

CONTRIBUTIONS
FROM THE
CUSHMAN FOUNDATION
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FOR FORAMINIFERAL RESEARCH
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306. A NEW MORPHOLOGIC VARIATION
OF THE FORAMINIFER *CIBICIDES LOBATULUS*

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University of Washington, Department of Oceanography, Contribution No. 301

ABSTRACT

Samples taken in the northeast Pacific contained a new form which is a variation of the foraminifer *Cibicides lobatulus* (Walker and Jacob). A diagram of the life cycle of *Cibicides lobatulus* after Nyholm is given and the probable development of the new form is described and illustrated.

INTRODUCTION

In an examination of samples from the Washington, Oregon, British Columbia, and Alaska coasts, an attached foraminifer was noted which appeared to be a new species. Enbysk (1960) figured portions of this form in her unpublished thesis and suggested that it was an anomalinid. In later examination of samples the foraminifer was frequently found attached to pebbles and boulders. After examining several specimens, Miss Ruth Todd, U. S. National Museum, referred the author to an article by Nyholm (1961). This paper described several types of tests which Nyholm believes to be different phases of *Cibicides lobatulus*: a monothalamous test, a chambered test and a planorbulinoid test. All of these were found associated with the new form in the material from the Northeast Pacific, and it became apparent that this form was part of the complex life cycle of *Cibicides lobatulus*.

The illustrations were drawn by Janet Griffin. This study was supported by National Science Foundation Grant GP 337 and contract Nonr 477(10), Project NR 083 012 with the Office of Naval Research. Ten samples collected by the U. S. Bureau of Commercial Fisheries chartered vessel *Tordenskjold* in the Gulf of Alaska were examined in addition to selected samples from collections of the University of Washington's Department of Oceanography.

DESCRIPTION OF VARIANT

Test attached, first few chambers low and coiled. Later chambers uncoiled and expanded rapidly with development of heavy irregular ridges (Figures 1, 3, and 4, Plate 21). The change to the heavy chambers may be gradual or it may be abrupt. Early chambers are tectin and the next few have a thin calcareous layer over the dark reddish-brown tectin (Figure 2, Plate 21). Successive chambers have thicker calcareous walls and the final, heavily ridged chambers have an almost porcellaneous texture. The tectin layer is present under the calcareous layer in the final chambers. The aperture is round, with a

lip of the same texture as the ridges. Under certain bottom conditions—apparently rocks and pebbles subject to influxes of fine sediment—a flexible arenaceous tube protrudes from the aperture. The tube is often broken but when preserved it may be as long as the test (Figure 4, Plate 21). Small specimens with only a few calcareous chambers were 0.4 mm. long and 0.3 mm. wide. Heavily ridged forms which meander across the rock surface were 2.3 mm. long and 1.5 mm. wide.

NOMENCLATURE

The work of Nyholm has raised interesting questions concerning the taxonomy of the Cibicididae and Planorbulinidae. Until these families can be restudied, it is most reasonable to use the parataxonomic category of *forma* as a stop-gap measure, as suggested by Boltovskoy (1961). As he has pointed out, *forma* has no status and does not enlarge our systematic household but still retains all the differences which are important in ecology and life-cycle studies. This new form, with its unusual ridges and aperture, occurs with such frequency that it seemed necessary to utilize some name. The Latin word for "tripe" was used, as it was descriptive, short, and not incumbered by references to any previously named allied genera. The new form is thus named: *Cibicides lobatulus* (Walker and Jacob), *forma omasicus*. This form and rough specimens of *Cibicides lobatulus*, like Figure 1, Plate 21, were probably the forms which Saidova (1964) referred to as *Cibicides cicatricosus* (Schwager), *Cibicides tuberculata* Natland, *Dyocibicides biserialis* Cushman and Valentine, and perhaps even *Anomalina polymorpha* Costa from a station north of the Queen Charlotte Islands. This is quite near station BB110-38, which contained almost all the forms illustrated in this paper.

OCCURRENCE

This form was found along the Washington, Oregon, British Columbia and Alaska coasts at depths of 17 to 139 fathoms. It may occur shallower, but no samples were available. An attached form, it occurs on pebbles, rocks or hard bottom. All the available samples of this sediment type examined from the Washington, Oregon, and British Columbia coasts contained the above described variant. However, it was found in only five of the eleven

samples examined from the Alaskan coast, although the involute *Cibicides lobatulus* was present. No limiting factor could be detected, as the sediment type, depth, temperature and latitude were similar to other localities where the form did occur. Table 1 lists the locations and depths of the stations where *Cibicides lobatulus* forma *omasicus* was found. Samples from Cobb Seamount, which rises to 18.5 fathoms, contained many involute *Cibicides lobatulus* but none of the new form.

TABLE 1
LOCATION OF STATIONS CONTAINING
THE NEW FORM

Station No.	Latitude (north)	Longitude (west)	Depth (fathoms)
BB108-34	43°13.1'	124°36.0'	57
BB108-28	44°15.6'	124°35.8'	59
BB291-31	44°25.8'	124°39.4'	74
BB108-25	44°43.1'	124°23.6'	58
BB108-20	45°43.3'	124°19.3'	81
BB291-56	45°55.2'	124°33.0'	65
BB291-11	47°22.9'	124°25.7'	17
BB312-12	48°06.3'	125°13.5'	90
BB322-4	48°26.9'	124°36.0'	130
BB322-2	48°17.6'	123°58.8'	102
BB322-1	48°14.5'	123°39.1'	95
BB110-43	54°30.0'	133°25.0'	139
BB110-38	54°33.3'	133°17.0'	91
Tord 2-21	58°14.7'	137°10.5'	64
Tord 2-3	58°37.1'	137°56.5'	52
Tord 2-14	58°47.9'	139°02.7'	124
Tord 2-8	58°49.2'	138°31.2'	59
BB110-7	59°53.7'	147°56.8'	85

LIFE CYCLE

Text figure 1 diagrams the life cycle of *Cibicides lobatulus* as described by Nyholm (1961). The involute *Cibicides lobatulus* (Figure 1, Plate 22) is the microspheric form, or schizont. By asexual reproduction, four-chambered schizozoites with calcareous tests are produced, which, after adding chambers, become evolute megalospheric gamonts (Figure 2, Plate 22). However, some of the schizozoites do not develop into the gamont stage but act as schizonts and asexually produce more four-chambered schizozoites. These are identical with the other calcareous schizozoites and may develop into the thin-walled gamont stage. The gamont disintegrates to produce gametes. Two gametes pre-

sumably unite to form a zygote. This uninucleate mass apparently develops an agglutinated coniform test. Under the coniform test a four-chambered tectin test develops which adds calcareous chambers. As the calcareous test grows the agglutinated outer test breaks down, exposing the top of the involute calcareous test. In the mature involute *Cibicides lobatulus* schizont, only a fringe of the agglutinated material remains.

Nyholm found that the involute *Cibicides lobatulus* at certain times of the year decalcified its test walls and presumably transformed to a flat crust with irregular chambers (Figure 8, Plate 22). This form, previously considered to belong to the genus *Planorbulina*, is a resting schizont of *Cibicides lobatulus*. The cytoplasm is concentrated in the center, but when the resting schizont starts to emit schizozoites the protoplasm migrates, little by little, to the outer chambers, which become quite porous (Figure 7, Plate 22). The schizozoites are flat, four-chambered, tectin forms which later develop calcareous chambers. Some of the schizozoites develop into forms like the planorbulinoidal resting stage but are differentiated from the resting stages formed from the involute *Cibicides lobatulus* by their tectin centers. The same generation of schizozoites may, depending on the conditions of growth, develop into forms which have been called *Cyclocibicides*, *Annulocibicides* and *Rectocibicides*. The new form, with the early tectin coiled portion, is most likely also of this generation. All these *Cibicides*-related forms produce schizozoites which are identical with the schizozoites produced by the planorbulinoidal resting schizont. Another variation these schizozoites may take is to become an evolute form like a gamont. Nyholm did not observe laboratory specimens of these forms emitting gametes, but identical forms collected from the field did produce them.

ACCESSORY STRUCTURES

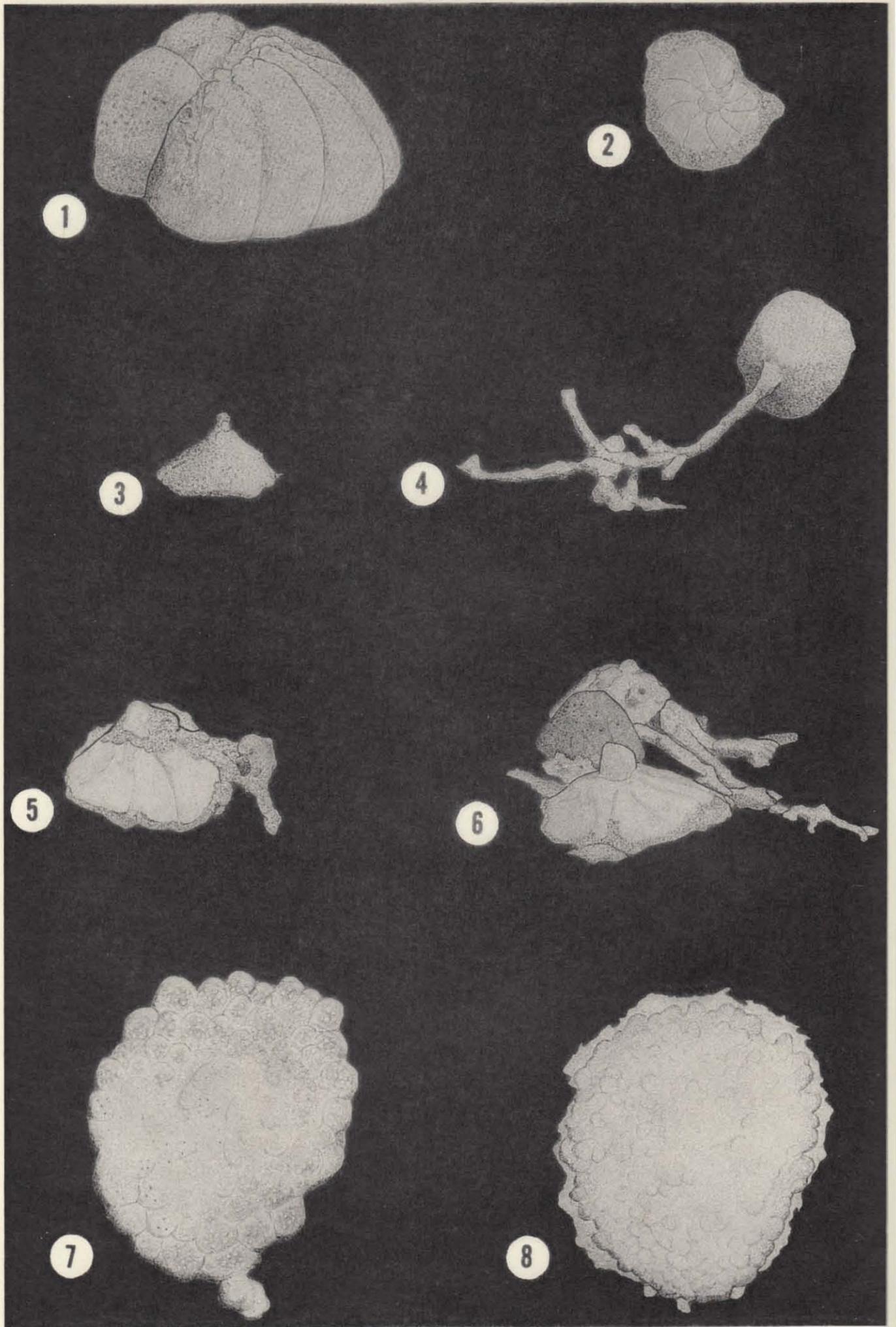
In well preserved specimens, flexible arenaceous tubes were found extending from the tests. The coniform stage often had a tube extending from the top (Figure 3, Plate 22), or, in later stages, from the apertural area. Usually one tube extended from the apertural area, but it was not uncommon to find it coming from another area, several tubes coming from one test, or branching tubes (Figure 4, Plate 22). The new ridged form also had an arenaceous tube coming from the aperture, but it was not ob-

EXPLANATION OF PLATE 21

FIGS.		PAGE
1.	<i>Cibicides lobatulus</i> forma <i>omasicus</i> . Typical specimen. Station BB 312-12	137
2.	Young <i>C. lobatulus</i> forma <i>omasicus</i> with arenaceous tube. Station BB 110-38	137
3.	<i>C. lobatulus</i> forma <i>omasicus</i> . Three specimens intergrown. Station BB 312-12	137
4.	<i>C. lobatulus</i> forma <i>omasicus</i> with long arenaceous tube. Station BB 322-1	137



Cooper: A Variant of *Cibicides lobatulus*



Cooper: A Variant of *Cibicides lobatulus*

served to branch. Some of the rocks that were examined had a layer of sediment adhering to the surface. Almost all the specimens on these rocks had arenaceous tubes and the surface was a mass of branching and intertwining tubes. Many planorbulooidal resting stages were found on this type of rock, but they had no tubes. This substantiates Nyholm's findings that they are resting schizonts and do not feed.

