PLANKTONIC FORAMINIFERA FROM THE PALAEOCENE-EOCENE SUCCESSION IN THE RAKHI NALA, SULAIMAN RANGE, PAKISTAN

BY

BIMAL KUMAR SAMANTA

University of Calcutta

Pp. 421–482; 15 *Plates*, 3 *Text-figures*, 2 *Tables*

BULLETIN OF
THE BRITISH MUSEUM (NATURAL HISTORY)
GEOLOGY Vol. 22 No. 6
LONDON : 1973

THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in* 1949, *is issued in five series, corresponding to the Departments of the Museum, and an Historical series.*

Parts will appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

In 1965 *a separate supplementary series of longer papers was instituted, numbered serially for each Department.*

This paper is Vol. 22, *No.* 6 *of the Geological (Palaeontological) series. The abbreviated titles of periodicals cited follow those of the World List of Scientific Periodicals.*

World List abbreviation
Bull. Br. Mus. nat. Hist. (Geol.).

TRUSTEES OF
THE BRITISH MUSEUM (NATURAL HISTORY)

Issued 2 February, 1973 *Price* £3·55

PLANKTONIC FORAMINIFERA FROM THE PALAEOCENE-EOCENE SUCCESSION IN THE RAKHI NALA, SULAIMAN RANGE, PAKISTAN

By B. K. SAMANTA

SYNOPSIS

The Palaeocene-Eocene succession exposed in the Rakhi Nala section, Sulaiman Range, Pakistan is made up of four formations, in ascending order the Ranikot, Dunghan, Ghazij and Khirthar. About one hundred and twenty samples from this sequence were examined for planktonic foraminifera. None was recognized in the Ranikot Formation, in the lower part of the Dunghan Formation or in the upper part of the lower Khirthar Formation. The upper part of the Dunghan Formation, the lower part of the Ghazij Formation and the upper part of the Khirthar Formation contain good autochthonous planktonic foraminifera. In contrast, the upper part of the Ghazij Formation and the lower part of the lower Khirthar Formation yielded only reworked Upper Cretaceous forms.

A total of seventy-nine species and subspecies of foraminifera belonging to ten genera are discussed and figured. Two are described as new. Eight zones are recognized from the base upwards: the *Globorotalia angulata* Zone, the *Globorotalia velascoensis* Zone, the *Globorotalia aequa* Zone, the *Globorotalia formosa formosa* Zone, the *Globorotalia aspensis/Globorotalia esnaensis* Zone, the *Globorotalia crassata/Truncorotaloides topilensis* Zone, the *Truncorotaloides rohri* Zone and the *Globigerina officinalis* Zone. The lower three zones are assigned to the Palaeocene and the two succeeding zones to the Lower Eocene. Of the remaining three zones, two are assigned to the Middle Eocene and one to the Upper Eocene. The upper part of the Dunghan Formation is here dated as Middle Palaeocene to early Lower Eocene, the lower part of the Ghazij Formation as middle Lower Eocene and the upper part of the Khirthar Formation as late Middle Eocene to Upper Eocene.

INTRODUCTION AND ACKNOWLEDGEMENTS

THE fossiliferous marine sequence exposed in the Rakhi Nala, a river in the Sulaiman Range, Western Punjab, Pakistan, has attracted the attention of geologists mainly because of its accessibility and good exposures. Eames' (1952*b*, *c*) detailed account of the Rakhi Nala section, based on the observations made by geologists of the Burmah Oil Company, revealed that the succession there extends from the Cretaceous to the Upper Eocene. In his biostratigraphical paper (1952*c* : 174) he considered all the fossils, except the smaller foraminifera and ostracods, recovered from the Palaeocene-Eocene part of the sequence. However, only the molluscan fauna from the Rakhi Nala succession was treated systematically (Eames 1951, 1952*a*).

During the 1956–57 field season, Dr D. D. Bayliss visited the Rakhi Nala section with geologists of the Standard Vacuum Oil Company, and systematically collected two hundred and sixty five samples through the Lower Tertiary part of the sequence.

The larger foraminifera from these samples were described by Bayliss (1961 : unpublished thesis). Latif (1961)* listed the planktonic foraminifera from the same residues and commented on their ranges.

This paper, the main objects of which are the description and illustration of the plankton and the zonation of the Palaeocene-Eocene part of the Rakhi Nala sequence, is based on a study of Bayliss' original samples, now deposited in the Department of Geology, University College of Wales, Aberystwyth. The stratigraphy and larger foraminifera will be described separately in a joint paper with Dr Bayliss.

The writer is greatly indebted to Dr J. R. Haynes of the Geology Department of the University College of Wales, Aberystwyth for making available the material for the present study, for help, advice, and for critically reading the manuscript; to Professor Alan Wood for providing facilities in the Geology Department at Aberystwyth; to Dr C. G. Adams of the British Museum (Natural History), London, for valuable suggestions and for access to the collections in his care; to Dr D. D. Bayliss, lately of the British Museum (Natural History) for much help and useful discussions and to Dr F. E. Eames for helpful correspondence and discussions on the Palaeocene-Eocene biostratigraphy of the Indian region. Thanks are also due to Dr C. L. Forbes (Sedgwick Museum, Cambridge) and to Professor H. M. Bolli (of the Swiss Federal Institute of Technology, Zürich), for access to collections and for helpful discussions.

STRATIGRAPHY AND MATERIAL

The Palaeocene-Eocene succession exposed in the Rakhi Nala valley is summarized in Table 1. It comprises in ascending order the Ranikot, Dunghan, Ghazij, and Khirthar Formations. The sequence, about 7130 feet thick is apparently conformable throughout, and rests conformably on the Pab formation which is usually regarded as Upper Cretaceous in age. It is overlain by an unfossiliferous sandstone unit questionably assigned to the Siwalik group. The succession is dominantly argillaceous with beds of limestone and marls at several horizons. Gypsiferous layers occur at some levels and it is sandy towards the base.

The hard, compact limestone samples were examined only in thin sections. The shale, mudstone and marl samples were disaggregated by boiling in water with washing soda for several hours, the residue then being washed through a 200 mesh sieve. When necessary the procedure was repeated several times to obtain completely matrix-free specimens. One hundred and twenty samples were processed in this way.

The illustrations are shaded camera lucida drawings by the writer.

PLANKTONIC FORAMINIFERA

The samples from the Ranikot Formation did not yield determinable foraminifera (see Table 1). Only the uppermost 384 feet of the Dunghan Formation contained

* Latif's results are not further considered here as he appears to have illustrated at least part of his paper with figures taken from Bolli's (1957) work on the faunas of Trinidad.

satisfactorily preserved, determinable plankton, which proved to be rare to abundant in this part of the succession.

Planktonic foraminifera are rare to common in the Ghazij Formation, preservation

FORMATION		SAMPLE NUMBER	THICKNESS IN FEET	LITHOLOGY	PLANKTONIC FORAMINIFERA
Khirthar	Upper	3666 3603	959	Predominantly shales and mud-stones gypsiferous at places; a few layers of marls and limestones.	Samples 3665 & 3666: no planktonic foraminifera. Samples 3650 to 3664: rare to common well preserved planktonic foraminifera. Samples 3627 to 3647: very rare and poorly preserved planktonic foraminifera. Samples 3603 to 3626: common to abundant, well preserved planktonic foraminifera.
	Lower	3602 3453	1253	Mainly limestones and shales with some mudstones at places; shales gypsiferous at places and a thick massive gypsum bed.	Samples 3498 & 3499: very rare, poorly preserved, indeter-minable planktonic foraminifera. Samples 3465 to 3497: no planktonic foraminifera recognised. Samples 3453 to 3464: rare to frequent, reworked plank-tonic foraminifera.
Ghazij		3452 3140	3607	Mainly shales and siltstones with thin bands of limestones near the top.	Samples 3199 to 3452: Rare to frequent, reworked plank-tonic foraminifera. Samples 3140 to 3195: rare to common planktonic foraminifera; preservation poor to satisfactory.
Dunghan	Upper	3667 3125	384	Alternations of mudstones and shales with few thin bands of fine grained sandstones in the lower part and a hard limestone bed at the top.	Rare to abundant planktonic foraminifera; preservation poor to satisfactory.
	Lower	3124 3116	375	Alternations of fine grained sand-stones and shales.	No determinable planktonic foraminifera.
Ranikot		3115 3110	553	Dominantly ferruginous sandstone, conglomeratic and cross bedded in the upper part, and with a few shaly layers in the lower part.	No determinable planktonic foraminifera.

TABLE 1—The Palaeocene-Eocene succession exposed in the Rakhi Nala, Sulaiman Range, Pakistan and its planktonic foraminiferal content.

varying from poor to fairly satisfactory. In the upper 920 feet only reworked Upper Cretaceous plankton was found.

The lowest 280 feet of the Khirthar Formation also contains only rare reworked Upper Cretaceous foraminifera. In the succeeding 918 feet no planktonic foraminifera were recognized. In the uppermost 55 feet of the lower Khirthar very rare, poorly preserved and indeterminable foraminifera were observed.

The upper Khirthar is rich in planktonic foraminifera and preservation in general is good. Some samples from the lower part contain the richest planktonic foraminiferal faunas in the sequence. In the samples corresponding to an interval of 350 feet in the middle of the upper Khirthar only rare and poorly preserved foraminifera were observed.

Seventy nine species and subspecies of foraminifera belonging to ten genera are identified. The distribution of these forms is shown in Text-figs 1 and 2. Two species are described as new. All species, except the two which are provisionally identified, are represented by material adequate for satisfactory identification.

Among the ten genera represented, *Globigerina* and *Globorotalia* constitute more than 80% of the total planktonic foraminiferal fauna. *Globorotalia* is the dominant genus with thirty-four species and subspecies. This genus is most abundant in the Dunghan Formation where it is represented by twenty-seven species and subspecies. The angulo-conical forms of *Globorotalia* are dominant here, but in the overlying Ghazij Formation the genus is represented by only seven species. The fauna here is dominated by coarsely ornamented forms. In the upper Khirthar, *Globorotalia* is again represented by seven species. Here, as in the Ghazij Formation, coarsely ornamented forms are dominant. This genus was not recognized in the upper part of the upper Khirthar.

Globigerina, represented by twenty-four species and subspecies, is the next most abundant genus in the sequence. It is the only genus which ranges from the base of the upper Dunghan to the top of the upper Khirthar in this succession. In the upper Dunghan Formation it is represented by ten species while in the overlying Ghazij it is represented by only two species. In the older samples from the upper part of the Dunghan Formation, reticulate forms are most numerous. In samples from the highest part of this Formation and from the Ghazij Formation, spinose forms are more common.

Globigerina becomes most abundant in the upper part of the Khirthar Formation where it is represented by fourteen species and subspecies, some of which develop very distinctive tests. Species with finely papillose and hispid surfaces are dominant.

Pseudohastigerina, which is represented by five species, appears for the first time in the uppermost part of the Dunghan Formation. It is represented by two species as in the overlying Ghazij Formation. In the upper part of the Khirthar Formation it is represented by three species and is most abundant in the middle part.

The representatives of the remaining seven genera appear for the first time in the upper part of the Khirthar Formation. The genus *Globigerinita* which is represented by four species occurring throughout. *Chiloguembelina* and *Truncorotaloides* are each represented by three species. The representatives of the former occur throughout while those of the latter are restricted to the lower part. *Globigerapsis* and

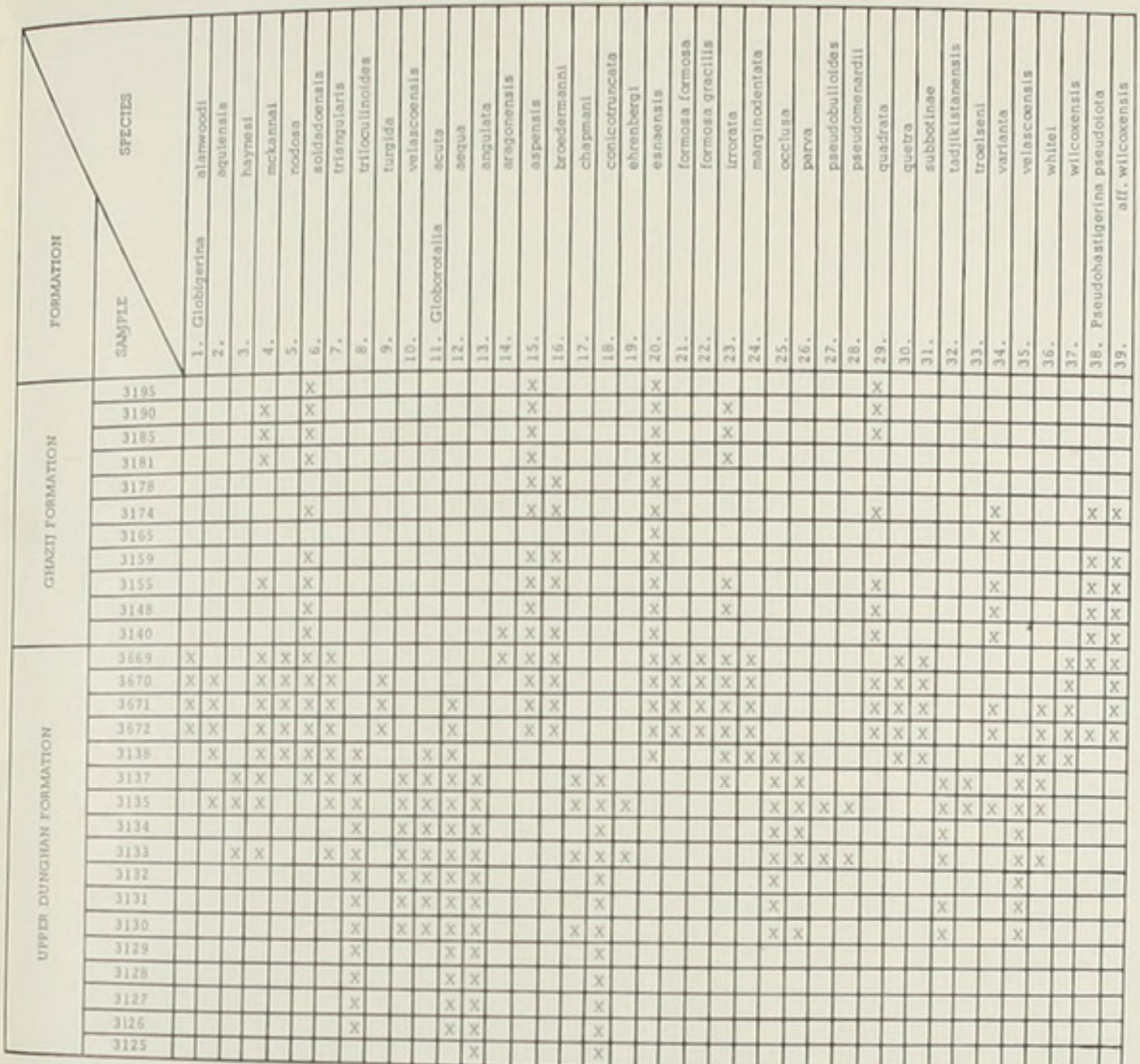


FIG. 1—Distribution of planktonic foraminifera in the Upper Dunghan and Ghazij Formations exposed in the Rakhi Nala section, Pakistan.

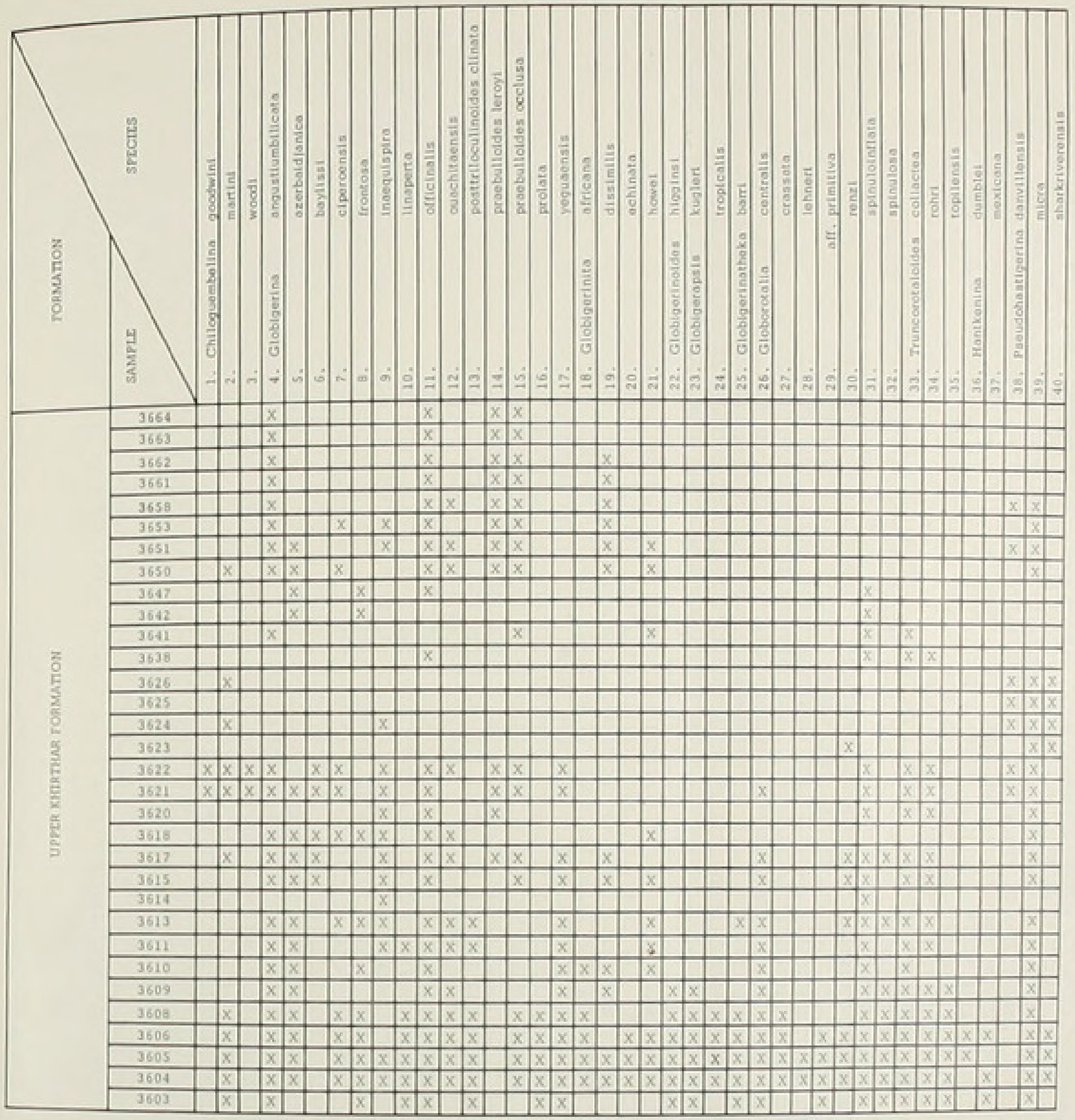


FIG. 2—Distribution of planktonic foraminifera in the Upper Khirtar Formation exposed in the Rakhi Nala section, Pakistan.

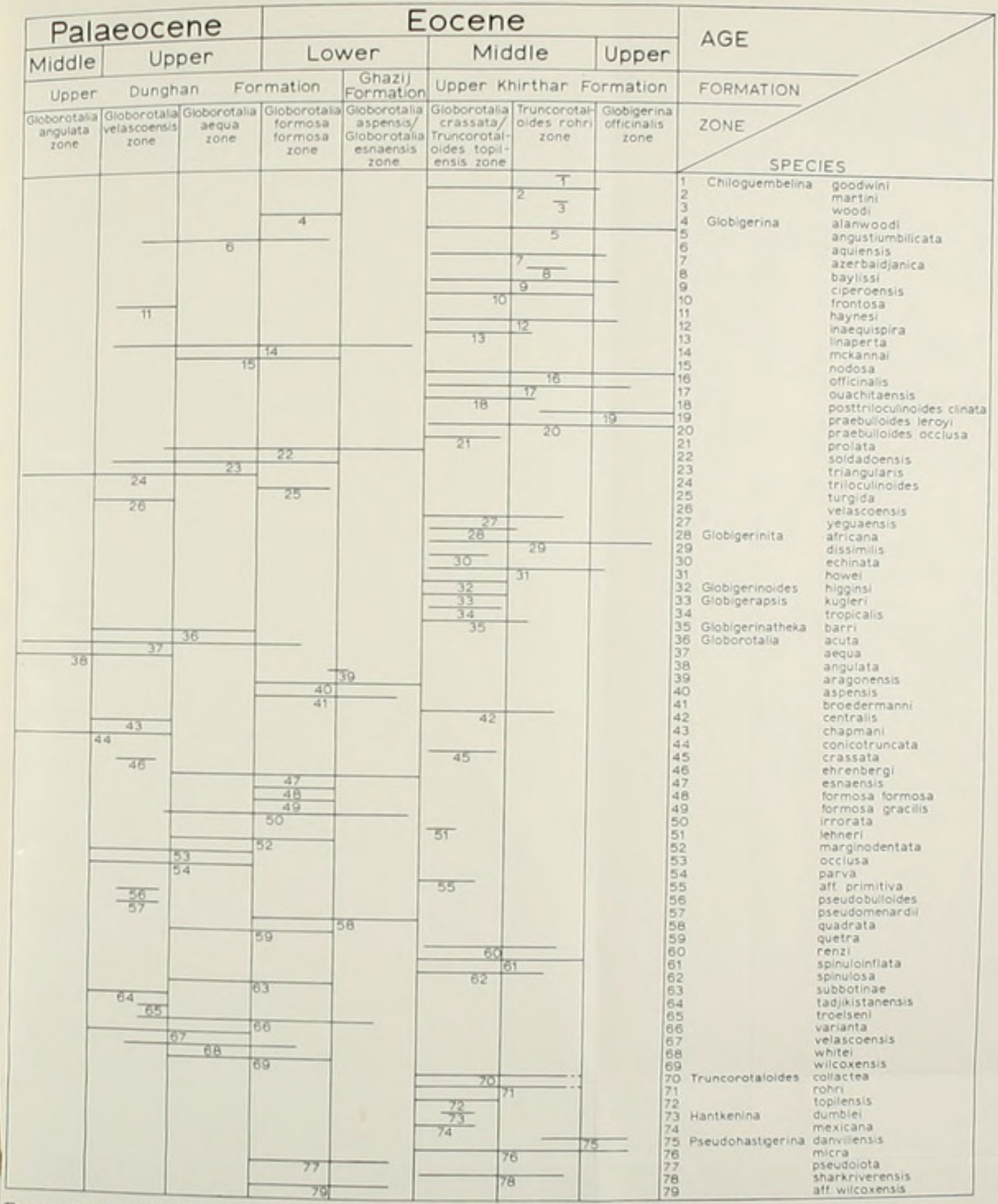


FIG. 3—Stratigraphic distribution of planktonic foraminifera in the Palaeocene-Eocene succession exposed in the Rakhi Nala, Sulaiman Range, Pakistan.

Hantkenina are each represented by two species, and *Globigerinoides* and *Globigerinatheka* by one species; these four genera are restricted to the lower part of the upper Khirthar Formation. They include some of the most distinctive species in the sequence.

ZONATION AND CORRELATION

Eight faunal zones have been recognized in the sequence (Table 2, Text-fig. 3). There is an interval between the fifth and the sixth which contains reworked Upper Cretaceous foraminifera in its lower part and which lacks any identifiable planktonic foraminifera in the upper part. The eight zones are discussed below in statigraphical order.

FORMATION		PLANKTONIC FORAMINIFERAL ZONES	AGE	
Khirthar	Upper	*Globigerina officinalis* Zone	Upper	EOCENE
		Truncorotaloides rohri Zone	Middle	
		Globorotalia crassata/*Truncorotaloides topilensis* Zone		
	Lower	No determinable planktonic foraminifera in the upper part; rare, poorly preserved and reworked planktonic foraminifera in the lower part.		
Ghazij		*Globorotalia aspensis*/*Globorotalia esnaensis* Zone	Lower	
Dunghan	Upper	*Globorotalia formosa formosa* Zone		
		Globorotalia aequa Zone	Upper	PALAEOCENE
		Globorotalia velascoensis Zone		
		Globorotalia angulata Zone	Middle	
	Lower	No determinable planktonic foraminifera		

TABLE 2—Planktonic foraminiferal zonation of the Palaeocene-Eocene succession exposed in the Rakhi Nala, Sulaiman Range, Pakistan.

1. The *Globorotalia angulata* Zone

This is represented by samples 3125 to 3129 from the upper Dunghan Formation. Four species, *Globigerina triloculinoides* Plummer, *Globorotalia aequa* Cushman & Renz, *G. angulata* (White) and *G. conicotruncata* Subbotina, occur here, and of these, *G. angulata* is the most distinctive. Preservation is not very satisfactory. All four species range up into the next zone where they become more common. Immediately underlying this zone is an interval with no planktonic foraminifera.

On the basis of its foraminifera and stratigraphical position this zone is tentatively correlated with the combined *Globorotalia angulata* and *Globorotalia pusilla pusilla* Zones of Bolli (1966). It is assigned here to the Middle Palaeocene.

2. The *Globorotalia velascoensis* Zone

This is represented by samples 3130 to 3137 from the upper Dunghan formation. It is characterized by the abundance of *Globorotalia velascoensis* (Cushman) and closely related species such as *G. acuta* Toulmin, *G. occlusa* Loeblich & Tappan and *G. parva* Rey. The lower limit of the zone is marked by the first appearance of *G. velascoensis* (Cushman).

Of the twenty-three species of *Globigerina* and *Globorotalia* occurring here four range up from the *G. angulata* zone.

Among the nineteen species appearing in this zone, eight are restricted to it. They are *Globigerina haynesi* El-Naggar, *G. velascoensis* Cushman, *Globorotalia chapmani* Parr, *G. ehrenbergi* Bolli, *G. pseudobulloides* (Plummer), *G. pseudomenardii* Bolli, *G. tadjikistanensis* Bykova and *G. troelseni* Loeblich & Tappan. *Globorotalia angulata* (White) and *G. conicotruncata* Subbotina disappear at the top of the zone. Thirteen species range up in to the overlying zone. This zone is correlated with the combined *Globorotalia pseudomenardii* and *Globorotalia velascoensis* Zones of Bolli (1957*a*, 1966). It is regarded here as belonging to the lower part of the Upper Palaeocene.

3. The *Globorotalia aequa* Zone

This is represented by sample 3138 from the upper Dunghan Formation. It is characterized by the occurrence of *Globorotalia aequa* Cushman & Renz, *G. acuta* Toulmin, *G. velascoensis* (Cushman), *G. marginodentata* Subbotina, *G. subbotinae* Morozova and *G. wilcoxensis* Cushman & Ponton. This zone is marked by the first appearance of *G. marginodentata, G. subbotinae* and *G. wilcoxensis,* and by the disappearance of *Globorotalia acuta, G. occlusa, G. parva, G. velascoensis* and *Globigerina triloculinoides.*

Among the nineteen species of *Globigerina* and *Globorotalia* occurring here thirteen range up from the underlying zone and six appear for the first time. None of the species is restricted to the zone although five do not range above it. The remaining fourteen extend up into the overlying zone.

The foraminifera and stratigraphical position of this zone indicate that it is comparable to the *Globorotalia aequa* Zone as recognized by Luterbacher (1965) in the Gubbio section of Central Italy. Luterbacher correlated his *Globorotalia aequa*

Zone with the *Globorotalia rex* Zone recognized by Bolli (1957*a*) in Trinidad. The *G. aequa* Zone is here assigned to the upper part of the Upper Palaeocene.

4. The *Globorotalia formosa formosa* Zone

This is represented by samples 3672 to 3669 from the upper part of the Dunghan Formation. It is characterized by the first appearance of the planispiral genus *Pseudohastigerina* Banner & Blow, and by the occurrence of *Globorotalia formosa formosa* Bolli and *G. formosa gracilis* Bolli. Its upper limit is marked by the disappearance of the two last-mentioned subspecies together with *G. marginodentata* and *G. subbotinae*.

Of the twenty-four species and subspecies occurring here, fourteen range up from the underlying zone. Four of the ten species appearing at the base of this zone are restricted to it. These are *Globorotalia formosa formosa, G. formosa gracilis, Globigerina alanwoodi* El-Naggar and *G. turgida* Finlay. Nine species ranging up from the underlying zone occur here for the last time and eleven species range up into the overlying zone.

This zone was first recognized by Bolli (1957*a*) in Trinidad. It is regarded here as belonging to the lower part of the Lower Eocene.

5. The *Globorotalia aspensis/Globorotalia esnaensis* Zone

This is represented by samples 3140 to 3195 from the lower part of the Ghazij formation. It is characterized by the abundance of *Globorotalia aspensis* (Colom) and *G. esnaensis* (Le Roy). The lower limit is defined by the disappearance of *Globorotalia formosa formosa* Bolli, *G. formosa gracilis* Bolli, *G. marginodentata* Subbotina and *G. subbotinae* Morozova.

All eleven species occurring in this zone range up from the underlying zone, and none extends upwards into the higher zones. The stratigraphically significant species *Globorotalia aragonensis* Nuttall disappears in the lower part of the zone. The genus *Globigerina* is represented by two spinose species, *G. mckannai* White and *G. soldadoensis* Bronnimann. The two species of *Pseudohastigerina* which appear in the underlying zone become more common here.

This zone is tentatively correlated with the *Globorotalia aragonensis* Zone recognized by Bolli (1957*a*) in Trinidad, and is here assigned to the middle part of the Lower Eocene. It is followed directly by beds which contain only reworked Upper Cretaceous planktonic foraminifera.

6. The *Globorotalia crassata/Truncorotaloides topilensis* Zone

This is represented by the samples 3603 to 3609 from the upper Khirthar Formation. It is characterized by the presence of *Globorotalia crassata* (Cushman), *Truncorotaloides topilensis* (Cushman), *Globigerapsis kugleri* Bolli, Loblich & Tappan and *Globigerinoides higginsi* Bolli. Immediately underlying the strata representing this zone are beds with very rare, poorly preserved and indeterminable planktonic foraminifera. The upper limit of the zone is marked by the disappearance of *Truncorotaloides topilensis, Globigerapsis kugleri* and *Globigerinoides higginsi*.

None of the species occurring in the underlying zones are represented here. The representatives of seven genera, *Chiloguembelina, Hantkenina, Truncorotaloides, Globigerinita, Globigerinoides, Globigerapsis* and *Globigerinatheka* appear for the first time. With thirty-five species and subspecies representing ten genera, this zone contains the richest assemblage in the succession. Species of *Truncorotaloides,* and the spinose and keeled forms of *Globorotalia* dominate the fauna. Of the species occurring here, eleven are restricted to this zone while the remaining twenty-four range up in to the overlying zone. The genera *Hantkenina, Globigerapsis* and *Globigerinoides* are restricted to this zone, *Hantkenina* being represented by very rare specimens. *Globorotalia lehneri* Cushman & Jarvis is restricted to the lower part of the zone.

This zone is tentatively regarded as equivalent to the combined *Globorotalia lehneri* and *Orbulinoides beckmanni* (=*Porticulasphaera mexicana*) Zones recognized by Bolli (1957*c*) in Trinidad. It is assigned here to the middle part of the Middle Eocene.

7. The *Truncorotaloides rohri* Zone

This is represented by samples 3610 to 3647 from the upper Khirthar Formation. Samples 3627 to 3647 yielded rare and poorly preserved specimens and are only provisionally included in the zone which is characterized by the occurrence of *Truncorotaloides rohri* Bronnimann & Bermudez and *Globorotalia spinuloinflata* (Bandy) in abundance. In some samples from the upper part of the zone, representatives of *Chiloguembelina* and *Pseudohastigerina* are very abundant. In these samples, representatives of the other genera are rare. The upper limit of the zone is marked by the disappearance of *Truncorotaloides.*

Of the twenty-nine species and subspecies occurring here, twenty-four range up from the underlying zone. Among the five forms appearing for the first time, three, *Chiloguebelina goodwini* (Cushman & Jarvis), *C. woodi* sp. nov. and *G. baylissi* sp. nov. are restricted to it. Representatives of the genera *Truncorotaloides, Globorotalia* and *Globigerinatheka* do not range above this zone. Thirteen species and subspecies range up into the overlying zone. This zone correlates well with the *Truncorotaloides rohri* Zone in Trinidad (Bolli 1957*c*). It is assigned to the upper part of the Middle Eocene.

