CONTRIBUTIONS

FROM THE

CUSHMAN LABORATORY

FOR

FORAMINIFERAL RESEARCH

VOLUME 25, PART 2
June, 1949

Contents

SHARON, MASSACHUSETTS, U. S. A.
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CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

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These Contributions will be issued quarterly. They will contain short papers with plates, describing new forms and other interesting notes on the general research work on the foraminifera being done on the group by the workers in this laboratory. New literature as it comes to hand will be briefly reviewed.

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Copies of Volume 25, part 2 were first mailed June 4, 1949

DORR'S PRINT SHOP, BRIDGEWATER, MASSACHUSETTS, U. S. A.

Joseph A. Cushman
1881 - 1949

This Laboratory has suffered an irreparable loss in the death on April 16, 1949, of its founder and Director.

The work of the Laboratory will continue through the present year, carrying out to completion some of the works left unfinished at Dr. Cushman's death. The 25th volume of the Contributions will be the concluding volume and the 5-year index to vols. 21-25 will be published. In addition, a Memorial Volume to Dr. Cushman will be published. This will contain descriptions of his life's work, the history of the Laboratory, and the complete bibliography of his publications, nearly 550 in number.

Dr. Cushman willed all his collections, mounted and unmounted, his library, and his card catalog, and all the cases and cabinets containing these things to the Smithsonian Institution and they will eventually be transferred to the U. S. National Museum in Washington, D. C., and a room provided for them where they may be kept as a unit. They will be added to and kept up to date and made available for future workers on the Foraminifera.

It is hoped that a Cushman Memorial series of publications may be established, patterned after the Special Publication series from this Laboratory. This would be a series of faunal, ecologic, or monographic papers, in general too large for inclusion in one of the already-existing paleontologic journals, and of an irregular schedule of appearance.

It is with a very deep sense of loss, not only for the field of micropaleontology, but also in a personal way, that we shall carry on the work so well begun by our beloved master who for these 26 years worked with us and his host of students and colleagues from far and near as Director of this Laboratory, "and wist not that his face shone."

THE LABORATORY STAFF

CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

NO. 326. SOME CUBAN SPECIES OF *GLOBOROTALIA*

By Joseph A. Cushman and Pedro J. Bermudez

The present work contains the study of the species and varieties of *Globorotalia* found in Cuba in the uppermost Cretaceous and Tertiary and in the Recent seas that surround the island. Many of these species are good index fossils, not only in Cuba but also in other countries of the Antillean-Caribbean area. The geologic ranges of the various forms are indicated on the accompanying chart.

Apparently three groups of species can be established and these groups are probably phylogenetically distinct. These groups, which we believe worthy of subgeneric rank, are:

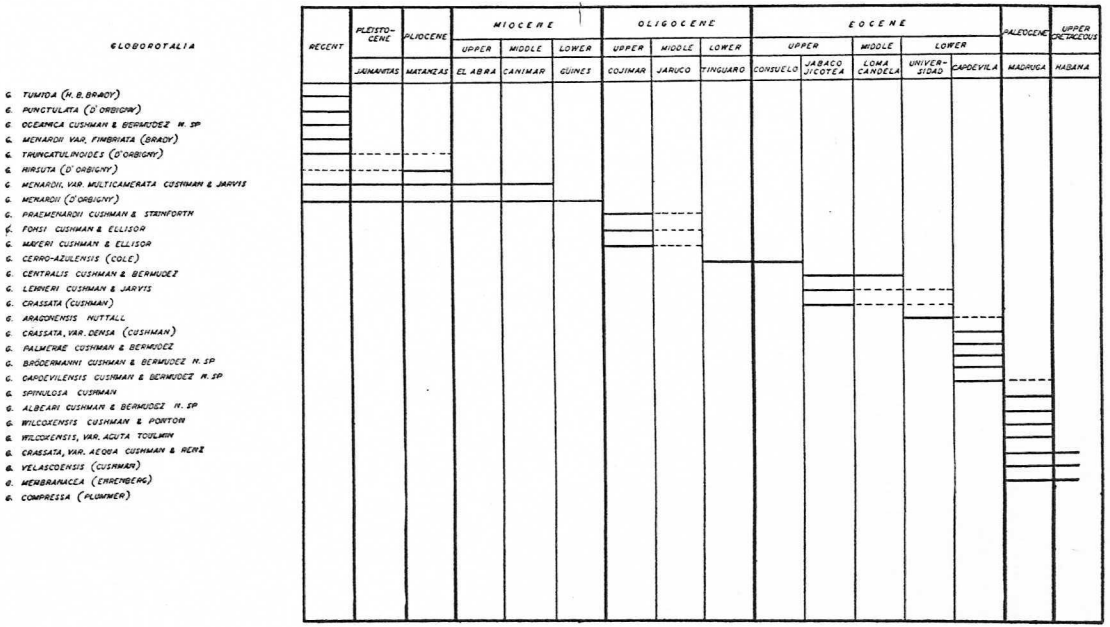
Globorotalia s. s.

G. tumida (H. B. Brady)
G. menardii (d'Orbigny)
G. menardii (d'Orbigny), var. *multicamerata* Cushman and Jarvis
G. menardii (d'Orbigny), var. *fimbriata* (H. B. Brady)
G. fohsi Cushman and Ellisor
G. praemenardii Cushman and Stainforth
G. capdevilensis Cushman and Bermudez, n. sp.
G. membranacea (Ehrenberg)
G. compressa (Plummer)
G. lehneri Cushman and Jarvis
G. palmerae Cushman and Bermudez
G. albeari Cushman and Bermudez, n. sp.

Globorotalia (Truncorotalia)

G. truncatulinoides (d'Orbigny)
G. aragonensis Nuttall
G. velascoensis (Cushman)
G. wilcoxensis Cushman and Ponton
G. wilcoxensis Cushman and Ponton, var. *acuta* Toulmin
G. brödermanni Cushman and Bermudez, n. sp.
G. hirsuta (d'Orbigny)

GEOLOGICAL DISTRIBUTION OF THE CUBAN SPECIES OF GLOBOROTALIA



G. crassata (Cushman)
G. crassata (Cushman), var. *aequa* Cushman and Renz
G. crassata (Cushman), var. *densa* (Cushman)
G. spinulosa Cushman

Globorotalia (Turborotalia)
G. centralis Cushman and Bermudez
G. cerro-azulensis (Cole)
G. punctulata (d'Orbigny)
G. oceanica Cushman and Bermudez, n. sp.
G. mayeri Cushman and Ellisor

We are indebted to Mrs. Caridad V. Bermudez, wife of the junior author, who made the drawings illustrating the species.

Subgenus GLOBOROTALIA s. s.

Subgenotype, *Pulvinulina menardii, var. tumida* H. B. Brady

Test trochoid, biconvex and more or less compressed, periphery angular and becoming increasingly angular with growth of the test, umbilicus small and inconspicuous; chambers increasing in size but not in thickness as added.

GLOBOROTALIA TUMIDA (H. B. Brady) (Pl. 5, figs. 1-3)

Pulvinulina menardii (d'Orbigny), var. *tumida* H. B. Brady, Geol. Mag., dec. 2, vol. 4, 1877, p. 294.

Pulvinulina tumida H. B. Brady, Rep. Voy. *Challenger,* Zoology, vol. 9, 1884, p. 692, pl. 103, figs. 4-6.—Flint, Ann. Rep. U. S. Nat. Mus., 1897 (1899), p. 329, pl. 73, fig. 5.—Cushman, Bull. 71, U. S. Nat. Mus., pt. 5, 1915, p. 56, pl. 22, fig. 3; Bull. 100, vol. 4, 1921, p. 337, pl. 66, fig. 3.

Globorotalia tumida Cushman, Bull. 104, U. S. Nat. Mus., pt. 8, 1931, p. 95, pl. 17, fig. 3.—Phleger, Bull. Geol. Soc. Amer., vol. 50, 1939, p. 1405, pl. 1, figs. 5-7.—Cushman, Amer. Journ. Sci., vol. 239, 1941, pl. 3, fig. 3.—Parker, Bull. Mus. Comp. Zoöl., vol. 100, 1948, p. 238 (list), pl. 7, figs. 16, 17.

Globorotalia menardii (d'Orbigny), var. *tumida* Bermudez, Mem. Soc. Cubana Hist. Nat., vol. 9, 1935, p. 218.

Test large for the genus, biconvex, inflated ventrally, periphery rounded in the early stages, acute on the last few chambers, bordered by a limbate keel, umbilicus open; chambers fairly distinct, usually 6 in the last-formed whorl, flat on the dorsal surface, strongly inflated ventrally, rather rapidly increasing in size as added; sutures limbate and curved on the dorsal surface, distinctly incised and nearly radial on the ventral surface; wall distinctly perforate, with rather coarse papillae on the ventral surface surrounding the umbilicus; aperture a low, arched opening under the edge of the last-formed chamber, extending from the um-

bilicus nearly to the periphery. Length 1.00-1.15 mm.; breadth 0.90 mm.; thickness 0.55 mm.

The plesiotypes are from *Atlantis* sta. 2971, 810 fms., lat. 20° 34′ N., long. 74° 24′ W., north of Oriente Prov., Cuba.

GLOBOROTALIA MENARDII (d'Orbigny) (Pl. 5, figs. 4-6)

Rotalia menardii D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 273; Modèles, No. 10, 1826. —PARKER, JONES and H. B. BRADY, Ann. Mag. Nat. Hist., ser. 3, vol. 16, 1865, p. 20, pl. 3, fig. 81.

Pulvinulina menardii GOËS (part), Kongl. Svensk. Vet.-Akad. Handl., vol. 19, No. 4, 1882, p. 112, pl. 8, figs. 289-291 (not figs. 292-294).—H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 690, pl. 103, figs. 1, 2.—FLINT, Ann. Rep. U. S. Nat. Mus., 1897 (1899), p. 329, pl. 73, fig. 3.—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 5, 1915, p. 54, pl. 22, fig. 2; Bull. 100, vol. 4, 1921, p. 333, pl. 66, fig. 1; Publ. 311, Carnegie Instit. Washington, 1922, p. 50, pl. 8, figs. 3, 4.—NUTTALL, Quart. Journ. Geol. Soc., vol. 84, 1928, p. 101, pl. 7, fig. 20.

