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92. NOTE ON *GLOBIGERINA CONCINNA* REUSS 1850

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The value of pelagic foraminifera for stratigraphic zonation has been stressed on many occasions during recent years and is now widely accepted. Minor differences in the morphology of the test, wall structure, arrangement of chambers and apertures, size, etc. are recognised as being of decisive specific or sub-specific value. Authors describing such forms often did not pay sufficient attention to these facts, thus species names frequently found a wider application than they really deserved. In many cases this led to a seemingly longer life range which again reduced the value of the form as a stratigraphic index fossil.

Determinations of most authors seem to have been based in the past on comparison with illustrations only. Type figures are, as it is well known, often not very accurately drawn, especially those of some older authors who showed the tendency to conventionalize their objects. Where minor morphological differences are recognised as being of specific and stratigraphic value, determinations based on such drawings alone can, therefore, not be of the accuracy and reliability required by present day working standards.

A good example of the latitude of a species name is that of *Globigerina bulloides* Orbigny which was originally described as Recent from the Adriatic Sea near Rimini, Italy. Subsequently it appeared in the literature as being present throughout the stratigraphic column from the Lower Cretaceous to the Present. As far as can be ascertained by the writer, typical representatives of this species do not appear before the Middle-Upper Miocene. So often has *Globigerina bulloides* been cited from Lower Cretaceous to Recent (Cushman, 1941) that the name must have been applied many times without much consideration, apparently based on similarity with d'Orbigny's 1839 drawings (no type figure was given by him in his original description in 1826).

Another species name that has been used with almost as much laxness as *Globigerina bulloides* is *Globigerina concinna* Reuss. Reuss described and figured under this name a *Globigerina* of 0.5-0.6 mm. diameter with a 5 chambered whorl surrounding a wide open umbilicus (Text figures 1, 1a). The material originated from Grinzing near Vienna, the age being given as Tertiary.

According to a letter received from R. Grill (Vienna) most of Reuss' original material — including *Globigerina concinna* — can no longer be located and must, therefore, be considered lost. A direct comparison of species of *Globigerina* believed to be identical with Reuss' original *Globigerina concinna* (the only way to arrive at reliable determinations) is thus no longer possible. Dr. Grill also states in his letter that the "Tegel" of Grinzing, from which Reuss' *Globigerina concinna* appears to originate, is Tortonian (Upper Miocene) in age.

Globigerina concinna has been cited by various subsequent authors as occurring in beds ranging from the Lower Oligocene to Recent. Some of those references follow:

In Trinidad, B.W.I., a *Globigerina* cf. *concinna* has been described from the lower part of the Cipero formation (Lower Oligocene) by Cushman and Stainforth, 1945, (Text figures 3, 3a). It is known there to have a very limited range and thus useful as an excellent stratigraphic marker. This Lower Oligocene *Globigerina* and probably some others from the Pliocene and Recent described under the name of *Globigerina concinna* possibly are homonymous.

As far as can be judged from Reuss' figures there are certain morphological affinities between his Upper Miocene form and the Lower Oligocene specimens from Trinidad. Both display a wide, open umbilicus, surrounded by five chambers. The chambers of the Miocene type, however, increase in size more rapidly than in the Oligocene one. Further, the size of 0.5-0.6 mm. as given by Reuss varies considerably from the Lower Oligocene Trinidadian forms (which vary between only 0.3-0.4 mm.). Reuss' size range has been observed in specimens which are apparently identical with the original material from the Badener Tegel, Soos, near Baden, Austria (material kindly supplied by R. Grill). In addition, *Globigerina* cf. *concinna* known to be restricted to the Lower Oligocene of Trinidad has apparently no direct phylogenetic relations with the species described by Reuss from the Upper Miocene.

Based on the above mentioned observations the following new name for the Lower Oligocene form is, therefore, proposed:

Globigerina ciperoensis Bolli nov. spec.

Text figures 3, 3a; 4, 4a, 4b

Globigerina concinna REUSS, 1850.—NUTTALL, 1932, Jour. Pal., Vol. 6, p. 29, pl. 6, figs. 9-11.—FRANKLIN, 1944, Jour. Pal., Vol. 18, p. 317, pl. 48, fig. 5.

Globigerina cf. *concinna* REUSS, 1850.—CUSHMAN and STAINFORTH, 1945, Cushman Lab. Foram. Research, Special Pub. No. 14, p. 67, pl. 13, figs. 1a, 1b.

Test low to medium trochoid, last whorl consisting of 5 chambers, the first one often only partly visible from the umbilical side. Chambers globular, gently in-

The pore plugs reveal a meshed structure when critically differentiated in thionin (Plate 1, Fig. 14). It is difficult to determine whether the exceedingly minute (less than 0.5 micron in diameter), colorless interstices between the darkly-stained elements of this meshwork actually penetrate the entire disc or not, but they do suggest that the structure is itself micro-porous, and in favorable preparations it is possible to impregnate the micro-pores and leave the surrounding matrix unstained. The nature of the pore plugs may be of great physiological significance and should eventually be studied with the higher magnification of an electron microscope. Myers (1943) in his studies on various species of *Tretomphalus* observed that the "smaller pseudopodial pores are spanned by a pigmented film that prevents the escape of gametes, and it is obvious that only protoplasm or other substances in a sol state could pass this membrane." Le Calvez (1947) considers that the thickened portion of the organic layer of *Discorbis erecta* (which corresponds to the pore plugs of *Discorinopsis aguayoi*) is inseparable from the rest of the organic layer and cannot be penetrated to permit "une communication directe entre le protoplasme d'une loge et l'extérieur." He has concluded that the pores are blind and never permit the protoplasm to contact the outside medium. The meshwork observed in *Discorinopsis aguayoi,* however, indicates that the pore plugs themselves may actually possess pores of sufficient magnitude to permit an effective exchange not only by osmotic processes, as implied by Le Calvez, but by actual pseudopodial transfer as well.

Both Le Calvez (1947) and Bonte (1936) have described more complicated structural organization within the tests of the forms on which they worked than have been detected in *Discorinopsis aguayoi.* Le Calvez described sections in the protoplasmic remains of decalcified specimens of *Discorbis erecta* which bear numerous sequentially-formed discs representing the points of contact between the thickened organic layer and successively formed calcareous layers. In *D. erecta* a new layer of calcium carbonate is deposited as each chamber is added, so that the resultant test when seen in section shows successive layers of calcium carbonate. The contact between the inner opening of the pore and the underlying calcareous layer is marked by the thickened organic discs that apparently serve to close the pores and prevent protoplasmic contact with the surrounding medium except through the oral regions. The discs of *D. erecta* are apparently never discharged from their position in the organic layer. Bonte (1936) listed five elements in the test of *Cristellaria landinensis* and *Nodosaria raphanistrum:*

1. La coquille calcaire
2. La membrane perforée externe
3. La couche des piliers (couche celluleuse)
4. La membrane perforée interne (couche granuleuse)
5. La membrane chitineuse interne (capsule interne)

He stated, however, that elements 2, 3 and 4 comprise a chitinous layer which is generally impregnated with calcium carbonate (No. 1). The "chitinous layer" (No. 5) probably corresponds to the undifferentiated organic layer observed in *Discorinopsis aguayoi.*

The exact nature of the attachment between the pore plugs and the organic layer has not been determined, nor does it seem probable that it can be determined by the methods employed in this study. Each plug seems to fit tightly into a protruding cone of the organic layer, which, in turn, fits snugly into the base of the pore tube of the calcareous layer. Certainly the plugs, for the most part, remain within the external mouth of the truncated cones in which they are situated long after the protoplasmic elements of the animal vanish and even after the violent action of decalcification with excessively strong hydrochloric acid. The only indication that their attachment may not be a permanent one lies in the observation that the pore plugs are rather easily dislodged from the organic-test matrix during the process of grinding thin sections of undecalcified tests. Although it does seem that the attachment is a permanent one, it is conceivable that the pore plugs could act as valves to permit the escape of the pseudopodia and then close the pores as soon as the pseudopodia are retracted, but there is no evidence of such action.

If the pore plugs are ultimately found to be permanently attached (and the evidence for this appears very strong at the present time) within the conical elevations of the organic layer in *Discorinopsis aguayoi,* they can then be stated to differ as fundamentally from the "foraminal plugs" or "bouchons" as do the "disques sombres" observed in *Discorbis erecta* by Le Calvez (1947).

There is a striking superficial similarity between the "bouchons" and the pore plugs of *Discorinopsis,* although the pore plugs are lenticular in cross section rather than rectangular as they are in *Elphidium* and *Planorbulina.* Foraminal plugs *in situ* within the decalcified, hematoxylin-stained, protoplasmic body of *Elphidium crispum* are illustrated in Plate 1, Fig. 15. The plugs are approximately 12 microns in diameter and 3 microns in thickness, but they lie between the contiguous protoplasmic elements of adjacent chambers and are not imbedded or entrapped within an organic-test layer as they are in the specimens of *Discorinopsis aguayoi.* Jepps (1942) and Le Calvez (1947) have indicated that the foraminal plugs may have hollow centers or be solid and imperforate, another point of contrast with the micro-porous pore plugs of *D. aguayoi.* Foraminal plugs, furthermore, are frequently, and possibly periodically, discharged from their position in the test, whereas there is no evidence for dislodgement of the pore plugs during the normal life activities of *Discorinopsis aguayoi.* The pore plugs must, therefore, be considered more nearly comparable to the "disques sombres" of *Discorbis erecta* than to the "bouchons" or "foraminal plugs" of *Elphidium crispum* and *Planorbulina mediterranensis*.

The ventral surface filling.—The shell material which is presumably deposited as a secondary filling over the ventral surface of specimens of *Discorinopsis aguayoi* shows certain variations of fundamental significance. In some specimens, particularly those which most closely resemble the typical variety, the ventral filling is a spongy, almost frothy, mat of hyaline shell material which resembles a mass of coalescing bubbles spread over a portion or nearly all of the ventral surface. In other specimens — the *vadescens* variety[1] — the filling is spread like dense, smooth, porcellanous cake frosting over the ventral surface. Topotypic specimens of *D. gunteri* compared by the writer resemble the *vadescens* type more than they do the typical variety. The ventral filling of the topotypic specimens was suggestive of the formation seen in the test of the *vadescens* variety illustrated in Plate 1, figure 4, and of the asterigerine plates described by Carpenter, Parker and Jones (1862) in *Discorbina vesicularis,* a form which might possibly be referred to the genus *Discorinopsis* on the basis of this similarity.

In the *vadescens* variety there is no indication of the frothy surface texture of the typical variety, but variations in the actual quantity of ventral filling range from an almost complete and unbroken encrustation over the ventral chambers to a very loose network of thin, interlaced lines of porcellanous material. All gradations between the two extremes can be observed in the suites of specimens obtained from laboratory cultures.

The ventral filling of either of the above types may at times be tightly appressed to the ventral chamber walls, but at other times it is raised above the surface of the chambers at a few or many points. As a general rule the filling does not extend to the periphery of the test, and in some cases it appears to have been cut away or dissolved peripherally and no longer in contact with the subjacent chamber walls. As the dissolution of the ventral surfaces of the outer chambers begins, portions of the ventral filling become detached from the disappearing walls and the interior of the test becomes visible under the filling. Portions of the filling may be carried away with the lost fragments of the ventral chamber walls, and the pressure of the escaping young could tear other portions away from their tenuous points of attachment to the ever-thinning chamber walls. The remaining sections of the ventral filling overlie the inner whorl of intact chambers after the outer ventral walls have been dissolved and the young have escaped. In such specimens a prominent space between the filling and the inner chamber walls is observable, representing the space previously occupied by the dissolved chamber walls. This seems to indicate a solubility differential between the dissolved walls and the secondary filling, an exhaustion of the solvent action before the ventral filling is reduced, or a very carefully regulated solution mechanism which selectively removes the critical obstacles to escape and leaves the unimportant elements more or less intact.

The over-all picture of the ventral filling strongly suggests the possibility of the evolutionary origin of the Amphisteginidae from a form similar to this which deposits shell material over its ventral surface, frequently leaving an intervening space which may be divided into quasi-chambers by the irregular furrows and ridges of the secondarily deposited filling. Some specimens from laboratory cultures (Plate 1, Figure 4, for example) bear a rather close superficial appearance to the asterigerine-plate-bearing *Discorbina vesicularis* illustrated by Carpenter, Parker and Jones (1862) in their Plate XIII, Figure 3.

The ventral dissolution of chambers.—Prior to the liberation of young individuals the ventral surfaces of some of the outer chambers are dissolved to make an escape hatch for the developing young. The reproductive processes involved in the life cycle of *Discorinopsis aguayoi* are not understood, but asexual reproduction involving the liberation of numerous incompletely developed young from the parent test was observed during the early days of this study. The dissolution of the ventral chambers probably occurs shortly before the developing young are ready to leave the parental incubation chambers and generally involves only the ventral surfaces of the outermost quarter- or half-whorl of adult chambers. The inner whorl typically remains intact along with the overlying remnant of the ventral filling. The fine, though very subtle, control which initiates and regulates the solution of the ventral surfaces of only the outer adult chambers of the last whorl is interesting to contemplate in its physiological complexity, but only the results of the process and not its mechanism have been observed in the present study.

Adventitious chambers.—The development of adventitious or supernumerary chambers is another frequently observed variation in these laboratory materials. Six of the 100 specimens set aside as a basic, randomly sampled group in this study show adventitious chambers, and in a second group of 100 randomly selected individuals, 9 had additional or aberrant chambers of the same type. Extra chambers may be formed on all whorls, but appear to develop on the outer whorl with slightly greater frequency than they do on the innermost whorl. They develop with approximately equal frequency on porcellanous and hyaline forms. Aberrant chambers forming on porcellanous forms vary in color from milky white to porcellanous, but those forming on hyaline tests are typically colorless and hyaline, although most of the normal chambers may be orange-brown in color. The pores of the adventitious chambers of both types appear to fall within

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[1] Several of the type specimens of **D. vadescens** show an identical ventral filling.

the size and frequency range of the pores on the normal chambers.

Adventitious chambers may be spherical, oval, or irregular in shape, and it is not uncommon to find two or three fused together on the dorsal or marginal surface of one of the regular chambers.

The ventral surfaces of the normal chambers seem to be relatively, if not totally, immune from the development of secondary chambers, a possible correlate of the attachment habit of the species. In a few instances adventitious chambers have formed so close to the margin of the test as to extend partially onto the ventral surface, but in every case of this type the adventitious chamber stops short when it encounters the secondary filling. This may indicate that the secondary filling forms before the extra chamber does and then serves to inhibit its growth on the ventral surface of the test.

Tests with two to four separate groups of adventitious chambers have been found, and it is sometimes difficult to distinguish between single tests with numerous adventitious chambers and double or multiple tests. (Plate 2, Figures 8 and 9.)

Rhumbler (1911) considered a series of test anomalies involving the formation of adventitious chambers to be regeneration phenomena. Some of the adventitious chambers observed in *Discorinopsis aguayoi* may represent regenerated surfaces, but most of them show no evidence whatsoever of subjacent ruptures in the test-wall, so they have been treated separately from the forms resulting from regenerative activities.

Double or multiple tests.—Rhumbler (1911) in his treatment of double or multiple tests divided such anomalies into three groups: (1) *"Spaltungsmonstra"* (split monsters) — single, unilocular individuals which for one reason or another have divided the normal sequence of chambers into one or more secondary or adventitious series; (2) *"echte Doppelschalen"* (true double-shells) — resulting from the permanent fusion of two (or more) individuals and characterized by the possession of two proloculi; (3) *"Koppelschalen"* (coupled shells) — paired or multiple tests, resulting from the temporary union of animals for the purpose of exchanging gametes (the equivalent of Myers', 1933, plastogamic pairs, as observed in *Patellina corrugata* Williamson).

Two of the three types have been encountered in specimens of *Discorinopsis aguayoi* from laboratory cultures. Individuals with a single proloculus but with an adventitious series of chambers of the type illustrated in Plate 2, Figure 4, have been observed. A more complex variation, involving the proliferation of more numerous chambers and a grotesque distortion of the principal axes of growth is shown in Figure 8 of the same plate. In each of these individuals only a single proloculus was developed, and the animals are therefore of the type designated *"Spaltungsmonstra"* by Rhumbler.

Individuals produced by the permanent fusion of two or more tests (true double or multiple tests) are illustrated in Figures 13 and 14-16 of Plate 2. Two ventral surfaces are visible (but not illustrated) on the individual in Figure 13, but the proloculus of the partially-hidden test is not discernible. In this case the dorsal surface of one animal has been fused obliquely onto the ventral surface of a larger specimen. The pair illustrated in Figures 14-16 was formed by the fusion of the dorsal surfaces of two individuals of approximately equal size.

SUMMARY

1. A study of variation in laboratory specimens of *Discorinopsis aguayoi* (Bermudez) indicates that *D. vadescens* Cushman and Bronnimann should be considered a variety of the former species, since variants of the former produce an unbroken sequence from the typical form to forms which appear identical with some of the paratypes of the latter.
2. The typical variety is distinguished from the *vadescens* variety on the basis of the degree of porcellanization and the nature of the secondary filling of the ventral surface of the test.
3. The test of the species consists of an organic layer and a laminated, calcareous layer.
4. At the base of the pores of the calcareous layer of the test lie organic pore plugs which resemble the "disques sombres" of *Discorbis erecta* more than they do the "foraminal plugs" or "bouchons" of *Elphidium crispum* and *Planorbulina mediterranensis.*
5. Only one pore plug is present in each pore of *D. aguayoi,* while several are deposited in sequence in *Discorbis erecta.* The pore plugs of the former are microporous, in contrast to the imperforate condition of the latter.
6. The variation observed in several additional morphological and ontogenetic features is described.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 1, JANUARY, 1954

94. SOME EOCENE FORAMINIFERA FROM THE BAVARIAN ALPS AND ADJACENT AREAS

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ABSTRACT—This paper deals with new or little known smaller Foraminifera from the Eocene in the Bavarian Alps and adjacent regions. One new genus, two new species, one new subspecies, and two new names are proposed for Foraminifera collected in the calcareous "Stockletten" marls of middle and upper Eocene age.

INTRODUCTION

The monograph on the Eocene of the regions of Kressenberg and Neubeuern (Bavaria) published by Gümbel (1868) appears to be little used by European micropaleontologists. It is a general tendency of European workers to compare their materials with species published from the Eocene of Mexico and Cuba rather than with those described and figured by Gümbel (see f.i., Cita, 1950). There is no question that close relationships exist between Europe and the Caribbean region in Eocene time, but there is a great need for a taxonomic revision of the European species. Cushman (1937 a, b, c, etc.) has done valuable work in this respect and given excellent revisions of species published by Gümbel, Hantken, Terquem, Halkyard and others, but still more intensive work will have to be done in future and it is hoped that this paper will clear up some misunderstandings in foraminiferal taxonomy of some Eocene genera and species.

The type material for Gümbel's monograph, unfortunately, was destroyed during the last war, and the only collection still available in Munich are topotypes collected and determined by Gümbel's assistant, C. Schwager. The writer has added new material to this topotype-collection from the famous localities in the Kressenberg and Neubeuern region. All types, mentioned in the present paper are deposited in the collections of the Institute of Paleontology and Historical Geology at the University of Munich (Coll. Munich Prot.).

MATERIAL

The Foraminifera described and discussed below come from beds termed "Stockletten" by Bavarian geologists, a series of light yellowish or bluish-grey calcareous marls, interfingered with compact and dense whitish *Lithothamnion*-limestones (so-called "Granitmarmor") containing *Nummulites complanatus* Lam. and *Assilina exponens* (Sow.). The lower part of the "Stockletten" marls are of Upper Lutetian, the upper part of Ledian age. Detailed descriptions of this marl series, which forms part of the sediments of the so-called "Helveticum" (a stratigraphic and tectonic unit N of the flysch zone and S of the subalpine Molasse trough in the Bavarian Alps), have recently been given

EXPLANATION OF PLATE 3

FIGS.		PAGE
1-4.	*Gaudryinella schröderi* Hagn n. sp. 1, Holotype, Mattsee near Salzburg. Coll. Munich Prot. 272. × 30; 2, Paratype, Coll. Munich Prot. 274-a, × 30; 3, Paratype, Coll. Munich Prot. 274-b; in upper part of test a fourth angle appears so that transverse section becomes irregularly quadrate. × 30; 4, Paratype, Coll. Munich Prot. 274-c: juvenile form. × 30.	15
5-8.	*Karreriella subglabra* (Gümbel). 5, Hypotype. Dandlberg near Neubeuern, Bavaria. Coll. Munich Prot. 275, × 50; 6, Hypotype, road from Neubeuern to Nussdorf. Inn valley, Bavaria, Coll. Munich Prot. 276, × 50; 7, Hypotype, road from Rohrdorf to Langweid, Neubeuern, Bavaria, Coll. Munich Prot. 277a, × 50; 8, Hypotype, from same locality as 7, 8a, side view, 8b edge view. Coll. Munich Prot. 277b, × 50.	16
9.	*Bulimina arndti* Hagn. Hypotype, for comparison with fig. 10, Chattian, Wildenwart, Prien valley, Bavaria. Coll. Munich Prot. 280, × 80.	17
10.	*Bulimina subtruncana* Hagn nom. nov., Hypotype (for holotype see Plate 4, fig. 9). Kirchberg near Neubeuern, Bavaria. Coll. Munich. Prot. 279, × 80.	17
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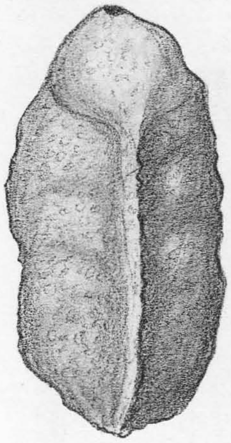
13.	*Bulimina truncana* Gümbel. Hypotype. Kirchberg near Neubeuern, Bavaria. Coll. Munich Prot. 278, × 80.	16
14.	*Mississippina dehmi* Hagn n. sp. Holotype. 14a, dorsal view; 14b, ventral view. Hammer near Kressenberg, Bavaria. Coll. Munich Prot. 271, × 36.	19
15.	*Schlosserina asterites* (Gümbel). Genoholotype. 15a, dorsal view; 15b, ventral view. w.s.: whitish, nearly opaque wall; c.sp.: clear spaces filled with hyaline shell material; p: pores in septal face of last-formed chamber; a.o.: additional openings. Rollgraben near Kressenberg, Bavaria. Coll. Munich Prot. 272, × 36.	18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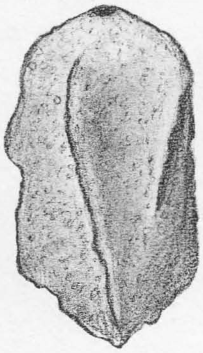
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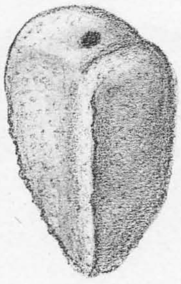
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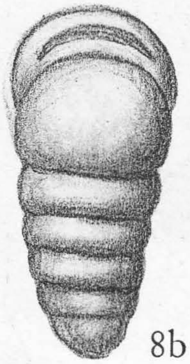
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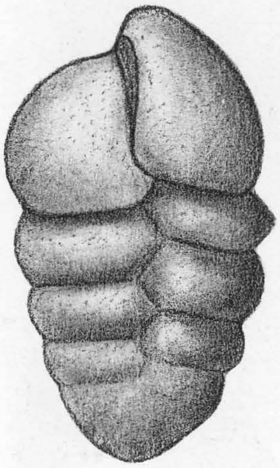
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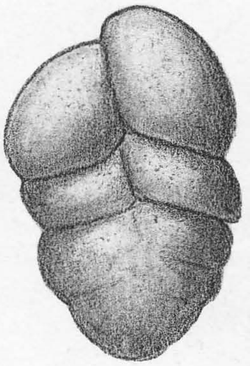
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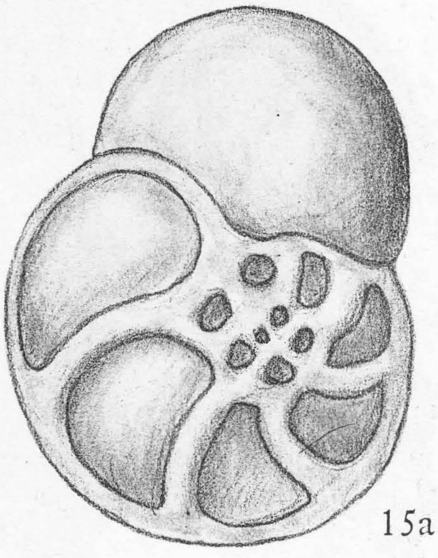
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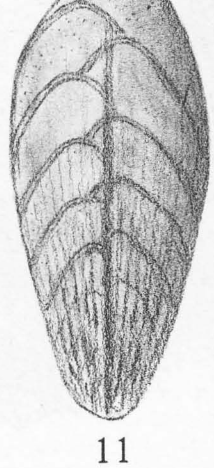
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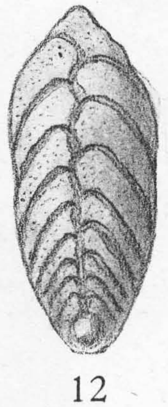
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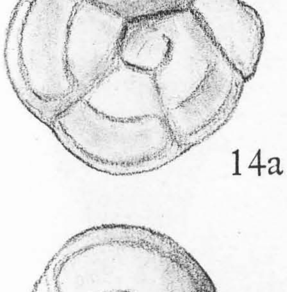
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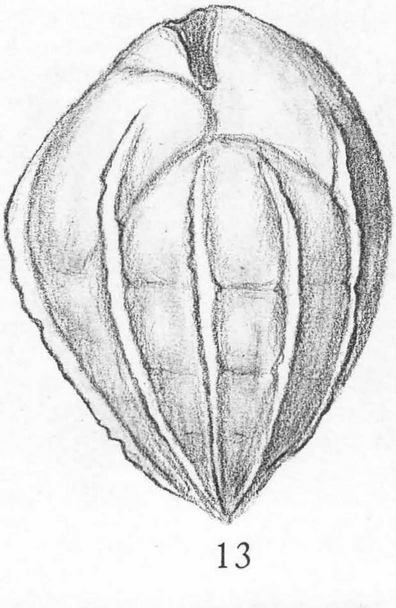
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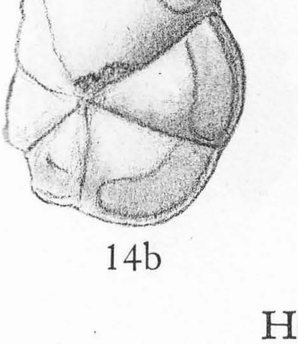
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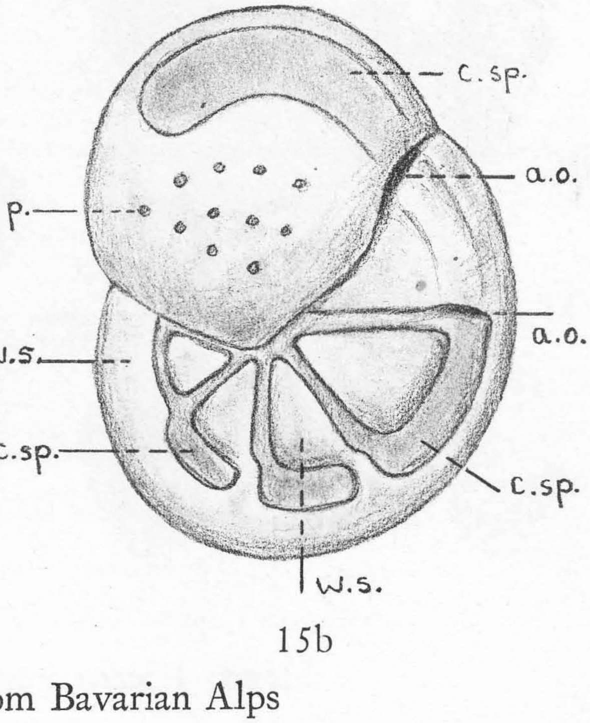

