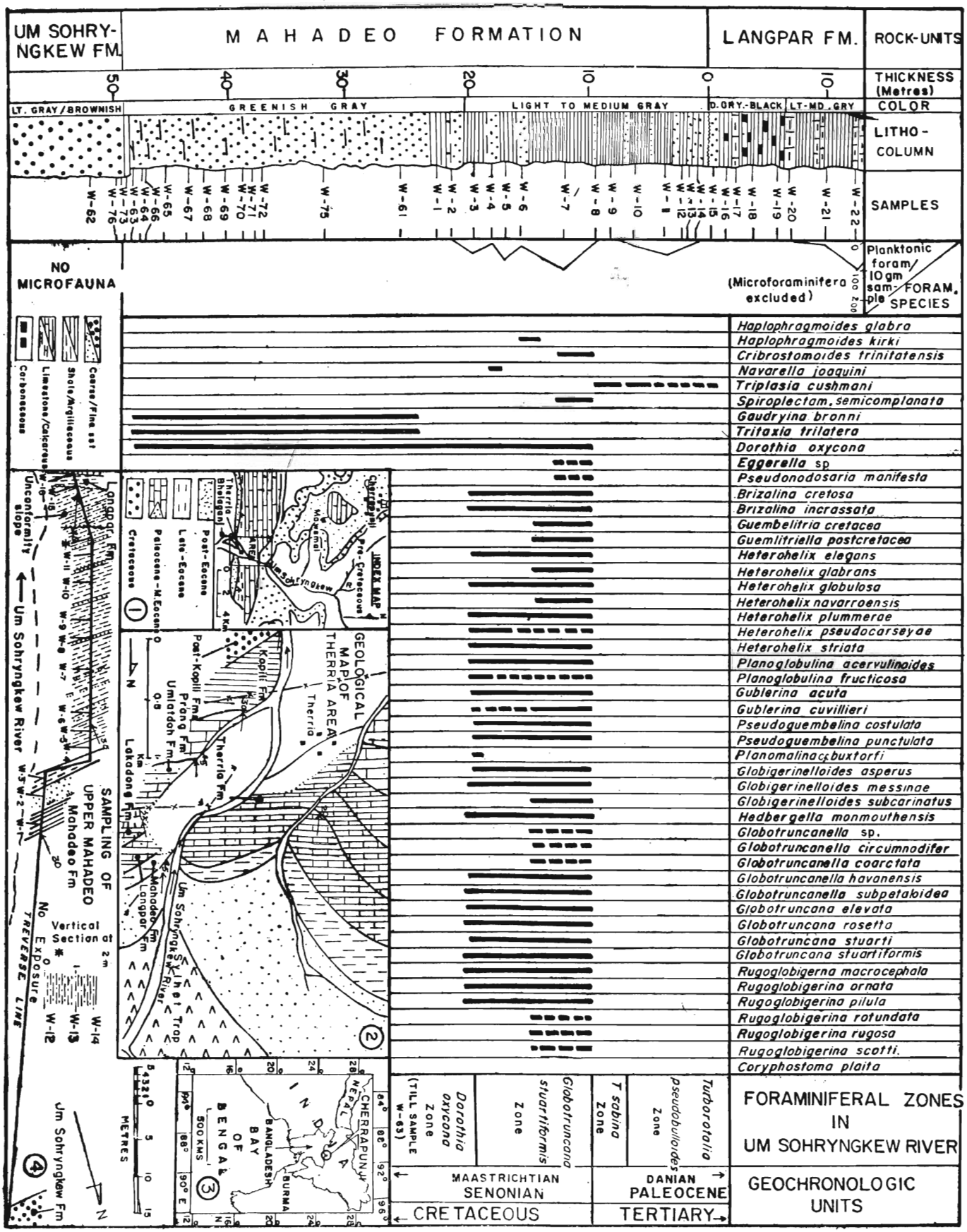

Fig. 1. Cretaceous Foraminiferal ranges in the Um Sohryngkew River section.

The overlying Langpar Formation represents a second transgression and its boundary with the overlying Therria Formation of the Sylhet Group was placed at the appearance of first arkosic, whitish sandstones (with plant leaves) In the Therria area, Therria Formation is the obvious facies of Cherra Sandstone of Cherrapunji and mapped as Cherra lithotope earlier by Ghosh (1940).

The Mahadeo Formation, wherein the Cretaceous/Tertiary boundary has been placed about ten metres below the Mahadeo-Langpar contact in the Therria area (Pandey 1978), exhibits the following succession in Um Sohryngkew River :

Upper Member 21 m...Light to dark gray and greenish gray silty shales ; greenish gray, fine grained nodular, calcareous and noncalcareous sandstones.

Lower Member 28 m..Fine to medium grained, greenish gray graywackes and subgraywackes ; brownish and greenish sandy shales. A 15 to 30 centimeter thick bed of 'shell limestone' at the base.

The Mahadeo Formation is well exposed between the Um Sohryngkew River and the path between Therria and Mahadeo (25°13' N : 91° 45'E) villages. The Upper Member is clearly seen on the western bank of the river where it has been continuously sampled (Fig. 1, inset 4). The Lower Member is also exposed almost continuously a little to the west of the river.

SAMPLING AND PROCESSING

Sampling, for the purposes of microfaunal studies was carried out on the western bank of Um Sohryngkew River. The Lower Member was sampled about 15 to 30 metres to the west of the main channel and the Upper Member between 3 and 8 metres west of the stream.

The sampled lithology is invariably an argillaceous, medium to fine, greenish sandstone in the Lower Member. Similar, fine greenish sandstones as also greenish or gray shales were collected from the Upper Member for microfaunal investigation vide the traverse details and litholoculmn (figure 1).

The collected samples were boiled with washing soda and washed over a 200 mesh sieve. The residue, when sorted under microscope, gave a moderate to rich yield of smaller forminifera.

GROSS ASSEMBLAGE AND PALEOECOLOGY

Both agglutinated and calcareous foraminifers occur in the Mahadeo Formation. The arenaceous or agglutinated ones commence with the base, whereas the calcareous types typically appear at the base of the Upper Member. Thus the boundary between the two principal lithological subdivisions of the Mahadeo Formation is also an approximate boundary between the two ecologically distinct assemblages.

The foraminiferal assemblage occurring in the Lower Mahadeo being composed of simple arenaceous foraminiferal types connotes estuarine, lower salinity environments. On the contrary, the Upper Mahadeo assemblage, including not only arenaceous and calcareous benthonic types but also planktonic ones, reflects an open shelf, neritic environment when sea bottom could have deepened down to central or outer shelf.

BIOZONATION

The Mahadeo Formation, comprises of a single marine cycle. *Pari passu*, the foraminiferal succession of the lithotope is continuous and the boundary between the succession faunal zones tend to be gradational. The Cretaceous/Tertiary boundary, nevertheless, is abruptly defined in the planktonic foraminiferal scale, albeit only with minor changes in the benthonic assemblage.

The Cretaceous sediments of the Mahadeo Formation are easily biozoned into two: a lower *Dorothia oxycona* Zone and an Upper *Globotruncana stuartiformis* Zone. The diagnostic planktonic foraminifera of the formation occur in the *G. stuartiformis* Zone, corresponding to the Upper Mahadeo. This assemblage seems typically Maastrichtian on overall considerations. However, for the purposes of correlation of the Mahadeo Formation it seems imperative to briefly invoke the more recently followed Cretaceous biozones of global significance, (Bolli, 1966 ; Bandy, 1967 ; Van Hinte, 1969, and Postuma, 1971).

That the Cretaceous biozonation has reached a plateau beyond which it is difficult to increase biostratigraphic resolution in the planktonic foraminifera is emphasized by Masters (1977)). He has re-fortified the datum-plane concept in foraminiferal record, adversely commented upon by Blow (1970). However, as a primary basis of global biostratigraphic homotaxis, zones remain a living concept since they are, in essence, defined by prominent and valid datum planes in the evolution of foraminifera themselves. The following review, therefore, seeks a comparison of Late Cretaceous foraminifer Zones of the Um Sohryngkew River with some of the global planktonic zones.

LATE CRETACEOUS-PALEOCENE PLANKTONIC FORAMINIFERAL ZONES

Following Bandy (1967), the Late Cretaceous is a period of the dominance of *Globotruncana*. The planktonic zones of this period are, accordingly, based mainly on the ranges of the *Globotruncana* species. The generalised planktonic foraminiferal zonation of this period has been discussed in detail by Bolli (1966), Bandy (1967) and Van Hinte (1969). In Maghalaya, as noted above, only the highest Cretaceous sequence, corresponding to the upper range of *Globotruncana stuartiformis* Dalbiez develops. The

Table 1. Correlation of Late Cretaceous Planktonic Forminifer Zones.

Late Cretaceous Stages	Global Planktonic Zones			Meghalayan Cretaceous Zones
	Bolli, 1966	Bandy, 1967	Van Hinte, 1969	
Maastrichtian	*Globotruncana mayaroensis* Zone.	*G. mayaroensis gansseri* Zone	*G. contusa* Zone	*Globotruncana stuartiformis* Zone.
			G. stuarti Zone	
	G. gansseri Zone.		*G. gansseri* Zone	
	G. lapparenti tricarinata Zone.	*G. ventricosa-Guembelitria cretacea* Zone	*G. calciformis* Zone	*Dorothia oxycona* Zone
Campanian	*G. calcarata* Zone	*G. calcarata rosetta* Zone	*G. calcarata* Zone	
	G. stuarti s. 1. Zone	*Praeglobotruncana inornata-Rugoglo bigerina rugosa subruga* Zone	*G. subspinosa-calciformis* Zone.	Non Marine
			G. subspinosa-fornicata Zone	
			G. stuartiforms Zone	

species is typically associated with the Campanian-Maastrichtian sediments world over and the total range is classified into several zones.

A significant change in the *Globotruncana* assemblage within the Campanian-Maastrichtian *Globotruncana stuartiformis* range is the sudden appearance of a spinose form, *Globotruncana calcarata* Cushman. Its first appearance level marks the base of upper Campanian while its extinction is taken as the base of Maastrichtian (Table 1). During the Maastrichtian, appearance of *Globotruncana gansseri* Bolli from *G. rosetta* (Crasey) is a widely recorded event marking the base of *G. gansseri* Zone . Again a dicarinate form, *Globotruncana mayaroensis* Bolli, appears within *G. gansseri* range zone and divides it into a lower *G. gansseri* Zone and an upper *G. mayaroensis* Zone in the zonal scheme of Bolli (1966).

Globotruncana gansseri range zone has been divided into three zones by Van Hinte (1969) considering the evolutionary changes in the unicarinate forms of *Globotruncana stuartiformis* group. *G. gansseri* Zone covers the interval between the first appearances of *G. gansseri* and *G. stuarti* (De Lapparent) ; *G. stuarti* zone is the interval from the first appearance of this species till the appearance of *G. contusa* (Cushman); and, *G. contusa* is the uppermost zone of Maastrichtian.

In the biozonation adopted by Postuma (1971) the framework remains essentially that of Bolli (1966) except for the substitution of *G. elevata* zone in place of *G. stuarti* s.l. Zone of Bolli (1966).

The generalised zonal schemes of *G. stuartiformis* range as suggested by Bolli (1966), Bandy (1967) and Van Hinte (1969a) are indicated in Table 1 alongwith the suggested correlation of the two zones of Therria. Detailed discussion of the correlation between these two local zones and global zonation is discussed under the description of Zones in the subsequent paragraphs.

DESCRIPTION OF CRETACEOUS ZONES

Dorothia oxcona Zone

Nomenclature : Named after the commonly occurring species.

Description : Type section in Um Sohryngkew River; lower and upper boundaries marked by the first appearances of the marker species and *Globotruncana stuartiformis* Dalbiez respectively; lower boundary marks an ecological change between nonmarine and estuarine sediments and the upper boundary a change from estuarine to holomarine. The zone occurs between sample Nos. W-73 and W-2 (both inclusive); in type section thickness of the zone 28m; a moderately diverse suite of agglutinated benthonics occurs. These include :

Haplophragmoides glabra Cushman and Waters
Spiroplectammina semicomplanata (Carsey)
Dorothia oxycona (Reuss)
Gaudryina bronni (Reuss)
G. rugosa d' Orbigny

None of the above species, except *Dorothia oxycona* survive this zone.

Correlation : On the evidence of the stratigraphic position this zone is tentatively correlated with *Globotruncana lapparenti linneiana*—*G. gansseri* Zones of Bolli (1966) since

the overlying zone is homotaxial with *G. mayaroensis* and a part of *G. gansseri* Zone of Bolli (1966). *G. lapparenti linneiana* is the lower zone of Maastrichtian hence *D. oxycona* Zone is placed in the Early Maastrichtian.

Globotruncana stuartiformis Zone

Nomenclature : Named after the commonly occurring species.

