most distinctive feature. On a few shells the suture on the last half of the body whorl descends more sharply than on the common form, producing a correspondingly higher spire.

The more distinct depression on the umbilical callus lobe and the narrower groove at the outer edge of the lobe differentiate *Tectonatica agna* from *T. pusilla* (Say), which moreover is slightly larger. *T. pusilla* is the only fossil *Tectonatica* recorded from the Caribbean region (Woodring, 1928, p. 384, pl. 30, fig. 12). It now ranges from Massachusetts to Florida. A Recent West Indian species, possibly *T. sagraiana* (d'Orbigny) also lacks the callus depression. No Recent Panamic species is represented in the U. S. National Museum collection.

Occurrence: Middle and upper parts of Gatun formation (middle and late Miocene). Middle part, eastern area, localities 146, 147b, 147f, 147g, 147h, 151, 153a. Upper part, eastern area, locality 177c; western area, locality 185 (identification doubtful).

Subfamily POLINICINAE

Genus Polinices Montfort

Montfort, Conchyliologie systématique, v. 2, p. 223, 1810.
Type (orthotype): *Polinices albus* Montfort (=*Natica mamillaris* Lamarck=*Natica brunnea* Link), Recent, West Indies.

Incomplete and poorly preserved naticids from the Gatuncillo formation, the marine member of the Bohio(?) formation, and the Culebra formation are doubtfully referred to *Polinices*. The umbilical features of these fossils, most of which are molds, are not known.

Polinices canalizonalis (Brown and Pilsbry)

Plate 20, figures 7, 8

Natica canalizonalis Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 64, p. 508, pl. 22, fig. 10, 1913 (Miocene, Canal Zone).

Of medium size, thick-shelled. Body whorl appressed at suture, strongly inflated below appressed area. Aperture small for size of shell. Apical whorl small. Faint microscopic spiral lineation visible on unworn parts of shell. Umbilicus wide. Umbilical rib strong on immature shells, somewhat flattened on mature shells, ending in a wide callus lobe. Parietal callus very thick, bearing a shallow transverse groove.

Height 21 mm, diameter 18.7 mm (figured mature specimen). Height 11 mm, diameter 10 mm (figured immature specimen).

Type: Acad. Nat. Sci. Phila. 3844.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Polinices canalizonalis is the least abundant of the three Gatun species of *Polinices*. It also is the only one of the three that has a conspicuous umbilical rib. The type is an immature shell (height 8.2 millimeters). The well-defined umbilical rib indicates alliance with a Recent Caribbean species labelled *P. porcellanus* (d'Orbigny) in the U. S. National Museum collection. The Recent species has a stronger rib and is less appressed at the suture. *P. carolinianus* (Conrad) (Mansfield, 1930, p. 127, pl. 19, fig. 1), which occurs in the Duplin formation of North Carolina and in deposits of late Miocene age in western Florida, is larger, less appressed at the suture, and has a stronger rib. A late Miocene species from Trinidad, *P. boutakoffi* Rutsch (1942, p. 139, pl. 6, figs. 7a, 7b), belongs in this group of species characterized by a strong umbilical rib. According to Rutsch's illustrations, it is more inflated, less appressed at the suture, and has a deeper groove on the parietal callus.

Occurrence: Lower middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 136a. Middle part, eastern area, Gatun Locks excavation (Brown and Pilsbry); western area, locality 161a. Upper part, eastern area, localities 177b, 177c.

Polinices brunneus subclausus (Sowerby)

Plate 20, figure 9

Natica subclausa Sowerby, Geol. Soc. London Quart. Jour., v. 6, p. 51, 1850 (Miocene, Dominican Republic).
Polinices subclausa (Sowerby), Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 360, 1911 (Miocene, Canal Zone). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 136, pl. 23, fig. 14, 1917 (Miocene, Dominican Republic). Olsson, idem, v. 9, no. 39, p. 157, pl. 13, figs. 16–17, 1922 (Miocene, Costa Rica, Canal Zone). Hodson, Hodson, and Harris, idem, v. 13, no. 49, p. 69, pl. 36, fig. 5, 1927 (Miocene, Jamaica). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 124, 1929 (Miocene, Colombia, Canal Zone).
Polinices brunnea subclausa (Sowerby), Woodring, Carnegie Inst. Washington Pub. 385, p. 385, pl. 30, fig. 13, 1928 (Miocene, Jamaica); see this publication for other citations.
?*Polinices* (*Mammilla*) cf. *brunnea* Link, Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 29, pl. 9, fig. 12, 1929 (Miocene, Colombia).

