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Return to:- 
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INTRODUCTION

Pliocene foraminiferal assemblages of the Repetto and Pico formations of the Los Angeles Basin have been studied extensively because of their stratigraphic value in the petroleum industry. Paradoxically, however, aside from several brief specific studies no faunal analysis has ever been published or presented. This paper, by no means complete or exhaustive, invites attention to this distinctive foraminiferal fauna.

The lithological and faunal contents analyzed herein were obtained from University of Southern California (USC) locality 106 located on Fourth and Flower Streets in the downtown area of the city of Los Angeles, California (fig. 1). Aims of this paper are fivefold: (1) to figure and describe the fauna, (2) to determine and indicate the stratigraphic ranges and relative abundance of diagnostic species, (3) to describe the lithology, (4) to attempt a reconstruction of the depositional environment of the sediments at this particular outcrop, and (5) to determine the ecological conditions at the time of the faunas interment.

It was originally planned to sample the locality by establishing substations every 2 feet stratigraphically and to then divide the section into 10 foot intervals, each containing 5 mixed samples. In the Pico this gave admirable results, but in the Repetto less nearly perfect results were attained. In the latter formation several stations yielded poor foraminiferal concentrates and stations 1 and 2 produced completely negative results both times they were sampled and processed. Furthermore, it was not possible to maintain continuity of 2 foot substation interval in the Repetto because leached zones occur at and near the base of the exposed formation. Hence the station stratigraphic interval for the Repetto averages 20 feet, whereas that of the Pico averages 10 feet as originally planned. In the Pico only station 12 proved to be barren (fig. 1). Despite the difference between the station intervals of the lower and upper Pliocene, it is felt that adequate coverage was accomplished.

The collecting of samples and the pursuance of other necessary field and laboratory work was carried on during the summer of 1949. The figures were drawn by the author, using a camera lucida for outlining the structures. Approximately one academic year was spent in the analysis of the fauna and the preparation of this paper.

By necessity, any project of this type is made possible and aided by the assistance and cooperation of a number of individuals and agencies. This study is no exception and first to be mentioned are H. L. Driver and W. H. Holman of the Standard Oil Company of California, who not only suggested the locality but its possibilities as well. R. W. Crouch and W. Elliot of the Richfield Oil Corporation kindly assisted with identifications. W. H. Easton and K. O. Emery of the University of Southern California furnished valuable assistance and helpful suggestions. Finally it is a pleasure to acknowledge the aid and encouragement given by O. L. Bandy of the University of Southern California during the planning and preparation of this study.

HISTORICAL REVIEW

General

Nomenclaturally the marine Pliocene formations of the Los Angeles area have undergone an evolution that more or less parallels the stratigraphic and paleontological developments in the basin. Eldridge and Arnold (1907, p. 22) mapped the northern portion of the basin Pliocene in the vicinity of the old Los Angeles City oil field as Fernando. Subsequently Kew (1924, p. 70) raised the Fernando to group status and added
the Pico and Saugus formations, the latter having their type sections in the Ventura basin. In 1930 the Society of Economic Paleontologists and Mineralogists established the name Repetto for the lower Pliocene and limited the use of the Pico to the upper Pliocene. This latter development resulted from the confusion in terminology arising from more extensive and detailed work of micropaleontologists that revealed two distinct faunal facies in the basin (Wissler, 1943, p. 212).

Reed (1932, p. 31) first defined the Repetto formation in print.

Table No. 1 Nomenclatural Development of the Los Angeles Basin Pliocene

<table>
<thead>
<tr>
<th>Eldridge and Arnold, 1907</th>
<th>Kew, 1924</th>
<th>S.E.P.M., 1930</th>
<th>Reed, 1932</th>
</tr>
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<tbody>
<tr>
<td>Saugus</td>
<td>Pico</td>
<td>Pico</td>
<td>Repetto</td>
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<tr>
<td>Fernando</td>
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<td>Repetto</td>
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Fourth and Flower Streets Locality

The Pliocene locality described in this paper has received considerable attention from various workers in past years. Eldridge and Arnold (1907) presented maps and cross-sections as well as detailed discussions of the area near the Elysian anticline, of which the Fourth and Flower Streets locality forms part of the southern limb. H. L. Driver, A. Ferrando, and W. H. Holman (1931) in an unpublished report, described the lithology and micropaleontology of part of the immediate vicinity. In 1932 Soper and Grant described and mapped in detail a portion of the downtown section of Los Angeles including the area under consideration. Edwards (1934) investigated the inferred environments of Pliocene conglomerates including the conglomeratic lenses at the locality. Finally Wissler (1943) refers to the Fourth and Flower Streets area in his analysis of the producing zones of the Los Angeles basin.

STRATIGRAPHY

Inasmuch as the stratigraphy of the area has been described previously by Soper and Grant (1932) it is discussed only briefly herein. The Los Angeles valley area is structurally a deep basin-like depression similar to the present-day deep-water basins on the continental shelf of southern California. The valley floor is somewhat synclinal in structure with subordinate folds. Its substructure to great depths is composed of strata of Pliocene age capped by wash and terrace material of Pleistocene age. The total thickness of sediments is in excess of 10,000 feet or about 2 miles (Reed, 1933, p. 228). The locality discussed herein lies in the northern portion of the Los Angeles basin. In this section of the city of Los Angeles the oldest beds are the Puente shales of upper Miocene age. Conformably overlying a conspicuous white band of diatomaceous shale that marks the uppermost Miocene are the Pliocene series. Overlying unconformably and partly concealing both Miocene and Pliocene formations are Pleistocene gravels and alluvium.

Although in the general vicinity Pliocene strata have been assigned an estimated thickness of 1,000 feet (Soper and Grant, 1932, p. 1048), at Fourth and Flower Streets only several hundred feet are well ex-
Fig. 2. GEOLOGIC MAP OF A PORTION OF THE DOWNTOWN AREA OF LOS ANGELES, CALIFORNIA

(Contouring after USGS topographic map of L.A.; Geology modified from Soper and Grant)
especially by Savornin (lit. 3) and Flandrin (lit. 2). During the geological mapping it was found, however, that a study of the detailed stratigraphy of these layers is severely hampered by the occurrence of lateral facies changes. In the region along and to the west of Oued Ksob two fairly constant levels could be mapped, which fortunately, are situated respectively near the base and close to the top of this complex. In the lower part of the sequence a thick, light-coloured limestone occurs, in which, in addition to other ill-preserved fossils, numerous fragments of *Pinna* sp. were observed. In the upper portion of the 80 meters' complex a thin, fossiliferous, yellowish, marly zone with numerous Cardita beaumonti d'Archiac was encountered, lying at the base of a series of dark gypsiferous clays, which in turn are overlain by the topographically protruding complex of Eocene (Ypresian) limestones with silex.

In two sections on the northern slopes of Rhamsa and of Kef el Ouerad, three samples of each of the sections contained smaller Foraminifera and a few larger ones. Their exact stratigraphic position has been marked on the accompanying drawings (Text Figs. 2 and 3). Sample 699 has been taken from a level, slightly above that of Cardita beaumonti, in the southern Djebel Maadid near Oued Menzah. Sample G 64 is a composite one, derived from beds directly below, in and slightly above this same horizon, in the isolated outcrop of these strata of El Melab, south of Bordj Rh'dir. The exact stratigraphical position of sample R 109 is unknown.

The megafauna of the higher part of the sequence involved, in and some distance below the level, marked by the abundance of *Cardita beaumonti*, is characterized by *Cardita beaumonti* d'Archiac, *Roudairea druiri* Munier-Chalmas and *Exogyra overwegi* von Buch. Moreover, especially near the Rhamsa, numerous, mainly fragmentary oysters, were encountered in several horizons throughout the section, even some meters below the *Pinna*-limestone. These strongly variable oysters may all be considered to belong to a single species, most likely *Alectryonia aucapitainei* (Coquand).

The three first mentioned species of these mollusks in the higher part of the Cretaceous-Tertiary transitional strata are now generally considered to characterize the North African Danian. *Alectryonia aucapitainei* is considered by Savornin to be restricted to the Danian in the vicinity of Oued Ksob. It should be remarked, however, that the age of the layers, dealt with here, is evaluated differently by Savornin and Flandrin. As far as can be concluded from his general description, Savornin places the complex between the *Pinna*-limestone and the *Cardita beaumonti*-level nearly entirely in the Danian; the latter horizon, however, he considers to be Montian. On the other hand, Flandrin places the majority of our section in the Uppermost Maestrichtian, whereas he considers the Danian to range from about 25 meters below to 35 meters above the *Cardita beaumonti*-horizon. The upper limit of Flandrin's Danian is evidently based on the occurrence of some oyster-beds, which contain a. o. *Alectryonia villei* (Coquand), near the top of the dark gypsiferous clays. This *A. villei* is generally considered to be a typical Cretaceous species, occurring abundantly in the Campanian and the Maestrichtian of this part of North Africa. Unfortunately, the oysters, collected during our mapping survey, are too poorly preserved to allow a specific determination, but some fragments from these oyster-beds were observed, which, indeed, strongly resemble the well-known Cretaceous species.

The stratigraphical problems concerning our strata, are not yet satisfactorily solved. It is therefore thought recommendable at present either to name these beds simply "Cretaceous-Tertiary transitional strata" or possibly to use the name Dano-Montian, introduced by Flandrin (lit. 2) and Sigal (lit. 4). The writer is inclined to place the larger part of or even the entire section in the Danian, as in none of his samples a typical Maestrichtian microfauna was encountered. On the other hand, however, no criterions are available to separate the Danian from the Paleocene.
The microfaunal assemblages of the samples have a rather different aspect with respect to associations, known from other localities of the Algerian Cretaceous-Tertiary transitional sediments (lit. 1 and 4). The latter have a more cosmopolitan character and compare better with several described fauna of America, as for instance the Midway of Texas, and also with those from the Caucasus and Sweden. This difference in faunal composition may be explained by assuming that the corresponding sediments along the northern border of the Hodna Basin were deposited under rather extreme, i.e. comparatively shallow, and possibly partly brackish water conditions. The lateral facies changes of the individual layers, the numerous oyster-beds and the gypsum content of many of the samples support this opinion. Further evidence is found in several of the species which were reported as shallow water forms elsewhere or which may be anticipated as such. The occurrence of many of the species with numerous individuals of relatively small, but constant, size in samples with a rather low number of species, together with the comparatively high amount of new species, may also point to the former existence of some special environmental influence during sedimentation.

The established stratigraphical ranges of earlier described species in our samples indicate a dominance of Danian-Paleocene forms. Only three of the determined species have so far been recorded from Upper Senonian strata only: _Loxostomum plaitum_, _Siphogenerinoides parva_ and _Omphaocyclus macropora_. Especially the latter is an important species of the European Uppermost Cretaceous (excluding Danian), for instance of the Maestrichtian at its type-locality Maestricht. REY (in FLANDRIN, lit. 2, p. 155), however, reports this species from the Algerian Danian. Only three species are probably restricted, as far as known, to the Eocene: _Nonion acutidorsatus_, _Gümbelitria triserialis_ and _Globorotalia wilcoxiensis_ var. _acuta_. The majority of the other earlier described 25 species are known from, and in many cases restricted to, Danian, Paleocene or Danian-Paleocene. Comparing the foraminiferal associations from the Hodna region with those of about the same age in the neighbourhood of Constantine (lit. 1 and 4), a somewhat better correlation is indicated with the fauna of the Velasco shale and Tabasco formations of Mexico and with the Lizard Springs marls of Trinidad. Relations exist also with the fauna of the Paleocene of El-Guss-Abu-Said, Egypt, and of the Netherlands. It has been pointed out already that distinct Maestrichtian markers are absent in our material, but the conclusion herefrom is weakened by the scarcity of pelagic species, though those that are present, point to levels, younger than Upper Senonian.

When combining our individual samples to a tentative single stratigraphical sequence, no distinct zoning is observed from the vertical distribution of the species.
cies. This negative result is probably mainly due to a lack of sufficient data. Possibly the middle of the "section" (C 265 and C 267) represents an intercalation of sediments, deposited under extremely aberrant environmental conditions. Although this may have been of local importance only, it may explain the interrupted occurrences of some, otherwise common species, as for instance Virgulina troosteri and Virgulina koenigswaldi.

The author is gratefully indebted to H. Cruys, Q. A. Palm and Th. Raven, who collected part of the samples, and to G. Bétier, Directeur du Service de la Carte géologique de l’Algérie, who allowed a substantial grant for making the drawings. Many thanks are due to H. E. Thalmann for valuable assistance in correcting the English, to P. Marks for his helpful criticism and the drawing of the figures, and to J. H. van Dijk for the making of the photographs.

DESCRIPTION OF THE SPECIES

Family AMMODISCIDAE
Genus Ammodiscoides Cushman, 1909
Ammodiscoides turbinatus Cushman


As far as known this species evidently has a long stratigraphical range: Upper Cretaceous to Recent.

Occurrence—Rare in C 263.

Family LITUOLIDAE
Genus Haplophragmoides Cushman, 1910
Haplophragmoides eggeri Cushman

Plate 15, figure 1


Remarks—Many of the Algerian specimens, considered to belong to this species, have been somewhat distorted, resulting in rather varying external appearances of the test, because of different directions of distortion for the separate specimens. In some individuals the sutures appear strongly limbate (see Pl. 15, fig. 1).

Occurrence—Few in 699 and R 109, rare in C 263. Originally described from the Velasco shale of Mexico. Reported from Uppermost Cretaceous (about Danian) deposits in Mexico and Trinidad and from the Paleocene of the Caucasus.

Family TEXTULARIIDAE
Genus Spiroplectammina Cushman, 1927
Spiroplectammina ravenni Drooger, n. sp.

Plate 15, figures 2a-3b

Description—Test minute, about 1½ times as long as broad, gradually tapering to the broadly rounded initial end, compressed, early portion distinctly coiled, later part biserial with inter-fingerling chambers; periphery sharp, slightly keeled and often indented; chambers distinct, in the biserial portion about twice as broad as high; sutures strongly limbate, occasionally raised in the early portion, in the adult usually slightly depressed and somewhat curved, forming an angle with the median line of about 70 degrees in their inner portion; wall arenaceous, rather roughly finished; aperture a narrow slit at the base of the final chamber. Maximum observed length 0.25 mm.

Remarks—Except for its much smaller size S. ravenni differs from S. richardi Martin (1943, Publ. Stanford Univ., Univ. Ser., Geol. Sci., vol. 3, no. 3, p. 104, pl. 5, f. 3) from the Eocene-Paleocene Lodo formation of California by its strongly limbate sutures, which show a different arrangement near the median line, whereas the early coiled stage is relatively better developed in the Algerian species.

Occurrence—Rare in Q 1.

Genus Textularia Defranc, 1824
Textularia plummerae Lalicker

Plate 15, figures 4a-5

Textularia cocaena PLUMMER (non Gümbel), 1926, Univ. Texas Bull. 2644, p. 67, pl. 3, f. 2.


Remarks—Typical specimens are rare in our material, but many others were found with obviously the same features, but in which the test is strongly compressed, probably due to collapse of the chamber walls (see Pl. 15, fig. 5). In these specimens the sutures appear as somewhat limbate and often slightly elevated ridges.

The Algerian specimens differ from T. plummerae in being of much smaller size (maximum length 0.35 mm.). Megalospheric specimens resemble best those pictured by Lalicker; microspheric ones are closest to the specimen pictured by Plummer.

Occurrence—Few in Q 1.

T. plummerae has been reported from the Upper Midway of Texas and the Paleocene of the Caucasus.

Family VERNEUILINIDAE
Genus Gaudryina Orbigny, 1839
Gaudryina laevigata Franke var. pyramidata Cushman

Plate 15, figure 6

Gaudryina laevigata Franke var. pyramidata CUSH-


Occurrence—Common in Q 3.

Originally described from the Velasco shale of Mexico. Furthermore recorded from the Upper Cretaceous—lower zone of the Lizard Springs formation—and the Eocene of Trinidad and from the Danian of Algeria.

Family TROCHAMMINIDAE

Genus Trochammina Parker and Jones, 1859

Trochammina bradyi (Schwager)

Plate 15, figures 7a-c


Haplophragmoides diagoni (Carsey), 1926, Univ. Texas Bull. 2612, p. 22, pl. 3, f. 1.


Description—Test slightly, often indistinctly, trochoid, strongly compressed. Usually flattened by later distortion; periphery narrowly rounded, usually sharp, lobulate; chambers about six in the final whorl; sutures straight to moderately and often irregularly curved; wall finely arenaceous, generally smoothly finished; aperture indistinct. Maximum diameter 0.4 mm.

Remarks—It is highly probable that in all the above quoted references one and the same species is meant, the individuals of which are usually completely flattened by compression of the embedding sediment (see Pl. 15, fig. 7). As a result of this action the early characteristics of the test have mostly been obliterated, often giving a bilaterally symmetrical appearance to the test.

Occurrence—Common in Q 1, Q 3 and 699, few in Q 12.

The species was originally described from the Paleocene of El-Guss-Abu-Said, Egypt. It also occurs in beds of Taylor and Navarro age in Texas and in the Uppermost Cretaceous (about Danian) of Mexico.

Family LAGENIDAE

Genus Lenticulina Lamarck, 1804

Lenticulina sp. cf. L. velascoensis (White)


Remarks—The few specimens, found in the Algerian material, are rather badly preserved. In most of them the sutures are moderately raised and for which reasons they are tentatively referred to White's species.

Occurrence—Rare in Q 3.

Reported from Upper San Felipe to Velasco of Mexico.

Genus Dentalina d'Orbigny, 1826

Dentalina sp. cf. O. inornata Orbigny


Remarks—Few fragmentary specimens were found, which resemble the one pictured by Schwager from the Paleocene of Egypt.

Occurrence—Rare in C 265.

Genus Nodosaria Lamarck, 1812

Nodosaria bacillum Defracne

Plate 15, figure 8


Remarks—Many fragments of a large costate Nodosaria were found, usually consisting of single chambers only, showing the following characteristics: chambers globular to somewhat longer than broad, variably ornamented with 8-25 heavy, longitudinal costae, which pass in diminishing strength, but uninterrupted, over the broad, deeply depressed sutures. Maximum observed breadth of a single chamber 0.8 mm.

In the literature numerous specific names were given to similar forms of Nodosaria, occurring in sediments from many parts of the world and from widely varying stratigraphic levels. Several of these forms have been referred to N. affinis Orbigny, which in our opinion is identical with Defracne's species. Thus the Algerian fragments are considered to belong to the earlier described N. bacillum.

Occurrence—Rare in Q 3, 699 and R 109.

In addition to the rare occurrences in some of the samples from the southern slopes of the Djebel Maa-did, this species is abundant in several samples from the Cretaceous-Tertiary transitional strata of the neighbourhood of Ain Fakroun and Oued Athismenia (Dept. of Constantine).
Genus Vaginulina Orbigny, 1826

Vaginulina legumen (Linné)
Plate 15, figures 9, 10


Occurrence—Common in Q 3, few in G 64, rare in E 29D (collection Cruys). It is the only species present in E 29D from the Cretaceous-Tertiary transitional marls in the vicinity of Bordj Rh’dir.

Originally described as a recent species from the Adriatic sea, V. legumen has subsequently been widely reported from numerous different stratigraphical levels from Mesozoic to Recent. Many of these references, however, do not seem to belong to this species.

Family NONIONIDAE
Genus Nonion Montfort, 1808
Nonion acutidorsatum Dam
Plate 15, figures 11a, b


Remarks—Part of our specimens closely resemble the one, pictured by ten Dam, whereas others are somewhat more rounded in outline or with a slightly thicker test (see Pl. 15, fig. 11). The average number of chambers in the final whorl is eight, thus slightly less than in the typical form. Some specimens approach the type of the recent Nonion labradoricum (Dawson) (1860, Canad. Naturalist, vol. 5, p. 191, f. 4), whereas others again are slightly oblique and Nonionella-like. Notwithstanding these minor differences it is considered preferable to place the group of Algerian specimens as a whole in N. acutidorsatum.

Occurrence—Common in Q 12 and C 265, few in C 263, 699 and G 64.

Originally described from the Eocene of Alabama and the Caucasus.

Nonionella insecta (Schwager)
Plate 15, figure 12


Occurrence—Few in C 265.

Originally described from the brackish-water Paleocene of the Netherlands.

Genus Nonionella Cushman, 1926
Nonionella insensata (Schwager)
Plate 15, figures 13a-c

Anomalina infecta Schwager, 1883, Palaeontogr., vol. 30, pt. 1, pal. pt., p. 128, pl. 28, f. 2a-d.


Remarks—The Algerian representatives of this species are small (larger diameter about 0.2 mm.) and closest to the young stage of the species, pictured by Cushman and Ponton. They show a faint resemblance with some of the individuals of Nonion acutidorsatum Dam, occurring in the same samples, but it was impossible to find convincing transient specimens between them and immature individuals of Nonion acutidorsatum. For this reason they are treated as belonging to a separate species.

Occurrence—Few in Q 12 and C 265.