Description : Type section in Um Schryngkew River ; marked by the observed range of *G. stuartiformis* ; conformably underlain and overlain by *Dorothia oxycona* and *Turborotalia sabina* Zones respectively ; the lower limit an ecological boundary between euryhaline and stenohaline waters; zone confined between sample Nos. W-3 and W-7, (both inclusive); maximum thickness considered to be 12 m ; characterised by a rich suite of planktonic and smaller benthonic foraminifera which includes following species :

Planktonic

Guembelitria cretacea Cushman
Guembelitriella postcretacea Pandey sp. nov
Heterohelix naverroensis Loeblich
H. glabrans Cushman, *H. globulosa* Ehrenberg
H. precarseyae Pandey, n. sp.
H striata Ehrenberg, *H. plummerae* Loetterle
H. elegans Rzehak
Gublerina cuvillieri Kikoine, *G. acuta* De Klasz
Pseudoguembeline excolata (Cushman)
P. punctulata Cushman, *P. palpebra* Bronnimann & Brown
Planoglobulina fruncticosa (Egger)
Planoglobulina acervulinoides (Egger)
Planomalina buxtorfi (Gandolfi)
Globigerinelloides asperus (Ehrenberg)
G. massinae (Bronnimann), *G. subcarinata* (Bronnimann)
Schackoina sp. cf. *S. moliniensis* Reichel
Hedbergella monmouthensis (Olsson)
Globotruncanella havanensis (Voorvijk)
Globotrancanella sp.
G. subbetaloidea (Gandolfi)
G. circumnodifer (Finlay), *G. coarctata* (Bolli)
Globotruncana rosetta (Carsey)
G. stuarti (De Lapparent)
G. stuartiformis, *G. elevata* (Brotzen)
Rugoglobigerina macrocephale Bronnimann
R. ornata Bronnimann, *R. rugosa* (Plummer)
R. scotti Bronnimann, *R. pilula* Belford
R. rotundata Bronnimann

Benthonic

Bathysiphon alexanderi Cushman, *Reophax texana* Cushman
Haplophragmoides kirki Wickenden, *Ammobaculites expansus* Plummer
Navarella joaquini Ciry and Rat
Spriroplectammina lalickeri Albritton & Phleger
Tritaxia trilatera Cushman, *Dorothia oxycona* (Reuss)
D. hokkaidoana Takayanagi, *Nodosaria affinis* Reuss
Dentalina megalopolitiana Reuss, *D. basiplanata* Cushman
Frondicularia cf. *F. archiaciana* D'orbigny
Lagena acuticostata Reuss, *L. hipida* Reuss
Lenticulina jonesi Sandidge, *L. rumoiensis* Takayanagi
L. matsumotoi Takayanagi, *Marginulina texasensis* Cushman
M. bullata Reuss, *Marginulopsis decorata* (Reuss)
Pseudonodosaria manifesta (Reuss)
Saracenaria triangularis D'Orbigny, *Brizalina incrassata* (Reuss)
B. cretosa (Cushman), *Brizalina* sp., *Bulimina kikkapooehsis* Cole
Nodosarella jarvisi (Cushman), *Coryphostoma plaita* (Carsey)
C. clavata (Cushman)
Anomalinoides cubana (Cushman & Bermudez)
Gyroidina girardana (Reuss)
Heterolepa alleni (Brotzen)

All the planktonic species of the zone are restricted to it. In addition the following benthonics do not survive this zone :

Haplophragmoids kirki, *Navarella joaquini*
Brizalina incrassata, *B. cretosa*
Coryphostoma plaita, *C. clavata*, *Dorothia oxycona*
Tritaxia trilatera

The appearance of *Guembelitria cretacea* in the upper part of this zone suggests that the zone may be suitably classified into a lower and an upper subzone. These are being named as *Globotruncana rosetta* and *G. cretacea* Subzones respectively. The former being a partial range zone and the latter a true range zone. Among planktonic foraminifera *Planomalina buxtorfi* is restricted to the *G. rosetta* Subzone and *Guembelitriella postcretacea*, *Rugoglobigerina rotundata* and *R. scotti* are restricted to the *G. cretacea Subzone*. No significant faunal change is observed between the two subzones.

Correlation : Occurrence of *Globotruncana stuarti* through out the zone, a sepecies commonly restricted to the *G. gansseri* and *G. mayaroensis* zones of Bolli (1966), suggests that the *G. stuartiformis* Zone is not older than *G. gansseri* Zone of Bolli. *G. mayaroensis* Bolli is absent in Meghalaya, Occurrence of *R. scotti* and *R. rotundata*, however, is sufficient evidence to suggest that upper part of *G. stuartiformis* may be correlated with *Globotruncana mayaroensis* Zone. As evidenced by the planktonic fauna, this zone covers *G. mayaroensis* as also a part of *G. gansseri* Zone.

TAXONOMY

As noted earlier, the present paper covers only the species which are restricted to Cretaceous and the forms common to Cretaceous and Paleocene are included in another paper (Pandey, 1978). The taxonomic arrange-

ment of Genera and supergeneric taxa in the following pages follows (Loeblich and Tappan, 1964) with slight deviations in some cases. Thus Genus *Heterohelix* Ehrenberg includes all the biserial types with simple terminal aperture irrespective of chamber shape and ornamentation. The polyserial forms of subfamily Heterohelicinae are referred to *Planoglobulina* Cushman when devoid of a nonseptate cavity, and *Gublerina* Kikoine when this cavity is present.

In family Globotruncanidae, *Globotruncanella* Reiss, considered synonymous with *Globotruncana* by Loeblich and Tappan (1964), has been retained.

ILLUSTRATIONS

Figures of the planktonic and benthonic foraminifera, in plates 1 to 6 were made by the author from the photographs of specimens. Outlines were traced from photographs on a drawing paper and subsequently the drawings were shaded. Magnifications have been calculated to the nearest multiple of 5 and could vary by ± 2 when it is more than 35X.

DEPOSITORY

Figured and enlisted specimens of foraminifera in the present work are deposited in the Palaeontology Laboratory, Oil & Natural Gas Commission, Baroda.

SYSTEMATIC DESCRIPTION

Family Lituolidae De Blainville, 1825
Subfamily Haplophragmoidinae Myang, 1952
Genus *Haplophragmoides* Cushman, 1910

Haplophragmoides glabra Cushman and Waters
(Pl. I—1-2)

Haplophragmoides glabra Cushman and Waters, 1921, p. 83.

Figured Specimen : Figured specimen BF 429 is from sample W-72.

Remarks : The diameter of the forms varies from 0.28 mm to 0.50 mm. Forms are 0.1 to 0.2 mm thick.

Occurrence : *H. glabra* is frequent to common in *Dorothia oxycona* Zone of Um Sohryngkew River section.

Haplophragmoides kirki Wickenden
(Pl. I—3-4)

Haplophragmoides kirki Wickenden, 1932, p. 85.

Figured specimen : Figured specimen BF 430 is from sample W-6.

Remarks : Diameter and thickness of the figured specimen are 0.45 mm and 0.28 mm respectively.

Occurrence : *H. kirki* occurs rarely in the *G. stuartiformis* Zone of Um Sohryngkew River section.

Genus *Cribrostomoides* Cushman, 1910

Cribrostomoides trinitatensis Cushman and Jarvis
(Pl. I—5-6)

Cribrostomoides trinitatnsis Cushman and Jarvis, 1928, p. 91.

Figured Specimen : Figured specimen BF 431 is from sample W-7.

Remarks : Largest diameter of the forms from the Mahadeo Formation is 0.54 mm and thickness 0.48 mm.

Occurrence : *C. trinitatensis* is rather rare in Um Sohryngkew River and occurs in the upper part of *G. stuartiformis* Zone.

Subfamily Lituolinae De Blainville, 1825
Genus *Navarella* Ciry and Rat, 1951

Navarella joaquini Ciry and Rat
(Pl. I—7-9)

Navarella joaquini Ciry and Rat, 1951, p. 76 (fide Ellis and Messina, 1940 et. seq.)

Figured specimen : Figured specimen BF 432 is from sample W-4.

Remarks : Specimens referred to *N. Joaquini* are upto 4.0 mm long, 2.2 mm broad and 1.1 mm thick.

Occurrence : The species is restricted to the Maastrichtian of the Um Sohryngkew River. Profuse occurrence of the species is seen in a thin band within *G. stuartiformis* Zone of the Mahadeo Formation wherefrom sample W-4 has been collected.

Genus *Triplasia* Reuss, 1854

Triplasia cushmani (Alexander and Smith)
(Pl. I—20-21)

Frankeina cushmani Alexander and Smith, 1932, p. 309.

Figured Specimen : Figured specimen BF 433 is from sample W-26.

Remarks : The *Triplasia* population in Um Sohryngkew River section compares well with *T. cushmani* (Alexander and Smith) both in appearance and size. *T. cushmani* seems to be closely related to *Triplasia taylorensis*, originally described as *Frankeina taylorensis* by Cushman and Waters (1929). It is hardly distinguishable from the latter but for its smaller size. The studied forms of *T. cushmani* are up to 0.75 mm. in length and 0.38 mm. in thickness.

Occurrence : In Um Sohryngkew River section, *T. cushmani* is impersistently recorded in large numbers from *T. pseudobulloides* s. l. and *G. pusilla* Zones of Mahadeo and Langpar Formations. The Meghalayan occurrence is younger than the American occurrence of the species which is typically Cretaceous (Cushman, 1946).

Family Textulariidae Ehrenberg, 1838
Subfamily Spiroplectamininae Cushman, 1927
Genus *Spiroplectammina* Cushman, 1927

Spiroplectammina semicomplanata (CARSEY)

(Pl. I—16-17)

Textularia semicomplanata Carsey, 1926, p. 25.

Figured Specimen : Figurred specimen BF 434 is from sample W-67.

Remarks : Specimens are up to 0.81 mm long, 0.55 mm broad and 0.28 mm thick.

Occurrence : *S. semicomplanata* is commonly recorded in the lower part of the Mahadeo Formation and extend from base of the formation till the base of *G. stuartiformis* Zone.

Family Ataxophragmiidae SCHWAGER, 1877
Subfamily Verneuilinae CUSHMAN, 1911
Genus *Gaudryina* D'ORBIGNY, 1839

Gaudryina bronni (REUSS)

(Pl. I—10-11)

Verneuilina bronni Reuss, 1845, p. 38 (fide Ellis and Messina, 1940 *et. seq*)

Figured specimen : Figured specimen BF 435 is from sample W-67.

Remarks : Length, breadth and thickness of the forms from the Mahadeo Formation are 0.54 mm-1.00 mm, 0.30 mm-0.80 mm and 0.45 mm-0.55 mm respectively.

Occurrence : In Um Sohryngkew River *G. bronni* occurs commonly in the *Dorothia oxycona* Zone.

Genus *Tritaxia* REUSS, 1860

Tritaxia trilatera (CUSHMAN)

(Pl. I—14-15)

Clavulina trilatera Cushman, 1926, p. 588.

Figured specimen : Figured specimen BF 436 belongs to sample W-7.

Remarks : Length and breadth of the specimens are up to 1.60 mm and 0.62 mm respectivley.

Occurrence : *T. trilatera* is common in the *G. stuartiformis* Zone of the Mahadeo Formation.

Dorothia oxycona (REUSS)

(Pl. I—18-19)

Gaudryina oxycona Reuss, 1860, p. 229 (fide Ellis and Messina, 1940 *et seq.*)

Figured specimen : Figured specimen BF 437 is from sample W-7.

Remarks : Meghalayan forms are up to 0.85 mm long 0. 50 mm diameter.

Occurrence : In Um Sohryngkew River *D. oxycona* is common in the marine Cretaceous sequence ; its frequency varies from common to rare in different samples

Genus *Eggerella* CUSHMAN, 1923

Eggerella sp.

(Pl. I—12-13)

Figured specimen : Figured specimen BF 438 is from sample W-7.

Remarks : A rarely occurring form of *Eggerella* in the Mahadeo Formation is characterised by medium size, indistinct early spire, penultimate whorl with four chambers and three appressed globular chambers with slightly depressed sutures in the last whorl. Wall is rather rough and non-calcareous. Comparison of this form with species of *Eggella* is difficult due to paucity of well preserved material.

Forms referable to this species are up to 0.72 mm long and 0.48 mm broad.

Occurrence : The species occurs rarely in the upper part of *G. stuartiformis* Zone of Um Sohryngkew River section.

Family Nodosariidae EHRENBERG, 1838
Subfamily Nodosariinae EHRENBERG, 1838
Genus *Pseudonodosaria* BOOMGART 1949

Pseudonodosaria manifesta (REUSS)

(Pl. II—1-2)

Glandulina manifesta Reuss, 1851, p. 22 (Fide Ellis and Messina 1940, et seq.)

Figured specimen : Figured specimen BF 439 is from sample W-7.

Remarks : Specimens from the Mahadeo Formation are 0.45 mm-0.55 mm long and 0.15-0.23 mm thick.

Occurrence : This species occurs in the upper part of *G. stuartiformis* Zone where it is recorded infrequently.

Family Bolivinidae CUSHMAN, 1927
Genus *Brizalina* COSTA, 1856

Brizalina cretosa (CUSHMAN)

(Pl. II—3-4)

Bolivina cretosa Cushman, 1936, p. 49.

Figured specimen Figured specimen BF 440 is from sample W-7.

Remarks : Form figured as *B. incrassata* Reuss, by Rasheed and Govindan (1968), from Vridhachalam Cretaceous of Coromandel Coast is more compressed than *B. incrassata* and may possibly be referred to this species.

Forms from the Mahadeo Formation are up to 0.45 mm long, 0.20 mm broad and 0.10 mm thick.

Occurrence : *B. cretosa* is typically associated with the Campanian-Maastrichtian lithotopes of Coromandel Coast (Rasheed and Govindan, 1968) and occurs commonly in the *G. stuartiformis* Zone of the Mahadeo Formation.

Brizalina incrassata (REUSS)

(Pl. II—5)

Bolivina incrassata Reuss, 1851, p. (fide Ellis and Messina, 1940 *et seq.*)

Figured specimen : Figured specimen BF 441 belongs to sample W-7.

Remarks : Length, breadth and thickness of the specimens are up to 0.45 mm, 0.25 mm and 0.13 mm respectively.

Occurrence : The species is restricted to Cretaceous section of Meghalaya and reported from the Mahadeo Formation by Nagapà (1959). *B. incrassata* is of common occurrence in *G. stuartiformis* Zone of Um Sohryngkew River section.

Family Heterohelicidae CUSHMAN, 1927

Subfamily Guembelitriinae MONTANARO GALLITELLI, 1957

Genus *Guembelitria* CUSHMAN, 1933

Guembelitria cretacea CUSHMAN

(Plate II—7)

Guembelitria cretacea Cushman, 1933, p. 37.

Figured specimen : Figured specimen BF 442 is from sample W-7.

Remarks : Forms from the Mahadeo Formation are 0.16 mm-0.22 mm long and 0.12 mm-0.17 mm thick. Variation in the height to the thickness ratio of the spire is from 1 : 1 to 2 : 1. There is little morphologic distinction between *G. cretacea* and *G. harrisi* Tappan (1940) but these two forms appear to constitute chronologically distinct populations.

Occurrence : In Meghalaya, *G. cretacea* occurs in the upper part of *G. stuartiformis* Zone, corresponding to *Globotruncana mayaroensis* Zone of Bolli (1966).

Genus *Guembelitriella* TAPPAN, 1940

Guembelitriella postcretacea PANDEY, sp. nov.

(Pl. II—8-14)

Figured specimen : Figured specimen (holotype) BF 443 and figured paratype BF 444 are from sample W-7.