A variation of the involute *Cibicides lobatulus* was found which has a clear calcareous knob filling the umbilicus (Figure 5, Plate 22). A form with sinuous sutures, it is often covered with arenaceous material, as is the involute *Cibicides lobatulus*.

Foraminifera with tubes and calcareous knobs are illustrated in Figure 6, Plate 22. The three specimens were clustered in an area 1.5 mm. long and 1.2 mm. wide. The foremost has a knob and remnants of the arenaceous test, the middle is an involute *Cibicides lobatulus* with a circular test; the farthest form is completely covered with agglutinated material and has several tubes, some broken and others branching.

SUMMARY

In the complex life cycle of *Cibicides lobatulus*, Nyholm found that the different Cibicidinae genera, *Planorbulina*, and a form with an arenaceous coniform test are all related. The new form described in this paper apparently is a schizozoite of the planorbulooidal resting schizont. The early tectin cham-

bers, and the development of arenaceous tubes are indicative of this. The recurrent association of *Cibicides lobatulus*, the planorbulooidal stage, and the ridged form is also significant. To add another generic or specific name to this group would be adding more confusion to the existing taxonomic disorder made apparent by Nyholm's work.

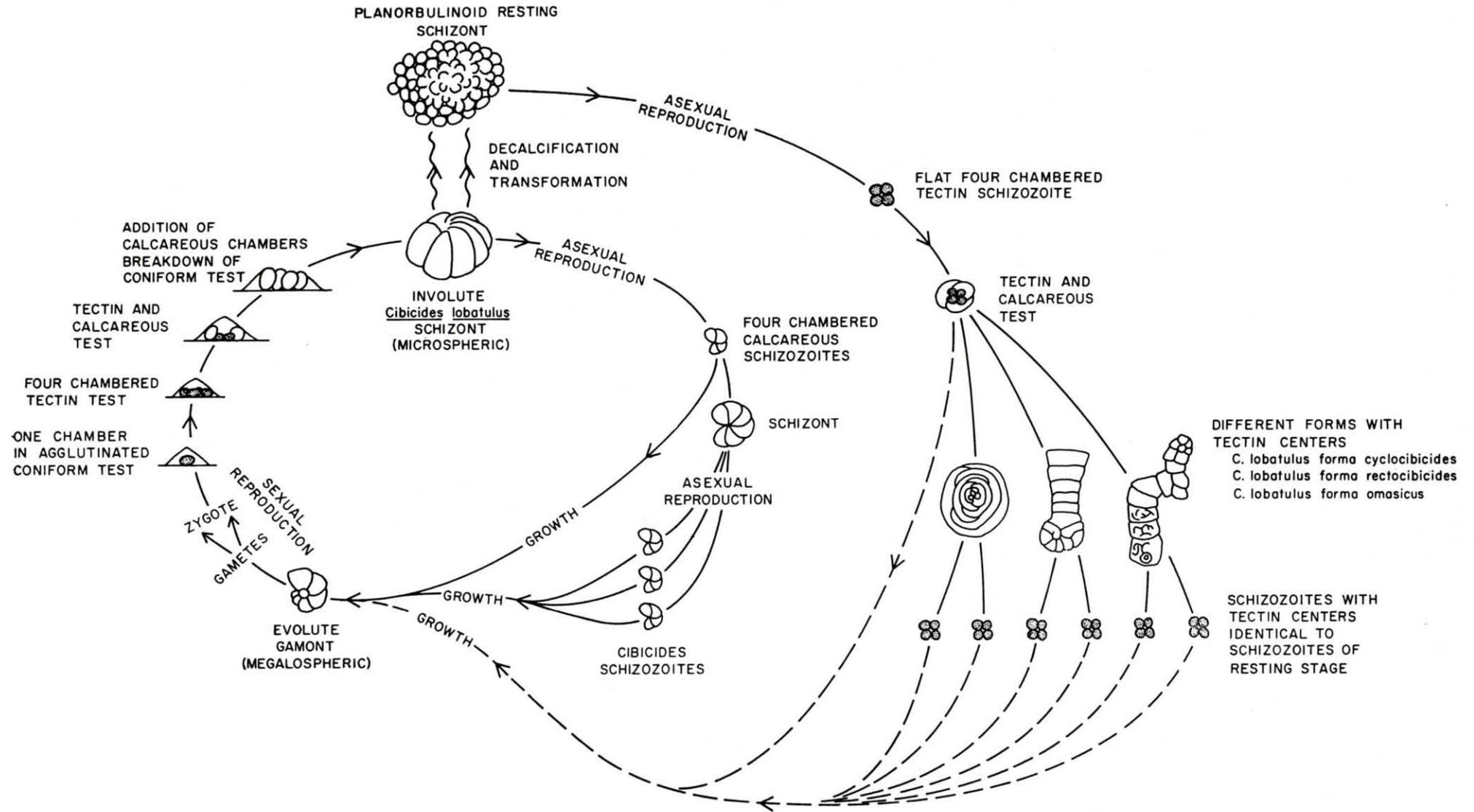
The use of *forma* is suggested as a stop-gap measure and the new form is called *Cibicides lobatulus* (Walker and Jacob), *forma omasicus*.

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EXPLANATION OF PLATE 22

FIGS.	PAGE
1. <i>Cibicides lobatulus</i> (Walker and Jacob). Typical microspheric form. Station T. 204	138
2. Gamont. Megalospheric form. Station BB 110-38	138
3. Coniform stage with short arenaceous tube. Station BB 110-38	138
4. Test covered with agglutinated material showing branching tubes. Station BB 110-38	138
5. <i>Cibicides lobatulus</i> with knob and remnants of agglutinated test and tube. Station BB 110-38	139
6. <i>Cibicides</i> group. Foremost: with knob and fringe of agglutinated material; middle: involute <i>Cibicides lobatulus</i> with a dark porous test; farthest: agglutinated test with branching tubes, some broken. Station BB 110-38	139
7. Planorbulooidal stage. Thick specimen showing dense center and porous outer chambers. Station BB 322-2	138
8. Planorbulooidal stage. Crust-like specimen showing some porous chambers. Station BB 322-2	138



TEXT FIGURE 1

Diagram of the life cycle of *Cibicides lobatulus* (Walker and Jacob) after Nyholm.

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307. THE GENUS *GLANDULINA* IN THE UPPER CRETACEOUS
OF VRIDHACHALAM AND PONDICHERRY, SOUTH INDIA

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ABSTRACT

Species of the genus *Glandulina* are described for the first time from the Upper Cretaceous Lower Ariyalur Stage of Vridhachalam and Pondicherry areas of South India. A new variety, *Glandulina marginuliniformis* (Frizzell) var. *elongata* Banerji, is noted. The systematic position of the genus *Glandulina* is also discussed.

INTRODUCTION

Little has been published on the Upper Cretaceous foraminifera of South India except for those from localities near Trichinopoly. The present paper deals only with the species of the genus *Glandulina* Cushman recorded for the first time from the various zones of Lower Ariyalur Stage of Vridhachalam and Pondicherry, South India. It is the writer's intention to describe the Cretaceous foraminiferal fauna from each of these zones and sub-zones in the near future.

Samples were collected during 1960-62 from almost all the complete and best exposed sections in an area of about 50 sq. miles just north of the town of Vridhachalam and from an area of about 40 sq. miles just northwest of the town of Pondicherry, in Madras State, where the Lower Ariyalur Stage is best developed. The biostratigraphic relationships described herein were established on the basis of foraminifera recovered from these samples.

ACKNOWLEDGEMENTS

The material in this paper represents a portion of a study in partial fulfilment of the requirements for the degree of Doctor of Philosophy at the Indian Institute of Technology, Kharagpur, India. The writer wishes to express his gratitude to Dr. T. C. Bagchi, professor of Geology, who suggested

the study as a long range program and supervised the thesis work. Sincere appreciation is due to Dr. Orville L. Bandy, Professor of Geology, University of Southern California, Los Angeles, for his critical comments on the systematic position of the genus *Glandulina*. For the illustrations, the writer is indebted to Dr. A. B. Mukherji. A research scholarship granted by the authorities of the Indian Institute of Technology, Kharagpur, is duly acknowledged.

BIOSTRATIGRAPHIC RELATIONSHIPS

Although the Upper Cretaceous strata exposed near Vridhachalam and Pondicherry, Madras State, South India, have been investigated for more than a century (Blanford, 1865), almost no work has been done on the smaller foraminifera from these localities. The present writer in 1960-62 undertook such a study to assist in interpreting the biostratigraphy of the area. About 30 genera and 90 species of foraminifera have been recorded from the Lower Ariyalur Stage (Upper Turonian to Lower Maestrichtian) of the Vridhachalam and Pondicherry areas of South India. On the basis of the foraminiferal assemblage the lithologically uniform Lower Ariyalur Stage, formerly considered to be paleontologically uniform as well, has been subdivided into five distinct biostratigraphic zones and sub-zones, as indicated in Table 1.

DISCUSSION

The systematic position of the genus *Glandulina* is somewhat interesting to note. Cushman (1950) placed this genus in the family Polymorphinidae and according to him the genus evolved from *Pyru-*

TABLE 1.—Biostratigraphy of the Vridhachalam Cretaceous

STAGE	ZONE	SUB-ZONE	AGE
LOWER ARIYALUR STAGE	E. <i>Globotruncana linneiana</i> <i>tricarinata</i> zone		Upper Campanian to Lower Maestrichtian
	D. <i>Globotruncana</i> <i>globigerinoides</i> zone	{ D ₂ D ₁	Upper Campanian Lower Campanian
	C. <i>Globotruncana</i> <i>concovata</i> zone		Santonian
	B. <i>Globotruncana linneiana</i> <i>coronata</i> zone		Coniacian
	A. Unfossiliferous		Upper Turonian (?)

lina in the Tertiary. He described it as biserial initially and uniserial subsequently. But the type figure of *Glandulina* d'Orbigny unquestionably shows a uniserial chamber arrangement in section; this is more similar to the genus *Pseudoglandulina* described by Cushman (1955, p. 216) as follows:

"Test similar to *Nodosaria* but the chambers embracing, the last formed one making up a large proportion of the test, chambers uniserial throughout, aperture radiate, terminal."

Based on the study of the type section of the genus *Glandulina* and the description of *Pseudoglandulina*, Bandy (personal communication, September 17, 1962) considers the genus *Pseudoglandulina* Cushman a junior synonym of *Glandulina* d'Orbigny. Cushman, on the basis of morphology and chronology, advocates that the genus *Pseudoglandulina* has evolved as follows: *Marginulina* gave rise to *Dentalina*, *Dentalina* to *Nodosaria*, and *Nodosaria* to *Pseudoglandulina*. The present study of the genus *Glandulina* from Upper Cretaceous strata reveals that the genus has more affinity with *Marginulina*, *Dentalina* and *Nodosaria* and thus is placed in the family Nodosariidae.

SYSTEMATIC DESCRIPTION

Family NODOSARIIDAE Schultze, 1854

Genus *Glandulina* d'Orbigny, 1926

Glandulina inflata Bornemann

Plate 23, figures 2 and 3

Glandulina inflata BORNEMANN, 1855, Deutsche geol. Gesell., Zeitschr., vol. 7, p. 320, pl. 12, figs. 6, 7.—FRIZZELL, p. 347, pl. 56, fig. 18.

Genotype: *Nodosaria* (*Glandulina*) *laevigata* D'ORBIGNY, 1826, p. 25

Test small, obovoid, consisting of linear series of strongly overlapping chambers; chambers 4 in number, initial chamber pointed, last chamber rounded and largest, about two-thirds the length of the test; sutures straight to slightly curved due to overlapping of chambers; wall smooth; aperture terminal, circular and radiate. Diameter 0.52 mm.; height 0.71 mm.

Occurrence.—Frizzell reported it from Upper Cretaceous of Peru. Studied specimens are from zone E of the Pondicherry area.

Glandulina marginuliniformis (Frizzell)

Plate 23, figure 7

Pseudoglandulina marginuliniformis FRIZZELL, pl. 56, figs. 20, 21a-b.

Test small, obovoid, consisting of a linear series of slightly overlapping chambers; chambers 4 to 5 in number, width of the chambers about two to three times the height, initial chamber pointed; sutures straight, little depressed; wall smooth, unornamented; aperture terminal, central, circular and

slightly produced. Diameter 0.52 mm.; height 1.01 mm.

Occurrence.—Recorded by Frizzell from Upper Cretaceous of Peru. Studied specimens are from sub-zone D₂ of Pondicherry.

Glandulina marginuliniformis (Frizzell) var. *elongata* n. var.

Plate 23, figures 8 and 9

This form differs slightly from *G. marginuliniformis* in having a more elongate test. The initial chamber is more pointed and the last chamber is more globular than in the above species. Diameter 0.45 mm.; height 1.20 mm.

Occurrence.—Holotype (F. 4/5/36) of this new variety is from the sub-zone D₂ of Vridhachalam.