Of medium size, thick shelled. Whorls strongly and smoothly appressed at suture. Apical whorl small. Umbilicus moderately narrow; umbilical rib almost flat. Umbilical callus lobe narrow, slightly widened by umbilical rib. Parietal callus very thick, bearing a shallow transverse groove.

Height 20.3 mm, diameter 16.7 mm (figured specimen).

Type material: British Mus., Natural History, Geol. Depart., Geol. Soc. London 12826 (6 syntypes).

Type locality: Dominican Republic, Miocene.

This *Polinices* is fairly common in the middle part of the Gatun formation at locality 161c, west of Gatun Dam, and occurs at other localities, all in the middle part of the Gatun formation. The groove on the

parietal callus is relatively deep on some small specimens. The largest Gatun shells are half as large as the largest from the Miocene of the Dominican Republic and Bowden, Jamaica (height 40 millimeters), and are much smaller than large specimens of the Recent Caribbean *P. brunneus* proper (height 50 millimeters). Like the Miocene fossils from the Dominican Republic and Jamaica, the Gatun fossils have a slightly narrower umbilicus than Recent shells of the same size. The fairly wide umbilicus of Weisbord's *Polinices* cf. *P. brunnea* indicates, however, that the Miocene form cannot consistently be distinguished by the width of the umbilicus. Recent shells that are not worn show a faint microscopic spiral lineation, which has not been observed on the fossils from the Canal Zone, the Dominican Republic, and Jamaica. The apparent absence of lineation on the fossils, however, may be due to slight wear. A small form of *P. brunneus subclausus* from the Miocene of Banana River, Costa Rica, has faint spiral lineation and also has a deep groove on the parietal callus, as shown by Olsson's illustrations.

A form of *P. brunneus subclausus* that has a notch between the parietal callus and the umbilical callus lobe has been recognized in the Miocene of Venezuela and Jamaica, and has been named *P. subclausa lavelana* F. Hodson (Hodson, Hodson, and Harris, 1927, p. 69, pl. 36, fig. 8, pl. 37, figs. 12, 14).

Polinices nelsoni Olsson (1932, p. 208, pl. 24, figs. 8, 10), which is more slender than *P. brunneus* and has a narrower umbilicus, is a late Miocene Peruvian relative of *P. brunneus*, but no close allies are known to be living in the Panamic region.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 155b, 155c; western area, localities 161 (immature, identification doubtful), 161c, 161d, 170 (immature, identification doubtful). Cercado and Gurabo formations (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica. Middle Miocene, Costa Rica. Miocene, Bolívar, Colombia.

Polinices stanislas-meunieri Maury

Plate 21, figures 11–14

Polinices stanislas-meunieri Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 136, pl. 23, figs. 15–16, 1917 (Miocene, Dominican Republic). Olsson, idem, v. 9, no. 39, p. 157, pl. 13, fig. 7, 1922 (Miocene, Costa Rica). Maury, idem, v. 10, no. 42, p. 240, pl. 40, fig. 7, 1925 (Miocene, Trinidad). Anderson, Calif. Acad. Sci. Proc. 4th ser., v. 18, no. 4, p. 124, 1929 (Miocene, Colombia).

Polinices stanislas-meunieri venezuelana F. Hodson, Bull. Am. Paleontology, v. 13, no. 49, p. 70, pl. 37, figs. 10, 15, 1927 (Miocene, Venezuela).

Not *Polinices stanislas-meunieri* Maury, Li, Geol. Soc. China Bull., v. 9, p. 267, pl. 6, fig. 48, 1930 (Miocene, Panama Bay; =*P. uber* (Valenciennes) and *P. rapulum limi* Pilsbry, fide Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 83, p. 432, 1931, Recent, Panama Bay).