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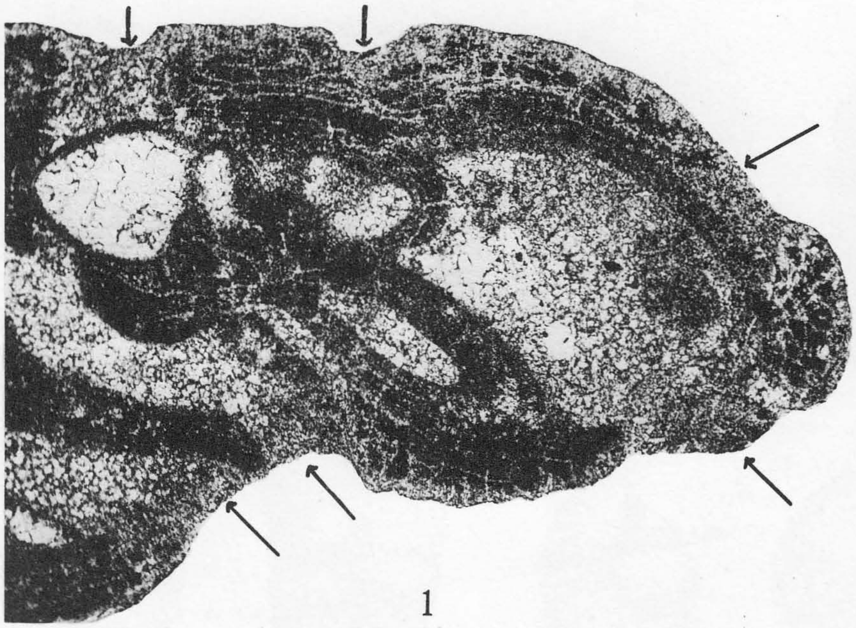
Hagn: Eocene Foraminifera from Bavarian Alps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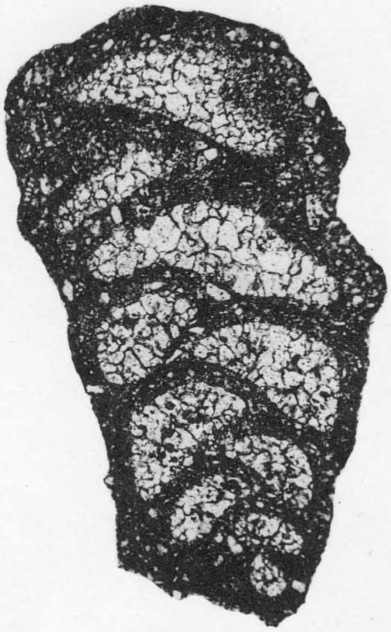
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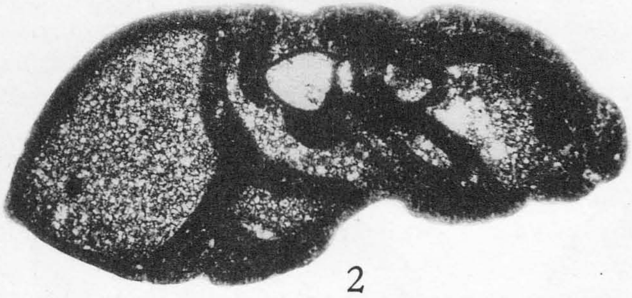
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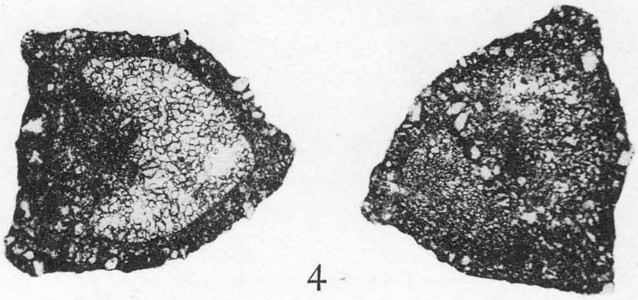
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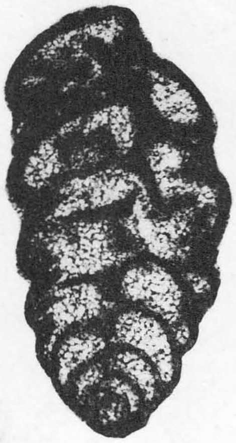
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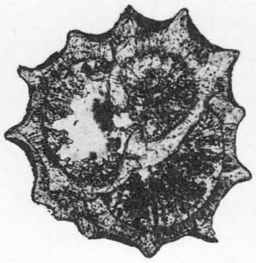
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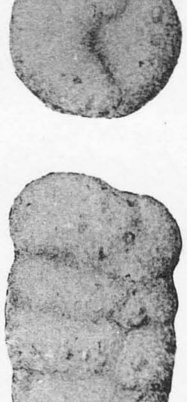
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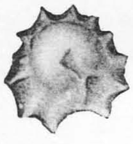

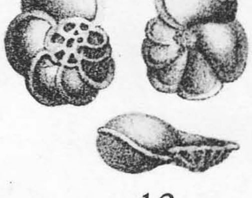
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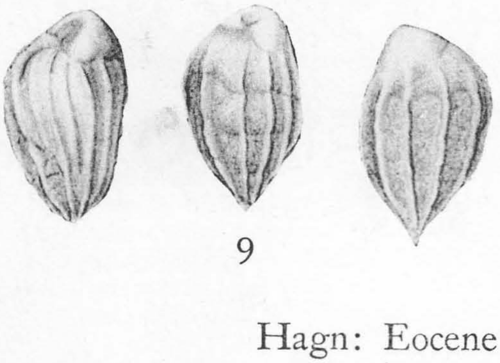
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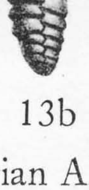
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Hagn: Eocene Foraminifera from Bavarian Alps by Hagn (1952). One species is described from the same marls near Salzburg, Austria.

SYSTEMATIC DESCRIPTION OF FORAMINIFERA

Family VERNEUILINIDAE

Genus **Gaudryinella** Plummer, 1931

Gaudryinella schröderi Hagn, n. sp.

Plate 3, figures 1-4; Plate 4, figures 3, 4

Description.—Test elongate, rarely slightly curved, tapering in early portion, nearly parallel sides in adult portion, irregularly triangular in cross section with one side narrower than the other two, distinctly angled. In some specimens upper portion of test with a fourth angle showing a quadrate form in cross-section. Initial part of test triserial and comparatively small; biserial portion well developed, making up most of test and tending to become uniserial; chambers indistinct in initial part, later ones distinct and gently inflated; sutures generally indistinct, the last formed ones slightly depressed; wall finely arenaceous with much cement and including occasionally larger quartz grains; surface appears rather rough; aperture terminal, rounded, on a slight elevation of the youngest chamber; in biserial stage the rounded aperture slightly removed from the base of last-formed chamber and not yet terminal.

Dimensions.—Length: holotype 1.52 mm., width 0.72 mm.; ratio of length to width in paratypes: 1.5 : 0.7; 1.3 : 0.6; 0.9 : 0.55 (juvenile forms).

Occurrence.—Holotype from Mattsee, near Salzburg, Austria. Upper Lutetian, "Stockletten." This species has not yet been found elsewhere in the Bavarian Eocene.

Derivation of name.—Species named in honor of Joachim Schröder, Professor at the Institute of Paleontology and Historical Geology, University of Munich.

Relationships.—This new species is allocated to the genus *Gaudryinella* Plummer, 1931, because its biserial stage tends towards a uniserial development. The genus *Bermudezina* Cushman, 1937, shows similarity but is completely biserial in its adult stage, excepting *B. elegans* Keijzer (lower Oligocene, Cuba), which becomes slightly uniserial. According to Cushman (1937 a, p. 102) *Bermudezina* developed during Oligocene from *Pseudogaudryina* Cushman, 1936, but recently a form from the Campanian of California, *Bermudezina extans,* was described by Bandy, 1951.

Our new species resembles the genus *Pseudogaudryinella* in that one side is narrow and truncate, but differs from it in lacking rounded, inflated, uniserial chambers (note the distinctly angled section of the uniserial chamber figured on Plate 3, fig. 4). From *Gaudryinella cubana* Cushman and Bermudez, 1936, it differs in its triangular (not quadrate) aspect and in having less distinct sutures and chambers, although there is a close resemblance, at least in cross section, with megalospheric forms of the Cuban species (see Cushman, 1937-a, pl. 14, fig. 23b). Great similarity exists between

EXPLANATION OF PLATE 4

Figs.		Page
1, 2.	*Schlosserina asterites* (Gümbel). 1, Axial section showing structure of test. Arrows point to deposits of clear shell material. Slide No. 138b/53 from Rollgraben near Kressenberg, Bavaria. × 94; 2, Same. × 40.	18
3, 4.	*Gaudryinella schröderi* Hagn n. sp. 3, Longitudinal section showing biserial portion of test with its tendency to develop uniserially arranged chambers. Wall is finely arenaceous with some larger quartz grains. Slide No. 139b/53. Mattsee near Salzburg, Austria. × 54; 4, Cross section of two specimens. Slide No. 140b/53. × 54.	15
5-7.	*Karreriella subglabra* (Gümbel). 5, Longitudinal section of a slightly deformed specimen. Septa in middle of test partly broken and removed from original position. Lower part of each chamber slightly undercut giving truncate appearance. Slide No. 135b/53. Road from Rohrdorf to Langweid near Neubeuern, Bavaria. × 54; 6, Interior of pyrite-filled test, septa distorted but unbroken, wall finely arenaceous with much cement; same locality as fig. 5. Slide No. 136b/53. × 54; 7, Strongly deformed specimen with septa folded and partially removed from former position; same locality as figs. 5 and 6. Slide No. 136b/53. × 54.	16
8.	*Bulimina truncana* Gümbel. Calcareous wall perforated by numerous fine pores. Slide No. 137b/53. Kirchberg near Neubeuern, Bavaria. × 54.	16
9.	*Bulimina subtruncana* Hagn nom. nov. This is *Bulimina truncana* Cushman and Parker (non Gümbel) from Eocene of Budapest, Hungary. Figures copied from Cushman and Parker, 1947, U. S. Geol. Surv., Prof. Pap. 210, pl. 21, figs. 7, 8a-c. (Holotype: Cushman and Parker's figures 8a-c).	16
10, 11.	*Dorothia fallax* Hagn nom. nov. 10, This is *Dorothia subglabra* Cushman (non Gümbel) from "Eocene, Häring, Tyrol, Austria" copied from Cushman, 1937, Cushman Lab. Foram. Research, Spec. Publ. No. 8, pl. 9, figs. 13a, b).; 11, From Rollgraben near Kressenberg, Bavaria. This specimen is the holotype, copied from Cushman, 1937, Cushman Lab. Foram. Research, Spec. Publ. No. 8, pl. 21, figs. 14a, b.	16
12.	*Schlosserina asterites* (Gümbel). Copy of Gümbel's *Rosalina asterites* (see Gümbel, 1868, pl. 2, figs. 101a-c).	18
13.	*Karreriella subglabra* (Gümbel). Copy of Gümbel's *Gaudryina subglabra* (see Gümbel, 1868, pl. 1, figs. 4a, b).	16
14.	*Bulimina truncana* Gümbel, taken from Gümbel, 1868, pl. 2, figs. 77a, b.	16

(Note: The thin sections have been prepared with the artificial resin "Polestar." See: Hagn, H., 1953, The Micropaleontologist, vol. 7, No. 1, pp. 34-43.)

G. schröderi and *Bermudezina pleionensis* (Cushman) from the Hungarian Miocene, at least in general appearance, but the latter species has a smoother surface and more distinct sutures and chambers.

Types and Depository.—Holotype, Collection Munich, Prot. 273; paratypes, Collection Munich Prot. 274a-c.

Family VALVULINIDAE

Genus **Karreriella** Cushman, 1933

Karreriella subglabra (Gümbel)

Plate 3, figures 5-8; Plate 4, figures 5-7, 13

Synonymy.—*Gaudryina subglabra* Gümbel, 1868, Abhandl. k. bayer. Akad. Wiss., II Cl., vol. 10, p. 24, pl. 1, figs. 4a-b. [*Non: Dorothia subglabra* (Gümbel) in Cushman, 1937, Cushman Lab. Foram. Research, Spec. Publ. 8, p. 86, pl. 9, figs. 13, 14.]

Description.—Test rather stout, usually one and one-half times as long as broad, tapering, initial end rounded or gently pointed; slightly compressed; periphery broadly rounded, lobulate, greatest breadth somewhat above middle of test or toward apertural end; earliest whorl with 4 or 5 chambers, later becoming triserial; adult biserial specimens occasionally twisted; biserial part of test mostly built up by 4 or 5 pairs of chambers; chambers in initial portion indistinct, in adult stage very distinct, slightly overlapping, somewhat inflated especially the two last-formed ones; chambers increase in breadth as added, their height somewhat variable; two last-formed chambers about twice as high as the preceding ones; lowermost part of each chamber usually more or less under-cut, producing peculiar aspect in side view (see Plate 4, figs. 5-7); sutures indistinct in initial portion, quite distinct in biserial stage, somewhat oblique and strongly depressed; wall finely arenaceous with much cement; surface smooth; aperture an elongate, low, arched slit just above the base of the apertural face, with a distinct lip.

Specimens of this species are often deformed even when the concomitant fauna does not show any signs of deformation. Last-formed chambers are often strongly compressed and distorted in all directions. Longitudinal sections reveal septa which are partly removed from their original position and mostly folded or broken. Only in specimens with tests filled with mineral substance (pyrite) is the degree of deformation lessened, because, obviously, infiltration with pyrite occurred prior to deformation of test. The peculiar under-cutting of the lower part of the chambers appears to be partly due to the original flexibility of the finely arenaceous test.

Dimensions.—Length 0.63 to 0.9 mm.; breadth 0.3 to 0.5 mm.

Occurrence.—This species is widely distributed in the Eocene of the northern, and probably also of the southern Alps. The writer observed it in the Ledian *Globigerina*-shales of Varignano near Riva, Garda Lake, Italy and it is quite possible that *Karreriella chapapotensis* (Cole) cited by Cita (1950) from the western shore of Lake Garda is identical with *K. subglabra* (Gümbel). In the "Stockletten" marls this species is so abundant that it can hardly be overlooked in an assemblage. Gümbel (1868, p. 25) records it also from the "Mergel des Nummulitenkalkes am Hammer im Traunthal."

Relationships.—*Karreriella calva* Cushman, 1936, is probably a synonym of *K. subglabra* (Gumb.). No essential differences can be seen between the two species. *K. calva* was described by Cushman from Gassino near Turin and is recorded by the same author from lower Oligocene of Häring in Tyrol, and from Siegsdorf.

K. chapapotensis (Cole) from the Mexican upper Eocene shows similarity in general appearance with our form but differs in being stouter, exhibiting fewer and higher chambers and having a slightly more rounded cross-section of the test. The already mentioned record of Cita (1950, p. 87) refers apparently to *K. subglabra* rather than to *K. chapapotensis.* In *K. arenasensis* Cushman and Bermudez, Eocene of Cuba, the initial end is more pointed, the general form more slender, and the initial portion more multi-chambered than in *K. subglabra. K. chilostoma* (Reuss) from the North-German Oligocene *Septaria*-clay is a small form compared with *K. subglabra* and possesses quite distinct sutures and a differently shaped aperture.

Remarks.—Cushman (1937 b, p. 86, pl. 9, figs. 13, 14) described and figured specimens of *Dorothia subglabra* (Gümbel) which, to this writer, do not appear to be identical with Gümbel's species. Gümbel's species shows an elongate, low, arched aperture like in *Karreriella* (see his original figure reproduced on Plate 4, figs. 13a, b) and not a re-entrant like in *Dorothia* or *Gaudryina* (compare Plate 4, figs. 10 and 11). *Dorothia subglabra* Cushman (non Gümbel), moreover, is coarsely arenaceous with indistinct depressed sutures, whereas *Karerriella subglabra* (Gümbel) has a smooth bright surface and strongly depressed sutures. For this reason *Dorothia fallax* nom. nov. is herewith proposed for the above-cited *Dorothia subglabra* Cushman (non Gümbel) with holotype Figure 14a and b on Plate 9 in Cushman, 1937-b (see also Plate 4, fig. 11 of this paper). The type-locality of the new named form is Rollgraben, near Kressenberg, Bavaria.

Types and depository.—Hypotypes, Collection Munich, Prot. 275, 276, 277a, b.

Family BULIMINIDAE

Genus **Bulimina** Orbigny, 1826

Bulimina truncana Gümbel

Plate 3, figure 13; Plate 4, figures 8, 14

Synonymy.—*Bulimina truncana* Gümbel, 1868, loc. cit., p. 66, pl. 2, figs. 77a, b. (*Non: Bulimina truncana* Gümbel in: Cushman and Parker, 1947, U. S. Geol. Surv., Prof. Pap. 210-D, p. 89, pl. 21, figs. 7, 8.)

Description.—Test usually one and one-half times as long as broad, somewhat stout, tapering rapidly; initial end pointed; apertural end broadly rounded; cross-section of test rounded; chambers numerous, fairly distinct; sutures flush, distinct only in well-preserved specimens; wall finely perforate, surface ornamented by 8 to 12 fairly high, thin, plate-like longitudinal costae reaching from acute initial portion without interruption to lower half of last-formed whorl with outer margin slightly serrate; aperture elongate, comma-shaped, with slightly developed lip. In addition to the stout rapidly tapering forms there are larger and slender tests which may represent the microspheric generation.

Dimensions.—Length: 0.69 to 0.90 mm.; breadth: 0.50 to 0.55 mm. [Gümbel (1868, p. 66) measured forms 1.4 mm. long and 1.1 mm. broad, regarded by the writer as being probably inaccurate measurements].

Occurrence.—Gümbel's *B. truncana* is one of the most striking species in the "Stockletten" marls. He states (1868, p. 67) that this species, however, is "sehr selten im Nummulitenmergel von Hammer, im Granitmarmor von Sinning." The writer collected this species in outcrops near the swimming-pool at Siegsdorf and in the *Globigerina* shales of Varignano near Riva, Lake Garda, Italy.

Relationships.—The upper Eocene (Jacksonian) *Bulimina jacksonensis* Cushman from the Gulf States, U.S.A., differs from *B. truncana* Gümbel in its more slender test and fewer costae (six to eight). Comparison of the two species was made with topotype material from Cocoa Post Office, Alabama, kindly furnished by A. R. Loeblich, Jr. (Washington, D.C.). *B. jacksonensis* Cushman, cited by Bolli (1951, p. 111) from the so-called "Stadschiefer" of the Swiss Alps, a stratigraphic equivalent of the "Stockletten" marls of Bavaria, seems to the writer to be a *Bulimina truncana* Gümbel.

Remarks.—*Bulimina truncana* Gümbel in Cushman and Parker (see reference above under synonymy) is, apparently not Gümbel's species. Their specimen (Cushman and Parker, 1947, loc. cit., pl. 21, figs. 7, 8) is distinctly smaller in size, shows triangularity in cross-section, a different shape of the last-formed chamber and a different aperture than exemplified in the original *B. truncana* Gümbel 1868. For these reasons *Bulimina subtruncana* nom. nov. is herewith proposed for *Bulimina truncana* Cushman and Parker, 1947 (*non* Gümbel, 1868). Holotype: pl. 21, fig. 8 of Cushman and Parker, 1947, U. S. Geol. Surv. Prof. Pap. 210; type-locality: *Clavulinoides szaboi* beds, Budapest, Hungary. Our hypotype (see Plate 3, fig. 10) is from the Eocene "Stockletten" marls, Neubeuern, Inn Valley. The new-named species also occurs in the Eocene of Biarritz, France, in cores (submarine) from off the Eastern Coast of U.S.A. (Eocene), and was found by the writer in Ledian and Lattorfian beds of the Lake Garda region, Italy. It is quite possible that *Bulimina alazanensis* Cushman, cited by Bolli (1951, p. 111) from the Eocene of the Swiss Alps might be conspecific with *B. subtruncana*. *Bulimina alazanensis* Cushman from the Mexican Oligocene has fewer, somewhat coarser and more irregular costae than *B. subtruncana*. *B. arndti* Hagn from the Chattian of Prien Valley, Bavaria is longer and tapers less rapidly than *B. subtruncana* (see Hagn and Hölzl, 1952, p. 168, pl. 2, fig. 15). A hypotype of *B. arndti* Hagn from the Chattian of Bavaria is figured on Plate 3, fig. 9 for comparison purposes.

Types and depository.—Hypotype of *Bulimina truncana* Gümbel: Collection Munich Prot. 278; hypotype of *B. subtruncana* nom. nov., Collection Munich Prot. 279; hypotype of *B. arndti* Hagn, Collection Munich Prot. 280.

Genus **Bolivina** Orbigny, 1839

Bolivina vaceki Schubert

Plate 3, figure 11

Synonymy.—*Bolivina vaceki* Schubert, 1902, Beitr. Pal. Geol. Osterreich-Ungarns. etc., vol. 14, p. 25, pl. 1, fig. 29.

Description.—Test elongate, two and one-half to three times as long as broad, tapering throughout, greatest breadth just above middle of test, initial end rounded; sides strongly compressed, gently carinate in median line; periphery not lobulate, distinctly carinate without hyaline wing-like flange; chambers distinct, low, twice as broad as high, slightly overlapping; sutures distinct, oblique, strongly curved, flush with surface; wall finely perforate, ornamented, at least in lower half of test, by numerous fine longitudinal costae; aperture narrow, elongate.

Dimensions.—Length: 0.61 mm.; breadth: 0.25 mm.; thickness: 0.1 mm.

Occurrence.—Schubert (1902) described this species from "lower Oligocene" (now regarded to be upper Eocene) of Cologna near Riva, Lake Garda, Italy. It occurs in nearly all samples collected from "Stockletten" marls in the Neubeuern region, Inn Valley, Bavaria. *Bulimina striatella* Bandy, cited by Bolli (1951, p. 112) from the Eocene of the Swiss Alps most possibly belongs to *B. vaceki* Schubert.

Relationships.—The Italian upper Eocene *Bolivina striatocarinata* Cushman (Cushman, 1937c, p. 54, pl. 7, fig. 16) is similar to *B. vaceki* Schubert but differs in its higher and much less compressed chambers.

Type and depository.—Hypotype, Collection Munich Prot. 281.

Bolivina vaceki Schubert subsp. **glabra** Hagn, n. subsp.

Plate 3, figure 12

This new subspecies differs from the type species in lacking the longitudinal costae on the surface of the test, in being somewhat smaller in size and in having slightly limbate sutures. As in the type, the keel in the median line of the test is fairly distinct.

Dimensions.—Length: 0.42 mm.; breadth: 0.2 mm.; thickness: 0.05 mm.

Occurrence.—The holotype was found in the Jobsten quarry near Kressenberg, Bavaria. The new subspecies has also been observed in the *Globigerina* marls of Varignano near Riva, Lake Garda, Italy, a stratigraphic equivalent of the beds at Cologna from which Schubert described the type species. It appears, however, that species and subspecies do not occur together.

Derivation of name.—From the Latin *glaber* = smooth, not ornamented.

Relationships.—The new subspecies is closely allied to *Bolivina carinata* Terquem from the Lutetian of the Paris Basin. According to Cushman's figures (1937c, pl. 6, figs. 14-16) the French species is broader in relation to the length of the test, with higher chambers and more strongly curved sutures.

Type and depository.—Holotype, Collection Munich Prot. 282.

Family ROTALIIDAE

Subfamily EPISTOMININAE

Genus **Schlosserina** Hagn, gen. nov.

Genoholotype: *Schlosserina asterites* (Gümbel) = *Rosalina asterites* Gümbel 1868

Generic Diagnosis.—Test biconvex with low trochoid spire; dorsal sutures broad and limbate, ventral sutures depressed and connected with the "clear spaces" of ventral side; aperture complex: 1) a slit at base of last-formed chamber, 2) deepenings, or clear spaces, on ventral side of each chamber, near periphery, closed by secondary hyaline shell substance, 3) pores on septal face of last-formed chamber, 4) additional openings along septa of last-formed chamber in the neighborhood of the periphery; wall finely perforate, dense, with deposits of clear secondary shell material on dorsal and ventral side, especially near the "clear spaces" of the ventral side; interior of test subdivided by secondary septa.

Generic relationships.—This new genus differs from *Stomatorbina* Dorreen, 1948, mainly in the possession of a more complex apertural system and in having deposits of clear shell material on the chambers of the dorsal side of the test; moreover, the interior of the test is subdivided by secondary septa. Another closely related genus is *Mississippina* Howe, 1930. Both genera show clear shell material deposited on the dorsal side of the test but *Mississippina* has depressed sutures on the dorsal side and its aperture extends to the periphery in adult tests. *Poroeponides* Cushman, 1944 has, like *Schlosserina,* the septal face of the last-formed chamber punctured by numerous rounded openings and exhibits an open umbilicus which is not present in *Schlosserina.*

Derivation of name.—The genus is named in honor of the late Max Schlosser, Professor of Geology and Paleontology at the University of Munich.

Occurrence of genus.—Fairly well-distributed in the European Alpine Eocene according to present records. With its complex apertural system this genus represents a highly specialized form of possible biostratigraphic value.

Schlosserina asterites (Gümbel)

Plate 3, figures 15a, b; Plate 4, figures 1, 2

Synonymy.—*Rosalina asterites* Gümbel, 1868, loc. cit., p. 80, pl. 2, figs. 101a-c.

Description.—Test somewhat longer than broad, biconvex, dorsal side more convex than ventral side; 6 chambers in adult whorl; ventral side involute showing only chambers of last-formed whorl, slightly and narrowly umbilicate; periphery with thick, rounded keel, lobulate only on last-formed chamber; chambers increasing rapidly in size with last-formed one greatly inflated, surpassing the preceding chambers in size; sutures on dorsal side curved, broadly thickened obscuring the earlier chambers in central area; on ventral side, sutures straight, radial, depressed and opening into umbilicus; wall finely perforate, dense, appearing whitish but due to weathering nearly opaque with deposits of clear secondary shell material on both dorsal and ventral sides; clear shell mass on dorsal side rests upon perforate wall; this shell mass partly interrupted or substituted by secondary shell material on ventral side of test; aperture complex: an indistinct ventral slit at base of last-formed chamber, deepenings on ventral side of each chamber near periphery, spirally elongated and filled with clear shell substance corresponding probably to supplementary apertures, numerous (up to about 12) regularly arranged pores in strongly inflated septal face of last-formed chamber and additional openings along septa of youngest-formed chamber; without distinct lip. This complex aperture is pictured on Plate 3, fig. 15b.

