CONTRIBUTIONS
FROM THE
CUSHMAN FOUNDATION
FOR
FORAMINIFERAL RESEARCH

Volume V, Part 4
October, 1954

Contents

WASHINGTON, D. C., U. S. A.
1954

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 4, OCTOBER, 1954

114. THE TOOTHPLATE OF *CERATOBULIMINA*

JAN HOFKER
Den Haag, Holland

The existence of a toothplate in the genus *Ceratobulimina* was first mentioned by Glaessner (1, p. 20) and described, as follows:

"In *Ceratobulimina* the aperture of the last chamber is a narrow slit on the base of the apertural face near the umbilicus. The partition takes its origin from a notch and dent on the ventral side of the septal face, and is connected with the wall of the preceding chamber. The foramen is situated in the part of the wall which lies between the base of the partition and the peripheral part of the chamber. The free margin of the partition extends from the angle between the septum and the dorsal chamber wall to the ventral notch and forms a finely denticulate 'shelf' in a short distance from the dorsal chamber wall."

Although Glaessner's description is accurate it does not give enough details regarding the adherence of the toothplate (Glaessner's "partition") on the septal wall.

Hofker (2, pp. 316-321) closely analysed the morphology and development of the toothplate by using his method of glass-plate drawings, based on individuals of the recent *Ceratobulimina pacifica* Cushman and Harris. The toothplate in this recent species is somewhat more complicatedly built than in fossil material, but it originates from the dorsal border of the septal foramen, runs along the septal wall towards the dorsal wall where it adheres, forms a dorsal suture, and then, with its free folded part dorsally to the apertural foramen of the chambers forms a large wing and adheres at its end at the ventral border of the apertural foramen. The former apertural foramen, which becomes now the septal one, is partly closed by the toothplate in such a manner that only its areal part remains as septal foramen.

Troelsen (3, p. 452 ff.), however, states that in Cretaceous and Paleocene species of *Ceratobulimina* the toothplate is not attached to the dorsal wall and regards this assumption to present the primitive stage of toothplate development in *Ceratobulimina*. Without mentioning Hofker's analysis (2, pp. 316-321) he concludes that "the septal foramen lies above (distally to) the partition and is evidently of secondary origin." He further states (3, p. 453): "Because the internal partition is comparatively complete in *C. contraria*, a particularly clear picture is obtained of the relationship between the aperture, the partition, and the septal foramen; the figures show that the bend of the partition completely surrounds the aperture, while a line connecting the septal foramen would lie on the outside (distal side) of the partitions. The septal foramen can, therefore, not be homologous with any part of the aperture but must be of secondary origin." Since Troelsen bases fundamental taxonomic conclusions on this statement, and since Glaessner (4, p. 23) stresses the attention to the fact that Hofker (2) had some doubt as to the origin of the toothplate in *Ceratobulimina pacifica*, specimens of *Ceratobulimina contraria* from the Miocene of Holland were studied by the writer with the glass-plate method, and the following results obtained:

In *C. contraria* the septal foramen at its distal border shows the attached part of the toothplate of the former chamber very clearly. This septal foramen must, therefore, be the original apertural foramen of the former chamber. (See text fig. 1, a-g). At its opposite (dorsal or proximal) border the next toothplate of the next-following chamber adheres and closes with its basal part the sutural part of that foramen; this, now septal, foramen lies distally from the origin of the next toothplate, which, in turn, creeps along the basal septal wall towards the dorsal wall of the next-formed chamber, attaches with a distinct suture to that dorsal wall, and runs with its free folded part forming a broad flange up to the highest point or top of the apertural foramen of that chamber where it attaches to the ventral, or distal, border of the foramen.

It, therefore, seems that Troelsen's statement was inaccurate, and the conclusion is reached that the apertural as well as the septal foramina in *Ceratobulimina* are true protoforamina. The septal foramina in *Ceratobulimina* are undoubtedly homologous to the apertural foramen, but it must be kept in mind that only the areal part of the apertural foramen remains as a septal foramen. Each toothplate originates from the opposite border of the foramen, where it is attached on the next foramen, a fact which is also evident in *Bolivina* and *Bulimina* which indicates that in all these protoforaminate forms the toothplates are homologous.

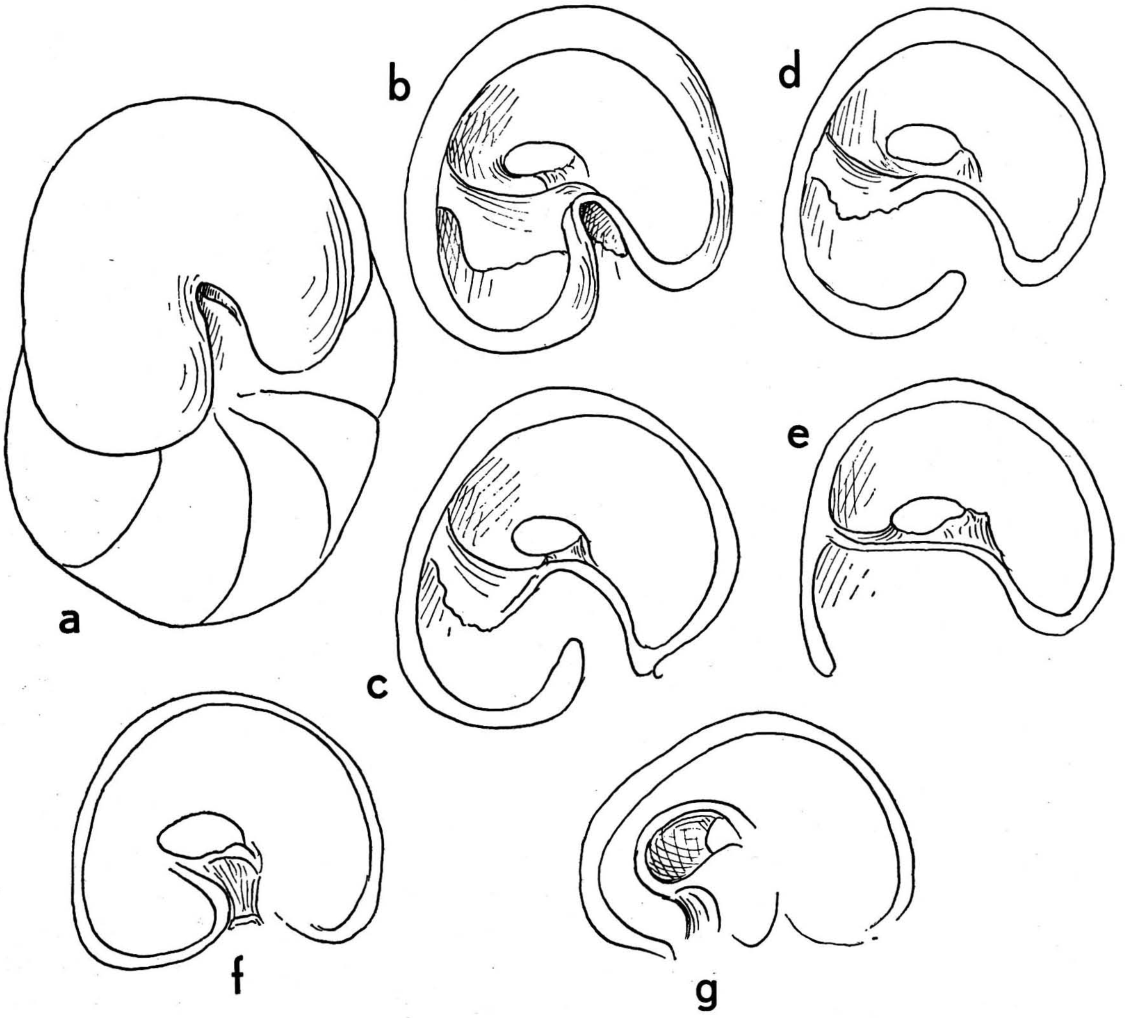
REFERENCES

1. GLAESSNER. F. M., 1937, Studies in Micropaleontology, vol. 1, fasc. 3, p. 20.

2. Hofker, J., 1951, Siboga-Reports, Monogr. IV a, vol. III, pp. 316-321, text figs. 215-217.

3. Troelsen, J. C., 1954, Medded. Dansk Geol. Förening., Band 12, pp. 448-477, pls. 10, 11, text figs. 1-3.

4. Glaessner, F. M., 1954, Contr. Cushman Found. Foram Research, vol. V, p. 23.



TEXT FIGURE 1

Ceratobulimina contraria (Reuss) from the Miocene of Holland.

All figures magnified ca. 85 ×

a: specimen in position in which it was ground down.
b: first sectioning: the aperture is mostly intact, the septal foramen already visible; toothplate surrounds the highest and ventral border of the aperture and is attached to the dorsal wall.
c: second sectioning: the free folded part of toothplate ground down.
d: third sectioning:
e: fourth sectioning: the base of toothplate becomes visible and is attached to the proximal and lower part of the septal foramen closing its basal part.
f: fifth sectioning: only closing part of toothplate remains.
g: sixth sectioning: part of septal wall is ground; the septal foramen is touched and opened so that the toothplate of the former chamber becomes visible, attached in the same manner to this protoforamen (now septal foramen).

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 4, OCTOBER, 1954

115. THE TAXONOMIC POSITION OF *ALLOMORPHINA TRIGONA* REUSS

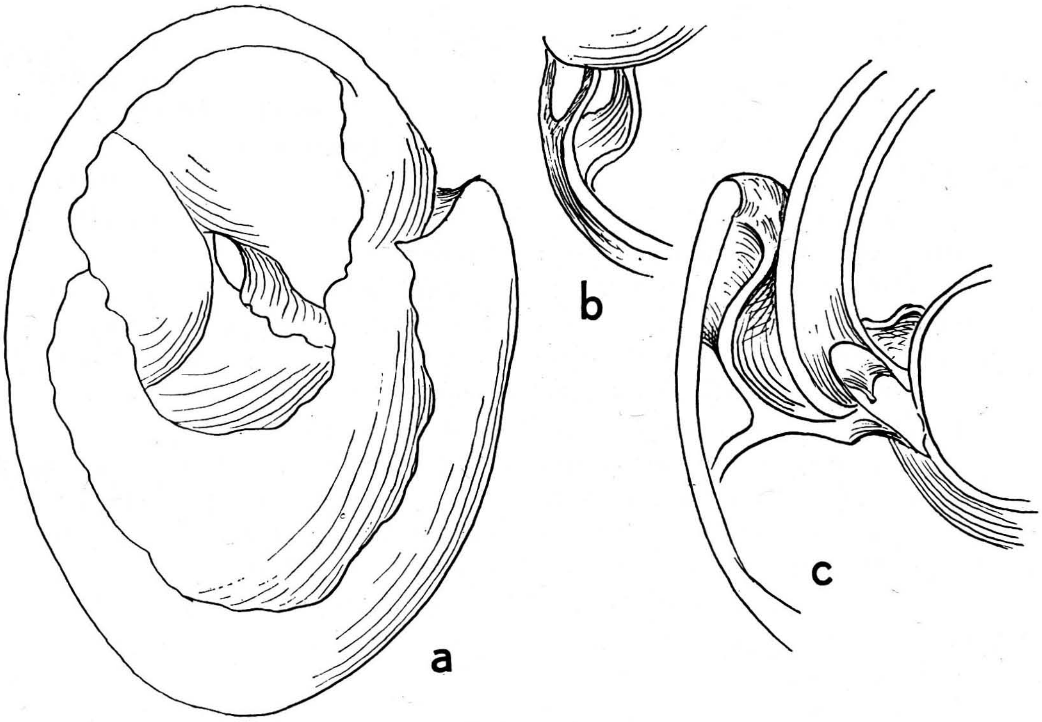
JAN HOFKER
Den Haag, Holland

In his recent study of representatives of the family Ceratobuliminidae J. C. Troelsen (Meddedel. Dansk. Geol. Fören., vol. 12, 1954, p. 469) refers to the genus *Allomorphina* Reuss, as follows:

> "The genus *Allomorphina* is easily dealt with. Brotzen (1948, p. 129) declares that he has not examined the genotype, *A. trigona* Reuss, and that it may not have the same structure as *"Allomorphina" halli* Jennings. Through the courtesy of Drs. R. Grill and C. W. Drooger I have had occasion to examine good specimens of *A. trigona* from the Vienna Basin, and I have found that they have no internal partitions at all."

Based on this statement all species in which toothplates have been found (hitherto the bulk of *"Allomorphina"* species) Troelsen concludes that such forms cannot belong to the genus *Allomorphina* Reuss. It may well be possible that Troelsen's method of examination used for his investigations of the finer structures of Foraminifera, namely Brotzen's technique of breaking tests open in dry state, was inadequate. This method, undoubtedly, gives good results if and when larger and strongly built foraminiferal tests are examined, but it fails in such cases in which the inner structures of the test are fine and delicate, or in cases where the test is filled with mineral materials. The method, however, of grinding such tests in hardened canada balsam never fails, and this method was employed when studying specimens of *Allomorphina trigona* Reuss from Ziegelei Soos, Miocene Badener Tegel, Vienna Basin, Austria, kindly submitted by O. Kühn (Vienna).

All specimens examined proved to be megalospheric forms with a relatively large proloculus which shows



TEXT FIGURE 1

Allomorphina trigona Reuss from the Tortonian Badener Tegel, Ziegelei Soos, Vienna Basin, Austria.
All figures 240 ×

a: small test, partly ground down, showing one of the first-formed chambers with a distinct toothplate.
b: section through the apertural part of an inner chamber, showing behind the septal foramen (protoforamen) the typical toothplate.
c: section through the apertural region of the last-formed chamber. The toothplate behind the slit-like aperture originates from the border of the septal foramen of the formerly built chamber, which, likewise, shows its toothplate at its inner side.

NOTE: All these fine internal structures of the test can only be detected with high magnification.

a rounded septal foramen without any trace of a toothplate. However, all following chambers in the test show the toothplate as already described by Brotzen for *Allomorphina halli* Jennings. The plate is simple, attached to the former septal foramen and running along the basal wall up to the opposite wall of the next-formed chamber where it becomes attached above the foramen (aperture) of this chamber. The toothplate is extremely thin and may be easily overlooked in preparations made by Brotzen's and Troelsen's method. It was, however, found invariably in all chambers following the proloculus and is attached to the distal part of the next foramen but open for communication on the opposite side.

In our opinion, there is, therefore, no doubt that *Allomorphina trigona* Reuss, *A. halli* Jennings, and *A. cretacea* Cushman belong to the same genus. The conclusions drawn by Troelsen, as given above, can therefore not be correct. The genus *Quadrimorphina* Finlay, as correctly stated by Troelsen, shows also the typical toothplate and belongs, together with *Allomorphina,* to a group of allomorphinid genera having four chambers to the whorl. In a forthcoming paper on Upper Cretaceous Foraminifera the proposition will be made to unite both genera, *Allomorphina* and *Quadrimorphina* into the single genus *Allomorphina* and it will be demonstrated that *Valvulineria,* which never shows internal structures, cannot be taxonomically connected with *Allomorphina.*

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 4, OCTOBER, 1954

116. MORPHOLOGY OF *GLOBIGERINATELLA INSUETA* CUSHMAN AND STAINFORTH

JAN HOFKER
Den Haag, Holland

Specimens of *Globigerinatella insueta* Cushman and Stainforth from the type locality, Middle Oligocene, of Trinidad, B.W.I., were studied in ricinus-oil and the following results obtained:

The surface of the test is covered with minute hyaline chalk knobs between which, under high magnification (about ×630) very fine and densely placed pores can be seen (text fig. 1f). The walls are very thin, about 16 microns in sections, originally with a smooth surface on which the fine hyaline chalk knobs are deposited closing the minute fine pores underneath.

The first chambers are arranged in a close spiral, always four chambers to a whorl. The same kind of coiling can also be observed in individuals of the genus *Quadrimorphina* from Upper Cretaceous beds which exhibit also the same wall structure as in *G. insueta.* At the ventral side these minute chambers are globular, but not so at the dorsal side. This quadrimorph arrangement is maintained for about three whorls then becomes irregular. In contrast to *Quadrimorphina* no toothplates could be observed in *Globigerinatella.*

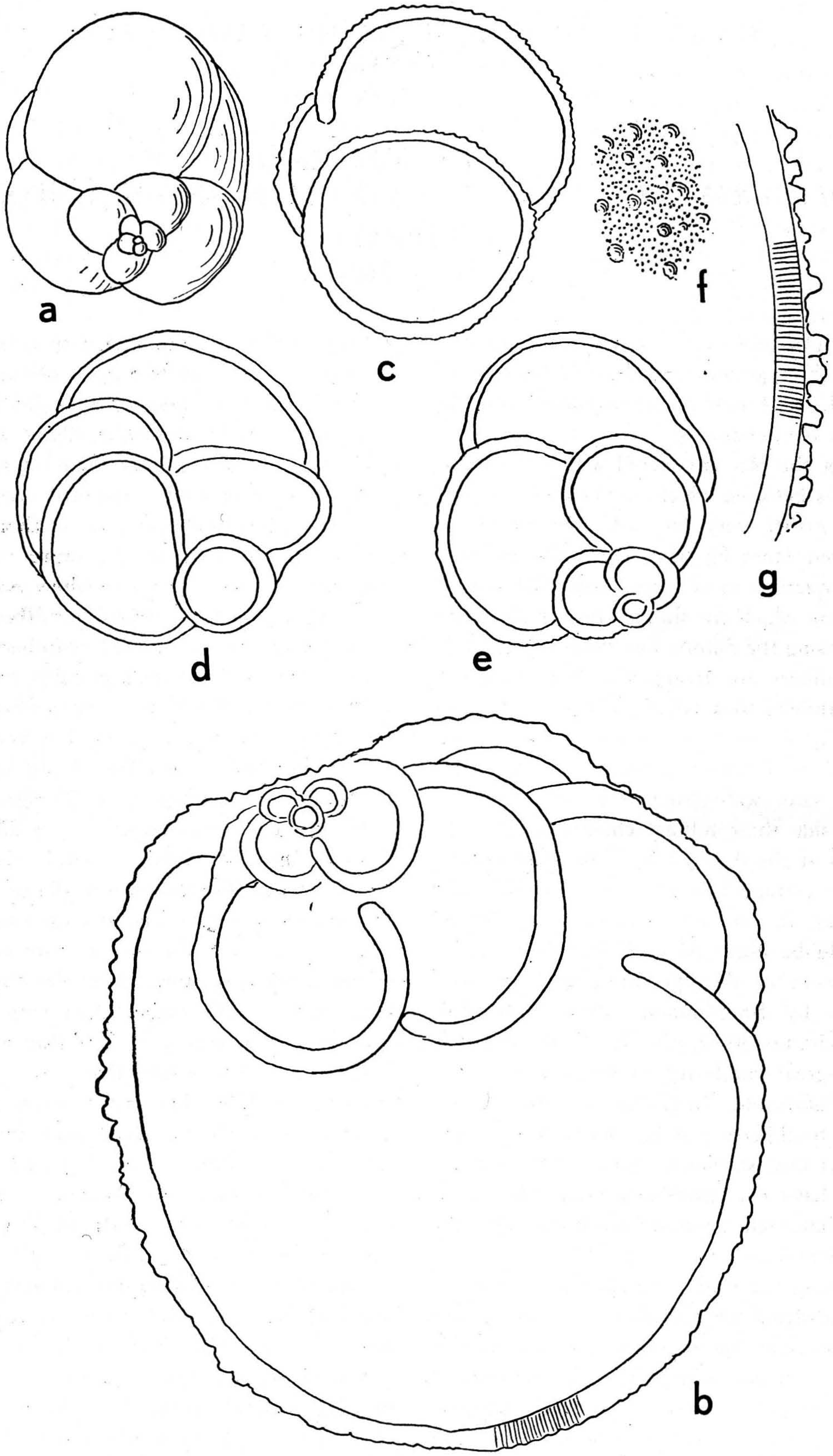
The arrangement of the apertures, already excellently described by Bronnimann (these "Contributions," vol. I, 1950, pp. 80-82, pls. 13, 14) shows in the juvenile stages great similarity to the one found in *Candeina* and *Pullenoides.* In *Candeina* a minute and highly reduced toothplate can be observed in stages with simple aperture; specimens with a row of apertures, however, have this toothplate obliterated. It is quite possible that such a minute toothplate also existed in *Globigerinatella.*

The fine pores in the wall, very closely set, the arrangement of quadrimorph chambers in a whorl and the rounded multiple apertures in *Globigerinatella* do not suggest a relationship with *Globigerina* but strongly point towards a connection with *Quadrimorphina, Pullenoides, Candeina* and possibly also with *Chilostomellina.* A new description of the genoholotype of *Globigerinatella insueta* Cushman and Stainforth, is, therefore, given as follows:

"Test spherical, beginning with a trochoid development with 4 chambers in a whorl, always with a very small proloculus (? apogamic); chambers increasing rapidly in size as added, especially at the ventral side where each chamber is globular. First chambers with simple rounded apertures and with no traceable toothplate; later chambers with multiple apertures along the outer suture. In adult specimens these apertures show protruding borders and may become scattered areally over the ventral surface of the last-formed chamber which is somewhat irregularly shaped and fills the depressions of the sutures. Walls thin, somewhat opaque, very finely porous, with fine pore-less knobs covering the originally smooth surface. Walls in polarized light granular, not radiate as in *Globigerina.*"

The genus *Globigerinatella* is, in all its finer structures of the test, closely allied to the Maestrichtian *Pullenoides* Hofker and also to the geologically younger *Candeina* Orbigny. The four chambers in the earlier stages of the test, the wall texture and the presence of fine pores point towards a relationship with *Quadrimorphina* Finlay rather than with *Globigerinoides* Cushman as suggested by Cushman and Stainforth.

It is interesting to note that specimens of *G. insueta* from the Middle Oligocene of western Ecuador generally show a thicker outer wall than those of the same age in Trinidad. In the Ecuadorean individuals the areal apertures are formed in earlier chambers than is the case in specimens of Trinidad. Moreover, they are much better preserved and show in the initial chambers reduced toothplates very similar to those found in *Candeina nitida* Orbigny from the Caribbean Sea. It seems that the morphologic characters of *Globigerinatella* are those of *Candeina* except for the forming of areal apertures in the ultimate chambers. There seems to be no doubt that *Globigerinatella* represents to some extent a *Candeina* in which the rounded apertures of the last-formed chamber become areal.



TEXT FIGURE 1

Globigerinatella insueta Cushman and Stainforth, 1951, from Middle Oligocene of Trinidad, British West Indies.

a: dorsal side of small specimen showing the arrangement of the chambers as seen in ricinus-oil preparations. × 85.
b: transverse section. × 240.
c, d, and e: successive sections through a small specimen. × 85.
f: part of loosened wall from the outside, showing the fine pores and minute chalk knobs. × 315.
g: transverse section of wall showing fine pores and superimposed chalk knobs. × 315.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 4, OCTOBER, 1954

117. *PIJPERSIA* NOM. NOV. FOR *RUTTENIA* PIJPERS, 1933, A HOMONYM OF *RUTTENIA* RODHAIN, 1924

HANS E. THALMANN
Stanford University

The writer recently detected that *Ruttenia* Pijpers, 1933 is preoccupied by *Ruttenia* Rodhain, 1924, a genus of the Diptera. In order to pay tribute to the late P. J. Pijpers, who died during the occupation of Indonesia in a Japanese prison camp like other young and promising Dutch micropaleontologists (L. W. Vermunt, W. Krijnen, L. J. Bakx), the new name *Pijpersia* is herewith proposed with *Bonairea coronaeformis* Pijpers, 1933, as genoholotype from the Eocene of the Bonaire Island, Dutch West Indies.

This species was originally erected by Pijpers for his new genus *Bonairea* 1933, (Geology and Paleontology of Bonaire, Thesis Utrecht) which, however, was already preoccupied by *Bonairea* Burrington Baker in the Mollusca, and, therefore, changed by Pijpers in the same year (Contr. Cushman Lab. Foram. Res., vol. 9, 1933, p. 30) to *Ruttenia* nom. nov. Rodhain's name of 1924, however, antedates Pijper's (Bull. Soc. Pathol. Exot., vol. 17, p. 92, Diptera).

To the writer's knowledge, *Pijpersia* so far has only been reported from Eocene formations, and is represented by its genotype from the Upper Eocene of Bonaire Island, West Indies, by *Pijpersia dariensis* (Coryell and Embich, 1937), from the Upper Eocene of Panama, and by *Pijpersia geleenensis* (Van Bellen) from the Eocene of The Netherlands. Since there is some disagreement as to the taxonomic position of the genus (Anomalinidae or Epistominidae?) it would be advisable to restudy and refigure the genotype apparently housed in the micropaleontological collections of the Geological Institute of the Rijksuniversiteit Utrecht. Being generally of very small size it ought to be carefully looked for in finer screenings of Upper Eocene assemblages.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 4, OCTOBER, 1954

118. UPPER CRETACEOUS AND LOWER TERTIARY *BOLIVINOIDES* FROM ISRAEL

Z. REISS
Geological Institute of Israel, Jerusalem

ABSTRACT—Fourteen species and subspecies of **Bolivinoides** from the Late Cretaceous and Early Tertiary of Israel are recorded and figured. Five of them are described as new. The recorded species and subspecies are divided into three major groups. The stratigraphical ranges of the recorded **Bolivinoides** are summarized in a range-chart.

INTRODUCTION

Particular attention has been paid in recent years to certain specialized genera of smaller Foraminifera, such as *Neoflabellina, Bolivinoides, Stensiöina,* and others. These genera evolve rather rapidly through a succession of short-living, mostly widely-distributed forms and are, therefore, extremely valuable in stratigraphical work, especially as far as Late Cretaceous and Early Tertiary deposits are concerned.

Up to the present detailed research on these genera was restricted to northern and northwestern Europe, where various European authors have investigated the taxonomy, phylogeny and stratigraphic distribution of the species and subspecies belonging to the above-mentioned genera. Relatively little is known on these important forms from other parts of the world.

Detailed studies of the genera *Neoflabellina* and *Bolivinoides,* carried out at present by the writer in Israel, have already proved the importance of these genera for the Upper Cretaceous and Lower Tertiary stratigraphy of this region.

Some results regarding the occurrence of the species and subspecies of the genus *Bolivinoides* in the Upper Cretaceous and Lower Tertiary of Israel are given below. These investigations are still in progress because more material will have to be examined in order to solve various problems. Nevertheless, taking into account the scarcity of knowledge regarding the genus *Bolivinoides* in the Middle East and Mediterranean area in general, and in view of the importance of this genus for the Upper Cretaceous and Lower Tertiary stratigraphy, it seemed useful to publish the results so far obtained in Israel.

As far as known to the writer, no specimen of Upper Cretaceous-Lower Tertiary *Bolivinoides* has ever been figured from the Middle East region, except by LeRoy (1953) under the name of *Bolivina.* Published records give only generic references (Henson 1938, Tromp 1943, 1949, 1952), except *Bolivinoides decorata* (Jones) recorded by the writer (1952a, 1952b) from Israel and by LeRoy (1953) from Egypt; *B. rhomboidea* (Cushman) recorded by Nakkady (1950) from Egypt; *B. decorata* (Jones) *delicatula* Cushman and *B. draco* (Marsson) recorded by the writer (1952a) from Israel.

For microfaunal evidence of the age of the stratigraphical units of Israel, as given in the accompanying range-chart, reference is made to the writer's (1952a, 1952b) publications. The writer now regards: a) the strata carrying *Globotruncana concavata* (Brotzen) (=*Globotruncana ventricosa* Reiss, 1952a, *non* White) and *Texanites* as Santonian (lower part of the Santonian-Campanian of Reiss 1952a); b) all strata carrying *Bolivinoides peterssoni* Brotzen as Upper Maestrichtian (Stevnsian of Brotzen 1945); c) the lower part of the "Dano-Paleocene" (i.e., the *Globigerina*-zone) as Danian; d) and the upper part of the "Dano-Paleocene" (i.e., the *Globigerina-Truncorotalia* zone) as Paleocene. The writer prefers to include the Danian (regarded by him to belong to the Lower Tertiary) and the Paleocene in a *"Dano-Paleocene"* unit, separated from the Maestrichtian by an unconformity marked in the range chart.

For synonymies and additional references the reader is referred to the publications cited at the end of this paper, especially to Hiltermann and Koch (1950).

The figures are camera-lucida drawings by the writer.

All figured specimens are deposited in the micropaleontological collection of the Geological Institute of Israel, Jerusalem.

ACKNOWLEDGMENTS

The writer gratefully acknowledges the advice and constructive criticism of the manuscript by M. Avnimelech, Jerusalem. Sincere thanks are due to F. Brotzen, Stockholm, for making available, specimens of *Bolivinoides* from Scandinavia and Germany, for his kindness to compare specimens of *B. delicatula* from Israel with topotype-material from Mexico and for many valuable suggestions and important information. The writer is greatly indebted to H. Hiltermann, Hannover, H. Hagn, Munich and C. A. Wicher, Peine, who most kindly and generously put at the disposal of the writer material for comparison, as well as to H. E. Thalmann, Stanford, for his valuable suggestions with regard to the form of the present paper. Thanks are due to Mrs. K. Klug and Mrs. P. Merling who helped

with picking, counting and measuring specimens and to Miss R. Strassburger for drawing the accompanying tables.

SYSTEMATIC PALEONTOLOGY

The discussion of the species and subspecies mentioned here follows the order maintained in the accompanying range-chart and in the table showing the length/breadth index-values.

Genus **Bolivinoides** Cushman, 1927

Bolivinoides angulata Reiss, sp. nov.

Plate 28, figures 1-4

Holotype.—Pl. 28, fig. 1a, b, × 110, from the Lower Campanian of Tulkarem, well 6 (Type-locality). No. 2139. Pal. Coll. of Geol. Institute Jerusalem.

Diagnosis.—Test carrot-like to bolt-shaped in outline; section rounded-rectangular, concave towards the medial part of the test; chambers roof-like and angular with rather deep excavations towards the medial part of the test, giving this part of the test a grooved character; ornamentation consisting of prominently raised and elongated lobes of the chambers, forming ribs and knots, mostly obscuring the sutures; length: up to 0.5 mm. (For length/breadth index-values of this and the following species, see accompanying table).

Relationships and remarks.—*B. angulata* is apparently closely related to *B. strigillata strigillata* (Chapman) and to *B. clavata* (Cushman). These latter species have, however, a broadly oval section always with convex sides and rarely rounded-rectangular, and do not have such angular (hence the *derivatio nominis*) or excavated chambers as our species.

Occurrence.—*B. angulata* occurs sporadically at various localities in the country, where it is usually frequent. It seems to be restricted to the Campanian and occurs mainly in the Lower Campanian and only rarely in the deepest layers of the Upper Campanian.

Bolivinoides decorata decorata (Jones)

Plate 28, figures 5-8, 13

1950. *B. decorata decorata* (JONES) HILTERMANN and KOCH, p. 606, figs. 2-4, No. 14-25, 27-31, 35-38, 42-45 and fig. 5 No. 36, 71.

Remarks.—Specimens of this subspecies occur frequently in the Campanian and Lower Maestrichtian of Israel. They show a rather great range of variation as far as dimensions and ornamentation are concerned, a fact observed also by Hiltermann and Koch (1950) in northern Europe.