Description : Test small, early stage triserial in many forms, in others triseriation obliterated. Early part of the test constituted by closely appressed globular chambers arranged in three or four series ; later part of the test made up of an irregular cluster of chambers which grow in the distal part of the test ; some of these chambers attach themselves to one of the sides of triserial test and spread till the proximal part of the initial test. The test has either a racemose appearance spreading gradually base upwards or an appearance of a two-layered cluster of globular chambers—the first layer of triserial stage and second layer of proliferation stage (Cf. plate II—8-10 and 11-14 respectively). Forms in which triseriation is completely obliterated, test is an irregular cluster of globular chambers. Surface of chambers is smooth and sutures are distinct and deep. Primary aperture in the triserial stage is a narrow opening at the inner margin of the last formed chamber ; small sutural apertures, mostly at trijunction of chambers, are also seen. A few of these secondary apertures are covered by a very small bulla-like plates. The holotype is 0.21 mm long, 0.15 mm broad and 0.15 mm thick.

Remarks : The recorded species is referred to genus *Guembelitriella* Tappan which is so far known to be represented only by a single species *G. graysonensis* Tappan (1940) of Early-Middle Cretaceous. This is second occurrence of the genus. *G. postcretacea* is transitional and derived from *G. cretacea* is unrelated to *G. graysonensis* which is derived from *Guembelitria harrisi* Tappan. Trivial nomenclature has been chosen to denote the intimate relationship between *Guembelitriella postcretacea* and *Guembelitria cretacea*. The two species occur together and also show some cases of intergradation.

Length, breadth and thickness of the observed population are up to 0.25 mm, 0.20 mm and 0.15 mm respectively.

Occurrence : This species is restricted to and occurs abundantly in upper part of *G. stuartiformis* Zone.

Subfamily Heterohelicinae CUSHMAN, 1927

Genus *Heterohelix* EHRENBERG, 1844

Remarks : *Heterohelix* of current usage is either completely biserial or possesses a small spire (Montanaro Gallitelli, 1957 ; Brown, 1969 ; Stenetad, 1969). El-Naggar (1971 a) regards *Pseudotextularia* Rzehak, *Planoglobulina* Cushman and *Racemiguembelina* Montanaro Gallitelli as junior synonyms of this genus.

Pseudotextularia as redefined by Montanaro Gallitelli (1957) and adopted by Loeblich and Tappan (1964) is biserial throughout. Others like Berggren (1962), Bandy (1967), Brown (1969) include in this genus biserial populations like *Pseudotextularia elegans* (Rzehak) and polyserial types like '*Guembelina fructicosa*' Egger. The latter species is the genotype of *Racemiguembelina* but regarded as a species of genus *Pseudotextularia* (Nagappa, 1959 ; Berggren, 1962), subspecies of *P. elegans* (Bandy, 1967) and as a variant of *P. elegans* (Nagappa, 1959 ; Brown, 1969). Scanning electron microscope studies by Pessagno and Brown (1969) suggest distinctive and specialised wall structure in '*G. fructicosa*' as compared to the biserial population of *Pseudotextularia deformis* (Kikoine) illustrated by Pessagno (1969b). *P. deformis* has been considered as a junior synonym of *P. elegana* by Montanaro Gallitelli (1957, p. 139). Accordingly, *P. elegans* and related biserial forms could not be included in the group of polyserial forms like '*G. fructicosa*'.

P. elegans and related species closely resemble a typical *Heterohelix*, e.g., *H. globulosa* or *H. striata*, except in chamber geometry. In a typical *Heterohelix*, chambers are generally inflated and globular to reniform (Montanaro Gallitelli, 1957, p. 137). In *Pseudotextularia* (*sensu*

Montanaro Gallitelli, 1957) later chambers are strongly compressed laterally and broad initial aperture becomes linear in 'most appressed form'. This development is opposite of 'lateral flattening' seen in *Heterohelix glabrans* (Cushman) in which chambers flatten rapidly and aperture is reduced to a narrow slit extending upface.

Neither *H. glabrana* nor *P. elegans* could be accommodated within *Heterohelix* if the chamber geometry, in place of apertural characteristics are considered for generic classification. However, emphasis on chamber shape seems to carry the splitting of otherwise homogeneous group too far. Accordingly, both the trends—'compression' and 'flattening' of later chambers—could be placed as specific variations within a genus. Thus, El-Naggar (1971 a) appears to be well justified in considering *Pseudotextularia* a junior synonym of *Heterohelix*.

Polyseriation and multiple apertures are distinctive generic characters shown neither by *Heterohelix navarroensis* Loeblich, the genotype of *Heterohelix*, nor by any of its related species. *Racemiguembelina*, *Planoglobulina* and *Ventilabrella* Cushman, all characterised by proliferation of chambers in the later part of the test, are not considered as junior synonyms of *Heterohelix* by this writer, contrary to the opinion of El-Naggar (1971 a).

Heterohelix elegans (RZEHAK)

(Pl. III—9-10)

Cuneolina elegans Rzehak, 1891, p. 4 (fide Ellis and Messina, 1940 *et seq.*)

Figured specimen : Figured specimen BF 445 is from sample W-7.

Remarks : Cushman (1946) figured three forms of *Heterohelix elegans* plexus with moderate to strong striae and referred them to *H. plummerae*. In these forms the costae are much stronger than *H. plummerae* of original description (Loetterle, 1937). Montanaro Gallitelli (1957) referred one of these forms to *H. elegans* (=*Pseudotextularia elegans*). Similar material has also been figured by Nagappa (1959) as *H. plummerae* (=*P. plummerae*). Brown (1969) designated a new species—*Heterohelix cushmani* (Brown), originally described as *Pseudotextularia cushmani* Brown—based on the figures of Cushman (1946). His distinction of this species is based on intermediate striations in this species as compared to finely striated *H. plummerae* and coarsely striated *H. elegans*. In all other characters, this species is similar to *H. elegans* Although the striae of *H. cushmani*, as figured by Cushman (1946) may be termed as moderately strong, Gallitelli's (1957) drawing of one of these same forms shows coarse striation. The writer is, therefore, not inclined to separate *H. elegans* from *H. cushmani* and hence *H. cushmani* is treated here as a junior synonym of *H. elegans*. Forms figured as *Pseudotextularia plummerae* (Loetterle) by Nagappa (1959) are typical population of *H. elegans* from the Mahadeo Formation of Meghalaya and are included here.

The length, breadth and thickness of the studied specimens are up to 0.40 mm, 0.30 mm and 0.35 mm respectively.

Occurrence : This species was reported from the Mahadeo Formation of Um Sohryngkew River by Nagappa (1959) as *Pseudotextularia plummerae*. *H. elegans* is confined to *G. stuartiformis* Zone of Um Sohryngkew River and is of common occurrence.

Heterohelix glabrans (CUSHMAN)

(Pl. IV—5-6)

Guembelina glabrans Cushman 1938, p. 15.

Figured specimen : Figured specimen BF 446 is from sample W-7.

Remarks : Specimens from Um Sohryngkew River are up to 0.32 mm long, 0.25 mm broad and 0.10 mm thick.

Occurrence : In Um Sohryngkew River *H. glabrans* is restricted to upper part of *G. stuartiformis* Zone. It is associated with the *Globotruncana mayaroensis* assemblage of Coromandel Coast (Govindan, 1972).

Heterohelix globulosa (EHRENBERG)

(Pl. II—17-18)

Textularia globulosa Ehrenberg 1840, p. 135.
(fide Ellis and Messina, 1940 *et seq.*)
Not *Guembelina globulosa* (Ehrenberg) : Nagappa, 1959, p. 7, figs. 11-12 (no description).

Figured specimen : Figured specimen BF 447 is from sample W-7.

Remarks : Nagappa (1959) has figured two forms of '*Guembelina globulosa*' from the Langpar Formation of the Khasi Hills. These are very similar to *Chiloguembelina morsei* (Kline) occurring abundantly in the Langpar. Nagappa's forms, being from the Paleocene Langpar Formation, are not *H. globulosa* and should be referred to *C. morsei*.

Forms from Um Sohryngkew River are up to 0.28 mm long, 0.21 mm broad and 0.15 mm thick.

Occurrence: *H. globulosa* is a common Cretaceous species in the Indian subcontinent. Govindan (1972) has reported the species from Campanian-Maastrichtian strata of Coromandel Coast and Pandey and Rao (1976) figured it from the Campanian-Maastrichtian sediments of Andaman Islands. It is of common occurrence in the *G. stuartiformis* Zone of the Um Sohryngkew River Section.

Heterohelix navarroensis LOEBLICH

(Pl. II—15-16 ; Pl. IV—1-2)

Spiroplecta americana Ehrenberg, 1844, p. 75 (fide Ellis and Messina, 1940 *et. seq.*)
Heterohelix navarroensis Loeblich, 1951, p. 107.
Heterohelix americana (Ehrenberg) : Masters, 1977, p. 338.

Figured specimen : Figured specimens BF 448 and BF 449 are from sample W-7.

Remarks : This species, documented originally from the Late Cretaceous Chalk of North-eastern Mississippi has been considered under two names—*Heterohelix americana* (Ehrenberg) and *Heterohelix navarroensis* Loeblich. Loeblich and Tappan (1964, p. 654) considered *H. navarroensis* a junior synonym, Brown (1969) remarks "but because *H.* (*Spiroplecta*) *americana* (Ehrenberg, 1844) is a junior secondary homonym of *H.* (*Textillaria*) *americana* (Ehrenberg, 1843) the existing available name *H. navarroensis* may be retained as the correct name for the species". Masters (1977), however, considers a non-reporting or non discussion about *Textillaria americana* Ehrenberg, a senior homonym of *H.* (*Spiroplecta*) *americana* (Ehrenberg) during the last fifty years, as a weighty argument to recognize it as a *nomen oblitum*. Hence, *H. americana* is a valid senior synonym of *H. navarroensis*. However, once the anomaly is discovered, the concept of *nomen oblitum* becomes slender and, accordingly, in the present work *H. navarroensis* is being retained. The species is remarkably similar to *Heterohelix globulosa* (Ehrenberg). Distinguishing features of this species include slightly compressed chambers, smaller rate of flaring in the test and inclined intercameral sutures as compared to more globular chambers, rapidly flaring test and horizontal sutures in *H. globulosa*. Vertical striae are more prominent in this species as compared to *H. globulosa*.

The studied forms are up to 0.28 mm long, 0.18 mm broad and 0.18 mm thick.

Occurrence : In Um Sohryngkew valley *H. navarroensis* occurs sporadically in *G. stuartiformis* Zone.

Heterohelix plummerae (LOTTERLE)

(Pl. II—19-22)

Guembelina plummerae Loetterle, 1937, p. 33.

Not *Guembelina plummerae* Loetterle : Nagappa, 1959 p. 7, figs. 5-6, (no description).

Figured specimens : Figured specimen BF 450 and BF 451 are from sample W-7.

Remarks : Considering the original description and figures of *Heterohelix plummerae* (Loetterle), three main points of distinction may be made out between *H. plummerae* and *H. elegans* : first, the test is very slightly to feebly ornamented by striae in *H. plummerae* in comparison to *H. elegans* ; second, chambers are more globular and test gradually flares upward in *H. plummerae* as compared to compressed and non-flaring test of *H. elegans* ; and, the third, although later chambers are broader in edge view as compared to the side view in most forms of *H. plummerae* they are distinctly inflated in contrast to much compressed final chambers of *H. elegans*. The species is robust and seems to be closely related to *Heterohelix robusta* Stenetad (1969).

The Meghalayan specimens are up to 0.35 mm long, 0.26 mm broad and 0.20 mm thick.

Occurrence : In Um Sohryngkew River section this species occurs sporadically in *G. stuartiformis* Zone.

Heterohelix pseudocarseyae PANDEY, sp. nov.

(Pl. III—6-8)

Ventilabrella carsevae Plummer, 1931, (part), p. 178, p. 9, figs. 7, 9 (not fig. 8)

Ventilabrella carseyae Plummer : Cushman, 1946, (Part), p. 112, pl. 48, figs. 1-3 (not figs. 4-5).

Planoglobulina acervulinoides (Egger) : Cushman, 1946, (part), p. 111, pl. 47, fig. 14 (not figs. 12-13 15).

Pseudotextularia carseyae (Plummer) : Brown, 1969, (part), p. 54, pl. 4, fig. 8, text-figs. 11-12 (not pl. 4, fig. 9).

Figured specimen : Figured specimen BF 452 is from sample W-7.

Description : Test small to medium sized, biserial throughout, constituted by about six pairs of subglobular chambers, increasing gradually in size as added, last chamber slightly smaller than penultimate and shifted towards the middle, distinct depressed sutures, surface ornamented with moderately strong vertical striae ; primary aperture a large, low to high arch at the base of the final chamber on its inner margin ; about 25% forms possess secondary aperture—a small arcuate opening at the outer margin of the final chamber. Both microspheric and megalospheric types occur within this population.

Remarks : Vertical striae in this species are similar to *Heterohelix striata* (Ehrenberg) and *H. elegans*. The species differs from *H. striata* owing to its stronger striae and deflection of the last chamber to the middle ; and, from *H. elegans* by its comparatively feeble ornamentation, absence of lateral compression in the late chambers and low arch-shaped aperture in contrast to much compressed chambers and slit-like aperture in *H. elegans*. Presence of an auxiliary aperture in the last chamber, at least in 25% forms, is also its distinctive character. Such an aperture is not seen in *H. elegans* and *H. striata*. Plummer (1931) included in the '*Ventilabrella carseyae*' both biserial and polyserial forms. But Cushman (1946, p. 112) remarked "large part of the specimens do not progress beyond *Guembelina* stage but in any large series a certain number of megalospheric forms show ventilabrelloid chambers". These megalospheric, polyserial planoglobuline forms, including the holotype of '*Ventilabrella carseyae*' Plummer (1931, pl. 9, fig. 8) and referred specimens of Cushman (1946, p. 48, figs. 4-5), appear to be the megalospheric generation of *Planoglobulina acervulinoides* (Egger) and may be referred to *P. acervulinoides*. Accordingly, '*Ventilabrella carseyae*' Plummer, as defined by its holotype, is treated as a junior synonym of *P. acervulinoides* (Egger) and biserial forms included by Plummer (1931), Cushman (1946) and Brown (1969)

under '*Ventilabrella carseyae*' or '*Pseudotextularia carseyae*' are regarded as an undesignated species. It is being named as *H. pseudocarseyae* with holotype of the species represented by plate 9, figure 7 of Plummer (1931). The trivial nomenclature *pseudocarseyae* is coined to denote the relationship of these biserial forms with the polyserial forms of *Planoglobulina carseyae* (Plummer) which is regarded as conspecific with *P. acervulinoides* (Egger) by this writer. A biserial form, figured by Cushman (1946, pl. 47, fig. 14) as *Planoglobulina acervulinoides* (Egger), however, is included in this species.

