CONTRIBUTIONS

FROM THE

CUSHMAN LABORATORY

FOR

FORAMINIFERAL RESEARCH

VOLUME 25, PART 3
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Contents

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CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

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CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

327. FORAMINIFERA FROM THE EOCENE, CHACRA FORMATION, OF PERU*

By Joseph A. Cushman and Benton Stone

The foraminifera of this formation are of interest as many of them are undescribed and others show relationships with other areas.

CHACRA FORMATION

Wiedey and Frizzell[1] proposed the Chacra shale for that part of Bosworth's Lobitos formation directly overlying the Parinas sandstone. These shales provided the Restin foraminifera described by Berry[2]. The formation is named from the International Petroleum Company's garden (*chacra,* in Spanish) which is located southeast of the type locality in Square Mile 3-N-3[3]. In view of the extremely poor figures and inadequate descriptions in Berry's paper it is considered desirable to publish the complete fauna of the Chacra shale.

Lithologically, the formation consists of firm, thinly laminar shale with carbonaceous partings and occasional silty layers. The lower part of the formation is sandier, with occasional thin beds of platy, fine grained sandstone. In outcrop the middle and upper parts of the formation are gray in color weathering to bluish-gray and the lower part is bluish-gray weathering to tan. Fish scales, bones and teeth as well as rare ostracods are present in the lower part of the formation where the foraminiferal fauna is more abundant. The upper part of the formation contains only rare foraminifera and is often completely barren. Due to faulting and the unconformity which separates it from the overlying Talara shale the Chacra formation is extremely variable in thickness and is absent in some areas. Although 900 to 1000 feet is usually considered maximum thickness for this formation a much greater interval

* Published with the permission of the International Petroleum Company, Ltd.

1 Wiedey, L. W., and D. L. Frizzell, Revision of the Eocene stratigraphy of northwestern Peru, Proc. 6th Pacific Sci. Congress, 1939.

2 Berry, W., The foraminifera of the Restin shale of northwestern Peru, Eclogae geol. Helvetiae, vol. 21, 1928, pp. 130-135, 1 text fig.

3 A description of the coordinate system employed by the International Petroleum Co., Ltd., in northwestern Peru may be found in Frizzell, D. L., Upper Cretaceous Foraminifera from northwestern Peru, Journ. Pal., vol. 17, 1943, p. 335.

has recently been encountered in one well. A thickness of some 750 feet has been measured in the type area.

The Chacra formation rests upon the middle Eocene Parinas sandstone. It is overlain by the Talara shale from which it is separated by an unconformity. The Chacra shale is considered middle Eocene in age and the presence of such forms as *Robulus* cf. *midwayensis* (Plummer) and *Globigerina* cf. *pseudobulloides* Plummer indicates a relationship with the Wilcox-Claiborne groups of the Texas Gulf Coast. Two of the typical Chacra species: *Virgulina restinensis* (Berry) and *Bolivina ignara* n. sp., are present also in the middle Eocene of Colombia. This fauna, in part at least, may be expected to occur at other localities in South America.

Most of the specimens in this paper come from the outcrop locality near the south edge of the Talara Golf Course, but in order to make the fauna as complete as possible several forms from well samples have been included. These latter species occur chiefly in the almost barren part of the formation and are seldom found well preserved in outcrop samples where the weathered zone may attain a thickness of some 50 feet.

We are grateful to the Directors of the International Petroleum Company, Ltd., for permission to publish this fauna from the Chacra formation. The drawings of specimens illustrating the fauna were prepared by Sr. Manuel Alban of Negritos, Peru. The types and figured specimens are deposited in the collections of the Cushman Laboratory for Foraminiferal Research at Sharon, Massachusetts.

Family REOPHACIDAE

Genus REOPHAX Montfort, 1808

REOPHAX ? sp. (Pl. 9, figs. 1, 2)

A number of specimens in the Chacra material are difficult to place owing to the rather poor preservation. The aperture is evidently small and at the end of a short neck as shown in the shorter, broken specimen figured. Specimens show a considerable amount of variation. Some appear possibly biserial in the early stages and others suggest coiling.

Family AMMODISCIDAE

Genus AMMODISCUS Reuss, 1861

AMMODISCUS RESTINENSIS Berry (Pl. 9, fig. 3)

Ammodiscus restinensis BERRY, Eclogae geol. Helvetiae, vol. 21, No. 1, 1928, p. 131, pl., fig. 4; vol. 21, No. 2, 1928, p. 390.

Specimens occurring frequently in the lower Chacra seem to be identical with this species described from the Restin shale of Peru and also recorded from the Lobitos shales.

Family LITUOLIDAE

Genus HAPLOPHRAGMOIDES Cushman, 1910

HAPLOPHRAGMOIDES cf. MAURICENSIS Howe and Ellis (Pl. 9, fig. 4)

Rare specimens in the Chacra formation seem to be related to this species described from the Eocene, Cook Mountain formation, of Louisiana (Howe and Ellis, in Howe, Geol. Bull. 14, Louisiana Geol. Survey, 1939, p. 30, pl. 1, figs. 3-5) and recorded from the Eocene, Yegua formation, of Texas (Cushman and Applin, Contr. Cushman Lab. Foram. Res., vol. 19, 1943, p. 30, pl. 7, fig. 2).

The Chacra specimens are slightly thicker but otherwise seem closely related to the types. The figured specimen is from the Chacra formation, I.P.C. well No. 3719, Square Mile 6-N-7, from a core at 2600-2608′.

Family TROCHAMMINIDAE

Genus TROCHAMMINA Parker and Jones, 1859

TROCHAMMINA TEASI Cushman and Ellisor (Pl. 9, fig. 5)

Trochammina teasi CUSHMAN and ELLISOR, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 52, pl. 7, fig. 3.—ELLISOR, Bull. Amer. Assoc. Petr. Geol., vol. 17, No. 11, 1933, pl. 1, fig. 9.—CUSHMAN and ELLISOR, Journ. Pal., vol. 19, 1945, p. 552, pl. 72, fig. 20.

Fairly well preserved specimens from the Chacra material seem close to, although somewhat more compressed than, this species described from the Eocene of Texas and recorded from the Oligocene of Texas. Specimens are common in the lower Chacra.

Family LAGENIDAE

Genus ROBULUS Montfort, 1808

ROBULUS MULTISEPTAE (Berry) (Pl. 9, fig. 6)

Cristellaria multiseptae BERRY, Eclogae geol. Helvetiae, vol. 21, No. 1, 1928, p. 132, pl., fig. 2.

This species was described from the Eocene, Restin shale, of Peru. Specimens common in the lower Chacra formation have similar thickened costae and seem to belong to this species.

ROBULUS cf. MIDWAYENSIS (Plummer) (Pl. 9, figs. 7, 8)

Common specimens in the lower Chacra formation seem to be very close to if not identical with this species described from the Paleocene of Texas.

Genus FRONDICULARIA Defrance, 1824

FRONDICULARIA CAPITANA Cushman and Stone, n. sp. (Pl. 9, figs. 9-11)

Test fairly large, strongly compressed, microspheric form tapering at the base, megalospheric form broad at the base; chambers numerous, coiled in the early stages of the microspheric form, increasing very

slightly and evenly in height as added; sutures distinct, very slightly depressed; wall smooth except for the central area which has three well developed costae, the median one extending nearly the whole length of the test, the two lateral ones variable in length but not usually more than half the length; aperture terminal, radiate, slightly projecting. Length 1.85-2.90 mm.; breadth 1.10-1.60 mm.; thickness 0.17-0.20 mm.

Holotype (Cushman Coll. No. 47491) from the Eocene, Chacra formation, sample No. S-145, from east bank of road cut on south edge of Talara golf course and at north end of tunnel, Talara, Peru.

This species is unique in its very strong median costae which are very constant in their character. It is fairly common and well preserved and is restricted to the lower part of the Chacra formation.

Family BULIMINIDAE

Genus BULIMINA d'Orbigny, 1826

BULIMINA PUNCTATO-COSTATA Cushman and Stone, n. sp. (Pl. 9, figs. 12, 13)

Test tapering from the rounded initial end to the greatest diameter at the last-formed whorl, apertural end broadly rounded, sides convex; chambers numerous, increasing very regularly in size as added, slightly inflated; sutures distinct, deeply incised; wall coarsely perforate, ornamented with numerous longitudinal costae, the upper portions of the last-formed chambers in the adult often smooth; aperture an elongate comma-shaped slit in the apertural face extending to the inner margin. Length 0.75-0.90 mm.; breadth 0.45-0.50 mm.

Holotype (Cushman Coll. No. 47508) from the Eocene, Chacra formation, I.P.C. well No. 3139, Square Mile 12-N-7, from a core at 3299-3305′, Peru.

This species differs from *B. instabilis* Cushman and Parker in the coarsely perforate test and the more even costae. It occurs rarely in the upper part of the Chacra formation.

BULIMINA (DESINOBULIMINA) EXPANSA Cushman and Stone, n. sp. (Pl. 9, fig. 14)

Test with the initial end subacute, thence expanding rapidly to the greatest diameter at the last-formed chamber, apertural end broadly rounded; chambers somewhat irregular in height in the early portion, very broad and progressively higher in the last-formed portion; sutures indistinct, slightly depressed, very irregular in pattern; wall smooth; aperture terminal, with a distinct tooth. Length 1.00-1.25 mm.; breadth 0.50-0.62 mm.

Holotype (Cushman Coll. No. 47512) from the Eocene, Chacra formation, I.P.C. well No. 2779, Square Mile 6-N-7, from cuttings at 1980′, Peru.

