

CONTRIBUTIONS
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FOR
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PALAEOLOGICAL LABORATORY
BEAUFORT HOUSE

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH

VOLUME VIII, PART 2, APRIL, 1957

163. CERTAIN SMALLER BRITISH PALEOCENE FORAMINIFERA

PART II—*CIBICIDES* AND ITS ALLIESALAN WOOD¹ AND JOHN HAYNES²

ABSTRACT

Ten species are described, three of which are new, from the Thanet Beds of East Kent in the United Kingdom. Wall structure and pore character are shown to cut across the generic groupings, at present based on external shape and apertural characters.

INTRODUCTION

Scope of the paper.—This paper on *Cibicides* and allied genera is the second of a series representing the results of a taxonomic and stratigraphic revision of the foraminiferal fauna of the Thanet Beds of Kent in the United Kingdom. Ten species are described.

Species previously recorded.—H. Burrows and R. Holland in their pioneer work on the Thanet Beds reported the occurrence of the following species—

- Cibicides lobatulus* (d'Orbigny)
- Cibicides ungerianus* (d'Orbigny)
- Anomalina ammonoides* (Reuss)
- Anomalina grosserugosa* (Gümbel)

In this work the specimens referred to *C. lobatulus* are described as *Cibicides cassivellauni* n.sp. Specimens referred to *C. ungerianus* are described as *C. proprius* Brotzen and specimens referred to *A. grosserugosa* are described as *Anomalinoides nobilis* Brotzen. *A. ammonoides* was not found during the present investigation. *Rosalina mariae* Jones, represented by a single broken specimen in the British Museum of Natural History collections, is described here as *Cibicides mariae*.

Provenance.—Provenance of the species described is given in numbers referring to the stratigraphical columns illustrated in Certain Smaller British Paleocene Foraminifera, Part 1. The figures of the species were drawn by the junior author (J.H.) with the aid of camera lucida.

RELATIONSHIP OF *CIBICIDES* and
ALLIED GENERA

The relationships of the genera *Anomalina*, *Cibicides* and their allies are not known with certainty. This is revealed by inspection of the modern classifications (Sigal 1952, Bermudez 1952, Glaesner 1945, Cushman 1948) which are often surprisingly divergent. The reason for this uncertainty seems to be that these forms do not show enough independent character to enable the course of evolution to be accurately traced. Some of the characters used, e.g. the flattening of one side of the test in *Cibicides*, and the irregularity in growth of the attached genera, are adaptive and might well arise independently in unrelated stocks.

Of late years Wood (1949) and Hofker (1951) have studied the structure of the test in some detail, the former in polarized light, the latter with attention concentrated on the pores and the aperture. Such work, adding as it does to the total number of characters which can be observed and used in classification, may well lead to increased precision in generic nomenclature, and enable relationships to be traced with more accuracy. The structure of the test wall, in particular, is not known to be adaptive, and may persist unmodified while natural selection affects other characters. There is an obvious danger that an enthusiast might be carried away by his own discoveries, and erect a classification without regard to other work. It would be calamitous if two new classifications arose, one based on wall structure in polarized light and one on the pores and aperture, by the side of the present one based on the general morphology of the test. For this reason it is advisable to make an early attempt to see how far these characters are reliable, and how far they can be combined and with characters already used, even before the results of a full study are available.

The present note on *Cibicides* and its allies is mainly based on an examination of the species found by the junior author (J.H.) in his work on the Foraminifera of the Thanet Sands. It

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does not claim to be comprehensive even so far as *Cibicides* goes, and, as stated above, is of the nature of an interim report.

The type species of *Cibicides*, *C. refulgens* (Montfort), was erroneously stated to have a granular wall structure in 1949. Thin sections show the structure to be radiate; the individual crystals being apparently larger than usual. *Anomalina*, *Laticarinina*, *Cibicidella* and *Cyclocibicides* were also shown to be radially built.

Investigation of the wall character of species of *Cibicides* and its allies from the Thanet Sands shows the following species to be radiate hyaline:

Cibicides (Cibicidina) mariae (Jones).

Cibicides (Cibicidina) succedens Brotzen.

Cibicides (Cibicidina) cunobelini Haynes, n.spec.

The pores of these species are illustrated in Plate 6, and are closely similar. Both sides of the test are densely perforated by irregular pores, which tend to coalesce. Between them are numerous round micropores.

One specimen was found of another species which falls in the sub-genus *Cibicidina*. This is recorded as *C.(C.)* aff. *yazooensis* Cushman. The wall structure of this species also is radiate hyaline and the pores are small on both sides of the test. Since only the one specimen was found, crushing to observe the pores by high magnification was not deemed advisable.

The other species examined (except *C. cf. C. carinata* Terquem which is radiate hyaline) were found to be granular.

Cibicides (Cibicidoides) proprius Brotzen.

Cibicides cassivellauni Haynes, n. spec.

Cibicides cantii Haynes n. spec.

These species show micropores on both sides with very large round pores in addition on the dorsal side. The large pores apparently contain both imperforate plates and perforate sieve plates (well shown in Pl. 6, fig. 6, where they reach up to 7 microns in diameter) presumably related to the "pore plugs" described in the organic layer of *Discorinopsis aguayoi* Bermudez by Zach Arnold (1954). It is significant that the presence of sieve plates is associated with the presence of milk white layers of secondary calcite on the dorsal sides of these species. The pores were not closely studied in *C. cf. carinata* Terquem, since only two specimens were obtained, but observation at ordinary magnification suggests that they may be slightly different.

These results appear to show that both radial and granular species are included in *Cibicides* as

at present understood. This also appears to be the case in *Cibicidoides*, for a specimen of *Cibicides (Cibicidoides) pseudoungerianus* Cushman from the Challenger material was found to be radial, as was *Cibicides (Cibicidoides) alleni* (Plummer) from Midway material. *Cibicidoides eriksdalensis* Brotzen from the English Chalk is also radially built. Though this may not be strictly speaking, the genotype of *Cibicidoides*, it is at least the species with which Brotzen actually worked.

In addition to the species mentioned the wall structure of *Anomalinoides nobilis* Brotzen was investigated and found to be granular. The test wall on both sides is perforated with round pores of a comparable size to the irregular pores in *C. succedens* and similarly there are numerous micropores between them. However, *C. succedens* has been shown to be radially built, and the test shape is markedly divergent. When all the other characters differ the character of the pores alone can scarcely be considered to indicate relationship. There is some evidence in the material at our disposal that pores can be more densely packed and more perfectly developed in granular species with a thin test (like *A. nobilis*) than in those with a thicker test such as *C. cassivellauni*.

Wall structure and pore character thus cut across the generic groupings based on external shape and apertural character, at present used in the Anomalininae. Furthermore, it seems clear that pore character alone cannot be used in establishing relationships. The evidence as to the value of the wall structure in classification is as yet inconclusive. When, however, the wall structure and the pore character reinforce the evidence of outward form, as is the case with those species here assigned to the sub-genus *Cibicidina* there would seem to be strong evidence of close natural links between the species.

SYSTEMATIC PART

Order FORAMINIFERA.

Family DISCORBIDAE.

Sub-family ANOMALININAE.

Genus *Cibicides* Montfort, 1808.

Cibicides (Cibicidoides) proprius Brotzen

Plate 5, figures 1-1b, 2-2b

1897, *Truncatulina ungeriana* Burrows and Hol-

land (not d'Orbigny), Proc. Geol. Assoc., vol. 15, p. 47, pl. II, fig. 23; Thanet Beds.

1944, *Cibicides cryptomphalus* Ten Dam (not Reuss), Med. Geol. Sticht, Ser. C-V-3, p. 132, pl. I, fig. 4; Paleocene; Holland.

1948, *Cibicidoides proprius* Brotzen, Sver. Geol. Undersok. Ser. C, Ars. 42, p. 78, pl. 12, figs. 3, 4; Paleocene (Ystad) Sweden.

Distinguishing features.—A granular, biconvex *Cibicides* with subangular periphery, eight chambers in the second whorls of megalospheric specimens and eight or nine chambers in the second whorls of microspheric specimens. The dorsal side is coarsely perforate and the diameter of the area not covered by the last whorl on this side is much greater than the height of the last chamber.

Description.—(Plate 5, figs. 1-1b). Test biconvex, ventral side involute, dorsal side partially evolute with inner coil of six chambers visible; periphery sub-angular and slightly lobate; chambers, about 20, increasing in size slowly, 8 visible on the periphery; ventral sutures impressed and backward curving, meeting at the small umbilicus which is filled with clear calcite; dorsal sutures backward curving, limbate and becoming impressed; pores on dorsal side large and irregular with very fine ones between them, very fine only on the ventral side; test granular; aperture periphero-dorsal beneath a lip which continues as weakly developed lappets on previous chambers.

Dimensions.—Diameter 0.59 mm.; width 0.26 mm.; height of chambers at close of second whorl about twice that at the close of the first; proloculus approximately 30 microns in diameter; dorsal umbilicus greater than one third of the total diameter.

Horizon.—P24, Pegwell Marls.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42610.

Alternation of generations.—At least two groups of proloculus size appear to be shown by this species. One group, possibly the microspheric generation, tends to develop 7:8 or 9:10-, chambers in successive whorls, while the other group, possibly the megalospheric generation tends to develop 6:8:8:3 or 4-, chambers in successive whorls. Lobation and impression of the sutures appear to be connected with growth. For instance, the microspheric specimen illustrated (Pl. 5, figures 2-2b) shows an entire periphery and flush sutures. Representatives of this generation are rare.

Variation.—The dorsal side may be raised and the ventral side flattened with connected changes in the shape of the apertural face.

Discussion.—This specimen was referred to *Truncatulina ungeriana* d'Orbigny by Burrows and Holland. D'Orbigny's figure in the Vienna Basin monograph shows a form with acute, keeled periphery and numerous chambers. That d'Orbigny's species is different from the Paleocene species is confirmed by the work of P. Marks (1951) in a revision of the Miocene Vienna Basin fauna where *Cibicides ungerianus* is shown to be a keeled form with ten chambers visible, coarsely perforate on both sides and with the dorsal umbilicus filled with secondary shell material.

The Thanet specimens appear to be identical with *Cibicides cryptomphalus* in Ten Dam's sense, included by Brotzen in his species, *C. proprius* although his type figures appear to show specimens with more acute peripheries than are typical in the Netherlands and Kentish populations.

Further difficulty is created by the fact that very closely allied forms have been described from the Oligocene and Recent as *Cibicides pseudoungerianus* Cushman. Cushman's type figure shows only the dorsal side of the species but other figures such as those in his North Atlantic monograph, show specimens which are generally larger, more acute, show more chambers in each whorl and are apparently distinctly punctate ventrally. One specimen picked from *Challenger* material was found to be radial so it is possible that the Recent species is also different in its wall structure from the Paleocene species. *C. ungerianus* in Hofker's sense, is globose with punctations on both sides and may be a variety of Cushman's species. The same may be true of specimens in the British Museum of Natural History from the Barton Beds and London Clay, listed as *Truncatulina ungeriana* and *Planorbulina ungeriana*.

Cibicides cassivellauni Haynes, n. sp.

Plate 5, figures 3-3b, 4-4b; Plate 6, figure 6

1897, *Truncatulina lobatula* Burrows and Holland (not d'Orbigny). Proc. Geol. Assoc., vol. 15, p. 47, pl. II, fig. 24; Thanet Beds.

Distinguishing features.—A granular, planoconvex *Cibicides* with sub-angular periphery and about eight chambers in the second whorl. The pores are large with very fine ones between them on the dorsal side of the test and large pores also occur on the ventral side of the last few chambers in some megalospheric forms. The dorsal umbilicus is small.

Description.—(Pl. 5, figs. 3-3b). Test planoconvex and low, ventral side involute with small,

shallow umbilicus filled with clear calcite, dorsal side evolute; chambers 16 in number arranged as follows, 7:3:1, seven chambers visible ventrally; ventral sutures backward curving and impressed, dorsal sutures backward curving and limbate; pores large and round with sieve plates (Pl 6, fig. 6), with very fine pores between them on the dorsal side, very fine only on the ventral side, except for a few large ones on the last two chambers; test granular, milk white dorsally (due in part to perforation), vitreous ventrally; aperture periphero-dorsal beneath a lip which continues on previous chambers as weakly developed lappets.

Dimensions.—Diameter 0.60 mm.; width 0.15 mm.; height of chambers at close of second whorl about twice that at the close of the first whorl; dorsal umbilicus less than the height of the last whorl.

Horizon.—P31, Pegwell Marls.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42611. Additional specimens P42614.

Alternation of generations.—There appear to be at least two groups of proloculus size, one ranging in diameter about 15 microns, and the other ranging between 30 and 40 microns. Both groups appear to show eight chambers in the second

whorl. Characters apparently related to growth are limbation and impression of the sutures and the incoming of coarse pores on the ventral side. Microspheric specimens are rare.

Discussion.—This species is quite distinct from *Cibicides lobatulus* d'Orbigny which has medium sized pores on both sides. It differs from the *C. proprius* Brotzen, *C. pseudoungerianus* Cushman group in its flat dorsal side and in its relatively small dorsal umbilicus. *C. howelli* Toulmin is equi-punctate with high, umbonate ventral side and nine to ten chambers in each whorl.

Derivation of Name.—The species is named after a chief of the Belgae, a tribe inhabiting Kent in Romano-British times.

***Cibicides cassivellauni* var. *buximargo* Haynes,
n. var.**

Plate 5, figures 5-5b

Distinguishing features.—A variety of *Cibicides cassivellauni* with inflated chambers, rounded periphery and strongly limbate dorsal sutures.

Description.—Test plano-convex, ventral side involute, dorsal side evolute; periphery rounded and semi-lobate; chambers 16, arranged as fol-

EXPLANATION OF PLATE 5

X 50

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lows:—7:8:1-, 8 visible on the ventral side; sutures slightly impressed on the ventral side, limbate on the dorsal side; pores large with very fine pores between them on the dorsal side, very fine on the ventral side with larger ones scattered on later chambers; wall granular; aperture periphero-dorsal beneath a lip which continues on previous chambers as weakly developed lappets.

Dimensions.—Diameter 0.32 mm.; height of chambers at the close of the second whorl about twice that at the close of the first whorl; dorsal umbilicus less than a third of the total diameter.

Horizon.—P48. Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42615.

Alternation of generations.—Proloculus diameters in the specimens examined ranged about 30 microns, similar to the lower range of megalospheric diameters in *Cibicides cassivellauni*.

Cibicides cantii Haynes, n.sp.

Plate 5, figures 13-13b, 14; Plate 6, figure 2

Distinguishing features.—A small, compressed plano-convex *Cibicides* with granular test and coarsely perforate dorsal side. The chambers are lobate and variable in number but tend to become arcuate and reduced in number to six in the second whorls of megalospheric forms. There are eight or nine chambers in the second whorls of microspheric forms.

Description.—(Pl. 5, figs. 13-13b). Test plano-convex, compressed with angular, slightly lobate periphery, ventral side involute, dorsal side evolute; chambers 12, arranged as follows: 7:5:-, in successive whorls, 6 visible ventrally; sutures on ventral side slightly impressed, meeting in a small, shallow umbilicus filled with clear shell material, sutures on dorsal side limbate and backward curving; wall granular; pores large and round with very fine ones between them on dorsal side, very fine pores only on ventral side; aperture periphero-dorsal beneath a slight lip.

Dimensions.—Diameter 0.34 mm.; width 0.06 mm.; height of chambers at the close of the second whorl three times that at the close of the first whorl.

Horizon.—RB3, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42616. Additional specimens P42617.

Alternation of generations.—There appear to be at least two groups of proloculus size, one, presumably the microspheric generation, ranging about 10 to 15 microns in diameter and the other rang-

ing about 20 to 25 microns in diameter. The former tends to develop 7:8 or 9:5-, chambers in successive whorls, up to about 23 in all, the latter, 6 or 7:67-, chambers in successive whorls, up to about 14 in all. Microspheric specimens are rare.

Variation.—There is apparently variation in the lobation of the periphery and the rate of chamber size increase apart from that related to polymorphism. Specimens with high ventral sides also occur.

Discussion.—The Thanet population is apparently distinct from finely porous species such as *C. ribbingi* Brotzen and the concavo-convex *C. geleensis* van Bellen. *C. burlingtonensis* Jennings is coarsely perforate on both sides as is *C. convexa* Reuss. Adult size and the rate of chamber size increase distinguish this species from the closely related *C. cassivellauni*.

Derivation of name.—This species is named after the Belgic tribe of Cantii, inhabiting the Canterbury district of Kent in early Romano-British times.

Cibicides cf. *C. carinata* Terquem.

Plate 5, figures 15, 15a

Description.—Test plano-convex, compressed, lobate with well developed keel; chambers 16 in number, arranged as follows: 8:6:2:-, in successive whorls, 6 visible at the periphery, initial whorl visible on the incompletely involute ventral side; sutures impressed on the ventral side, distinct and backward curving on the dorsal side; test wall radiate; pores large on the dorsal side, fine on the ventral side; aperture periphero-dorsal.

Dimensions.—Diameter 0.37 mm.; height at close of second whorl five times that at close of the first whorl; proloculus diameter approximately 15 microns.

Horizon.—RB5, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42619.

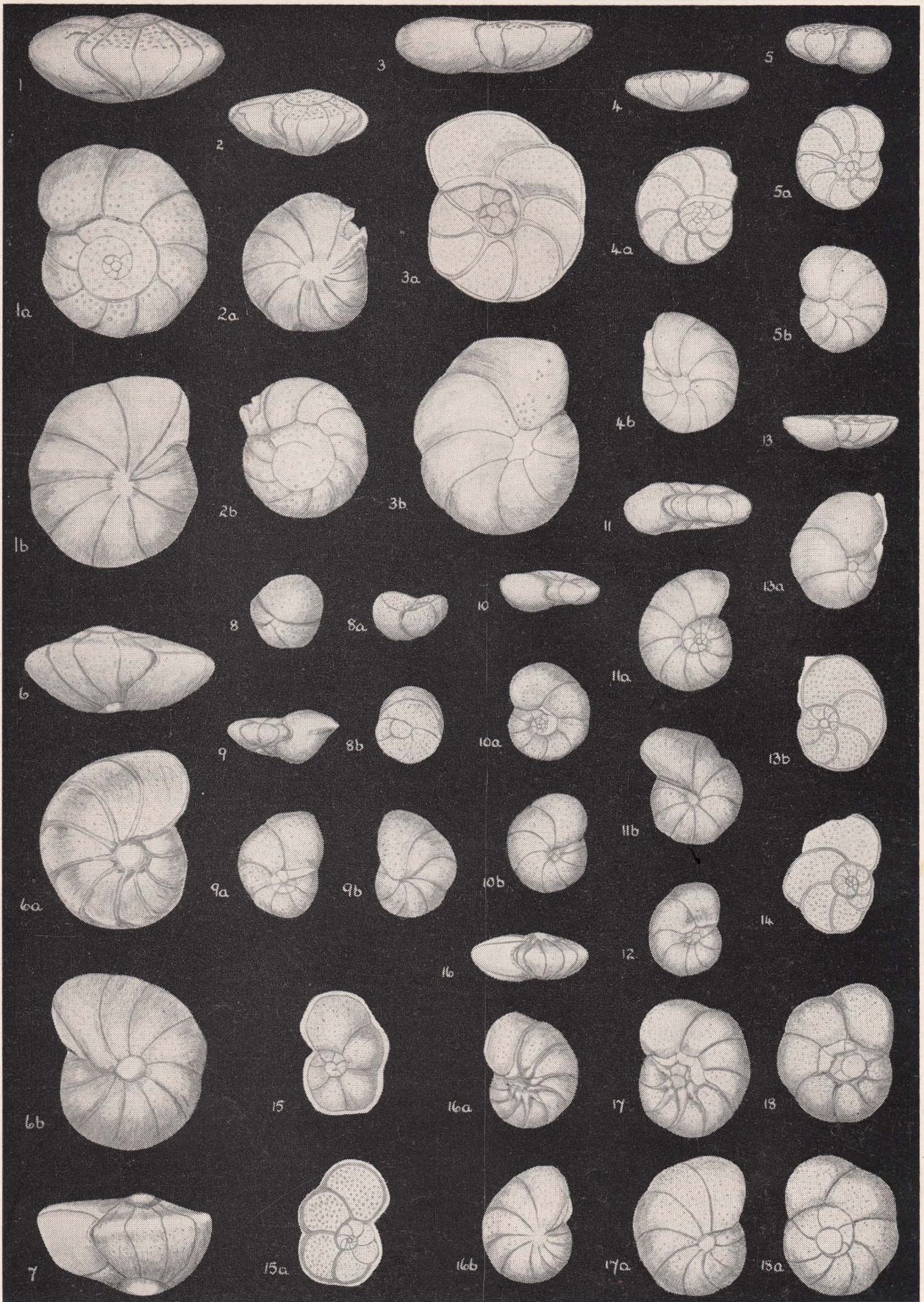
Discussion.—The Thanet specimen described differs from the type in its rather pentagonal outline and greater rate of chamber size increase.

Cibicides (*Cibicidina*) *succedens* Brotzen.

Plate 5, figures 6-6b, 7; Plate 6, figure 1

1948, *Cibicides succedens* Brotzen, Sver. Geol. Undersök., Ser. C, Ars. 42, p. 80, pl. 12, figs. 1, 2; Paleocene (Ystad) Sweden.

Distinguishing features.—A plano-convex, in-



Wood and Haynes: British Paleocene Foraminifera

volute, radiate hyaline *Cibicides* with entire sub-angular periphery, high ventral side with distinct sutures and umbilical bosses on both sides. There are fine irregular pores with very fine pores scattered between them.

Description.—(Pl. 5, figs. 6-6b), Test plano-convex and entire with high ventral side and dorsal side raised at the umbilicus, involute, with umbilical bosses; 10 chambers visible at the periphery, sutures flush, backward curving, limbate on the dorsal side; pores small, irregular with very fine pores between them; test wall radiate hyaline; aperture periphoro-dorsal beneath a lip which continues on previous chambers as weakly developed lappets.