8. The *Globigerina officinalis* Zone

This is represented by samples 3650 to 3664 from the upper Khirthar Formation. The succeeding two samples 3665 and 3666 representing the topmost part of the succession did not yield planktonic foraminifera. It is characterized by the occurrence of *Globigerina officinalis* Subbotina, *G. augustiumbilicata* Bolli, *G. praebulloides leroyi* Blow & Banner and *G. praebulloides occlusa* Blow & Banner in considerable numbers.

Thirteen species and subspecies belonging to four genera, *Globigerina, Globigerinita, Pseudohastigerina* and *Chiloguembelina* occur in this zone. Of these, *Globigerina* is dominant, being represented by eight species and subspecies. The other three genera are poorly represented.

In the absence of more diagnostic foraminifera, direct correlation of this zone with those established for the late Eocene successions in well-known localities like Trinidad and Tanganyika is difficult. It seems to correspond to the interval represented by the *Globigerapsis mexicana* (=*Globigerapsis semiinvoluta*) and *Globorotalia cerroazulensis* Zones in Trinidad (Bolli 1957*c*), and is assigned here to the Upper Eocene.

SYSTEMATIC DESCRIPTIONS

The classification followed here is based on that of Bolli, Loeblich & Tappan (1957) with modifications and additions by later workers. It has been discussed in detail by the writer (1969, 1970*a*). Synonymies are restricted to the original description and to references providing important information on the taxonomy and distribution of the various species.

All figured specimens are deposited in the British Museum (Natural History).

Order FORAMINIFERIDA Eichwald 1830

Family **CHILOGUEMBELINIDAE** Reiss 1963

Genus ***CHILOGUEMBELINA*** Loeblich & Tappen 1956

TYPE SPECIES. *Guembelina midwayensis* Cushman 1940.

See Samanta (1969, 329) for discussion of genus.

Chiloguembelina goodwini (Cushman & Jarvis)

(Pl. 14, figs 7–8)

1933 *Gümbelina goodwini* Cushman & Jarvis (in Cushman): 69, pl. 7, figs 15a–16b.
1948 *Gümbelina goodwini* Cushman & Jarvis; Cushman & Renz: 23.

REMARKS. The number and the inflation of the chambers vary in the present material. The aperture is filled with crystalline material which often renders observation difficult. The chambers appear to be slightly more inflated than those in the holotype, but are otherwise closely comparable.

Drooger (1953), followed by Beckmann (1957), treated *C. goodwini* as a junior synonym of *C. martini* (Pijpers), but neither author gave his reasons. As indicated previously (Samanta 1969), the two species can be distinguished by their apertures.

In its symmetrical, high and narrow aperture, the specimen figured here closely resembles the holotype of *Chiloguembelina parallela* Beckmann, described from the *Globorotalia 'rex'* Zone of Trinidad.

DISTRIBUTION. *Chiloguembelina goodwini* was originally described from the Upper Eocene of Trinidad. Its range is reported to be Middle to Upper Eocene.

In the Rakhi Nala section it is restricted to the *Truncorotaloides rohri* Zone.

Chiloguembelina martini (Pijpers)

(Pl. 15, figs 13–14)

1933 *Textularia martini* Pijpers: 57, text-figs 6–10.
1953 *Gümbelina martini* (Pijpers); Drooger (pars): 100, pl. 1, fig. 2; non text-figs 4a–b.
1957 *Chiloguembelina martini* (Pijpers); Beckmann (pars): 89, pl. 21, figs 14a–b; text-fig 14 (9–11, 14–18, 20–23).
1968 *Chiloguembelina martini* (Pijpers); Raju: 291, pl. 1, fig. 12.

Remarks. In the present material *C. martini* shows variation in the shape and size of the test, rate of enlargement and compression of the chambers, and the character of the aperture. Specimens with markedly twisted tests occur. The apertural flange is usually only partially preserved.

C. martini is readily distinguished from related species in the present material by its tendency to develop a twisted test and asymmetrical aperture, and by having less inflated chambers.

As indicated by the writer (1969), *Chiloguembelina goodwini* (Cushman & Jarvis) and *C. venezuelana* (Nuttall) are not junior synonyms of *C. martini*. These species can be distinguished by their apertural characters.

The specimen figured by Drooger (1953, text-figs 4a–b) as *Gumbelina martini* (Pijpers) differs from the types in having more inflated chambers and a semicircular aperture. It is morphologically very close to *C. venezuelana* (Nuttall).

Distribution. *Chiloguembelina martini* was originally described from an Upper Eocene marl recovered from a well in Bonaire, Netherlands West Indies. Its stratigraphic range is reported as Lower to Upper Eocene. Raju (1968) recorded it from the Middle and Upper Eocene of southern India.

In the Rakhi Nala section, *C. martini* ranges from the *Globorotalia crassata*/*Truncorotaloides topilensis* Zone to the base of the *Globigerina officinalis* Zone.

Chiloguembelina woodi sp. nov.

(Pl. 15, figs 15–16)

1970*b* *Chiloguembelina* sp. Samanta: 31, pl. b, figs 13, 14.

Diagnosis. A *Chiloguembelina* with inflated, subglobular chambers between depressed, oblique sutures; surface smooth to weekly hispid; aperture large, semicircular to subcircular, bordered by a narrow lip-like structure.

Description. Test flaring, biserial; periphery lobate. Chambers arranged in 5 to 7 pairs, increasing regularly in size; those in the initial part of the test small and compressed, later becoming inflated, subglobular. Sutures oblique, slightly depressed in the early part becoming strongly depressed later. Surface almost smooth to weakly hispid. Aperture a large, semicircular to subcircular opening bordered by a narrow lip-like structure.

Dimensions.

Holotype.	Length: 0·28 mm
Paratypes.	Length: 0·27 mm–0·33 mm

LOCALITY AND HORIZON. Types from sample No. 3622, Rakhi Nala section, West Pakistan.

REMARKS. The chambers vary in number and in degree of inflation; the last two chambers also vary in size. The aperture varies in shape and size, and is often obscured by a crystalline infilling.

Among the Middle and Upper Eocene representatives of the genus, *C. venezuelana* (Nuttall) shows some resemblance to *C. woodi*. However, the latter can be distinguished by its more inflated chambers and larger aperture.

With its inflated subglobular chambers and large semi-circular aperture, *C. woodi* shows a relationship to *C. wilcoxensis* (Cushman & Ponton), a Palaeocene to Lower Eocene species from which it may have evolved.

The form from the Upper Eocene of the Mikir Hills, Assam, recorded by the writer (1970*b*) as *Chiloguembelina* sp., shares with *C. woodi* the inflated chambers, depressed sutures, and large subcircular aperture.

This species is named after Professor Alan Wood, Aberystwyth.

DISTRIBUTION. In the Rakhi Nala section, *C. woodi* is restricted to the *Truncorotaloides rohri* Zone.

Family **GLOBIGERINIDAE** Carpenter, Parker & Jones 1862

Subfamily **GLOBIGERININAE** Carpenter, Parker & Jones 1862

Genus ***GLOBIGERINA*** d'Orbigny 1826

TYPE SPECIES. *Globigerina bulloides* d'Orbigny 1826.

See Samanta (1969) for discussion of genus.

Globigerina alanwoodi El-Naggar

(Pl. 3, figs 7–9)

1966 *Globigerina alanwoodi* El-Naggar: 156–157, pl. 16, figs 6a–c.

REMARKS. When describing *Globigerina alanwoodi*, El-Naggar (1966) illustrated only the holotype and did not discuss variation. For its proper understanding, an examination was made of the holotype and 3 paratypes deposited in the British Museum (Natural History); the 3 paratypes in the Geology Department of the University College of Wales, Aberystwyth were also examined. The holotype is an ill-preserved, partially damaged specimen in which the aperture cannot be seen as the final chamber is incompletely preserved. The main variation observed in the 6 paratypes is in the shape of the spiral side of the test where the early chambers may be depressed below the outer whorl; in the number of chambers in the last whorl which usually enlarge somewhat irregular in size, and in the width of the umbilicus which is mostly filled with crystalline material obscuring the aperture. Around the umbilicus the surface of the chambers is distinctly papillose, while on the flattened spiral side of some paratypes the surface is finely pitted. The rest of the shell surface appears to be nearly smooth or very weakly papillose.

The Rakhi Nala specimens show all the distinctive features of *G. alanwoodi*. The surface of the test is distinctly papillose around the umbilicus and nearly smooth to faintly papillose elsewhere. The aperture in some specimens tends to extend partly outside the umbilicus. It appears to be furnished with a delicate lip. The dorsal side of the test is weakly convex to flat.

G. alanwoodi as noted by El-Naggar (1966 : 156), is closely related to *Globigerina mckannai* White, from which it differs in lacking the spinose surface ornamentation. El-Naggar suggested that *G. alanwoodi* might have evolved from *Globigerina spiralis* Bolli.

DISTRIBUTION. *Globigerina alanwoodi* was first described from the lower part of the Upper Palaeocene of the Esna-Idfu region, Egypt.

In the Rakhi Nala section it occurs in the *Globorotalia formosa formosa* Zone.

Globigerina angustiumbilicata Bolli

(Pl. 1, figs 1–3)

1957*b* *Globigerina ciperoensis angustiumbilicata* Bolli: 109, pl. 22, figs 12a–13c.
1969 *Globigerina angustiumbilicata* Bolli; Samanta: 330, pl. 1, figs 1a–c.
1970*a* *Globigerina angustiumbilicata* Bolli; Samanta: 189, pl. 1, fig. 1.

REMARKS. *G. angustiumbilicata* differs from *G. ciperoensis* Bolli in possessing a much smaller umbilicus and a lower and smaller aperture. The average size of the present specimens is less than that of *G. ciperoensis*, which usually has a higher dorsal spire and a coarser surface.

G. angustiumbilicata is very similar to *G. officinalis*, from which species it is believed to have been derived, but differs in that the rate of enlargement of the chambers is greater.

DISTRIBUTION. According to reliable reports, this species ranges from the Middle Eocene to the Lower Miocene. It has been recorded from the Upper Eocene of eastern India (Samanta 1969) and from the Middle Eocene of western India (Samanta 1970*a*).

In the Rakhi Nala section *G. angustiumbilicata* ranges from the *Globorotalia crassata/Truncorotaloides topilensis* Zone to the *Globigerina officinalis* Zone.

Globigerina aquiensis Loeblich & Tappan

(Pl. 4, figs 1–3)

1957*a* *Globigerina aquiensis* Loeblich & Tappan: 180, pl. 51, figs 4a–5c; pl. 56, figs 4a–6c.
1970*c* *Globigerina aquiensis* Loeblich & Tappan; Samanta: 610, pl. 94, figs 1–2.

REMARKS. The enlargement of the chambers in the last whorl is rather irregular. The final chamber often tends partly to cover the umbilicus The dorsal surface of the test seems to be smoother than the ventral one Owing to adherent matrix in the umbilical region, the apertural lip could not be observed clearly.

DISTRIBUTION. The range of *G. aquiensis* is reported to be Upper Palaeocene to Lower Eocene. It has been reported by the writer (1970*c*) from the Upper Palaeocene, Pondicherry Formation of southern India.

In the Rakhi Nala section *G. aquiensis* ranges from the *Globorotalia velascoensis* Zone to the *Globorotalia formosa formosa* Zone.

Globigerina azerbaidjanica Khalilov

(Pl. 2, figs 1–3)

1956 *Globigerina azerbaidjanica* Khalilov: 243–244, pl. 4, figs 1a–c.

DESCRIPTION. Test inflated, coiled in a moderately high trochospire; dorsal side sub-conical; ventral side prominently convex; equatorial periphery roughly quadrangular, lobate; axial periphery rounded. Chambers on the dorsal side about 13, arranged in 3 whorls and enlarging very rapidly in size; chambers in the first whorl not very distinct; on the ventral side 3 large strongly inflated chambers very rapidly enlarging in size; the last chamber is perpendicular to the two preceding ones. Sutures on the dorsal side straight to slightly curved, moderately depressed; on the ventral side nearly straight, deeply depressed. Umbilicus well developed, deep and open. Surface of test finely pitted, hispid. Aperture interiomarginal, umbilical, a large semicircular opening bordered in some specimens by a weakly developed lip.

REMARKS. *Globigerina azerbaidjanica* is characterized by a raised dorsal spire; 3 strongly inflated chambers in the last whorl, the final chamber situated across the two preceding ones and occupying about half of the whole ventral view of the test and a large umbilical aperture.

The Rakhi Nala specimens show variation in the height of the spire, the size of the final chamber and the size of the aperture. The initial chambers are too minute to be observed readily. There is an abrupt increase in the size of the chambers of the last whorl which occupies most of the test. The aperture is very often filled with crystalline material. The final chamber in some specimens appears to be smoother than the rest.

G. azerbaidjanica was compared by its author with *Globigerina posttriloculinoides* Khalilov, from which it was distinguished by its large semicircular umbilical aperture. In its rapidly enlarging, globular chambers in the last whorl and large umbilical aperture, *G. azerbaidjanica* shows some resemblance to *G. baylissi* sp. nov. However, the latter has more chambers in the last whorl, a more strongly lobate periphery and a radially elongate last chamber.

DISTRIBUTION. *Globigerina azerbaidjanica* was originally described from the 'Lower upper Eocene' of the Maly Caucasus, Azerbaidzan, U.S.S.R.

In the Rakhi Nala section it ranges from the *Globorotalia crassata/Truncorotaloides topilensis* Zone to the lower part of the *Globigerina officinalis* Zone.

Globigerina baylissi sp. nov.

(Pl. 2, figs 4–6)

DIAGNOSIS. A *Globigerina* with a roughly triglobular, elongate, hispid test coiled in a low trochospire; a strongly inflated, radially elongate final chamber constitutes about one-half of the test; the moderately large, arched umbilical aperture is furnished with a narrow lip.

DESCRIPTION. Test roughly triglobular, elongate, coiled in a low trochospire; ventral side more convex than the dorsal; equatorial periphery ovoid, elongate and strongly lobate; axial periphery rounded. Chambers inflated, globular and arranged in about three whorls; those in the initial whorl extremely small and tightly arranged; the last 3 chambers are large, strongly inflated and enlarge rapidly; the final chamber is radially elongate and constitutes about one half of the whole test; it often tends to be slightly displaced towards the ventral side. Sutures on the ventral side nearly straight, short and strongly depressed; on the dorsal side straight to slightly curved and moderately depressed. Umbilicus wide, open. Wall calcareous, finely perforate; surface weakly hispid. Aperture interio-marginal, umbilical, a moderately wide arched opening bordered with a narrow lip-like structure.

DIMENSIONS.

Holotype.	Maximum diameter: 0·31 mm
Paratypes.	Maximum diameter: 0·28 mm–0·30 mm

LOCALITY AND HORIZON. Types from sample No. 3622. Rakhi Nala section, West Pakistan.

REMARKS. The main variation is in the shape of the dorsal side of the test, the degree of lobation of the periphery, the shape and size of the final chamber and the character of the aperture. The initial chambers in some specimens are depressed below the outer whorl. The aperture varies in size and often tends to extend outside the umbilicus; in most specimens, including the holotype, it is filled with crystalline material. The final chamber may be larger than the rest of the test. In well preserved specimens the umbilicus tends to reveal the apertures of the earlier chambers in the last whorl.

G. baylissi is readily distinguished from contemporaneous species of the genus by its elongate test and large, strongly inflated and radially elongate last chamber. However, it resembles *Globigerina bulbosa* Le Roy (originally described from the Middle Miocene of Sumatra), which species has more prominently elongate, bulbous later chambers.

G. baylissi seems to have been derived from *G. inaequispira* by the development of the elongate test, more rapidly enlarging chambers in the last whorl and radially elongate final chamber, and transitional specimens were observed in the present material.

The species is named after Dr D. D. Bayliss whose samples formed the basis of the present investigation.

DISTRIBUTION. In the Rakhi Nala section *Globigerina baylissi* is restricted to the *Truncorotaloides rohri* Zone.

Globigerina ciperoensis Bolli

(Pl. 2, figs 10–12)

1945 *Globigerina cf. concinna* Reuss; Cushman & Stainforth: 67, pl. 13, figs 1a–b.
1954 *Globigerina ciperoensis* Bolli: 1–3, text-figs 3–4b.
1957*b* *Globigerina ciperoensis ciperoensis* Bolli; Bolli: 109, pl. 22, figs 10a–b.

Remarks. When reporting specimens from the Upper Eocene to Middle Oligocene of Ecuador, South America as *Globigerina* cf. *concinna* Reuss, Stainforth (1948 : 119) remarked that, 'This form has been variously described in tropical America as *G. concinna* and *G.* cf. *concinna* . . . It is probably a distinct species and because of its limited stratigraphic range deserves careful separation from the '*G. bulloides* tribe'.

Bolli (1954) proposed a new name, *Globigerina ciperoensis*, for this form and selected as holotype the specimen figured as *Globigerina* cf. *concinna* Reuss, by Cushman & Stainforth (1945) from the lower part of the Cipero formation of Trinidad. Later (1957*b*), he described two new subspecies, *G. ciperoensis angulisuturalis* and *G. ciperoensis angustiumbilicata*. He figured (Pl. 22, figs 10a–b) a paratype of *G. ciperoensis ciperoensis* showing its morphology in detail.

Blow & Banner (1962) examined topotype material from Trinidad and considered the three subspecies of *G. ciperoensis* described by Bolli as specifically distinct. They regarded *G. ciperoensis* as a subspecies of *G. ouachitaensis* Howe & Wallace.

The present specimens show all the diagnostic features of *G. ciperoensis* but also include individuals with higher dorsal spires than are seen in types and with more chambers in the last whorl. The height of the spire, rate of enlargement of the chambers in the last whorl and width of the umbilicus all show variations in this material. The specimen figured here compares well with the paratypes of *G. ciperoensis* illustrated by Bolli (1957*b*).

As indicated by Blow & Banner *G. ciperoensis* seems to have evolved from *G. ouachitaensis*, having acquired 5 chambers in the later whorls and a roughly pentagonal umbilicus.

Distribution. The holotype of *Globigerina ciperoensis* was originally described as *G.* cf. *concinna* Reuss from the Cipero formation of Trinidad. The stratigraphic range of *G. ciperoensis* is reported to be Upper Eocene to Lower Miocene.

In the Rakhi Nala section it ranges from the *Globorotalia crassata/Truncorotaloides topilensis* Zone to the lower part of the *Globigerina officinalis* Zone.

Globigerina frontosa Subbotina

(Pl. 1, figs 22–24)

1953 *Globigerina frontosa* Subbotina: 84, pl. 12, figs 3–7.
1957*c* *Globigerina boweri* Bolli: 163, pl. 36, figs 1a–2b.

Remarks. The Rakhi Nala specimens closely resemble those from Trinidad described by Bolli (1957*c*) as *Globigerina boweri*, which species following Bermudez (1961) and Bandy (1964*b*) is here included in the synonymy of *G. frontosa* Subbotina.

DISTRIBUTION. According to most authors this species ranges from Middle to Upper Eocene. The writer (1970*a*) has recorded it from the Middle Eocene of Western India.

In the Rakhi Nala section it ranges from the *Globorotalia crassata/Truncorotaloides topilensis* Zone to the *Truncorotaloides rohri* Zone.

Globigerina haynesi El-Naggar

(Pl. 4, figs 7–9)

1966 *Globigerina haynesi* El-Naggar: 165–166, pl. 15, figs 5a–c.

REMARKS. Variable features in the Rakhi Nala specimens are the convexity of the dorsal side of the test, the size of the final chamber and the width of the umbilicus. The specimen figured here resembles the holotype of *G. haynesi* in possessing a smaller final chamber that tends partly to cover the umbilicus.

The holotype and three paratypes deposited in the British Museum (Natural History) and the two paratypes deposited in the Geology Department, University College, Aberystwyth, were examined. The final chamber in the holotype is not perfectly preserved, and appears to be flattened on the ventral side. In contrast with the holotype, the paratypes include an individual having the final chamber larger than the penultimate one. The low, arched umbilical aperture is better seen in one of the paratypes than in the holotype.

The evolution of *G. haynesi* from *Globigerina spiralis* Bolli during the later part of the Lower Palaeocene (Danian) has been suggested by El-Naggar (1966 : 166, text-fig. 13).

DISTRIBUTION. *Globigerina haynesi* was first described from the Esna-Idfu region of Egypt where it was observed to range from the uppermost part of the Danian to Upper Palaeocene.

In the Rakhi Nala section it occurs in the *Globorotalia velascoensis* Zone.

Globigerina inaequispira Subbotina

(Pl. 2, figs 7–9)

1953 *Globigerina inaequispira* Subbotina: 69, pl. 6, figs 1a–4c.

REMARKS. The final chamber tends to be radially elongate and is very often slightly displaced towards the ventral side.

The present specimens agree well with the original description of *G. inaequispira*. The specimen figured here compares closely with the holotype, although the aperture in the former appears to be slightly higher. Individuals comparable to Subbotina's paratype (1953, figs 4a–c) and having radially elongate and peripherally widely separated later chambers, occur in the present material.

G. inaequispira is readily distinguished by its low trochospiral, strongly lobate and loosely coiled test with a tendency to develop radially elongate chambers. According to Berggren (1962 : 93) *G. inaequispira* has probably developed from *Globigerina pseudoeocaena* Subbotina in the Lower Eocene. *Globigerina foliata* Bolli, from the Miocene of Trinidad, closely resembles to *G. inaequispira*.

The specimens from North America described as *G. inaequispira* by Loeblich & Tappan (1957*a*) and by Olsson (1960) differ from Subbotina's form in having a tightly coiled test with a slightly lobate periphery. Again, the form illustrated by Hillebrandt (1962*b*, pl. 11, figs 12a–b) as *G. inaequispira* does not show clearly the characteristic features of the species.

The specimen figured by El-Naggar (1966, pl. 15, figs 8a–c) as *G. inaequispira* appears to be closely comparable to Subbotina's form. However, his specimens are from the Palaeocene while *G. inaequispira* appears only in the Lower Eocene elsewhere.

DISTRIBUTION. *Globigerina inaequispira* was originally described by Subbotina (1953) from her zone of conical Globorotalias, Northern Caucasus, U.S.S.R., which she dated as Lower to Middle Eocene.

In the Rakhi Nala section it ranges from the *Globorotalia crassata/Truncorotaloides topilensis* Zone to the lower part of the *Globigerina officinalis* Zone.

Globigerina linaperta Finlay

1939*a* *Globigerina linaperta* Finlay: 125, pl. 13, figs 54–57.
1956 *Globigerina linaperta* Finlay; Haque: 173, pl. 8, figs 1a–c, 4a, b.

REMARKS. The main variation in the present specimens is in the rate of enlargement of the chambers in the last whorl, the degree of flattening of the later chambers and the character of the aperture.

DISTRIBUTION. The reported stratigraphic range of the species is Palaeocene to Upper Eocene. The writer (1969, 1970*a*, 1970*b*) recorded *G. linaperta* from the Middle and Upper Eocene of Assam, eastern India and from the Middle Eocene of Cutch, western India.

In the Rakhi Nala section *G. linaperta* occurs in the *Globorotalia crassata/Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Globigerina mckannai White

(Pl. 4, figs 13–15)

1928*a* *Globigerina mckannai* White: 194, pl. 27, figs 16a–c.

REMARKS. The convexity of the dorsal side of the test, the size and position of the final chamber and the width of the umbilicus all vary in the Rakhi Nala material. The surface of the test is weakly spinose. The umbilicus in most specimens is filled with extraneous material.

Globigerina dubia Egger var. *lakiensis* described by Haque (1956) from the Nammal limestone, Salt Range, West Pakistan, appears to be very close to *G. mckannai* White. Haque described it as having a cancellated surface. However, his figures seem to indicate the presence of fine spines on the surface of the holotype.

DISTRIBUTION. According to most workers *G. mckannai* ranges from the Upper Palaeocene to the Lower Eocene. Its occurrence in the Palaeocene Pondicherry formation of southern India has been observed by the writer (1970*c*).

In the Rakhi Nala section *G. mckannai* ranges from the *Globorotalia valascoensis* Zone to the *Globorotalia aspensis/Globorotalia esnaensis* Zone.

Globigerina nodosa El-Naggar

(Pl. 4, figs 4–6)

1966 *Globigerina nodosa* El-Naggar: 173–174, pl. 15, figs 6a–c.

REMARKS. The Rakhi Nala specimens show variation in the inflation of the chambers, the size of the final chamber and in the intensity of surface ornamentation. In contrast to the holotype, the specimen figured here possesses fewer and more regularly enlarging chambers in the last whorl.

DISTRIBUTION. *Globigerina nodosa* was first described from the Upper Palaeocene of Egypt. The writer (1970*c*) has observed well preserved specimens in the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section *G. nodosa* occurs in the *Globorotalia aequa* and *Globorotalia formosa formosa* Zones.

Globigerina officinalis Subbotina

(Pl. 1, figs 7–9)

1953 *Globigerina officinalis* Subbotina (pars): 78, pl. 11, figs 1a–2c, 6a–7c, ?5a–c, non figs 3a–4c.

DISTRIBUTION. *Globigerina officinalis* was first described from the Upper Eocene and Lower Oligocene of the Caucasus, U.S.S.R. It was later described (Bolli 1957*b*) as *Globigerina parva* from the Cipero formation of Trinidad. Its reported range is Middle Eocene to basal Miocene. It was recorded from the Middle and Upper Eocene of eastern India (Samanta 1969) and from the Middle Eocene of western India (Samanta 1970*a*).

In the Rakhi Nala section *G. officinalis* ranges from the *Globorotalia crassata*/*Truncorotaloides topilensis* Zone to the *Globigerina officinalis* Zone.

Globigerina ouachitaensis Howe & Wallace

(Pl. 1, figs 19–21)

1932 *Globigerina ouachitaensis* Howe & Wallace: 74, pl. 10, figs 7a–b.

REMARKS. The Rakhi Nala specimens show variation in the height of the dorsal spire, lobation of the equatorial periphery and the size of the umbilicus. The final chamber varies from distinctly larger to slightly smaller than the penultimate one.

DISTRIBUTION. *Globigerina ouachitaensis* was originally described in association with an Upper Eocene foraminiferal fauna. Its reported range is Middle Eocene to Lower Miocene.

In the Rakhi Nala section *G. ouachitaensis* ranges from the *Globorotalia crassata*/*Truncorotaloides topilensis* Zone to the *Globigerina officinalis* Zone.

Globigerina posttriloculinoides clinata Khalilov

(Pl. 1, figs 13–15)

1956 *Globigerina posttriloculinoides* Khalilov var. *clinata* Khalilov: 243, pl. 3, figs 3a–c.

DESCRIPTION. Test inflated, globular, coiled in a low trochospire; equatorial periphery roughly triangular, lobate; axial periphery rounded. Chambers inflated, globular forming $2\frac{1}{2}$ to 3 rapidly enlarging whorls; initial chambers very small; the last whorl with 3 globular chambers which are much larger than those in the earlier whorls. Sutures straight to slightly curved, on the dorsal side moderately depressed and on the ventral side strongly depressed, incised. Umbilicus narrow, deep, open. Surface moderately pitted. Aperture an elongate slit-like opening with a narrow lip.

REMARKS. In his original description, Khalilov mentioned that a distinctive feature was the deflection of the final chamber towards the ventral side of the test. However, this is not very clear in the holotype, with which the specimen figured here compares satisfactorily.

G. posttriloculinoides clinata appears to be related to the contemporaneous *G. linaperta-angiporoides* group.

DISTRIBUTION. *Globigerina posttriloculinoides clinata* was originally described by Khalilov from the Upper Eocene of U.S.S.R.

In the Rakhi Nala section it occurs in the *Globorotalia crassata/Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Globigerina praebulloides leroyi Blow & Banner

(Pl. 1, figs 4–6)

1953 *Globigerina officinalis* Subbotina (pars): 78, pl. 11, figs 4a–c, non figs 1a–3c, 5a–7c.
1958 *Globigerina globularis* Roemer; Batjes (pars): 161–162, pl. 11, figs 4a–c, non figs 3, 5.
1962 *Globigerina paraebulloides leroyi* Blow & Banner: 93, pl. 9, figs R–T; text-fig. 9 (v).

REMARKS. Blow & Banner (1962) included in the synonymy of *G. praebulloides leroyi* a form from the Oligocene of Belgium identified by Batjes (1958) as *Globigerina globularis* Roemer. They considered *G. globularis* Roemer as *nomen dubium*. Recently, Butt (1966 : 86) identified late Oligocene specimens from Escornebeau as *G. globularis* which he regarded as a senior synonym of *G. praebulloides leroyi*. This synonymy is not accepted here.

The convexity of the dorsal side of the test, rate of enlargement of the chambers and the size of the final chamber vary in the present material.

With its 4 inflated chambers in the last whorl, lobate equatorial periphery and small umbilicus, *G. praebulloides leroyi* resembles *Globigerina officinalis* from which it is distinguished by its deeper umbilicus, symmetrical aperture and more coarsely perforate wall. Subbotina (1953 : pl. 11, fig. 4a–c) included a specimen of *G. praebulloides leroyi* as a paratype of *G. officinalis*.

According to Blow & Banner, *G. praebulloides leroyi* evolved from *G. praebulloides*

occlusa by developing more inflated and embracing chambers, an almost closed umbilicus and a more laterally restricted aperture.

DISTRIBUTION. *G. praebulloides leroyi* was first described from the Lindi area of Tanganyika where it was found to range from the Upper Eocene to the top of the Oligocene. Its total range is reported to be Upper Eocene to Lower Miocene.

In the Rakhi Nala section it ranges from the *Truncorotaloides rohri* Zone to the *Globigerina officinalis* Zone.

Globigerina praebulloides occlusa Blow & Banner

(Pl. 1, figs 16–18)

1962 *Globigerina praebulloides occlusa* Blow & Banner: 93–94, pl. 9, figs R–U; text-figs 14 (i–ii).
1969 *Globigerina praebulloides occlusa* Blow & Banner; Samanta: 331, pl. 1 figs 5a–c.
1970*a* *Globigerina praebulloides occlusa* Blow & Banner; Samanta: 191, pl. 1, figs 5–6.
1970*b* *Globigerina praebulloides occlusa* Blow & Banner; Samanta 33, pl. 6, figs 6–8.

REMARKS. The main variation observed in the present material is in the degree of lobation of the periphery, size of the final chamber and in the character of the umbilicus. The initial whorl on the dorsal side of the test is slightly raised in some individuals. The sharp, minute spine bases between the fine pits give the surface a hispid appearance.

Earlier, workers had referred specimens of this subspecies to *Globigerina trilocularis* d'Orbigny, which according to Blow & Banner (1962 : 94) is a *nomen nudum.*

Much importance has been attached to this subspecies since its recognition as the ancestor of the stratigraphically significant *Globigerinoides 'quadrilobatus'* group of forms (see Blow & Banner 1962 : 136–138).

DISTRIBUTION. *G. praebulloides occlusa* was first described from the Oligocene of Tanganyika, East Africa. It was earlier reported by Bolli as *G.* cf. *trilocularis* d'Orbigny from Trinidad. The range of the subspecies is reported to be Middle Eocene to Lower Miocene. The writer (1969, 1970*b*) has recorded it from the Middle and Upper Eocene of eastern India and from the Middle Eocene of western India (Samanta 1970*a*).

In the Rakhi Nala section *G. praebulloides occlusa* ranges from the *Globorotalia crassata/Truncorotaloides topilensis* Zone to the *Globigerina officinalis* Zone.