Dimensions.—Length: 1.5 mm.; breadth: 1.25 mm.; thickness: 0.7 mm.

Occurrence.—The genoholotype comes from the "Stockletten" marls of the Rollgraben near Kressenberg (Schwager's Collection). Same species also found by the writer in same marls at Sinning in the Neubeuern region. Gümbel (1868) records his species from the marls at Hammer and Götzreuther Graben and from the "Granitmarmor" of Sinning near Neubeuern. Hantken (1875, p. 75) found the species in the lower parts of the *Clavulinoides szaboi* beds (upper Eocene, Ofen beds) near Budapest. It is possible that it also occurs in the Dalmatian Eocene [see *Eponides concentricus* in De Witt Puyt (1941, p. 44) with which species *"Rosalina" asterites* Gümbel has sometimes been confused].

Relationships.—A close relationship exists between *Schlosserina asterites* (Gümbel) and *Stomatorbina torrei* (Cushman and Bermudez) found in the Eocene of Cuba, United States of America, and New Zealand. Unfortunately, the writer had no specimens of *Stomatorbina torrei* available for studying closely the apertural characteristics and the behaviour of the clear shell material on the ventral side of *Stomatorbina.*

Brady (1884, p. 690), for some unknown reasons, attributed Gümbel's species to *"Pulvinulina" menardii* Orb. (= *Globorotalia menardii* auct.) which is not justified. Uhlig (1886, p. 190, pl. 3, figs. 3 and 4) gave an excellent description of *"Rosalina" asterites* which he, however, allocated to *"Pulvinulina" concentrica* Parker and Jones. His specimens came from the Eocene Wola Luzanska beds in the Carpathians. Concerning the peripheral depressions of the chambers on the ventral side of his species, Uhlig writes: "Dieselben könnten vielleicht am ehestens als Narben ehemaliger randlicher Mündungen betrachtet werden, wie sie bei der *elegans*-Gruppe der Gattung *Pulvinulina* (*Epistomina* Terquem) bekannt geworden sind."

Unfortunately, the writer had no access to a recent publication by Uchio (1952) in which, according to a reference in R. Todd (Cushman Found. Foram. Research, Contr., vol. 4, p. 40, 1953) Uchio allocates *"Pulvinulina" concentrica* Parker and Jones to the genus *Mississippina* Howe, and discusses the relationships of this latter genus with *Stomatorbina* Dorreen. As far as the writer is aware, however, the recent *"Pulvinulina" concentrica* Parker and Jones (from off the Shetland Islands) is certainly not identical with our *Schlosserina asterites* (Gümbel).

Type and depository.—Genoholotype, Collection Munich Prot. 272.

Genus **Mississippina** Howe, 1930

Mississippina dehmi Hagn, n. sp.

Plate 3, figures 14a, b

Description.—Test somewhat longer than broad, biconvex, ventral side more convex than dorsal side, trochoid with tendency to planispiral arrangement of chambers; dorsal side strongly involute for one and one-half whorl; adult whorl with 5 chambers; ventral side involute throughout, only 5 chambers of last-formed whorl visible, slightly umbilicate; periphery acute, distinctly lobulate; chambers on dorsal side rapidly increasing in size, nearly as high as broad, gently inflated; chambers on ventral side slightly higher than broad, triangular, fairly inflated; sutures on dorsal side slightly depressed and curved, nearly radial; sutures on ventral side distinctly depressed. On both dorsal and ventral sides, wall of each chamber just below periphery, with clear spirally elongated narrow spaces which are slightly thinner and gently depressed against the surrounding wall; last-formed chamber of figured specimen partially broken, aperture, therefore, incompletely known.

Dimensions.—Length: 0.9 mm.; breadth: 0.7 mm.; thickness: 0.3 mm.

Occurrence.—Holotype from "Stockletten" marls of Hammer near Kressenberg, Bavaria (Collection Schwager).

Derivation of name.—Species named in honor of Richard Dehm, Professor of Geology, University of Munich, Institute of Paleontology and Historical Geology.

Relationships.—Our species agrees with the generic diagnosis given in Cushman (1948, p. 296). *Mississippina monsouri* Howe from the Oligocene of Mississippi, U.S.A., differs from the new species in having the spiral and dorsal sides more evolute and the umbilical region more open; furthermore, the adult whorl contains two more chambers, the periphery is more rounded and the diameter of the Oligocene species smaller. *Mississippina pacifica* Parr, recent from off the eastern coast in Tasmania, has a stronger compressed test, is more involute, with the last-formed whorl made up by 9 (against 5) chambers and shows a higher developed planispiral chamber-arrangement than *M. dehmi.*

Remarks.—This is, to the writer's knowledge, the first record of the genus *Mississippina* in the European Eocene. Bermudez (1952, p. 35) gives the stratigraphic range as lower and middle Oligocene, but apparently *Mississippina occurs* already in the middle Eocene and extends into Recent.

Type and depository.—Holotype, Collection Munich Prot. 271.

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creasing in size. Wall finely spinose. Large umbilicus with apertures of each chamber opening into it. Diameter 0.3-0.4 mm.

Type Locality: Northern end of Cipero Coast, South of San Fernando, Trinidad, B.W.I.

Type Level: *Globigerina ciperoensis* zone, Cipero formation, Lower Oligocene.

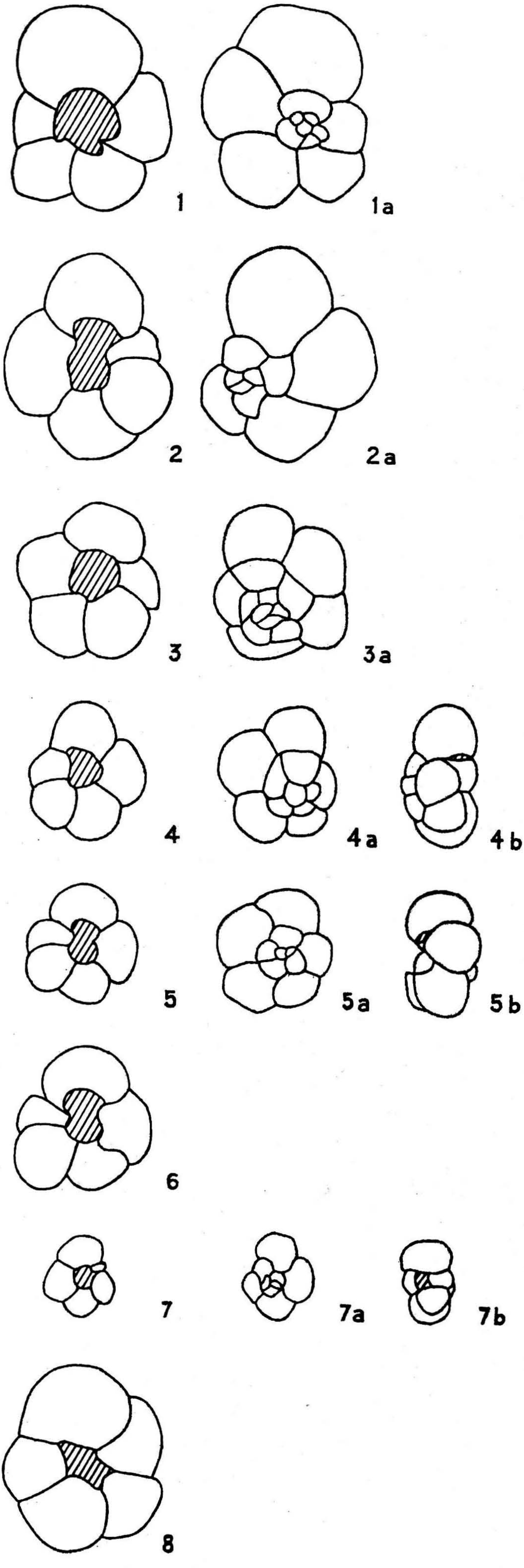
Type Specimen: Pl. 13, figs. 1a, 1b, in: Cushman, J. A. and Stainforth, R. M., 1945. Will be deposited in the Collections of the Cushman Foundation.

No direct comparison with the Lower Oligocene forms described by Nuttall, 1932, (Text figures 5, 5a, 5b) and Franklin, 1944, (Text figure 6) as *Globigerina concinna* has been made, but from the stratigraphic position and figures given it appears most likely that the forms are synonymous with *Globigerina ciperoensis* from Trinidad.

The writer is pleased to mention that his observations on the Lower Oligocene form have been confirmed by P. J. Bermudez (Caracas), who, according to a letter dated July 30, 1953, independently arrived at the same conclusions.

Globigerina concinna Reuss, described and figured by Marks, 1951 (Text figures 2, 2a), from the Miocene of the Vienna Basin is probably identical with Reuss' form. Galloway and Wissler, 1928, described *Globigerina concinna* from the Pleistocene of California (Text figures 7, 7a, 7b). This form is considerably smaller (0.2 mm.) than the original of Reuss (0.5-0.6 mm.), either a dwarfed or juvenile or more likely a different species.

The umbilical view only of a *Globigerina concinna* from the Pliocene of Panama is given by Coryell and Mossman, 1942 (Text figure 8). The size of 0.45 mm. conforms approximately with Reuss' original but the chambers appear to be less globular and lobate, and the umbilicus is not as open or wide.



TEXT FIGURES 1 - 8

(Nos. 1-3, 5-8 are line drawings of published figures)
All figures × 50

Figs. 1, 1a *Globigerina concinna* Reuss (Reuss, 1850, p. 373, pl. 47, fig. 8).

Figs. 2, 2a *Globigerina concinna* Reuss (Marks, 1951, p. 70, pl. 8, figs. 6a, b).

Figs. 3, 3a *Globigerina ciperoensis* Bolli, nov. spec. (*Globigerina* cf. *concinna* Reuss of Cushman and Stainforth, 1945, p. 67, pl. 13, figs. 1a, 1b). Holotype.

Figs. 4, 4a, 4b *Globigerina ciperoensis* Bolli, nov. spec. *Globigerina ciperoensis* zone, Cipero formation (Oligocene), Cipero Coast, South Trinidad (Type Locality) (Trinidad Leaseholds Ltd., Cat. No. 193,265).

Figs. 5, 5a, 5b *Globigerina ciperoensis* Bolli, nov. spec. (*Globigerina concinna* Reuss of Nuttall, 1932, p. 29, pl. 6, figs. 9-11).

Fig. 6 *Globigerina ciperoensis* Bolli, nov. spec. (*Globigerina concinna* Reuss of Franklin, 1944, p. 317, pl. 48, fig. 5).

Figs. 7, 7a, 7b *Globigerina ? concinna* (*Globigerina concinna* Reuss of Galloway and Wissler, 1928, p. 41, pl. 7, fig. 7).

Fig. 8 *Globigerina* sp. (*Globigerina concinna* of Coryell and Mossman, 1942, p. 238, pl. 36, fig. 27).

Colom, 1952, described a recent form of *Globigerina concinna* from the coast of Galicia in which the figures deviate considerably from those of Reuss. He is, however, now of the opinion that his determination as *Globigerina concinna* can not be maintained. (Personal communication).

Based on the present state of knowledge regarding the short life ranges of most *Globigerina* species the following conclusions are reached:

1) the type species, *Globigerina concinna* Reuss 1850 is no longer accessible for comparative purposes;
2) the dorsal and ventral views of this species as illustrated by Reuss are possibly conventionalized, therefore,

all *Globigerina concinna* determinations in beds other than Miocene should be regarded with doubt.

In general more care should be exercised in the application of "popular" *Globigerina* names such as *concinna, bulloides,* etc., especially in cases when the specimens differ in age from that of the type species.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
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93. *DISCORINOPSIS AGUAYOI* (BERMUDEZ) AND *DISCORINOPSIS VADESCENS* CUSHMAN AND BRONNIMANN: A STUDY OF VARIATION IN CULTURES OF LIVING FORAMINIFERA[1]

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INTRODUCTION

During the course of a study of the cytology and life history of **Allogromia laticollaris** Arnold from laboratory cultures, large numbers of discorbid foraminifers belonging to the genus **Discorinopsis** developed in the cultures. Culture populations of this calcareous species could be differentiated into two groups which grade almost imperceptibly into one another: one group had extreme variants which resemble **Discorinopsis aguayoi** (Bermudez) very closely[2] and are here termed the "typical variety"; the other group had extreme variants which appear conspecific with **D. vadescens** Cushman and Bronnimann and are here termed the **"vadescens"** variety of **D. aguayoi.** The present study has been conducted to shed some light upon the relationship between the two groups by a detailed description of the variations observed in specimens taken from the laboratory cultures.

MATERIALS, METHODS, AND ECOLOGICAL RELATIONSHIPS

The original collections for starting the laboratory cultures were made from the warm, littoral waters of the Bay of Saint Andrew at Panama City, Florida, in June of 1946. The actual depth of the water at the time of collecting ranged from one to three feet, and the foraminifers were obtained by washing turtle grass in shallow enamel pans and retaining the materials thus removed. These washings were transferred a distance of 300 miles by means of refrigerated culture containers; the foraminifers were sorted from the remaining debris and then placed in finger-bowls containing nutrient sea water and unicellular algae. After a period of experimentation with various nutrient media, Føyn's "Erdschreiber" (Føyn, 1934) was found to produce the best growth of food organisms and was routinely used thereafter. A mixture of unicellular algae, including a species of *Chrysosphaera* and unidentified pennate diatoms, was used as the food source for the foraminifers. Associated organisms included *Allogromia laticollaris* Arnold, several miliolid foraminifers, including a species resembling *Spiroloculina hyalina* Schulze, a large uroleptid ciliate (*Uroleptus* cf. *U. muscorum*), an aphasmid nematode, and the following filamentous algae:

Oscillatoria chlorina Gom.
O. amphibia Gom.
Lyngbya lagerheimii Gom.
Anabaena sp.

In addition, several species of smaller flagellate protozoa and unidentified bacteria were normally present in the cultures.

The highest temperature recorded in the water on the collecting date was 32° C., with an observed range extending from 28° C. in the immediate collecting area. The discorbid forms flourished in an inland laboratory at Emory University, Atlanta, Georgia, where temperatures frequently attained or exceeded 32° C., and they managed to survive periods of near-freezing temperatures on numerous occasions. They were eventually transferred across the continent and lived for more than a year in the cooler laboratory temperatures of Berkeley, California; but within two years after their transfer to the cooler climate (average room temperature between 23 and 26° C.), they had all perished. Experiments have shown that the species can survive relatively great extremes of temperature if subjected to them for short periods, but it is probable that the average temperature in the northern California laboratory was lower than the lower thermal limit for successful reproduction and maintenance of the species. The animals lived normal lives but apparently failed to reproduce. This hypothesis is in keeping with the present information concerning the distribution of *D. aguayoi* (Bermudez) and *D. vadescens* Cushman and Bronnimann, forms which have been reported only from the warm waters of the Gulf of Mexico and the Caribbean Sea. The only other species within the genus, *D. gunteri* Cole, is so far known only from the fossil record, but the paleoecological evidence indicates that the environment in which it occurs was probably as mild as the one in which the living representatives of the genus now thrive.

No information can be obtained concerning the salinity of the water at the type locality of *D. aguayoi,* but Parker, Phleger and Peirson (1953) reported it only from the brackish environments of the Matagorda Island and Grassy Point marshes of the coast of Texas. *D. vadescens* has been reported only from the brackish water of a Trinidad mangrove swamp (Cushman and Bronnimann, 1948). Laboratory specimens were grown in salinities ranging from 20 to 57 parts per thousand, indicating a wide salinity tolerance.

The detailed morphology of the test is best studied in sectioned preparations. The following method has been devised for this purpose and yields preparations which can be studied under the highest magnifications

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[1] A contribution from the Museum of Paleontology, University of California, Berkeley.

[2] Identified by Miss Frances L. Parker, Scripps Inst. of Oceanography, La Jolla, California.

of the compound microscope; it is only at such magnifications that critical structural relationships within the test itself become apparent. Specimens are first decalcified in weak hydrochloric acid. Bonte (1936) recommends the use of a 1:100 dilution in the study of fossil tests, but in our experience, the only precaution necessary is to prevent excessive effervescence which would rupture the delicate chamber walls. An insoluble organic layer is left following decalcification, and it is this transparent layer which becomes the subject of further treatment. This organic "moullage" is stained for a few moments in a fairly strong aqueous solution of thionin. The staining process can be observed under the microscope and concluded when the "pores" become distinctly darker than their organic matrix. If the specimen is overstained it may be destained or suitably differentiated in a very weak solution of nitric acid. The specimens are then thoroughly rinsed in distilled water, passed through a graded series of dehydrating alcohols, cleared in xylol and mounted in piccolyte or other suitable medium. For some purposes it may be desirable to obtain a refractive rather than a color image of the structures in the organic layer, in which case the staining process may be omitted and the subsequent steps completed as described. It is frequently desirable to flatten portions of the organic layer to facilitate subsequent microscopical examination. This can best be accomplished with finely sharpened entomology needles (mounted in suitable wooden handles) while the specimens are still immersed in a drop of water or glycerine under the dissecting microscope. Flattening should not be attempted after the specimens have been treated with xylol, since this fluid hardens the organic test and renders it quite brittle.

The observations recorded below were based on the study of living animals, empty tests prepared as described above, sectioned tests, and protoplasm-filled, decalcified tests sectioned serially at 10 microns and stained according to routine cytological procedures. All illustrated specimens of empty tests have been filed in the micropaleontological collections of the Museum of Paleontology of the University of California at Berkeley under Accession Number 1435.

TAXONOMIC BACKGROUND AND COMPARISONS

When the tests were first set aside for separate treatment several specimens were identified by Miss Parker as belonging to the species *Discorinopsis aguayoi* (Bermudez). As she made the identification, Miss Parker indicated the probable synonymy of *D. vadescens* Cushman and Bronniman, a synonymy which was subsequently published (Parker, Phleger and Peirson, 1953). Specimens examined by Pedro J. Bermudez were pronounced conspecific with his Cuban materials and topotypes were sent by him to the author for comparative study. These topotypes have been deposited in the University of California micropaleontological collections under Accession Number 1248 of the Museum of Paleontology.

The species *Discorinopsis aguayoi* was originally described within the genus *Discorbis* by Bermudez (1935) on the basis of specimens collected from undescribed stations off the northwest coast of Cuba. They were glassy or hyaline in appearance and the principal feature which seemed to distinguish these specimens from other discorbids was the ventral filling, termed a "callo vitreo" by Bermudez. It is interesting to note that Bermudez mentions only a vitreous filling and never a porcellanous one in his original description.

Cushman (1933) described a very large, finely perforate, Recent species, *Discorbis bartletti,* from Fox Basin, Canada, which he later (1948) referred to the genus *Discorinopsis.*

Cole, in 1941, established the genus *Discorinopsis* to include discorbid rotalids with the "umbilical area closed by a spongy mass of shell material" and established *D. gunteri* from the middle Eocene (*Dictyoconus cookei* zone) of Florida as the genoholotype. In his type description he did not further characterize the spongy filling as to its texture, density, color, or relative opacity.

Seven topotypes of *D. gunteri* were loaned the writer by W. Storrs Cole for comparison with laboratory specimens. These specimens, which Cole considered "entirely typical both in size and structure," were almost completely re-crystallized, so it was not possible to make a detailed comparison with them, but it is certainly obvious that this Eocene species belongs to the peculiar complex of forms bearing a secondary ventral filling of the type so well developed in *D. aguayoi.* On the basis of the examination of the *D. gunteri* topotypes, however, it seems that they resemble the *vadescens* variety of *D. aguayoi* more than they resemble the typical variety. The subsequent discussion will cover the details of these similarities.

Cushman and Bronnimann (1948) described a form from the Recent muds of a mangrove swamp on the west coast of Trinidad under the name *Discorinopsis vadescens,* stating that the "ventral side (was) covered with a secondary growth of irregular shape." They further observed that the "species differs from *D. gunteri* Cole in the much smaller size, larger number of chambers in the adult whorl, and much more complex ventral side."

Parker, Phleger and Peirson (1953) observed that: "There are slight differences between the specimens of Bermudez and those of Cushman and Bronnimann, but they appear to be insufficient for specific differentiation." The only differences discussed by these authors, however, are those of number of chambers in the outer whorl and maximum test diameter of the two forms.

A suite of type specimens of *D. vadescens* consisting of the holotype (Cushman Collection No. 56647) and 33 paratypes (Cushman Collection Nos. 56648 and 56751) has been compared by the author with the materials from laboratory cultures. These types are most certainly conspecific with the specimens obtained from cultures. Among the paratypes are specimens which are indistinguishable from examples of the *vadescens* variety of *D. aguayoi,* but of greater taxonomic interest are those which are identical with laboratory specimens of the typical *D. aguayoi* variety. The size range of the type specimens falls well within the range shown by laboratory specimens, and in every other feature the type suite parallels observed variants obtained from laboratory cultures.

MORPHOLOGICAL OBSERVATIONS

In the presentation which follows, these characteristic test features are discussed in sequence: color, texture and light-transmitting qualities, size, contortion, limbation, apertures, direction of coiling, lobation, pores and the relation between the organic and calcareous layers, ventral surface filling, ventral dissolution of chambers, adventitious chambers, and double or multiple tests. The observed variation of these features and the gradation of a variant from one extreme to another are emphasized, illustrating one method by which our understanding of such variants and infraspecific relationships can be increased.

Color.—The color of the test of this species is correlated with its texture, quasi-porcellanous forms (the *vadescens* variety) being generally pearly-white in color, whereas hyaline or vitreous forms (the typical variety) are either colorless, grey or burnt orange. The inner chambers of transparent adult tests are typically brownish or reddish orange for the first half- or three-quarter-whorl, and the remaining chambers are usually greyish or colorless and hyaline. Occasionally the pigmentation extends throughout the entire adult test, but the outer chambers generally appear less intensely colored than the inner ones. The *vadescens* variety may at times also exhibit some test pigmentation.

Texture and light-transmitting qualities.—There is in the laboratory populations of this species a closely graded progression from completely hyaline tests on the one hand to quasi-porcellanous ones on the other. The luster and opacity of the latter type, when viewed with reflected illumination, are highly comparable to the appearance of truly porcellanous miliolids, although the pores remain prominent in the tests of the discorbids, giving them a very distinctive appearance. When viewed with transmitted light, the discorbid tests are brownish, but less strongly so than most miliolids. All of the chambers of some tests develop porcellaneity, but only the outer chambers of others show it. In a small percentage of tests the inner chambers are brownish red by reflected light, and the outer chambers are porcellanous. The contrast is very striking! In most cases, however, the inner chambers are monotonously grey and transparent. No tests have been found which show porcellanization of the inner chambers only, so it seems that there is an inalterable sequence in the development of this character: hyalinity or porcellaneity may each develop to the complete exclusion of the other, but if both are developed, the ontogenetic sequence is invariably from hyaline to porcellanous and never *vice versa.*

Carpenter, Parker, and Jones (1862) noted porcellanization in *Planorbulina vulgaris* and considered the changes to be post-mortem, saying that in hyaline or vitreous tests "which have been long dead and exposed to the action of sea-water, the vitreous transparency often gives place to a lustrous white opacity, that is particularly striking in the prominent tubercles." The possibility of post-mortem porcellanization in the laboratory specimens of *D. aguayoi* can be eliminated, since the observed variations in texture occur in the tests of living as well as dead individuals, and tests which have lain empty in cultures for many months have shown no observable change in their texture or light-transmitting qualities.

Wood (1949), in his interesting historical survey of the usage of the terms "porcellanous," "perforate," "hyaline," and "imperforate," has emphasized the fact that "there is no *necessary* correlation between perforate and hyaline, and imperforate and porcellaneous . . ." He observes that it is not unusual for perforate forms to appear porcellanous, noting that many "rotalids, such as for instance *Epistomina elegans,* appear almost as porcellaneous as a miliolid." Wood attributes this appearance, in part at least, to the size of the pores and the thickness of the test, saying that when "the pores are coarser, the light rays are more strongly bent," and when there is an "increase in thickness of the test, the chances of refraction of the light rays are increased, and a sub-porcellaneous appearance becomes characteristic of forms with both delicate and coarse perforations." Wood implies, however, that other factors may be involved, since the very thick, imperforate pillars or sutural thickenings of the rotalids may appear glassy clear.

Preliminary observations on laboratory specimens of *D. aguayoi* indicate that the degree of porcellanization does vary with test thickness. The average wall thickness of the outer chambers of hyaline tests is less than half that of some specimens of the porcellanous (*vadescens*) variety which attain a thickness of 10-15 microns on the average. Additional data are required, however, before a statistically valid conclusion concerning the relationship between porcellaneity and wall thickness can be made.

Test size.—Measured laboratory specimens have a range in length from 60 to 750 microns and a range in breadth from 35 to 400 microns. These measurements include juvenile as well as adult forms. The average size of the 5 measured co-types of *D. aguayoi* and of 16 topotypic specimens sent the writer by P. J. Bermudez is well above the average of the measured laboratory populations, but the measurements on Bermudez' specimens were all of adult forms. In every other respect Bermudez' specimens fall well within the observed range of variation found in laboratory-grown specimens, so it is possible that some size-sorting has occurred in the materials obtained by him. The largest of Bermudez' specimens exceeds the maximum observed in laboratory specimens by 50 microns. Parker, Phleger and Peirson (1953) have noted that *D. aguayoi* from the San Antonio Bay region of Texas are smaller than those described by Bermudez from Cuba. The Texas specimens fall within the size range of laboratory forms. It may be, as the above authors have suggested, that environmental conditions account for the apparent size differences. It is interesting that neither the laboratory specimens nor the Texas materials appear to attain the size of the Cuban forms.

Contortion.—Between 10 and 15 percent of the specimens show noticeable contortion, making this anomaly one of the most frequently encountered variations observed in tests obtained from laboratory cultures. For descriptive purposes, it is simplest to discuss contortion in terms of twisting along one or more of the three axes illustrated by the inserted diagram to the upper right of the normal test in Figure 1, Plate 2. Distortion of the B-B′ and C-C′ axes is much more common than distortion along the A-A′ axis. Moreover, when the latter axis is distorted, one or both of the other two generally undergo a certain amount of complementary distortion. Most of the tests illustrated in Plate 2 show some distortion, and the details are indicated by the accompanying axial diagrams.

The ventral surface is rarely flat, since a slight twisting of the B-B′ or C-C′ axes almost invariably occurs in the juvenile stages of test development. This surface is usually less strongly curved than the dorsal surface, however, the animal in Figure 11 of Plate 2 being a noteworthy exception.

Limbation.—Bermudez in his type description of *D. aguayoi* noted that the sutures were limbate in the first whorls of the spire, and in a few specimens all the sutures were limbate (his plate 15, fig. 11). Laboratory populations of this species also show considerable variation in the degree of limbation. The broad pore-less sutures of porcellanous forms are very prominent against the pore-bearing portions of the test, and they gave rise to an early impression that these forms are more frequently limbate than are the hyaline forms. A closer examination of large numbers of specimens has shown that porcellanous forms are actually more frequently limbate, but limbation is not an infrequent feature in hyaline forms. The maximum width of sutures observed in both forms was approximately 25 microns, with an average around 5 microns.