Glandulina manifesta Reuss

Plate 23, figure 6

Glandulina manifesta REUSS, 1851, p. 6, pl. 1, fig. 4.

Test small, little enlarged and elongated, consisting of 5 chambers arranged in a linear fashion, initial chamber less pointed, last chamber largest, about one third of the total length of the test; sutures straight, visible and depressed; wall smooth, unornamented; aperture subcentral, circular to radiate and produced. Diameter 0.51 mm.; height 1.15 mm.

Occurrence.—In the Vridhachalam area this species is common in sub-zone D₁. Similar occurrences have been noted from both sub-zones D₁ and D₂.

Glandulina mutabilis Reuss

Plate 23, figures 4 and 5

Glandulina mutabilis REUSS, 1863, p. 58, pl. 5, fig. 7-11.—EGGER, 1900, K. Bayer Akad. Wiss. München, Math-Physik, Kl. Abh., Bd. 21, p. 83, pl. 5, figs. 21, 29.—BROTZEN, 1938, Sveriges Geol. Undersökning, ser. C., no. 396, p. 89, pl. 4, fig. 16.

Test small, elongate, more or less cylindrical in shape; chambers 5 in number, arranged in a linear fashion, initial chamber very bluntly rounded, last one globular and largest; sutures straight, transverse and depressed, wall smooth, unornamented; aperture terminal, radiate, subcentral, produced on a short pointed neck. Diameter 0.58 mm.; height 1.20 mm.

Occurrence.—Reuss reported it from the Upper Hils and Gault from Germany. It has also been reported from the Santonian of California. Studied specimens are from zone E of Pondicherry.

Glandulina pygmaea Reuss

Plate 23, figure 1

Glandulina pygmaea REUSS, 1851, Haidinger's naturwiss. Abh. vol. 4, p. 6, pl. 1, fig. 3.—BROT-

ZEN, 1936, no. 3P, p. 90, pl. 4, fig. 14.—TRUJILLO, 1960, p. 326, pl. 47, figs. 1a-b.

Test small, ovoidal, pointed at both ends; greatest diameter at the middle; chambers 4 in number, arranged in a linear fashion, strongly overlapping, initial chamber small and pointed, the last one two-thirds the total length of the test; sutures straight, slightly indistinct; wall smooth, unornamented; aperture terminal, central, radiate and produced. Diameter 0.34 mm.; height 0.88 mm.

Occurrence.—Recorded from the Upper Cretaceous of Lemberg, Ostgalizien, Poland, and also from Upper Cretaceous (Santonian) of Shasta County, California. In the Vridhachalam and Pondicherry areas it has been recorded from zone C only.

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308. A UNIQUE UPPER DEVONIAN *UMBELLINA*
FROM THE WILLISTON BASIN OF MONTANA

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ABSTRACT

Thin-sections prepared from two well cores penetrating the Upper Devonian (Frasnian) Duperow Formation of northeastern Montana, have yielded many specimens of a unique Devonian foraminifer that is probably conspecific with the Russian form *Umbellina bella* (Maslov). The Duperow specimens differ from previously described forms by the possession of well developed lateral nodose projections. This unique morphological characteristic has not been mentioned or illustrated in any of the earlier descriptions. It is suggested that these projections may possibly have aided in stabilizing the mature organism for an attached benthonic existence. The Duperow umbellinid microfauna is thought to be a "normal" intergrading population, since all growth stages are believed to be represented. Only specimens that appear to be mature forms show well developed nodose projections.

The Duperow umbellinids are found in rocks that are classified as intraclastic lime wackestones. The associated fauna consists of amphiporids, echinodermal debris, brachiopod fragments, and ostracodes. The lithology and fauna is thought to be indicative of shallow water marine conditions.

A brief résumé of reported occurrences of *Umbellina*, and a list of described species is also included.

INTRODUCTION

Early in 1958, Dr. James Lee Wilson, of Shell Development Company, asked the writer to examine a series of thin-sections prepared from two well cores which penetrated the Upper Devonian (Frasnian) Duperow Formation in the Williston Basin of Montana. These thin-sections, seven in all, contain

numerous remains of a distinctive microorganism with which both Dr. Wilson and I were totally unfamiliar. Fortunately, we were able to obtain a copy of a Soviet monograph by Bykova and Polenova (1955) which describes and illustrates similar forms from the Upper Devonian rocks of the Russian Platform. Study and comparison of the Duperow specimens with those described in the Russian paper demonstrated that both forms are identical. This microorganism is presently described under the foraminiferal genus *Umbellina*. However, some Duperow specimens differed from previously described Soviet forms in the possession of basal lateral nodose projections.

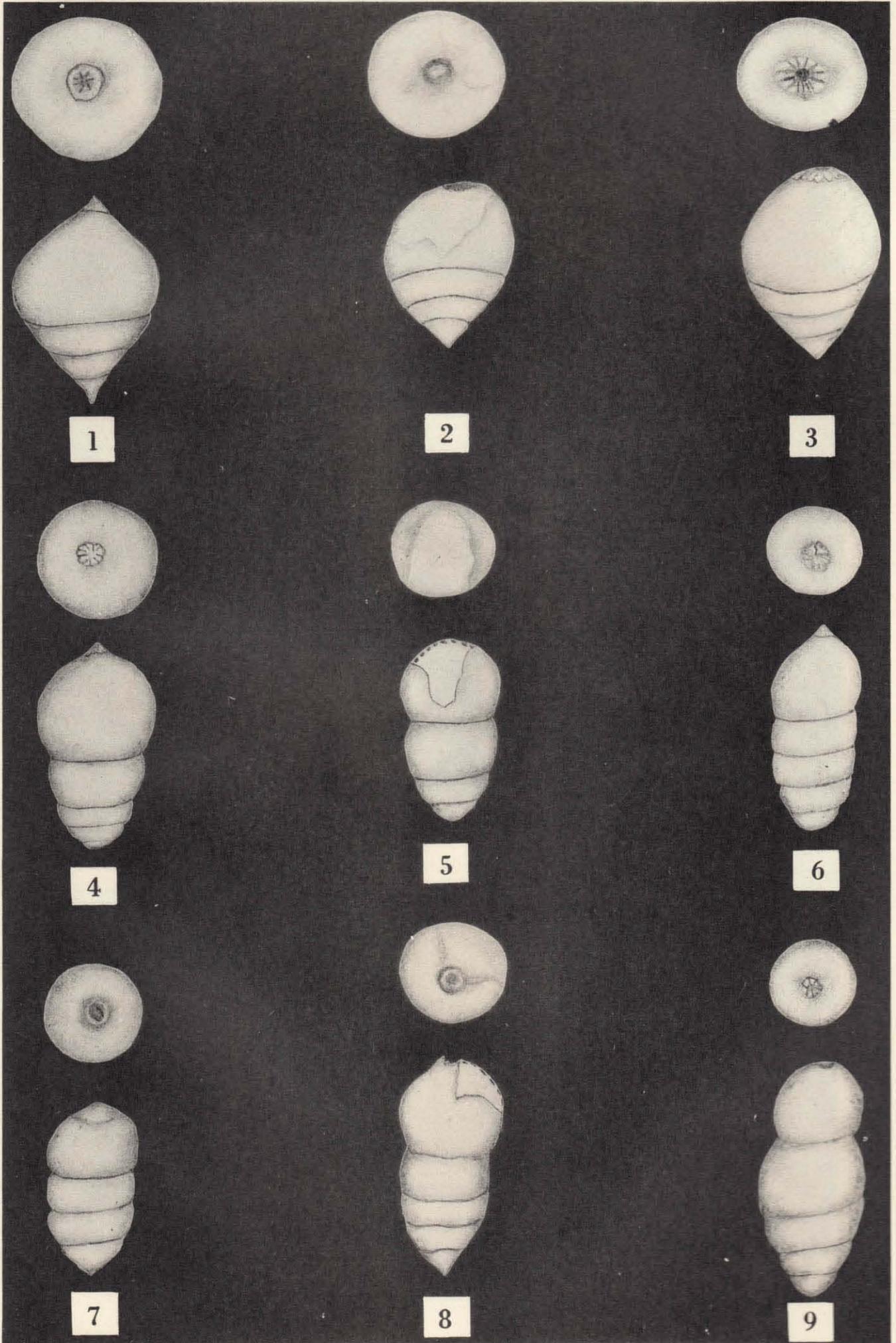
Further study of the Duperow thin-sections indicated that the umbellinid microfauna was a "normal" intergrading population containing various growth stages. It was noted that well developed nodose projections occur only on those forms which are thought to represent adult to gerontic individuals. No nodes are observed on those specimens which by their size and stage of development are thought to be juvenile. It is suggested that the lateral nodose projections may possibly have aided in stabilizing the mature organism for an attached benthonic existence.

The Duperow specimens are probably conspecific with the Russian form *Umbellina bella* (Maslov). The unique nodose specimens are thought to be mature individuals which represent the culminating growth stage of the organism.

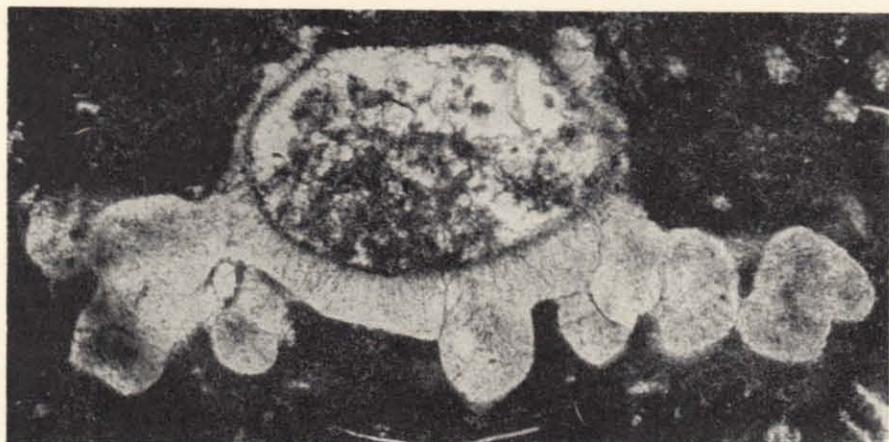
¹ The work reported herein was done in part while the writer was employed by Shell Development Company, Houston, Texas.

EXPLANATION OF PLATE 23

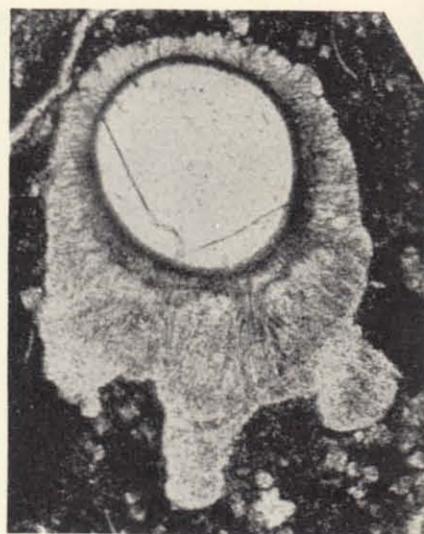
FIGS.	PAGE
1. <i>Glandulina pygmaea</i> Reuss, Hypotype, side and apertural views; from <i>Globotruncana concavata</i> zone. × 50	142
2-3. <i>Glandulina inflata</i> Bornemann, Hypotype, side and apertural views; from <i>Globotruncana linneiana tricarinata</i> zone. × 50	142
4-5. <i>Glandulina mutabilis</i> Reuss, Hypotype, side and apertural views; from <i>Globotruncana linneiana tricarinata</i> zone. × 35	142
6. <i>Glandulina manifesta</i> Reuss, Hypotype, side and apertural views; from subzone D ₁ of <i>Globotruncana globigerinoides</i> zone. × 35	142
7. <i>Glandulina marginuliformis</i> (Frizzell), Hypotype, side and apertural views, from subzone D ₂ of <i>Globotruncana globigerinoides</i> zone. × 35	142
8. <i>Glandulina marginuliformis</i> (Frizzell) var. <i>elongata</i> Banerji n. var., Hypotype, side and apertural views; from the subzone D ₂ of <i>Globotruncana globigerinoides</i> zone. × 38	142
9. <i>Glandulina marginuliformis</i> (Frizzell) var. <i>elongata</i> Banerji n. var., Holotype, side and apertural views; from subzone D ₂ of the <i>Globotruncana globigerinoides</i> zone. × 40	142