Nonionella ovata Brotzen


Remarks—In sample Q 1, slightly above the Cardita beaumonti-level near the river Ksob, a single specimen of Nonionella was found, which is considered to belong to Brotzen’s species. The only differing feature is in the very slight depression of the suture in the Algerian specimen. Because of this characteristic there is some resemblance with the Upper Cretaceous Nonionella austi­nana Cushman (1933, Contrib. Cushman Lab. Foram. Res., vol. 9, p. 57, pl. 7, f. 2), which is, however, considerably more compressed.

Occurrence—Rare in Q 1.

Described from the Paleocene of Sweden.

Family HETEROHELICIDAE
Genus Gümbeлина Egger, 1899
Gümbeлина morsei Kline
Plate 15, figure 14


Remarks—An insignificant number of small and strongly variable Gümbeлина specimens from some of the samples seems to be closest to this species. Since variation among them is rather wide, several of the specimens approach the types of other species, but specific determination of these more or less aberrant forms would be impossible because of the lack of sufficient material. As a matter of fact, in the genus Güm­beлина several of the described species are less different from one another than the specimens of a single fossil assemblage, which are reasonably considered to belong to one and the same species. When the variation of the individuals in a newly established species is insufficiently described as is often the case, later specific determination is severely hampered. Among the material of our samples some larger specimens are close to G. striata (Ehrenberg) and G. ultimatumida White, others again approach the type of G. midwayensis Cushman.
Occurrence—Few in C 263, 699 and G 64.

Originally described from the Paleocene Midway series of Mississippi.

Genus Giembelitria Cushman, 1933
Giembelitria triseriata (Terquem) Plate 15, figures 15, 16


Remarks—Many of the Algerian specimens are somewhat twisted or irregular in the later stages of individual development. The aperture is a semicircular opening at the base of the final chamber. Measured length up to 0.20 mm.

It should be remarked that in our material G. triseriata is found together with numerous representatives of Bulimina trigonalis Dam. In general appearance both species are very similar, the main distinguishing feature being the shape of the aperture. Unfortunately, in many specimens the aperture is rather ill-preserved, thus causing doubtful determinations in such cases. Intergradation of both species could not be observed, but it should be borne in mind that the indistinct apertural characteristics in many individuals hamper a clear decision on this subject. Such an intergradation is thought to be not entirely impossible, as many older species of Bulimina show a considerable amount of variation in the shape of their aperture.

Occurrence—Few in C 263.

Originally described from the Lower Eocene of France. Specimens resembling G. stavenisis Bandy from the Claiborne Eocene of Alabama are equally represented in the Algerian material. They cannot be separated specifically here.

Family BULIMINIDAE

Genus Buliminella Cushman, 1911

Buliminella parvula Brotzen


Remarks—In sample Q 3 one specimen was found, which closely resembles the one pictured by Brotzen as Fig. 3 from the Paleocene of Sweden.

Genus Bulimina d'Orbigny, 1826

Bulimina marksi Drooger, n. sp.
Plate 15, figures 17a-19

Description—Test small, 1 1/2 times to twice as long as broad, bluntly triangular in transverse section, sides about parallel, initial end truncate and somewhat rounded; early chambers indistinct, later ones triserial, slightly inflated and overlapping, very slowly increasing in size as added; sutures somewhat depressed and sinuous; wall smooth, distinctly and rather coarsely perforate; aperture slightly elongate, at the inner margin of the last-formed chamber, extending upwards into the apertural face, lying in a wide depression of the latter. Length up to 0.20 mm.

Remarks—The most characteristic features of B. marksi, which also serve to distinguish it from the other representatives of the genus Bulimina, are the truncate initial end and the triangular, prismatic appearance of the test. Possibly B. rugifera Glaessner (1937, Probl. Paleont., Moscow Univ., vols. 2-3, p. 372, pl. 2, f. 19) from the Upper Senonian and the Paleocene of the Caucasus and the same species, reported from the Upper Velasco of Mexico [B. velascoensis] White (non Cushman), 1929, Journ. of Pal., vol. 3, p. 50, pl. 5, f. 13] are related to the Algerian species, which is different by the more truncate lower part of the test and the lack of surface ornamentation. Another possibly allied species is B. mendezensis White (1929, Journ. of Pal., vol. 3, p. 49, pl. 5, f. 10) from the Upper Cretaceous Mendez shale of Mexico, which differs from B. marksi by the less truncate initial end and the more rounded cross section.

Occurrence—Common in C 263.

Bulimina ovata Orbigny


Occurrence—Rare in Q 3.

Originally described from the Miocene of the Vienna Basin. Probably ranging from Upper Cretaceous to Recent.

Bulimina trigonalis Dam

Plate 15, figures 20-22


Remarks—Especially the smaller Algerian specimens closely resemble the individuals, pictured by ten Dam. In most of the larger ones the later chambers are somewhat more rapidly increasing in size than those of the early stages of individual development. Moreover the final chambers become more strongly twisted than those of the pictured Dutch forms, often tending towards biseriality. Length up to 0.4 mm.

Occurrence—Common to abundant in Q 3 and C 263. Originally described from the littoral-marine Paleocene of the Netherlands.

Genus Virgulina Orbigny, 1826

Virgulina troosteri Drooger, n. sp.
Plate 15, figures 23a-24

Description—Test small, elongate, 2 1/2-4 times as
long as broad, slightly to moderately compressed, sides about parallel to slowly tapering to the initial end; early triserial portion relatively very small, biserial part somewhat twisted, made up of 6-12 slightly inflated chambers; early biserial chambers broader than high, increasing upwards in relative height, resulting in final chambers with greater height than breadth; sutures distinct, slightly curved, making an angle of 50-80 degrees with the longer axis of the test, slightly depressed; wall smooth, finely perforate; aperture a large, wide opening at the inner margin of the final chamber. Length 0.24-0.36 mm., breadth about 0.9 mm.

Remarks—In general appearance *V. troosteri* resembles *V. tegulata* Reuss (1845, Verst. böhm, Kreide, pt. 1, p. 40, pl. 13, f. 81), reported from the Turonian of Central Europe and the same species pictured by Cushman (1937, Cushman Lab. Foram. Res., Spec. Publ. 9, p. 4, pl. 1, f. 9-12) from the Upper Cretaceous of North America, mainly differing in the shape of the aperture.

The species has been named in honor of the late S. G. Trooster, Professor of Geology of the State University of Utrecht.

Occurrence—Common in C 263 and 699, few in Q 1 and Q 12. Holotype and paratypes from C 263.

**Virgulina cruysi** Drooger, n. sp.

Plac 15, figures 25a-26b

Description—Test elongate, 1½-3 times as long as broad, slightly compressed, occasionally from a somewhat oblique direction, more or less tapering, often with about parallel sides in the adult; triserial portion relatively small, biserial part slightly if at all twisted with 6-10 inflated chambers, which are in most larger specimens more or less protruding basally, forming processes, especially near the angles of the test; sutures depressed, at about right angles to the median line of the test; wall smooth, finely perforate; aperture large and wide, often with lateral extensions into the apertural face, at the inner margin of the last-formed chamber. Length up to 0.5 mm.

Remarks—The abundant specimens of *V. cruysi* show a wide variation as to the general appearance of the test, the degree of overhanging of the chambers and the shape of the aperture. Those with a distinctly tapering test throughout may be microspheric individuals, whereas others, which are more abundantly present, with about parallel sides and a very small triserial initial part may represent the megalospheric generation. On account of the peculiar apertural features several specimens were tested with hydrochloric acid, after which action only trifling amounts of fer-

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Drooger, Algerian Cretaceous—Tertiary Foraminifera
Drooger, Algerian Cretaceous—Tertiary Foraminifera
ruginous material remained undissolved, these probably originating from secondary impregnation, as was observed in many more species of these samples. Because of this negative result the species is thought to belong to the genus *Virgulina*.

*V. cruysi* differs from *V. primitiva* Cushman (1936, Cushman Lab. Foram. Res., Spec. Publ. 6, p. 46, pl. 7, f. 1) and *V. subcreataea* Cushman (ibid., p. 46, pl. 7, f. 2) from the Lower Cretaceous of Texas and *V. miniacea* Cushman and Bermudez (1936, Contrib. Cushman Lab. Foram. Res., vol. 12, p. 30, pl. 5, f. 14) from the Upper Eocene of Cuba, by a relatively long, rather regularly biserial portion of the test and by the peculiar processes of the chambers. The latter characteristic together with the shape of the aperture distinguish *V. cruysi* from *V. sandegreni* Broten (1948, Sver. Geol. Unders., Avh., ser. C, no. 493, årsb. 42, no. 2, p. 65, pl. 9, f. 2) from the Lower Paleocene of Sweden.

**Occurrence**—Common in G 64.

*Virgulina cruysi* Drooger

*var. maadidensis* Drooger, n. var.

Plate 15, figures 27a-28

**Description**—Variety differing from the typical by its smaller size, the relatively unimportant biserial stage and the aperture, which in larger specimens is strongly contracted at its base, often being entirely separated from the inner margin of the final chamber. Length up to 0.35 mm.

**Remarks**—The individuals of sample 699 are smaller and usually less developed than those of sample G 64, showing a predominance of the triserial part, which often makes up the entire test. In the largest specimens, which possess a biserial part of 2-4 chambers, the aperture is separated or nearly so from the inner margin of the last-formed chamber. The latter feature allows to distinguish this variety from immature individuals of *V. cruysi*. Among the specimens of the latter in sample G 64 of El Melab no distinct representatives of *V. cruysi* var. *maadidensis* were encountered, whereas on the other hand in sample 699 mainly this variety is present. In another sample from the region of Bordj Rh’dir specimens were found which show a longer biserial portion of the test. Part of them somewhat resemble *Loxostomum cushmani* Wickenden (1932, Trans. Roy. Soc. Canada, ser. 3, vol. 26, sect. 6, p. 91, pl. 1, f. 6) from the American Upper Cretaceous.

**Occurrence**—Few in 699.

**Genus Bolivina** Orbigny, 1839

*Bolivina betieri* Drooger, n. sp.

Plate 15, figures 29a-30

**Description**—Test minute, 1½-2½ times as long as broad, gradually tapering to the rounded initial end, compressed, especially in the early portion of the test; periphery rounded; early chambers narrow, later ones more rapidly increasing in relative height and often also in thickness; sutures oblique, curved and slightly limitate in the early portion, in the upper part of the test crenulate with one or two deep reentrants on each side of the chambers, the crenulate sutures appearing rather abruptly; wall smooth, finely perforate; aperture elongately oval at the inner margin of the final chamber, extending to the top of the test. Length up to 0.25 mm.

**Remarks**—*B. betieri* differs from most other *Bolivina* species with crenulate sutures by the absence of these crenulations on the early chambers. Some variation exists as to the relative length of the test. Extremely short variants (see Pl. 15, fig. 30) show some resemblance with *B. plicatella* Cushman var. *mora* Cushman and Ponton (1932, Florida Geol. Survey, Bull. 9, p. 82, Plate 10).

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pl. 12, f. 4) from the Miocene of Florida and with B. thomsoni Howe (1939, Louis. Dept. Conserv., Geol. Survey, Bull. 14, p. 69, pl. 9, f. 17) from the Claiborne Eocene of Louisiana. B. crenulata Loetterle (non Cushman) (1937, Nebraska Geol. Survey, ser. 2, Bull. 12, p. 38, pl. 6, f. 1) from the Upper Cretaceous Niobrara formation has much higher early chambers than the Algerian species.

The species has been named in honour of G. Bétier, Inspecteur Général des Mines, Directeur du Service de la Carte Géologique de l’Algérie.

Occurrence—Common to abundant in C 263.

Genus Loxostomum Ehrenberg, 1854

Loxostomum plaitum (Carsey)

Bolivina plaita Carsey, 1926, Univ. Texas Bull. 2612, p. 26, pl. 4, f. 2.


Occurrence—A single distinct specimen in C 263. Originally described from the Lower Navarro of Texas. Widely distributed in the Upper Taylor and Navarro of the United States.

Genus Siphogenerinoides Cushman, 1927

Siphogenerinoides parvus Cushman

Plate 15, figure 31


Remarks—As far as could be ascertained the aperture in our specimens is arcuate, usually with a slight neck and a thickened rim. In the larger individuals the bi- (tri-) serial portion of the test is relatively small, even smaller than in the pictured American specimens. A drawing is given of one of the small specimens from our material (Pl. 15, fig. 31).

Occurrence—Few in Q 3.

Originally described from the Upper Cretaceous Colon shale of Venezuela.

Family ROTALIIDAE

Genus Valvulineria Cushman, 1926

Valvulineria koenigswaldi Drooger, n. sp.

Plate 15, figures 34a-35c

Description—Test small, trochoid, compressed, about equally biconvex; periphery rounded, slightly lobulate in the later portion; chambers distinct, somewhat inflated, especially in the adult, rapidly increasing in size as added, about two whorls visible dorsally, 7-9 chambers in the final convolution; sutures ventrally depressed and even curve, radiating from the small umbilical depression, dorsally depressed and curved, the spiral sutures being most strongly depressed; wall smooth and finely perforate; aperture somewhat variable and often indistinct, usually consisting of a narrow slit along the inner margin of the final chamber from the periphery to about half way towards the ventral umbilicus, with a curved narrow opening from about the middle of the basal slit, extending obliquely upwards into the apertural face and pointing to the ventral umbilicus. Larger diameter up to 0.85 mm., thickness up to 0.35 mm.

Remarks—In many specimens only the oblique opening of the aperture is distinct, whereas in others this part could not be traced. Sometimes it is less well-developed and evidently it is replaced then by a shallow closed furrow in the apertural face. Similar apertures occur in some described species of the genus Valvulineria, for which reason our species is placed here although distinct umbilical plates of the chambers are hardly developed, if not entirely lacking. The peculiar apertural characteristics of this species make its generic placement uncertain. In some respects the specimens resemble compressed Gyroidina species, whereas on the other hand the extension of the aperture towards the periphery seems to place this form in the vicinity of the Anomaliniidae. A similar species in general appearance is Gyroidina childsi Martin (1943, Publ. Stanford Univ., Calif., Univ. Ser., Geol. Sci., vol. 3, no. 3, p. 112, pl. 6, f. 6) from the Eocene and Paleocene Lodo formation of California, which is different from V. koenigswaldi in its slightly higher number of less elongate chambers, whereas the aperture is evidently a simple basal slit in this American species.

The species has been named in honour of G. H. R. von Koenigswald, Professor of Palontology of the State University of Utrecht.

Occurrence—Common in 699 and G 64, few in Q 1 and C 263, rare in R 109. Holotype and paratype from G 64.

Valvulineria palmi Drooger, n. sp.

Plate 15, figures 34a-35c

Description—Test small, trochoid, about equally biconvex; periphery broadly rounded and lobulate; chambers inflated, rather rapidly increasing in size as added, each with a slight extension over the small depressed ventral umbilicus, dorsally two whorls visible, about 5 chambers in the final coil; sutures depressed, curved; wall finely granular and coarsely perforate; aperture ventral, at the base of the last-formed chamber as a low arched slit from near the periphery to close to the umbilicus. Diameter up to 0.20 mm., thickness up to 0.13 mm.

Occurrence—Few in Q 12. In C 263 some rare specimens were encountered, which are close to V. palmi, only being relatively somewhat thicker with a wider aperture.

Genus Rotalia Lamarck, 1804
Rotalia sigali Drooger, n. sp.
Plate 15, figures 36a-37c

Description—Test small, trochoid, unequally biconvex to plano-convex, dorsal side most strongly elevated, forming a low, somewhat rounded cone, ventral side occasionally slightly convex, usually about flat; periphery subacute, formed by the thick peripheral wall smooth, perforate; aperture ventral at the base of the last-formed chamber, running from near the periphery to slightly tangential to the umbo, slightly curved, more strongly so near the periphery, where they often show a more or less developed bifurcation; wall smooth, perforate; aperture ventral at the base of the last-formed chamber, running from near the periphery to the umbo, in well-preserved specimens covered by a narrow, plate-like structure. Diameter up to 0.45 mm., thickness up to 0.18 mm.

Remarks—No clear thin sections of this small species could be made.

R. sigali shows morphologically some resemblance with R. orientalis Cushman and Bermudez (1947, Contrib. Cushman Lab. Foram. Res., vol. 23, p. 26, pl. 7, f. 2) from the Upper Eocene of Cuba and R. cushmani Applin and Jordan (1945, Journ. of Pal., vol. 19, p. 143) from the Upper Eocene of Florida. Since little is remarked upon the variation of these species, it is impossible to obtain a clear comparison of the Algerian with the American forms. Some extreme variants of R. sigali approach the types of each of these species, but both from the figures and from the descriptions it is evident that many differences exist with the group of individuals from the Hodna Mountains. For this reason the latter is described as a new species. Bifurcating sutures and peripheral spines are shown in much higher development than in R. sigali in R. lithothamnica Uhlig (1886, Jahrb. Geol. Reichsanst., Wien, vol. 36, p. 195, pl. 5, f. 9-11) from the Lower Tertiary of the Carpathians.

Occurrence—Common in C 265, few in C 267. Holotype and paratype from C 265.
CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION

STRATIGRAPHIC AND ABUNDANCE DISTRIBUTION OF SOME CHARACTERISTIC FORAMINIFERA FROM FOURTH AND FLOWER STREETS, LOS ANGELES, CALIFORNIA

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* Allocated to Epistominella
posed. The stratigraphic thickness of the sampled section is approximately 325 feet (fig. 1). These beds are characterized by the massive nature of the silts and several interbedded conglomeratic lenses. The Repetto and Pico formations are similar lithologically so that age determinations must be made on the basis of microfaunal evidence. The Repetto dips about 60 degrees to the south whereas the Pico is less inclined and dips 40 degrees south. Both formations strike approximately in an east-west direction. In the area studied, the Puente, Repetto, and Pico formations appear to form a southward dipping monocline (fig. 2). Actually this is the southern limb of the Elysian Park anticline located about 2 1/2 to 3 miles to the north (Arnold, 1907, p. 151).

Of significant interest is the angular unconformity of 5 to 10 degrees between the Repetto and Pico (fig. 1). This accounts for a change in dip of from 40 to 35 degrees. Directly below another angular unconformity is readily discernible by a change in dip of the conglomerate layers of 60 to 40 degrees south (fig. 1). This latter unconformity is considered to be within the Repetto formation. In general, at this outcrop the portion of the exposed Repetto is one of deposition of fine clastics interrupted at intervals by the introduction of conglomeratic material, whereas that of the Pico, with the exception of the basal conglomerate, represents a continuous deposition of fine clastics.

On the basis of microfaunal evidence to be presented in a later section, 2 major groups or zones are recognized in this paper. The lower portion of the outcrop below the 5 to 10 degree angular unconformity is assigned to the Repetto and the remaining overlying portion to the Pico (fig. 1; table 2) formations.

LITHOLOGY

As previously stated, the characteristic features of the Pliocene strata exposed in the northern part of the Los Angeles basin are the massiveness of the siltstone component and the presence of numerous thin conglomeratic lenses. Lithologically, the Repetto and Pico siltstones are similar and were it not for the conglomeratic layers any attempts to establish bedding planes would indeed be difficult.

The siltstone of both formations is olive-gray in color when dry, and a dark brownish yellow when wet. It disintegrates quite readily when placed in water and heated, and upon drying has a buff-yellow color. Near the base of the exposed Repetto several individual cobbles were found embedded in the silt (fig. 3). These do not constitute a conglomerate nor do they show any preferred orientation. Microscopic examination of the siltstone prior to preparation for analysis, reveals a random distribution of numerous foraminiferal tests. Similarly the large amounts of mica grains present display a lack of alignment of any kind. The degree of preservation of the tests varies throughout the outcrop, those of the Repetto silt are not well preserved, whereas those of the Pico yield excellent working material.

A wet sieve analysis was conducted to determine the percentages by weight of the clay and silt, very fine sand, and organic constituents of the siltstone. Two 50 gram composite samples were prepared from alternate stations of both formations and washed through a Tyler 250 mesh screen. In both instances, a very large amount of the clay and silt passed through the screen, leaving residues of very fine sand and foraminiferal tests. These residues were put through a carbon tetrachloride separation resulting in concentrates of Foraminifera and very fine sand. The latter concentrate revealed a distinct quartzose-mica element not seen in the unprocessed samples owing to blanketing by silt particles. As shown in Fig. 4, the amount of foraminiferal tests in the Repetto siltstone is somewhat less than that of the Pico. This discrepancy is thought to be partly correlative with the degree and nature of preservation, as many weathered broken tests were found in the very fine sand concentrate of the Repetto. The very fine sand constituents exhibit a 2:1 ratio in favor of the Pico suggesting that the Repetto received a greater amount of clay and silt. The clay and silt components differ conversely to a slight degree, but in both cases constitute an overwhelming percentage of the mass.

Direct measurements and counts were made of the very fine sand with the aid of an ocular micrometer. In both cases the bulk of the very fine sand residues falls within the assigned limits of Wentworth's classification of that category. Median size ranges, however, lie between 80 to 100 microns. An insignificant fraction of the grains were found to range up to 180 microns.