Dimensions.—Diameter 0.57 mm.; width 0.21 mm.

Horizon.—P16, Pegwell Marls.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42618.

Alternation of generations.—There appear to be at least two groups of proloculus size, one, possibly representing the microspheric generation, ranging about 15 microns in diameter; the other, possibly representing the megalospheric generation, ranging about 30 microns in diameter. Whereas the microspheric generation tends to develop 10 chambers in the third whorl, the megalospheric generation tends to develop 8 chambers.

Variation.—The curvature and limbation of the dorsal sutures are variable. The tests also vary in height and in the development of umbilical bosses.

Cibicides (Cibicidina) cunobelini Haynes n. sp.

Plate 5, figures 16-16b, 17, 17a, 18, 18a;

Plate 6, figure 3

?1944 *Cibicides praecursorius* ten Dam (not Schwager), Med. Geol. Sticht., Ser. C-V-3, p. 134, pl. 5, fig. II; Paleocene, Holland.

Distinguishing features.—A biconvex, involute *Cibicides* in which the ventral side is the highest and the periphery rounded. There are up to ten chambers visible ventrally in microspheric forms, eight in megalospheric forms. The dorsal sutures are limbate and swell into small bosses towards the umbilicus. In later chambers the bosses disappear and the chambers develop lappets with re-entrants at each suture. This development is accelerated in megalospheric forms. The test wall is radiate hyaline and the pores small and irregular with very fine ones between them.

Description.—Holotype (Pl. 5, figs. 16-16b). Test

biconvex, involute, terminal chamber broken, ventral side highest, periphery rounded; 10 chambers visible, ventral sutures distinct, flush, backward curving, dorsal sutures limbate and swelling into small bosses towards the umbilicus; test wall radiate hyaline; pores small and irregular with very fine pores between them; aperture periphoro-dorsal beneath a lip.

Dimensions.—Diameter 0.35 mm.; width 0.14 mm.

Horizon.—P46, Pegwell Marls.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42620. Additional specimens P42621.

Alternation of generations.—There appear to be at least three groups of proloculus size. One, presumably representing the microspheric generation with diameters ranging about 15 microns, tends to develop 7:9 or 10:10 chambers in successive whorls, up to 27 in all. A second group, possibly representing the megalospheric generation with diameter ranging about 35 microns, tends to develop 7:8-, chambers in successive whorls, up to about 15 in all. A third group, possibly representing a further megalospheric generation with diameters ranging about 60 microns, tends to develop 7:7-, chambers in successive whorls, up to 14 in all. Microspheric specimens are rare.

Variation.—The involution of the ventral side is variable and sometimes part of the first whorl can be seen. The dorsal side is variable in height and occasionally rather flattened.

Discussion.—The species is most closely related to *Anomalinoidea midwayensis* (Plummer) which differs from it in its raised ventral sutures and distinct ventral umbilicus. *Cibicides vulgaris* (Plummer) is more coarsely punctate in addition to bearing raised sutures on each side.

Derivation of name.—This species is named after a chief of the Trinovantes inhabiting Essex and the London Basin in Romano-British times.

Cibicides (Cibicidina) mariae (Jones)

Plate 5, figures 10-10b, 12; Plate 6, figure 4

1852, *Rosalina mariae* Rupert Jones, Quart. Journ. Geol. Soc., vol. 8, p. 267, pl. xvi, fig. 13; Thanet Beds.

?1927, *Discorbis newmaniae* Plummer, Texas Univ. Bull., 2644, p. 138, pl. 9, figs. 4a-c; Midway Texas.

1942, *Cibicides newmaniae* Cushman and Todd, Contr. Cushman Lab. Foraminif. Res., vol. 18, p. 46, pl. 8, fig. 16.

1955, *Cibicides newmaniae* Weiss, Journ. Pal., vol. 29, no. I, p. 20, pl. 6, figs. 18-20; Paleocene, Peru.

Distinguishing features.—A concavo-convex radiate hyaline *Cibicides* partially involute on the dorsal side with well-developed lappets. There are eight or nine chambers in the second whorl and the pores are small on both sides with very fine ones between.

Description.—(Pl. 5, figs. 10-10b). Test concavo-convex, involute ventrally, partially involute dorsally, periphery sub-acute and entire; chambers 19 in number, arranged as follows, 7:3:4-, 7 visible ventrally; sutures flush and backward curving ventrally, limbate and backward curving dorsally; aperture periphero-dorsal beneath a lip which continues on previous chambers as strongly developed lappets; wall radiate hyaline; pores small, irregular, with very fine pores between.

Dimensions.—Diameter 0.29 mm.; width 0.06 mm.; proloculus diameter about 15 microns; height of chamber at the close of the second whorl about twice that at the close of the initial whorl.

Horizon.—P53, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42622.

Alternation of generations.—There appear to be at least three groups of proloculus size. One group, possibly representing the microspheric generation with diameters ranging about 5 microns, tends to develop 7:8 or 9:3 or 4-, chambers in successive whorls, up to 20 in all. A second group, possibly representing the megalospheric generation with diameters ranging about 15 microns tends to develop 7:8 or 9:3 or 4-, chambers in successive whorls, up to 20 in all. A third group, possibly representing a further phase of the megalospheric generation with diameters ranging about 25 microns, tends to develop 7:7 or 8:2-, chambers in successive whorls, up to 17 in all. Microspheric specimens are rare.

Variation.—There is variation in the limbation of the dorsal sutures and in the development of lappets.

Discussion.—Plummer's figure shows a specimen with evolute ventral side, a feature not shown by specimens picked from Midway material. These last are indistinguishable from Thanet specimens as is the specimen described by Weiss. *Cibicides danwillensis* Howe and Wallace may be synonymous with *C. mariae*.

Cibicides aff. *C. yazoensis* Cushman

Plate 5, figures 9-9b

Description.—Test plano-convex, involute, ventral side high; periphery sub-angular; 7 chambers visible; ventral sutures distinct, sigmoid, flush, backward curving, dorsal sutures limbate; wall radiate hyaline; pores small on both sides; aperture periphero-dorsal beneath a lip which continues on previous chambers as well developed lappets.

Dimensions.—Diameter 0.32 mm.

Horizon.—RB4, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42623.

Discussion.—The Thanet specimens appear to be very near Cushman's species from the Jackson Eocene but lack raised ventral sutures.

Cibicides sp.

Plate 5, figures 8-8b

Description.—Test plano-convex, ventral side involute, high, dorsal side evolute; chambers approximately 6 in number, four visible ventrally, the last making up one third of the test; sutures flush, backward curving on the dorsal side; wall granular; pores small on both sides; aperture periphero-dorsal.

Dimensions.—Diameter 0.22 mm.

Horizon.—P50, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42624.

Genus *Anomalinoides* Brotzen, 1942.

Anomalinoides nobilis Brotzen.

Plate 5, figures 11-11b; Plate 6, figure 5

1897, *Anomalina grosserugosa* Burrows and Holland (not Reuss), Proc. Geol. Assoc., vol. 15, p. 48, pl. II, fig. 26; Thanet Beds.

1948, *Anomalinoides nobilis* Brotzen, Sver. Geol. Undersök., Ser. C, Ars. 42, p. 89, pl. 19, fig. 5; Paleocene (Klagshamn) Sweden.

Distinguishing features.—An *Anomalinoides* with rounded periphery and eight or nine chambers in the second whorl. The chambers increase slowly in size. The ventral umbilicus is small and deep, the dorsal umbilicus wide and shallow.

Description.—(Pl. 5, figs. 2-2b). Test semi-inflated, a very low trochospire with entire, rounded periphery, ventral side involute with small, deep

umbilicus, dorsal side partially involute with shallow umbilicus; chambers 20 in number, 8 visible ventrally, arranged as follows, 7:3:5-; sutures distinct on the ventral side, limbate on the dorsal side; wall granular, pores small, round with very small ones between them on both sides; aperture extends from umbilicus to umbilicus beneath a marked lip which continues as weak lap-pets on the dorsal side.

Dimension.—Diameter 0.37 mm.; width 0.15 mm.; proloculus about 15 microns in diameter; dorsal umbilicus about one third of the total diameter; height of chambers at close of the second whorl about twice that at the close of the first whorl.

Horizon.—RB1, Reculver Silts.

Depository.—Brit. Mus. Nat. Hist., Cat. no. P42625.

Alternation of generations.—There appear to be at least two groups of proloculus size ranging about 75 microns, and about 20 microns. A clear cut distinction could not be made between the chambering developed in the two groups.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH

VOLUME VIII, PART 2, APRIL, 1957

164. SOME NEW TERTIARY AND RECENT FORAMINIFERA FROM
CALIFORNIA AND THE EASTERN PACIFIC OCEAN*

ORVILLE L. BANDY¹ AND ROBERT E. ARNAL²

ABSTRACT

Ten new species and varieties of Foraminifera from fossil and Recent localities are described and illustrated.

INTRODUCTION

Ten new species and varieties of Foraminifera have been found in the course of researches of a non-taxonomic nature. A few of these new forms have been reported incorrectly in the literature, most of them are from subsurface sections and are unknown elsewhere, and one species is Recent from off the coast of Central America. The fossil species are from well cores in the San Joaquin Valley of California.

The holotype specimens representing the new species described herein are deposited in the micropaleontology laboratory at the University of Southern California. Figures of the Foraminifera were drawn by Miss Mary E. Taylor.

Research for this paper was conducted in the Allan Hancock Foundation at the University of Southern California. Thanks are given to the Western Gulf Oil Company for making the well samples available and for permission to publish the descriptions of these new species.

Locations are given with reference to the Mount Diablo Base Meridian.

SYSTEMATIC DESCRIPTIONS

Family TROCHAMMINIDAE Schwager, 1877

Genus *Alveolophragmium* Stschedrina, 1936

Alveolophragmium becki Bandy and Arnal,
n. sp.

Plate 7, figure 1

Haplophragmoides trullissata, Cushman and Laiming, 1931, Jour. Paleontology, vol. 5, no. 2, p. 93, pl. 9, fig. 5.

Test arenaceous, planispiral, bilaterally symmetrical, outer whorl embraces about two-thirds of the previous whorl exposing the earlier chambers in the umbilical areas; periphery slightly lobate; edge rounded; chambers average about 13 in the final whorl, increasing very gradually in size as added; sutures flush to slightly depressed, nearly straight; wall arenaceous and smoothly finished; aperture a broad low opening near the base of the last septal face. Diameter 0.70 mm.; thickness 0.35 mm.

Holotype.—USC No. 4572. Saucian. The specimens are from wells in section 28, T. 32 S., R. 23 E, MDBM.

This species is often referred to *Haplophragmoides trullissatum* (H. B. Brady) (Quart. Jour. Micr. Sci., vol. 19, 1879, p. 56, pl. 5, figs. 10, 11) but is quite distinct from Brady's species in being very much thicker, and with about 13 chambers per whorl as compared with 8 or 9 in Brady's. It is also similar to *Alveolophragmium veleronis* (Cushman and McCulloch) (Allan Hancock Pacific Exped., vol. 6, no. 1, p. 82, pl. 7, fig. 2) differing in being not as evolute. Because the aperture is above the base of the last septal face, this new species is placed in the genus *Alveolophragmium* rather than *Haplophragmoides*. Typical specimens occur in the Los Sauces Creek section, described by Cushman and Laiming.

Genus *Haplophragmoides* Cushman 1910

Haplophragmoides translucens Bandy and Arnal, n. sp.

Plate 7, figure 2

Test arenaceous, planispiral, compressed, close coiled in the early part tending to become evolute in the later portion; periphery slightly lobulate in the later portion of larger specimens, otherwise entire; edge abruptly to slightly carinate; cham-

*Contribution No. 190 of the Allan Hancock Foundation, University of Southern California, Los Angeles, California.

1 University of Southern California, Los Angeles
2 Western Gulf Oil Company, Ventura

bers usually 7 to 9 in the final whorl, enlarging fairly rapidly in size as added; sutures radial, curved, slightly raised above the surface of the chambers; surface rather roughly finished; wall rather translucent, especially near the sutures; aperture appears to be at the base of the septal face. Diameter 0.70 mm., thickness 0.14 mm.

Holotype.—USC No. 4577. Zemorrian. The type specimens are from wells in section 22, T. 24 S., R. 23 E., MDBM.

This species is quite distinctive in its highly compressed form, in the translucent character of the test, especially the coarse sutures, and in the tendency to become evolute. It is known only from the subsurface sections.

Family NODOSARIIDAE Schultze 1854

Genus *Robulus* Montfort 1808

Robulus hedbergi Cushman and Renz var.

subregius Bandy and Arnal, n. var.

Plate 7, figure 3

Test biconvex, ovate in side view, tending to become evolute; periphery sharply angled or with narrow keel; also with flat short spinose projections near the ends of most of the sutures; 9 to 11 chambers in the last whorl, increasing more rapidly in width than length; sutures limbate, raised and bead-like in the early portion, depressed in the later part of the test; surface smooth with irregular papillae in the early part of some specimens; septal face rounded, narrow; aperture at the outer margin of the last septal face, slightly produced, radiate. Diameter 1.20 mm.; thickness 0.35 mm.

Holotype.—USC No. 4578. Saucian. The type specimens are from wells in section 20, T. 28 S., R. 28 W. MDBM.

This new variety is more involute than *R. hedbergi* Cushman and Renz (Cushman Lab. Foram. Res. Contrib., vol. 17, p. 10, 1941) and the chambers are much wider than long in the adult portion of the test. The variety is also distinct from *R. subpapillosus* (Nuttall) (Jour. Paleontology, vol. 6, p. 12, 1932) which has very prominent raised limbate sutures throughout. It is known only in the subsurface section.

Robulus laimingi Bandy and Arnal, n.sp.

Plate 7, figures 4, 5

Robulus simplex, Cushman and Laiming, 1931, Jour. Paleontology, vol. 5, no. 2, p. 98, pl. 10, figs. 5, 6.

Robulus simplex, Kleinpell, 1938, Miocene Stratigraphy of California, Amer. Assoc. Petroleum Geologists, Tulsa, Oklahoma, p. 202, pl. 8, fig. 1. See the synonymy here for other references to specimens which probably belong in *R. laimingi*.

Test lenticular, large, biumbonate, close-coiled; periphery with slight keel; edge acute; chambers about 10 in number, closely appressed, slightly inflated, especially in large individuals; sutures raised and limbate in the early portion, becoming flush and depressed in the later part of the test, slightly curved; wall smooth; aperture at the outer end of the septal face. Diameter 0.80 mm.; thickness 0.27 mm.

Holotype.—USC No. 4579. Paratype.—USC No. 4582. Saucian. The type specimens are from the wells located in sec. 34, T. 28 S., R. 20 E., MDBM.

Robulus laimingi is distinguished from *Robulus simplex* (d'Orbigny) (Foram. Foss. Vienne, p. 103, pl. 4, figs. 27, 28, 1846) by possessing raised limbate sutures that fuse into central umbonal masses. D'Orbigny's original figure and description makes no mention of umbonal masses and raised limbate sutures. Typical specimens of this species may be found in the Los Sauces Creek section as described by Cushman and Laiming.

Family NONIONIDAE Reuss 1860

Genus *Elphidium* Montfort 1808

Elphidium strattoni (Applin) var. *joaquinensis*

Bandy and Arnal, n. sp.

Plate 7, figure 6

Test small, nautiloid, sides nearly parallel in edge view, circular in side view; periphery mostly entire, becoming slightly lobulate in the later portion; umbilici flush, revealing only a small portion of the previous whorls, chambers about 12-15 in the final whorl, increasing very gradually in size as added; sutures slightly curved, nearly radial, nearly flush, marked by about 5 or 6 conspicuous retral processes on each side; surface of test smooth; wall finely perforate; aperture a series of pores at the base of the last septal face, and a few scattered pores on the septal face. Diameter 0.30 mm.; thickness 0.10 mm.

Holotype.—USC No. 4574 Pliocene. The type is

from wells in section 7, T. 29 S., R. 21 E., MDBM.

This new variety is distinguished from *Elphidium strattoni* (Applin) (Amer. Assoc. Petroleum Geologists, vol. 9, no. 1, p. 100, 1925) by the more prominent retral processes and nautiloid shape with rounded edge. This variety is not known from surface sections.

Family ROTALIIDAE Reuss 1860

Genus *Buccella* Anderson, 1952

Buccella bella Bandy and Arnal, n. sp.

Plate 7, figure 7

Test very small, trochoid, nearly biconvex; edge abruptly rounded; periphery slightly lobate; chambers five to seven in the final whorl, enlarging very slowly as added, very slightly inflated ventrally; dorsal spire with limbate spiral suture; dorsal sutures limbate, curved and tangential; ventral sutures slightly curved, radial, and slightly depressed; wall finely perforate and smooth; aperture consists of many pores located at and near the base of the apertural face and along the sutures on the ventral side of the test. Diameter 0.25 mm.; thickness 0.20 mm.

Holotype.—USC No. 4573. Upper Miocene. The types are from wells in section 5, T. 28 S., R. 23 E., MDBM.

This species is similar in many respects to *Buccella frigida* (Cushman) (Contr. Can. Biol., no. 9, p. 12, 1921), differing mainly in lacking the pustulose covering, in its smaller size, fewer whorls, and in the greater development of limbations dorsally. It is unknown from surface sections.

Genus *Epistominella* Husezima and Maruhasi

Epistominella obesa Bandy and Arnal, n. sp.

Plate 7, figure 8

Test ovate in side view, rotaloid and somewhat inflated; periphery smooth in the early portion, becoming slightly lobulate in the later portion of the final whorl; edge rounded; chambers about 9 in the final whorl, closely appressed at first and then becoming slightly inflated in the adult whorl; sutures very narrowly limbate, flush in the early part of the test, somewhat depressed in the later part, especially on the ventral side; dorsal sutures slightly arcuate and tangential; ventral sutures arcuate, occasionally sinuate, and nearly radial; wall finely perforate, smooth; aperture elongate, on the terminal face of the last chamber slightly oblique to the plane of coiling and with a very slight lip. Diameter of one of the larger specimens selected as the holotype, maximum diameter 0.39 mm.; thickness 0.22 mm.

Holotype.—USC No. 4575. Recent, off Central America, Lat. 12° 17½' N., Long. 88° 12' W., at a depth of 250 fathoms.

This species is generally similar to *E. bradyana* (Cushman) (1927, Bull. Scripps Inst. Oceanography, vol. 1, no. 10, p. 165) but differs from that species in having a rounded edge and in being much more obese.

Genus *Eponides* Montfort 1808

Eponides pseudoaffinis Bandy and Arnal, n. sp.

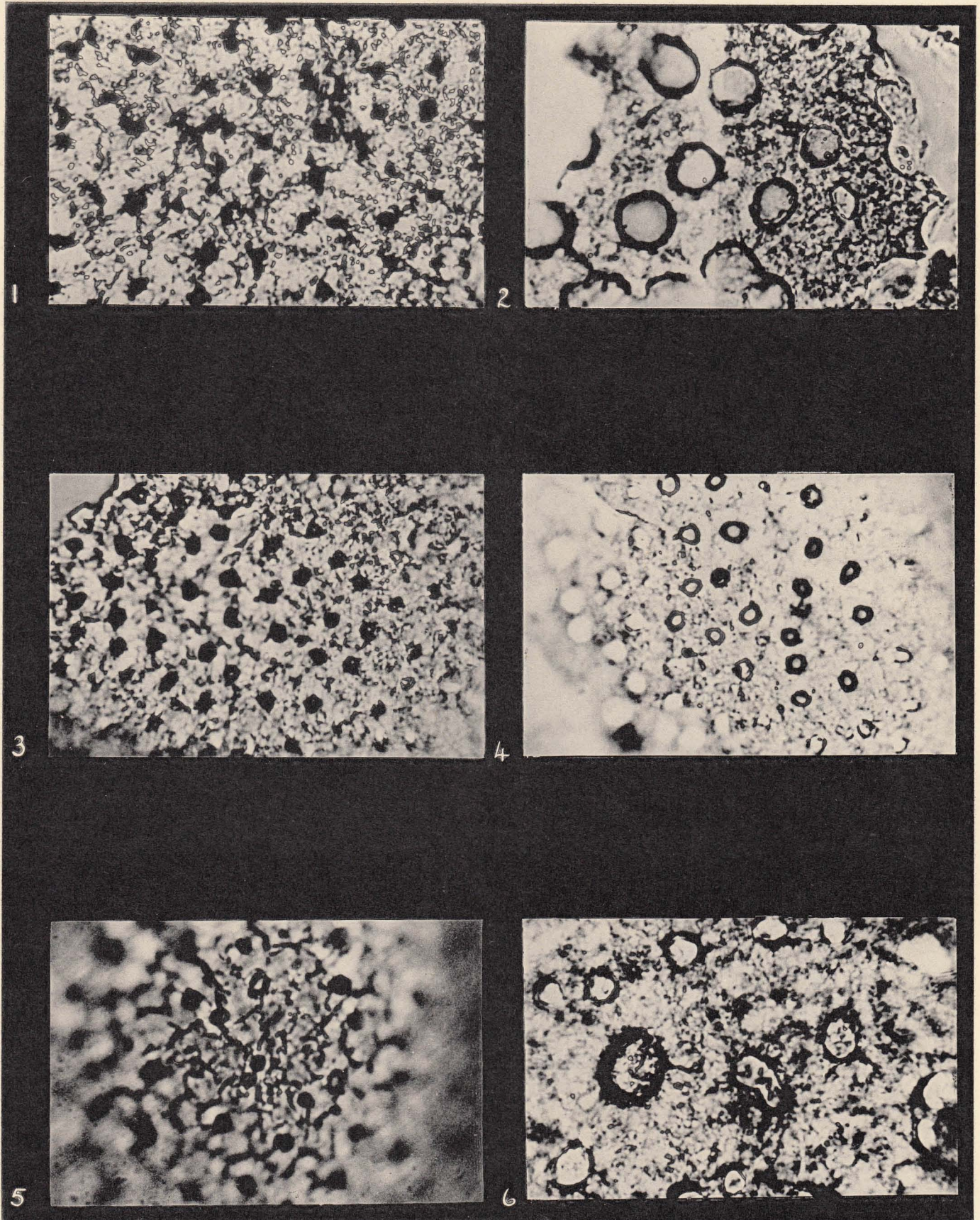
Plate 7, figure 9

Eponides affinis, Cushman and Laiming, 1931, Jour. Paleontology, vol. 5, no. 2, p. 114, pl. 13, fig. 8.