Rare specimens resembling somewhat *B. decorata gigantea* Hiltermann and Koch were found in the Maestrichtian of Israel, but a closer study is required to establish their identity with any known species of *Bolivinoides*.

Bolivinoides draco miliaris Hiltermann and Koch

Plate 28, figures 9-12, 14

1950. *B. draco miliaris* HILTERMANN and KOCH, p. 604, figs. 2-4 No. 26, 32-34, 39-41, 46-48, fig. 5 No. 39a-c.

Remarks.—The stratigraphical range of this subspecies is greater in Israel than in northern Europe. It occurs in Israel together with *B. peterssoni* Brotzen, *Neoflabellina coranica* (Marie), etc. There is no evidence that the specimens of *B. draco miliaris* in these Upper Maestrichtian strata are redeposited. Additional study might reveal certain characteristics of the late Maestrichtian specimens which may distinguish them from those of the Campanian and early Maestrichtian. It might be noteworthy in this connection that *Bolivina decurrens* (Ehrenberg) Marsson also has a shorter stratigraphical range in northern Europe than in either the Gulf-Caribbean area or in Israel. It seems that ecological factors have affected the stratigraphical ranges of certain species in northwestern Europe, since except the above-mentioned two species, *Bolivinoides paleocenica* (Brotzen) also occurs in that region only in the Lower Maestrichtian. In Scandinavia, however, it occurs also in the Paleocene and in Israel in the Maestrichtian, as well as in the Dano-Paleocene (see also below). Most probably ecological factors are also responsible for the "Stensiöinen-freier Bereich" of Wicher (1953) in the lower part of the Upper Maestrichtian, characteristic of boreal Europe, according to Wicher (1953).

In Israel *B. draco miliaris* occurs most frequently in the Upper Campanian.

Bolivinoides draco draco (Marsson)

Plate 29, figures 1-3

1878. *Bolivina draco* MARSSON, p. 157, pl. 3, 25a-d.

1950. *Bolivinoides draco draco* (MARSSON) HILTERMANN and KOCH, p. 598, figs. 2-4 No. 52-54, 58-60, fig. 5 No. 53, 69, 70, fig. 1 No. 72a-c, 73a-b.

Remarks.—This subspecies is a guide-fossil for the Maestrichtian of Israel, where it occurs very frequently. In the higher Maestrichtian it occurs associated with the closely related *B. draco dorreeni* Finlay.

Bolivinoides draco dorreeni Finlay

Plate 29, figures 4-7

1940. *Bolivinoides dorreeni* FINLAY, p. 453, pl. 63, figs. 56-58.

Remarks.—This form is characterized mainly by the prominently "fenestrate" or reticulate ornamentation, which distinguishes it from *B. draco draco*. It is, however, closely related to this latter subspecies and is connected with it by transition-forms.

Our specimens correspond closely to *B. dorreeni* Finlay, except in the fact that the specimens figured by Finlay (1940) are somewhat more elongated than ours. The index of the specimens figured by Finlay, ca. 1.5, remains, however, within the range of the *draco*-group (see below). On the other hand, Finlay mentions only the greatest length of *B. dorreeni*, but not the greatest breadth, or the length/breadth index.

The most interesting fact about *B. dorreeni* Finlay is its occurrence in the Piripauan stage of New Zealand, the age of which is given by Finlay as Santonian (!). Three alternative explanations might be offered for this surprising stratigraphical range of a member of the *draco*-group, to which *B. dorreeni* certainly belongs. a) either the specimens of *B. dorreeni* have not been found by Finlay *in situ*; b) or the *draco*-group is polyphyletic and evolves in New Zealand from another than the *decorata*-group, appearing there as early as Santonian; c) or the age-determination of the Piripauan stage as given by Finlay is incorrect. Although no literature which would allow any conclusion on the age of the Piripauan stage is available to this writer, the latter assumes an incorrect age-determination as the most likely explanation. Finlay states that *B. dorreeni* is a Piripauan index fossil; on the other hand neither in the Eastern, nor in the Western hemisphere are rhomb-shaped *Bolivinoides* with a continuous rib ornamentation known to occur before the Maestrichtian. Furthermore, the evolution of the *draco*-group has been traced back clearly to the *decorata*-group (Hiltermann and Koch, 1950) which itself does not appear earlier than Campanian.

These considerations allow the identification of our specimens with *B. dorreeni* Finlay, which we regard as a subspecies of the *draco*-group (*s. str.*, not in the sense of Hiltermann and Koch, 1950).

Most probably *B. draco dorreeni* is involved in Wicher's (1953) record of a "reticulate new subspecies" belonging to the *draco*-group and appearing in the boreal Upper Maestrichtian. The specimen of *B. rhomboidea* (Cushman) figured by Wicher (1949) on pl. 7 probably represents *B. draco dorreeni* Finlay.

Length of *B. draco dorreeni*: up to 0.7 mm.

Frequent in the higher Maestrichtian (especially Upper Maestrichtian) of Israel.

Bolivinoides watersi (Cushman)

Plate 29, figure 8

1927. *Bolivina watersi* CUSHMAN, Cushm. Lab. Foram. Research Contr. vol. 2, p. 88, pl. 12, fig. 6.

Remarks.—Specimens belonging to this species occur in the Lower Campanian of Israel. Certain individuals of this small and easily overlooked species somewhat resemble in outline and chamber-form *Bolivina decurrens* (Ehrenberg) Marsson (*non* Wicher, 1942).

B. watersi occurs sporadically at a number of localities in Israel.

Bolivinoides pustulata Reiss, sp. nov.

Plate 29, figures 9-10

Holotype.—Pl. 29, fig. 9a, b, × 110, from the Lower Campanian of Judeida (Type-locality). No. 813: Pal. Coll. of Geol. Institute of Jerusalem.

Diagnosis.—Test elongated, club-shaped in outline; section flatly elliptical, periphery sharply rounded to subacute; ornamentation consisting of prominently raised, circular knobs, arranged in two paramedian rows on the earlier chambers, followed by fairly indistinct knobs and elongated weakly raised lobes, arranged in two or—rarely—three paramedian rows in the later chambers; ornamentation restricted to the medial part of the test; sutures depressed, distinct and slightly curved; length: up to 0.5 mm.

Relationships and remarks.—This species resembles somewhat *B. texana* Cushman, which, however, is much less ornamented and has no knobs on the earlier chambers. Our species differs from *B. laevigata* Marie in its more elongated form, in its more rounded periphery and in its ornamentation consisting of prominent pustule-like knobs on the early chambers.

Occurrence.—*B. pustulata* occurs rather rarely in the Lower Campanian of Israel.

Bolivinoides compressa Reiss, sp. nov.

Plate 30, figures 1-3

Holotype.—Pl. 30, fig. 1a, b, × 110, from the Upper Campanian of Er Ruweis (Type-locality). No. 839 (a): Pal. Coll. Geol. Institute, Jerusalem.

Diagnosis.—Test extremely flat; periphery very acute and keeled; sutures strongly curved, limbate, clear and somewhat depressed; ornamentation consisting of nearly circular, weakly raised knobs, arranged in two (very rarely only one) paramedian rows; length: up to 0.5 mm.

Relationships and remarks.—Our species is apparently closely related to a hitherto undescribed species occurring in the Campanian of Germany. *B. compressa* also resembles the species figured by Hiltermann (1952, fig. 5) as *B. decorata laevigata* Marie, which, in the writer's opinion, does not correspond to *B. decorata laevigata* Marie. Marie's subspecies has no circular knobs, as shown in Hiltermann's specimen, but has very faintly raised, elongated lobes, arranged in two to three paramedian rows (Marie, 1941). Furthermore, the holotype of *B. decorata laevigata* figured by Marie does not show any ornamentation on the lower part of the test. Our species seems also near to *Bolivina decurrens* Wicher (*non* Ehrenberg, *nec* Marsson) figured by Wicher, 1942 on pl. 26, fig. 24. Wicher's specimen, however, shows more prominently raised knobs.

Occurrence.—*B. compressa* occurs rarely and sporadically in the Campanian of Israel.

Bolivinoides praecursor Reiss, sp. nov.

Plate 30, figures 4-7

Holotype.—Pl. 30, fig. 4a, b, × 110, from the Upper Campanian of Er Ruweis (Type-locality). No. 839 (b): Pal. Coll. Geol. Institute, Jerusalem.

Diagnosis.—Test flatly elliptical in section; periphery acute, sometimes slightly keeled in the early chambers; sutures distinct, very oblique and slightly curved; ornamentation consisting in the early stages of rather faintly raised, somewhat irregular knobs, in the later stages of distinct, somewhat nodular and short, elongated lobes; the latter are arranged in two (rarely three) paramedian rows; length: up to 0.45 mm.

Relationships and remarks.—*B. praecursor* is apparently closely related to *B. peterssoni* Brotzen and is regarded by the writer as the ancestor of the latter species (hence the *derivatio nominis*). It is distinguished from *B. peterssoni* by its more elongated form, less acute and only rarely slightly keeled periphery and also by the elongated form of the lobes. Our species is apparently related to *B. decorata laevigata* Marie (length/breadth index, from data given by Marie, 1941: 1.6-2.0), which, however, has very faintly raised, scarcely perceptible lobes. Marie's figure of the holotype suggests furthermore that the ornamentation of *B. decorata laevigata* is restricted to the upper half of the test. Since it appears doubtful that *B. decorata laevigata* is indeed a subspecies of *B. decorata* (Jones) or even that it is directly connected with the latter, the writer proposes to elevate *B. decorata laevigata* to specific rank.

The writer was unable to examine topotypes of *B. laevigata*, but has seen specimens of *Bolivinoides* from western Europe, labelled *B. decorata laevigata*, which represent at least two different species, differing moreover in some details from the original figure of *B. laevigata*. One of the forms from Germany is apparently closely related to our *B. praecursor*. Most probably a similar form is involved in Hiltermann's (1952) record of *B. peterssoni* from the Upper Campanian and Lower Maestrichtian of northwestern Germany. Wicher (1953) on the other hand believes his *Bolivinoides* sp. ("traubig")—considered by Wicher to be the ancestor of *B. peterssoni*—to be involved. This writer has examined specimens of *B.* sp. ("traubig") most kindly supplied by C. A. Wicher and found them to belong to the species recorded and figured by Hiltermann and Koch (1950) and Hiltermann (1952) as *Bolivinoides decorata delicatula* Cushman. For reasons to be discussed later, it is most unlikely that this latter species, which is different from *B. decorata delicatula* Cushman, is the ancestor of *B. peterssoni*. Wicher's (1953) figure of his *B.* sp. ("traubig") is not sufficiently clear.

Such extremely broad forms as figured on pl. 30, fig. 8 might represent transition forms between *B. praecursor* and *B. paleocenica* (Brotzen).

Occurrence.—*B. praecursor* occurs fairly frequently in the Upper Campanian and Lower Maestrichtian of Israel.

Bolivinoides sp.
Plate 29, figure 11

Remarks.—The identity of this species is not yet established. Extremely rare specimens have been found in the Upper Campanian of Israel (with *Globotruncana calcarata* Cushman). It is characterized by its rather broad general form with an acute periphery and 3 paramedian rows of distinctly raised oblong lobes. It seems to be related to *B. laevigata* Marie, which, however, is apparently not ornamented in the early stages. More material is needed to establish the identity and relationships of our form. A specimen is figured for further reference.

Bolivinoides peterssoni Brotzen
Plate 30, figures 12-14

1945. *B. peterssoni* Brotzen, p. 49, pl. 1, fig. 10.

Remarks.—Specimens belonging to this species occur in the Upper Maestrichtian of Israel.

Bolivinoides paleocenica (Brotzen)
Plate 30, figures 9-11

1948. *Bolivina paleocenica* Brotzen, p. 66, pl. 9, fig. 5.
1952. *Bolivinoides paleocenica* (Brotzen) Hiltermann, pp. 61, 63, figs. 4, 5.

Remarks.—This species has been recorded from the Paleocene of Scandinavia (Brotzen, 1948) and from the Lower Maestrichtian of northwestern Germany (Hiltermann, 1952, Wicher, 1953). In Israel it occurs throughout the Maestrichtian (except in the basal layers), and also in the "Dano-Paleocene."

The writer has so far not observed any essential differences between the specimens from the Maestrichtian and those from the "Dano-Paleocene." After discussion with F. Brotzen he agrees that the Maestrichtian form should be separated from the post-Maestrichtian one. However, until more material has been examined, both forms are included for the time being in *B. paleocenica*.

We do not believe that the post-Maestrichtian specimens are redeposited, as is supposed by Wicher (1953) to be the case in the Paleocene of Sweden. In the first place *B. paleocenica* ranges in Israel higher in the Maestrichtian than in northern Europe (see also the remarks concerning *B. draco miliaris, Bolivina decurrens* and *Stensiöina* above). Secondly, it would be surprising that just one of the rarest forms of the Maestrichtian of Israel should be found redeposited in the "Dano-Paleocene," while much more common and abundant species occur redeposited only rarely and then mostly in the basal layers of the "Dano-Paleocene."

Bolivinoides delicatula Cushman
Plate 31, figures 1-4

1926. *Bolivina decorata* Cushman (*non* Jones), p. 586, pl. 15, fig. 11.

1927(a). *Bolivinoides decorata delicatula.* CUSHMAN, p. 90, pl. 12, fig. 8.
1927(b). *Bolivinoides decorata delicatula.* CUSHMAN, p. 158, pl. 28, fig. 7.
1928. *Bolivinoides decorata delicatula.* CUSHMAN, p. 99, Pl. 14, 9.
1929. *Bolivina decorata* WHITE (*non* JONES), p. 43, pl. 5, fig. 1.
1932. *Bolivinoides decorata delicatula.* CUSHMAN and JARVIS, pl. 13, fig. 2.
1946. *Bolivinoides decorata delicatula.* CUSHMAN and RENZ, p. 36, pl. 6, fig. 4.
pars 1946. *Bolivinoides decorata delicatula.* CUSHMAN, p. 313, pl. 48, figs. 10, 13 (*non* figs. 11, 12, 14).
non 1926. *Bolivina latticea* CARSEY, p. 27, pl. 4, fig. 9.
non 1931. *Bolivinoides decorata delicatula.* CUSHMAN, p. 308, pl. 35, fig. 13.
non 1931. *Bolivina decorata.* PLUMMER, p. 181, pl. 10, fig. 10 (refigured holotype of *B. latticea* CARSEY 1926).
non 1932. *Bolivinoides decorata delicatula.* CUSHMAN, p. 388, pl. 51, fig. 6.
non 1941. *Bolivinoides decorata delicatula.* MARIE, p. 188, pl. 29, fig. 280.
non 1950. *Bolivinoides decorata delicatula.* HILTERMANN and KOCH, p. 612, fig. 5, No. 65-67.
non 1952. *Bolivinoides decorata delicatula.* HILTERMANN, pp. 61, 63, figs. 4, 5.

Remarks.—This writer intentionally does not apply the trinominal name *B. decorata delicatula,* since there is yet no evidence that this species is derived from *B. decorata* (Jones) or even from the *decorata*-group, and thus representing a subspecies of *B. decorata.*

Specimens of this species from Israel have been compared by F. Brotzen with topotype-material from the Velasco-shale formation of Mexico and found to correspond entirely to the American species (written communication, October 22, 1952).

The writer separates from *B. delicatula* the specimens figured by Cushman (1931, 1932, refigured 1946 pl. 48, figs. 11 and 12) from the Taylor and Navarro formations of the Gulf Coast region. These specimens differ from *B. delicatula,* figured from the Velasco shale and from the Lizard Springs marl, in the rapid increase of the breadth of the test, smaller length/breadth index (1.7-1.8 as against 2.2-2.5), in the ornamentation composed of elongated and short, almost rectangular, closely spaced ribs, arranged in a very regular pattern all over the chambers, and in their different stratigraphical range (Campanian-Maestrichtian against late Danian to Paleocene). It might be significant that Cushman himself (1931, 1932) notes with regard to the Taylor and Navarro specimens the comparatively short test with an "ornamentation of the surface.... more like that of the variety than of the typical species" (*B. decorata* (Jones), writer's note) and "on the whole (tending) toward the variety (*B. decorata delicatula* Cushman, aut. note) rather than the typical form of the species."

The writer proposes, therefore, for this species the name *Bolivinoides* **regularis**, sp. nov. (holotype: pl. 35, fig. 13, Cushman, 1931, from the Saratoga Chalk, Saratoga, Arkansas, Howard County (station 79 of Cushman 1946), refigured in Cushman 1946, pl. 48, fig. 12. Deposited (see Cushman 1946) in the Cushman Collection, U. S. Nat. Museum, Washington, D. C.

As far as the specimen figured by Cushman (1946) as *B. decorata delicatula* from the Taylor marl of Texas (*l.cit.*, pl. 48, fig. 14) is concerned, the writer agrees with Hiltermann and Koch (1950) that it belongs to the group of poorly ornamented *Bolivinoides* (such as *B. watersi, B. laevigata, B. pustulata, compressa, praecursor,* etc.).

Although the specimens figured as *B. decorata delicatula* by Hiltermann and Koch (1950) and Hiltermann (1952) have a greater length/breadth index than *B. regularis,* sp. nov. as figured by Cushman (1931, 1932) they show a markedly similar ornamentation and general form. On the other hand the writer has seen material from Germany which leads him to the conclusion that generally the specimens of *B. decorata delicatula* Hiltermann and Koch (*non* Cushman) have a smaller length/breadth index than the specimens figured by Hiltermann and Koch (1950), (i.e., mostly between 1.7-2.0, agreeing closely with the specimens of *B. regularis,* sp. nov. as figured by Cushman). The specimens from Germany, furthermore, have tests which increase rapidly in breadth and the ornamentation is distinctly that of *B. regularis.* The stratigraphical range of *B. decorata delicatula* Hiltermann and Koch (*non* Cushman) also agrees closely with that of *B. regularis* in the Gulf Coast region (Campanian-Lower Maestrichtian), but not with that of *B. delicatula* Cushman (Danian-Paleocene). For these reasons the writer includes *B. decorata delicatula* Hiltermann and Koch (*non* Cushman) in *B. regularis.* To this latter species also belongs—as pointed out above—*B.* sp. ("traubig") of Wicher (1953). The specimen figured by Marie (1941) as *B. decorata delicatula,* might belong to *B. regularis;* it is certainly not a *B. delicatula. B. latticea* Carsey might be an independent species. The publications of Dain (1934), Subbotina (1936) and Keller (1939) were not available to the writer.

No specimens of *B. regularis* have been observed so far in Israel.

In its typical form *B. delicatula* occurs in Israel only in the "Dano-Paleocene."

Bolivinoides curta Reiss, sp. nov.
Plate 30, figures 15-16

Holotype.—Pl. 30, fig. 16 a, b, × 110, from the Dano-Paleocene (*Globigerina-Truncorotalia* zone) of

Tzor'a (Type-locality). No. 1845: Pal. Coll. Geol. Institute, Jerusalem.

Diagnosis.—Test small, rather flat and elongated, often subelliptical; section flatly elliptical; periphery acute; ornamentation consisting of rather strong short ribs, formed by the raised lobes, covering very regularly the chambers of the whole test; suture-lines marked by the ornamentation pattern; length: up to 0.35 mm.

Relationships and Remarks.—*B. curta* is apparently closely related to *B. delicatula* Cushman, but is distinguished from the latter by its much smaller and shorter test and smaller length/breadth index. It is much smaller than *B. regularis,* sp. nov. and has a more acute periphery.

Occurrence.—This small and short species occurs fairly frequently in the "Dano-Paleocene" of Israel.

GENERAL REMARKS

The material from Israel, as well as published records, descriptions and figures of the various species of *Bolivinoides* lead the present writer to distinguish three major groups of Upper Cretaceous and Lower Tertiary *Bolivinoides,* which have been segregated in the text, the range-chart and the tables showing the length/breadth index-values. Each group differs from the other in several constant characters, especially in the ornamentation. Within each group related sub-groups can be distinguished. Each group evolves through a stratigraphically well-marked succession of species and subspecies with certain evolutionary tendencies as far as both, form and ornamentation, are concerned.

1). The first major group comprises forms with strong ornamentation, distributed over the whole length of the chambers, obscuring the sutures and composed of oblique rows of strongly raised, oblong tubercules, knots, beads or continuous *costae* (ribs). In some forms the *costae* are connected by thickenings of the chambers, running parallel with and covering the sutures, resulting in a fenestrate or reticulate pattern. The outline of the forms belonging to the first major group evolves from carrot-like through wedge-shaped to broadly rhomboid. The section evolves from rounded-rectangular (with convex or concave sides) through broadly oval or elliptical to flatly rhomboid. The apertural face of the test is, mostly prominently, a thickened "rim". Forms with a broad to rounded periphery are followed by those with a sub-acute to acute periphery, which in turn are followed by keeled forms.

The evolutionary pattern of this major group has been analyzed by Hiltermann and Koch (1950).

To this group belong: *B. strigillata austinana* Cushman, *B. strigillata strigillata* (Chapman) [the writer accepts for the time being Hiltermann's (1952) suggestion to regard *B. austinana* and *B. strigillata* as subspecies of *B. strigillata, B. strigillata austinana* appearing, however, apparently earlier than *B. strigillata strigillata*]; *B. clavata* (Cushman), *B. explicata* (Cushman and Hedberg), *B. angulata,* sp. nov. *B. decorata decorata* (Jones), *B. decorata gigantea* Hiltermann and Koch, *B. draco miliaris* Hiltermann and Koch, *B. draco draco* (Marsson), *B. draco dorreeni* Finlay.

Three sub-groups might be distinguished within this major group: one including the elongated carrot- or bolt-shaped forms with a broad periphery: *B. strigillata austinana, B. strigillata strigillata, B. clavata, B. explicata, B. angulata*; the second comprising wedge- or club-shaped flat forms, whose ornamentation does not show a continuous *costae*-pattern or a marked tendency toward it: *B decorata decorata, B. decorata gigantea;* and the third sub-group comprising broadly rhomboid forms, the ornamentation of which is composed of rows of beads and knots, partly connected, with a marked tendency to form continuous *costae,* or by continuous *costae,* which in some forms are connected by transversal thickenings of the chambers: *B. draco miliaris, B. draco draco, B. draco dorreeni.*

The three sub-groups follow each other stratigraphically, but are generally co-existent for some time.

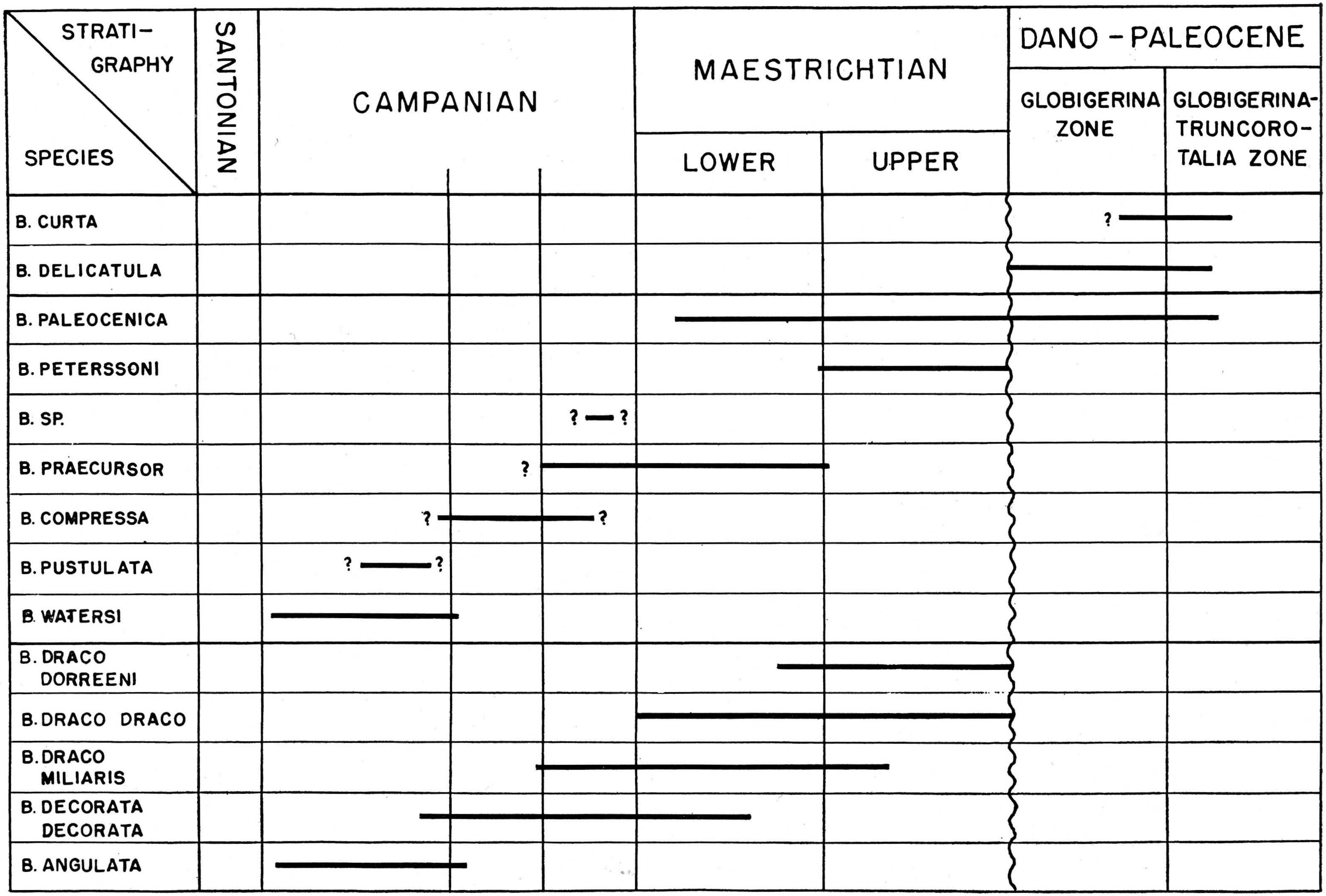
In the accompanying table of length/breadth indices the succession of indices of the forms belonging to the first major group also marks their stratigraphic sequence, in support of Hiltermann's and Koch's (1950) conclusions.

The first major group disappears completely at the end of the Maestrichtian.

2). The second major group, as interpreted by the writer, comprises forms characterized mainly by a rather poor ornamentation, which is, moreover, localized and restricted to the medial part of the test. The ornamentation is composed of circular to oval knobs, weakly raised, sometimes somewhat tubercular, more or less elongated lobes or, more rarely, of short, dash-like and rather weak ribs. Sutures not obscured by the ornamentation, mostly depressed, often limbate. The general outline of the test evolves from "drop"-shaped through wedge-shaped to oval or broadly elliptical and even broadly rhomboid. Section broadly to flatly elliptical in older forms, extremely flat, lense-shaped in later forms. Apertural end of the test devoid of a thickened rim. Periphery sharply rounded to sub-acute in older forms, acute to keeled in later ones.

To this major group belong: *B. texana* Cushman, *B. pustulata,* sp. nov., *B. compressa,* sp. nov., *B. praecursor,* sp. nov., our *Bolivinoides* sp., *B. laevigata* Marie, *B. watersi* (Cushman), *B. peterssoni* Brotzen and *B. paleocenica* (Brotzen).

The succession of length/breadth indices of the species belonging to this second major group occurring in Israel also marks their stratigraphic sequence, with one noteworthy exception, *B. paleocenica.* This latter species would be expected, according to the table of



TEXT FIGURE 1
Range-chart of Upper Cretaceous and Lower Tertiary *Bolivinoides* from Israel.

SPECIES \ L/B INDEX	2·5	2·4	2·3	2·2	2·1	2·0	1·9	1·8	1·7	1·6	1·5	1·4	1·3	1·2	1·1	1·0
B. CURTA					—	—	▬	▬	▬	—						
B. DELICATULA	—	—	▬	▬	▬	—										
B. PALEOCENICA													—	▬	▬	—
B. PETERSSONI									—	▬	▬	—	—			
B. SP.									—	▬	—					
B. PRAECURSOR							—	▬	▬	—	—					
B. COMPRESSA					—	—	▬	▬	▬	—						
B. PUSTULATA			—	▬	▬	▬	—	—								
B. WATERSI	—	—	—	▬	▬	▬	▬	—								
B. DRACO DORREENI											—	—	▬	▬	▬	—
B. DRACO DRACO									—	—	—	▬	▬	▬	▬	—
B. DRACO MILIARIS									—	—	—	▬	▬	▬	—	
B. DECORATA DECORATA							—	—	—	▬	▬	▬	▬	—		
B. ANGULATA			—	—	▬	▬	▬	—	—	—						

TEXT FIGURE 2
Table showing ranges of length/breadth indices of *Bolivinoides* from Israel. (Thick lines indicate optimum occurrence).

indices, to appear in the late Maestrichtian or even later, but it occurs already in Lower Maestrichtian. However, as already noted under *B. praecursor* such very broad forms as figured on pl. 30, fig. 8, possibly belonging to this latter species and occurring in Israel in the highest Campanian and early Maestrichtian, MIGHT represent transition forms to *B. paleocenica.* We would have, therefore, to extend the length/breadth index-range of *B. praecursor* to about 1.1 thus linking *B. paleocenica* with *B. praecursor.* In this case *B. praecursor* would be the "co-existing," more elongated form, while the broadly rhomboid *B. paleocenica* would represent the end form of this group. A similar example is seen in the case of *B. decorata gigantea* (optimum index 1.5-1.6, maximum 2.0) which appears even later than the first broadly rhomboid forms of the *draco*-subgroup, co-existing, however, with this latter sub-group, which actually represents the last development of the first major group. It might be significant that *B. paleocenica* is the last survivor of the second major group, which disappears almost completely at the end of the Maestrichtian, leaving only *B. paleocenica* to continue into Paleocene times. It appears, therefore, that the evolutionary tendency of the general form of the test in the second major group is the same as that in the first one. The second major group appears later than the first one.

The writer does not agree with Hiltermann and Koch (1950) who believe the group of poorly ornamented *Bolivinoides* (such as *B. watersi, B. laevigata, B. peterssoni*) to have evolved from *B. regularis* (=*B. decorata delicatula* Hiltermann and Koch, *non* Cushman): such forms as *B. texana, B. watersi, B. pustulata* are at least as old, or even older, than *B. regularis.* It might be possible, however, that this second major group has evolved from such forms as *B. strigillata austinana,* which has been described by Cushman (1946) as having walls which are "smooth, except for a series of deep rounded pits marking the suture-lines." Both major groups might, therefore, have evolved from a common ancestor (*B. strigillata austinana* ?), one line of development leading to forms rich in ornamentation, the other to forms which are poorly ornamented. The apparently parallel development in general form of both major groups is an additional suggestion for such an assumption.