Polinices springvalensis Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 241, pl. 40, fig. 6, 1925 (Miocene, Trinidad).

Moderately large, moderately thick-shelled, moderately slender to strongly inflated. Whorls not appressed at suture, except near outer lip or on most of body whorl of large specimens. Apical whorl small. Microscopic spiral lineation distinct on unworn shells. Umbilicus and umbilical callus lobe narrow. Parietal callus moderately thick, much wider than umbilical lobe, bearing a faint to distinct transverse groove on immature shells.

Height 43.5 mm, diameter 33 mm (figured large slender specimen). Height 32.5 mm., diameter 28 mm (figured inflated specimen).

Type: Cornell University 36931.

Type locality: Río Cana, Dominican Republic, Gurabo(?) formation (middle Miocene).

Polinices stanislas-meunieri is the most widespread of the Gatun species of *Polinices*. It is locally common in the lower part of the formation, but many of the specimens are relatively slender, like that shown on plate 21, figure 14. The large figured specimen (pl. 21, fig. 13) was collected by T. F. Thompson. The umbilical rib is so flat that it is virtually absent. Therefore the narrow umbilical callus lobe widens very slightly. The umbilicus is of varying width on immature shells, and is practically closed on one from locality 136 (height 6 millimeters). The transverse groove on the parietal callus is absent on shells of large and medium size, and generally is faint on small shells.

Differentiation of *P. stanislas-meunieri venezuelanus* appears to be unwarranted. *P. springvalensis* is a shouldered form of *P. stanislas-meunieri*, but is not much more strongly shouldered than the Gatun specimen shown on plate 21, fig. 12. The early Miocene Costa Rican *P. eminuloides* (Gabb) (1881, p. 339, pl. 44, fig. 4) probably is related to *P. stanislas-meunieri*. The type, and only specimen, is high spired; the umbilical area is not completely exposed; and the parietal callus is damaged.

P. stanislas-meunieri is widely distributed in the Miocene of the Caribbean region, but has no living allies there. It is closely related, however, to the Recent Panamic *P. uber* (Valenciennes). *P. stanislas-meunieri* is not much more than half as large, but its parietal callus is thicker than that of specimens of *P. uber* of the same size, indicating maturity. The outline of *P. stanislas-meunieri* ranges from strongly and smoothly inflated to moderately slender, whereas that of *P. uber* is more uniformly strongly and smoothly inflated.

P. coensis (Dall) (Mansfield, 1930, p. 124, pl. 17, fig. 8), which occurs in deposits of late Miocene age in western Florida, and *P. robustus* Gardner (1926–47, p. 550, pl. 59, figs. 5, 14, 1947), a middle Miocene form, are the representatives of *P. stanislas-meunieri* in the Miocene of Florida. *P. coensis* is smaller than the Caribbean species. It has a more distinct notch between the umbilical callus lobe and parietal callus, thicker parietal callus, and the transverse groove on the parietal callus persists to a later stage than on Gatun fossils. *P. robustus*, which perhaps is to be considered a large high-spired subspecies of *P. coensis*, closely resembles high-spired Gatun shells, but has a thicker parietal callus.

P. coensis is the type of the subgenus *Dallitesta* Mansfield (1930, pp. 124, 125), which was proposed without any discussion of differentiating characters. Perhaps it was proposed because of the distinct spiral lineation. Should the genus *Polinices* be subdivided into subgenera, *Dallitesta* would be available for species that have a narrow umbilicus, virtually no umbilical rib, narrow umbilical callus lobe, and distinct spiral lineation. There are, however, gradations from a strong umbilical rib, like that *P. canalizonalis*, to virtually none; and many species, including *P. brunneus*, the type of the genus, have more or less distinct spiral lineation.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle and late Miocene). Lower part, localities 136, 136a, 137, 138, 138a. Middle part, eastern area, localities 140, 146 (immature, identification doubtful), 147b (immature, identification doubtful), 147g (immature, identification doubtful), 147h (immature, identification doubtful), 155, 155c (incomplete, immature, identification doubtful), 157, 159a; western area, localities 161, 161c. Upper part, eastern area, localities 171, 173 (incomplete, identification doubtful), 177b; western area, localities 182, 182a, 183, 185 (immature, identification doubtful). Middle Miocene, Costa Rica. Gurabo(?) formation (middle Miocene), Dominican Republic. Miocene, Bolívar, Colombia. Miocene, Falcón, Venezuela. Springvale formation (late Miocene), Trinidad.