This species differs from *Bulimina (Desinobulimina) quadrata* Plummer in the larger and much more tapering form and broadly rounded apertural end. It differs from *B. (D.) diversa* Cushman and Stone from the Chira shale of Peru in its more gradually tapering form and the irregular pattern of its sutures.

This species occurs frequently and ranges from middle to lower Chacra. It is usually associated with *Siphogenerina solitaria* n. sp.

Genus VIRGULINA d'Orbigny, 1826

VIRGULINA RESTINENSIS (Berry) (Pl. 9, figs. 15, 16)

Bolivina restinensis BERRY, Eclogae geol. Helvetiae, vol. 21, No. 2, 1928, p. 391, pl., fig. 5.
Virgulina restinensis CUSHMAN, Special Publ. 9, Cushman Lab. Foram. Res., 1937, p. 11, pl. 2, figs. 4, 5.

Numerous specimens of this rather ornate species described from the Restin shale of Peru occur in the Chacra formation. They are restricted to the lower part of the Chacra where they are frequently very abundant.

The type figure is rather indefinite and does not show the surface ornamentation but topotypes from the author show the longitudinal costae very definitely. Our figured specimens show the extreme development of the costae and thickened sutures. Evidently, from our material and the topotypes, there is a considerable amount of variation in the species.

VIRGULINA DIVERSA Cushman and Stone, n. sp. (Pl. 9, fig. 17)

Test small, the triserial portion distinct, biserial portion forming a little more than half the test, sides in the biserial portion nearly parallel; chambers distinct, inflated, broader than high in the biserial portion; sutures distinct, depressed; wall smooth, distinctly perforate; aperture terminal, elongate. Length 0.45-0.55 mm.; breadth 0.20-0.30 mm.

Holotype (Cushman Coll. No. 47513) from the Eocene, Chacra formation, I.P.C. well No. 2902, Square Mile 11-N-7, from a core at 3333-3345′, Peru.

This species somewhat resembles *V. wilcoxensis* Cushman and Ponton from the Wilcox Eocene of Alabama but differs in the much broader and lower chambers and more depressed sutures. Though often comparatively rare, *V. diversa* first appears in the uppermost part of the Chacra shale and ranges through the middle and lower parts of this formation.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA INSUETA Cushman and Stone, n. sp. (Pl. 10, figs. 1, 2)

Test strongly compressed, initial end subacute, greatest breadth at the last-formed pair of chambers, sides nearly straight, slightly lobulate, periphery rounded; chambers distinct, inflated, increasing very gradually and evenly in size as added; sutures distinct, depressed, slightly curved;

wall smooth but coarsely perforate; aperture elongate, in the terminal face of the last-formed chamber. Length 0.35-0.40 mm.; breadth 0.20-0.23 mm.; thickness 0.10 mm.

Holotype (Cushman Coll. No. 47514) from the Eocene, Chacra formation, I.P.C. well No. 2902, Square Mile 11-N-7, from a core at 3333-3345′, Peru.

This is an unusual species but a close study of a considerable series shows constant characters and that it should belong in *Bolivina*. It differs from *B. crenulata* Cushman in the thinner test, narrow aperture, and lack of indentations along the sutures.

Bolivina insueta occurs rarely and first appears in the uppermost part of the Chacra formation. It is almost invariably associated with *Virgulina diversa* n. sp. and *Bulimina punctato-costata* n. sp.

BOLIVINA IGNARA Cushman and Stone, n. sp. (Pl. 10, figs. 3, 4)

Test elongate, initial end subacute, early portion rapidly increasing in width, main portion of the test with the sides nearly parallel, apertural end broadly rounded, periphery subacute to slightly rounded; chambers numerous, earlier ones slightly if at all inflated, increasing very slightly in height as added, adult chambers more inflated and much higher, distinctly crenulate along the lower margin; sutures distinct, earlier ones limbate and raised; later ones depressed; wall smooth except for the limbate sutures and crenulate margins; aperture narrow, elongate, in the terminal face of the last-formed chamber. Length 0.50-0.62 mm.; breadth 0.20-0.25 mm.; thickness 0.12-0.14 mm.

Holotype (Cushman Coll. No. 47494) from the Eocene, Chacra formation, sample No. S-145, from east bank of road cut on south edge of Talara golf course and at north end of tunnel, Talara, Peru.

This species differs from *B. chirana* Cushman and Stone in the limbate sutures in the early portion and different pattern of the crenulate portion. Its range is from middle to lower Chacra.

Genus UVIGERINA d'Orbigny, 1826

UVIGERINA MINUTA Cushman and Stone, n. sp. (Pl. 10, figs. 5, 6)

Test elongate, initial end subacute, greatest breadth near the middle, apertural end tapering with a distinct neck; chambers inflated, distinct; sutures distinct, depressed; wall distinctly hispid or finely spinose; aperture terminal at the end of a distinct neck with a phialine lip. Length 0.35-0.50 mm.; breadth 0.17-0.20 mm.

Holotype (Cushman Coll. No. 47497) from the Eocene, Chacra formation, sample No. S-145, from east bank of road cut on south edge of Talara golf course, and at north end of tunnel, Talara, Peru.

This species differs from *U. mantaensis* Cushman and Edwards in its smaller and more slender test and from *U. garzaensis* Cushman and Siegfus in its more elongate form. It occurs in the lower part of the Chacra formation where it is very rare.

Genus SIPHOGENERINA Schlumberger, 1883

SIPHOGENERINA SOLITARIA Cushman and Stone, n. sp. (Pl. 10, figs. 7, 8)

Test elongate, stout, about twice as long as broad, rounded at the initial end, apertural end broadly rounded, sides slightly convex, circular in transverse section; chambers of the early triserial portion rather indistinct, later uniserial chambers increasing very gradually in height as added, slightly inflated; sutures distinct, depressed, slightly crenulate; wall ornamented with numerous low, longitudinal costae, not extending across the sutures; aperture terminal, depressed, without a definite lip. Length 0.85-1.05 mm.; diameter 0.50-0.55 mm.

Holotype (Cushman Coll. No. 47511) from the Eocene, Chacra formation, I.P.C. well No. 2779, Square Mile 6-N-7, from cuttings at 1980′, Peru.

This species resembles *S. hughesi* Cushman in general shape but differs in the costate surface, less distinct triserial portion, and lack of a definite neck. It occurs very rarely in the middle to lower Chacra.

Family ELLIPSOIDINIDAE

Genus ELLIPSONODOSARIA A. Silvestri, 1900

ELLIPSONODOSARIA sp. (Pl. 10, fig. 9)

A very few specimens from the Chacra formation evidently belong to this genus. They somewhat resemble *E. curvatura* Cushman but there are not enough specimens to give the full specific characters.

Family ROTALIIDAE

Genus VALVULINERIA Cushman, 1926

VALVULINERIA SUTURALIS Cushman and Stone, n. sp. (Pl. 10, figs. 10, 11)

Test trochoid, biconvex, ventral side somewhat more convex than the dorsal, periphery rounded; chambers distinct, 6 or 8 in the adult whorl, increasing very gradually in size as added, very slightly inflated; sutures distinct, curved, limbate and raised on the dorsal side, on the ventral side slightly depressed, somewhat curved; wall smooth except for the raised sutures on the dorsal side; aperture an elongate opening on the ventral margin of the last-formed chamber with a distinct lobular projection over the umbilical area. Diameter 0.70-0.90 mm.; thickness 0.45-0.55 mm.

Holotype (Cushman Coll. No. 47500) from the Eocene, Chacra for-

mation, sample No. S-145, from east bank of road cut on south edge of Talara golf course and at north end of tunnel, Talara, Peru.

This species differs from *V. floridana* Cushman in the more evolute dorsal side, strongly limbate sutures and much thicker test. It is common and ranges from middle to lower Chacra.

Genus GYROIDINA d'Orbigny, 1826

GYROIDINA SCITA Cushman and Stone, n. sp. (Pl. 10, fig. 12)

Test very small, trochoid, composed of about 2½ whorls, periphery broadly rounded, dorsal side only slightly convex, ventral side deeply umbilicate; chambers numerous, 9 or 10 in the adult whorl, of uniform shape, increasing very gradually in size as added, only slightly inflated; sutures distinct, little if at all depressed, nearly radial in the adult, slightly curved in the early stages; wall smooth; aperture a low opening under the edge of the last chamber on the ventral side. Diameter 0.18-0.20 mm.; thickness 0.10-0.12 mm.

Holotype (Cushman Coll. No. 47501) from the Eocene, Chacra formation, sample No. S-145, from east bank of road cut on south edge of Talara golf course and at north end of tunnel, Talara, Peru.

This species belongs to the group of Gyroidinas represented by *G. scalata* Garrett, *G. planulata* Cushman and Renz, and *G. multilocula* Coryell and Mossman, but differs from all these in its fewer chambers, more rounded periphery, and smaller size. It is rare in the lower Chacra.

Genus EPONIDES Montfort, 1808

EPONIDES cf. MINIMUS Cushman (Pl. 10, fig. 13)

Very rare specimens from the lower part of the Chacra formation are very much like this species which is rather widely recorded in the American Eocene. The dorsal side is somewhat less convex than in the types.