Globorotalia menardii CUSHMAN, Bull. 4, Florida State Geol. Survey, 1930, p. 60, pl. 12, fig. 1; Bull. 104, U. S. Nat. Mus., pt. 8, 1931, p. 91, pl. 17, fig. 1.—NUTTALL, Journ. Pal., vol. 6, 1932, p. 29, pl. 4, fig. 16.—CUSHMAN and CAHILL, U. S. Geol. Survey Prof. Paper 175-A, 1933, p. 34, pl. 12, fig. 5.—HADLEY, Bull. Amer. Pal., vol. 20, No. 70A, 1934, p. 25, pl. 3, figs. 12, 13.—BERMUDEZ, Mem. Soc. Cubana Hist. Nat., vol. 9, 1935, p. 218.—PHLEGER, Bull. Geol. Soc. Amer., vol. 50, 1939, p. 1405, pl. 1, figs. 1, 2. —CORYELL and RIVERO, Journ. Pal., vol. 14, 1940, p. 336, pl. 42, figs. 34, 35.—ELLISOR, Bull. Amer. Assoc. Petr. Geol., vol. 24, No. 3, 1940, pl. 6, fig. 8.—CUSHMAN and HENBEST, U. S. Geol. Survey Prof. Paper 196-A, 1940, p. 46, pl. 8, fig. 3.—CUSHMAN, Amer. Journ. Sci., vol. 239, 1941, pl. 3, fig. 2.—GALLOWAY and HEMINWAY, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Ids., vol. 3, pt. 4, 1941, p. 368, pl. 16, fig. 5.—D. K. PALMER, Mem. Soc. Cubana Hist. Nat., vol. 15, 1941, p. 291.—CORYELL and MOSSMAN, Journ. Pal., vol. 16, 1942, p. 234, pl. 36, fig. 5.—D. K. PALMER, Bull. Amer. Pal., vol. 29, No. 115, 1945, p. 70.—PARKER, Bull. Mus. Comp. Zoöl., vol. 100, 1948, p. 238 (list), pl. 7, fig. 10.—STAINFORTH, Journ. Pal., vol. 22, 1948, p. 124, pl. 26, figs. 36, 37.—RENZ, Mem. 32, Geol. Soc. Amer., 1948, p. 137, pl. 10, fig. 3.

Test large for the genus, compressed, about equally biconvex, composed of 2½ to 3 whorls, periphery acute, becoming more so as chambers are added, umbilicus open; chambers distinct, 5 or 6 forming the last whorl, very slightly inflated on the ventral surface, rapidly increasing in size as added; sutures distinct, limbate and curved on the dorsal surface, distinctly incised and radial on the ventral surface; wall thin, distinctly and finely perforate, ornamented by the limbate dorsal sutures and a very prominent, rather blunt keel of clear shell material surrounding the periphery; aperture an arched opening under the edge of the last-formed chamber extending from the umbilicus nearly to the periphery, protected by an irregular lip. Length 1.00-1.15 mm.; breadth 0.90 mm.; thickness 0.35 mm.

This species has a wide geographic distribution and is very abundant in the deep and moderately deep deposits of the seas which surround Cuba. There are numerous records from the middle Oligocene to the Pleistocene.

The plesiotypes are from *Atlantis* sta. 3328, 260-275 fms., lat. 22° 08′ N., long. 81° 10′ W., Bahía de Cochinos, south of Cuba.

GLOBOROTALIA MENARDII (d'Orbigny), var. FIMBRIATA (H. B. Brady) (Pl. 5, fig. 7)

Pulvinulina menardii (D'ORBIGNY), var. *fimbriata* H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 691, pl. 103, fig. 3.—FLINT, Ann. Rep. U. S. Nat. Mus., 1897 (1899), p. 329, pl. 73, fig. 4.—CUSHMAN, Bull. 100, U. S. Nat. Mus., vol. 4, 1921, p. 335, pl. 66, fig. 2.

Globorotalia menardii (D'ORBIGNY), var. *fimbriata* CUSHMAN, Bull. 104, U. S. Nat. Mus., pt. 8, 1931, p. 94, pl. 17, fig. 2.

This variety differs from the typical form in the highly spinose keel. This ornamentation continues in the middle of the dorsal surface as a fringing spinose border to the earlier whorl.

The plesiotype is from *Atlantis* sta. 3328, 260-275 fms., lat. 22° 08′ N., long. 81° 10′ W., Bahía de Cochinos, south of Cuba.

GLOBOROTALIA MENARDII (d'Orbigny), var. MULTICAMERATA Cushman and Jarvis (Pl. 5, figs. 8-13)

Globorotalia menardii (D'ORBIGNY), var. *multicamerata* CUSHMAN and JARVIS, Journ. Pal., vol. 4, 1930, p. 367, pl. 34, fig. 8.—CUSHMAN and TODD, Special Publ. 15, Cushman Lab. Foram. Res., 1945, p. 68, pl. 11, fig. 19.

This variety differs from the typical form in having the adult whorl composed of 7 or 8 chambers, and in its slightly smaller size. Length 0.80-0.95 mm.; breadth 0.65-0.80 mm.; thickness 0.30-0.35 mm.

The plesiotypes (figs. 8-10) are from the Miocene, probably middle of the mouth of Macaguanigua River, Baracoa, Oriente Prov., Cuba (Bermudez sta. 353). The plesiotypes (figs. 11-13) are from *Atlantis* sta. 2971, 810 fms., lat. 20° 34′ N., long. 74° 24′ W., north of Oriente Prov., Cuba.

GLOBOROTALIA FOHSI Cushman and Ellisor (Pl. 5, figs. 14-16)

Globorotalia fohsi CUSHMAN and ELLISOR, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 12, pl. 2, fig. 6.—ELLISOR, Bull. Amer. Assoc. Petr. Geol., vol. 24, No. 3, 1940, pl. 3, fig. 1.—D. K. PALMER, Mem. Soc. Cubana Hist. Nat., vol. 15, 1941, p. 291, pl. 29, fig. 3.—CUSHMAN and STAINFORTH, Special Publ. 14, Cushman Lab. Foram. Res., 1945, p. 70, pl. 13, fig. 13.—RENZ, Mem. 32, Geol. Soc. Amer., 1948, p. 137, pl. 11, fig. 2.

Test small for the genus, thick, dorsal side somewhat less convex than the ventral side, periphery rounded on the earlier chambers, becoming acute but not keeled on the later chambers, umbilicus small, open; chambers 6 or 7 in the last-formed whorl, increasing rapidly in size and height

as added, flat on the dorsal side, slightly inflated on the ventral side; sutures distinct, depressed and curved both dorsally and ventrally but indistinct between the earlier chambers; wall finely perforate, slightly spinose over the earlier whorls on the dorsal side and surrounding the umbilicus on the ventral side; aperture an elongate, low opening extending from the umbilicus under the edge of the last-formed chamber nearly to the periphery, protected by a prominent, projecting lip. Length 0.37-0.47 mm.; breadth 0.32-0.37 mm.; thickness 0.20 mm.

The plesiotypes are from the upper Oligocene, Cojimar formation, deep cut at Asilo Nacional de Ancianos, Casa Blanca, Habana Prov., Cuba (Bermudez sta. 518).

GLOBOROTALIA PRAEMENARDII Cushman and Stainforth
(Pl. 5, figs. 17-19; pl. 6, figs. 1-3)

Globorotalia praemenardii CUSHMAN and STAINFORTH, Special Publ. 14, Cushman Lab. Foram. Res., 1945, p. 70, pl. 13, fig. 14.—STAINFORTH, Journ. Pal., vol. 22, 1948, p. 121, pl. 26, figs. 34, 35.—CUSHMAN and STEVENSON, Contr. Cushman Lab. Foram. Res., vol. 24, 1948, p. 66, pl. 10, figs. 21, 22.

Test of medium size for the genus, dorsal side slightly convex, especially in the early portion, flattened toward the periphery, ventral side more strongly convex, periphery lobulated, acute, with a narrow, blunt keel throughout, umbilicus open; chambers indistinct, 5 to 7 comprising the last whorl, flat on the dorsal side but distinctly inflated ventrally, gradually increasing in size as added; sutures limbate and curved on the dorsal side, distinctly incised and radial on the ventral side; wall finely perforate, smooth except for the limbate dorsal sutures and blunt peripheral keel; aperture a low, elongate opening under the edge of the last-formed chamber, extending from the umbilicus to the periphery. Length 0.50-0.62 mm.; breadth 0.40-0.50 mm.; thickness 0.20 mm.

The plesiotypes (figs. 17-19) are from the upper Oligocene, Cojimar formation, Finca El Junco, Limonar, Matanzas Prov., Cuba (Bermudez sta. 1196). The plesiotypes (figs. 1-3) are from the upper Oligocene, Cojimar formation, Yumuri gorge, Matanzas Prov., Cuba (Bermudez sta. 3).

GLOBOROTALIA PALMERAE Cushman and Bermudez (Pl. 6, figs. 4-6)

Globorotalia palmerae CUSHMAN and BERMUDEZ, Contr. Cushman Lab. Foram. Res., vol. 13, 1937, p. 26, pl. 2, figs. 51-53.—BERMUDEZ, Mem. Soc. Cubana Hist. Nat., vol. 11, 1937, p. 167; vol. 12, 1938, p. 11.

Test small for the genus, strongly compressed, composed of about 2 whorls, periphery acute, slightly keeled, and with prominent spines, umbilicus open; chambers distinct, 6 comprising the last whorl, not much increasing in size as added, slightly inflated on the ventral side; sutures

depressed and radial on both sides, spiral suture distinct, depressed; wall smooth, ornamented by the peripheral spines of clear shell material; aperture a low opening near the umbilical end of the ventral margin of the last-formed chamber. Length 0.32-0.37 mm.; breadth 0.30-0.32 mm.; thickness 0.10 mm.

The types of this species are from the lower beds of Tejar "Cuba," Arroyo Naranjo, Habana Prov., Cuba. These beds are in the lower Eocene, Capdevila formation, where the species is a good index fossil. It is often associated with *Loxostomum applinae* (Plummer) and other typical species of the lower Eocene. The plesiotypes figured on our plate are topotypes from Bermudez sta. 235C.

GLOBOROTALIA LEHNERI Cushman and Jarvis (Pl. 6, figs. 7-9)

Globorotalia lehneri Cushman and Jarvis, Contr. Cushman Lab. Foram. Res., vol. 5, 1929, p. 17, pl. 3, fig. 16.—Renz, Proc. 8th Amer. Sci. Congress, 1942, p. 537 (list).—Cushman and Renz, Special Publ. 24, Cushman Lab. Foram. Res., 1948, p. 40, pl. 8, figs. 3, 4.

Test of medium size for the genus, compressed, periphery strongly indented, acute, surrounded by a thin spinose keel throughout; chambers 6 to 8 in the last whorl, not increasing in size as added, slightly inflated on the ventral side; sutures distinct, depressed and slightly curved on the dorsal side, radial and distinctly incised on the ventral side; wall finely perforate, smooth except finely granular over the earliest chambers and about the umbilicus, ornamented by a prominent spinose keel of clear shell material surrounding the periphery; aperture ventral, opening into the umbilicus. Diameter 0.45-0.50 mm.; thickness 0.20 mm.