Globigerina prolata Bolli

(Pl. 1, figs 10–12)

1957*a* *Globigerina prolata* Bolli: 72, pl. 15, figs 24–26.

REMARKS. The surface of the test in well preserved specimens in my material is weakly hispid. The aperture is furnished with a narrow lip. The final chamber is usually deflected towards the ventral side as in the holotype.

Bolli (1957*a*) suggested that *G. prolata* was derived from *Globorotalia collactea* Finlay. However, Bolli's figured specimen (pl. 15, figs 21–23) of *G. collactea* from Trinidad differs distinctly from the holotype and the paratype of Finlay's species,

which was well illustrated and redescribed by Jenkins (1965) who assigned it to *Truncorotaloides*.

The specimen from the Navet formation of Trinidad figured by Bolli (1957*c*, pl. 35, figs 7a–b) as *G. prolata* differs from the holotype in having a much smaller and centrally located aperture. Again, in the original description of *G. prolata*, Bolli mentioned that the surface of the test is smooth, while in the figures of the Navet specimen the surface of the test appears to be hispid.

Hillebrandt's (1962*b*) figured specimen of *Globigerina* cf. *prolata* differs from the Rakhi Nala specimens in having a flatter test, less inflated chambers and a lower aperture.

DISTRIBUTION. *G. prolata* was first described from the Lower Eocene, Upper Lizard Springs Formation of Trinidad where it ranges from the *Globorotalia formosa formosa* Zone to the *G. palmerae* Zone. In the Paderno d'Adda section of Northern Italy Bolli & Cita (1960*a*) reported it from the Lower Eocene *G. formosa formosa* Zone to the Middle Eocene, *Hantkenina aragonensis* Zone.

In the Rakhi Nala section it occurs in the *Globorotalia crassata/Truncorotaloides topilensis* Zone.

Globigerina soldadoensis Bronnimann

(Pl. 4, figs 10–12)

1952*b* *Globigerina soldadoensis* Bronnimann: 9–11, pl. 1, figs 1–9.
1970*c* *Globigerina soldadoensis* Bronnimann; Samanta: 612, pl. 95, figs 14, 15.

REMARKS. Bronnimann (1952*b*) stated that *G. soldadoensis* seemed to be related to the spinose *Globigerina decepta* Martin and to *Globigerina nitida* Martin, both described from the Lodo formation of California. This view was not accepted by later workers who considered *Globigerina mckannai* White to be the species from which *G. soldadoensis* had probably been derived.

DISTRIBUTION. *Globigerina soldadoensis* was originally described from the Palaeocene and Lower Eocene of Trinidad. The writer (1970*c*) has recorded it from the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section it ranges from the upper part of the *Globorotalia velascoensis* Zone to the *Globorotalia aspensis/Globorotalia esnaensis* Zone.

Globigerina triangularis White

(Pl. 2, figs 13–15)

1928*a* *Globigerina triangularis* White: 195–196, pl. 28, figs 1a–b.
1957*a* *Globigerina triangularis* White; Bolli: 71, pl. 15, figs 12–14.
1965 *Globigerina triangularis* White; Proto Decima & Zorzi: 17, 18, pl. 1, figs 4a–c.

REMARKS. The original description and illustration of *G. triangularis* were not detailed enough for a thorough understanding of this species. Bolli (1957*a*) identified *G. triangularis* from the Palaeocene—Lower Eocene of Trinidad and illustrated one specimen well, showing the details of its morphology. The specimen

figured here agrees well with that of Bolli. The apertural lip in my specimen is not preserved.

Loeblich & Tappan (1957*a* : 183) regarded *G. triangularis* as a junior synonym of *G. triloculinoides* Plummer, while Bolli (1957*c*) considered the former to have been derived directly from the latter. If *G. triangularis* is synonymised with *G. triloculinoides*, then the range of the latter will be Palaeocene to Lower Eocene.

DISTRIBUTION. *G. triangularis* was originally described from the lower part of the Velasco Formation, Mexico, where, according to Hay (1960), it ranges from the *Globorotalia uncinata* Subzone (Danian) to the *Globorotalia velascoensis* Zone (Upper Palaeocene). According to Bolli (1957*a*) the range of *G. triangularis* in Trinidad is Palaeocene, *G. pusilla pusilla* Zone to Lower Eocene, *G. aragonensis* Zone, Lizard Springs formation, possibly continuing into the overlying Navet formation.

In the Rakhi Nala section *G. triangularis* ranges from the *Globorotalia velascoensis* Zone to the *Globorotalia formosa formosa* Zone.

Globigerina triloculinoides Plummer

1926 *Globigerina triloculinoides* Plummer: 134–135, pl. 8, figs 10a–c.
1970*c* *Globigerina triloculinoides* Plummer; Samanta: 614, pl. 94, figs 5, 9, 13–16.

REMARKS. In her original description of *Globigerina triloculinoides* Plummer (1926) figured two specimens showing the dorsal and ventral views respectively. She designated the former as the type, and her description was adequate for a proper understanding of the species. Later, Loeblich & Tappan (1957*a* pl. 43, figs 9a–c) figured three views of a well-preserved topotype showing its morphology in detail.

A wide range of variation has been attributed to this species by some workers who have placed in synonymy forms which differ from the original description of *G. triloculinoides*. The writer does not follow Loeblich & Tappan (1957*a*) in regarding *Globigerina finlay* Bronnimann, *G. hornibrooki* Brönnimann, *G. stainforthi* Bronnimann and *G. triangularis* White as synonyms of *G. triloculinoides*.

Individuals closely comparable to *G. pseudotriloba* White occur in the Rakhi Nala material. They are not treated here separately. White's species shows all the distinctive features of *Globigerina incisa* Hillebrandt, described from the Palaeocene of Austria. When describing *G. incisa*, Hillebrandt (1962*b*) did not compare it with *G. pseudotriloba*.

G. triloculinoides is believed to have evolved from *Globorotalia pseudobulloides* (Plummer) by a reduction in the number of chambers in the last whorl, the development of coarsely reticulate surface ornamentation and the confinement of the aperture to an intraumbilical-umbilical position.

DISTRIBUTION. According to most workers the range of *G. triloculinoides* is Lower Palaeocene (Middle Danian) to Upper Palaeocene. It is well represented in the Palaeocene Pondicherry formation of southern India (Samanta 1970*c*).

In the Rakhi Nala section *G. triloculinoides* ranges from the *Globorotalia angulata* Zone to the *Globorotalia aequa* Zone.

Globigerina turgida Finlay

(Pl. 3, figs 4–6)

1939*a* *Globigerina linaperta* Finlay var. *turgida* Finlay: 125.
1952*b* *Globigerina turgida* Finlay; Bronnimann: 19–21, pl. 3, figs 1–3.
1964 *Globorotaloides turgida* (Finlay); Jenkins: 117–118, pl. 7, figs 1a–11a, 1b–10b; pl. 8, figs 1c–11c, 1d–10d, 11–12, 13a–c.

Remarks. *G. turgida*, when originally erected as a variety of *Globigerina linaperta* was neither figured nor adequately described. Bronnimann (1952*b*), examined topotypes of *G. turgida* and of *G. linaperta* and considered them to be separate species.

Jenkins (1964) figured the holotype of *G. turgida* showing its morphology in detail for the first time. He discussed its ontogeny on the basis of specimens from the type sample, and considered it to belong to the genus *Globorotaloides* Bolli.

Bolli's (1957*a*, pl. 15, figs 3–5) figured specimen of *G. turgida* from the Lower Eocene, *Globorotalia aragonensis* Zone, Upper Lizard Springs formation of Trinidad lacks the characteristic umbilical bulla, while his figured specimen from the *G. palmerae* Zone (on. cit. pl. 35, figs 13a–c), Navet formation with a high trochospirally coiled test seems to be specifically distinct from Finlay's form.

The specimen from the Middle Eocene of Puerto Rico figured by Pessagno (1961, pl. 2, figs 3–5) differs from the holotype in having a low conical test and in lacking the umbilical bulla.

Distribution. *G. turgida* was originally described from the Middle Eocene of New Zealand. Jenkins (1964) gave its range as Eocene, but later (1966*a*) extended it into the Palaeocene.

In the Rakhi Nala section it occurs in the *Globorotalia formosa formosa* Zone.

Globigerina velascoensis Cushman

(Pl. 3, figs 10–12)

1925*b* *Globigerina velascoensis* Cushman: 19, pl. 3, figs 6a–c.
1970*c* *Globigerina velascoensis* Cushman; Samanta: 615, pl. 94, figs 7, 8.

Remarks. In the present material *G. velascoensis* shows appreciable variation in the degree of peripheral flattening of the later chambers and in the size of the final chamber.

According to Bolli (1957*a* : 71) *G. velascoensis* was apparently developed from *G. triangularis* White.

Distribution. *Globigerina velascoensis* was originally described from the Velasco formation of Mexico, where Hay (1960) found it to range from the *Globorotalia uncinata* Subzone (Upper Danian), to the top of the *Globorotalia velascoensis* Zone (Upper Palaeocene). Typical representatives of the species were found by the writer (1970*c*) in the Palaeocene Pondicherry Formation of southern India.

In the Rakhi Nala section *G. velascoensis* is restricted to the *Globorotalia velascoensis* Zone.

Globigerina yeguaensis Weinzierl & Applin

(Pl. 3, figs 1–3)

1929 *Globigerina yeguaensis* Weinzierl & Applin: 408, pl. 43, figs 1a–b.

REMARKS. *G. yeguaensis* is the largest species of this genus in the present material. The figured specimen closely resembles the holotype.

There is considerable difference of opinion about the true range of variation of this species. Weinzierl & Applin (1929) illustrated only the holotype and showed its dorsal and ventral sides. They did not describe any variation seen in their material.

Bolli (1957*c* : 163), in discussing material from the Middle to Upper Eocene of Trinidad, remarked that 'There is considerable variation in the specimens regarded as belonging to *Globigerina yeguaensis*'. He figured two specimens to show the main variation. One (pl. 35, fig. 15a–c), was later included by Bermudez (1961 : 1183) in the synonymy of his new species *Globigerina galavisi*.

Berggren (1960*a*) lumped together several species under *G. yeguaensis*. The statistical analysis of three assemblages from the Lower Eocene of Denmark and northwestern Germany (Berggren & Kurten 1961) indicated that this species is highly variable.

DISTRIBUTION. The reported range of *G. yeguaensis* is Lower Eocene to Oligocene. It has been recorded by the writer from the Middle and Upper Eocene of eastern India (Samanta 1969, 1970*b*) and from the Middle Eocene of western India (Samanta 1970*a*.

In the Rakhi Nala section it occurs in the *Globorotalia crassata/Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Genus ***GLOBIGERINITA*** Bronnimann 1951, emended Blow & Banner 1962

TYPE SPECIES. *Globigerinita naparimaensis* Bronnimann 1951.

Globigerinita africana Blow & Banner

(Pl. 5, figs 7–9)

1962 *Globigerinita africana* Blow & Banner: 105–106, pl. 15, figs A–C; text-fig. 11, (i–iv).

REMARKS. The specimen figured here resembles the paratype of *G. africana* Blow & Banner (text-fig. 11 (iv)) in possessing four accessory openings in the umbilical bulla. The Rakhi Nala material shows less variation than that reported by Blow & Banner (1962).

DISTRIBUTION. The reported range of *G. africana* is Middle-Upper Eocene. The writer (1970*a*) has reported it from the Middle Eocene *Orbulinoides beckmanni* Zone in Western India.

In the Rakhi Nala section it occurs in the *Globorotalia crassata/Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Globigerinita dissimilis (Cushman & Bermudez)

(Pl. 5, figs 10–12)

1937 *Globigerina dissimilis* Cushman & Bermudez: 25–26, pl. 3, figs 4–6.
1961 *Globigerinita dissimilis* (Cushman & Bermudez); Bermudez: 1262–1263, pl. 7, figs 4–5.
1970*b* *Globigerinita dissimilis* (Cushman & Bermudez); Samanta: 35, pl. 6, fig. 1.

Remarks. Cushman & Bermudez (1937) illustrated three specimens, the holotype and two paratypes, showing the ventral, peripheral, and dorsal views respectively. Later, Bolli, Loeblich & Tappan (1957 : 36) designated it as the type species of their new genus *Catapsydrax* and gave three views of the holotype showing its morphology in detail. They also figured two specimens from the Cipero formation of Trinidad to demonstrate the main morphological variation. Subsequently, *Catapsydrax* was regarded as synonymous with *Globigerinita* Bronnimann by Bermudez (1961) and Blow & Banner (1962).

The surface of the test is weakly hispid in the present specimens. The accessory openings are bordered by weakly developed narrow lip-like structures. In some specimens they are filled with extraneous material which renders satisfactory observation difficult.

Distribution. The range of *G. dissimilis* is reported to be from the upper part of the Middle Eocene to the Lower Miocene. Samanta (1970*b*) has recorded it from the Upper Eocene of the Mikir Hills, Assam.

In the Rakhi Nala section it ranges from the *Globorotalia crassata/Truncorotaloides topilensis* Zone to the *Globigerina officinalis* Zone.

Globigerinita echinata (Bolli)

(Pl. 5, figs 4–6)

1957*c* *Catapsydrax echinatus* Bolli: 165–166, pl. 37, figs 2a–5b.
1961 *Globigerinita echinata* (Bolli); Burmedez: 1263–1264.

Remarks. The convexity of the dorsal side of the test, lobation of the equatorial periphery, intensity of the surface ornamentation and the character of the bulla vary in the present material. The surface of the bulla is usually smoother than that of the rest of the test. The accessory openings are furnished with a very narrow smooth border.

G. echinata is a distinctive form of the genus. It is readily distinguished from contemporaneous species by its characteristic spinose surface.

Distribution. *Globigerinita echinata* was originally described from Trinidad where it was observed to range from the upper part of the *Globorotalia lehneri* Zone to the lower part of the *Truncorotaloides rohri* Zone.

In the Rakhi Nala section it occurs in the *Globorotalia crassata/Truncorotaloides topilensis* Zone.

Globigerinita howei Blow & Banner
(Pl. 5, figs 13–15)

1962 *Globigerinita howei* Blow & Banner: 109–110, pl. 14, figs P–R; text-fig. 11 (x–xiv).
1969 *Globigerinita howei* Blow & Banner; Samanta: 332, pl. 1, figs 3a–c.

Remarks. *G. howei* is easily distinguished from other species of the genus in the Rakhi Nala section by its exceptionally inflated, large bulla.

Distribution. *Globigerinita howei* was first described from Tanganyika, East Africa. Its reported range is Middle-Upper Eocene. This species has been recorded by the writer (1969) from the Upper Eocene of Assam, eastern India.

In the Rakhi Nala section *G. howei* ranges from the *Globorotalia crassata/Truncorotaloides topilensia* Zone to the *Globigerina officinalis* Zone.

Genus ***GLOBIGERINOIDES*** Cushman 1927

Type species. *Globigerina rubra* d'Orbigny 1839.

Globigerinoides higginsi Bolli
(Pl. 5, figs 1–3)

1957*c* *'Globigerinoides' higginsi* Bolli: 164–165, pl. 36, figs 11a–13b.
1968 *Globigerinoides higginsi* Bolli; Raju: 290, pl. 2, figs 7a–b.
1970*a* *Globigerinoides higginsi* Bolli; Samanta: 194, pl. 2, fig. 15.

Remarks. The surface of the test in well-preserved specimens is weakly hispid. The chambers enlarge regularly in size. Usually one dorsal sutural aperture is present at the intersection of the spiral suture with the intercameral suture between the penultimate and final chambers. It is often too minute to be observed clearly.

Distribution. The reported range of *G. higginsi* is from the upper part of Lower Eocene to the Middle Eocene. It has been reported from southern and western India (Raju 1968; Samanta 1970*a*).

In the Rakhi Nala section it occurs in the *Globorotalia crassata/Truncorotaloides topilensis* Zone.

Subfamily **ORBULININAE** Schultze 1854

Genus ***GLOBIGERAPSIS*** Bolli, Loeblich & Tappan 1957

Type species. *Globigerapsis kugleri* Bolli, Loeblich & Tappan 1957.

1962 *Globigerapsis* Bolli, Loeblich & Tappan; Blow & Banner: 123–124 (see for discussion).

Globigerapsis kugleri Bolli, Loeblich & Tappan
(Pl. 6, figs 4–6)

1957 *Globigerapsis kugleri* Bolli, Loeblich & Tappan: 34, pl. 6, figs 6a–c.
1968 *Globigerapsis kugleri* Bolli, Loeblich & Tappan; Raju: 290, Pl. 2, figs 8a–b.
1970*a* *Globigerapsis kugleri* Bolli, Loeblich & Tappan; Samanta: 198, pl. 2, figs 11–13.

Remarks. The size of the last chamber, the degree of depression of the sutures

and the number of sutural openings vary in this material. The final chamber may constitute about one half of the test. The apertural openings are bordered by distinct, narrow rims. The specimen figured here compares well with the holotype.

DISTRIBUTION. According to Bolli (1957*c*) this species ranges from the upper part of the *Globigerapsis kugleri* Zone to the top of the *Orbulinoides beckmanni* Zone in Trinidad. It has also been reported from Barbados, Cuba, France, western and southern India (Samanta 1970*a*; Raju 1968).

In the Rakhi Nala section it occurs in the *Globorotalia crassata/Truncorotaloides topilensis* Zone.

Globigerapsis tropicalis Blow & Banner

(Pl. 6, figs 7–8)

1962 *Globigerapsis tropicalis* Blow & Banner: 124–125, pl. 15, figs D–F.
1970*a* *Globigerapsis tropicalis* Blow & Banner; Samanta: 199, pl. 2, fig. 18.
1970*b* *Globigerapsis tropicalis* Blow & Banner; Samanta: 35, pl. 6, figs 21–23.

DISTRIBUTION. The reported range of *G. tropicalis* is Middle-Upper Eocene. The writer (1970*a* and *b*) has recorded it from the Middle Eocene of western India and from the Upper Eocene of eastern India. Raju (1968) has figured a specimen comparable to *G. tropicalis* from the Middle Eocene of southern India.

In the Rakhi Nala section *G. tropicalis* occurs in the *Globorotalia crassata/Truncorotaloides topilensis* Zone.

Genus ***GLOBIGERINATHEKA*** Bronnimann 1952

TYPE SPECIES. *Globigerinatheka barri* Bronnimann 1952.

Globigerinatheka barri Bronniman

(Pl. 6, figs 1–3)

1952*a* *Globigerinatheka barri* Bronnimann (pars): 27–28, text-figs 3a–c, g–h, *non* text-figs 3d–f.
1968 *Globigerinatheka barri* Bronnimann; Raju: 290–291, pl. 2, fig. 6.

REMARKS. The size of the final chamber, the number and size of the sutural bullae and the number of accessory openings vary in the material. The maximum number of bullae observed is four. Each bulla is usually provided with 2 to 3 accessory openings which are bordered by distinct narrow rims. It is the only representative of the genus observed in the Rakhi Nala material.

DISTRIBUTION. This characteristic species has been reported from a number of areas including western and southern India. Its reported range is Middle to Upper Eocene.

In the Rakhi Nala section *G. barri* occurs in the *Globorotalia crassata/Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Family **GLOBOROTALIIDAE** Cushman 1927

Genus ***GLOBOROTALIA*** Cushman 1927

TYPE SPECIES. *Pulvinulina menardii* (d'Orbigny) var. *tumida* Brady 1877.

1965 *Globorotalia* Cushman; Luterbacher: 635–646 (see for discussions).

Globorotalia acuta Toulmin

(Pl. 10, figs 8–10)

1941 *Globorotalia wilcoxensis* Cushman & Ponton var. *acuta* Toulmin: 608, pl. 82, figs 6–8.
1970*c* *Globorotalia acuta* Toulmin; Samanta: 615, pl. 97, figs 1, 2.

DISTRIBUTION. According to most authors *G. acuta* is restricted to the Upper Palaeocene. Samanta (1970*c*) has examined well-preserved typical representatives of *G. acuta* from the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section it occurs in the *Globorotalia velascoensis* and *Globorotalia aequa* Zones.

Globorotalia aequa Cushman & Renz

(Pl. 10, figs 1–4)

1942 *Globorotalia crassata* (Cushman) var. *aequa* Cushman & Renz: 12, pl. 3, figs 3a–c.

REMARKS. The main variation in the Rakhi Nala specimens is in the shape of the dorsal side of the test, the size of the final chamber and the intensity of the surface ornamentation, specifically along the periphery. Specimens with weakly developed spinose peripheral keels were observed.

DISTRIBUTION. According to most authors this species ranges from the base of the Upper Palaeocene to the Lower Eocene. Well preserved, abundant specimens of *G. aequa* were examined by the writer (1970*c*) from the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section it ranges from the *Globorotalia angulata* Zone to the *Globorotalia formosa formosa* Zone.

Globorotalia angulata (White)

(Pl. 8, figs 7–9)

1928 *Globigerina angulata* White: 191–192, pl. 27, figs 13a–c.
1970*c* *Globorotalia angulata* (White); Samanta: 619, pl. 96, figs 6–8.

REMARKS. The main variation in the present specimens is in the number and rate of enlargement of the chambers in the last whorl, the character of the final chamber and the ornamentation along the periphery of the test. The final chamber may be smaller than the penultimate chamber. A faint, spinose peripheral keel is observed in some individuals.

DISTRIBUTION. *G. angulata* was originally described from the Velasco formation of Mexico where, according to Hay (1960), it ranges from the upper part of the *Globorotalia uncinata* Subzone to the top of the *Globorotalia velascoensia* Zone.

Well preserved, abundant material of *G. angulata* from the Palaeocene Pondicherry Formation of southern India were examined by the writer (1970*c*).

In the Rakhi Nala section it ranges from the *Globorotalia angulata* Zone to the *Globorotalia velascoensis* Zone.

Globorotalia aragonensis Nuttall

(Pl. 8, figs 4–6)

1930 *Globorotalia aragonensis* Nuttall: 288–289, pl. 24, figs 6–8, 10–11.
1937*a* *Globorotalia aragonensis* Nuttall; Glaessner: 30, pl. 1, figs 5a–c.
1956 *Globorotalia aragonensis* Nuttall; Haque: 180, pl. 4, figs 4a–c.
1957*a* *Globorotalia aragonensis* Nuttall; Bolli: 75, pl. 18, figs 7–9.
1961 *Pseudogloborotalia aragonensis* (Nuttall); Bermudez: 1338–1340, pl. 16, figs 5a–c.
1965 *Globorotalia aragonensis* Nuttall; Luterbacher: 696, figs 121–123 only.
1968 *Globorotalia aragonensis* Nuttall; Raju: 288, pl. 3, figs 6a–c.

Remarks. The main variation observed in the Rakhi Nala material is in the number and rate of enlargement of the chambers in the last whorl, the size of the umbilicus and the peripheral ornamentation. The dorsal side in most specimens is flattened. The umbilical ends of the chambers are tightly arranged. The chambers in the last whorl do not always enlarge regularly.

When describing *G. aragonensis*, Nuttall (1930) figured the dorsal, ventral and peripheral views of one specimen and the dorsal and ventral views respectively of two others. He did not designate a holotype. Nuttall mentioned the close morphological resemblance of his form to *G. velascoensis* (Cushman) from which he distinguished it by its smaller umbilicus, fewer chambers in the last whorl and more elevated dorsal surface.

Bolli (1957*a*) considered that *G. aragonensis* was not directly related to *G. velascoensis*. In the Rakhi Nala material, this species is easily distinguished from *G. velascoensis* by its smaller test, more tightly arranged chambers in the last whorl, much smaller umbilicus, unornamented and tightly arranged umbilical chamber tips and weaker peripheral keel. According to Luterbacher (1965 : 696) the sutures on the dorsal side 'form a distinct and characteristic angle with the periphery'.

The specimen from Trinidad figured by Cushman & Renz (1948, pl. 8, figs 1–2) as *Globorotalia aragonensis* differs specifically from Nuttall's form in having an almost equally biconvex test and in lacking a peripheral keel.

Haque's (1956, pl. 4, figs 4a–c) figured specimen from the basal Laki of the Nammal Gorge, West Pakistan shows a somewhat lower test and smoother surface. Otherwise it agrees with the original definition of *G. aragonensis*.

Of the six specimens figured by Luterbacher (1965) from the Gubbio section of Central Italy, one (figs 126a–c) with 4 very rapidly enlarging chambers in the last whorl seems to be specifically distinct.

Globorotalia caucasica Glaessner, originally described as a variety of *G. aragonensis*, differs from Nuttall's species in having a much wider umbilicus, steeper lateral sides of the chambers in the last whorl, ornamented umbilical shoulders and a more prominent peripheral keel.

Mallory (1959) described a new variety, *G. aragonensis* Nuttall var. *twisselmanni*, from the Lower Eocene of California, which he distinguished from *G. aragonensis* by its more strongly curved dorsal sutures, fewer chambers in the last whorl and usually larger umbilicus. An examination of the type material of Mallory's form is necessary to determine its true relationship to *G. aragonensis*.

Distribution. *G. aragonensis* was originally described by Nuttall from the Aragon Formation of the Tampico region of Mexico. He assigned a Lower Eocene age to the Aragon Formation. However, according to Luterbacher (1965 : 696) 'the occurrence of *Hantkenina aragonensis* in its type-sample indicates a Middle Eocene age'. According to Bolli (1957*a*, *c*), it ranges from the Lower Eocene, *G. formosa formosa* Zone to the Middle Eocene, *Globigerapsis kugleri* Zone in Trinidad. Haque (1956) has reported *G. aragonensis* from the Laki of the Nammal gorge, West Pakistan. It was recently reported by Raju (1968) from the subcrops of the Cauvery basin where he found it to range from the Lower Eocene to the lower part of the Middle Eocene.

In the Rakhi Nala section *G. aragonensis* occurs in the *Globorotalia formosa formosa* and *Globorotalia aspensis/Globorotalia esnaensis* Zones.

Globorotalia aspensis (Colom)

(Pl. 15, figs 10–12)

1954 *Globigerina aspensis* Colom: 151–152, pl. 3, figs 1–35, pl. 4, figs 1–31.
1957*c* *Globorotalia aspensis* (Colom); Bolli: 166–167, pl. 37, figs 18a–c.
1961 *Globigerina aspensis* Colom; Bermudez: 1157–1158, pl. 1, figs 2a–c.
1965 *Acarinina aspensis* (Colom); Hillebrandt: 20.

Remarks. In the original description of *G. aspensis*, Colom (1954) figured numerous specimens which he regarded as belonging to two different groups, 'formas aplanadas' and 'formas trocoidales' respectively. He did not designate a holotype. It seems that only one view of each specimen was figured. His figures were of rather low magnification and the details of some morphological features are not clearly discernable.

When reporting this species from Trinidad, Bolli (1957*c*, 167) remarked that 'The position of the apertures in the type specimens of *Globigerina aspensis* figured by Colom is interiomarginal, umbilical-extraumbilical. For this reason the species is here placed in *Globorotalia*'. He also mentioned that in material from the lower Navet formation of Trinidad, *G. aspensis* shows a range of variation similar to that reported by Colom in his original description. Bolli's (1957*c*, pl. 37, figs 18a–c) figured specimen of *G. aspensis* shows more chambers in the last whorl than that reported by Colom.

Bermudez (1961 : 1157–1158, 1167) postulated that the two groups of forms distinguished by Colom (1954) belong to two different species. Accordingly he proposed the new species *Globigerina colomi* Bermudez for the specimens included by Colom in 'formas trocoidales'. It may be possible that more than one species was included in Colom's original concept of *G. aspensis*. However, an examination

of Colom's figures alone without a re-examination of his figured material, does not permit a definite decision on this matter.

According to Bolli (1957*c*) *G. aspensis* has probably developed from *Globigerina soldadoensis* Bronnimann.

DISTRIBUTION. *G. aspensis* was originally described from Alicante, south-eastern Spain, where it was found to range from the Upper Ypresian to the Lower Lutetian. Bolli (1957*c*) reported it from the *Globorotalia palmerae* Zone to the *Globigerapsis kugleri* Zone in Trinidad. The reported range of *G. aspensis* is from Lower Eocene to the lower part of the Middle Eocene.

In the Rakhi Nala section *G. aspensis* occurs in the *Globorotalia formosa formosa* and *Globorotalia aspensis/Globorotalia esnaensis* Zones.

Globorotalia broedermanni Cushman & Bermudez

(Pl. 15, figs 4–6)

1949 *Globorotalia* (*Truncorotalia*) *broedermanni* Cushman & Bermudez: 40, pl. 7, figs 22–24.
1957*a* *Globorotalia broedermanni* Cushman & Bermudez; Bolli: 80, pl. 19, figs 13–15.
1961 *Pseudogloborotalia broedermanni* (Cushman & Bermudez); Bermudez: 1340, pl. 16, figs 6a–c.
1968 *Globorotalia broedermanni* Cushman & Bermudez; Raju: 288, pl. 3, figs 3a–c.

REMARKS. The shape of the test in peripheral view and the intensity of the surface ornamentation vary in the present material. The enlargement of the chambers in the last whorl is often irregular. The specimen figured here possesses more chambers in the last whorl than does the holotype.

Cushman & Bermudez (1949) figured the dorsal view of the holotype and ventral and peripheral views of the paratype. They compared *G. broedermanni* with the Palaeocene species *G. albeari* Cushman & Bermudez, from which it was distinguished by its more open umbilicus and less acute periphery. According to the original description the number of chambers in the last whorl is greater in *G. albeari* than in *G. broedermanni*. The two species seem to be directly related.

Bolli's (1957*c*, pl. 37, figs 13a–c) figured specimens from the *Globorotalia palmerae* Zone, Navet formation of Trinidad differs somewhat from the original description of *G. brodermanni* in showing more, and less tightly arranged, chambers in the last whorl, a more lobate periphery and slightly more inflated later chambers. It also differs from the specimen figured by the same author (1957*a* pl. 19, figs 13–15) from the *Globorotalia formosa formosa* Zone, upper Lizard Springs formation of Trinidad.

Gohrbandt (1967*b* : 322) remarked that his Middle Eocene specimens of *Globorotalia mattseensis* from Austria 'are very close to *Globorotalia broedermanni* as illustrated by Bolli (1957*b*, pl. 37) from Trinidad, from the *Globorotalia palmerae* Zone, uppermost Lower Eocene . . . It is possible that the forms determined by Bolli as *Globorotalia broedermanni* in the *Hantkenina aragonensis* and *Globigerapsis kugleri* Zones of Trinidad are actually the morphologically similar *Globorotalia mattseensis* . . . The form illustrated by Bolli from the *Globorotalia palmerae* Zone of Trinidad might be transitional between *Globorotalia broedermanni* and *Globorotalia mattseensis*'. It may be possible that Gohrbandt's species is closely related to *G. broedermanni*.

However, the figured paratype of *G. mattseensis*, considered by Gohrbandt as an immature individual, seems to show a closer resemblance to *Globorotalia aspensis* (Colom).

DISTRIBUTION. *Globorotalia broedermanni* was originally described from the Lower Eocene of Cuba. It was thought to be a good index fossil for the Capdevila Formation. Bolli (1957*a*, *c*) reported it from Trinidad where he gave its range as *Globorotalia 'rex'* Zone to *Globigerapsis kugleri* Zone. Raju (1968) has reported *G. broedermanni* from the Cauvery Basin, southern India where he found it to range from the Lower Eocene to the lower Middle Eocene.

In the Rakhi Nala section, *G. broedermanni* occurs in the *Globorotalia formosa formosa* and *Globorotalia aspensis/Globorotalia esnaensis* Zones.

Globorotalia centralis Cushman & Bermudez

(Pl. 12, figs 10–12)

1937 *Globorotalia centralis* Cushman & Bermudez: 26–27, pl. 2, figs 62–65.
1968 *Turborotalia centralis* (Cushman & Bermudez); Raju: 290–291, pl. 4, figs 3a–c.
1969 *Globorotalia centralis* Cushman & Bermudez; Samanta: 333, pl. 2, figs 2a–c.
1970*a* *Globorotalia centralis* Cushman & Bermudez; Samanta: 203, pl. 1, figs 18–20.
1970*b* *Globorotalia centralis* Cushman & Bermudez; Samanta: 36.