Analysis of the conglomerates discloses a range in thickness of from 8 to 26 inches and a spacing of from 4 to 12 feet (fig. 1). The thicker conglomerates are found in the Repetto with a gradual decrease occurring from the Repetto to the Pico suggesting a lessening in magnitude in the sedimentary interruptions of the overall depositional pattern. Nine conglomerates, from which the attitude of the siltstone is indicated, are exposed. The lowermost conglomerate is some 500 feet above the base of the Repetto (Soper and Grant, 1932, p. 1050). Making up the bulk of the lenses are granules, pebbles, and cobbles, some of which are sub-angular and others which are fairly well rounded. The conglomerates contain a large percentage of slabs, pebbles, cobbles, and blocks of a grey to buff whitish colored limestone. A varied assortment of igneous rocks account for the minor remaining elements. Edwards (1934, p. 797) presents a detailed petrologic analysis and discussion of these conglomerates and their source areas to which the reader is directed. He
favors a possible derivation of the conglomerates from the limestone lenses of the Modelo formation in the Santa Monica Mountains.

Much of the conglomeratic limestone material shows distinct pholadid borings. Several of the limestone cobbles were broken by the author and cross-sections of rotaloid Foraminifera that appear to be representative of the genera Bagghia and Valvuliniera were found. Also found associated with the conglomerates are occasional fragments of pectens, none of which, unfortunately, were specifically identifiable. Significantly enough, the silstone failed to yield any organic remains save that of the foraminifer tests and occasionally of carbonized plant fragments.

**FAUNAL CHARACTERISTICS**

The microfauna described herein consists predominantly of smaller benthonic forms with a small pelagic representation. Both elements are present in large numbers, the pelagic forms making up in abundance what they lack in species. Following Galloway’s classification, 10 families, 31 genera, and 92 species and varieties comprise the fauna. Among the more common and characteristic genera are: *Bolivina*, *Bulimina*, *Cassidulina*, *Globigerina*, *Lagena*, *Nodosaria*, *Epistominella*, and *Uvigerina*.

Full realization of the limitations imposed upon estimates of stratigraphic ranges of species in a section containing unconformities is taken into account, and for that reason no attempt has been made to define zones or subzones. On the basis of characteristic species, percentage abundance counts, and association of species in the section however, two major groups or zones are recognized. Table 2 illustrates the stratigraphic ranges of the 25 most characteristic and abundant species. Forms listed are those considered to be diagnostic of the Repetto and Pico, as well as transitional forms. The latter group consists of species that occur quite commonly throughout the section, and which may have significant stratigraphic value if their vertical distribution and associations are understood. Table 3 tabulates the stratigraphic and relative abundance of the entire fauna. Both tables are based on a percentage abundance count of 7280 specimens, or 260 specimens per station.

In general, the fauna ranges indiscriminately throughout the section. Only two species were found to be restricted in the established zones, namely *Cribicineta concentrica* (Cushman) and *Virgulinia brumletti* Galloway and Morrey, both of which were found in the Pico. A few species nominally associated with the Repetto occurred in the Pico, among these are *Bulimina subcalva* Cushman and K. C. Stewart, *Nonion pom-pilioides* (Fichtel and Moll), and *Plectofrondicularia californica* Cushman and R. E. Stewart. The occurrence is intermittent, involving only 2 or 3 specimens of each species and does not nullify their value as stratigraphic markers.

Of general interest is the specific relationships of the fossil fauna and Recent homeomorphs from other provinces outside the California area. In the course of this study, it was found that 32% of the fauna has been reported from the Atlantic Ocean, 39% from the Gulf of Mexico and Caribbean areas, and 49% from the Pacific Ocean. A large number of these references are from more recent publications and no doubt subsequent work will continually alter the picture. (See synonymies).

The fauna as a whole shows striking resemblance and affinities to that reported by Natland (1933) from Hall Canyon in the Ventura basin and that of Cushman and R. E. and K. C. Stewart (1930) from the Wildcat series in Humboldt County, California.

**ECOLOGY**

Reconstruction of ecological conditions existing during Repetto and Pico times necessitates comparison

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**EXPLANATION OF PLATE 17**

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</tr>
<tr>
<td>5. <em>Glandulina tenuistriata</em> (Bermudez). × 56; a, side view; b, apertural view; hypotype no. 825.</td>
<td>118</td>
</tr>
<tr>
<td>6. <em>Dentalina baggi</em> Galloway and Wissler. × 25; a, side view; b, end view; hypotype no. 816.</td>
<td>118</td>
</tr>
<tr>
<td>7. <em>Nodosaria anomala</em> Reuss. × 25; a, side view; b, end view; hypotype no. 846.</td>
<td>119</td>
</tr>
<tr>
<td>8. <em>Dentalina rohata</em> Reuss. × 56; a, side view; b, apertural view; hypotype no. 817.</td>
<td>119</td>
</tr>
<tr>
<td>9. <em>Nodosaria calomorpha</em> Reuss. × 56; a, side view; b, apertural view; hypotype no. 847.</td>
<td>119</td>
</tr>
<tr>
<td>10. <em>Nodosaria hiripida</em> Orbuligny. × 56; a, side view; b, apertural view; hypotype no. 848.</td>
<td>119</td>
</tr>
<tr>
<td>11. <em>Nodosaria longicata</em> Orbuligny. × 25; a, side view; b, apertural view; hypotype no. 849.</td>
<td>120</td>
</tr>
<tr>
<td>12. <em>Nodosaria parexilis</em> Cushman and K. C. Stewart. × 25; a, side view; b, apertural view; hypotype no. 850.</td>
<td>120</td>
</tr>
<tr>
<td>13. <em>Lagena acuticosta</em> Reuss. × 63; a, side view; b, apertural view; hypotype no. 853.</td>
<td>120</td>
</tr>
<tr>
<td>14. <em>Lagena angulina</em> Cushman. × 63; a, side view; b, apertural view; hypotype no. 834.</td>
<td>120</td>
</tr>
</tbody>
</table>
Martin: Pliocene Foraminifera, Los Angeles, California
between Pliocene and Recent faunas, preferably, of the same province. Natland's (1933, pp. 227-228) contribution to the ecology of Foraminifera provides direct means for determining past conditions. His depth and ecological zones are as follows:

ZONE I.
Shallow, brackish-water lagoon
Depth at low tide, 1 foot; at high tide 4 to 7 feet
Abundant: Retalia beccarii (Linnaeus)

ZONE II.
Bottom temperature range, 21.43 to 13.20 degrees C.
Depth range, 14 to 125 feet (open ocean)
Abundant: Nonion scapha (Pichtel and Moll)
Elphidium articulatum (Orbigny)
Bulimina marginata (Orbigny)
Bulimina elegansissima (Orbigny)
Eponides ernutus (Orbigny)

ZONE III.
Bottom temperature range, 13.20 to 8.50 degrees C.
Depth range, 125 to 900 feet
Abundant: Cassidulina californica Cushman and Hughes
limbata Cushman and Hughes
torquata Cushman and Hughes
Eponides repandus (Pichtel and Moll)
Polyvorphinia charlottensis Cushman
Quinqueloculina angulyma (Lamarcé)
Robertina charlottensis (Cushman)
Sigmorphina frondiculariformis (Galloway and Wissler)
Triloeulina trionulosa (Lamarcé)

ZONE IV.
Bottom temperature range, 8.50 to 4.00 degrees C.
Depth range, 900 to 6500 feet
Abundant: Bolivina spissa Cushman
arenca Cushman
Cassidulina cushmani Stewart and Stewart
Globobulima pacifica Cushman
Epistominella pacifica (Cushman) (Pulvinulinella pacifica of author)
Uvigerina peregrina Cushman

ZONE V.
Bottom temperature range, 4.00 to 2.40 degrees C.
Depth range, 6500 to 8400 feet
Abundant: Bulimina rostrata Brady
Pullenia bulboides (Orbigny)
Nonion pacificus Cushman

It is at once apparent that the fauna reported in this study is wholly representative of zone IV. All of the zone indicators with the exception of Globobulima pacifica Cushman occur abundantly within the section (Tables I, 2). The limited occurrence of the Plectofrondicularia californica assemblage in association with large numbers of Cassidulina cushmani Stewart and Stewart and Uvigerina peregrina Cushman, both diagnostic of zone IV, indicates that differences in distribution of species between the Repetto and Pico formations at the locality are suggestive of shallowing within zone IV itself. This suggestion may be further amplified inasmuch as Repetto sediments are usually associated with the Plectofrondicularia californica assemblage and the depth indicators of zone V (Natland, 1933, p. 256). However such an affinity is not evident in this case and it appears that the marginal facies of the Repetto was deposited at a shallower depth somewhere within the prescribed limits of zone IV. This offers a unique example of time and ecologic indicators overlapping.

The periodic and recurrent fluctuations of the pelagic elements of the faunas as determined by the percentage abundance count has been plotted on Table 2. Whatever significance may be attributed to this oscillatory pattern must be highly conjectural and it may be that some unknown current action is intimately related with their deposition.

Adding to the general complexities of the ecological interpretation is the known occurrence of molluscan faunas from nearby areas in the Third Street tunnel between Hill and Hope Streets, Fourth and Hill Streets, and Fifth and Flower Streets (M; fig. 2). Soper and Grant (1932, p. 1065) assigned a general shallow-water facies to these faunas but state that more than one ecologic association is present. Woodring (1938, p. 16) has presented evidence in support of a fairly deep-

EXPLANATION OF PLATE 18

Figs.

1. Lagena dilatata Parker and Jones. × 56; a, side view; b, apertural view; hypotype no. 835. ............ 120
2. Lagena elongata (Ehrenberg). × 56; a, side view; b, apertural view; hypotype no. 836. .................. 121
3. Lagena hexagona (Williamson). × 63; a, side view; hypotype no. 837. .......................... 121
4. Lagena hispida Reuss. × 63; a, side view; b, apertural view; hypotype no. 838. .......................... 121
5. Lagena scalariformis (Williamson). × 63; a, side view; b, apertural view; hypotype no. 839. .............. 121
6. Lagena striata (Orbigny). × 63; a, side view; b, apertural view; hypotype no. 840. ....................... 121
7. Lagena sp. cf. L. sulcata (Walker and Jacob). × 63; a, side view; b, apertural view; hypotype no. 841. ......... 122
8. Lagena sulcata var. laevicostata Cushman and Gray. × 56; a, side view; b, apertural view; hypotype no. 842. ........ 122
9. Lagena vulgaris Williamson. × 56; a, side view; b, apertural view; hypotype no. 843. .................. 122
10. Lagena williamsoni (Alcock). × 63; a, side view; b, apertural view; hypotype no. 844. ................. 122
11. Robulus sp. cf. R. cultitatus Montfort. × 56; a, edge view; b, side view; hypotype no. 860. .............. 122
12. Fissurina marginata (Walker and Boys). × 56; a, side view; b, apertural view; hypotype no. 820. ....... 123
13. Fissurina orbignyana var. elliptica (Cushman). × 63; a, side view; b, apertural view; hypotype no. 821. .... 123
Fig. 3. STRATIGRAPHIC COLUMN
Fourth and Flower Streets, Los Angeles, California
water environment. He reports a mixed assemblage of shallow, intermediate, and deep-water mollusks from the Third Street tunnel fauna. The shallow-water variety consists of broken and worn specimens which suggest transportation by some as yet unknown or not understood agency. In the same locality deep-water mollusks have been found together with foraminiferal silts (Woodring, 1938, p. 6). Modern counterparts of these Pliocene mollusks have been dredged from depths of 1800 to 2400 feet off the coast of California (Woodring, 1938, p. 15). The faunas from the Fourth and Hill and Fifth and Flower Streets localities are assigned a moderate or intermediate depth facies by Woodring (1938, p. 21).

The overwhelming numbers of specimens representative of *Bolivina, Bulimina, Casidulina, Epistominella,* and *Uvigerina* invites comparison with recent work being done in the Gulf area. Lowman (1949, pp. 1954-1955) presents a generic depth distribution chart of Recent Gulf of Mexico Foraminifera in which he has erected a number of faunal associations. On the basis of generic affinities the Pliocene fauna analyzed herein is similar to faunal association number 10. The depth zone assigned to this faunal association ranges from 300 to over 2000 feet and within the designated limits the more typical generic representatives are *Bolivina* and *Uvigerina* (Lowman, 1949, p. 1956). While generic faunal comparisons appear to have grounds for validity, it is well to inject a note of caution in making regional comparative studies as in this case the depositional pattern of the basins off the southern California coast and that of the Gulf of Mexico differ greatly (Lowman, 1949, p. 1994).

**DEPOSITIONAL ENVIRONMENT**

As in the case of the Foraminifera where comparisons between Pliocene and Recent forms are made, so will the conglomerates be compared with their present-day counterparts. The constant and uniform occurrence of deep-water Foraminifera in an outcrop with angular unconformities and other interruptions in the sedimentary record leads to some rather interesting speculations regarding the origin of this phenomenon. At the onset of this work, it was thought that faunal evidence indicative of possible shallowing conditions about the unconformities encountered would be found. Such evidence is completely lacking and instead it is believed that a gradual shallowing occurred within the entire section. Inasmuch as the locality is held to be in Natland’s zone IV, a relatively deep-water facies, the problem arises as to the mode of deposition of the conglomeratic lenses.

As depicted by Fig. 1, the conglomerates have a uniform thickness and size range of pebbles and cobbles. The only notable contrast in the size range of the conglomeratic material is noted at the 5 to 10 degree unconformity separating the Repetto and Pico formations. Several boulders ranging in size from 1 1/2 to 2 feet are found associated with the more characteristic cobbles. This marked deviation in size points to an irregularity from the overall depositional pattern within the section.

An immediate lithologic change is exhibited at all contact planes of the siltstones and conglomerates. Samples of the siltstone collected directly above and below the lenses are found to contain the same deep-water Foraminifera that occur throughout the outcrop. The only exception is a 10 foot zone above station 12 suspected to be leached out (fig. 1). It would seem then that the conglomerates were deposited in deep-water and in themselves are not diagnostic of any environment but only indicate transportation from another area (Twenhofel, 1947, p. 121). Critical examination of the conglomerates has produced broken unidentifiable fragments of thick-shelled pectens and the cobbles themselves bear evidence of pholadid borings. While not entirely conclusive, these features subscribe to a possible derivation of conglomeratic material from a shallower site as in general thick-shelled invertebrates and particularly borers are restricted to rocky littoral bottoms (Hesse, 1937, p. 199). This suggested redeposition of pebbles and cobbles in deep waters has been observed in other areas where similar deposits are accumulating. As stated by Twenhofel (1936, p. 680) gravels may be deposited on the upper fourth or half of bathyal bottoms. Such occurrences are found close to land as in the case of many East and West Indian islands and off the coast of Japan. Similar rock fragments have been reported by Revelle and Shepard (1939, p. 254) along steep submarine slopes off the coast of southern California. Inasmuch as the problem of gravel and cobble deposition in deep waters is not fully understood at the present time, any possible conjectures or explanations, such as submarine slumping or action of submarine density currents should not be wholly overlooked in affecting a solution.

Intimately associated with the deposition of the conglomerates is the development of unconformities, which, according to the evidence produced thus far, points to a submarine origin. Readily discernible by means of physical criteria, the circumstances peculiar to their origin appear to be quite complex. Essentially, the Pliocene strata at this locality represent a time of fine clastic deposition interrupted at intervals by the introduction of conglomeratic debris redeposited from another site. Accompanying intermittent periods of non-deposition, as indicated by the marginal hiatus found in the Los Angeles basin (Edwards, 1934, p. 808), and folding account for the unconformities and the present attitude of the strata. Accordingly, tilting or folding occurred in (1) late Repetto, (2) between
## Table 3

### Stratigraphic Distribution of Pliocene Foraminifera

**Legend**

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Distribution</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale</td>
<td>Very common</td>
<td>1:1</td>
</tr>
<tr>
<td>Limestone</td>
<td>Abundant</td>
<td>1:100</td>
</tr>
<tr>
<td>Sandstone</td>
<td>Rare</td>
<td>1:1000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DIAGNOSTIC REPETTO FORAMINIFERA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulimina subvalva</td>
</tr>
<tr>
<td>Cibicidella aculeata var. aculeata</td>
</tr>
<tr>
<td>Gyrodina saldana var. altiformis</td>
</tr>
<tr>
<td>Nodosaria angulosa</td>
</tr>
<tr>
<td>Plectrangulina californica</td>
</tr>
<tr>
<td>Siphonodiscus obora</td>
</tr>
<tr>
<td>Siphonodiscus pelagica</td>
</tr>
<tr>
<td>Siphonodiscus frigida</td>
</tr>
<tr>
<td>Usigera inuncta</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>DIAGNOSTIC PICO FORAMINIFERA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulimina argoetra</td>
</tr>
<tr>
<td>Bulimina seminuda var. foraminata</td>
</tr>
<tr>
<td>Bulimina seminuda</td>
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<tr>
<td>Bulimina margaritula var. grandissima</td>
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<tr>
<td>Bulimina margaritula</td>
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<td>Bulimina ovata</td>
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<tr>
<td>Bulimina pogoda</td>
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<td>Bulimina pachyderma</td>
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<td>Bulimina subcomunotata</td>
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<tr>
<td>Bulimina brevis</td>
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<tr>
<td>Bulimina alta var. baukspina</td>
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<tr>
<td>Bulimina alta</td>
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<tr>
<td>Cassidulina californica</td>
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<tr>
<td>Cassidulina callosa</td>
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<tr>
<td>Cassidulina rubrae</td>
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<tr>
<td>Cassidulina minima</td>
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<td>Cassidulina limatae</td>
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<tr>
<td>Cassidulina limatae</td>
</tr>
<tr>
<td>Chilostomella cretacea</td>
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<tr>
<td>Chilostomella grandis</td>
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<tr>
<td>Chilostomella flabellae</td>
</tr>
<tr>
<td>Discina baggi</td>
</tr>
<tr>
<td>Discina palpata</td>
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<tr>
<td>Epistominella subinsera</td>
</tr>
<tr>
<td>Epistominella tresera</td>
</tr>
<tr>
<td>Fissurina magnipila</td>
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<tr>
<td>Fissurina subrugosa var. elliptica</td>
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<tr>
<td>Frondicularia callosa</td>
</tr>
<tr>
<td>Glandulina laevapatula</td>
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<tr>
<td>Glandulina occidentalis</td>
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<tr>
<td>Glandulina frutescens</td>
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<td>Globigerina inflata</td>
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<td>Globigerina quadrivalvata</td>
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<td>Globigerina antiquata</td>
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<td>Globigerina uhni</td>
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<tr>
<td>Globorotalia escharina</td>
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<tr>
<td>Gyrodina saldana var. multiscula</td>
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<tr>
<td>Lagena multiscula</td>
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<tr>
<td>Lagena angulosa</td>
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<tr>
<td>Lagena angulosa</td>
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<tr>
<td>Lagena multiscula</td>
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<td>Lagena elongata</td>
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<tr>
<td>Lagena hexagona</td>
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<td>Lagena hexagona</td>
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<tr>
<td>Lagena scalariformis</td>
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<td>Lagena scalariformis</td>
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<td>Lagena el. L. sulcata</td>
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<tr>
<td>Lagena sulcata var. laevicosta</td>
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<tr>
<td>Lagena vulgata</td>
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<tr>
<td>Lagena vulgata</td>
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<tr>
<td>Lagena williamsoni</td>
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<tr>
<td>Lagena williamsoni</td>
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<tr>
<td>Nodosaria inquilla</td>
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<tr>
<td>Nodosaria inquilla</td>
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<tr>
<td>Nodosaria angulosa</td>
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<tr>
<td>Nodosaria agatina</td>
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<td>Nodosaria catarina</td>
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<tr>
<td>Nodosaria hospedia</td>
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<tr>
<td>Nodosaria hospedia</td>
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<td>Nodosaria lappata</td>
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<td>Nodosaria parviscula</td>
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<td>Nodosaria lappata</td>
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<td>Orbulina universa</td>
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<td>Orbulina universa</td>
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<td>Asterigerina bradyana</td>
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<td>Asterigerina scalariformis</td>
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<td>Asterigerina scalariformis</td>
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</tbody>
</table>

* Allocated to Epistominella
Martin: Pliocene Foraminifera, Los Angeles, California
Repetto and Pico, and in (3) presumably middle Pleistocene times.

SUMMARY

The more significant results of this study are:
1. The presentation as a faunal study of a portion of the Pliocene foraminiferal assemblage of the Los Angeles basin.
2. The describing and figuring of 92 species and varieties.
3. The discovery of 1 new species and 2 new varieties.
4. The determination of relative abundance and stratigraphic distribution of the faunas within the strata studied herein.
5. The determination of 2 major faunal facies assigned to the Repetto and Pico formations respectively. These groups are in accordance with previously established zones.
6. An attempt to present a well integrated overall picture of the ecological and depositional conditions obtaining during a portion of Pliocene time based on comparison with their Recent counterparts.

Foraminifera

<table>
<thead>
<tr>
<th>Weight percentage frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0.3%</td>
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</tbody>
</table>

**Fig 4a.** Wet sieve analysis of Repetto silstone, Fourth and Flower Streets locality.

Foraminifera

<table>
<thead>
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<th>Weight percentage frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0.9%</td>
</tr>
</tbody>
</table>

**Fig 4b.** Wet sieve analysis of Pico silstone, Fourth and Flower Streets locality.

SYSTEMATIC DESCRIPTIONS

All figured specimens are catalogued and deposited in the micropaleontological collection of the University of Southern California.