Family CASSIDULINIDAE

Genus CASSIDULINA d'Orbigny, 1826

CASSIDULINA DIVERSA Cushman and Stone, n. sp. (Pl. 10, fig. 14)

Test small, periphery subacute to slightly rounded, chambers distinct, slightly inflated, five pairs making up the adult whorl, only a very small

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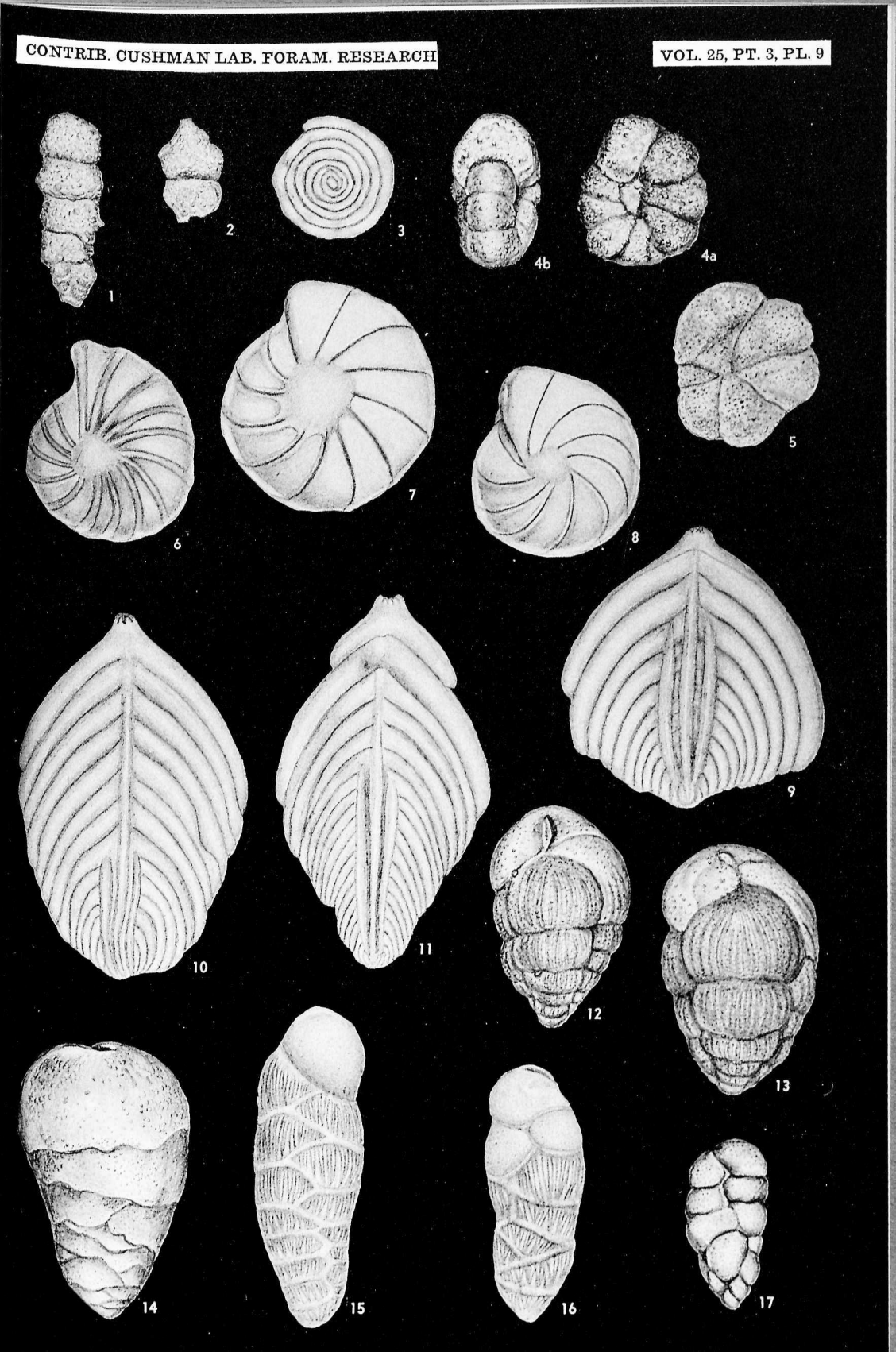
EXPLANATION OF PLATE 9

FIGS. 1, 2. *Reophax* ? sp. × 55. 3. *Ammodiscus restinensis* Berry. × 55. 4. *Haplophragmoides* cf. *mauricensis* Howe and Ellis. × 100. *a*, side view; *b*, apertural view. 5. *Trochammina teasi* Cushman and Ellisor. × 55. 6. *Robulus multiseptae* (Berry). × 35. 7, 8. *R.* cf. *midwayensis* (Plummer). × 55. 9-11. *Frondicularia capitana* Cushman and Stone, n. sp. × 25. 10, Holotype. 9, 11, Paratypes. 12, 13. *Bulimina punctato-costata* Cushman and Stone, n. sp. × 100. 12, Paratype. 13, Holotype. 14. *B. (Desinobulimina) expansa* Cushman and Stone, n. sp. × 35. 15, 16. *Virgulina restinensis* (Berry). × 55. 17. *V. diversa* Cushman and Stone, n. sp. × 55.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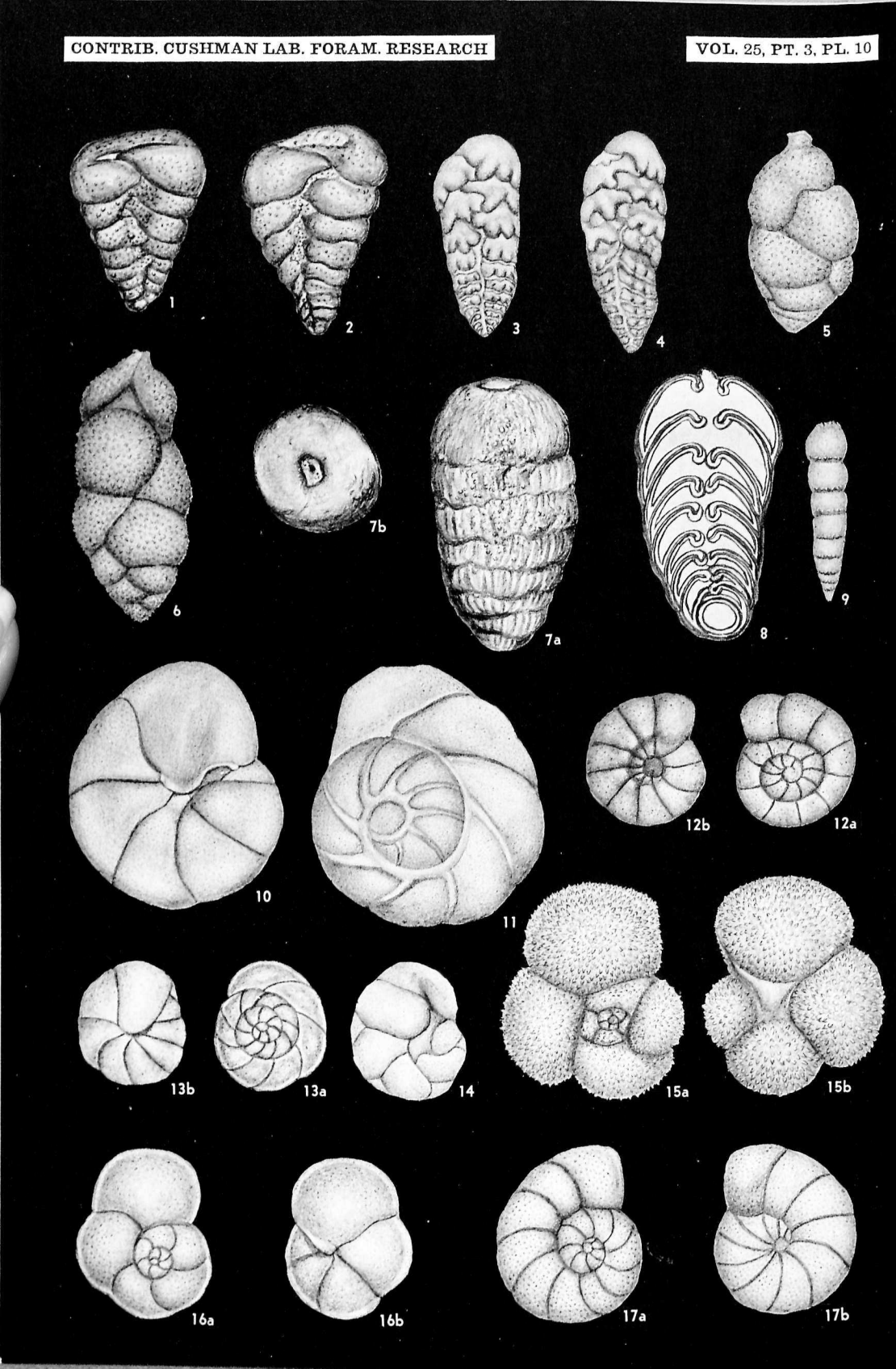
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portion of each set showing on the opposite side at the periphery, very gradually increasing in size as added; sutures distinct, slightly depressed; wall smooth; aperture elongate, on the ventral side of the last-formed chamber. Diameter 0.20-0.27 mm.; thickness 0.10-0.12 mm.

Holotype (Cushman Coll. No. 47503) from the Eocene, Chacra formation, sample No. S-145, from east bank of road cut on south edge of Talara golf course and at north end of tunnel, Talara, Peru.

This is a very small species, differing from *C. crassa* d'Orbigny in the smaller size and broader chambers. It is common in the lower Chacra.

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA cf. PSEUDOBULLOIDES Plummer (Pl. 10, fig. 15)

Specimens occurring commonly in the lower Chacra seem close to this species described from the Paleocene of Texas and recorded also from beds of Wilcox age and perhaps younger in the Eocene.

Family GLOBOROTALIIDAE

Genus GLOBOROTALIA Cushman, 1927

GLOBOROTALIA cf. MEMBRANACEA (Ehrenberg) (Pl. 10, fig. 16)

Very rare specimens in the lower Chacra are very similar to this species described from the Upper Cretaceous and recorded also from the Paleocene and Wilcox Eocene.