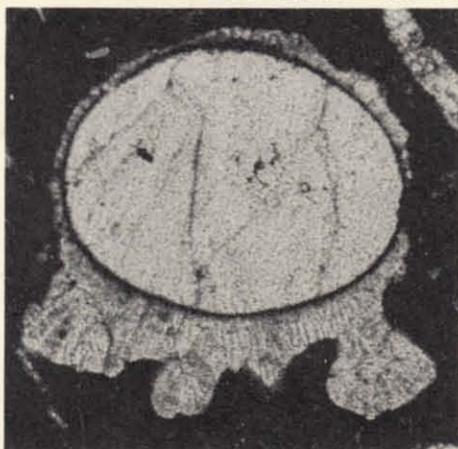
Banerji: *Glandulina* in South India



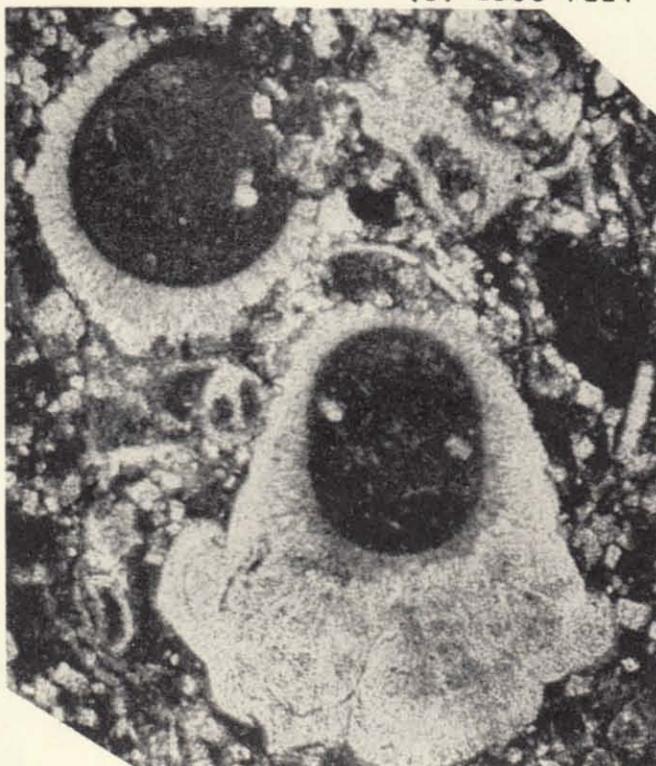
(a) 8887 - 88 FEET



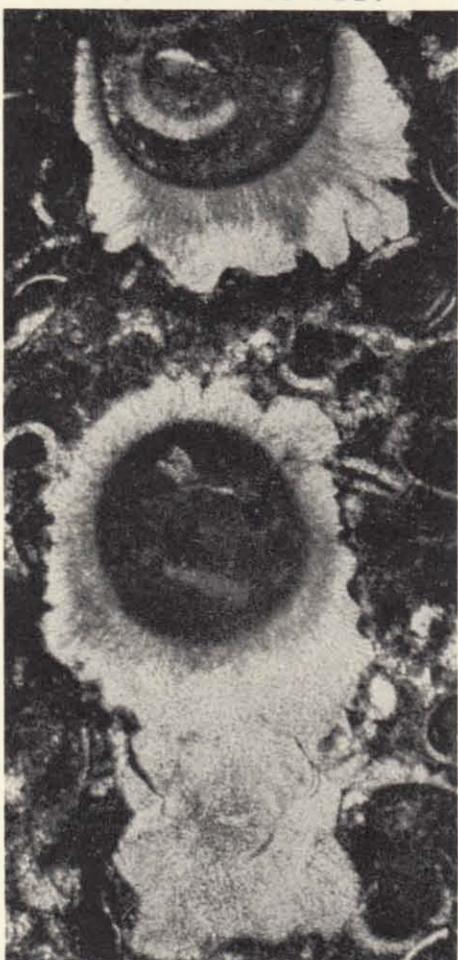
(b) 8900 FEET



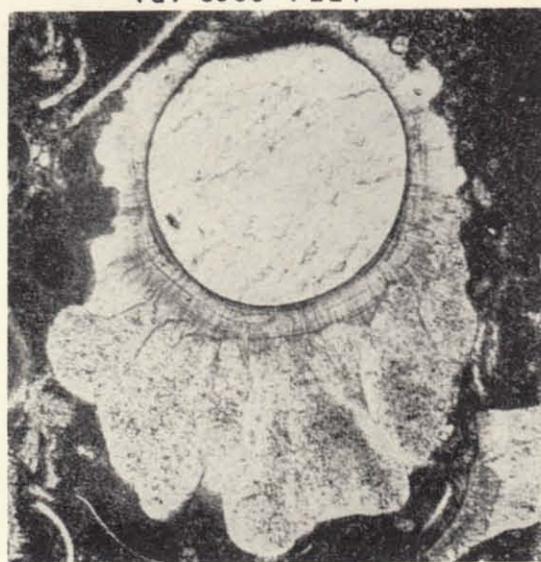
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(d) 8900 FEET



(e) 8900 FEET



(f) 8900 FEET

Toomey: Devonian *Umbellina* from Montana

HISTORY AND DESCRIPTION OF *UMBELLINA*

Superfamily ENDOTHYRACEA Brady, 1884

Family NODOSINELLIDAE Rhumbler, 1895

Subfamily UMBELLININAE Loeblich and
Tappan, 1961

Genus *Umbellina* Loeblich and Tappan, 1961

In 1950, Maslov reported finding large numbers of a new form, of uncertain affinity, which he described as *Umbella bella* from the Evlanova-Livstrata (Frasnian) of Moscow and the Fammenian Stage of Kazakhstan (Semiz-Bugu). Later that same year, Lipina (1950) noted in a plate legend that the name *Umbella bella* was one of manuscript usage only, thus implying that the form had not been properly described originally. Reitlinger (1954) was the first worker to regard *Umbella* as a true foraminifer; she placed it in the family Lagenidae. In 1955, Bykova and Polenova felt that Maslov's original description was not comprehensive enough, so they emended both the genus and the genotype. Finally, in 1961, Loeblich and Tappan reported that the genus *Umbella* was preoccupied and proposed the new name *Umbellina* [type species *Umbellina bella* (Maslov) = *Umbella bella* Maslov, 1955]. To accommodate this form a new subfamily Umbellininae was also proposed. In addition, *Umbellina* was removed from the family Lagenidae and placed in the family Nodosinellidae. *Umbellina* was placed in the Nodosinellidae primarily because its test wall possesses a compound microstructure in which the prominent outer layer is fibrous. The genus was described as follows by Bykova and Polenova (1955):

"Test calcareous, single-chambered, sometimes has extra skeletal formation in the form of ribs or tubercles, and in places a thickening of the walls. Aperture is a simple rounded opening; in several species the aperture is closed by a small rounded plate or lid composed of the same material as the test. Aperture found at the end of a short neck in some specimens, or simply in the wall of the test. Test wall double. Inner wall thin, dark, fine-grained. Outer wall thick, light-colored, with a mass or bundles of thin radial canal-like pores which may be either straight or flared."

Description and Measurement of the Duperow Umbellinids:

The Duperow specimens agree closely with this description. They differ from *Umbellina bella* (Mas-

lov) in that some specimens (those that would be considered adult individuals) show a pronounced development of nodose flange-like projections extending outward from the base and sides of the test wall, most of which seem to have developed in a bizarre, almost haphazard manner. Specimens that are regarded as juvenile do not possess these unique lateral nodose projections. To consider the possession of lateral nodose projections as a basis for speciation, however, appears to be biologically unrealistic. Results of this preliminary study suggest that the lateral nodose projections develop as the organism reaches maturity and may in essence be considered a culminating phase of the organism's growth. No apertural plates or lids were observed *in situ*, but numerous small arcuate calcareous fragments were strewn throughout the slides. These could possibly represent scattered apertural plates, but, more probably, they are fragmented tests of thin-shelled ostracodes.

Measurements of a few "typical mature specimens" are as follows: (in millimeters)

Inner Wall Thickness	Greatest Thickness Outer Wall	Greatest Length	Greatest Width
.031	.462	1.001	.696
.022	.182	.696	.810
.013	.487	1.098	.899
.020	.397	.997	.939
.011	.651	1.221	.736
.015	.199	.800	.772

Bykova and Polenova (1955) believe that the thickened umbellinid wall, the irregular and elongate shape, and the cap-like apertural plate or lid suggest that this form is probably an attached foraminifer, possibly analogous to operculated brachiopods and pelecypods. However, since true apertural lids were not observed on any Duperow specimen, the contention that this form is operculated must remain speculative. Furthermore, it should be noted that no thin-section photomicrograph of *Umbellina* published to date shows an apertural lid, although Ozonkova (1962, p. 115-116) reports that "specimens with lids covering the aperture were observed in some thin-sections."

The umbellinid microfauna reported herein occurs in rocks that may be classified lithologically as intraclastic wackestones. Dunham (1962, p. 116, pl. 5c) gives an illustration of this lithologic type

EXPLANATION OF PLATE 24

Umbellina sp. cf. *U. bella* (Maslov), from the Shell-Richey NP-1, McCone County, Montana; figures *a* and *c*: core depth 8887-88 feet; figures *b*, *d-f*: core depth 8900 feet; photos $\times 50$.

All photos are from randomly oriented thin-sections. They show the distinctive two-layered wall structure, consisting of a dark, thin, microgranular inner layer and a light, thick, irregular, outer layer that is radially perforated. Figure *a* shows well developed lateral nodose projections.

from the identical umbellinid horizon and describes it as a slightly dolomitized, ostracod-lithiclast lime wackestone.

REPORTED OCCURRENCES OF *UMBELLINA*

As noted above, Maslov (1950) reported finding large numbers of *Umbella bella* from the Frasnian rocks of Moscow and the Fammenian rocks of Kazakhstan. Lipina (1950) briefly notes finding the same form from an Upper Devonian horizon on the Russian Platform and gave thin-section photomicrographs of *U. bella*. Reitlinger (1954) apparently accepted Maslov's original description of *Umbella* and described two species and one new variety under this genus. All of her forms are from the Upper Devonian (Frasnian) of the eastern part of the Russian Platform.

Bykova and Polenova (1955) found abundant *Umbella* in an Upper Devonian horizon in the Volga-Ural region. From this interval nine new species were described and illustrated by whole-specimen drawings and thin-section photomicrographs.

In 1959, Konolipina described five species of *Umbella*, of which one was new, from the Upper Devonian rocks of the Ukraine. Thin-section photomicrographs of all described forms were given.

Additional Soviet occurrences include the following: (a) Ilyina (1961) reports *Umbellina bella* (Maslov) from a well penetrating Upper Devonian (Frasnian) sediments in the central region of the Russian Platform, (b) Menner (1961) reports *U. ex. gr. bella* (Maslov) from the Upper Devonian (Frasnian) sediments of the northwestern Siberian Platform, (c) Miklukho-Maklay (1961) notes the occurrence of *Umbellina* from the Upper Devonian rocks of the Alay and Turkestan Ranges of central Asia, and (d) Shevchenko (1961) reports finding *U. saccamminiformis* (Bykova) in the Upper Devonian (Fammenian) rocks of the Stalingrad region of the Soviet Union.

From Poland, Ozonkowa (1962) reports the presence of three species of *Umbellina* from a thin limestone bed of Middle Devonian age (Givetian) from the eastern part of the Kielce-Lagow synclinorium, Holy Cross Mountains. Of the three described species, two are new. Ozonkowa notes that two forms described by Bykova and Polenova (*U. baschkirica* and *U. pugatchovensis*) may possibly be varieties of *U. bella* (Maslov). Thin-section photomicrographs and whole-specimen drawings of all described forms are given.

Two instances can be noted in which *Umbellina* has been incorrectly identified as a calcisphere: (1) Lombard and Monteyne (1952) illustrated and described a form as "Calcisphere Form A" from the Upper Devonian (Frasnian) rocks of Namur, Belgium, and (2) Konishi (1958) also illustrated and described a form as "Calcisphere Form A" from

the Upper Devonian (Frasnian) Cooking Lake Formation, of Alberta, Canada. In both instances the forms described as calcispheres may now be placed under *Umbellina*, probably *U. bella* (Maslov).

Forms of the genus *Umbellina* occur in widely separated areas of the Soviet Union in rocks of Upper Devonian age (Frasnian-Fammenian). In Poland, *Umbellina* occurs in the Middle Devonian (Givetian) rocks of the Holy Cross Mountains. In western Europe, *Umbellina* is only found in the Upper Devonian (Frasnian) rocks of the Namur Region of Belgium. In North America, *Umbellina* occurs in the Upper Devonian (Frasnian) Cooking Lake Formation, Alberta, Canada; in two wells penetrating the Upper Devonian (Frasnian) Duperow Formation of eastern Montana, and in Duperow outcrop in the Sawtooth Range of northwestern Montana (personal communication by Dr. R. J. Stanton, Jr. 8/60).

At present, fifteen species and one variety of the genus *Umbellina* have been described in the literature. These are:

- Umbellina baschkirica* (Bykova and Polenova)
- U. bella* (Maslov)
- U. bykova* (Reitlinger)
- U. bykova* var. *grandis* (Reitlinger)
- U. famena* (Bykova and Polenova)
- U. grandis* (Bykova and Polenova)
- U. nana* (Reitlinger)
- U. ollaria* (Bykova and Polenova)
- U. ornata* (Bykova and Polenova)
- U. patella* (Bykova and Polenova)
- U. polonica* Ozonkowa
- U. pugatchovensis* (Bykova and Polenova)
- U. radiata* (Konolipina)
- U. rotunda* (Bykova and Polenova)
- U. saccamminiformis* (Bykova and Polenova)
- U. sanctacrucensis* Ozonkowa.