Phylum PROTOZOA

Class SARCODINA

Order FORAMINIFERA

Family TEXTULARIIDAE Orbigny, 1826

Genus SIPHOTEXTULARIA Finlay, 1939

Siphotextularia flintii (Cushman)

Plate 17, figures 1a-c

1911. Textularia flintii Cushman, U. S. Nat. Mus. Bull. 71. pl. 2, p. 21, figs. 36a, b; Recent, Guam.


1930. Textularia flintii. Cushman, Stewart and Stewart. Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 56, pl. 1, figs. 1a, b; Pliocene, California.


Description.—Test roughly triangular in front view, short and broad, compressed and pointed at the initial end, apertural end broadly arched, widest portion formed by last pairs of chambers, broadly oval in end view, edge acute towards initial end, rounded towards apertural end; chambers numerous, about 10 pairs in adult form, broader than high, slightly inflated, increasing uniformly in size; sutures slightly curved, depressed, making an angle of about 35 degrees with the horizontal; wall finely arenaceous, smooth; aperture an elongate slit located at the base of last-formed chamber, with a distinct lip. Length, 0.80 mm.; width, 0.40 mm.; thickness, 0.20 mm. Rare.

Hypotype.—USC No. 865.

Family NODOSARIIDAE Schultze, 1854

Genus FRONDICULARIA Defrance, 1826

Frondicularia advena Cushman

Plate 17, figures 2a, b


1923. Frondicularia advena Cushman. U. S. Nat. Mus. Bull. 104, pl. 4, p. 141, pl. 29, figs. 1, 2; Recent, Atlantic.

1927. Frondicularia advena. Galloway and Wissler, Journ Pal., vol. 1, no. 1, p. 41, pl. 8, figs. 7, 8; Pleistocene, California.


Description.—Test compressed, subelliptical in side view, initial end usually pointed with a subspherical proloculum, apertural end broadly rounded, thin marginal keel in adult forms; chambers inverted v-shaped, inflated, about 6 to 7 in number; sutures distinct, depressed; walls thin, transparent, smooth; aperture terminal, central, round. Length, 1.10 mm.; width, 0.35 mm.; thickness, 0.15 mm. Rare.

Hypotype.—USC No. 822.
### Genus Glandulina Orbigny, 1839

**Glandulina laevigata** Orbigny

- Plate 17, figures 3a, b


1846. **Glandulina laevigata**. Orbigny. Foraminifères fossiles du Bassin Tertiaire de Vienne, p. 29, pl. 1, figs. 4, 5; Miocene, Vienna Basin.


1926. **Glandulina laevigata**. Cushman, Stewart and Todd, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 56, pl. 3, fig. 4; Pliocene, California.

1945. **Glandulina laevigata**. Cushman and Todd, Special Publ. 15, Cushman Lab. Foram. Res., p. 34, pl. 5, fig. 19; Miocene, Jamaica.

1949. **Glandulina laevigata**. Bandy, Amer. Pal. Bull. 131, p. 49, pl. 6, figs. 13a, b; Eocene, Alabama.

Description.—Test small, elliptical in outline, circular cross section, greatest width around the midlength, initial and apertural end pointed; chambers about 6 to 8 in adult form, greatly embracing preceding chamber; sutures flush with surface, transverse, sometimes at an angle; wall smooth, finely perforate; aperture terminal, central, radiate. Length, 0.35 mm.; diameter, 0.35 mm. Common.

Hypotype.—USC No. 823.

**Glandulina occidentalis** Cushman

- Plate 17, figures 4a, b

1923. **Nodosaria (Glandulina) laevicata** var. occidentalis Cushman, U. S. Nat. Mus., Bull. 194, pt. 4, p. 64, pl. 12, fig. 8; Recent, Western Atlantic.

1949. **Glandulina occidentalis**. Bandy, Amer. Pal. Bull. 131, p. 49, pl. 6, figs. 14a, b; Eocene, Alabama.

Description.—Test subovate, circular in cross section, widest usually above the middle, initial end pointed, apertural end sharply rounded; chambers 5 to 6 in adult form, greatly embracing; sutures transverse, flush with the surface, sometimes at an angle; wall smooth, finely perforate; aperture terminal, central, radiate. Length, 0.60 mm.; diameter, 0.35 mm. Rare.

Hypotype.—USC No. 824.

### Genus Dentalina Orbigny, 1839

**Dentalina baggi** Galloway and Wissler

- Plate 17, figures 6a, b


1946. **Dentalina baggi**. Cushman and Gray, Special Publ. 19, Cushman Lab. Foram. Res., p. 12, pl. 2, figs. 26, 27; Pleistocene, California.

Description.—Test elongate, curved, chambers circular in cross section, initial end with the first-formed chamber often larger than the succeeding ones; chambers uniserial, inflated, increasing in size irregularly, sutures depressed, normal to longitudinal axis of test, may show some obliquity; wall smooth, finely perforate; aperture not observed but has been reported as terminal, radiate, produced, located towards the concave side of the test. Length of figured specimen, 2.0 mm.; diameter, 0.50 mm. Rare.

Hypotype.—USC No. 816.

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**EXPLANATION OF PLATE 19**

<table>
<thead>
<tr>
<th>Fig.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Nonion labradoricus</em> (Dawson). ( \times 63 ); a, side view; b, edge view; hypotype no. 851.</td>
</tr>
<tr>
<td>2.</td>
<td><em>Nonion pompiloides</em> (Fichtel and Moll). ( \times 63 ); a, side view; b, edge view; hypotype no. 852.</td>
</tr>
<tr>
<td>3.</td>
<td><em>Pullenia sp. cf. P. bulloides</em> (Orbigny). ( \times 63 ); a, side view; b, edge view; hypotype no. 858.</td>
</tr>
<tr>
<td>4.</td>
<td><em>Pullenia malkinae</em> Coryell and Mossman. ( \times 56 ); a, side view; b, edge view; hypotype no. 859.</td>
</tr>
<tr>
<td>5.</td>
<td><em>Globorotalia sacharina</em> (Schwager). ( \times 56 ); a, ventral view; b, edge view; c, dorsal view; hypotype no. 830.</td>
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<td>6.</td>
<td><em>Eponides subtener</em> (Galloway and Wissler). ( \times 56 ); a, ventral view; b, edge view; c, dorsal view; hypotype no. 818.</td>
</tr>
<tr>
<td>7.</td>
<td><em>Eponides tener</em> (Brady). ( \times 56 ); a, ventral view; b, edge view; c, dorsal view; hypotype no. 819.</td>
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<td>8.</td>
<td><em>Gyroidina aliformis</em> R. E. and K. C. Stewart. ( \times 56 ); a, ventral view; b, edge view; c, dorsal view; hypotype no. 831.</td>
</tr>
</tbody>
</table>
Martin: Pliocene Foraminifera, Los Angeles, California
Martin: Pliocene Foraminifera, Los Angeles, California
Dentalina soluta Reuss
Plate 17, figures 8a, b


1912. Nodosaria soluta. Batsch. U. S. Geol. Surv. Bull. 513, p. 59, pl. 15, fig. 2; pl. 16, fig. 7; Pleistocene, California.


Description.—Test elongate, slightly curved, chambers circular in cross section, initial with a small basal spine; chambers uniserial, 5 to 6 in the adult form, inflated, increasing in size gradually; sutures straight, deeply constricted; wall smooth, finely perforate; aperture terminal, offset towards concave side of test, produced, radiate. Length, 0.70 mm.; diameter, 0.15 mm. Rare.

Hypotype.—USC No. 817.

Genus Nodosaria Lamarck, 1812
Nodosaria anomala Reuss
Plate 17, figures 7a, b


Description.—Test elongate, straight, sides parallel, initial and apertural ends round; chambers up to 6, uniserial, circular in cross section, more or less equal in size, inflated; sutures depressed, normal to longitudinal axis of the test, distinct; wall smooth, finely perforate; aperture terminal, central, radiate. Length, 1.10 mm.; diameter, 0.35 mm. Rare.

Hypotype.—USC No. 846.

Remarks.—Several broken specimens were observed consisting of from 2 to 5 chambers. The figured specimen is typical of the material and agrees with other figures.

Nodosaria calomorpha Reuss
Plate 17, figures 9a, b


Description.—Test elongate, slender, straight, initial end with a basal spine, chambers uniserial, 2 to 3 in number, circular in cross section; sutures strongly constricted, limbate; wall smooth, finely perforate; aperture terminal, central, radiate, at the end of a short tapering neck. Length, 0.90 mm.; diameter, 0.30 mm. Rare.

Hypotype.—USC No. 847.

Nodosaria hispida Orbigny
Plate 17, figures 10a, b


Description.—Test elongate, slender, straight, gradually tapering to the initial end; chambers uniserial, up to 5 or 6 in the adult form, globular, circular in cross section, very gradually increasing in size; sutures deeply constricted, sometimes extended forming a short neck between chambers; wall ornamented by numerous fine, delicate spines; aperture terminal, central, round, at the end of a short neck. Length, 0.60 mm.; diameter, 0.20 mm. Rare.

Hypotype.—USC No. 848.
Nodosaria longiscata Orbigny
Plate 17, figures 11a, b


1837. Nodosaria longiscata. Hedberg, Journ. Pal., vol. 11, no. 8, p. 671, pl. 91, figs. 3, 4; Oligocene, Venezuela.

1858. Nodosaria longiscata. Kleinpell, Miocene Stratigraphy of California, p. 218, pl. 9, fig. 16, Miocene. California.


Description.—Test elongate, slender, straight, initial and apertural end not preserved; chambers 2 or 3, uniserial, circular in cross section, cylindrical; sutures slightly depressed, normal to longitudinal axis of test; wall smooth, finely perforate; aperture not preserved, reported round or radiate. Length, 1.20 mm.; diameter, 0.15 mm. Present.

Hypotype.—USC No. 849.

Nodosaria parexilis Cushman and K. C. Stewart
Plate 17, figures 12a, b


Description.—Test elongate, slender, straight, sides nearly parallel; chambers 6 or 7 in the adult form, circular in cross section, those of initial end as high as wide, later ones higher than broader, initial chamber globular and larger than second or third chamber, all slightly inflated; sutures depressed, normal to longitudinal axis of test; aperture terminal, central, round, slightly produced. Length, 2.75 mm.; diameter, 0.25 mm. Present.

Hypotype.—USC No. 850.

Genus Lagena Walker and Boys, 1784
Lagena acuticosta Reuss
Plate 17, figures 13a, b


1938. Lagena acuticosta. Kleinpell, Miocene Stratigraphy of California, p. 224, pl. 17, fig. 13; Miocene, California.

1946. Lagena acuticosta Cushman and Gray, Special Publ. 19, Cushman Lab. Foram. Res., p. 19, pl. 3, fig. 16; Pleistocene, California.

Description.—Test unilocular, subglobular to pyriform, broadest towards the basal end, sharply tapering towards the apertural end, circular in cross section; wall ornamented with 10-15 thin, highly elevated longitudinal costae which extend from the base to near the apertural end where they join to form a plate-like area around the aperture, finely perforate; aperture terminal, round. Length, 0.25 mm.; diameter, 0.20 mm. Rare.

Hypotype.—USC No. 833.

Lagena angelina Cushman
Plate 17, figures 14a, b


Description.—Test unilocular, small, pyriform, circular cross section, basal end rounded, apertural end tapering with a long slender neck; wall ornamented with high plate-like costae which combine at the base of the neck, surface between the costae containing longitudinal rows of elliptical pits; aperture small, terminal, round, with a slight lip. Length, 0.30 mm.; diameter, 0.20 mm. Rare.

Hypotype.—USC No. 834.

Lagena distoma Parker and Jones
Plate 18, figures 1a, b


1946. Lagena distoma Cushman and Gray, Special Publ. 19, Cushman Lab. Foram. Res., p. 24, pl. 4, figs. 8, 9; Pleistocene, California.

Description.—Test unilocular, elongate, slender, sides nearly parallel in the central portion, circular in cross section, apertural end tapering into a long slender neck with a lip, basal end tapering to a long narrow spine; wall smooth; thin, ornamented with 8 to 15 fine delicate longitudinal costae; aperture round with a slight lip. Length, 0.80 mm.; diameter, 0.20 mm. Rare.

Hypotype.—USC No. 835.
Lagena elongata (Ehrenberg)
Plate 18, figures 2a, b


Description.—Test elongate, unilocular, slender, both ends tapering, the basal end to a long spine, the aper­ture terminal, round, with a slight lip. Length, 0.95 mm.; diameter, 0.15 mm. Rare.

Hypotype.—USC No. 836.

Lagena hexagona (Williamson)
Plate 18, figure 3

1929. Lagena hexagona var. scalariformis. Cushman.

Description.—Test unilocular, globular, with an elongate slender neck, circular in cross section; wall thin, ornamented with uniformly distributed small fine spines; aperture terminal, round. Length, 0.30 mm.; diameter, 0.15 mm. Rare.

Hypotype.—USC No. 839.

Lagena hispida Reuss
Plate 18, figures 4a, b

1858. Lagena hispida Reuss, Zeltschr. deutsch. geol. Ges., vol. 10, p. 43; Oligocene, Germany.

Description.—Test unilocular, globular to subglobular, circular in cross section, surface ornamented with a net-like design which is arranged in a series of longitudinal rows, the sides of which are often thickened forming costae; aperture round, slightly protruding. Length, 0.25 mm.; diameter, 0.20 mm. Rare.

Hypotype.—USC No. 837.

Lagena striata (Orbigny)
Plate 18, figures 6a, b

1839. Oolina striata Orbigny, Foram. Amer. Mérid., p. 21, pl. 5, fig. 12; Recent, Falkland Islands.

Description.—Test unilocular, globular to subglobular, circular in cross section, basal end broadly round, apertural end with a neck which may vary in length; wall ornamented with numerous fine longitudinal costae extending the entire length of the test; aperture terminal, round. Length, 0.20 mm.; diameter, 0.15 mm. Rare.

Hypotype.—USC No. 840.
Lagena sp. cf. L. sulcata (Walker and Jacob)  
Plate 18, figures 7a, b

1784. "Serpula (Lagena) striata sulcata rotunda" Walker and Boys, Test. Min. p. 2, pl. 1, fig. 6; Recent, England.

1785. Lagena sulcata var. laevicostata Cushman and Gray. Cushman, Stewart and Stewart.  
Plate 18, figures 8a, b


1946. Lagena williamsoni (Alcock)  
Plate 18, figures 10a, b


1923. Lagena williamsoni. Cushman, U. S. Nat. Mus. Bull. 104, pt. 4, p. 58, pl. 11, fig. 2; Recent, Caribbean. (Contains prior synonymy).

1944. Lagena williamsoni. Cushman, Stewart and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 59, pl. 8, fig. 5; Pleistocene, California.


Genus Robulus Montfort, 1808

Robulus sp. cf. R. cultratus Montfort  
Plate 18, figures 11a, b

1930. Robulus cultratus Montfort. Conch. Syst., vol. 1, p. 214; 54 genre; Type level not designated; Italy.


1928. Robulus cultratus. Cushman, Special Publ. no. 1, Cushman Lab. Foram. Res., p. 155, pl. 24, figs. 1, 2; Original figure shown.

1933. Robulus cultratus. Galloway, A Manual of Foraminifera, p. 251, pl. 22, fig. 14; Original figure shown.

Description.—Test planispiral, bilaterally symmetric, close coiled, compressed, lenticular in edge view, thin narrow peripheral keel; chambers 6 to 7 in last-formed coil, triangular in side view, slightly overlapping; sutures distinct, slightly curved, flush with surface, radiating from central boss; wall smooth, finely perforate; aperture radiate, with a median slit extending down on apertural face; apertural face triangular with a narrow rim on either side. Diameter, 0.60 mm.; thickness, 0.25 mm. Rare.

Hypotype.—USC No. 860.

Remarks.—Figure specimens by various authors show considerable variation from Montfort's original figure. Inasmuch as only a few specimens were found at USC locality 106 it seems best to refer them to Montfort's species with which they show the greatest affinities.
Genus Fissurina Reuss, 1850
Fissurina marginata (Walker and Boys)
Plate 18, figures 12a, b

1874. "Serpula (Lagena) marginata" Walker and Boys, Test. Min., p. 2, pl. 1, fig. 7; Recent, England.
1893. Lagena marginata, Klement, Miocene Stratigraphy of California, p. 225, pl. 11, fig. 5: Miocene, California.
1894. Lagena marginata, Bermudez, Special Publ. 25, Cushman Lab. Foram. Res., p. 117, pl. 10, figs. 55-58; Recent, Dominican Republic.

Description.—Test unilocular, more or less pyriform, tapering to the apertural end, basal end broadly rounded, elliptical in cross section, widest about the middle; wall smooth, finely perforate, pronounced lateral keel extending around the entire test coalescing at the base of the apertural face; aperture fissurine, parallel with keel, cylindrical tube leading into chamber. Length, 0.35 mm.; width, 0.40 mm.; thickness, 0.15 mm. Rare. 

Hypotype.—USC No. 820.

Fissurina orbignyana (Seguenza) var. elliptica (Cushman)
Plate 18, figures 13a, b

1923. Lagena orbignyana var. elliptica Cushman, U. S. Nat. Mus. Bull. 104, pt. 4, p. 42, pl. 6, figs. 10-12; Recent, Caribbean.

Description.—Test unilocular, pyriform, elliptical cross section about the middle, length about ½ times as long as wide, in side view tapering towards the apertural end, sharp thin edge with lateral keels; wall thin, finely perforate, translucent, area between keel and adjacent inner margin opaque; aperture elliptical. Length, 0.35 mm.; width, 0.30 mm.; thickness, 0.15 mm. Present.

Hypotype.—USC No. 821.

Family NONIONIDAE Reuss, 1860
Genus Nonion Monfort, 1808
Nonion labradoricus (Dawson)
Plate 19, figures 1a, b

1860. Nonion labradoricus Dawson, Canadian Naturalist, vol. 5, p. 191, fig. 4; Recent, Canada.
1866. Nonion labradorica Jones, Parker, and Brady, Crag Foraminifera. Pal. Soc. Publ., vol. 19, pl. 12, figs. 44, 45; Late Tertiary, Labrador.
1930. Nonion labradoricus Cushman, U. S. Nat. Mus. Bull. 104, pl. 7, p. 11, pl. 4, figs. 6-12; Recent, Western Atlantic.

Description.—Test small, planispiral, completely involute, bilaterally symmetrical, edge bluntly rounded, broad triangular apertural face, sides convex; chambers few, increasing in size rapidly and uniformly, last-formed chamber overlapping either side of earlier chambers; sutures distinct, slightly depressed, curved; wall thin, finely perforate, aperture a narrow slit at the base of the apertural face. Diameter, 0.50 mm.; thickness, 0.35 mm. Rare. 

Hypotype.—USC No. 851.

Nonion pompilioides (Fichtel and Moll)
Plate 19, figures 2a, b

1788. Nautilus pompilius Fichtel and Moll, Test. Micr., p. 31, pl. 2, figs. a-c; Recent, Mediterranean.

Description.—Test planispiral, bilaterally symmetrical, subcircular in side view, nearly as long as broad, closely coiled, ovate in apertural view, umbilici moderately large and deep; chambers 6 to 8 in the last-formed whorl, increasing in size gradually and uniformly, closely apressed; sutures narrow, flush with surface, marked by clear test material; wall smooth, coarsely perforate; aperture an arched elongate slit at the base of the last septal face, apertural face convex, wider than high. Diameter, 0.35 mm.; thickness, 0.25 mm. Present.

Hypotype.—USC No. 852.

Genus Pullenia Parker and Jones, 1862
Pullenia sp. cf. P. bulloides (Orbigny)
Plate 19, figures 3a, b

1938. **Pullenia bulloides**. Kleinpell. Miocene Stratigraphy of California, p. 338, pl. 5, figs. 16-18; Miocene, California.


**Description.**—Test small, planispiral, close coiled, subglobular, periphery slightly if at all lobulate, very broadly rounded; chambers involute, 4 in the last-formed whorl, increasing very slightly in size as added; sutures radial, straight; wall smooth, finely perforate; aperture a low crescentic opening at base of last chamber, with a slight lip, apertural face low. Diameter, 0.25 mm.; width, 0.20 mm. Rare.

**Hypotype.**—USC No. 858.

**Remarks.**—This small characteristic foraminifer is referred to d’Orbigny’s species. His original figure shows very strongly curved and depressed sutures. As witnessed by our figure the California Pliocene variety has straight sutures that are slightly depressed. The publications cited in the synonymy illustrate the variability of this species.

**Eponides** Montfort, 1808

**Eponides subtener** (Galloway and Wissler)

Plate 19, figures 6a-c

1927. **Rotalia subtener** Galloway and Wissler. Journ. Geol. Pal., vol. 1, no. 1, p. 60, pl. 10, fig. 4; Pleistocene, California.

**Description.**—Test trochoid, unequally biconvex, dorsal side nearly flat, ventral side convex, edge acute, periphery slightly lobulate, small umbilicus on ventral side, about 2 to 2½ seen on dorsal side, only last-formed whorl seen on ventral side; chambers 8 in last-formed whorl, increasing gradually and uniformly in size; sutures slightly limbate on the dorsal side, straight, not radial, on ventral side slightly depressed, radial, straight; wall smooth, finely perforate; aperture a curved slit at the middle of the septal face of the last chamber, with a slight lip. Diameter, 0.40 mm.; thickness, 0.20 mm. Rare.