Family ANOMALINIDAE

Genus ANOMALINA d'Orbigny, 1826

ANOMALINA RESTINENSIS Berry (Pl. 10, fig. 17)

Anomalina restinensis BERRY, Eclogae geol. Helvetiae, vol. 21, No. 1, 1928, p. 134, pl., fig. 1; No. 2, p. 392.

This species was described from the Eocene, Restin shale, of Peru and recorded from the Lobitos shales. Even though the figures and description are rather inadequate, our specimens seem to be enough like the

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EXPLANATION OF PLATE 10

FIGS. **1, 2.** *Bolivina insueta* Cushman and Stone, n. sp. × 100. 1, Paratype. 2, Holotype. **3, 4.** *B. ignara* Cushman and Stone, n. sp. × 55. 3, Holotype. 4, Paratype. **5, 6.** *Uvigerina minuta* Cushman and Stone, n. sp. × 100. 5, Paratype. 6, Holotype. **7, 8.** *Siphogenerina solitaria* Cushman and Stone n. sp. × 55. 7, Holotoype. *a*, side view; *b*, apertural view. 8, Thin section. **9.** *Ellipsonodosaria* sp. × 55. **10, 11.** *Valvulineria suturalis* Cushman and Stone, n. sp. × 55. 10, Paratype, ventral view. 11, Holotype, dorsal view. **12.** *Gyroidina scita* Cushman and Stone, n. sp. × 100. *a*, dorsal view; *b*, ventral view. **13.** *Eponides* cf. *minimus* Cushman. × 100. *a*, dorsal view; *b*, ventral view. **14.** *Cassidulina diversa* Cushman and Stone, n. sp. × 100. **15.** *Globigerina* cf. *pseudobulloides* Plummer. × 100. *a*, dorsal view; *b*, ventral view. **16.** *Globorotalia* cf. *membranacea* (Ehrenberg). × 100. *a*, dorsal view; *b*, ventral view. **17.** *Anomalina restinensis* Berry. × 100. *a*, dorsal view; *b*, ventral view.

original figures to be assigned to this species. It is very rare in the lower Chacra.

328. *PAVONINOIDES*, A NEW GENUS OF THE MILIOLIDAE FROM PANAMA

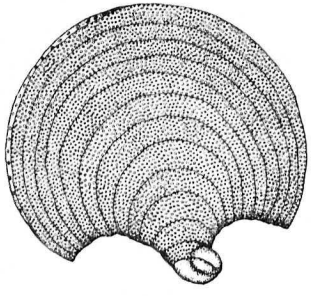
By Pedro J. Bermúdez

In the marly limestone of the Oligocene (probably middle) of Panama were found numerous specimens of this peculiar fragile species of foraminifera of the family Miliolidae. The following new genus and new species is proposed.

Genus PAVONINOIDES Bermúdez, n. gen.

Genotype: *Pavoninoides panamensis* Bermúdez, n. sp.

Test in the early stages triloculine, later uniserial, flabelliform; wall calcareous, imperforate, surface covered with fine granulations; apertures in the adult many small openings in a single line along the periphery of the last chamber.—Oligocene.



Pavoninoides panamensis Bermúdez, n. sp.

Test large, compressed, very thin, flabelliform, chambers numerous, early stages triloculine, later ones uniserial, broad and low, interior undivided; wall calcareous, imperforate, with very fine ornamentation which consists of a regular fine granulation extending over the entire surface of the test; apertures in the adult many small openings in a single line along the periphery of the last chamber. Length 1.75-2.00 mm.; breadth 1.75-2.50 mm.; thickness 0.08-0.10 mm.

Holotype (Cushman Coll. No. 47483) from the Oligocene (probably middle), Madden Lake, Panama Canal Zone.

The form of this genus seems to be similar to that of *Pavonina* of the family Buliminidae but the triloculine initial stage and imperforate wall relate the genus to the Miliolidae.

329. SPECIES OF THE GENERA *ALLOMORPHINA* AND *QUADRIMORPHINA**

By Joseph A. Cushman and Ruth Todd[1]

The subfamily Allomorphininae of the foraminiferal family Chilostomellidae includes the genera *Allomorphina* and *Quadrimorphina,* forms which are trochoid throughout and have three or more chambers per whorl. The subfamily ranges from the Jurassic, where its occurrence is very rare, through the Cretaceous and Tertiary to the Recent. The epoch of its greatest abundance, both in individuals and species, is the Upper Cretaceous. Since then it seems to have been steadily decreasing in abundance, and Recent specimens, while usually large in size, are quite rare.

Genus ALLOMORPHINA Reuss, 1850

Genotype, *Allomorphina trigona* Reuss

Allomorphina Reuss, Denkschr. Akad. Wiss. Wien, vol. 1, 1850, p. 380.—H. B. Brady, Rep. Voy. *Challenger,* Zoology, vol. 9, 1884, p. 437.—Chapman, The Foraminifera, 1902, p. 183.—Cushman, Bull. 71, U. S. Nat. Mus., pt. 4, 1914, p. 3; Bull. 104, pt. 5, 1924, p. 3.—White, Journ. Pal., vol. 2, 1928, p. 304.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 71; Foraminifera, 4th Ed., 1948, p. 318.

Bulimina (part), *Eggerella* (part), and *Chilostomella* (part) of authors.

Test trochoid, adult with three chambers to a whorl; chambers inflated and enlarging rapidly as added, often very involute but not completely enclosing the earliest chambers; wall calcareous, perforate; aperture an elongate arched opening, below the border of the last-formed chamber on the ventral side, sometimes with a slight lip.—Jurassic?, Upper Cretaceous to Recent.

Ecologically, from its Recent records, the genus is a deep-water, probably benthonic, form. It has been recorded from 80 to 805 fathoms. It apparently ranges from tropical to arctic regions.

In our previous study of *Sphaeroidina* it was suggested that that genus had originated in the early Eocene from a *Pullenia* ancestor by the addition of the later chambers in an irregular and more embracing manner. It now seems possible that the genus *Sphaeroidina* originated from an *Allomorphina* ancestor whose chambers became more embracing so that they completely enclosed the spire, and by the changes in the position of the aperture, both with respect to the spire and to the adjacent sutures. Our previous paper (These Contributions, vol. 25, pt. 1, 1949, pp. 12, 13)

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1 This paper was only partly completed at the time of Dr. Cushman's death. Therefore, the responsibility for any errors of fact or interpretation is my own. R. T.

gives a discussion of the structure of *Sphaeroidina,* and figures 2 and 6 on plate 4 in that paper show species of *Sphaeroidina* which may be considered transitional from *Allomorphina. Allomorphina conica,* n. sp., described in the present paper (plate 11, figure 8), likewise may be considered a transitional form tending toward *Sphaeroidina.*

Seventeen species and one variety are here included in *Allomorphina* and are grouped according to geologic age.

JURASSIC SPECIES

ALLOMORPHINA PRIMA Terquem (Pl. 11, fig. 1)

Allomorphina prima TERQUEM, Mém. Soc. géol. France, sér. 3, vol. 4, 1886, p. 64, pl. 7, fig. 20.

"Test oval-oblong, compressed, smooth, anterior end broad, posterior end rounded and narrowed, oval in end view, composed of a large final chamber and three crescent-shaped projecting ones; aperture a straight slit with a bordering lip, at the base of the last chamber. Length 0.78 mm.; breadth 0.70 mm."—Translation.

The types of this species are from the Jurassic, Fuller's Earth, of Wepazow, near Varsovie, France. It has not been recorded elsewhere. We have not found any Allomorphinas in any Jurassic material we have examined, nor have any other Jurassic Allomorphinas been recorded.

From the figure and description this would seem to be definitely an *Allomorphina* and is the earliest record for the genus and family.

CRETACEOUS SPECIES

ALLOMORPHINA OBLIQUA Reuss (Pl. 11, fig. 2)

Allomorphina obliqua REUSS, Haidinger's Nat. Abhandl., vol. 4, pt. 1, 1851, p. 42, pl. 4, fig. 5.—OLSZEWSKI, Sprawozd. Kom. Fizyj. Akad. Umiej. Krakowie, vol. 9, 1875, p. 122.—CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 71.

Test in front view nearly triangular, the base formed by the earlier chambers nearly straight, and the last-formed chamber with the sides convex but the end of the chamber subacute, in end view broadly oval; chambers distinct, the last-formed one making up nearly the whole of the surface of the test, largely covering the earlier ones; sutures slightly depressed; wall smooth; aperture elongate, very narrow, at the base of the last-formed chamber. Length 0.50-0.60 mm.

The types of this species are from the Upper Cretaceous of Lemberg and it has also been recorded from the Upper Cretaceous of Hungary. It is somewhat larger than *A. cretacea* Reuss, the last-formed chamber making up a larger proportion of the test, and the whole very different in shape. We have not found any specimens in the material from Lemberg we have examined.

ALLOMORPHINA CRETACEA Reuss (Pl. 11, figs. 3, 4)

Allomorphina cretacea REUSS, Haidinger's Nat. Abhandl., vol. 4, pt. 1, 1851, p. 42, pl. 4, fig. 6; Sitz. Akad. Wiss. Wien, vol. 44, 1861 (1862), p. 320.—GÜMBEL, Sitz. k.-bay. Akad. Wiss., vol. 2, 1870, p. 287 (list).—KARRER, Jahrb. k. k. geol. Reichs., vol. 20, 1870, p. 182.—OLSZEWSKI, Sprawozd. Kom. Fizyj. Akad. Umiej. Krakowie, vol. 9, 1875, p. 122.—FRANKE, Abhandl. geol.-pal. Inst. Univ. Greifswald, vol. 6, 1925, p. 28, pl. 2, fig. 26.—STORM, Lotos, Prag, vol. 77, 1929, p. 60 (list).—CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 71.