REMARKS. In describing this species, Cushman & Bermudez showed a peripheral view of the holotype, and ventral, peripheral and dorsal views respectively of three paratypes. They did not adequately enlarge their figures. Bolli, Loeblich & Tappan (1957) provided three good illustrations of the holotype.

G. centralis is easily distinguished from the contemporaneous species of the genus in the Rakhi Nala material by its inflated chambers, nearly smooth surface, rounded periphery of the test, and large open aperture.

DISTRIBUTION. This species has been recorded from the Middle and Upper Eocene of southern India (Raju 1968), from the Middle and Upper Eocene of eastern India (Samanta 1969, 1970*b*) and from the Middle Eocene of western India (Samanta 1970*a*).

In the Rakhi Nala section it occurs in the *Globorotalia crassata/Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Globorotalia chapmani Parr

(Pl. 13, figs 13–15)

1938 *Globorotalia chapmani* Parr: 87, pl. 3, figs 8–9b.
1970*c* *Globorotalia chapmani* Parr; Samanta: 621, pl. 98, figs 15–18.

REMARKS. Parr (1938) described *Globorotalia chapmani* from borings in the Perth Basin, Western Australia. He figured the ventral and the peripheral views of the holotype and the dorsal view of another specimen. However, his figures were not sufficiently detailed. He regarded *G. chapmani* as an Upper Eocene species.

McGowran (1964), after a re-examination of Parr's original material, concluded that the King's Park Shale, from which *G. chapmani* was described, is Palaeocene in age. He illustrated four specimens, including Parr's paratype, showing the

distinctive features of *G. chapmani*. However, he neither re-illustrated the holotype nor commented on its morphology. Again, only the dorsal view of the paratype was shown.

The concept of *G. chapmani* followed here is based on McGowran's discussion and illustration.

In the present material, the rate of enlargement of the chambers in the last whorl, the degree of lobation of the periphery, and the angularity of the axial periphery all display variation. The inner whorls on the dorsal side may be raised in some specimens. From stereoscan illustrations (see Samanta 1970*c*) it appears that the peripheral margin of *G. chapmani* may not be wholly imperforate. The pores in the periphery, when present, are much finer and more widely spaced than those in the other parts of the surface.

G. chapmani is closely related to *Globorotalia compressa* (Plummer) from which it differs in having more compressed chambers and in the character of the periphery of the test. It has been suggested that it was derived from Plummer's form. Berggren & Olsson (1967) have attributed much significance to *G. chapmani* by considering it as the direct ancestor of the planispiral genus *Pseudohastigerina* Banner & Blow.

DISTRIBUTION. *G. chapmani* has been reported to range from the Middle to Upper Palaeocene. The writer (1970*c*) has observed typical representatives in the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section it occurs in the *Globorotalia velascoensis* Zone.

Globorotalia conicotruncata Subbotina

(Pl. 8, figs 1–3)

1947 *Globorotalia conicotruncata* Subbotina: 115–117, pl. 4, figs 11–13, pl. 9, figs 9–11.
1953 *Acarinina conicotruncata* (Subbotina); Subbotina: 220, pl. 20, figs 5a–8c, 10a–c; *non*. figs 9a–c, 11a–12c.

REMARKS. Unlike Subbotina (1947, 1953), the writer restricts his concept of this species to specimens with more than 5 chambers in the last whorl. The present specimens show all the distinctive features of the types of *G. conicotruncata*.

DISTRIBUTION. According to reliable reports the species ranges from the base of the Middle Palaeocene to the Upper Palaeocene. The writer has examined well-preserved specimens of *G. conicotruncata* from the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section *G. conicotruncata* ranges from the *Globorotalia angulata* Zone to the *Globorotalia velascoensis* Zone.

Globorotalia crassata (Cushman)

(Pl. 11, figs 7–9)

1925*d* *Pulvinulina crassata* Cushman: 300–301, pl. 7, fig. 4.
1964*a* *Globorotalia crassata* (Cushman); Bandy: 34–35, text-fig. 1a–c.

Remarks. The specimen figured here agrees well with the description and illustrations of the lectotype of *G. crassata*, (see Bandy 1964*a*).

In the Rakhi Nala material the final chamber is very often smaller than the penultimate and appears to be smoother than the earlier chambers. The periphery of the test varies from just spinose to distinctly keeled. The ornamentation of the umbilical shoulders and dorsal sutures is variable. The chambers in the last whorl often enlarge irregularly.

The present investigation does not support Bandy's (1964*a*) postulation that *G. crassata* is intermediate between *Globorotalia angulata* (White) and *Globorotalia rex* Martin.

As pointed out by Luterbacher (1965) the lectotype of *G. crassata* bears a close morphological resemblance to *Globorotalia marginodentata* Subbotina.

Distribution. *Globorotalia crassata* was originally described from the Eocene of Mexico. In selecting the lectotype of *G. crassata* Bandy (1964*a*: 35) noted that 'Its exact range is not known; however, it appears to extend from the Upper Paleocene through the Lower Eocene into the Middle Eocene'. Banner & Blow (1965 : 113) correctly pointed out that 'the range of *G. crassata* given by Bandy (1964*a*, p. 35) is a synthesis of old and incorrect records, which do not apply to the lectotype'.

G. crassata has been recorded by the writer (1970*a*) from the Middle Eocene of Western India. In the Rakhi Nala section it occurs in the *Globorotalia crassata*/*Truncorotaloides topilensis* Zone.

Globorotalia ehrenbergi Bolli

(Pl. 13, figs 4–6)

1957*a* *Globorotalia ehrenbergi* Bolli: 77, pl. 20, figs 18–20.
1960*b* *Globorotalia ehrenbergi* Bolli; Bolli & Cita: 382–383, pl. 35, figs 4a–c.
1963 *Globorotalia ehrenbergi* Bolli; Dallan: 15–16, pl. 1, figs 3a–c.

Remarks. The earlier chambers on the dorsal side may be slightly depressed below the outer whorl. The final chamber in some individuals is smaller than the penultimate. Although the present specimens agree quite well with the original description of *G. ehrenbergi*, the specimen figured here shows slightly more chambers in the last whorl than does the holotype, and has a more prominent apertural lip and weakly curved ventral sutures.

G. ehrenbergi is closely related to *Globorotalia compressa* (Plummer) from which it is thought to have been derived. Loeblich & Tappan (1957*a* : 188) considered the former to be a junior synonym of the latter, a view which Berggren (1962 : 96) regarded as unjustified.

Bolli (1957*a* : 77) remarked that 'Ehrenberg (1854) figured under *Planulina membranacea* the spiral views of 2 rotalid Foraminifera from the Cretaceous that are at least specifically different. Of these, one (pl. 26, fig. 43) could be near to a form subsequently described on several occasions as *Globorotalia membranacea* . . . No description or depository of a holotype was given by Ehrenberg however. It is for these reasons that a new name had to be chosen for these Paleocene specimens

described as *Globorotalia membranacea'*. However, as pointed out by Loeblich & Tappan (1957*a* : 193) and accepted by others including Bolli & Cita (1960*b*), some of the keeled specimens from the Palaeocene earlier referred to *Globorotalia membranacea* (Ehrenberg) actually belong to *Globorotalia pseudomenardii* Bolli.

G. ehrenbergi resembles to *G. chapmani* Parr from which it differs in having more chambers, a less rapid enlargement of the chambers in the last whorl, a somewhat more compressed test and no 'imperforate' marginal band. McGowran (1968, pl.4, fig. 12) recently regarded *G. ehrenbergi* Bolli as a subspecies of *G. chapmani*.

Globorotalia haunsbergensis Gohrbandt (1963), described from the Palaeocene of Austria, was considered by Berggren & Olsson (1967 : 266) to be a junior synonym of *G. ehrenbergi*. Gohrbandt mentioned that *G. ehrenbergi* is distinguished from *G. haunsbergensis* essentially by the slower rate of the enlargement of the chambers and only slightly curved and more strongly depressed sutures on the dorsal side of the test. *G. haunsbergensis* is not here regarded as a synonym of *G. ehrenbergi*.

DISTRIBUTION. *G. ehrenbergi* was originally described from the Palaeocene, lower part of the Lizard Springs Formation of Trinidad and reported to range from the base of the *G. pusilla pusilla* Zone to the middle of the *G. pseudomenardii* Zone. Earlier, Subbotina (1953) had reported it as *Globorotalia membranacea* (Ehrenberg) from the Palaeocene of the Caucasus. It has also been reported from several other European localities.

In the Rakhi Nala section *G. ehrenbergi* occurs in the *Globorotalia velascoensis* Zone.

Globorotalia esnaensis (Le Roy)

(Pl. 15, figs 7–9)

1953 *Globigerina esnaensis* Le Roy: 31, pl. 6, figs 8–10.

REMARKS. The Rakhi Nala specimens show all the distinctive features of *G. esnaensis*. The main variation observed is in the degree of flattening of the dorsal side of the test, the shape and rate of enlargement of the chambers in the last whorl and the size of the aperture.

Le Roy (1953) compared *G. esnaensis* with *Globorotalia quadrata* (White) from which he distinguished the former by its roughened surface, more inflated last chamber and wider umbilicus. The two species, as represented in the Rakhi Nala material, are regarded as belonging to two distinctly different groups.

DISTRIBUTION. According to most authors this species ranges from the base of the Upper Palaeocene to the Lower Eocene. The writer (1970*c*) has examined abundant, well-preserved material of *G. esnaensis* from the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section *G. esnaensis* ranges from the *Globorotalia aequa* Zone to the *Globorotalia aspensis/Globorotalia esnaensis* Zone.

Globorotalia formosa formosa Bolli

(Pl. 9, figs 1–3)

1957*a* *Globorotalia formosa formosa* Bolli: 76, pl. 18, figs 1–3.

Remarks. Although the Rakhi Nala specimens agree satisfactorily with the original description and illustration of the subspecies, individuals with 8 chambers in the last whorl were not observed. The enlargement of the chambers in the last whorl may be irregular. Often the final chamber is smaller than the penultimate one. The sutures are incised round the umbilicus.

Distribution. The reported range of the subspecies is Upper Palaeocene to Lower Eocene. The writer has examined well-preserved, typical specimens of *G. formosa formosa* from the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section *G. formosa formosa* occurs in the *Globorotalia formosa formosa* Zone.

Globorotalia formosa gracilis Bolli

(Pl. 11, figs 4–6)

1957*a* *Globorotalia formosa gracilis* Bolli: 75–76, pl. 18, figs 4–6.

Remarks. The main variation observed in the Rakhi Nala specimen is in the shape of the test in peripheral view, the rate of enlargement of the chambers in the last whorl and in the size of the umbilicus. The chambers in the last whorl may enlarge irregularly.

Bolli (1957*a* : 66) has indicated that *G. formosa gracilis* was probably derived from *G. aequa* Cushman & Renz.

Distribution. The range of this subspecies is reported to be Upper Palaeocene to Lower Eocene. The writer has examined well-preserved, typical specimens of *G. formosa gracilis* from the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section *G. formosa gracilis* occurs in the *Globorotalia formosa formosa* Zone.

Globorotalia irrorata Loeblich & Tappan

(Pl. 14, figs 4–6)

1957*a* *Globorotalia irrorata* Loeblich & Tappan: 191, pl. 46, figs 2a–c; pl. 61, figs 5a–c.
1966 *Globorotalia irrorata* Loeblich & Tappan; El-Naggar: 216–217, pl. 23, figs 9a–c.

Remarks. The Rakhi Nala specimens agree most closely to *G. irrorata* Loeblich & Tappan to which they are assigned here. The specimen figured here compares well with the holotype of *G. irrorata*.

In the present material, *G. irrorata* shows a close resemblance to *Globorotalia quadrata* (White) from which it seems to have been derived by the development of the spinose surface.

In the course of his investigation on the Lower Eocene planktonic foraminifera from Denmark and northwestern Germany, Berggren (1960*a*) assigned specimens

with roughly subcircular equatorial periphery, 5 chambers in the last whorl, wide umbilicus and umbilical aperture to Loeblich & Tappan's species which he transferred to the genus *Globigerina*. As pointed out by El-Naggar (1966 : 217) Berggren's figured specimen of *G. irrorata* differs distinctly from the holotype of *G. irrorata*.

Berggren (1960*a* : 67) remarked that it is questionable whether the paratype of *G. irrorata* figured by Loeblich & Tappan is conspecific with its holotype. As can be seen from the figures, the paratype differs from the holotype in lacking the small final chamber.

G. irrorata was compared by its authors with *Globigerina soldadoensis* Bronnimann and *Globorotalia convexa* Subbotina. These three species as represented in the present material are distinctly different from each other.

Distribution. The holotype of *G. irrorata* was described from the Nanafalia Formation of Alabama, U.S.A., which was considered by Loeblich & Tappan (1957*a*, *b*) as Lower Eocene in age, but later studies have proved it to be Palaeocene. The paratype was described from the underlying Coal Bluff marl member of the Naheola Formation of Alabama. El-Naggar (1966) has reported *G. irrorata* as a rare to common form in the Upper Palaeocene of Nile Valley, Egypt.

In the Rakhi Nala section *G. irrorata* ranges from the *Globorotalia velascoensis* Zone to the *Globorotalia aspensis*/*Globorotalia esnaensis* Zone.

Globorotalia lehneri Cushman & Jarvis

(Pl. 14, figs 12–14)

1929 *Globorotalia lehneri* Cushman & Jarvis: 17, pl. 3, figs 16a–c.
1968 *Globorotalia lehneri* Cushman & Jarvis; Raju: 290, pl. 4, figs 1a–c.
1969 *Globorotalia lehneri* Cushman & Jarvis; Samanta: 334, pl. 2, figs 7a–c.
1970*a* *Globorotalia lehneri* Cushman & Jarvis; Samanta: 203, pl. 3, figs 13, 14.

Remarks. The Rakhi Nala specimens are closely comparable to *G. lehneri* although individuals with radially elongated later chambers were not observed. The aperture appears to be furnished with a thin lip.

G. lehneri is distinguished from *Globorotalia spinulosa* Cushman by its compressed test, greater number of chambers in the last whorl, distinctly radially elongate later chambers and smoother surface. Bolli (1957*c* : 168) has suggested that *G. lehneri* was probably derived from *G. spinulosa*.

Globorotalia nagappai Raju (1968) described from the Lower Eocene *Globorotalia rex* to *Globorotalia palmerae* Zones of the Cauvery basin, southern India, shows strong affinities to *G. lehneri* although it differs in being smaller in size and in having fewer and more rapidly enlarging chambers in the last whorl.

Distribution. *G. lehneri* had been reported from several areas including western India (Samanta 1970*a*), eastern India (Samanta 1969) and southern India (Raju 1968). According to most authors it is restricted to the Middle Eocene.

In the Rakhi Nala section *G. lehneri* occurs in the *Globorotalia crassata*/*Truncorotaloides topilensis* Zone.

Globorotalia marginodentata Subbotina

(Pl. 11, figs 1–3)

1953 *Globorotalia marginodentata* Subbotina (pars): 212–213, pl. 17, figs 15a–16c; pl. 18, figs 2a–3c; non pl. 17, figs 14a–c; non pl. 18, figs 1a–c.

Remarks. The main variation in the Rakhi Nala specimen is in the shape of the test in peripheral view, the number of chambers in the last whorl, and in the size of the final chamber. The umbilicus is narrow and deep, and the umbilical shoulders are without special ornamentation.

Distribution. The range of the species is reported to be Upper Palaeocene to Lower Eocene. The writer has examined well preserved, typical representatives of *G. marginodentata* from the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section *G. marginodentata* ranges from the *Globorotalia aequa* Zone to the *Globorotalia formosa formosa* Zone.

Globorotalia occlusa Loeblich & Tappan

(Pl. 10, figs 11–13)

1957*a* *Globorotalia occlusa* Loeblich & Tappan: 191, pl. 64, figs 3a–c; ?pl. 55, figs 3a–c.

Remarks. This taxon is used here in the sense of Hillebrandt (1962*b*), Gohrbandt (1963) and Luterbacher (1965).

The main variation observed in the Rakhi Nala material is in the shape of the test in peripheral view, the number and rate of enlargement of the chambers in the last whorl, and in the size of the umbilicus.

Distribution. According to most authors this species is restricted to the Upper Palaeocene. The writer (1970*c*) has examined well-preserved, abundant material of *G. occlusa* from the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section *G. occlusa* occurs in the *Globorotalia velascoensis* and *Globorotalia aequa* Zones.

Globorotalia parva Rey

(Pl. 9, figs 4–6)

1955 *Globorotalia velascoensis* (Cushman) var. *parva* Rey: 209, pl. 12, figs 1a–b.

Distribution. *G. parva* is reported to be restricted to the Upper Palaeocene. The writer (1970*c*) has examined well-preserved typical representatives of *G. parva* from the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section *G. parva* occurs in the *Globorotalia velascoensis* and *Globorotalia aequa* Zones.

Globorotalia aff. *primitiva* (Finlay)

(Pl. 14, figs 9–11)

?1947 *Globoquadrina primitiva* Finlay: 291, pl. 8, figs 129–134.

Remarks. The Rakhi Nala specimens are characterized by a low trochospirally coiled test; flattened dorsal side; strongly convex ventral side; subquadrate, lobate equatorial periphery; subrounded axial periphery; about $3\frac{1}{2}$ to 4 subglobular to subangular, rapidly enlarging chambers in the last whorl; straight to slightly curved sutures, deeply depressed on the ventral side, slightly depressed on the dorsal; small, deep umbilicus; coarsely spinose surface and low arched umbilical—extraumbilical aperture. The degree of flattening of the dorsal side of the test, angularity of the chambers in the last whorl and the size and shape of the final chamber show variation in the material. The final chamber is often strongly flattened and may be large enough in some specimens to occupy about half of the whole ventral side of the test. The umbilical region may be more coarsely ornamented than the rest of the test.

The present specimens differ from the types in lacking the mamillated surface and deeply incised sutures.

The present specimens also closely resemble *Globorotalia triplex* (Subbotina) described from the Palaeocene-Lower Eocene of Northern Caucasus, U.S.S.R. Gohrbandt (1963) has treated *G. triplex* as a junior synonym of *G. primitiva*.

Distribution. *G. primitiva* was described by Finlay (1947) from the Middle Eocene of New Zealand where according to Jenkins (1966*a*), it ranges from his *G. triloculinoides* Zone, Palaeocene to his *G. inconspicua inconspicua* Zone, lower Upper Eocene.

In the Rakhi Nala section *G.* aff. *G. primitiva* occurs in the *Globorotalia crassata*/*Truncorotaloides topilensis* Zone.

Globorotalia pseudobulloides (Plummer)

(Pl. 12, figs 1–3)

1926 *Globigerina pseudobulloides* Plummer: 133–134, pl. 8, figs 9a–c.

Remarks. In the original description of *G. pseudobulloides* Plummer figured three specimens showing the dorsal, peripheral and ventral views respectively. She did not designate a holotype. Later, Loeblich & Tappan (1957*a*, pl. 44, figs 6a–c) illustrated three views of a topotype showing its morphology in detail.

The Rakhi Nala specimens show all the distinctive features of the species. The number and the rate of enlargement of the chambers in the last whorl, size of the final chamber and the height of the aperture all show variation. In the figured specimen the first chamber of the final whorl is partly damaged.

Distribution. According to most authors, *G. pseudobulloides* ranges from the base of the Danian to the Upper Palaeocene. There are several reports of the species in the Indian region. The writer (1970*c*) has examined well-preserved, typical individuals from the Palaeocene Pondicherry Formation of southern India.

In the Rakhi Nala section *G. pseudobulloides* occurs in the *Globorotalia velascoensis* Zone.

Globorotalia pseudomenardii Bolli

(Pl. 13, figs 7–9)

1957*a* *Globorotalia pseudomenardii* Bolli: 77, pl. 20, figs 14–17.

Remarks. The Rakhi Nala specimens show all the distinctive features of *G. pseudomenardii*. The main variation observed is in the convexity of the dorsal side of the test, the degree of development of the peripheral keel and the rate of enlargement of chambers. Individuals with the final chamber smaller than the penultimate, and with a moderately lobate periphery occur.

Bolli (1957*a*) figured the holotype and the dorsal side of a paratype which was about twice as large. In the paratype the final chamber appears to be slightly smaller than the penultimate, and the equatorial periphery of the test is prominently lobate.

G. pseudomenardii is a very distinctive species. It differs from *G. chapmani* in having raised early chambers on the dorsal side of the test and a distinct peripheral keel. According to Bolli (1957*a*) *G. pseudomenardii* is closely related to *Globorotalia ehrenbergi* Bolli from which it seems to have been derived.

Distribution. *G. pseudomenardii* was first described from the lower part of the Lizard Springs Formation of Trinidad where it was found to be restricted to the *G. pseudomenardii* Zone. It has been reported from numerous other localities, and has been said to range through an interval corresponding to the combined *G. pseudomenardii* and *G. velascoensis* Zones of Bolli. The writer (1970*c*) has examined materials from the Pondicherry formation of southern India where *G. pseudomenardii* was found to range throughout the Upper Palaeocene.

In the Rakhi Nala section it occurs in the *Globorotalia velascoensis* Zone.

Globorotalia quadrata (White)

(Pl. 12, figs 4–6)

1928*a* *Globigerina quadrata* White: 195, pl. 27, figs 18a–b.

Remarks. White (1928*a*) figured only the ventral and dorsal views of a single specimen. His figures were of rather low magnification and the details of some features are not readily observed. He stated that the aperture was obscured. To the best of the writer's knowledge, no attempt has since been made to discuss and demonstrate in detail the morphological characteristics and the variability of the species either in the type or in topotypic material.

Bolli (1957*a*) assigned specimens with an extra-umbilical-umbilical aperture to this species which he accordingly transferred to the genus *Globorotalia*, a change accepted by later workers.

In the Rakhi Nala material, the main variation is in the rate of enlargement of the chambers in the last whorl and the shape and size of the final chamber. The

four chambers in the last whorl may be subequal in size. Often the final chamber is smaller than the penultimate in size.

G. quadrata is readily distinguished from *Globorotalia pseudobulloides* (Plummer) by its fewer less rapidly enlarging and more tightly arranged chambers in the last whorl, the quadrate equatorial outline of the test and the character of the intercameral sutures.

The two specimens from the basal Laki of Western Pakistan identified by Haque (1956, pl. 26, figs 7–8) as *Globigerina quadrata* White are inadequately illustrated and do not show the distinctive features of the species.

Distribution. White (1928*a* : 195) described *G. quadrata* from the Tampico Embayment of Mexico where Hay (1960) found it to range from the *Globigerinoides daubjergensis* Subzone, lower part of the Velasco Formation to the *Globorotalia velascoensis* Zone, top of the Velasco Formation. The writer (1970*c*) has examined well-preserved, typical representatives from the Palaeocene Pondicherry formation of southern India.

In the Rakhi Nala section *G. quadrata* occurs in the *Globorotalia formosa formosa* and *Globorotalia aspensis/Globorotalia esnaensis* Zones.

Globorotalia quetra Bolli

(Pl. 10, figs 5–7)

1957*a* *Globorotalia quetra* Bolli: 79–80, pl. 19, figs 1–6.
1961 *Pseudogloborotalia quetra* (Bolli); Bermudez: 1348.
1962*b* *Globorotalia* (*Acarinina*) *quetra* Bolli; Hillebrandt: 144, pl. 14, figs 2a–c.
1965 *Acarinina quetra* (Bolli); Hillebrandt: 17.

Remarks. The Rakhi Nala specimens agree well with the original definition of the species. The chambers in the last whorl are elongated in the direction of coiling. The later chambers are usually peripherally flattened. The intensity of the surface ornamentation varies. The dorsal side of the test appears to be less spinose than the ventral. As pointed out by Bolli (1957*a*) *G. quetra* bears a close morphological resemblance to the *Truncorotaloides rohri-topilensis* group of forms. However, the sutural opening on the dorsal side of the test, the characteristic feature of the representatives of the genus *Truncorotaloides*, is lacking in *G. quetra*.

Bolli distinguished *G. quetra* from *Globorotalia wilcoxensis* Cushman & Ponton by the distinct angular shape of the test. He reported the occurrence of forms intermediate between these two species in the lower part of the Upper Lizard Springs formation of Trinidad. *Globorotalia whitei* Weiss was regarded by Bolli as the ancestral form of *G. quetra*.

The specimen from the Lower Eocene of Caucasus, U.S.S.R. figured by Subbotina (1953, pl. 22, figs 1a–c) as *Acarinina pseudotopilensis* strongly resembles *G. quetra* in possessing subangular, peripherally flattened chambers in the last whorl, and a coarsely spinose surface. The chambers are elongated in the direction of coiling.

According to El-Naggar (1966 : 192) some specimens with weak marginal keels described by Loeblich & Tappan (1957*a*) as *Globorotalia aequa* Cushman & Renz probably belong to *G. quetra* Bolli.

DISTRIBUTION. *Globorotalia quetra* was described by Bolli (1957*a*) from the Lower Eocene, Upper Lizard Springs formation of Trinidad. Its reported range is Upper Palaeocene to Lower Eocene.

In the Rakhi Nala section *G. quetra* ranges from the Upper Palaeocene *Globorotalia aequa* Zone to the Lower Eocene *Globorotalia formosa formosa* Zone.

Globorotalia renzi Bolli

(Pl. 13, figs 10–12)

1957*c* *Globorotalia renzi* Bolli: 168, pl. 38, figs 3a–c.

REMARKS. The specimen figured here closely resembles the holotype. With its compressed biconvex test, smooth surface and thin peripheral keel, *G. renzi* is readily distinguished from contemporaneous species in the Rakhi Nala material.

In his original description, Bolli compared *G. renzi* only with *Globorotalia lehneri* Cushman & Jarvis. In the writer's view these two species belong to different groups.

DISTRIBUTION. Originally described from the Middle Eocene of Trinidad by Bolli, the species is reported to range from Lower to Middle Eocene. The writer (1970*a*) has recorded *G. renzi* from the Middle Eocene *Orbulinoides beckmanni* and *Truncorotaloides rohri* Zones of western India.

In the Rakhi Nala section *G. renzi* occurs in the *Globorotalia crassata*/*Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Globorotalia spinuloinflata (Bandy)

1949 *Globigerina spinuloinflata* Bandy: 122, pl. 23, figs 1a–c.
1968 *Globorotalia spinuloinflata* (Bandy); Raju: 290, pl. 3, figs 1a–b.
1969 *Globorotalia spinuloinflata* (Bandy); Samanta: 335, pl. 2, figs 5a–c.
1970*a* *Globorotalia spinuloinflata* (Bandy); Samanta: 204, pl. 3, figs 1–4.

REMARKS. The Rakhi Nala specimens show all the diagnostic features of the species. *Globorotalia crassata* var. *densa* (Cushman), first described from Mexico, may be closely related to *G. spinuloinflata*. However, the absence of an illustration in the original publication of Cushman's form does not permit a proper comparison with the present species.

DISTRIBUTION. This species is reported to range from the Lower Eocene to the upper Middle Eocene. It has been reported from the Middle Eocene of eastern India (Samanta 1969), western India (Samanta 1970*a*) and southern India (Raju 1968).

In the Rakhi Nala section *G. spinuloinflata* occurs in the *Globorotalia crassata*/*Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Globorotalia spinulosa Cushman

(Pl. 14, figs 1–3)

1927 *Globorotalia spinulosa* Cushman: 114, pl. 23, figs 4a–c.
1969 *Globorotalia spinulosa* Cushman; Samanta: 335, pl. 2, figs 6a–c.
1970*a* *Globorotalia spinulosa* Cushman; Samanta: 204, pl. 3, figs 7–8.

REMARKS. In the present material this species shows variation in the shape of the dorsal side of the test, the number and rate of enlargement of the chambers in the last whorl, and in the intensity of the surface ornamentation. The earlier chambers may be more coarsely ornamented than the later ones. The spines along the periphery of the test, when close spaced, produce a keel-like structure The final chamber may constitute about one-third of the ventral side of the test. The specimen figured here closely resembles the illustrations of the holotype.

When commenting on Bandy's (1964*a*) selection of a lectotype for *Globorotalia crassata* (Cushman), Banner & Blow (1965 : 113) wrote: 'Bandy's lectotype . . . is virtually identical to Bolli's hypotypes of *Globorotalia spinulosa* (Bolli, 1957*a*, p. 168, pl. 38, figs 6, 7) and is very similar indeed to the holotype of *G. spinulosa* as originally figured by Cushman, 1927. Thus, as a result of Bandy's work, it can be seen that *G. crassata* (Cushman, 1925) is a prior synonym of *G. spinulosa* Cushman, 1927'.

Globorotalia spinulosa can be satisfactorily distinguished from *G. crassata* by its smaller, more delicate test; fewer, and more rapidly enlarging chambers in the last whorl; narrower umbilicus and weaker peripheral ornamentation.

DISTRIBUTION. *Globorotalia spinulosa* was first described from the 'Upper Eocene Alazan Clay' of Mexico. In well-described sections *G. spinulosa* does not range above the Middle Eocene. The reports of its occurrence in the Lower Eocene need verification. The writer (1969 and 1970*a*) has recorded *G. spinulosa* from the Middle Eocene of eastern India and western India.

In the Rakhi Nala section *G. spinulosa* occurs in the *Globorotalia crassata*/*Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Globorotalia subbotinae Morozova

(Pl. 10, figs 14–16)

1939 *Globorotalia subbotinae* Morozova: 80, pl. 2, figs 16–17.

REMARKS. The Rakhi Nala specimens show all the distinctive features of *G. subbotinae*. The main variation observed is in the shape of the dorsal side of the test, the number and rate of the enlargement of the chambers in the last whorl and the intensity of the surface ornamentation, especially along the periphery.

The two specimens from the *Globorotalia rex* Zone of the Cauvery Basin, southern India, figured by Raju (1968, pl. 3, figs 4a–5) as *G. rex* Martin show some resemblance to *G. subbotinae*.

DISTRIBUTION. The recorded range of *G. subbotinae* is Upper Palaeocene to Lower Eocene. The writer (1970*c*) has examined well preserved material of *G. subbotinae* from the Palaeocene Pondicherry Formation of southern India.

In the Rakhi Nala section *G. subbotinae* ranges from the *Globorotalia aequa* Zone to the *Globorotalia formosa formosa* Zone.

Globorotalia tadjikistanensis Bykova

(Pl. 8, figs 10–12)

1953 *Globorotalia tadjikistanensis* Bykova: 86, pl. 3, figs 5a–c.
1965 *Globorotalia tadjikistanensia* Bykova; Luterbacher: 663–665, text-figs 52a–c.

REMARKS. The Rakhi Nala specimens show most of the distinctive features of *G. tadjikistanensis*, although a specimen like the holotype, i.e. with about 8 chambers in the last whorl, was not observed.

G. tadjikistanensis shows some resemblance to *G. conicotruncata* Subbotina, but is readily distinguished by the biconvexity of its test. Subbotina's form also possesses a more acute axial periphery, often with a faint keel, and usually has a more distinctly developed umbilicus.

Bykova's species differs from *G. angulata* in having more chambers in the last whorl and in the convexity of the dorsal side of the test. The chambers in the last whorl also enlarge more slowly than in *G. angulata*. According to Bykova, *G. tadjikistanensis* was derived directly from *G. angulata*.

The biconvex test of *G. tadjikistanensis* also resembles *Globorotalia simulatilis* (Schwager) as discussed and illustrated by Luterbacher (1965). The latter is distinguished by having fewer chambers in the last whorl and usually in being less convex dorsally.

DISTRIBUTION. *G. tadjikistanensis* was originally described from the *Globorotalia tadjikistanensis* Zone in Central Asia. It was reported by Leonov & Alimarina (1961) from the Palaeocene, *Globorotalia conicotruncata/Globorotalia tadjikistanensis* Zone of the Caucasus. Luterbacher (1965) reported it from the Gubbio section of Central Italy where he found it to range from the middle of the *Globorotalia pusilla pusilla* Zone to the middle of the *G. pseudomenardii* Zone.