All of the above species have been described either from the Soviet Union or from Poland. It is indeed probable that some of them are synonyms, since they have been, for the most part, defined solely on the basis of random thin-section cuts. None have been formally described from North America; the Duperow occurrence reported in this paper represents the first recognition of the genus *per se* in North America.

CONCLUDING REMARKS

For some time this writer has entertained serious doubt as to whether or not *Umbellina* is actually a foraminifer. Thought has been given to the proposition that *Umbellina* might possibly be a charophyte oögonium. However, the distinctive umbellinid test wall microstructure, much like that of other members of the foraminifer family Nodosinellidae, attests to its foraminifer affinity. In addition, a cursory examination of the literature per-

taining to Paleozoic charophytes failed to reveal any forms possessing a similar wall microstructure. Most Paleozoic charophyte oögonia possess a wall microstructure recrystallized to blocky mosaic calcite; more rarely, a few forms show distinctive laminae of organic material. Nonetheless, forms recently illustrated by Perkins (1962, pl. 5, fig. 2) from the Middle Devonian (Jefferson Limestone) and considered by him as charophyte oögonia do appear to show some rather disturbing similarities to the umbellinids described above.

ADDENDUM

While this paper was in press, a short note appeared which briefly documented the occurrence of *Umbellina* from three well cores that penetrated the Duperow Formation in western North Dakota (Rich, M., 1965, "Calcspheres" from the Duperow Formation (Upper Devonian) in western North Dakota: Jour. Paleontology, v. 39, no. 1, p. 143-45, pl. 20).

It is of some interest to note that none of Rich's umbellinids show the unique lateral nodose projections seen in the Montana umbellinids; however, both microfaunal assemblages do appear to occur in a similar rock type—intraclastic lime wackestone. In a concluding statement Rich (p. 144) states that *Umbellina* "may be a widespread index of the Late Devonian," but evidence presented above (Ozonkova, 1962) shows that *Umbellina* has also been found in rocks of Middle Devonian (Givetian) age from Poland.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XVI, PART 4, OCTOBER, 1965

309. TWO SPECIES OF BRITISH RECENT FORAMINIFERIDA

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ABSTRACT

The interpretation of *Nonion depressulus* (Walker and Jacob) is emended and a new species, *Protelphidium anglicum* n. sp., erected.

Superfamily CASSIDULINACEA d'Orbigny

Family NONIONIDAE Schultze

Nonion depressulus (Walker and Jacob) sensu stricto, emended diagnosis

Plate 25, figures 6, 7; Plate 26, figures 7, 8

"*Nautilus spiralis* utrinque . . ." WALKER and BOYS, 1784, *Testacea minuta rariora*, p. 19, fig. 68.

Nautilus depressulus WALKER and JACOB, 1798, in Kanmacher, Adam's essays on the microscope, ed. 2, p. 641, fig. 33.

Emended diagnosis based on topotype 1962.2.12.533 (Plate 25, figs. 6 and 7).

Test free, planispiral, compressed, bilaterally symmetrical, nearly involute; 10 chambers in the outer whorl, rapidly increasing in height as added, only slightly inflated; sutures distinct, initially only slightly depressed, but later becoming deeply depressed, recurved; aperture obscure, apparently a row of 3 or 4 minute pores at the base of the apertural face of the last chamber, which are not easily distinguished from the surrounding white granular material; periphery rounded, slightly lobate; umbilical regions slightly depressed and infilled with white granular material extending into the umbilical regions of the depressed sutures; wall transparent to opaque and white, calcareous, granular, perforate. Greatest diameter 0.313 mm., greatest thickness 0.104 mm.

Reg. nos.—Dead topotypes, 1962.2.12.457-532; Emended diagnosis based on topotype, 1962.2.12.533; 'Living' topotypes, 1962.2.12.534-554.

Topotype Locality.—Beach sand, about 250 yds. west of Reculver Towers, Reculver, Kent.

Discussion.—The full description given by Walker and Boys (1784) is: "*Nautilus Spiralis* utrinque subumbilicatus geniculis depressis plurimis — The spiral subumbilicated nautilus, with many depressed

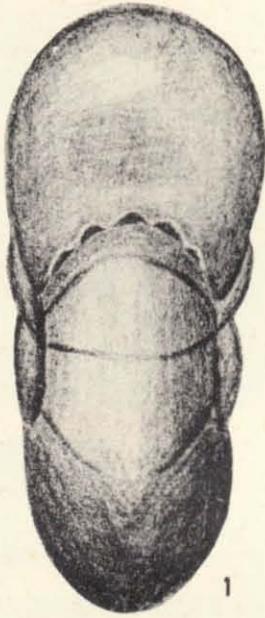
joints. The colour opaque white. From Reculver, very rare." Their figure, which is diagrammatic, shows a planispirally coiled form with 13 chambers visible in the outer whorl. The chambers increase rapidly in height as they are added; they are wide and thin and show no marked inflation. The periphery is very slightly lobed. The form appears to be more or less involute and the umbilicus is occupied by a plug (questionable). A copy of Walker and Boys' *Testacea minuta rariora* was examined and it was noticed that the figure reproduced in the Catalogue of Foraminifera (Ellis and Messina) is inaccurate: the right hand view gives the impression of the last chambers uncoiling; this was found not to be the case in the original plates. Walker and Jacob (1798) gave the valid binomial name *Nautilus depressulus* to this form.

The exact fate of the Walker and Boys collection is unknown, but it is certain that their specimens are lost. According to Sherborn (1940) the Sandwich types were in the Portland Museum, but the curator, Mr. H. Lidbetter, has no information on the collection. There appears always to have been doubt about the exact nature of *N. depressulus*, and the majority of authors have referred to it forms which are distinct. It was in an attempt to sort out the confusion that topotype material was collected. Walker and Boys obtained their specimens from Reculver in north Kent; the title of their book suggests that it was from the beach sands. Local information indicates that the cliffs at Reculver have receded about four miles in the past two hundred years, but this seems to be an exaggeration. Whitaker and Dowker (1885) believed the amount of erosion to be overestimated and stated, "In 1788, Mr. Boys found that the northern wall of the Roman Castrum, which was 80 yards from the church, had lately been overthrown by a fall of cliff." The double towers of the church (Reculver Towers) are still preserved, although they are on the edge of the present cliff, which is strongly de-

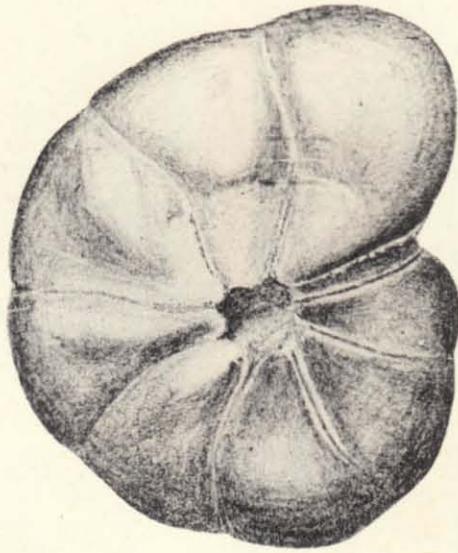
EXPLANATION OF PLATE 25

The scale for figures 1 - 6 equals 0.1 mm.

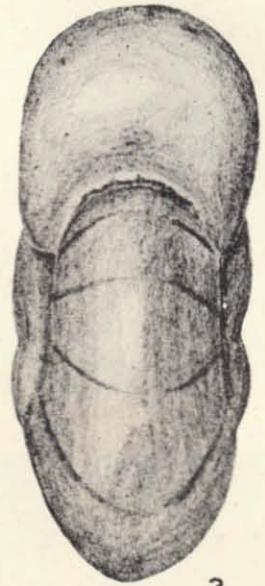
FIGS.	PAGE
1, 2. <i>Protelphidium anglicum</i> n. sp. Holotype, 1962.2.12.230. (1) apertural view, (2), side view.	149
3, 4. <i>Protelphidium anglicum</i> n. sp. Paratype, 1962.2.12.338. (3) apertural view, (4) side view.	149
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6. <i>Nonion depressulus</i> (Walker and Jacob) emended. Topotype, 1962.2.12.533. Apertural view. The emended diagnosis is based on this specimen.	148
7. (Stereo pair) <i>Nonion depressulus</i> (Walker and Jacob) emended. Topotype, 1962.2.12.533. Side view. $\times 82$. The emended diagnosis is based on this specimen.	148



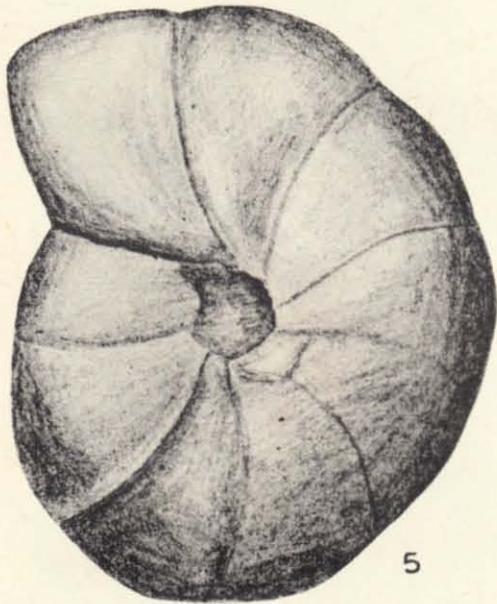
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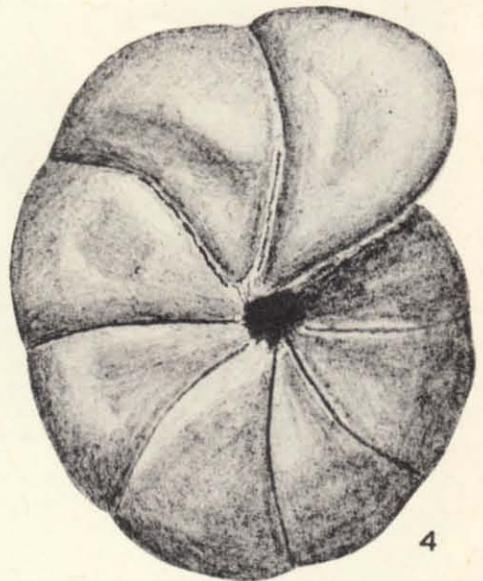
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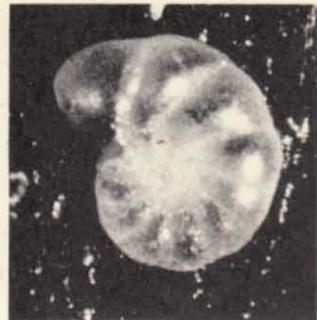
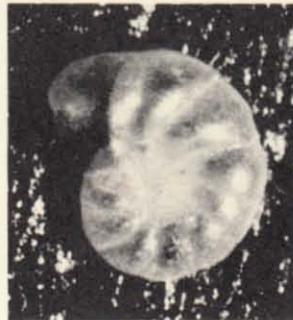
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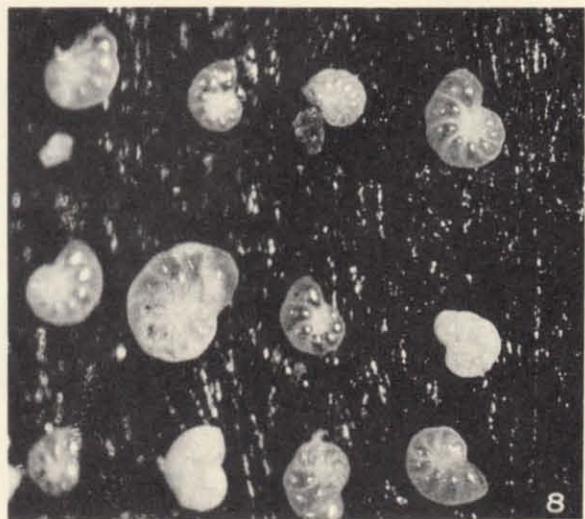
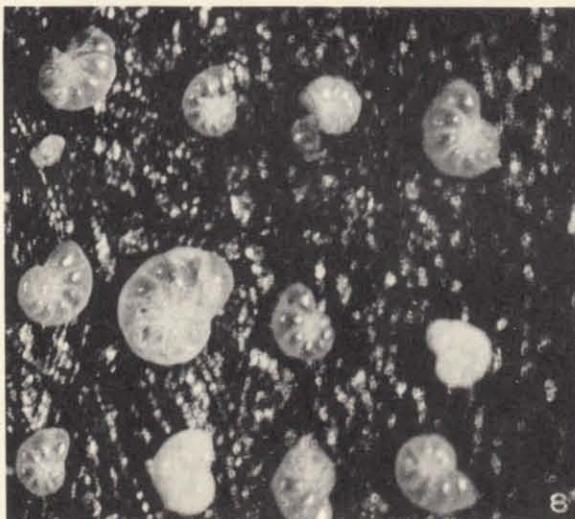
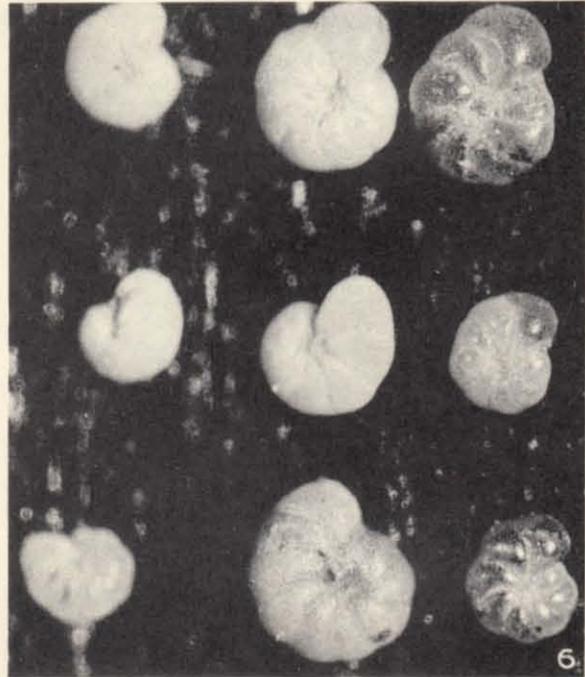
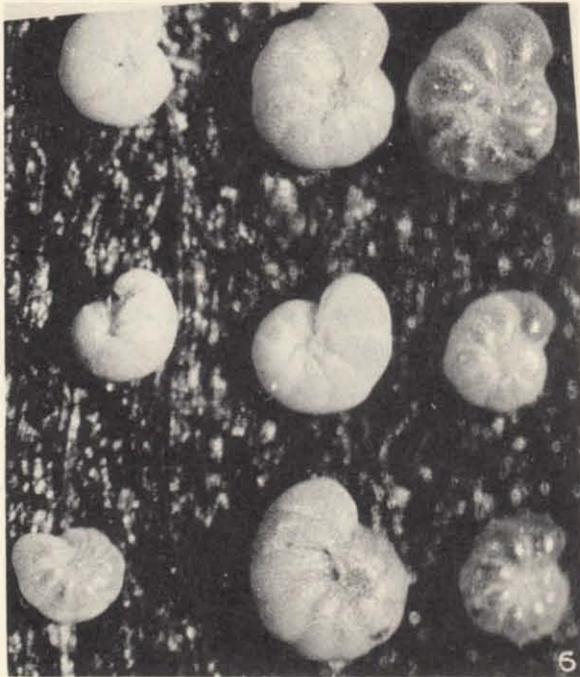
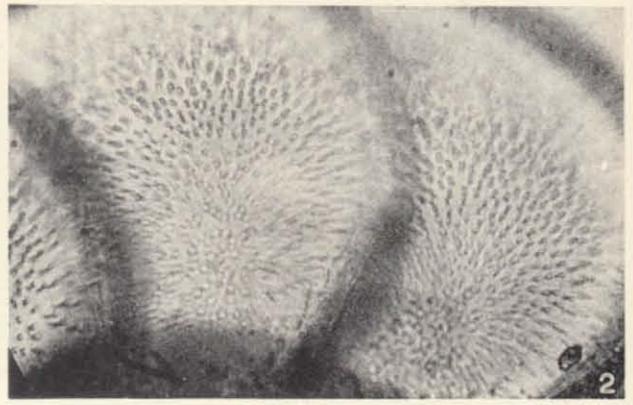
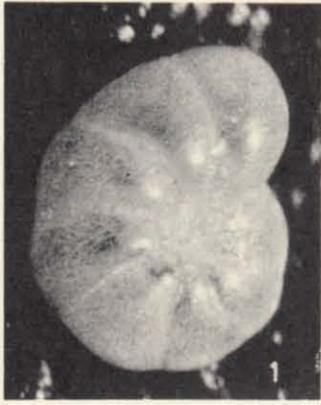
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6