There is some correlation between limbation and the amount of ventral filling in the porcellanous forms. Forms with heavy ventral fillings frequently show no limbation, but limbate forms typically have prominent ventral deposits. The limbation on the dorsal surface of the early chambers may be so strongly developed as to overgrow large areas of the chambers' surface and form a network of imperforate, porcellanous sutures with greatly reduced pore-bearing interstices representing the inter-sutural areas of the chamber surface.

Apertures.—The aperture, on immature individuals, lies on the ventral surface of the chamber, and may extend as an arcuate slit from the margin along the inner chamber wall. A lip is frequently developed in adult forms, as Cushman and Bronnimann (1948) noted in their type description of *D. vadescens.* In those adult forms which show only slight ventral filling, the slit appears in the same relative position, but after much filling has been deposited most of the apertures on successively formed chambers appear to be occluded. The filling may be tightly appressed against the ventral surface of the test, and probably covers the oral surface at times. Eventually, however, larger apertures do appear along the margin of the ventral filling, and may also come to riddle the entire mass. Such apertures develop secondarily after the occlusion of the primary apertures in some forms, but in many individuals no apertures are apparent, indicating that the apertures may be occluded and redeveloped only by subsequent dissolution of the ventral filling.

Direction of coiling.—In a total of 100 randomly selected individuals from the laboratory cultures 49 showed dextral and 51 sinistral coiling. From a total of 26 specimens of *D. aguayoi* sent the author by Miss Parker from the Texas locality, 14 specimens were dextrally coiled and 12 were sinistrally coiled; and in a total of 16 topotypic specimens furnished by Bermudez, 6 were dextrally coiled and 10 were sinistrally coiled. This seems ample evidence that the direction of coiling in this species is not fixed.

Bolli (1950, 1951) has suggested that fixation in the direction of coiling in certain globorotalids and globigerinids appears at a later stage in the evolution of the lineages and that random coiling characterizes the primitive members of these groups. This hypothesis may apply in the case of *Discorinopsis aguayoi,* but no data to prove or disprove it are available from the incomplete fossil record of the genus.

Lobation.—The degree of lobation, particularly in young individuals, is fairly variable. In young forms the chambers of the first whorl generally show only slight lobation, but the chambers of the second whorl frequently become prominently lobed, with deeply indented sutures. The sutures of forms of the typical variety appear to be deeper than those of the *vadescens* type, indicating, possibly, that the latter form has resulted from the secondary deposition of material on or within the test of one of the hyaline forms. Such secondary deposition could partially fill the sutures and reduce their depth, reducing the apparent degree of lobation as well.

Pores and the relation between the organic and calcareous layers.—The pores of empty tests of both the typical *D. aguayoi* form and its *vadescens* variety are prominent when viewed under reflected illumination, but the details of the variation and composition and the relation between the component test layers are best studied in materials which have been prepared according to the techniques previously described.

The pores of the calcareous layer range from 1.5 to 7 microns in diameter, with an average of approximately 3 microns. Porcellanous forms typically have slightly smaller pores than do the hyaline forms, a reduction probably resulting from the secondary deposition of shell material. Considerable variation in diameter of pores occurs from one whorl to the next or even from one chamber to the next. The pores are distributed fairly evenly over the surface of a chamber, but in certain regions, such as the area of fusion between successive chambers, may actually be contiguous. They are generally absent from the suture regions themselves, particularly in limbate forms, but may occur in these areas in the forms which have less conspicuous sutures. The number of pores per unit area is generally reduced in the marginal portion of the chambers and is often conspicuously reduced in the inflated chambers of immature as well as adult tests.

In un-decalcified sections of the test the calcareous test is transparent and colorless, whereas the underlying organic layer is yellowish brown in transmitted light, a condition suggestive of the appearance in miliolids. The calcareous test averages between 4 and 10 microns in thickness, and the external walls of the chambers are composed of several successive layers which average less than one-half micron in thickness. The walls of the inner chambers show layering just as do those of the outer. The contact between successive layers appears as an irregular striation in the otherwise hyaline, calcareous section. Le Calvez (1947) in his studies on *Discorbis erecta* has found dark discs deposited in the pores at the level of each successively formed calcareous lamella, but successively formed discs are absent in the calcareous layer of *Discorinopsis aguayoi.* Structures which are possibly comparable to the "dark discs" of Le Calvez are found in the organic layer of the latter species and will be discussed subsequently, but the absence of such discs at successive levels in the calcareous test is a strikingly different feature of *Discorinopsis aguayoi.* A schematic section of the test is seen in Text Figure 1.

The application of the decalcification and staining procedure results in the dissolution of the calcareous layer and the disclosure of the subjacent organic layer. A similar organic layer has been observed by numerous other students of the Foraminifera in such calcareous forms as *Orbitolites complanata* (Carpenter, Parker and Jones, 1862), *Truncatulina lobatula* (Rhumbler, 1911), *Planorbulina larvata* (Hofker, 1927), *Tretomphalus* (Myers, 1943), and *Discorbis erecta* (Le Calvez, 1947). Bonte (1936) has reported the discovery of the organic *moullage* of a dozen species from the Landenian tuff of Lille, France, and he described very complex structural differentiation within the organic test remains of *Cristellaria landinensis* Bonte and *Nodosaria raphanistrum* (Linné).

The organic layer of the test of *Discorinopsis* is transparent, very thin (averaging less than one-half micron), fragile, and tightly appressed against the inner surface of the calcareous layer which normally covers it. The entire outer surface of the organic layer is pot-marked with truncated, conical elevations (Plate 1, Fig. 13) whose exposed necks fit rather nicely into the basal openings of the pores of the calcareous layer. These truncated cones have a diameter which seems to be slightly less than that of the corresponding pores into which they fit, and in stained specimens from which the calcareous layer has not been removed it is possible to demonstrate the outer rim of the cones projecting into the inner portion of the pores in the calcareous layer. The height of the cone is typically less

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EXPLANATION OF PLATE 1

Figs.		Page
1.	Assemblage of empty tests harvested from three typical laboratory cultures. Single arrow indicates the ventral surface of a specimen of the typical variety. Double arrows indicate porcellanous specimens of the *vadescens* variety. Field diameter: 10 mm.	6
2, 9.	Ventral surface of specimens of the typical variety. This surface is covered with a frothy mass of hyaline, calcareous bubbles. Diameter of Fig. 2: 400 microns. Diameter of Fig. 9: 350 microns.	6
3-8, 10.	Variation in ventral filling. The specimen of Figure 4 has a ventral filling which resembles that of *D. gunteri* Cole and *Discorbina vesicularis.* Largest specimen diameter: 370 microns; smallest, 200 microns.	11
11.	Vertical section through the laminated calcareous test of *D. aguayoi.* The arrow indicates a sectioned pore. Wall thickness: 4 microns.	11
12.	Vertical section through test showing lenticular pore plugs lying in organic layer at base of overlying calcareous layer. Pore plugs stained with thionin. Pore plug diameter: 2.5 microns.	9
13.	Section through organic layer of test after decalcification. Pore plugs appear as darkly stained pustules, marking the former position of the pores of the calcareous layer. Pore plugs stained with iron-alum hematoxylin. Pore plug diameter: 2.5 microns.	8
14.	Isolated pore plug seen from above. Note darkly-stained micropores which have been impregnated with thionin. Pore plug diameter: 3 microns.	9
15.	Decalcified, sectioned protoplasmic cast of *Elphidium crispum.* Arrows indicate foraminal plugs ("bouchons") *in situ.* Hematoxylin stain. Plug diameter: 12 microns; thickness: 3 microns.	10
16.	Horizontal section through ventral surface of an undecalcified specimen of the *vadescens* variety, showing the meshwork of ventral filling with interspersed "apertures" and fissures.	11


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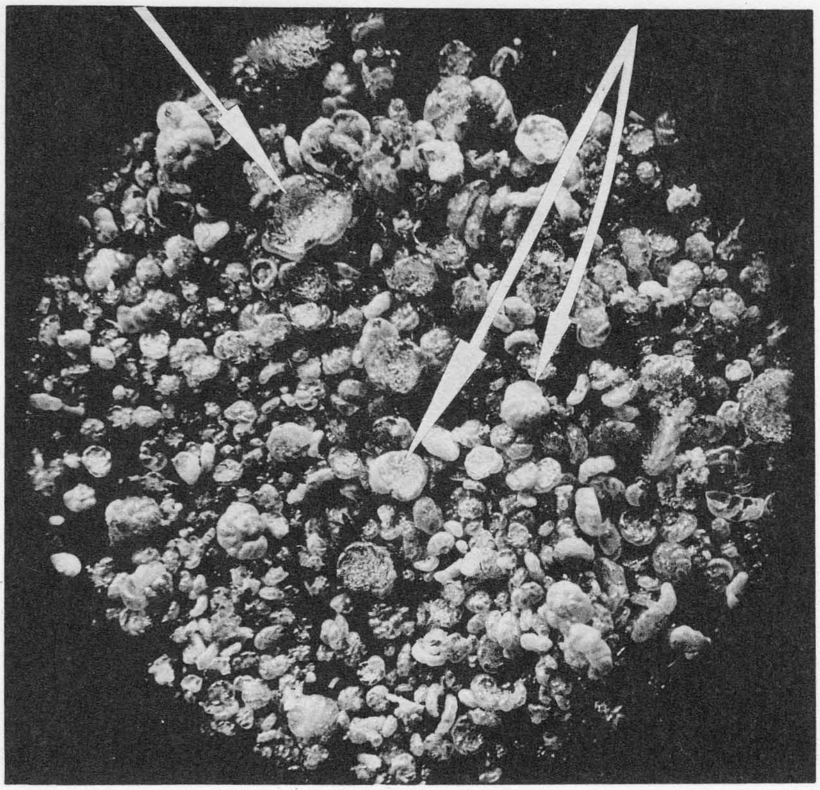
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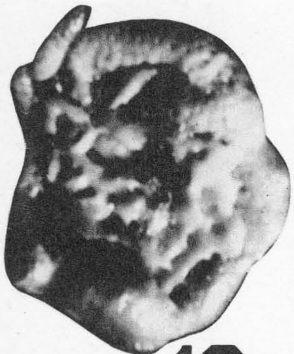
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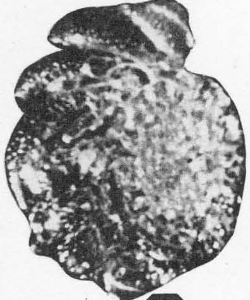
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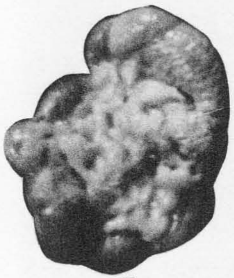
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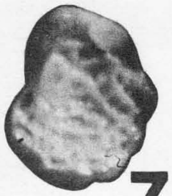
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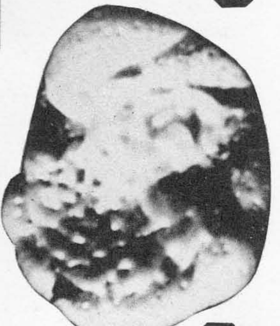
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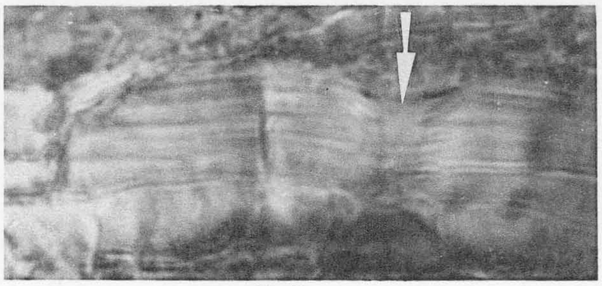
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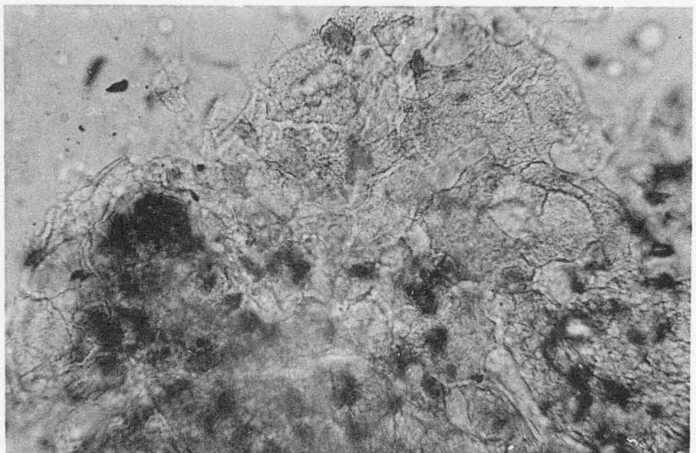
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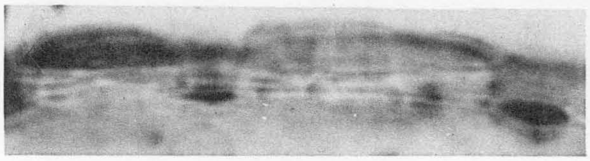
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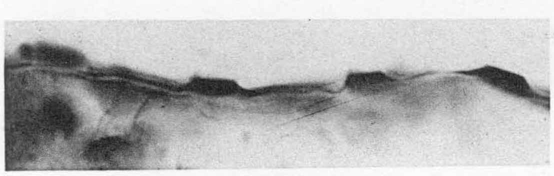
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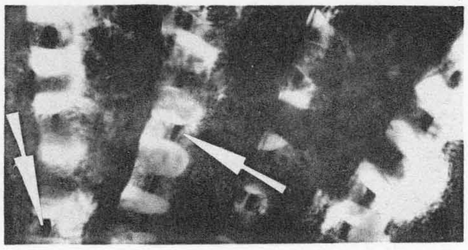
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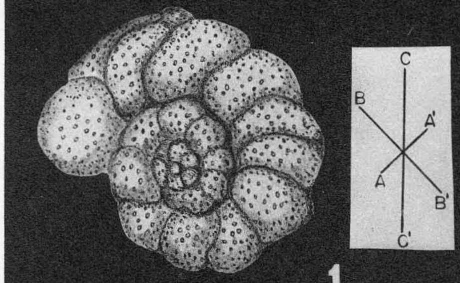
Arnold: Discorinopsis, Variation in Cultures



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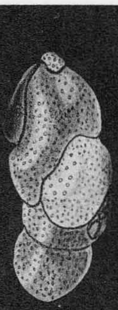

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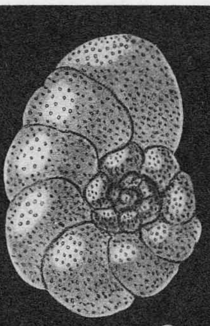

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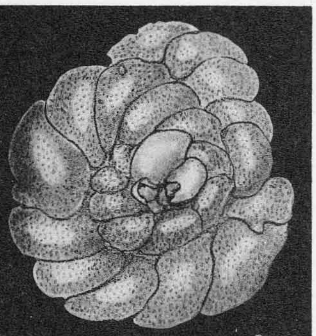

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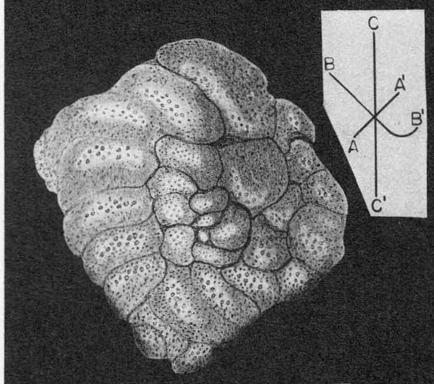

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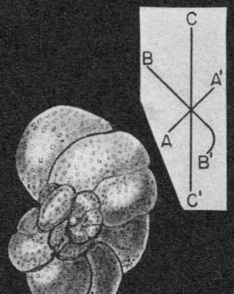

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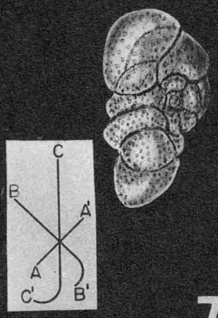

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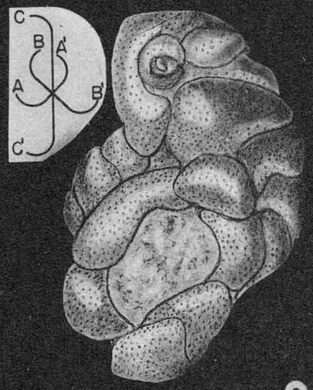

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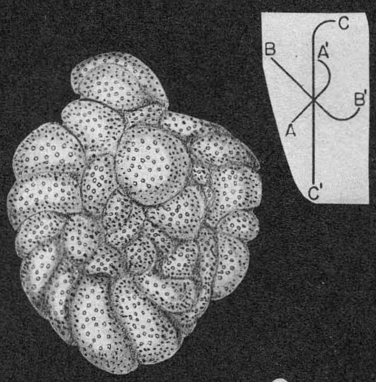

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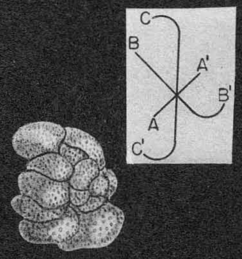

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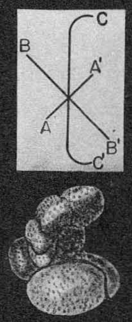

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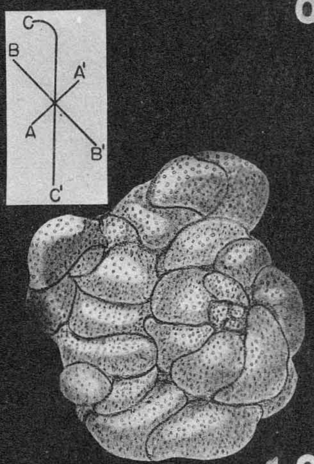

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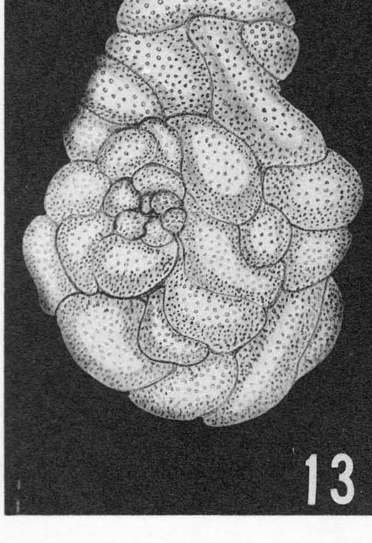

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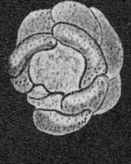

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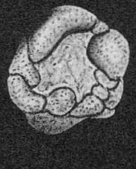

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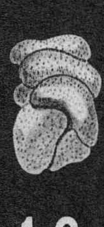

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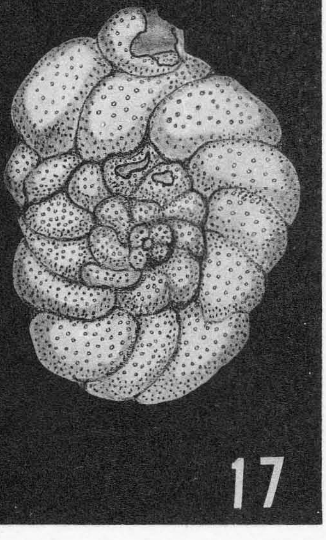

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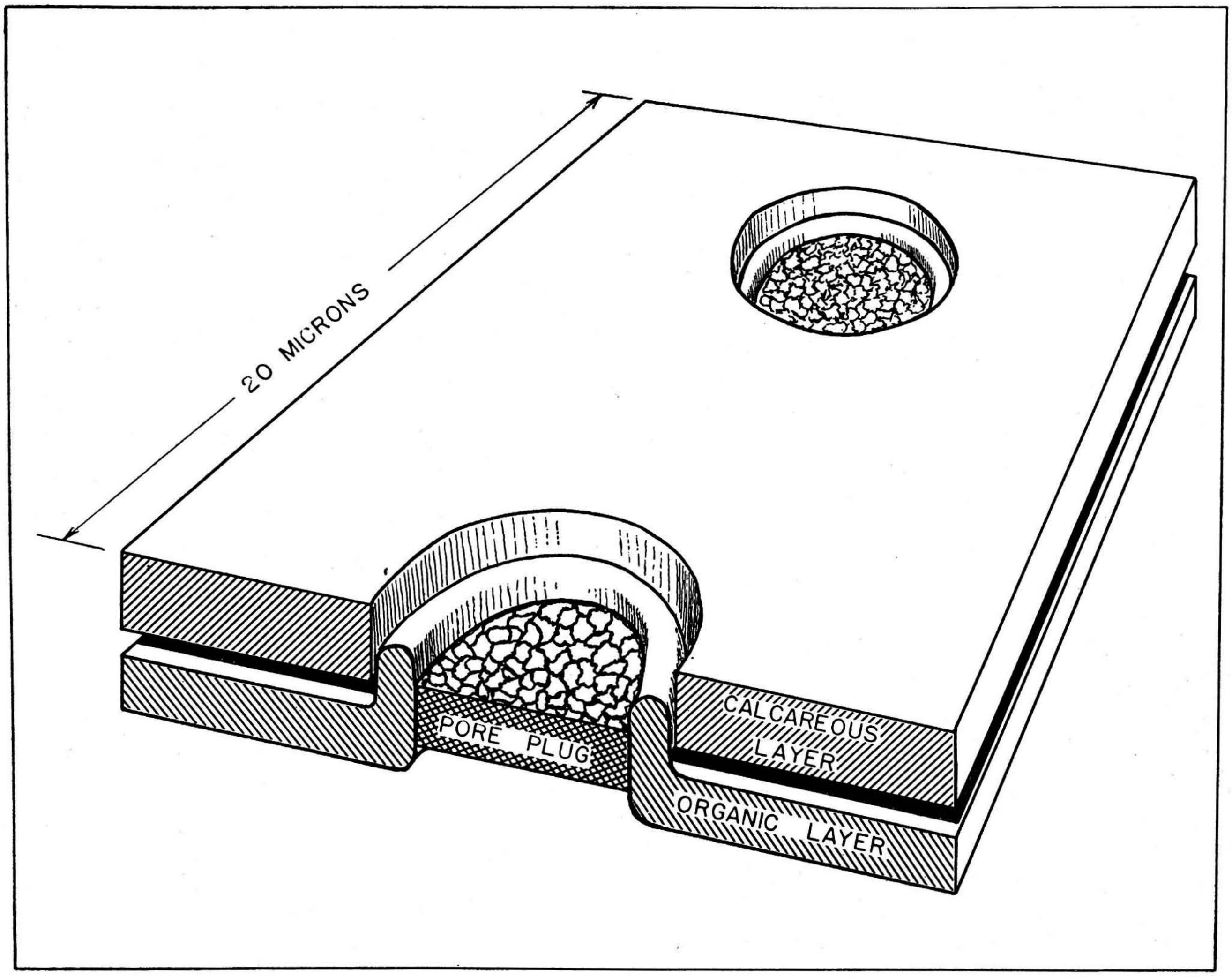
Arnold: Discorinopsis, Variation in Cultures



Text Figure 1: Diagrammatic section of test of *Discorinopsis aguayo* (Bermudez)

than two microns, but within this minute cone there is an even more minute crater-like depression. At the bottom of the depression lies a conspicuously stainable structure, which is here designated a "pore plug" to distinguish it from the "foraminal plugs" or "bouchons" of *Elphidium crispum* (L.) (Jepps, 1942) and *Planorbulina mediterranensis* Orb. (Le Calvez, 1938, and 1953). The inner surface of the organic layer is covered with funnel-like depressions which are the proximal openings of the truncated cone. The pore plug generally lies slightly closer to the protruding distal mouth of the cone than to the depressed inner opening.

The pore plugs can be seen in unstained, decalcified specimens, but they are best studied in the stained condition. They may be heavily stained with a dilute, aqueous solution of thionin and then nicely differentiated from the surrounding organic layer, since the latter is less retentive of the stain than are the pore plugs themselves.

They are round when viewed in a section parallel or tangential to the surface of the pore, but lenticular in cross-section (Plate 1, Figs. 12 and 14). They are typically between 2 and 6 microns in diameter, and have a thickness of 0.5 to 3 microns.

EXPLANATION OF PLATE 2

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Note: All drawings prepared on same scale. Largest specimen (Fig. 13) is 890 microns (a double test); smallest (Figs. 14-16) is 260 microns.

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95. NEW ASPECTS OF FORAMINIFERAL MORPHOLOGY AND TAXONOMY

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1. HOFKER'S MORPHOLOGICAL PRINCIPLES

(a) Cyclic polymorphism

For many years Hofker has insisted on the dominance of a trimorphic life cycle in foraminifera. He is now prepared to accept Le Calvez' distinction of different reproductive cycles and comes to the conclusion that "trimorphic reproduction is found especially in the more primitive or geologically older species, whereas in more advanced species or even in whole genera the reproduction scheme was found to become paratrimorphic, dimorphic, or even apogamic" (1951a p. x; see also pp. 2-4 and 1951b p. 361). This is based entirely on morphological studies of the frequency distribution of size of proloculus, size of test and number of chambers. No new biological or cytological observations could be made on Hofker's material. The results of his measurements are presented in standard diagrams but no mathematical tests of the significance of distributions have been applied. The radical combining of morphological species into trimorphic groups which was found in Hofker's earlier work is generally absent from the Siboga monograph (1951a) but some of the deduced distinctions between A_2, A_1 and B forms in populations are unlikely to pass more rigorous statistical tests. The entire question of the life cycles in foraminifera in relation to their phylogeny should be re-examined in the light of Myers' and Le Calvez' work which has covered a limited number of species. The most advanced larger foraminifera are most strongly dimorphic and in some cases possibly trimorphic, but certainly not apogamic.

(b) Shell wall and pores

Hofker pays little attention to the wall structure and does not refer to A. Wood's recent interesting studies. His statement that some genera and species hitherto considered as calcareous possess arenaceous walls [*Pavonina, Bolivinitella eleyi* (Cushman), *"Bifarina" mackinnoni* Millett and *Cymbalopora radiata* (Hagenow)] requires confirmation by petrographic methods. It should not be forgotten that fossil tests should be carefully compared with tests from the same deposit known to have been originally calcareous perforate, as diagenetic recrystallization may transform them into microcrystalline calcite of agglutinated appearance.

In his discussion of *pores* Hofker distinguishes *protopores* or single fine openings which are rounded at least on the inner wall from *deuteropores* which are groups of protopores opening into a single larger cavity in the outer walls of some "more specialised genera" (1951a, p. 10). He also claims that the protopores became coarser in more advanced genera and species. A photomicrographic demonstration of these features would be desirable. Hofker rightly claims that too little attention has been given in the past to the shape, position and structure of the pores. He supposes that perforation is connected in some way with respiration and excretion but offers no proof for this opinion. He considers it as axiomatic that the "toothplate" is imperforate. This is the basis for far-reaching attempts to recognise homologous parts of the test. There is not likely to be much support for Hofker's suggestion that the keel of the Globorotaliidae is derived from the "toothplate" because it is poreless and connected with the poreless part of the ventral and apertural chamber wall, as the keels of *Nodosaria vertebralis, Uvigerina* or *Discorbis dimidiatus* are also poreless. Other conclusions concerning the "toothplates" are, however, of very great importance.