Forms referred to this species, from Um Sohryngkew River, are up to 0.37 mm long, 0.26 mm broad and 0.17 mm thick.

Occurrence : As suggested by Cushman (1946) this species is a typical Navarroan (Maastrichtian) heterohelicoid. Pessagno (1969a) has shown its occurrence in *G. gansseri—G. mayaroensis* Zones. Brown (1969) extended its lower limit in Campanian. In Um Sohryngkew River *H. pseudocarseyae* is common in the lower and rare in the upper part of *G. stuartiformis* Zone.

Heterohelix striata (EHRENBERG)

(Pl. IV—3-4)

Textularia striata Ehrenberg 1840, p. 135 (fide Ellis and Messina, 1940 *et seq.*)

Figured specimen : Figured specimen BF 453 is from sample W-3.

Remarks : In the Mahadeo material the surface ornamentation of striae is gradational between *H. globulosa* and *H. striata* supporting the observation of Berggren (1962) who contends that the two species appear to be end members of a gradational morphologic series.

The forms referred to *H. striata* are up to 0.31 mm long, 0.25 mm broad and 0.18 mm thick.

Occurrence : *H. striata* occurs commonly in the *G. stuartiformis* Zone of Um Sohryngkew River.

Genus *Planoglobulina* CUSHMAN, 1927

Remarks : Rzehak (1891) included in his *Cuneolina elegans*—the type species of his genus *Pseudotextularia* Rzehak (1896)—completely biserial as also such biserial forms which developed chamber proliferation in the distal part of the test. These polyserial forms were figured as *Pseudotextularia varians* by Rzehak (1895, p. 217, figs. 1-3). As discussed by Montanaro Gallitelli (1957) *P. varians* is an invalid synonym of '*Pseudotextularia elegans*' (Rzehak). The biserial population of '*P. elegans*' has been discussed under *Heterohelix* in the proceeding text.

Populations with initial biserial stage and later chamber proliferation were first validly named by Egger (1895, 1899). He designated (1895, p. 217) *Guembelina acervulinoides* Egger for the flabellate types lacking a conical appearance and suggested nomenclature *Guembelina fructicosa* Egger (1899, p. 35) for forms possessing initial biserial stage followed by chamber proliferation resulting into a conical shape. Three generic names were suggested to classify these proliferated heterohelicoids which are characterised by an ornamentation of vertical costae or striae and absence of a non-camerate apical cavity. These were : *Planoglobulina* Cushman (1927), *Ventilabrella* Cushman (1928) and *Racemiguembelina* Montanaro Gallitelli (1957). Montanaro Gallitelli (1957) has vividly clarified how *Planoglobulina* is a valid senior synonym of *Ventilabrella* in view of the Cushman's initial (1928) and later (1946) treatment of *Ventilabrella*. In *Racemiguembelina*, as per the original description (Montanaro Gallitelli, 1957, p. 142), the crown of the chamberlets produces a nearly circular outline in apertural view and the test is conical with typical "proportion of breadth to thickness 1 : 1". *Planoglobulina* is characterised by "a more or less abundant proliferation of globular chambers, which spread out in the plane of biseriality, giving a flabelliform shape to the test" (Montanaro Gallitelli, 1957, p. 141). In the material figured by her (1957, pl. 32, figs. 14a-15b) as '*Racemiguembelina fructicosa*' Egger minimum to maximum diameter ratio of the crown is 1 : 1 and 1 : 1.3. In the forms attributed to '*Pseudotextularia* (*Racemiguembelina*) *fructicosa*' (Egger) by Berggren (1962) this ratio is 1 : 1·6. In the latter case, test has a definite flabelliform appearance. Intermediate types between these populations occur in Meghalaya and are also figured by Govindan (1972). Similar gradation may also be inferred from figures of Cushman (1946, pl. 47). This gradation from nearly conical to thick flabelliform shape is gradual and demonstrates that circular crown of *Racemiguembelina* grades into flabelliform test of *Planoglobulina*. *Planoglobulina acervulinoides* (Egger) and *Racemiguembelina fructicosa* (Egger) have been considered as conspecific by Brown (1969). The two species, however, seem to be distinguishable not only by their general test morphology and chamber geometry but also by specialised wall structure in the latter (Pessagno and Brown, 1969). The generic separation between the two species appears to be carrying the 'taxonomic splitting' too far. *Planoglobulina* Cushman being the earliest generic name for '*acervulinoides-fructicosa*' group has been adopted by the author. As suggested by Brown (1969) and El-Naggar (1971a), who consider *Planoglobulina* as synonyms of *Pseudotextularia* and *Heterohelix* respectively, *Ventilabrella* Cushman is a valid genus. *Ventilabrella* has been appropriately recognised as a junior synonym of *Planoglobulina* by Montanaro Gallitelli (1957). The heterohelicoid genus *Gublerina* Kikoine, initially biserial but showing chamber proliferation in the later stage, is distinguished from *Planoglobulina* due to its wide non-camerate space between the two divergent series of chambers (Plate III—17) and absence of proliferation in the test excepting the apical area.

Planoglobulina acervulinoides (EGGER)

(Pl. III—11-12)

Guembelina acervulinoides Egger, 1899, p. 36, (fide Ellis and Messina, 1940 *et seq.*)

Figured specimen : Figured specimen BF 454 is from sample W-7.

Remarks : The thick flabelliform test is easily distinguished *P. acervulinoides* from conical forms of *Planoglobulina fructicosa* (Egger). Ratio between thickness and breadth in the observed material is more than 1 : 1.5 but less than 1 : 2. In the same range also falls the specimen referred by Berggren (1962, pl. 6, fig. 6) to '*P. fructicosa*'. Cushman (1946, pl. 47) figured a biserial and a quadriserial conical form under *P. acervulinoides*. The former is referred to *Heterohelix pseudocarseyae* and the latter to *P. fructicosa*. The matreial figured as *Platystaphyla brazoensis* (Martin) by Masters (1977, pl. 4, figs. 3-4) is probably a variant of *P. acervulinoides*.

Forms from Um Sohryngkew River are up to 0.51 mm long, 0.45 mm broad and 0.24 mm thick.

Occurrence : *P. acervulinoides* is of common occurrence in Um Sohryngkew River and occurs throughout *G. stuartiformis* Zone.

Planoglobulina fructicosa (EGGER)

(Pl. III—13-14)

Pseudotextularia varians Rzehak, 1895, p. 217, figs. 2-3 (not fig. 1) ; (fide Ellis and Messina, 1940 *et seq.*)
Guembelina fructicosa Egger, 1899, p. 35 ; (fide *edem.*)

Figured specimen : Figured specimen BF 455 is from sample W-3.

Remarks : Forms from the Mahadeo Formation are up to 0.35 mm long and 0.25 mm in diameter.

Occurrence : In Meghalaya the species has been reported by Nagappa (1959) earlier. It is of frequent occurrence in the *G. Stuartiformis* Zone.

Genus *Gublerina* KIKOINE, 1948

Gublerina acuta DE KLASZ

(Pl. III—18-19)

Gublerina acuta De Klasz, 1953, p. 246.

Figured specimen : Figured specimen BF 456 is from sample W-7.

Remarks : This species has been distinguished from *G. cuvillieri* Kikoine due to lack of chamber proliferation in the apical part of its test. It grades into referred *G. cuvillieri* in the Um Sohrygnkew assemblage.

Forms of this species are up to 0.41 mm long, 0.33 mm broad and 0.10 mm thick.

Occurrence : *Gublerina acuta* occurs in *G. stuartiformis* Zone of Um Sohryngkew River.

Gublerina cuvillieri KIKOINE

(Pl. III—15-17)

Gublerina cuvillieri Kikoine, 1948, p. 26.

Figured specimens : Figured specimens BF 457 and BF 458 are from sample W-7.

Remarks : Montanaro Gallitelli (1957), after studying the topotype material of this species and holotype and paratypes of '*Ventilabrella ornatissima*' Cushman and Church, concluded that *G. cuvillieri* is an invalid synonym of *G. ornatissima* (Cushman Church). Her view, accepted by Loeblich and Tappan (1964) and Bandy (1967) has not been incorporated by Brown (1969), Dupeuble (1969) and El-Naggar (1971a). This species is probably conspecific with *G. ornatissima* as already suggested by Montanaro Gallitelli (1957).

Specimens from Um Sohryngkew River are up to 0.48 mm long, 0.40 mm broad and 0.08 mm thick.

Occurrence : *G. cuvillieri* occurs commonly in the *G. stuartiformis* Zone of River Um Sohryngkew.

Genus *Pseudoguembelina* BRONNIMANN and BROWN, 1953

Pseudoguembelina costulata (CUSHMAN)

(Pl. III—4-5)

Guembelina costulata Cushman, 1938, p. 16

Figured specimen : Figured specimen BF 459 is from sample W-3.

Remarks : Length, breadth and thickness of the forms from Um Sohryngkew River are up to 0.30 mm, 0.16 mm and 0.08 mm respectively.

Occurrence : *P. costulata* occurs infrequently in *G. stuartiformis* Zone of Um Sohryngkew River section.

Pseudoguembelina punctulata (CUSHMAN)

(Pl. III—1-3)

Guembelina punctulata Cushman, 1938, p. 13.

Figured specimen : Figured specimen BF 460 is from sample W-3.

Remarks : *P. punctulata* is distinguished from *P. constulata* (Cushman) by its thicker test, globular chambers, nearly uniform breadth in greater part of the test and feeble ornamentation. *P. costulata* as figured by Govindan (1972), possesses globular chambers and feeble ornamentation. His form could better be placed in this species.

Forms from Um Sohryngkew River are up to 0.33 mm long, 0.23 mm broad and 0.15 mm thick.

Occurrence : *P. punctulata* is infrequent in the *G. stuartiformis* Zone of Um Sohryngkew River.

Family Planomalinidae BOLLI, LOEBLICH and TAPPAN, 1957

Genus *Planomalina* LOEBLICH and TAPPAN, 1946

Planomalina cf. *P. buxtorfi* (GANDOLFI)

(Pl. V—1-2)

Planulina buxtorfi Gandolfi, 1942, p. 103.

Figured specimen : Figured specimen BF 461 is from sample W-3.

Remarks : A solitary form of *Planomalina*, recorded from the upper Mahadeo, is characterised by planispiral, biumbilicate, slightly evolute test, slightly lobulate equatorial and keeled axial periphery, nine and half chambers in the last whorl, and, an equatorial aperture extending from one umbilicus to another with umbilical portions of successive apertures left as secondary apertures. This form is very similar to *Planomalina buxtorfi* (Gandolfi) to which it is tentatively compared. Rare occurrence of this species, commonly occurring in Albian to Cenomanian sediments of world (Bolli, Loeblich and Tappan, 1957 ; Bandy, 1967 ; Postuma, 1971 ; Barr, 1972), in the Meghalayan Maastrichtian is rather curious. It may either be a homeomorphic development simulating *P. buxtorfi*, or most probably, the last stratigraphic record of *P. buxtorfi* which became exceedingly rare after Cenomanian.

The form measures 0.31 mm in diameter and 0.11 in thickness.

Occurrence : *P. buxtorfi* has been commonly reported from Albian Cenomanian sediments from different parts of world including Pakistan in Indian subcontinent (Dorren, 1974). Solitary form of Um Sorhryngkew River section falls in the lower part of *G. sutartiformis* Zone.

Genus *Globigerinelloides* CUSHMAN and TEN DAM, 1948.

Globigerinelloides asperus (EHRENBERG)

(Pl. V—3-4)

Phanerostomum asperum Ehrenberg, 1854, pl. 30, fig. 26 ; pl. 32 figs. 24, 42 (fide Ellis and Messina, 1940 *et seq.*)

Figured specimen : Figured specimen BF 462 is from sample W-7.

Remarks : Variation in this species is best illustrated by Dain (1953). The species, with typically five to seven gradually increasing chambers, appears to be conspecific with '*Globigerina voluta*' White (1928). '*Globotruncana* (*Rugoglobigerina*) *bedlengi*' Gandolfi and '*G.* (*R*) *subbedlingi*' Gandolfi have been considered as junior synonyms of *Globigerinelloides messinae* (Bronnimann) by Berggren (1962). He, however, seems to include all planispiral planktonic forms *ex gr. G. asperus*, from the Scandinavian Maastrichtian, in his *G. messinae*. Bandy (1967, p. 12) has drawn attention towards four to four and half chambers in the last whorl of *G. messinae*. This concept, followed by the author, excludes *Globigerinelloides* populations with typically five to seven gradually increasing chambers of last whorl from *G. messinae*. *Globigerinelloides asperus* (Ehrenberg) is earliest name for these forms figured subsequently from the Late Cretaceous of different parts of world under different names (White, 1928 ; Gandolfi, 1955 ; Hofker, 1956). Five to seven chambered forms of *G. messinae*, as figured by Berggren (1962), and Govindan (1972), may also be included under *G. asperus*.

Aperture, in this species, as pointed out by Dain (1953) and Berggren (1962), shows variation in the range of perfect equatorial to bifid equatorial ; and the latter is sometimes followed by '*Biglobigerinella*' stage (Berggren, 1962). Although bifid equatorial aperture is common in *G. asperus* of Mahadeo Formation, '*Biglobigerinella*' stage is not encountered.

The diameter of the studied forms is up to 0.35 mm and thickness up to 0.16 mm.

Occurrence : In Meghalaya *G. asperus* is common in the upper part of *G. stuartiformis* Zone and rare in the lower part.

Globigerinelloides messinae (BRONNIMANN)

(Pl. V—7-8)

Globigerinella messinae messinae Bronnimann, 1952, p. 42.

Figured specimen : Figured specimen BF 463 is from sample W-7.

Remarks : As suggested by Bandy (1967), *G. mesinnae* is derived from *G. asperus* by reduction of chambers in the last whorl. Some of the Berggren's (1962) illustrations are referable to this species but greater part of Scandinavian material may be referred to *G. asperus*.

In the studied forms the diameter is up to 0.25 mm and thickness up to 0.15 mm.

Occurrence : In Um Sohryngkew River Section, *G. messinae* is restricted to the upper part of *G. stuartiformis* Zone.

Globigerinelloides subcarinaius (BRONNIMANN)

(Pl. V—5-6)

Globigerinella messinae subcarinata Bronnimann, 1952, p. 44.

Figured specimen : Figured specimen BF 465 is from sample W-5.

Remarks : The studied forms are up to 0.35 mm in diameter and up to 0.12 mm in thickness.