Test ovoid in front view, slightly broader at one end, periphery broadly rounded, broadly elliptical in end view; chambers distinct, strongly involute, the last-formed one making up a large part of the surface and the two preceding ones the remainder; sutures distinct, very slightly depressed; wall smooth; aperture an elongate, narrow slit at the ventral margin of the last-formed chamber, with a very narrow lip. Length 0.33-0.50 mm.

The types of this species are from the Upper Cretaceous of Lemberg. It has been recorded from numerous localities in the Cretaceous of Central Europe. Reuss also recorded it from Cretaceous greensand of New Jersey. Very similar specimens occur in the Upper Cretaceous of California but are unlike the specimens referred to it by Cushman and Church (Proc. Calif. Acad. Sci., ser. 4, vol. 18, 1929, p. 517, pl. 41, figs. 12, 13).

A number of Cretaceous records for *A. trigona* Reuss may belong to *A. cretacea,* but the figures given are not very distinctive, and it would be necessary to examine the original specimens to confirm their identification.

ALLOMORPHINA VELASCOENSIS Cushman (Pl. 11, fig. 5)

Allomorphina velascoensis CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 604, pl. 20, fig. 20; Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 72, pl. 13, fig. 2; U. S. Geol. Survey Prof. Paper 206, 1946, p. 146, pl. 60, fig. 8.

Test small, in dorsal view broadly oval, in side view subtriangular, consisting of a few chambers, 3 making up each coil, the chambers rapidly increasing in size as added, inflated; sutures distinct but only slightly depressed; aperture on the ventral side near the central point, with a distinct, overhanging lip. Length 0.30 mm.; breadth 0.30 mm.; thickness 0.22 mm.

The types are from the Velasco shale (Upper Cretaceous), of the Tampico Embayment region of Mexico. The other records for the species from Colombia and Trinidad probably belong elsewhere, but a larger series of specimens is needed to determine their specific position with certainty.

ALLOMORPHINA NAVARROANA Cushman (Pl. 11, fig. 6)

Allomorphina navarroana CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, 1936,

p. 73, pl. 13, fig. 1.—CUSHMAN and TODD, l. c., vol. 19, 1943, p. 70, pl. 12, fig. 9.—CUSHMAN, U. S. Geol. Survey Prof. Paper 206, 1946, p. 145, pl. 60, fig. 5.

Test of rather small size, trochoid, slightly longer than broad, height and breadth about equal, spire low but test not much compressed, periphery generally rounded; chambers distinct, very slightly inflated in early portion, last two of the final whorl making up a very large proportion of the test, triserially arranged in the young, almost biserial in the adult; sutures distinct, very slightly depressed; wall smooth, finely perforate; aperture ventral, elongate, low, with a distinct, overhanging lip. Length 0.30-0.35 mm.; breadth 0.25 mm,; thickness 0.25 mm.

The types are from the Corsicana marl (Upper Cretaceous), Corsicana marl pit near Corsicana, Navarro County, Tex. It is also recorded from other localities in the Corsicana marl and Kemp clay of Texas.

It differs from *A. velascoensis* Cushman in the lower, less pointed spire, and less inflated chambers with the last two making up a very large part of the test. The species tends toward *Chilostomella.*

ALLOMORPHINA MINUTA Cushman (Pl. 11, fig. 7)

Allomorphina minuta CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 72, pl. 13, fig. 3; vol. 20, 1944, p. 14, pl. 3, fig. 7; U. S. Geol. Survey Prof. Paper 206, 1946, p. 145, pl. 60, fig. 6.

Test small, trochoid, with a depressed spire, ventral side flattened, or slightly convex, dorsal side slightly convex, periphery rounded; chambers triserially arranged, enlarging rapidly as added, slightly inflated; sutures rather indistinct, except in the last whorl, very slightly depressed; wall smooth, distinctly perforate; aperture on the ventral side with a distinct, arched, overhanging lip. Length 0.15 mm.; breadth 0.12 mm.; height 0.08 mm.

The types are from the Gober tongue of the Austin chalk, public road, east of junction with U. S. Highway 69, in east-facing slope, 1 mile east of Trenton, Fannin County, Tex. Other occurrences include the typical Austin chalk and the Pecan Gap chalk member of the Taylor marl.

It differs from *A. velascoensis* Cushman in its smaller size and greatly depressed spire.

ALLOMORPHINA CONICA Cushman and Todd, n. sp. (Pl. 11, fig. 8)

Bulimina (?) *trochoides* CUSHMAN (not "*Globigerina trochoides* REUSS"), Tenn. Div. Geol., Bull. 41, 1931, p. 48, pl. 7, fig. 20.

Allomorphina trochoides CUSHMAN and JARVIS (not "*Globigerina trochoides* REUSS"), Proc. U. S. Nat. Mus., vol. 80, Art. 14, 1932, p. 49, pl. 15, fig. 3.—CUSHMAN (part), U. S. Geol. Survey Prof. Paper 206, 1946, p. 145, pl. 60, fig. 7.—CUSHMAN and RENZ, Special Publ. 18, Cushman Lab. Foram. Res., 1946, p. 46, pl. 8, fig. 6; l. c., Contr., vol. 23, 1947, p. 49.

Eggerella (?) *trochoides* CUSHMAN (part) (not "*Globigerina trochoides* REUSS"), Special

Publ. 8, Cushman Lab. Foram. Res., 1937, p. 46, pl. 5, fig. 1 (not fig. 2); U. S. Geol. Survey Prof. Paper 206, 1946, p. 43, pl. 12, fig. 2.—CUSHMAN and RENZ, Special Publ. 18, Cushman Lab. Foram. Res., 1946, p. 22, pl. 2, fig. 20; l. c., Contr., vol. 23, 1947, p. 39.—CUSHMAN, Bull. 2, Maryland Dept. Geol., Mines and Water Resources, 1948, p. 247, pl. 21, fig. 10.

Test triserial, consisting of a small, sharply conical early portion, and an inflated later portion made up of the last three chambers in the adult; chambers indistinct in the early portion, strongly embracing, becoming increasingly inflated and subglobular; sutures distinct and depressed in the later portion, early sutures obscure; wall smooth and polished, very finely perforate; aperture an elongate, slightly arched slit under the ventral edge of the last-formed chamber. Length 0.40 mm.; breadth 0.35-0.38 mm. (measured in conventional position for *Allomorphina*); greatest dimension from tip of spire 0.45-0.48 mm.

Holotype (Cushman Coll. No. 15458) from the Lizard Springs formation (Upper Cretaceous), pit at Lizard Springs, near Guayaguayare, SE. Trinidad, B.W.I.

Although there has been considerable confusion about this form, it seems to be properly included in this genus, and may provide a clue to the connecting link between *Allomorphina* and *Sphaeroidina.*

The original description and figures of "*Globigerina trochoides* Reuss" fail to indicate definitely whether the species is a calcareous or an agglutinated one. Only "very fine roughness" is mentioned. It was described from the Planermergel of Luschitz. We have been unable to find any specimens referable to it in a considerable amount of Luschitz material examined, nor in any other European Upper Cretaceous material.

In the American Upper Cretaceous material, however, there seem to be two separate forms, one a finely arenaceous isomorph of the other, both of which have been referred to under Reuss' specific name of *trochoides: Eggerella ? trochoides* (Reuss) (Cushman, U. S. Geol. Survey Prof. Paper 206, 1946, p. 43, pl. 12, fig. 2) and *Allomorphina trochoides* (Reuss) (Cushman, l. c., p. 145, pl. 60, fig. 7).

It would be necessary to examine the types of Reuss' "*Globigerina trochoides*" to determine in what genus his form belongs. Lacking such examination we are erecting the new species *conica* for those Upper Cretaceous forms of North America and Trinidad which we have examined and which seem to belong in *Allomorphina.* These records include the Lizard Springs formation of Trinidad, the Selma formation of Tennessee; the Annona chalk, Taylor marl and Pecan Gap chalk member of the Taylor marl of Texas, and well samples from the Upper Cretaceous strata of Maryland.

ALLOMORPHINA WHANGAIA Finlay (Pl. 11, figs. 9-13)

Allomorphina whangaia FINLAY, Trans. Roy. Soc. New Zealand, vol. 69, 1940, p. 468, pl. 66, figs. 193-197.

"Small, inflated, sub-trigonal; spire very depressed, little raised above surface of last whorl, 3 closely knit chambers per coil. Somewhat bulbous, but base flattened, not globular as in *trochoides;* aperture at junction of chambers about half width of shell, hidden by thin sinuous lip projecting from last chamber. Size, 0.4 mm."—Finlay.

The types are from the Upper Cretaceous, Panikau Dome, Whangara, New Zealand, and it is recorded from other Cretaceous localities in New Zealand, ranging in age from Santonian to Campanian.

It differs from *A. minuta* Cushman in the less compressed test and differently shaped chambers.

TERTIARY SPECIES

ALLOMORPHINA GLOBULOSA Plummer (Pl. 11, fig. 14)

Allomorphina globulosa PLUMMER, Univ. Texas Bull. 2644, 1926 (1927), p. 130, pl. 8, fig. 4.

"Test bluntly ellipsoidal, last three chambers only partly embracing on superior face thus revealing the inner whorl; chambers very smooth and thin shelled; sutures not depressed; aperture a narrow slit at base of final chamber and protected by a conspicuous, somewhat flaring lip. Length of only specimen .35 mm."