In the Rakhi Nala section *G. tadjikistanensis* occurs in the *Globorotalia velascoensis* Zone.

Globorotalia troelseni Loeblich & Tappan

(Pl. 13, figs 1–3)

1957*a* *Globorotalia troelseni* Loeblich & Tappan: 196, pl. 60, figs 4a–c; pl. 63, figs 5a–c.
1957*a* *Globorotalia elongata* Glaessner; Bolli: 77, pl. 20, figs 11–13.

REMARKS. This species is distinguished from its close relatives in the Rakhi Nala material by its distinctly elongate test, greater number of chambers in the last whorl, and tendency to become evolute.

In the original description, Loeblich & Tappan figured the holotype and one paratype. The large subcircular opening in the holotype appears to be a foramen and the final chamber seems not to be preserved. The prominent keel-like structure shown in the peripheral view of the holotype is somewhat unusual in this group of

forms. In contrast to the holotype, the paratype shows a subacute axial periphery without a keel, and the earlier whorls are not visible within the umbilicus.

Gohrbandt (1967*a*) and Berggren & Olsson (1967) considered *G. troelseni* to be a junior synonym of *G. chapmani* Parr. However, the former differs in having a more elongate test, more, but less rapidly enlarging, chambers in the last whorl, in its tendency towards evolute coiling in the last whorl, and in lacking an 'imperforate' marginal band.

In its elongate test, about 6 slowly enlarging chambers in the last whorl, depressed early spire on the dorsal side and subacute axial periphery, Bolli's (1957*a*) figured specimen of *Globorotalia elongata* Glassener from the *G. pseudomenardii* Zone of Trinidad seems to fall within the range of variation of *G. troelseni*. It closely resembles the figured paratype.

Berggren's (1960*c*, pl. 1, figs 21a–c) figured specimen of *G. troelseni* from the Upper Palaeocene of Nigeria shows a more rounded axial periphery but is otherwise similar to the types.

The holotype of *Globorotalia emilei* El-Naggar resembles very closely the figured paratype of *G. troelseni*. However, El-Naggar did not compare his species with *G. troelseni*, and an examination of well-preserved material of *G. emilei* is needed to establish their relationships.

The specimen from the Palaeocene of Austria figured by Gohrbandt (1963, pl. 6, figs 13–15) as *G. troelseni* shows all the distinctive features of *G. chapmani* to which I think it belongs.

The preservation of the specimen from the Esna-Idfu region of Egypt recorded by El-Naggar (1966, pl. 17, figs 10a–c) as *G. troelseni* is not satisfactory enough to make definite remarks about its identification.

DISTRIBUTION. The holotype of *G. troelseni* was described from the Nanafalia formation of Alabama and the figured paratype from the Velasco formation of Mexico. Some records of *G elongata* Glaessner seem to refer to *G. troelseni*. This species apparently ranges from Middle to Upper Palaeocene.

In the Rakhi Nala section, *G. troelseni* occurs in the *Globorotalia velascoensis* Zone.

Globorotalia varianta (Subbotina)

(Pl. 12, figs 7–9)

1947 *Globigerina pseudobulloides* Plummer; Subbotina: 106–107, pl. 4, figs 8–10.
1953 *Globigerina varianta* Subbotina (pars): 63–64, pl. 3, figs 5a–7c, 9a–12c; pl. 4, figs 1a–3c; ?pl. 15, figs 1a–3c; *non* pl. 3, figs 8a–c.
1957*a* *Globigerina triloculinoides* Plummer; Bolli (pars): 70, pl. 17, figs 25–26; *non* pl. 15, figs 18–20.
1962*b* *Globorotalia* (*Globorotalia*) *varianta* (Subbotina); Hillebrandt: 125, pl. 12, figs 10a–11b.
1963 *Globigerina pseudobulloides varianta* Subbotina; Gohrbandt: 45, pl. 1, figs 16–18.
1965 *Globorotalia varianta* (Subbotina); Berggren: 295–196, text-fig. 12a–c.

REMARKS. Subbotina (1953) illustrated fourteen specimens in her original description. Of these, one (pl. 3, figs 8a–c) has a spinose surface and three others (pl. 15) have abnormal final chambers. These four should not be assigned to *G. varianta* in the opinion of the present author.

Because of its extraumbilical-umbilical aperture the species was removed by later workers from the genus *Globigerina* to *Globorotalia*.

The Rakhi Nala specimens show all the distinctive features of *G. varianta*. However, the aperture is slightly higher in these specimens than in the holotype and figured paratypes. Individuals with slightly less than 4 chambers in the last whorl are present. Often the final chamber tends to be radially elongate. The surface of the test is usually finely perforate.

As observed by Subbotina (1953), *G. varianta* is morphologically very similar to *Globorotalia pseudobulloides* (Plummer). Earlier, (1947) she included a specimen of *G. varianta* in *G. pseudobulloides*. Gohrbandt (1963) treated *G. varianta* as a subspecies of *G. pseudobulloides*, while Berggren (1962) and El-Naggar (1966) regarded it as a junior synonym of *G. pseudobulloides*. However, as noted by some previous authors the two species are morphologically and stratigraphically distinct.

Gohrbandt (1963 : 45) suggested that *Globorotalia quadrata* (White) (=*Globigerina quadrata*) may be senior synonym of *G. varianta*. Specimens transitional between them occur in the Rakhi Nala material.

As pointed out by Gohrbandt (1963), Bolli's (1957*a*, pl. 17, figs 25–26) figured specimen of *Globigerina triloculinoides* Plummer from the Palaeocene of Trinidad should be placed in synonymy with *G. varianta*.

The prominently spinose specimens with 5–6 chambers in the last whorl which Loeblich & Tappan (1957*a*) identified as *G. varianta* are here regarded as a different species.

The specimen figured by Berggren (1965, text-fig. 12a–c) from the Mexia Clay of Texas differs from the holotype in having a less tightly coiled test, a wider umbilicus and a higher aperture.

Berggren's (1965) statement that Said & Kerdany's (1961, pl. 1, figs 3a–c) figured specimen of *Globigerina eocaena* Gümbel from the Palaeocene of Egypt belongs to *G. varianta* is not accepted here. The Egyptian specimen differs from *G. varianta* in having slowly enlarging and less inflated chambers, and a subrounded to subangular axial periphery.

Distribution. *G. varianta* was first described from the Zone of Rotalia-like Globorotalias, Elburgan horizon, of the Caucasus. Subbotina (1953) gave the range as ?Danian to Middle Eocene. This long stratigraphic range has not been accepted by later workers.

G. varianta is widely distributed and has been reported from the Palaeocene of Austria, Trinidad, U.S.A. and North Africa. According to most workers it ranges from the Palaeocene to the Lower Eocene.

In the Rakhi Nala section *G. varianta* ranges from the *Globorotalia velascoensis* Zone to the *Globorotalia aspensis*/*Globorotalia esnaensis* Zone.

Globorotalia velascoensis (Cushman)

(Pl. 9, figs 7–9)

1925*b* *Pulvinulina velascoensis* Cushman: 19, pl. 3, figs 5a–c.
1956 *Globorotalia velascoensis* (Cushman); Haque: 181, pl. 24, figs 2a, b.
1970*c* *Globorotalia velascoensis* (Cushman); Samanta: 636, pl. 97, figs 7–10.

Remarks. The main variation observed in the Rakhi Nala material is in the number and rate of enlargement of the chambers in the last whorl, the degree of lobation of the equatorial periphery, the size of the umbilicus, and the degree of ornamentation. With its large, planoconvex, multichambered test; wide, open umbilicus and heavily ornamented umbilical shoulders, peripheral keel and dorsal sutures, *G. velascoensis* is one of the most conspicuous and readily recognizable planktonic foraminifera in the present material.

Distribution. According to most authors *G. velascoensis* is restricted to the Upper Palaeocene. The writer (1970*c*) has examined well-preserved typical and abundant representatives of *G. velascoensis* in the Palaeocene Pondicherry Formation of South India.

In the Rakhi Nala section *G. velascoensis* occurs in the *Globorotalia velascoensis* and *Globorotalia aequa* Zones.

Globorotalia whitei Weiss

(Pl. 15, figs 1–3)

1955*a* *Globorotalia whitei* Weiss: 18–19, pl. 6, figs 1–3.

Remarks. The specimen figured here closely resembles the holotype. As in the holotype, the ventral sutures form an X-shaped pattern and the final chamber is about twice the size of the penultimate chamber.

Weiss (1955*a*) pointed to the resemblance between *G. whitei* and *Globorotalia crassula* Cushman & Stewart, described from the Pliocene of California. He did not compare it with the morphologically similar contemporaneous forms of the genus, neither did he discuss the range of variation in the type material. These deficiencies might have made its identification difficult for later authors.

Distribution. The range of *G. whitei* is reported to be Palaeocene to Lower Eocene. The writer (1970*c*) has examined abundant well-preserved specimens from the Palaeocene Pondicherry Formation of southern India.

In the Rakhi Nala section *G. whitei* ranges from the *Globorotalia velascoensis* Zone to the *Globorotalia formosa formosa* Zone.

Globorotalia wilcoxensis Cushman & Ponton

1932 *Globorotalia wilcoxensis* Cushman & Ponton: 71, pl. 9, figs 10a–c.
1949 *Globorotalia* (*Truncorotalia*) *wilcoxensis* Cushman & Ponton; Cushman & Bermudez: 39, pl. 7, figs 16–18.
1956 *Globorotalia wilcoxensis* Cushman & Ponton; Haque: 183, pl. 4, figs 6a–c.
1957*a* *Globorotalia wilcoxensis* Cushman & Ponton; Bolli: 79, pl. 19, figs 7–9.

Remarks. In their original description, Cushman and Ponton mentioned that there are 4 chambers in the last whorl, although their figures of the holotype show clearly about $4\frac{1}{2}$ chambers in the last whorl. The aperture as shown in the peripheral view of the holotype does not extend much outside the umbilicus. The last two chambers were almost the same in size. The variability of *G. wilcoxensis* in the type material was not discussed by its authors.

G. wilcoxensis and *G. whitei* Weiss are very closely related. Gohrbandt (1963) regarded *G. whitei* as a junior synonym of *G. wilcoxensis*, while Bolli (1957*a*) regarded *G. whitei* as the ancestral form of *G. wilcoxensis*.

DISTRIBUTION. *G. wilcoxensis* was originally described from the Lower Eocene of Alabama. In Trinidad, Bolli (1957*a*) found it to be restricted to the lower part of the upper Lizard Springs Formation. The range of the species is reported to be Palaeocene to Upper Eocene. Records of this species from the Middle and Upper Eocene require verification. The illustrations of the specimen (or specimens, as the two figures differ in size) from the Middle Eocene, of Mississippi provided by Cushman & Todd (1948, pl. 6, figs 24–25) are not adequate for satisfactory identification. Bermudez (1961 : 1351) pointed out that earlier records of Upper Eocene occurrences of *G. wilcoxensis* are doubtful.

In the Rakhi Nala section *G. wilcoxensis* ranges from the *Globorotalia aequa* Zone to the *Globorotalia formosa formosa* Zone.

Genus ***TRUNCOROTALOIDES*** Bronnimann & Bermudez 1953

TYPE SPECIES. *Truncorotaloides rohri* Bronnimann & Bermudez 1953.

See Samanta (1969) for discussion of genus.

Truncorotaloides collactea (Finlay)

(Pl. 7, figs 13–15)

1939*b* *Globorotalia collactea* Finlay: 327, pl. 29, figs 164–165.
1970*a* *Truncorotaloides collactea* (Finlay); Samanta: 205, pl. 3, figs 15–17.

REMARKS. In the Rakhi Nala material the dorsal sutural openings are too minute to be observed readily. The main variation observed is in the shape of the chambers in the last whorl, lobation of the equatorial periphery and the surface ornamentation of the test. Individuals with subangular chambers are rare.

According to Jenkins, *T. collactea* is possibly related to *T. rohri* Brönnimann & Bermudez, but differs in having a smaller and more compact test, much smaller dorsal sutural openings and a less spinose surface.

DISTRIBUTION. The range of *T. collactea* is reported to be Lower Eocene to lower Upper Eocene. The writer (1970*a*) has reported it from the Middle Eocene of western India.

In the Rakhi Nala section, *T. collactea* occurs in the *Globorotalia crassata*/*Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Truncorotaloides rohri Brönnimann & Bermudez

(Pl. 6, figs 11–12)

1953 *Truncorotaloides rohri* Brönnimann & Bermudez: 818–819, pl. 87, figs 7–9.
1968 *Truncorotaloides rohri* Brönnimann & Bermudez; Raju: 290, pl. 2, figs 3a–c.
1970*a* *Truncorotaloides rohri* Brönnimann & Bermudez; Samanta: 207, pl. 3, figs 20–21.

REMARKS. The Rakhi Nala specimens show all the diagnostic features of the

species. The dorsal sutural openings are observed in well-preserved specimens.

DISTRIBUTION. *Truncorotaloides rohri* is believed to be restricted to the Middle Eocene. Raju (1968) has recorded it from bore holes in southern India, and it has been reported by the writer (1969, 1970*a*) from the Middle Eocene of eastern and western India.

In the Rakhi Nala section *T. rohri* occurs in the *Globorotalia crassata/Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Truncorotaloides topilensis (Cushman)

(Pl. 6, figs 9–10)

1925*a* *Globigerina topilensis* Cushman: 7, pl. 1, figs 9a–c.
1968 *Truncorotaloides topilensis* (Cushman); Raju: 290, pl. 2, figs 9a–c.

REMARKS. The Rakhi Nala specimens show all the distinctive features of the species. The specimen figured here is more tightly coiled than the holotype.

DISTRIBUTION. In the original description it was stated that the holotype was obtained from the 'Upper Eocene, Tantoyuca formation, yellow clay from Palacho Hacienda, S. of Panuco—Tampico R. R., State of Vera Cruz, Mexico'. However, according to Barker (quoted in Blow & Saito 1968) the original age determination of the specimens described from the Palacho Hacienda area was not reliable as Cushman's sample was probably obtained from a derived block in the post-Eocene beds.

T. topilensis is believed to be restricted to the Middle Eocene. The writer (1969, 1970*a*) has recorded it from the Middle Eocene of eastern and western India. Raju (1968) has reported it from southern India.

In the Rakhi Nala section *T. topilensis* occurs in the *Globorotalia crassata/Truncorotaloides topilensis* Zone.

Family **HANTKENINIDAE** Cushman 1927

Genus ***HANTKENINA*** Cushman 1925

TYPE SPECIES. *Hantkenina alabamensis* Cushman 1925.

See Samanta (1969) for discussion of genus.

Hantkenina dumblei Weinzierl & Applin

(Pl. 7, fig. 18)

1929 *Hantkenina dumblei* Weinzierl & Applin: 402, pl. 43, figs 5a–b.
1939 *Hantkenina cf. dumblei* Weinzierl & Applin; Cushman & Siegfus: 32, pl. 7, fig. 2.
1942 *Hantkenina* (*Applinella*) *dumblei* Weinzierl & Applin; Thalmann: 812, pl. 1, figs 2a–b (after Weinzierl & Applin 1929).
1950 *Hantkenina* (*Applinella*) *dumblei* Weinzierl & Applin; Brönnimann: 408–410, pl. 55, figs 18, 22–24.
1958 *Hantkenina* (*Applinella*) cf. *dumblei* Weinzierl & Applin; Crespin (pars): 318, text-figs 3–4, ?1–2.
1966 *Hantkenina aragonensis* Nuttall; Premoli Silva & Luterbacher: 1192, text-fig. 5.
1968 *Hantkenina dumblei* Weinzierl & Applin; Raju; 290, pl. 1, fig. 5.

REMARKS. The original illustrations of *Hantkenina dumblei* were the side views of two specimens. Of these, the smaller was regarded as a young specimen and the larger as a more mature form. The latter was designated lectotype by Brönnimann (1950).

Bolli, Loeblich & Tappan (1957) examined and refigured both the lectotype and the paratype of *H. dumblei* and remarked that 'The final chamber is broken from the lectotype of *H. dumblei*, but the remnants of this final chamber show an attachment partially enveloping the base of the spine of the penultimate chamber'. However, an examination of their figures shows that it is not in the lectotype (fig. 6) but in the paratype of *H. dumblei* that the final chamber is not preserved. As can be seen from the side view, the lectotype seems to possess a partially damaged apertural face. Neither Weinzierl & Applin nor Bolli, Loeblich & Tappan provided an illustration showing the apertural view of the lectotype. Although the preservation of both the lectotype and the figured paratype of *H. dumblei* is not completely satisfactory, they show adequately the characteristic features of the species.

The Rakhi Nala specimens agree satisfactorily with the original description and illustration of *Hantkenina dumblei*. The earlier chambers in the last whorl are slightly separated peripherally, and the later chambers are roughly triangular in side view. In the specimen figured here each chamber is about double the size of the previous chamber, the final chamber forming about one-third of the test. The spines which are only partly preserved, shift towards the anterior suture during ontogenesis. The surface of the test is smooth except for the first two chambers of the last whorl which are hispid. The aperture is an elongate arched opening with a tendency to develop besal lobes. It extends up to about half the height of the apertural face and is furnished with distinctly developed lateral lip-like projections. In all the three specimens the aperture is filled up with recrystallized material.

H. dumblei was designated type species for the subgenus *Applinella* Thalmann. However, the writer does not accept subgeneric divisions of the genus *Hantkenina* (see Samanta 1969).

H. dumblei is similar to *H. longispina* Cushman but is distinguished by its more elongate chambers and shorter and more slender spines.

According to Brönnimann (1950) *H. dumblei* was probably derived from *H. mexicana* Cushman.

The two specimens from the Navet formation of Trinidad illustrated by Brönnimann (1950, pl. 55, fig. 17; pl. 56, fig. 5) as *Hantkenina* (*Applinella*) cf. *dumblei* differ from Weinzierl & Applin's form in having peripherally separated later chambers with the spines not directly situated below the anterior suture.

The specimens from Italy illustrated by Premoli Silva & Luterbucher (1966, text-fig. 5) as *Hantkenina aragonensis* Nuttall show about 5 to 6 rapidly enlarging chambers in the last whorl; these are not distinctly separated peripherally and the spines are situated directly below the anterior suture.

DISTRIBUTION. *Hantkenina dumblei* was originally described from the Middle Eocene of Texas. It was later recorded from California, Trinidad, several European localities, North Africa, southern India, Japan, Borneo and Australia. According

to most authors the species is restricted to the Middle Eocene. Its reported occurrence in the Upper Eocene and in the basal Oligocene of Morocco (Rey 1939) is not reliable (see Thalmann 1942 : 818).

In the Rakhi Nala section *H. dumblei* occurs in the *Globorotalia crassata/ Truncorotaloides topilensis* Zone.

Hantkenina mexicana Cushman

(Pl. 7, figs 16–17)

1925*c* *Hantkenina mexicana* Cushman: 3, pl. 2, fig. 2.
1953 *Hantkenina mexicana* Cushman var. *aragonensis* Nuttall; Hamilton: 229, pl. 32, fig. 18, ?17.
1968 *Hantkenina mexicana* Cushman; Raju: 290, pl. 1, fig. 1.
1968 *Hantkenina aragonensis* Nuttall; Raju: 290, pl. 1, figs 2, 8.

Remarks. Only five specimens were observed in the Rakhi Nala material and their preservation is not very good. However, the presence of peripherally well separated chambers with the spines situated in the prolongation of the chamber axis permits their satisfactory identification. The aperture is not preserved. The final chamber differs from the rest in being much more elongate.

H. mexicana is a very distinctive species. It is easily distinguished from other species of the genus by its peripherally well separated elongate chambers tapering more or less gradually into the terminal spines situated in the prolongation of the chamber axis. The rate of enlargement of the chambers, the degree of lobation of the periphery, the length of the spines and the shape of the chambers all vary.

Hamilton (1953, pl. 32, figs 17–18) figured two specimens from the Pacific Seamounts as *H. mexicana* Cushman var. *aragonensis* Nuttall. One (Figure 17) differs from typical *N. mexicana* in having narrower, much elongated and almost cylindrical chambers which are widely separated peripherally. It bears a striking resemblance to some specimens of *Clavigerinella jarvisi* figured by Cushman (1930, pl. 3, figs 8–11) from Trinidad.

In its elongated chambers deeply separated from each other at the periphery, *H. mexicana* bears close resemblance to *H. lehneri* Cushman & Jarvis. The specimen from Tanganyika figured by Ramsay (1962, pl. 16, fig. 2) as *H. lehneri* appears to be transitional between *H. mexicana* and *H. lehneri*.

H. mexicana is the earliest species of the genus. According to Berggren & Olsson (1967) it probably evolved from a form such as *Clavigerinella* aff. *akersi* Bolli, Loeblich & Tappan illustrated by Bolli (1957*c*, pl. 35, figs 3a–b) from the Navet Formation of Trinidad.

Distribution. *H. mexicana* has been reported from numerous areas including western India and southern India. According to most workers it is restricted to the Middle Eocene.

In the Rakhi Nala section *H. mexicana* occurs in the *Globorotalia crassata/ Truncorotaloides topilensis* Zone.

Genus ***PSEUDOHASTIGERINA*** Banner & Blow 1959

TYPE SPECIES. *Nonion micrus* Cole 1927.
See Samanta (1969) for discussion.

Pseudohastigerina danvillensis (Howe & Wallace)

(Pl. 7, figs 7–8)

1932 *Nonion danvillensis* Howe & Wallace: 51–52, pl. 9, figs 3a–b.
1939 *Nonion danvillensis* Howe & Wallace; Cushman: 5, pl. 1, figs 19a–b.
1945 *Nonion danvillensis* Howe & Wallace; Cushman & Todd: 92, pl. 15, fig. 4.
1960*c* *Hastigerina danvillensis* (Howe & Wallace); Berggren: 85–86.

REMARKS. In the original figure of the holotype Howe & Wallace showed a papillate 'filling' in the umbilicus. However, they did not mention it in their description. Bandy (1949) in assigning specimens from the Eocene of Alabama to *Nonion danvillensis*, used this feature as one of the diagnostic characters. On the other hand, Cushman (1939) and Barker (quoted in Berggren 1960*a* : 86), who examined topotype material did not mention a pillate umbilicus. An examination of the holotype is needed to ascertain whether or not it possesses a truly papillate umblicus. Matrix in the umbilical depression could give the appearance of papillate ornamentation. Following Berggren's (1960*a*) observations, *N. danvillensis* is here assigned to *Pseudohastigerina*.

The degree of evoluteness of the test, the compression of the chambers, the lobation of the periphery and the height of the aperture vary in the material. Often the later chambers are much compressed producing an angular periphery.

P. danvillensis is closely related to *P. micra* (Cole) from which it is distinguished by its more numerous chambers in the last whorl, higher aperture, more compressed chambers and the tendency to evolute coiling. It seems to have been derived from *P. micra*.

DISTRIBUTION. This species was originally described from the Upper Eocene of Louisiana. It was later reported from the Lower Oligocene of Alabama (Howe 1942) and from several other Upper Eocene localities in North America.

In the Rakhi Nala section *P. danvillensis* ranges from the upper part of the *Truncorotaloides rohri* Zone to the *Globigerina officinalis* Zone.

Pseudohastigerina micra (Cole)

(Pl. 7, figs 11–12)

1927 *Nonion micrus* Cole: 22, pl. 5, fig. 12.

REMARKS. The number and degree of inflation of the chambers in the last whorl, and the height of the aperture vary in this material.

The axial periphery of the test may be almost subangular. The surface of the early chambers in the last whorl is very often weakly hispid.

Pseudohastigerina iota (Finlay), regarded by Berggren (1960*a* : 86) as a junior synonym of *P. micra*, can be distinguished by its fewer and more rapidly enlarging

chambers in the last whorl, and its higher aperture. The two also differ in their stratigraphic ranges.

DISTRIBUTION. *Pseudohastigerina micra* was originally described from the Middle Eocene of Mexico. According to Blow & Banner (1962), its range is Middle Eocene to Middle Oligocene.

In the Rakhi Nala section it ranges from the *Globorotalia crassata/Truncorotaloides topilensis* Zone to the *Globigerina officinalis* Zone.

Pseudohastigerina pseudoiota (Hornibrook)

(Pl. 7, figs 3–4)

1958*a* *Globigerina pseudoiota* Hornibrook: 34, pl. 1, figs 16–18.
1958*b* *Globigerina pseudoiota* Hornibrook; Hornibrook: 664–665, figs 23, 26–28.
1967 *Pseudohastigerina wilcoxensis* (Cushman & Ponton); Berggren & Olsson: 278–280, text-fig. 5 (1a–9c).

REMARKS. While describing this species, Hornibrook (1958*a*) noted its 'striking resemblance to the small group of planispiral Eocene species of *"Globigerinella"* '. He (1958*b*) stressed the distinctly asymmetrical coiling and aperture, and the inflated rounded shape of the chambers.

Berggren & Olsson (1967), in discussing the development of *Pseudohastigerina* Banner & Blow, regarded *P. pseudoiota* as a junior synonym of *P. wilcoxensis* (Cushman & Ponton). The writer accepts these as congeneric but not conspecific. *P. pseudoiota*, as described by Hornibrook, can be readily distinguished from the holotype of *P. wilcoxensis* Cushman & Ponton (1932, pl. 8, figs 11a–b) by its distinctly asymmetrical test, more inflated chambers and higher and slightly asymmetrical aperture. The present material agrees well with the original description of the species. Specimens similar to that figured by Hornibrook (1958*b*, fig. 26) showing a wide open aperture were not observed in this material.

The derivation of *P. pseudoiota* from a globorotaliid ancestor has been suggested by earlier workers.

DISTRIBUTION. This species was originally described from the Waipawan stage of New Zealand which Hornibrook dated as Palaeocene. He observed that it ranged up into the overlying Mangaorapan stage (Lower Eocene). It has been recorded from the Upper Palaeocene of Victoria, Australia (McGowran 1968).

In the Rakhi Nala section *P. pseudoiota* occurs in the *Globorotalia formosa formosa* and *Globorotalia aspensis/Globorotalia esnaensis* Zones.

Pseudohastigerina sharkriverensis Berggren & Olsson

(Pl. 7, figs 1–2, 5–6)

1967 *Pseudohastigerina sharkriverensis* Berggren & Olsson: 280–281, pl. 1, figs 7–11; text-figs 7–8.

REMARKS. The size and the shape of the test, the rate of enlargement and the

inflation of the chambers, and the character of the aperture show variation in the present material.

The last two chambers sometimes make up more than one-half of the test as in the type material. Specimens with bipartite apertures (figs 1–2) were also observed. A weakly developed narrow lip usually borders the aperture.

P. sharkriverensis is readily distinguished from related contemporary species by its 5 to 6 inflated globular chambers in the last whorl, the last 2 to 3 of which enlarge much more rapidly in size than the earlier ones. Its globular chambers indicate a relationship with *P. pseudoiota* (Hornibrook) from which it seems to have been derived.

DISTRIBUTION. *Pseudohastigerina sharkriverensis* was originally described from the early Middle Eocene of New Jersey, U.S.A.

In the Rakhi Nala section it occurs in the *Globorotalia crassata/Truncorotaloides topilensis* and *Truncorotaloides rohri* Zones.

Pseudohastigerina aff. wilcoxensis (Cushman & Ponton)

(Pl. 7, figs 9–10)

?1932 *Nonion wilcoxensis* Cushman & Ponton: 64, pl. 8, figs 11a–b.
1964 *Globanomalina ovalis* Haque; Loeblich & Tappan: c 665, fig. 531, 5a, b.

REMARKS. The present form is characterized by a slightly evolute biumbilicate test; ovate equatorial periphery, subrounded axial periphery; about $5\frac{1}{2}$ to 7 ovate, rapidly enlarging chambers in the last whorl; slightly curved, depressed sutures; smooth surface and low equatorial aperture provided with narrow lip. It is distinguished from *P. pseudoiota* (Hornibrook), with which it occurs associated in the material, by its evolute test, compressed chambers and lower, more symmetrical aperture.

With its compressed chambers and low symmetrical aperture the Pakistani form shows affinity to *P. wilcoxensis* Cushman & Ponton. However, the former differs in having a slightly evolute, less tightly coiled test and more chambers in the last whorl.

Pseudohastigerina eocenica (Berggren), described from the Lower Eocene of Denmark and Germany, shows a close resemblance to the present form in having a slightly evolute test and an equal number of chambers in the last whorl. Berggren's form, however, differs in having more inflated chambers.

The specimen from the Lower Eocene of Pakistan identified by Loeblich & Tappan (1964) as *Globanomalina ovalis* Haque, resembles the Rakhi Nala specimens in having a slightly evolute test, about 6 slightly compressed chambers, and a low equatorial aperture.

DISTRIBUTION. *P.* aff. *wilcoxensis* occurs in the *Globorotalia formosa formosa* and *Globorotalia aspensis/Globorotalia esnaensis* Zones.

REFERENCES

BANDY, O. L. 1949. Eocene and Oligocene foraminifera from Little Stave Creek, Clarke County, Alabama. *Bull. Amer. Paleont.*, Ithaca, New York, **32** : 1–211, pls 1–27.

—— 1964*a*. The type of *Globorotalia crassata* (Cushman). *Contr. Cushman Fdn. Foramin. Res.*, Sharon, Mass., 15 : 34–35, fig. 1.

—— 1964*b*. Cenozoic planktonic foraminiferal zonation. *Micropaleontology*, New York, **10** : 1–17, figs 1–6.

BANNER, F. T. & BLOW, W. H. 1959. The classification and stratigraphical distribution of the Globigerinaceae. *Palaeontology*, London, 2 : 1–27, pls 1–3, figs 1–5.

—— 1965. *Globigerinoides quadrilobatus* (d'Orbigny) and related forms: Their taxonomy, nomenclature and stratigraphy. *Contr. Cushman Fdn. Foramin. Res.*, Sharon, Mass., **16** : 105–115, pl. 16, figs 1–19.

BATJES, D. A. J. 1958. Foraminifera of the Oligocene of Belgium. *Mem. Inst. Roy. Sci. Nat. Belgique*, Brussell, **143** : 1–188, pls 1–13.

BAYLISS, D. D. 1961. *An investigation of certain larger fossil foraminifera from Pakistan*, Ph.D. Thesis, Univ. Wales: 1–253, pls 1–26.

BECKMANN, J. P. 1957. *Chiloguembelina* Loeblich & Tappan and related Foraminifera from the lower Tertiary of Trinidad, B.W.I. *Bull. U.S. Nat. Mus.*, Washington, **215** : 83–95, pl. 21, figs 14–16.

BERGGREN, W. A. 1960*a*. Some planktonic Foraminifera from the Lower Eocene (Ypresian) of Denmark and North Western Germany. *Stockh. Contr. Geol.*, **5** (3) : 41–108, pls 1–13.

—— 1960*b*. Biostratigraphy, planktonic Foraminifera and the Cretaceous-Tertiary boundary in Denmark and Southern Sweden. *21st Int. Geol. Congr.*, Copenhagen, **5** : 181–192, figs 1–2.

—— 1960*c*. Paleogene biostratigraphy and planktonic Foraminifera of Nigeria (West Africa); *21st Int. Geol. Congr.*, Copenhagen, **6** : 41–55, pl. 1.

—— 1962. Some planktonic Foraminifera from the Maestrichtian and type Danian stages of Southern Scandinavia. *Stockh. Contr. Geol.* **9** (1) : 1–106, pls 1–14.

—— 1965. Some problems of Paleocene–Lower Eocene planktonic foraminiferal correlations. *Micropaleontology*, New York, **11** : 278–300, pl. 1, figs 1–12.

BERGGREN, W. A. & KURTEN, B. 1961. Notes on the biometry of *Globigerina yeguaensis*. *Stockh. Contr. Geol.*, **8** (1) : 1–16, figs 1–6.