Occurrence : In Meghalaya, *G. subcarinatus* occurs sporadically in the *G. stuartiformis* Zone.

Family Rotaliporidae SIGAL, 1958

Subfamily Hedbergellinae LOEBLICH and TAPPAN, 1961

Genus *Hedbergella* BRONNIMANN and BROWN, 1958

Hedbergella monmouthensis (OLSSON)

(Pl. V—9-11)

Globorotalia monmouthensis Olsson, 1960, p. 47.
Hedbergella holmdelensis Olsson, 1964, p. 160.

Figured specimen : Figured specimen BF 464 is from sample W-7.

Remarks : Bandy (1967, p. 10) has suggested the occurrence of dimorphic population in *Hedbergella planispira* (Tappan). He observed in the study of American material that *Hedbergella holmdelensis* (Olsson) and *Hedbergella monmouthensis* (Olsson) "are difficult to separate from megalospheric forms of *H. planispira sensu stricto*" and "specimens of *H. planispira* from the Middle Cretaceous include forms amazingly similar" to the two species of Olsson. Barr (1972) has also pointed out towards similarity of *H. holmdelensis* and *H. planispira*, although he is not certain "whether these two species are closely related or homeomorphic". Bandy's arguments, however, suggest the conspecific nature of three populations : megalospheric generation of *H. planispira*, *H. holmdelensis* and *H. monmouthensis*. The last being the earliest name for this group has been adopted by the author.

The diameter and thickness of the studied forms are up to 0.35 mm and 0.14 mm respectively.

Occurrence : In Um Sohryngkew River Section, *H. monmouthensis* occurs commonly in the *G. stuartiformis* Zone.

Genus Globotruncanella REISS, 1957

Remarks : Reiss (1957) established genus *Globotruncanella* based on '*Globotruncana citae*' Bolli. This species, now regarded as synonymous with '*Globotruncana havanensis*' Voorwijk (Berggren, 1962 ; Loeblich and Tappan, 1964 ; Douglas, 1969b), is intimately related to '*Rugoglobigerina glaessneri*' Gandolfi and '*Globotruncana petaloidea*' Gandolfi. Although Loeblich and Tappan (1964) retained '*G. havanensis*' in *Globotruncana* and considered *Globotruncanella* a synonym of *Globotruncana*, the extraumbilical umbilical aperture in this species prompted others (Berggren, 1962 ; Bandy, 1967 ; Postuma, 1971) to refer it to *Praeglobotruncana* Bermudez (1952). The latter genus, however, lacks the weekly developed apertural flaps or tegilla which are seen in well preserved '*G. havanensis*'. In this aspect *G. havanensis* group seems parallel to *Globotruncana* and *Rugoglobigerina*. Genus *Globotruncanella* has been adopted by the author due to unsatisfactory assignation of '*G. havanensis*'—'*G. glaessneri*' group either in *Globotruncana* or in *Praeglobotruncana*.'

As adopted here, *Globotrunanella* lacks well-formed true keel except in terminal forms, umbilical aperture and prominent rugosities on surface—typical characters of *Globotruncana* and *Rugoglobigerina* and, possess feebly developed tegilla covering extraumbilica-umbilical aperture. Feebly developed tegilla, whenever broken away, give the forms of this genus a typical *Praeglobotruncana* appearance. Five species have been ascribed to *Globotruncanella* in the Um Sohryngkew assemblage. These have been grouped as under :

1. High trochospiral, pseudocarina prominent.	(*a*) Chambers little to moderately compressed and petaloid : *G. havanensis* (=*G. citae*= *G. petaloidea*). (*b*) Chambers much compressed and highly petaloid : *G. subpetaloidea*.
2. Low trochospiral, pseudocarina feeble or absent.	(*a*) Chambers compressed *G. coarctata*. (*b*) Chambers subglobular to slightly compressed ; *G. circumnodifer*.
3. High trochospiral, pseudocarina absent.	*Globotruncanella* sp.

Globotruncanella circumnodifer (FINLAY)

(Pl. IV—10-12)

Globigerina circumnodifer Finlay, 1940, p. 469.
(fide Ellis and Messina, 1940 *et seq.*)
Globotruncana (*Rugoglobigerina*) *glaessneri glaessneri* Gandolfi, 1955, p. 50.
Rugoglobigerina jersyensis Olsson 1960, p. 49.
Globotruncanella petaloidea (Gandolfi) : Govindan, 1972, p. 180, (not of Gandolfi).

Figured specimen : Figured specimen BF 468 is from sample W-7.

Remarks : This population is intimately related to and possibly derived from *Globotruncanella inornata* (Bolli), originally described as *Globotruncana inornata* by Bolli (1957), which is distinguished by its carinate appearance, curved dorsal sutures, less petaloid chambers and wide umbilicus. The holotype of '*G.* (*R.*) *glaessneri glaessneri*' Gandolfi (1955, pl. 3, fig. 11) is characterised by five chambers in the final whorl, spire lower than the dorsal profile of the last whorl, straight dorsal sutures, smooth test and 'umbilical aperture or apertures with fine lips?". In these characters it is distinct from spiroconvex '*G.* (*R.*) *glaessneri subglaessneri*' Gandolfi which has been considered by the author synonymous with *G. havanensis*. '*G.* (*R.*) *glaessneri glaessneri*' seems to be conspecific with *G. circumnodifer*. Four and half chambered form designated as *Rugoglobigerina jersyensis* by Olsson (1960) also seems to be synonymous with this species. *G. petaloidea* (Gandolfi), as figured by Govindan (1972), is a very low trochospiral form referable to this species. Population figured as *Rugoglobigerina glaesseneri* (Gandolfi) by El-Naggar (1971b, pl. 15, figs. 1, 4) from Egypt appears to be *R. arwae* El-Naggar and unrelated to *G. circumnodifer*.

The Meghalayan forms of the species are up to 0.42 mm in diameter and 0.16 mm in thickness.

Occurrence : In Um Sohryngkew River *G. circumnodifer* occurs sporadically in the *G. stuartiformis* Zone.

Globotruncanella coarctata (Bolli)

(Pl. IV—7-9)

Praeglobotruncana coarctata Bolli, 1957, p. 55.

Figured specimen : Figured specimen BF 469 is from sample W-7.

Remarks : As pointed out by Bolli (1957, p. 55), distinctive features of this species, from *G. havanensis*, are its low trochospiral test and five gradually increasing chambers in the last whorl as compared to generally high trochospiral test with rapidly increasing four chambers in the last whorl of *G. havanensis*.

The figured specimen is 0.30 mm in diameter and 0.13 mm in thickness.

Occurrence : *G. coarctata* has been described and figured by Bolli (1957) from the Campanian sequence of Trinidad corresponding to *G. stuarti* s. 1. Zone (Bolli, 1966). *G. coarctata* is of rare occurrence in the upper part of *G. stuartiformis* Zone. Apparently this is a somewhat younger occurrence of the species.

Globotruncanella havanensis (Voorwijk)

(Pl. V—12-17)

Globotruncanella havanensis Voorwijk, 1937, p. 195.
Globorotalia pschadeae Keller 1946, p. 99, (Fide Ellis and Messina, 1940 *et seq.*)
Globotruncana citae Bolli, 1951, p. 197
Globotruncana (Rugoglobigerina) petaloidea petaloidea Gandolfi, 1955, p. 52.

Figured specimen : Figured specimen BF 470 and BF 471 are from sample W-7.

Remarks : *Globotruncanella havanensis* (Voorwijk) as described originally by Voorwijk (1937, p. 195) is characterised by high trochospiral test and compressed chambers. In the generalised drawing of the holotype compression is not well seen and the form looks very similar to the original drawing of '*Globotruncana* (*Globotruncana*) *petaloidea petaoidea*' Gandolfii (1955, pl. 3, fig. 13). *Globotruncanella citae* (Bolli), figured by Gandolfi (1955) as *Globotruncana citae*, shows same degree of difference from '*G. petaloidea*' as from, '*G. havanensis*'. A good deal of variation is observed in the pseudocarinate high trochospiral *Globotruncanella* population of Mahadeo Formation which are characterised by four to five subglobular to much compressed, gradually increasing petaloid chambers. The forms at globular end are very similar to specimen figured as *Globotruncana* (*Rugoglobigerina*) *glaessneri subglaessneri* by Gandolfi (1955, pl. 3, fig. 9) and compressed forms compare well with the '*Globotruncana citae*' Bolli (1951, pl. 35, fig. 4). In light of the gradation observed in the Mahadeo material, this author is inclined to include in *Globotruncanella havanensis* all populations referred to '*G.* (*R.*) *glaessneri subglaessneri*' Gandolfi, '*G.* (*R.*) *petaloidea petaloidea* Gandolfi and '*C. citae*' Bolli in the original designation, and subsequently described by various workers from different parts of world. '*Globorotalia pschadae*' Keller of original designation and subsequent description (Subbotina, 1953) is also a junior synonym of this species.

The Meghalayan forms are up to 0.31 mm in diameter and 0.14 mm high.

Occurrence : In Meghalaya, *G. havanensis* occurs commonly in the *G. stuartiformis* Zone.

Globotruncanella subpetaloidea (Gandolfi)

(Pl. V—18-20)

Globotruncana (Rugoglobigerina) petaloidea subpetaloidea Gandolfi, 1955, p. 52.

Figured specimen : Figured specimen BF 472 is from sample W-7.

Remarks : Gandolfi (1955) pointed out towards two of the main features of this species—lobed periphery and drawnout chambers. He related these features to *Plumerita hantkeninoides* (Bronnimann). The form illustrated by him in text-figure 8 is low trochospire and much similar to *G. coarctata* except its extremely lobulate periphery and drawnout last two chambers. Its ancestral stock, therefore, seems to be a *Globotruncanella* and not *Plumerita hantkeninoides* as suggested by Gandolfi (1955). This species seems to have been derived, as suggested by Bandy (1967), from *Globotruncanella havanensis*.

Forms studied are up to 0.37 mm in diameter and 0.14 mm thick.

Occurrence : The species has been originally described from the Late Campanian—Early Maastrichtian sequence of Colon Shale of northeastern Colombia. *G. subpetaloidea* is restricted to upper part of *G. stuartiformis* Zone in Um Sohryngkew River.

Globotruncanella sp.

(Pl. IV—13-17)

Rugoglobigerina sp. cf. *R. rotundata* Bronnimann : Berggren, 1962, p. 80.
Rugoglobigerina (*Archeoglobigerina*) sp. El-Naggar, 1971, p. 480.

Figured specimen : Figured specimens BF 466 and BF 467 are from sample W-7.

Description : Test of small to medium size, high trochospiral ; equatorial periphery rounded, entire to slightly lobulate, axial periphery rounded ; all chambers visible on spiral side, numbering about twelve to fourteen, arranged in a high trochospire of about three whorls, four chambers in the last whorl ; spiral sutures distinct, slightly depressed, intercameral sutures gently curved outwards and backwards ; four semiglobular chambers seen on the

ventral side ; ventral sutures depressed, deep, slightly curved ; umbilicus rather wide, deep ; aperture umbilical-extra-umbilical bordered by a distinct lip and covered by feeble tegilla ; surface smooth in the Um Sohryngkew material except small areas of slight regosity. Dimensions of the studied material : Diameter up to 0.25 mm ; thickness up to 0.21 mm.

Remarks : *Globotruncanella* sp. looks somewhat similar to *Rugoglobigerina rotundata* Bronnimann due to its high trochospiral coiling. However, it is distinguished from *R. rotundata* by its smaller size, nearly smooth to feebly rugose test, extraumbilical extensions of umbilical aperture and weekly developed tagilla.

Berggren (1962) figured a small high trochospiral form, rarely occurring in the upper Maastrichtian of Scandinavia, as *Rugoglobigerina* cf. *rotundata* Bronnimann and considered it as a juvenile form of *R. rotundata*. It, however, differs from *R. rotundata* by its smaller size and "apparent lack of meridional ornament". Its surface rugosity, as may be made out from figures of Berggren (1962, pl. 13, fig. 2), is similar to but lesser than the Scandinavian specimens of *G. havanensis* figrued by Berggren (1962, pl. 7, fig. 1), suggesting its close relationship with genus *Globotruncanella*. A very similar high trochospiral form has also been figured by El-Naggar (1971b) as *Rugoglobigerina* (*Archeoglobigerina*) sp. from Egyptian Maastrichtian. The Meghalayan population is invariably smooth although some forms show slight rugosity in some parts of the test. In lack of sufficient material for further studies no new name is suggested here for this species.

Forms are up to 0.25 mm in diameter and 0.21 mm in thickness.

Occurrence : This widely distributed but uncommon species is restricted to Maastrichtian in Europe and North Africa, it seems (cf. Berggren, 1962 ; El-Naggar, 1971b). In Um Sohryngkew River Section it occurs sporadically in the upper part of *G. stuartiformis* Zone.

Family Globotruncanidae BROTZEN, 1942

Genus *Globotruncana* CUSHMAN, 1927

Remarks : *Globotruncana* is represented in the Cretaceous sequence of Um Sohryngkew River by unicarinate forms constituting *G. rosetta—G. stuarti* group. Dalbiez (1955, p. 63) stressed the need for a complete revision of this group in view of confusion in the diagnoses of species and their conflicting ranges. Inconsistency in the identification, range and morphological characters of these populations could not be solved even in two decades after Dalbiez's remarks. The causal factors, here, are : first "these species are closely related and often there are intermediate forms making a typological approach to identification difficult" (Barr, 1972, p. 24), and, second "there are factual and philosophical differences in species concept" (Van Hinte, 1969, p. 258). A unanimous agreement on these species is rather difficult and criteria laid down by one worker for one species of this group often overlap on the second species of the other worker. The following tentative basis has been adopted for classifying *G. rosetta—G. stuarti* group in Meghalaya.

1. Equatorial periphery lobate ; dorsal sutures curved ; chambers of last whorl petaloid.	(*a*) Ventral chambers much elevated around umbilicus, depressed towards the sutures and periphery ; keel mostly smooth ; *G. rosetta*.
	(*b*) Ventral chambers elevated around umbilicus, sloping gradually towards periphery, very little depressed at sutures ; keel beaded : *G. elevata*.
2. Equatorial periphery entire ; rounded or angular ; dorsal sutures of the last whorl straight; keel beaded.	(*a*) Chambers on the spiral side of last whorl triangular : *G. stuartiformis*.
	(*b*) Chambers on the spiral side of last whorl trapezoidal : *G. stuarti*.