The plesiotypes are from the lower part of the upper Eocene, San Luis formation, 2 km. SW. of Mir, Oriente Prov., Cuba (C 5210).

GLOBOROTALIA CAPDEVILENSIS Cushman and Bermudez, n. sp. (Pl. 6, figs. 10-12)

Test minute, about equally biconvex, periphery acute but not keeled, umbilicus open; chambers indistinct, 5 or 6 in last-formed whorl, gradually increasing in size as added, flat on the dorsal side but distinctly in-

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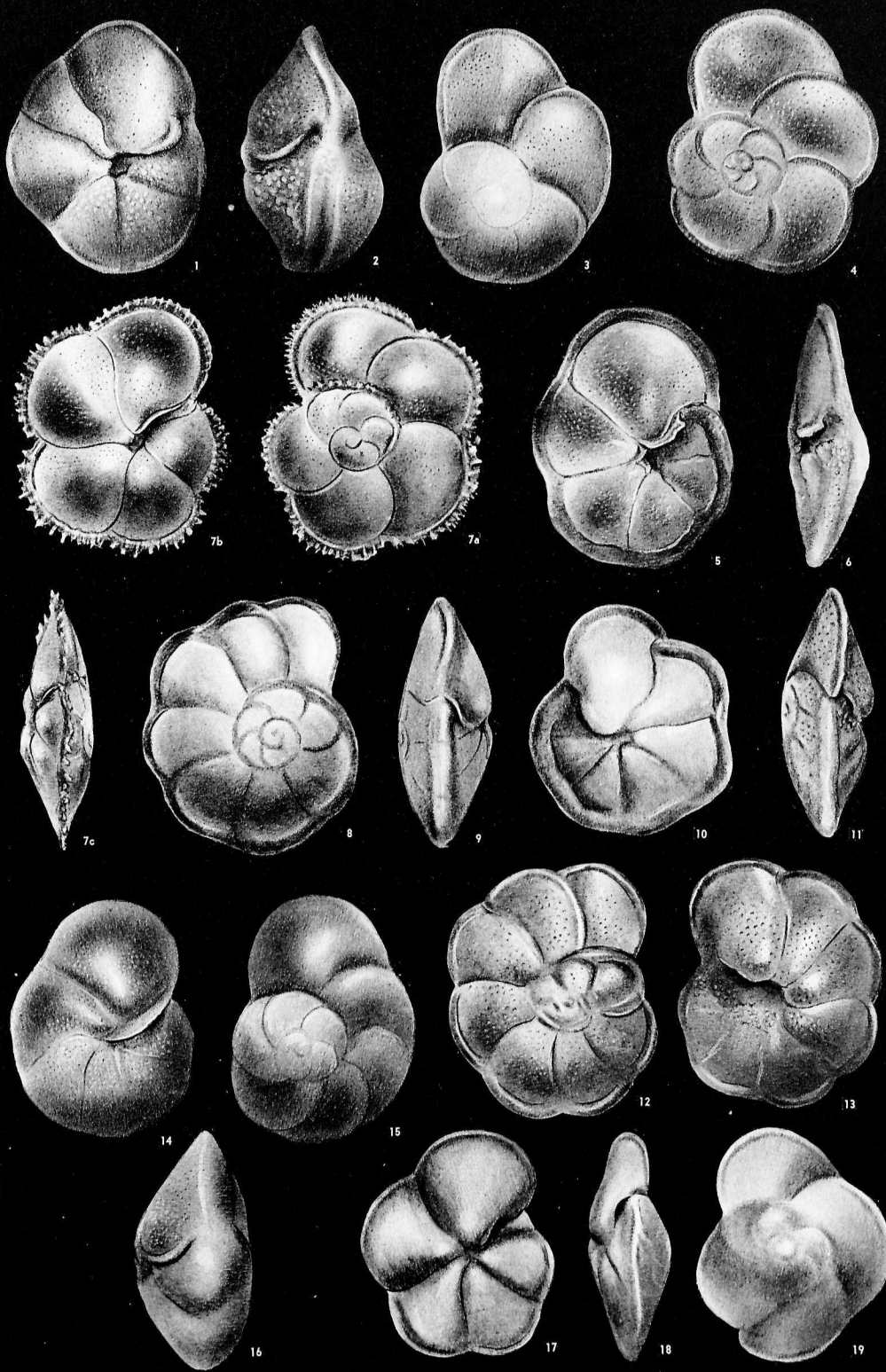
EXPLANATION OF PLATE 5

Figs. 1-3. *Globorotalia tumida* (H. B. Brady). × 35. 1, Ventral view. 2, Peripheral view. 3, Dorsal view. 4-6. *G. menardii* (d'Orbigny). × 40. 4, Dorsal view. 5, Ventral view. 6, Peripheral view. 7. *G. menardii* (d'Orbigny), var. *fimbriata* (H. B. Brady). × 35. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. 8-13. *G. menardii* (d'Orbigny), var. *multicamerata* Cushman and Jarvis. 8-10, × 50. 11-13, × 40. 8, 12, Dorsal views. 9, 11, Peripheral views. 10, 13, Ventral views. 14-16. *G. fohsi* Cushman and Ellisor. × 80. 14, Ventral view. 15, Dorsal view. 16, Peripheral view. 17-19. *G. praemenardii* Cushman and Stainforth. × 65. 17, Ventral view. 18, Peripheral view. 19, Dorsal view.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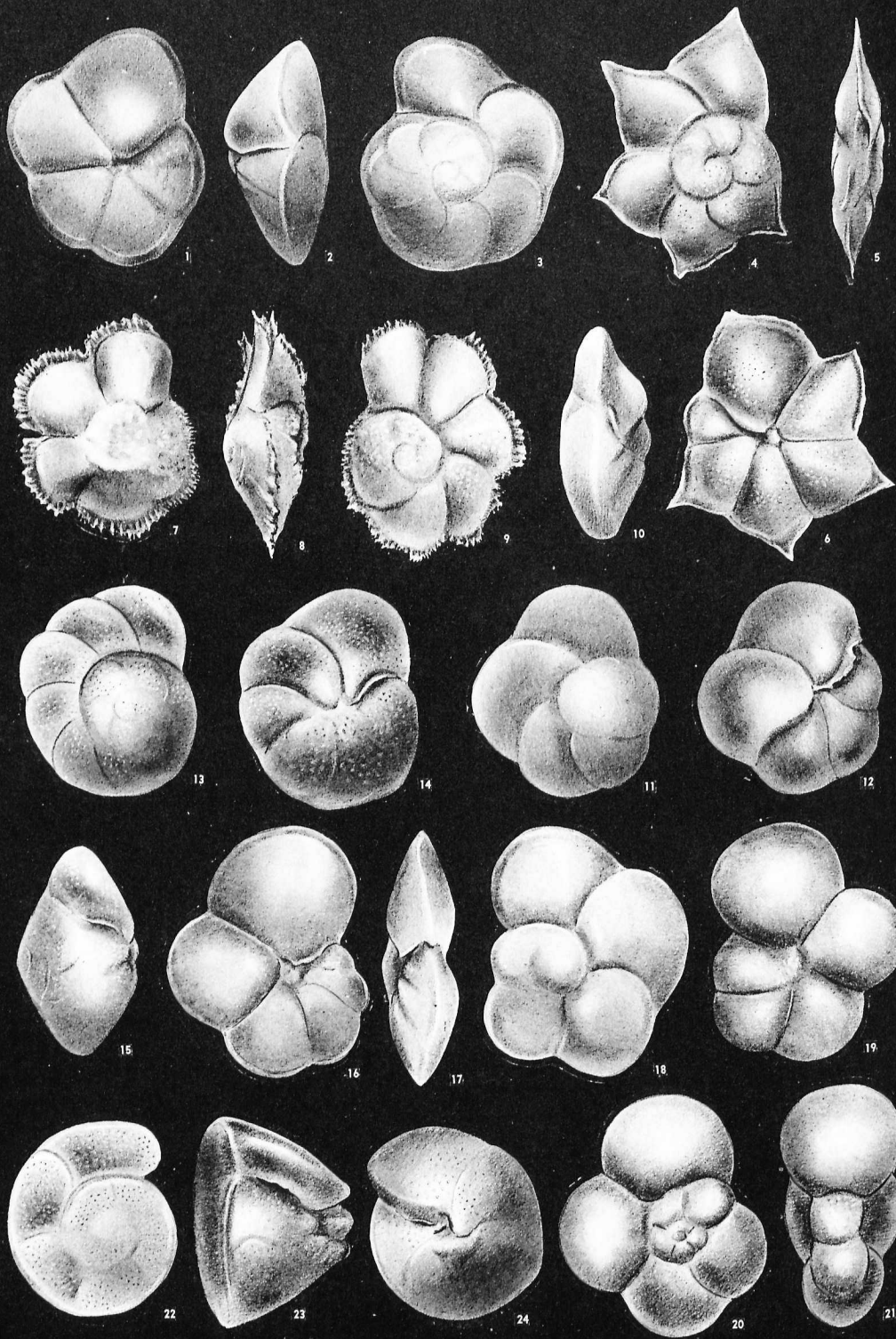
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flated ventrally; sutures curved but indistinct on the dorsal side, radial and distinctly incised on the ventral side; wall thin, finely perforate, finely granular; aperture a low opening under the edge of the last-formed chamber, protected by a projecting lip. Length 0.17-0.20 mm.; breadth 0.15-0.17 mm.; thickness 0.10 mm.

Holotype (Cushman Coll. No. 47405) from the lower Eocene, Capdevila formation, N-dipping sandstone 250 meters N. of Tejar Retiro on road to Habana-Rancho Boyeros, Habana Prov., Cuba (Bermudez sta. 205).

This small species occurs frequently in numerous samples in the lower Eocene, Capdevila formation, where it is a good index fossil although easily overlooked because of its very small size. It differs from *G. fohsi* Cushman and Ellisor in its much smaller size, less inflated test, fewer chambers, and more distinct sutures on the ventral side.

GLOBOROTALIA ALBEARI Cushman and Bermudez, n. sp. (Pl. 6, figs. 13-15)

Test very small for the genus, strongly biconvex, dorsal side showing all the coils and ventral side only the last-formed whorl, periphery somewhat rounded; chambers not very distinct, 9 or 10 in the last-formed whorl, only slightly inflated ventrally, increasing very gradually in size as added; sutures fairly distinct but only slightly depressed except in the last whorl on the ventral side, rather strongly curved on the dorsal side; wall slightly spinose, coarsely perforate; aperture an elongate opening on the ventral side of the last-formed chamber extending from nearly the inner end to the periphery and with a distinct thin lip. Diameter 0.30-0.32 mm.; thickness 0.20 mm.

Holotype (Cushman Coll. No. 47413) from the Paleocene, Madruga formation, under bridge in the highway, Central San Antonio, Madruga, Habana Prov., Cuba (Bermudez sta. 76).