BERGGREN, W. A. & OLSSON, R. K. 1967. Taxonomy and phylogeny: 265–281, pl. 1, figs 1–10. *In:* BERGGREN, W. A., OLSSON, R. K. & REYMENT, R. A. Origin and development of the foraminiferal genus *Pseudohastigerina* Banner and Blow, 1959. *Micropaleontology*, New York, **13**.

BERMUDEZ, P. J. 1961. Contribucion al estudio de las Globigerinidea de la region Caribe-Antillana (Paleocene-Reciente). *Mem. del III Congr. Geol. Venez. III. Boln. geol.*— Publicacion especial 3, Caracas, Venezuela: 1119–1393, pls 1–20.

BLOW, W. H. & BANNER, F. T. 1962. The mid-Tertiary (Upper Eocene to Aquitanian) Globigerinaceae: 61–151, pls 8–17, figs 6–20. *In:* EAMES, F. E., BANNER, F. T., BLOW, W. H. & CLARK, W. J. *Fundamentals of mid-Tertiary stratigraphical correlation.* London (Cambridge University Press).

BLOW, W. H. & SAITO, T. 1968. The morphology and taxonomy of *Globigerina mexicana* Cushman, 1925. *Micropaleontology*, New York, **14** : 357–360, figs 1–4.

BOLLI, H. M. 1954. Note on *Globigerina concinna* Reuss 1850. *Contr. Cushman Fdn. Foramin. Res.*, Sharon, Mass., **5** : 1–3, figs 1–8.

—— 1957*a*. The genera *Globigerina* and *Globorotalia* in the Paleocene–lower Eocene Lizard Springs formation of Trinidad, B.W.I. *Bull. U.S. Nat. Mus.*, Washington, **215** : 61–81, pls 15–20, figs 11–13.

—— 1957*b*. Planktonic Foraminifera from the Oligocene-Miocene Cipero and Lengua formations of Trinidad, B.W.I. *Bull. U.S. Nat. Mus.*, Washington, **215** : 97–123, pls 22–29, figs 17–21.

BOLLI, H. M. 1957*c*. Planktonic Foraminifera from the Eocene Navet and San Fernando formations of Trinidad, B.W I. *Bull. U.S. Nat. Mus.*, Washington, **215** : 155–172, pls 35–39, figs 25–26.

—— 1966. Zonation of Cretaceous to Pliocene marine sediments based on Planktonic Foraminifera. *Bol. Informativo. Assoc. Venez. Geol. Min Y Pet.*, Caracas, **9** : 3–32.

BOLLI, H. M. & CITA, M. B. 1960*a*. Upper Cretaceous and Lower Tertiary planktonic Foraminifera from the Paderno d'Adda Section, Northern Italy. *21st Int. Geol. Congr,*. Copenhagen, **5** : 150–161.

—— 1960*b*. Globigerine e Globorotalie del Paleocene di Paderno d'Adda (Italia). *Riv. ital. Paleont.*, Milano, **66** : 361–402, pls 33–35.

BOLLI, H. M., LOEBLICH, A. R., JR. & TAPPAN, H. 1957. Planktonic foraminiferal families Hantkeninidae, Orbulinidae, Globorotaliidae and Globotruncanidae. *Bull. U.S. Nat. Mus.*, Washington, **215** : 3–50, pls 1–11, figs 1–9.

BRONNIMANN, P. 1950. The genus *Hantkenina* Cushman in Trinidad and Barbados, B.W.I. *J. Paleont.*, Tulsa, Oklahoma, **24** : 397–420, pls 55–56, figs 1–2.

—— 1951. *Globigerinita naparimaensis* n. gen., n. sp., from the Miocene of Trinidad, B.W.I. *Contr. Cushman Fdn. Foramin. Res.*, Ithaca, New York, **2** : 16–18, figs 1–14.

—— 1952*a*. *Globigerinoita* and *Globigerinatheka*, new genera from the Tertiary of Trinidad, B.W.I. *Contr. Cushman Fdn. Foramin. Res.*, Ithaca, New York, **3** : 25–28, figs 1–3.

—— 1952*b*. Trinidad Paleocene and Lower Eocene Globigerinidae. *Bull. Am. Paleont.*, Ithaca. New York, **34** : 1–34, pls 1–3.

BRONNIMANN, P. & BERMUDEZ, P. J. 1953. *Truncorotaloides*, a new foraminiferal genus from the Eocene of Trinidad, B.W.I. *J. Paleont.*, Tulsa, Oklahoma, **27** : 817–820, pl. 87.

BROTZEN, F. & POZARYSKA, K. 1961. Foraminiferes du Paleocene et de l'Eocene inferieur en Pologne septentrionale. Remarques paleogeographiques. *Rev. Micropaleont.*, Paris, **4** : 155–166, pls 1–4.

BUTT, A. A. 1966. *Late Oligocene foraminifera from Escornebeou, S.W. France.* 123 pp., 8 pls. Utrecht, Nederlands.

BYKOVA, N. K. 1953. Foraminifera of the Suzakian Stage of the Tadzhik Basin. *Trudy Vses. Neft. geol. Rav. Inst.*, Leningrad-Moscow (n.s.) **6** : 5–114, pls 1–5.

COLE, W. S. 1927. A foraminiferal fauna from the Guayabal Formation in Mexico. *Bull. Am., Paleont.*, Ithaca, New York, **14** : 1–46, pls 1–5.

COLOM, G. 1954. Estudio de las biozonas con foraminiferos del Terciario de Alicante. *Bol. Inst. Geol. Min. Espana*, Madrid, **66** : 1–279, pls 1–35.

CRESPIN, I. 1958. The occurrence of *Hantkenina* in Western Australia. *Micropaleontology*, New York, **4** : 317–319, figs 1–5.

CUSHMAN, J. A. 1925*a*. New Foraminifera from the Upper Eocene of Mexico. *Contr. Cushman Lab. Foramin. Res.*, Sharon, Mass., **1** : 4–9, pl. 1.

—— 1925*b*. Some new Foraminifera from the Velasco Shale of Mexico. *Contr. Cushman Lab. Foramin. Res.*, Sharon, Mass., **1** : 18–22, pl. 3.

—— 1925*c*. A new genus of Eocene Foraminifera. *Proc. U.S. Nat. Mus.*, Washington, **66** (2567) : 1–4, pls 1–2.

—— 1925*d*. An Eocene fauna from the Moctezuma River, Mexico. *Bull. Amer. Ass. Petrol. Geol.*, Tulsa, Oklahoma, **9** : 298–303, pls 6–7.

—— 1927*a*. An outline of a re-classification of the Foraminifera. *Contr. Cushman Lab. Foramin. Res.*, Sharon, Mass., **3** : 1–105, pls 1–21.

—— 1930. Fossil species of *Hastigerinella*. *Contr. Cushman Lab. Foramin. Res.*, Sharon, Mass., **6** : 17–19, pl. 3.

—— 1933. Post-Cretaceous occurrence of *Gumbelina* with a description of a new species. *Contr. Cushman Lab. Foramin. Res.*, Sharon, Mass., **9** : 64–69, pl. 7.

—— 1939. A monograph of the foraminiferal family Nonionidae. *U.S. Geol. Surv. Prof. Paper*, Washington, **191** : 1–100, pls 1–20.

—— 1946. A rich foraminiferal fauna from the Cocoa Sand of Alabama. *Cushman Lab. Foramin. Res. Spec. Publ.*, Sharon, Mass., **16** : 1–40, pls 1–8.

CUSHMAN, J. A. & BERMUDEZ, P. J. 1937. Further new species of Foraminifera from the Eocene of Cuba. *Contr. Cushman Lab. Foramin. Res.* Sharon, Mass., **13** : 1–29, pls 1–2.

—— 1949. Some Cuban species of *Globorotalia*. *Contr. Cushman Lab. Foramin. Res.*, Sharon, Mass., **25** : 26–45, pls 5–8.

CUSHMAN, J. A. & JARVIS, P. W. 1929. New Foraminifera from Trinidad. *Contr. Cushman Lab. Foramin. Res.*, Sharon, Mass., **5** : 6–17, pls 2–3.

CUSHMAN, J. A. & PONTON, G. M. 1932. An Eocene foraminiferal fauna of Wilcox age from Alabama. *Contr Cushman Lab. Foramin. Res.*, Sharon, Mass., **8** : 51–72, pls 7–9.

CUSHMAN, J. A. & RENZ, H. H. 1948. Eocene Foraminifera of the Navet and Hospital Hill Formations of Trinidad, B.W.I. *Cushman Lab. Foramin. Res. Spec. Publ.*, Sharon, Mass., **24** : 1–42, pls 1–8.

CUSHMAN, J. A. & SIEGFUS, S. S. 1939. Some new and interesting foraminifera from the Kreyenhajen Shale of California. *Contr. Cushman Lab. Foramin. Res.*, **206**, 23–33, pl. 5–6.

CUSHMAN, J. A. & STAINFORTH, R. M. 1945. The Foraminifera of the Cipero Marl Formation of Trinidad, British West Indies. *Cushman Lab. Foramin. Res. Spec. Publ.*, Sharon, Mass., **14** : 1–75, pls 1–16.

CUSHMAN, J. A. & TODD, R. 1945. Foraminifera of the type locality of the Moodys Marl Member of the Jackson Formation of Mississippi. *Contr. Cushman Lab. Foramin. Res.*, Sharon, Mass., **21** : 79–105, pls 13–16.

—— —— 1948. A Foraminiferal fauna from the Cook Mountain Formation of Mississippi. *Contr. Cushman Lab. Foramin. Res.*, Sharon, Mass., **24** : 27–37, pls 5–6.

DALLAN, L. 1963. Studio paleontologico di una microfauna paleocenica ritrovata nel flysch calcareo dei Monti di Massarosa (F°104, 1 SE). *Boll. Soc. Geol. Ital.*, Pisa, **82** : 1–34, pls 1–4.

DROOGER, C. W. 1953. Late Eocene smaller foraminifera from Curacao and Bonaire (N.W.I.) *Proc Kon. Nederl. Akad. Wetensch.*, Amsterdam, (B) **56** : 93–103, pl. 1, figs 1–5.

EAMES, F. E. 1951. A contribution to the study of the Eocene in Western Pakistan and Western India: B. The description of the Lamellibranchia from standard sections in the Rakhi Nala and Zinda Pir areas of the Western Punjab and in the Kohat district. *Phil. Trans. R. Soc.*, London, (B), **235** : 311–482.

—— 1952*a*. A contribution to the study of the Eocene in Western Pakistan and Western India: C. The description of the Scaphopoda and Gastropoda from standard sections in the Rakhi Nala and Zinda Pir areas of the Western Punjab and in the Kohat district. *Phil. Trans. R. Soc.*, London, (B), **236** : 1–68.

—— 1952*b*. A contribution to the study of the Eocene in Western Pakistan and Western India: A. The geology of standard sections in the Western Punjab and in the Kohat district. *Q. Jl. geol. Soc.*, London. **107** : 159–171.

—— 1952*c*. A contribution to the study of the Eocene in Western Pakistan and Western India: D. Discussion of the faunas of certain standard sections, and their bearing on the classification and correlation of the Eocene in Western Pakistan and Western India. *Q. Jl. geol. Soc.*, London, **107** : 173–196.

EL-NAGGAR, Z. R. 1966. Stratigraphy and Planktonic Foraminifera of the Upper Cretaceous-Lower Tertiary succession in the Esna-Idfu region, Nile Valley, Egypt, U.A.R. *Bull. Br. Mus. nat. Hist.* (Geol.), Supp. **2** : 1–291, pls 1–23, figs 1–18.

FINLAY, H. J. 1939*a*. New Zealand Foraminifera: Key species in Stratigraphy. No. 2. *Trans. Roy. Soc. New Zealand*, Wellington, **69** (1) : 89–128, pls 11–14.

—— 1939*b*. N.Z. Foraminifera: Key species in Stratigraphy—No. 3. *Trans. Roy. Soc. New Zealand*, Wellington, **69** (3) : 309–329, pls 24–29.

—— 1947. New Zealand Foraminifera: Key species in Stratigraphy—No. 5. *N. Z. J. Sci. Tech.*, Wellington, B **28** (5) : 259–292.

GLAESSNER, M. F. 1937*a*. Planktonforaminiferen aus der Kreide und dem Eozan und ihre stratigraphische Bedeutung. *Publis. Lab. Paleont., Moscow Univ., Studies in Micropaleont.*, Moscow, **1** : 27–52, pl. 1, figs 1–6.

GOHRBANDT, K. H. A. 1963. Zur Gliederung des Paleogan im Helvetikum nordlich Salzburg nach planktonischen Foraminiferen. I. Teil: Paleozan und tiefstes untereozan. *Mitt. Geol. Gesell. Wein*, **56** : 1–116, pls 1–11.

—— 1967*a*. The geologic age of the type locality of *Pseudotextularia elegans* (Rzehak). *Micropaleontology*, New York, **13** : 68–74, pl. 1.

—— 1967*b*. Some new planktonic foraminiferal species from the Austrian Eocene. *Micropaleontology*, New York, **13** : 319–326, pl. 1.

HAMILTON, E. L. 1953. Upper Cretaceous, Tertiary and Recent Planktonic Foraminifera from Mid-Pacific flat-topped seamounts. *J. Paleont.*, Tulsa, Oklahoma, **27** : 204–237, pls 29–32.

HAQUE, A. F. M. M. 1956. The smaller Foraminifera of the Ranikot and the Laki of the Nammal Gorge, Salt Range. *Palaeontol. Pakist.*, Quetta, **1** : 1–300, pls 1–35.

HAY, W. W. 1960. The Cretaceous-Tertiary boundary in the Tampico Embayment, Mexico. *21st Int. Geol. Congr.*, Copenhagen **5** : 70–77.

HILLEBRANDT, A. VON. 1962*a*. Das Alttertiar im Becken von Reichenhall und Salzburg (Nordliche Kalkalpen). *Z. df. geol. Ges.*, Hannover, **113** : 339–358, figs 1–7.

—— 1962*b*. Das Paleozan und seine Foraminiferen fauna im Becken von Reichenhall und Salzburg. *Bayer. Akad. Wiss. Math.-Nat. Kl. Abhandl.*, Munchen, (N.F.) **108** : 1–182, pls 1–15.

—— 1965. Foraminiferen-Stratigraphie im Alttertiar von Zumaya (Provinz Guipúzcoa, NW Spanien) und ein Vergleich mit anderen Tethys—Gebieten. *Bayer. Akad. Wiss. Math., Nat. Kl. Abhandl.*, Munchen, (NF) **123** : 1–62.

HORNIBROOK, N. DE B. 1958*a*. New Zealand Upper Cretaceous and Tertiary foraminiferal zones and some overseas correlations. *Micropaleontology*, New York, **4** : 25–38, pl. 1.

—— 1958*b*. New Zealand Foraminifera: Key species in stratigraphy—No. 6. *N. Z. J. Geol. Geophys.*, Wellington, **1** : 653–676, figs 1–36.

HOWE, H. V. 1939. Louisiana Cook Mountain Eocene foraminifera. *Geol. Bull. Louisiana Dep. Conserv.*, New Orleans, **14** : 1–122, pls 1–14.

HOWE, H. V. & WALLACE, W. E. 1932. Foraminifera of the Jackson Eocene at Danville Landing on the Ouachita, Catahoula Parish, Louisiana. *Geol. Bull. Louisiana Dep. Conserv.*, New Orleans, **2** : 7–111, pls 1–15.

JENKINS, D. G. 1964. A history of the holotype, ontogeny and dimorphism of *Globorotaloides turgida* (Finlay). *Contr. Cushman Fdn. Foramin. Res.*, Ithaca, New York, **15** : 117–121, pls 7–8.

—— 1965. A re-examination of *Globorotalia collactea* Finlay, 1939. *N. Z. J. Geol. Geophys.*, Wellington, **8** : 843–848, figs 1–27.

—— 1966. Planktonic foraminiferal zones and new taxa from the Danian to Lower Miocene of New Zealand. *N. Z. J. Geol. Geophys.* Wellington, **8** : 1088–1126, figs 1–15.

KHALILOV, D. M. 1956. On the pelagic foraminiferal fauna of the Paleogene of Azerbaidzhan. *Trudy Akad. Nauk. Azerb. S.S.R., Inst. Geol. Baku*, **17** : 234–261, pls 1–5.

LATIF, M. A. 1961. The use of Pelagic Foraminifera in the subdivision of the Paleocene-Eocene of the Rakhi Nala, West Pakistan. *Geol. Bull. Panjab Univ.*, Lahore, **1** : 31–45, pls 1–3.

LEONOV, G. P. & ALIMARINA, V. P. 1961, Stratigraphy and planktonic Foraminifera of the Cretaceous-Paleogene 'Transition' beds of the central part of the North Caucasus. [In Russian, with English abstract.] *Coll. Papers Geol. Fac. Univ. Moscow 21st Int. Geol. Congr.*: 29–60.

LE ROY, L. W. 1953. Biostratigraphy of the Maqfi section, Egypt. *Mem. Geol. Soc. Amer.*, New York, **54** : 1–73, pls 1–13.

LOEBLICH, A. R., JR. & TAPPAN, H. 1956. *Chiloguembelina*, a new Tertiary genus of the Heterohelicidae (Foraminifera). *J. Washington Acad. Sci.*, **46** : 340.

—— —— 1957*a*. Planktonic Foraminifera of Paleocene and early Eocene age from the Gulf and Atlantic Coastal Plains. *Bull. U.S. Nat. Mus.*, Washington, **215** : 173–198, pls 40–64.

LOEBLICH, A. R., JR & TAPPAN, H. 1957*b*. Correlation of the Gulf and Atlantic Coastal Plain Paleocene and Lower Eocene formations by means of planktonic Foraminifera. *J. Paleont.*, Tulsa, Oklahoma, **31** : 1109–1137, figs 1–5.

—— —— 1957*c*. The new planktonic foraminiferal genus *Tinophodella*, and an emendation of *Globigerinita* Bronnimann. *J. Washington Acad. Sci.*, **47** : 112–116, figs 1–3.

—— —— 1964. *Treatise on Invertebrate Paleontology, C, Protista 2*, vols. **1–2** : 900 pp., 653 figs. New York.

LUTERBACHER, H. 1965. Studies in some *Globorotalia* from the Paleocene and Lower Eocene of the central Apennines. *Ecl. geol. Helv.*, Basel, **57** : 631–730, figs 1–134.

MALLORY, V. S. 1959. Lower Tertiary biostratigraphy of the California Coast ranges. *Am. Ass. Petrol. Geol., Spec. Publ.*, Tulsa, Oklahoma: 1–416, pls 1–42.

MCGOWRAN, B. 1964. Foraminiferal evidence for the Paleocene age of the King's Park Shale (Perth Basin, Western Australia). *J. Roy. Soc. W. Australia*, Perth, **47** : 81–86, pl. 1.

—— 1968. Reclassification of early Tertiary *Globorotalia*. *Micropaleontology*, New York, **14** : 179–198, pls 1–4.

MOROZOVA, V. G. 1939. The stratigraphy of the Upper Cretaceous and Lower Tertiary deposits in the Emba oil-bearing district according to the foraminiferal fauna. *Byull. Mosk. Obsc. Ispyt. Prir., N.S. 47, Otd. geol.*, Moscow, **17** : 59–86, pls 1–2.

NAGAPPA, Y. 1957. Direction of coiling in *Globorotalia* as an aid in correlation. *Micropaleontology*, New York, **3** : 393–398, pl. 1, figs 1–8.

—— 1959. Foraminiferal biostratigraphy of the Cretaceous-Eocene succession in the India-Pakistan-Burma region. *Micropaleontology*, New York, **5** : 145–192, pls 1–11, figs 1–11.

NUTTALL, W. L. F. 1930. Eocene Foraminifera from Mexico. *J. Paleont.*, Tulsa, Oklahoma, **4** : 271–293, pls 23–25.

—— 1932. Lower Oligocene Foraminifera from Mexico. *J. Paleont.*, Tulsa, Oklahoma, **6** : 3–35, pls 1–9.

OLSSON, R. K. 1960. Foraminifera of the latest Cretaceous and earliest Tertiary age in the New Jersey Plain. *J. Paleont.*, Tulsa, Oklahoma, **34** : 1–58, pls 1–12.

PARR, W. J. 1938. Upper Eocene foraminifera from deep borings in King's Park, Perth, Western Australia. *J. Roy. Soc. W. Australia*, Perth, **24** : 69–101, pls 1–3.

PESSAGNO, E. A., JR. 1961. The micropaleontology and biostratigraphy of the middle Eocene Jacaguas group, Puerto Rico. *Micropaleontology*, New York, **7** : 351–358, pls 1–2.

PIJPERS, P. J. 1933. Geology and paleontology of Bonaire (Dutch West Indies). *Meded. Geogr. Geol. Physiogr.-Geol. Recks*, Utrecht, **8** : 1–103, pls 1–2.

PLUMMER, H. J. 1926. Foraminifera of the Midway formation in Texas. *Univ. Texas, Bull.*, Austin **2644** : 1–206, pls 1–15.

PREMOLI SILVA, I. & LUTERBACHER, H. 1966. The Cretaceous-Tertiary boundary in the Southern Alps (Italy). *Riv. ital. Paleont.*, Milano, **72** : 1183–1266, pls 91–99, figs 1–28.

PROTO DECIMA, F. & ZORZI, P. 1965. Studio Micropaleontologico-Stratigrafico della serie Cretaceo—Terziaria del Molinetto di Pederobba. *Mem. Ist. Geol. Min. Univ. Padova*, **25** : 1–44, pls 1–5.

RAJU, D. S. N. 1968. Eocene-Oligocene Planktonic Foraminiferal biostratigraphy of Cauvery Basin, South India. *Mem. geol. Soc. India*, Bangalore, **2** : 286–299, pls 1–4, figs 1–3.

RAMSAY, W. R. 1962. Hantkenininae in the Tertiary rocks of Tanganyika. *Contr. Cushman Fdn. Foramin. Res.*, Ithaca, New York, **13** : 79–89, pl. 16.

REY, M. 1939. Distribution stratigraphique des *Hantkenina* dans le Nummulitique du Rharb (Maroc). *Bull. Soc. geol. Fr.*, Paris, (5) **8** : 321–340, pl. 22.

—— 1955. Description de quelques especes nouvelles de Foraminiferes dans le Nummulitique nord—marocain. *Bull. Soc. geol. Fr.*, Paris, (6) **4** : 209–211, pl. 12

SAID, R. & KERDANY, M. T. 1961. The geology and micropaleontology of the Farafra Oasis, Egypt. *Micropaleontology*, New York, **7** : 317–336, pls 1–2.

SAMANTA, B. K. 1969. Eocene planktonic foraminifera from Garo Hills, Assam, India. *Micropaleontology*, New York, **15** : 325–350, pls. 1–3, figs 1–2.

SAMANTA, B. K. 1970*a*. Middle Eocene planktonic foraminifera from Lakhpat, Cutch, Western India. *Micropaleontology*, New York, **16** : 185–215, pls 1–3, figs 1–3.
—— 1970*b*. Upper Eocene planktonic foraminifera from Kopili formation, Mikir Hills, Assam, India. *Contr. Cushman Fdn. Foramin. Res.*, Ithaca, New York, **21** : 28–39, pls 6–7.
—— 1970*c*. Planktonic Foraminifera from the early Tertiary Pondicherry Formation of Madras, South India. *J. Paleont.*, **44** : 605–641, pls 94–98.
STAINFORTH, R. M. 1948. Applied Micropaleontology in Coastal Ecuador. *J. Paleont.*, Tulsa, Oklahoma, **22** : 113–151, pls 24–26.
SUBBOTINA, N. N. 1947. Foraminifera of the Danian and Paleogene deposits of the northern Caucasus. *Vses. Neft. Naukno-Issl. geol. rav. Inst.*, Leningrad-Moscow: 39–160, pls 1–9.
—— 1953. Fossil foraminifera of the U.S.S.R., Globigerinidae, Hantkeninidae and Globorotaliidae. *Trudy Vses. Neft. geol. rav. Inst.*, Leningrad-Moscow (n.s.) **76** : 1–296, pls. 1–41.
THALMANN, H. E. 1942. Foraminiferal genus *Hantkenina* and its subgenera. *Am. Jl. Sci.*, New Haven, Connecticut, **240** : 809–820, pl. 1.
TODD, R. 1966. Smaller Foraminifera from Guam. *U.S. Geol. Surv. Prof. Pap.*, Washington, **403** (I) : 11–141, pls 1–19.
WEINZIERL, L. L. & APPLIN, E. R. 1929. The Claiborne Formation on the coastal domes. *J. Paleont.*, Tulsa, Oklahoma, **3** : 384–410, pls 42–44.
WEISS, L. 1955*a*. Foraminifera from the Paleocene Pale Greda formation of Peru. *J. Paleont.*, Tulsa, Oklahoma, **29** : 1–21, pls 1–6.
—— 1955*b*. Planktonic index foraminifera of north western Peru. *Micropaleontology*, New York, **1** : 301–319, pls 1–3.
WHITE, M. P. 1928*a*. Some index Foraminifera of the Tampico Embayment area of Mexico. Part I: *J. Paleont.*, Tulsa, Oklahoma, **2** : 177–215, pls 27–29.
—— 1928*b*. Some index Foraminifera of the Tampico Embayment area of Mexico. Part II. *J. Paleont.*, Tulsa, Oklahoma, **2** : 280–317, pls 38–42.

B. K. SAMANTA, D. Phil., Ph.D.
Department of Geology
UNIVERSITY OF CALCUTTA
35 BALLYGUNGE CIRCULAR ROAD
CALCUTTA 19
INDIA

PLATE 1

All figures approximately × 100 except 13–15, which are approximately × 50.

FIGS. 1–3. ***Globigerina angustiumbilicata*** Bolli. P48827. Dorsal, peripheral and ventral views. Sample 3604, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 4–6. ***Globigerina praebulloides leroyi*** Blow & Banner. P48828. Ventral, peripheral and dorsal views. Sample 3658. ***Globigerina officinalis*** Zone, upper Khirthar Formation.

FIGS 7–9. ***Globigerina officinalis*** Subbotina. P48829. Peripheral, ventral and dorsal views. Sample 3650, ***Globigerina officinalis*** Zone, upper Khirthar Formation.

FIGS 10–12. ***Globigerina prolata*** Bolli. P48830. Dorsal, peripheral and ventral views. Sample 3605, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 13–15. ***Globigerina posttriloculinoides clinata*** Khalilov. P48831. Peripheral, dorsal and ventral views. Sample 3605, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 16–18. ***Globigerina praebulloides occlusa*** Blow & Banner. P48832. Ventral, peripheral and dorsal views. Sample 3650, ***Globigerina officinalis*** Zone, upper Khirthar Formation.

FIGS 19–21. ***Globigerina ouachitaensis*** Howe & Wallace. P48833. Dorsal, peripheral and ventral views. Sample 3605, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 22–24. ***Globigerina frontosa*** Subbotina. P48834. Ventral, peripheral and dorsal views. Sample 3606, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

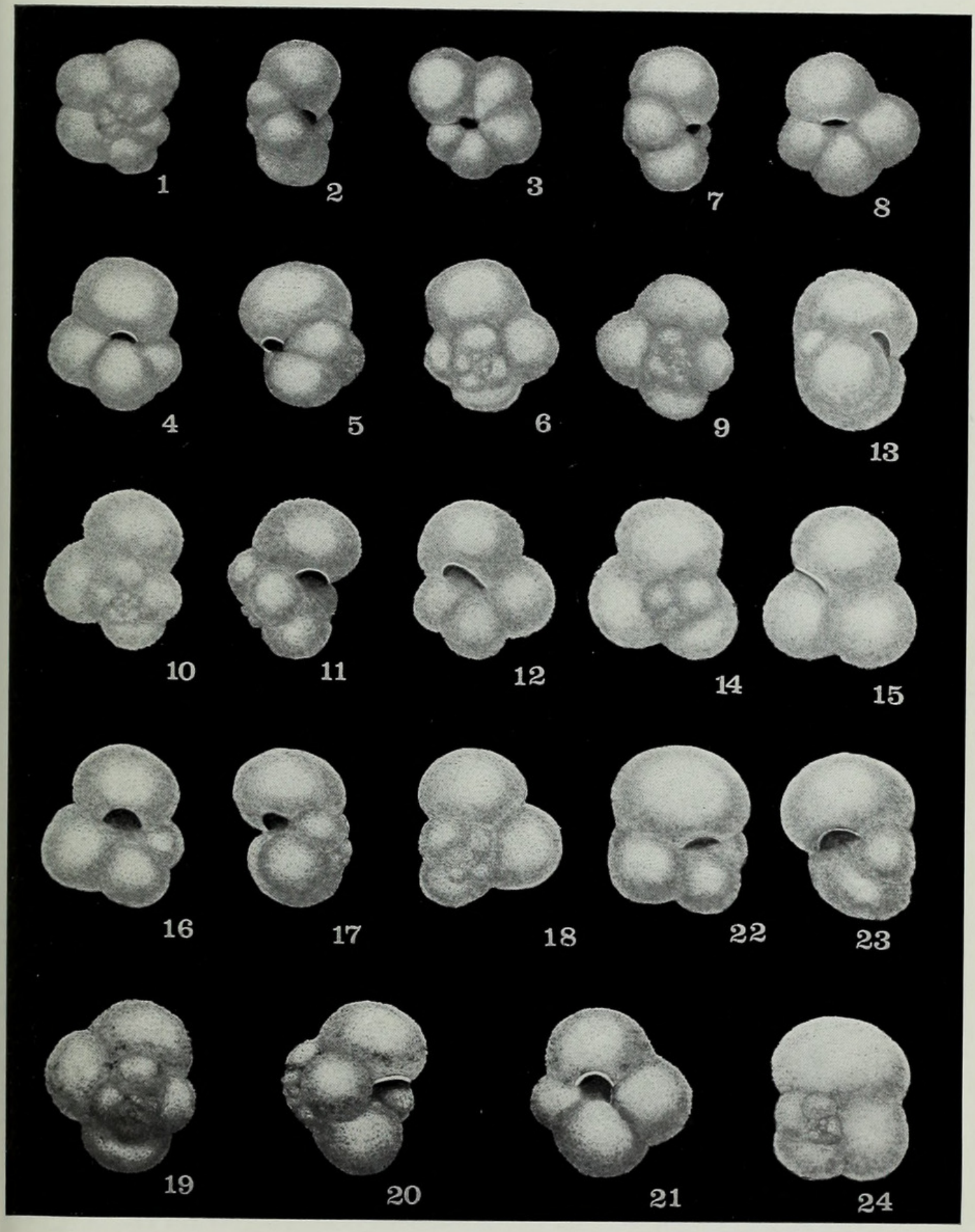

1
2
3
7
8
4
5
6
9
13
10
11
12
14
15
16
17
18
22
23
19
20
21
24

PLATE 2

All figures approximately × 100.

FIGS 1–3. ***Globigerina azerbaidjanica*** Khalilov. P48835. Dorsal, peripheral and ventral views. Sample 3650, ***Globigerina officinalis*** Zone, upper Khirthar Formation.

FIGS 4–6. ***Globigerina baylissi*** sp. nov. P48836. Dorsal, peripheral and ventral views. Holotype, sample 3622, ***Truncorotaloides rohri*** Zone, upper Khirthar Formation.

FIGS 7–9. ***Globigerina inaequispira*** Subbotina. P48837. Dorsal, peripheral and ventral views. Sample 3613, ***Truncorotaloides rohri*** Zone, upper Khirthar Formation.

FIGS 10–12. ***Globigerina ciperoensis*** Bolli. P48838. Ventral, dorsal and peripheral views. Sample 3604, ***Globorotalia crassata/Truncorotatoides topilensis*** Zone, upper Khirthar Formation.