Genus Neverita Risso

Risso, Histoire naturelle des principales productions de l'Europe méridionale, v. 4, p. 149, 1826.

Type (monotype): *Neverita josephinia* Risso, Recent, Mediterranean Sea.

The Gatuncillo and Culebra formations, Emperador limestone member of the Culebra formation, and the La Boca marine member of the Panamá formation yielded molds of low-spired naticids identified as *Neverita?* sp. A large low-spired naticid from the marine member of the Bohio(?) formation near Palenquilla Point (diameter 39 millimeters), the umbilicus of which is not exposed, also is identified as *Neverita?* sp.

Subgenus Glossaulax Pilsbry

Pilsbry, Nautilus, v. 42, p. 113, 1929.

Type (orthotype): *Neverita reclusiana* (Deshayes) (*Natica reclusiana* Deshayes), Recent, southern California to Gulf of California.

The subgenus *Glossaulax* embraces neverites that have a groove on the umbilical callus, dividing it into anterior and posterior lobes. The groove of the type species is located on the anterior part of the callus.

Glossaulax is widely distributed on both sides of the northern Pacific and is represented in the Eocene of western North America by a typical species, *N. secta* Gabb, which Stewart (1927, p. 325) suggested may be treated better as a subspecies of *N. reclusiana*. This subgenus formerly had a more extensive distribution. It is represented in the Eocene of southeastern United States by *N. limula* (Conrad) (Palmer, 1937, p. 125, pl. 13, figs. 13, 14, 16, 19–22, pl. 80, figs. 13, 16), in the Eocene of the Caribbean region by *N. bolivarensis* Clark, and in the Eocene or Oligocene of Peru by *N. subreclusiana* (Olsson). These early Tertiary species are hardly typical, as the umbilical callus groove is not consistently present. Typical species, however, mentioned under *N. reclusiana xena*, are found in the Miocene of Florida and the Caribbean region.

Neverita (Glossaulax) bolivarensis tapina Woodring, n. subsp.

Plate 15, figures 7, 8, 11

Of medium size, depressed, conical. Umbilical callus partly filling umbilicus, the wide unfilled space decreasing in width toward parietal callus, but extending to junction of umbilical and parietal callus. Parietal callus set off from umbilical callus by a faint groove. Posterior part of umbilical callus bearing a faint groove. Umbilical wall faintly striate.

Height 14.5 mm, diameter 19 mm (type). Height 16.5 mm, diameter 26.5 mm (largest specimen).

Type: USNM 561354. Paratype, USNM 561442.

Type locality: 40d (USGS 6028a, Gatun Lake area, lower bed at Vamos Vamos, off Palenquilla Point, Canal Zone, now submerged), marine member of Bohio(?) formation.

Though *Neverita bolivarensis tapina* is represented by 12 specimens from the marine member of the Bohio(?) formation, only a few show the callus features. The callus is completely exposed on the type and paratype, both of which have a relatively wide unfilled umbilical space, a faint groove between the umbilical and parietal callus, and a faint groove on the posterior part of the umbilical callus. The groove on the umbilical callus of the type probably is modified by an artificial crack. The paratype has a shallow groove that disappears before reaching the umbilical border. Enough of the umbilical callus is exposed on two other specimens to

show that a considerable part of the umbilicus is not filled.

This neverite is considered a subspecies of *N. bolivarensis* Clark (Clark and Durham, 1946, p. 16, pl. 15, figs. 10, 11, 14, 15, 18–20, 22, 26)—a subspecies characterized by its depressed outline and wide umbilical space gradually tapering toward the parietal callus. The specimen of *N. bolivarensis* proper shown by Clark on plate 15, figure 11, is depressed and has a wide umbilical space. The umbilical space, however, separates the callus from the entire umbilical wall. *N. bolivarensis* proper occurs in the late Eocene of Colombia. It and the subspecies from Panamá are related to *N. subreclusiana* (Olsson) (1931, p. 68, pl. 10, figs. 1, 4), of the late Eocene or early Oligocene Chira shale of Perú. That species has a high spire and practically filled umbilicus.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), Gatun Lake area, localities 40, 40a, 40d, 41 (immature).