EXPLANATION OF PLATE 6

FIGS. 1-3. *Globorotalia praemenardii* Cushman and Stainforth. × 65. 1, Ventral view. 2, Peripheral view. 3, Dorsal view. 4-6. *G. palmerae* Cushman and Bermudez. × 115. 4, Dorsal view. 5, Peripheral view. 6, Ventral view. 7-9. *G. lehneri* Cushman and Jarvis. × 70. 7, Ventral view. 8, Peripheral view. 9, Dorsal view. 10-12. *G. capdevilensis* Cushman and Bermudez, n. sp. × 150. 10, Paratype, peripheral view. 11, Holotype, dorsal view. 12, Paratype, ventral view. 13-15. *G. albeari* Cushman and Bermudez, n. sp. × 115. 13, Holotype, dorsal view. 14, Paratype, ventral view. 15, Paratype, peripheral view. 16-18. *G. membranacea* (Ehrenberg). × 65. 16, Ventral view. 17, Peripheral view. 18, Dorsal view. 19-21. *G. compressa* (Plummer). × 65. 19, Ventral view. 20, Dorsal view. 21, Peripheral view. 22-24. *G. (Truncorotalia) truncatulinoides* (d'Orbigny). × 40. 22, Dorsal view. 23, Peripheral view. 24, Ventral view.

This species differs from *G. praemenardii* Cushman and Stainforth in its smaller size, more numerous chambers, more strongly biconvex test, and less umbilicate ventral side.

The species has been found only in samples of the Madruga formation where it is a good marker.

The species is named in honor of Ing. Jesús F. de Albear of the Cuban Geological Survey.

GLOBOROTALIA MEMBRANACEA (Ehrenberg) (Pl. 6, figs. 16-18)

Planulina membranacea Ehrenberg, Mikrogeologie, 1854, pl. 26, fig. 43 (not pl. 25, i, A, fig. 41).

Pulvinulina membranacea Cushman, Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 608, pl. 21, fig. 10.

Globorotalia membranacea White, Journ. Pal., vol. 2, 1928, p. 280, pl. 38, fig. 1.—Muir, Geol. Tampico Region, 1936, pp. 88, 101, 102 (lists).—Toulmin, Journ. Pal., vol. 15, 1941, p. 608, pl. 82, figs. 4, 5.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 45, pl. 8, fig. 10; vol. 19, 1943, p. 71, pl. 12, fig. 12.—Cushman, l. c., vol. 20, 1944, p. 16, pl. 3, fig. 12.—Applin and Applin, Bull. Amer. Assoc. Petr. Geol., vol. 28, No. 12, 1944, pl. 5, fig. 2.—Cushman, U. S. Geol. Survey Prof. Paper 206, 1946, p. 152, pl. 63, fig. 5.—Cushman and Renz, Special Publ. 18, Cushman Lab. Foram. Res., 1946, p. 48, pl. 8, figs. 15, 16; l. c., Contr., vol. 23, 1947, p. 50.

Test of medium size for the genus, strongly compressed, periphery distinctly lobulate, acute throughout but not keeled, umbilicus large and open; chambers 5 or 6 in the last-formed whorl, very rapidly increasing in size as added, slightly inflated; sutures distinctly depressed on both dorsal and ventral sides, curved on the dorsal side and radial on the ventral side; wall smooth and finely perforate throughout; aperture an elongate opening under the edge of the last-formed chamber, extending from the umbilicus to the periphery, protected by a narrow, projecting lip. Length 0.82-0.87 mm.; breadth 0.45-0.47 mm.; thickness about 0.17 mm.

This species has been recorded in the Upper Cretaceous, Velasco formation, of Mexico, and has also been found in the beds of Navarro and Taylor age in Texas. In Florida the species is considered as a good index fossil for the Paleocene. We have found this species abundant in the Paleocene, Madruga formation, of Cuba and also in numerous samples of the Upper Cretaceous, Habana formation. The species is found frequently associated with *G. velascoensis* (Cushman). The plesiotypes are from the Paleocene, 200 meters N. of Cerro Avenue on road to Rancho Boyeros, Habana Prov., Cuba (Bermudez sta. 530).

GLOBOROTALIA COMPRESSA (Plummer) (Pl. 6, figs. 19-21)

Globigerina compressa Plummer, Univ. Texas Bull. 2644, 1926 (1927), p. 135, pl. 8, fig. 11.—Jennings, Bull. Amer. Pal., vol. 23, No. 78, 1936, p. 35, pl. 4, fig. 8.—Glaess-

NER, Problems of Paleontology, Moscow Univ., vols. 2-3, 1937, p. 382, pl. 4, fig. 32.—TOULMIN, Journ. Pal., vol. 15, 1941, p. 607, pl. 82, figs. 1, 2.—CUSHMAN and TODD, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 44, pl. 8, figs. 5, 6.—KLINE, Bull. 53, Mississippi State Geol. Survey, 1943, p. 58, pl. 6, figs. 5, 6.

Test of medium size for the genus, composed of about 2 whorls, periphery strongly lobulate, smoothly rounded throughout, umbilicus large and open; chambers globular, 5 in the last-formed whorl, increasing rather rapidly in size as added; sutures radial and distinctly depressed throughout; wall smooth and finely perforate; aperture a low, elongate opening under the ventral edge of the last-formed chamber. Diameter 0.40-0.57 mm.; thickness 0.27 mm.

This species was originally described from the upper Midway of Texas and has been reported from numerous localities in the Paleocene and Eocene of Texas, Mississippi, Alabama, and New Jersey. In Cuba the species is rare in the Paleocene, Madruga formation. The plesiotypes are from the Paleocene, water well 200 meters N. of Cerro Avenue on Rancho Boyeros road, Habana Prov., Cuba (Bermudez sta 530).

Subgenus TRUNCOROTALIA Cushman and Bermudez, n. subgen.
Subgenotype, *Rotalina truncatulinoides* d'Orbigny

Test planoconvex, thick, dorsal side flattened, ventral side sharply conical except for a large open umbilicus surrounded by the raised knobs of the inner ends of the chambers on the ventral side, periphery angular throughout; chambers not much increasing in size but rapidly in thickness as added, ventral face of the last-formed chamber above the aperture forming a concave surface.

GLOBOROTALIA (TRUNCOROTALIA) TRUNCATULINOIDES (d'Orbigny)
(Pl. 6, figs. 22-24)

Rotalina truncatulinoides D'ORBIGNY, in BARKER-WEBB and BERTHELOT, Hist. Nat. Iles Canaries, 1839, vol. 2, pt. 2, "Foraminifères," p. 132, pl. 2, figs. 25-27.

Pulvinulina truncatulinoides CUSHMAN, Bull. 100, U. S. Nat. Mus., vol. 4, 1921, p. 339, pl. 67, fig. 2.

Globorotalia truncatulinoides CUSHMAN and WICKENDEN, Proc. U. S. Nat. Mus., vol. 75, Art. 9, 1929, p. 14, pl. 6, fig. 3.—CUSHMAN, Bull. 104, U. S. Nat. Mus., pt. 8, 1931, p. 97, pl. 17, fig. 4.—BERMUDEZ, Mem. Soc. Cubana Hist. Nat., vol. 9, 1935, p. 218.—PHLEGER, Bull. Geol. Soc. Amer., vol. 50, 1939, p. 1405, pl. 1, figs. 9, 10.—CUSHMAN and HENBEST, U. S. Geol. Survey Prof. Paper 196-A, 1940, pl. 8, fig. 7.—CUSHMAN, Amer. Journ. Sci., vol. 239, 1941, pl. 4, fig. 1.—D. K. PALMER, Bull. Amer. Pal., vol. 29, No. 115, 1945, p. 71.—PARKER, Bull. Mus. Comp. Zoöl., vol. 100, 1948, p. 238 (list), pl. 7, figs. 12, 15.

Pulvinulina micheliniana H. B. BRADY (not D'ORBIGNY), Rep. Voy *Challenger*, Zoology, vol. 9, 1884, p. 694, pl. 104, figs. 1, 2.—FLINT, Ann. Rep. U. S. Nat. Mus., 1897 (1899), p. 330, pl. 74, fig. 2.

Test large for the genus, conical, composed of about 2 whorls, periphery acute and very bluntly keeled, dorsal side flat or slightly concave, ventral side conical with a deep, open umbilicus; chambers indistinct, about 6 in the last-formed whorl, very slightly increasing in size but rapidly in thickness as added, not inflated; sutures indistinct, curved-tangential on the dorsal side, radial or slightly curved on the ventral side; wall thin, translucent, finely perforate, ornamented by small papillae surrounding the umbilicus and fine granulations covering the earliest chambers on the dorsal side; aperture a low, elongate, arched opening at the base of the last-formed chamber, about midway between the umbilicus and the periphery. Length 0.72-0.85 mm.; breadth 0.62 mm.; thickness 0.62 mm.

This species is very abundant in *Globigerina* oozes, being a typical species of pelagic deposits. There are many records in the Recent but few as a fossil. Mrs. Palmer found it in the Bowden formation of Jamaica which is middle Miocene in age.

The plesiotypes are from *Atlantis* sta. 2980, 250 fms., lat. 22° 47′ N., long. 78° 40′ W., off North Cuba.

GLOBOROTALIA (TRUNCOROTALIA) HIRSUTA (d'Orbigny) (Pl. 7, figs. 1-3)

Rotalina hirsuta D'ORBIGNY, in BARKER-WEBB and BERTHELOT, Hist. Nat. Iles Canaries, 1839, vol. 2, pt. 2, "Foraminifères," p. 131, pl. 1, figs. 37-39.

Globorotalia hirsuta CUSHMAN, Bull. 104, U. S. Nat. Mus., pt. 8, 1931, p. 99, pl. 17, fig. 6.—CUSHMAN and HENBEST, U. S. Geol. Survey Prof. Paper 196-A, 1940, pl. 8, fig. 6.—PARKER, Bull. Mus. Comp. Zoöl., vol. 100, 1948, p. 238 (list), pl. 7, figs. 11, 14.

Pulvinulina canariensis H. B. BRADY (not D'ORBIGNY), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 692, pl. 103, figs. 8-10.

Globorotalia menardii PALMER and BERMUDEZ (not D'ORBIGNY), Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, 1936, p. 241 (list).

Test of medium size for the genus, composed of 2½ whorls, more strongly convex on the ventral side than on the dorsal, periphery bluntly acute throughout; chambers 4 in the adult whorl, rapidly increasing in size as added, individual chambers elongate and narrow on the dorsal side; sutures strongly curved and limbate on the dorsal side, radial and deeply incised on the ventral side; wall thin, finely perforate, finely spinose; aperture a narrow, arched opening under the edge of the last-formed chamber, nearer to the periphery than to the umbilicus, surrounded by a very narrow lip. Length 0.55-0.60 mm.; breadth 0.47-0.52 mm.; thickness 0.30 mm.