FIGS 13–15. ***Globigerina triangularis*** White. P48839. Dorsal, peripheral and ventral views. Sample 3670, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

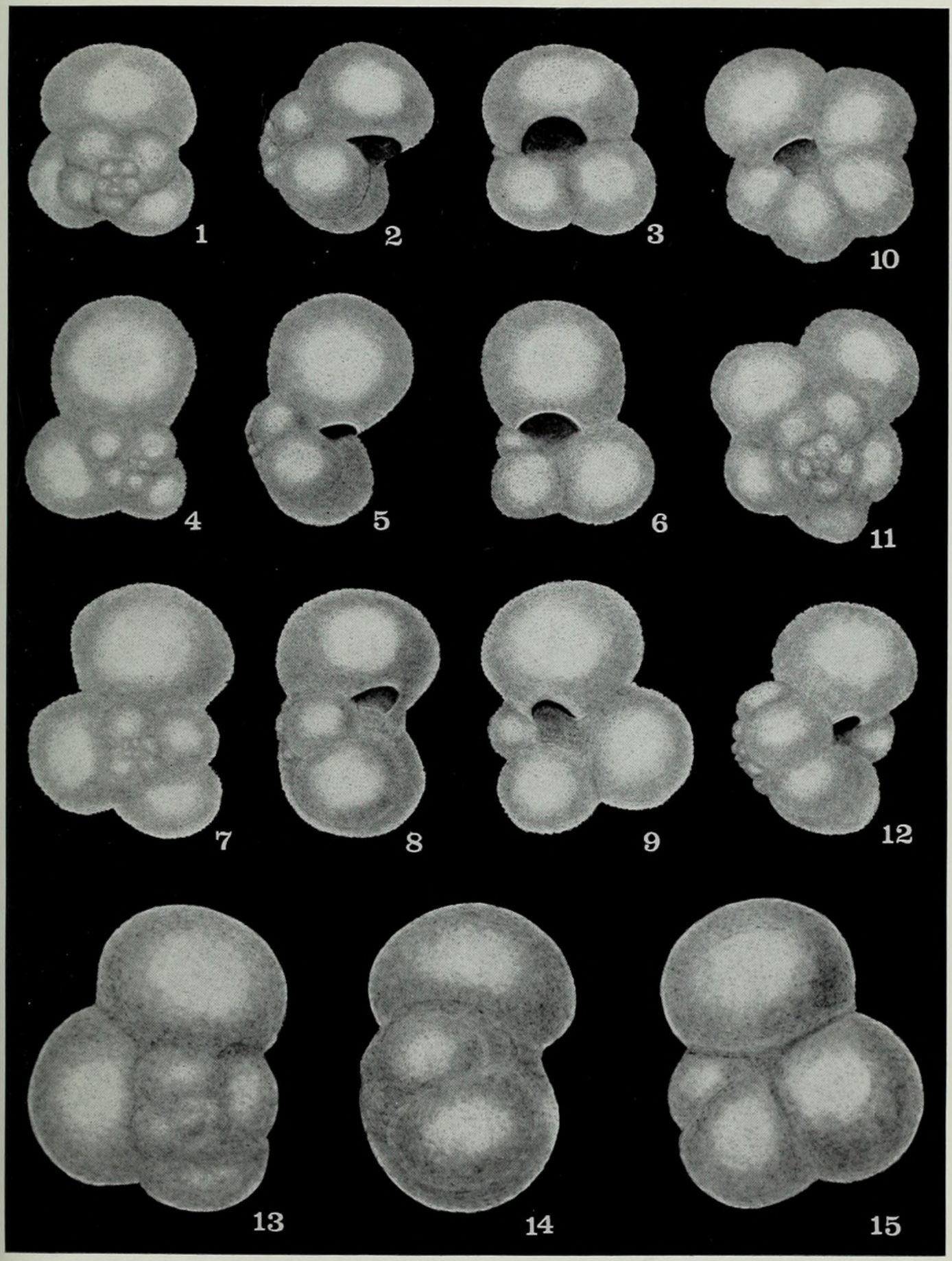

1
2
3
10
4
5
6
11
7
8
9
12
13
14
15

PLATE 3

All figures approximately × 100 except 1–3, which are approximately × 50.

FIGS 1–3. ***Globigerina yeguaensis*** Weinzierl & Applin. P48840. Ventral, peripheral and dorsal views. Sample 3604, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 4–6. ***Globigerina turgida*** Finlay. P48841. Dorsal, peripheral and ventral views. Sample 3670, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 7–9. ***Globigerina alanwoodi*** El-Naggar. P48842. Ventral, peripheral and dorsal views. Sample 3670, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 10–12. ***Globigerina velascoensis*** Cushman. P48843. Ventral, peripheral and dorsal views. Sample 3135, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

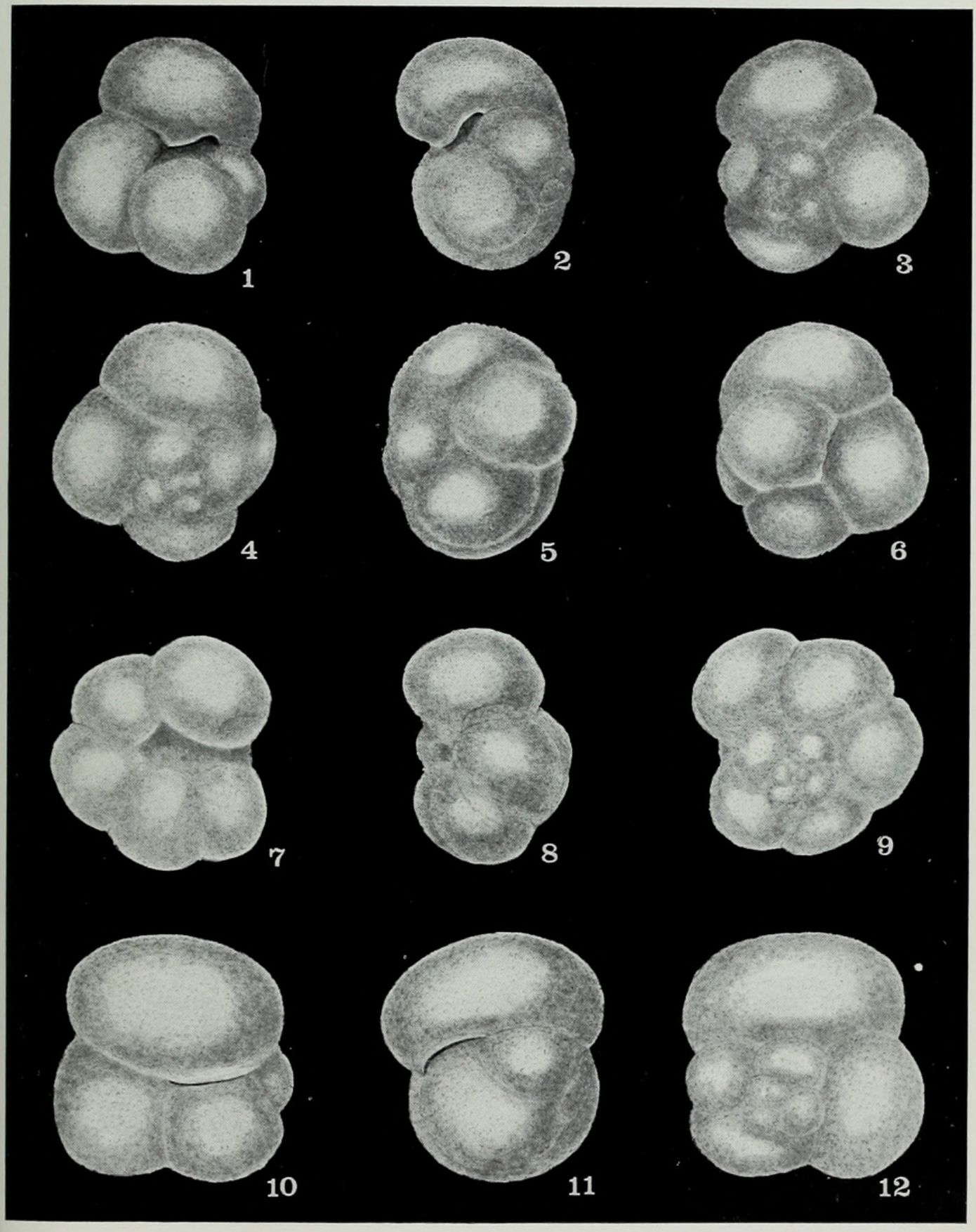

1
2
3
4
5
6
7
8
9
10
11
12

PLATE 4

All figures approximately × 100.

FIGS 1–3. ***Globigerina aquiensis*** Loeblich & Tappan. P48844. Ventral, peripheral and dorsal views. Sample 3671, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 4–6. ***Globigerina nodosa*** El-Naggar. P48845. Dorsal, peripheral and ventral views. Sample 3671, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 7–9. ***Globigerina haynesi*** El-Naggar. P48846. Dorsal, peripheral and ventral views. Sample 3135, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

FIGS 10–12. ***Globigerina soldadoensis*** Bronnimann. P48847. Dorsal, ventral and peripheral views. Sample 3155, ***Globorotalia aspensis/Globorotalia esnaensis*** Zone, Ghazij Formation.

FIGS 13–15. ***Globigerina mckannai*** White. P48848. Dorsal, peripheral and ventral views. Sample 3670, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

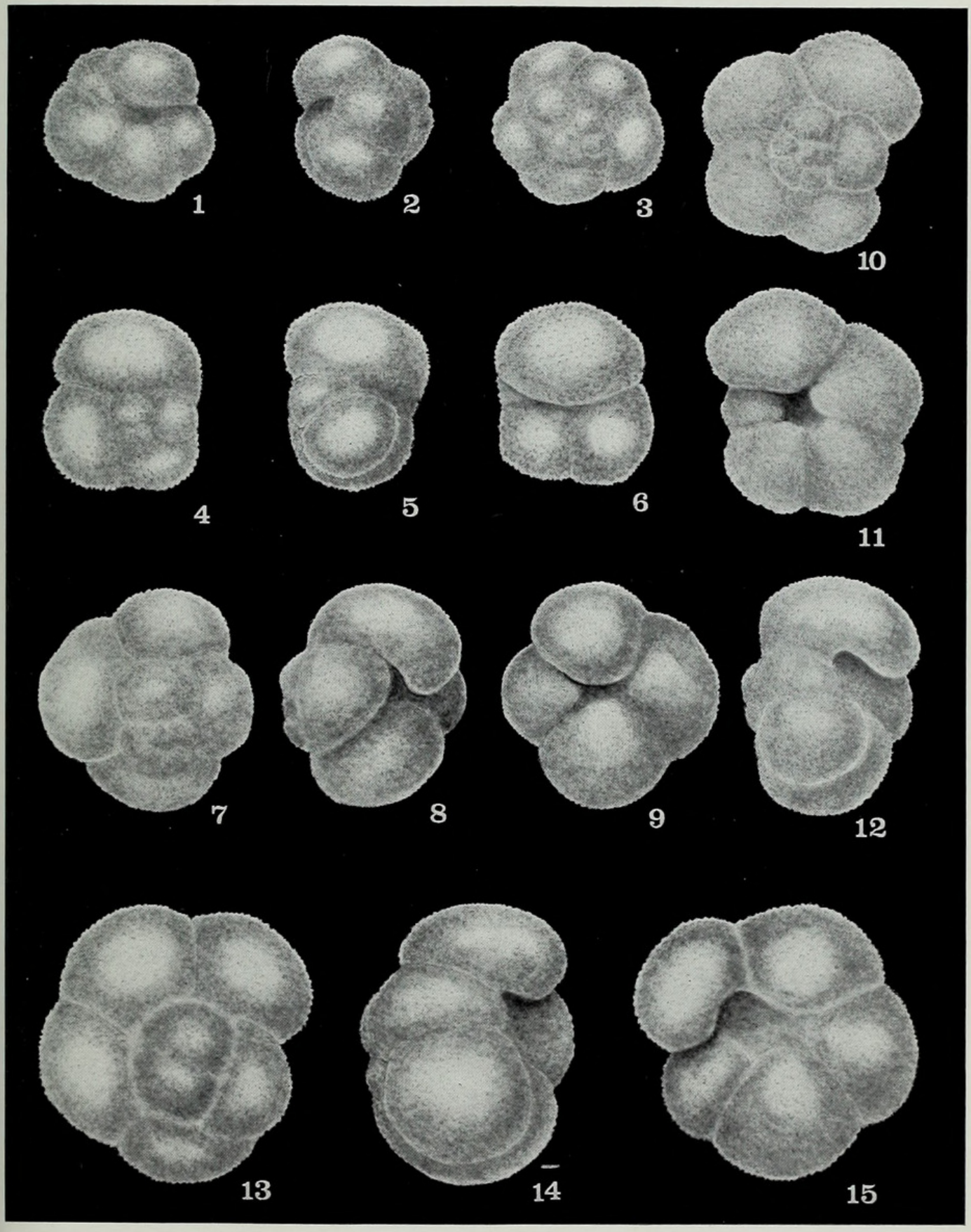

1
2
3
10
4
5
6
11
7
8
9
12
13
14
15

PLATE 5

All figures approximately × 100.

FIGS 1–3. ***Globigerinoides higginsi*** Bolli. P48849. Ventral, peripheral and dorsal views. Sample 3605, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 4–6. ***Globigerinita echinita*** (Bolli). P48850. Ventral, peripheral and dorsal views. Sample 3605, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 7–9. ***Globigerinita africana*** Blow & Banner. P48851. Dorsal, peripheral and ventral views. Sample 3608, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 10–12. ***Globigerinita dissimilis*** (Cushman & Bermudez). P48852. Dorsal, peripheral and ventral views. Sample 3651, ***Globigerina officinalis*** Zone, upper Khirthar Formation.

FIGS 13–15. ***Globigerinita howei*** Blow & Banner. P48853. Dorsal, peripheral and ventral views. Sample 3604, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

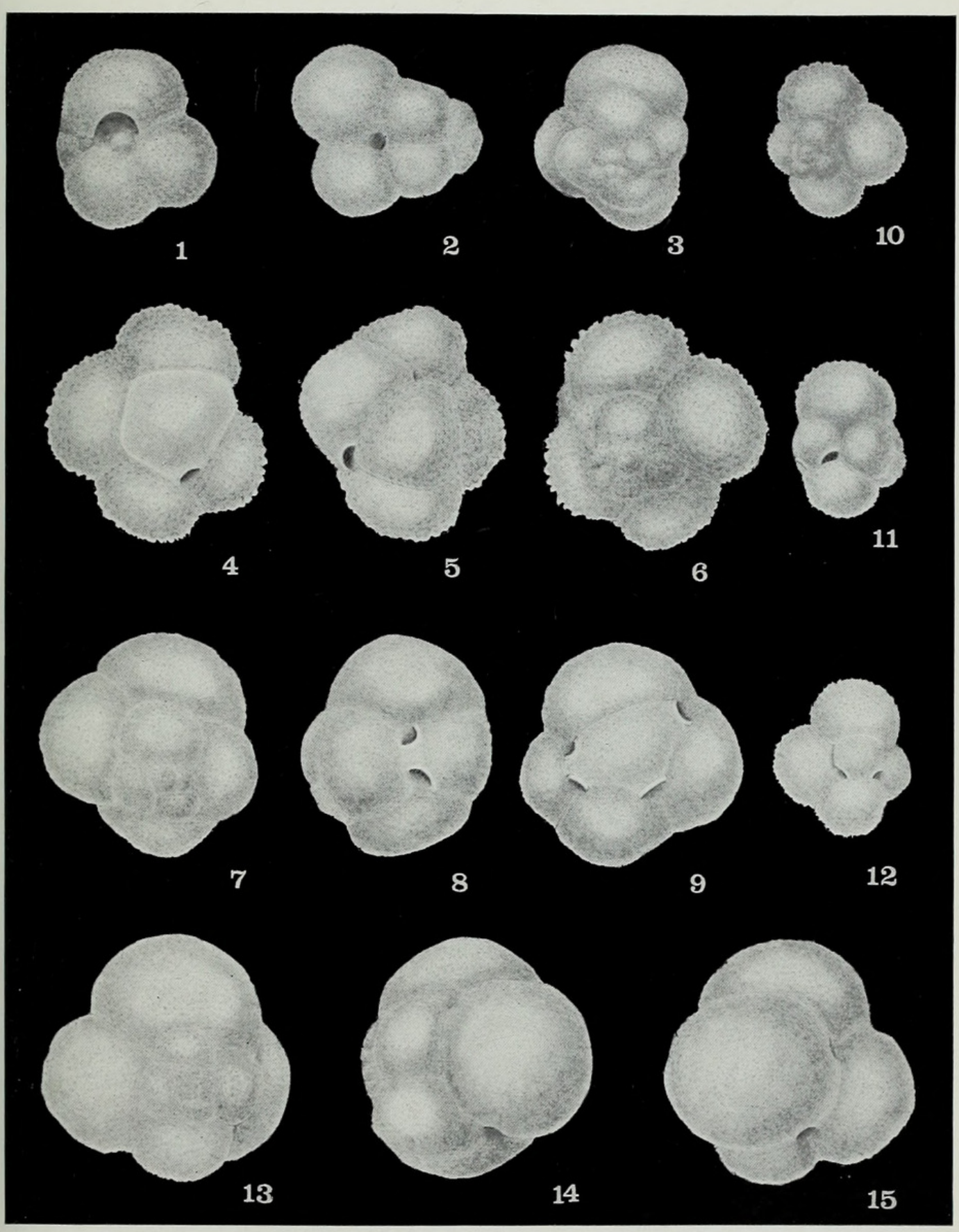

1
2
3
10
4
5
6
11
7
8
9
12
13
14
15

PLATE 6

All figures approximately × 100.

FIGS 1–3. ***Globigerinatheka barri*** Bronnimann. P48854. Dorsal, peripheral and ventra views. Sample 3604, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, Upper Khirthar Formation.

FIGS 4–6. ***Globigerapsis kugleri*** Bolli, Loeblich & Tappan. P48855. Ventral, peripheral and dorsal views. Sample 3604, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 7 & 8. ***Globigerapsis tropicalis*** Blow & Banner. P48856. Peripheral and dorsal views. Sample 3604, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 9 & 10. ***Truncorotaloides topilensis*** (Cushman). P48857. Dorsal and ventral views. Sample 3603, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 11 & 12. ***Truncorotaloides rohri*** Bronnimann & Bermudez. P48858. Ventral and dorsal views. Sample 3605. ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

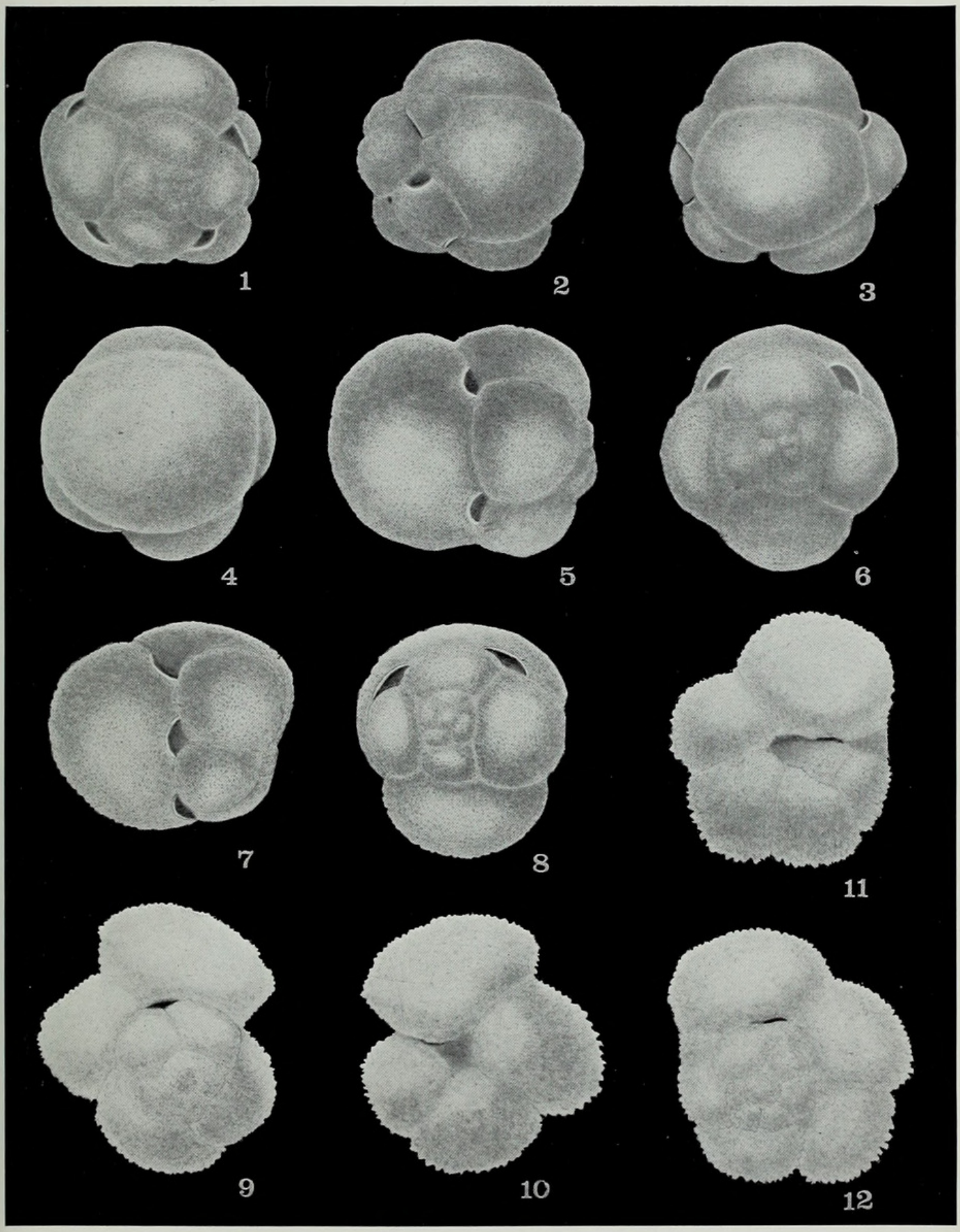

1
2
3
4
5
6
7
8
11
9
10
12

PLATE 7

All figures approximately × 100.

FIGS 1 & 2, 5 & 6. ***Pseudohastigerina sharkriverensis*** Berggren & Olsson. 1, 5, peripheral views; 2, 6, side views. Figs 1 & 2, P48859. Sample 3624, ***Truncorotaloides rohri*** Zone; figs 5 & 6, P48861. Sample 3606, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone. Both upper Khirthar Formation.

FIGS 3 & 4. ***Pseudohastigerina pseudoiota*** (Hornibrook). P48860. Peripheral and side views. Sample 3672, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 7 & 8. ***Pseudohastigerina danvillensis*** (Howe & Wallace). P48862. Peripheral and side views. Sample 3622, ***Truncorotaloides rohri*** Zone, upper Khirthar Formation.

FIGS 9 & 10. ***Pseudohastigerina*** sp. aff. ***P. wilcoxensis*** (Cushman & Ponton.) P48863. Side and peripheral views. Sample 3672, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 11 & 12. ***Pseudohastigerina micra*** (Cole). P48864. Peripheral and side views. Sample 3625, ***Truncorotaloides rohri*** Zone, upper Khirthar Formation.

FIGS 13–15. ***Truncorotaloides collactea*** (Finlay). P48865. Ventral, peripheral and dorsal views. Sample 3605, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 16 & 17. ***Hantkenina mexicana*** Cushman. Side views. Fig. 16, P48866; fig. 17, P48946. Sample 3606, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIG. 18. ***Hantkenina dumblei*** Weinzierl & Applin. P48867. Side view. Sample 3606, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

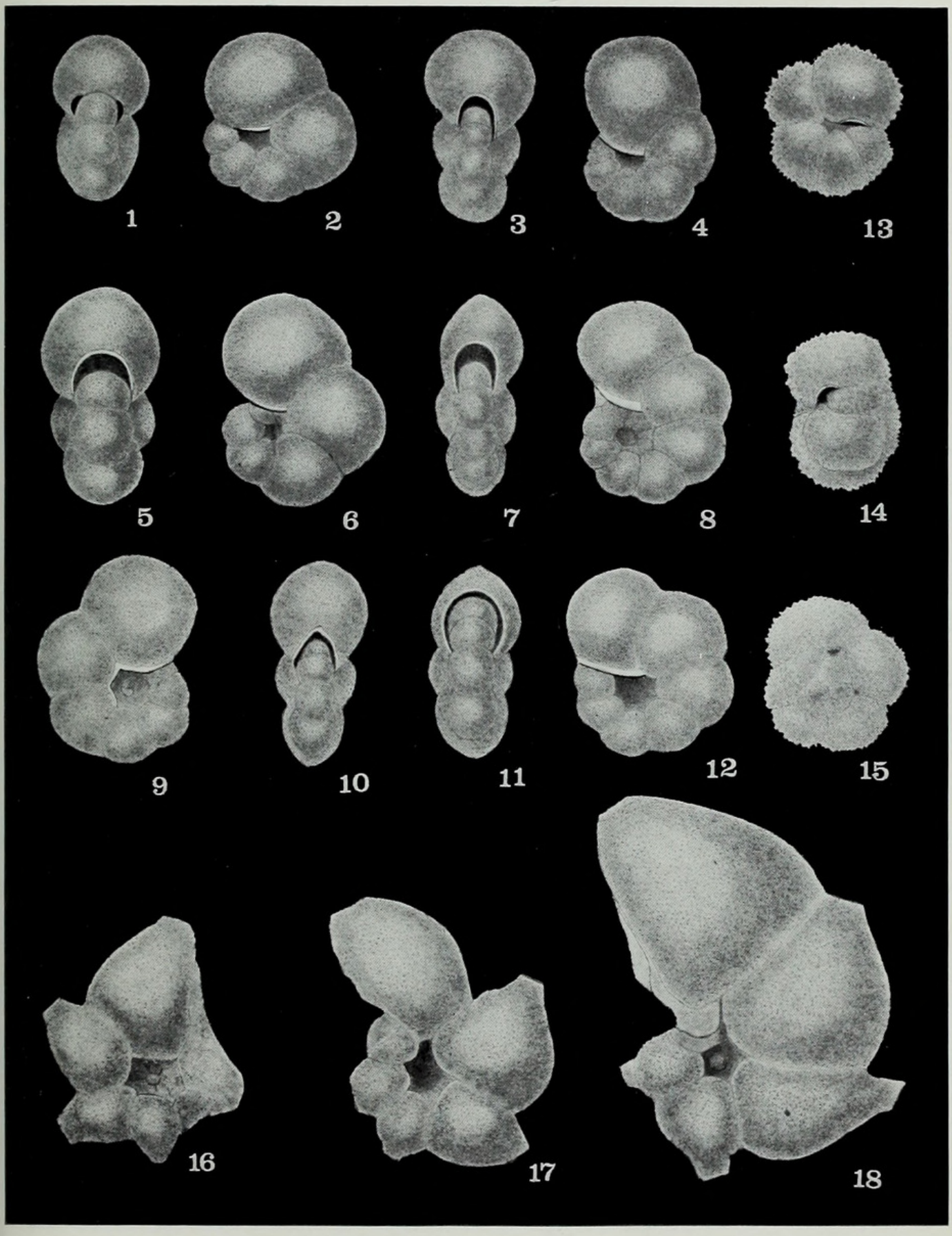

1
2
3
4
13
5
6
7
8
14
9
10
11
12
15
16
17
18

PLATE 8

All figures approximately × 100.

FIGS 1–3. ***Globorotalia conicotruncata*** Subbotina. P48868. Ventral, peripheral and dorsal views. Sample 3133, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

FIGS 4–6. ***Globorotalia aragonensis*** Nuttall. P48869. Ventral, peripheral and dorsal views. Sample 3140, ***Globorotalia aspensis/Globorotalia esnaensis*** Zone, Ghazij Formation.

FIGS 7–9. ***Globorotalia angulata*** (White). P48870. Ventral, peripheral and dorsal views. Sample 3130, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

FIGS 10–12. ***Globorotalia tadjikistanensis*** Bykova. P48871. Dorsal, peripheral and ventral views. Sample 3135. ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

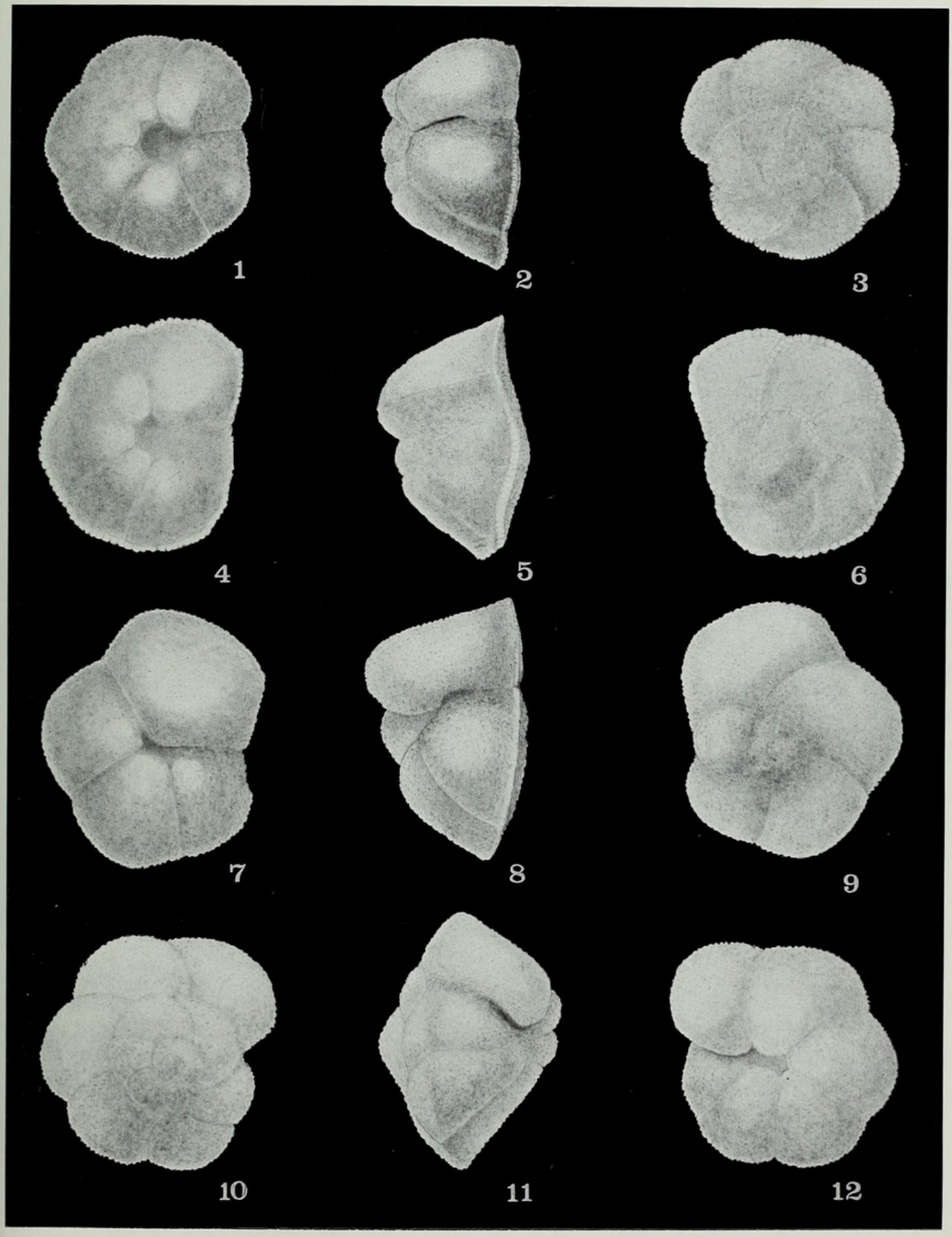

1
2
3
4
5
6
7
8
9
10
11
12

PLATE 9

All figures approximately × 100.