7



Murray: New Recent British Foraminifera

fended by a sea wall and groyne. This suggests that only about 80 yards of land have been removed since Boys' time, which is important in assessing the value of the topotype material.

In April, 1961, samples were collected both from the foreshore and from the cliffs at Reculver. The cliffs consist of Thanet Sands and Woolwich Beds; the Thanet Sands also form much of the beach. Recent sand is not very abundant near high tide mark but increases seawards, where it is of the quicksand type. Some of the beach sand was preserved in alcohol so that living Foraminiferida could be stained.

The foraminiferid faunas of the Thanet Sands and Woolwich Beds are abundant; at least 90% of the fauna of the beach sands consists of foraminiferids derived from these formations. Thus, all Recent forms are rare and, of these, few were found to be alive at the time of collection. However, in spite of the greater abundance of derived Tertiary forms, Walker and Boys seem mainly to have described the Recent forms. Haynes' suggestion (1956) that his specimen of *Nonionella cretacea* Cushman closely resembles Walker and Boys' figure of *Nautilus depressulus* is not accepted; the two are quite distinct.

The form herein taken to represent *Nautilus depressulus* is comparatively rare at Reculver and becomes progressively rarer toward Herne Bay. It is undoubtedly a Recent form, as many specimens gave a positive reaction when stained with rose Bengal. Also, in the unstained material, the protoplasm, green either with ingested food or symbiotic algae, was clearly seen.

One of the main differences between the topotype here described and Walker and Boys' original figure is that in the former there appear to be fewer chambers. In the topotypes examined, the number of chambers in the outer whorl was counted for 37 perfect specimens:

Number of chambers	Frequency
7	1
8	6
9	17
10	12
11	1

The only other difference is that Walker and Boys described their type as 'opaque white.' This is of no significance, as the derived Tertiary and the Recent forms vary from opaque white to translucent or transparent. Opacity in this case is a secondary effect produced by slight etching of the calcareous test.

In the type collections of the British Museum of Natural History the forms normally referred to *Nonion depressulus* should be referred to *Protelphidium anglicum*, while many of the specimens referred to *Nonion asterizans* (Fichtel and Moll) rightly belong in *Nonion depressulus*. Milton placed specimens of this species in both *N. depressulus* and *N. asterizans*. Nyi Nyi and Kureshy (1956) both referred it to *Nonion asterizans*, but Harris (1958) correctly identified his specimens from the North Sea.

Macfadyen (1940) drew a comparison between topotypes of *N. depressulus* and *N. orbicularis*. However, his figure is too poor to identify. Nyi Nyi (1956) examined Macfadyen's topotype and expressed the view that it was not the same as that originally described by Walker and Jacob.

Superfamily ROTALIACEA Ehrenberg

Family ELPHIDIIDAE Galloway

Protelphidium anglicum n. sp.

Plate 25, figures 1-5; Plate 26, figures 1-6

Nonionina crassula (Walker), WILLIAMSON, 1858, On the Recent Foraminifera of Great Britain. Ray Soc. pp. 33-34, pl. 3, figs. 70 and 71 (listed as *Nonionina umbilicatula* on p. 97) (non *Nautilus crassulus* Walker and Jacob, 1798).

Nonionina depressula (Walker and Jacob), BRADY, 1884, Rep. voy. Challenger, Zool., vol. 9, pp. 725-6, pl. 109, fig. 6a, b, (in part); and of authors, in part. (non *Nautilus depressulus* Walker and Jacob, 1798).

Description of holotype.—Plate 25, fig. 1, 2; Plate 26, fig. 1):

Test free, planispiral, bilaterally symmetrical, involute; 9 chambers visible in the last whorl, early ones not inflated, later becoming inflated; sutures distinct, flush or very slightly depressed in the early

EXPLANATION OF PLATE 26

With the exception of figure 2, all the photographs on this plate are stereo-pairs.

FIGS.		PAGE
1-6.	<i>Protelphidium anglicum</i> n. sp.	149
1.	Holotype, 1962.2.12.230. Side view $\times 82$.	
2.	Metatype showing radial pores in a surface view of the wall $\times 450$.	
3.	Paratype, 1962.2.12.277. Side view $\times 41$.	
4.	Paratype, 1962.2.12.275. Apertural view $\times 41$.	
5.	Paratype, 1962.2.12.293. Side view $\times 41$.	
6.	Paratypes, 1962.2.12.247-249, 263-265, 279-281. Side view $\times 41$.	
7, 8.	<i>Nonion depressulus</i> (Walker and Jacob) emended.	148
7.	Topotype, 1962.2.12.480. Side view $\times 41$.	
8.	Topotypes, 1962.2.12.487-490, 498-501, 509-512. Side view $\times 41$.	

portion, later becoming strongly depressed as the chambers become more inflated; umbilici depressed and partly infilled with white granular material which extends into the umbilical portions of the depressed sutures; aperture a row of 5 pores at the base of the apertural face of the last chamber, extending laterally toward the umbilici, partly obscured by a zone of small white granulations covering this part of the apertural face; wall transparent to opaque, calcareous, radiate and lamellar, finely perforate. Greatest diameter 0.400 mm., greatest thickness 0.188 mm.

Reg. nos.—Dead holotype, 1962.2.12.230; Dead paratypes, 1962.2.12.231-339; 'Living' paratypes, 1962.2.12.340-435.

Locality.—Sample 119/A/D, from the surface sediment about 400 feet east of the small arcuate island in the center of Christchurch Harbour, Hampshire, England.

Discussion.—It is unfortunate that the species described by Walker and Boys as "Nautilus spiralis utrinque . . ." and later validly named *Nautilus depressulus* by Walker and Jacob (see p. 148) is comparatively rare around British shores. The new species, *Protelphidium anglicum*, is very abundant all round the coast, particularly in areas of lowered salinities, and has previously been referred erroneously to Walker and Jacob's species *depressulus* by the majority of authors and to *Nonionina crassula* by Williamson. The latter author's illustration is the best ever given, although the details of the aperture are far from clear.

Protelphidium anglicum is readily distinguished from *Nonion depressulus* (Walker and Jacob) as here emended. The former is very much less compressed and has more inflated chambers. Although the average number of chambers in the outer whorl is the same (9), *N. depressulus* is not completely involute, while in *P. anglicum* the umbilici tend to be deeper when not infilled with granular material. However, the major point of difference between the two species is in the wall structure: *Nonion depressulus* has a calcareous granular wall, whereas *Protelphidium anglicum* has a calcareous radiate lamellar wall. It is this character which has led to placing this species in the genus *Protelphidium* Haynes, 1956. Haynes wrote (p. 86):

"The genus *Protelphidium* includes members of the Nonionidae which are radiate hyaline, involute, with or without multiple apertures but without sutural pores or retral processes. The genus differs from *Nonion* Montfort in being radiate hyaline not granular and in the development of multiple foramina. It differs from *Elphidium* Montfort in its lack of retral processes and from *Elphidiella* Cushman, in its lack of sutural pores."

Topotypes of the type species, *Protelphidium hofkeri* Haynes have been examined. In view of the

wall structure, this genus should be placed in the family Elphidiidae (rather than the Nonionidae) although it has no retral processes.

Protelphidium anglicum is quite variable, as is shown by the 205 'living' and dead paratypes mounted with the holotype. One of the principle trends of variation is the degree of inflation of the chambers and the concomitant degree of depression of the sutures. A count of the number of chambers in the outer whorl in 50 of the dead paratypes gave the following results:

Number of chambers	Frequency
11	1
10	7
9	19
8	19
7	4

Thus, the average specimen has either 8 or 9 chambers in the outer whorl.

Voorthuysen (1957) described and figured *Nonion depressulus* (Walker and Jacob) forma *asterotuberculatus* from the Eemian of Holland. No types of this species have been examined and its wall structure is not known. However, apart from any other differences, it is described as having from 5 to 7 chambers, usually 6. Thus it barely overlaps with the number found in *P. anglicum*; it is not considered that it would be synonymous even if it proved to be a *Protelphidium*.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XVI, PART 4, OCTOBER, 1965

310. A NEW PLANKTONIC SPECIES (FORAMINIFERIDA)
FROM THE PLIOCENE OF PACIFIC DEEP-SEA CORES

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ABSTRACT

The new planktonic species *Pulleniatina spectabilis* (Foraminiferida) from the lower part of the Pliocene of Pacific deep-sea cores is described. This species appears to have a short range in the Pliocene and thus far has been found only in Pacific Ocean sediments.