The type of this species is from the Midway (Paleocene), from a gully close to the short NW-SE road about 2½ miles S. 25° E. of Littig, Tex. The species is based on a single specimen and there are no further records for it.

ALLOMORPHINA SUBTRIANGULARIS (Kline) (Pl. 11, fig. 15)

Chilostomella subtriangularis KLINE, Bull. 53, Mississippi State Geol. Survey, 1943, p. 56, pl. 6, fig. 3.

EXPLANATION OF PLATE 11

FIG. 1. *Allomorphina prima* Terquem. (After Terquem). × 30. *a,* ventral view; *b,* peripheral view. 2. *A. obliqua* Reuss. (After Reuss). × 40-50. *a,* ventral view; *b,* end view. 3, 4. *A. cretacea* Reuss. 3, (After Reuss). × 55-80. *a,* ventral view; *b,* dorsal view; *c,* end view. 4, Cretaceous, California. × 35. *a,* ventral view; *b,* peripheral view. 5. *A. velascoensis* Cushman. Holotype. × 100. *a,* dorsal view; *b,* peripheral view. 6. *A. navarroana* Cushman. Holotype. × 100. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. 7. *A. minuta* Cushman. Holotype. × 100. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. 8. *A. conica* Cushman and Todd, n. sp. Holotype. × 58. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. 9-13. *A. whangaia* Finlay. (After Finlay). × 45. 9, 11, Dorsal views; 10, 12, 13, Ventral views. 14. *A. globulosa* Plummer. (After Plummer). ×45. *a,* dorsal view; *b,* ventral view. 15. *A. subtriangularis* (Kline). (After Kline). × 37. Ventral view. 16. *A. paleocenica* Cushman. Holotype. × 58. *a,* dorsal view; *b,* ventral view. 17. *A. abbreviata* Terquem. (After Terquem). × 35. *a,* dorsal view; *b,* ventral view. 18. *A. halli* Jennings. (After Jennings). × 95. *a,* dorsal view; *b,* ventral view. 19, 20. *A. cubensis* Palmer and Bermudez. (After Palmer and Bermudez). × 23. 19, Apertural view. 20, Opposite side.


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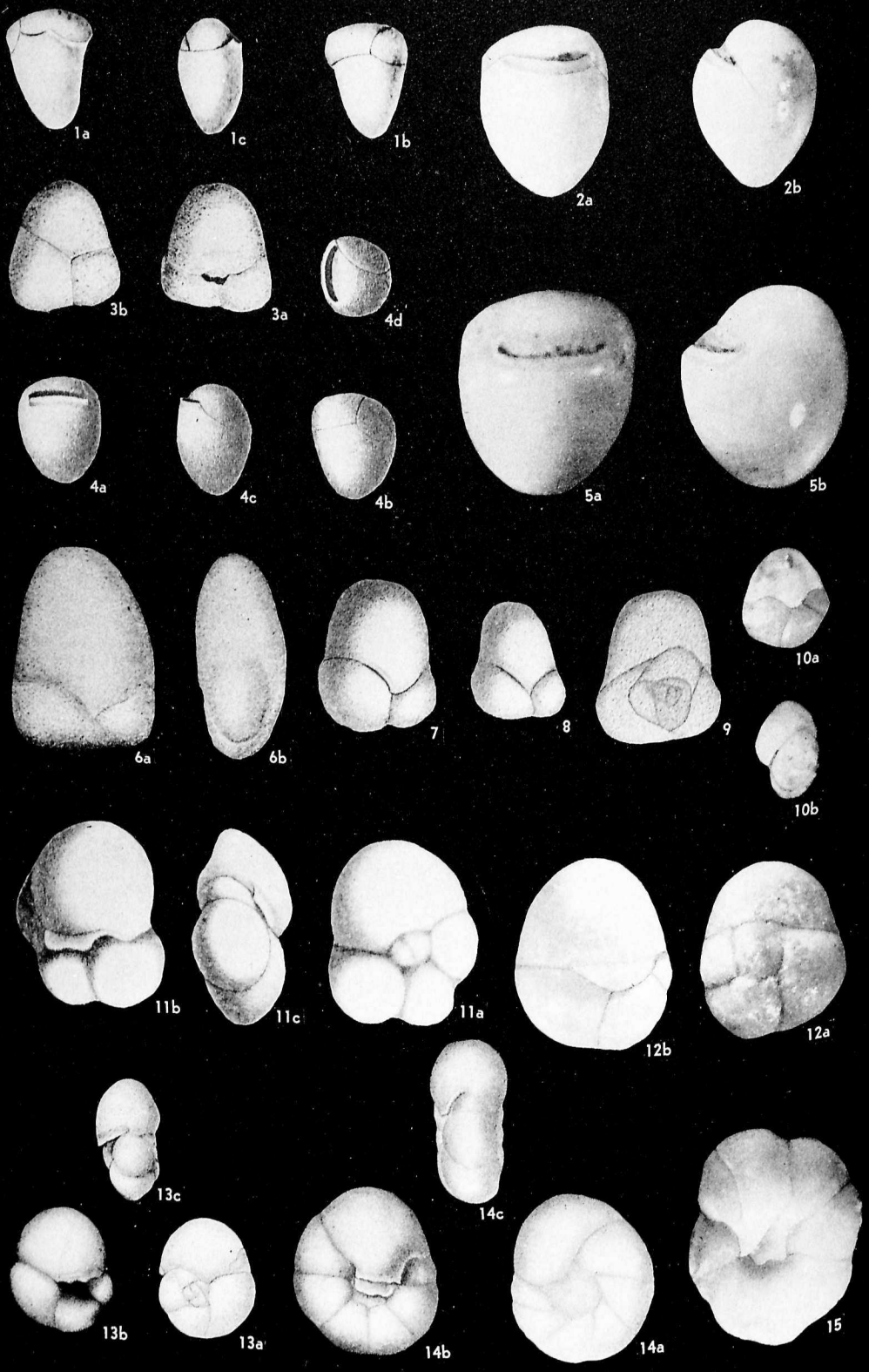
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"Test subtriangular, about one and one-half times as long as broad, greatest width a little above middle, ends bluntly rounded; wall smooth, finely punctate; aperture narrow, nearly straight. Average length 0.75 mm."

The types are from the Porters Creek clay (Paleocene), 1½ miles NW. of Montpelier, Clay County, Miss.

The dorsal side of specimens shows the chambers to be arranged in a triserial manner and the species seems to belong in *Allomorphina*. We have specimens from the Paleocene of Texas and Arkansas that seem identical with this species.

ALLOMORPHINA PALEOCENICA Cushman (Pl. 11, fig. 16)

Allomorphina paleocenica CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 24, 1948, p. 45, pl. 8, fig. 10.

Allomorphina trigona PLUMMER (not REUSS), Univ. Texas Bull. 2644, 1926 (1927), p. 129, pl. 8, fig. 5.—KLINE, Bull. 53, Mississippi State Geol. Survey, 1943, p. 56, pl. 6, figs. 1, 2.—CUSHMAN and TODD, Contr. Cushman Lab. Foram. Res., vol. 22, 1946, p. 63, pl. 11, figs. 11, 15.

Test semi-elliptical in outline, trochoid, one side nearly straight, the others strongly curved, periphery broadly rounded; chambers distinct, slightly inflated, three in a whorl in the adult, increasing very rapidly in size as added; sutures distinct, slightly depressed; wall smooth; aperture an elongate opening on the ventral side at the base of the last-formed chamber with distinct, overhanging lip. Length 0.35-0.45 mm.; breadth 0.25-0.30 mm.; thickness 0.22-0.27 mm.

The types are from the Paleocene, 4.6 miles N. of Fentress, Caldwell County, Tex. It also occurs in the Paleocene of Alabama, Mississippi, and Arkansas.

EXPLANATION OF PLATE 12

FIGS. 1, 2. *Allomorphina trigona* Reuss. 1, (After Reuss). × 40-45. *a*, ventral view; *b*, dorsal view; *c*, peripheral view. 2, Miocene, Möllersdorf, near Baden, Austria. × 50. *a*, ventral view; *b*, peripheral view. 3. *A. trigona* Reuss, var. *obtusa* Andreae. (After Andreae). × 50. *a*, ventral view; *b*, dorsal view. 4, 5. *A. macrostoma* Karrer. 4, (After Karrer). *a*, ventral view; *b*, dorsal view; *c*, peripheral view; *d*, end view. 5, Recent, off Philippines. × 35. *a*, ventral view; *b*, peripheral view. 6-9. *A. pacifica* Cushman and Todd, n. sp. 6, Holotype. × 140. *a*, ventral view; *b*, peripheral view. 7-9, (After H. B. Brady). 7, 8, Ventral views, × 55. 9, Specimen mounted in Canada balsam and viewed by transmitted light, showing the arrangement of the chambers. × 95. 10-12. *Quadrimorphina allomorphinoides* (Reuss). 11, Type figures. (After Reuss). × 65. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. 10, 12, Upper Cretaceous, lower Senonian, Westphalia, Germany. × 50. 10*a*, ventral view; *b*, peripheral view. 12*a*, dorsal view; *b*, ventral view. 13. *Q. advena* (Cushman and Siegfus). Holotype. × 35. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. 14. *"Valvulineria allomorphinoides* (Reuss)" of Cushman and Jarvis = *"Rotamorphina cushmani* Finlay" = *Valvulineria*. Upper Cretaceous, Trinidad. × 30. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. 15. *Valvulineria californica* Cushman. × 35. Ventral view showing overlapping umbilical flaps.

It differs from *A. trigona* Reuss in the much broader form and the wide aperture.