This species is abundant in the Atlantic from the coast of Carolina to the British Isles. We do not have any record in the seas near Cuba, although it has been found in the waters off Florida. The species is par-

ticularly abundant in the Pliocene, Matanzas formation, of Cuba. The plesiotypes are from the Pliocene, Matanzas formation, 800 meters from the mouth of río Canimar, Matanzas Prov., Cuba (Bermudez sta. 218, type locality of the Matanzas formation).

GLOBOROTALIA (TRUNCOROTALIA) CRASSATA (Cushman) (Pl. 7, figs. 4-6)

Pulvinulina crassata CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 9, 1925, p. 300, pl. 7, fig. 4.

Globorotalia crassata COLE, Bull. Amer. Pal., vol. 14, No. 51, 1927, p. 34, pl. 1, figs. 7, 8. —CUSHMAN and BARKSDALE, Contr. Dept. Geol., Stanford Univ., vol. 1, No. 1, 1930, p. 67, pl. 12, fig. 7.—HOWE, Geol. Bull. 14, Louisiana Geol. Survey, 1939, p. 84, pl. 12, figs. 7-9.—CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 74, pl. 12, fig. 19.—CUSHMAN and APPLIN, l. c., vol. 19, 1943, p. 44, pl. 8, fig. 10.—CUSHMAN and RENZ, l. c., Special Publ. 24, 1948, p. 40, pl. 8, figs. 5, 6.

Test of medium size for the genus, dorsal side flat, ventral side truncated-conical, with a large, open umbilicus, periphery strongly indented, bluntly angular but not keeled; chambers distinct, 5 or 6 in the last-formed whorl, not much increasing in size or thickness as added, not inflated; sutures distinctly depressed on both sides, tangential on the dorsal side, radial on the ventral side; wall thickly covered by heavy spines throughout; aperture elongate, on the inner edge of the ventral face of the last-formed chamber. Length 0.45 mm.; breadth 0.40 mm.; thickness 0.25 mm.

The plesiotypes are from the lower part of the upper Eocene, San Luis formation, 2 km. SW. of Mir, Oriente Prov., Cuba (C 5210).

GLOBOROTALIA (TRUNCOROTALIA) CRASSATA (Cushman), var. AEQUA Cushman and Renz (Pl. 7, figs. 7-9)

Globorotalia crassata (CUSHMAN), var. *aequa* CUSHMAN and RENZ, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 12, pl. 3, fig. 3.—CUSHMAN and TODD, l. c., p. 44, pl. 8, figs. 7-9.—CUSHMAN and BERMUDEZ, l. c., vol. 24, 1948, p. 89 (list).—CUSHMAN, Bull. 2, Maryland Dept. Geol., Mines and Water Resources, 1948, p. 243, pl. 20, fig. 8.

This variety differs from the typical form in the less coarse ornamentation, in the chambers being broader and more arcuate and 4 in number instead of 5 or 6 in the last-formed whorl, and in the sutures being less deeply depressed on the dorsal side, resulting in a more compact test. Length 0.60 mm.; breadth 0.45 mm.; thickness 0.30 mm.

This variety seems to be limited to the Paleocene where it has been found in various samples. The plesiotypes are from the Paleocene, south end of cut through marlstone, in abandoned road, 100-150 meters S. of narrow gage railroad tracks on trail leading SW. from east edge of San Ramón, some 900 meters slightly W. of S. of Carretera San Ramón, Pinar del Rio Prov., Cuba (Bermudez sta. 536).

GLOBOROTALIA (TRUNCOROTALIA) CRASSATA (Cushman), var. DENSA (Cushman)
(Pl. 7, figs. 10-12)

Pulvinulina crassata CUSHMAN, var. *densa* CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 9, 1925, p. 301.

Globorotalia crassata (CUSHMAN), var. *densa* CUSHMAN and BARKSDALE, Contr. Dept. Geol., Stanford Univ., vol. 1, No. 1, 1930, p. 68, pl. 12, fig. 8.—GLAESSNER, Studies in Micropaleontology, Moscow Univ., vol. 1, fasc. 1, 1937, p. 32, pl. 1, fig. 8.—CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 74, pl. 12, fig. 20.—MARTIN, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, No. 3, 1943, p. 11 (list).—CUSHMAN and RENZ, Special Publ. 24, Cushman Lab. Foram. Res., 1948, p. 40, pl.8, figs. 7, 8. —CUSHMAN, Bull. 2, Maryland Dept. Geol., Mines and Water Resources, 1948, p. 243.

This variety differs from the typical form in the slightly less coarse ornamentation, the fewer chambers in the adult whorl, the more rounded periphery, and the proportionately thicker test. Length 0.45 mm.; breadth 0.40 mm.; thickness 0.30 mm.

This form has been found in numerous samples of the lower Eocene. The plesiotypes are from the lower Eocene, 850 meters NW. of Peñón, 7 km. S. of Marti, Matanzas Prov., Cuba (Bermudez sta. 110). This locality was originally considered early middle Eocene but more recent studies have shown that it ought to be placed in the lower Eocene, in fact probably in the same horizon as the Capdevila formation.

GLOBOROTALIA (TRUNCOROTALIA) ARAGONENSIS Nuttall (Pl. 7, figs. 13-15)

Globorotalia aragonensis NUTTALL, Journ. Pal., vol. 4, 1930, p. 288, pl. 24, figs. 6-8, 10, 11.—GLAESSNER, Studies in Micropaleontology, Moscow Univ., vol. 1, fasc. 1, 1937, p. 30, pl. 1, fig. 5.—BERMUDEZ, Mem. Soc. Cubana Hist. Nat., vol. 12, 1938, p. 10.—RENZ, Proc. 8th Amer. Sci. Congress, 1942, p. 537 (list).—SELLI, Ann. Mus. Geol. Bologna, ser. 2, vol. 17, 1943-44 (1944), p. 76.—CUSHMAN and RENZ, Special Publ. 24, Cushman Lab. Foram. Res., 1948, p. 40, pl. 8, figs. 1, 2.

Test planoconvex, dorsal side flat or very slightly convex in the middle, ventral side strongly convex with a large open umbilicus, in some cases with a flattened area immediately inside the periphery on the ventral side, resulting in a flanged test, periphery acute and keeled; chambers indistinct, 6 or 7 in the last-formed whorl, not increasing in size as added, the ventral face of the last-formed chamber forming a concave surface; sutures indistinct except the last few on the ventral side which are incised and radial; wall finely perforate, covered with rather coarse granulations which are more distinct over the earliest chambers on the dorsal side and around the umbilicus on the ventral side, the peripheral keel sometimes slightly spinose; aperture an elongate slit at the base of the last chamber extending from the umbilicus to near the periphery. Length 0.50-0.75 mm.; breadth 0.42-0.60 mm.; thickness 0.37-0.45 mm.

This species somewhat resembles "*Rotalina boueana* d'Orbigny," "*Truncatulina insignis* Reuss," and "*Discorbina elegans* Hantken," from

all of which it differs in being thicker. It more closely resembles *Globorotalia velascoensis* (Cushman) but differs in having a shallower umbilicus and a more convex dorsal surface and in its ornamentation being of a coarser texture.

The species was described from the Aragon formation and also reported from the Chicontepec formation, both formations of lower Eocene age in the Tampico region, Mexico. In Cuba the species is very abundant in the Universidad formation which is the very high part of the lower Eocene. It is also found in the Capdevila formation, which is below the lower Eocene, but is less abundant and the specimens in general are very small. The species has also been found in the Abuillot formation of lower Eocene age of Haiti and San Domingo. The plesiotypes are from the upper part of the lower Eocene, Universidad formation, Avenida de los Presidentes, Vedado, Habana, Cuba (Bermudez sta. 20).

GLOBOROTALIA (TRUNCOROTALIA) WILCOXENSIS Cushman and Ponton
(Pl. 7, figs. 16-18)

Globorotalia wilcoxensis CUSHMAN and PONTON, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 71, pl. 9, fig. 10.—CUSHMAN and GARRETT, l. c., vol. 15, 1939, p. 88, pl. 15, figs. 21, 22.—CUSHMAN, Amer. Journ. Sci., vol. 242, 1944, p. 15, pl. 2, figs. 14, 15; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 27.—CUSHMAN and TODD, l. c., vol. 24, 1948, p. 36, pl. 6, figs. 24, 25.

Test rather small for the genus, planoconvex, dorsal side flat or slightly convex in the middle, ventral side sharply convex but with an open umbilicus, periphery acute but not keeled; chambers narrow, elongate and oblique on the dorsal side, 4½ to 5 comprising the last-formed whorl, increasing rapidly in thickness and inflation ventrally so that the umbilicus is surrounded by a series of raised knobs; sutures distinct, tangential on the dorsal side, radial and deeply depressed on the ventral side; wall covered thickly by very fine, sharp spines; aperture a semicircular opening toward the umbilical end of the ventral side of the last-formed chamber. Diameter 0.33-0.42 mm.; thickness 0.22 mm.

The plesiotypes are from the Paleocene, 200 meters N. of Cerro Avenue on road to Rancho Boyeros, Habana Prov., Cuba (Bermudez sta. 530).

GLOBOROTALIA (TRUNCOROTALIA) WILCOXENSIS Cushman and Ponton, var. ACUTA Toulmin (Pl. 7, figs. 19-21)

Globorotalia wilcoxensis CUSHMAN and PONTON, var. *acuta* TOULMIN, Journ. Pal., vol. 15, 1941, p. 608, pl. 82, figs. 6-8.—CUSHMAN and RENZ, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 12, pl. 3, fig. 2.—CUSHMAN, Amer. Journ. Sci., vol. 242, 1944, p. 15, pl. 2, figs. 16, 17; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 48, pl. 8, fig. 5.—CUSHMAN and BERMUDEZ, l. c., vol. 24, 1948, p. 89 (list).

This variety differs from the typical form in the more sharply angled

periphery, the more rapid increase in thickness of the test, and the lack of the fine, sharp spines on the surface.

The plesiotypes are from the Paleocene, 3.5 kms. W. of Madruga, Habana Prov., Cuba (Bermudez sta. 75).

GLOBOROTALIA (TRUNCOROTALIA) BRÖDERMANNI Cushman and Bermudez, n. sp.
(Pl. 7, figs. 22-24)

Test of small size for the genus, thick and compact, composed of about 2 whorls, about equally biconvex, periphery rounded and blunt, umbilicus large and open; chambers indistinct, about 6 in the last-formed whorl, very gradually increasing in size as added, slightly inflated; sutures depressed, curved on the dorsal side and radial on the ventral side; wall covered by thick, short, coarse spines; aperture a narrow, low opening under the ventral edge of the last-formed chamber, without a lip. Length 0.33 mm.; breadth 0.28 mm.; thickness 0.18 mm.