(c) The "toothplates," foramina, internal partitions and canal systems

Hofker's new approach to foraminiferal classification and phylogeny is based mainly on the results of his studies of apertural characters. He describes the fully developed *toothplate* as an often contorted plate running from a former aperture (septal foramen) to the next one, through the chamber. It is often attached with one side to the axial wall of the chamber and at its base to the proximal border of the foramen while the opposite side of the plate is free and folded. It also forms often a larger or smaller part of the apertural face (1951b, p. 353). Ultimately, it develops into a highly complex folded structure forming internal partitions, or into a canal system. It can also be secondarily reduced.

Hofker claims that "this toothplate is formed within the protoplasmic body, and thus not exposed to outward circumstances. So, while often species vary due to different surroundings, the toothplate remains unaltered . . . " In this way the toothplate is a much more reliable character than the texture of the outer walls (1951a, p. 15).

Although the structure had been observed in many genera by earlier authors, a new descriptive term is required to include what Höglund who first described it very clearly had named internal tube, apertural tongue, diaphragm or internal trough, according to its shape, while Brotzen used the terms partition, septum inferior or infundibulum, in different genera.

The function of this structure has not been observed in the living animal. From its shape, position, and presumed evolution Hofker (1950) concluded that originally it established a direct passage towards the aperture for digestive enzymes "procured" by the nucleus resting in the initial chambers. In more advanced forms it "protects the apertural region" or it is related to necessities of pelagic[1] or attached life; finally it forms canals "through which locomotor protoplasm streams towards the surface of the test." The internal partitions formed in some groups "may be connected with the apogamic reproduction of the animal (Asterigerinidae, Robertinidae)." This generalisation seems partly in conflict with Hofker's earlier suggestion of trimorphism in *Asterigerina gürichi.*

It will be a necessary but difficult task to establish by observation on living specimens the ontogenetic development of the toothplate and to confirm its hypothetical functions. Meanwhile, the claim for homology and taxonomic significance of this structure does not rest on its internal position and supposed independence from external influences. If observed morphological relations and distribution in time of well known foraminifera can be better explained by assuming such homology then the case for it is as good as any claim of homology of organs whose function is unknown. The following discussion will show that a good case has been made for a reconsideration of phylogenetic and taxonomic relations in the light of Hofker's new morphological hypothesis.

Before these implications can be discussed it is necessary to examine Hofker's thesis that two different types of foramina exist in the "Foraminifera Dentata." They are the *protoforamen* which is recognisable by its connection with the fully developed or rudimentary toothplate, and the *deuteroforamen* which is independent of this structure. Only the protoforamen exists in the more primitive forms. In later evolutionary stages either the proto- or the deuteroforamen may become reduced or lost. Hofker also recognises supplementary foramina formed at additional points of contact of the toothplate and the outer wall. Assumed taxonomic relations depend often on the homology of the foramina, particularly on the recognition of a single aperture as either a proto- or a deuteroforamen.

Hofker's morphological terminology is somewhat unorthodox. He describes as "proximal" the part of the chamber in coiled tests which is nearest to the proloculus *in a radial direction* and as "distal" the opposite part while these terms are more commonly (and also more properly) referred to the *direction of growth,* so that the apertural wall of the last chamber would normally be termed distal and that separating it from the preceeding chamber would be considered as proximal. Hofker makes the terms interchangeable with axial and peripheral. He describes the external apertures as "apertural foramina" and the internal foramina connecting the chambers as "septal foramina." He is not much concerned with "the place of the septal foramen in respect to the sutures" which he believes to be affected by the rate of coiling and the amount of overlap of the whorls while he considers the place of the "apertural foramen" of "much more generic value." He does not refer specifically to the function of the aperture in the process of growth of the new chamber and does not recognise the importance of a difference in shape and position between the aperture ("apertural foramen") and foramen ("septal foramen") as observed in the Ceratobuliminidae and other genera.

In forms possessing only a protoforamen the toothplate is attached proximally (in Hofker's terminology) from the apertural and distally from the septal foramen so that when seen from the apertural end the toothplate is in coiled forms generally placed on the side of the septal foramen which is nearer to the periphery of the test. Where a deuteroforamen exists, it is found on the peripheral side of the toothplate, while the protoforamen lies on its axial side. These relations are explained in a somewhat involved manner (1951a, pp. 6-7) and a diagram (1951a, fig. 1) fails to clarify them as it shows the positional relations without taking account of the shape of the chambers and other essential structural elements. In these relations lies the key to the re-classification of the Rotaliidea attempted by Hofker. Its validity depends largely on whether these relative positions are accepted as evidence of the proposed homology of the elements involved, particularly where either the typical toothplate or one of the foramina is absent.

2. HOFKER'S RE-CLASSIFICATION OF SOME FORAMINIFERA

(a) Principles

While it is obvious that the establishment of the homology of important structures which previously had not been well understood must lead to a revision of taxonomy, the problems usually connected with such comprehensive attempts are not easily overcome, particularly that of "horizontal" versus "vertical" classification. Hofker resolutely chooses the vertical system. This leads to serious practical difficulties in which the author himself becomes occasionally entangled. His major groupings are not always consistent and where he gives formal definitions they are often not particularly helpful. A vertical classification must ultimately separate forms which the author considers as closely related, just because he believes that divergent lineages are derived from them. Where the required proof lies

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[1] "At first the plate which in benthonic forms seems to have had the function of place for attachment of musculous protoplasm, reduced, as this function was no longer necessary; but then, as a spreading net formed for floating purpose, the free extending border of the plate was gradually shaped into a fan . . . " (Hofker 1951a, p. 142).

in internal structures which are unknown and in many instances not preserved in fossils it becomes impossible to make the classification comprehensive and capable of including all reasonably well known forms. Nevertheless, workers who are forced to classify many "Foraminifera Dentata" in which the toothplate is not well known or preserved and who prefer strict morphological definitions of all taxonomic units to the introduction of phylogenetic hypotheses into taxonomy will find much in Hofker's proposals deserving careful consideration and eventual incorporation in probably less revolutionary schemes. The outcome of these necessary revisions cannot be fully anticipated here but the following notes are offered in the hope that criticism of some unacceptable propositions will lead to a more rapid acceptance of the taxonomic consequences of Hofker's numerous valuable discoveries.

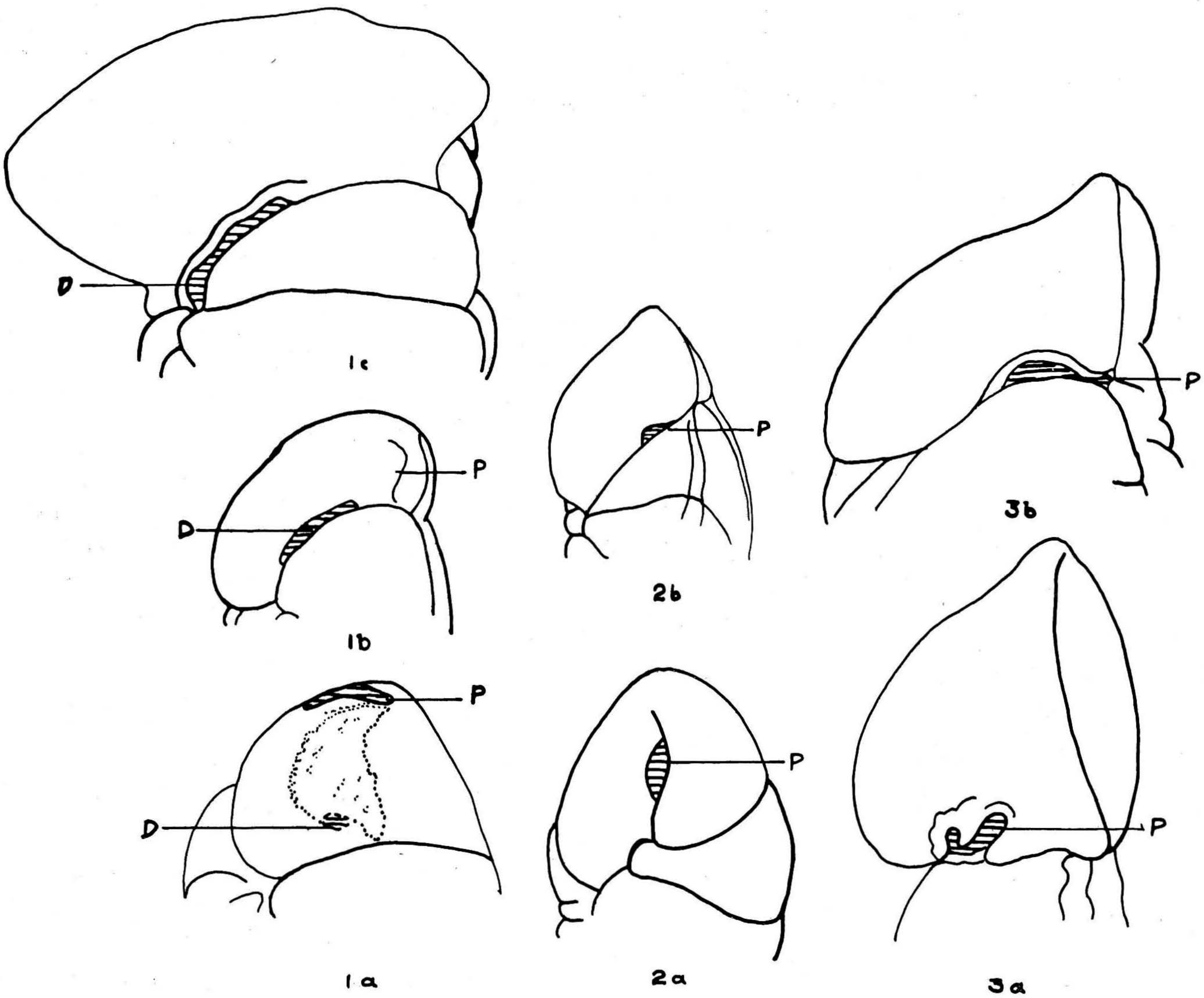
(b) Supra-generic taxonomy

Hofker distinguishes as an Order Dentata the Buliminidea and Rotaliidea of Glaessner's classification, adding the Peneroplidae which on account of their perforate proloculus are not considered to be related to the other Miliolidea. The Valvulinidae are included as an ancestral group, according to the principle of vertical classification followed by the author. The underlying phylogeny may well be correct but it appears that morphologically this group has closer relations outside this "Order" which is of little practical value as long as its relations to those foraminifera which have not yet been placed in other "Orders" remain undetermined.

Within the Dentata Hofker distinguishes the Suborders Protoforaminata, Biforaminata and Deuteroforaminata. The first of these Suborders is identical with Glaessner's Superfamily Buliminidea. They are divided into the Families Buliminellidae, Buliminidae, Virgulinidae, Cassidulinidae, Bolivinidae and Uvigerinidae. The Pleurostomellidae are also mentioned. Apart from greater "splitting" few changes are seen in this group on the supra-generic level. The remaining two Suborders are Rotaliidea. Their definitions (1951a, pp. 306, 412) suggest that they are groupings according to a phylogenetic hypothesis rather than morphologically defined taxonomic categories. This is true to some degree of all "natural" larger groupings but as it is patently impossible to distinguish the suggested "Biforaminata protoforaminata, biforaminata and deuteroforaminata" (1951a, p. 307) from the Protoforaminata protoforaminata, biforaminata and deuteroforaminata by *any* diagnosis these groups cannot be regarded as taxonomic units.

The Biforaminata are basically those Rotaliidea which possess the two types of foramina postulated by Hofker but "in some of the lower organised genera and families there never existed a deuteroforamen, or it has been obliterated" (1951a, p. 306). The Biforaminata as a whole are those groups which Hofker derives from the Family Ceratobuliminidae as originally established by Glaessner. This is now split into three families. Hofker considers the Robertinidae (with *Pseudobulimina*) as derived from the Epistominidae from which he separates the Ceratobuliminidae s. str. (with *Lamarckina*) taxonomically and phylogenetically. Of more importance than this fine splitting is the linking of lines supposed to form one genetic group and to be sharply distinguished from the remaining "deuteroforaminate" Rotaliidea. The "biforaminate" (in name but not in fact) Rotaliidea are mainly Hofker's families "Cibicidae," "Eponidae" and "Alabaminidae." The first family includes *Cibicides* and allied forms, *"Parrella"* and *Siphonina* with its derivatives, the second *"Pulvinulinella"* and *Eponides,* and the third *Alabamina* and *Gyroidina.* The validity of this grouping rests on the acceptance of Hofker's homology of the foramina according to their relation to the toothplates (which are often rudimentary), rather than according to their position. The reasons for linking the *Cibicides* and *Eponides* group with *Ceratobulimina* (and *Lamarckina*) and the *Alabamina-Gyroidina* group with *Epistomina,* and for removing both from the vicinity of *Discorbis* or *Valvulineria* are best explained in a diagram (Fig. 1). The foramina in *"Parrella," Cibicides* and *Eponides* are described as protoforamina while the septal foramen of *Epistomina* and the apertures of *Alabamina* and *Gyroidina* are deuteroforamina. In the *Ceratobuliminidae* it seems that "the single aperture and foramen is a protoforamen, though in *Ceratobulimina* there is a slight doubt about it" (1951a, p. 313, see also p. 310). It appears that in basing his conclusions on the advanced species *C. pacifica* Hofker has not been able to see the structure of this genus and its relations to *Lamarckina* and *Epistomina* as clearly as they could be seen in other species. It also seems that the main reason for separating all these forms from the *Discorbis* group ("Deuteroforaminata") lies for Hofker in the difficulty of relating their more complex apertural structures to those of his genera *"Conorboides"* and *"Discopulvinulina"* though he draws attention to the resemblance between *Lamarckina* and *"Discopulvinulina."* Unless one follows him in distinguishing sharply between forms with open and closed umbilicus (which would introduce an additional and seemingly unwarranted complication), the similarities between *Valvulineria, Gyroidina, Gyroidinoides, Anomalina* (and related forms) seem greater than their differences. The suggested relations of *Eponides, "Pulvinulinella," "Parrella"* and *Alabamina* with *Lamarckina* and other Ceratobuliminidae deserve further study.

Other "biforaminate" families supposedly derived from the Robertinidae are the Nonionidae and "Polystomellidae," "Camerinidae" and Peneroplidae. The reasons for this radical step in taxonomy have not yet been fully discussed by Hofker. Judging from what he has stated we are inclined to doubt the validity of the arguments. The close relations existing between the Early Tertiary *Miscellanea,* Nummulitidae and Calcarinidae have apparently not been taken into con-



TEXT FIGURE 1

Homology of apertures and foramina in three lineages of foraminifera, according to Hofker. 1a - *Epistomina elegans*, 1b - *Alabamina solnasensis*, 1c - *Gyroidina soldanii;* 2a - *"Pulvinulinella" exigua*, 2b - *"Eponides repanda";* 3a - *"Parrella" venusta*, 3b - *Cibicides refulgens.* P - protoforamen, D - deuteroforamen. Adapted from Hofker's original drawings.

sideration by Hofker who is impressed by the possibility of deriving the nummulite structure from the aberrant Late Tertiary to Recent *Cushmanella.* The early history of the Nonionidae is not well known. Hofker (1951b) believes that the umbilical structures of *Astrononion* could be derived from toothplates and thus arrives at the homology of the septal openings of *Elphidium* with protoforamina. This explanation could equally well apply to the Rotaliidae s. str. *(Rotalia)* which Hofker prefers to place in the Deuteroforaminata. The planispiral or trochospiral coiling is of secondary importance compared with the question whether on the basis of the recognition of proto- and deuteroforamina a clear distinction can be made between a canal system derived from the protoforamen and toothplate of *Epistomina* and a similar system derived from the protoforamen of *Discorbis.*

In the Deuteroforaminata the apertural apparatus consists typically of a protoforamen with a toothplate which is in the earlier forms pillar-shaped and later reduced, a deuteroforamen, and a more or less well developed lip between the two openings. The protoforamen comes to lie in the septum between the last-formed and the preceding chamber and the deuteroforamen is the normal aperture from which the next chamber is formed. This is typically seen in *"Discopulvinulina."* Hofker derives this genus from *"Conorbis* n. g.[2]" The description of its apertural characters is difficult to follow but there seems to be no good reason for distinguishing it from Brotzen's genus *Conorbina* though the toothplate was not mentioned by Brotzen. Hofker derives from his *"Conorbis"* the group of *Patellina, Patellinella* and *Patellinoides* and incorrectly renames it *"Discobolivina."* The close relation between *Patellina* and *Conorbina* was observed by Brotzen but he and other authors considered *Patellina* as the more primitive form. This should be carefully reconsidered. Also derived from *"Conorbis"* are the valid genus *Neoconorbina* with a better developed deuteroforamen and a reduced toothplate, and the genera *Reinholdella, Asterigerina* and *Amphistegina* (Amphisteginidae).

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[2] Now called **Conorboides** nom. nov. Hofker. The Editors.

Hofker explains, ingeniously and convincingly, how the supplementary chamberlets in these forms originated in the Jurassic *Reinholdella* as coverings over the protoforamina (Hofker 1951b, p. 358). Another line leads to *"Discopulvinulina."* The family names Pulvinulinidae (1951a, p. 413), and Discopulvinulinidae (1951b, p. 363) are invalid and so is the name Marginolamellidae. This is proposed for the Globorotaliidae (and *Cancris*) to indicate the supposed origin of their marginal keel from a toothplate. The real apertural characters of early representatives of this group have been recently clearly described by Reichel and are seen to be closely related to those of *Discorbis* and *Pseudovalvulineria* which supports the taxonomic and phylogenetic position of the group as shown by Hofker though his nomenclature and homology are unacceptable. The remaining descendants of the *Discorbis vesicularis* - *D. bertheloti* group (*"Discopulvinulina"*) are the Valvulineriidae and the Cymbaloporettidae. These are renamed because *Cymbalopora* is eliminated as an arenaceous form. This interesting suggestion should be carefully checked. The close relations of *Cymbaloporetta* (with which the allied forms are generically united) to *Discorbis* are clearly demonstrated. *Valvulineria* is considered as a *"Discopulvinulina"* without a protoforamen and toothplate. Brotzen's Valvulineriidae are now emended by the removal of some genera which are placed in the Biforaminata. As Hofker no longer believes in a family distinction between *Gyroidina* and *Gyroidinoides* (1951c, p. 27), this leaves essentially the position of the Anomalinidae to be considered. Hofker's reason for removing them from the Deuteroforaminata is his interpretation of the *Cibicides* aperture as a protoforamen without a toothplate (1951a, p. 341). He states that the lip in *Cibicides* is "situated marginally from the aperture," not axially as in *Discorbis*. This could lead to the alternative conclusion that the aperture is a deuteroforamen for if this moves from the umbilical position which it occupies in *Discorbis* to the peripheral position as in *Cibicides*, the lip would come to lie marginally. In the absence of a toothplate this is at least a possible alternative. Not its inherent characters but the comparison with *"Parrella"* proves for Hofker the homology of the *Cibicides* - aperture with the protoforamen. The wall and pore structure to which reference is made (1951a, pp. 342, 485) are not sufficiently well known to be decisive.

The Rotaliidae are derived from *"Conorbis"* through *"Streblus"* which is defined mainly by the primitive and incomplete state of the canal system. The observation that the covering plates of the canal system in the higher forms are outgrowths from the protoforamen and thus related to the toothplate is of considerable interest, and that applies also to the derivation of the spines from the canal system. Considerable taxonomic confusion arises out of the similarity of the apertures of *"Parrella" venusta* and of some species of *Asterorotalia*. The characters of this species play an important part in Hofker's arguments for the removal of the *Cibicides*-group from the *Discorbis*-group. Finlay showed in 1939 that *venusta* was not a *"Parrella"* but that it was related to *Rotalia calcar* (placed by Finlay in *Calcarina*). This proves again that the toothplate alone gives no more reliable indications of taxonomic and phylogenetic relations than other single characters, and that it is desirable to base conclusions on these relations on a thorough study of the earliest representatives of each phyletic line rather than on their better known recent descendants. Much of this still remains to be done but we are deeply indebted to Hofker for the wealth of morphological information which has come from his study of the often neglected detailed characters of many genera and species. It can be expected that a continuation of this line of research, together with further work on the biology of foraminifera, with more attention given to stratigraphically well documented bioseries and, in the presentation of its results, to the Rules of Zoological Nomenclature, will solve the many puzzling problems of foraminiferal phylogeny.

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96. NOTE ON *SCHLUMBERGERELLA* HANZAWA AND RELATED GENERA

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ABSTRACT—A compilation of the present knowledge of the anatomy, systematic position and stratigraphic distribution of the genus **Schlumbergerella** Hanzawa is given. The genus **Silvestriella** Hanzawa, a synonym of **Baculogypsinoides**, does not have the "raspberry-type" of embryonic apparatus, characteristic of **Schlumbergerella. Calcarina, Baculogypsinoides, Baculogypsina** and **Schlumbergerella** are easily differentiated by their juvenarium. **Calcarina** is the most primitive and **Schlumbergerella** the most specialised genus. **Baculogypsinoides** and **Baculogypsina** have intermediate positions.

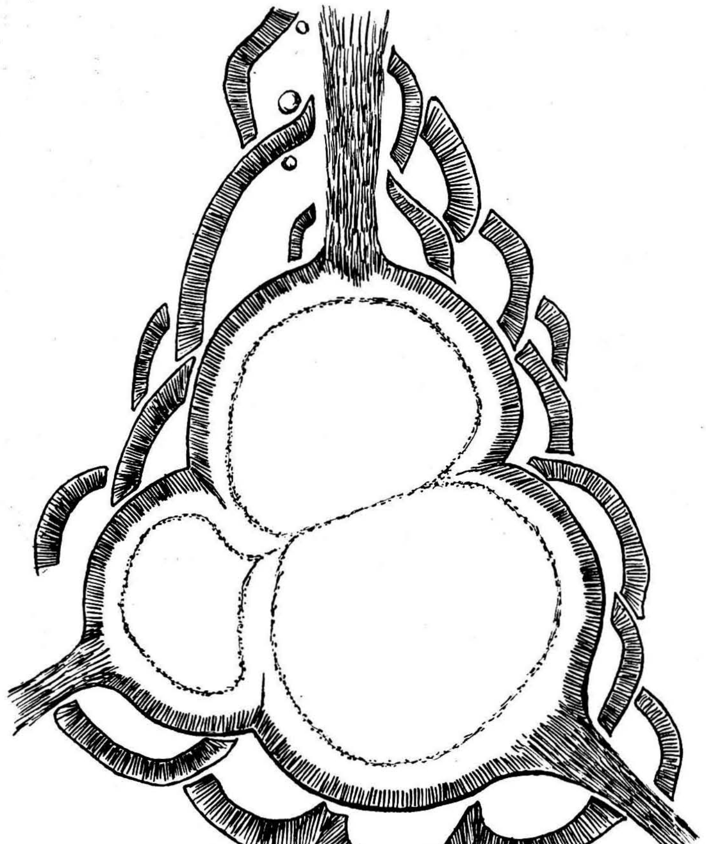
INTRODUCTION AND MATERIAL

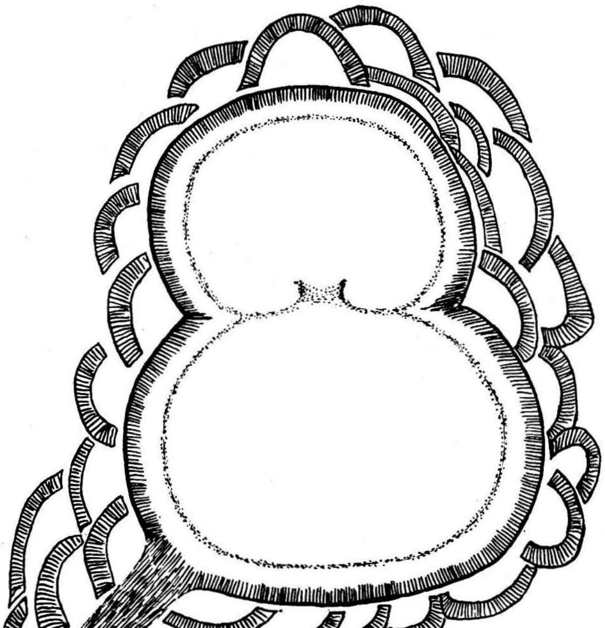
A recent publication of Hanzawa (1952) mentioned two new genera of Calcarinidae: *Schlumbergerella* and *Silvestriella.* As the differentiation of these genera was not clear it seemed necessary to investigate their anatomical character. The material studied comes from shore-sand collected near Sanoer, Island of Bali, Indonesia. In addition, a few sections from the micropaleontological collection (Stanford University), labeled "*Tinoporus* sp." but of unknown provenience were examined.

A. The Anatomy of the Genus Schlumbergerella Hanzawa 1952

a. *Juvenarium*

The "raspberry-type" of juvenarium consists of a normal first and second chamber of the same type as found in all other genera of Calcarinidae. On the top of these two initial chambers a third one can be observed in oriented sections. The first two chambers communicate with each other through a slit-like aperture. The second chamber communicates with the third through an aperture of unknown shape. To these three chambers spines are attached, and between the spines acervuline lateral chambers develop, composing the remainder of the shell. There is no intermediate





TEXT FIGURE 1 *Schlumbergerella floresiana* (Schlumberger). ca. × 225. Section through the three initial chambers shows position of spines on chambers. Locality unknown. Stanford Coll. (Micropal.)

TEXT FIGURE 2 *Schlumbergerella floresiana* (Schlumberger). ca. × 225. Section through first and second (initial) chambers shows aperture. Locality unknown. Stanford Coll. (Micropal.)