FIGS 1–3. ***Globorotalia formosa formosa*** Bolli. P48872. Dorsal, peripheral and ventral views. Sample 3670, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 4–6. ***Globorotalia parva*** Rey. P48873. Ventral, peripheral and dorsal views. Sample 3135, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

FIGS 7–9. ***Globorotalia velascoensis*** (Cushman). P48874. Ventral, peripheral and dorsal views. Sample 3135, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

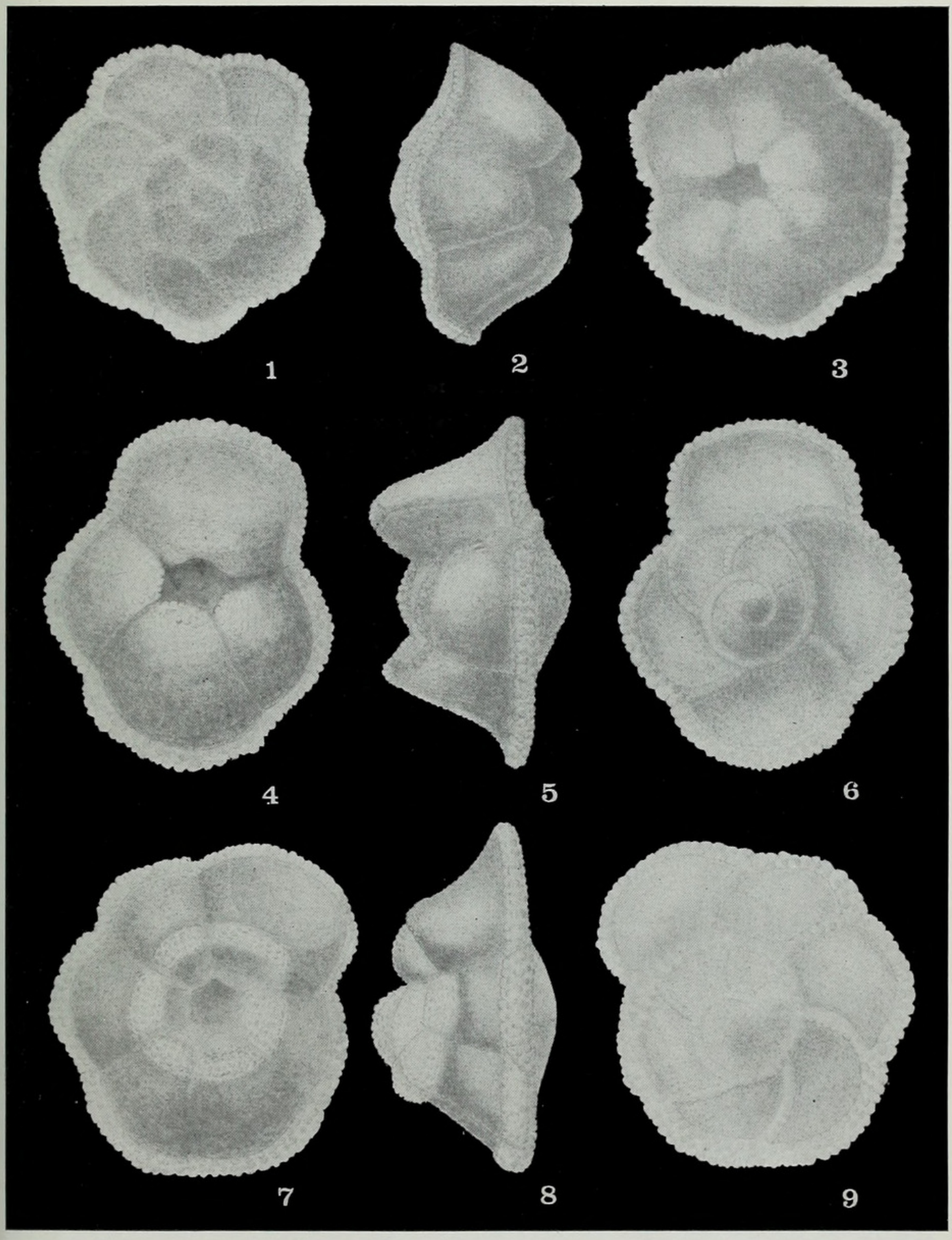

1
2
3
4
5
6
7
8
9

PLATE 10

All figures approximately × 100.

FIGS 1–4. ***Globorotalia aequa*** Cushman & Renz. Fig. 1, P48875. Ventral view; figs 2–4, P48876. Ventral, peripheral and dorsal views. Sample 3130, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

FIGS 5–7. ***Globorotalia quetra*** Bolli. P48877. Dorsal, peripheral and ventral views. Sample 3672, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 8–10. ***Globorotalia acuta*** Toulmin. P48878. Ventral, peripheral and dorsal views. Sample 3130, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

FIGS 11–13. ***Globorotalia occlusa*** Loeblich & Tappan. P48879. Ventral, peripheral and dorsal views. Sample 3131, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

FIGS 14–16. ***Globorotalia subbotinae*** Morozova. P48880. Peripheral, ventral and dorsal views. Sample 3671, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

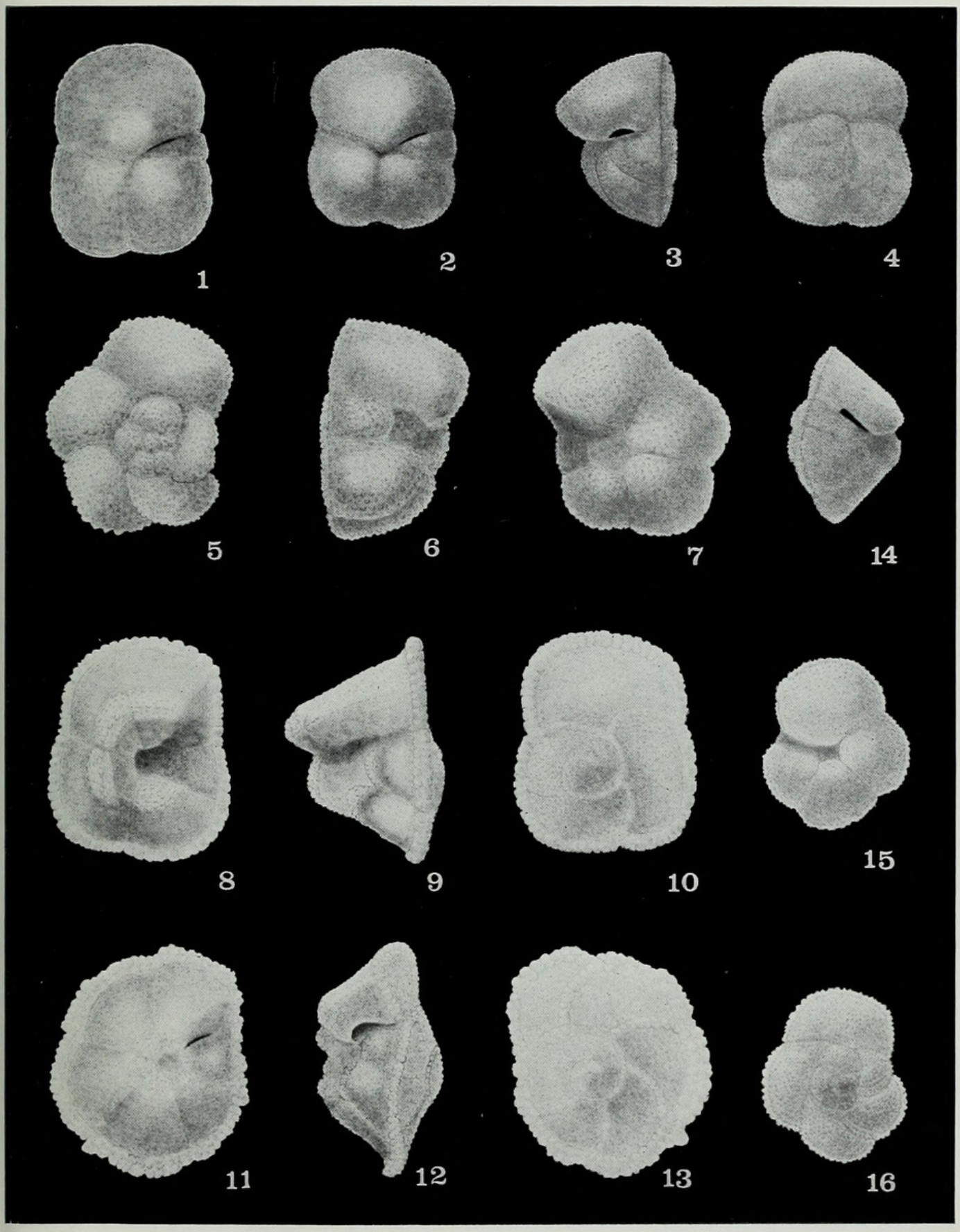

1
2
3
4
5
6
7
14
8
9
10
15
11
12
13
16

PLATE 11

All figures approximately × 100.

FIGS 1–3. ***Globorotalia marginodentata*** Subbotina. P48881. Dorsal, peripheral and ventral views. Sample 3138, ***Globorotalia aequa*** Zone, upper Dunghan Formation.

FIGS 4–6. ***Globorotalia formosa gracilis*** Bolli. P48882. Dorsal, peripheral and ventral views. Sample 3669, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 7–9. ***Globorotalia crassata*** (Cushman). P48883. Dorsal, peripheral and ventral views. Sample 3605, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

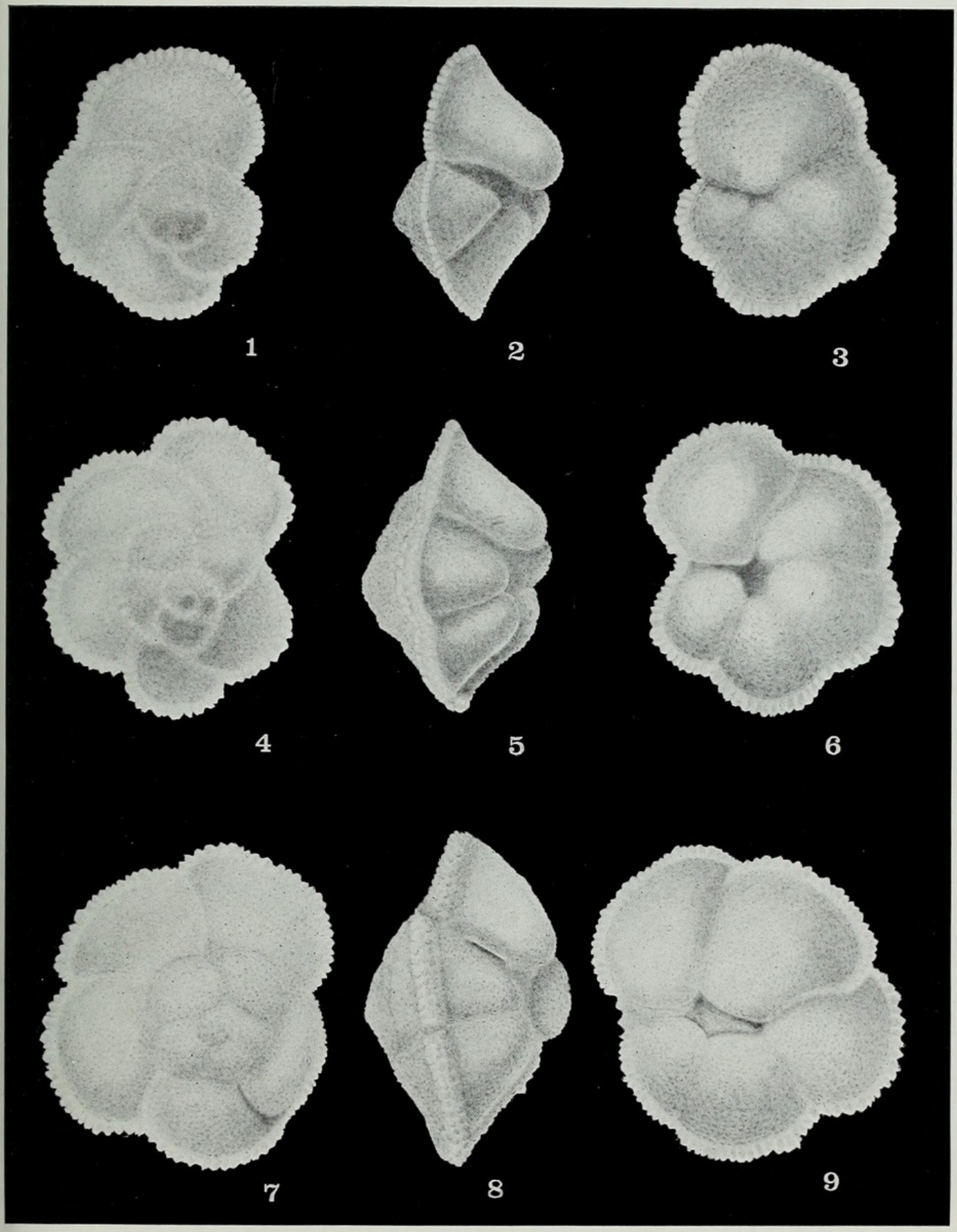

1
2
3
4
5
6
7
8
9

PLATE 12

All figures approximately × 100.

FIGS 1–3. ***Globorotalia pseudobulloides*** (Plummer). P48884. Ventral, peripheral and dorsal views. Sample 3135, ***Globorotalia velascoensis***, upper Dunghan Formation.

FIGS 4–6. ***Globorotalia quadrata*** (White). P48885. Peripheral, ventral and dorsal views. Sample 3671, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 7–9. ***Globorotalia varianta*** (Subbotina) P48886. Peripheral, ventral and dorsal views. Sample 3140, ***Globorotalia aspensis/Globorotalia esnaensis*** Zone, Ghazij Formation.

FIGS 10–12. ***Globorotalia centralis*** Cushman & Bermudez. P48887. Ventral, peripheral and dorsal views. Sample 3606, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

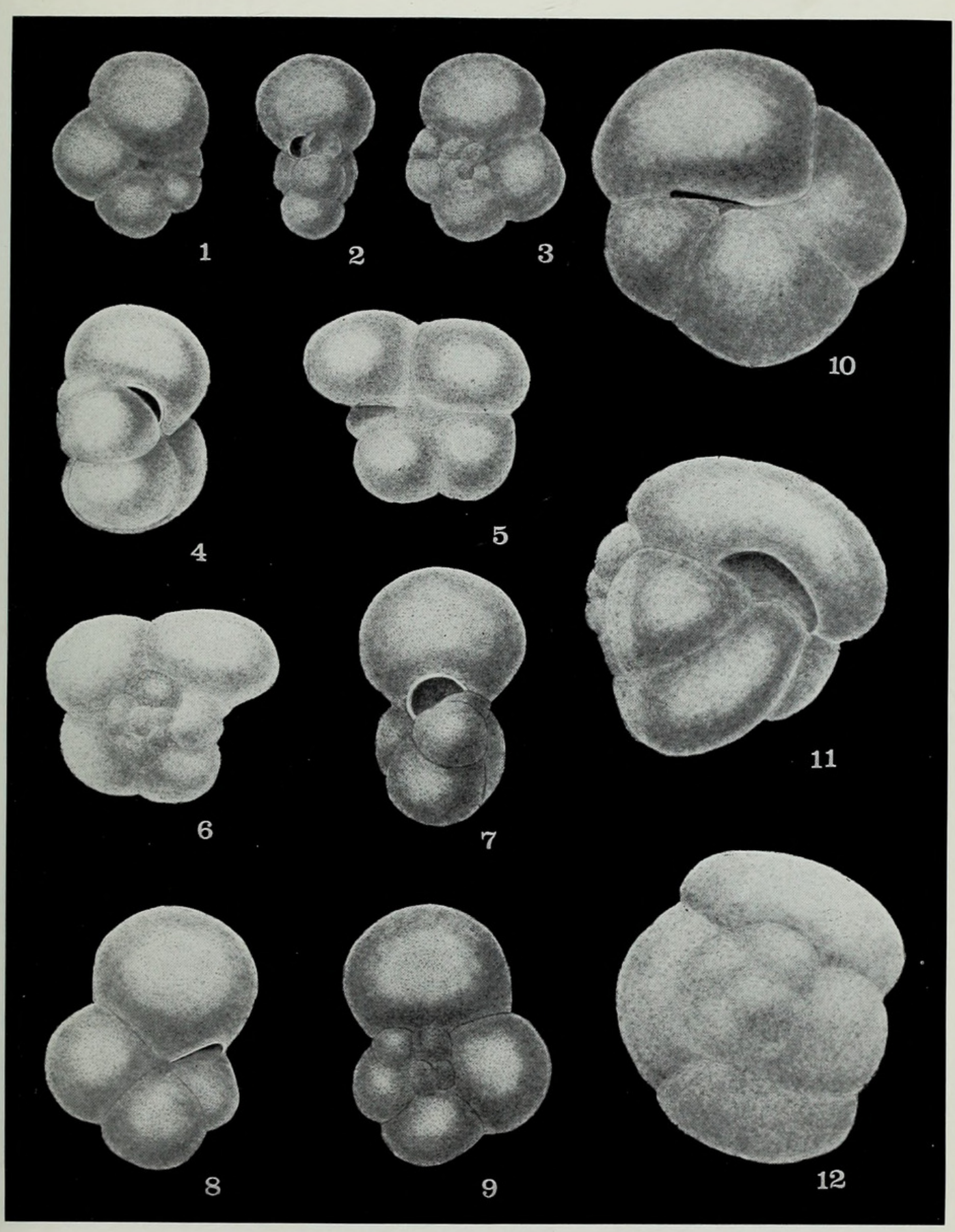

1
2
3
10
4
5
11
6
7
8
9
12

PLATE 13

All figures approximately × 100.

FIGS 1–3. ***Globorotalia troelseni*** Loeblich & Tappan. P48888. Dorsal, peripheral and ventral views. Sample 3137, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

FIGS 4–6. ***Globorotalia ehrenbergi*** Bolli. P48889. Dorsal, peripheral and ventral views. Sample 3135, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

FIGS 7–9. ***Globorotalia pseudomenardii*** Bolli. P48890. Ventral, peripheral and dorsal views. Sample 3135, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

FIGS 10–12. ***Globorotalia renzi*** Bolli. P48891. Dorsal, ventral and peripheral views. Sample 3623, ***Truncorotaloides rohri*** Zone, upper Khirthar Formation.

FIGS 13–15. ***Globorotalia chapmani*** Parr. P48892. Dorsal, peripheral and ventral views. Sample 3135, ***Globorotalia velascoensis*** Zone, upper Dunghan Formation.

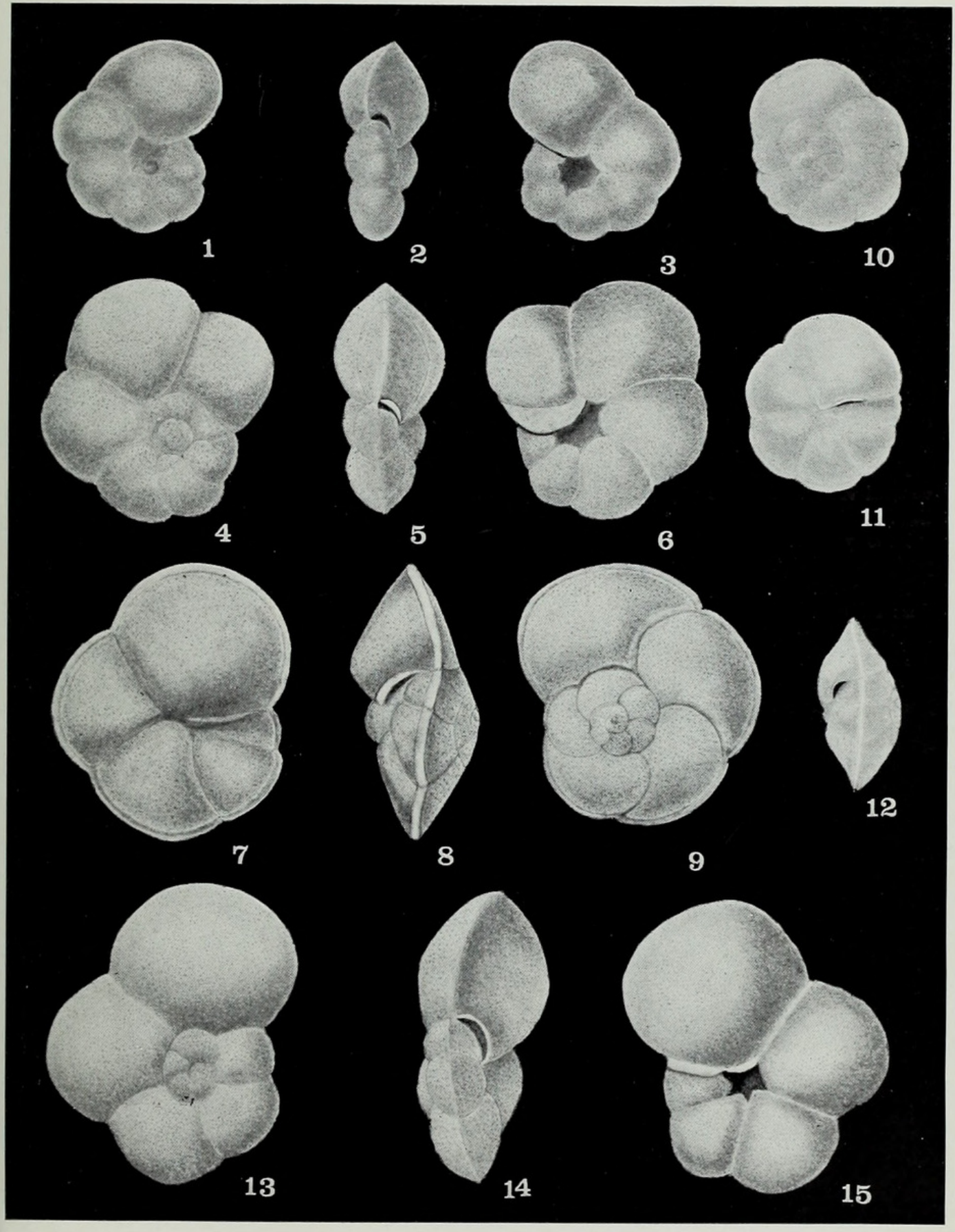

1
2
3
10
4
5
6
11
7
8
9
12
13
14
15

PLATE 14

All figures approximately × 100.

FIGS 1–3. ***Globorotalia spinulosa*** Cushman. P48893. Dorsal, peripheral and ventral views. Sample 3605, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 4–6. ***Globorotalia irrorata*** Loeblich & Tappan. P48894. Dorsal, peripheral and ventral views. Sample 3671, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 7 & 8. ***Chiloguembelina goodwini*** (Cushman & Jarvis). P48895. Side and peripheral views. Sample 3622, ***Truncorotaloides rohri*** Zone, upper Khirthar Formation.

FIGS 9–11. ***Globorotalia*** sp. aff. ***G. primitiva*** (Finlay). P48896. Ventral, peripheral and dorsal views. Sample 3604, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

FIGS 12–14. ***Globorotalia lehneri*** Cushman & Jarvis. P48897. Ventral, peripheral and dorsal views. Sample 3604, ***Globorotalia crassata/Truncorotaloides topilensis*** Zone, upper Khirthar Formation.

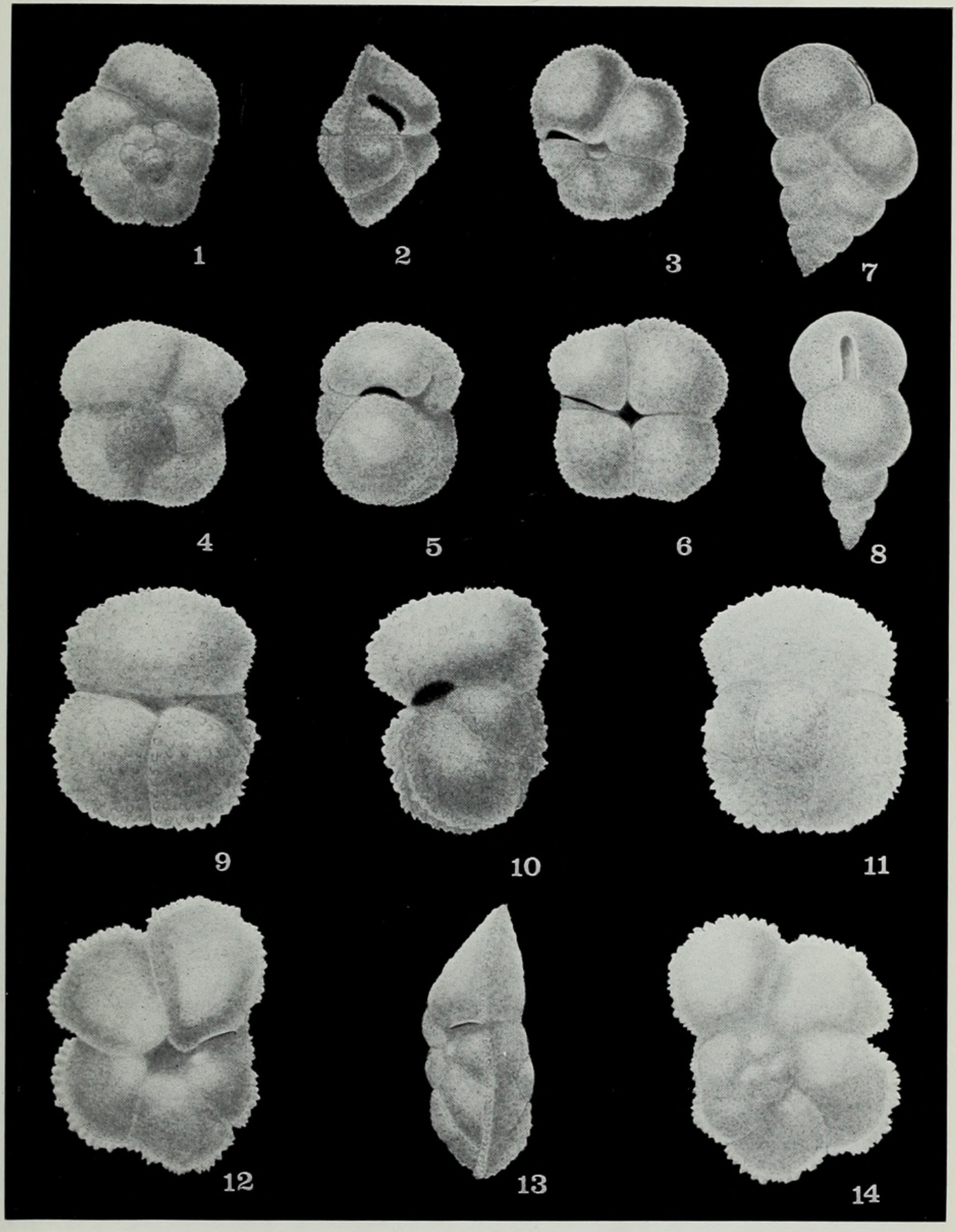

1
2
3
7
4
5
6
8
9
10
11
12
13
14

PLATE 15

All figures approximately × 100.

FIGS 1–3. ***Globorotalia whitei*** Weiss. P48898. Dorsal, peripheral and ventral views. Sample 3671, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

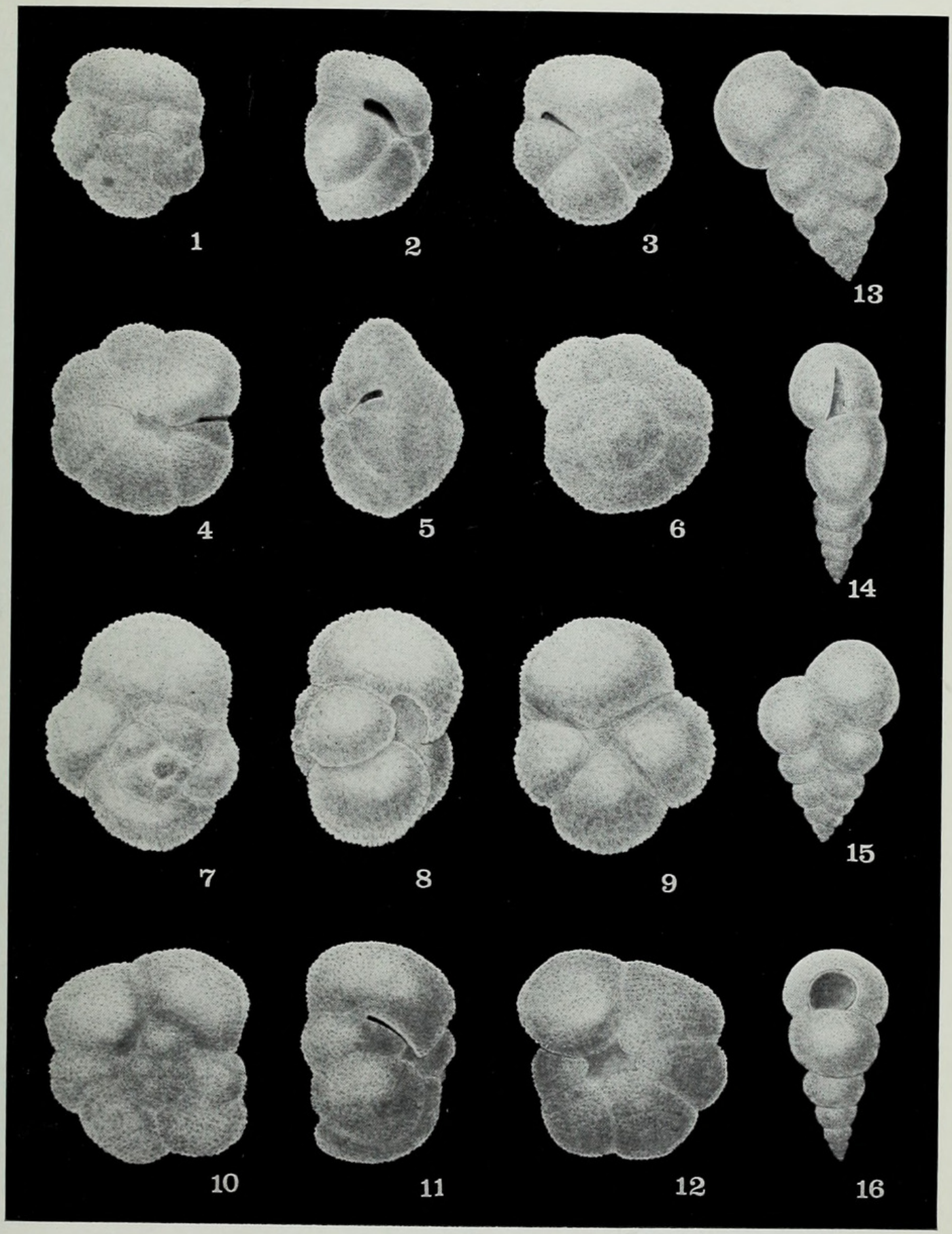
FIGS 4–6. ***Globorotalia broedermanni*** Cushman & Bermudez. P48899. Ventral, peripheral and dorsal views. Sample 3140, ***Globorotalia aspensis/Globorotalia esnaensis*** Zone, Ghazij Formation.

FIGS 7–9. ***Globorotalia esnaensis*** (Le Roy). P48900. Dorsal, peripheral and ventral views. Sample 3671, ***Globorotalia formosa formosa*** Zone, upper Dunghan Formation.

FIGS 10–12. ***Globorotalia aspensis*** (Colom). P48901. Dorsal, peripheral and ventral views. Sample 3155, ***Globorotalia aspensis/Globorotalia esnaensis*** Zone, Ghazij Formation.

FIGS 13 & 14. ***Chiloguembelina martini*** (Pijpers). P48902. Side and peripheral view. Sample 3621, ***Truncorotaloides rohri*** Zone, upper Khirthar Formation.

FIGS 15 & 16. ***Chiloguembelina woodi*** sp. nov. P48903. Side and peripheral views. Holotype, sample 3622, ***Truncorotaloides rohri*** Zone, upper Khirthar Formation.


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