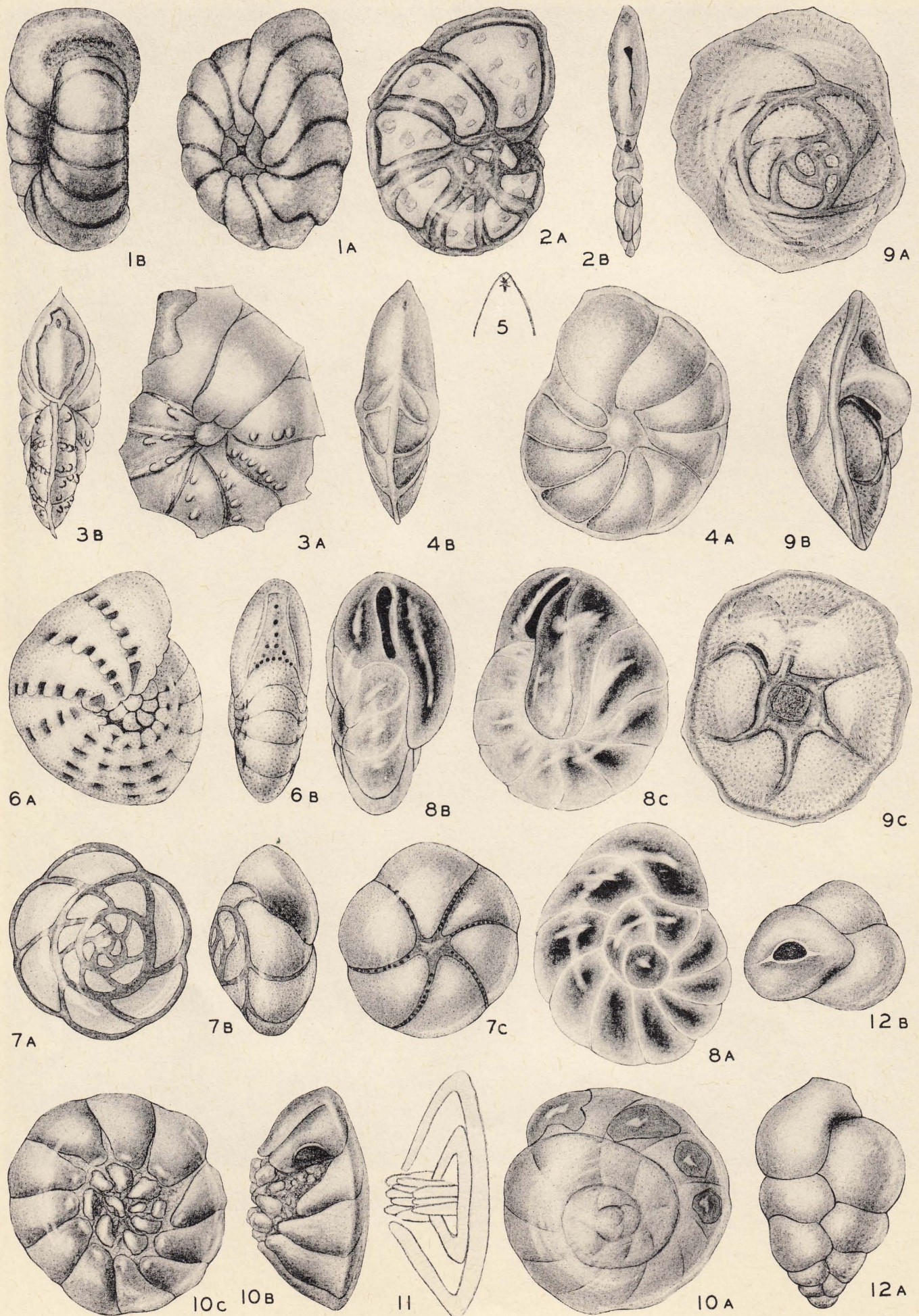
EXPLANATION OF PLATE 6

X 770

FIGS.	PAGE
1. Micropores between irregular pores in <i>Cibicides (Cibicidina) succedens</i> Brotzen.	50
2. Large round pores and micropores in <i>Cibicides cantii</i> n.sp.	50
3. Micropores between irregular pores in <i>Cibicides (Cibicidina) cunobelini</i> n. sp.	51
4. Micropores between irregular pores in <i>Cibicides (Cibicidina) mariae</i> (Jones).	51
5. Round scattered pores with micropores in <i>Anomalinoidea nobilis</i> Brotzen.	52
6. Large oval dorsal pores with sieve plates in <i>Cibicides cassioellauni</i> n.sp.	47



Wood and Haynes: British Paleocene Foraminifera



Test nearly equally biconvex, subcircular in side view; periphery slightly lobulate, edge sharply angled to slightly keeled; usually 6 or 7 chambers in the final whorl, not inflated, enlarging gradually, whorls about 2 to 3; ventral side with a small umbilical depression surrounded by a rim of secondary thickening; dorsal sutures limbate and flush with the surface; ventral sutures curved, nearly radial, and with marked raised limbations which are more pronounced toward the umbilicus where they fuse into a ring of secondary thickening; surface of test smooth; wall finely but conspicuously perforate; aperture a small arched opening midway between umbilicus and periphery, at the base of the septal face, with a slight upper lip. Diameter 0.50 mm.; thickness 0.27 mm.

Holotype.—USC No. 4576. Zemorrian. The types are from wells in section 20, T. 28 S., R. 28 E., MDBM.

This species is often referred to *Eponides affinis* (Czjzek) (Haidinger's Nat. Abhandl, vol. 2, p. 144, pl. 12, figs. 36-38, 1848). *E. pseudoaffinis* differs from Czjzek's species in possessing limbate sutures which are raised on the ventral side, and in being biconvex. Cushman and Laiming report it as *E. affinis* in the Los Sauces Creek section.

Genus **Rotalia** Lamarck 1804

Rotalia becki Bandy and Arnal, n. sp.

Plate 7, figures 10, 11

Test unequally biconvex, ventral side deep, dorsal side only slightly convex; periphery entire in the early portion, becoming slightly lobulate in the later part; edge abruptly rounded to bluntly angled; chambers 8 to 12 in number, rotaloid in arrangement, not involute on the dorsal

EXPLANATION OF PLATE 7

FIGS.	PAGE
1. <i>Alveolophragmium becki</i> Bandy and Arnal, n.sp., x33, a. side view; b. edge view	54
2. <i>Haplophragmoides translucens</i> Bandy and Arnal, n.sp., x55, a. side view; b. edge view	54
3. <i>Robulus hedbergi</i> Cushman and Renz var. <i>subregius</i> Bandy and Arnal, n. var., x26, a. side view; b. edge view	55
4. <i>Robulus laimingi</i> Bandy and Arnal, n. sp., x36, a. side view; b. edge view	55
5. <i>Robulus laimingi</i> Bandy and Arnal, n.sp., x36, diagram of aperture from paratype	55
6. <i>Elphidium strattoni</i> (Applin) var. <i>joaquinensis</i> Bandy and Arnal, n. sp., x80, a. side view; b. edge view	55
7. <i>Buccella bella</i> Bandy and Arnal, n.sp., x100, a. dorsal view; b. edge view; c. ventral view	56
8. <i>Epistominella obesa</i> Bandy and Arnal, n. sp., x85, a. dorsal view; b. edge view; c. ventral view	56
9. <i>Eponides pseudoaffinis</i> Bandy and Arnal, n. sp., x60, a. dorsal view; b. edge view; c. ventral view	56
10. <i>Rotalia becki</i> Bandy and Arnal, n. sp., x45, a. dorsal view; b. edge view; c. ventral view	57
11. <i>Rotalia becki</i> Bandy and Arnal, n. sp., x45, cross section of test	57
12. <i>Uvigerinella californica</i> Cushman var. <i>perparva</i> Bandy and Arnal, n. name, x75, a. side view; b. edge view; c. ventral view	58

side, but with the wall of each whorl extending completely across the dorsal surface (fig. 11); umbilical pillars prominently developed; radial sutures on the dorsal surface oblique and curved, obscured in earlier whorls by subsequent dorsal walls of later whorls, ventral sutures slightly oblique, depressed; surface smooth, wall finely perforate; aperture an arched opening midway between the umbilicus and periphery. Diameter 0.60 mm.; thickness 0.30 mm.

Holotype.—USC No. 4580. *Paratype*.—USC No. 4583. Luisian-Relizian. The type specimens are from wells in section 32, T. 30 S., R. 22 E., MDBM.

This new species is a typical *Rotalia* in that each whorl provides a new complete dorsal wall and it has the umbilical pillars so characteristic of the type of the genus, *Rotalia trochidiformis* (Lamarck). This new *Rotalia* is one of the most highly complex species of the genus known in the California Tertiary. Specimens are known only from the subsurface section.

Family UVIGERINIDAE Galloway and Wissler
1927

Genus *Uvigerinella* Cushman 1926

***Uvigerinella californica* Cushman var.
perparva Bandy and Arnal, n. name**

Plate 7, figure 12

Uvigerinella californica Cushman var. *parva* Kleinpell, 1938, Miocene Stratigraphy of California, Amer. Assoc. Petroleum Geologists, Tulsa, Oklahoma, p. 289, pl. 9, fig. 14 (Saucesian, Relizian, Luisian). (Not *Uvigerinella parva* Cushman and Jarvis, 1929, Cushman Lab. Foram. Res., Contrib., vol. 5, pt. 1, p. 12, pl. 3, fig. 7).

Test shortened fusiform, greatest width near the apertural end; periphery lobulate; chambers arranged three to a whorl, regularly arranged with the corresponding chambers of each succeeding whorl located directly above one another; sutures moderately depressed; aperture broadly elliptical and surrounded by a low collar. Length 0.40 mm.; breadth 0.27 mm.

Hypotype.—USC No. 4581. Saucesian. Hypotype specimens from the Western Gulf Oil Co., Spencer, A-US 18, well located in sec. 34, T. 28 S., R. 20 E., MDBM.

Kleinpell was advised that the name *parva* was preoccupied by the species of Cushman and Jarvis quoted above and he kindly granted permission to the authors to rename his variety.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH

VOLUME VIII, PART 2, APRIL, 1957

165. NOTES ON SOME SPECIES OF *GLOBOTRUNCANA*¹

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ABSTRACT

Several forms of *Globotruncana* are discussed and changes of name suggested to conform with a trinomial system of nomenclature. Two new subspecies are described and one new name given.

INTRODUCTION

The genus *Globotruncana* has assumed importance in recent years due to the steadily increasing number of species, subspecies and varieties found and because of their value for stratigraphic subdivision of the Upper Cretaceous sediments all over the world. There is no doubt that this genus displays a rapid and complicated evolutionary pattern, which tends to become somewhat confusing and to make identification of species and subspecies increasingly difficult. In the writer's opinion a thorough study of the genetic and morphologic relationship of each new form is needed. As a preliminary step to achieve this, the trinomial nomenclature, proposed by Thalmann and adopted by Vogler, Bolli, Cita and others, especially for the "lapparenti-forms" of the genus, may be useful in establishing some order in the taxonomy of *Globotruncana*. In the following discussion some nomenclatorial changes for stratigraphically important species and subspecies are proposed and comments are made regarding a few other forms of *Globotruncana* and its subgenera.

Thanks are expressed to H. E. Thalmann, Stanford University, California, and Hans Bolli, Trinidad Leaseholds Ltd., Trinidad, for their valuable comments and suggestions.

SYSTEMATIC DESCRIPTIONS

Globotruncana (*Thalmanninella*) *ticinensis*
subticinensis Gandolfi, n. subsp.

Plate 8, figure 1a-c

Holotype. — *Globotruncana* (*Thalmanninella*) *ticinensis* Gandolfi var. *alpha* Gandolfi (1942, p. 114, pl. 2, fig. 4a-c).

Depository.—Institute of Geology and Paleontology, University of Basel, Switzerland.

Type Locality.—Breggia River, near Chiasso, Canton Ticino, Switzerland.

Type Level.—"Scaglia bianca" Niveau 28, upper Albian-lowermost Cenomanian.

The new subspecies is proposed for tests of *Globotruncana* (*Thalmanninella*) *ticinensis* Gandolfi with a partially developed keel. It serves as a link between the completely keeled form of *G. (T.) ticinensis* and *Globotruncana* (*Ticinella*) *roberti* Gandolfi (see Gandolfi, 1942, p. 135 and Reichel, 1949, p. 600-01). The subspecies, however, needs a new description because Gandolfi (1942, p. 113) states that *Globotruncana ticinensis* var. *alpha* has beaded sutures restricted to the inner coils of the test. The type description of the new subspecies, therefore, is as follows:

"Test rotaliform, similar to that of *Globotruncana* (*Thalmanninella*) *ticinensis ticinensis* Gandolfi, with a single-keeled test and beaded sutures in the early stages (inner coils) only. The keel is thicker than that in the type, with coarser papillae (see Reichel 1949, p. 604). Chambers in the last coil inflated and with a rounded periphery. Faint indications of beaded sutures in the earliest chambers of the last coil."

A good illustration of the form showing apertural details is given by Reichel (1949, pl. 16, fig. 2).

Globotruncana (*Thalmanninella*) *ticinensis*
ticinensis Gandolfi

Plate 8, figure 2a-c

Holotype. — *Globotruncana* (*Thalmanninella*) *ticinensis* Gandolfi (1942, p. 113-115, pl. 2, fig. 3a-c).

Depository.—Institute of Geology and Paleonto-

¹ Published with the permission of the board of directors, International Petroleum Company, Ltd.

logy, University of Basel, Switzerland.

Type Locality.—Breggia River, near Chiasso, Canton Ticino, Switzerland.

Type Level.—"Scaglia bianca" Niveau 29, lowermost Cenomanian.

A description of this completely keeled form is given by Gandolfi (1942, p. 113). A good illustration showing apertural details is given by Reichel (1949, pl. 16, fig. 3; pl. 17, fig. 3).

***Globotruncana (Rotalipora) apenninica balernaensis* Gandolfi, n. subsp.**

Plate 8, figure 3a-c

Holotype.—*Globotruncana apenninica* Renz 1936, var. *alpha* Gandolfi (1942, p. 118-19, text fig. 40).

Depository.—Institute of Geology and Paleontology, University of Basel, Switzerland.

Type Locality.—Breggia River, near Chiasso, Canton Ticino, Switzerland.

Type Level.—"Scaglia bianca" Niveau 34, middle part of lower Cenomanian.

Gandolfi's (1942, p. 118) description of this form is herein amended as follows: "Test rotaliform, large and thin, with a well developed single keel. Outline subcircular, tending to become elongated, spiral side slightly convex, umbilical side slightly concave. Chambers flat on dorsal side, convex on ventral side, becoming elongated. Umbilical sutures generally radial and depressed, thickening slightly around the umbilicus."

The subspecific name is derived from the town

of Balerna near the Breggia River. The subspecies differs from *Globotruncana (Rotalipora) evoluta* Sigal in not having the extremely elongated test and the loosely coiled spiral (see pl. 8, figs. 4-5).

***Globotruncana (Rotalipora) apenninica apenninica* O. Renz**

Plate 9, figure 1a-c

Holotype.—*Globotruncana (Rotalipora) apenninica* O. Renz in Gandolfi (1942, p. 116, pl. 2, fig. 5a-c).

Depository.—Institute of Geology and Paleontology, University of Basel, Switzerland.

Type Locality.—Breggia River, near Chiasso, Canton Ticino, Switzerland.

Type Level.—"Scaglio rossa" Niveau 50, Cenomanian.

The species, erected by O. Renz from thin sections only, probably includes different forms. To the original description of isolated tests (Gandolfi, 1942, p. 116) the following is added:

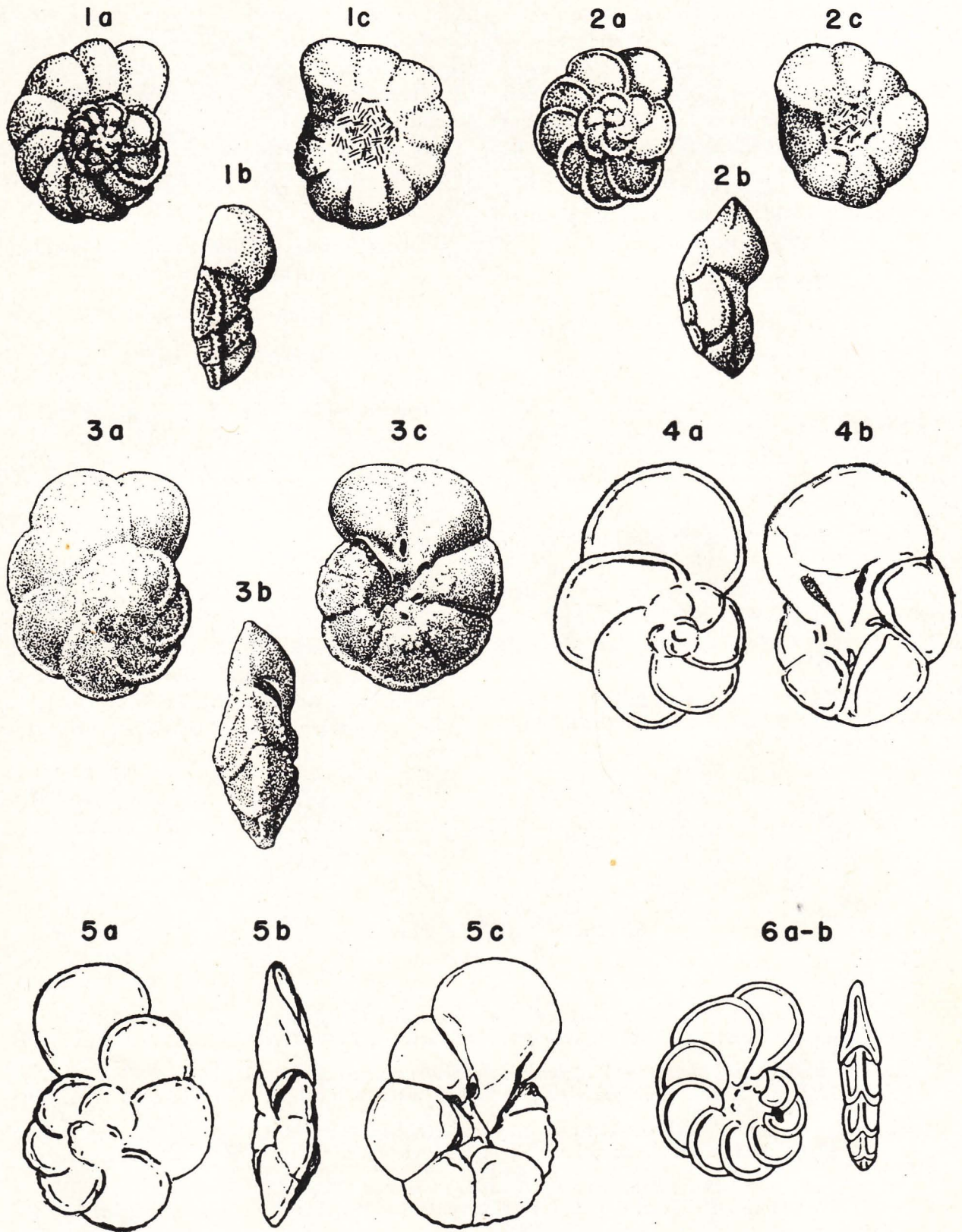
"Umbilical sutures generally radial and depressed, eventually becoming curved and raised in the early chambers of the last whorl, thickening and often with some form of ornamentation (papillae, beads) especially around the umbilicus."

This species is well illustrated by Mornod (1949, figs. 3/1, 3/2, and 3/3) and Reichel (1949, pl. 16, fig. 4; pl. 17, fig. 4).

Globotruncana (Rotalipora) globotruncanoides Sigal (pl. 9, fig. 2) is certainly a closely related

EXPLANATION OF PLATE 8

FIGS.	PAGE
1. <i>Globotruncana (Thalmaninella) ticinensis subticinensis</i> Gandolfi, n. subsp., x 50; after Gandolfi (1942, pl. 2, fig. 4). a. dorsal view; b. side view; c. ventral view	59
2. <i>Globotruncana (Thalmaninella) ticinensis ticinensis</i> Gandolfi, x50; after Gandolfi (1942, pl. 2, fig. 3). a. dorsal view; b. side view; c. ventral view.	59
3. <i>Globotruncana (Rotalipora) apenninica balernaensis</i> Gandolfi, n. subsp., x50; after Reichel (1949, text fig. 3). a. dorsal view; b. side view; c. ventral view.	60
4. ? <i>Globotruncana (Rotalipora) apenninica balernaensis</i> (Gandolfi), x60; after Sigal (1948, pl. 2, fig. 2). a. dorsal view; b. ventral view.	60
5. <i>Globotruncana (Rotalipora) apenninica evoluta</i> (Sigal), x60; after Sigal (1948, pl. 1, fig. 3). a. dorsal view; b. side view; c. ventral view.	60
6. <i>Planomalina buxtorfi</i> (Gandolfi), x50; after Sigal (1952, text fig. 22).	64



Gandolfi: Notes on *Globotruncana*

form, which seems to differ from the above described species in that it has curved, raised and well developed umbilical sutures. A particular evolutionary trend (bioseries) is therefore suggested, i. e. from tests with radial and depressed umbilical sutures to tests with curved and raised umbilical sutures, inasmuch as *Globotruncana (Rotalipora) globotruncanoides* Sigal appears late in the Turonian.