**Hypotype.**—USC No. 818.

**Remarks.**—This species does not appear to have been previously reported from the Pliocene of California. It differs from **Eponides tener** (Brady) in its greater number of chambers in the last whorl and in its smaller size.

**Eponides tener** (Brady)

Plate 19, figures 7a-c


1926. **Truncatulinia tenera**. Plummer. Univ. Texas. Bull. 2466, p. 140, pl. 9, figs. 5a-c; Eocene, Texas.

FOR FORAMINIFERAL RESEARCH

1930. *Eponides tenera.* Cushman, Stewart and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 72, pl. 6, figs. 3a-c; Pliocene, California.

**Description.**—Test trochoid, unequally biconvex, ventral side much convex, dorsal side less so, edge acute, periphery lobulate, about 2 whorls seen dorsally, only last-formed whorl seen on ventral side; chambers 5 to 6 in the last whorl, increasing in size gradually; sutures distinct, dorsally straight, radially, ventrally slightly depressed and offset with regard to the umbilicus; wall smooth, finely perforate; aperture elongate, narrow slit on septal face of last-formed chamber, between periphery and umbilicus. Diameter, 0.50 mm.; thickness, 0.45 mm. Present.

**Hypotype.**—USC No. 832.

**Remarks.**—This additional numbers of chambers distinguishes this variety from Obigny's species which only has 9 chambers in the last-formed whorl.

**Genus Cibicidina** Bandy, 1949

*Cibicidina concentrica* (Cushman)

Plate 20, figures 4a-c

1918. *Truncatulina concentrica* Cushman, U. S. Geol. Surv. Bull. 676, p. 64, pl. 21, fig. 2; Upper Miocene, Florida.

1926. *Cibicides concentricus.* Cushman, Florida Geol. Surv. Bull. 4, p. 61, pl. 12, figs. 4a-c; Miocene, Florida.

1921. *Cibicides concentricus.* Cushman, U. S. Nat. Mus. Bull. 104, pt. 8, p. 126, pl. 21, figs. 1, 2; Recent, Florida.

1948. *Cibicides concentricus.* Dorsey, Maryland Geol. Surv. Bull. 2, p. 315, pl. 34, figs. 1a-c, 2a-c; Miocene, Maryland.


**Description.**—Test rotaloid, unequally biconvex, dorsal side slightly convex, ventral side very much so, edge acute, periphery slightly lobulate, umbilicate on ventral side, dorsal spine almost concealed by the involute last whorl, only last whorl visible on ventral side; chambers 7 to 9 in last-formed whorl, closely appressed, increasing in size uniformly and gradually; dorsal sutures radial, flush with surface, ventral sutures slightly curved, flush with surface; wall smooth, finely perforate; aperture a narrow slit at base of the last-formed septal face, midway between the periphery and umbilicus. Diameter, 0.60 mm.; thickness, 0.45 mm. Present.

**Hypotype.**—USC No. 815.

**Remarks.**—This planoconvex species is placed in the genus *Cibicidina* Bandy, 1949, because of the involute and concealed character of the dorsal side and also because of its finer perforations.

1927. *Cibicides fletcheri* Galloway and Wissler, Journ. Pal., vol. 1, no. 1, p. 64, pl. 10, figs. 8, 9; Pleistocene, California.

**Description.**—Test planoconvex, ventral side convex with umbo of clear shell material, dorsal side slightly concave, edge subacute, periphery lobulate, slightly oval in side view; chambers 10 to 12 in the last-formed whorl, increasing in size uniformly; sutures limbate on...
dorsal side, curved on both sides; wall smooth, coarsely perforate; aperture an arched-like opening not extending very far on the ventral side but dorsally extending along the suture line for 3 or 4 chambers, with a lip. Diameter, 0.50 mm.; thickness, 0.10 mm. Rare.

_Hypotype._—USC No. 813.

_Remarks._—The figured specimen shows greater affinities with Galloway and Wissler's paratype than with their holotype. Their holotype has a strongly concave dorsal side, whereas the paratype exhibits a slight dorsal concavity. The few specimens found at the Fourth and Flower Streets locality tend to display the latter characteristic.

**Cibicides mckannai** Galloway and Wissler

_var. suppressus_ Martin, _n._ _var._

Plate 20, figures 3a-c

_Description._—Test slightly unequally biconvex, the dorsal side less so, compressed, umbonate, edge acute but not keeled. Periphery slightly lobulate particularly the last 4 or 5 chambers; chambers numerous, 9 to 10 in the last-formed whorl; sutures on dorsal side slightly curved, oblique, central portion umbonate obscuring early sutures, ventral sutures slightly depressed, curved at outer margin, straight at inner central portion continuing on to central ventral umbo; wall smooth, coarsely perforate; aperture peripheral with a distinctive lip, extending a short distance ventrally, dorsally extending along the spiral suture for 1 or 2 chambers. Diameter, 0.50 mm.; thickness, 0.15 mm. Common.

_Holotype._—USC No. 814, Station No. 4.

_Remarks._—The distinguishing features of this variety which separate it from _Cibicides mckannai_ Galloway and Wissler are the compressed test and the oblique nearly straight dorsal sutures. _C. mckannai_ is much thicker and has strongly curved dorsal sutures.

Genus _Planulina_ Orbigny, 1826

_Planulina_ sp. cf. _P. ornata_ (Orbigny)

Plate 20, figures 5a-c

1839. _Truncatulin a ornata_ Orbigny. Voy. Amér. Mérid., vol. 5, pt. 5. Foraminifères, p. 40, pl. 6, figs. 7, 9; Recent, Chile.


1930. _Planulina ornata._ Cushman, Stewart and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 78, pl. 7, figs. 7a-c; Pliocene, California.

1942. _Planulina ornata._ Coryell and Mossman, Journ. Pal., vol. 16, no. 2, p. 237, pl. 36, fig. 2, 3; Pliocene, Panama.

1946. _Planulina ornata._ Cushman and Gray, Special Publ. 19, Cushman Lab. Foram. Res., p. 44, pl. 8, figs. 9-12; Pleistocene, California.

_Description._—Test nearly biconvex, compressed, slenderly lenticular in end view, edge subacute, with thickened keel, periphery lobulate; chambers about 9 in last-formed whorl, elongate, curved; distinct; sutures limbate, curved, raised in the early portion, depressed in later portion of test, joining with the peripheral keel; wall coarsely perforate, reticulated; aperture peripheral, extending on dorsal side, with a flat lip. Diameter, 1.0 mm.; thickness, 0.20 mm. Rare.

_Hypotype._—USC No. 854.

_Remarks._—Comparison with d'Orbigny's original figure revealed that the specimens obtained from Fourth and Flower Streets tend to be nearly biconvex, a characteristic not shared by d'Orbigny's holotype.

Family CHILOSTOMELLIDAE Brady, 1884

Genus _Chilostomella_ Reuss, 1850

_Chilostomella czizeki_ Reuss

Plate 20, figures 7a-c


1928. _Chilostomella czizeki._ Cushman, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 4, p. 74, pl. 11, fig. 2; Miocene, Austria.

1941. _Chilostomella czizeki._ Galloway and Heminway, Journ. Pal., vol. 16, no. 2, p. 237, pl. 36, figs. 24, 25; Pliocene, Panama.


**Figs.**

1. _Chilostomella grandis_ Cushman. × 47; a, side view; b, dorsal view; c, end view; hypotype no. 812. 127

2. _Globigerina inflata_ Orbigny. × 56; a ventral view; b, edge view; c, dorsal view; hypotype no. 826. 127

3. _Globigerina quadrilat erata_ Galloway and Wissler. × 63; a, ventral view; b, edge view; c, dorsal view; hypotype no. 827. 128

4. _Orbulina universa_ Orbigny. × 56; hypotype no. 853. 128

5, 6. _Bolivia argentea_ Cushman. × 56; a, side view; b, apertural view; hypotype no. 786. 5, Megalospheric, 6, Microspheric. 128

7. _Bolivia beyrichi_ Reuss. × 56; a, side view; b, apertural view; hypotype no. 787. 128

8. _Bolivia seminuda_ Cushman. × 56; a, side view; b, apertural view; hypotype no. 788. 129

9. _Bolivia seminuda_ Cushman var. _foraminata_ R. E. and K. C. Stewart. × 56; a, side view; b, apertural view; hypotype no. 789. 129

10, 11. _Bolivia semiperforata_ Martin, _n._ _sp._ × 56; a, side view; b, apertural view; holotype no. 790. 129

10, Holotype, Megalospheric. 11, Paratype, Microspheric.
Martin: Pliocene Foraminifera, Los Angeles, California
Martin: Pliocene Foraminifera, Los Angeles, California
Description.—Test small, elliptical in side view, circular cross section, widest about the middle, ends broadly rounded, about 1 ½ times as long as wide; chambers distinct, slightly inflated, the last-formed chamber covering up almost ⅔ of the ventral portion of the preceding chamber, proloculus and early chambers sometimes seen on back of the test; suture line distinct, extremely concave on the back of the test; wall smooth, finely perforate; aperture a narrow crescentic opening, with a lip on the inner margin. Length, 0.60 mm.; diameter, 0.30 mm. Common.

Hypotype.—USC No. 811.

Chilostomella grandis Cushman
Plate 21, figures 1a-c
1921. Chilostomella grandis, Cushman, U. S. Nat. Mus. Bull. 100, vol. 4, p. 283, pl. 57, fig. 5; Recent, California.
1926. Chilostomella grandis, Cushman, Contr. Cushman Lab. Foram. Res., vol. 1, pl. 4, p. 78, pl. 11, figs. 12; Recent, Australia.

Description.—Test large, broadly elliptical in side view, circular in end view, length about 1½ times as long as wide, widest about the middle; chambers distinct, slightly inflated, the last-formed one making up about ⅔ of the ventral portion of the test; sutures distinct, slightly if at all depressed, the suture line being deeply concave on the back of the test, sometimes earlier chambers partially seen; wall smooth, thick, finely perforate; aperture narrow, crescentic, extending about ⅔ of the circumference of the test, with a slight marginal lip. Length, 1.25 mm.; diameter, 0.60 mm. Common.

Hypotype.—USC No. 812.

Genus Sphaeroidina Orbigny, 1826

Sphaeroidina chilostomata Galloway and Morrey
Plate 20, figures 6a, b
1930. Sphaeroidina bulloides, Cushman and Stewart and Stewart, (not Orbigny). Trans. San Diego Soc. Nat. Hist., vol. 6, no. 5, p. 75, pl. 7, figs. 2; Pliocene, California.
1945. Sphaeroidina bulloides, Cushman and Todd, Special Publ. no. 15, Cushman Lab. Foram. Res., p. 65, pl. 11, fig. 9; Miocene, Jamaica.
1948. Sphaeroidina bulloides, Cushman and Stewart and Stewart, Bull. 36, Ore. Dept. Geol. and Min. Ind., pl. 1, p. 22, pl. 4, figs. 1, 2; Miocene, Oregon.

Description.—Test subcircular in outline, cubic in shape; chambers inflated, rapidly increasing in size as added, 4 in the last-formed whorl, the last-chamber making up about 4/5 of the test; sutures straight, depressed; wall smooth, polished, finely perforate; aperture a curved slit surrounded by an arched lip, located at the base of the last septal face just above the suture. Diameter, 0.30 mm. Rare.

Hypotype.—USC No. 861.

Family ORBULINIDAE Schultze, 1854

Genus Globigerina Orbigny, 1826

Globigerina inflata Orbigny
Plate 21, figures 2a-c

EXPLANATION OF PLATE 22

Figs.

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<td>Bolivina sinuata Galloway and Wissler.</td>
<td>× 56; a, side view; b, apertural view; hypotype no. 791.</td>
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<td>2.</td>
<td>Bolivina spicata Cushman.</td>
<td>× 56; a, side view; b, apertural view; hypotype no. 792.</td>
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<td>3.</td>
<td>Microspheic.</td>
<td>2, Megalospheric.</td>
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<td>4.</td>
<td>Bolivina sulcata Cushman var. sulphurensis Cushman and Adams.</td>
<td>× 56; a, side view; b, apertural view; hypotype no. 793.</td>
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<td>5.</td>
<td>Plectofrondicularia californica Cushman and R. E. Stewart.</td>
<td>× 25; a, side view; b, end and apertural views; hypotype no. 855.</td>
</tr>
<tr>
<td>6.</td>
<td>Loxostomum instabile Cushman and McCulloch.</td>
<td>× 56; a, side view; b, apertural view; hypotype no. 845.</td>
</tr>
<tr>
<td>7.</td>
<td>Bulimina marginospinata Cushman and Parker.</td>
<td>× 56; a, side view; b, apertural view; hypotype no. 795.</td>
</tr>
<tr>
<td>8.</td>
<td>Bulimina ovula Orbigny.</td>
<td>× 56; a, side view; b, apertural view; hypotype no. 796.</td>
</tr>
<tr>
<td>9.</td>
<td>Bulimina pagoda Cushman.</td>
<td>× 56; a, side view; b, apertural view; hypotype no. 797.</td>
</tr>
<tr>
<td>10.</td>
<td>Bulimina subacuminata Cushman and R. E. Stewart.</td>
<td>× 56; a, side view; b, apertural view; hypotype no. 799.</td>
</tr>
<tr>
<td>11.</td>
<td>Bulimina subcavata Cushman and K. C. Stewart.</td>
<td>× 56; a, side view; b, apertural view; hypotype no. 800.</td>
</tr>
</tbody>
</table>
1927. **Globigerina inflata**. Galloway and Wissler, Journ. Pal., vol. 1, no. 1, p. 43, pl. 8, fig. 1; Pleistocene. California.


**Description.**—Test rotaloid, consisting of 2 or 3 whorls, dorsal side nearly flat, ventral side rather deep due to rapid increase in volume and height of chambers, periphery lobulate; chambers distinct, inflated, about 12-14 seen on dorsal side, last whorl consisting of 4; sutures depressed, slightly curved; wall finely perforate, surface smooth; aperture a high arch on the ventral side extending from the periphery to the umbilicus with a thin lip. Diameter, 0.50 mm.; thickness, 0.30 mm. Abundant.

**Hypotype.**—USC No. 826.

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**Globigerina quadrilatera** Galloway and Wissler

Plate 21, figures 3a-c


1944. **Globigerina quadrilatera**. Cushman and Gray, Special Publ. 19, Cushman Lab. Foram. Res., p. 44, pl. 8, fig. 5; Pleistocene, California.

**Description.**—Test rotaloid, length about as long as broad, consisting of 2½ whorls arranged in a low spire, 4 chambers making up the last whorl, periphery lobulate; chambers distinct, inflated, about 12-14 seen on dorsal side, last whorl consisting of 4; sutures depressed, slightly curved; wall finely perforate, surface smooth; aperture a high arch on the ventral side extending from the periphery to the umbilicus with a thin lip. Diameter, 0.30 mm.; width, 0.25 mm. Common.

**Hypotype.**—USC No. 827.

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**Orbulina universa** Orbigny, 1839

**Orbulina universa** Orbigny

Plate 21, figure 4


1923. **Orbulina universa**. Cushman, U. S. Nat. Mus. Bull. 104, pt. 5, p. 28, pl. 5, figs. 2-9; Recent, Atlantic. (Contains prior synonymy).

1927. **Orbulina universa**. Galloway and Wissler, Journ. Pal., vol. 1, no. 1, p. 45, pl. 8, fig. 3; Pliocene, Panama.

1942. **Orbulina universa**. Coryell and Mossman, Journ. Pal., vol. 16, no. 2, p. 239, pl. 36, fig. 32; Pliocene, Panama.

1946. **Orbulina universa**. Cushman and Gray, Special Publ. 19, Cushman Lab. Foram. Res., p. 44, pl. 8, fig. 7; Pleistocene, California.

**Description.**—Test globular, consisting of only one exterior chamber, earlier chambers sometimes seen on surface; wall finely reticulate, smooth; aperture simple, round, not always present.

**Hypotype.**—USC No. 853.

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**Family HETEROHELICIDAE** Cushman, 1927

**Bolivina argentea** Cushman Plate 21, figures 5a, b; 6a, b


1927. **Bolivina argentea**. Cushman, Bull. Scripps Inst. Oceanography, Tech. Ser., vol. 1, p. 155, pl. 3, fig. 5; Recent, Eastern Pacific.

1930. **Bolivina argentea**. Cushman and Moyer, Contr. Cushman Lab. Foram. Res., vol. 6, pt. 2, p. 57, pl. 8, fig. 3; Recent, California Coast.

1937. **Bolivina argentea**. Cushman, Special Publ. 9, Cushman Lab. Foram. Res., p. 146, pl. 19, figs. 7-11; Pliocene, California.

1942. **Bolivina argentea**. Cushman and McCulloch. Allan Hancock Pacific Exped., vol. 6, no. 4, p. 188, pl. 22, figs. 2-6; Recent, West Coast, Gulf of California to Oregon.

**Description.**—Test elongate, very much compressed, length 3 to 4 times longer than broad, edge acute, usually not keeled, initial end sharply pointed in microspheric specimens, rounded in megalospheric specimens, tapering with the greatest width formed by the last pair of chambers; chambers biserial, numerous, 12 to 14 pairs, increasing in size uniformly, narrow in young stage, less so towards the apertural end; sutures curved, oblique, early ones limbate, later ones slightly depressed; wall smooth, except at the initial end where longitudinal costae may be found, very finely perforate; aperture elongate, narrow, on face of last-formed chamber. Length, 0.85 mm.; width, 0.35 mm.; thickness, 0.10 mm. Abundant.

**Hypotype.**—USC No. 786.

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**Bolivina beyrichi** Reuss Plate 21, figures 7a, b

1851. **Bolivina beyrichi** Reuss, Zeitschr. deutsch. geol. Ges., vol. 3, p. 83, pl. 6, fig. 51; Eocene, Germany.


1912. **Bolivina beyrichi**. Bagg, U. S. Geol. Surv., Bull. 513, p. 40, pl. 16, fig. 10; Pliocene, California.


1922. **Bolivina beyrichi**. Cushman, U. S. Nat. Mus., Bull. 104, pt. 3, p. 30, pl. 9, fig. 6; Recent, Atlantic. (Contains prior synonymy).

1937. **Bolivina beyrichi**. Cushman, Special Publ. 9, Cushman Lab. Foram. Res., p. 74-75, pl. 9, figs. 3-6; Middle Oligocene, Germany.

**Description.**—Test elongate, length 3 to 4 times...
longer than broad, much compressed, edge subacute, lower margin of the chambers forming a backward projecting point, initial end acute, apertural end rounded; chambers biserial, numerous, 8 to 10 pairs, increasing rapidly in height towards the aperture, being higher than broad; sutures distinct, early ones limbate, later ones very slightly depressed, obliquely curved; wall longer than broad, slightly compressed, initial end very slightly inflated, increasing in size uniformly, very slightly lobulate; chambers biserial, numerous, with a slight lip. Length, 0.80 mm.; breadth, 0.20 mm.; thickness, 0.10 mm. Rare.

_Hypotype.—USC No. 787._

**Bolivina seminuda** Cushman

- Plate 21, figures 8a, b

_Plate 21, figures 9a, b_

1911. **Bolivina seminuda** Cushman, U. S. Nat. Mus., Bull. 71, pt. 2, p. 34, fig. 55; Recent, Bering Sea.


_Description._—Test elongate, length 3 to 4 times longer than broad, slightly compressed, initial end rounded, apertural end broadly rounded, periphery very slightly lobulate; chambers biserial, numerous, very slightly inflated, increasing in size uniformly, early ones broader than higher, later ones higher than broad; sutures slightly dispersed and curved, increasing the angle with the horizontal towards the apertural end; wall smooth, finely perforate and clear in the upper portion of the chambers, coarsely perforate in the lower half, lower portion of chambers whitish contrasting with the upper portion; aperture elongate, narrow slit. Length, 0.70 mm.; thickness, 0.20 mm.

_Hypotype.—USC No. 788._

**Bolivina seminuda** var. foraminata R. E. and K. C. Stewart

_Plate 21, figures 10a, b_

1930. **Bolivina seminuda** var. foraminata R. E. and K. C. Stewart, Journ. Pal., vol. 4, no. 1, p. 66, pl. 8, figs. 5a, b; Pliocene, California.

1937. **Bolivina seminuda** var. foraminata. Cushman, Special Publ. 9, Cushman Lab. Foram. Res., p. 119, pl. 14, fig. 11; Pliocene, California.

1942. **Bolivina foraminata.** Corayell and Moesman, Journ. Pal., vol. 16, no. 2, p. 239, pl. 36, fig. 34; Pliocene, Panama.

_Description._—Test elongate, length 3 to 4 times longer than broad, slightly compressed, initial end bluntly rounded, apertural end broadly rounded, slight tapering towards the initial end, oval in cross section, 4 high rounded, thick costae which are discontinuous at the sutures, develop into sinuate lobes on later parts of the test; chambers numerous, biserial, 12 to 15 pairs in the adult forms; sutures lobate, distinct towards the apertural end, less so towards the initial end; wall finely perforate; aperture narrow, elliptical, at base of the last-formed chamber. Length, 0.95 mm.; width, 0.30 mm. Abundant.