Globotruncana elevata (BROTZEN)

(Pl. VI—4-6)

Rotalia elevata Brotzen, 1934, p. 66 (fide Ellis and Messina, 1940 *et seq.*)

Figured specimen : Figured specimen BF 473 is from sample W-7.

Remarks : In the synonymy of *Globotruncana elevata*, author has included unicarinate un-equally biconvex forms with a distinctly lobed periphery and five to seven chambers in the last whorl which show limbate intercameral sutures and petaloid chambers on the dorsal side. Their nearness to *G. stuarti* is obvious and Subbotina (1953), Berggren (1962) and Govindan (1972) preferred to include some of the morphotypes in *G. stuarti*. Cushman (1946) included some unicarinate globotruncanids, e.g., *G. rosetta* in his *Globotruncana arca* (Cushman). One of his figured specimens of *G. arca* from Anona Chalk (Campanian) of Gulf Coastal Region may be referred to this species. Dupueble (1969) has figured some forms of this species under *G. falsostuarti* Sigal. *G. falsostuarti* is characterised by double keels, fusing in the middle part of each chamber as pointed out by Postuma (1971), hence figured specimens of Dupueble could be referred to *G. elevata*.

Meghalayan specimens are up to 0.52 mm in diameter and 0.27 mm in thickness.

Occurrence : In Um Sohryngkew River it occurs commonly throughout *G. stuartiformis* Zone.

Globotruncana rosetta (CARSEY)

(Pl. V—21-23)

Globigerina rosetta Carsey, 1926, p. 44.

Figured specimen : Figured specimen BF 474 is from sample W-7.

Remarks : Transitional forms between *G. rosetta* and *G. gansseri* Bolli (1951) occur in Meghalaya but *G. gansseri* (*forma typica*) is absent. The specimen illustrated by Govindan (1972, pl. 5, figs. 20-22) as *G. gansseri* is transitional between *G. rosetta* and *G. gansseri ;* and, better retained in *G. rosetta*. *G. rosetta* (Carsey) of Rao, Mamgain and Sastry (1968) is a spiroconvex form with nearly flat ventral side and horse-shoe shaped ventral sutures. It could better be placed as *Globotruncana fornicata* Plummer (1931).

Forms of this species are up to 0.52 mm in diameter and 0.18 mm in thickness.

Occurrence : In Um Sohryngkew River *G. rosetta* occurs sporadically in the *G. stuartiformis* Zone.

Globotruncana stuarti (DE LAPPARENT)

(Pl. IV—17-20)

Rosalina stuarti De Lapparent, 1918, p. 11, (fide Ellis and Messina, 1940 *et seq.*)

Figured specimen : Figured specimen BF 475 is from sample W-7.

Remarks : Forms figured by Nagappa (1959) as *G. stuarti*, from the Mahadeo Formation, possess triangular chambers and are best referred to *G. stuartiformis*.

Specimens from Mahadeo Formation are up to 0.55 mm in diameter and 0.27 mm in thickness.

Occurrence : Nagappa (1959) has placed the occurrence of this species in the Meghalayan Cretaceous. However this species is reported from the basal part of Langpar Formation by Govindan (1972, p. 77). This report, appears erroneous since the species is restricted to *G. stuartiformis* Zone of Mahadeo Formation. The species occurs commonly throughout *G. stuartiformis* Zone.

Globotruncana stuartiformis (DALBIEZ)

(Pl. V—1-3)

Globotruncana (*Globotruncana*) *elevata stuartiformis* Dalbiez, 1955, p. 168.

Figured specimen : Figured specimen BF 476 is from sample W-7.

Remarks : Diameter of the recorded specimens is up to 0.54 mm and their thickness up to 0.25 mm.

Occurrence : In Meghalaya *G. stuartiformis* is of common occurrence in the upper member of the Mahadeo Formation. From here it was figured as *G. stuarti* by Nagappa (1969). Disappearance level of the species marks top of the Cretaceous in Um Sohryngkew River.

Genus Rugoglobigerina BRONNIMANN, 1952

Rugoglobigerina macrocephala BRONNIMANN

(Pl. IV—21-23)

Rugoglobigerina macrocephala macrocephala Bronnimann, 1952, p. 25.

Figured specimen : Figured specimen BF 477 is from sample W-7.

Remarks : Main distinction of this species from *R. ornata* is its consistent smaller size. Small forms of *R. rugosa* group, designated as *R. arwae* by El-Naggar (1971b), show good gradation with *R. macrocephala* and figured with it in many cases (cf. Berggren, 1962, pl. 12, fig. 5 ; El-Naggar, 1971b, pl. 14, figs. 2, 4 12-14 ; Govindan, 1972, pl. 3, figs. 19-21). The author prefers to restrict *R. macrocephala* for four to four and half chambered smaller *Rugoglobigerina* showing rapidly increasing chambers in last whorl. Others, exhibiting somewhat regular increase in the chambers of last whorl, like *R. rugosa*, and possibly the dimorphs of *R. rugosa* may be placed within *R. arwae* El-Naggar (1971b).

Forms from Um Sohryngkew River are up to 0.23 mm in diameter and 0.15 mm in thickness.

Occurrence : *R. macrocephala* is a characteristic Maastrichtian species (Bandy, 1967 ; Berggren, 1962 ; El-Naggar, 1971b). It occurs in *G. stuartiformis* Zone of Um Sohryngkew River.

Rugoglobigerina ornata BRONNIMANN

(Pl. VI—7-9)

Rugoglobigerina macrocephala ornata Bronnimann, 1952, 0. p. 27.

Figured specimen : Figured specimen BF 478 is from sample W-5.

Remarks : *R. ornata* was recognised as subspecific population by Bronnimann (1952), distinct species by Gandolfi (1955) and El-Naggar (1971), and, synonymous with *R. macrocephala* by Berggren (1962). Its consistent large size and strongly developed ornamentation distinguish it from typical *R. macrocephala* hence it has been recognised as a distinct species in the Mahadeo material. *R. macrocephala* and *R. ornata*, however, seem to be A and B forms, respectively, of a single dimorphic population.

Diameter of the studied forms up to 0.39 mm and thickness up to 0.27 mm.

Occurrence : *R. ornata* occurs frequently in the *G. stuartiformis* Zone of the Therria area.

Rugoglobigerina pilula BELFORD

(Pl. VI—10-12)

Rugoglobigerina pilula Belford, 1960, p. 92.

Figured specimen : Figured specimen BF 479 is from sample W-7.

Remarks : In its characters this species is close to *R. pennyi* Bronnimann, from which it is distinguished by

its smaller size, fewer chambers in the last whorl and smaller umbilicus.

R. pilula measure up to 0.30 mm in diameter and 0.12 mm in thickness.

Occurrence : The sporadic Meghalayan occurrence of *R. pilula* is from Late Maastrichtian *G. stuartiformis* Zone of Therria area.

Rugoglobigerina rotundata BRONNIMANN

(Pl. VI—16-18)

Rugoglobigerina rugosa rotundata Bronnimann, 1952, p. 34.

Figured specimen : Figured specimen BF 480 is from sample W-7.

Remarks : Although rare in occurrence, *R. rotundata* Bronnimann is a readily distinguished species in Um Sohryngkew assemblage because of its high spiroconvex test, moderate to large size, five chambers in the last whorl of which last is smaller than the penultimate one, and, a deep umbilicus. Some of the large high spired forms figured by Subbotina (1953) as *Rotundina ordinaria* may be referred to this species. Berggren (1962) has figured a small spiroconvex '*Rugoglobigerina*' rarely occurring in the White Chalk (upper Maastrichtian) of Denmark and considered it to be juvenile form of *R. rotundata*. It has been now referred to *Globotruncanella* sp. by the author. Dupueble (1969) has figured a high trochospiral *Rugoglobigerina* from upper Maastrichtian of Western Aquitaine and referred it to *R. rugosa*. This form is more appropriately placed as *R. rotundata*.

In the studied forms diameter is upto 0.38 mm and thickness up to 0.28 mm.

Occurrence : In Um Sohryngkew River Section *R. rotundata* occurs sporadically in the upper part of *G. stuartiformis* Zone.

Rugoglobigerina rugosa (PLUMMER)

(Pl. VI—13-15)

Globigerina rugosa Plummer, 1926, Texas Univ. Bull., no. 2644, p. 38, pl. 2, fig. 10.

Figured specimen : Figured specimen BF 481 is from sample W-5.

Remarks : In the *R. rugosa* from Um Sohryngkew River, dorsal side of the last-whorl is lightly convex due to inflation of chambers and extends above the spire. This character is displayed not only by the type figures of Plummer (1926) but also by the specimens figured by Bolli, Loeblich and Tappan (1957) and a number of illustrations provided by El-Naggar (1971b). Two forms illustrated by El-Naggar (*loc. cit.*, pl. 1, fig. 3 ; pl. 3, fig. 2) are quite small and could be referred to *R. arwae* El-Naggar. Berggren (1962) suggested that *R. ordinaria* (Subbotina), designated initially as *Rotundina ordinaria*, by Subbotina (1953), is partly a junior synonym of *R. rugosa*. This view has not been supported by Bandy (1967) who holds *R. ordinaria* to be a distinct species. Characteristic difference between *R. rugosa* (*forma typica*) and *R. ordinaria* lies in the height of the spire. In *R. rugosa* the spire is either in level with or lower than the dorsal side of the last-whorl. In *R. ordinaria*, excluding some of the very high trochospiral forms referable to *R. rotundata* Bronnimann, spire is invariably above the last-whorl. The same feature is shown by the Scandinavian population of "*R. rugosa*" figured by Berggren (1962) and doubtfully referred to *R. rugosa* by El-Naggar (1971b). The author recognizing *R. ordinaria* as distinct from *R. rugosa*, prefers to refer such forms to *R. ordinaria*.

Studied forms from Um Sohryngkew River are up to 0.37 mm in diameter and 0.22 mm in thickness.

Occurrence : The species occurs frequently in *Globotruncana stuartiformis* Zone of Um Sohryngkew River.

Rugoglobigerina scotti (BRONNIMANN)

(Pl. VI—19-21)

Trinitella scotti Bronnimann, 1952, p. 57.

Figured specimen : Figured specimen BF 482 is from sample W-7.

Remarks : The medium-sized low trochospiral Meghalayan form possessing flat dorsal side, slightly lobulate equatorial periphery, about fourteen chambers arranged in two and half whorls, five to five and half gradually increasing chambers in last whorl, and with a pseudocarina in last few chambers are included here. El-Naggar (1971b) has figured a good number of *Rugoglobigerina* characterised by flat dorsal side, five and a half to six chambers in the last-whorl and angular periphery in the last one or two chambers. These have been named by him as *Rugoglobigerina bronnimanni*. Some of these (e.g. pl. 12, fig. 2) are very similar to the American forms of *R. scotti* figured by Bolli, Loeblich and Tappan (1957) from the Navarro Formation and Tunisian specimen illustrated by Postuma (1971). El-Naggar (1971b) observed that *R. bronnimanni* shows a certain degree of similarity to *R. scotti*, although it is much larger in size and lacks the compressed and keeled later chambers. Bolli, Loeblich and Tappan (1957) noted the absence of keel in the latter species. Accordingly *R. bronnimanni* is treated as a junior synonym of *R. scotti*.

Original designation of genus *Trinitella* Bronnimann (1952) with *T. scotti* as type species, was based on globigerine chambers and angled periphery of this species, giving it an appearance between *Rugoglobigerina* and *Globotruncana*. Although placed under *Rugoglobigerina* by Bolli, Loeblich and Tappan (1957), *Trinitella* has been adopted by Loeblich and Tappan (1964b) as a valid genus. El-Naggar (1971b, p. 484) suggested that forms with angled periphery merge imperceptibly into the

typical Rugoglobigerine population ; hence, *Trinitella* should be placed in *Rugoglobigerina* as its junior synonym. Accordingly, the species has been included in the *Rugoglobigerina* here.

The Meghalayan forms are up to 0.32 mm in diameter and 0.17 mm in thickness.

Occurrence : The present record appears to be first Indian occurrence because the species is noted for its absence in the Coromandel Coast (Govindan, 1972, p. 165). In Um Sohryngkew River it is restricted to higher horzions of *Globotruncana stuartiformis* Zone where it occurs rather commonly.

Family Loxostomidae LOEBLICH AND TAPPAN, 1964.

Genus *Coryphostoma* LOEBLICH and TAPPAN, 1962.

Coryphostoma plaita (CARSEY)

(Pl. II—6)

Bolivina plaitum Carsey, 1926, p. 26

Figured specimen : Figured specimen BF 483 is from sample W-3.

Remarks : Studies forms are up to 0.50 mm long, 0.17 mm broad and 0.10 mm thick.

Occurrence : This species is restricted to *G. stuartiformis* Zone in Um Sohryngkew River.

ACKNOWLEDGEMENTS

The author is grateful to Dr. D. K. Chandra of ONGC (now retird) and Dr. M. S. Srinivasana of Banaras Hindu University for their invaluable help in the study of Cretaceous microfauna from Therria area.

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EXPLANATION OF PLATES

PLATE I

1-2 *Haplophragmoides glabra* Cushman and Waters
Specimen BF 429, ×75
1, Side view ; 2, peripheral view.

3-4 *Haplophragmoides kirki* Wickenden
Specimen BF 430, ×75
3, Side view ; 4, peripheral view.

5-6 *Cribrostomoides trinitatensis* Cushman
Specimen BF 431, ×65
5, Side view ; 6, peripheral view.

7-9 *Navarella joaquini* Ciry and Rat
Specimen BF 432, ×20
7, spiral view ; 8, umbilical view ; 9, apertural view.

10-11 *Gaudryna bronni* (Reuss)
Specimen BF 435, ×40
10, side view ; 11, apertural view.

12-13 *Eggrella* sp.
Specimen BF 438, ×80
12, side view ; 13, apertural view.

14-15 *Tritaxia trilatera* (Cushman)
Specimen BF 436, ×35
14, side view ; 15, apertural view.

16-17 *Spiroplectammina semiconplanata* (Carsey)
Specimen BF 434, ×75
16, side view ; edge view.

18-19 *Dorothia oxycona* (Reuss)
Specimen BF 437, ×65
18, side view ; 19, apertural view.

20-21 *Triplasia cushmani* (Alexander and Smith)
Specimen BF 433 ×70
20, side view ; 21, apertural view.