INTRODUCTION

Pulleniatina spectabilis n. sp. is believed to be an excellent marker for the "lower" part of the Pliocene in equatorial deep-sea cores of the Pacific Ocean. The Miocene-Pliocene boundary is placed tentatively at the point where *Sphaeroidinella dehiscens* (Parker and Jones) develops from *Sphaeroidinellopsis subdehiscens* (Blow). According to Blow (1959, and personal communication), this evolution is observed in the lower part of the Trubi beds of Sicily which generally are considered to be basal Pliocene. Further work on Italian strata nearer the type locality of this boundary is needed before this datum can be used with certainty. Such work is also needed before we can place the Pliocene-Pleistocene boundary with exactness, beyond the reach of controversy. By using Blow's datum for the lower boundary of the Pliocene and the boundary postulated by Ericson *et al.* (1963) for the upper one (at present their boundary has no tie-in with the Italian section) the range of *P. spectabilis* can be placed quite precisely. The species appears in the section at the same time, or shortly after, the appearance of *S. dehiscens*. Transitional specimens between this new species and *P. semiinvoluta* Germeraad were found in the very uppermost Miocene and at the base of the Pliocene in one core. *P. spectabilis* disappears soon after the disappearance of *Globigerina nepenthes* Todd, well below the boundary suggested by Ericson *et al.* It must be remembered, however, that the section seen in deep-sea cores is greatly telescoped as compared to land sections, and it may be that the range of this species is even shorter than it appears to be at present. Blow (personal communication) says that this entire range occurs within the Neogene Zone N19 of Blow and Banner. This zone represents what they consider to be the lowest of three Pliocene zones.

Thus far, *P. spectabilis* has appeared in three cores between Longs. 168°02'E. to 119°11'W. and Lats. 14°16'S. to 7°17.7'N. It probably will be

found eventually in Indian Ocean sediments because the faunas of that ocean show a close affinity with those of the Pacific. It seems rather doubtful that it will be found in the Atlantic region because it has not so far been observed either in the ocean sediments or at land localities in that general area.

This study was supported by the Office of Naval Research; it is a contribution of the Scripps Institution of Oceanography, and Contribution No. 50 of the Marine Foraminifera Laboratory. The figured specimens have been deposited in the U. S. National Museum, Washington, D.C.

Superfamily GLOBIGERINACEA Carpenter

Pulleniatina spectabilis n. sp.

Text figures 1-4

Test plano-convex, trochospiral in initial whorls, later streptospiral, left-coiling, consisting of 4-5 whorls, periphery sharply angled, lobulate with the outer edge of the chambers of the final whorl sometimes extending above those of previous chambers near the peripheral edge; chambers rounded and inflated in the earlier part of the test, later ones slightly inflated on involute side, angular and uninflated on evolute side, 4½ to 5½ in the final whorl, 4 in the initial whorl, up to about 19 in all; early sutures distinct on both sides, curving, later ones distinct on involute side but obscure on evolute side and only slightly curving; wall of adult smooth and somewhat polished, in young forms coarsely pitted with occasional short spines near the periphery; early apertures almost semicircular becoming increasingly narrow and elongate, very narrow in adult. Diameter up to 0.83 mm.; height up to 0.50 mm.

Holotype—(USNM 642379) from Core LSDH 78P, 100-102 cm., Lat. 4°31'S., Long. 168°22'E., at 3208 meters.

This species is quite distinct from its ancestor *P. semiinvoluta* Germeraad (text figs. 5, 6), differing from that species in its plano-convex test and narrowly angled periphery. *P. spectabilis* seems to have accelerated rapidly, because the plano-convexity appears early in the development of the test (text figs. 3, 4). Both these species and *P. obliqui-*

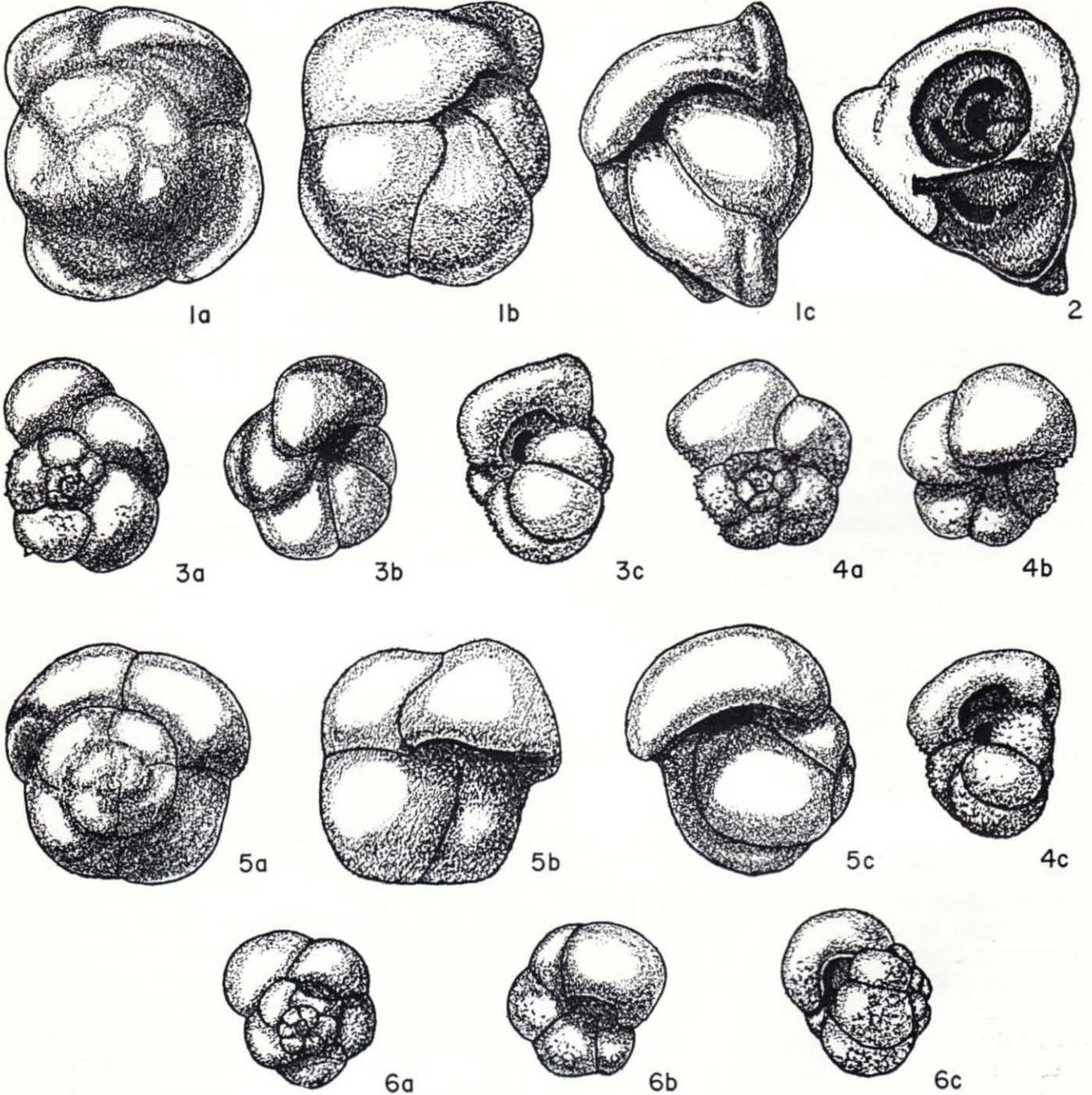
loculata (Parker and Jones) occur concurrently during parts of their ranges.

zuela: Bull. Am. Paleontology, vol. 39, no. 178, pp. 67-251, pls. 6-19.

REFERENCES

BLOW, W. H., 1959, Age, correlation, and biostratigraphy of the upper Tocuyo (San Lorenzo) and Pozón Formations, eastern Falcón, Vene-

ERICSON, D. B., EWING, MAURICE, and WOLLIN, GOESTA, 1963, Pliocene-Pleistocene boundary in deep-sea sediments: Science, vol. 139, no. 3556, pp. 727-737.



TEXT FIGURES 1-6

Figs. 1-3, 5, $\times 60$; 4, 6, $\times 77$; a, b, side views; c, edge view.

Figs. 1-4, *Pulleniatina spectabilis* n. sp. 1, holotype (USNM 642379); 2-4, paratypes (USNM 642380, 642381, 642382). Fig. 2 represents a dissected specimen showing the streptospiral coiling; the two earlier apertures are shown from their outward aspect; the two later ones are seen from the interior side of the chambers; the final aperture is not shown in the figure.

Figs. 5, 6, *Pulleniatina semiinvoluta* Germeraad (USNM 642383, 642384).

All figured specimens are from the type locality of *Pulleniatina spectabilis* n. sp.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
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311. *NONIONELLA ASTRICTA*, NEW NAME FOR
NONIONELLA JAPONICA (ASANO) VAR. *MEXICANA*
CUSHMAN AND McCULLOCH PREOCCUPIED

IRENE McCULLOCH

Allan Hancock Foundation, Los Angeles, California, 90007

Nonionella japonica (Asano) var. *mexicana* Cushman and McCulloch (Allan Hancock Pacific Exped. vol. 6, no. 3, 1940, p. 160, pl. 17, fig. 10) (= *Nonionella mexicana* Cushman and McCulloch) is preoccupied by *Nonionella turgida mexicana* (Cole) [originally *Nonion turgidus* (Williamson) var. *mexicanus* Cole, 1927]. The new name *Nonionella astricta* is proposed for *Nonionella japonica* (Asano) var. *mexicana* Cushman and McCulloch, 1940.

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CORRECTIONS

The following corrections should be made in the paper "*Globigerinoides quadrilobatus* (d'Orbigny) and Related Forms: Their Taxonomy, Nomenclature and Stratigraphy," by F. T. Banner and W. H. Blow, published in July of this year (vol. 16, pt. 3, p. 115, Explanation of Plate 16):

1. All figures on plate 16 are reproduced at $\times 140$ linear, rather than $\times 50$.
2. In the description of fig. 1, delete "Same size as original."
3. In the description of fig. 3, read "intermediate" for "indeterminate."

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XVI, PART 4, OCTOBER, 1965
RECENT LITERATURE ON THE FORAMINIFERA

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

- AKHVLEDIANI, D. G. Stratigraphy of the Upper Cretaceous deposits of the southern periphery of the Dzirula Massif according to Foraminifera (English summary of Russian text), in *Problems of the Geology of Georgia, Paleontology-Stratigraphy*.—Acad. Sci. Georgian SSR, Tbilisi, 1964, p. 289-291.
- APPLIN, PAUL L., and APPLIN, ESTHER R. The Comanche series and associated rocks in the subsurface in central and south Florida.—U. S. Geol. Survey Prof. Paper 447, May 20, 1965, p. 1-84, pls. 1-11 (microfossils, logs, sections, maps), text figs. 1-53 (maps, geol. section, photomicrographs, core photographs), tables 1, 2.—Foraminifera, mostly in thin section, are recorded and illustrated.
- ARNI, P. L'évolution des Nummulitinae en tant que facteur de modification des dépôts littoraux.—Mém. Bureau de Recherches Géol. et Min., No. 32, Colloque Internat. de Micropaléont. (Dakar, 6-11 mai 1963), 1965, p. 7-20, text figs. 1, 2 (range chart, block diagram).—Based on studies in the middle and lower Eocene of the Sirte Basin in Libya, 5 biotopes related to the nummulites bank are recognized, each with its characteristic fauna or faunas.
- Contribution a la systématique des *Nummulites* s. l.—Mém. Bureau de Recherches Géol. et Min., No. 32, Colloque Internat. de Micropaléont. (Dakar, 6-11 mai 1963), 1965, p. 21-28, 1 table.—“*Nummulites cordelées*” are separated into 2 kinds: *Chordoperculinoidea* new subgenus (type species *Operculina bermudezi* Palmer) erected to include the flat operculinid ones and the subgenus *Ranikothalia* to include the inflated ones with coarsely structured marginal plexus.
- ASANO, KIYOSHI. Japanese Paleogene from the view-point of Foraminifera with descriptions of several new species (in Japanese with English abstract).—Contrib. Instit. Geol. and Paleont., Tohoku Univ., No. 57, Nov. 1962, p. 1-32, pl. 1, text figs. 1, 2 (photographs of outcrops), tables 1-6 (occur. tables, correl. charts).—Seven new species from the Eocene of East Hokkaido.
- BANNER, F. T., and WOOD, G. V. Recrystallization in microfossiliferous limestones.—Geol. Jour., v. 4, pt. 1, March 18, 1964, p. 21-34, pls. 1-6, text fig. 1 (line diagrams), table 1.—Different family groups of Foraminifera are recrystallized selectively, those having Mg ions first. Various stages of recrystallization and obliteration of microfossils in Miocene limestones from Papua are illustrated.
- BARBIERI, F. Micropaleontologia del Lias e Dogger del pozzo Ragusa 1 (Sicilia).—Riv. Ital. Paleont. Stratig., v. 70, No. 4, 1964, p. 709-830, pls. 56-66, text figs. 1-20 (map, columnar section, line drawings, correl. chart).—Illustrated systematic catalog includes 119 species of Foraminifera (3 new) but only 35 specifically identified.
- BECKER, DELIA. Micropaleontologia del Superpatagoniense de las localidades Las Cuevas y Monte Entrance (Provincia de Santa Cruz).—Ameghiniana, Rev. Asoc. Pal. Argentina, tomo 3, No. 10, Dec. 1964, p. 319-351, pls. 1-6, text fig. 1 (map), tables 1-4 (check lists, range chart).—Includes illustrated catalog of 26 species of Foraminifera (none new) from the middle Miocene of southernmost Argentina.
- BERGGREN, W. A. Some problems of Paleocene-Lower Eocene planktonic foraminiferal correlations.—Micropaleontology, v. 11, No. 3, July 1965, p. 278-300, pl. 1, text figs. 1-12 (correl. charts, phylogenetic diagrams, drawings), table 1.—Discussion of correlation between zones used in the Western Hemisphere and those of the Crimea and Caucasus. Five species of *Globorotalia* are discussed and illustrated from Mexia Clay. Phylogenetic diagrams from Subbotina, 1960, are copied.
- BHALLA, S. N. New species of Foraminifera from the Raghavapuram shales (Lower Cretaceous), Andhra Pradesh, India.—Geol. Soc. India Bull., v. 2, No. 2, April 1965, p. 39-43, text fig. 1.—Five species of *Ammobaculites* and one of *Haplophragmoides*.
- BHATIA, S. B., and BHALLA, S. N. Recent Foraminifera from Beach Sand at Puri, Orissa.—Jour. Pal. Soc. India, v. 4 (1959), 1964, p. 78-81, pls. 1, 2.—Fourteen species, none new.
- BLOW, W. H. *Clavatorella*, a new genus of the Globorotaliidae.—Micropaleontology, v. 11, No. 3, July 1965, p. 365-368, text figs. 1-5.—For species in which the aperture becomes umbilical-extraumbilical, the Neogene analogue of *Clavhedbergella*.