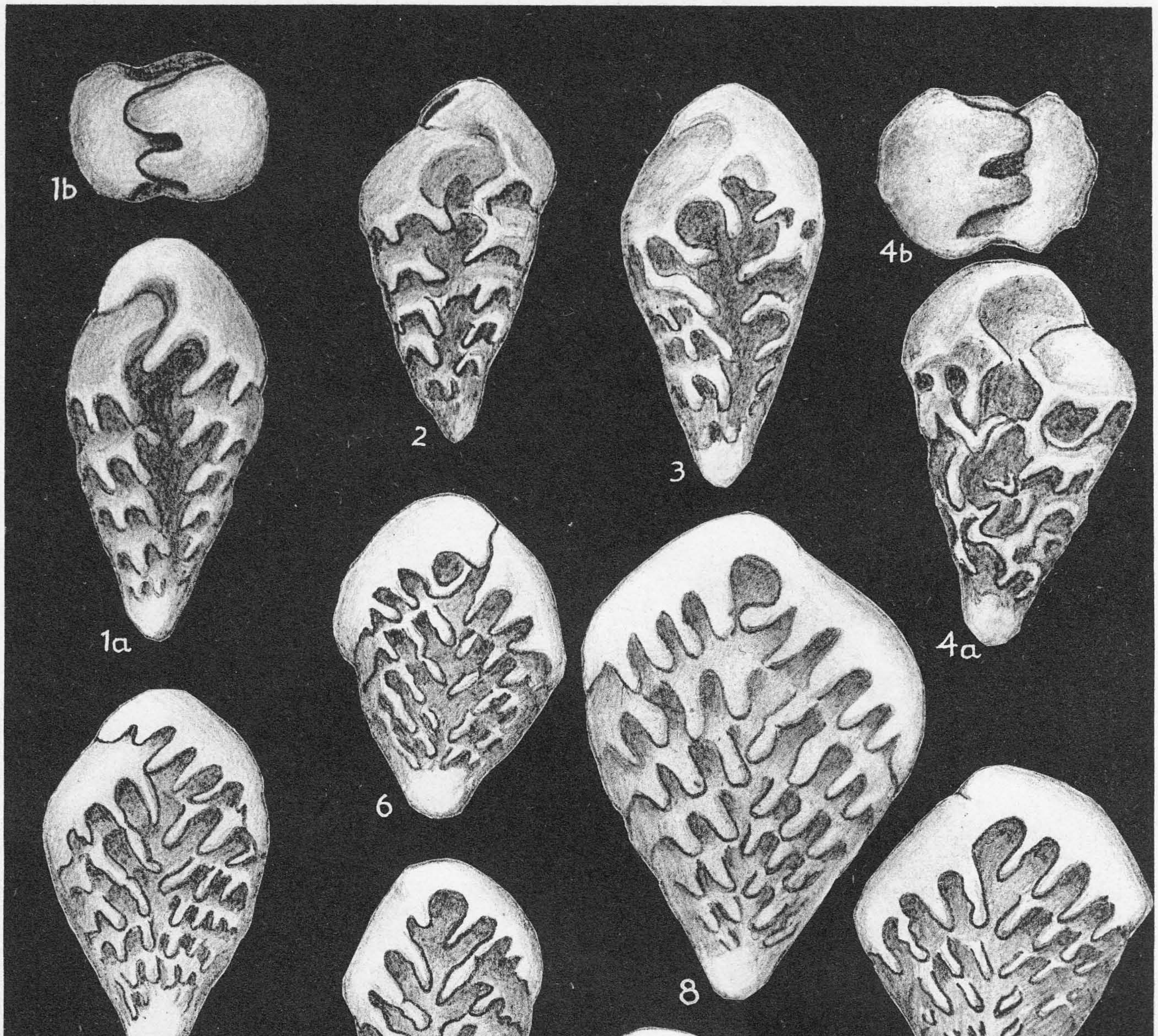
The second major group disappears with *B. paleocenica* in the Paleocene. Brotzen (1948) believes *B. paleocenica* to belong to a group of *Bolivinoides* including *B. velascoensis* (Cushman) and to be near to such Tertiary forms as *Bolivina reticulata* Hantken, *Bolivina byramensis* Cushman, *B. scalprata retiformis* Cushman, *B. subreticulata* Parr and *B. fastigia* Cushman. However, none of these species, except the last named one, can be regarded as belonging to the genus *Bolivinoides* as originally defined by Cushman and as lately redefined by Hofker (1952). *B. velascoensis* (Cushman) and *B. trinitatensis* Cushman and Jarvis show certain characteristics (raised and somewhat sinuous sutures, ornamentation, lack of retral processes) which place them in the genus (or subgenus) *Aragonia* Finlay rather than in the genus *Bolivinoides* Cushman. Furthermore the wall-structure of *B. velascoensis* and *B. trinitatensis* will have to be studied in detail to establish the genus to which these species belong. In agreement with Hofker (*l.cit.*) we exclude these species from the genus *Bolivinoides.* The writer, furthermore, believes that *B. paleocenica* is not related to any one of the above mentioned forms, except to *B. fastigia* to which it is generically related.

3). The third major group which, in the writer's opinion should be distinguished, comprises forms which are usually club-like or broadly subelliptical in outline, with a rounded, subacute or acute periphery, never distinctly keeled. Section flatly elliptical. Apertural end devoid of a thickened rim. Ornamentation covering the whole test in a regular pattern and clearly marking the suture-lines at the junction of the ornamentation (lobes) of consecutive chamber-pairs. The ornamentation is composed of rather weakly raised short ribs, formed by the basal lobes, sometimes associated with weak knots. Often the ornamentation is marked by the depressions, grooves, or pits, between the basal lobes and by the depressed sutures, rather than by the ribs or knots themselves.

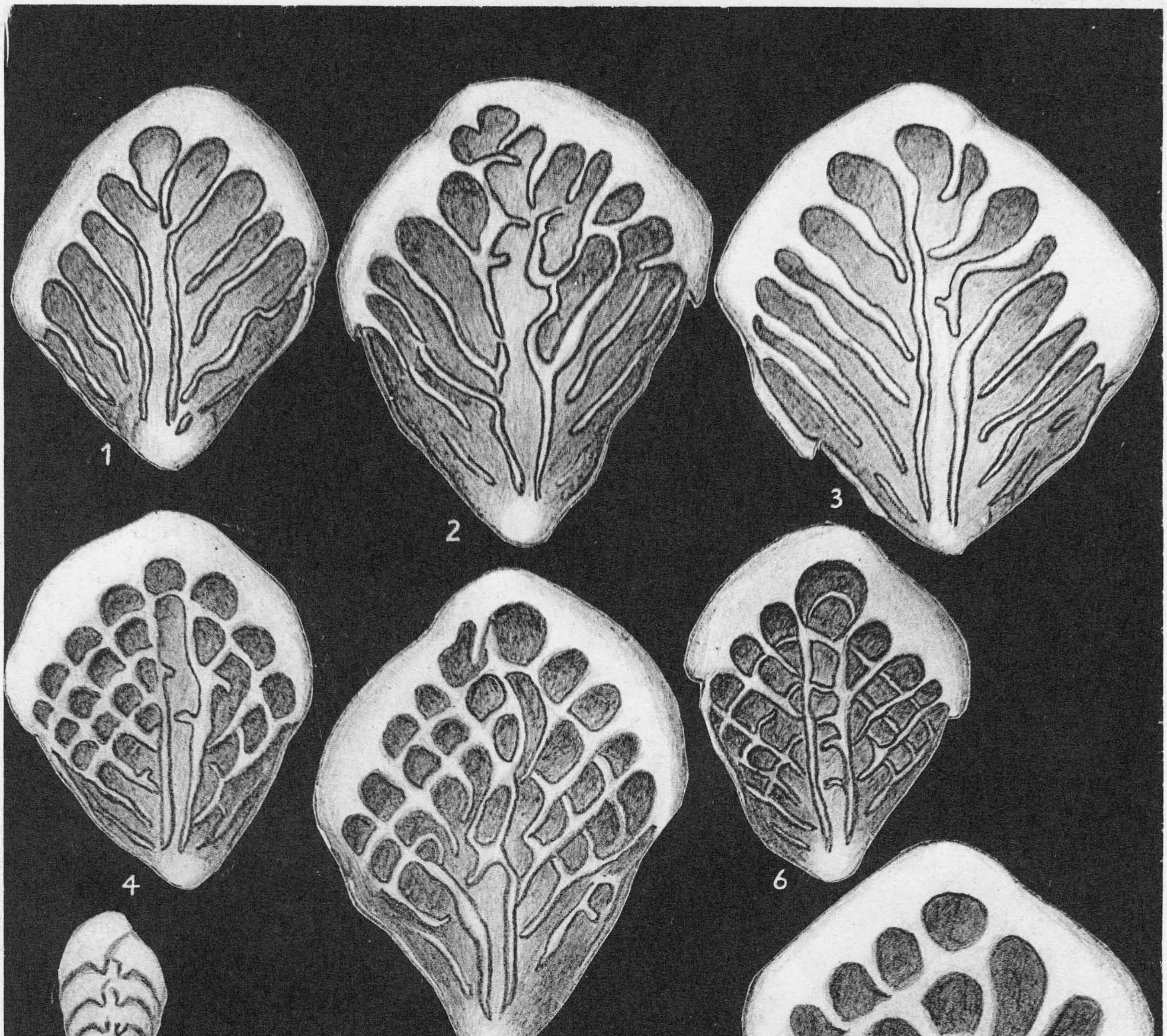
The relationship between the forms of this third major group, as well as the relationship between this group and the other two major groups, is not yet understood. Even the evolutionary tendency is still difficult to comprehend. To this group belong *B. regularis,* sp. nov., *B. delicatula* Cushman and *B. curta,* sp. nov. The succession of length/breadth indices of

EXPLANATION OF PLATE 28

FIGS.		PAGE
1-4.	*Bolivinoides angulata* Reiss, sp. nov. × 110. No. 2139. Campanian. Tulkarem. Holotype: fig. 1a, b.	155
5-8, 13.	*Bolivinoides decorata decorata* (Jones). × 110.	155
	5-6. No. D-2635. Lower Maestrichtian. Negev.	
	7-8. No. D-2753. Upper Campanian. Negev.	
	13. No. D-2580. Lower Maestrichtian. Negev.	
9-12, 14.	*Bolivinoides draco miliaris* Hiltermann and Koch. × 110.	155
	9. No. D-2748. Upper Campanian. Negev.	
	10-11. No. 619. Upper Campanian Innabe.	
	12, 14. No. D-3663. Upper Maestrichtian. Negev.	



Reiss: *Bolivinoides* in Upper Cretaceous and Lower Tertiary of Israel



Reiss: *Bolivinoides* in Upper Cretaceous and Lower Tertiary of Israel

B. delicatula and *B. curta* correspond again with their stratigraphic sequence. However, *B. regularis* which appears much earlier, has a length/breadth index sometimes as small as 1.7, reaching, on the other hand, such high values as 2.4. No form is known as yet which would prove a direct relationship between *B. regularis* and *B. delicatula,* and the time-lapse between these forms is considerable in both hemispheres. Hiltermann and Koch (1950) believe that *B. regularis* (=*B. decorata delicatula* Hiltermann and Koch, *non* Cushman) is derived from the *decorata*-group. Cushman (1946) on the other hand, interprets *B. texana* to be the ancestor of *B. regularis* (=*B. decorata delicatula* Cushman 1931, 1932, *non* 1927). Perhaps *B. regularis* represents a side-branch of the *decorata*-group or has evolved from *B. strigillata austinana.* It is even possible that *B. regularis* is not directly related to *B. delicatula* and the latter, an early Tertiary form, is more closely related to the Tertiary and Recent *Bolivinoides* (which form other groups) and resembles *B. regularis* only in type of ornamentation. Close study and additional evidence are needed to ascertain the relationships of this interesting group of *Bolivinoides,* which is especially difficult as long as no linking form between *B. regularis* and *B. delicatula* is known.

More detailed knowledge of the various species and subspecies of *Bolivinoides* will most probably result in the tracing of complete evolutionary series. In any case the present known species and subspecies of *Bolivinoides* can now be used in Israel for exact stratigraphical correlation and age-determination. The same is true of *Neoflabellina.* It has been ascertained by the writer that the different species and subspecies of *Neoflabellina* from the Upper Cretaceous and Lower Tertiary of Israel show evolutionary tendencies and phyletic changes which successfully can be used in stratigraphical work, as has been done by various authors in other regions of the world. Such short-living forms as *N. interpunctata-reticulata* (Wicher), *N. reticulata* (Reuss), *N. coranica* (Marie) or *N. semireticulata* (Cushman and Jarvis), to mention only one group, have been found to be especially valuable for stratigraphical work in Israel.

Although the more detailed studies on *Bolivinoides* and *Neoflabellina* of Israel are still in their first stages, they support earlier stratigraphical conclusions arrived at by the writer on the basis of interregional correlation by means of small Foraminifera.

REFERENCES

Brotzen, F., 1945, De geologiska resultaten fran borrningarna wid Höllviken. Del. I: Kritan. *Sver. Geol. Unders.* Ser. C. No. 465, Arsbok 38(1944) No. 7.

———, 1948, The Swedish Paleocene and its Foraminiferal Fauna. Ibid. Ser. C. No. 493, Arsbok 42(1948) No. 2.

Cushman, J. A., 1926, The Foraminifera of the Velasco Shale of the Tampico Embayment. *Bull. Amer. Assoc. Petrol. Geol.,* vol. 10, pp. 581-612.

———, 1927(a), American Upper Cretaceous species of *Bolivina* and related Species. Contr. Cushman Labor. Foram. Res., vol. 2, pp. 85-91.

———, 1927(b), Some Characteristic Mexican fossil Foraminifera. *J. Paleontol,* vol. 1, pp. 147-172.

———, 1931, The Foraminifera of the Saratoga Chalk. Ibid. vol. 5, No. 4.

———, 1932, The Foraminifera of the Annona Chalk. Ibid. vol. 6, No. 4.

———, 1937, A Monograph of the subfamily Virgulininae of the foraminiferal family Buliminidae. *Spec. Publ. Cushman Labor. Foram. Res.* No. 9.

———, 1946, Upper Cretaceous Foraminifera of the Gulf Coastal Region of the United States and adjacent Areas. *U. S. Geol. Survey Prof. Paper* 206.

——— and Jarvis, P. W., 1932, Upper Cretaceous Foraminifera from Trinidad. *Proc. U. S. Nat. Mus.* vol. 80, Art. 14.

——— and Renz, H. H., 1946, The foraminiferal fauna of the Lizard Springs formation of Trinidad, British West Indies. *Spec. Publ. Cushman Labor. Foram. Res.* No. 18.

Ellis, B. F. and Messina, A. R., Catalogue of Foraminifera (up to and including suppl. 1, 1953). *The American Mus. Nat. Hist.,* New York.

Finlay, H. T., 1940, New Zealand Foraminifera; Key species in stratigraphy No. 4; *Roy. Soc. N. Zealand, Trans. and Proc.* vol. 69, pt. 4.

EXPLANATION OF PLATE 29

Figs.		Page
1-3.	*Bolivinoides draco draco* (Marsson). × 110.	155
	1. No. D-3656. Upper Maestrichtian. Negev. 2. No. D-3648. Upper Maestrichtian. Negev. 3. No. D-3663. Upper Maestrichtian. Negev.	
4-7.	*Bolivinoides draco dorreeni* Finlay. × 110.	155
	4, 6. No. D-3667. Upper Maestrichtian. Negev. 5, 7. No. D-3663. Upper Maestrichtian. Negev.	
8.	*Bolivincides watersi* (Cushman). × 110. No. 4012. Lower Campanian. Beth Haemek	156
9-10.	*Bolivinoides pustulata* Reiss, sp. nov. × 110. No. 813. Lower Campanian. Judeida. Holotype: fig. 9a, b.	156
11.	*Bolivinoides* sp. × 110. No. 4177. Upper Campanian. Megiddo.	157

Henson, F. R. S., 1938, Stratigraphical Correlation by small Foraminifera in Palestine and adjoining Countries. *Geol. Mag.* vol. 75, No. 887.

Hiltermann, H. and Koch, W., 1950, Taxonomie und Vertikal-verbreitung von *Bolivinoides*-Arten im Senon Nordwestdeutschlands. *Geol. Jahrb.* vol. 64, Hannover.

Hiltermann, H., 1952, Stratigraphische Fragen des Campan und Maastricht unter besonderer Berücksichtigung der Mikropaläontologie. *Geol. Jahrb.* vol. 67.

Hofker, J., 1952, Zur Fassung der Foraminiferengattung *Bolivinoides* Cushman 1927. Ibid., vol. 67.

LeRoy, L. W., 1953, Biostratigraphy of the Maqfi Section, Egypt. *Geol. Soc. America, Memoir* 54.

Marie, P., 1941, Les Foraminifères de la Craie à *Belemnitella mucronata* du Bassin de Paris. *Mém. Mus. Nat. d'Hist. Nat.*, n. ser., vol. 12, fasc. 1.

Nakkady, S. E., 1950, A new foraminiferal fauna from the Esna shales and Upper Cretaceous Chalk of Egypt. *J. Paleont.* vol. 24 No. 6.

Plummer, H. J., 1931, Some Cretaceous foraminifera in Texas. *The Univ. of Texas Bull.* 3101.

Reiss, Z., 1952(a), On the Upper Cretaceous and Lower Tertiary microfaunas of Israel. *Bull. Res. Counc. Israel.* vol. 2 No. 1.

———, 1952(b), On the occurrence of *Globotruncana calcarata* Cushman 1927 in the Upper Cretaceous of Israel. Ibid. vol. 2 No. 3.

Tromp, S. W., 1943, Micro-fauna of the Upper Cretaceous and Tertiary sections (Arabian Facies) in the Urfa and Gaziantep regions (Southern Turkey). *Maden Tatk. ve Arama.* No. 1/29.

———, 1949, The determination of the Cretaceous-Tertiary boundary by means of quantitative, generic, microfaunal determination and the conception "Danian" in the Near East. *J. Paleontol.* vol. 23 No. 6.

White, M. P., 1929, Some index foraminifera of the Tampico Embayment area of Mexico. Ibid. vol. 3, No. 1.

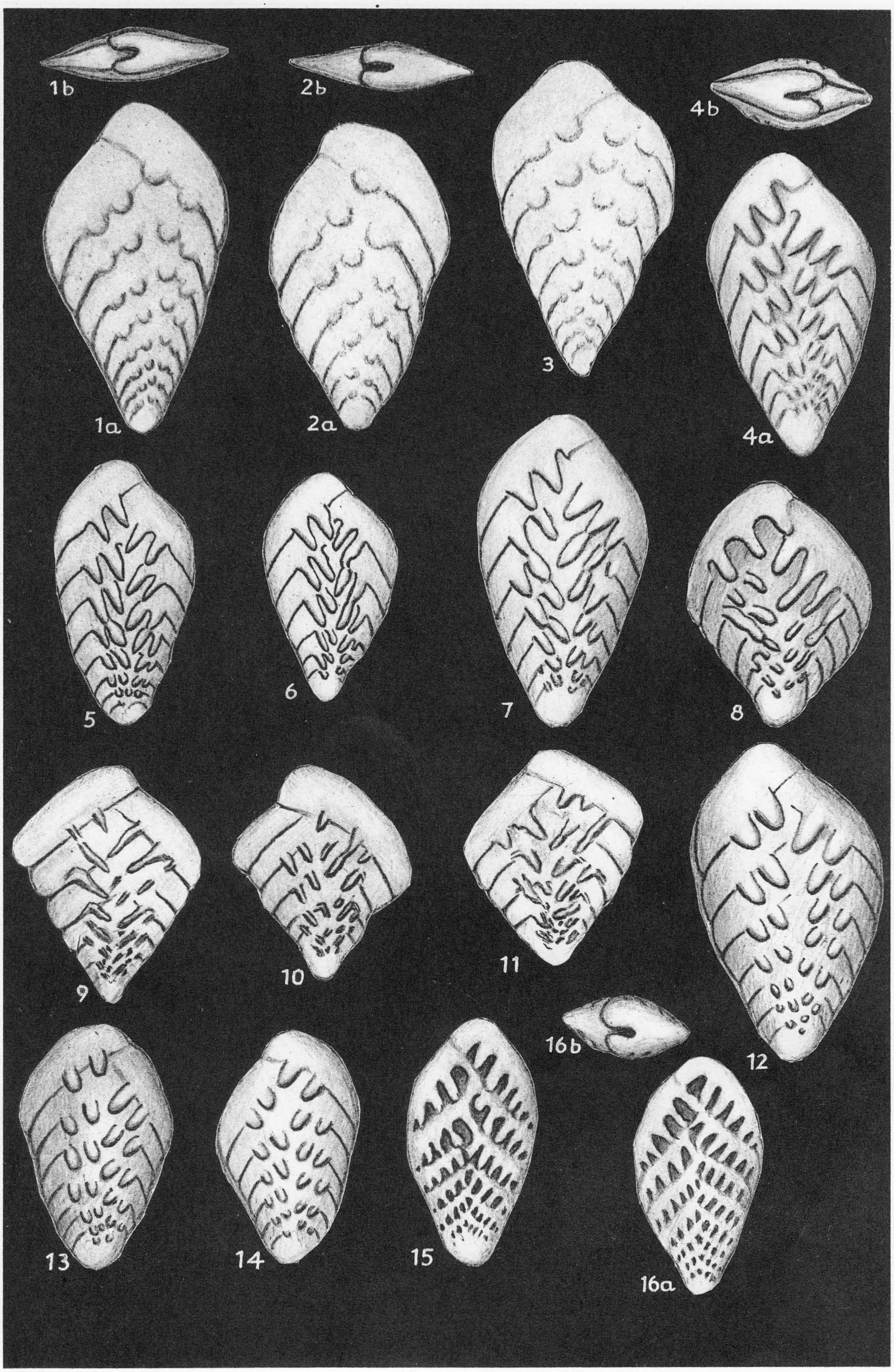
Wicher, C. A., 1942, Praktikum der angewandten Mikropaläontologie. Borntraeger, Berlin.

———, 1949, On the Age of the higher Upper Cretaceous of the Tampico Embayment area in Mexico, as an example of the world-wide existence of microfossils and the practical consequences arising from this. *Bull. Mus. d'Hist. Nat. Pays Serbe.* Ser. A-2. Belgrad.

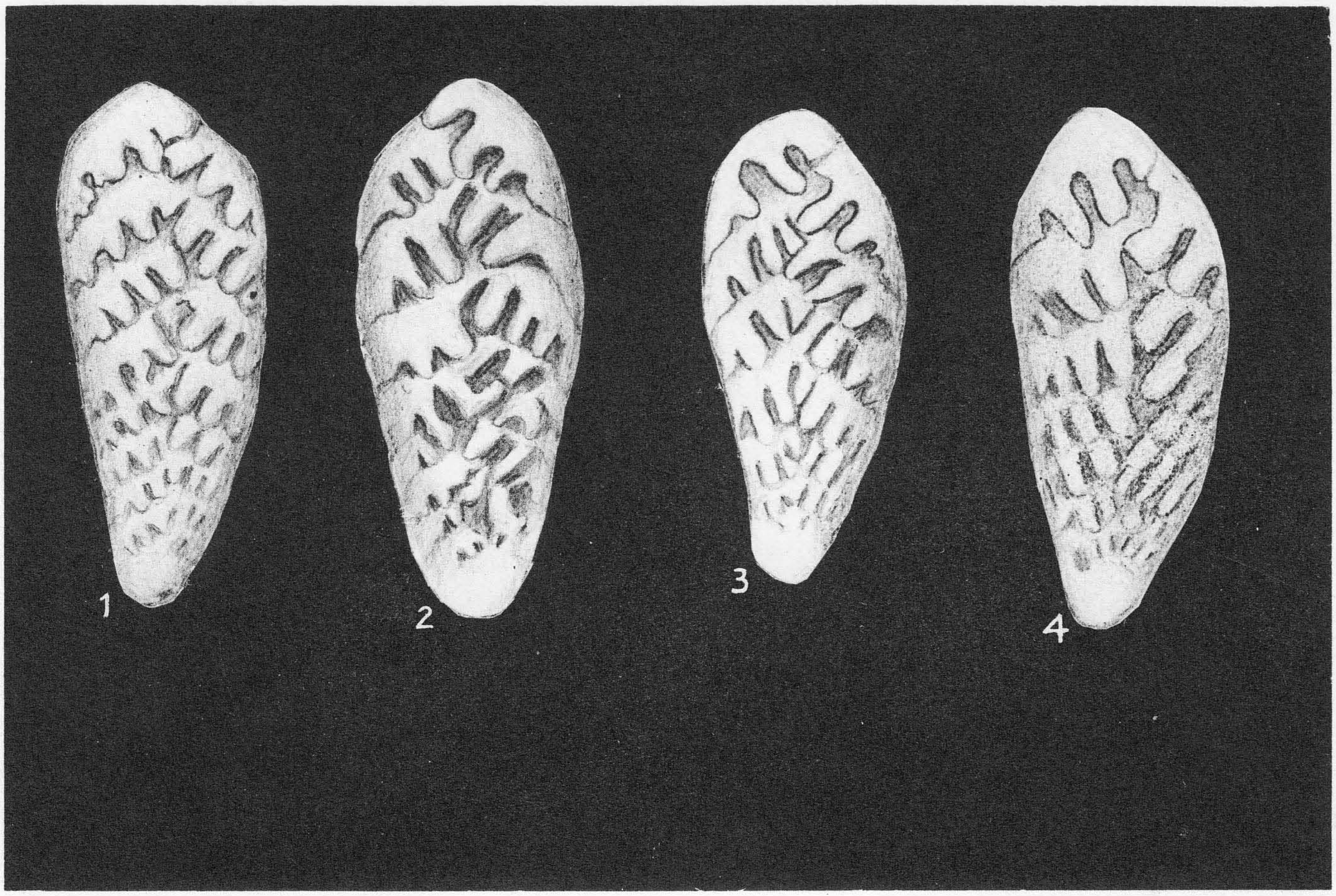
———, 1953, Mikropaläontologische Beobachtungen in der höheren borealen Oberkreide, besonders im Maastricht. *Geol. Jahrb.* vol. 68.

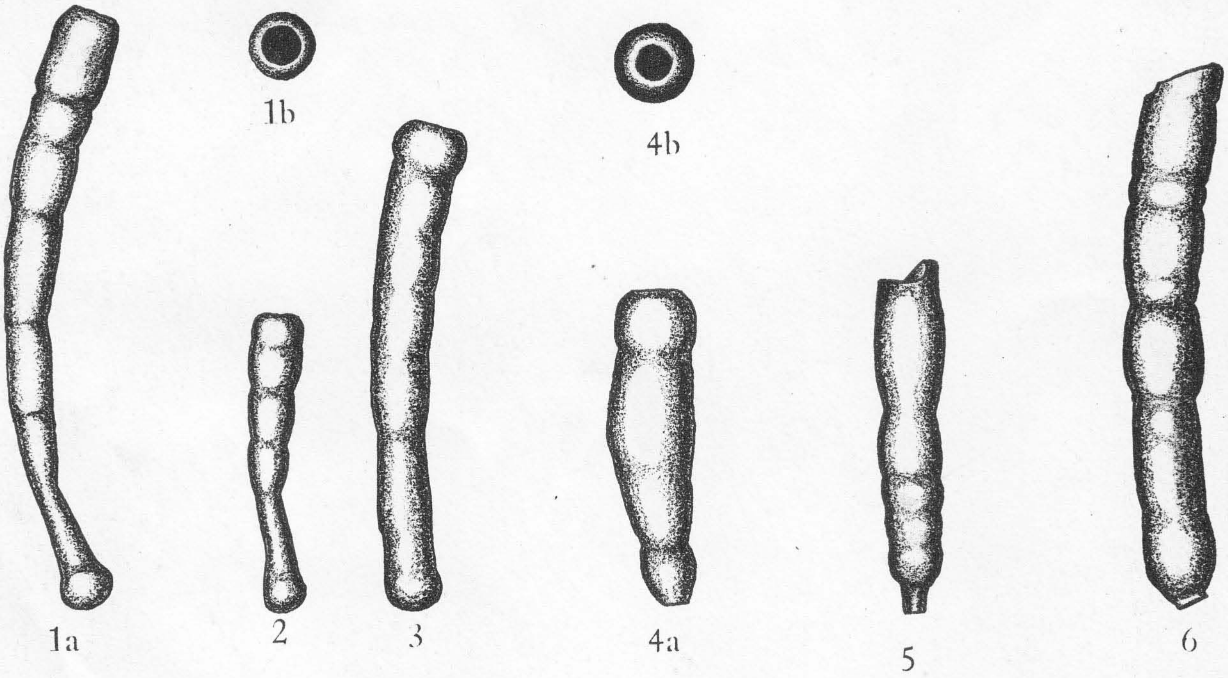
EXPLANATION OF PLATE 30

Figs.		Page
1-3.	*Bolivinoides compressa* Reiss, sp. nov. × 110. No. 839(a). Upper Campanian. Er Ruweis. Holotype: fig. 1a, b.	156
4-7.	*Bolivinoides praecursor* Reiss, sp. nov. × 110. 4-6. No. 839(b). Upper Campanian. Er Ruweis. 7. No. D-2302. Lower Maestrichtian. Negev. Holotype: fig. 4a, b.	156
8.	*Bolivinoides* sp. [?*praecursor* Reiss, sp. nov., ?transition to *B. paleocenica* (Brotzen)]. × 110. No. D-2688. Lower Maestrichtian. Negev.	157
9-11.	*Bolivinoides paleocenica* Brotzen. × 110. 9-10. No. D-3660. Upper Maestrichtian. Negev. 11. No. 2629. Lower Maestrichtian. Negev.	157
12-14.	*Bolivinoides peterssoni* Brotzen. × 110. 12. No. D-3660. Upper Maestrichtian. Negev. 13-14. No. D-3362. Upper Maestrichtian. Negev.	157
15-16.	*Bolivinoides curta* Reiss, sp. nov. × 110. No. 1845. "Dano-Paleocene" (*Globigerina-Truncorotalia* zone). Tzor'a. Holotype: fig. 16a, b.	158



Reiss: *Bolivinoides* in Upper Cretaceous and Lower Tertiary of Israel





Reiss: *Bolivinoides* in Upper Cretaceous and Lower Tertiary of Israel
Conkin: *Hyperammina Kentuckyensis* n. sp. from Mississippian of Kentucky, U.S.A.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 4, OCTOBER, 1954

119. *HYPERAMMINA KENTUCKYENSIS* N. SP. FROM THE MISSISSIPPIAN OF KENTUCKY, AND DISCUSSION OF *HYPERAMMINA* AND *HYPERAMMINOIDES*

JAMES E. CONKIN
Union Producing Co., Beeville, Texas

ABSTRACT.—**Hyperammina kentuckyensis** n. sp. is described from the Mississippian (Osagean) Floyds Knob formation of southwestern Jefferson County, Kentucky.

The megalospheric form of **Hyperammina kentuckyensis** externally resembles the megalospheric forms of **Hyperammina coleyi** Parr, 1942 and **Hyperamminoides acicula** Parr, 1942 in possessing "hourglass tapering" of the early part of the second chamber.

The megalospheric form of **Hyperammina kentuckyensis** has true affinities to, but is specifically distinct from, the megalospheric form of **Hyperammina glabra** Cushman and Waters, 1927.

The microspheric form of **Hyperammina kentuckyensis** has no close specific affinities to any known **Hyperammina.**

The ratio of megalospheric to microspheric forms is four to one.

Hyperammina kentuckyensis was probably an inhabitant of an off shore shallow sea.