Holotype (Cushman Coll. No. 47407) from the lower Eocene, Capdevila formation, .5 km. S. of Capdevila, Habana Prov., Cuba (Bermudez sta. 349).

This species resembles *G. albeari* n. sp., particularly in dorsal view. It differs, however, in its large, open umbilicus and its less acute periphery.

G. brödermanni is found only in the Capdevila formation of the lower Eocene where it is a good index fossil.

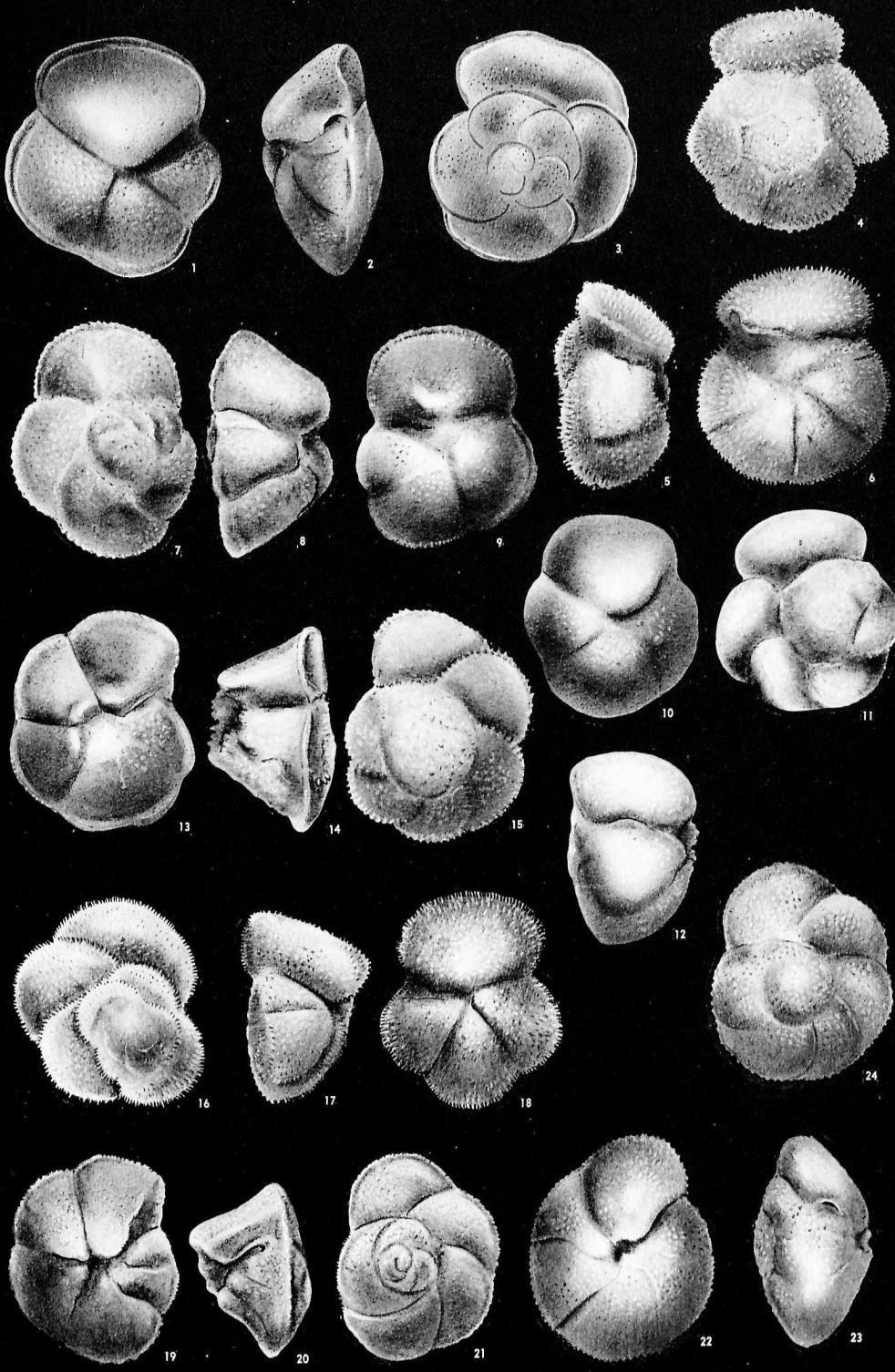
The species is named in honor of Ing. Jorge Brödermann, Director del Mapa Geológicó de Cuba.

GLOBOROTALIA (TRUNCOROTALIA) SPINULOSA Cushman (Pl. 8, figs. 1-3)

Globorotalia spinulosa CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 3, 1927, p. 114, pl. 23, fig. 4.—COLE, Bull. Amer. Pal., vol. 14, No. 51, 1927, p. 34, pl. 2, fig. 9.—NUTTALL, Journ. Pal., vol. 4, 1930, pp. 276, 288.—HOWE, Geol. Bull. 14, Louisiana Geol. Survey, 1939, p. 85, pl. 12, figs. 10-12.—CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 75, pl. 12, fig. 21.—FRANKLIN, Journ. Pal., vol. 18, 1944, p. 318, pl. 48, fig. 8.

EXPLANATION OF PLATE 7

FIGS. 1-3. *Globorotalia (Truncorotalia) hirsuta* (d'Orbigny). × 55. 1, Ventral view. 2, Peripheral view. 3, Dorsal view. 4-6. *G. (T.) crassata* (Cushman). × 80. 4, Dorsal view. 5, Peripheral view. 6, Ventral view. 7-9. *G. (T.) crassata* (Cushman), var. *aequa* Cushman and Renz. × 60. 7, Dorsal view. 8, Peripheral view. 9, Ventral view. 10-12. *G. (T.) crassata* (Cushman), var. *densa* (Cushman). × 65. 10, Ventral view. 11, Dorsal view. 12, Peripheral view. 13-15. *G. (T.) aragonensis* Nuttall. × 45. 13, Ventral view. 14, Peripheral view. 15, Dorsal view. 16-18. *G. (T.) wilcoxensis* Cushman and Ponton. × 80. 16, Dorsal view. 17, Peripheral view. 18, Ventral view. 19-21. *G. (T.) wilcoxensis* Cushman and Ponton, var. *acuta* Toulmin. × 80. 19, Ventral view. 20, Peripheral view. 21, Dorsal view. 22-24. *G. (T.) brödermanni* Cushman and Bermudez, n. sp. × 100. 22, Paratype, ventral view. 23, Paratype, peripheral view. 24, Holotype, dorsal view.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Test rather attenuated, dorsal side convex in the middle but the surface of the last-formed whorl flat, ventral side strongly convex with the inner points of each chamber rising as knobs surrounding the open umbilicus, periphery lobulated, sharply acute throughout and surrounded by a spinose keel; chambers indistinct in the earlier whorl, last whorl composed of 4 chambers, very rapidly increasing in size as added, somewhat inflated on the ventral side; sutures indistinct on the dorsal side, distinctly depressed and radial on the ventral side; wall finely perforate, covered by fine, low spines; aperture a rather high, arched, narrow opening midway between the umbilicus and the periphery, at the base of the last-formed chamber. Length 0.38-0.42 mm,; breadth 0.30-0.35 mm.; thickness 0.25 mm.

The plesiotypes are from the lower Eocene, 7.5 kms. W. of Madruga on the highway, Habana Prov., Cuba (Bermudez sta. 97).

GLOBOROTALIA (TRUNCOROTALIA) VELASCOENSIS (Cushman) (Pl. 8, figs. 4-6)

Pulvinulina velascoensis CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 19, pl. 3, fig. 5; Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 608, pl. 21, fig. 9.

Globorotalia velascoensis CUSHMAN, Journ. Pal., vol. 1, 1927, p. 169, pl. 27, figs. 7-9.—WHITE, Journ. Pal., vol. 2, 1928, p. 281, pl. 38, fig. 2.—CUSHMAN and JARVIS, Proc. U. S. Nat. Mus., vol. 80, Art. 14, 1932, p. 51, pl. 15, fig. 8.—MUIR, Geol. Tampico Region, 1936, pp. 79 etc. (lists).—APPLIN and APPLIN, Bull. Amer. Assoc. Petr. Geol., vol. 28, No. 12, 1944, pl. 5, fig. 4.—APPLIN and JORDAN, Journ. Pal., vol. 19, 1945, p. 132 (list); p. 146, pl. 19, fig. 8.—CUSHMAN, U. S. Geol. Survey Prof. Paper 206, 1946, p. 153, pl. 63, fig. 6.—CUSHMAN and RENZ, Special Publ. 18, Cushman Lab. Foram. Res., 1946, p. 47, pl. 8, figs. 11, 12.

Test planoconvex, dorsal side flat or very slightly convex in the middle, ventral side strongly convex with a large, open umbilicus surrounded by the raised knobs formed by the inner ends of the chambers, periphery acute throughout, keeled, ventral side of the test with a depressed area inside the periphery appearing to increase the width of the keel; chambers indistinct on the dorsal side except in the last whorl, 6 or 7 chambers comprising the last-formed whorl, not much increasing in size or

EXPLANATION OF PLATE 8

FIGS. 1-3. *Globorotalia (Truncorotalia) spinulosa* Cushman. × 100. 1, Dorsal view. 2, Peripheral view. 3, Ventral view. 4-6. *G. (T.) velascoensis* (Cushman). × 90. 4, Ventral view. 5, Peripheral view. 6, Dorsal view. 7-9. *G. (Turborotalia) punctulata* (d'Orbigny). × 50. 7, Peripheral view. 8, Dorsal view. 9, Ventral view. 10-12. *G. (T.) cerro-azulensis* (Cole). × 50. 10, Ventral view. 11, Peripheral view. 12, Dorsal view. 13-15. *G. (T.) oceanica* Cushman and Bermudez, n. sp. × 70. 13, Paratype, ventral view. 14, Paratype, peripheral view. 15, Holotype, dorsal view. 16-18. *G. (T.) mayeri* Cushman and Ellisor. × 95. 16, Ventral view. 17, Peripheral view. 18, Dorsal view. 19-21. *G. (T.) centralis* Cushman and Bermudez. × 50. 19, Dorsal view. 20, Peripheral view. 21, Ventral view.

thickness as added; sutures indistinct, slightly depressed, curved and tangential on the dorsal side, very deeply incised and radial or slightly curved on the ventral side; wall covered throughout by a fine spinosity becoming more conspicuous on the peripheral keel; aperture an elongate, narrow opening under the ventral edge of the last-formed chamber. Length 0.40-0.50 mm.; breadth 0.35-0.40 mm.; thickness 0.25 mm.