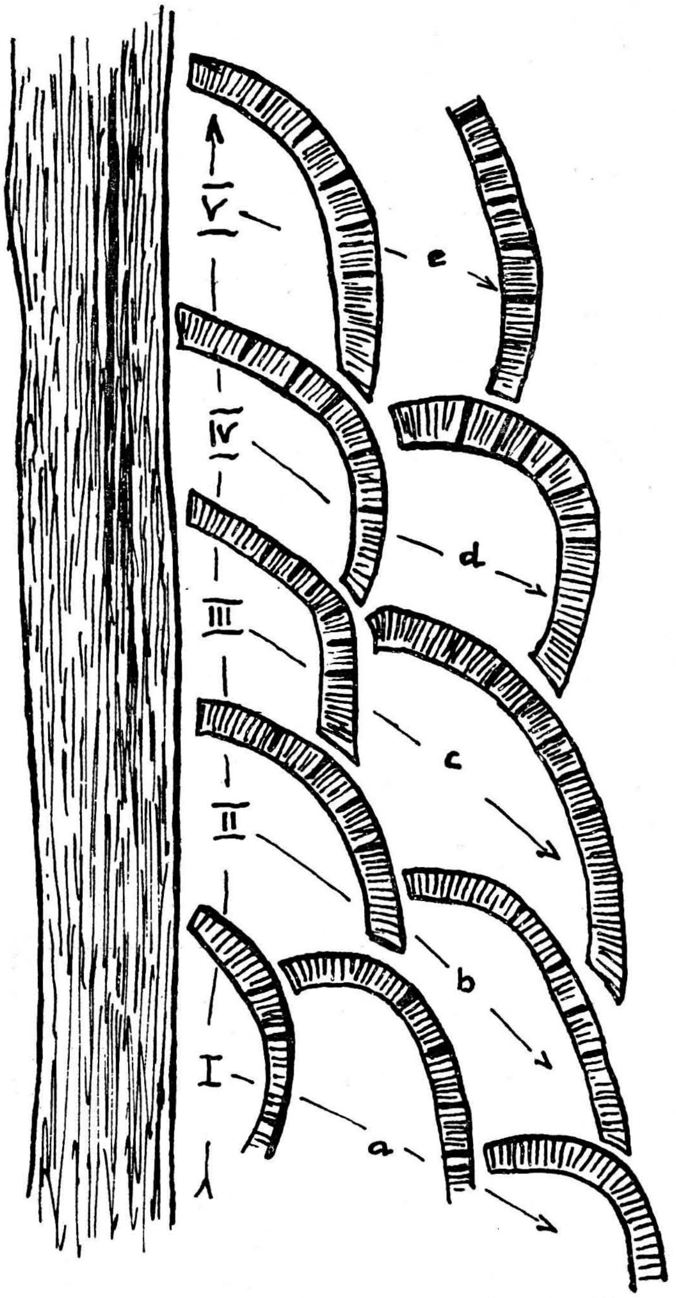
stage in which the chambers are spirally arranged as in *Baculogypsinoides.*

b. Spines

The spines attached to the first three chambers are usually four in number. A few specimens, however, were observed with more than four spines. The spines are distinctive in that they are pierced by radially directed canals which give rise to a complicated ramifying system. They extend from the acervuline chambers in distances which depend on the stage of growth of the specimen.

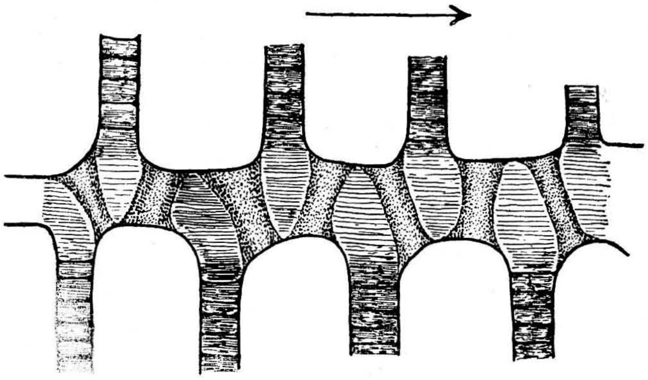
c. Acervuline Chambers

All the lateral chambers are built in the same manner and without any differentiation. A first layer of chambers is built around the spines and from here the test is formed in regular layers. Thus the chambers around the spines have the function of median chambers in other larger foraminifers but do not develop a distinctive shape (Text fig. 3). The chambers are connected with each other in various ways:



Text Figure 3 *Schlumbergerella floresiana* (Schlumberger). ca. × 275. Section shows chamber arrangement near spine. Recent, Sanoer, Bali, Indonesia. (Coll. H. E. Thalmann)

1. Stolons. At the base of each chamber in oriented sections is found a system of two stolons. Each chamber communicates with the preceding one through one stolon and by two stolons with two younger chambers (Fig. 4). The number of stolons was determined solely on the basis of thin section study. Additional stolons, however, may be present since only a two-dimensional system is encountered in thin sections.



Text Figure 4 *Schlumbergerella floresiana* (Schlumberger). ca. × 350. Section shows stolons between acervuline lateral chambers. Arrow points to direction of growth. Recent, Sanoer, Bali, Indonesia (Coll. H. E. Thalmann)

2. Perforations. The roofs of the chambers are pierced by numerous perforations observable in horizontal and vertical sections of the chamber roofs. They are thin canals with a wider opening on the outside of the shell.

3. Apertures. The large openings in the roofs of the chambers near the base of the overlying chamber are known as apertures. They are arranged in rows and vary in outline from elliptical to round. There may be two to four apertures in one row.

d. Pillars

Pillars differ anatomically from spines by having fewer thin canals. In addition they show in tangential direction structures of uncertain character which parallel the roofs of the adjacent acervuline lateral chambers. The canal system in horizontal section is similar to the roof-structure of the normal acervuline chambers. Possibly the pillars represent radial rows of calcified lateral chambers.

B. Diagnoses of related Calcarinidae

In the following diagnoses only the Tertiary genera are treated. The genera *Pellatispira, Pellatispirella* and *Biplanispira* are excluded because they are regarded by some authors to belong to the *Nummulitidae* (Umbgrove 1928). The genus *Ranikothalia* is anatomically imperfectly known.

Genus **Calcarina** Orbigny, 1826

(Genotype: *Nautilus spengleri* Linné)

Test consists of a single trochoid spire, with spines extending from the shell in the plane of coiling. No acervuline lateral chambers present.

Genus **Baculogypsinoides** Yabe and Hanzawa, 1930

(Genotype: *Baculogypsinoides spinosus* Y. & H.)

A long trochoid spire with spines extending from the surface mostly in the plane of coiling. Acervuline chambers are present.

Genus **Baculogypsina** Sacco, 1893

(Genotype: *Orbitolina sphaerulata* Parker and Jones)

A short trochoid spire with spines extending from the shell surface mostly in the plane of coiling. Acervuline lateral chambers present. (The asymmetrical character of the spire mentioned by Hanzawa (1952) and thought to be comparable with that of *Cibicides* does not indicate any genetic relationship with this latter genus.)

Genus **Schlumbergerella** Hanzawa, 1952

(Genotype: *Baculogypsina floresiana* Schlumberger)

Juvenarium reduced to three chambers and without spire, followed by acervuline lateral chambers. Spines are usually tetrahedral.

The following generic names, often cited in literature, are regarded as invalid:

Genus **Tinoporus** Montfort, 1808

(Genotype: *Tinoporus baculatus* Montfort)

The type of *Tinoporus* has often been referred to *Calcarina spengleri* Orbigny 1826. Since it is difficult to recognize Montfort's type on account of inadequate description and poor illustration the use of this genus is not recommended. Although *Tinoporus* has priority over *Calcarina,* it is advisable to maintain the name *Calcarina* because of its clear definition and better illustration. A definite solution of this taxonomic problem can only be made after additional information and re-examination of the genotype of *Tinoporus* has been made.

Genus **Silvestriella** Hanzawa, 1952

(Genotype: *Calcarina tetraedra* Gümbel)

Hanzawa states that *Silvestriella* is characterised by an embryonic apparatus of the "raspberry-type." But the figures of both the type species and those species listed as synonyms by Hanzawa show distinct long spirals. Hanzawa's text figures 3a and 3b probably correspond with Osimo's specimens in Plate III, figs. 3 and 7 of which figure 3 is an oblique section without central chambers, and figure 7, though indistinct in the centre, apparently also an oblique section. Other figures of Osimo in the plate mentioned above from the same locality, however, show a clear, long spiral stage succeeded by acervuline lateral chambers. Hence, it is, therefore, inferred that *Silvestriella* Hanzawa 1952 is a synonym of *Baculogypsinoides* Yabe and Hanzawa 1930.

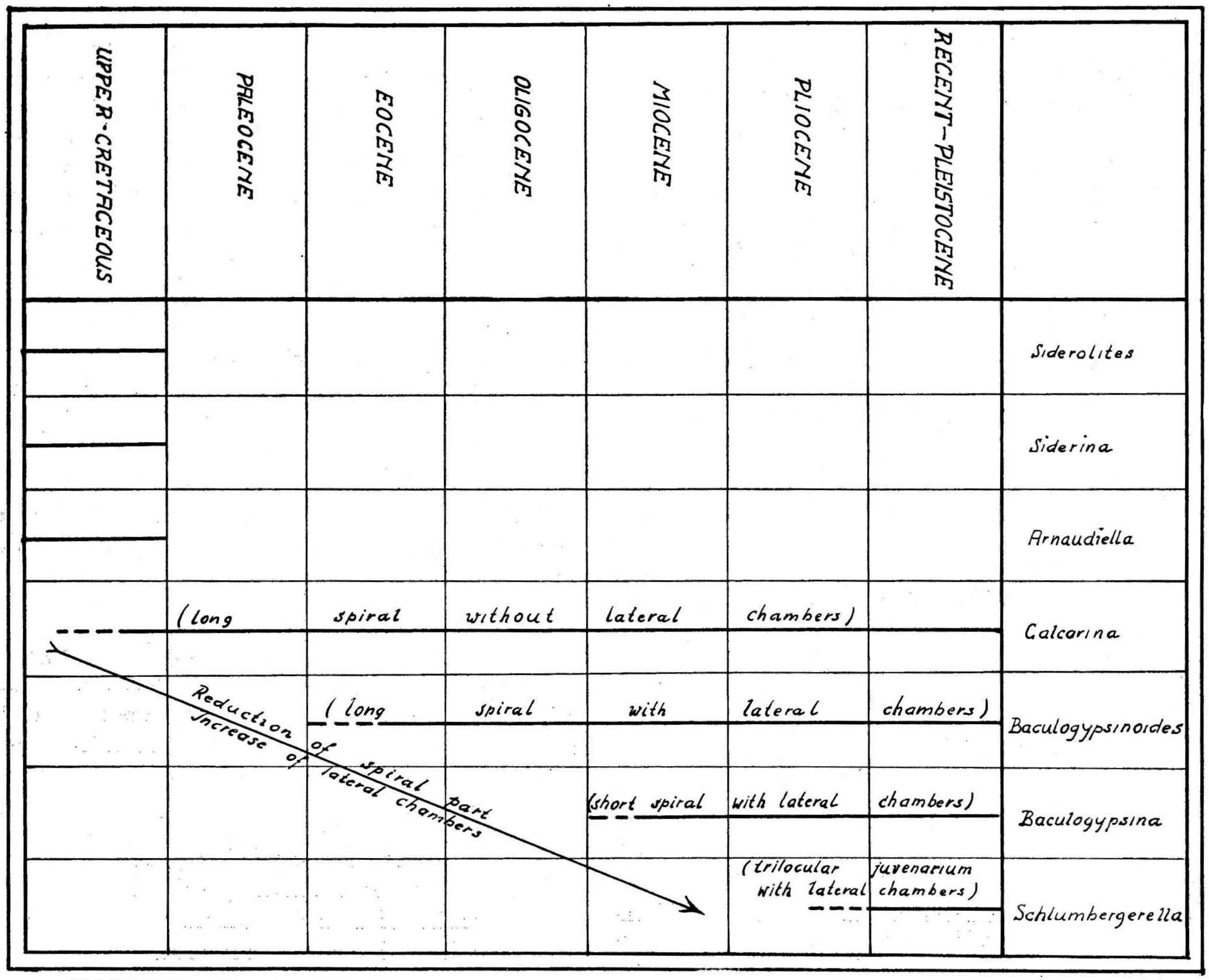


TABLE I: Stratigraphic Distribution of Calcarinidae with Indication of Evolutionary Trend.

C. Stratigraphic Distribution and Genetic Relations

Since the main difference between the genera mentioned above is indicated by fewer spirals in the central part of the test it is interesting to note that *Calcarina* with the longest spiral is the first to appear stratigraphically. Its earliest record is from the Cretaceous. *Baculogypsinoides* makes its first appearance in the Eocene, *Baculogypsina* in the Miocene, and *Schlumbergerella* in the Pleistocene and Recent (Table I).

The stratigraphic distribution of these genera is in conformance with the reduction of the juvenile spiral stage: the younger stratigraphically the appearance of a genus, the more reduced is its embryonic spiral stage. Further study may reveal intermediate species linking the different genera, but since the so far known genera make their stratigraphic appearance consecutively their coexistence implies generic differentiation, a fact which seems to be well established. Further study of the genus *Calcarina* and its differentiation from the rotalid genera *Lockhartia* and *Sakesaria* is necessary. These latter genera appear to be closely related to *Calcarina*.

Calcarina, Baculogypsinoides, Baculogypsina and Schlumbergerella belong undoubtedly to the same morphogenetic lineage. The decrease of the spiral portion of the test is a further example of nepionic acceleration among the Foraminifera.

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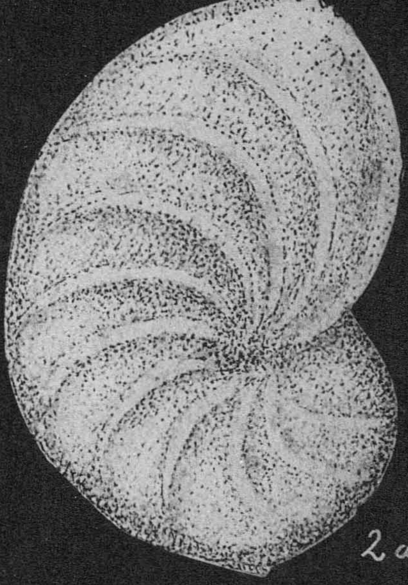
EXPLANATION OF PLATE 5

FIGS.		PAGE
1.	*Lenticulina rivadaviaensis* Camacho, n. sp. — Holotype × 30.	32
2, 3.	*Planularia wichmanni* Camacho, n. sp. — × 30. 2, Holotype. 3, Paratype.	32
4.	*Dentalina* sp. × 50.	33
5.	*Nodosaria affinis* Reuss. × 50.	33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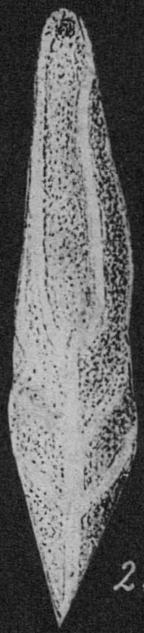
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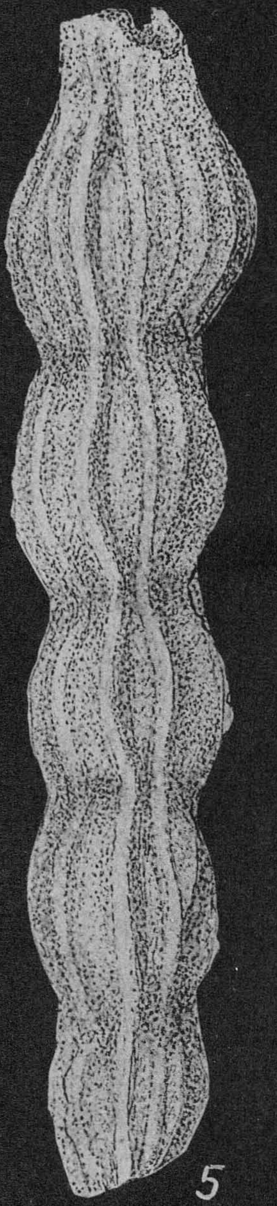
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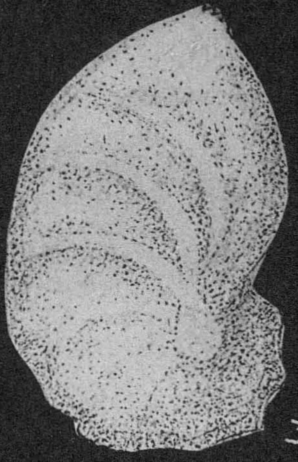
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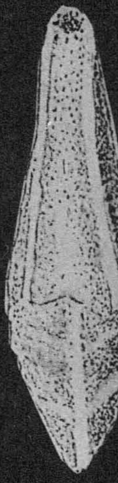
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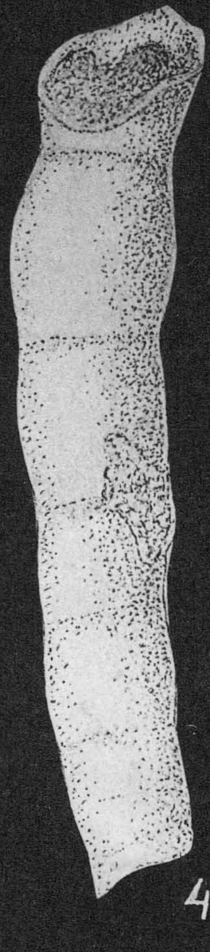
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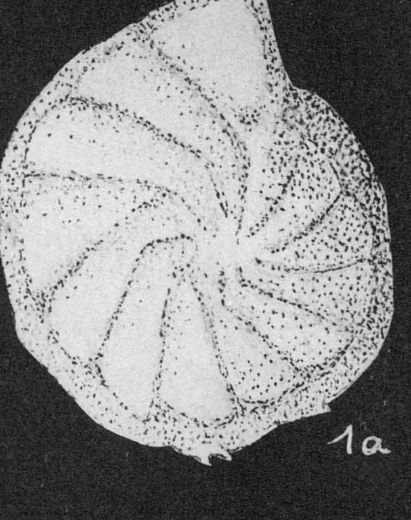
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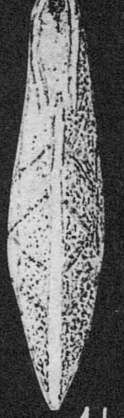
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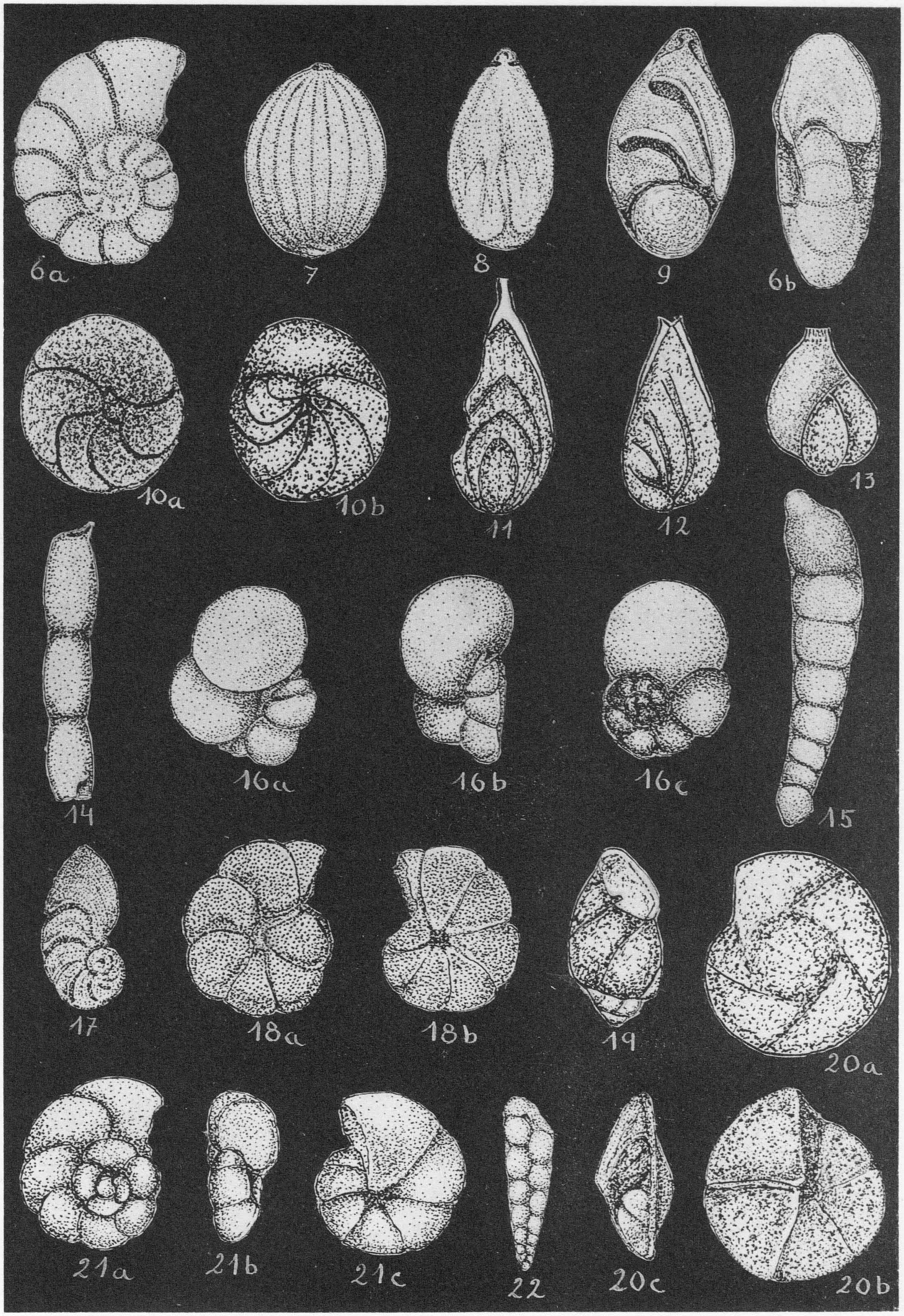
Camacho: Upper Cretaceous Foraminifera from Argentina



Camacho: Upper Cretaceous Foraminifera from Argentina

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 1, JANUARY, 1954

97. SOME UPPER CRETACEOUS FORAMINIFERA FROM ARGENTINA

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ABSTRACT—This paper records two faunules of Foraminifera found in some wells drilled at Comodoro Rivadavia, Argentina, on the Atlantic Coast of Patagonia. These faunas are considered to be of Upper Cretaceous age and seem to be related to faunas described from sediments deposited on the Gulf Coast Region of the United States.

INTRODUCTION

The first note on Argentinean fossil Foraminifera is by Charles Darwin (1876) who collected samples in the Pampean formation "between the Colorado and Santa Fé bajada," containing polythalamous Foraminifera, according to Carpenter's determination.

Steinmann and Wilckens (1908) found *Quinqueloculina seminulum* Linné in Tierra del Fuego; Richter (1925) figured as "? *Oligostegina laevigata* Kfm" a section of a *Globigerina* from the Cretaceous sediments at the boundary between Tierra del Fuego and Chile; Feruglio (1944-1945) mentioned the presence of "*Globigerina, Textularia, Rotalina, Cristellaria,* etc.," in the Tithonian-Cretaceous complex of Lago Argentino (Patagonia), and Heim (1947), observed Foraminifera and other microfossils in thin sections of Paleozoic limestones from Huaco, (San Juan Province). At present, the only works of geological importance, relating to these microfossils, are Macfadyen's study (1933) on the fossil Foraminifera from the Burdwood Bank and Holland's paper (1916) on fossil Foraminifera (Cretaceous and Pliocene) of the Antarctic islands.

Recent Foraminifera from the continental shelf and the Antarctic region were studied by d'Orbigny (1839), H. B. Brady (1884), Egger (1893), Pearcey (1914), Cushman and Parker (1931), Heron-Allen and Earland (1932) and Frenguelli (1935, 1937, 1945 and 1946).

Papers on micropaleontological techniques or stratigraphical correlation in Argentina were published by Cordini (1937) and Braccacini (1940), and Argentinean activities in micropaleontology are summarized by Boltovskoy (1953).

MATERIAL

Some of the specimens here described were collected at Comodoro Rivadavia, on the Atlantic coast of Patagonia, by the late R. Wichmann, from oil well No. 46, at a depth of 450-456 m. The well is located about 5 Km. NE. of Comodoro Rivadavia. The fossiliferous horizon is a glauconitic sandstone in the Senonian (Wichmann, 1921). The stratigraphic section given by Wichmann for well No. 46 is now interpreted as follows:

0.— m. - 18.75 m.	Gray and yellow clays. Lower Patagonian formation (Juliense member). *Oligocene* ? (Marine).
18.75 m. - 112.50 m.	White tuffs, clays and green marls. Sarmiento formation. *Eocene* (Continental).
112.50 m. - 378.— m.	Green-bluish clays and marls with concretions and nodules of pyrite, silica, gypsum and limestone. Río Chico formation. *Eocene* (Continental).
378.— m. - 385.50 m.	Black clays, considered as the basal horizon of the above mentioned formation.
385.50 m. - 624.80 m.	Gray clays with intercalations of glauconitic sandstones including the foraminiferal fauna. Salamanca formation. *Danian* (Marine).

EXPLANATION OF PLATE 6

FIGS.		PAGE
6.	*Anomalina elegantoides* Camacho, n. sp. — Holotype × 60; 6a dorsal view.	34
7.	*Lagena* sp. × 10.	33
8.	*Sigmomorphina translucida* Camacho, n. sp. — Holotype × 75.	33
9.	*Planularia chubutensis* Camacho, n. sp. — Holotype × 11.	32
10.	*Discorbis luciferus* Camacho, n. sp. — Holotype × 60.	34
11.	*Frondicularia superbissima* Camacho, n. sp. — Holotype × 65.	33
12.	*Marginulina delecta* Camacho, n. sp. — Holotype × 72.	33
13.	*Guttulina rivadaviaensis* Camacho, n. sp. — Holotype × 73.	33
14.	*Dentalina* sp. — Holotype × 36.	33
15.	*Dentalina astrae* Camacho, n. sp. — Holotype × 30.	33
16.	*Cibicides globosus* Camacho, n. sp. — Holotype × 66.	34
17.	*Planularia curviformis* Camacho, n. sp. — Holotype × 68.	32
18.	*Cibicides superbus* Camacho, n. sp. — Holotype × 69.	34
19.	*Buliminella isabelleana* Camacho, n. sp. — Holotype × 83.	33
20.	*Eponides perspicax* Camacho, n. sp. — Holotype × 83.	34
21.	*Gyroidina patagonica* Camacho, n. sp. — Holotype × 83.	34
22.	*Loxostomum* ? sp. — × 60.	34

The age of the Salamanca formation is still not settled as it is assigned by different authors either to the Danian or to the Lower Eocene, based on the study of the invertebrate fauna. Some species are in common with the "Rocanense" fauna (Danian) and a few with the Patagonian (Tertiary).

The presence in the green sandstone of the Salamanca formation of *Nodosaria affinis* Reuss, a widespread species in the Upper Cretaceous of North America and Bohemia strengthens, however, the Danian age of these sediments.

A second set of Foraminifera comes from the oil well No. A363 drilled at Comodoro Rivadavia by the Astra Oil Co. in the vicinity of well No. 46.

Here again, the sediments are glauconitic and show intercalations of trachydacitic and andesitic tuffs.

The foraminiferal fauna, composed entirely of new species, is considered to be of Upper Cretaceous age on account of the resemblance of the species to others mainly from the United States. In the drilled region the Upper Cretaceous is found about 450 m. below the surface and the presence of this microfauna at a depth of 1,659 meters, proves the existence of nearly 1,200 m. of Upper Cretaceous sandstones and tuffs in the subsurface of Comodoro Rivadavia.

Although this is the first description of fossil foraminifera from Comodoro Rivadavia (and also from Argentina), the existence of such fossils in that region had been recorded some years ago, by Luis Déletang (1922), María Casanova (1930) and Rafael Cordini (1932), but apparently the faunas have never been published excepting some drawings and a few generic determinations by Cordini.

ACKNOWLEDGMENTS

The author wishes to express his sincere thanks to Miss Ruth Todd and Hans E. Thalmann who have reviewed the manuscript. He is also indebted to the Argentinean Association for the Advancement of Science which has sponsored the drawing of the species, to the Astra Oil Co. for permitting him to publish the fauna from well A363, as well as the geologic information, and to the Dirección Nacional de Minería de Buenos Aires, which allowed the study of the Wichmann collection.