Generic characters of **Hyperammina** Brady, 1878, and **Hyperamminoides** Cushman and Waters, 1927 are discussed; **Hyperamminoides** is considered invalid and is suppressed in favor of **Hyperammina.** Generic definitions of **Hyperammina** given by Brady in 1878 and 1884 are accepted, with three additions as follows: (1) second chamber may be non-tapering, tapering toward proloculus, or tapering toward both aperture and proloculus, (2) aperture may be moderately or strongly constricted, and (3) exterior of test may be marked by transverse constrictions of varying strength. With the above additions, **Hyperammina** embraces all known species of **Hyperammina** and **Hyperamminoides.** A new name, **Hyperammina neoglabra** is proposed on account of generic reallocation.

INTRODUCTION

Hyperammina kentuckyensis n. sp. occurs throughout the 11 foot 10 inch section of the Mississippian (Osagean) Floyds Knob formation on the north side of Mitchell Hill in southwestern Jefferson County, Kentucky. *H. kentuckyensis* was found in the summer of 1952 during a study of the lower Mississippian rocks in northwestern Kentucky, and it is believed to be the first species of the genus to be reported from Kentucky. Cooper (1947, pp. 88, 89) listed *Hyperammina* cf. *H. glabra* Cushman and Waters, 1927, *H.* cf. *H. elongata clavulata* Howchin, 1888, and *H.* sp. from the Mississippian (Chesterian) Kincaid formation of Johnson County, Illinois.

ACKNOWLEDGMENTS

Thanks are due to Mrs. Barbara Moyer Conkin for preparation of the illustrations, and to Cecil G. Lalicker for reading the manuscript.

Thanks go also to Don Frizzell and John Chronic for aid in type designation, and to Miss Lynn and Samuel Ellison, Jr., of the University of Texas for allowing use of facilities there.

METHODS

Limestone and calcareous siltstones from each of the beds of the Floyds Knob formation (see Measured Section) were dissolved in either dilute or concentrated hydrochloric acid, and residues were picked for foraminifers. Of the 350 specimens recovered in identifiable condition, 280 were megalospheric and 71 microspheric, giving a ratio of megalospheric to microspheric forms of four to one.

MEASURED SECTION

Section was measured at the outcrop of the Floyds

EXPLANATION OF PLATE 31

FIGS.		PAGE
	Upper half: (Z. Reiss)	
1-4.	*Bolivinoides delicatula* Cushman. × 110. No. D-3665. "Dano-Paleocene" (*Globigerina*-zone). Negev.	157
	Lower half: (J. E. Conkin)	
1a.	*Hyperammina kentuckyensis* Conkin, n. sp., holotype, No. 64548, megalospheric form.	166
1b.	Holotype, apertural view.	166
2.	Paratype, No. 64549, megalospheric form.	166
3.	Paratype, No. 64550, aberrant megalospheric form.	166
4a.	Paratype, No. 64551, microspheric form, early part of second chamber missing.	166
4b.	Paratype, No. 64551, apertural view.	166
5.	Paratype, No. 64552, microspheric form, showing early part of second chamber.	166
6.	Paratype, No. 64553, microspheric form, showing a small portion of early part of second chamber.	166

All figures × 30. Type numbers are Cushman Collection (U. S. Nat. Mus.) numbers.

Knob formation on the north side of Mitchell Hill in southwestern Jefferson County, Kentucky.

	THICKNESS	
	Feet	Inches
Top of measured section: Muldraugh formation		
12. Limestone, siliceous and calcareous, with abundant geodes; fossils infrequent	not measured	
Top of Floyds Knob formation		
11. Limestone, silty, with geodes becoming larger as contact with Muldraugh formation is approached, abundant glauconitic pebbles; **Hyperammina** uncommon	1	3
10. Limestone, silty, with small and large siliceous geodes; **Hyperammina** uncommon	1	9
9. Siltstone, calcareous, brown, with abundant glauconitic pebbles; **Hyperammina** very rare	0	1
8. Limestone, silty, brownish, with abundant pebbles of glauconite; **Hyperammina** frequent	0	3
7. Limestone, cross-bedded, crinoidal, silty; frequent brachiopod and bryozoan fragments, **Hyperammina** abundant	0	2.5
6. Limestone, oolitic, crinoidal, silty; frequent bryozoan and brachiopod fragments, **Hyperammina** frequent	4	10.5
5. Covered interval	1	0
4. Limestone, oolitic, crinoidal, with two gray shale partings; brachiopod and bryozoan fragments; **Hyperammina** rare	1	0
3. Shale, blue-gray; **Hyperammina** rare	0	2.5
2. Limestone, oolitic, crinoidal; abundant brachiopod and bryozoan fragments, **Hyperammina** frequent	0	10
1. Limestone, crinoidal, with pebbles of limestone and glauconite; abundant brachiopod and bryozoan fragments, **Hyperammina** frequent; slight erosional surface at base	0	4.5
Total thickness	11	10

Datum: top of Holtsclaw facies of the Broadhead formation.

DESCRIPTION OF SPECIES

Genus **Hyperammina** Brady, 1878

Hyperammina kentuckyensis Conkin, n. sp.

Plate 31, figs. 1-6

Description.—Megalospheric form shows an oblate proloculus and a moderately curved, undivided second chamber, tapering initially toward the aperture, then expanding toward the aperture the remainder of the test, producing a necking at position of reversal of direction of tapering (this double tapering of the early part of the second chamber is herein termed "hourglass tapering"); test moderately constricted externally at irregular intervals; part of test between last constriction and moderately constricted aperture, slightly inflated forming a distinct lip which ranges up to 16 percent of the total length of the test; wall cream colored and smoothly finished, consisting of minute siliceous grains in siliceous cement; rarely a specimen approaches a cylindrical shape (fig. 3), but this is merely an individual aberration within the species.

Microspheric form shorter, stouter, and less curved than megalospheric form; proloculus of all microspheric forms broken off; very early part (less than 10 percent of total length of second chamber) narrow, and very gradually expanding, followed by a rapid expansion, and thereafter approaching a cylindrical shape, but always retaining a definite expansion; in plate 31, fig. 4, the very early narrow part of the second chamber is not preserved; aperture slightly constricted; lip as in megalospheric form, but thicker than in megalospheric form; wall same as in megalospheric form, but thicker.

Measurements of figured types in millimeters:

Cushman Coll. No.	Diam. of proloculus (megalospheric forms); initial end (microspheric forms)	Length of test	Maximum diam. of test (excluding lip)	Diam. of lip	Diam. of aperture
Megalospheric forms:					
64548	0.086	1.031	0.100	0.120	0.066
64549	0.073	0.533	0.073	0.100	0.033
64550	0.117	0.850	0.117	0.133	0.067
Averages:	0.092	0.805	0.096	0.118	0.055
Microspheric forms:					
64551	0.050	0.566	0.163	0.180	0.063
64552	0.040	0.600	0.117	0.117	0.067
64553	0.053	0.900	0.130	0.133	0.070
Averages:	0.048	0.690	0.137	0.143	0.067

Condition of Types.—Several megalospheric forms are perfectly preserved, but few microspheric forms show the nature of the aperture and none shows the nature of the proloculus. Attempt has been made to select enough types to show the variation within the species.

A megalospheric form is chosen as holotype because (1) megalospheric forms are well preserved, but microspheric forms are fragmentary, and (2) megalospheric forms are abundant, but microspheric forms are infrequent, and many species of *Hyperammina* are known only as megalospheric forms.

Type Depositories.—The holotype, Cushman Collection No. 64548, five figured paratypes, Cushman Collection Nos. 64549 through 64553, and 20 unfigured paratypes, Cushman Collection Nos. 64554 and 64555, are deposited in the U. S. National Museum at Washington, D. C.

Four unfigured paratypes are deposited in each of the following institutions in the United States:

Micropaleontology Department, American Museum of Natural History, New York, N. Y., No. FT-1139.
University of Cincinnati Museum, Department of Geology and Geography, Cincinnati, Ohio, No. 26363.
Department of Geology, University of Colorado, Boulder, Colorado, No. 733.
Department of Geology, University of Iowa, Iowa City, Iowa, No. 4246.
Department of Geology, University of Kansas, Lawrence, Kansas, No. 11115 F2.
Department of Geology, University of Kentucky, Lexington, Kentucky, No. 14209.
H. V. Howe Collection, Geology Museum, Louisiana State University, Baton Rouge, La., No. 3502.
Museum of Paleontology, University of Michigan, Ann Arbor, Mich., No. 30520.
Department of Geology, University of Missouri, Columbia, Missouri, No. 0-1206-1.
Department of Geology, Stanford University, Stanford, California, No. 8113.
Bureau of Economic Geology, Austin, Texas, No. 20232.

Four unfigured paratypes are deposited in each of the following institutions in foreign countries:

Department of Geology, University of Alberta, Edmonton, Canada, No. Cb 562.
Laboratorio de Paleontologia, Petroleos Mexicanos, Mexico City, No. ZS-485.
British Museum of Natural History, London, England, Nos. P41684-P41687.
Geologisch-Paläontologisches Institut der Universität Tübingen, Deutschland, No. Pr. 1042/1.
Zaklad Paleontologii, U. Warszawa, Poland, No. F301.
Department of Geology, Hebrew University, Jerusalem, Palestine, No. "America" 4419.

A number of less well preserved specimens are retained by the writer and will be available to workers on request.

Type Locality.—Floyds Knob formation, Mississippian (Osagean), Mitchell Hill in southwestern Jefferson County, Kentucky.

Comparisons.—The megalospheric form of *Hyperammina kentuckyensis* surficially resembles the megalospheric forms of *Hyperammina coleyi* Parr (1942, p. 104, pl. 2, fig. 3) and *Hyperamminoides acicula* Parr (1942, p. 105, pl. 1, fig. 5) in that all three forms possess an "hourglass tapering" of the early part of the second chamber; in *Hyperammina coleyi* this structure is only weakly present; in *Hyperamminoides acicula* it is moderately developed; in *Hyperammina kentuckyensis* it is distinctly developed.

Hyperammina kentuckyensis has true affinities to, but is specifically distinct from, *Hyperammina glabra* Cushman and Waters (1927, p. 146, pl. 26, fig. 1). The megalospheric form of *Hyperammina kentuckyensis* differs from the megalospheric form of *H. glabra* in having: (1) numerous moderately developed, though distinct, external constrictions, (2) pronounced "hourglass tapering" of the early part of the second chamber, (3) distinct lip structure, and (4) oblate proloculus; these four characters will serve to differentiate the megalospheric form of *Hyperammina kentuckyensis* from all megalospheric forms of *Hyperammina.*

The microspheric form of *Hyperammina kentuckyensis* has no close affinities to any known microspheric form of *Hyperammina.* The following two characters differentiate the microspheric form of *H. kentuckyensis* form other microspheric forms of *Hyperammina*: (1) very early part (less than 10 percent of the second chamber) narrow and gradually expanding, followed by a rapid expansion, thereafter approaching, but never attaining a cylindrical shape, and (2) presence of a distinct lip. It is important to note that in *H. kentuckyensis* the microspheric form is shorter and stouter than the megalospheric form.

Ecology.—There is a slight erosional surface at the base of the Floyds Knob formation at Mitchell Hill. Rounded and angular pebbles of limestone and green glauconite are present in the basal bed. Glauconite increases upward in the section and is abundant in the silty limestones (beds 8, 10, and 11) and calcareous siltstones (bed 9) above the cross-bedded limestone (bed 7). Fragments of bryozoans and brachiopods are found in the crinoidal limestone of bed 1, and the oolitic and crinoidal limestones of beds 2, 4, 6, and 7.

Hyperammina kentuckyensis is found in all beds of the Floyds Knob formation, but is best represented in the calcareous beds, and is abundant in bed 7.

Recent species of *Hyperammina* have been reported as dredged from various depths; Brady (1884, pp. 260, 261) notes *Hyperammina subnodosa* from 20 to 2600 fathoms and *H. vagans* from 15 to 2900 fathoms.

It seems clear that *Hyperammina kentuckyensis* was an inhabitant of an off shore shallow sea.

DISCUSSION OF *HYPERAMMINA* AND *HYPERAMMINOIDES*

H. B. Brady (1878, pp. 433, 434, pl. 20, figs. 2a, b) first defined *Hyperammina* with *H. elongata* as the genotype, and in 1884 (pp. 257-260, pl. 23, figs. 4, 7-10) emended his original definition. A description based on Brady's descriptions and illustrations, with three additional observations, is quite capable of expressing the generic characters of all species of both *Hyperammina* and *Hyperamminoides.*

Brady considered *Hyperammina* to have: an arenaceous test, free or adherent, with an elongate, tubular, singular or branching, second chamber; aperture open or only slightly constricted; interior smooth; exterior roughly or smoothly finished with test tapering toward aperture; and a proloculus of varying bulbosity and shape. The three additions necessary to bring Brady's definitions of *Hyperammina* up to date and capable of embracing all species of *Hyperammina* and *Hyper-*

amminoides are: (1) the second chamber may be non-tapering, may taper toward the proloculus, or in a few species taper toward both the aperture and the proloculus ("hourglass tapering"); (2) aperture may be moderately or strongly constricted; and (3) exterior may be marked by transverse constrictions of varying strength. Point (1) is shown by many species; "hourglass tapering" is shown moderately in the megalospheric form of *Hyperamminoides acicula* Parr (1942, p. 105, pl. 1, fig. 5). Points (2) and (3) are well shown in Brady's *Hyperammina subnodosa* (1884, pp. 259, 260, pl. 23, figs. 11, 12) and *H. friabilis* (1884, pp. 258, 259, pl. 23, fig. 3).

Confusion has been introduced into the generic concept of *Hperammina* by the erection of the genus *Hyperamminoides*. Cushman and Waters (1928a, p. 36, pl. 4, figs. 3, 4) proposed the genus *Hyperamminella* with *H. elegans* as the genotype. In the same publication, *H. protea* (pp. 36, 37, pl. 4, figs. 5, 6) and *H. minuta* (p. 37, pl. 4, figs. 8, 9) were described. Within the description of *H. elegans, Hyperammina clavata* Waters (1928, p. 272, pl. 42, fig. 9) was referred to *Hyperamminella.*

Since *Hyperamminella* was preoccupied by De Folin's *Hyperamminella,* 1881, Cushman and Waters (1928b, p. 112,) proposed the new name *Hyperamminoides* for *Hyperamminella,* and on the same page referred the form previously referred to *Nodosinella, N. glabra* Cushman and Waters, 1927 (p. 147, pl. 26, figs. 4, 5a, b) to *Hyperamminoides.*

Cushman and Waters (1928a, p. 36) stated that *Hyperamminoides* is similar to *Hyperammina,* but that *Hyperamminoides* differs in having: (1) constricted aperture, (2) siliceous test, and (3) tapering shape of test; these observations were reiterated in 1930 (p. 35).

H. J. Plummer (1945, pp. 219, 220, 223) held that: (1) the form of the second chamber is the chief distinguishing feature to separate the two genera, (2) that the diameter of the second chamber in *Hyperamminoides* increases rapidly from the initial part toward the aperture, resulting in a stouter and more flaring test than in *Hyperammina;* further that the second chamber of *Hyperammina* has a gradually increasing diameter and tends to become cylindrical, longer, and more fragile than *Hyperamminoides.* Plummer also noted that tests of *Hyperammina* are generally rougher (containing less siliceous cement) than *Hyperamminoides* and that *Hyperamminoides* generally has stronger transverse constrictions on the test than *Hyperammina;* these latter two features were given only specific value by Plummer. Further, Plummer stated that many species of *Hyperammina* have faint to moderately constricted apertures, and pointed out that many species have been described from fragmentary specimens whose apertures were not preserved.

Plummer's main contention, that the rapid flaring of the second chamber is the chief generic character of *Hyperamminoides,* is shown in convincing strength only by *H. expansus* Plummer (1945, pp. 223, 224, pl. 16, figs. 1-6) and much less convincingly by the microspheric form of *H. elegans,* the genotype; the megalospheric form of *H. elegans* does not exhibit a rapidly expanding second chamber.

No clear generic definition is possible for either *Hyperammina* or *Hyperamminoides* as long as *Hyperamminoides* is accepted as a valid genus. *Hyperamminoides,* therefore, should be suppressed in favor of *Hyperammina.* The three characters considered diagnostic of *Hyperamminoides* by Cushman and Waters (constricted aperture, siliceous test, and tapering shape of test) and the one character considered diagnostic of *Hyperamminoides* by Plummer (the rapidly expanding nature of the second chamber) are here considered only of specific value. All the above characters are exhibited in varying degrees by species of *Hyperammina.*

The following species previously referred to *Hyperamminoides* are here considered to be referable to *Hyperammina*: *Hyperamminoides elegans* (Cushman and Waters), 1928; *H. expansus* Plummer, 1945; *H. acicula* Parr, 1942; *H. protea* (Cushman and Waters), 1928; and *H. glabra* (Cushman and Waters), 1927; *Hyperamminoides glabra* (Cushman and Waters), 1927 (p. 147, pl. 26, figs. 4, 5a, b) is herewith renamed *Hyperammina* **neoglabra** nom. nov. because the specific name is preoccupied by *Hyperammina glabra* Cushman and Waters, 1927 (p. 146, pl. 26, fig. 1.)

Hyperamminoides minuta (Cushman and Waters) has been referred to *Earlandia* by Plummer (1945, p. 224, pl. 15, figs. 37, 38).

LITERATURE CITED

Brady, H. B., 1878, On the reticularian and radiolarian Rhizopoda (Foraminifera and Polycystina) of the North-Polar Expedition of 1875-1876: Ann. Mag. Nat. Hist., ser. 5, vol. 1, pp. 425-440, pls. 20, 21.

———, 1884, Report on the Foraminifera dredged by H. M. S. Challenger, during the years 1873-1876: Rept. Voyage Challenger, Zool., vol. 9, 1 vol. text, 814 pp.; 1 vol. pls. 1-115.

Cooper, C. L., 1947, Upper Kincaid Mississippian microfauna from Johnson County, Illinois: Jour. Paleont., vol. 21, no. 2, pp. 81-94, pls. 19-23.

Cushman, J. A. and Waters, J. A., 1927, Arenaceous Paleozoic Foraminifera from Texas: Cushman Lab. Foram. Research Contr., vol. 3, pt. 3, pp. 146-156, pls. 26, 27.

——— and ———, 1928a, Some Foraminifera from the Pennsylvanian and Permian of Texas: Ibid, vol. 4, pt. 2, pp. 31-55, pls. 4-7.

——— and ———, 1928b, *Hyperamminoides,* a new name for *Hyperamminella* Cushman and Waters: Ibid, vol. 4, pt. 4, p. 112.

——— and ———, 1930, Foraminifera of the Cisco Group of Texas: Texas Univ. Bull. 3019, pp. 22-81, pls. 2-12.

Parr, W. J., 1942, Foraminifera and a tubicolous worm from the Permian of the North-West Division of Western Australia: Roy. Soc. Western Australia, Jour., vol. 27, (1940-1941), no. 8, pp. 104, 105, pl. 2, fig. 3, pl. 1, fig. 5; in Ellis, B. F., and Messina, A. R., A Catalogue of Foraminfera.

Plummer, H. J., 1945, Foraminifera in the Marble Falls, Smithwick, and lower Strawn strata around the Llano Uplift in Texas: Texas Univ. Bull. 4401, pp. 209-271, pls. 15-17.

Waters, J. A., 1928, A group of Foraminifera from the Canyon Division of the Pennsylvanian formation in Texas: Jour. Paleont., vol. 1, no. 4, pp. 271-275, pl. 42.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 4, OCTOBER, 1954

120. PURISIMA PLIOCENE FORAMINIFERA OF THE HALFMOON BAY AREA, SAN MATEO COUNTY, CALIFORNIA

JAMES C. GOODWIN and JOHN N. THOMSON
Stanford University

ABSTRACT.—A small faunule of twenty-seven foraminiferal species is found in the 2,900 stratigraphic feet of exposed shales and mudstones in the Purisima formation of the Halfmoon* Bay area, California. A faunal change permits a division of the two shales into two zones.

The environment of deposition is thought to be one of relatively quiet waters in an unrestricted basin. The included Foraminifera probably indicate depths of about 150 feet.

INTRODUCTION

This report records results of an investigation of a foraminiferal assemblage of that part of the Pliocene Purisima formation exposed along the coastline between Halfmoon Bay and Martins Beach in San Mateo County, California. Sixty-three Foraminifera-bearing samples were collected and examined from the 2,900-foot thickness of mudstones and shales in the exposed middle part of the Purisima formation. The results are shown on the accompanying abundance chart, Table 1, as 29 stratigraphic occurrences, each representing a 100-foot stratigraphic interval. A sketch map of the area appears at the base of Table I. More detailed work was not considered of value, due to the consistently small assemblages.

The work was carried out during the winter and spring of 1954. The figures were drawn by the authors with the aid of a camera lucida. Acknowledgments are due to Joseph J. Graham and Hans E. Thalmann for suggesting the problem and furnishing much helpful assistance. Thanks are also due to Miss Myra Keen for advice and critical reading of the manuscript.

PAST WORK

The Purisima formation was mapped by Branner, Newsom, and Arnold (1) as a lower sandstone and conglomerate, a middle clay shale, and an upper sandstone. A complete list of the megafossils found in the formation was given. Grant and Gale (2) gave a detailed description of the megafossils of the Purisima formation and discussed the similarity of the upper Pliocene fauna of California to the Recent fauna of more northern latitudes. The history of oil exploration in the Halfmoon Bay area was summarized by Crandall (3). A middle Purisima foraminiferal assemblage was mentioned by Crandall as being present in cores taken from a well drilled about one mile south of Purisima Creek. The assemblage indicated age equivalence of the middle Purisima and the Sisquoc formation of Santa Barbara County, California. The writers of this paper attempted to obtain this material for the purpose of more adequate coverage, but its depository could not be determined.

Little previous work on the Purisima microfauna is shown by a search of the literature. Cushman (4) described *Elphidium hughesi* var. *obesum* from a locality near the mouth of Purisima Creek which is in the area discussed in this report. Stewart and Stewart (5) have discussed the Foraminifera of the Merced formation which crops out between the Halfmoon Bay area and Seven Mile Beach to the north. The exact relation between the Purisima and Merced formations is still in doubt.

LOCAL GEOLOGY

The Purisima formation is exposed in the seacliffs along the coast from just north of the town of Halfmoon Bay south to Point Año Nuevo. In the north it extends eastward into the foothills of the Coast Ranges for about two miles. The eastward extension increases south of Halfmoon Bay until it is found as much as ten miles east of the coast in the vicinity of Pescadero Creek. The width of the area of outcrop thins to about one mile between Pescadero and Año Nuevo, the eastern boundary being the San Gregorio Fault, east of which uplifted Miocene sediments are exposed. Branner, Newsom, and Arnold believed that the area enclosed by the present Purisima outcrops is essentially the same as the limits of the basin of deposition. The Purisima beds overlie the Monterey shale and the Vaqueros sandstone unconformably, locally with a conglomerate at the base.

The relation between the Purisima and the Merced formations is not clearly known. The Merced is commonly considered to be younger, but the two units are not found in contact, except perhaps at Point Año Nuevo where the beds overlying the Purisima have been mapped as Merced. Grant and Gale believe that the Merced and the Purisima are the results of the same cycle of deposition. In the area covered in this report, the Purisima sediments are everywhere overlain by horizontal Pleistocene terrace gravels.

Crandall states that the total stratigraphic thickness of the Purisima formation exceeds 9,500 feet near Purisima Creek. The writers were concerned only with

---

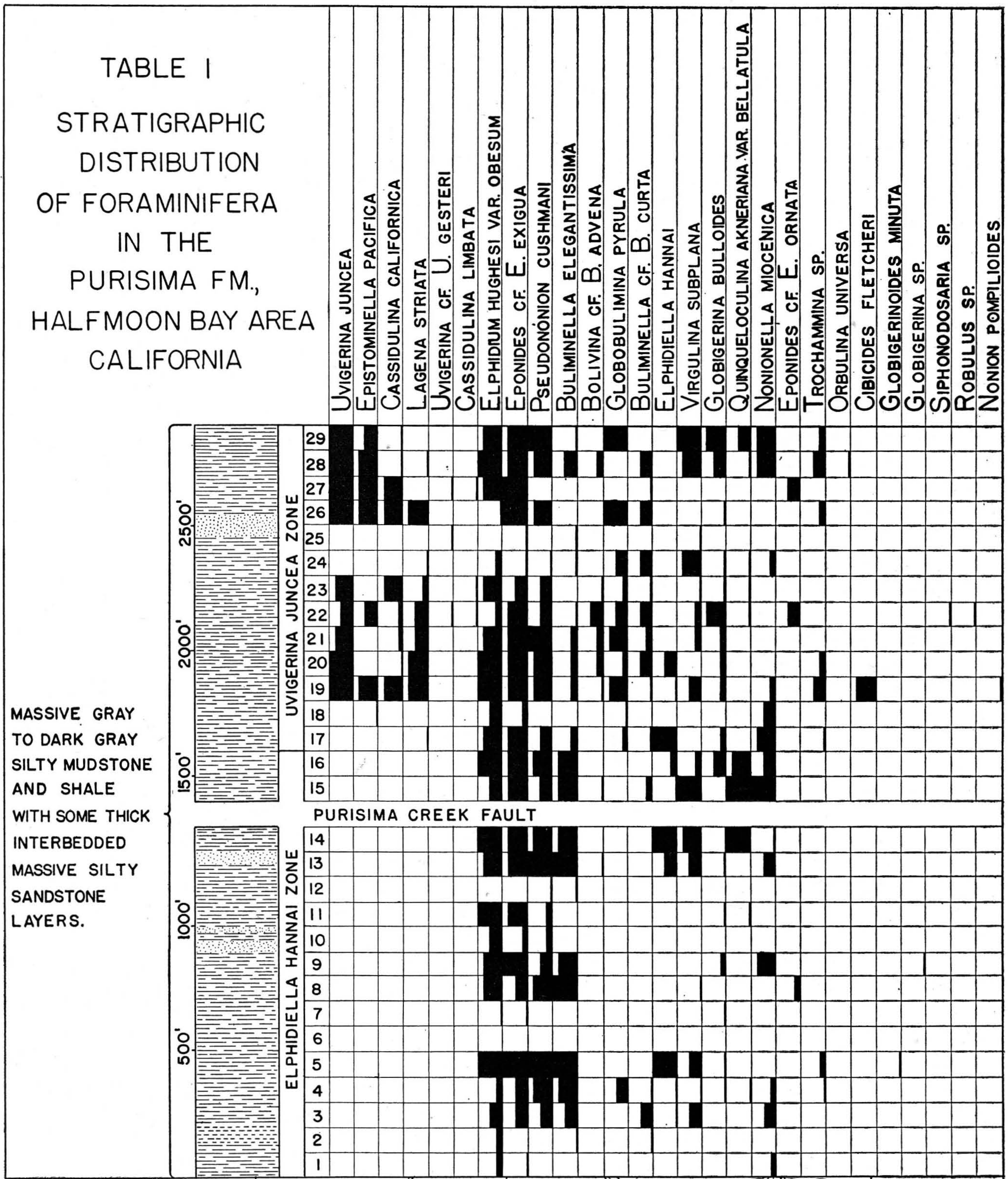
* "Halfmoon" is the spelling of the U. S. War Department 1940 map of the Halfmoon Bay Quadrangle, (used as a base by the authors), as well as of the latest U. S. Geol. Survey maps of the same area. "Half Moon" is used by the U. S. Post Office and also on a recent National Geographic Society map of California.—Ed.

1 See "References" at the end of this paper.

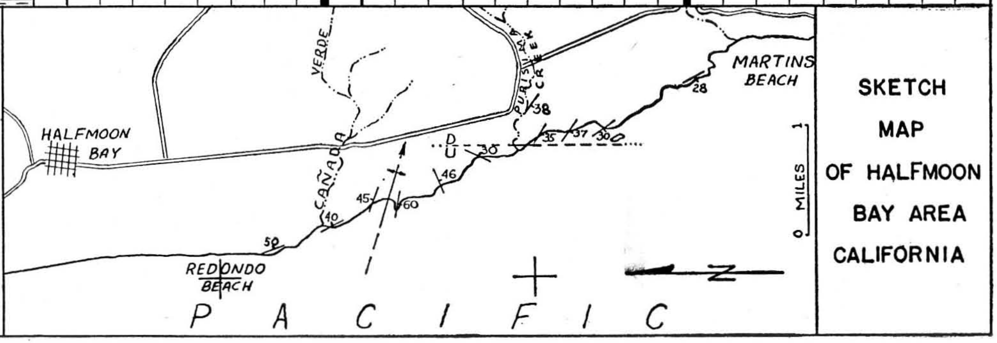
the middle unit composed of gray silty mudstones and shales, with a few massive silty sandstone layers up to 120 feet in thickness. The total thickness of this member cannot be determined along the section sampled, since the base of it is not exposed along the coastline. Although terrace gravels overlie the Purisima, good

TABLE I

STRATIGRAPHIC DISTRIBUTION OF FORAMINIFERA IN THE PURISIMA FM., HALFMOON BAY AREA CALIFORNIA



KEY	NO. PER SAMPLE
■ ABUNDANT	> 30
◧ VERY COM.	20-30
◨ COMMON	10-20
▯ PRESENT	5 - 10
☐ RARE	< 5



SKETCH MAP OF HALFMOON BAY AREA CALIFORNIA exposures are found in the 100-foot-high, nearly vertical cliffs along the seashore. Access to some parts of the section is impossible during periods of high tide. The lowest beds sampled were at the base of the seacliffs where the Purisima anticline intersects the coastline. The highest beds sampled are at the top of the mudstone member where it grades into the upper sandstone member. This contact parallels the coast for about one mile just to the north of Martins Beach and is well exposed in the small coves cutting into the seacliffs. The contact may also be seen at the south end of Martins Beach.

A reverse fault with a north-south strike, dipping 85° to the west, cuts the shales just south of the mouth of Purisima Creek; strata east of the fault are down-thrown. A distinct faunal change takes place in the beds on the opposite sides of the fault. A traverse was made eastward up Purisima Creek in order to determine the location of the beds containing this faunal change. Samples collected in the creek bed about ⅓ mile east of the mouth of Purisima Creek contained the same fauna as the beds on the west side of the fault at the coastline. Stratigraphic control on the beds on both sides of the fault enable the minimum displacement of the fault to be calculated as 475 feet where it intersects the coast. Since the faunal change is not seen on the west side of the fault due to the overlying terrace deposits, the actual displacement may be in excess of this figure, and the total thickness of the mudstone member of the Purisima formation may be greater than 2,900 feet.

ZONATION

The shale member of the Purisima formation is here divided into the *Uvigerina juncea* zone and the underlying *Elphidiella hannai* zone on the basis of the appearance of *Uvigerina juncea, Epistominella pacifica, Cassidulina californica,* and *Lagena striata* in the upper part of the mudstone member. These four very common species are restricted to the upper zone. All the forms of the lower zone are also present in the upper, so that the lower zone is recognized on a negative basis, that is, on the lack of those forms found to be confined to the upper zone. The lower zone is named on an arbitrary basis, since *Elphidiella hannai* is not confined to the zone which bears its name. The stratigraphic boundary between the two zones is found to be in the shales in the bottom of Purisima Creek midway between California State Highway #1 and the coastline.