***Globotruncana (Globotruncana ?) stephani*
stephani Gandolfi**

Plate 9, figure 3a-c

Holotype.—*Globotruncana stephani* Gandolfi (1942, p. 130, pl. 3, fig. 4a-c).

Depository.—Institute of Geology and Paleontology, University of Basel, Switzerland.

Type Locality.—Breggia River, near Chiasso, Canton Ticino, Switzerland.

Type Level.—"Scaglia rossa" Niveau 43, Cenomanian.

This form differs from the typical *Globotruncana* in that it possesses an "interio-marginal" aperture, while the typical *Globotruncana* exhibits a complicated system of cover plates over the umbilical apertures. These apertures are the only ones present.

Bermúdez (1952) erected a new genus, *Praeglobotruncana*, with *Globorotalia delrioensis* Plum-

mer 1931 as the genotype. This form, however, according to a personal communication from H. Bolli is closely related to *Globotruncana stephani* Gandolfi, therefore, *Praeglobotruncana* should be considered as a subgenus of *Globotruncana* which includes all single-keeled forms with a genetically primitive apertural system.

For a good illustration of *G. stephani stephani* showing apertural details see Reichel (1949, pl. 16, fig. 6; pl. 17, fig. 6).

***Globotruncana (Globotruncana ?) stephani*
turbinata (Reichel)**

Plate 9, figure 4a-b

Holotype.—*Globotruncana apenninica* var. *beta* Gandolfi (1942, p. 119, text fig. 41/2a-b).

Depository.—Institute of Geology and Paleontology, University of Basel, Switzerland.

Type Locality.—Breggia River, near Chiasso, Canton Ticino, Switzerland.

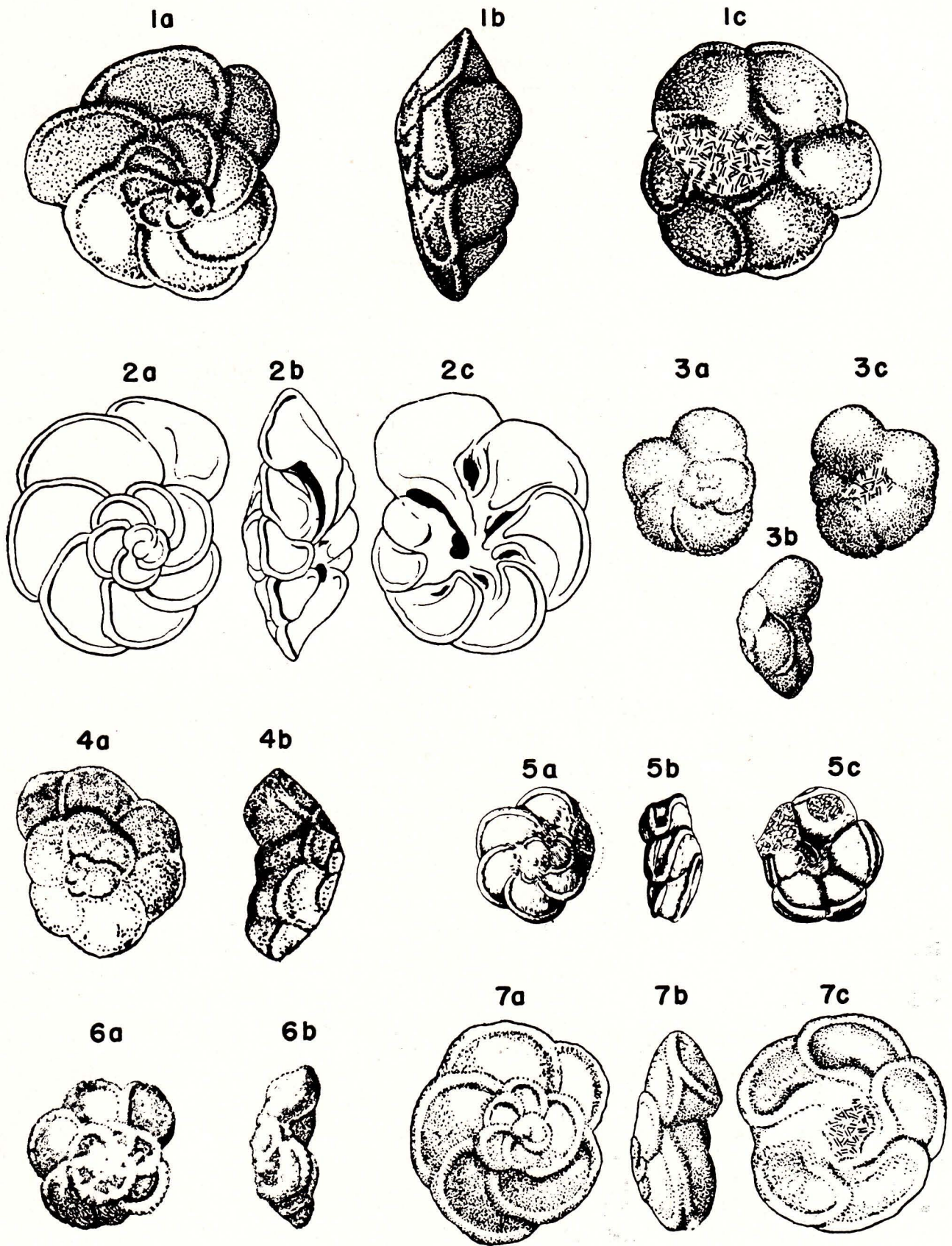
Type Level.—"Scaglia rossa" Niveau 57, upper Cenomanian.

The species was recognised by Reichel (1949, p. 609) to be closely related to *G. stephani stephani* and not to *G. (R.) apenninica apenninica* as previously believed by Gandolfi (1942). Subsequently it was named *Globotruncana stephani* Gandolfi var. *turbinata* by Reichel (1949).

Its relationship to *G. stephani stephani* as well

EXPLANATION OF PLATE 9

FIGS.	PAGE
1. <i>Globotruncana (Rotalipora) apenninica apenninica</i> (O. Renz), x50; after Gandolfi (1942, pl. 2, fig. 5). a. dorsal view; b. side view; c. ventral view	60
2. <i>Globotruncana (Rotalipora) apenninica globotruncanoides</i> (Sigal), x60; after Sigal (1952, text fig. 24). a. dorsal view; b. side view; c. ventral view.	60
3. <i>Globotruncana (Globotruncana ?) stephani stephani</i> Gandolfi, x50; after Gandolfi (1942, pl. 3, fig. 4). a. dorsal view; b. side view; c. ventral view.	62
4. <i>Globotruncana (Globotruncana ?) stephani turbinata</i> (Reichel), x50; after Gandolfi (1942, text fig. 41/2). a. dorsal view; b. ventral view.	62
5. <i>Globotruncana (Globotruncana) imbricata</i> Mornod, x 50; after Mornod (1949, text fig. 2). a. dorsal view; b. side view; c. ventral view.	64
6. <i>Globotruncana (Globotruncana) aff. renzi</i> , x50; after Reichel (1949, pl. 17, fig. 8). a. dorsal view; b. side view.	64
7. <i>Globotruncana (Globotruncana) colderiensis</i> Gandolfi, n. name, x50; after Gandolfi (1942, pl. 3, fig. 1). a. dorsal view; b. side view; c. ventral view.	64



Gandolfi: Notes on *Globotruncana*

as the genetical position within the genus of the latter still needs further investigation. In fact it is doubtful if the "turbinata" type is to be seen as an evolved form of the type "stephani" or "stephani" may represent an ecologic differentiation towards fully pelagic tests (forms reminiscent of *Globigerina*, see Gandolfi 1953). Moreover its relationship to the subgenus *Rotalipora* is still rather obscure.

Globotruncana (Globotruncana) coldrieriensis

Gandolfi, n. name

Plate 9, figure 7a-c

Holotype.—*Globotruncana renzi* Gandolfi (not Thalmann) (Gandolfi, 1942, p. 124, pl. 3, fig. 1).

Depository.—Institute of Geology and Paleontology, University of Basel, Switzerland.

Type Locality.—Scabriana Quarry, near Chiasso, Canton Ticino, Switzerland.

Type Level.—"Flysch", lower Turonian.

Gandolfi and Thalmann contemporaneously gave the name *Globotruncana renzi* to some early Turonian *Globotruncana*-like tests, in which the double keel of the early chambers is reduced to a single one in the adult stage. The species was believed to be intermediate between *G. (R.) apenninica* and *Globotruncana (Globotruncana) lapparenti*. However, structural studies of Reichel (1949) show that substantial apertural differences exist between *Rotalipora* and *Globotruncana* and intermediate species between *Globotruncana* and *Rotalipora* are doubtful. Consequently, the validity of the name *Globotruncana renzi* Thalmann (not Gandolfi) appears to depend to a great degree on a revision and recheck of the Renz toptype material.

With regard to the Gandolfi form, these tests are definitely *Globotruncana*-like, and, in agreement with Reichel (1949), seem to show already evolved "lapparenti" characteristics (thick, sigmoidal and raised sutures on umbilical side). Consequently, and in order to avoid confusion, Gandolfi's form needs to be distinguished from Thalmann's and to have its own specific name as proposed here. Its relationship to the single-keeled *Globotruncana sigali* Reichel should be closely investigated inasmuch as Reichel's (1949, text fig. 6) figure of the latter species suggests a double keel in the earliest chambers.

The species is named after Coldrierio, a small town near the Scabriana Quarry in Canton Ticino, Switzerland.

COMMENTS ON SOME OTHER SPECIES OF
GLOBOTRUNCANA

Rotalipora evoluta Sigal (1948, p. 100, pl. 1, fig. 3). The relationship of this species with *Rotalipora apenninica balernaensis* should be examined for some kind of bioseries (see pl. 8, figs. 3-6) tending towards extremely elongated and thin forms (see *Planomalina buxtorfi* (Gandolfi)). The morphological similarity between the two forms is striking as previously noted by the writer (Gandolfi, 1942, p. 118). Moreover, a certain asymmetry between the dorsal and ventral sides of *P. buxtorfi* is shown, as well as peculiar apertural features, by Sigal's (1952, text fig. 22) illustration of this species.

In this connection it should be noted that the form illustrated by Sigal (1948, pl. 2, fig. 2) as a paratype of *Rotalipora cushmani* var. *evoluta* seems to have little similarity with the holotype (*idem*, pl. 1, fig. 3), being more closely related to *Globotruncana (Rotalipora) apenninica balernaensis* n. subsp. (see pl. 8, figs. 3-5). It has fewer (5-6) chambers, however, in the last whorl than the "balernaensis" typical form, suggesting that the number of chambers may also be an important stratigraphic variation.

Globotruncana imbricata Mornod (1949, p. 589, text fig. 5/3). This species (pl. 9, fig. 5) seems to be closely related to *Globotruncana indica* (Jacob and Sastry) which is also characterized by a beaded double keel and by radial, depressed sutures on the umbilical side. However, *Globotruncana imbricata* Mornod, according to the author's description and a series of thin sections, is related to *G. (G.) stephani stephani* Gandolfi through gradational changes.

A study of the reciprocal relationship between the above mentioned species is believed to furnish interesting details and also to be an aid in determining the genetic position of the form described and illustrated by Reichel (1949, pl. 16, fig. 8; pl. 17, fig. 8) as *Globotruncana* aff. *renzi* Thalmann (pl. 9, fig. 6) from the lower Turonian of Algeria. This last form, which shows quite typical features, should be renamed.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH

VOLUME VIII, PART 2, APRIL, 1957

166. APERTURE IN FORAMINIFERA

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ABSTRACT

Great variability in apertural characters is met in both fossil and Recent Foraminifera. It may be inferred that no type or types possess adaptational advantages over others. The occurrence of many different types in one genus renders the aperture unsuitable for use as a taxonomic criterion.

INTRODUCTION

The aperture among the Foraminifera is the chief opening through which protoplasm obtains egress to the exterior. Some groups have perforate walls, others have imperforate ones, but all possess apertures. In multilocular forms, successive chambers are built up by absorption of calcium carbonate and its subsequent precipitation after the protoplasm has coalesced, passed through the aperture of what will become the penultimate chamber and formed an initially external globule which later becomes enclosed by the ultimate chamber—the result of the precipitation. While the aperture may show a certain constancy within a given species when adult, the juvenile stages often have apertures with differing characters. Within any one genus, there is frequently tremendous variation. Glaessner (1945) referred to the aperture as “a comparatively independent taxonomic feature” and Cushman (1950) stated that “the aperture of the test is one of its most important parts from the standpoint of relationships and descriptive work.”

APERTURAL CHARACTERS

The simplest form of aperture is a round hole in the test wall placed distally and referred to as terminal and central or eccentric. Such a position in multilocular species leads to the formation of a row of chambers which may be rectilinear or curvilinear in arrangement. In spirally coiled species, the aperture may be peripheral

and either central or basal on the apertural face of the ultimate chamber. These basic possible positions of the aperture are connected with subsequent growth—the former with recti- or curvilinearity and the latter with the trochospiral development of chambers when central. The shape of the aperture shows such wide variation that it is impossible to do more than cite a few typical forms. The circular type has been noted and to it may be added oval, elongate, crescentic, “buliminid” (comma-shaped) and radiate, i.e. consisting of a central opening surrounded by radiating slits. In some forms, it has a lip and it may lie at the end of a tubular neck (often with a flange round the aperture itself—termed a phialine lip). Internal cylindrical projections (entosolenian tubes) may occur and plates or teeth develop within the aperture itself. Occasionally, the aperture may be separated from the ultimate chamber by a small partition which thus demarcates an apertural chamberlet. Some Foraminifera have multiple apertures which may differ from each other in shape and position. Frequently, the aperture is divided into a row of simple openings. Cribrate apertures—composed of numerous close-set perforations—may arise either as original structures or by coalescence of apertural teeth.

Where apertures can be detected among the earliest and most primitive Foraminifera, they are found to be simple usually at the open ends of tubes. This is the case among the *Astrorhizidae* and *Rhizamminidae*. In some groups, e.g. *Lagenidae* and *Buliminidae*, there appears to be a trend towards obstruction or possibly concealment of the aperture. This is expressed in the teeth, etc., already noted.

INTRAGENERIC VARIATION

So many genera compete for the honour of illustrating intrageneric variation among Foraminifera that it is difficult to select any one as representative of the whole. Within the genus

Dentalina d'Orbigny 1826 (a member of the family Lagenidae : Cushman classification), however, great variation in apertural characters may occur. It may or may not lie on a neck, be eccentric or central and usually shows radiate apertural features.

Plate 10 is designed to illustrate the variation in apertural characters within selected foraminiferal genera, namely *Lenticulina* Lamarck 1804, *Nodosaria* Lamarck 1812 and *Quinqueloculina* d'Orbigny 1826.

Cushman (1950) stated that "in many species it is very difficult to separate *Robulus* from *Lenticulina* and it may be best as a practical matter to drop *Robulus* and use *Lenticulina* for both". The author has adopted this suggestion. Apart from the tendency to uncoiling seen in some species of *Lenticulina*, the difference between this genus (in its restricted sense) and *Robulus* lies in the presence of the slit in the latter. This is an invalid distinction as is evidenced above and even Cushman admitted that "there are all gradations between *Robulus* and *Lenticulina*". Some examples of taxonomic confusion in this case may be cited:

- a: *Robulus degolyeri* (Plummer)—Bandy, Journ. Pal., 18, 1944.
Lenticulina degolyeri (Plummer)—Toulmin, Journ. Pal., 15, 1941.
- b: *Robulus formosus* (Cushman) Renz, Geol. Soc. Am., 32, 1948.
Lenticulina formosa (Cushman)—Hadley, Bull. Am. Pal., 20, 1934.
- c: *Robulus clericii* (Fornasini)—Renz, Geol. Soc. Am., 32, 1948.
Lenticulina clericii (Fornasini)—Palmer, Mem. Soc. Cubana Hist. Nat., 14, 1940.
- d: *Robulus bowdenensis* (Cushman)—Bermudez, Cush. Lab. For. Res., Sp. Pub. 25, 1949.
Lenticulina bowdenensis (Cushman)—Palmer, Bull. Am. Pal., 29, 1945.
- e: *Robulus vaughani* (Cushman)—Ellisor, Bull. Am. Ass. Pet. Geol., 24, 1940.
Lenticulina vaughani (Cushman)—Bermudez, Cont. Cush. Lab. For. Res. Sp. Pub. 25, 1949.

Such examples could be multiplied indefinitely.

In the four species of *Nodosaria* figured (pl. 10, figs. 9-12), four different types of aperture occur. Yet Cushman (1950) defined this biocharacter as "terminal, radiate" adding that "the length of neck is entirely a variable feature even at different stages in the same specimen". He omitted to mention that this latter is often absent.

Cushman (1950) referred to the genus *Quinqueloculina* as "typically with a simple tooth". The value of this generalization can be seen from the illustrated forms (pl. 10, figs. 13-15).

INTRASPECIFIC VARIATION

Barnard (1954) has described a perfect example of this, namely in *Hantkenina alabamensis* Cushman 1925. All specimens were adult and the simplest form of aperture found was basal on the apertural face of the ultimate chamber and elongate with a tendency to extend downwards and backwards into the umbilici. From this two morphological series can be established, one towards the development of a tooth and the other towards the development of a multiple cribrate aperture.

A rapid jump from the "normal aperture of the adult *H. alabamensis* Cushman, which usually occurs until the penultimate whorl, to a more advanced aperture in the adult chambers" is said to take place. This variation among *adults* must be carefully distinguished from the normal ontogenetic variation in shape noted earlier.

SOME INFERENCES

Selective pressure cannot have been exerted with any power upon this foraminiferal biocharacter since the many varietal forms occur throughout Mesozoic and subsequent time and hence its significance to the living organism can be regarded as consisting not in its shape and position, but in its *presence*. In this connection, it is interesting to note that in a study of *Allogromia laticollaris* Arnold 1948, a living species, Arnold (1953) found that on examining three biocharacters, number of apertures, overall shape and flattening, only one—the latter—"seems to be a response to environmental conditions".

CONCLUSIONS

The use of apertural variation as a taxonomic criterion has led to confusion in the literature. Many instances could be given, *e.g.* the separation of *Robulus* Montfort 1808 and *Lenticulina* Lamarck 1804 (*v.* Cushman 1950, Bowen 1954). While apertural variation may still be retained as a character useful in delimiting species on a purely morphological basis when fully described for all ontogenetic stages and in conjunction with several other biocharacters (as many as possible), it must be emphasised that alone, it is useless

for generic determinations and even in association with other features has little taxonomic importance.

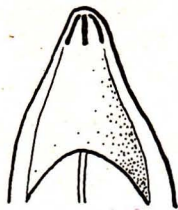
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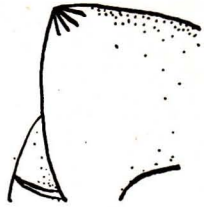
EXPLANATION OF PLATE 10

FIGS.

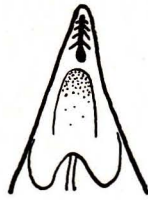
- 1,2. *Lenticulina abuillotensis* (Bermudez).
Apertural and side views. The type description stated that the aperture is radiate, at the outer margin of the last septal face, with a slit extending down into the last septal face. This latter is the well-known "robuline" slit found singly in some, represented by the expanded ventral slit of the radiate aperture in others and absent in others (when the ventral slit is not enlarged).
- 3,4. *Lenticulina rotulata* (Lamarck).
Apertural and side views. The confusion over the identification and nomenclature of this species and the difficulty of establishing the true geological age of the original specimens examined by Lamarck are discussed in Bowen (1954). Cushman refigured the type specimen from which the author identifies his material. The robuline slit may be present or absent in this species and there are more slits in the radiate aperture than was the case in 1,2.
- 5,6. *Lenticulina trinae* (Bermudez).
Apertural and side views. The type description referred to "aperture terminal, radiate, with a small robuline slit". Very few slits occur in the radiate aperture.
- 7,8. *Lenticulina articulata* (Reuss).
Apertural and side views. Here, the robuline slit is present, almost circular in shape and completely separated from the radiate part of the aperture which lies on a distinct protuberance (which gives the end chamber a sub-triangular appearance in side view).
9. *Nodosaria fistuca* Schwager.
Terminal chamber.
Aperture at the end of a distinct neck with a collar-like expansion at the outer end and a distinct tooth in the opening.
10. *Nodosaria spinicosta* d'Orbigny var. *adelinensis* Palmer and Bermudez.
Here the apertural neck is no longer simple as in Fig. 9, but ridged, more prominent and bearing a simple *toothless* aperture.
11. *Nodosaria soluta* Reuss.
The aperture occurs at the tapering terminal end of the ultimate chamber and is radiate.
12. *Nodosaria longiscata* d'Orbigny.
The type figure shows the same termination as that figured (from the London Clay, v. Bowen, 1954. The specimen is in the British Museum, Natural History, Number P 41103,2).
The aperture is simple at the end of a long tapering neck.
13. *Quinqueloculina vulgaris* d'Orbigny.
Apertural view.
A distinct simple tooth is present.
14. *Quinqueloculina impressa* Reuss var. *cognata* (Bornemann).
Apertural view.
A prominent bifurcate tooth exists.
15. *Quinqueloculina imperialis* Hanna and Hanna var. *porterensis* Rau.
Apertural view.
This variety does not possess a tooth.