Plate II

1-2 *Pseudonodosaria manifesta* (Reuss)
Specimen BF 439, ×80
1, side view ; 2, apertural view.

3-4 *Brizalina cretosa* (Cushman)
Specimen BF 440, ×140
3, side view ; 4, apertural view.

5 *Brizalina incrassata* (Reuss)
Specimen BF 441, ×110
Side view.

6 *Coryphostoma plaita* (Carsey)
Specimen BF 483
Side view.

7 *Guembelitria cretacea* Cushman
Specimen BF 442, ×220
Side view.

8-14 *Guembelitriella postcretacea* Pandey sp. nov.

8-10 Paratype BF 444, ×200
8, spiral view ; 9, side view ; 10, apertural view.

11-14 Holotype BF 443, ×190
11-13, side views ; 14, apertural view.

15-16 *Heterohelix navarroensis* Loeblich
Specimen BF 448, ×200
15, side view ; 1,6 edge view.

17-18 *Heterohelix globulosa* (Ehrenberg)
Specimen BF 447, ×200
19, side view ; 20, edge view.

19-22 *Heterohelix plummerae* (Loetterle)

19-20 Specimen BF 450, ×160
19, side view ; 20, edge view.

21-22 Specimen BF 451, ×100
21, side view ; 22, edge view.

Plate III

1-3 *Pseudoguembelina punctulata* (Cushman)
Specimen BF 460, ×130
1, side view ; 2, edge view ; 3, apertural view.

4-5 *Pseudoguembelina costulata* (Cushman)
Specimen BF 459, ×150
4, sde view ; 5, edge view.

6-7 *Heterohelix pseudocarseyae* Pandey n. sp.
Specimen BF 452, ×115
6, side view ; 7, apertural view ; 8, edge view

9-10 *Heterohelix elegans* (Rzehak)
Specimen BF 445, ×105
9, side view ; 10, edge view.

11-12 *Planoglobulina acervulinoides* (Egger)
Specimen BF 454, ×100
11, side view ; 12, apertural view.
13, side view ; 14, apertural view.

13-14 *Planoglobulina fructicosa* (Egger)
Specimen BF 455, ×115
13, side view ; 14, apertural view.

15-17 *Gublerina cuvillieri* Kikoine
15-16 ; Specimen BF 457, ×100
15 side view ; 16, apical view.
17 : Specimen BF 458, under transmitted light, ×100

18-19 *Gublerina acuta* de Klasz
Specimen BF 456, ×105.
18, side view ; 19, apical view.

PLATE IV

1-2 *Heterohelix navarroensis* Loeblich
Specimen BF 449, ×140
1, side view ; 2, edge view.

3-4 *Heterohelix striata* (Ehrenberg)
Specimen BF 453, ×170
3, side view ; 4, edge view.

5-6 *Heterohelix glabrans* (Cushman)
Specimen BF 446, ×150
5, side view ; 6, edge view.

7-9 *Globotruncanella coarctata* (Bolli)
Specimen BF 469, ×150
7, apiral view ; 8, umbilical view ; 9, peripheral view.

10-12 *Globotruncanella circumnodifer* (Finlay)
Specimen BF 468, ×105
10 spiral view ; 11, umdilical view ; 12, peripheral vew

13-17 *Globotruncanella* sp.
13-15 Specimen BF 466 ×150
13, spiral view ; 14, umbilical view ; 15, peripheral view.
16-17 Specimen BF 567, ×155
16, umbilical view ; 17, peripheral view.

18-20 *Globotruncana stuarti* (de Lapparent)
Specimen BF 475, ×75
18, spiral view ; 19, umbilical view ; 20, peripheral view.

21-23 *Rugoglobigerina macrocephala* Bronnimann
Specimen BF 447 ×120
21, spiral view; 22, apertural view ; 23, peripheral view.

PLATE V

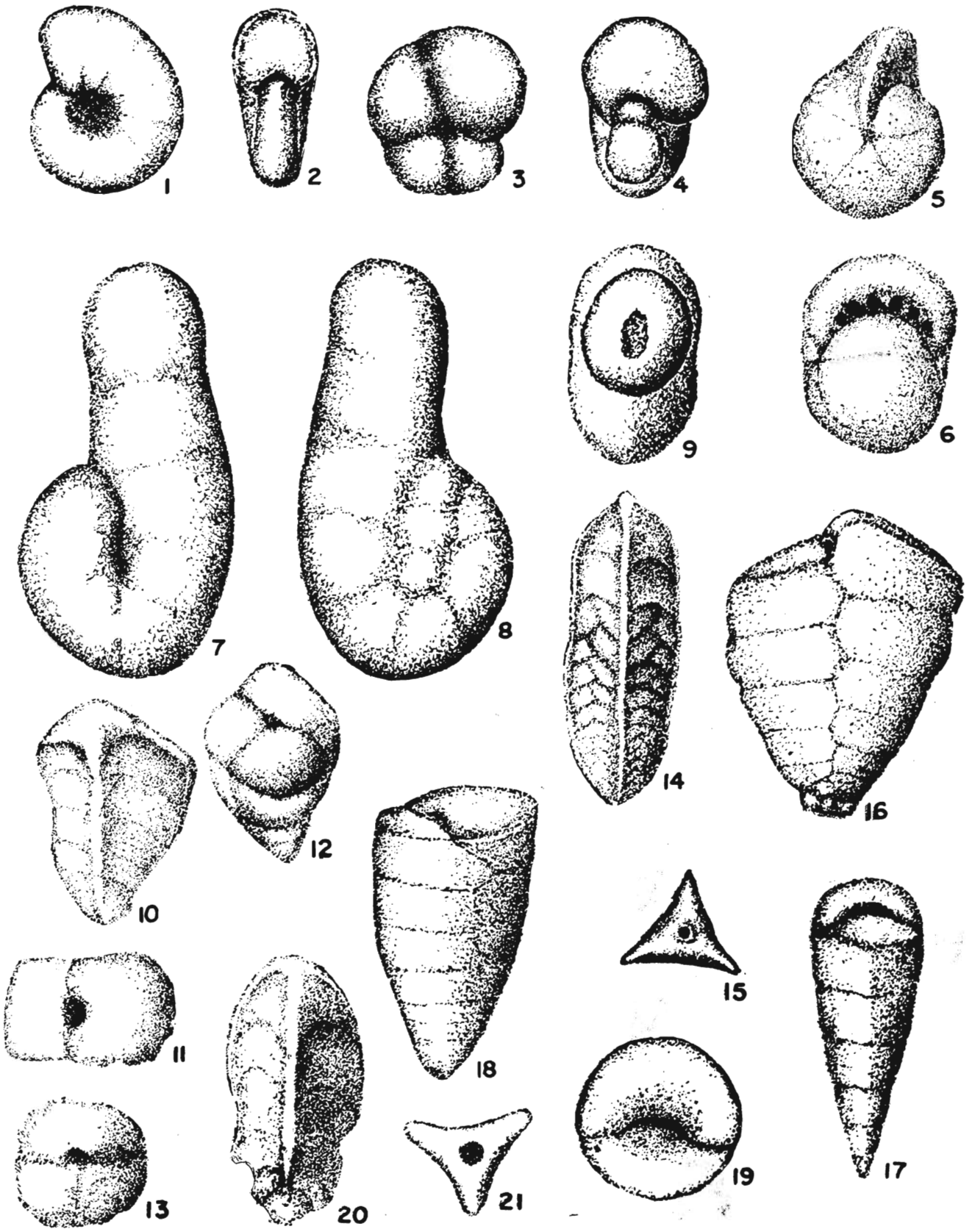
1-2 *Planomalina* cf. *buxtorfi* (Gandolfi)
Specimen BF 461, ×100
1, side view ; 2, periphreal view.

3-4 *Globigerinelloides asperus* (Ehrenberg)
Specimen BF 462, ×100
3, side view ; 4, peripheral view.

5-6 *Globigerinelloides subcarinatus* (Bronnimann)
Specimen BF 464, ×115
5, side view ; 6, peripheral view.

7-8 *Globigerinelloides messinae* (Bronnimann)
Specimen BF 463, ×100
7, side view, 8, peripheral view.

9-11 *Hedbergella monmouthensis* (Olsson)
Specimen BF 465, ×80
9, spiral view ; 10, umbilical view ; 11, peripheral view.



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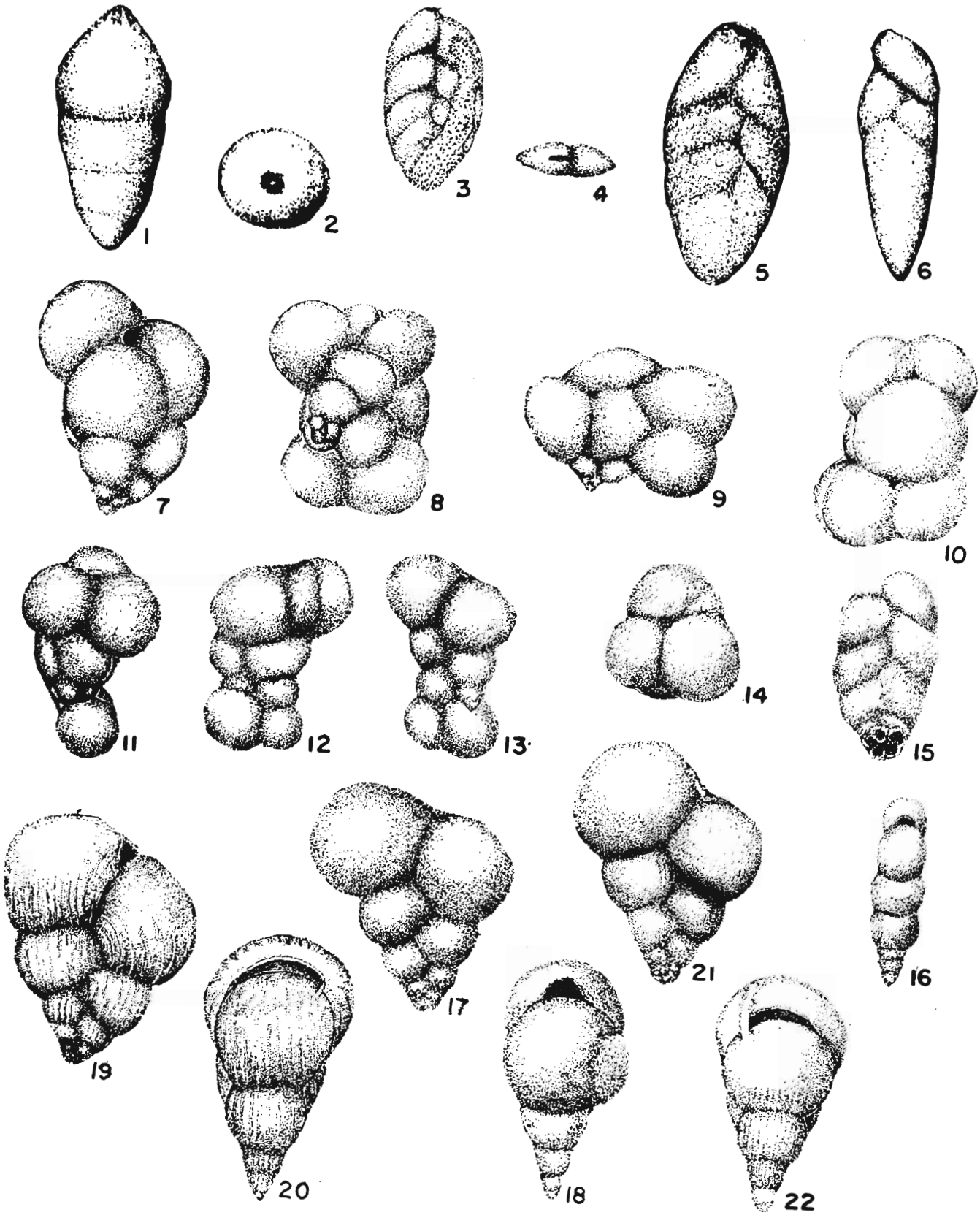
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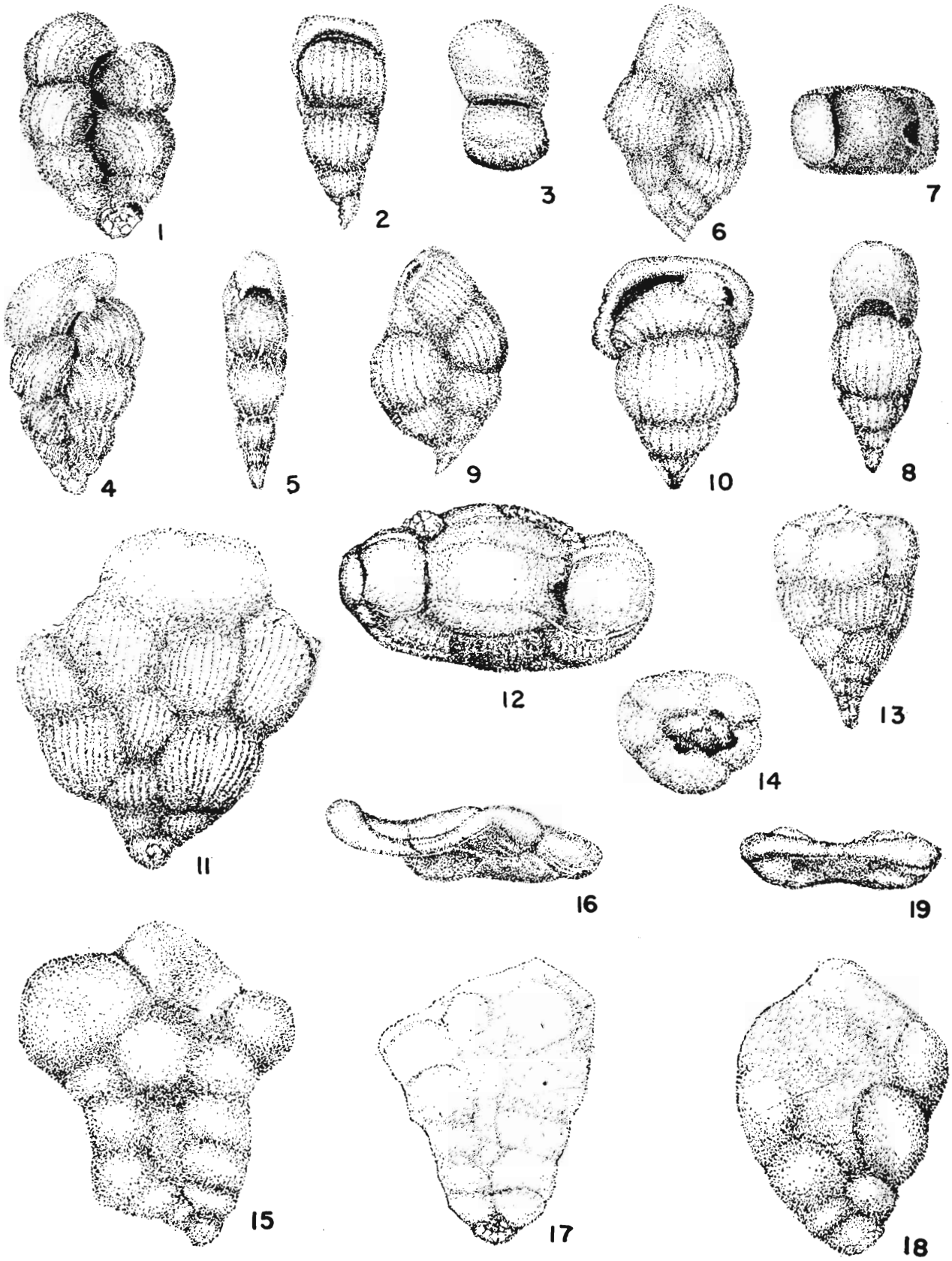