ECOLOGY

The majority of the common species found in the Purisima formation are represented in the Pliocene to Recent sediments of the Pacific Coast. A comparison with Natland's work on the temperature and depth distribution of Recent and fossil Foraminifera in the Southern California region indicates that the Purisima assemblage existed at a depth near that of the boundary of Natland's zones II and III, that is, about 125 feet, with a possible deepening of the basin of sedimentation as the four species restricted to the *Uvigerina juncea* zone became abundant. Rather than a deepening of the basin, however, it may be that a colder water environment enabled these typically deeper, colder water forms in the *Uvigerina juncea* zone to exist in the shallower waters. If then, temperature was the controlling factor, the forms of the *Elphidiella hannai* zone which continue into the *Uvigerina juncea* zone would have to be types that could tolerate this lowering of the temperature. If any depth change occurred, it left no lithologic expression in the sediments, and therefore the writers believe that a slight temperature change is the most likely mechanism to account for the faunal change.

The megafossil content of the Purisima formation also furnishes information on the environment of deposition. This assemblage is believed to have lived at a depth of about 20 to 25 fathoms (7), which figure agrees well with the work of Natland based on the foraminiferal content. The depth estimate of the megafossil assemblage is based on the environment of a very similar Recent one in the Puget Sound area, Washington.

Living representatives of both microfossils and megafossils are found to be typically marine organisms living in areas of normal salinity. The fossil content indicates that the basin of deposition of the Purisima formation was freely connected with the open sea, but was restricted in some manner such that the sediments were not affected by currents and wave action. No depositional features such as current bedding or ripple marks are found in the Purisima sediments. These features would be expected in a shallow water deposit such as this if marine currents and wave action were acting in the basin.

SYSTEMATIC DESCRIPTIONS

All of the hypotype material described is in the Stanford University Paleontology Type Collection. Material given only a generic identification has been placed in the Stanford University general micropaleontology collection. Also included in the general collection are additional specimens of all the hypotype material showing variations noted within the described species. Only the species considered to be most characteristic of the fauna have been figured.

Phylum PROTOZOA
Class SARCODINA
Order FORAMINIFERA
Family MILIOLIDAE
Genus **Quinqueloculina** Orbigny, 1826
Quinqueloculina akneriana var. **bellatula** Bandy

Plate 32, figures 19, 25, 26

1950. *Quinqueloculina akneriana* var. *bellatula* BANDY, Journ. Pal., vol. 24, no. 3, p. 273, pl. 41, fig. 1.

Description.—Test triangular in cross section with rounded edges, ⅔ as wide as high, rounded at basal end; calcareous imperforate; sutures flush with surface; aperture terminal, at the end of the last formed chamber, rounded, with a simple tooth.

Length, .57 mm., width, .47 mm., thickness, .35 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8264.

Locality.—L.S.J.U. Loc. M-594.

Family TROCHAMMINIDAE

Genus **Trochammina** Parker and Jones, 1859

Trochammina sp.

Description.—Test trochoid, planoconvex, flat on the dorsal evolute side; ventrally, slightly umbilicate; 5 to 7 chambers in the last formed whorl; arenaceous with much cement, showing much selectivity of grain size; chambers flattened and disc-shaped, overlapping much of the previous chamber on the ventral side; sutures slightly depressed on ventral side; apertural opening not visible.

Our specimens bear a great resemblance to *T. asagaiensis* Asano from the Oligocene of Japan, but the features are so inconspicuous that a positive identification cannot be made.

Diameter, .38 mm., thickness, .15 mm.

Locality.—L.S.J.U. Loc. M-595.

Family LAGENIDAE

Genus **Robulus** Montfort, 1808

Robulus sp.

Description.—Test planispiral, bilaterally symmetrical, involute; close coiled; lenticular in edge view, periphery acute; sutures flush with surface; indistinct; about 6 chambers in the last whorl; aperture a median slit extending from the periphery partially down the apertural face.

Diameter, .38 mm., thickness, .22 mm.

Locality.—L.S.J.U. Loc. M-594.

Genus **Lagena** Walker and Boys, 1784

Lagena striata (Orbigny)

Plate 32, figure 18

1839. *Oolina striata* Orbigny, Foram. Amer. Merid., p. 21, pl. 5, fig. 12.

1862. *Lagena striata.* Reuss, Sitz. Akad. Wiss. Wien, vol. 46, pt. 1, p. 237, pl. 3, figs. 44, 45; pl. 4, figs. 46, 47.

1912. *Lagena striata.* Bagg, U. S. Geol. Survey. Bull. 513. p. 51. pl. 14, fig. 6.

1952. *Lagena striata.* Martin, Contr. Cushman Found. Foram. Res., vol. III, pts. 3 and 4, p. 121, fig. 6.

Description.—Test unilocular, circular in cross section, basal end round, calcareous perforate, subglobular in shape with 24 to 34 pronounced longitudinal costae; aperture rounded, terminal at end of a neck, which is variable in length.

The specimens from the Purisima formation belonging to this species show a great deal of variation in the shape of the test and the number of costae. The more elongate forms seem to have fewer costae and a longer neck.

Length, .40 mm.; diameter, .30 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8265.

Locality.—L.S.J.U. Loc. M-595.

Family NONIONIDAE

Genus **Nonion** Montfort, 1808

Nonion pompilioides (Fichtel and Moll)

1798. *Nautilus pompilioides* Fichtel and Moll, Test. Micr., p. 31, pl. 2, figs. a-c.

1884. *Nonionina pompilioides.* Brady, Rep. Voy. Challenger, Zool., vol. 9, p. 727, pl. 109, figs. 10, 11.

1929. *Nonion pompilioides.* Cushman, Contr. Cushman Lab. Foram. Res., vol. 5, pt. 4, p. 89, pl. 13, figs. 25 a, b.

1952. *Nonion pompilioides.* Martin, Contr. Cushman Found. Foram. Res., vol. III, pts. 3 and 4, p. 127, pl. 19, fig. 2.

Description.—Test planispiral, bilaterally symmetrical, periphery strongly rounded; 6 to 7 chambers in the last formed whorl, completely involute; moderately umbilicate; sutures slightly depressed and moderately curved; apertural face convex, extending from one umbilicus to the other, wider than high; aperture an elongate slit at the base of the apertural face.

Diameter, .32 mm., thickness, .25 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8266.

Locality. L.S.J.U. Loc. M-595.

Genus **Nonionella** Cushman, 1926

Nonionella miocenica Cushman

Plate 32, figures 7, 8, 9

1926. *Nonionina auris* Cushman, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 4, p. 91.

1926. *Nonionella miocenica* Cushman, Contr. Cushman Lab. Foram. Res., vol. 2, pt. 3, p. 64.

Description.—Test small, subtrochoid, broadly rounded periphery, 8 to 9 chambers in the last formed whorl, uniformly increasing in size; sutures moderately depressed, curved back slightly, partially evolute on the dorsal side; last formed chamber extends over the umbilicus on the ventral side; aperture a low elongate opening at the base of the last formed chamber.

Length, .45 mm.; width, .32 mm.; thickness, .22 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8267.

Locality.—L.S.J.U. Loc. M-595.

Genus **Pseudononion** Asano, 1936

Pseudononion cushmani (Stewart and Stewart)

Plate 32, figures 4, 5, 6

1933. *Nonionella cushmani* Stewart and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 7, no. 21, p. 264.

Description.—Test bilaterally asymmetrical; evolute dorsal side flat to slightly convex, ventrally involute, umbilicus distinct with filling of shell material; septal sutures distinct, slightly depressed; last formed chamber extends to umbilicus on ventral side; periphery moderately rounded; 10 to 12 chambers in the last formed whorl; aperture a low opening at the base of the apertural face, extending slightly on the ventral side.

The authors believe that the generic name *Pseudononion* proposed by Asano to cover the *Nonionella*-like forms in which the last chamber does not extend across the umbilicus, should be accepted.

Length, .40 mm.; width, .30 mm.; thickness, .18 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8268.

Locality.—L.S.J.U. Loc. M-594.

Genus **Elphidium** Montfort, 1808

Elphidium hughesi var. **obesum** Cushman

Plate 32, figures 23, 24

1927. *Elphidium hughesi* CUSHMAN and GRANT, Trans. San Diego Soc. Nat. Hist., vol. 5, no. 6, p. 75, pl. 7, figs. 4 a, b.

1939. *Elphidium hughesi* var. *obesum* CUSHMAN, U. S. Geol. Survey, Prof. Paper 191, p. 49.

Description.—Test planispiral, bilaterally symmetrical, involute, periphery well rounded, sides of test nearly parallel, sutures depressed; retral processes moderately developed, but usually worn and not easily recognized; umbilicus depressed, often filled with clear shell material; test somewhat inflated; 9 to 10 chambers in last-formed whorl.

The type locality of Cushman's variety is near the mouth of Purisima Creek. This variety is the most abundant form in our Purisima assemblage.

Diameter, .42 mm.; thickness, .22 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8269.

Locality.—L.S.J.U. Loc. M-594.

Genus **Elphidiella** Cushman, 1936

Elphidiella hannai (Cushman and Grant)

Plate 32, figures 27, 28

1927. *Elphidium hannai* CUSHMAN and GRANT, Trans. San Diego Soc. Nat. Hist., vol. 5, no. 6, p. 77, pl. 8, figs. 1, 2.

1936. *Elphidiella hannai.* CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, pt. 4, p. 89.

1939. *Elphidiella hannai.* CUSHMAN, U. S. Geol. Survey, Prof. Paper 191, p. 66.

Description.—Test planispiral, bilaterally symmetrical, involute, lenticular, periphery smooth and rounded; sutures flush with surface, curved back toward earlier chambers at periphery; double row of pores along septal sutures; about 10 chambers to a whorl; aperture, 10 or more openings along the base of the apertural face extending from one side of test to the other.

Most of our specimens are worn, the surfaces having a rough, nodose appearance. The nodes are the remains of septal material at the base of the septa between the apertural openings.

Diameter, .60 mm.; thickness, .38 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8270.

Locality.—L.S.J.U. Loc. M-595.

Family BULIMINIDAE

Genus **Buliminella** Cushman, 1911

Buliminella cf. **B. curta** Cushman

Plate 32, figure 22

1925. *Buliminella curta* CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, p. 33.

1946. *Buliminella curta.* CUSHMAN and PARKER. U. S. Geol. Survey, Prof. Paper 210-D, pp. 64-65, pl. 16, fig. 22.

Description.—Test an elongate spiral, tapering toward initial end; four chambers in the last coil, which is the broadest and extends back over earlier coils so that it makes up ½-⅔ the length of the test; aperture a small semi-circular opening at the side of a large loop-shaped depressed apertural face, a slightly raised ridge on the apertural face adjacent to the aperture.

These specimens are very similar to *B. curta* as described by Cushman and Parker in 1946, except that in our specimens the last-formed chambers make up more of the test. The apertural characteristics of our specimens are identical to those described by Cushman and Parker. The description of *B. curta* given by Cushman in 1925 does not agree with the 1946 description.

Length, .38 mm.; width, .20 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8271.

Locality.—L.S.J.U. Loc. M-594.

Buliminella elegantissima (Orbigny)

1839. *Bulimina elegantissima* ORBIGNY, Voy. Amer. Merid., Foraminiferes, vol. 5, pt. 5, p. 51.

1911. *Buliminella elegantissima.* CUSHMAN, U. S. Nat. Mus. Bull., no. 71, pt. 2, p. 89.

Description.—Test an elongate close spiral, spiral suture distinct, 3 spirals visible, the last making up ⅔ to ¾ the length of the test; last spiral made up of 8-10 elongated chambers lying obliquely to the direction of spiraling; septal sutures slightly depressed; aperture an elongate, slightly twisted loop-shaped opening.

Length, .32 mm.; width, .15 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8272.

Locality.—L.S.J.U. Loc. M-594.

Genus **Globobulimina** Cushman emend. Hoglund, 1947

Globobulimina pyrula (Orbigny)

Plate 32, figure 21

1846. *Bulimina pyrula* ORBIGNY, Foraminiferes fossiles du Bassin Tertaire de Vienne, p. 104, pl. 11, figs. 9, 10.

1932. *Globobulimina pyrula.* ADAMS, Micropaleontology Bull., vol. 3, no. 4, p. 125, pl. II, fig. 2.

1952. *Globobulimina pyrula.* MARTIN, Contr. Cushman Found. Foram. Res., vol. III, pts. 3 and 4, p. 132.

Description.—Calcareous perforate, wall smooth; 3 chambers to a whorl, chambers slightly inflated, last whorl envelops earlier portion of test so that only one earlier whorl is barely visible; sutures slightly depressed; aperture a loop-shaped opening, subterminal, with a tooth.

These specimens belong to the genus *Globobulimina* as amended by Hoglund in 1947. They would not be included in this genus as it was originally described by Cushman. Our specimens have been compared with those of Adams from the Pliocene of Southern California and are identical with them.

Length, .40 mm.; diameter, .27 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8273.

Locality.—L.S.J.U. Loc. M-595.

Genus **Virgulina** Orbigny, 1826

Virgulina subplana Barbat and Johnson

Plate 32, figure 20

1934. *Virgulina subplana* BARBAT and JOHNSON, Journ. Pal., vol. 8, No. 1, p. 14, pl. 1, figs. 16, 17.

Description.—Test elongate, slightly compressed in cross section, tapering towards initial end, rounded at apertural end, irregularly biserial, entire test twisted; sutures moderately depressed, chambers of variable size, 5 to 6 pairs of chambers making up biserial stage of test; chambers do not overlap each other; aperture loop-shaped, at the apex of the test, with a slit extending to the last septal suture.

Length, .62 mm.; width, .20 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8274.

Locality.—L.S.J.U. Loc. M-594.

Genus **Bolivina** Orbigny, 1839

Bolivina cf. **B. advena** Cushman

1925. *Bolivina advena* CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, p. 29, pl. 5, fig. 1.

Description.—Test small, biserial, compressed, tapering; rounded at apertural end; lateral margins straight, greatest width at apertural end; calcareous, finely perforate; longitudinal suture depressed and almost straight, septal sutures strongly convex upward; aperture a loop-shaped opening.

These specimens bear all the characteristics of Cushman's *B. advena,* but are consistently of much smaller size.

Length, .24 mm.; width, .08 mm.; thickness, .06 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8275.

Locality.—L.S.J.U. Loc. M-594.

Genus **Uvigerina** Orbigny, 1826

Uvigerina cf. **U. gesteri** Barbat and Von Estorff

1933. *Uvigerina gesteri* BARBAT and VON ESTORFF, Journ. Pal., vol. 7, no. 2, p. 171, pl. 23, figs. 7, 18.

Description.—Test elongate, rounded at apertural end, bluntly rounded at initial end; globular chambers with distinct sutures; 9 to 12 distinct costae, starting at initial end and continuing across sutures, but not present on last few chambers; aperture terminal, rounded, with a short neck and a pronounced lip.

The few specimens of this species found in the Purisima assemblage have had the last chambers broken off, hindering precise identification. The nature of the aperture and the characteristics of the costae suggest relationship to *U. gesteri* from the Miocene of California.

Length, .80 mm.; diameter, .45 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8276.

Locality.—L.S.J.U. Loc. M-594.

Uvigerina juncea Cushman and Todd

Plate 32, figure 17

1941. *Uvigerina juncea* CUSHMAN and TODD, Contr. Cushman Lab. Foram. Res., Vol. 17, pt. 3, p. 78.

Description.—Test generally triserial, some mature specimens becoming biserial in the last few chambers, circular in cross-section, elongate, tapering toward initial end; in some mature specimens the sides of the test become nearly parallel; test more than twice as long as wide, widest portion being toward apertural end; apertural end broadly rounded; chambers inflated, increasing in size rapidly and uniformly; sutures distinct, depressed; entire test usually costate with 12 or more low costae to a chamber, occasionally last few chambers without costae; aperture small, round, terminal, at the end of a short neck with a slight lip.

Length, .40 mm.; width, .27 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8277.

Locality.—L.S.J.U. Loc. M-594.

Genus **Siphonodosaria** Silvestri, 1924

Siphonodosaria sp.

Description.—Test elongate, rectilinear, uniserial, straight and tapering; chambers globular, partially embracing, with slight ornamentation around the lower part of each chamber; aperture terminal, rounded without a neck. Circular in cross section, sutures perpendicular to long axis of test.

Only one specimen was found and it has had both ends broken off, leaving only 5 chambers intact.

Length, .27 mm.; diameter, .10 mm.

Locality.—L.S.J.U. Loc. M-594.

Family ROTALIIDAE

Genus **Eponides** Montfort, 1808

Eponides cf. **E. exigua** (Brady)

Plate 32, figures 1-3

1884. *Pulvinulina exigua* BRADY, Rept. Challenger Expedition, pt. 22, vol. 9, p. 696.

1930. *Eponides exigua.* CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 6, pt. 3, p. 60, pl. 8, fig. 11a, b.

1934. *Eponides exigua.* BARBAT and JOHNSON, Journ. Pal., vol. 8, no. 1, p. 16, pl. 1, fig. 5-7.

1938. *Eponides exigua.* KLEINPELL, R. M., "Miocene Stratigraphy of California," A.A.P.G., p. 318, pl. XX, figs. 6, 10, 12.

Description.—Test trochoid, calcareous perforate, completely involute ventrally, evolute dorsally, strongly convex ventrally, slightly convex dorsally, chambers slightly inflated, 6 to 8 chambers in the last-formed whorl; spiral suture distinct but not depressed, septal sutures moderately depressed; umbilical area closed with small lobes which extend partially along sutures; aperture simple, at the base of the last formed chamber, narrow at peripheral end and widening toward umbilical end, about half the length of the apertural face, midway between periphery and umbilicus.

These specimens were compared with the type material of *E. exigua* (Brady) of Kleinpell, and differ by being less convex dorsally and by having more fully developed filling of the umbilical area.

Diameter, .35 mm.; thickness, .22 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8278.

Locality.—L.S.J.U. Loc. M-594.

Eponides cf. **E. ornata** (Orbigny)

1839. *Rosalina ornata* ORBIGNY, Voy. Amer. Merid., vol. 5, pt. 5, p. 42, pl. 1, figs. 18-20.

1930. *Eponides ornata.* CUSHMAN, STEWART and STEWART, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 72, pl. 6, fig. 2.

Description.—Test trochoid, biconvex, slightly flattened on the dorsal side, calcareous perforate; 6 to 7 chambers in the last whorl, 3 to 4 whorls visible dorsally; periphery slightly keeled; septal sutures radial ventrally, strongly curved backward dorsally, slightly depressed; spiral suture slightly limbate; umbilical area smooth, without a plug or a depressed umbilicus; aperture ventral, a low arched slit at the base of the apertural face midway between the umbilicus and the periphery.

Diameter, .30 mm.; thickness, .20 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8279.

Locality.—L.S.J.U. Loc. M-594.

Genus **Epistominella** Husezima and Maruhasi, 1944

Epistominella cf. **E. pacifica** (Cushman)

Plate 32, figures 10-12

1927. *Pulvinulinella pacifica* CUSHMAN, Bull. Scripps Inst. Oceanography, Tech. Ser., vol. 1, p. 165, pl. 5, figs. 14, 15.

1952. *Epistominella pacifica.* MARTIN, Contr. Cushman Found. Foram. Res., vol. III, pts. 3 and 4, p. 136, pl. 24, fig. 8a-c.

Description.—Test trochoid, calcareous perforate, biconvex, dorsal side sometimes flattened, 6 to 7 chambers in the last formed whorl; sutures distinct but not depressed, strongly curved dorsally, radial and slightly curved ventrally; umbilicus slightly depressed, periphery gently keeled; aperture lies in the plane of coiling on the ventral side of the periphery, tapering, widest at the base of the apertural face, narrowing toward the periphery.

Comparison with Cushman's original figure shows our specimens differ in being unequally biconvex and only slightly umbilicate. In these respects they resemble *E. bradyana,* but the presence of a fairly well developed keel, 6 to 7 chambers in the last-formed whorl, and suture and aperture characteristics strongly resemble *E. pacifica.*

Diameter, .35 mm.; thickness, .18 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8280.

Locality.—L.S.J.U. Loc. M-598.

Family CASSIDULINIDAE

Genus **Cassidulina** Orbigny, 1826

Cassidulina californica Cushman and Hughes

Plate 32, figure 16

1925. *Cassidulina californica* CUSHMAN and HUGHES, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 1, p. 12, pl. 2, fig. 1.

Description.—Test broadly oval, nearly circular except for last chamber, which projects slightly; periphery slightly lobulate; in peripheral view, the sides are flat and parallel with broadly rounded periphery; chambers alternating, 5 pairs making up the last formed coil; sutures distinct, very slightly depressed; wall smooth and highly lustrous; aperture lies in the plane of coiling, opening toward the side of the test, a crescentic shaped opening with a small plate-like tooth partially filling it.

The specimens are identical in all respects with Cushman's paratype material in the Stanford collection, except that they are ⅓ to ½ as large.

Diameter, .25 mm.; thickness, .15 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8281.

Locality.—L.S.J.U. Loc. M-594.

Cassidulina limbata Cushman and Hughes

1925. *Cassidulina limbata* CUSHMAN and HUGHES, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 1, p. 12, pl. 2, fig. 2.

Description.—Test close coiled, biconvex, lenticular in edge view, subcircular in side view, last formed chamber projecting slightly; central umbo of clear shell material; periphery keeled; 4 to 5 pairs of chambers make up the last coil; chambers narrowed in central portion; sutures limbate; curved; wall smooth, finely perforate; aperture a narrow elongate slit parallel to the plane of coiling.

Diameter, .40 mm.; thickness, .22 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8282.

Locality.—L.S.J.U. Loc. M-599.

Family GLOBIGERINIDAE

Genus **Globigerina** Orbigny, 1826

Globigerina bulloides Orbigny

Plate 32, figures 13, 14, 15

1826. *Globigerina bulloides* ORBIGNY, Ann. Sci. Nat., vol. 7, p. 277, no. 1.

1950. *Globigerina bulloides.* BANDY, Journ. Pal., vol. 24, no. 3, p. 279, pl. 42, fig. 2.

Description.—Test a low trochoid spiral, longer than wide, 3 whorls dorsally of 4 chambers each; chambers inflated, globular; sutures moderately depressed dorsally; surface coarsely perforate; aperture a large semicircular hole opening into the last chamber in the umbilical area, with a slight lip.

Length, .35 mm.; thickness, .22 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8283.

Locality.—L.S.J.U. Loc. M-595.

Globigerina sp.

Description.—Test small, trochoid, chambers inflated, 3 whorls of 5 chambers each, chambers in last formed whorl increasing rapidly in size; dorsal sutures moderately depressed, radial; aperture a low arched hole opening into the last chamber in the umbilicus, without a lip.

One specimen of the above described form was encountered in the Purisima assemblage. It has many similarities with *G. quinqueloba* Natland, notably in the size and shape of the test and in the chamber arrangement. However, it differs from the hypotype material of *G. quinqueloba* (kindly supplied by Dr. Natland) by possessing a larger aperture, lacking a lip over the aperture, and being less perforate. A valid identification cannot be made on the basis of one specimen.

Length, .20 mm.; width, .18 mm.; thickness, .13 mm.

Locality.—L.S.J.U. Loc. M-597.

Genus **Globigerinoides** Cushman, 1927

Globigerinoides minuta Natland

1938. *Globigerinoides minuta* NATLAND, Bull. Scripps Inst., Ocean. Tech. Series, Vol. 4, no. 5, p. 150, pl. 7, figs. 2, 3.

Description.—Test trochoid, but showing a tendency to become an elongate spiral; 3 inflated chambers to a whorl, 4 to 5 whorls exposed; calcareous perforate; sutures distinct, depressed; aperture a low arched opening in the umbilicus at the base of the last formed chamber; no supplementary apertures are visible.

Diameter, .18 mm.; length, .22 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8284.

Locality.—L.S.J.U. Loc. M-596.

Genus **Orbulina** Orbigny, 1839

Orbulina universa Orbigny

1839. *Orbulina universa* ORBIGNY, DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminiferes, p. 3, pl. 1, fig. 1.

1952. *Orbulina universa.* MARTIN, Contr. Cushman Found. Foram. Res., vol. III, pts. 3 and 4, p. 128, pl. 1, fig. 4.

Description.—Test consists of one large external spherical chamber; earlier chambers are barely visible when specimen is wet; wall finely perforate; numerous small rounded apertures scattered randomly over the test.

Diameter, .35 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8285.

Locality.—L.S.J.U. Loc. M-598.

Family ANOMALINIDAE

Genus **Cibicides** Montfort, 1808

Cibicides fletcheri Galloway and Wissler

1927. *Cibicides fletcheri* GALLOWAY and WISSLER, Journ. Pal., vol. 1, no. 1, p. 64, pl. 10, figs. 8, 9.

1952. *Cibicides fletcheri.* MARTIN, Contr. Cushman Found. Foram. Res., vol. III, pts. 3 and 4, p. 125, pl. 20, fig. 2.

Description.—Test planoconvex, dorsal side slightly flattened in most specimens; small umbo of clear shell material present in umbilical area; 3 whorls show on evolute dorsal side, septal sutures flush with surface and strongly curved; sutures moderately depressed and slightly curved ventrally; periphery gently lobulate; 8 to 10 chambers in the last formed whorl; calcareous, coarsely perforate; aperture at the base of the apertural face, extending slightly on ventral side and projecting back dorsally along the spiral suture line for 3 or 4 chambers, with a slight lip at the periphery.

Our specimens are identical to those pictured by Martin, except that dorsally they are usually slightly convex. Only one specimen was found which was concave dorsally.

Diameter, .50 mm.; thickness, .23 mm.

Hypotype.—Stanford Univ. Paleo. Type Coll. No. 8286.

Locality.—L.S.J.U. Loc M-595.

LOCALITY DESCRIPTIONS

The following locality descriptions of the material described in this paper are referred to the U. S. Army Corps of Engineers map of the Halfmoon Bay Quadrangle, San Mateo County, California, Grid Zone "G," 15-minute series, 1943. Localities are given in reference to the five thousand yard grid system.

L.S.J.U. Loc. M-594.	Grid coord. 862300-1624650. Purisima formation Pliocene
L.S.J.U. Loc. M-595.	Grid coord. 862000-1625290. Purisima formation Pliocene
L.S.J.U. Loc. M-596.	Grid coord. 860750-1628490. Purisima formation Pliocene
L.S.J.U. Loc. M-597.	Grid coord. 861490-1626350. Purisima formation Pliocene
L.S.J.U. Loc. M-598.	Grid coord. 862980-1622825. Purisima formation Pliocene
L.S.J.U. Loc. M-599.	Grid coord. 862390-1624160. Purisima formation Pliocene

REFERENCES

1. Branner, J. C., Newsom, J. F., and Arnold, Ralph, 1909. Description of the Santa Cruz Quadrangle, California, U. S. Geol. Survey, Santa Cruz Folio, no. 163.
2. Grant, U. S. and Gale, H. R., 1931. Catalog of the Marine Pliocene and Pleistocene Mollusca of California, San Diego Society of Natural History, Memoir 1.
3. Crandall, R. R., 1943. Halfmoon Bay District, Oil and Gas Fields of California, California State Division of Mines, Bulletin 118, pp. 478-480.
4. Cushman, J. A., 1939. A Monograph of the Family Nonionidae, U. S. Geol. Survey, Prof. Paper 191, p. 49.
5. Stewart, R. E. and Stewart, K. C., 1933. Notes on the Foraminifera of the type Merced at Seven Mile Beach, San Mateo County, California. Trans. San Diego Society Natural History, vol. 7, no. 21.
6. Natland, M. L., 1933. The Temperature and Depth Distribution of some Recent and Fossil Foraminifera in the Southern California Region, Bull. Scripps Inst. Ocean., Tech. Ser., vol. 3, no. 10.
7. Myra Keen, personal communication, June 10, 1954.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 4, OCTOBER, 1954

121. NOTES ON UPPER CRETACEOUS LARGER FORAMINIFERA

II. Genera of the Subfamily *Orbitoidinae* with remarks on the microspheric generation of *Orbitoides* and *Omphalocyclus*

KLAUS KÜPPER
Stanford University

ABSTRACT—The morphology of the microspheric generation of **Orbitoides** and **Omphalocyclus** is described. Both genera are characterized by a biserial embryonic apparatus which indicates a possible relation with the **Heterohelicidae.** The relationships of **Orbitoides** with **Monolepidorbis**, and **Omphalocyclus** with **Torreina** are discussed. The structural identity of the microspheric generation of **Omphalocyclus** and **Orbitoides** indicates a close relationship and suggests their belonging to one subfamily **Orbitoidinae**, thus eliminating the subfamily **Omphalocyclinae.**

Acknowledgments.—I am especially indebted to the following gentlemen and institutions for the loan of material: R. M. Kleinpell and Zach M. Arnold from the Museum of Paleontology, University of California, Berkeley; The Palmer Collection of the Paleontological Research Institute, and the Humble Oil Co.

Description of the morphology of microspheric specimens of *Orbitoides*

Plate 34, figures 1, 2; text figures 1, 2

In the two sections available the biserial center is distinct. The specimens differ in not having an identical number of chambers in the biserial part but they have two auxiliary chambers each, from which two spirals evolve, leading over from the biserial part to the normal annular part of the test. In the specimen of text fig. 2, one auxiliary chamber is located in a terminal position and not laterally as in the specimen illustrated by text fig. 1. The earliest part of the biserial stage is indistinct in all sections making impossible any definite statements about the chamber arrangement in the earliest part of the test.

Measurements in millimeters:

	FIG. 1	FIG. 2
Diameter of test	11.7	10.0
Length biserial part	0.21	0.17
Width biserial part	0.12	0.14
Number of chambers in biserial part	9	5
Thickness of wall of distal chambers	0.05	0.03
Thickness of wall of central chambers	0.025	0.016
Thickness of wall of proximal chambers	0.012	0.008
Thickness of wall of embryonic apparatus	0.008	0.006
Measurements of chambers		
external	0.16 x 0.08	0.13 x 0.008
central	0.15 x 0.15	0.10 x 0.08
internal	0.10 x 0.05	0.07 x 0.05

The allocation of the specimens to the genus *Orbitoides* is certain as they cannot be confused with *Omphalocyclus* on account of the thinner walls of the median chambers, nor with *Lepidorbitoides* as the latter has differently shaped median chambers with a four stolon system. It is probable that these microspheric specimens belong to the species *Orbitoides tissoti* Schlumberger as the latter has been described from the same locality. Until more information is available on the variation and differences of the morphology of the microspheric generation of different species of *Orbitoides*, an open nomenclature only is applied. In literature, only very little information is available on the microspheric generation. Schlumberger, 1902, illustrated microspheric specimens of *Orbitoides apiculata* but unfortunately his description does not cover the initial part and the magnification of his figures is too small to make out details of the structure of the embryonic apparatus. Some other references describe the initial part as spiral, but these statements are not substantiated by adequate figures. This, however, is due to a large extent to the very small dimensions of the embryonic apparatus which is preserved only in very favorable sections.