The species was described from the Upper Cretaceous, Velasco formation, of Mexico and has been reported in the Upper Cretaceous of Trinidad and the Paleocene of Florida. In Cuba it has been found in the higher beds of the Upper Cretaceous, Habana formation, and in the Paleocene, Madruga formation. The plesiotypes are from the Paleocene, 200 meters N. of Cerro Avenue on the road to Rancho Boyeros, Habana Prov., Cuba (Bermudez sta. 530).

Subgenus TURBOROTALIA Cushman and Bermudez, n. subgen.

Subgenotype, *Globorotalia centralis* Cushman and Bermudez

Test globular and thick, periphery rounded and becoming more rounded with growth of the test, no definite umbilicus; chambers not much increasing in size but rapidly in thickness as added.

GLOBOROTALIA (TURBOROTALIA) PUNCTULATA (d'Orbigny) (Pl. 8, figs. 7-9)

Globigerina punctulata D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 277.—FORNASINI, Pal. Ital., vol. 4, 1898, p. 210, text fig. 5.

Globorotalia punctulata CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 17, 1941, p. 41, pl. 10, figs. 24, 25; pl. 12, fig. 1.—CUSHMAN and TODD, l. c., Special Publ. 15, 1945, p. 68, pl. 11, fig. 18.

Test of medium size for the genus, subglobular, composed of 2½ to 3 whorls, dorsal side nearly flat, ventral side strongly convex; chambers indistinct, 4 comprising the last whorl, not increasing in size but rapidly in thickness as added, inflated, especially ventrally; sutures distinct, depressed, straight and radial on the dorsal side, distinctly incised and radial on the ventral side; wall smooth, finely perforate, polished except on the earlier chambers on the ventral side surrounding the aperture where it is granular; aperture a large, arched opening under the edge of the last-formed chamber, extending from the umbilicus to the periphery, with the adjacent wall of the last-formed chamber immediately above the aperture being smooth and polished. Diameter 0.50-0.60 mm.; thickness 0.50 mm.

The plesiotypes are from *Atlantis* sta. 3374, 300 fms., lat. 20° 45′ N., long. 75° 19′ W., north of Oriente Prov., Cuba.

GLOBOROTALIA (TURBOROTALIA) CERRO-AZULENSIS (Cole) (Pl. 8, figs. 10-12)

Globigerina cerro-azulensis COLE, Bull. Amer. Pal., vol. 14, No. 53, 1928, p. 217 (17), pl. 1, figs. 11-13.

Eponides cerro-azulensis NUTTALL, Journ. Pal., vol. 4, 1930, p. 274.

Globorotalia cerro-azulensis MUIR, Geol. Tampico, Mexico, 1936, p. 119 (list).—BERMUDEZ, Mem. Soc. Cubana Hist. Nat., vol. 12, 1938, p. 10.

Test of medium size for the genus, dorsal side slightly convex in the middle, surface of the last whorl flat, ventral side strongly inflated, umbilicus not open, periphery bluntly acute around the earlier chambers, later becoming rounded; chambers 4 in the last-formed whorl, not much increasing in size but rapidly in thickness as added, long and narrow on the dorsal side, globular and inflated ventrally; sutures curved, tangential and slightly depressed on the dorsal side, depressed and radial on the ventral side; wall finely perforate and finely granular; aperture a high, arched, narrow opening under the ventral edge of the last-formed chamber, slightly in from the periphery. Diameter 0.55-0.60 mm.; thickness 0.38 mm.

This species resembles *G. cocoaensis* Cushman but is a generally larger and more robust form and is more inflated on the ventral side. It was originally described from the upper Eocene, Chapapote formation of Mexico. In Cuba it is a good index fossil for the upper Eocene, Guantanamo and Consuelo formations. The plesiotypes are from the upper Eocene, N. of grua 9, Ramal Juan Criollo of Central Jatibonico, Camaguey Prov., Cuba (Bermudez sta. 481).

GLOBOROTALIA (TURBOROTALIA) OCEANICA Cushman and Bermudez, n. sp.

(Pl. 8, figs. 13-15)

Pulvinulina crassa H. B. BRADY (not *Rotalina crassa* D'ORBIGNY), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 694, pl. 103, figs. 11, 12.—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 5, 1915, p. 58, pl. 27, fig. 1.

Test of medium size for the genus, dorsal side nearly flat, ventral side strongly convex but with an open umbilicus, periphery bluntly angled around the earlier chambers, later becoming rounded; chambers 4 in the last-formed whorl, very little increasing in size but rapidly in thickness as added; sutures slightly depressed, tangential and slightly curved on the dorsal side, incised and radial on the ventral side; wall thin, very finely perforate, smooth except slightly granular over the earliest chambers on the dorsal side and with thick spinose projections on the three earlier chambers surrounding the umbilicus; aperture a low, elongate opening under the ventral edge of the last-formed chamber, extending nearly from the umbilicus to the periphery and overhung by a very narrow, thin lip. Diameter 0.50-0.65 mm.; thickness 0.37 mm.

Holotype (Cushman Coll. No. 47387) from *Atlantis* sta. 2980, 250 fms., lat. 22° 47′ N., long. 78° 40′ W., north coast of Cuba.

This species differs from *G. (T.) punctulata* (d'Orbigny) in its more

angular periphery, larger and more open umbilicus, and the very low, elongate aperture.

GLOBOROTALIA (TURBOROTALIA) MAYERI Cushman and Ellisor (Pl. 8, figs. 16-18)

Globorotalia mayeri CUSHMAN and ELLISOR, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 11, pl. 2, fig. 4.—ELLISOR, Bull. Amer. Assoc. Petr. Geol., vol. 24, No. 3, 1940, pl. 2, fig. 9.—D. K. PALMER, Mem. Soc. Cubana Hist. Nat., vol. 15, 1941, p. 292, pl. 28, fig. 5.

Test small for the genus, thick but about equally inflated on both sides, periphery lobulated, rounded throughout, umbilicus open; chambers indistinct, 5 or 6 in the last-formed whorl, inflated and rather gradually increasing in size as added; sutures indistinct on the dorsal side, incised and radial on the ventral side; wall very coarsely perforate; aperture a large, arched opening under the ventral edge of the last-formed chamber, extending nearly from the umbilicus to the periphery and bordered by a distinct, thin rim. Diameter 0.33-0.37 mm.; thickness 0.20-0.22 mm.

This species is found in the upper middle to uppermost Oligocene, frequently associated with *G. fohsi* Cushman and Ellisor. The plesiotypes are from the upper Oligocene, upper Cojimar formation, Finca El Junco, Limonar, Matanzas Prov., Cuba (Bermudez sta. 1196).

GLOBOROTALIA (TURBOROTALIA) CENTRALIS Cushman and Bermudez
(Pl. 8, figs. 19-21)

Globorotalia centralis CUSHMAN and BERMUDEZ, Contr. Cushman Lab. Foram. Res., vol. 13, 1937, p. 26, pl. 2, figs. 62-65.—BERMUDEZ, Mem. Soc. Cubana Hist. Nat., vol. 12, 1938, p. 93.—HOWE, Geol. Bull. 14, Louisiana Geol. Survey, 1939, p. 84, pl. 12, figs. 4-6.—BERGQUIST, Bull. 49, Mississippi State Geol. Survey, 1942, p. 97, pl. 9, figs. 34, 36, 37.—KEIJZER, Geol. Oriente, Cuba, Thesis Utrecht Univ., 1945, p. 90 (list).

Test subglobular, inflated, composed of about 2½ whorls, dorsal side flat or slightly convex, ventral side strongly convex, periphery bluntly angled around the first chambers, later becoming rounded; chambers 5 in the last-formed whorl, increasing rapidly in size and very rapidly in thickness as added, ventral face of last-formed chamber concave above the aperture; sutures distinct, depressed, straight and tangential on the dorsal side, more deeply depressed and radial on the ventral side; wall finely perforate, covered by a fine spinosity which becomes coarser surrounding the umbilical area; aperture very large for the genus, a high, arched opening, extending from the umbilicus to the periphery and bordered by a narrow lip. Diameter 0.50-0.65 mm.; thickness 0.40-0.50 mm.

This species was originally described from the lower part of the upper Eocene, Jicotea formation, Cuba, where it is very abundant and a good marker for this horizon. It has also been found in the San Luis and

Jabaco formations in the lower part of the upper Eocene and in the Loma Candela formation of the middle Eocene. The record of *Globigerina inflata* d'Orbigny (Cole, Bull. Amer. Pal., vol. 14, No. 51, 1927, p. 33, pl. 4, fig. 19) from the Guayabal formation of Mexico is probably this species. The figures accompanying Howe's record from the Cook Mountain Eocene of Louisiana correspond very closely to the Cuban specimens. Our plesiotypes are from the lower part of the upper Eocene, Jabaco formation, Cantera (quarry) Punta Brava, in the vicinity of Punta Brava village, Habana Prov., Cuba (Bermudez sta. 464).

RECENT LITERATURE ON THE FORAMINIFERA

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

Asano, Kiyosi. Fossil Foraminifera from the Moniwa Shell Beds in the Vicinity of Sendai, Japan.—Journ. Geol. Soc. Japan, vol. 44, No. 520, 1937, pp. 28-35, text figs. 1-6.—Four new species are described in the English résumé.

Recent and Fossil Foraminifera from Tosa, Japan.—L. c., pp. 36-55, map.—Numerous lists and distribution tables are given.

Recent Foraminifera from Onagawa Bay, Japan.—Botany and Zoology, vol. 6, No. 7, 1938, pp. 83-90, map.—A distribution table is given. The text is in Japanese.

Recent Foraminifera from Urasima Bank, Wakasa Bay, Japan.—L. c., vol. 7, No. 10, 1939, pp. 39-46, text figs. 1-4.—A distribution table is given. The text is in Japanese.

Fossil Foraminifera from Miura Peninsula, Japan.—Japanese Reports of the Institute of Geology and Paleontology, Tohoku University, No. 31, 1938, pp. 1-56, pls. I-V, map.—Text in Japanese.

Fossil Foraminifera from Bôsô Peninsula, Japan.—L. c., pp. 57-96, pls. VI-IX, map.—Text in Japanese.

Limestones of the South Sea Islands under the Japanese Mandate.—Jubilee Publ. Comm. Prof. H. Yabe's 60th Birthday, 1939, pp. 537-550, pls. 27, 28, map.—Numerous larger foraminifera are mentioned. English résumé.

Silvestri, A. La *Siphonclavulina trigona* A. Silv. dell'Eocene Piemontese.—Boll. Soc. Geol. Ital., vol. 66, 1947, 3 pp., 2 text figs.—A new arenaceous genus, *Siphonclavulina,* is erected.

Colom, G. Los microforaminíferos fósiles y su utilidad en geología estratigráfica.—Bol. Instit. Geol. Min. España, vol. LX, 20° de la Ter. Ser., 1947, pp. 113-151, pls. I-VIII, text figs. 1-10.—Charts showing ranges of arenaceous genera in the Cretaceous and Tertiary and of species of *Globotruncana* in the Cretaceous are given. Numerous sections, mostly *Globotruncana,* are figured.