DEPOSITORY OF TYPES

The type specimens are deposited in the Micropaleontological Collection of the Instituto de Geología de Buenos Aires.

SYSTEMATIC DESCRIPTIONS

Family LAGENIDAE

Genus **Lenticulina** Lamarck, 1804

Lenticulina rivadaviaensis Camacho, sp. nov.

Plate 5, figures 1a, 1b

Test large, closely coiled throughout, slightly flattened, with a peripheral keel 3 mm. thick; thickness about one quarter of the diameter; chambers of uniform shape and slightly increasing in size as added, 13 in the final coil; sutures limbate, slightly raised, curved near the umbilicus; wall smooth; aperture radiate, at the peripheral angle.

Diameter of the test 1.3 mm.; thickness 0.3 mm.

Well No. 46; 450-456 meters.

This species closely resembles *L. rotulata* Lamarck, though the umbo is not as distinct as in the specimens of the Upper Cretaceous of North America.

Genus **Planularia** Defrance, 1824

Planularia wichmanni Camacho, sp. nov.

Plate 5, figures 2a, 2b, 3a, 3b

Test large, much compressed, periphery slightly keeled; chambers low and broad, becoming elongated as added, 11 in the last coil of the holotype; sutures limbate, raised and becoming flush and even disappearing on the periphery; wall smooth; aperture at the peripheral angle, radiate. Length 2 mm.; breadth 1.3 mm.; thickness in the umbonal region 0.3 mm. Figure 3 shows a smaller specimen with an umbilical boss.

Well No. 46; 450-456 meters.

Planularia wichmanni resembles *Planularia advena* Cushman and Jarvis (in Cushman and Renz 1946) but, it differs in the general aspect.

Planularia chubutensis Camacho, sp. nov.

Plate 6, figure 9

Test compressed, periphery rounded; chambers distinct, with tendency to become uncoiled in the adult, increasing in length as added, height remaining about the same throughout; sutures distinct, limbate, somewhat raised above the surface; wall finely perforate, with a few very weak longitudinal costae; aperture at the peripheral angle, radiate. Length 0.30 mm.; breadth 0.2 mm.; thickness 0.1 mm.

Well A363; 1,659 meters.

Planularia chubutensis is similar to *P. tricarinella* (Reuss) from the Upper Cretaceous of North America and Europe, but in our species the periphery is not keeled. In its earlier stages it resembles *P. californica* (Galloway and Wissler).

Planularia curviformis Camacho, sp. nov.

Plate 6, figure 17

Test strongly compressed, early portion coiled, later portion becoming uncoiled and slightly inflated, periphery curved; chambers distinct, increasing in length and height as added; sutures distinct, limbate, curved especially in the later portion; wall smooth; aperture at the peripheral angle, radiate. Length 0.35 mm.; breadth 0.2 mm.; thickness 0.1 mm.

Well A363; 1,659 meters.

P. dissona (Plummer) resembles this species, but in our species the sutures are more strongly curved and the wall is smooth.

Genus **Marginulina** Orbigny, 1826

Marginulina delecta Camacho, sp. nov.

Plate 6, figure 12

Test compressed, peripheral margin subacute; early portion very little coiled, rapidly becoming nearly uncoiled; chambers distinct, increasing gradually in height and rapidly in breadth as added; sutures distinct, limbate, curved in the lower portion; wall smooth; aperture at the peripheral angle. Length 0.4 mm.; breadth 0.2 mm.; thickness 0.1 mm.

Well A363; 1,659 meters.

Marginulina siliqua Cushman has some resemblance to *Marginulina delecta* but in that species the chambers are much broader than high.

Genus **Dentalina** Orbigny, 1826

Dentalina sp.

Plate 5, figure 4

A broken specimen of the genus *Dentalina* very similar to *Dentalina gracilis* Orbigny. It has an elongated, slightly curved test, composed of six chambers, with the lowest chambers of equivalent height and breadth and the lower sutures not as distinct as between the upper, and more inflated, chambers.

Well No. 46; 450-456 meters.

Dentalina sp.

Plate 6, figure 14

Test incomplete, composed of three elongated chambers, resembling *D. consobrina* Orbigny.

Well A363; 1,659 meters.

Dentalina astrae Camacho, sp. nov.

Plate 6, figure 15

Test elongate, curved, with a short spine at the base; chambers distinct, becoming more inflated as added, earlier ones overlapping; sutures distinct, somewhat limbate, oblique, later ones more depressed; wall smooth, aperture terminal, radiate. Length 1.6 mm.; diameter 0.3 mm.

Well A363; 1,659 meters.

Dentalina basiplanata Cushman differs from this species in the absence of the basal spine and showing oblique costae indicating coiling in the earlier portion of the test.

Genus **Nodosaria** Lamarck, 1812

Nodosaria affinis Reuss

Plate 5, figure 5

For synonymy, see Cushman, 1946, page 70.

A broken test with inflated chambers and about 15 longitudinal costae continuous over the adjacent chambers.

Well No. 46; 450-456 meters.

Genus **Frondicularia** Defrance, 1826

Frondicularia superbissima Camacho, sp. nov.

Plate 6, figure 11

Test strongly compressed, outline elliptical, apertural end extended, periphery entire; chambers narrow, elongate, increasing regularly in size as added; proloculus elongate, surrounded by the later chambers; sutures distinct, almost flush with surface; wall smooth throughout except for very fine longitudinal costae; aperture small, at the end of a slender neck. Length 0.6 mm.; breadth 0.3 mm.; thickness 0.19 mm.

Well A363; 1,659 meters.

This species resembles some forms from the Upper Cretaceous of the United States and Europe, such as *F. cordai* Reuss, *F. cordata* Roemer, *F. goldfussi* Reuss, and *F. mucronata* Reuss, but the Patagonian species lacks a basal spine, and its proloculus is surrounded by the later chambers.

Genus **Lagena** Walker and Jacob, 1798

Lagena sp.

Plate 6, figure 7

Test elongate to nearly spherical; wall finely perforate, with 18 longitudinal perforate costae; apertural end with a short neck. Length of the figured specimen: 0.3 mm.; diameter of the same: 0.25 mm.

Well A363; 1,659 meters.

Genus Guttulina Orbigny, 1839

Guttulina rivadaviaensis Camacho, sp. nov.

Plate 6, figure 13

Test ovate, subglobular, broadest below the middle, rounded at the base, acute toward the apertural end; chambers clavate, arranged in a quinqueloculine series, each succeeding chamber slightly removed from the base; sutures distinct; wall smooth; aperture radiate. Length 0.3 mm.; breadth 0.25 mm.; thickness 0.2 mm.

Well A363; 1,659 meters.

This species is very similar to *Guttulina adherens* (Olszewski) but the apertural end is more acute and the test subglobular.

Family POLYMORPHINIDAE

Genus **Sigmomorphina** Cushman and Ozawa, 1928

Sigmomorphina translucida Camacho, sp. nov.

Plate 6, figure 8

Test much compressed, oval, apical end somewhat pointed; chambers elongated, extending down to the base; sutures flush with the surface or nearly so; wall smooth, finely perforate; aperture terminal, radiate. Length 0.40 mm.; breadth 0.24 mm.; thickness 0.14 mm.

Well A363; 1,659 meters.

This species differs from *Sigmomorphina semitecta* (Reuss) by the more compressed test, the pointed apical end and sutures flush with the surface.

Family BULIMINIDAE

Genus **Buliminella** Cushman, 1911

Buliminella isabelleana Camacho, sp. nov.

Plate 6, figure 19

Test of medium size, ovate, somewhat fusiform; initial end pointed; chambers about six in the last whorl, distinct, inflated, increasing in size as added; sutures distinct, depressed; wall smooth; aperture in the middle of the lower margin of the apertural face. Length 0.3 mm.; diameter 0.16 mm.

Well A363; 1,734 meters.

This form very much resembles *Buliminella carseyae* Plummer, but differs in having 6 chambers in the last whorl and in the lower degree of inflation of the chambers.

Genus **Loxostomum** Ehrenberg, 1854

Loxostomum ? sp.

Plate 6, figure 22

The broken specimen does not allow generic determination and is only figured here. Length, 0.4 mm.

Well A363; 1,659 meters.

Family ROTALIDAE

Genus **Gyroidina** Orbigny, 1826

Gyroidina patagonica Camacho, sp. nov.

Plate 6, figures 21a, 21b, 21c

Test small, dorsally flattened, very convex ventrally, composed of three whorls; periphery broadly rounded; chambers distinct, somewhat inflated, 7 in the dorsal view, oblique, ventrally radial; sutures depressed; wall finely perforate; aperture elongate, arched from the periphery at least half way to the umbilicus along the ventral border of the last formed chamber. Diameter 0.3 mm.; thickness 0.1 mm.

Well A363; 1,659 meters.

This species resembles *Gyroidina soldani* Orbigny, but it is not so umbilicate, the sutures are more depressed and the section of the last whorl is more circular.

Genus **Eponides** Montfort, 1808

Eponides perspicax Camacho, sp. nov.

Plate 6, figures 20a, 20b

Test trochoid, unequally biconvex, dorsal side less convex, periphery subacute, last formed coil visible from the ventral side, which is umbonate; sutures distinct, strongly oblique on the dorsal side, radial on the ventral side; wall smooth, perforate; aperture elongate, on the middle part of the inner margin of the ventral side of the last formed chamber. Diameter 0.36 mm.; thickness 0.2 mm.

Well A363; 1,659 meters.

This species is similar to *Eponides elevata* (Plummer), but the chambers are less inflated.

Genus **Discorbis** Lamarck, 1804

Discorbis luciferus Camacho, sp. nov.

Plate 6, figures 10a, 10b

Test medium size, strongly compressed, subcircular, dorsal side convex, ventral side slightly concave; periphery acute, eight distinct chambers in the last whorl; the last chamber well developed, somewhat inflated; sutures distinct, oblique, depressed; wall smooth, coarsely perforated; aperture ventral. Diameter 0.40 mm.; height 0.1 mm.

Well A363; 1,659 meters.

Discorbis midwayensis Cushman has some resemblance to our species, but it differs by having a distinctly papillate wall.

Family ANOMALINIDAE

Genus **Anomalina** Orbigny, 1826

Anomalina elegantoides Camacho, sp. nov.

Plate 6, figures 6a, 6b

Test medium size, ventral side slightly more convex than the dorsal side; earlier whorls exposed on both sides, mainly on the dorsal side; periphery broad and rounded; chambers distinct, slightly inflated, increasing in size as added, ten in the dorsal view of the last whorl; sutures distinct, limbate, somewhat depressed, gently curved; wall coarsely perforate, smooth; aperture a low opening near the periphery, at the base of the last formed chamber. Diameter 0.40 mm. to 0.60 mm.; thickness 0.22 mm. to 0.28 mm.

Well A363; 1,659 meters.

No species was found similar to or comparable with the above described form.

Genus **Cibicides** Montfort, 1808

Cibicides globosus Camacho, sp. nov.

Plate 6, figures 16a, 16b, 16c

Test plano-convex, dorsal side nearly flat, ventral side convex, periphery lobulate, chambers distinct, seven in the adult whorl, increasing in size and thickness in the adult, especially the last two chambers; sutures limbate, depressed; wall smooth; aperture at the periphery. Length 0.38 mm.; breadth 0.30 mm.; thickness 0.10 mm. to 0.2 mm.

Well A363; 1,659 meters.

This species differs from *Cibicides kugleri* Cushman and Renz, in being not keeled, with sutures depressed and chambers very globose.

Cibicides superbus Camacho, sp. nov.

Plate 6, figures 18a, 18b

Test trochoid, plano-convex, dorsal side flattened, ventral side strongly convex, with a central umbo; periphery subacute; chambers of the last whorl distinct, inflated, 7 to 8 in the adult, of rather uniform shape increasing gradually in size as added; sutures distinct, depressed, curved; wall smooth, coarsely punctated; aperture at the base of the last formed chamber. Diameter 0.36 mm.; thickness 0.12 mm.

Well A363; 1,659 meters.

The writer knows of no similar species.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 1, JANUARY, 1954

98. STUDIES ON RECENT ALLOGROMIIDAE (3): *TINOGULLMIA HYALINA* N. GEN., N. SP., FROM THE GULLMAR FJORD, SWEDEN

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In continuation of a study of recent Allogromiidae the following new genus has been found in the muddy bottoms of the Gullmar Fjord, Sweden:

Tinogullmia hyalina Nyholm, n. gen., n. sp.
Plate 7, figures 1-8

Generic diagnosis.—See description of genotype.

Description of genotype.—Slight curved organism with hyalina, imperforate, chitinoid envelope or test; two narrow terminal apertures at either end of test; plasma extruding at apertures and visible outside of test; both apertures of equal character and size; position of organism horizontally in detritus layer of soft sediment; cytoplasm cordiform in the envelope or test and without storage of detrital elements; one nucleus visible in sections; a large vacuole sometimes present in center of cytoplasm. Size: 1.1 to 1.3 mm.

Occurrence.—On detritus layer of soft muddy bottoms at a depth of 30-70 meters; Recent, Gullmar Fjord, Sweden.

Depositary of genotype.—Collections of the Department of Zoology, University of Uppsala, Sweden.

Remarks.—The pseudopodia are highly fragile and exceedingly thin. They are incapable of holding the organism in a perpendicular position. The natural orientation of the animals is, therefore, more or less horizontal on the detritus layer of the muddy bottom sediment.

In contrast to many other monothalamous rhizopods, as for instance *Hippocrepinella* Heron-Allen and Earland (1929, 1930), remains of diatoms were not found in the cytoplasma of *Tinogullmia.* Its cytoplasma is entirely free of such detrital particles which usually can be well observed under a high-power microscope.

The narrow apertures and the straight delicate pseudopodia indicate that the organism can only take in very small particles of detritus. The spherical body visible in living specimens in the middle or center of the cytoplasma is a vacuole, not a nucleus (Plate 7, figure 1). The two apertures show the same width and are used simultaneously when taking up or discharging food particles.

Tinogullmia with its two permanent apertures resembles the genus *Shepheardella* Siddall (1880) (see also Rhumbler, 1904). Differences between the two genera exist only in the form and length of the test; moreover, such narrow tube-shaped apertures as found in *Tinogullmia* are not observed in *Shepheardella.* The latter genus also shows adherence of cytoplasma outside the envelope between the apertures, while in *Tinogullmia* such outside cytoplasma is only observed at the apertures.

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EXPLANATION OF PLATE 7

(*Tinogullmia hyalina* Nyholm, n. gen., n. sp.)

FIGS.		PAGE
1, 2.	Slight curved *Tinogullmia* photographed alive. *ap* aperture, *en* envelope. × 70.	36
3.	A living specimen of *Tinogullmia* photographed at 2000 ×. *ap* aperture, *d* detritus-agglutinations, *en* envelope, *cy* cytoplasma, *va* vacuole, *ps* pseudopodial plasma.	36
4.	Longitudinal section. *va* vacuole. × 90.	36
5-7.	Longitudinal sections. *nu* nucleus, *en* envelope, *va* vacuole. Fig. 5, × 90, Fig. 6, × 200, Fig. 7, × 300.	36
8.	Nucleus in section. *nu* nucleus, *en* envelope. × 750.	36

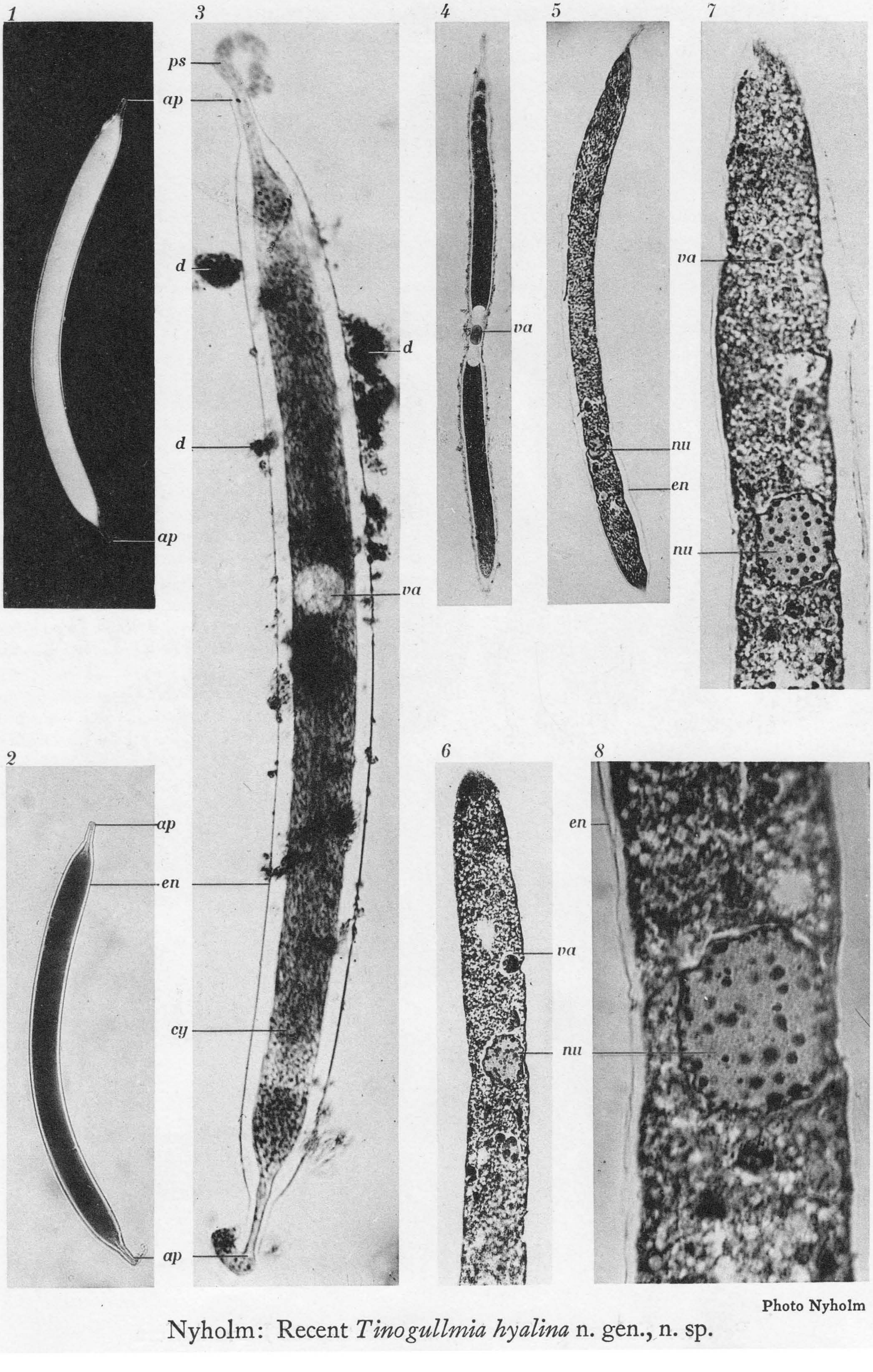
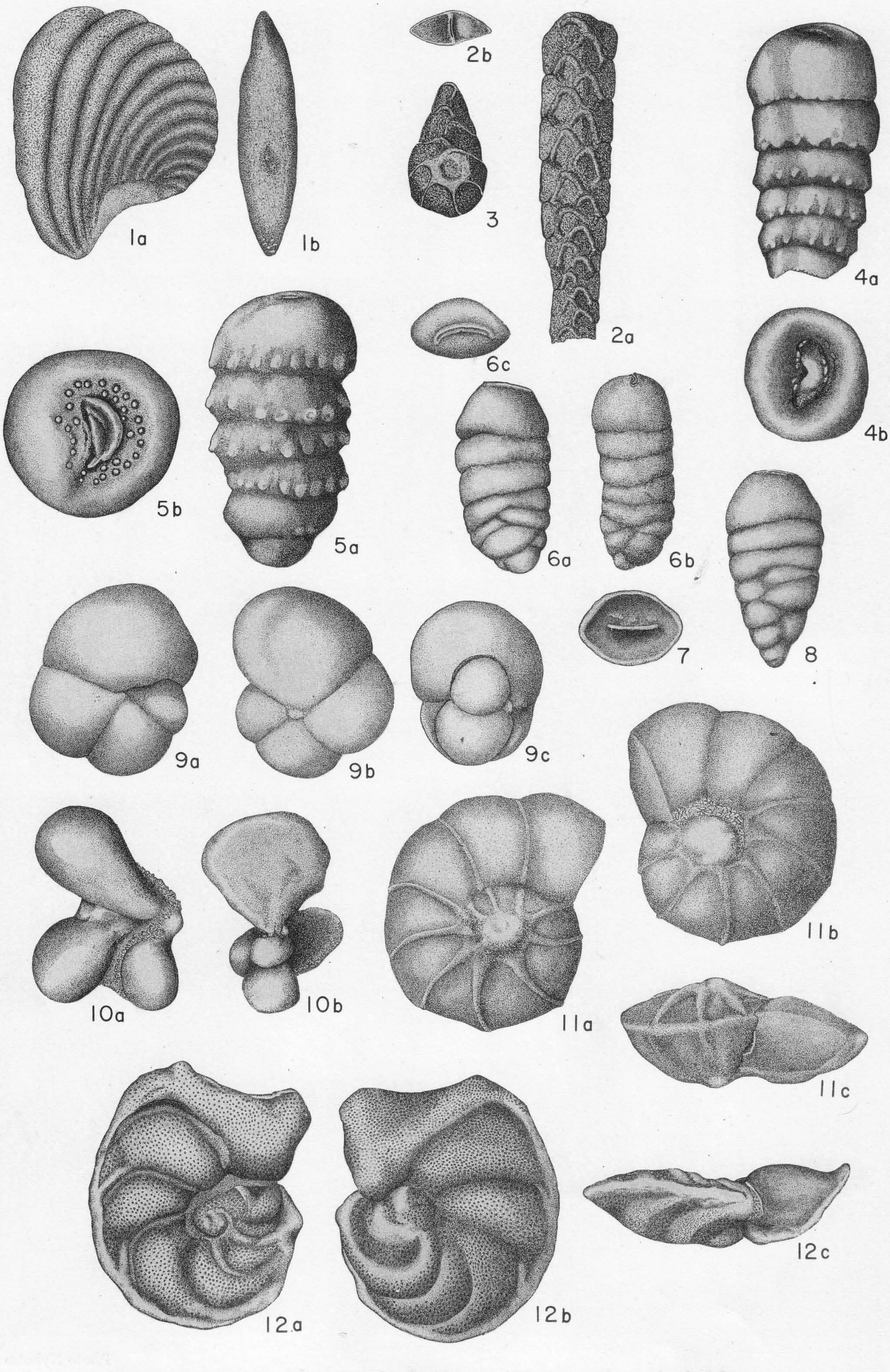


Photo Nyholm

Nyholm: Recent *Tinogullmia hyalina* n. gen., n. sp.



Petters: Colombian Tertiary and Cretaceous Foraminifera

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 1, JANUARY, 1954

99. TERTIARY AND UPPER CRETACEOUS FORAMINIFERA FROM COLOMBIA, S. A.

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ABSTRACT—The first fossil representative of the genus **Ammoastuta**, together with a few Oligocene, Eocene and Upper Cretaceous marker fossils and **Wheelerella**, a new Upper Cretaceous genus of the family Ellipsoidinidae are described. This latter genus suggests derivation of its family from **Bulimina** and the existence of two evolutionary lines within the Ellipsoidinidae. The rank of subfamilies (Wheelerellinae and Ellipsoidininae) is proposed for these two branches.

INTRODUCTION

The author is gratefully indebted to International Petroleum Company for the permission to publish this paper, and also to the Compañia de Petroleo Shell de Colombia for permission to use fossil material from well San Martin No. 2. The plate is prepared from camera lucida ink drawings of Miss Soffy Torres Gálvez.

Holotypes of the new species will be deposited in the collection of the U. S. National Museum, Washington, D. C., and paratypes in the Department of Micropaleontology of the American Museum of National History, New York, in the Museo del Servicio Geológico Nacional, Bogotá, Colombia, and in the Geologische Bundesanstalt, Vienna, Austria.

Formational names used are those appearing in unpublished reports of International Petroleum (Colombia) Ltd.

SYSTEMATIC DESCRIPTIONS

Family LITUOLIDAE

Genus **Ammoastuta** Cushman and Bronnimann, 1948

Ammoastuta caudriae Petters, n. sp.

Plate 8, figures 1a, b

Test finely arenaceous, planispiral and closely coiled in early portion, where chambers increase rapidly in height; later chambers uncoiled, straight in middle, more curved in upper portion. First four or five uncoiled chambers are short below, not reaching apex of coiled portion of test; fifth or sixth uncoiled chamber rapidly becomes much longer at the base as do following chambers which extend beyond apex of coiled portion. Space between apex and these protruding uncoiled chambers is bridged by solid shell material. Chamber lumina do not extend into this bridge. Earliest sutures somewhat indistinct, later ones distinct, depressed. Chambers 12-15 in number. Periphery lobulate. Test narrow in apertural view. Apertures consist of several small pores at basal end of last-formed chamber. Shallow depression in middle of ventral face of final chamber may hold another aperture. Height of test at youngest chamber 0.52 mm., breadth 0.43 mm., thickness 0.12 mm.

Ammoastuta caudriae has many more chambers than the two Recent species *A. inepta* (Cushman and McCulloch) and *A. salsa* Cushman and Bronnimann. Furthermore it differs in peculiar type of growth at basal ends of uncoiled chambers, giving rise to characteristic bridge of solid shell material between apex and younger uncoiled chambers.

Ecology.—The two Recent species noted above are known from brackish water only. *A. salsa* Cushman and Bronnimann is recorded from mangrove swamps on the west coast of Trinidad; *A. inepta* (Cushman and McCulloch) from Piñas bay on the Pacific coast of Panama. Lowman (1949) mentions presence of the genus in estuaries of the Gulf Coast. These species and the foraminiferal assemblage (mostly small *Ammobaculites* ssp., *Haplophragmoides* ssp., and *Troch-*

EXPLANATION OF PLATE 8

FIGS.		PAGE
1.	*Ammoastuta caudriae* Petters, n. sp. Holotype. a, side view; b, apertural view. × 75.	37
2.	*Spiroplectammina zigzag* Petters, n. sp. Holotype. a, front view; b, apertural view. × 53.	38
3.	*Spiroplectammina zigzag* Petters, n. sp. Paratype, initial portion of megalospheric form. × 75.	38
4.	*Siphogenerinoides uhli* Petters, n. sp. Internal cast. Holotype. a, side view; b, apertural view. × 25.	38
5.	*Siphogenerinoides uhli* Petters, n. sp. Internal cast. Paratype, megalospheric form. a, side view; b, apertural view. × 35.	38
6.	*Wheelerella magdalenaensis* Petters, n. sp. Holotype, megalospheric form. a, front view; b, side view; c, apertural view. × 75.	40
7.	*Wheelerella magdalenaensis* Petters, n. sp. Roof of last chamber as observed from inside. × 75.	40
8.	*Wheelerella magdalenaensis* Petters, n. sp. Paratype, microspheric form. Front view. × 75.	40
9.	*Globigerina wilsoni bolivariana* Petters, n. subsp. Holotype. a, ventral view; b, dorsal view; c, apertural view. × 53.	40
10.	*Hastigerinella colombiana* Petters, n. sp. Holotype. a, ventral view; b, apertural view. × 53.	41
11.	*Anomalina redmondi* Petters, n. sp. Holotype. a, dorsal view; b, ventral view; c, apertural view. × 40.	41
12.	*Cibicides hedbergi* Petters, n. sp. Holotype. a, dorsal view; b, ventral view; c, side view. × 40.	41

ammina ssp.,) which accompanies the species herein described suggest brackish water conditions for the Tertiary deposits in which *Ammoastuta caudriae* occurs.