Description of the Genus *Orbitoides* Orbigny, 1847

The description of the genus so far covers only a restricted number of features. An attempt is here made to give the following emendation:

Test round, usually symmetrical, although asymmetrical species occur. Surface smooth or ornamented with knobs and grooves. The embryonic apparatus of the megalospheric generation which is enveloped in a thick shell, is composed of a subspherical protoconch and a kidney shaped deuteroconch, both laterally compressed. These two cells are embraced by two half-spherical cells on each side. If the deuteroconch is reduced in younger species, the two lateral chambers become united, thus building the advanced two-cellular type of embryonic apparatus. The embryonic apparatus is surrounded by a thick shell which is perforated by a number of stolons—a number which increases in time. The stolons provide direct communication between the embryonic apparatus and the auxiliary chambers which become in turn the first median chambers. The median chambers do not vary greatly in the different species but the number of superimposed stolons in median chambers increases in time from 2 to 7. The lateral part of the test is made up of lateral chambers which are invariably present in all species. Pillars may be present or absent. The microspheric generation is characterized by a biserial initial stage followed by a nepionic stage with four spirals. The structure of the remainder of the test is identical with the megalospheric generation.

Occurrence.—Orbitoides is widely distributed in deposits of Maastrichtian and Campanian age. It has been recorded from Europe, the Far and Near East, Central and North America.*

Discussion of the
Genus *Simplorbites* de Gregorio, 1882

In recent textbooks the genus *Simplorbites* de Gregorio is usually listed in the synonymy of *Orbitoides*. The unusual embryonic apparatus is interpreted as a teratologic form of *Orbitoides*. It was shown in a recent paper by A. Papp and K. Küpper to be a species stratigraphically and morphologically intermediate to a normal *Orbitoides*, and *Simplorbites gensacicus* was there described as *Orbitoides jaegeri*, suggesting that *O. jaegeri* and *S. gensacicus* are related to *Orbitoides* but belong to a different bioseries. However, until this series is better known, it is advisable to leave this group of species within the genus *Orbitoides* although it is probable that later the name *Simplorbites* may become valid and be given subgeneric rank. For this reason it has not been included in the emended description of *Orbitoides* given above.

Description of *Monolepidorbis* Astre, 1928

This genus was described in detail by Astre in 1928 but only a few authors mentioned it later, mainly because it seems to be restricted geographically and stratigraphically. So far it has been recorded from Southern France and Spain in rare but interesting associations of larger Foraminifera in the Campanian. These faunas deserve more attention, as many problematic larger Foraminifera in the Maastrichtian are intimately related with species and genera of this group.

Astre (1928) indicates that this genus should be regarded as ancestral to both *Lepidorbitoides* and *Orbitoides*, two genera which are now thought to be distinct. Rutten (1941) regarded *Monolepidorbis* ancestral to *Orbitoides*, a concept that could be further substantiated by the study of the embryonic apparatus of *Monolepidorbis*. A short compilation of the most important features is given for comparison with the other genera discussed.

Diagnosis of *Monolepidorbis* Astre, 1928

Test round, flat to slightly concave-convex, surface unornamented. Median chambers highly arched, connected with each other through a one stolon system. No lateral chambers are present. This feature is important to distinguish between *Monolepidorbis* and *Orbitoides*; the latter has lateral chambers distinctly developed.

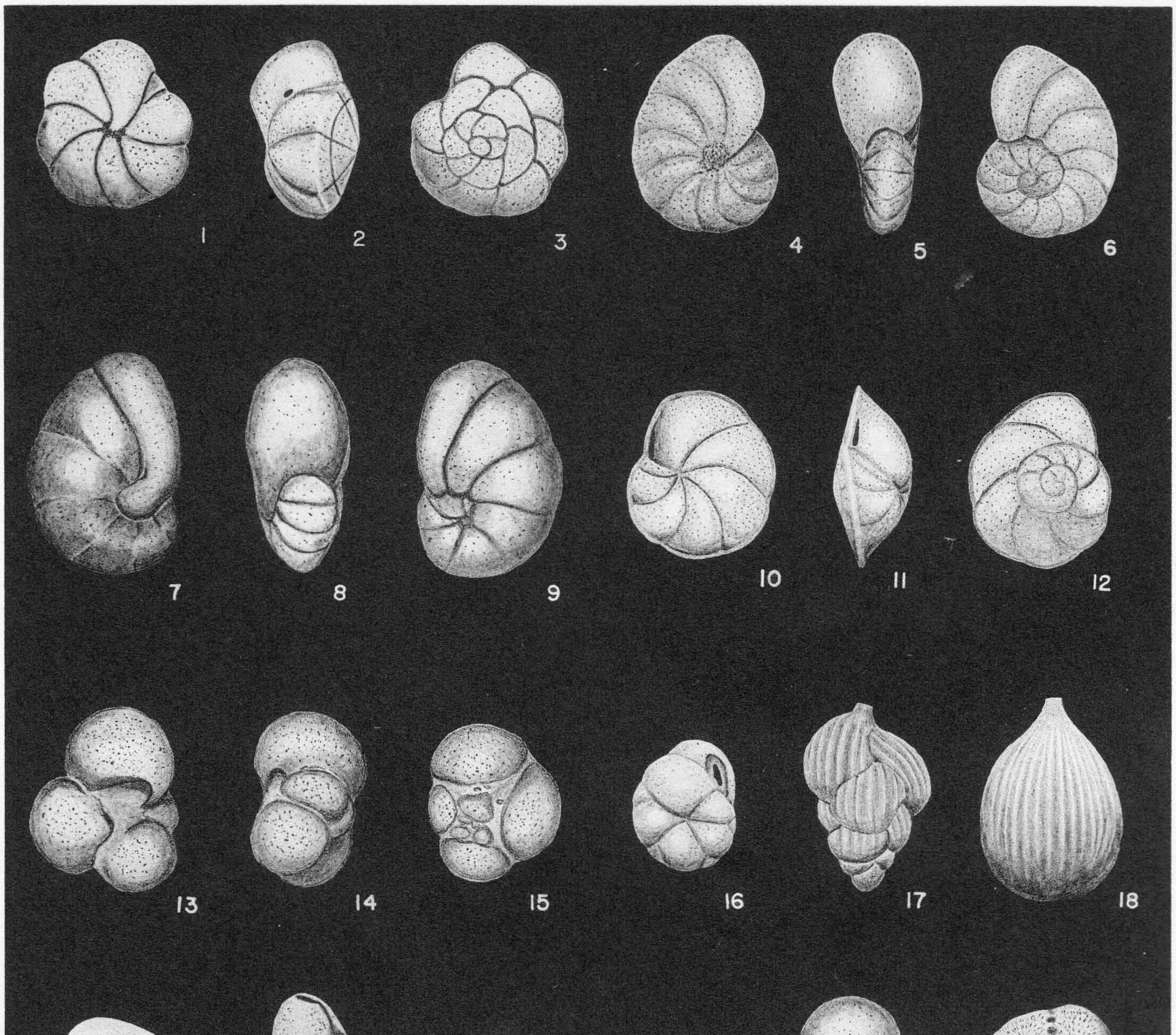
The small embryonic apparatus shows a type of structure similar to that of *Orbitoides* as represented by primitive species with a four-celled embryonic apparatus. The first cell is usually smaller than the second so that the sidewalls are not parallel but converging. The cells III and IV (nomenclature as used by Papp and Küpper 1953 and Küpper 1954) embrace the first two cells but the whole apparatus is not enveloped by a thick shell as in *Orbitoides*. Auxiliary chambers are formed in the same way as in *Orbitoides tissoti* Schlumberger.

---

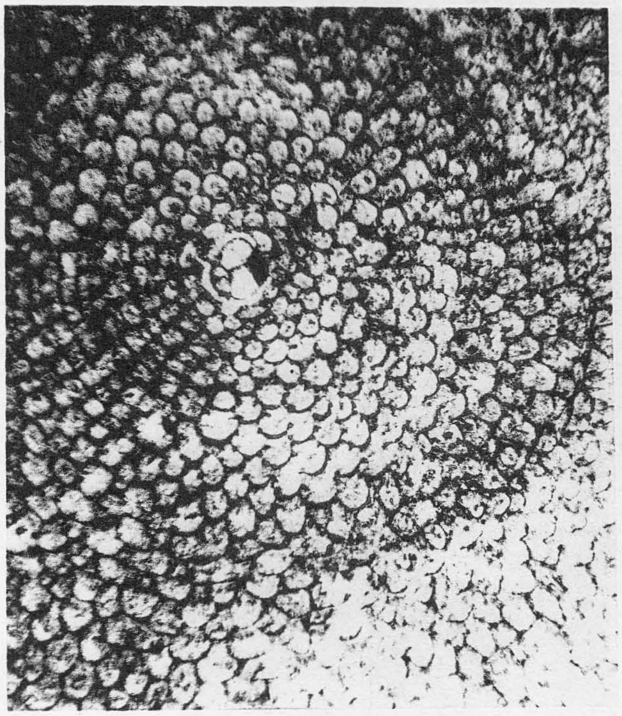
* The author wishes to apologize for a regrettable oversight in his paper on "**Orbitoides in America**" in which Cole's description of **Orbitoides palmeri** had not been mentioned in the list on page 65. Cole's description proved the occurrence of the genus Orbitoides on the North American continent.

EXPLANATION OF PLATE 32

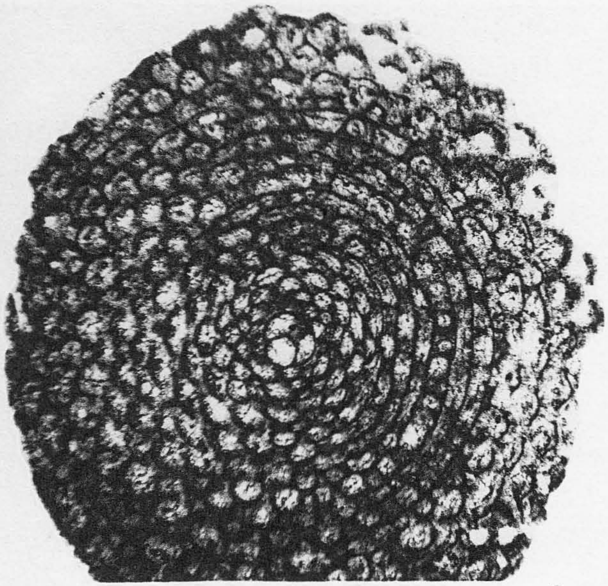
Figs.		Page
1, 2, 3.	*Eponides* cf. *E. exigua* (Brady). × 55; hypotype no. 8278.	176
4, 5, 6.	*Pseudononion cushmani* (Stewart and Stewart). × 55; hypotype no. 8268.	173
7, 8, 9.	*Nonionella miocenica* Cushman. × 55; hypotype no. 8267.	173
10, 11, 12.	*Epistominella* cf. *E. pacifica* (Cushman). × 55; hypotype no. 8280.	176
13, 14, 15.	*Globigerina bulloides* Orbigny. × 55; hypotype no. 8283.	177
16.	*Cassidulina californica* Cushman and Hughes. × 55; hypotype no. 8281.	176
17.	*Uvigerina juncea* Cushman and Todd. × 55; hypotype no. 8277.	175
18.	*Lagena striata* Orbigny. × 55; hypotype no. 8265.	173
19, 25, 26.	*Quinqueloculina akneriana* var. *bellatula* Bandy. × 55; hypotype no. 8264.	172
20.	*Virgulina subplana* Barbat and Johnson. × 55; hypotype no. 8274.	175
21.	*Globobulimina pyrula* (Orbigny). × 55; hypotype no. 8273.	175
22.	*Buliminella* cf. *B. curta* Cushman. × 55; hypotype no. 8271.	174
23, 24.	*Elphidium hughesi* var. *obesum* Cushman. × 55; hypotype no. 8269.	174
27, 28.	*Elphidiella hannai* (Cushman and Grant). × 55; hypotype no. 8270.	174



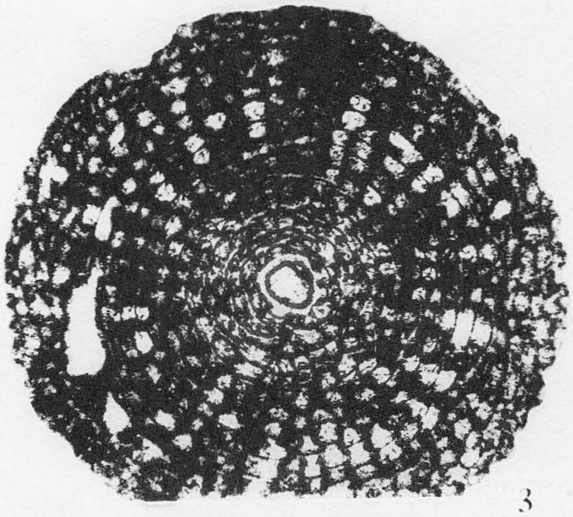
Goodwin and Thomson: Purisima Pliocene Foraminifera



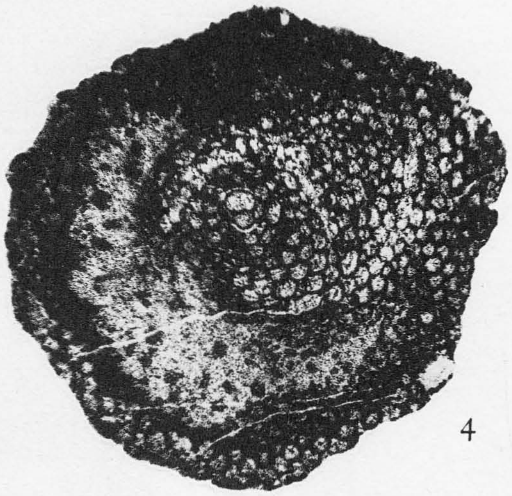
1



2

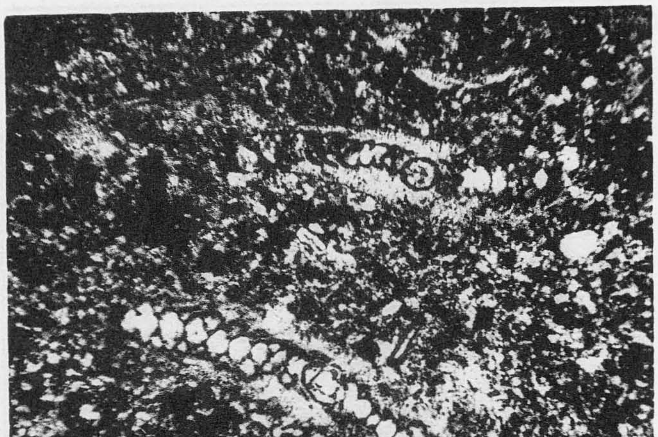


3



4

5



6

Küpper: Genera of Subfamily *Orbitoidinae*

Discussion and discrimination from *Orbitoides*

The discrimination between *Orbitoides* and *Monolepidorbis* in regard to the most important feature, i.e., the presence and absence of lateral chambers, is not very satisfactory. Astre (1928) described together with the type species *Monolepidorbis sanctae-pelagiae densa*[1] the second subspecies *vacuolaris*, which was differentiated on account of the presence of vacuoles in the lateral part of the test, which in fact are the first lateral chambers. However, the presence or absence of lateral chambers is usually regarded as a feature of generic value in larger Foraminifera, but it has to be remembered that such a differentiation is artificial. If a strict application of the definition is advocated, the subspecies *vacuolaris* belongs to the genus *Orbitoides* and represents as *Orbitoides vacuolaris* (Astre) the most primitive species of the genus. Similar conditions have been encountered in some other genera of larger Foraminifera, as for instance *Heterostegina*—*Spiroclypeus* (see discussion by Tan Sin Hok 1937). The differences between the embryonic apparati are only those of size and therefore only of secondary importance for generic discrimination. There is no evidence of a spiral arrangement in the embryonic apparatus of *Monolepidorbis* as stated by Rutten (1941); the microspheric generation has not yet been found.

The Campanian age of *Monolepidorbis*

In 1928 Astre gave a few revelant observations on the age of the rocks containing this genus. In 1942 he dealt again with the same localities and described a rich foraminiferal fauna and gave a list of the megafossils of this assemblage. As this association seems to be rather unique it is well worthwhile to quote Astre and thus give the evidence for a Campanian age:

Foraminifera: *Lacazina elongata* Munier Chalmas; *Broeckina dufrenoyi* (Archiac); *Praesorites moureti* Douvillé; *Siderolites vidali* Douvillé; *Monolepidorbis sanctae-pelagiae* Astre; *Nonionina cretacea* Schlumberger.[2]

Cephalopoda: *Hoplitoplacenticeras varians* (Schlüter) *marroti* Coquand.

Gastropoda: *Pleurotomaria* cf. *turbinoides* Orbigny; *Delphinula cf. radiata* Zekeli; *D. cf. grossouvrei* Cossman; *Trochus sensuyi* Vidal.

Lamellibranchiata: *Pinna decussata* Goldfuss; *Pecten dujardini* Roemer; *Alectryonia (Arctostrea) serra* Defrance; *Exogyra auricularis* Geinitz; *E. matheronia* Orbigny; *Lucina* sp.; *Cardium subguttiferum* Archiac.

Rudistae: *Plagioptychus* cf. *aquilloni* Orbigny; *Praeradiolites aristidis* Munier-Chalmas; *P. subcoquandi* Toucas; *P. hoeninghausi* Des Moulins; *P. balensis* Astre; *Radiolites nouleti* Bayle; *R. aurigerensis* Munier-Chalmas; *H. vidali* Matheron; *H. variabilis* Munier-Chalmas; *H. (Vaccinites) sulcatus* Defrance; *H. archiaci* Munier-Chalmas; *H. robustus* Toucas.

Echinoidea: *Cidaris* sp.; *Phymosoma magnificum* Agassiz *sulcata* Agassiz & Desor; *Holectypus* cf. *proximus* Lambert.

Anthozoa: *Cyclolites* div. sp.; *Astrocoenia decaphylla* Michelin; *Barysmilia* sp.

Description of the microspheric generation of *Omphalocyclus*

In the only section available a biserial stage very similar to that of *Orbitoides* occurs (see pl. 34, fig. 3; text fig. 3) with five chambers distinctly observable. The earliest part is not recognizable. It is therefore not possible to ascertain whether the embryonic apparatus started out coiled and became biserial or was biserial from the very beginning. The last two chambers do not communicate through terminal apertures with the annular stage, but through apertures at their base. These apertures connect with semi-circular chambers which represent auxiliary chambers in the microspheric generation. From these chambers a spiral direction of growth starts around the biserial part and leads over

---

[1] However, according to the IRN the typical subspecies has to have the same name as the species. Thus the name should be quoted as **Monolepidorbis sanctae-pelagiae sanctae-pelagiae** Astre and the name **densa** becomes a synonym.

[2] This species has to be restudied with material described as **Meandropsina** n. sp. aff. **Nonionina cretacea** Schlumberger from the Maastrichtian of Alfermee by O. Renz 1936. It apparently belongs to a new genus of the Rotaliidae.

EXPLANATION OF PLATE 33

Figs.		Page
1.	*Omphalocyclus macropora* (Lamarck) quadrilocular embryonic apparatus, Near Coliseo, Matanzas Province, Cuba, Palmer Collection, Paleontological Research Institute PC 27 g.	182
2.	*Omphalocyclus schlumbergeri* (Silvestri) bilocular embryonic apparatus, Near Coliseo, Matanzas Province, Cuba, Palmer Collection, Paleontological Research Institute, PC 27 i.	182
3.	*Torreina torrei* Palmer, embryonic apparatus multilocular, 1 km. South of Central Jesus Maria, Matanzas Province, Cuba, Palmer Collection Paleontological Research Institute 909/29.	182
4.	*Monolepidorbis sanctae-pelagiae* Astre, quadrilocular embryonic apparatus, between Col de Cabrillas and Val de Lluch, Spain, Collection Museum of Paleontology, University of California, Berkeley.	181
5.	*Orbitoides vacuolaris* (Astre) lateral chambers distinctly developed, locality and depository as for fig. 4.	181
6.	*Monolepidorbis sanctae-pelagiae* Astre, no lateral chambers developed, locality and depository as for fig. 4.	181

All photographs unretouched; magnification ca. 28 ×

to the normal median chambers. The median chambers can be subdivided according to their shape: an internal part with oval shaped chambers and an external part with radially elongated chambers. The latter have very thick perforated walls and are typical of *Omphalocyclus*.

Measurements in millimeters:

Diameter of test	70
Length, biserial part	0.20
Width, biserial part	0.13
Number of chambers in biserial part	5
Thickness of wall of distal chambers	0.15
Thickness of wall of central chambers	0.10-0.15
Thickness of wall of radially elongated chambers	0.005
Thickness of wall of embryonic apparatus	0.008
Measurements of chambers	
external	0.10 x 0.13
central	0.06 x 0.16
internal	0.03 x 0.10

Microspheric specimens of this genus have so far not been described in detail, but according to information from A. Papp, such material is available from the Frusca Gora, Yugoslavia.

The following species and subspecies have already been described from the Upper Cretaceous:

Omphalocyclus macropora (Lamarck)
Omphalocyclus macropora crassa Quenstedt
Omphalocyclus macropora disculus Leymerie[3]
Omphalocyclus macropora schlumbergeri (Silvestri)
Omphalocyclus macropora tenuis Quenstedt

Of the five forms mentioned only two are substantially different and specific rank is proposed for *Omphalocyclus macropora schlumbergeri* (Silvestri). *Omphalocyclus macropora* is characterized by a quadricellular, *Omphalocyclus schlumbergeri* by a bilocular embryonic apparatus. A final evaluation of the other described subspecies must await a monographic study of this genus. Both species quoted above have a worldwide distribution; *Omphalocyclus macropora* has been recorded from Europe, the Near East, India and America, *Omphalocyclus schlumbergeri* from Europe but occurs also in Central America (see pl. 33, fig. 2).

Definition of *Omphalocyclus*

Test round, centrally depressed, with or without ornamentation; median chambers arched in true median sections, in oblique sections becoming rectangular; communications between median chambers by marginally located, exceptionally large stolons; embryonic apparatus either quadrilocular or bilocular. The microspheric generation, in the material available, has a biserial embryonic apparatus; there are no differences in the structure of the remainder of the test between the generations. No true lateral chambers present in *Omphalocyclus*. A repetition of the median layer of the test is a unique structure characteristic of this genus.

Discussion of *Torreina* Palmer

The genus *Torreina* is apparently restricted in its geographical distribution to Central America and the southern part of North America. It differs from *Omphalocyclus* in one important feature: it is spherically built by a uniform development of chambers among which it is impossible to distinguish a median layer. The structure of the chambers is identical with that of *Omphalocyclus* indicating a close relationship. The embryonic apparatus of *Torreina torrei* is multilocular, excellently illustrated by Palmer and Rutten. However, a species has been observed from Florida which differs from *Torreina torrei* in having a quadrilocular embryonic apparatus. Unfortunately the material available does not permit description.

Ancestors of *Orbitoides* and *Omphalocyclus* as indicated by their microspheric generations.

Although the material of microspheric specimens is exceedingly scarce it seems to be of interest to discuss some of the possible implications caused by the observation of a biserial stage in the embryonic apparatus. The writer is aware of the fact that so far nothing is known about the variation of the microspheric generation, but it is expected that more information will become available if some of the problems and possible implications arouse interest.

In all larger Foraminifera the "retardation of the microspheric generation" is generally regarded as a reliable clue to the ancestry of the genus. As the microspheric generation of *Orbitoides* and *Omphalocyclus* appear to be identical in all important features, it seems possible to discuss both genera at the same time. The microspheric generation apparently indicates a calcareous biserial ancestor for both genera, which must have lived in Coniacian-Santonian time,

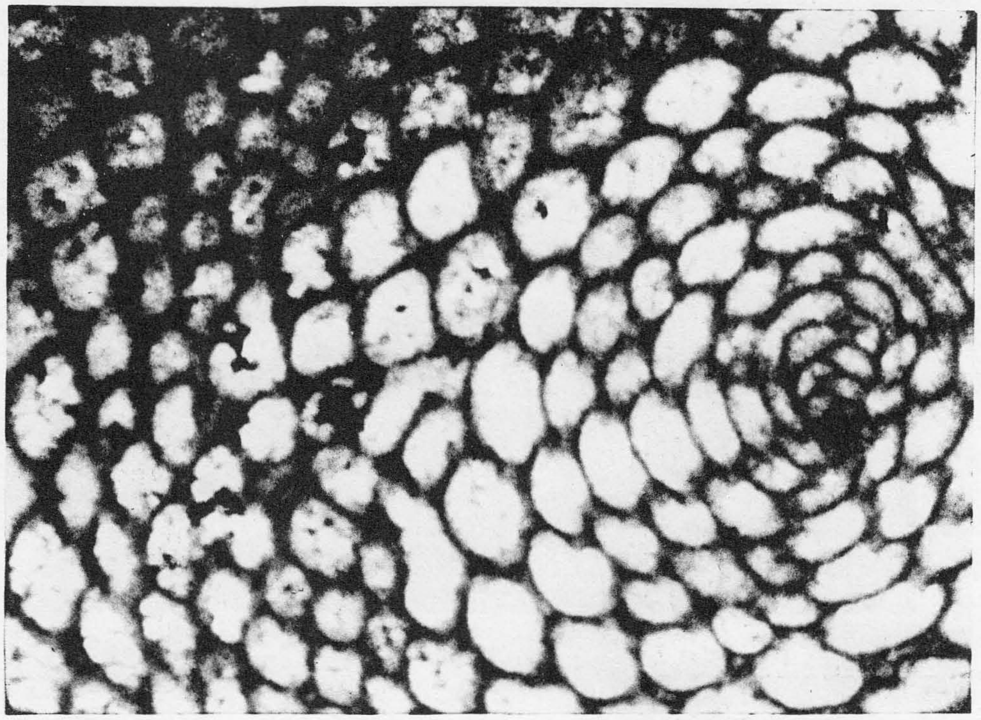
---

[3] Quoted by Douville 1920, original reference could not be checked, probably described by Leymerie 1851.

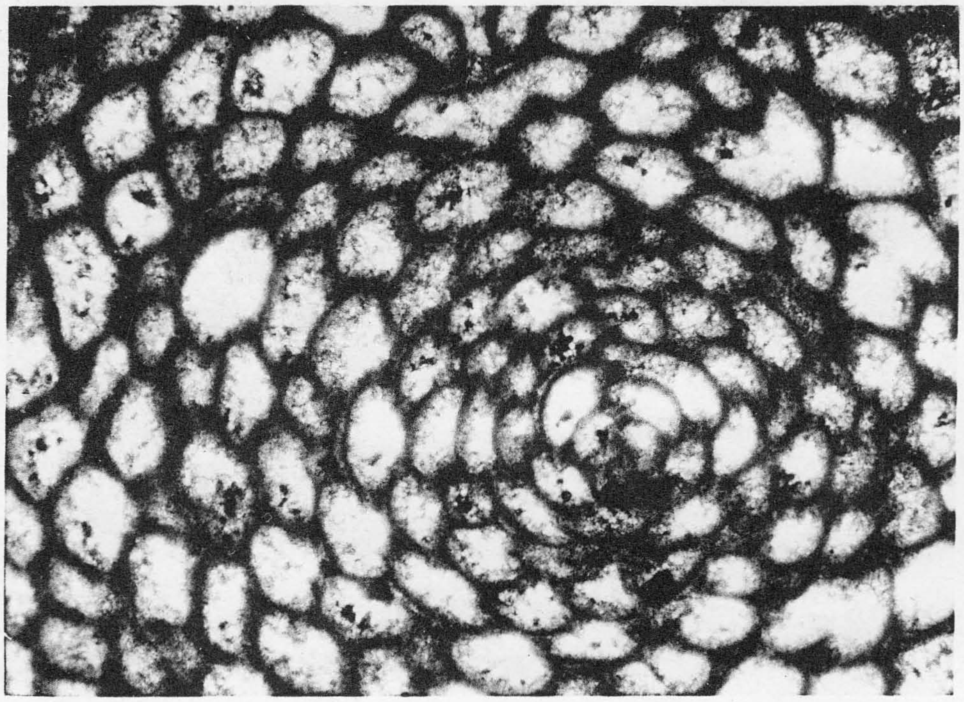
EXPLANATION OF PLATE 34

Figs.		Page
1.	*Orbitoides* sp., photograph of specimen drawn on text figure 1. Bergerac, France, Collection Museum of Paleontology, University of California, Berkeley.	179
2.	*Orbitoides* sp., photograph of specimen drawn on text figure 2. Bergerac, France, Collection Museum of Paleontology, University of California, Berkeley.	179
3.	*Omphalocyclus* sp., photograph of specimen drawn on text figure 3. St. Marcet, Haute Garonne, France, Collection Museum of Paleontology, University of California, Berkeley.	181

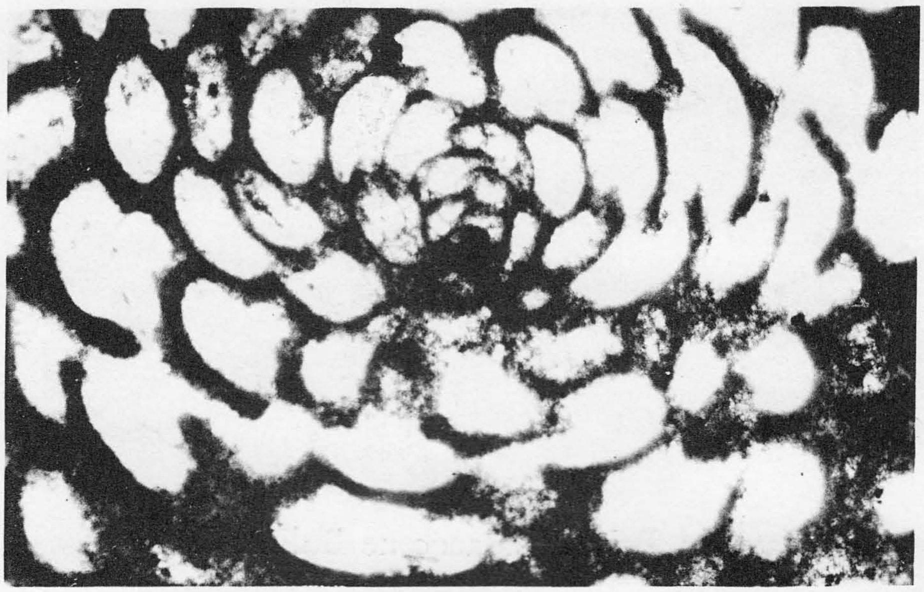
All photographs unretouched; magnification ca. 100 ×