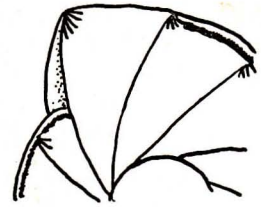
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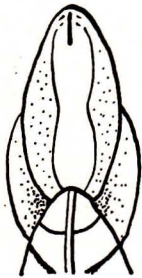
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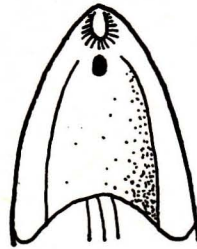
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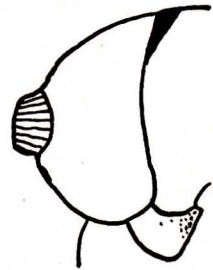
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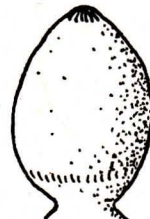
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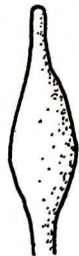
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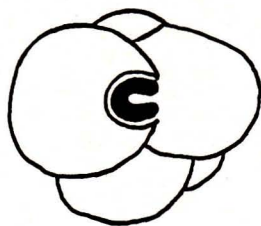
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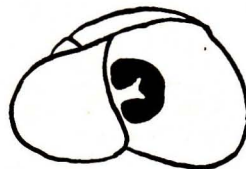
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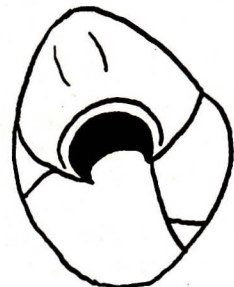
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Bowen: Aperture in Foraminifera

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH

VOLUME VIII, PART 2, APRIL, 1957

167. NOTE ON THE NOMINAL SPECIES *CRISTELLARIA
WETHERELLII* JONES AND *MARGINULINA WETHERELLII* JONES

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ABSTRACT

The taxonomic history of the nominal species *Cristellaria wetherellii* Jones 1852 and *Marginulina wetherellii* Jones 1854 is traced and the holotypes are located. *Marginulina wetherellii* Jones is found to be a secondary homonym of *Cristellaria wetherellii* Jones but it is proposed that since the name *Marginulina wetherellii* Jones 1854 is firmly established for another species, it should be retained pending further work. Opinions are sought concerning the submission of a case for the suppression of *Cristellaria wetherellii* Jones. *Marginulina enbornensis* Bowen is shown to be a junior synonym of *Marginulina wetherellii* Jones 1854.

DISCUSSION

The name *Cristellaria wetherellii* Jones was first published in 1852 when its author contributed an appendix on the Foraminifera to a paper by J. Prestwich (1852 p. 267). Although Jones described the Thanet Sands form assigned to his new species, he also referred to it a specimen figured by J. de C. Sowerby as *Cristellaria* sp. in a paper by N. T. Wetherell (1837 pl. IX fig. 19) on the London Clay. This was the only illustration of the species.

The name *Marginulina wetherellii* Jones was originally listed in Morris's Catalogue of British Fossils 2nd edition (1854, p. 37). This name was supplied by T. R. Jones (*ibid.*p.iii) also for a specimen which had been figured by J. de C. Sowerby as *Marginulina* sp. in Wetherell (1837 pl. IX fig. 12).

Jones retained the name *Cristellaria wetherellii* in Morris's 1854 catalogue (p. 34).

There are thus two nominal species involved in the discussion:

1. *Cristellaria wetherellii* Jones 1852
(=*Cristellaria* sp. J. de C. Sowerby, 1837, in Wetherell, pl. IX, fig. 19)
Jones, 1852, in Prestwich, Quart. Journ. Geol. Soc., vol. VIII, p. 267.
2. *Marginulina wetherellii* Jones 1854
(=*Marginulina* sp. J. de C. Sowerby *op. cit.* pl. IX, fig. 12)
Jones, 1854, in Morris's Catalogue of British Fossils p. 37.

J. de C. Sowerby's determination in Wetherell (1837) were critically considered by Jones and Parker in 1864 (pp. 87, 89) and they recorded the original of pl. IX, fig. 12, *Marginulina wetherellii*, as before (Jones, 1854), and renamed the original of pl. IX, fig. 19 *Cristellaria italica* (Defrance) 1824 (not *Cristellaria wetherellii* as in Jones 1852).

Later Jones (1882 pp. 20, 21) listed two distinct forms, *Marginulina italica* (Defrance) var. *wetherellii* Jones and *Cristellaria italica* (Defrance) var. *wetherellii* Jones.² He cited both these forms under a former British Museum (Natural History) Number P 226,³ as being in the Wetherell Collection and the locality as Hamstead Well, which data agree with that of Sowerby's original specimens. Also in this publication Jones (1882 p. 19) listed under a former British Museum (Natural History) No. P 239 (now P 43289), the original material of the Thanet Sands paper of 1852, under the name *Cristellaria italica* var. *wetherellii*.

The details of the type specimens and other data can now be summarised:

Cristellaria wetherellii Jones 1852
Syntypes: British Museum (Natural History) Reg. No. P 9796 (formerly part of P 226) 1 specimen P 43289 (formerly part of P 239)
6 specimens

correct and should read Quart. Journ. Geol. Soc., vol. VIII (1852).

³ Since re-registered as P 9789 for *Marginulina italica* var. *wetherellii* and P 9796 for *Cristellaria italica* var. *wetherellii*.

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² The reference to Jones, Quart. Journ. Geol. Soc., vol. XXII (1866) after this name (p. 21) is in-

Type-Description: Jones, 1852, in Prestwich, Quart. Journ. Geol. Soc., vol. VIII, p. 267.

Type-Figure: J. de C. Sowerby, 1837, in Wetherell, Trans. Geol. Soc. Lond., 2nd series, vol. V, pl. IX, fig. 19.

Marginulina wetherellii Jones 1854

Holotype: British Museum (Natural History) Reg. No. P 9789 (formerly part of P 226). (There are 6 specimens on the slide but the type is mounted separately and quite distinct.)

Type-Reference: Jones, 1854, in Morris's Catalogue of British Fossils, p. 37.

Type-Figure: J. de C. Sowerby, 1837, in Wetherell, *op. cit.* pl. IX, fig. 12.

The slides or cards on which the above mentioned specimens are mounted, have been examined and all bear notes referring them to the publication wherein they were determined and figured.

Brady (1884), and Sherborn and Chapman (1886) both re-figured and described *Marginulina wetherellii* Jones 1854, Brady referring it to the genus *Cristellaria*, while Sherborn and Chapman retained it in *Marginulina*.

Burrows and Holland (1897 p. 38) discussed fully the taxonomy of the two forms and quoted private correspondence with Jones, but they were mainly concerned with the Thanetian forms. They placed *Cristellaria wetherellii* Jones 1852 in the synonymy of *Cristellaria crepidula* (Fichtel and Moll 1798), Jones having (*in litt.*) admitted that his identification in 1882 of *C. italica* (Defrance) var. *wetherellii* Jones (= *C. wetherellii* Jones 1852) was incorrect. However Burrows and Holland considered that the specimen named *Marginulina wetherellii* by Jones in 1854 was a member of the genus *Cristellaria* and that the name thus became a secondary homonym of *Cristellaria wetherellii* Jones 1852. They revived the name *Cristellaria fragaria* (Gümbel) considered by Brady (1884 p. 537) to be a synonym of *Marginulina wetherellii* Jones 1854. But since this species established by Jones in 1854 is no longer regarded as a member of the genus *Cristellaria*, the name *Marginulina wetherellii* takes precedence before *Cristellaria fragaria* (Gümbel).

Bagg (1904) re-figured and described *Marginulina wetherellii* Jones 1854, but placed it in the genus *Cristellaria*, thus recording the form as *Cristellaria wetherellii* (Jones 1854).

Cushman (1918) listed a *Cristellaria wetherellii* (Jones 1854) citing Bagg (1904) for figure and description and gave the following synonymy:

"*Cristellaria wetherellii* (Jones) Prestwich
M. wetherellii Jones 1854

C. wetherellii Prestwich 1852⁴

Brady 1884

Bagg 1904"

Cushman seemingly failed to appreciate that there were two entirely independent forms with the specific appellation *wetherellii*, with the result that he has considered them as being conspecific. The apparent interpretation of the above synonymy would be that 'Prestwich' had placed *Marginulina wetherellii* Jones 1854 in the genus *Cristellaria*, but the 'Prestwich' paper antedates the erection of the species *Marginulina wetherellii* Jones by two years. It is therefore submitted that Cushman's synonymy is incapable of a rational interpretation in its published form. Deletion of the second line however, would not only make the synonymy rational but also correct.

The latest author who has critically examined *Marginulina wetherellii* Jones 1854 is Bowen in 1954. Bowen, after examination of what he believed to be the remaining type specimens of *Marginulina wetherellii* Jones 1854, claimed that there was no likeness between these specimens and the figures given by Jones to illustrate the species, stating that probably the figured specimens are lost (p. 151). Bowen interpreted *Marginulina wetherellii* Jones as being a smooth marginulinid and therefore re-described the decorated form as *Marginulina enbornensis* Bowen 1954. This was summarised by Bowen (1954 p. 151): "This very common species (i.e. *Marginulina enbornensis* Bowen) has usually been assigned to *Marginulina wetherellii* Jones (1852)⁵ but the examination of Jones's original specimens at the British Museum (Natural History) showed that this identification is incorrect."

Dr. Bowen has described very helpfully to the author the specimens he examined and these have been located and re-examined. It would appear that they are in fact the basis of the description given by Jones in 1852 for the form *Cristellaria wetherellii*, although Jones did not figure any of them. They are Thanetian forms and a reference to the 1852 paper appears on the card on which the specimens are mounted, British Museum (Natural History) Reg. No. P 43289 (formerly part of P 239). Bowen did not record any difference between *Cristellaria wetherellii* Jones and *Marginulina wetherellii* Jones and like Cushman presumably regarded them as conspecific. Bowen had apparently been unable to locate any

⁴ The 1852 reference should read 'Jones in Prestwich'.

⁵ It should be noted that Jones erected the name *Cristellaria wetherellii* (= *C. crepidula* Fichtel and Moll sp. of Burrows and Holland) and not *Marginulina wetherellii* in 1852 as stated.

further specimens available to Jones of either species and hence he had assumed that the missing specimens were those figured by Jones. The type specimens have since been located as indicated earlier in this communication. Those of *Cristellaria wetherellii* Jones 1852 are the smooth margulinids referred to by Bowen as "*Marginulina wetherellii* Jones (1852)" (p. 151 line 20) and that of *Marginulina wetherellii* Jones 1854 is the decorated form identical with the holotype of *Marginulina enbornensis* Bowen (British Museum (Natural History) Reg. No. P 41095(1)). Thus *Marginulina enbornensis* Bowen 1954 must be a subjective junior synonym of *Marginulina wetherellii* Jones 1854.

The nomenclatorial history of the specimens is thus established but some complications regarding the taxonomy of *Marginulina wetherellii* 1854 are still outstanding.

Bermudez (1949) regarded *Cristellaria crepidula* Fichtel and Moll 1798 sp. (which includes *Cristellaria wetherellii* Jones 1852 as a junior synonym) as being a member of the genus *Marginulina*. Thus once again the name *Marginulina wetherellii* Jones 1854 becomes a secondary homonym of *Cristellaria wetherellii* Jones 1852. Since *Cristellaria wetherellii* Jones 1852 has not been used for over a hundred years, and as *Marginulina wetherellii* Jones 1854 is so firmly established, it is proposed that the name *Marginulina wetherellii* Jones be retained pending more detailed work on this and allied forms.

The author however, would appreciate views on the advisability of putting a case to the International Commission of Zoological Nomenclature for a suspension of the rules in order to establish *Marginulina wetherellii* Jones 1854 and to suppress *Cristellaria wetherellii* Jones 1852.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH

VOLUME VIII, PART 2, APRIL, 1957

168. NEW GENERA AND SPECIES OF FORAMINIFERA FROM THE
LOWER PERMIAN OF WESTERN AUSTRALIAIRENE CRESPIN AND D. J. BELFORD¹Bureau of Mineral Resources, Geology and Geophysics,
Canberra, Australia

ABSTRACT

Two new genera belonging to the family Ophthalmitidae, from the lower Permian of Western Australia, are described. The genus *Streblospira* is represented by three species, *S. meandrina*, *S. kimberleyensis*, and *S. australae*, and the genus *Flectospira* by one species, *F. prima*. These forms may prove to be of value in Permian stratigraphy.

INTRODUCTION

In 1955, West Australia Petroleum Pty. Limited submitted an excellent suite of cores and cuttings from Giralia No. 1 Bore in the Carnarvon Basin, 650 miles north of Perth at Lat. 22°59'30"S., Long. 114°10'20"E. Two assemblages of Permian Foraminifera were discovered in the cores, one between 500 feet and 640 feet (cores Nos. 14 and 15), and the other between 3115 feet and 3225 feet (cores Nos. 66 and 67), with a considerable thickness of unfossiliferous sediments separating them. Each assemblage contained genera and species which could not be identified with any described Foraminifera.

More recently, a re-examination was made of cores from Freney Kimberley Oil Company's Nerrima No. 1 Bore, Fitzroy Basin, Western Australia, drilled in 1941, and situated about 800 miles northeast of Giralia. One of these new genera was found in some abundance. It was also found to be common in samples from the Nerrima No. 1 Bore of Associated Freney Oilfields, drilled during 1955 and 1956, about 2 miles west of the earlier bore at Nerrima, and from a bore drilled for the Bureau of Mineral Resources, Geology and Geophysics at Jurgurra Creek, 46 miles west northwest of Nerrima, in the Canning Basin (see locality map).

The two genera described below are *Streblospira* and *Flectospira*, which belong to the family

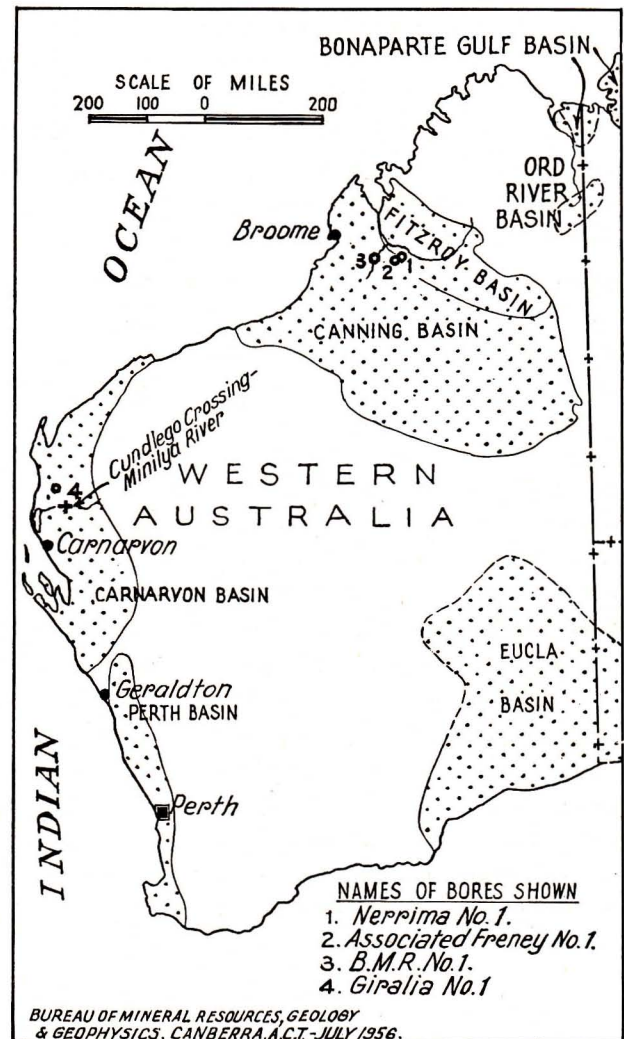


FIGURE 1

Map showing sedimentary basins in Western Australia and localities of new genera.

Ophthalmitidae. Three species of *Streblospira*, *S. australae*, *S. meandrina* and *S. kimberleyensis*, and one species of *Flectospira*, *F. prima*, have been recognized. It is quite possible that these forms will be of stratigraphical importance. *Streblospira kimberleyensis* has been recorded only from bores in the Fitzroy Basin in beds considered to be part of the Noonkanbah Formation of Guppy, Cuthbert

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and Lindner (1950); *Streblospira meandrina* has been found in bores in beds of the Noonkanbah Formation of the Fitzroy Basin, and in outcrop material in the Carnarvon Basin included in the Byro Group of Condon (1954). *Flectospira prima* has been discovered only in subsurface deposits in both the Fitzroy Basin (Noonkanbah Formation) and the Carnarvon Basin (Byro Group).

Streblospira australae has been found only in the Carnarvon Basin, in beds regarded as equivalent of the Callytharra Formation (Condon, 1954). This form, when first discovered, was thought to belong to the minute fusuline genus *Pseudostaffella* M. L. Thompson 1942, but Dr. Thompson, who examined some of the specimens, found that they could not be placed in the Fusulinidae.

SYSTEMATIC DESCRIPTIONS

Family OPHTHALMIDIIDAE

Genus *Streblospira* Crespin and Belford, n. gen.

Test free, minute, depressed in axial region, wholly or partly involute. Proloculus large, globular, followed by a tubular undivided second chamber which coils around the proloculus in short zigzag bends. Planispirally coiled for one or two whorls, the plane of coiling then continuously changing and the test becoming asymmetrical. Wall calcareous imperforate, composed of single layer. Aperture a simple, rounded opening at the end of tube.

Type species.—*Streblospira meandrina* Crespin and Belford, n.sp., from Freney Kimberley Oil Company No. 1 Bore, Nerrima, Fitzroy Basin, Western Australia in core at 129 feet (Noonkanbah Formation).

Remarks.—This new genus *Streblospira* is distinct from any described Foraminifera, but its general chamber arrangement is similar to the genus *Meandrospira* described by Loeblich and Tappan (1946) from the Lower Cretaceous of Texas. It differs from that form in the asymmetrical test and the continuously changing axis of coiling in the adult form. A recently proposed genus, *Aulotortus*, (Weynschenk, 1956), has a twisted spiral coil, but the wall has irregular sinuses and varies in thickness, and the test becomes loosely coiled in the adult.

Streblospira meandrina Crespin and Belford, n. sp.

Plate 11, figures 1-12

Diagnosis.—A minute asymmetrical involute species with a distinct axial depression.

Holotype.—Test free, minute, involute, asymmetrical, slightly flattened, with a distinct axial depression and an undivided tubular second chamber visible. Periphery broadly rounded. Only the last whorl visible, showing the characteristic zigzag structure of the test. Wall thin, calcareous, imperforate, white. Test infilled with matrix, with wall partially eroded away. Aperture not observed.

Paratype.—Similar to holotype but with more depressed axial area. Last coil only visible, showing characteristic zigzag structure of test.

Sectioned specimens.—Horizontal sections: Test circular, with large proloculus followed by undivided tubular chamber of about three and a half whorls, showing gradual increase in size of tube. Periphery lobate.

Vertical sections: Test elongate, oval, with large proloculus; showing gradual change in direction of coiling of undivided tubular chamber. The angle between plane of coiling of first and last whorl varies from *circa* 23° to *circa* 30°.

	Max.	Min.	
<i>Dimensions.</i> —	diameter	diameter	Thickness
Holotype	0.30 mm.	0.27 mm.	0.19 mm.
Paratype	0.33 mm.	0.30 mm.	0.20 mm.

Remarks.—Almost all tests available are worn, showing the intricate internal structure of the test. The angular change in the plane of coiling varies somewhat; in all specimens sectioned the planes of coiling in successive whorls follow a flattened sigmoidal curve. The species occurs abundantly in a core at 129 feet in Freney Kimberley Oil Company No. 1 Bore, Nerrima, Fitzroy Basin.

Occurrence.—Holotype (Comm. Pal. Coll. No. 2289) from core at 129 feet, Freney Kimberley Oil Company No. 1 Bore, Nerrima, Fitzroy Basin, Western Australia (Noonkanbah Formation). Paratype (Comm. Pal. Coll. No. 2290) same locality and depth as holotype. Figured sections (Comm. Pal. Coll. Nos. 2291, 2292, 2293, 2294, 2295, 2302, 2303) from same locality and depth as holotype. Also in Associated Freney Oilfields No. 1 Bore, Nerrima at 490 feet, and at 440, 470 and 494 feet in BMR. No. 1 Bore, Jurgurra Creek, Canning Basin, and in outcrop 6500 feet east of Cundlego Crossing, Minilya River, Carnarvon Basin.

Age.—Lower Permian (Artinskian)

Streblospira kimberleyensis Crespin and
Belford, n. sp.

Plate 11, figures 13-21

Diagnosis.—A minute asymmetrical not completely involute species, with a slight axial depression.

Holotype.—Test free, minute, not fully involute, asymmetrical, compressed, slightly depressed in axial region, early whorls of undivided tubular second chamber visible. Periphery broadly rounded, lobate in edge view, where zigzag coiling is also visible. Whorls strongly overlapping but all visible. Wall calcareous, imperforate, white. Aperture not seen.

Paratype A.—Similar to holotype, but slightly more asymmetrical, the last whorl showing the beginning of a change in direction of coiling.

Paratype B.—Test complete, outer wall intact, internal structure not visible, but simple rounded aperture present at end of tube.

Sectioned specimens.—Horizontal sections: Proloculus large, followed by tubular second chamber of three and a half whorls. Vertical sections: Show large proloculus, asymmetrical form of test and gradual change in plane of coiling in successive whorls. The angle between plane of coiling of first and last whorls varies from *circa* 14° to *circa* 20°.

	Max. diameter	Min. diameter	Thickness
<i>Holotype</i>	0.37 mm.	0.32 mm.	0.15 mm.
<i>Paratype A.</i>	0.40 mm.	0.35 mm.	0.17 mm.
<i>Paratype B.</i>	0.41 mm.	0.40 mm.	0.17 mm.

Diameter of proloculus of *S. kimberleyensis* varies from 0.037 to 0.046 mm.

Remarks.—This species is distinguished from *S. meandrina* by the elongate, compressed, not completely involute test. The specimens are usually worn, showing the complicated structure of the test.