In the original description of *A. paleocenica,* an error in the use of the type figures was made. Figure 10*b* is not the ventral view of the holotype but instead a figure copied from Cushman and Todd (Contr. Cushman Lab. Foram. Res., vol. 22, 1946, p. 63, pl. 11, fig. 11) of a specimen from the Paleocene of Arkansas. On our present plate this error is corrected and figures 16*a* and *b* are the dorsal and ventral views of the holotype of *A. paleocenica;* the ventral view, figure 16 *b,* being first published here.

ALLOMORPHINA HALLI Jennings (Pl. 11, fig. 18)

Allomorphina halli Jennings, Bull. Amer. Pal., vol. 23, No. 78, 1936, p. 34, pl. 4, fig. 5. —Brotzen, Sver. Geol. Under., ser. C, No. 493, 1948, p. 127, pl. 19, fig. 4; text figs. 39-41.

Allomorphina trigona Franke (not Reuss), Danmarks Geol. Unders. II, Raekke, No. 46, 1927, p. 12, pl. 1, fig. 11.

"Test bluntly triangular in outline; biconvex, slightly compressed; periphery broadly rounded, chambers few, 3 or 4 in the final whorl; sutures depressed, shell wall thin, smooth; aperture a slit beneath a flap at the base of final chamber on the ventral side. Diameter, 0.35 mm.; thickness, 0.23 mm."—Jennings.

The types are from the Hornerstown marl (Eocene), tributary to Crosswicks Creek, south of New Egypt, New Jersey. The species has been recorded from the Paleocene of Denmark and Sweden.

In his original description Jennings referred to Mrs. Plummer's *Allomorphina trigona* (not Reuss) (Univ. Texas Bull. 2644, 1926 (1927), p. 129, pl. 8, fig. 5). Although no material of *A. halli* has been available for comparison, the Texas material seems to be quite different from that from New Jersey, differing in its much larger last-formed chamber and much smaller earlier chambers, and its more triangular form.

ALLOMORPHINA ABBREVIATA Terquem (Pl. 11, fig. 17)

Allomorphina abbreviata Terquem, Mém. Soc. géol. France, sér. 3, vol. 2, 1882, p. 138, pl. 14 (22), fig. 22.

"Test short, smooth, ovate, anterior end broad, posterior end narrow, obtuse; first four chambers small, rounded, the last-formed one enlarged, triangular; aperture narrow, with a very slight lip. Length 0.50 mm.; breadth 0.40 mm."—Translation.

The types are from the Eocene of Vaudancourt, Paris Basin, France, where it was recorded as very rare. We have failed to find specimens in the material from Vaudancourt that we have examined.

ALLOMORPHINA CUBENSIS Palmer and Bermúdez (Pl. 11, figs. 19, 20)

Allomorphina cubensis PALMER and BERMÚDEZ, Mem. Soc. Cubana Hist. Nat., vol. 10, 1936, p. 308, pl. 14, figs. 10, 11.

"Test small, smooth and very thin-shelled; circular in section; oval in side view. Three chambers exposed; strongly embracing so that only a small portion of the third chamber appears. Sutures very slightly but distinctly depressed. Aperture an elongate slit situated approximately one-third the distance from the narrower end of the test and bearing a broad, flaring lip. Length 0.55 mm.; maximum breadth 0.3 mm."—Palmer and Bermúdez.

The types are from the Oligocene of Cuba.

It differs from *A. globulosa* Plummer in its oval instead of elliptical shape, somewhat larger and more flaring aperture and more depressed sutures. It is recorded as rare at the type locality and not recorded elsewhere.

ALLOMORPHINA TRIGONA Reuss (Pl. 12, figs. 1, 2)

Allomorphina trigona REUSS, Denkschr. Akad. Wiss. Wien, vol. 1, 1850, p. 380, pl. 48, fig. 14.

Test with one end broadly rounded, the opposite end much contracted but rounded, broadly oval in end view; chambers distinct, the last-formed one making up a large part of the surface, the two earlier ones extending laterally beyond the breadth of the base of the last-formed chamber, one nearly twice as large as the preceding; sutures distinct, slightly depressed; wall smooth; aperture a somewhat arched, elongate opening at the ventral margin of the last-formed chamber extending from the periphery to the middle of the ventral face. Length 0.50-0.70 mm.

The types are from the Miocene of Baden, near Vienna, Austria, and it was also recorded from Möllersdorf and Grinzing, near Vienna, and from Wieliczka in Galicia. We have abundant topotypes from Möllersdorf and additional specimens which seem to be the same, although considerably larger, from the Septaria clay (Oligocene), from Cöthen, Anhalt, Germany.

There are many fossil and Recent records for this species, mostly without figures, but where figures are given most of them are definitely not the same as the typical form from the Miocene of the Vienna Basin.

ALLOMORPHINA TRIGONA Reuss, var. OBTUSA Andreae (Pl. 12, fig. 3)

Allomorphina trigona REUSS, var. *obtusa* ANDREAE, Abhandl. Geol. Special-Karte Elsass-Lothringen, vol. 2, 1884, p. 133, pl. 7, fig. 11.

Variety differing from the typical in the broader form, and more inflated chambers. Length 0.4 mm.

The types are from the Oligocene of Heiligenstein, Alsace, France.

ALLOMORPHINA MACROSTOMA Karrer (Pl. 12, figs. 4, 5)

Allomorphina macrostoma KARRER, Sitz. Akad. Wiss. Wien, vol. 44, 1861 (1862), p. 448, pl. 2, fig. 4.—NUTTALL, Journ. Pal., vol. 9, 1935, p. 129, pl. 15, fig. 28.—CUSHMAN and TODD, Special Publ. 15, Cushman Lab. Foram. Res., 1945, p. 64, pl. 11, fig. 3.

Allomorphina cf. *macrostoma* CUSHMAN and MCMASTERS, Journ. Pal., vol. 10, 1936, p. 516, pl. 76, fig. 7.—RAU, l. c., vol. 22, 1948, p. 173, pl. 31, figs. 4, 5.

Test in front view with one end slightly curved and very broadly rounded, the opposite end rounded but narrower, periphery very broadly rounded, ventral side slightly less convex than the dorsal side, nearly circular in end view; chambers fairly distinct, the last-formed chamber making up almost the entire ventral surface, the two earlier chambers projecting only slightly; sutures rather indistinct, not depressed; wall smooth; aperture a moderately arched elongate opening extending nearly across the ventral side, at the base of the last-formed chamber, with a distinct overhanging lip. Length 0.45-0.60 mm.; breadth 0.35-0.50 mm.

The types are from the Miocene of the Vienna Basin. There are typical specimens in our collection from Voslau near Vienna. Specimens from the Miocene of Buff Bay, Jamaica, are very similar. Many of the Miocene species of the two areas are identical. Other records included in the above synonymy are from the upper Eocene of Venezuela, Llajas formation (middle Eocene), of California, and the Porter shale (Lincoln formation of Weaver) (upper Eocene ?), of Washington. Other specimens figured and referred to this species from other areas are evidently not the same. The figured specimen from Recent dredgings off the Philippines is very close to if not identical with this species, but is somewhat larger.

A. macrostoma and *A. trigona* are very close but seem to be separable on the following characters: *A. macrostoma* is a more compact form with the two earlier chambers almost indistinguishable and not at all projecting out from the general outline of the test; and in *A. macrostoma* the aperture is more widely open and in side view projects out farther from the general oval outline of the test.

ALLOMORPHINA PACIFICA Cushman and Todd, n. sp. (Pl. 12, figs. 6-9)

Allomorphina trigona H. B. BRADY (not REUSS), Quart. Journ. Micr. Sci., vol. 19, 1879, p. 67, pl. 8, figs. 13, 14; Rep. Voy. *Challenger,* Zoology, vol. 9, 1884, p. 438, pl. 55, figs. 24-26.—EGGER, Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 305, pl. 9, figs. 3, 4.—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 4, 1914, p. 3, pl. 1, figs. 6-8; Bull. 100, vol. 4, 1921, p. 284; Bull. 104, pt. 5, 1924, p. 4, pl. 1, figs. 11-13.—THALMANN, Eclogae geol. Helvetiae, vol. 25, 1932, p. 303.—CUSHMAN, Special Publ. 4, Cushman Lab. Foram. Res., 1933, pl. 26, fig. 7; Special Publ. 5, 1933, pl. 33, fig. 8; Bull. 27, Bernice P. Bishop Mus., 1925 (1926), p. 133, pl. 17, fig. 2; Foraminifera, 3rd Ed., 1940, pl. 26, fig. 7; Key, pl. 33, fig. 8.

Valvulineria aff. *allomorphinoides* LEROY, Colorado School Mines Quart., vol. 39, No. 3, pt. 2, 1944, p. 87, pl. 3, figs. 21-23.

Test with one end somewhat broader than the other and nearly straight but somewhat incised in the middle, the opposite end broadly rounded; chambers very distinct, inflated, the last-formed one making up a large part of the test but the preceding two chambers inflated, one only slightly larger than the preceding one, the last-formed chamber extending backward on the ventral side in the middle of the test forming a distinct projecting angle; sutures distinct, depressed on the ventral side; wall smooth; aperture a low, narrow opening at one side of the ventral angle of the last-formed chamber. Length of holotype 0.23 mm.; breadth 0.17 mm. Length of Recent specimens 0.33-0.46 mm.; breadth 0.26-0.37 mm.

Holotype (Cushman Coll. No. 23887) from the Pliocene, marl about 1¾ miles SSE. of Suva Post Office, Fiji.

Brady recorded the species from two *Challenger* stations, in 345 fathoms, south of Japan, and 620 fathoms, off Tahiti, Society Islands. LeRoy's record from the Miocene of West Java seems to be the same.