1

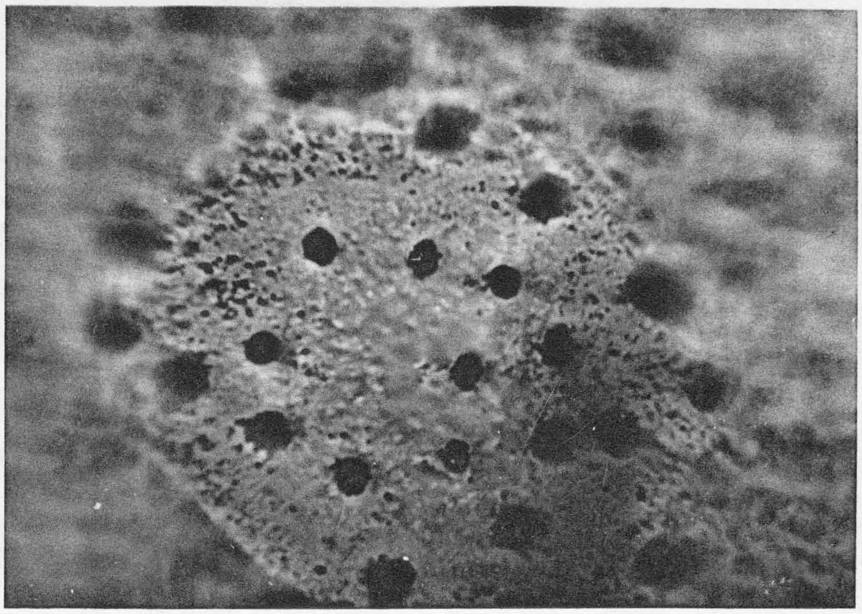


2

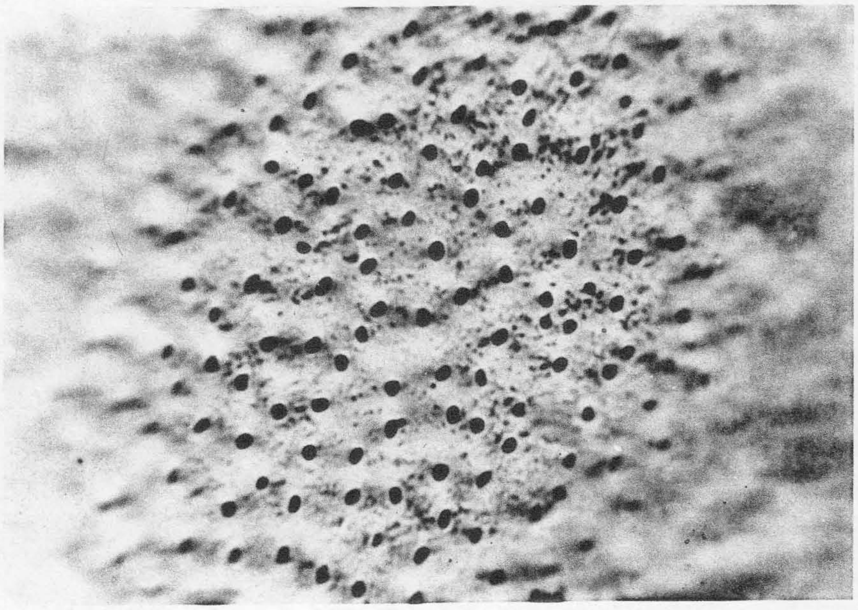


3

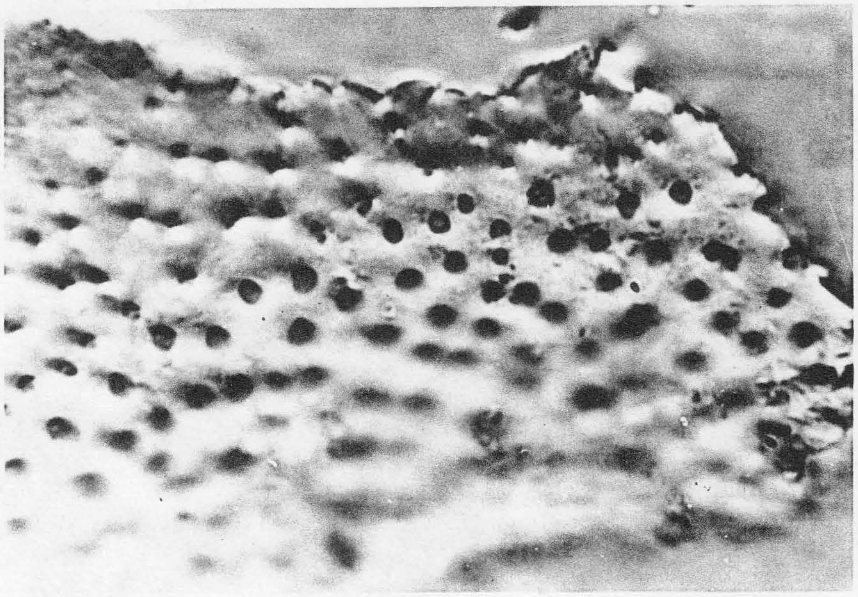
Kupper: Genera of Subfamily *Orbitoidinae*



1



2



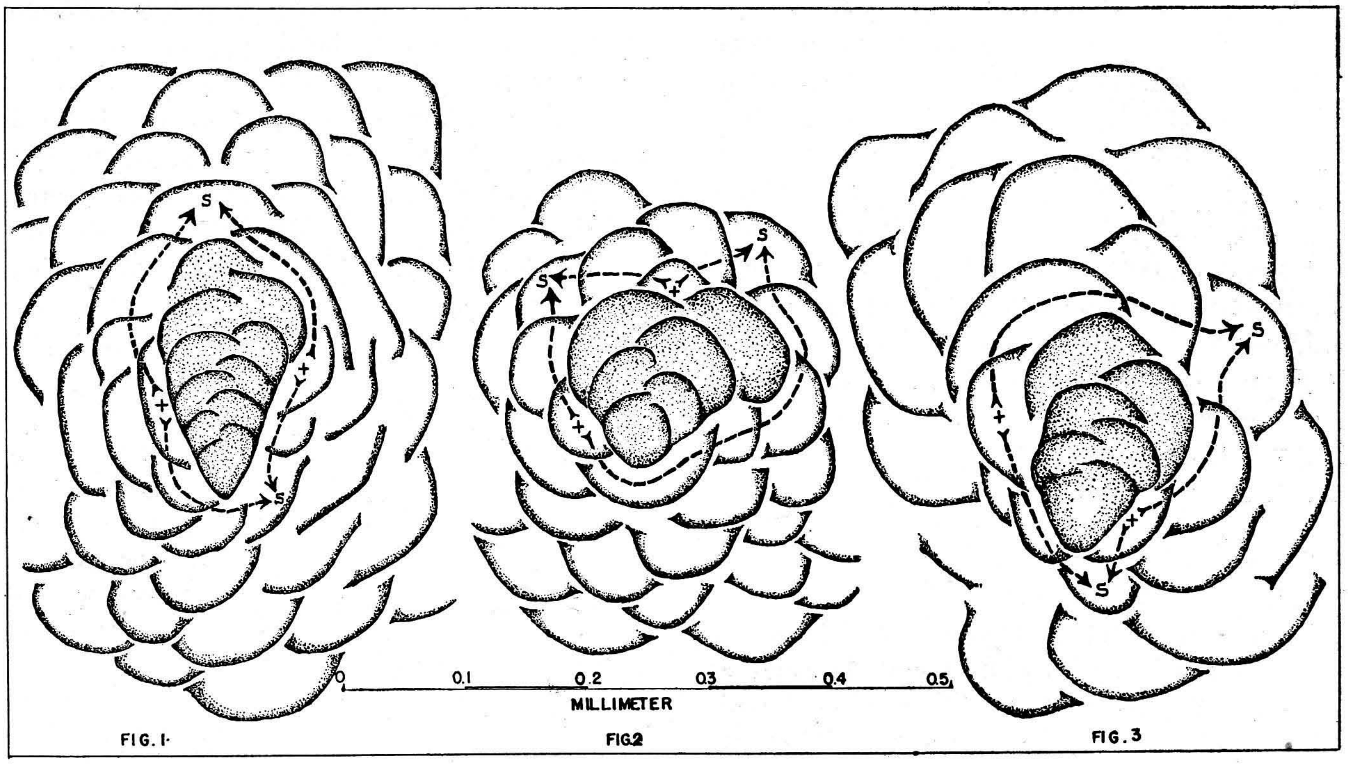
3

Haynes: British Palaeocene Buliminidae

as the first genus distinctly related to *Orbitoides*, *Monolepidorbis* has been reported from the Campanian. These requirements are met satisfactorily by the *Gümbelininae* of the *Heterohelicidae*. Although at first glance it seems quite improbable that there is a genetic relationship between the *Gümbelininae* and *Orbitoidinae*, it has to be borne in mind that only a minor morphologic change is necessary to transfer a *Ventilabrella* or *Planoglobulina* into a form with acervuline chambers surrounding the biserial part instead of being accumulated at one side only. As stated above these indications are nothing but suggestions of possible relationships and may demonstrate the scope of work still to be done in this group of Foraminifera. Whatever the final interpretation of the microspheric generation of *Orbitoides* and *Omphalocyclus* may be, it seems to be certain that they are closely related and that they should not be separated on a subfamily basis as done by Sigal and Glaessner. It also seems to be preferable to retain the classification of Rutten, and of Vaughan and Cole in Cushman. However the latter authors include some genera in the subfamily *Orbitoidinae* which seem to have different relationships, thus only the following genera should be retained in the subfamily *Orbitoidinae*:

Monolepidorbis Astre 1928
Orbitoides Orbigny 1847
Omphalocyclus Bronn 1852
Torreina Palmer 1934

The remarkable geographical distribution of the species of *Orbitoides* and *Omphalocyclus* finds a reasonable explanation in the morphology of the microspheric generation. It is easy to visualize the embryonic stage as a temporarily planktonic floater, similar to the *Gümbelininae*. This would explain the worldwide distribution of these larger Foraminifera.



TEXT FIGURES 1 - 3

Fig. 1 *Orbitoides* sp., schematical drawing corresponding to Pl. 34, fig. 1.
Fig. 2. *Orbitoides* sp., schematical drawing corresponding to Pl. 34, fig. 2.
Fig. 3. *Omphalocyclus* sp., schematical drawing (reversed) corresponding to Pl. 34, fig. 3.

crosses mark auxiliary chambers, *s* marks symmetrical chambers and *arrows* indicate direction of spirals in periembryonic chambers. Approximate magnification indicated by scale.

EXPLANATION OF PLATE 35

The pores in *Bulimina thanetensis* and in *Praeglobobulimina ovata*.

Figs.		Page
1.	External view of the pores in *Bulimina thanetensis*, Cushman and Parker.	186
2.	External view of the pores in *Praeglobobulimina ovata*, (Orbigny).	190
3.	Internal view of the pores in *Praeglobobulimina ovata*, (Orbigny).	190

All magnifications approx. 2160 X

BIBLIOGRAPHY

ASTRE, G., 1928, Sur *Monolepidorbis*, Foraminifère voisin des Linderines et Orbitoides. Bull. Soc. Géol. France, tome 27, 4.ieme Ser.

———, 1943, Sur une faune Campanienne de foraminifères des Pyrénées Catalans. Bull. Soc. Hist. Nat. Toulouse, tome 77(442).

COLE, W. S., 1944, Stratigraphic and paleontologic studies of wells in Florida, No. 3. Florida State Geol. Survey Bull. No. 26.

CUSHMAN, J. A., 1948, Foraminifera, their classification and economic use. Harvard University press, Cambridge, Mass.

GAONA, M. R., 1948, Los Orbitoidos de las Sierras de Urbasa y Encia. Bol. Real. Soc. Espanola Hist. Nat., vol. 16.

GLAESSNER, M. F., 1947, Principles of Micropaleontology. Melbourne University Press, Carlton, Victoria, Australia.

HOFKER, J., 1926, Die Foraminiferen aus dem Senon Limburgens. IV. *Sporadotrema errantium* nov. spec. Natuurhist. Maandblad 15. Jaarg. No. 6 Maastricht.

KÜPPER, K., 1954, Notes on Cretaceous larger Foraminifera. I. Genus *Orbitoides* in America. Contrib. Cushman Found. Foram. Research, vol. V, no. 2.

LAMARCK, J. B., 1816, Histoire naturelle des animaux sans vertèbres, tome 2. Verdière Paris.

LEYMERIE, A. F. G. A., 1851, Mémoire sur un nouveau type pyrénéen. Mém. Soc. géol. France ser. 2, vol. IV.

ORBIGNY, A. D', 1848, in LYELL, C.: On the relative age and position of the so-called Nummulite Limestone of Alabama. Geol. Soc. London, Quart. Jour. vol. IV.

PALMER, D. K., 1934, Some larger fossil Foraminifera from Cuba. Soc. Cubana Historia Nat., Mem. vol. 8, no. 4.

PAPP, A. and KÜPPER, K., 1953, Die Foraminiferenfauna von Guttaring und Klein St. Paul (Kärnten). I. Ueber Globotruncanen suedlich Pemberger bei Klein St. Paul. Sitzber. Oesterr. Akad. Wiss., Math.-natw. Kl., Abt. 1, 162 Bd., 1. u. 2. Heft.

———, 1953, Die Foraminiferen von Guttaring und Klein St. Paul (Kärnten). II. Orbitoiden aus Sandsteinen vom Pemberger bei Klein St. Paul. Ibid. 1. u. 2. Heft.

———, 1954, Die Foraminiferen von Guttaring und Klein St. Paul (Kärnten). III. Foraminiferen aus dem Campan von Silberegg. Ibid, 4. Heft.

———, 1954, Ueber Stolonen von Auxiliarkammern bei *Orbitoides* und *Lepidorbitoides*. Ibid. 4. Heft.

QUENSTEDT, F. A., 1879, Petrefactenkunde Deutschlands; Korallen (Roehren- und Sternkorallen). Leipzig, Feuss Verlag. Abt. I. Bd. 6 (1881) Lief. 8.

RENZ, O., 1936, Ueber ein Maastricht- Cenomanien Vorkommen bei Alfermée am Bielersee. Eclogae Geol. Helvetiae, 29. Basel.

SCHLUMBERGER, M. Ch., 1902, Deuxieme note sur les Orbitoides. Bull. soc. géol. France, ser. 4, No. 2.

RUTTEN, M. G., 1935, Larger Foraminifera from Northern Santa Clara Province, Cuba. Journal Paleontology, vol. 9, No. 6.

———, 1941, A synopsis of the Orbitoididae. Geologie en Mijnbouw, vol. 3, No. 2.

SIGAL, J., 1952, Ordre des Foraminifera: in PIVETEAU, J., Traité de Paleontologie I. Masson et Cie. Editeurs, Paris.

SILVESTRI, A., 1907, Fossili Dordoniani nei dintorni di Termini-Imerese (Palermo). Accad. Pont. Romana, Nuovi Lincei, Atti, Roma.

———, 1908, Fossili Cretacei della contrada Calcasacco presso Termini-Imerese (Palermo). Palaeontographica Italica XIV.

TAN SIN HOK, 1937, On the Genus *Spiroclypeus* H. Douvillé with a description of the Eocene *Spiroclypeus vermicularis* nov. sp. from Koetai in East Borneo. Mijningenieur vol. 4, no. 6.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 4, OCTOBER, 1954

122. TAXONOMIC POSITION OF SOME BRITISH PALAEOCENE BULIMINIDAE

JOHN HAYNES
University College of Wales, Aberystwyth

ABSTRACT—**Bulimina** and **Praeglobobulimina** are redefined and the species **Bulimina thanetensis** Cushman and Parker and **Praeglobobulimina ovata** (Orbigny) redescribed together with a new variety, **Bulimina thanetensis** var. **hengesti,** nov. var.

INTRODUCTION

During a revision of the smaller foraminifera of the Thanet Sands of Kent numerous specimens were recovered of two species originally referred to *Bulimina elongata* Orbigny and *Bulimina ovata* Orbigny by H. Burrows and R. Holland 1897. At that time the taxonomic value of the character of the aperture, and the details of the tongue and pores were not recognised. The species are therefore redescribed. This work on early members of the Buliminidae sheds light on the evolution of the group.

DESCRIPTIVE PART

Genus **Bulimina** Orbigny, 1826 emend. Haynes, 1954

Genotype: *Bulimina marginata* Orbigny

1826. *Bulimina* ORBIGNY, Ann. Sci. Nat., Vol. 7, p. 269.

1946. *Bulimina* CUSHMAN, U. S. Geol. Survey Prof. Paper, 210-D, p. 77.

1948. *Bulimina* CUSHMAN, Foraminifera, p. 266.

1947. *Bulimina* HÖGLUND, Zool. Bidrag fran Uppsala, Band 26, p. 227-231, 241-242.

1951. *Bulimina* HOFKER, Foram. Siboga Exped. Part III. P. 146, pp. 154-157.

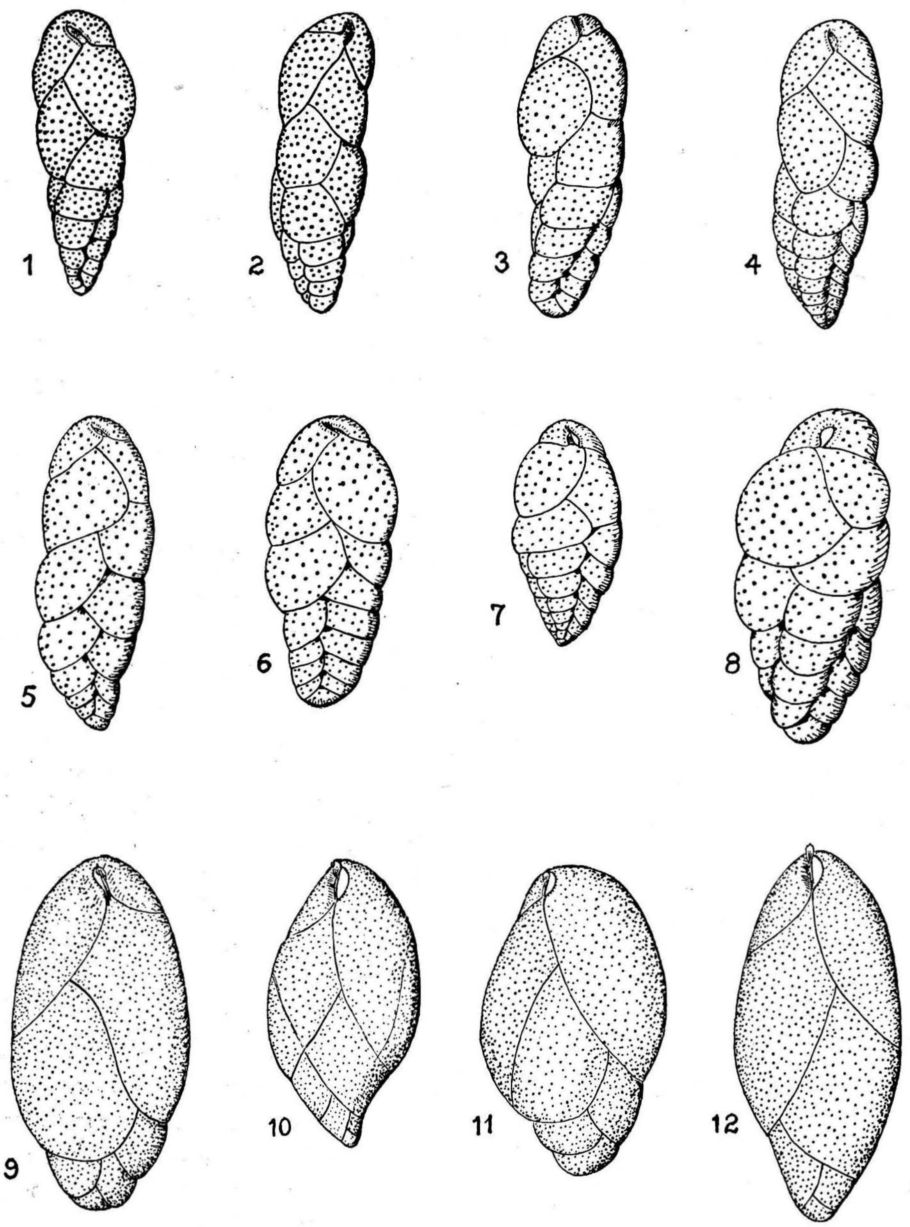
Generic description.— The test is elongate, always triserial initially and sometimes tending to become biserial in the last few adult chambers. The spiral suture may be marked or obsolete and the radiate hyaline wall may be finely or coarsely perforate. The aperture joins the basal suture and possesses both a free border, often with a raised collar, and a fixed border attached to an internal tongue. The tongue, which connects the aperture to the foramina, is folded and joined by one edge, the fixed shank, to the internal chamber wall below the aperture. The other edge, the free shank, is not so joined and may be dentate, or smooth, sometimes flaring, with a reduced or hooked base, or rolled on itself to form a tube.

Discussion.—The generic description given above differs from that given in Cushman (1948), in that it includes the results of the researches of Höglund, (1947) and Hofker, (1951) into the tongue of *B. marginata.* Furthermore it is framed so as to include species such as *B. thanetensis* Cushman and Parker in which the free shank is not rolled on itself to form a tube as it is in the genotype.

Pore size and distribution are not considered to be of generic or sub-generic significance. According to Hofker, *Bulimina* may have arisen from the finely-porous *Praebulimina* in the late Cretaceous, diverging into two groups, one with small pores, represented in modern seas by *B. marginata* Orbigny, and one with coarse, represented by *B. pagoda* Cushman. It is important in this connection that *B. thanetensis* has both large irregular pores and small pores scattered amongst them. Hofker, (1951, p. 42) also asserts that in no case known to him do deuteropores (large pores considered by him to have developed on the exterior of the test by the opening out and absorption of small pores) occur in his Sub-Order Protoforaminata, which includes the Buliminidae. However, certain of the large pores in *B. thanetensis* appear to have absorbed small pores at their edges and are thus to some extent analagous to the large pores said to occur in some species of *Cibicides.*

The occurrence of two sizes of pores in the adult chambers of the Thanetian species makes Hofker's tentative sub-generic grouping on the ground of pore size doubtful. Sub-generic distinction, if possible, would appear more securely based on tongue structure; for instance *B. thanetensis* and *B. trigonalis* Ten Dam, another Palaeocene species, differ from both *B. pagoda* Cushman and Parker and *B. marginata* Orbigny in that the free shank is simple and not rolled up to form a tube or sipho. A grouping on this feature would cut across that made on pore size.

Differences from related genera.—Hofker, (1951, p. 144), has erected the genus *Praebulimina* to include Cretaceous Buliminids distinguished from *Bulimina* by the possession of a simple tongue without a developed free border. *Globobulimina* and its allies differ from *Bulimina* in the possession of a tongue in which both shanks are fixed. In advanced Globobuliminas further differences include complication of the tongue and the tendency for the aperture to become terminal and the chambers embracing.



TEXT FIGURES 1 - 12

Figs. 1-6. *Bulimina thanetensis* Cushman and Parker. × 66.
Figs. 7 & 8. *Bulimina thanetensis* var. *hengisti,* nov. var. × 66.
Figs. 9-12. *Praeglobobulimina ovata* (Orbigny). × 66.

Bulimina thanetensis Cushman and Parker

Text figures 1-6, 13-16, 20; plate 35, figure 1

1947. *Bulimina thanetensis* Cushman and Parker, U. S. Geol. Survey Prof. Paper 210-D, p. 92, pl. 21, fig. 26.

1897. *Bulimina elongata* Burrows and Holland (not Orbigny), Proc. Geol. Assoc., p. 32, pl. 11, fig. 12.

Distinguishing features.—An elongate, thin walled *Bulimina* with well marked spiral sutures in the initial part which is trigonal in section. In the later part the test tends to become parallel sided and round in section. There are up to thirty chambers in microspheric forms which reach up to 0.5 mm. in length, up to twenty in megalospheric forms reaching approximately 0.45 mm. in length. The aperture is open with a raised neck on the free border. The free shank of the tongue is not flaring and neither the edge or the free tip is serrated. Dorsally the free shank bears a small flange.

Description.—(Text fig. 6). The test is elongate and tapering and the dextrally coiled whorls of semi-inflated chambers increase in size slowly attaining an almost constant width in the last two whorls. There are nineteen chambers arranged in six whorls and the spiral suture is well marked in the early, trigonal part. The sutures are distinct and impressed.

As the aperture joins the basal suture it can be termed open. It is comma shaped, perpendicular to the basal suture and extends almost to the apex.

A tongue joins the fixed edge of the aperture to the preceeding foramina and one side of it, the fixed shank, is joined to the anterior chamber wall below the aperture. The other side of the tongue, the free shank, has no connection with the chamber wall. The free shank of the tongue is folded, making a trough, and is smooth and produced into a slight flange dorsally. The free border of the aperture possesses a raised collar and is underlain internally by a ridge of shell material which is fused with the tongue.

There is no ornament and the wall is thin and transparent with numerous irregular pores, between 1 and 2 microns in diameter, scattered amongst very small ones, some of which appear at the edges of the large pores.

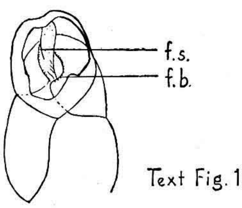
Dimensions.—Length 0.51 mm.; greatest diameter 0.18 mm.; diameter of proloculus 0.053, approx.

Alternation of Generations.—The accompanying graph (Text fig. 20), illustrates the marked dimorphism found in a hundred specimens of *B. thanetensis* from the *Astacolus crepidula* band, a one metre band of brown marl near the base of the Thanet Beds at Pegwell Bay, Kent. Two groups of proloculus sizes occur and possibly a minor intermediate group.

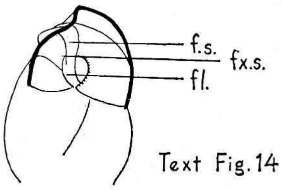
The group with proloculus diameters ranging about 15 microns, probably the microspheric or B_1 generation, tends to develop up to thirty chambers. The group with proloculus diameters between 45 and 60 microns, probably the megalospheric generations, has up to twenty chambers. This second group may represent the A_2 generation if the minor group between the two in proloculus size and chamber number represents a subsidiary A_1 generation.

Variation.—Megalospheric forms tend to reach a slightly greater maximum diameter than microspheric forms but in both there is a range of thickness from slender to more robust forms, approximately 0.17 mm.-0.19 mm. in the microspheric generation, 0.16 mm.-0.21 mm. in the megalospheric generation. This is related both to spiral twisting and to the rate of chamber size increase. The twisting of the "spiral suture" is variable. It tends to be straight or only slightly twisted in microspheric forms. It is generally deeply impressed but is little marked in most megalospheric forms after the first few chambers.

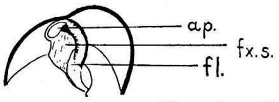
Direction of Coiling.—As shown by the graph, specimens that were found to be dextrally coiled in dorsal view slightly outnumbered sinistral forms, 54% to 46%, and fall into the same proloculus size groups, the distribution scatters on the two limbs of the graph being mirror images of one another. In a hundred specimens from near the top of the "D" marls sinistral forms were found to be slightly preponderant, 53%-47%. (These alphabetically designated units refer to the stratigraphical column used by Burrows and Holland 1897). In the sand at the top of the Thanet formation, both at Pegwell and Reculvers, the species, though less abundant, again shows both directions of coiling approximately equally developed.



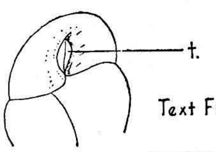
Text Fig. 13



Text Fig. 14



Text Fig. 15



Text Fig. 16

TEXT FIGURES 13 - 16

The tongue in

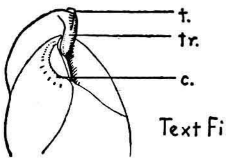
Bulimina thanetensis Cushman and Parker

Fig. 13. Rear view of breached apertural chamber. *f.s.*, free shank; *f.b.*, free border.

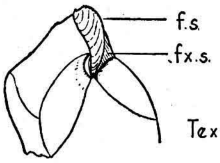
Fig. 14. View showing the fixed shank. *f.s.*, free shank; *fx.s.*, fixed shank; *fl.*, flange.

Fig. 15. Internal view of the aperture. *ap.*, aperture.

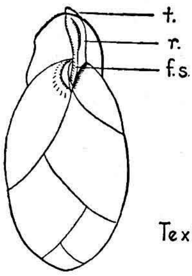
Fig. 16. External view of the aperture. *t.*, tip of tongue.



Text Fig. 17



Text Fig. 18



Text Fig. 19

TEXT FIGURES 17 - 19

The tongue in *Praeglobobulimina ovata* (Orbigny)

Fig. 17. Posterior view with free border of aperture removed. *t.*, free tip of tongue; *tr.*, trough; *c.*, collar.

Fig. 18. Side view of tongue. *f.s.*, free shank; *fx.s.*, fixed shank.

Fig. 19. Internal view of free border. *t.*, free tip of tongue; *r.*, ridge underlying free border; *f.s.*, free shank.

According to Bolli, (1951), it is the stratigraphically older Globorotalias and Globigerinas which show both directions of coiling. If, in fact, a preferred direction of coiling is inherited and of adaptative value it may be important that *B. thanetensis*, an early species of the genus, shows both directions of coiling equally developed.

Discussion.—The holotype chosen by Cushman and Parker has a curved vertical axis. Study of large numbers from the Thanet Beds indicates that this is merely a sporadic individual variation presumably caused by external factors during growth.

Differences from related species.—The Thanet species is closely related to *B. trigonalis* Ten Dam, but is thin, not thick walled and larger, up to 0.5 mm. in length rather than 0.3 mm. for the same number of whorls.

Comparison with Hofker's description of the Netherlands Palaeocene species also shows that the proloculus size groups are different, each generation being larger in *B. thanetensis* and that the tongue is simpler in the Thanet species. Hofker supposed that *B. trigonalis* was a shallow water form as it is generally found with plant remains. The differences shown by *B. thanetensis* in size and tongue structure, and especially in shell thickness might conceivably be the result of adaptation to deeper shelf water conditions.

Both of these species are distinguished from *B. elongata* Orbigny by their well developed spiral sutures, trigonal initial parts and coarsely porous walls. *B. simplex* Terquem is distinguished by a large quadrangular aperture, *B. palaeocenica* Brotzen by its triangular chamber shape, *B. rosenkrantzi* Brotzen by its large terminal whorl.

Bulimina thanetensis var. **hengisti** nov. var.

Text figures 7, 8

Distinguishing features.—A variety of *B. thanetensis* with inflated chambers, greater rate of chamber size increase, therefore greater width in the adult part, and generally with less whorls.

Description of a characteristic form.—(Text fig. 8). The test is elongate with inflated chambers slowly increasing in size. There are eighteen chambers in six whorls. The spiral suture is well marked and the septal sutures are deeply impressed. Except in the last part the test is distinctly trigonal. The aperture is oval and otherwise has the features described in *B. thanetensis*.

Dimensions.—Length 0.55 mm.; width at last whorl 0.25 mm.

Alternation of Generations.—Specimens occur with proloculi of a diameter of less than 0.02 mm., possibly representatives of the microspheric generation, and at least one other group occurs with proloculus diameters varying between 0.05 mm. and 0.08 mm.

Remarks.—This variety occurs as an extreme form of the more robust type of *B. thanetensis* at the top of Bed F and Bed D. Both directions of coiling occur.

Genus **Praeglobobulimina** Hofker, 1951

emend. Haynes, 1954

Genotype: *Praeglobobulimina spinescens* Hofker

1951. *Praeglobobulimina.* HOFKER, Foram. Siboga Exp. pt. III, p. 248.