Occurrence.—Holotype (Comm. Pal. Coll. No. 2296) from core at 129 feet in Freney Kimberley Oil Company No. 1 Bore, Nerrima, Fitzroy Basin, Western Australia. Paratype A. (Comm. Pal. Coll. No. 2297) from same locality and depth as holotype. Paratype B. (Comm. Pal. Coll. No. 2293) from Associated Freney Oilfields No. 1 Bore, Nerrima, at 490 feet. Figured specimens (Comm. Pal. Coll. Nos. 2299, 2300, 2301) from Freney Kimberley Oil Company No. 1 Bore, Nerrima, at 129 feet. Also at 470 and 480 feet in Associated Freney Oilfields No. 1 Bore, Nerrima.

Age.—Lower Permian (Artinskian)

Streblospira australae Crespin and Belford,
n. sp.

Plate 12, figures 1-10

Diagnosis.—A minute involute, globular, very asymmetrical species with very slight axial depression.

Holotype.—Test free, minute, involute, globular, only last whorl of undivided tubular second chamber visible, greatest width at margin of last formed whorl. Very slightly depressed in axial region. Periphery broadly rounded. Wall thin, calcareous, imperforate, specimens usually infilled with matrix. Outer wall is eroded away, clearly revealing the characteristic structure of the test. Aperture not observed.

Paratype.—Test worn, infilled with matrix; structure similar to that shown in holotype but test slightly less globular.

Sectioned specimens.—Proloculus large, rounded, followed by tubular undivided second chamber coiling in zigzag bends around proloculus, at first small, planispiral, later enlarging quickly and becoming asymmetrical with plane of coiling continually changing. The penultimate whorl is at an angle of 34 degrees to the last whorl and the first whorl is at about 90 degrees to the last one.

	Max. diameter	Max. Thickness
<i>Holotype</i>	0.33 mm.	0.31 mm.
<i>Paratype</i>	0.31 mm.	0.27 mm.

Diameter of proloculus in sectioned specimens varies from 0.035 to 0.040 mm.

Remarks.—*S. australae* is distinguished from *S. meandrina* and *S. kimberleyensis* by its minute globular test and its very rapid changes in plane of coiling. It has been extremely difficult to obtain a satisfactory illustration of the external characters of this species. This minute form occurs abundantly in Cores Nos. 66 (3115-3120 feet) and 67 (3220-3225 feet) in Giralia No. 1 Bore, Carnarvon Basin, and more than one hundred specimens were found. As far as is known, *S. australae* is restricted to beds equivalent to the Callytharra formation in the Carnarvon Basin.

Occurrence.—Holotype (Comm. Pal. Coll. No. 2268) from Giralia No. 1 Bore, Carnarvon Basin, Western Australia, at 3,115-3,120 feet (core No. 66). Paratype (Comm. Pal. Coll. No. 2269) from same locality and depth as holotype. Figured sections (Comm. Pal. Coll. Nos. 2270-2275) from same level as holotype. Other specimens from 3220-3225 feet (core No. 67) in the same bore.

Age.—Lower Permian (Artinskian)

Genus *Flectospira* Crespin and Belford, n. gen.

Test free, small, planispiral, evolute, compressed, each whorl slightly overlapping preceding one. Proloculus large, globular, followed by tubular undivided second chamber, which coils around proloculus in short zigzag bends. Wall calcareous, imperforate, white, consisting of only one layer. Aperture large and rounded, at end of tubular chamber.

Type species.—*Flectospira prima* Crespin and Belford, n.sp., from Giralia No. 1 Bore, Carnarvon Basin, Western Australia, at 560-570 feet (core No. 14).

Remarks.—The genus *Flectospira* is structurally similar to the genus *Streblospira* described above, but it differs in the planispiral and evolute form of the test. It is also structurally similar to the genus *Meandrospira* Loeblich and Tappan but may be distinguished by the distinctly evolute test.

Flectospira prima Crespin and Belford, n. sp.

Plate 12, figures 11-19

Diagnosis.—A planispiral, evolute, compressed species.

Holotype.—Test free, small, planispiral, compressed, evolute, each whorl of undivided tubular second chamber slightly overlapping preceding one, and with each whorl gradually increasing in width with growth. Periphery rounded. Spiral sutures distinct, depressed. Wall of test deeply incised at each loop of tubular chamber, giving the periphery, in edge view, a lobate appearance. Wall calcareous, imperforate. Aperture large, round and open, at end of tube.

Paratypes A. and B.—These specimens are figured to show the distinct evolute form and zigzag chambers of the species.

Sectioned specimens.—Horizontal sections: Show large proloculus followed by 4 or 5 planispiral whorls of the tubular second chamber, which coils around proloculus in short zigzag bends, and also the single layered wall structure.

Vertical sections: Show large proloculus, the slightly overlapping whorls which gradually increase in width during growth, and the large rounded aperture at end of tube.

<i>Dimensions.</i> —Diameter	Thickness of periphery
Holotype 0.33 mm.	0.09 mm.
Paratype A. 0.31 mm.	0.11 mm.
Paratype B. 0.34 mm.	0.09 mm.

Diameter of proloculus of holotype 0.046 mm., and of sectioned specimens, 0.055 mm.

Remarks.—This species does not occur as abundantly as *Streblospira australae*. It is present approximately 2,500 feet stratigraphically higher in the Giralia No. 1 Bore, Carnarvon Basin and occurs over a limited stratigraphical range. It is found 440 feet above the first occurrence of *S. meandrina* in the Associated Freney Oil fields Bore No. 1, Nerrima, Fitzroy Basin, about 800 miles to the northeast.

Occurrence.—Holotype (Comm. Pal. Coll. No. 2275) from Giralia No. 1 Bore, Carnarvon Basin, Western Australia at 560-570 feet, (core No. 14). Paratypes A. and B. (Comm. Pal. Coll. Nos. 2276, 2277) from Core No. 14 at 560-570 feet in the bore. Also very rare at depth of 45 feet in Associated Freney Oilfields No. 1 Bore, Nerrima, Fitzroy Basin.

Age.—Lower Permian (Artinskian)

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VOLUME VIII, PART 2, APRIL, 1957

169. FORAMINIFERA FROM THE TURONIAN ROCKS OF
ABU-ROASH, EGYPTRUSHDI SAID AND A. KENAWY¹

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ABSTRACT

This paper describes and illustrates twenty species of Foraminifera separated from the type locality of the Turonian rocks in Egypt at Abu-Roash near Cairo.

INTRODUCTION

The classic Abu-Roash dome which made the subject of the memorable memoir of Beadnell (1902) lies only some 10 kms. to the Northwest of Cairo along the Cairo-Alexandria road. This dome constitutes a conspicuous feature in the vicinity of Cairo for here lies the only Cretaceous outcrop in the otherwise Tertiary covered northern

Egypt and the only topographic feature of any importance to the west of Cairo.

The core of this structure is made of some 30 m. of Cenomanian sands and clays followed by some 250 m. of Turonian dolomites, marls and limestones and some 110 m. of Senonian clays and chalks. The Turonian rocks of Abu-Roash are among the best developed in Egypt and are, in fact, the type locality of the rocks of this age. The Turonian limestones and dolomites form the conspicuous peaks and ridges of the entire structure. The following is a section of the Turonian of this locality after Faris (1948). Figure I is a composite columnar section of the lower Turonian as it outcrops in this area.

Time rock unit	Bed No.	Description	Thickness in m.	Total thickness in m.
Upper Turonian	14	White hard limestone (Lower <i>Acteonella</i> series)	80	150
Lower Turonian	13	Reddish brown sandstone	1	70
	12	Yellow green marl	5	69
	11	Limestone with <i>Bournonia excavata</i> d'Orbigny	12	64
	10	Yellow brown clay	5	52
	9	White hard limestone	2	47
	8	Sandy clay	3.5	45
	7	White limestone with flint bands	17	41.5
	6	Yellow soft marl	3	24.5
	5	White hard limestone	4.5	21.5
	4	Yellow soft marl fossiliferous	6	17
	3	Sandy clay	3	11
	2	White hard marl	5	8
	1	Chalky limestone, fossiliferous	3	
Cenomanian		fossiliferous marl		

¹ The senior author is responsible for the identification, description and writing of this paper while the junior author assisted in the collection of the material, carried out the laboratory procedure and helped in the illustrations. Miss G. Demerdash has graciously consented to shade the plate that accompanies this paper.

Most samples collected were barren of Foraminifera except three which came from the marly intercalations in the lower Turonian series. These samples contained a peculiar collection of species,

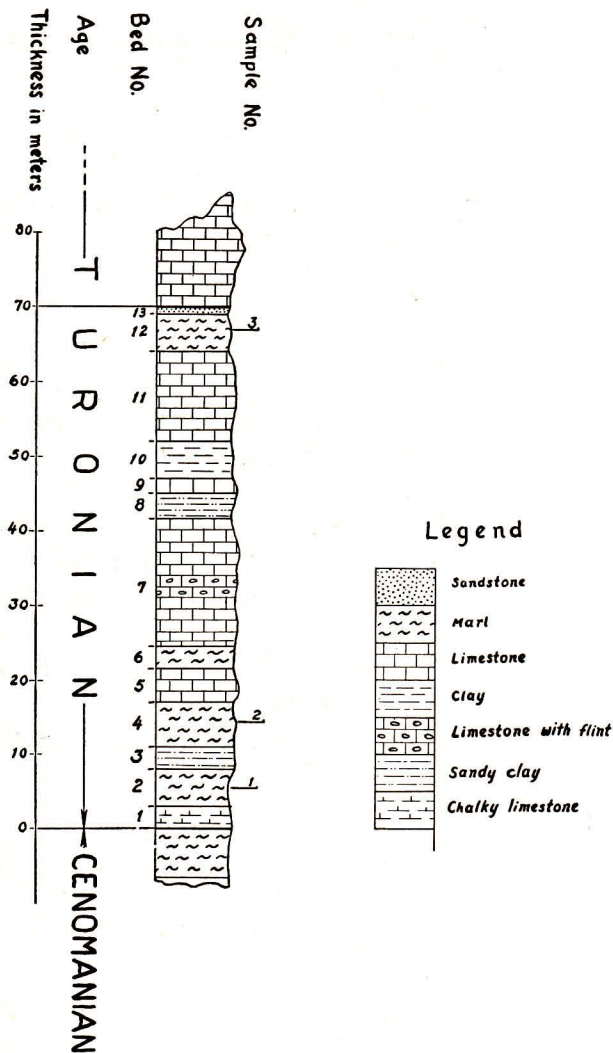


FIGURE 1

the most distinctive of which are *Cuneolina conica*, and *Ceratobulimina aegyptiaca* n.sp. The assemblage consists of a large number of *Discorbis* species as well as *Ammomarginulina* species. Remarkable is the presence of numerous specimens of *Peneroplis* sp., *P. turonicus* n. sp. and *Spirolina schweinfurthi* n. sp. They seem to represent the oldest records of these genera.

SYSTEMATIC DESCRIPTIONS

Family LITUOLIDAE

Genus *Haplophragmoides* Cushman, 1910

Haplophragmoides gracilis Said and Kenawy, n. sp.

Plate 13, figure 1 a-b

Test fragile, very thin, rounded in outline, involute, very indistinctly umbilicate, periphery sharp; chambers indistinct, four to five in the last whorl, of uniform shape, increasing gradually in size as added; sutures indistinct, radial, straight; wall arenaceous, roughly finished, made of sand grains of variable size; aperture not obvious in holotype. Diameter 0.25 mm.; thickness 0.03 mm.

This species is unlike any other species of *Haplophragmoides* known to the authors. It is characterised by an exceedingly thin test and indistinct sutures. Few specimens are found.

Holotype.—U.S.N.M. P 5362.

Genus *Ammomarginulina* Wiesner, 1931

Ammomarginulina aburoashensis Said and Kenawy, n. sp.

Plate 13, figure 5 a,b,c

Test free, compressed; early portion close coiled, evolute, distinct; later portion uncoiling, composed of three to four chambers; dorsal periphery acute, ventral periphery lobulate; chambers distinct, rapidly increasing in length as added; wall coarsely arenaceous, smoothly finished; aperture slit-like towards the dorsal angle of the last chamber. Length 0.8 mm.; breadth 0.5 mm.

This species differs from *A. ensis* Wiesner in having fewer chambers in the uniserial part and lobulate ventral periphery. Several specimens occur.

Holotype.—U.S.N.M. P 5363.

Ammomarginulina blanckenhorni Said and Kenawy, n. sp.

Plate 13, figure 9 a,b,c

Test free, early portion close coiled, evolute, composed of four to five chambers, later portion uncoiling; chambers distinct, increasing in length and slightly in breadth as added; sutures indistinct, depressed, slightly curved towards the early coil; wall arenaceous, smoothly finished; aperture subterminal, slit-like. Length 0.65 mm.; breadth 0.3 mm.

This species differs from *A. aburoashensis* in having a slightly thicker test, a completely evolute early coil and more chambers in the uniserial part. Numerous specimens are found.

Holotype.—U.S.N.M. P 5364.

Ammomarginulina ovoidea Said and Kenawy,
n. sp.

Plate 13, figure 7 a,b,c

Test free, flattened; periphery acute; early portion close-coiled, evolute, composed of three to four chambers to the coil, later portion uncoiled, uniserial; chambers arcuate, increasing in size as added; sutures indistinct, slightly depressed, curved so strongly as to reach the early coil; wall arenaceous, smoothly finished; aperture slit-like, terminal. Length 0.75 mm.; breadth 0.5 mm.

This species is quite distinct. It resembles in chamber arrangement those of the genus *Astacolus* but the wall is coarsely arenaceous and the aperture is terminal and slit-like. A large number of specimens is found.

Holotype.—U.S.N.M. P 5365.

Genus **Ammobaculites** Cushman, 1910

Ammobaculites turonicus Said and Kenawy,
n. sp.

Plate 13, figure 2 a,b

Test free, consisting of an early close-coiled involute portion composed of as many as six chambers, later uniserial part made of three chambers; chambers uniform in shape and size as added, broader than long; sutures indistinct, slightly depressed particularly in the later uniserial part; wall coarsely arenaceous, smoothly finished; aperture slit-like, terminal. Length 0.4 mm.; breadth of coiled part 0.2 mm.

This species differs from *A. coprolithiformis* (Schwager) in having a depressed earlier coil with acute periphery, in having a less arenaceous exterior and a smoothly finished test. Numerous specimens are found.

Holotype.—U.S.N.M. P 5366.

Family TEXTULARIIDAE

Genus **Spiroplectammina** Cushman, 1927

Spiroplectammina cf. *S. biformis* (Parker and Jones)

Plate 13, figure 4 a,b

Textularia agglutinans var. *biformis* Parker and Jones, 1865, Phil. Trans., p. 370, pl. 15, figs. 23, 24.

A flood of specimens that seem to belong to this species is found. The specimens are elon-

gate, many chambered and quadrangular in apertural view.

Figured specimen.—U.S.N.M. P 5367.

Spiroplectammina multicamerata Said and Kenawy, n. sp.

Plate 13, figure 3 a,b

Test free, early portion rounded, close coiled, involute, made of eight to ten chambers, biumbilicate; later portion uncoiled, biserial part made of three to four rows of chambers, very slightly increasing in size as added, oval to circular in cross section; sutures thickened, distinct, flush; wall finely arenaceous, smoothly finished; aperture at the base of the last formed chamber, slit-like. Length 0.35 mm.; breadth 0.2 mm.

This species differs from *S. mordenensis* Wickenden in having a well developed many chambered early part and a small and more circular biserial part.

Holotype.—U.S.N.M. P 5368.

Family VALVULINIDAE

Genus **Cuneolina** d'Orbigny, 1839

Cuneolina conica d'Orbigny

Plate 13, figure 10a, b

Cuneolina conica d'Orbigny, 1850, Prodrôme de Paléont., vol. 2, p. 186, No. 762.—Schlumberger, 1889, Bull. Soc. Géol. France, vol. 27, p. 461, pl. 8, figs. 8-10.

Numerous specimens that seem to belong to this species are found. Our specimens are very similar to those recorded from the Cretaceous rocks of the Mediterranean region.

Figured specimen.—U.S.N.M. P 5369.

Family MILIOLIDAE

Genus **Quinqueloculina** d'Orbigny, 1826

Quinqueloculina antiqua var. *angusta* Franke

Plate 13, figure 13 a,b

Quinqueloculina antiqua Franke var. *angusta* Franke, Cushman, 1946, U.S. Geol. Survey, Prof. Paper 206, p. 48, pl. 14, figs. 8-11.

Several specimens that seem to belong to this species are recorded.

Figured specimen.—U.S.N.M. P 5370.

EXPLANATION OF PLATE 11

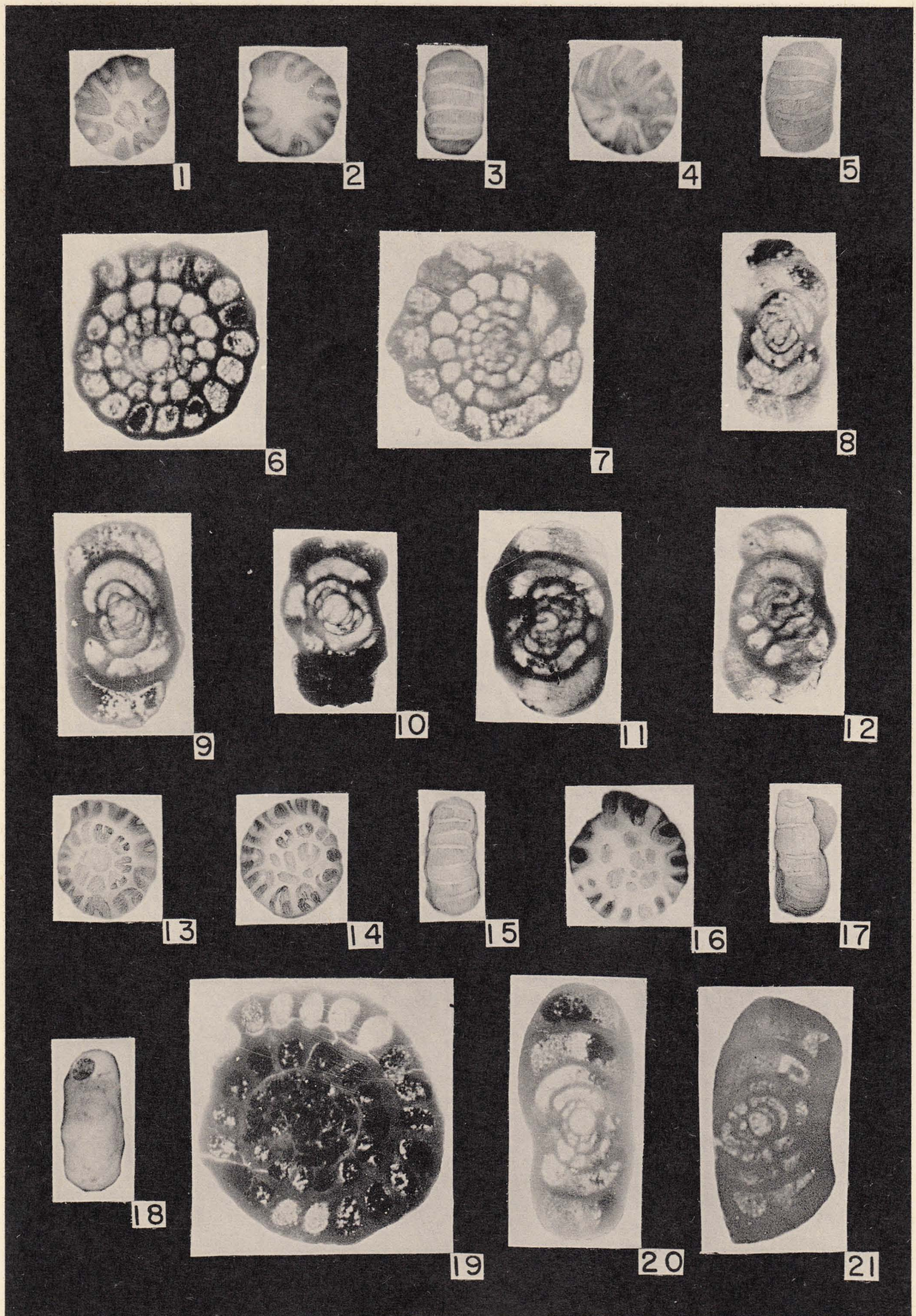
	PAGE
Figures 1-12: <i>Streblospira meandrina</i> Crespin and Belford, n. gen., n. sp.	74

FIGS.