_Hypotype.—USC No. 791._

**Bolivina sinuata** Galloway and Wissler

_Plate 22, figures 11a, b_

1927. **Bolivina sinuata** Galloway and Wissler, Journ. Pal., vol. 1, no. 1, p. 71, pl. 11, figs. 9a, b; Pleistocene, California.

1937. **Bolivina sinuata.** Cushman, Special Publ. 9, Cushman Lab. Foram. Res., p. 120, pl. 14, figs. 19, 20; Pliocene, California.

_Description._—Test elongate, slender, compressed in cross section; initial end acute in microspheric forms, sharply rounded in megalospheric forms; latter forms often with a small basal spine; sides gradually tapering towards initial end, edge rounded; chambers numerous, biserial, 8 to 9 pairs in megalospheric forms, 12 to 15 pairs in microspheric forms, increasing in size gradually and uniformly; sutures oblique, making angle of about 50 degrees with the horizontal, slightly curved and limbate; wall smooth, translucent, distinctly perforate only in the lower portion of chambers with the exception of the last 2 pairs which are entirely perforate; aperture a narrow elliptical slit, with a slight lip. Length, 0.80 mm.; width, 0.20 mm.; thickness, 0.10 mm. Common.

_Holotype.—USC No. 790; Station No. 17._

_**Remarks.**—This characteristic foraminifer is distinguished from *Bolivina doniesi* Cushman and Wicken­den by its more slender test, greater number of chambers, the degree of tapering, which is greater in Cushman’s species, and in the greater obliquity of the sutures._

**Bolivina semiperforata** Martin, n. sp.

_Plate 21, figures 10a, b; 11a, b_

_Description._—Test elongate, slender, compressed in cross section; initial end acute in microspheric forms, sharply rounded in megalospheric forms; latter forms often with a small basal spine; sides gradually tapering towards initial end, edge rounded; chambers numerous, biserial, 8 to 9 pairs in megalospheric forms, 12 to 15 pairs in microspheric forms, increasing in size gradually and uniformly; sutures oblique, making angle of about 50 degrees with the horizontal, slightly curved and limbate; wall smooth, translucent, distinctly perforate only in the lower portion of chambers with the exception of the last 2 pairs which are entirely perforate; aperture a narrow elliptical slit, with a slight lip. Length, 0.80 mm.; width, 0.20 mm.; thickness, 0.10 mm. Common.

_Holotype.—USC No. 790; Station No. 17._

_**Remarks.**—This characteristic foraminifer is distinguished from *Bolivina doniesi* Cushman and Wicken­den by its more slender test, greater number of chambers, the degree of tapering, which is greater in Cushman’s species, and in the greater obliquity of the sutures._

**Bolivina sinuata** Galloway and Wissler

_Plate 22, figures 11a, b_

1927. **Bolivina sinuata** Galloway and Wissler, Journ. Pal., vol. 1, no. 1, p. 71, pl. 11, figs. 9a, b; Pleistocene, California.

1937. **Bolivina sinuata.** Cushman, Special Publ. 9, Cushman Lab. Foram. Res., p. 120, pl. 14, figs. 19, 20; Pliocene, California.

_Description._—Test elongate, length 3 to 4 times longer than broad, compressed, initial end bluntly rounded, apertural end broadly rounded, slight tapering towards the initial end, oval in cross section, 4 high rounded, thick costae which are discontinuous at the sutures, develop into sinuate lobes on later parts of the test; chambers numerous, biserial, 12 to 13 pairs in the adult forms; sutures lobate, distinct towards the apertural end, less so towards the initial end; wall finely perforate; aperture narrow, elliptical, at base of the last-formed chamber. Length, 0.95 mm.; width, 0.30 mm. Abundant.

_Hypotype.—USC No. 791._
Bolivina spissa Cushman

Plate 22, figures 2a, b; 3a, b


1942. Bolivina spissa. Cushman and Mc Culloch, Allan Hancock Pacific Exped., vol. 6, no. 4, p. 211, pl. 26, figs. 7-11; Recent, California.

Description.—Test much compressed, thickened along the median part line, tapering towards the initial end, length 2 to 3 times longer than broad, widest at the apertural end, edge acute, ranging from a smooth to a serrate edge, initial end of microspheric forms sharply rounded, apertural end broadly rounded, uniserial in side view, greatest width at last-formed chamber, edge ornamented with 3 plate-like keels, one central, 2 lateral, chambers numerous, biserial in early stage, uniserial in later portion, rectilinear, curved, convex towards the apertural end, low broader than high, increasing in height gradually and uniformly as added; sutures curved, limbate, later ones slightly curved, depressed; wall smooth, with a small costae at the initial end; aperture a broad oval opening in septal face of last-formed chamber, ornamented with 6 small teeth. Length, 2.10 mm.; width, 0.35 mm.; thickness, 0.10 mm. Common.

Hypotype.—USC No. 782.

Bolivina subadvena Cushman var. sulphurensis Cushman and Adams

Plate 22, figures 4a, b; 5a, b


1937. Bolivina subadvena var. sulphurensis. Cushman, Special Publ. 9, Cushman Lab. Foram. Res., p. 117, pl. 12, figs. 19, 20; Late Tertiary, California.

Description.—Test elongate, length 2 to 3 times longer than broader, compressed, tapering towards the initial end, initial end in microspheric forms sharply acute, rounded in megalospheric forms, edge subacute; chambers numerous, biserial, 12 to 14 pairs, increasing in height uniformly, the later chambers as high as broad; sutures distinct in the adult stage, less so towards initial end; wall lower end of test ornamented with matte process obscuring chambers and sutures, towards the aperture wall tends to become smooth; aperture a small narrow slit at the base of the last-formed chamber. Length, 0.65 mm.; width, 0.20 mm.; thickness, 0.10 mm. Abundant.

Hypotype.—USC No. 793.

Genus Plectofrondicularia Liebus, 1903

Plectofrondicularia californica Cushman and R. E. Stewart

Plate 22, figures 6a, b; 7a, b


1938. Plectofrondicularia californica. Kleinpell, Miocene Stratigraphy of California, p. 239, pl. 4, figs. 17, 19; Miocene, California.

1946. Plectofrondicularia californica. Cushman and Gray, Special Publ. 19, Cushman Lab. Foram. Res., p. 27, pl. 15, figs. 1, 2; Pleistocene, California.


Description.—Test elongate, compressed, about 5 times as long as wide, usually bilaterally symmetrical, occasionally asymmetrical due to slight curvature of early portion, very gradual tapering towards the initial end, initial end sharply rounded, apertural end broadly rounded in side view, greatest width at last-formed chamber, edge ornamented with 3 plate-like keels, one central, 2 lateral, chambers numerous, biserial in early stage, uniserial in later portion, rectilinear, curved, convex towards the apertural end, low broader than high, increasing in height gradually and uniformly as added; sutures curved, limbate, later ones slightly curved, depressed; wall smooth, with a small costae at the initial end; aperture a broad oval opening in septal face of last-formed chamber, ornamented with 6 small teeth. Length, 2.10 mm.; width, 0.35 mm.; thickness, 0.10 mm. Present.

Hypotype.—USC No. 855.

Genus Loxostomum Ehrenberg, 1854

Loxostomum instabile Cushman and Mc Culloch

Plate 22, figures 8a, b

1942. Loxostomum instabile Cushman and Mc Culloch, Allan Hancock Pacific Exped., vol. 6, no. 4, p. 221, pl. 19, figs. 15-17; pl. 28; figs. 1-7; Recent, Eastern Pacific.

1946. Loxostomum instabile. Cushman and Gray, Special Publ. 19, Cushman Lab. Foram. Res., p. 26, pl. 6, fig. 7-9; Pleistocene, California.

Description.—Test elongate, slender, length 4 to 5 times as long as broad, compressed, tapering towards the initial end, edge at apertural end acute and keeled, initial and middle portions biserial, tending to become uniserial at the apertural end; chambers distinct, increasing in size gradually at the initial end, becoming rapidly larger, compressed, uniserial and keeled at the periphery at the apertural end, the basal margins of the chambers extending backwards into distinct spines; sutures distinct, depressed towards the apertural end, strongly curved; wall smooth, coarsely perforate; aper-

**Description.**—Test broadly oval, widest about the middle, length about 1½ times as wide, consisting of 2 or 3 whorls, last-formed whorl comprising 4/5 of the test, microspheric forms with a pointed initial end, megalospheric forms with a bluntly rounded initial end; chambers distinct, last-formed much inflated, increasing in size rapidly; sutures slightly depressed; wall smooth, finely perforate; aperture comma-shaped with a long curved tooth. Length, 0.60 mm.; diameter, 0.40 mm. Rare.

**Hypotype.**—USC No. 796.

**Bulimina pagoda** Cushman

**Plate 22, figures 11a, b**

**Description.**—Test broadly fusiform, widest below the middle, length about 2 times as long as wide, initial end acute, apertural end bluntly subangular, 5 whorls in the adult form; chambers triserial, numerous, inflated, basal margin undercut at a sharp angle; sutures distinctly depressed; wall ornamented by plate-like costae extending the full length of the chambers, forming short sharp spines, chambers of the last-formed whorl are ornamented only with marginal spines, the test of the apertural area being smooth; aperture a comma-shaped slit, terminal. Length, 0.90 mm.; diameter, 0.40 mm. Present.

**Holotype.**—USC No. 794; Station No. 5.

**Remarks.**—The terminal position of the aperture and the presence of costae extending the full length of the chambers distinguish the variety from *Bulimina marginata* Orbigny.

**Bulimina marginospinata** Cushman and Parker

**Plate 22, figures 9a, b**

**Description.**—Test elongate, large, tapering towards initial end, apertural end broadly rounded, widest part at apertural end formed by last whorl, 5 to 6 whorls in adult form; chambers triserial, numerous, inflated, basal margin undercut at a sharp angle; sutures distinctly depressed; wall ornamented by plate-like costae extending beyond the basal margin of the chambers forming short sharp spines, chambers of the last-formed whorl are ornamented only with marginal spines, the test of the apertural area being smooth; aperture a comma-shaped slit, terminal. Length, 0.90 mm.; diameter, 0.40 mm. Present.

**Holotype.**—USC No. 794; Station No. 5.

**Remarks.**—The terminal position of the aperture and the presence of costae extending the full length of the chambers distinguish the variety from *Bulimina marginata* Orbigny.

**Bulimina marginospinata** Cushman and Parker

**Plate 22, figures 11a, b**

**Description.**—Test broadly fusiform, widest below the middle, length about 2 times as long as wide, initial end acute, apertural end bluntly subangular, 5 whorls in the adult form; chambers triserial, numerous, inflated, basal margin undercut at a sharp angle; sutures distinctly depressed; wall smooth except for several small short spines at the basal margin of the chambers, finely perforate; aperture narrow, elongate with a raised lip. Length, 0.40 mm.; diameter, 0.25 mm. Present.

**Hypotype.**—USC No. 795.

**Bulimina ovula** Orbigny

**Plate 22, figures 10a, b**

**Description.**—Test medium size, widening at apertural end, initial end acute, apertural end broadly subangular, length 1½ times longer than broad, about 4 or 5 whorls in the adult; chambers undercut deeply at the basal margins, increasing in size rapidly, rather inflated, particularly those of the last whorl; early sutures defined by undercutting of the chambers, later sutures distinct, depressed; walls smooth, except at marginal base of each chamber where a number of broad spines project and curve downwards, coarsely perforate; aperture comma-shaped, at apex of test, above junction of the second and third chambers. Length, 0.50 mm.; diameter, 0.35 mm. Present.

**Hypotype.**—USC No. 797.

**Bulimina pseudoaffinis** Kleinpell

**Plate 23, figures 4a, b**

**Description.**—Test medium size, widest portion just above the middle, initial end sharply rounded, apertural end broadly rounded, tapering towards initial end, 3 whorls in the adult form, last whorls forming ⅓
of the test; chambers distinct, inflated, increasing in size rapidly; sutures distinct, depressed; wall smooth, finely perforate; aperture elongate, comma-shaped. Length, 0.70 mm.; diameter, 0.35 mm. Rare.

Hypotype.—USC No. 798.

**Bulimina subacuminata** Cushman and R. E. Stewart

Plate 22, figures 12a, b

1930. **Bulimina subacuminata** Cushman and R. E. Stewart. Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 65, pl. 5, figs. 2, 3a, b; Pliocene, California.


1946. **Bulimina subacuminata**. Cushman and Parker, U. S. Geol. Surv. Prof. Paper 210-D, p. 116, pl. 27, fig. 8; Pliocene, California.

**Description.**—Test small, length 2 times longer than broad, somewhat fusiform, initial end acute, apertural end tapering bluntly angled, widest above the middle, tapering towards the initial end, with a basal spine, 6 whorls in the adult form; chambers distinct, inflated in last whorl, increasing in size rapidly; sutures fairly distinct, depressed; wall finely perforate, upper portion of last-formed whorl smooth, remainder of test ornamented by high, narrow, plate-like costae; aperture loop-shaped, above the junction of second and third chambers. Length, 0.55 mm.; diameter, 0.30 mm. Present.

Hypotype.—USC No. 799.

**Bulimina subcalva** Cushman and K. C. Stewart

Plate 22, figures 13a, b

1930. **Bulimina subcalva** Cushman and K. C. Stewart. Trans., San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 65, pl. 4, figs. 8a-c; Pliocene, California.

1946. **Bulimina subcalva**. Cushman and Parker, U. S. Geol. Surv. Prof. Paper 210-D, p. 116, pl. 27, fig. 7; Pliocene, California. (Contains prior synonymy).

**Description.**—Test small, slightly longer than broad, widest towards the apertural end, initial end acute, apertural end tapering gradually, widest above the middle, tapering towards the initial end, with a small basal spine, 5 whorls in the adult form; chambers distinct, inflated in last whorl, increasing in size rapidly; sutures distinct, slightly depressed; wall finely perforate, second and third chambers making up 0.5/6 of the test; chambers slightly inflated, sutures distinct, slightly depressed; wall smooth, finely perforate; aperture comma-shaped, with a lip and high curved tooth. Length, 0.45 mm.; diameter, 0.30 mm. Rare.

Hypotype.—USC No. 828.

**Remarks.**—This species is distinguished from *Globobulimina pacifica* Cushman by the fact that the first chamber of the last-formed whorl is visible on both sides of the test.

**Globobulimina pyrula** (Orbigny)

Plate 23, figures 8a, b

1846. **Bulimina pyrula** Orbigny, Foraminifères fossiles du Bassin Tertiaire de Vienne. p. 104, pl. 11, figs. 9, 10; Miocene, Austria.

1884. **Bulimina pyrula**. Brady, Rep. Voy. Challenger, Zool., vol. 9, p. 399, pl. 50, figs. 7-10; Recent, All Oceans.


1946. **Bulimina pyrula**. Cushman and Parker, U. S. Geol. Surv. Prof. Paper 210-D, p. 104, pl. 25, fig. 2; Pliocene, California. (Contains prior synonymy).

**Description.**—Test of medium size, length 1½ times longer than wide, initial end sharply rounded, 2 to 3 whorls in the adult form, last-formed whorl comprising about 5/6 of the test; chambers slightly inflated, those of the last whorl more so, increasing in size rapidly; sutures distinct, slightly depressed, wall smooth, often translucent, sometimes ornamented by a small basal spine, coarsely perforated; aperture loop-shaped, with a lip and tooth. Length, 0.40 mm.; diameter, 0.25 mm. Present.

Hypotype.—USC No. 829.

**Remarks.**—This species is placed in the genus *Globobulimina* Cushman, 1927 because of the envolving nature of the last-formed whorl. Other atypical species of the genus *Bulimina* Orbigny 1826 such as *Bulimina ovula* Orbigny and *Bulimina margaritifera* Cushman and Parker may conceivably fall into this category. However these latter species show several of their earlier whors whereas *Globobulimina pyrula* (Orbigny) does not.

Genus *Globobulimina* Cushman, 1927

**Globobulimina glabra** Cushman and Parker

Plate 23, figures 7a-c

1884. **Bulimina pyrula** Brady (not Orbigny), Rep. Voy. Challenger, Zool., vol. 9, p. 399, pl. 50, figs. 7-10; Recent, New Zealand.
Genus Virgulina Orbigny, 1826

Virgulina bramlettei Calloway and Morrey
Plate 23, figures 10a, b

1929. **Virgulina bramlettei** Calloway and Morrey, Bull. Amer. Pal., vol. 15, p. 37, fig. 14; Upper Eocene (?), Ecuador.


1930. **Virgulina bramlettei**. Cushman and Moyer, Contr. Cushman Lab. Foram. Res., vol. 6, pt. 3, p. 57, pl. 8, fig. 2; Recent, California Coast.

1937. **Virgulina bramlettei**. Cushman, Special Publ. 9, Cushman Lab. Foram. Res., p. 20, pl. 3, figs. 6-9; Miocene, California.

1938. **Virgulina bramlettei**. Cushman and LeRoy, Journ. Pal., vol. 12, no. 2, p. 125, pl. 22, figs. 19a-c; Miocene, California.

*Description.*—Test elongate, slightly fusiform, widest towards the apertural end, length about 3 times as long as wide, slightly compressed in cross section, initial end sharply rounded, occasionally with a small basal spine, apertural end rounded, early portion of test triserial, later part irregularly biserial; chambers distinct, slightly inflated, higher than broad in the initial end subacute, spirally twisted, apertural end bivalved, last whorl making up about ½ the test; sutures curved on apertural side; sutures distinct, curved on apertural view, gradual tapering to a blunt initial end; chambers inflated, distinct, early chambers triserial, later ones biseria! the last 3 making up about ½ the test; sutures much depressed; wall smooth, finely perforate; aperture comma-shaped, in a depression on inner face of last-formed chamber. Length, 0.50 mm.; width, 0.20 mm.; thickness, 0.15 mm. Rare.

*Hypotype.*—USC No. 877.

Virgulina cornuta Cushman
Plate 23, figures 9a-c

1912. **Virgulina cornuta** Cushman, Proc. U. S. Nat. Mus., vol. 44, p. 637, pl. 40, fig. 1; Recent, Philippines.

1930. **Virgulina cornuta**. Cushman and Moyer, Contr. Cushman Lab. Foram. Res., vol. 6, pt. 3, p. 57, pl. 8, fig. 1; Recent, California Coast.

1937. **Virgulina cornuta**. Cushman, Special Publ. 9, Cushman Lab. Foram. Res., p. 28, pl. 4, figs. 20, 21; Recent, California.

*Description.*—Test short, broad, about ¾ times as long as wide, widest about the middle, slightly compressed in cross section, periphery broadly rounded, initial end subacute, spirally twisted, apertural end biserial with a slight twisted tendency; chambers distinct inflated towards the apertural end, particularly on the apertural side; sutures distinct, curved on apertural side, less so on opposite side, slightly depressed; wall smooth, finely perforate; aperture comma-shaped, in a slight depression. Length, 0.55 mm.; width, 0.35 mm.; thickness, 0.30 mm. Rare.

*Hypotype.*—USC No. 876.

Virgulina nodosa R. E. and K. C. Stewart
Plate 24, figures 1a-c

1930. **Virgulina nodosa** R. E. and K. C. Stewart, Journ. Pal., vol. 4, no. 1, p. 64, pl. 8. figs. 4a-c; Pliocene, California.


1937. **Virgulina nodosa**. Cushman, Special Publ. 9, Cushman Lab. Foram. Res., p. 22, pl. 3, fig. 24; Pliocene, California.

*Description.*—Test elongate, spiral, tapering towards...
initial end, somewhat fusiform, widest above the middle, length 2 times as long as wide, initial end bluntly pointed, numerous short, blunt spines covering first few chambers, about 4 to 5 whors in the adult form; chambers numerous, slightly inflated, 4 to 1 whor, increasing in size regularly; sutures distinct, depressed; wall smooth in later portion of test, spinose at initial end, finely perforate; aperture comma-shaped, at base of last-formed chamber, in a depression, usually with a tooth. Length, 0.85 mm.; diameter, 0.35 mm. Rare. Hypotype.—USC No. 802.

Buliminella dubia Barbat and Johnson
Plate 23, figures 3a, b
1938. Buliminella dubia. Kleinepell, Miocene Stratigraphy of California, p. 249, pl. 16, fig. 7; Miocene, California.

Description.—Test small, fusiform, spiral, widest towards the apertural end, 4 to 1 whors in the adult form, initial end pointed, apertural end sharply rounded, periphery slightly lobulate, length 2 times as long as wide; chambers distinct, inflated, 4 to a whorl, about as high as wide; sutures distinct, slightly depressed; wall smooth, finely perforate; aperture comma-shaped, in a depression of the last-formed chamber. Length, 0.35 mm.; diameter, 0.20 mm. Present. Hypotype.—USC No. 803.

Buliminella subfusiformis Cushman
Plate 23, figures 6a, b
1930. Buliminella subfusiformis. Cushman, Stewart and Martin, n. var. X 56; a, side view; b, apertural view; c, dorsal view; hypotype no. 803. 133
1946. Buliminella subfusiformis. Cushman and Parker, U. S. Geol. Surv. Prof. Paper 210-D, p. 64, pl. 16, fig. 21; Miocene, California.