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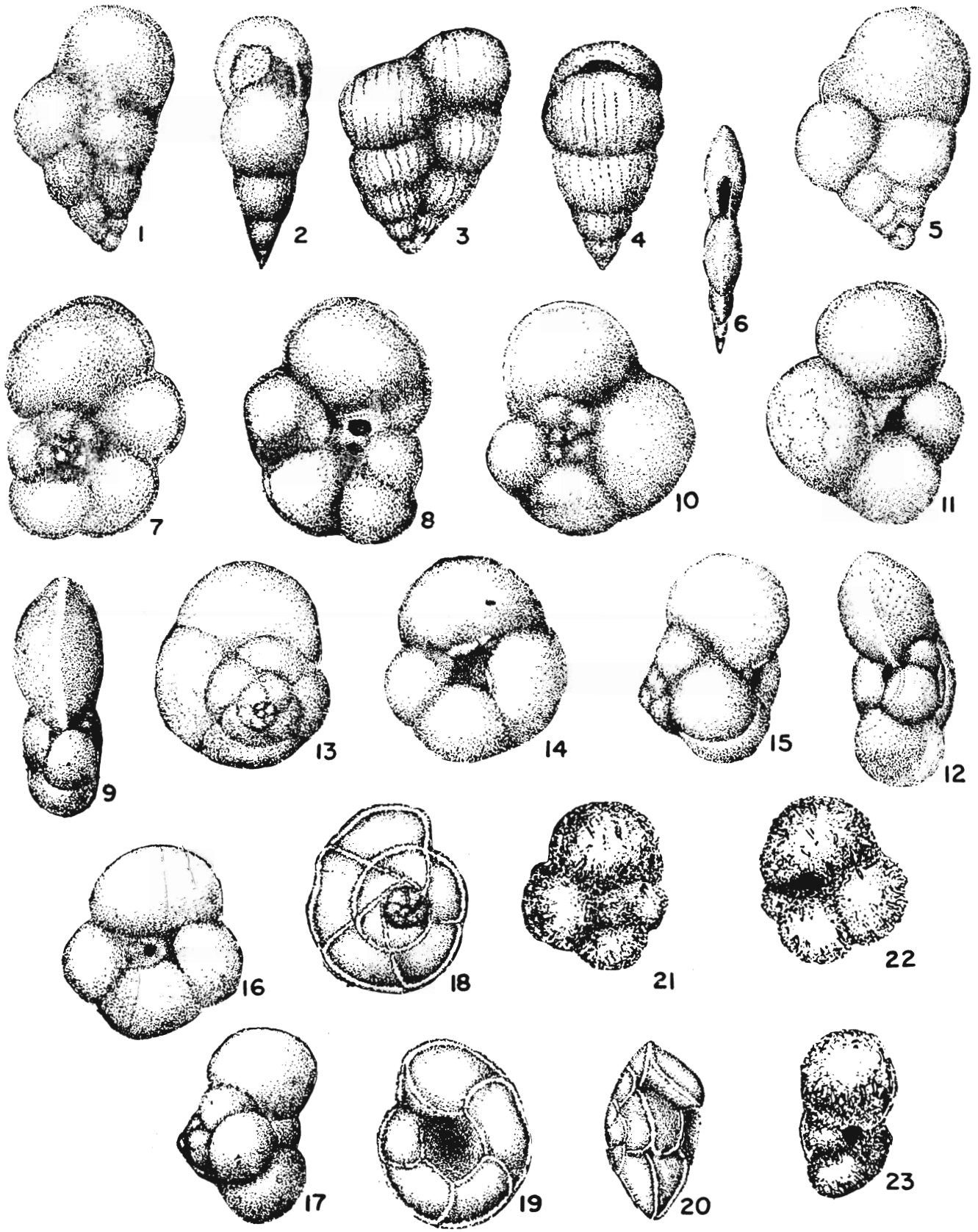
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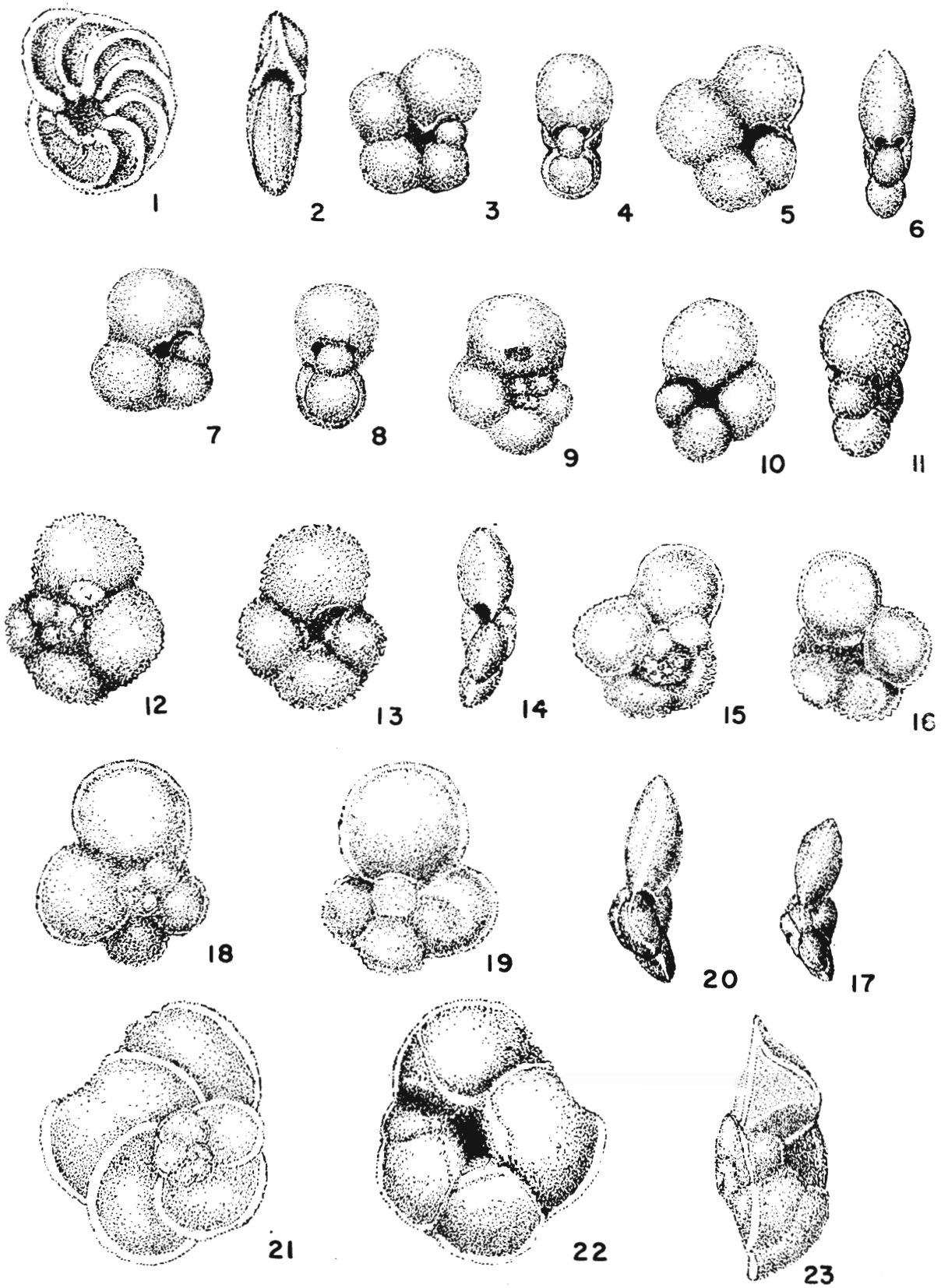
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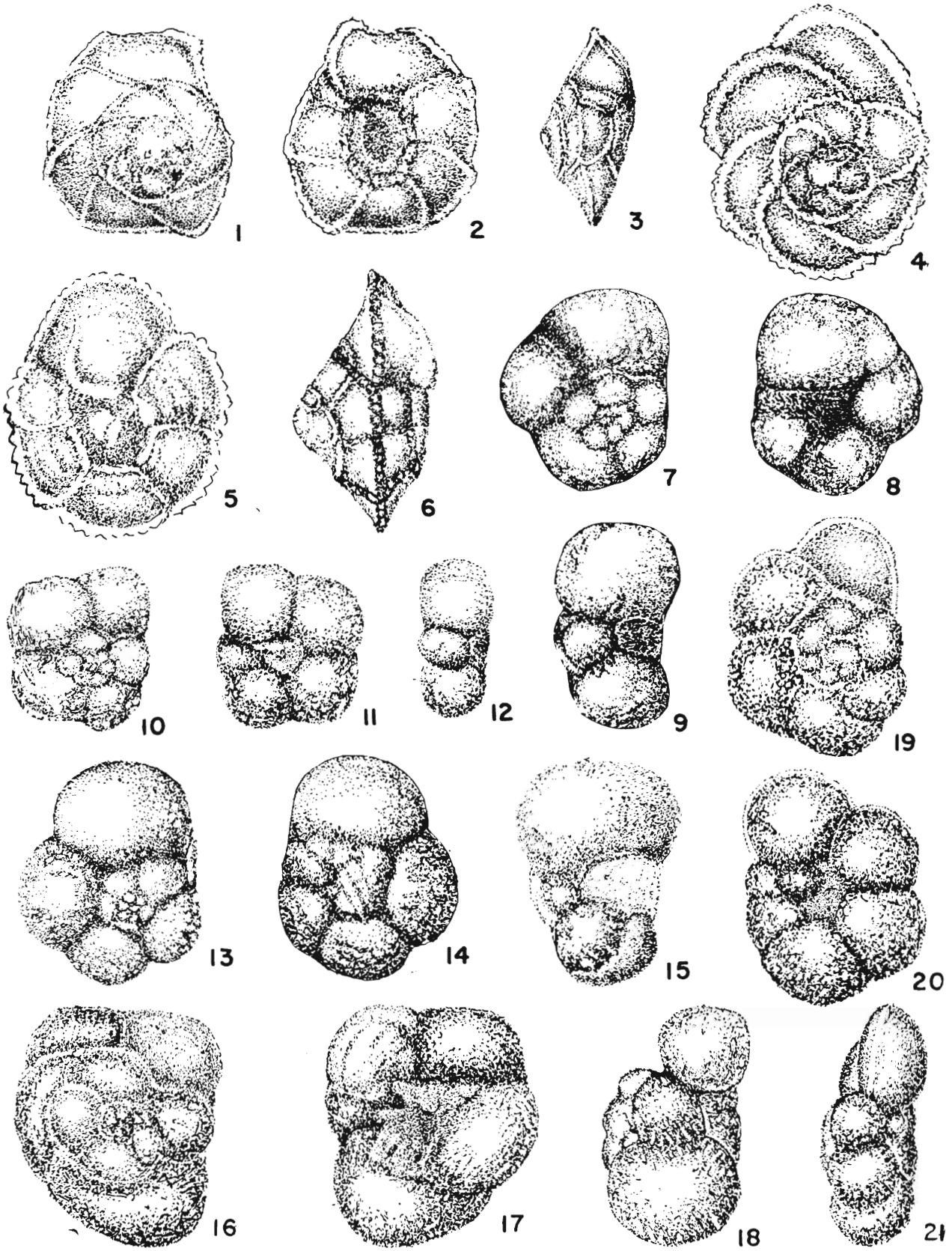
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12-17 *Globotruncanella havanensis* (Voorwijk)
12-14 : Specimen BF 470, ×105
12, spiral view ; 13, umbilical view ; 14, peripheral view.
15-17 : Specimen BF 471, ×110
15, spiral view ; 16, umbilical view ; 17, peripheral view.

18-20 *Globoruncanella subpetaloidea* (Gandolfi)
Specimen BF 472, ×125
18, spiral view ; 19, umbilical view ; 20, peripheral view.

21-23 *Globotruncana rosetta* (Carsey)
Specimen BF 474, ×125
21, spiral view ; 22, umbilical view ; 23, peripheral view.

PLATE VI

1-3 *Globotruncana stuartiformis* Dalbiez
Specimen BF 476, ×110
1, spiral view ; 2, umbilical view ; 3, peripheral view.

4-6 *Globotruncana elevata* (Brotzen)
Specimen BF 473, ×125
4, spiral view ; 5, umbilical view ; 6, peripheral view

7-9 *Rugoglobigerina ornata* Bronnimann
Specimen BF 478, ×120
7, spiral view ; 8, umbilical view ; 9, peripheral view.

10-12 *Rugoglobigerina pilula* Belforu
Specimen BF 479, ×110
10, spiral view ; 11, umbilical view ; 12, peripheral view.

13-15 *Rugoglobigerina rugosa* (Plummer)
Specimen BF 481, ×115
17, spiral view ; 14, umbilical view ; 15, peripheral view.

16-18 *Rugoglobigerina rotundata* Bronnimann
Specimen BF 480, ×135
16, spiral view ; 17, umbilical view ; 18, peripheral view.

19-21 *Rugoglobigerina scotti* (Bronnimann)
Specimen BF 482, ×180
19, spiral view ; 20, umbilical view ; 21, peripheral view.