- BODA, JENÖ. *Catalogus Originalium Fossilium Hungariae, pars Zoologica.*—Budapest, 1964, 229 p.
- BOLTOVSKOY, ESTEBAN. Provincias zoogeograficas de America del Sur y su Sector Antartico segun los Foraminiferos bentonicos.—*Bol. Inst. Biol. Mar.*, No. 7, Oct. 1964, p. 93-98, map.—Three provinces, each with 2 subprovinces, surround South America. The adjoining Antarctic sector is subdivided into 3 subprovinces.
- Twilight of foraminiferalogy.—*Jour. Paleontology*, v. 39, No. 3, May 1965, p. 383-390.—Prognosis of impending crises in the natural sciences.
- BOMBITA, GH. Contributions à l'étude stratigraphique des dépôts Éocènes de la Dobrogea, avec un aperçu spécial sur la faune de nummulites et d'assilines (in Rumanian with French résumé).—*Anuar. Comit. Geologic, Bucarest*, v. 33, 1964, p. 381-438, pls. 1-32b, text figs. 1-3 (maps, columnar section).
- BOZORGNIA, FATHOLLAH (with collaboration of SALEH BANAFI). Microfacies and microorganisms of Paleozoic through Tertiary sediments of some parts of Iran.—*National Iranian Oil Co.*, Tehran, Iran, Nov. 1964, 22 p., 158 pls.—Book consists of over 350 photomicrographs illustrating thin sections of rocks. Microfossil contents, including many Foraminifera, are identified.
- BRAZHNKOVA, N. E. K Izucheniju *Eosigmoilina* iz Nizhnego Karbona Bol'shogo Donbassa.—*Akad. Nauk Ukrain. RSR, Kiev, Instyt. Geol. Nauk, Trudy, ser. strat. paleont.*, vyp. 48, 1964, p. 3-15, pls. 1-3.—In the Lower Carboniferous, 3 species of *Eosigmoilina* (2 new), one having 4 forma and another 2 forma.
- BUZAS, MARTIN A. The distribution and abundance of Foraminifera in Long Island Sound.—*Smithsonian Misc. Coll.*, v. 149, No. 1, May 25, 1965, p. 1-89, pls. 1-4.—text figs. 1-22 (maps, graphs), tables 1-11 (available from Smithsonian Publ. Office, Washington, D. C., \$1.50).—Quantitative study of both living and total populations found during seasonal collections. No definite relationships between distribution and the physical or chemical factors of the environment were found. Distribution may be related to food supply. Fauna consists of 22 species and 1 variety, none new. Three zones are recognized in the change of relative abundance with depth of the major constituents: *Elphidium clavatum*, *Buccella frigida*, and *Eggerella advena*.
- CARALP, MICHELLE, and JULIUS, CHARLES. Les Foraminifères dans l'interprétation biostratigraphique du Cénozoïque terminal de Soustons (Aquitaine occidentale).—*Bull. Soc. Géol. Minéral. Bretagne*, 1962-1963, n. sér., March 1965, p. 11-16, pls. 1, 2 (map, pie diagrams), range and abund. chart.—Quantitative analyses of families in the upper and lower parts of the Pliocene.
- CASTELAIN, J. Aperçu stratigraphique et micropaléontologique du Bassin du Sénégal. Historique de la découverte paléontologique.—*Mém. Bureau de Recherches Géol. et Min.*, No. 32, Colloque Internat. de Micropaléont. (Dakar, 6-11 mai 1963), 1965, p. 135-159, pls. 1-4 (maps, geol. section, range chart), text fig. 1 (table).—Includes chart showing ranges of the major significant species of Foraminifera in stratigraphic units from Upper Jurassic to Quaternary.
- CHANG, LI-SHO. A biostratigraphic study of the Tertiary in the Hengchun Peninsula, Taiwan, based on smaller Foraminifera (II: Middle Part).—*Proc. Geol. Soc. China*, No. 8, April 1965, p. 9-18, pls. 1-4, text figs. 1, 2 (map, section), tables 1-5.—Distribution and abundance of 181 species and subspecies of smaller Foraminifera are recorded in several sections, and about a third are illustrated. Three of the West Indian planktonic zones are recognized.
- COLACICCHI, ROBERTO. La facies di transizione della Marsica nord-orientale. I—Serie della Serra Sparvera e della Rocca di Chiarano (with English abstract).—*Geologica Romana*, v. 3, 1964, p. 93-119, pls. 1, 2, text figs. 1-17 (map, schematic section, columnar sections, thin section photos).—Includes illustrations of foram-bearing facies in Lower and Upper Cretaceous.
- CONATO, VITTORIO. Alcuni foraminiferi nuovi nel Pliocene nordappenninico. Contributo I (with English abstract).—*Geologica Romana*, v. 3, 1964, p. 279-295, pls. 1, 2, map, text figs. 1-9 (line drawings).—Fifteen new species and 2 new varieties. Two new genera erected in the Buliminidae: *Spiroloxostoma* (type species *S. croarae* n. sp.) and *Felsinella* (type species *F. diaphana* n. sp.).
- CONIL, R., and LYS, M. Précisions complémentaires sur la micropaléontologie du Dinantien.—*Ann. Soc. Géol. Belgique*, v. 88, 1964-65, Bull. no. 3, April 1965, p. B23-B44, pls. 1-3.—Twelve Carboniferous (upper Tournaisian and Viséan) species (5 new) and 4 varieties (2 new).
- CONKIN, JAMES E., and CONKIN, BARBARA M. Devonian Foraminifera: Part 1, The Louisiana Limestone of Missouri and Illinois.—*Bull. Am. Paleontology*, v. 47, No. 213, March 20,

- 1964, p. 49-105, pls. 12-15, text figs. 1-5 (diagram, map, columnar sections), charts 1-3 (check list, correl. chart, range chart), tables 1-31.—Eighteen species (6 new and 4 indeterminate).
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- Zone ad Alveolini 'ae nel Cretaceo e Paleocene del Lazio ed Abruzzo centro-meridionali (with English abstract).—*Geologica Romana*, v. 3, 1964, p. 405-409, pls. 1, 2.—Five zones based on assemblages of alveolinids.
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- DUPEUBLE, P.-A. Sur une association microfauunique caractéristique de la Manche et des régions voisines.—*Bull. Soc. Géol. Normandie*, v. 54, Année 1964, p. 52-56, 1 text fig. (graph).—Foraminifera listed and a graph shows changing family composition from shore out to 60 meters.
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- Emendation of the genus and species based on specimens in the Jurassic of southern Latium.
- FUNNELL, B. M. Studies in North Atlantic Geology and Palaeontology: 1. Upper Cretaceous.—*Geol. Mag.*, v. 101, No. 5, Sept.-Oct. 1964, p. 421-434, text fig. 1 (map), table 1.—Depth interpretations of Upper Cretaceous sediments from the continental margin of North America suggest deposition in water less than 200 meters deep, and imply a continental shelf wider than at present. Even evidence from seamounts fails to support the existence of oceanic depths within the North Atlantic Basin. It is postulated that the North Atlantic was smaller ($\frac{1}{2}$ to $\frac{2}{3}$ its present size) in the Upper Cretaceous and that the Mid-Atlantic Ridge was a post-Cretaceous addition to it.
- FURSENKO, A. V., and GILEVICH, R. V. O Transgressivnoj Izmenchivosti Foraminifer iz Gruppy *Lenticulina kasanzevi*.—*Izvestija Vysshikh Uchebnykh Zavedenij, Geol. Razved.*, No. 1, 1965, p. 45-54, text figs. 1-3, table 1.—Comparison of measurements of *Lenticulina kasanzevi* and *L. ilovaikii* sp. n.
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- GIBSON, LEE B., and PERCIVAL, STEPHEN F., JR. La présence stratigraphique d'*Orbitolina* et de *Praealveolina* dans le centre de la république de Somalie.—*Mém. Bureau de Recherches Géol. et Min.*, No. 32, Colloque Internat. de Micropaléont. (Dakar, 6-11 mai 1963), 1965, p. 335-346, pl. 1, text figs. 1, 2 (map, distrib. chart).—In Cenomanian and Albian.
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- 283, pls. 1-5 (geol. sections, distrib. and abund. table, foram drawings), text figs. 1-4 (map, graph, distrib. and abund. table, correl. chart).—Description and illustrations of the agglutinating Foraminifera (43 species, none new) of the Flysch marls of the Vienna Woods. Stratigraphic subdivisions of the interval Maestrichtian to Ilerdian are based on maxima or absence of *Psammosiphonella*, *Dendrophrya*, and *Glomospira*.
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- HANSE, ALBERTE. Les microfaunes en Angola.—Mém. Bureau de Recherches Géol. et Min., No. 32, Colloque Internat. de Micropaléont. (Dakar, 6-11 mai 1963), 1965, p. 327-334, map, zone chart.—Lists of species and zonation by planktonics.
- HANZAWA, SHOSHIRO. The ontogeny and the evolution of Larger Foraminifera.—Sci. Repts. Tohoku Univ., 2nd Ser. (Geol.), v. 36, No. 2, Feb. 15, 1965, p. 239-256, pls. 30-40, table 1.—Eight Cenozoic families (nummulites and orbitoids) are discussed in general terms and illustrated by drawings, with phylogenetic lines indicated between genera.
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- KATSHARAVA, M. V. On the development of Paleogene Planktonic Foraminifers in Georgia (English summary of Russian text), in Problems of the Geology of Georgia, Paleontology-Stratigraphy.—Acad. Sci. Georgian SSR, Tbilisi, 1964, p. 323-330.
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- 2, graph.—Foraminifera recorded in a deep-sea core in the Norwegian Sea with 7 horizons noted in the 271-cm. core.
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- TZANKOV, V., KAMENOVA, J., SIMEONOV, A., and VAPTZAROVA, JA. La stratigraphie du Crétacé Supérieur entre les vallées de la rivière Ossam et le Danub—Bulgarie du Nord (French summary of Bulgarian text).—*Ann. Univ. Sofia, Fac. Geol. Geogr.*, livr. 1, Geol., tom 57, 1962/1963, 1964, p. 217-240, pls. 1-8.—Includes photomicrographs of typical Foraminifera assemblages between Cenomanian and Maestrichtian.
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- VIOTTI, CARLO. Microfaunes et microfaciès du sondage Puerto Consado 1 (Maroc Méridional—Province de Tarfaya).—*Mém. Bureau de Recherches Géol. et Min.*, No. 32, Colloque Internat. de Micropaléont. (Dakar, 6-11 mai 1963), 1965, p. 29-60, pls. 1-10, text fig. 1 (columnar sections), table 1 (range chart), range chart, correl. chart.—Includes listing of Foraminifera from Cenomanian to Lower Jurassic, with thin section illustrations of some Jurassic species.
- VITERBO, I. Examen micropaléontologique du Crétacé du Maroc Méridional (Bassin côtier de Tarfaya).—*Mém. Bureau de Recherches Géol. et Min.*, No. 32, Colloque Internat. de Micropaléont. (Dakar, 6-11 mai 1963), 1965, p. 61-100, pls. 1-11, text figs. 1, 2 (maps), tables 1-3 (range charts).—Includes illustrations of assemblages of planktonic Foraminifera from various ages between Albian and Maestrichtian.
- WALTERS, R. The *Globorotalia zealandica* and *G. miozea* lineages.—*New Zealand Jour. Geol. Geophysics*, v. 8, No. 1, Feb. 1965, p. 109-127, text figs. 1-8 (maps, range chart, graphs, lineage diagram, outline drawings).—Description and illustration of 2 gradational series covering the interval between Otaian-Hutchinsonian and Kapitean. Four new subspecies are recognized (2 each in *Globorotalia zealandica* and *G. miozea*).

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