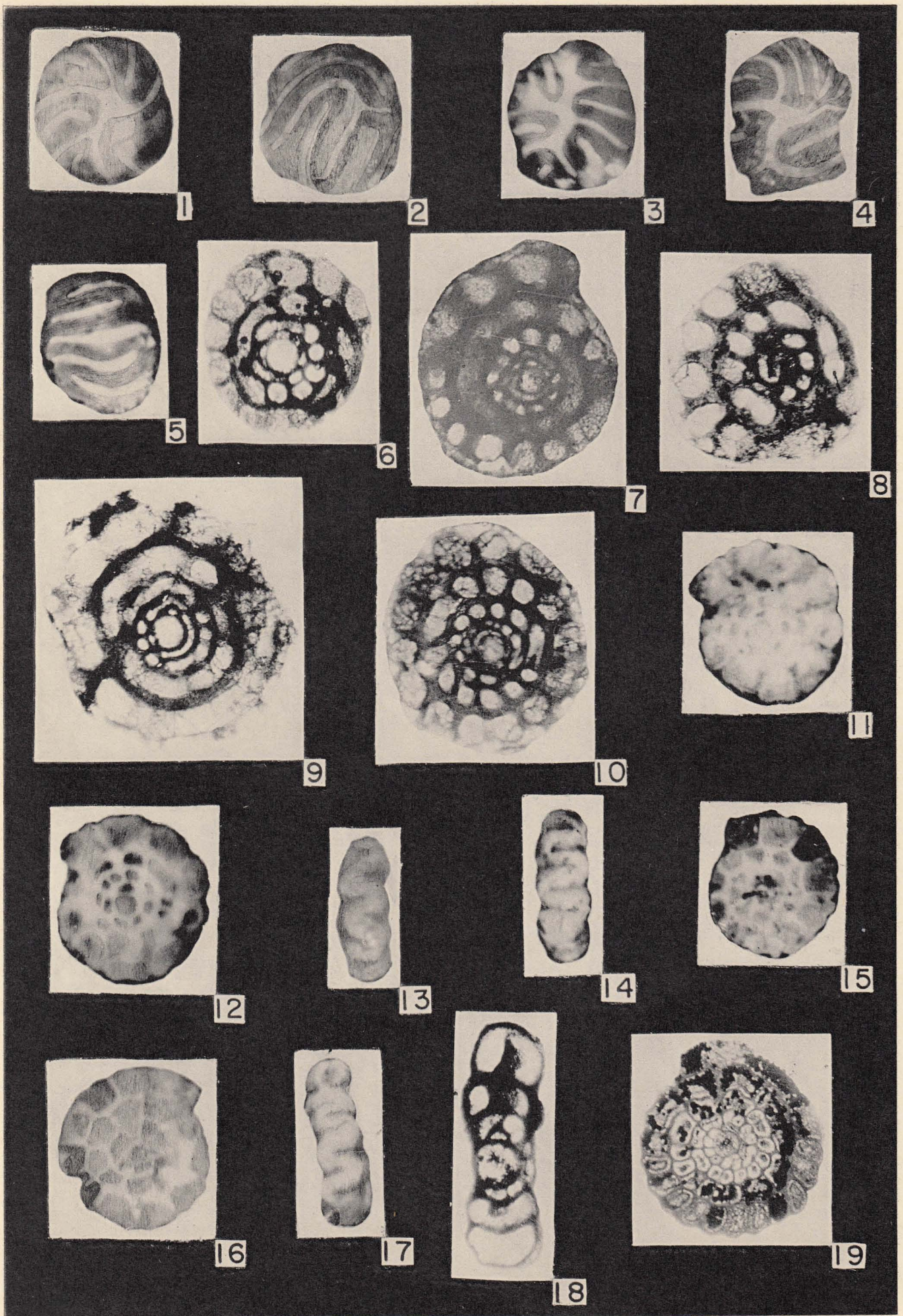
1. Holotype. Specimen in glycerine. Side view, showing involute test of form. x *circa* 53.
2. Holotype. Specimen in glycerine. Side view, with shell material covering involute central portion. x *circa* 53.
3. Peripheral view of holotype, showing zigzag arrangement of chambers and compression of test. x *circa* 53.
4. Paratype. Specimen in glycerine. Showing involute form and distinct, axial depression. x *circa* 53.
5. Paratype. Peripheral view showing zigzag arrangement of second chamber and compression of test. x *circa* 53.
6. Horizontal section, showing large proloculus and gradual increase in size of second chamber. x *circa* 90.
7. Horizontal section, showing small initial chamber. x *circa* 90.
8. Vertical section showing proloculus, involute form of test and change in plane of coiling. x *circa* 85.
9. Vertical section showing change in plane of coiling. x *circa* 85.
10. Vertical section showing large proloculus. x *circa* 85.
11. Vertical section showing irregular chamber arrangement. x *circa* 85.
12. Vertical section not completely central, showing zigzag arrangement of chamber in centre and apparent lateral chamberlets. x *circa* 85.

Figures 13-21: <i>Streblospira kimberleyensis</i> Crespin and Belford, n. gen., n. sp.	75
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13. Holotype. Specimen in glycerine. Side view showing slightly involute test. x *circa* 50.
14. Holotype. Specimen in glycerine. Side view showing slightly involute test. x *circa* 50.
15. Peripheral view of holotype, showing compressed test and zigzag arrangement of second chamber. x *circa* 50.
16. Paratype A. Specimen in glycerine. Side view, showing slightly involute form of test, x *circa* 50.
17. Peripheral view showing zigzag second chamber and variation in plane of coiling of test. x *circa* 50.
18. Paratype B. Peripheral view showing the rounded aperture. Zigzag coiling masked by shell wall. x *circa* 50.
19. Horizontal section of infilled specimen showing coiled second chamber. x *circa* 85.
20. Vertical section showing large proloculus and slightly involute form of test. x *circa* 88.
21. Vertical section showing large proloculus, asymmetrical, slightly involute test and change in plane of coiling. x *circa* 83.



Crespin and Belford: Lower Permian Foraminifera, Australia



Crespin and Belford: Lower Permian Foraminifera, Australia

Quinqueloculina sp. 1

Plate 13, figure 6 a,b,c

Test somewhat longer than broad; chambers distinct, angled; sutures distinct, slightly raised; aperture rounded, terminal; wall calcareous imperforate, ornamented with very faint longitudinal striations. Length 0.3 mm.; breadth 0.25 mm.

Figured specimen.—U.S.N.M. P 5371.

Quinqueloculina sp. 2

Plate 13, figures 11 a,b; 12 a,b

Test about 1½ times as long as broad; chambers very slightly sigmoidal, elongate, angled; sutures indistinct, slightly limbate, aperture with a large flat tooth.

This species may belong to the genus *Miliolinella*. Only a few specimens are found.

Figured specimens.—U.S.N.M. P 5372a,b.

Family NONIONIDAE

Genus **Nonion** Montfort, 1808**Nonion beadnelli** Said and Kenawy, n. sp.

Plate 13, figure 17 a,b,c

Test free, planispiral, close-coiled, bilaterally symmetrical, umbilicate; periphery rounded; chambers numerous, 13-15, similar in shape, very slightly increasing in size as added in the last whorl; wall calcareous, finely perforate; sutures flush, slightly arcuate towards the periphery; aperture slit-like, median, at the base of the last formed chamber. Diameter 0.25 mm.; thickness 0.08 mm.

This species differs from *N. jarvisi* Thalmann in having more chambers in the last coil and in having flush sutures. A large number of specimens is found.

Holotype.—U.S.N.M. P 5373.

Family PENEROPLIDAE

Genus **Peneroplis** Montfort, 1808**Peneroplis sp.**

Plate 13, figure 15 a,b

Test free, planispiral in early part which is close coiled, large, biumbilicate and made of large number of chambers, later chambers uniserial, made of slightly flaring chambers; periphery acute; sutures indistinct, thin and flush; wall calcareous, imperforate; aperture terminal, slit-like. Length 0.5 mm.; largest breadth 0.3 mm.

This species differs from *P. turonicus* n. sp., Said and Kenawy in having a large and biumbilicate early portion and in having numerous chambers.

Figured specimen.—U.S.N.M. P 5374.

Peneroplis turonicus Said and Kenawy, n. sp.

Plate 13, figures 14 a,b,c; 16 a,b,c

Test free, planispiral, periphery lobulate, sub-rounded; young close-coiled, involute, composed of 7-8 chambers, later uncoiling, flaring, annular chambers increasing in breadth but not in length as added; sutures distinct, thick, flush; wall calcareous, imperforate; aperture slit-like, terminal, divided into pores. Length 0.4 mm.; largest breadth 0.4 mm.

This species differs from *P. pertusus* (Forskal) in having no umbilicus in the early coiled part and in having more chambers and a smooth wall. Several specimens are found. This is one of the earliest records of this genus hitherto known to extend from the Eocene to Recent.

Holotype.—U.S.N.M. P 5375, figured paratype U.S.N.M. P 5376.

Genus **Spirolina** Lamarck, 1804**Spirolina schweinfurthi** Said and Kenawy,
n. sp.

Plate 13, figure 8 a,b

Test planispiral, depressed, partially evolute, composed of as many as three whorls, very slightly umbilicate; periphery acute; chambers numerous, of uniform shape, increasing gradually in size as added; sutures distinct, curved, limbate, thickened; wall imperforate; aperture cribrate made of row of openings at the apertural face. Diameter 0.35 mm.; thickness 0.1 mm.

This species is very similar to *S. arietina* (Batsch) except for the smooth test, acute periphery and limbate sutures. Numerous specimens

EXPLANATION OF PLATE 12

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Figures 1-10: <i>Streblospira australae</i> Crespin and Belford, n. gen., n. sp.	75

FIGS.

1. Holotype. Side view. Specimen in glycerine, showing method of coiling and zigzag tubular chambers. x *circa* 70.
 2. Peripheral view of holotype, showing zigzag spiral and change in direction of coiling. x *circa* 70.
 3. Paratype, Side view. Specimen in glycerine, showing zigzag character of coiling. x *circa* 70.
 4. View of other side of paratype. x *circa* 70.
 5. Peripheral view of paratype showing tubular zigzag coil. x *circa* 70.
 6. Section showing globular proloculus and early whorls. x 107.
 7. Section showing globular proloculus and early chambers; lower part of outer whorl shows chamber walls, with coiling in plane of section. x 107.
 8. Section showing zigzag coil in early portion of test. This section is approximately at right angles to first whorl, whilst last whorl is in plane of section. x 107.
 9. Section showing proloculus and first chambers, the coiling then being completely out of plane of section. x 107.
 10. Section of a form which seems to have retained uniform coiling for a greater number of whorls than in other specimens. x 107.
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|---|----|
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11. Holotype, side view of dry specimen. x 77.
 12. Same specimen in glycerine showing proloculus and planispiral coiling x 77.
 13. Edge view of holotype showing short zigzag bends of tubular second chamber. x77.
 14. Edge view of paratype A. x 77.
 15. Paratype A. in glycerine, showing side view of planispiral coiling. x 77.
 16. Paratype B. in glycerine; side view. x 77.
 17. Edge view of paratype B. x 77.
 18. Vertical section showing globular proloculus, planispiral coiling, slightly overlapping whorls and showing part of chamber wall with tubular openings at one edge. x 109.
 19. Horizontal section showing globular proloculus and the following planispiral whorl. x 77.

EXPLANATION OF PLATE 13

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1. <i>Haplophragmoides gracilis</i> Said and Kenawy, n.sp., a, dorsal view; b, ventral view of holotype	78
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10. <i>Cuneolina conica</i> d'Orbigny, a, side view; b, apertural view X65	79
11,12. <i>Quinqueloculina</i> sp. 2, a, b, different views	82
13. <i>Quinqueloculina antiqua</i> var. <i>angusta</i> Franke, a, b, different views	79
14,16. <i>Peneroplis turonicus</i> Said and Kenawy, n.sp., a, c, side views; b, apertural view (14 holotype, 16 paratype)	82
15. <i>Peneroplis</i> sp., a, side view; b, peripheral view of holotype	82
17. <i>Nonion beadnelli</i> Said and Kenawy, n. sp., a, c, side views; b, peripheral view of holotype X 260	82
18,20. <i>Gavelinopsis</i> ? <i>pseudobaccata</i> Said and Kenawy, n. sp., a, dorsal view; b, ventral view (20 holotype, 18 paratype)	83
19. <i>Discorbis minutus</i> Said and Kenawy, n. sp., a, dorsal view; b, ventral view of holotype	83
21. <i>Ceratobulimina aegyptiaca</i> Said and Kenawy, n. sp., a, dorsal view; b, peripheral view; c, ventral view of holotype	83
22. <i>Discorbis turonicus</i> Said and Kenawy, n. sp., a, dorsal view; b, ventral view of holotype	83

of this species are found.

Holotype.—U.S.N.M. P 5377.

Family ROTALIIDAE

Genus *Discorbis* Lamarck, 1804

Discorbis minutus Said and Kenawy, n. sp.

Plate 13, figure 19 a,b

Test depressed, small, plano-convex, rounded in outline; periphery rounded; dorsal side evolute, made of two whorls, final whorl large; ventral side with large plugged umbilicus; chambers indistinct, six to seven in the final whorl, of uniform shape, increasing gradually in size as added; wall calcareous, strongly perforate; sutures oblique, flush dorsally, depressed ventrally; aperture slit-like at the base of the final chamber extending ventrally. Diameter 0.23 mm.; thickness 0.08 mm.

This species may have some supplementary chambers that intercalate the regular series ventrally but these are not obvious as the umbilical plug is irregular and is made of shell matter that is difficult to remove. This species differs from the following in having a smaller plano-convex test, a more perforate wall and less inflated chambers. A large number of specimens is found.

Holotype.—U.S.N.M. P 5378.

Discorbis turonicus Said and Kenawy, n. sp.

Plate 13, figure 22 a,b

Test depressed, concavo-convex, rounded in outline but slightly longer than broad, periphery subrounded, lobulate; dorsal side very slightly convex, made of two whorls, last whorl large; ventral side with supplementary angular chambers between the regular series; chambers distinct, five to six in the final whorl, of uniform shape increasing slightly in size as added; supplementary chambers small, triangular in shape, sometimes inflated; wall calcareous, finely perforate; sutures slightly oblique, depressed; aperture an elongate slit at the base of the last formed chamber apparent only in side view. Diameter 0.35 mm.; thickness 0.1 mm.

This species is quite distinct. It differs from *D. vesicularis* Lamarck in being less convex on the dorsal side, in having a less perforate wall and fewer whorls on the dorsal side. A large number of specimens is found.

Holotype.—U.S.N.M. P 5379.

Genus *Gavelinopsis* Hofker, 1951

Gavelinopsis? pseudobaccata Said and Kenawy,
n. sp.

Plate 13, figures 18, 20 a,b

Test conical, small, rounded in outline; periphery subacute, consisting of about three whorls, the last having about eight to nine chambers; dorsal side conical, rounded at the apex; ventral side almost flat with a poorly developed plug; chambers distinct; sutures depressed in the later part, flush in the earlier part; wall distinctly perforate; aperture slit-like at the base of the last chamber extending slightly into the ventral face. Diameter 0.25 mm.; thickness 0.07 mm.

This species is close to the Recent species *Discorbis baccata* (Heron-Allen and Earland) but differs in having a less developed umbilical plug, in being smaller and less conical. It is placed tentatively in the genus *Gavelinopsis* because there is good indication that there are no supplementary ventral chambers. The details of the umbilical plug are, however, not quite obvious. A large number of specimens of this species is found.

Holotype.—U.S.N.M. P 5380, figured paratype U.S.N.M. P 5382.

Family CASSIDULINIDAE

Genus *Ceratobulimina* Toula, 1915

Ceratobulimina aegyptiaca Said and Kenawy,
n. sp.

Plate 13, figure 21 a,b,c,

Test slightly longer than broad, usually seven chambers in the final whorl, dorsal side flattened but elevated in the middle; sutures distinct, strongly oblique in the dorsal side, radial ventrally, depressed, distinct; wall smooth, polished; aperture extending into the last formed chamber in a rounded triangular depression. Diameter 0.5 mm.; thickness 0.3 mm.

This species differs from *C. cretacea* (Cushman and Harris) in having a more rounded test, more oblique sutures dorsally and a large rounded depression in the apertural face at the last formed chamber. A large number of specimens of this species is found.

Holotype.—U.S.N.M. P 5381.

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Said and Kenawy: Turonian Foraminifera, Egypt

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH

VOLUME VIII, PART 2, APRIL, 1957

170. TWO RECENT TEXTBOOK ACCOUNTS OF FORAMINIFERAN
BIOLOGY

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Two protozoology textbooks containing accounts of the current status of foraminiferan biology have appeared during the past year which should be of particular interest to the micropaleontologist, since each is written by a leading student of the biological activities of living representatives of this important microfossil group.

The first of these, *Protozoologie*, the work of Dr. Karl G. Grell of the *Max-Planck-Institut für Biologie* in Tübingen, was published by Springer during the early summer of 1956. Grell, a most capable and industrious biologist and one of Europe's leading protozoologists, has a broad research background, having already published the results of studies on various non-foraminiferan protozoa as well as several mono- and polythalamous foraminifera.¹ He brings to the study of foraminiferan biology a confidence-inspiring ability to generalize the many particulars of modern biological research into a practical set of logically classified principles. His own research on the life cycles and cytology of such diverse forms as *Myxotheca arenilega* and *Rotaliella heterocaryotica* is characterized by an ability to select a significant problem, pursue it to a meaningful conclusion and then insert the results, in the form of a well-balanced appraisal, into the general field of knowledge so skillfully that the overall picture is enhanced without distortion. All of this is presented in a literary style which, because of its simplicity and directness, is a pleasure for the non-German to read.

The first two-thirds of the text is devoted to general protozoological subjects, with emphasis on protoplasmic elements, their organization, structure and activities. The particular characteristics of the foraminifera are here fitted into the general protozoological scene, so that the reader can obtain the necessary perspective for evaluating the Order in its relationship to other protozoa and, in some cases, to higher organisms as well. The

non-specialist will, of course, have difficulty with some of the technical terms, but in most cases they are clearly defined or interpreted in nearby pages.

The characteristic German orderliness and attention to detail has been advantageously rendered less ponderous in an obvious effort to scale the text to the needs of the advanced student who, though a non-protozoan specialist himself, has the general breadth of training required to grasp complex relationships if they are expressed in the form of clearcut generalizations. The book is certainly outstandingly useful in helping such students tie together what would otherwise be a bewildering array of facts.

In the last third of the text, the equivalent of approximately four pages of print is devoted to a synoptic treatment of foraminiferan biology and one to a perfunctory taxonomic glimpse of the Order, here divided into two Suborders, the Monothalamia and Polythalamia, containing six representative genera each. The non-taxonomic section is a highly concentrated extract of the current knowledge of the biology of the foraminifera, and a genuine comprehension of the data contained within it would probably quite adequately fill the need of the average micropaleontologist for such information. Grell's primary concern is with life cycles and reproductive phenomena, no less than six illustrations of these cycles being included in the meagre space allotted to the entire Order. The principal weakness in the presentation, as any micropaleontologist will immediately discover, is in relation to the "hard parts" of the foraminifera and to those aspects of natural history which are of major interest to the paleontologist. Such a statement as "*Die Foraminiferen leben ausschliesslich marin*" would certainly give a micropaleontologist pause, but such disturbing remarks rapidly assume their proper proportions when viewed in the light of equally inadequate accounts of foraminiferan biology in paleontological texts. The general failure in ecological, distributional and taxonomic

¹ The term "foraminifera" is uncapitalized in deference to the author despite the strong protest of the editor. The editor prefers the common names "foraminifer(s)" or "foraminiferan(s)" reserving "Foraminifera" for the name of the order.

details would be a matter of real concern were it not for the convenient availability of such information in the paleontological literature. But one should refer to Grell's textbook for information on protoplasmic features and activity, to a micro-paleontology text for data on the test. The protozoologist's only concern with the test, as a rule, is how to dissolve this inconvenience without damaging the all-important nuclei and chromosomes. It's as interesting and refreshing as the story of the blind men and the elephant to see how the picture changes when viewed from a different angle. Grell merely supplies an essential view of another broad and important facet of the vast field of foraminiferology.

The format of this text is pleasing, the illustrations and paper superb, and the cost (59 marks) shattering. Many of the illustrations are original and based on Grell's own careful observations of living foraminifera and cytological preparations. The photography is often quite remarkable and the very painstakingly executed drawings are consistently so. It is very difficult, indeed, to find stippling of the quality exhibited in Freiberg's pen-and ink drawings. No effort has been spared in maintaining the illustrative excellence which has become traditional in German protozoological circles.

The clear, effective and concise literary style of the author was a pleasant and welcome relief and in striking contrast to much of the German literature on foraminiferan biology. Grell's similes are frequently picturesque and invariably effective; through them he has been able to transmit to the reader some of his own light-hearted zest for life and appreciation of beauty and symmetry wherever it occurs in Nature.

The second of the textbooks appearing in 1956 was *The Protozoa, Sarcodina*, published by Oliver and Boyd and written by Dr. Margaret W. Jepps, a retired member of the Department of Zoology of the University of Glasgow, now living in Cambridge.

Jepps' text, devoted not to the entire phylum but to a single class of protozoa, is among the most readable accounts of the sarcodinians in the English language, and the section on foraminifera one which no student of the group should miss. Jepps can transmit scientific data in such a pleasing manner that even familiar information takes on a new sparkle, and new information the fascination that so many writers seek but so few achieve. It is an opportunity for those of us who have derived countless hours of pleasure from

reading the classical English works on foraminifera to indulge ourselves in an up-to-date account in the same scholarly but human style of the nineteenth-century British natural historian. It is rare indeed to find textbooks today which combine such traits of scholarliness and readability. One feels, on reading this book, that the author was not completely inundated by the mad swirl of today's hurried existence but had time to admire the aesthetic attributes of the little creature she was watching under her microscope and, what is more important, were not afraid to defy convention by injecting a bit of her own personality into the book as she has done with unfailing regularity in all of her previous scientific communications. Her writing reflects the strength and independence of the Grampians and the placid, reassuring self-confidence of the Cam; and the book, like these two backdrops against which she worked, has an enduring quality which will be a source of strength and inspiration for many generations of students.

Approximately one fourth of the 33-page section on the foraminifera is devoted to an account of the life activities of *Elphidium crispum*, a species which serves as a point of reference for subsequent expansion and comparisons. Any student of the foraminifera who has not read her more detailed account of these activities (in the *Journal of the Marine Biological Association of the United Kingdom*, 1942) has failed to claim a part of his foraminiferological birthright; but the précis contained within her textbook gives a glimpse of the brilliance of her literary and scientific style. Her introductory lamentation over the fate of the name "*Polystomella*" in America might equally well have been bestowed upon the even more lamentable demise of the classical style in modern scientific literary efforts; but a perusal of her story of the foraminifera will re-impress our memory with the power and delightful efficacy of a style which has, like the term "*Polystomella*," been displaced by a striving for "efficiency" which stifles any attempt at the individualistic expression of the scientist's own reactions to natural phenomena as though the reader lacked the rudimentary intelligence necessary for differentiating between objective observations and subjective reactions to those observations. Perhaps those who insist upon such a thoughtless and thought-destroying emasculation are motivated by such a basic intellectual inadequacy.