Description.—Test elongate, slender, fusiform, initial end subacute, apertural end rounded, 4 to 5 whors in the adult form, widest towards the apertural end, length 4 times as long as wide; chambers distinct, inflated, 4 to a whorl, increasing in size uniformly and gradually, chambers of last whor higher than broad; sutures depressed, slightly curved, wall smooth, finely perforate; aperture comma-shaped, in a depression on face of last-formed chamber. Length, 0.60 mm.; diameter, 0.15 mm. Common. Hypotype.—USC No. 804.

Family CASSIDULINIDAE Orbigny, 1839

Genus Cassidulina Orbigny, 1826

Cassidulina californica Cushman and Hughes
Plate 24, figures 2a, b
1927. Cassidulina californica. Galloway and Wissler. Journ. Pal., vol. 1, no. 1, p. 78, pl. 12, figs. 6, 7; Pleistocene, California.
1930. Cassidulina californica. Cushman, Stewart and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 75, pl. 6, figs. 8a, b; Pliocene, California.

Description.—Test close coiled, circular in outline except for the last-formed chamber which projects slightly, periphery slightly lobulate, oval in edge view, sides parallel, ends broadly rounded; chambers few, alternating, about 5 pairs in last formed coil; sutures distinct, slightly depressed, radial; wall smooth, finely perforate; aperture elongate, with a plate-like tooth, in axis of coil. Diameter, 0.70 mm.; thickness, 0.40 mm. Present. Hypotype.—USC No. 805.

EXPLANATION OF PLATE 23

Figs.
1. Bulimina marginata Orbigny var. grandissima Martin, n. var. X 56; a, side view; b, apertural view; Holotype no. 794. 131
2. Bulimina curta Cushman var. basispinata R. E. and K. C. Stewart. X 56; a, side view; b, aperture view; hypotype no. 802. 133
3. Bulimina dubia Barbat and Johnson. X 56, a, side view; b, apertural view; hypotype no. 803. 134
4. Bulimina pseudoaofinis Kleinepell. X 56; a, side view; b, apertural view; hypotype no. 798. 131
5. Bulimina brevior Cushman. X 56; a, side view; b, apertural view; hypotype no. 801. 133
6. Bulimina subfusiformis Cushman. X 56; a, side view; b, apertural view; hypotype no. 804. 134
7. Globobulimina glabra Cushman and Parker. X 56; a, ventral view; b, apertural view; c, dorsal view; hypotype no. 828. 132
8. Globobulimina pyrula (Orbigny). X 63; a, side view; b, apertural view; hypotype no. 829. 132
9. Virgulina corueta Cushman. X 63; a, dorsal view; b, apertural view; c, ventral view; hypotype no. 876. 133
10. Virgulina bramlettii Galloway and Morrey. X 63; a, side view; b, apertural view; hypotype no. 875. 133
Martin: Pliocene Foraminifera, Los Angeles, California
**Cassidulina corbyi** Cushman and Hughes

Plate 24, figures 3a, b

1925. **Cassidulina corbyi** Cushman and Hughes. Contr. Cushman Lab. Foram. Res., vol. 1, no. 1, p. 14, pl. 2, figs. 3a, b; Pliocene, California.

*Description.*—Test oval, about 1½ times as long as broad, close coiled, edge strongly serrate, periphery acute, lenticular in edge view, central portion slightly umbilicate; chambers alternating, 5 to 6 pairs in last-formed coil, angled at the periphery; sutures straight, coiling, last-formed chamber usually projecting, edge acute, 4 pairs making up the last-formed coil; sutures distinct, depressed; aperture elongate slit in the axis of coding, narrow. Diameter, 0.35 mm.; thickness, 0.15 mm. Common.

*Hypotype.*—USC No. 806.

**Cassidulina cushmani** R. E. and K. C. Stewart

Plate 24, figures 5a, b

1930. **Cassidulina cushmani** R. E. and K. C. Stewart. Journ. Pal., vol. 4, no. 1, p. 71, pl. 9, figs. 5a, b; Pliocene, California.

1942. **Cassidulina cushmani.** Coryell and Mossman, Journ. Pal., vol. 16, no. 2, p. 243, pl. 36, fig. 48; Pliocene, Panama.

*Description.*—Test close coiled, equally biconvex, compressed, circular side view, lenticular in edge view, last-formed chamber usually projecting, edge acute, periphery slightly lobulate, carinate in adult forms; chambers distinct, alternating, slightly inflated, curved, 4 pairs making up the last-formed coil; sutures distinct, depressed; wall thin, finely perforate, smooth and polished; aperture elongate, narrow, slit, following the curve of the preceding chamber, with a slight tooth. Diameter, 0.25 mm.; thickness, 0.10 mm. Abundant.

*Hypotype.*—USC No. 807.

**Cassidulina limbata** Cushman and Hughes

Plate 24, figures 6a, b

1925. **Cassidulina limbata** Cushman and Hurshes. Contr. Cushman Lab. Foram. Res., vol. 1, pt. 1, p. 12, pl. 2, fig. 2; Pliocene, California.

1927. **Cassidulina limbata.** Galloway and Wissler. Journ. Pal., vol. 1, no. 1, p. 78, pl. 12, fig. 12; Pliocene, California.

1930. **Cassidulina limbata.** Cushman, Stewart and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, pp. 74-75, pl. 6, figs. 7a, b; Pliocene, California.


*Description.*—Test close coiled, equally biconvex, nearly circular in side view; lenticular in edge view, the last-formed chamber slightly projecting, central umbo of clear shell material, periphery slightly lobulate, edge carinate; chambers numerous, alternating, curved, 5 or 6 pairs making up the last coil, characteristically constricted in the middle portion; sutures distinct, limbate, curved; wall smooth, very finely perforate; aperture elongate, narrow, parallel to the plane of coding, with a slight plate-like tooth. Diameter, 0.65 mm.; thickness, 0.40 mm. Rare.

*Hypotype.*—USC No. 808.

**Cassidulina lomitensis** Galloway and Wissler

Plate 24, figures 7a, b

1927. **Cassidulina lomitensis** Galloway and Wissler. Journ. Pal., vol. 1, no. 1, p. 79, pl. 12, figs. 10a, b; Pleistocene, California.

1940. **Cassidulina lomitensis.** Cushman and Gray, Special Publ. 19, Cushman Lab. Foram. Res., p. 43, pl. 7, fig. 18; Pleistocene, California.


*Description.*—Test close coiled, broadly oval in edge view, round in side view, periphery non-lobulate; chambers not inflated, 5 pairs in last formed whorl, alternating; sutures limbate, flush with wall surface, at inner end of chambers in central part of the test form a stellate design of clear shell material; wall smooth, finely perforate; aperture elongate, elliptical, with a plate-like tooth, parallel to the plane of coding. Diameter, 1.20 mm.; thickness, 0.60 mm. Rare.

*Hypotype.*—USC No. 809.

**EXPLANATION OF PLATE 24**

1. *Virgilina nodosa* R. E. and K. C. Stewart. × 56; a, ventral view; b, apertural view; c, side view; hypotype no. 877.

2. **Cassidulina californica** Cushman and Hughes. × 55; a, side view; b, edge view; hypotype no. 805.

3. **Cassidulina corbyi** Cushman and Hughes. × 56; a, side view; b, edge view; hypotype no. 806.

4. **Cassidulina translucens** Cushman and Hughes. × 56; a, side view; b, edge view; hypotype no. 810.

5. **Cassidulina cushmani** R. E. and K. C. Stewart. × 56; a, side view; b, edge view; hypotype no. 807.

6. **Cassidulina limbata** Cushman and Hughes. × 56; a, side view; b, edge view; hypotype no. 808.

7. **Cassidulina lomitensis** Galloway and Wissler. × 55; a, side view; b, edge view; hypotype no. 809.

8. **Epistominella pacifica** (Cushman). × 56; a, ventral view; b, edge view; c, dorsal view; hypotype no. 857.

9. **Epistominella bradyana** (Cushman). × 56; a, ventral view; b, edge view; c, dorsal view; hypotype no. 856.
Cassidulina translucens Cushman and Hughes
Plate 24, figures 4a, b
1927. Cassidulina translucens. Galloway and Wissler. Journ. Pal., vol. 1, no. 1, p. 80, pl. 12, figs. 11a, b; Pleistocene, California.

Description.—Test close coiled, equally biconvex, circular in side view, lenticular in edge view, with thin broad keel; chambers alternating, 5 or 6 pairs in the last-formed whorl, not inflated, slightly overlapping; sutures distinct, straight, flush with wall surface; wall smooth, finely perforate, transparent, earlier chambers equally biconvex, edge acute, periphery slightly lobulate, oblique dorsally, nearly radial ventrally; wall late, slightly umbilicate; chambers about 8 in the last-formed whorl, not inflated, 6 in the last-formed whorl; sutures obliquely curved on dorsal side, slightly curved on ventral side, nearly radial, flush with surface; wall smooth, finely perforate; aperture elongate, narrow, nearly parallel to the periphery and to plane of coiling, ventral. Diameter, 0.40 mm.; thickness, 0.20 mm. Common.

Hypotype.—USC No. 857.

Remarks.—Some question exists as to the relationship between this species and Epistominella smithi (R. E. and K. C. Stewart). The author found that a series of specimens ranging from a very characteristic Epistominella smithi (R. E. and K. C. Stewart) to an equally characteristic Epistominella pacifica (Cushman) can be assembled. At one end of the scale a form similar to Epistominella smithi, without an umbilicus and almost biconvex, may be observed to gradually acquire the characteristics of Epistominella pacifica as succeeding chambers are added. The resulting form is trochoid with the ventral side strongly convex and a well-developed umbilicus. The periphery is often very lobulate but specimens with only the slightest tendency have been noted.

Genus Epistominella Huszczina and Maruhasi, 1944
Epistominella bradyana (Cushman)
Plate 24, figures 9a-c
1884. Truncatulina pyrenaica Brady (part), (not Hantken), Rep. Voy. Challenger, Zool., vol. 9, p. 666, pl. 95, fig. 10; Recent, Atlantic, Pacific.

Description.—Test small, rotoidal, close-coiled, unequally biconvex, edge acute, periphery slightly lobulate, slightly umbilicate; chambers about 8 in the last-formed whorl seen ventrally; sutures distinct, slightly limbate, oblique dorsally, nearly radial ventrally; wall smooth, finely perforate; aperture elongate, loop-shaped, nearly parallel to the plane of coiling, with a slight tooth on the ventral lip. Diameter, 0.35 mm.; thickness, 0.25 mm. Abundant.

Hypotype.—USC No. 856.

Epistominella pacifica (Cushman)
Plate 24, figures 8a-c
1938. Pulvinulinella pacifica. Cushman, Stewart and Stewart. Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 78, pl. 6, figs. 5a-c; Pliocene, California.

Description.—Test trochoid, plano-convex, dorsal side flattened, ventral side strongly convex, umbilicate edge acute or slightly keeled, periphery often lobulate; chambers distinct, not inflated, 6 in the last-formed whorl; sutures obliquely curved on dorsal side, slightly curved on ventral side, nearly radial, flush with surface; wall smooth, finely perforate; aperture elongate, narrow, nearly parallel to the periphery and to plane of coiling, ventral. Diameter, 0.40 mm.; thickness, 0.20 mm. Common.

Hypotype.—USC No. 857.

Remarks.—Some question exists as to the relationship between this species and Epistominella smithi (R. E. and K. C. Stewart). The author found that a series of specimens ranging from a very characteristic Epistominella smithi (R. E. and K. C. Stewart) to an equally characteristic Epistominella pacifica (Cushman) can be assembled. At one end of the scale a form similar to Epistominella smithi, without an umbilicus and almost biconvex, may be observed to gradually acquire the characteristics of Epistominella pacifica as succeeding chambers are added. The resulting form is trochoid with the ventral side strongly convex and a well-developed umbilicus. The periphery is often very lobulate but specimens with only the slightest tendency have been noted.

Family Uvigerinidae
Galloway and Wissler, 1927
Genus Uvigerina Orbigny, 1826
Uvigerina hispida Schwager
Plate 25, figures 1a, b
1938. Uvigerina hispida. Kleinpell, Miocene Stratigraphy of California. p. 295, pl. 5, figs. 8, 16; Miocene, California.

Description.—Test elongate, fusiform, about 2 times as long as broad, widest about the middle, slightly compressed, aperture strongly so, initial end somewhat blunt; chambers triserial, initial end spirally arranged, slightly inflated, later ones tending to become biserial, last-formed chamber twisted, pointed, and strongly everted with the upper part rather narrow; sutures deeply incised, distinct; wall ornamented with coarse spines, perforate; aperture at end of neck, round, central. Length, 0.70 mm.; diameter, 0.40 mm. Present.

Hypotype.—USC No. 866.

Uvigerina hispido-costata Cushman and Todd
Plate 25, figures 2a, b
Description.—Test stout, compact, fusiform, about 1½ to 2½ times as long as broad, initial end blunt, aperture end rounded, widest about the middle; chambers numerous, triserial, early ones low, later ones higher and slightly inflated; sutures slightly depressed; wall ornamented by numerous plate-like costae not continuous across the sutures, costae breaking into serrations and spines at both ends, aperture terminal, at end of long, slender neck, with a slight lip. Length, 0.75 mm.; diameter, 0.45 mm. Common.

Hypotype.—USC No. 867.

**Uvigerina hootsi** Rankin

Plate 25, figures 3a, b


1938. **Uvigerina hootsi**. Kleinpell, Miocene Stratigraphy of California, p. 295, pl. 22, fig. 6; Miocene, California.


1946. **Uvigerina hootsi**. Cushman and Gray, Special Publ. 19, Cushman Lab. Foram. Res., p. 36, pl. 6, fig. 13; Pleistocene, California.

1948. **Uvigerina hootsi**. Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 5, p. 229, pl. 33, fig. 8; Recent (?), Miocene (?), Eastern Pacific (Redeposition suggested.)

Description.—Test medium sized for the genus, about 2½ times as long as broad, greatest width above the middle, outline lobulate; chambers distinct, numerous, triserial, increasing in size rapidly; sutures distinct, depressed; wall ornamented with moderately raised costae, 7 to 9 per chamber, not continuing across suture lines, last 2 chambers may or may not have costae, usually ornamented with small spines; aperture terminal, round, at end of short neck with a very slight lip. Length, 0.60 mm.; diameter, 0.45 mm. Rare.

Hypotype.—USC No. 870.

**Uvigerina junccea** Cushman and Todd

Plate 25, figures 4a, b


1946. **Uvigerina junccea**. Cushman and Gray, Special Publ. 19, Cushman Lab. Foram. Res., p. 36, pl. 6, figs. 10-12; Pleistocene, California.

Description.—Test elongate, slender, circular in cross section, sides nearly parallel, outline slightly lobulate, initial end sharply rounded; chambers numerous, triserial, inflated, high, slightly overlapping; sutures distinct, depressed; wall smooth, finely perforate; aperture terminal, round, at end of short neck which may be seen at the inner face of the last-formed chamber. Length, 0.60 mm.; diameter, 0.25 mm. Rare.

Hypotype.—USC No. 871.

**Uvigerina peregrina** Cushman

Plate 25, figures 7a, b

1939. **Uvigerina peregrina** Flint (not Orbigny). Rep. U. S. Nat. Mus., p. 526, pl. 68, fig. 2; Recent, Western Atlantic.

1923. **Uvigerina peregrina** Cushman, U. S. Nat. Mus. Bull. 104, pt. 4, p. 166, pl. 42, figs. 7-10; Recent, Western Atlantic.

1927. **Uvigerina peregrina**. Galloway and Wissler, Journ. Pal., vol. 1, no. 1, p. 76, pl. 12, figs. 1, 2; Pleistocene, California.


Description.—Test elongate, fusiform, length about 2 to 2 ½ times as long as broad, widest at the middle, circular in cross section, initial end acute to subacute; chambers numerous, inflated, triserial; sutures depressed, distinct; wall ornamented with very high, thin, and sharp longitudinal costae, usually 10 to a chamber, not continuous with across suture lines, becoming irregular and spinose towards apertural and initial ends; aperture terminal, round, at end of short neck with a flaring lip. Length, 0.80 mm.; diameter, 0.50 mm. Very abundant.

Hypotype.—USC No. 872.

Uvigerina pigmea Orbigny
Plate 25, figures 8a, b


Description.—Test medium sized for genus, elongate, length about 2 to 3 times as long as broad, initial end acute to subacute, widest slightly above the middle; chambers triserial, inflated, increasing in size rapidly, last chamber somewhat extended, erect; sutures distinct, depressed; wall ornamented with longitudinal costae not continuous across the suture lines, last two chambers lacking costae and having a smooth surface; aperture terminal, round, at end of a long slender neck with a flaring lip. Length, 0.60 mm.; diameter, 0.20 mm. Present.

Hypotype.—USC No. 873.

Uvigerina proboscidea Schwager
Plate 25, figures 9a, b

1866. Uvigerina proboscidea Schwager, Novara-Exped., Geol. Thell., Bd. 2, p. 550, pl. 7, fig. 96; Pliocene, India.


1941. Uvigerina proboscidea. Cushman and Todd. Contr. Cushman Lab. Foram. Res., vol. 17, pt. 3, p. 73, pl. 17, fig. 9; pl. 19, figs. 3-9; Pliocene, India.

1948. Uvigerina proboscidea. Cushman and McCulloch. Allan Hancock Pacific Exped., vol. 6, no. 5, p. 261; pl. 24, fig. 4; Recent, Eastern Pacific. (Contains prior synonymy).


Description.—Test fusiform, stout, length about 2 times as long as broad, widest at the middle, apertural region elongated, initial area compact and broadly rounded, often with a small basal spine; chambers triserial, inflated, last-formed chamber elongated upward, erect; sutures distinct, deeply incised, not curved; wall ornamented with small spines; aperture terminal, round, at end of a long slender neck. Length, 0.70 mm.; diameter, 0.30 mm. Rare.

Hypotype.—USC No. 874.

Genus Siphonodosaria Silvestri, 1924

Siphonodosaria advena (Cushman and Laiming)
Plate 25, figures 10a, b

1931. Nodogenerina advena Cushman and Laiming, Journ. Pal., vol. 5, no. 2, p. 106, pl. 11, fig. 19; Miocene, California.


Description.—Test elongate, gradually tapering towards initial end, circular in cross section; chambers distinct, inflated, closely set, increasing gradually in size, later ones slightly higher than earlier chambers; sutures distinct, depressed, normal to longitudinal axis of test; wall with slight longitudinal spinose roughenings, otherwise smooth, finely perforate; aperture terminal, central, round, at the end of a short neck, with a slight lip. Length, 1.00 mm.; diameter, 0.25 mm. Present.

Hypotype.—USC No. 862.

Remarks.—As much as the original generic descriptions of Nodogenerina Cushman, 1927 and Siphonodosaria Silvestri, 1924 are identical, forms referred to Nodogenerina are placed in the latter genus which has priority. Some authors distinguish one from the other by the presence or absence of a tooth in the aperture. However, examination of most specific descriptions reveals that such a criterion, if it exists, has not been utilized.

Siphonodosaria antillea (Cushman)
Plate 25, figures 11a, b

1884. Sarcina virgula Brady (part). Rep. Voy. Challenger, Zool., vol. 9, p. 583, pl. 76, figs. 9, 10; Recent, Brazilian Coast, Pacific.

Description.—Test elongate, slender, tapering towards the initial end, straight, widest part formed by last-formed chambers; chambers uniserial, 6 to 7 in number, those of initial end appressed, later ones remote and high, circular in cross section, angled at the basal margin; sutures depressed, distinct, normal to longitudinal axis of test; wall smooth in the upper portion of chambers, spinose at the base; aperture terminal, central, round, with tooth, at end of a short neck with a phialine lip. Length, 1.00 mm.; diameter, 0.20 mm. Rare.

Hypotype.—USC No. 863.

Siphonodorsaria lepidula (Schwager)

Plate 25, figures 12a, b


1921. Nodosaria lepidula, Cushman, U. S. Nat. Mus. Bull. 100, vol. 4, p. 293, pl. 36, fig. 6; Recent, Philippines.

1929. Nodogenerina lepidula, Cushman, Stewart and Stewart, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 63, pl. 4, fig. 5; Pliocene, California.

1921. Nodogenerina lepidula, Galway and Morrey, Journ. Pal., vol. 5, no. 4, p. 337, pl. 38, fig. 1; Upper Cretaceous, Mexico.


Description.—Test elongate, slender, straight, gradually tapering towards the initial end; initial end sometimes with a small spine; chambers uniserial, 8 or 9 in adult form, circular in cross section, somewhat pyriform in shape with a series of short blunt spines about the widest portion; sutures deeply constricted, limbate; wall finely perforate; aperture terminal, central, round, at the end of a slight neck. Length, 0.95 mm.; diameter, 0.15 mm. Present.

Hypotype.—USC No. 864.