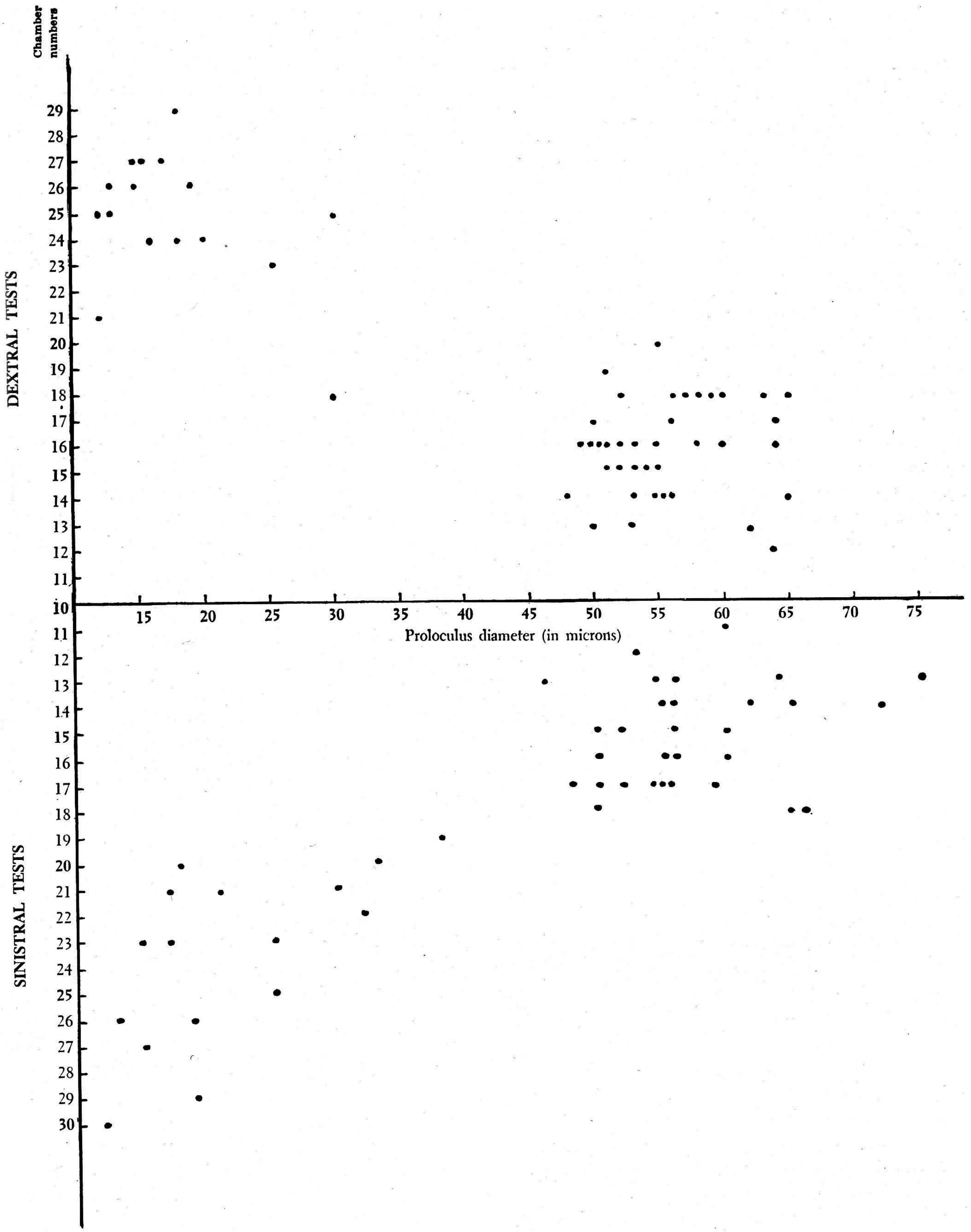
Generic description.—The test is elongate and triserial with chambers that tend to become involute and with the aperture in contact with the basal suture of the terminal chamber. The tongue between the foramina is a simple fold with a fixed shank, joined to the anterior wall below the aperture, and a wide free shank joined to the chamber wall only at the anterior end of the aperture. The free shank may be dentate and the basal part may be reduced. The free tip which protrudes through the aperture is small.

Discussion.—The generic description given above differs in detail from that originally given by Hofker which, being based upon one species, included characters considered here to be of specific rather than generic value.

As the Thanetian *P. ovata* (Orbigny) differs from *P. spinescens* Hofker in that the free shank is relatively much less reduced towards the base, the description has been widened to allow for this variation. In addition, ornament is disregarded and the character of the pores is not included. Hofker laid considerable stress on this last feature, postulating elongate pores in *Praeglobobulimina;* elongate pores among small ones in *Protoglobobulimina;* elongate pores or elongate pores among small pores in *Globobulimina.* This led him to suggest that *Globobulimina* may be polyphyletic, deriving from both the other genera. In *Praeglobobulimina ovata,* however, both Thanetian and Miocene specimens have round to oval pores in all parts of the test and, as the accompanying photograph shows, it is possible that very small pores occur between them. Unless still another genus is to be set up it would seem reasonable to suppose that pore size and shape is not of generic significance in *Praeglobobulimina.* Further evidence, resulting from the examination of fragments of *P. ovata* as transparent objects under the microscope, suggests also that the attempt to separate the other globobulimine genera on these grounds is equally unsound.

End sections of the test wall show that the length of the pores is much greater than their diameter. This has a not unimportant effect when the interior or exterior of the test is examined. Then, owing to the curvature of the walls most of the pores are observed in side view. In those rare instances where the pores are observed in vertical view they appear round to oval and shadow filled when the microscope is focused on the exterior and do not change shape when the focus is changed slightly. If the microscope is racked down a round white spot of light, possibly reflected from the pore sides, appears. When, as is more usually the case, the pores are seen running obliquely to the barrel of the microscope, the shape of the exterior orifice is distorted by the shadow of the pore walls. The pores then look elongate and appear to run with their long axes parallel to each other over the curve of the chamber wall. The shape is further distorted when the microscope is racked up and down. When the microscope is focused down into the test wall, what may be light reflected from the pore walls is now seen as a streak often defined by thin, parallel lines of shadow (as drawn by Höglund: *Globobulimina* species "C." 1947, pl. 22, fig. 4).

Specimens of *Globobulimina pacifica,* in Thalmann's sense the genotype, from the Challenger material show small, sparse, round pores, possibly among finer ones, which appear elongate in the same way when examined in the slightly oblique position.



TEXT FIGURE 20

Graph showing relation of proloculus size to chamber number in dextral and sinistral forms of *Bulimina thanetensis* Cushman and Parker

In the light of the foregoing the size and density of distribution of pores is considered here to be of specific distinction only.

The affinities of Praeglobobulimina.—Hofker's (1951), account of the affinities and origin of *Praeglobobulimina* and its allies is rather confused. On p. 140 they are included in the Buliminidae and on p. 142 he suggests that the group may have arisen through the group of coarsely perforate Buliminas. Then he goes on to state that *Globobulimina* is "nothing but a *Virgulina* which became pelagic." A pelagic habit being indicated by the development of the ventral end of the tongue into a flaring fan, supposedly as a spreading net of protoplasm was formed for floating. The genus is in fact described under the Virgulinidae and on p. 248 a phylogenetic scheme shows that the derivation of *Praeglobobulimina* and its allies is considered to be through *Virgulina schreibersiana* Czjzek. A. Wood, (1949, p. 243) has shown that *Virgulina* is a granular genus distinct from the radial *Bulimina* and *Globobulimina*. *Praeglobobulimina* is also radial. In this connection it is interesting to note that *V. schreibersiana* in Brady's sense, was found by Wood to be radial and was considered by Ovey to be quite possibly a species of *Bolivina*.

The Globobuliminids may have arisen from a granular group, for Wood considers it possible, though not proven, that radial genera have arisen many times from granular ancestors but there is a further argument against the view that these genera arose from *Virgulina* or its allies. It is, that if this were the case, the Globobuliminids would be expected to show advanced biseriality. Hofker, (1951, p. 236), states, "As in *Virgulina,* the beginning of the test of *Globobulimina* is triserial, ending, however, biserially throughout." This is not true for *Praeglobobulimina* and *Protoglobobulimina*. In *Globobulimina* convincing biserial arrangement is only found in the adult part of such advanced species as *G. auriculata* (Bailey) and *G. quadrata* (Plummer).

The species in Hofker's phylogenetic scheme are all from recent seas. It is, therefore, interesting that Cushman, (1937, p. 13), states that *V. schreibersiana* "apparently ranges from the Upper Oligocene to the present." This species is thus very possibly preceeded in the stratigraphical column by *Praeglobobulimina ovata* (Orbigny) and *Globobulimina quadrata* (Plummer) from the Paleocene Midway formation. Such a scheme, which ignores early Tertiary species, is of dubious value.

A simpler hypothesis on present knowledge is that *Praeglobobulimina* arose from a *Bulimina,* or *Praebulimina,* in which the free shank was produced to join the anterior end of the aperture.

In this work then *Praeglobobulimina* is placed in the Buliminidae.

Differences from related genera.—The species grouped by Hofker under *Protoglobobulimina* and *Globobulimina,* s.s. differ from *Praeglobobulimina* in the complication of the apertural parts, the tongue becoming a pillar-like trough with a straight collar-like free tip in *Protoglobobulimina* and a trough closed at the base in *Globobulimina,* with a tendency for the free tip to become fan-shaped. In these two groups the aperture tends to become terminal, with a closing suture as in *Protoglobobulimina turgida* (Bailey) or without as in *Globobulimina auriculata* (Bailey). In *Globobulimina pacifica* Cushman, the genotype, the aperture is open to the basal suture so the tendency for the aperture to become terminal and for the test to become involute, is to some extent independent of tooth structure.

Praeglobobulimina ovata (Orbigny)

Text figures 9-12, 17-19; plate 35, figures 2, 3

1846. *Bulimina ovata* ORBIGNY. Foram. Foss. Bass. Tert. Vienne, p. 185, pl. 11, figs. 13, 14.

1897. *Bulimina ovata* BURROWS and HOLLAND. Proc. Geol. Assoc. p. 32, pl. 11, fig. 11.

1937. *Bulimina ovata* CUSHMAN and PARKER, Contr. Cushman Lab. Foram. Res., vol. 13, p. 47, pl. 6, figs. 4, 5.

1947. *Bulimina ovata* CUSHMAN and PARKER, U. S. Geol. Surv. Prof. Paper, 210D, p. 106, pl. 25, figs. 8, 9.

Cushman and Parker 1947, give a large synonymy which will remain problematical until the internal characters in the particular populations referred to are known. Specimens referred to *Bulimina ovata* in the Dutch and Swedish Palaeocene may belong to this species.

Distinguishing features (based on topotypes and Thanetian forms).—An elongate, ovate to fusiform *Praeglobobulimina* with smooth surface and up to four whorls of chambers in megalospheric forms. The chambers are separated by oblique, impressed sutures and show variable involution but generally embrace about half the length of previous chambers. The tongue is simple with a plate like free shank that narrows gradually to the base. The free shank is smooth while the free tip which projects through the aperture is dentate though rounded in shape. The test is radiate hyaline with round to ovate pores.

Description of a megalospheric specimen from the Thanet sands.—(Text fig. 9). The test which is elongate ovate and circular in transverse section is broadest about the middle, its width being approximately half its length. There are ten chambers arranged in three and a third dextral whorls, each of which overlaps about half the previous one. All the chambers are thus visible. The sutures are distinct and slightly depressed while the radiate hyaline wall is thin, semi-transparent and densely perforated, with small, round to oval pores, about 0.005 mm. in diameter, possibly with very minute ones between. The large pores maintain a constant diameter through the test but widen slightly at the interior surface.

The aperture is open with a low, denticulate neck on its free border, underlain internally by a ridge of shell material. The tongue joins the fixed border and rises from within the trough formed by the tongue of the previous chamber. The free shank of the tongue is curved back on the fixed shank to form a trough and is produced to join the anterior end of the aperture. The tip of the free shank protrudes through the aperture and is denticulate and rounded in shape. The free shank narrows gradually to the base of the tongue.

Dimensions.—Length 0.58 mm.; greatest width 0.28 mm.; Proloculus, approx. 0.08 mm. at greatest diameter.

Alternation of Generations.—At least two groups of proloculus sizes were found to occur. At one horizon in the "D" marls, from which the specimens illustrated were taken, three specimens, presumably microspheric, showed proloculus diameters below 20 microns while the rest, approximately fifty specimens, varied between about 60 to 80 microns. Not enough microspheric forms occurred at any one horizon in order to relate proloculus size to chamber number.

Variation.—There is variation from subglobular forms with considerable overlap of chambers to more elongate forms. Sutures are considerably oblique to the vertical axis or relatively rather more at right angles to it, towards the type of *B. pupoides* Orbigny. Both directions of coiling were found. Some specimens showed slightly less dense perforation on the later chambers.

Affinities.—Comparison with topotypes of Orbigny's Vienna Basin species shows that the Thanetian population cannot be separated from it. Two of the topotypes examined are very close to the Thanet specimens figured in Text figs. 11 and 12. *Bulimina pupoides* Orbigny described by Hofker (1951, p. 252) as *Protoglobobulimina* on the evidence of the tongue is further distinguished by its greater size and number of whorls and its more inflated chambers.

Discussion.—It is important to point out here that the figures of topotypes of *B. ovata* given by Cushman, 1937 and 1946 are less like Orbigny's type figure than the Thanetian specimens and the topotype sent from the U. S. National Museum (from the Cushman collection). Cushman's figures show less embracing chambers than Orbigny's type figure, are rather less ovate, and the sutures are less oblique.

Acknowledgments.—Special thanks are due to A. Wood who has supervised the work in all its stages, to C. D. Ovey who gave the author access to British Museum collections and to A. Loeblich for topotype specimens of *Bulimina ovata.*

REFERENCES

Burrows, H. and Holland, R., 1897. The Foraminifera of the Thanet beds of Pegwell Bay: Proc. Geol. Assoc. Vol. XV, parts 1 and 2.

Bolli, H., 1950. The direction of coiling in the evolution of some Globorotalidae: Contr. Cush. Found. Foram. Research, Vol. I, p. 82.

———, 1951. Notes on the direction of coiling of rotalid forms. Ibid., vol. 2, part 4, p. 139.

Cushman, J. A., 1937. A Monograph of the Subfamily Virgulininae: Cushman Lab. Foram. Research, Spec. Publ. No. 9.

——— and Parker, F. L., 1947. *Bulimina* and related Foraminifera genera: U. S. Geol. Survey, Prof. Paper. 210-D.

———, 1948. Foraminifera: Fourth Edit., Harvard Press.

Glaessner, F. M., 1945. Principles of Micropalaeontology. Melbourne, p. 142.

Höglund, H., 1947. "Foraminifera in the Gullmar Fjord...:" Zool. Bidrag. fran Uppsala, Vol. 26. p. 227.

Hofker, J., 1951. The Foraminifera of the Siboga Expedition. Part III. Brill, Leiden.

Wood, A, 1949. The structure of the wall of the test in the Foraminifera...: Quart. Journ. Geol. Soc., vol. 104, pp. 229.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 4, OCTOBER, 1954

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the Foraminifera that have come to hand.

ABRARD, RENÉ. Les formes de passage dans le rameau phylétique **Nummulites atacicus** Leymerie—**N. aturicus** Joly et Leymerie.—C. R. S. Soc. Géol. France, No. 7, April 5, 1954, pp. 145-147.

ALLIATA, ENRICO DI NAPOLI. Stratigrafia di un sondaggio eseguito in corrispondenza alla "Pietra di Salomone" presso Palazzo Adriano (Palermo).—Contr. Sci. Geol., vol. 3, 1953, pp. 99-110, text figs. A-C, table.—The occurrence of a rich Tortonian-Helvetian planktonic fauna beneath Permian and upper Triassic leads to the dating of the tectonic movements.

ATHEARN, W. D. Bottom sediments and Foraminifera from Labrador, **Blue Dolphin**-1951 and 1952.—Woods Hole Oceanographic Instit., Ref. No. 54-42, unpublished manuscript, June 1954, pp. 1-17, text fig. 1.—Quantitative distribution of 66 species is recorded from 51 samples.

AUROUZE, GERMAINE, and BOULANGER, DOMINIQUE. **Ganella** n. gen., nouveau genre de Foraminifères de l'Yprésien de Gan (Basses-Pyrénées).—C. R. S. Soc. Géol. France, No. 10, May 17, 1954, pp. 186-188, text figs. 1-3.—**Ganella** n. gen. (genotype **G. neumannae** n. sp.) in the Anomalinidae.

BANDY, ORVILLE L. Distribution of some shallow-water Foraminifera in the Gulf of Mexico.—U. S. Geol. Survey Prof. Paper 254-F, June 10, 1954, pp. 123-141, pls. 27-31, text figs. 5-13.—The population is quantitatively studied and three gradational zones recognized between depths of 27 and 130 feet. Frequency distribution of species appears to be affected by depth and bottom prominences and, near shore, by chlorinity, but to be unaffected by bottom temperature and median grain size. Thirty-nine species are included, all illustrated, none new.

BECKMANN, JEAN PIERRE. Die Foraminiferen der Oceanic Formation (Eocaen-Oligocaen) von Barbados, Kl. Antillen.—Eclogae Geol. Helvetiae, vol. 46, No. 2, 1953 (May 1954), pp. 301-412, pls. 16-30, text figs. 1-29, table 1.—Age interpreted as uppermost middle Eocene to lower Oligocene and depth of deposition as 1000-1500 meters. Includes systematic description of 236 species and varieties (3 new).

BIELECKA, WANDA. Researches on the microfauna of the Upper Malm in central Poland.—Poland Instytut Geol., Biul. 87, 1953, pp. 21-36, pl. 1 (range chart).—The Upper Malm is divided into 13 zones on the basis of Foraminifera.

BOLTOVSKOY, ESTEBAN. The species and subspecies concepts in the classification of the Foraminifera. The Micropaleontologist, vol. 8, No. 3, July 1954, pp. 52-56.

CITA, M. B. Foraminiferi di un campione di fondo marino dei dintorni di Capri.—Riv. Ital. Pal. Stratig., vol. 60, No. 1, 1954, pp. 3-12, pls. 1, 2.—Quantitative analysis of the ooze obtained by Prof. Piccard in his bathyscaphe from 1100 meters in the Tyrrhenian Sea.

de CIZANCOURT, MARIE. Quelques commentaires sur **Miscellanea antillea** (Hanzawa) M. de Cizancourt et **Operculinoides georgianus** Cole et Herrick.—C. R. S. Soc. Géol. France, No. 9, May 3, 1954, pp. 178, 179.

de CIZANCOURT, MARIE, and CUVILLIER, JEAN. Les Nummulites cordelées du Sénégal occidental.—C. R. S. Soc. Géol. France, No. 7, April 5, 1954, pp. 130-133, text figs. 1-9.—A Paleocene fauna having Caribbean affinities.

COLOM, GUILLERMO. Distribution of **Globigerina inflata** d'Orbigny.—The Micropaleontologist, vol. 8, No. 3, July 1954, pp. 48, 49, 1 text fig.—**G. inflata,** a cold-water species, seems to be a post-Pliocene newcomer to western European seas.

CONATO, V. Sulla presenza dei genere **Globigerinita** Bronnimann nel Neogene Italiano.—Riv. Ital. Pal. Stratig., vol. 60, No. 1, 1954, pp. 29-31, pl. 3.—Occurrence of **Globigerinita naparimaensis** from lower to upper Pliocene.

Retifica de nomenclatura di Foraminiferi per omonimia.—Riv.. Ital. Pal. Stratig., vol. 60, No. 1, 1954, p. 38.—**Bolivina usensis** for **B. ornata** Conato 1952 (not Cushman 1925).

DROOGER, C. W. **Miogypsina** in northern Italy. I and II.—Proc. Kon. Nederl. Akad. Wetenschappen, ser. B, vol. 57, No. 2, March-April 1954, pp. 227-249, pls. 1, 2, text figs. 1-5, table 1.—Six species, one new. Discussion of correlation with Aquitanian to Helvetian of Bordeaux region.

EMILIANI, CESARE. Temperatures of Pacific bottom waters and Polar superficial waters during the Tertiary.—Science, vol. 119, No. 3103, June 18, 1954, pp. 853-855, text fig. 1.—Determination of temperatures, based on oxygen isotope analysis of benthonic Foraminifera from 3 samples, indicates a decrease of some 8°C from middle Oligocene to the end of the Pliocene in the deep waters of the equatorial Pacific.

Depth habitats of some species of pelagic Foraminifera as indicated by oxygen isotope ratios.—Amer. Journ. Sci., vol. 252, March 1954, pp. 149-158, text figs. 1-4, tables 1-6.—Certain species float at certain levels dependent upon temperature and water density, thus resulting in stratification of planktonic populations.

FOX, STEVEN K. JR. Cretaceous Foraminifera from the Greenhorn, Carlile and Cody formations, South Dakota, Wyoming.—U. S. Geol. Survey Prof. Paper 254-H, July 27, 1954, pp. 97-124, pls. 24-26, tables 1-4.—Ten new species are erected. Twenty-one other species, all but three indeterminate, are described and illustrated, and numerous other previously known species are listed.

FRIZZELL, DON L. Handbook of Cretaceous Foraminifera of Texas.—Bureau Econ. Geol., Rept. Invest. No. 22, June 1954, 232 pp., 21 pls., text figs. 1, 2 (correlation charts), tables 1-4.—An invaluable illustrated compilation. Three new species are erected, based on already known forms.

GIUNTA, M. **Quinqueloculina pentagona** n. sp.—Riv. Ital. Pal. Stratig., vol. 60, No. 1, 1954, p. 33, text fig. 2.—From 75 and 125 meters off Genoa.

HAYNES, JOHN. Note on **Bulimina elongata** d'Orbigny.

—The Micropaleontologist, vol. 8, No. 3, July 1954, p. 57.

HOFKER, JAN. The family Marginolamellidae Hofker, 1951.—The Micropaleontologist, vol. 8, No. 3, July 1954, pp. 50, 51.—Includes genera with poreless area around the aperture and poreless periphery, such as **Globorotalia, Cancris,** and others.

JABOLI, DANTE. Organizzazione e metodi di lavoro del laboratorio di micropaleontologia applicata dell' A. G. I. P.—Atti VII Conv. Naz. Met. e Petr., vol. 1, April 1952, pp. 207-220, pls. 1-4, text figs. 1-10.—Some Pliocene to Recent Foraminifera are illustrated by excellent photographs.

de KLASZ, I. **Quadratobuliminella** n. gen., eine neue Foraminiferen-gattung von der Wende Kreide-Tertiär. —Neues Jb. Geol. Pal., Mh., vol. 10, Oct. 1953, pp. 434-436, text figs. 1, 2.—**Quadratobuliminella** (genotype **Q. pyramidalis** n. sp.), from Danian (perhaps lower Paleocene) of Upper Bavaria.

KLEINPELL, ROBERT M. Neogene smaller Foraminifera from Lau, Fiji.—Bernice P. Bishop Museum Bull. 211, Jan. 25, 1954, 96 pp., 10 pls., text figs. 1-3 (maps, correlation chart), table 1 (checklist).—About 100 species and varieties, 5 species and 5 varieties new, from 25 samples. Most of the fauna is illustrated.

MAYNC, WOLF. The type species of **Bulbophragmium** Maync, 1952.—The Micropaleontologist, vol. 8, No. 3, July 1954, pp. 51, 52.—Suggests that planispiral vs. streptospiral coiling is not a generic criterion.

MURATA, SHIGEO. Miocene Foraminifera in Chugoku, Japan.—Bull. Fukuoka Kyushu Instit. Tech., No. 4, March 1954, pp. 63-75, table 1, pl. 1, 4 paleogeographic maps.—Foraminiferal assemblages are listed from Tortonian, Helvetian, and Burdigalian, and divided into warmer and colder types. One new species is described.

PERCONIG, ENRICO. Alcune osservazioni stratigrafiche e micropaleontologiche sulla zona di Ramacca (Estremità occidentale della piana di Catania).—Contrib. Sci. Geol., vol. 3, 1953, pp. 79-89, text figs. 1-20.—Re-determination of age of Ramacca zone as lower middle Miocene instead of Eocene is based on planktonic Foraminifera (16 of which are illustrated).

Note paleontologiche sulla zona costiera di Agrigento (Sicilia).—Contrib. Sci. Geol., vol. 3, 1953, pp. 91-98, text figs. 1-4.—Lists of Foraminifera and description of a new species, **Quinqueloculina padana,** from the upper Pliocene.

PETRI, SETEMBRINO. Foraminíferos Fósseis da Bacia do Marajó.—Bol. Fac. Filos., Ciencias e Letr., No. 176, Bol. Geol. No. 11, 1954, pp. 1-173, pls. 1-14, text figs. 1-10, tables 1-3.—One hundred and two species and varieties, of which 19 are new and 24 indeterminate, are described and illustrated from well samples of Cretaceous? to Pleistocene age in Marajó Island, Brazil. Four foraminiferal zones are recognized in the Miocene sequence.

POKORNY, VLADIMIR. The Microstratigraphical Position of the Herspice Gravels in the Eocene of the Zdanice Series (with a description of the Foraminifera of the neighbouring clays).—Bull. internat. Acad. tchèque Sci., Ann. 52, 1951, No. 28, (April 17, 1953), pp. 1-35, pl. 1, text figs. 1-18.—About 33 species are recorded and some of them illustrated. The author interprets the fauna as a warm-water one.

POZARYSKI, WLADYSLAW. Marine sediments of the younger Oligocene in Kujawy (Middle Poland).—Poland Instytut Geol., Biul. 87, 1953, pp. 9-20, text fig. 1 (map), tables.—Some 75 species of small Foraminifera are listed.

REICHEL, MANFRED. Les caractères embryonnaires de **Subalveolina.**—Eclogae Geol. Helvetiae, vol. 46, No. 2, 1953 (May 1954), pp. 256-262, pls. 13, 14, text figs. 1-4.—A new species, **S. pérébaskini,** from the Santonian of France.

ROCHA, A. TAVARES, and FERREIRA, J. MARTINS. Estudo dos Foraminíferos Fósseis do Pliocénico da Região de Pombal.—Rev. Fac. Ciências Lisboa, ser. 2C, vol. 3, fasc. 1, 1953, pp. 129-156, pls. 1-3, 1 text fig., 2 tables.—Twenty-two species, none new.

SCHMIDT, HERMANN. Okologische Beobachtungen an den Foraminiferen des Golfes von Neapel.—Paläont. Zeitschrift, vol. 27, No. 3/4, August 1953, pp. 123-128, text fig. 1.—Characteristic genera of three biotopes: seaweed, sand, and mud.

SZTEJN, JANINA. Researches on the foraminifers of the Lower Cretaceous of Poland.—Poland Instytut Geol., Biul. 87, 1953, pp. 37-45, text fig. 2.—Distinguishing features of Hauterivian and Valanginian. Smaller Foraminifera are listed.

THOMPSON, M. L. American Wolfcampian fusulinids.—Univ. Kansas Pal. Contr., Protozoa, Art. 5, May 5, 1954, pp. 1-225, pls. 1-52, text figs. 1-14, tables 1-10. —Includes 12 genera and 56 species, of which 41 are new. Notes on classification of Fusulinidae.

WEISS, LAWRENCE. Foraminifera and origin of the Gardiners clay (Pleistocene), eastern Long Island, New York.—U. S. Geol. Survey Prof. Paper 254-G, June 10, 1954, pp. 143-163, pls. 32, 33, text figs. 14-17 (map, sections, chart).—Twenty species and subspecies, 2 new, are recorded and illustrated.

WEYNSCHENK, R. A note on the Jurassic markers **Pseudocyclammina lituus** Yabe and Hanzawa and **Labyrinthina mirabilis** Weynschenk.—The Micropaleontologist, vol. 8, No. 3, July 1954, p. 47.

WICHER, C. A. Beobachtungen im borealen Maastricht. —Paläont. Zeitschrift, vol. 27, No. 3/4, August 1953, pp. 233-234, text figs. 1, 2 (range charts).

RUTH TODD

CUSHMAN FOUNDATION FOR FORAMINIFERAL RESEARCH, INC.

PATRONS

Mrs. Joseph A. Cushman, Sharon, Massachusetts
Waldo L. Schmitt, U. S. National Museum, Washington, D. C.
Sun Oil Company, Dallas, Texas

FELLOWS

Enrico di Napoli Alliata, c/o American Internat. Fuel & Petroleum Co., Rome Italy
Harold V. Andersen, Louisiana State University, Baton Rouge, Louisiana
Harry W. Anisgard, c/o Creole Petroleum Corp., Maracaibo, Venezuela
Orville L. Bandy, University of Southern California, Los Angeles
C. Lothrop Bartlett, c/o Sun Oil Company, Beaumont, Texas
R. Stanley Beck, 621 Truxtun, Bakersfield, California
Leroy E. Becker, c/o Creole Petroleum Corp., Quiriquire, Venezuela
Pedro J. Bermudez, c/o Creole Petroleum Corp., Jusepin, Venezuela
Paul Bronnimann, c/o Cuban Gulf Oil Company, Havana
James Bush, 1123 Bartlett, Houston 6, Texas
Kenneth E. Caster, University of Cincinnati, Ohio
W. Storrs Cole, Cornell University, Ithaca, New York
G. Arthur Cooper, U. S. National Museum, Washington, D. C.
Alice E. Cushman, Sharon, Massachusetts
Carl O. Dunbar, Yale University, New Haven, Connecticut
Arthur N. Dusenbury, Jr., c/o Creole Petroleum Corp., Caracas, Venezuela
R. F. Faull, California Research Corp., La Habra, California
Joseph J. Graham, Stanford University, California
Herbert Hagn, Mettinghstr. 4/1m, München 19, Germany
George L. Harrington, Stanford University, California
Hollis D. Hedberg, Gulf Oil Corp., Pittsburgh, Pennsylvania
Lloyd G. Henbest, U. S. Geological Survey, Washington, D. C.
Humble Oil and Refining Co., Houston, Texas
Louise Jordan, 1813 So. Magnolia Dr., Tallahassee, Florida
G. F. Kaufmann, Standard Vacuum Oil Co., New York
Robert M. Kleinpell, University of California, Berkeley
H. G. Kugler, c/o Trinidad Leaseholds, Ltd., Pointe-a-Pierre, Trinidad, B.W.I.
Doris L. Low, U. S. Geological Survey, Washington, D. C.
William K. MacFarquhar, c/o Mene Grande Oil Co., Caracas, Venezuela
Donald A. Myers, Route 4, Box 189, Austin, Texas
Frances L. Parker, Scripps Institution of Oceanography, La Jolla, California
Max B. Payne, 1600 Crestmont Drive, Bakersfield, California
Victor Petters, Myrthengasse 2, Vienna VII, Austria
Fred B Phleger, Jr., Scripps Institution of Oceanography, La Jolla, Californi
C. M. Quigley, Jr., c/o Standard Oil Company of Texas, Houston
J. B. Reeside, Jr., U. S. Geological Survey, Washington, D. C.
H. H. Renz, c/o Mene Grande Oil Company, Caracas, Venezuela
Hans E. Thalmann, Stanford University, California
M. Ruth Todd, U. S. Geological Survey, Washington, D. C.
James A. Waters, Sun Oil Company, Dallas, Texas
R. T. D. Wickenden, Geological Survey of Canada, Calgary, Alberta
Virgil Winkler, c/o Creole Petroleum Corp., Caracas, Venezuela
Gordon A. Young, c/o Mene Grande Oil Co., Caracas, Venezuela