The reader should under no circumstances neglect the footnotes, since these contain helpful information which is quite frequently enhanced by

the delightfully candid impressions or asides of one who has been able to view the fields of foraminiferal biology with a perspective and maturity that is exhilaratingly different.

Jepps, in good British tradition, confesses that the classification given in her textbook is "a minimum for convenience." In keeping with her preference for "*Polystomella*" rather than the new-fangled "*Elphidium*," she has essentially followed Lister's amplification of Brady's classification, including only eight families. The taxonomic survey consumes almost one fourth of the section on the Foraminifera, but points of more general biological interest are contained within this ration. The illustrations, as might be expected, are devoted largely to metagenetic and general biological phenomena rather than to sheer morphological details.

Jepps' text is far less expensive than Grell's as one would expect in view of the difference in the nature of the illustrations. The drawings are

adequate but lack the brilliance and grandeur of half-tone presentations. Photographs are, of course, completely wanting, and the stippling, when compared with the masterful Freiberg renditions, is mediocre. These technical shortcomings, however, are far outweighed by the literary excellence of the text. Technical perfection in illustrative matters is almost commonplace today, literary excellence rare indeed. As final proof of this excellence it might be added that the textbook contains not one graph or formula, good evidence of a mind which needs no symbolic crutch but which through practice and diligent application has managed to weld a line of communication from brain to paper that is sufficiently capacious and supple to permit the free flow and intelligible expression of the most complex thoughts. The reviewer commends Jepps' text to the reader as one of these rare accidents that, fortunately, still befalls the modern scientific public.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME VIII, PART 2, APRIL, 1957
RECENT LITERATURE ON THE FORAMINIFERA

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

- ALEXANDROWICZ, S., and PARACHONIAK, W. Miocene tuffites in the vicinity of Pinczow on the Nida-River (in Polish with English summary).—*Acta Geol. Polonica*, v. 6, No. 3, 1956, p. 301-325, pls. 1, 2, text figs. 1-5 tables.—Numerous Foraminifera are listed from Tortonian strata.
- BANDY, ORVILLE L. Ecology of Foraminifera in northeastern Gulf of Mexico.—*U. S. Geol. Survey Prof. Paper 274-G*, Dec. 10, 1956, p. 179-204, pls. 29-31, text figs. 25-28, tables 1-4, charts 1-7.—An important paper presenting results of frequency studies from the shore to the 100-fathom line, and discussion of the effects of numerous ecologic factors. Four gradational faunal assemblages are recognized in the brackish environments, and six in the marine. In the combined environments, 142 species were studied and about a third of them illustrated. Three species and one variety are new, and one species is given a new name.
- BETTENSTAEDT, F., and WICHER, C. A. Stratigraphic correlation of Upper Cretaceous and Lower Cretaceous in the Tethys and Boreal by the aid of microfossils.—*Proc. Fourth World Petr. Congress*, sec. I/D, Paper 5, 1955, p. 493-516, pls. 1-5.—Diagrams of stratigraphic ranges in the Tethys and Boreal provinces and brief notes on occurrences and affinities of 55 species with illustrations of 24 of them.
- BHATIA, S. B. The study of variation in some smaller Foraminifera.—*Journ. Pal. Soc. India*, Inaugural Number, v. 1, No. 1, 1956, p. 142-152, text figs. 1-11.—Variation in six unit characters and in polymorphic generations is illustrated and discussed.
- BOLTOVSKOY, ESTEBAN. Applications of chemical ecology in the study of the Foraminifera.—*Micro-paleontology*, v. 2, No. 4, Oct. 1956, p. 321-325.—Improvement of the fauna of part of the Argentine shelf is attributed to traces of lead.
- CIRY, RAIMUNDO, and RAT, PEDRO. Dos Foraminiferos nuevos del cretácico de Navarra.—*Instit. Invest. Geol. "Lucas Mallada"*, v. 7, No. 3, 1953, p. 287-317, pls. 12, 13 (1, 2), text figs. 1-7.—Spanish translation of the 1951 and 1953 papers in which the genera *Navarella* and *Simplorbitolina* were described.
- COLOM, G. Los Foraminiferos del Burdigaliense de Mallorca.—*Mem. R. Acad. Ciencias y Artes de Barcelona*, v. 32, No. 5, June 1956, p. 1-140, pls. 1-25, text figs. 1-5, tables.—A fauna of 364 species and subspecies, ten new. A new subgenus of *Lagena* is erected: *Reusoolina* (genotype *Lagena apiculata* Reuss).
- Una nueva *Cyclammina* (Foraminifero) de las costas del Senegal.—*Bull. Inst. Français Afrique Noire*, v. 18, sér. A, No. 1, 1956, p. 35-38, text figs.—*Cyclammina senegalensis* from 120-215 meters from holothurian intestines.
- COLOM, GUILLERMO, and MURAUOR, PIERRE. L'Oligocène supérieur du Cap Djinnet et de L'Oued el Arba.—*Publ. Serv. Carte Géol. Algérie (n. sér.)*, Bull. No. 5, 1954 (1955), p. 249-269, pls. 1-4, text fig. 1.—The fauna, largely planktonic, is listed and most of the species illustrated. Age is determined as Aquitanian.
- CUVILLIER, J. Stratigraphic correlations by microfossils in western Aquitaine, 2nd Ed. (with the collaboration of V. SACAL).—*Internat. Sedimentary Petrographical Ser.*, v. 2, 1956, p. 1-33, pls. 1-100, 1 map.—Book includes 200 microphotographs illustrating sediment types, ranging in age from Devonian to Miocene, from the western part of the Aquitaine basin. Microfossil contents of the thin sections are briefly described.
- EMILIANI, CESARE. On paleotemperatures of Pacific bottom waters.—*Science*, v. 123, No. 3194, March 16, 1956, p. 460, 461, table 1.—Lists of species and discussion in support of the middle Oligocene and lower-middle Miocene age of two eastern Pacific cores previously reported on.
- ERICSON, DAVID B., BROECKER, WALLACE S., KULP, J. LAWRENCE, and WOLLIN, GOESTA. Late-Pleistocene climates and deep-sea sediments.—*Science*, v. 124, No. 3218, Aug. 31, 1956, p. 385-389, text figs. 1-3, table 1.—Radiocarbon dating of cores, in which climatic curves are based on variations in frequencies of species of Foraminifera and on oxygen paleotemperatures, indicate that the transition from glacial to postglacial climate was marked by pronounced temperature rise of the upper layer of oceanic water about 11,000 years ago.
- FERASIN, FRANCESCO. Studio micropaleontologico e stratigrafico della campionatura del Pozzo A. G. I. P. N. 44 di Podenzano (Piacenza).—*Mem. Istit. Geol. Min., Univ. Padova*, v. 19, 1955-56 (1956), p. 1-77, pls. 1-5, 29 text figs.—Two hundred forty-one species (one new and 14 indeterminate) and 27 subspecies (one new) from boring samples of Miocene (Messinian and Langhian) and lower Pliocene age.
- GAZEL, J., HOURCQ, V., and NICKLES, M. Cameroons Direction des Mines et de la Géologie, Bull. No. 2, 1956, Carte Géol. du Cameroun, Notice explicative, p. 1-62, geol. map.—Some well sections are zoned by Foraminifera.
- GLINTZBOECKEL, CHARLES. Présence de Trocholines dans le Trias de la Tunisie.—*C. R. S. Soc. Géol. France*, No. 13, Nov. 5, 1956, p. 238-240, text figs.
- GRIMSDALE, T. F., and VAN MORKHOVEN, F. P. C. M. The ratio between pelagic and benthonic Foraminifera as a means of estimating depth of deposition of sedimentary rocks.—*Proc. Fourth World Petr. Congress*, sec. I/D, Paper 4, 1955, p. 473-489, text figs. 1-10.—Graphs from traverses in the NW Gulf of Mexico and along the Atlantic coast show increase in pelagics with depth but are disappointing in their lack of precision.
- HENRY, VERNON J. Investigation of shoreline-like features in the Galveston Bay region, Texas.—*Texas A. and M. College, Dept. Oceanography, Project 24*, April 25, 1956, 76 p. (mimeographed), 24 text figs.—Foraminifera were recovered from the borings.
- HOFKER, J. Foraminifera from the Cretaceous of southern Limburg Netherlands. XX. The development of *Coleites reticulosus* (Plummer).—*Natuurhist. Maandblad*, 45e Jrg., No. 7-8, Aug. 24, 1956, p. 75-78, text figs. 1-8.—Illustrations and descriptions of evolution from the middle Maestrichtian form, *Pseudoparrella ornata*, to the typical form of the species in the Paleocene.
- Foraminifera from the Cretaceous of southern Limburg, Netherlands. XXI. The species of the genera *Gavelinella* and *Gavelinopsis* in the Cretaceous above the Hervian in Germany, Holland and Belgium, and the increase of the diameters of their pores as indication for stratigraphic levels (including the development of the pores of some *Stensjöina*-species).—*Natuurhist. Maandblad*, 45e Jrg., No. 9-10, Oct. 31, 1956, p. 99-110, text figs. 1-18, graph.—Twelve species, none new, are described and illustrated. Pore-size ranges of 13 species are plotted for various stratigraphic levels from middle Campanian to Paleocene.
- The structure of *Globorotalia*.—*Micro-paleontology*, v. 2, No. 4, Oct. 1956, p. 371-373, text figs. 1-7.—True *Globorotalia* have a poreless peripheral area though it may be no longer keeled. The genus de-

- developed from single-keeled Globotruncanidae.
- HOSE, H. R. and VERSEY, H. R. Palaeontological and Lithological Divisions of the Lower Tertiary Limestones of Jamaica.—Geol. Survey Jamaica, Publ. No. 26, 1956, p. 19-39, pls. 1-6, text figs. 1, 2.—In the limestone sequence covering the interval from middle Eocene to lower Miocene, six zones based on larger Foraminifera are recognized, and four fossil bands. A major unconformity is present in the upper Oligocene at the base of the *Miogyssina* limestone.
- JACOB, K., and SASTRI, V. V. Miocene Foraminifera from Chavara, near Ouilon, Travancore.—Rec. Geol. Survey India, v. 82, pt. 2, 1952 (1953), p. 342-353, pls. 14-16.—Ten species, three new, mostly operculines and orbitoids.
- KANMERA, KAMETOSHI. Fusulinids from the Yama-madake Limestone of the Hikawa Valley, Kumamoto Prefecture, Kyushu, Japan. Part II. Fusulinids of the Upper Carboniferous.—Japanese Journ. Geol. Geogr., Trans., v. 26, Nos. 3-4, Dec. 20, 1955, p. 177-192, pls. 11, 12, text fig. 2 (section), tables 1, 2.—Five species, two new, two indeterminate.
- KOCHANSKY-DEVIDE, VANDA. Unterpermische Fusuliniden von Sustasi bei bar in Crna Gora (Montenegro) (German summary)—Geol. Vjesnik (Zagreb), sv. 8-9, 1954-1955 (1956), p. 7-13, pls. 1, 2.—Eight species, none new.
- KOHLI, G., and SASTRI, V. V. On the age of the Chikkim series.—Journ. Pal. Soc. India, Inaugural Number, v. 1, No. 1, 1956, p. 199-201, pls. 32, 33.—In the Himalayas, Upper Cretaceous age (Cenomanian to Senonian) established on the basis of species of *Globotruncana*.
- KOVARY, JOZSEF. Thécamoebiens (Testacées) des sédiments du Pannonien inférieur de la Hongrie (in Hungarian with Russian and French resums).—Földtani Közlöny, Bull. Hungarian Geol. Soc., v. 86, No. 3, July-Aug. 1956, p. 266-273, pls. 35-39.—*Silicoplacentina* n. gen. (genotype *S. hungarica* n. sp.) and four new species belonging to the Thecamoebina.
- KUPPER, KLAUS. Stratigraphische Verbreitung der Foraminiferen in einem Profil aus dem Becken von Gosau (Grenzbereich Salzburg—Oberösterreich).—Austria Geol. Bundesanstalt, Jahrbuch, Jahrgang 1956, Band 99, heft 2, July 1956, p. 273-320, pls. 10, 11 (map and stratigraphic range chart).—By means of Foraminifera several stages are recognized within the rock unit known as Gosau, which includes strata ranging from lower Senonian to Paleocene. About 100 of the commoner species and subspecies, none new, are mentioned in a systematic part, and their stratigraphic ranges graphically indicated.
- LE CALVEZ, YOLANDE. Les Foraminifères du Pliocène de la Corse.—Bull. Soc. Géol. France, ser. 6, tome 6, fasc. 4-5, 1956, p. 583-596.—Includes several lists of Foraminifera. Age determined as Plaisancian.
- LEFEBVRE, SIMONE. Observations sur *Nummulites millicaput* Boubée (forme macrosphérique).—Bull. Soc. Géol. France, ser. 6, tome 6, fasc. 4-5, 1956, p. 575-582, text figs. 1-3.
- LOEBLICH, ALFRED R., JR., and TAPPAN, HELEN. *Chiloguembelina*, a new Tertiary genus of the Heterohelicidae (Foraminifera).—Journ. Washington Acad. Sci., v. 46, No. 11, 1956, p. 340.—*Chiloguembelina*, n. gen. (type species *Gümbelina midwayensis* Cushman).
- MILLER, HALSEY W., JR. The index value of Silurian Foraminifera and some new forms from wells in Kansas.—Journ. Pal., v. 30, No. 6, Nov. 1956, p. 1350-1359, text fig. 1, table 1.—Includes lists of index forms and a chart showing stratigraphic and geographic range of about 150 species, all the Silurian Foraminifera so far known from North America. Three species (two new) and two unnamed new genera are described from a subsurface formation of Kansas.
- MOHAN, KRISHNA, and CHATTERJI, A. K. Stratigraphy of the Miocene beds of Kathiawar, western India.—Micropaleontology, v. 2, No. 4, Oct. 1956, p. 349-356, text figs. 1-3 (maps, section), table 1.—Age determined as Burdigalian on the basis of a few larger Foraminifera. Affinities are with the Indo-Pacific.
- MORIKAWA, ROKURO. Fusulinids from Onagata, Kamiyoshida-mura, Northern part of Kanto Mountainland.—Sci. Rept. Saitama Univ., ser. B, v. 2, No. 2, 1956, p. 249-260, pls. 32-34.—Six species, two new, two indeterminate.
- MORIKAWA, ROKURO, and HORIGUCHI, MANKICHI. *Parafusulina nakamigawai* n. sp. from the Adoyama formation in the neighborhood of Kuzu City, Tochigi Prefecture.—Sci. Repts. Saitama Univ., ser. B, v. 2, No. 2, 1956, p. 261-264, pl. 35.
- MULDINI, SLAVICA. Über die Mikrofauna der Bohrung Bunjani-15 (German summary).—Geol. Vjesnik (Zagreb), sv. 8-9, 1954-1955 (1956), p. 107-114, 1 text fig. (section), 1 table.—Smaller Foraminifera listed from the Tortonian section of the boring.
- Foraminiferen, in Fossilien aus Bohrungen in der Umgebung von Bunjani und Kriz (Kroatien), by A. PAPP and S. MULINI.—Geol. Vjesnik (Zagreb), sv. 8-9, 1954-1955 (1956), p. 81-83.
- NAGAPPA, Y. On the systematic position of *Alveolina meandrina* Carter together with a discussion on the age of the rocks in which this fossil has been found.—Rec. Geol. Survey India, v. 82, pt. 2, 1952 (1953), p. 317-324, pls. 8-10.—*Miscellanea meandrina* (Carter) from Eocene strata in W. Pakistan and Assam.
- Foraminifera of the genera *Fabiania* and *Eorupertia* from the Sylhet limestone of Assam.—Journ. Pal. Soc. India, Inaugural Number, v. 1, No. 1, 1956, p. 191-198, pls. 30, 31, text figs. 1-4, map.—*Fabiania indica* nov. and *Eorupertia boninensis* from middle to upper Eocene strata.
- PAPP, A. Die morphologisch-genetische Entwicklung von Orbitoiden und ihre stratigraphische Bedeutung in Senon.—Paläont. Zeitschr., Band 30, August 1956, p. 45-49, text figs. 1-33.
- PIERCE, RICHARD L. Upper Miocene Foraminifera and fish from the Los Angeles area, California.—Journ. Pal., v. 30, No. 6, Nov. 1956, p. 1288-1314, pls. 137-144, text figs. 1-6, table 1.—Eighty-eight species of Mohnian Foraminifera from the Modelo formation, seven species and three varieties new, are illustrated, and their frequency distribution in a stratigraphic thickness of 2240 feet, plotted. The sequence is subdivided into three zones, based on Foraminifera and fish scales.
- PURI, HARBANS S. Facies faunas and formations.—Journ. Pal. Soc. India, Inaugural Number, v. 1, No. 1, 1956, p. 153-162, text figs. 1-8.—Miocene Foraminifera of Florida are used to illustrate facies faunas.
- RAO, S. R. NARAYANA, and SINGH, SUKHBIR. Two species of *Lepidocyclina* from the agate-conglomerates (Burdigalian) of the Surat-Broach region, western India.—Journ. Pal. Soc. India, Inaugural Number, v. 1, No. 1, 1956, p. 70-74, pl. 5, text figs. 1-6, map.—A new variety and an already known species.
- ROBINSON, FLORENCE M. Core tests and test wells, Oumalik area, Alaska, with Paleontology of test wells and core tests in the Oumalik area, Alaska, by HARLAN R. BERGQUIST.—U. S. Geol. Survey Prof. Paper 305-A, Nov. 6, 1956, p. 1-70, pls. 1-6, text figs. 1-6 (maps, correlation table).—Numerous Foraminifera (none illustrated) characterize various formations and levels in the wells.
- SMITH, HUGH P. Foraminifera from the Wagonwheel formation, Devils Den District, California.—Univ. Calif. Publ. Geol. Sci., v. 32, No. 2, June 8, 1956, p. 65-126, pls. 9-16, text figs. 1-3 (map, stratigraphic column, distrib. table).—Sixty-three species of which four are new and 13 indeterminate, and four varieties are recorded and most of them illustrated from this Oligocene (Refugian stage) formation.
- SMOUT, A. H. Three new Cretaceous genera of Foraminifera related to the Ceratobuliminidae.—Micropaleontology, v. 2, No. 4, Oct. 1956, p. 335-348, pls. 1, 2, text figs. 1, 2.—*Begia* n. gen. (type species *B. gyra* n. sp.) in the Ceratobuliminidae and *Coxites* n. gen. (type species *C. zubairensis* n. sp.) and *Rabanitina* n. gen. (type species *R. basraensis* n. sp.) in the new family Barkerinidae. Nine species, all new, mostly from lower Turonian

- strata from deep boreholes in southern Iraq.
- STELCK, C. R., WALL, J. H., BAHAN, W. G., and MARTIN, L. J. Middle Albian Foraminifera from Athabasca and Peace River Drainage Areas of Western Canada.—Research Council of Alberta Rept. No. 75, 1956, p. 1-60, pls. 1-5, text figs. 1, 2.—Fifty-nine species, subspecies and varieties, of which nine species and one variety are new and 27 are indeterminate, are described and illustrated. Six microfaunal zones are recognized and tied in to megafaunal sequences. The faunas are indicative of a transgressive shallow sea with brackish margins.
- STONE, S. W. Some ecologic data relating to pelagic Foraminifera.—*Micropaleontology*, v. 2, No. 4, Oct. 1956, p. 361-370, text figs. 1-3, table 1.—The species, *Orbulina universa*, *Globigerinoides sacculifera*, and *G. rubra*, are studied quantitatively and qualitatively from selected Albatross stations between about 25° S and 40° N lat. along the western Atlantic.
- STSCHEDRINA, Z. G. Fauna Foraminifer Dalnevostochnykh Morei Sovetskogo Soiuza (in Russian).—*Akad. Nauk Zool. Inst., Trans. of problem and thematic conferences*, No. 6, 3rd Conf. on study of fauna of Far Eastern Seas, 1956, p. 65-71.
- TEWARI, B. S. The genus *Halkyardia* from Kutch, western India.—*Journ. Pal. Soc. India, Inaugural Number*, v. 1, No. 1, 1956, p. 172-175, text figs. 1-9.—*Halkyardia minima* var. *indica* nov. described from Lutetian strata.
- TOOMEY, DONALD F. Addendum to a bibliography of the family Fusulinidae.—*Journ. Pal.*, v. 30, No. 6, Nov. 1956, p. 1360-1366.
- TROELSEN, J. C. Internal structure and systematic position of the foraminifer *Cerobertina*.—*Journ. Pal. Soc. India, Inaugural Number*, v. 1, No. 1, 1956, p. 66-69, pl. 4.—Restudy of three species showing close relationship to *Ceratobulimina* and only superficial similarity to *Robertina*.
- VERVILLE, G. J., THOMPSON, M. L. and LOKKE, D. H.—Pennsylvanian fusulinids of eastern Nevada.—*Journ. Pal.*, v. 30, No. 6, Nov. 1956, p. 1277-1287, pls. 133-136.—Four species, all new, one placed in a new genus, *Bartramella* (type species *B. bartrami* n. sp.).
- WICHER, CARL A. Mikropaläontologische Beobachtungen in der höheren borealen Oberkreide, besonders im Maastricht.—*Geol. Jahrb.*, Band 68, Febr. 1953, p. 1-26, text fig. 1, tables 1-5.—*Pseudotextularia elegans* horizon occurs in the uppermost Boreal Maestrichtian, overlying the *Stensiöina*-free horizon. *Globotruncana* appeared earlier and persisted later in the Mediterranean than in the Boreal regions. Several species of *Bolivina* and *Bolivinoidea* and a few others are discussed and illustrated and their ranges indicated.
- WISSINK, A. J. Heterostegines du Miocene de l'Angola.—*Proc. Kon. Nederl. Akad. Wetenschappen*, ser. B, v. 59, No. 4, 1956, p. 386-388, text figs. 1, 2.—Two types, neither one new, are illustrated and described, the lower one with incompletely developed secondary septa.

RUTH TODD