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Maync: Alveolophragmium from Venezuela
64. **Alveolophragmium venezuelanum** n. sp.
FROM THE OLIGO-MIOCENE OF VENEZUELA
(with a discussion of other species of the genus)

**Wolf Maync**
Caracas, Venezuela

During his routine work in Venezuela the writer has encountered quite a number of specimens of a *Haplophragmoides*-like foraminifer which reveals an alveolar wall structure and, therefore, obviously belongs to the genus *Alveolophragmium* Stschedrina, 1936.

The genus *Alveolophragmium* was erected in 1936 by Stschedrina for an arenaceous form related to *Haplophragmoides* Cushman which — contrary to the latter genus — displays a cellular-alveolar wall structure (Stschedrina, 1936; see Ellis and Messina, 1940 etc.). Its genotype, *Alveolophragmium orbiculatum* Stschedrina, 1936, occurs in recent sediments dredged in the Bay of Peter The Great (Peta Velikogo Bay), off Vladivostok. The two varieties hitherto known, *A. orbiculatum* var. *caraensis* Stschedrina, and *A. orbicu-
latum var. ochotonensis Stschedrina, have been found in recent deposits in the Kara Sea and the Sea of Okhotsk, U.S.S.R.

SYSTEMATIC DESCRIPTIONS

Family LITUOLIDAE Brady
Subfamily SPIROCYCLININAE Maync, 1949
Genus Alveolophragmium Stschedrina, 1936
Alveolophragmium venezuelanum n. sp.

Synonymy. Haplophragmoides emaciatum Renz, 1948 (non Brady, 1884), Geol. Soc. America, Mem. 32, p. 142, Pl. I, figs. 6a-b.

Type figure. Holotype: Pl. 26, figs. 1-3, 5.

Type description. Test free, planispiral, laterally symmetrical; more or less evolute (inner whorl partly visible); depressed at the umbilicus; tending to be distorted, chambers sometimes collapsed, the last one often inflated; periphery rounded or subrounded, sometimes lobulate; chambers generally distinct, of uniform size, 5-7 in the last-formed coil; sutures fairly distinct, straight or slightly curved with marked constrictions; smoothly finished on the exterior (thin epidermal coating), translucent; walls labyrinthic (see Pl. 26, figs. 6-8); hypodermal layer with reticulate honeycomb pattern, showing at the surface as an areolate meshwork (figs. 1-5); aperture indistinct, apparently a crescentiform slit at the base of the apertural face (interior-marginal).

Dimensions. Holotype (Pl. 26, figs. 1-3, 5):
- Greatest diameter: 1.0 mm.
- Least diameter: 0.85 mm.
- Thickness: 0.24 mm.

Type level. Lower part of the La Pica formation (Lower-Middle Miocene).

Type locality. Venezuelan Atlantic Refining Company's well Jaito 1-A, about 15 Kms WSW of the town Maturin, State of Monagas, Eastern Venezuela; in cuttings from between 9210' and 9270' depth.

The holotype, as well as the figured specimens and thin-sections of Alveolophragmium venezuelanum n. sp. are deposited in the collection of the Cushman Foundation, U.S. National Museum, Washington, D.C.

Alveolophragmium venezuelanum n. sp. was observed by the writer in many well samples from Oligo-Miocene formations (Carapita and La Pica formations) of the Maturin Basin, Eastern Venezuela. Some rare specimens were also found in the Upper Oligocene Cerro Pelado formation of Western Venezuela (Churu­guara area, State of Lara).

Haplophragmoides emaciatum Renz, 1948 (non Brady), which is referred to Alveolophragmium venezuelanum n. sp., was found in Upper Oligocene to Lower Miocene surface formations of the Isidro region, State of Falcón, Western Venezuela (see Renz, 1948).

Haplophragmoides emaciatum Renz, 1948, is quite different from Brady's species; the latter shows no alveolar wall structure at all but is characterized by a roughly finished outer wall with incorporated angular sand grains and pieces of broken sponge spicules1 (see type figures in Brady, 1884, Pl. 33, figs. 26-28). Typical specimens showing this agglomeration of sponge spicules have been figured by Flint in his catalogue of recent foraminifera (Flint, 1899, Pl. 19, fig. 5). The very same type of test is also displayed in Trochammina spiculaeopera Parr (Parr, 1950, Pl. 5, figs. 8-10). The pitted surface shown in H. H. Renz' specimens (Renz, 1948, Pl. I, figs. 6a-b) and in most of the specimens at hand is not due to a coarsely arenaceous texture of the test but is a phenomenon of weathering which has attacked the inner reticulate layer of the wall. Topotype specimens of the Falcón species were kindly put at the writer's disposal by H. H. Renz, Mene Grande Oil Co., Caracas; thin-sections made from several of these specimens clearly reveal this alveolar wall structure which differentiates Alveolophragmium from Haplophragmoides.

H. H. Renz-Renz also provided the author with typical specimens of Alveolophragmium venezuelanum n. sp. from the Lower Miocene Cruse formation of the Guayaguayare area, southeastern Trinidad, B.W.I., which is herewith gratefully acknowledged.

Alveolophragmium peruvianum n. sp.


The form described by Cushman and Stone from the Eocene Verdun formation of Peru has nothing to do with Lituola (Haplophragmium) foliacus Brady, 1881:2 While the latter shows a simple internal structure (see Brady, 1884, Pl. 33, fig. 24), the Peruvian form distinctly displays a labyrinthic interior pattern (see Cushman and Stone, 1949, Pl. 13, fig. 14b; Pl. 26, fig. 12 of the present paper). On account of this characteristic alveolar wall structure, Ammobaculites cf. foliacus Cushman and Stone, 1949, is therefore referred to the genus Alveolophragmium Stschedrina, 1936. By its smaller size, its finely dendritic pattern of the wall, and by its stratigraphic occurrence (Eocene), the Peruvian species differs from Alveolophragmium venezuelanum n. sp., and the erection of a new species, A. peruvianum n. sp., seems to be justified.

1 The writer cannot support the statement that the wall in Haplophragmoides emaciatum (Brady) is labyrinthic and Cyclammina-like (Cushman, 1920, p. 40).

2 H. H. Brady's form Lituola (Haplophragmium) foliacus possesses a simple terminal aperture and can, accordingly, not be referred to Lituola or Haplophragmium, olivum (see Maync, 1952). On account of its strongly compressed test it can neither be placed in the genus Ammobaculites (see Cushman, 1910, p. 177) but is a representative of the genus Ammomarginilina Wiesner, 1931.
**Alveolophragmium reticulatum** (Boogart)

Synonymy. *Haplophragmoides reticulatus* BOOMGART, 1949, Smaller Foraminifera from Bodjonegoro (Java), p. 47, Pl. II, figs. 4a-b. Figured in the present paper, Pl. 26, figs. 9 and 10.

Boogart’s type figures positively show the reticulate hypodermal layer (near-surface honeycomb pattern) which is diagnostic of the genus *Alveolophragmium* Stschedrina, 1936.

Diagnosis. “Test close-coiled, moderately compressed; periphery subacute; seven to nine chambers, gradually increasing in size as added; sutures slightly depressed, practically straight, meeting in the umbilical point; wall smoothly finished, showing a reticulate texture; aperture at the base of the last-formed chamber. Dimensions: 1.00 x 0.70 x 0.48 mm.”

(Boogart, 1949, p. 47).

The Javanese form differs from *Alveolophragmium venezuelanum* n. sp. in being nearly involute, in having a subacute, not lobulate, periphery, more chambers, and very distinct straight sutures.

**Alveolophragmium planum** Bykova, 1939

In 1939, Bykova described a new species of *Alveolophragmium* from the Paleocene of the Ferghana Basin, Uzbek S.S.R. (Russian Turkestan), viz. *A. planum* Bykova (Bykova, 1939, see Ellis and Messina, 1940 etc.).

The figured sections (Bykova, 1939, p. 20, textfigs. 1a and 1b) as well as the holotype specimen (ibid., Pl. 1, fig. 10), however, do by no means prove that the Russian species was correctly referred to the genus *Alveolophragmium*. The given illustrations show, on the contrary, that *A. planum* Bykova lacks a reticulate hypodermis and a truly labyrinthic interior structure, but merely displays irregularly contoured lumina, such as are present in certain species of the genus *Ammobaculites* (*A. expansus* Plummer, *A. midwayensis* Plummer, *A. calcareum* (Brady), etc.). Although nothing is known concerning the character of the aperture, the writer is inclined in the light of the foregoing remarks to refer *Alveolophragmium planum* Bykova to *Ammobaculites*, the more so as the Russian form clearly shows a tendency of uncoiling in the adult (see Bykova, 1939, textfig. 1b). Bykova’s form from the Ferghana region should, therefore, be named: *Ammobaculites planus* (Bykova).

*Cyclammina tasmanica* Parr, 1950, has been compared by its author with *Alveolophragmium orbiculatum* var. *ochotonensis* Stschedrina (Parr, 1950, p. 274). In its outer appearance, the Australian species is a true *Cyclammina* (external shape and outline, sigmoidal sutures, etc.); its “thick internal layer which is closely perforated with tubular passages opening into the interior of the test” (Parr, 1950, p. 274) suggests a coarsely labyrinthic structure (*Cyclammina* type). *Cyclammina tasmanica* Parr, however, is stated to have a simple interio-marginal apertural slit, apparently without the supplementary pores which are typical of *Cyclammina*. The taxonomic position of this Tasmanian form is, therefore, still questionable.

**TAXONOMY**

According to Stschedrina, *Alveolophragmium* is not a member of the *Haplophragmodinae* (olim), which disclose a simple wall structure, but is referable to the *Litouolinae* (olim) with a labyrinthic interior. In accordance with the writer’s revised classification of the *Litouloideae* (Maync, 1952), all the genera characterized by a reticulate hypodermis and/or a labyrinthic interior structure are placed in the subfamily *Spirocyclininae* Maync, 1949, and the term *Litouloidae* is restricted to include only internally simple genera uncoiling in the adult. The non-labyrinthic genera that remain coiled through all ontogenetic stages are included in the subfamily *Haplophragmoinae* Maync, 1952. Conformably, the genus *Alveolophragmium* is regarded as being a member of the *Spirocyclininae* (see Maync, 1952).

On account of its labyrinthic interior structure, *Alveolophragmium* was compared by Stschedrina with *Pseudocyclammina* Yabe and Hanzawa. In view of the considerable difference of the apertures, however, *Pseudocyclammina* having a cribrate aperture while *Alveolophragmium* shows a curved interio-marginal slit, the new genus *Alveolophragmium* was established.

According to its author, *Alveolophragmium* is possibly a transitional form between Lituolids with simple wall structure and those with a labyrinthic interior. Yet as the given microphotographs reveal a truly labyrinthic wall structure (see Pl. 26, figs. 6-8), the genus *Alveolophragmium* Stschedrina positively belongs to the spirocyclicine group of lituolid foraminifera, and its resemblance with some representatives of the *Haplophragmoinae* is purely superficial.

**REFERENCES**


65. OCCURRENCE OF HANTKENINA AT TORQUAY, AUSTRALIA
AND THE AGE OF THE "JANJUKIAN" AND "ANGLESEAN" STAGES
Irene Crespin
Bureau of Mineral Resources, Canberra, Australia

In a paper on “Some Tertiary Foraminifera from Victoria, Australia” published in these “Contributions” (Vol. I, 1950, pp. 70-75, pl. 10) it was stated that certain of the species were of Lower Miocene and others of Oligocene age. Since that time, new information has become available which makes it necessary to reconsider that statement.

The recent discovery of Hantkenina abalameniensis Cushman in a thin bed in the basal part of the Bird Rock Cliff section, Torquay, which also contains Quinqueloculina ornithopetra Crespin, Quinqueloculina singletoni Crespin, Massiliina torquayensis (Chapman), Bulimina pupula Stache, Dimorphina janjukensis Crespin, Vaginulinopsis gipslandicus (Chapman and Crespin), Frondicularia victoriae Crespin, Sherbornina atkinsoni Chapman, and Victorilla plecte (Chapman) indicates an Upper Eocene age for the well-known “Janjukian” beds, which in the above-cited paper were placed into the Lower Miocene.

The beds containing Ammodiscus parri Crespin, Cyclammina incita Stache, Cyclammina rotundata Chapman and Crespin, Cyclammina papaera Chapman, and Bathysiphon angleseanensis Crespin occur stratigraphically below the Hantkenina horizon, and are usually referred to the “Anglesean” stage. They are most probably of Middle Eocene age, and not Oligocene, as previously stated.

Many species which are characteristic of the Miocene deposits of Australia make an early appearance in the “Janjukian” beds at Bird Rock and it is interesting to note that J. A. Cushman in discussing some of the species in his paper “New species of Foraminifera from the Lower Oligocene of Mississippi” (Contr. Cushman Labor. Foram. Research, vol. 11, 1935, pp. 25-39, pls. 4, 5) noted “a very close relationship [of the Lower Oligocene fauna of Mississippi] to the fauna of the Indo-Pacific, particularly to that of the Miocene of Australia.”

66. THREE NEW NAMES FOR BASAL MIDWAY FORAMINIFERA FROM ARKANSAS
R. W. Harris and B. I. Jobe
University of Oklahoma, Norman, Oklahoma

Dr. Hans Thalmann of Stanford, California, has called attention to three homonyms occurring in the publication “Microfauna of basal Midway outcrops near Hope, Arkansas,” by R. W. Harris and Billye Irene Jobe, Transcript Press of Norman, Oklahoma, October, 1951. We gratefully acknowledge the constructive criticism, and make herewith the following corrections:

Froendicularia frankei Cushman, 1936, var. costata
Harris and Jobe, 1951, loc. cit., p. 29, pl. 6, fig. 2,
Paleocene Arkansas, is preoccupied by: *Frondicularia costata* Kübler and Zwingli, 1866, Neujahrsw. Burgersbibl. Winterthur, p. 8, pl. 1, fig. 1, from the Jurassic of Switzerland; and by *Frondicularia inaequalis* Costa, 1857, var. *costata* Silvestri, 1896, Mem. Pont. Accad. N. Lincei, vol. 12, p. 187, pl. 6, figs. 28-31 from the Pliocene of Italy. (*Frondicularia costata* R. E. Koch, 1926, has been changed to *Frondicularia bulonganensis* R. E. Koch, 1935). For our homonym *Frondicularia surfrata* Harris and Jobe, nom. nov. is herewith proposed.

*Polymorphina palmaris* Harris and Jobe, 1951, var. *parallela* Harris and Jobe, 1951, loc. cit., p. 34, pl. 7, fig. 1, Paleocene, Arkansas, preoccupied by *Polymorphina regularis* Müster, 1838, var. *parallela* Millett, 1895, Trans. Roy. Geol. Soc. Cornwall, p. 658, figs. 5 and 6, Pliocene, England, is herewith changed to *Polymorphina undacuneata* Harris and Jobe, nom. nov.


Further corrections are made regarding *Bairdia magna* Alexander, 1927 (loc. cit., p. 69, pl. 12, fig. 2, Paleocene, Arkansas), and *Bairdia nasunca* Harris and Jobe 1951, (loc. cit., p. 69, pl. 12, fig. 1, Paleocene, Arkansas). Reexamination of these two ostracod species revealed that the accessory terminal hingement places them into the genus *Bairdopiplata* Coryell, Sample, and Jennings.

### 67. TWENTY YEARS OF "FORAMINIFERAL STATISTICS": 1931 TO 1950

**Hans E. Thalmann**
Stanford University, Stanford, California

For more than twenty years the writer has recorded regularly in the “Journal of Paleontology" the literature and new taxonomic units of Foraminifera. Ten years ago a summary was given covering the period from 1931 to 1940 inclusive (Bull. Geol. Soc. America, vol. 53, Nr. 12, pt. 2, p. 1810, 1942).

Since then another decade has been added, largely characterized by a slackening of “production” due to the years of World War II — but notably and rapidly picking up again since then. The following tabulation demonstrates the amount of new taxonomic units amongst the Foraminifera for the two decades 1931-1940, and 1941-1950 respectively, and the total for the twenty years period: 1931 to 1950 inclusive:

<table>
<thead>
<tr>
<th>Taxonomic Unit</th>
<th>1931-1940</th>
<th>1941-1950</th>
<th>1931-1950</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superfamiliae</td>
<td>0</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Familiae</td>
<td>28</td>
<td>15</td>
<td>43</td>
</tr>
<tr>
<td>Subfamiliae</td>
<td>44</td>
<td>17</td>
<td>61</td>
</tr>
<tr>
<td>Genera</td>
<td>270</td>
<td>262</td>
<td>532</td>
</tr>
<tr>
<td>Subgenera</td>
<td>38</td>
<td>21</td>
<td>59</td>
</tr>
<tr>
<td>Species</td>
<td>3833</td>
<td>3925</td>
<td>7758</td>
</tr>
<tr>
<td>Subspecies et Var.</td>
<td>674</td>
<td>605</td>
<td>1279</td>
</tr>
<tr>
<td>Nomina nova</td>
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<td>120</td>
<td>185</td>
</tr>
<tr>
<td>Homonyma</td>
<td>250</td>
<td>99</td>
<td>349</td>
</tr>
<tr>
<td>Scripta</td>
<td>3443</td>
<td>3418</td>
<td>6861</td>
</tr>
</tbody>
</table>

In other words, during these twenty years every six months two new families, every four months one new subfamily and one new subgenus, every month 2 new genera and 5 subspecies or varieties, and every day one new species and one paper on Foraminifera were published. Looking back over these twenty years the question arises: where does this sizeable production of new taxonomic units lead to? Are all these new forms necessary for the progress of foraminiferology? From a scientific point of view, we are still in the stage of recording and cataloguing the foraminiferal content of recent seas, bays, inlets, and of analysing the faunal assemblages of countless numbers of sedimentary layers from the Cambrian to the Pleistocene all the world over. In addition, modern phylo-morphogenetically and micro-anatomically oriented studies of whole faunas, genera and lineages of species, ecological, paleoecological investigations (facies studies) will add in future many new units in order to understand better than we do to-day the taxonomy and phylogeny of the Foraminifera and thus provide a firm base for their natural classification.

For such a purpose and final goal each new taxonomic unit will necessarily become an asset provided that it is erected with sound judgment after an extensive search of all available literature, comparison with nearly-related forms, examination of enough specimens to make sure beyond doubt that it is really new to science. It will be the duty of each worker to observe strictly the International Rules of Zoological Nomenclature in their present or future emended form regardless of the personal attitude of the individual scientist towards these Rules. Everyone intending to erect new genera, species or subspecies should always be aware of the fact that, by doing so, he takes over an obligation and responsibility not only towards the contemporaneous but also towards future generations, and
that a new taxonomic unit, once published, can not even be undone by its author. If new genera, species, subspecies or other taxonomic units are correctly and, most of all, conscientiously erected they will be a credit to their authors and a welcome and valuable contribution to the progress of foraminiferology — if not done so, they will be a tremendous burden and dead weight to our science. In case of doubt whether a certain form might unquestionably be new to science, the worker always has recourse to the nomenclature aperita, which has been developed to avoid a precocious taxonomic allocation and unnecessary encumbrance to nomenclature.

68. PLUMMERITA NEW NAME
FOR PLUMMERELLA BRONNIMANN, 1952
(non Plummerella DeLong, 1942)
PAUL BRONNIMANN
Habana, Cuba


69. NODOSARIA NOMENCLATURE
R. M. STAINFORTH
Talara, Peru

Mr. N. de B. Hornibrook has kindly drawn my attention to, and provided a copy of, a 1947 paper by the late H. J. Finlay1 which should have been cited in my own recent paper in this journal2 on the classification of uniserial calcareous foraminifera. Unfortunately I was not aware of Finlay's publication and must make up for the omission by the following notes.

Finlay strongly urges the suppression of Ellipsonodosaria as a synonym of Nodosarella. He cites Martinotti to the effect that the early chambers of Nodosarella may be biserial in the microspheric form. (Stainforth, 1952, preferred to regard Nodosarella as strictly uniserial and to use Ellipsoidella for the initially biserial forms, but recognized the difficulty of separating marginal species).

Finlay recognizes the synonymy of Siphonodosaria and Nodogenerina but draws attention to an awkward taxonomic point. Siphonodosaria Silvestri, 1924 was proposed as a genus with no designated species and ought to be considered a nude name until it was validated by Cushman, who referred Nodosaria abyssorum Brady to this genus in March 1927. Meanwhile Nodogenerina Cushman had been proposed, with N. bradyi as genotype, in January 1927. It can be argued from these facts that Nodogenerina has prior validity over Siphonodosaria. Finlay leaves this question open and goes on to claim that Stilostomella Guppy, 18943 is congeneric with Siphonodosaria and Nodogenerina and has priority over both of them. (Stainforth, 1952, considered that Siphonodosaria was the valid name by priority of publication. He overlooked Stilostomella but here states the opinion that Finlay appears to be correct. Guppy's description and figures of Stilostomella rugosa match only one well-known species-group in the Eo-Oligocene of Trinidad: unless his types can be located it appears impossible to identify the exact species, but S. rugosa falls in the plexus of "Ellipsonodosaria" curvatura Cushman, "E." subspinosa Cushman, "E." recta Palmer and Bermudez, etc.).

Finlay's views are expressed above in a highly compressed form. His paper should be read in full by anyone concerned with these taxonomic matters.

This opportunity is taken to mention that J. J. Galloway4 should be cited among others who have noted synonymy of nodosarian genera.

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