Foraminiferos del Cretaceo Superior del Sahara Español, Recogidos por el Profesor M. Alia.—Bol. Real Soc. Española Hist. Nat., vol. XLV, 1947, pp. 659-672, pls. XLVI-XLIX.—Nineteen species and varieties described and figured, 4 new.

Ovey, C. D. Some Ecological Aspects of the Foraminifera and their Application to Stratigraphy.—Trans. South-East. Naturalist and Antiquary, vol. LIII, 1948, pp. 39-47, text figs. 1-3.

Wood, Alan. *"Sphaerocodium,"* a Misinterpreted Fossil from the Wenlock Limestone. —Proc. Geol. Assoc., vol. 59, pt. 1, 1948, pp. 9-22, pls. 2-5.—A new encrusting genus from the Silurian, questionably referred to the Foraminifera, is erected: *Wetheredella* (genotype *W. silurica* n. sp.).

Cita, Maria Bianca. Ricerche stratigrafiche e micropaleontologiche sul Cretacio e sull'Eocene di Tignale (Lago di Garda).—Riv. Ital. Pal. Stratig., vol. LIV, Nos. 2-4, 1948, pp. 49-74, 117-134, 143-169, pls. 2-4.—Numerous species are described and figured, 2 new.

Emiliani, Cesare. Su Due Microfaune Contenute nelle "Argille Scagliose" di Castel dell'Alpi (Bologna).—L. c., No. 2, pp. 75-77.—Lists foraminifera.

Martinis, Bruno. Sulla Presenza del Pliocene Marino nel Sottosuolo di Albino (Prealpi Bergamasche).—L. c., No. 2, pp. 78-86, text fig. 10.—Lists foraminifera.

Petters, Victor, and Rolando Gandolfi. Contributo alla Conoscenza dei Foraminiferi Oligocenici nel Versante Nord dell'Appennino Settentrionale (Fam. Rotaliidae e Anomalinidae).—L. c., No. 3, pp. 97-116, pl. I, text fig. 16 and range chart.—Sixteen species, 1 new, and 1 new variety are described and figured.

Hanzawa, Shoshiro. A Comparative Study of the Fossil Foraminiferal Fauna of the Ryukyu Limestone and the Recent Fauna of the Ryukyu Islands.—Report of the Committee on a Treatise on Marine Ecology and Paleoecology, 1946-1947, No. 7, March 1948, pp. 77-88.—Numerous lists of foraminifera.

Morishima, Masao. The Accumulation of Foraminiferal Tests in Inlets of Wakasa Bay on the Inland Sea of Japan.—L. c., pp. 89-91.

Foraminiferal Thanatocoenoses of Ago Bay, Kii Peninsula, Japan.—L. c., No. 8, Dec. 1948, pp. 111-117, charts 1, 2.—Occurrence and relative abundance of species in different parts of the bay are studied.

Oinomikado, T., and Leo W. Stach. Recent Shallow Water Foraminiferal Assemblages from Niigata Prefecture, Japan.—L. c., pp. 104-110, text fig. 1 (graph).—A distribution table of numerous species is given.

Emery, K. O. Submarine Geology of Ranger Bank, Mexico.—Bull. Amer. Assoc. Petr. Geol., vol. 32, No. 5, May 1948, pp. 790-805, text figs. 1-10, tables I-V.—Lists foraminifera.

ten Dam, A. Observations sur le genre de Foraminifères *Karreria* Rzehak 1891.—Bull. Soc. Géol. France, ser. 5, vol. XVIII, 1948, pp. 285-288, pl. XIII.—The genus is recognized and placed in the Planorbulinidae. Three species are described and figured, none new.

Les genres de Foraminifères *Höglundina* Brotzen 1948 et *Epistomina* Terquem 1883.—C. R. S. Soc. Géol. France, séance du 7 juin 1948, pp. 226, 227.

Muraour, Pierre. Sur la présence d'une nouvelle espèce de *Siphonodosaria* dans la molasse astienne d'Alger.—L. c., séance du 21 juin 1948, pp. 250, 251, text figs. A-C.

Sur l'existence d'une cloison médiane chez certaines formes enroulées de Lagenidae.—C. R. S. Acad. Sci., vol. 228, séance du 31 janvier 1949, pp. 419, 420, text figs. 1, 2.

ten Dam, A., and J. Magne. Les espèces du genre de foraminifères *Globorotalites* Brotzen.—Rev. Instit. Français Pétrole et Ann. Combustibles liquides, vol. III, No. 8, Aug. 1948, pp. 222-228, text figs. 1-10, 2 charts.—Nine species, none new, are figured and described with their stratigraphic ranges. A scheme of evolution is also shown.

Brotzen, Fritz. A New Name.—The Micropaleontologist, vol. 2, No. 4, Oct. 1948, p. 13. *Planulina scanica* n. name replaces *P. limbata* Brotzen 1948 (not Natland 1938).

Burma, Benjamin H. Studies in Quantitative Paleontology: I. Some Aspects of the Theory and Practice of Quantitative Invertebrate Paleontology.—Journ. Pal., vol. 22, No. 6, November, 1948, pp. 725-761, text figs. 1-23.

Small, James. Quantitative Evolution. XIV. Production Rates.—Proc. Roy. Soc. Edinburgh, sec. B (Biol.), vol. LXIII, pt. II (No. 12), 1948, pp. 188-199, text figs. 1-4.—Foraminiferal families and genera are used as examples.

Flandrin, Jacques. Contribution a l'Étude Stratigraphique du Nummulitique Algérien.—Bull. Service de la Carte Géol. Algérie, 2e sér., Stratig., No. 19, 1948, pp. 1-340, pls. I-VIII, text figs. 1-90.—Large and small foraminifera are mentioned.

di Napoli Alliata, Enrico. La Micropaleontologia Applicata allo Studio dei Problemi Geopetroliferi della Pianura Padana.—Riv. Tecnica "Metano," No. 12, Dec. 1948, pp. 1-5, 1 text fig.—Includes a graph of a statistical study of *Uvigerina peregrina.*

Wickenden, R. T. D. *Eoeponidella,* a New Genus from the Upper Cretaceous.—Trans. Roy. Soc. Canada, ser. 3, vol. XLII, sec. IV, May 1948 (1949), pp. 81, 82, text fig. 1.—*Eoeponidella* n. gen. (genotype *E. linki* n. sp.).

Israelsky, Merle C. Oscillation Chart.—Bull. Amer. Assoc. Petr. Geol., vol. 33, No. 1, Jan. 1949, pp. 92-98, text figs. 1-3, chart.—Foraminifera are used in making the chart.

Woodring, W. P., and T. F. Thompson. Tertiary Formations of Panama Canal Zone and Adjoining Parts of Panama.—L. c., No. 2, Feb., 1949, pp. 223-247, text figs. 1, 2 (map and chart).—Various species of foraminifera are noted.

Moore, Raymond C., and M. L. Thompson. Main Divisions of Pennsylvanian Period and System.—L. c., No. 3, March, 1949, pp. 275-302, text figs. 1, 2.—Ranges of fusulinid genera are shown.

Hussey, Keith M. Louisiana Cane River Eocene Foraminifera.—Journ. Pal., vol. 23, No. 2, March, 1949, pp. 109-144, pls. 25-29.—One hundred twenty-one species, 77 new, and 1 new variety, are described or noted and most of them figured.

Stainforth, R. M. The *Hannatoma* Fauna in the Zapotal Sands of Southwest Ecuador. —L. c., pp. 155, 156.—Foraminifera mentioned.

Stone, Benton. Age of the Chira Group, Northwestern Peru.—L. c., pp. 156-160.—Foraminifera listed.

Thompson, M. L. The Permian Fusulinids of Timor.—L. c., pp. 182-192, pls. 34-36, text fig. 1.—Five species, 1 new, are described and illustrated.

Hanzawa, Shoshiro. A new type of the fusulinid Foraminifera from Central Japan.—L. c., pp. 205-209, pl. 43, text figs. 1-3.—A new subgenus and a new species are figured and described.

Morishima, Masao. A new Miocene *Lepidocyclina* from Shizuoka Prefecture, Japan. —L. c., pp. 210-213, pls. 44, 45, text fig. 1 (section).—A new species is described and figured.

Tromp, S. W. The Value of Globigerinidae Ratios in Stratigraphy.—L. c., pp. 223, 224.—Frequency ratios of genera can be used for local correlations.

Loeblich, Alfred R., Jr., and Helen Tappan. New Kansas Lower Cretaceous Foraminifera.—Journ. Washington Acad. Sci., vol. 39, No. 3, March 15, 1949, pp. 90-92. —A new genus *Verneuilinoides* (genotype *Verneuilina schizea* Cushman and Alexander) is erected, and 2 new species described: *Ammobaculites euides* and *A. obliquus*.

Newell, Norman D. Geology of the Lake Titicaca Region, Peru and Bolivia.—Mem. 36, Geol. Soc. Amer., March 28, 1949, pp. 1-111, pls. 1-21, text figs. 1-14.—Fusulinid foraminifera are mentioned.

Layer, D. B., and Members of Staff, Imperial Oil Limited. Leduc Oil Field, Alberta, a Devonian Coral-Reef Discovery.—Bull. Amer. Assoc. Petr. Geol., vol. 33, No. 4, April 1949, pp. 572-602, pls. 1, 2, text figs. 1-8.—Foraminifera are listed from the Cretaceous.

Cushman, Joseph A., and D. J. Cederstrom. An Upper Eocene Foraminiferal Fauna from Deep Wells in York County, Virginia.—Bull. 67, Virginia Geol. Survey, 1945 (April 15, 1949), pp. 1-58, pls. 1-6.—Ninety-two species and varieties, 13 new, are recorded and most of them figured from the new Chickahominy subsurface formation.

Shifflett, Elaine. Eocene Stratigraphy and Foraminifera of the Aquia Formation.—Bull. 3, Maryland Dept. Geol., Mines and Water Resources, 1948 (1949), pp. 1-93, pls. 1-5, text figs. 1-21 (maps, charts, sections, table).—Eighty-nine species and varieties of foraminifera are recorded and most of them described and figured, 6 species and 1 variety new.

Boomgaart, L. Smaller Foraminifera from Bodjonegoro (Java). Thesis Univ. Utrecht, 1949, pp. 1-175, pls. I-XIV, text figs. 1-3, tables 1-7, distribution chart.—Two hundred ninety-two species and varieties are recorded and most of them described and illustrated from well drillings of Pliocene to Miocene age. Thirty species and ten varieties are new and there are 3 new names and one new genus, *Pseudonodosaria* (genotype *Glandulina discreta* Reuss).

R. T.