The species is apparently limited to the Pacific area. It differs from *A. trigona* Reuss in the larger proportion of the surface occupied by the earlier chambers, their more nearly equal size, and the projection of the ventral side of the last-formed chamber with the aperture at one side of the projection.

Genus QUADRIMORPHINA Finlay, 1939

Genotype, *Valvulina allomorphinoides* Reuss

Quadrimorphina FINLAY, Trans. Roy. Soc. New Zealand, vol. 69, 1939, p. 325.

Gyromorphina MARIE, 1941.

Valvulina (part), *Allomorphina* (part), and *Valvulineria* (part) of authors.

Test similar to *Allomorphina* but with four chambers to the whorl.—Cretaceous and Tertiary.

Only three species are here included in this genus. Others will undoubtedly be recognized among the already known species assigned to *Valvulineria.*

QUADRIMORPHINA ALLOMORPHINOIDES (Reuss) (Pl. 12, figs. 10-12)

Valvulina allomorphinoides REUSS, Sitz. Akad. Wiss. Wien, vol. 40, 1860, p. 223, pl. 11, fig. 6.

Allomorphina allomorphinoides WHITE, Journ. Pal., vol. 2, 1928, p. 304, pl. 41, fig. 8.

Valvulineria allomorphinoides CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 43, pl. 6, fig. 2; Tenn. Div. Geol., Bull. 41, 1931, p. 53, pl. 9, fig. 6.—MOROZOVA, Bull. Soc. naturalistes Moscou, n. ser., vol. 47, sec. geol., vol. 17, 1939, p. 78, pl. 2, figs. 21, 22.—KLINE, Bull. 53, Mississippi State Geol. Survey, 1943, p. 52, pl. 5, figs. 11, 12.—CUSHMAN (part), U. S. Geol. Survey Prof. Paper 206, 1946, p. 138, pl. 57, fig. 6 (not fig. 7).

Quadrimorphina allomorphinoides FINLAY, Trans. Roy. Soc. New Zealand, vol. 69, 1939, p. 325, pl. 28, figs. 128,129.

"The species at first glance is very similar in outline to *Allomorphina trigona* Reuss. The test is compressed oviform, occasionally approaching rounded-triangular, periphery rounded angular, on both surfaces [dorsal and ventral] moderately and quite equally inflated.

"There are only two whorls visible, of which the inner one is very small and is represented by only a very flat little knob, on which sometimes a division is indicated by a very shallow furrow. The outer whorl increases very quickly in width and comprises the greatest part of the test. It consists of only four rounded chambers the last of which is very large and comprises more than half the entire test. They are moderately inflated and are outwardly separated only by very shallow sutures. In most cases the last chamber stands out more. The aperture is concealed by a rather broad lip-like projecting process, either truncated or somewhat curved at the edge."—Translation.

The species was described from a number of localities in Westphalia, Germany, of upper and lower Senonian age. We have fairly common to abundant specimens of this species from many Upper Cretaceous localities in Germany. Our specimens vary in size from 0.25 to 0.65 mm. in length.

Very similar specimens occur in the Upper Cretaceous of North America and do not seem to be distinguishable in any way. They are from the Neylandville marl, Taylor marl, Brownstown marl, Austin chalk, and Gober tongue of the Austin chalk, all of Texas, and the Arkadelphia marl of Arkansas, and the Selma chalk of Alabama and Tennessee. The same species also occurs rather rarely in the Paleocene of Texas and Arkansas.

Other records in the above synonymy include the Upper Cretaceous of Mexico and Antigua, the lower Eocene of the Emba region of Russia, and the Paleocene of Mississippi.

QUADRIMORPHINA MONTERELENSIS (Marie)

Gyromorphina monterelensis MARIE, Mém. Mus. Nation. Hist. Nat., n. sér., vol. 12, pt. 1, 1941, p. 231, pl. 35, figs. 332a-e.

"Test subglobular, trochoid, composed of a terminal whorl of 4 chambers, globular, crescent-shaped and strongly embracing, entirely enclosing those of the previous whorls. Sutures flush or slightly depressed. Wall calcareous, finely perforate, polished. Aperture ventral, elongated along the inner margin of the last chamber, which is slightly cleft in the middle. Dimensions: height 0.215 mm.; length 0.235 mm.; thickness

0.200 mm.; height of the first visible chamber 0.135 mm."—Translation.

This species was described as extremely rare (2 specimens) from the Craie à *Belemnitella mucronata,* Zone II (Upper Cretaceous), at Montereau, France.

QUADRIMORPHINA ADVENA (Cushman and Siegfus) (Pl. 12, fig. 13)

Valvulineria advena CUSHMAN and SIEGFUS, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 31, pl. 6, fig. 22; Trans. San Diego Soc. Nat. Hist., vol. 9, 1942, p. 418, pl. 17, fig. 30.

"Test trochoid, unequally biconvex, dorsal side less convex than the ventral, somewhat compressed, periphery rounded; chambers few, four in the adult whorl, of uniform shape, enlarging rapidly in size as added, the last-formed one making up nearly half the surface of the test; sutures distinct, slightly depressed, very slightly curved and nearly tangential on the dorsal side, ventrally nearly radial; wall smooth, conspicuously perforate; aperture a fairly large opening over the depressed umbilical region on the ventral side with a narrow but distinct overhanging lip. Length 0.50 mm.; breadth 0.45 mm.; thickness 0.30 mm."—Cushman and Siegfus.

The type is from the Kreyenhagen shale (Eocene), of Little Tar Canyon, Calif., and the species appears to be based on this single specimen. Examination of the type indicates that it should be placed in *Quadrimorphina.* It differs from *Q. allomorphinoides* (Reuss) in its less rapid increase in size so that the last-formed chamber comprises less than half of the test and does not project strongly out from the general outline of the test. The test is consequently more circular and not elongate, and is more compressed in side view.

At the time of erecting the genus *Quadrimorphina,* Finlay also erected the genus *Rotamorphina* (genotype *R. cushmani* n. sp.) from the Upper Cretaceous of New Zealand. He referred to this new species the specimen figured under the name of *Valvulineria allomorphinoides* (Reuss) from the Upper Cretaceous of Trinidad (Cushman and Jarvis, Proc. U. S. Nat. Mus., vol. 80, Art. 14, 1932, p. 46, pl. 13, fig. 17). We have examined this latter specimen together with the type figures and description of *Rotamorphina cushmani* Finlay (Trans. Roy. Soc. New Zealand, vol. 69, 1939, p. 325, pl. 28, figs. 130-133) and agree that they are probably the same. It seems, however, that they are not related to the Allomorphininae but belong instead to the genus *Valvulineria.* The Upper Cretaceous form from Trinidad (see our plate 12, fig. 14) shows very excellently the depressed pad-like umbilical flap rather than the more simple umbilicus

with a free lip extending over it, as is characteristic of *Allomorphina* and *Quadrimorphina*. In this connection we have figured a topotype of *Valvulineria californica* Cushman (plate 12, fig. 15) to show the typical aperture of that genus. The umbilicus is covered by a series of umbilical flaps, one above the other, as each chamber has a lobe extending over the umbilicus. With proper lighting it is frequently possible to see the edges of two or three of these flaps beneath one another. The difference between the *Allomorphina-Quadrimorphina*-type of aperture and the *Valvulineria*-type of aperture is best seen in peripheral view where the chamber may be seen to have a convex curve down to the edge of the lobe in the first case, and a concave curve extending out over the pad-like umbilical flap in the second case. Therefore, we believe that the genus *Rotamorphina* is not different from *Valvulineria,* and the form from the Upper Cretaceous of Trinidad should be renamed as "*Valvulineria cushmani*" is already preoccupied.

RECENT LITERATURE ON THE FORAMINIFERA

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

Wood, A. The Structure of the Wall of the Test in the Foraminifera; its Value in Classification.—Quart. Journ. Geol. Soc., London, vol. 104, pp. 229-255, pls. 13-15, Jan. 31, 1949.—The microstructure of the wall, studied with the aid of polarized light, is described for all the main groups of Foraminifera and it is shown that perforation of the wall may occur in any group.

Cuvillier, J., and **V. Szakall.** Foraminiferes d'Aquitaine, Premiere Partie (Reophacidae a Nonionidae).—Societe Nationale des Petroles d'Aquitaine, April 30, 1949, 113 pp., 32 pls.—Five hundred and nineteen species and varieties recorded and mostly described and figured, 14 new, and one new genus, *Daxia* (genotype *D. cenomana* n. sp.).

Loeblich, Alfred R., Jr., and **Helen Tappan.** Foraminifera from the Walnut Formation (Lower Cretaceous) of Northern Texas and Southern Oklahoma.—Journ. Pal., vol. 23, No. 3, May, 1949, pp. 245-266, pls. 46-51.—Forty-seven species are described and figured, 13 new, and 2 new genera are erected: *Buccicrenata* (genotype *Ammobaculites subgoodlandensis* Vanderpool) and *Histopomphus* (genotype *Globulina redriverensis* Tappan).

Cole, W. Storrs. Upper Eocene Larger Foraminifera from the Panama Canal Zone.—L. c., pp. 267-275, pls. 52-55.—Ten species are described and figured, none new. One new name, *Lepidocyclina (L.) montgomeriensis,* is proposed.

Thalmann, Hans E. Bibliography and index to new genera, species and varieties of Foraminifera for the year 1947.—L. c., No. 4, July, 1949, pp. 395-418.

Stainforth, R. M. Foraminifera in the Upper Tertiary of Egypt.—L. c., pp. 419-422.—Twenty-three species are recorded and the age of the beds is discussed.

R. T.