Remarks.—The newly described species is the first known fossil representative of this genus. It indicates that the genus existed at least from Upper Eocene to the Present without essential changes. The species is named after Miss C. M. B. Caudri, formerly with Tropical Oil Company, who recognized it as belonging to a hitherto unknown genus in unpublished Company reports as far back as 1946.

Holotype.—Plate 8, figures 1a, b.

Type level.—Upper Eocene to Oligocene. Grey micaceous shale.

Type locality.—Shell Company's well San Martin No. 2, 14 km. N. of San Martin on bank of Rio Guamal. Core from 1579-1582.5 m. depth. Intendencia of Meta.

Family TEXTULARIIDAE

Genus **Spiroplectammina** Cushman, 1927

Spiroplectammina zigzag Petters, n. sp.

Plate 8, figures 2a, b, 3

Test finely arenaceous, with much cement, sides long, slender and parallel, transverse section rhomboidal, periphery subacute but not keeled. Youngest planispiral portion of test in megalospheric form consists of about six chambers, and is followed by a biserial portion. Longest fragment shows ten pairs of chambers; however, complete specimens would probably consist of about twice as many. Chambers oblique, slightly longer than high. Sutures raised, limbate but rapidly thinning near periphery, strongly S-shaped, with indistinct blind ending appendix which reaches into preceding chamber. Length of 10-chamber fragment 0.96 mm., width 0.22 mm., thickness 0.10 mm.

The peculiar wavy sutures are unique for a species of this genus.

Holotype.—Plate 8, figures 2a, b.

Type level.—Porquero formation. *Cibicides perlucidus* zone, Lower Oligocene. Soft blue grey sandy shale.

Type locality.—International Petrol. Co. (Colombia) locality No. 22,583, 215 m. upstream from bridge of San Juan-San Jacinto trail on Arroyo Salvadór. Departamento of Bolívar.

Family BULIMINIDAE

Genus **Siphogenerinoides** Cushman, emend. Stone, 1946

Siphogenerinoides uhli Petters, n. sp.

Plate 8, figures 4a, b, 5a, b

The following description applies to internal casts, which represent the only material available. Small fragments only of the chamber wall are sometimes preserved.

Megalospheric form with large, rounded, smooth proloculus followed by two or three slightly irregularly arranged uniserial chambers; succeeding chambers arranged symmetrically. Diameter of megalospheric test increases slightly with age. Microspheric test is slightly more tapering. Greatest diameter of test at earliest-formed chambers. Uniserial chambers narrowest at upper (apertural), widest near lower end, where they are slightly overhanging. Low but sturdy knobs, 15 to 17, in form of retral processes on lower portion of chambers; knobs of older chambers continue into low folds which reach apertural end of chamber; these folds disappear on youngest two or three chambers where retral processes become weak and their presence is indicated only by a slightly waving outline of the suture. Folds on internal casts suggest presence of rather strong ribs on older portion of outer side of test (when judged from conditions found on internal casts and tests of other species of the same genus). Retral processes are irregularly arranged on test, neither alternating regularly nor alineated. Chambers nine to ten in number. Aperture reniform, central, in shallow depression, with traces of a lip sometimes preserved. This aperture is accompanied by two rows of low bosses on the convex and by one row on the concave side (Plate 8, figure 5b). Each boss is limited by a circular narrow furrow. These features on the internal casts do not represent additional apertures for they appear to be caused by an ornamentation of inner side of chamber wall (as seen on specimens with partially preserved test). Length of fragment with six oldest chambers preserved 1.56 mm., greatest diameter 0.84 mm.; diameter of internal cast of largest specimen slightly over 1 mm.

Detailed comparison with forms already described is not possible since internal casts only are preserved; however, similarity with *Siphogenerinoides whitei* Church from the Cretaceous of California is probable. Type of ornamentation, shape of test and its dimensions make it one of the sturdiest species of the genus and distinguish it from all other described forms.

Remarks.—This species is limited to Upper Chert of Olini group in the Upper Magdalena Valley. It is named after B. Uhl.

Holotype.—Plate 8, figures 4a, b.

Type level.—Upper Chert of Olini group. *Siphogenerinoides cretacea* zone, Campanian. Chert.

Type locality.—International Petrol. Co. (Colombia) locality No. 60,003, road El Valle-Chicoral, S. of bridge on Rio Luisa, Departamento of Tolima.

Family ELLIPSOIDINIDAE

Subfamily WHEELERELLINAE Petters, new subfamily

Genus **Wheelerella** Petters, new genus

Genotype.—*Wheelerella magdalenaensis* Petters, n. sp. Plate 8, figures 6a to c.

Diagnosis.—Test calcareous, finely perforate; chambers in the early portion of the test triserially arranged, later ones uniserial. Conical upper portion of each chamber of uniserial part is covered to a large extent by the following one. Aperture a long, narrow, slightly curved slit, surrounded by a raised lip which is slightly higher on convex side and somewhat overhanging on the concave side; an internal siphon or at least a short column extends from aperture inwards (figure 7.).

Remarks.—The aperture places *Wheelerella* in the family Ellipsoidinidae. The triserial initial stage is more reminiscent, however, of the family Buliminidae since all Ellipsoidinidae with a partially multiserial chamber arrangement are biserial. Some microspheric forms of *Nodosarella* known under the name of *Ellipsoidella* were described by Heron-Allen and Earland (1910) as beginning "irregularly triserial or biserial." This biseriality of the Ellipsoidinidae induced Galloway (1933) and Cushman (1948, etc.) to assume its derivation from the equally biserial *Virgulina* of the family Buliminidae. The well-developed triserial stage of *Wheelerella,* however, suggests that the roots of at least part of the *Ellipsoidinidae* appear to be somewhat closer to the triserial genus *Bulimina.* From there developed one branch of the Ellipsoidinidae by maintaining the primitive triserial *Bulimina*-coiling in the initial stage. A second branch became biserial, forming a line of development parallel to *Virgulina* rather than being derived directly from them. The following scheme of the systematics of the Ellipsoidinidae expresses these new ideas:

Ancestor.—Bulimina.

Family Ellipsoidinidae. Emended diagnosis.—Test with early stage triserial or biserial; becoming uniserial in most genera or suppressing completely the multiserial early stage; wall calcareous, etc. (For remaining diagnosis see Cushman 1948, p. 276.)

Subfamily Wheelerellinae Petters, new subfamily.—Initial stage of micro- and megalospheric forms definitely triserial, later stage uniserial, or uniserial throughout. Genus *Wheelerella* Petters, with *Wheelerella magdalenaensis* Petters n. sp. as genotype. The genus *Ellipsolingulina* Silvestri, 1907 is tentatively assigned to this subfamily. It is considered to have been derived from *Wheelerella* on basis of its aperture and compressed test.

Subfamily Ellipsoidininae Petters, new subfamily.—Initial stage biserial, later stage uniserial or uniserial throughout. Genera: *Pleurostomella* Reuss, 1860, *Pleurostomellina* Schubert, 1911, *Ellipsopleurostomella* Silvestri, 1903, *Ellipsobulimina* Silvestri, 1903, *Nodosarella* Rzehak, 1895 (which in the writer's opinion includes *Ellipsoidella* Heron-Allen and Earland, 1910), *Ellipsoglandulina* Silvestri, 1900, *Ellipsoidina* Seguenza, 1859.

Genera of *incertae sedis* within this family are the entirely uniserial *Dentalinoides* Marie, 1941, *Pinarina* Bermudez, 1937, *Gonatosphaera* Guppy, 1894, and *Parafissurina* Parr, 1947.

Wheelerella magdalenaensis Petters, n. sp.

Plate 8, figures 6a, b, c, 7, 8

Besides the characteristics of the genus the following additional features are typical of the species.

Megalospheric tests with rounded and microspheric ones with pointed early portion. Increase in width of test occurs mainly in its triserial portion. Greatest width of megalospheric forms is near middle, that of the microspheric forms near oldest part of test. This gives a barrel-like shape to megalospheric and a more conical one to microspheric specimens. Test slightly oval in transverse section. The triserial portion comprises one-third of test in megalospheric and about one-half in microspheric forms. Three to four chambers form uniserial part. Chambers are irregularly arranged in earlier portion of test, regularly arranged in later uniserial stage. Visible parts of chambers are low, only oldest chamber shows the true high trapezoidal shape in side view. Chambers slightly inflated. Sutures distinct, depressed and slightly bent backwards on both ends of the longer transversal axis of the test. Length 0.40 mm., diameter at longest axis 0.16 mm., diameter at shortest axis 0.13 mm.

Remarks.—No additional aperture (as is typical for the genus *Siphogenerinoides*) is present. Special attention was devoted to clarify this point, as the general chamber arrangement of *Wheelerella* is reminiscent of *Siphogenerinoides.* The genus is named after O. C. Wheeler for his contribution to the knowledge of the stratigraphy of Colombia. The species name is derived from the Rio Magdalena.

Holotype.—Plate 8, figures 6a, b, c.

Type level.—Highest part of Upper Sandstone member of Olini group, 2 m. below Upper Chert member. Uppermost Coniacian. Grey phosphatic shale.

Type locality.—International Petrol. Co. (Colombia) locality No. 56,059; 4325 m. southeast of Ortega on road to El Guamo. Departamento of Tolima.

Family GLOBIGERINIDAE

Genus **Globigerina** Orbigny, 1826

Globigerina wilsoni bolivariana Petters, n. subsp.

Plate 8, figures 9a, b, c

Test globular, almost planispirally coiled, completely involute on ventral, nearly so on dorsal side, which, at most, shows the proloculus uncovered but with never a trace of the penultimate whorl; umbilicus only slightly more depressed on ventral than on dorsal side, giving an almost equally rounded aspect to both sides. Four, more rarely five, globular chambers in last-formed coil, increasing fairly rapidly in size except for oldest chamber which, in a few specimens, is smaller than the penultimate one. Wall finely perforate. Aperture a narrow slit at base of last-formed chamber, extending more on ventral than on dorsal side. Greatest diameter 0.58 mm., least diameter 0.53 mm. Thickness 0.48 mm.

The subspecies is almost identical with the Mexican

Eocene *Globigerina wilsoni* Cole, especially to those figures of Stainforth (1948). The only difference is on the dorsal side where Cole (1927, plate 4, figure 8) and Stainforth (1948, plate 26, figure 2) show a small portion of the earlier whorls visible, in contrast to which the subspecies is almost completely involute. Another difference is that this new subspecies is larger than Cole's species. Cole (1927, p. 34) emphasizes the small size of the Mexican types (the figured type specimen measures 0.25 mm.), and Stainforth figures (1948, plate 26, figure 1) a specimen of about 0.4 mm. against an average of 0.6 to 1 mm. of the subspecies. Specimens corresponding in size and degree of dorsal involution with Stainforth's *G. wilsoni* (?) Cole (figures 1-3, plate 26) occur from the late Middle Eocene to the earliest Oligocene in Colombia, whereas the subspecies is common in the Middle Eocene and has so far never been found in younger beds.

Remarks.—The name of the subspecies is derived from the Departamento of Bolívar.

Holotype.—Plate 8, figures 9a, b, c.

Type level.—Upper Carreto formation. *Asterigerina crassaformis* zone, Middle Eocene. Blue grey sandy shale.

Type locality.—International Petrol. Co. (Colombia) locality No. 22,660-A. 2230 m. WNW. of Carreto on road to San Cayetano in a 50° SE. dipping limb of a small syncline. Departamento of Bolívar.

Genus **Hastigerinella** Cushman, 1927

Hastigerinella colombiana Petters, n. sp.

Plate 8, figures 10a, b

Test slightly trochoid; four, rarely up to six loosely arranged chambers in last-formed whorl. Chambers rapidly increasing in size, especially up to penultimate one, short for the genus, narrow at base which sometimes forms a short stem; rapidly widening towards periphery, much more so in apertural than in side view (ratio of greatest thickness to height is 1.7 : 1.), resulting in a distinct flattening of chambers in sense of coiling. Walls finely perforate. Aperture a rather wide arched slit with a slight lip at base of last-formed chamber, slightly ventrally of periphery. Greatest diameter 0.66 mm., least diameter 0.51 mm., greatest thickness (at periphery) 0.40 mm., least thickness (near umbilicus) 0.15 mm.

The flattening of the chambers, in the sense of coiling, gives the test the aspect of a paddlewheel and differentiates this species from all others of the genus. The shape of chambers is similar to that of the Recent *Hastigerina murrayi* Thomson.

Remarks.—Complete tests are rare and can be obtained only by carefully disintegrating the shale. Loose chambers, however, are common, easy to recognize, and characteristic of the *Asterigerina crassaformis* zone in the Upper Carreto formation of the Departamento of Bolívar.

Holotype.—Plate 8, figures 10a, b.

Type level.—Upper Carreto formation, *Asterigerina crassaformis* zone, Middle Eocene. Blue grey sandy shale.

Type locality.—International Petrol. Co. (Colombia) locality No. 22,660-A, 2230 m. WNW. of Carreto on road to San Cayetano, in a 50° SE. dipping limb of a small syncline. Departamento of Bolívar.

Family ANOMALINIDAE

Genus **Anomalina** d'Orbigny, 1826

Anomalina redmondi Petters, n. sp.

Plate 8, figures 11a, b, c

Test equally biconvex, compressed, slightly more evolute on dorsal than on ventral side. Nine, rarely ten chambers, earliest ones slightly inflated. Dorsal sutures slightly curved, limbate and strongly raised, except for the youngest one or two, which become thin and slightly depressed. Umbilical end of raised sutures much thicker than at periphery, sutures of oldest whorl of test fuse into a protruding, irregular mass of shell material. Spiral suture strongly depressed. Ventral side of test with chambers slightly inflated, and sutures limbate and little raised, except for youngest ones which are thin and slightly depressed; umbilicus covered by a strong plug of clear shell material which, however, does not reach inner margin of youngest half of last-formed whorl, thus, leaving a rather deep and wide furrow in this portion of test. Periphery subangular, slightly lobulate in youngest portion, angular in outline in older part; sutures of older chambers of last-formed whorl slightly protruding. Wall finely perforate. Aperture a narrow slit at base of apertural face between peripheral and umbilical end of chamber. Maximum diameter 0.95 mm., minimum diameter 0.91 mm., thickness 0.38 mm.

The form is related to Upper Cretaceous *Anomalina clementiana* (Orbigny) from which it differs, however, in having on the average a higher number of chambers, which are less inflated, by possessing a large umbilical boss, and by lacking raised umbilical chamber-ends on the ventral side. The Upper Cretaceous *Anomalina pseudopapillosa* Carsey has more but shorter chambers, a less flattened periphery in side view, and no ventral umbilical plug.

Remarks.—The species is named after C. D. Redmond who first discovered it and recognized its value as a marker fossil.

Holotype.—Plate 8, figures 11a, b, c.

Type level.—Upper Sandstone member of Olini group. *Anomalina redmondi* zonule. Upper Coniacian. Grey sandy shale with phosphatic nodules.

Type locality.—International Petrol. Co. (Colombia) locality No. 54,595; 1960 m. SE. of Nariño on road to Girardot. Departamento of Cundinamarca.

Genus **Cibicides** Montfort, 1808

Cibicides hedbergi Petters, n. sp.

Plate 8, figures 12a, b, c

Cibicides sp. CUSHMAN and HEDBERG, 1941, Contrib.

Cushman Lab. Foram. Res., vol. 17, pt. 4, p. 100, pl. 23, figs. 22a-c.

Test on dorsal side flat to slightly concave, moderately evolute, ventral side low, convex, somewhat less evolute, but with penultimate whorl still partly visible. Chambers increasing fairly rapidly in height; five or seven in last-formed whorl, those on dorsal side much higher than wide, strongly inflated. On dorsal side of test sutures very depressed near umbilicus, less so at periphery, strongly and uniformly curved backwards in the youngest stages, becoming more radial with age and bending backwards at an angle near periphery. Short raised extensions of the peripheral cord protruding into outer third of sutures. Inner spiral suture ending in a distinct umbilical button. On ventral side of test chambers less inflated, sutures somewhat indistinct, only slightly, but equally depressed, becoming quite limbate in early part of whorl; type of curvature as on dorsal side. Periphery of test circular. Wall except for peripheral cord and raised portions of sutures coarsely perforate. Aperture a slit at the base of the last-formed chamber, spreading on both sides of periphery. Greatest diameter 1.15 mm., least diameter 0.85 mm., thickness 0.16 mm.

Remarks.—Specimens from the locality of Cushman and Hedberg's *Cibicides* sp. are so poorly preserved that it was found necessary to select well-preserved types from the same stratigraphic level on Rio Hacha road and describe them as *Cibicides hedbergi* n. sp., after H. D. Hedberg, Chief Geologist of the Gulf Oil Corporation, Pittsburgh, Penn.

Holotype.—Plate 8, figures 12a, b, c.

Type level.—Lower Colon formation. *Siphogenerinoides cretacea* zone, Campanian. Blackish grey splintery shale.

Type locality.—International Petrol. Co. (Colombia) locality No. 5585, road from Rio Hacha to San Juan de César, 200 m. before Km. 92. Departamento de Magdalena.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME V, PART 1, JANUARY, 1954

RECENT LITERATURE ON THE FORAMINIFERA

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

ASANO, KIYOSHI. Miocene Foraminifera from the Honya shale, Jôban Coal-Field.—Trans. Proc. Pal. Soc. Japan, n. ser., No. 11, Sept. 30, 1953, pp. 55-59, 1 pl. —Ten of the 27 species and subspecies are illustrated, 2 new.

BOLTOVSKOY, ESTEBAN. Über Zersetzungserscheinen bei mikro-paläontologischem Sammlungsmaterial.—Paläont. Zeitschr., vol. 27, No. 3/4, August 1953, pp. 237-240.

CARSOLA, ALFRED J. Possible planktonic occurrence of **Globigerina pachyderma** (Ehrenberg).—Journ. Pal., vol. 27, No. 5, Sept. 1953, pp. 742, 743, text fig. 1.—In cores of sea-ice from the Bering Sea.

CHURCH, C. C. Foraminifera, an evaluation.—Bull. Amer. Assoc. Petr. Geol., vol. 37, No. 7, July 1953, pp. 1553-1559.

de CIVRIEUX, J. M. SELLIER. Estudio de la microfauna de la seccion-tipo del miembro Socuy de la formacion Colon, Distrito Mara, Estado Zulia.—Ministerio de Minas e Hidrocarburos Boletin de Geologia, vol. 2, No. 5, April-June 1952, pp. 231-310, pls. 1-11, text figs. 1-12.—A fauna of 107 species and varieties (one new) is recorded and illustrated and statistical evidence bearing on correlation with Upper Cretaceous units in adjacent areas is presented.

COLE, W. STORRS. Larger Foraminifera from the upper Eocene of Costa Rica.—Journ. Pal., vol. 27, No. 5, Sept. 1953, pp. 748, 749.

COLE, W. STORRS, and BRIDGE, JOSIAH. Geology and Larger Foraminifera of Saipan Island.—U. S. Geol. Survey Prof. Paper 253, Sept. 17, 1953, pp. 1-45, pls. 1-15, tables 1-5 (Correlation and systematic paleontology by W. Storrs Cole).—Thirty-seven species, six new, mostly camerinids and orbitoids, are recorded and illustrated.

DECIMA, F. PROTO. Studio micropaleontologico sulla serie miocenica del Trevigiano occidentale. Nota preliminare.—Riv. Ital. Pal. Stratig., vol. 59, No. 3, 1953, pp. 139-144.—Foraminifera are listed.

EMILIANI, C., and EDWARDS, G. Tertiary ocean bottom temperatures.—Nature, vol. 171, May 16, 1953, p. 887.—Determined by ratio of oxygen-18 to oxygen-16 in shells of benthonic Foraminifera from different levels in a submarine core.

FUJIMOTO, H. The fusulinid zones in the Japanese Carboniferous.—C. R. 3^{eme} Congrès Strat. Géol. Carbonifère, Heerlen, 1951, pp. 219-223, table.

FUJIMOTO, HARUYOSHI, and KAWADA, SHIGEMA. **Hayasakaina**, a new genus of Fusulinids from the Omi-Limestone, Niigata Prefecture, Japan.—Sci. Repts. Tokyo Bunrika Daigaku, sec. C, vol. 2, No. 13, 1953, pp. 207-210, pl. 1.—**Hayasakaina** n. gen. (genotype **H. kotakiensis** n. sp.).

GANDOLFI, ROLANDO. Il Lattorfiano del Monteccio di Costozza (Colli Berici), Parte Seconda: I Foraminiferi. —Italy. Consiglio Naz. delle Ricerche, Univ. Padova, 1950, pp. 211-216.—Sixty-nine species and varieties are listed with brief notes on occurrence and abundance.

HAGN, HERBERT. Wege und Möglichkeiten mikropaläontologischer Untersuchungen im oberbayerischen Alpenvorland.—Paläont. Zeitschr., vol. 27, No. 1/2, April 1953, pp. 16-25, text fig. 1 (map).

Ein neues Verfahren zur Anfertigung orientierter Dünnschliffe kleiner paläontologischer Objekte.—Paläont. Zeitschr., vol. 27, No. 1/2, April 1953, pp. 26-31, text fig. 1.—A new method of making oriented thin sections.

Beschreibung von **Triplasia loeblichi** n. sp. (Foram.) nebst Bemerkungen zu den Gattungen **Triplasia** und **Tribrachia**—Paläont. Zeitschr., vol. 27, No. 3/4, August 1953, pp. 212-219, pl. 14.

HOFKER, J. Recent Peneroplidae, Parts I-V.—Journ. Roy. Micr. Soc., vol. 70, 1950, pp. 388-396; vol. 71, 1951, pp. 223-239, 342-356, 450-463; vol. 72, 1952, pp. 102-122; vol. 73, 1953, pp. 40-46.—Two new genera: **Praepeneroplis** (n. name for **Protopeneroplis** Hofker (not Weynschenk), genotype **Peneroplis senoniensis** Hofker) and **Puteolina** (genotype **Peneroplis proteus** d'Orbigny) and 24 species, 6 new. Discussion of family and generic relationships is included.

The genus **Epistomaria** Galloway, 1933, and the genus **Epistomaroides** Uchio, 1952.—Paläont. Zeitschr., vol. 27, No. 3/4, August 1953, pp. 129-142, text figs. 1-14.

HORNIBROOK, N. de B. Immigration of Foraminifera to New Zealand in the Upper Cretaceous and Tertiary.—New Zealand Journ. Sci. and Tech., sec. B, vol. 34, No. 6, May 1953, pp. 436-444, text fig. 1.—An important paper in which numerous species are listed according to their first appearances. Fluctuating immigration rates are graphically shown from Albian to Recent. Notes are included on probable sources of the immigrant species.

JOHANNSEN, ALFRED. Schliffe durch Cristellarien aus Oberkreide und Tertiär.—Paläont. Zeitschr., vol. 25, No. 3/4, April 1952, pp. 181-192, pls. 12, 13, text figs. 1-3.—Test wall, septa, aperture, and sculpture studied in section.

LADD, H. S., INGERSON, EARL, TOWNSEND, R. C., RUSSELL, MARTIN, and STEPHENSON, H. KIRK. Drilling on Eniwetok Atoll, Marshall Islands.—Bull. Amer. Assoc. Petr. Geol., vol. 37, No. 10, Oct. 1953, pp. 2257-2280, pls. 1, 2, text figs. 1-5, table 1.—Preliminary age determinations of the strata penetrated are based on larger Foraminifera.

MALDONADO-KOERDELL, MANUEL. Formaciones con fusilínidos del permo-carbonífero superior de México.—Ciencía, vol. 12 (9-10), Jan. 15, 1953, pp. 235-248, table.

MENARD, HENRY W. Pleistocene and Recent sediment from the floor of the northeastern Pacific Ocean.—Bull. Geol. Soc. Amer., vol. 64, Nov. 1953, pp. 1279-1293, pls. 1, 2, text figs. 1-5.—A few Foraminifera are mentioned.

PAPP, A., and TURNOVSKY, K. Die Entwicklung der Uvigerinen im Vindobon (Helvet und Torton) des Weiner Beckens.—Jahrb. [Austria] Geol. Bundesanstalt, Jahrgang 1953, vol. 96, heft 1, 1953, pp. 117-142, pl. 5.—The Vindobonian Uvigerinas are arranged into 4 groups with evolutionary relationships shown. Twenty species and subspecies, 6 new, are described and illustrated, and their occurrence and abundance plotted.

PERCONIG, ENRICO. Elementi di Geologia Stratigrafica del Polesine.—Ente Naz. Met., Serv. Geol., Bologna, 1949, pp. 1-29, pls. 1-7.—Numerous Foraminifera are listed from the several subdivisions of the Quaternary of the region. Excellent photographs of the assemblages accompany the paper.

Faune di transizione da ambienti marini nel Neogene della pianura padana.—Atti VII Conv. Naz. Met. e Petr., April 1952, pp. 1-16, pls. 1-5.—Three new species are described.

La stratigrafia del sondaggio profondo n. 29 di Cortemaggiore.—Atti VII Conv. Naz. Met. e Petr., April 1952, pp. 1-14, stratigraphic section.—Numerous Foraminifera are listed from various levels in the well which penetrates to the Aquitanian. New species are mentioned but not described.

La stratigrafia del sondaggio N. 1 di Morrovalle eseguito dall'A.G.I.P. nelle Marche.—Boll. Serv. Geol. Italia, vol. 74, 1952 (1953), pp. 1-17, pl. 1 (stratigraphic section).—Numerous Foraminifera are listed from various levels in the well which penetrates to the Elvezian.

REDMOND, C. D. Miocene Foraminifera from the Tubara beds of northern Colombia.—Journ. Pal., vol. 27, No. 5, Sept. 1953, pp. 708-733, pls. 74-77, text fig. 1 (map).—Eighty-three species and varieties, 15 new, are recorded and illustrated.

REISS, Z. On the Upper Cretaceous and lower Tertiary Microfaunas of Israel.—Bull. Research Council Israel, vol. 2, No. 1, June 1952, pp. 37-50, chart.—Stratigraphic ranges of 53 species between Santonian and upper Eocene are graphically represented.

SHAW, ALAN B. Preliminary survey of the Foraminifera of the lower shale of the Niobrara formation in the Laramie Basin.—Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf. 1953, pp. 47-55, pls. 1, 2, tables 1-3.—Forty species are illustrated.

UCHIO, T. On some foraminiferal genera in Japan.—Jap. Journ. Geol. Geogr., vol. 23, March 31, 1953, pp. 151-162, pl. 14.—Nine species, 3 new, from the Late Tertiary.

WETZEL, W. Die Mikroskopierung der kalkigen Fossileinschlüsse der Feuersteine.—Mikroskopie, [Vienna], vol. 81, heft 5/6, 1953, pp. 173-179, text figs. 1-12.—Some Foraminifera are found as inclusions in flint.

RUTH TODD