Neverita (Glossaulax) reclusiana xena Woodring, n. subsp.

Plate 21, figures 5, 8, 9

Of medium size, generally low spired. Spiral lineation visible on umbilical wall, but not elsewhere, presumably due to slight wear. Posterior lobe of umbilical callus longer than anterior lobe, reaching umbilical wall. Space between umbilical wall and anterior lobe of umbilical callus narrow or very narrow.

Height 25 mm, diameter 27 mm (type). Height 34 mm, diameter (incomplete) 35 mm (figured large high-spired specimen).

Type: USNM 561355; paratypes, Stanford Univ.

Type locality: 137 (USGS 16911, Transisthmian Highway, 1.7 kilometers northwest of Sabanita, Panamá), lower part of Gatun formation.

Neverita reclusiana zena is based on 12 specimens from the lower part of the Gatun formation and one from the middle part. It is remarkably similar to a small form of *N. reclusiana* (Deshayes) found along the outer coast of Baja California and along the Gulf of California. The Gatun neverite in general has a narrower space between the umbilical wall and the anterior callus lobe. Some small Recent shells, however, are practically indistinguishable from the fossils. This Mexican form has been listed as a variety of *N. reclusiana* (Pilsbry and Lowe, 1932, p. 126), but its status is not yet satisfactorily determined.

Typical species of *Glossaulax* are found in the Miocene of Florida and the Caribbean region: *N. chipolana* (Dall) (Gardner, 1926–47, p. 551, pl. 59, fig. 22, 1947; Chipola formation, Florida), *N. subporcana* (F. Hodson) (Hodson, Hodson, and Harris, 1927, p. 70, pl. 36, fig. 3, pl. 37, figs. 5, 9, 16; Miocene, Venezuela), and *N. cuspidata* (Guppy) (Maury, 1925, p. 239, pl. 40, figs. 9, 10; Rutsch, 1942, p. 140; Springvale formation, Trinidad). *N. chipolana* has a short anterior callus lobe; *N. subporcana* has a narrow anterior lobe and the posterior lobe leaves part of the umbilicus unfilled; *N. cuspidata* is very large (height 60 mm) and has short subequal lobes. There are no living species of *Glossaulax* in the Caribbean Sea or elsewhere in the western Atlantic. The late Miocene *N. cuspidata* is the last Caribbean species.

Inasmuch as *N. reclusiana* has a long history in the eastern Pacific going back to the Miocene, if not earlier, *N. reclusiana xena* evidently is a migrant from the Pacific. The present distribution of *N. reclusiana* and its allies, which are not found south of the Gulf of California, shows a marked reduction since Miocene time.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136a, 137, 137a. Middle part, eastern area, locality 155.

Subgenus Hypterita Woodring, n. subgen.

Type: *Natica helicoides* Gray, Recent, Baja California to Perú.

Hypterita is proposed for neverites that are greatly depressed, and have a very wide umbilicus with gently sloping wall, a thin umbilical callus lobe perched on a narrow or moderately wide umbilical rib, and a very thin wash of parietal callus. This well defined group of neverites includes only two known species: the type species and the Miocene Caribbean *Neverita nereidis*. The type species is generally known as *Neverita glauca* (Lesson).

Neverita (Hypterita) helicoides (Gray)

Plate 18, figures 15, 16

Natica patula G. B. Sowerby, Zool. Jour., vol. 1, p. 60, pl. 5, fig. 4, 1824 (Recent, locality unknown, but another specimen cited as South American). Barnes, Lyceum Natural History New York Annals, vol. 1, p. 136, 1824 (Recent, Perú). Not *Natica patula* J. Sowerby, 1822.

Natica helicoides Gray, Zool. Jour., vol. 1, p. 511, footnote, 1825 (cited as manuscript name of Barnes).

Natica glauca "Humboldt", Lesson, Voyage autour du monde * * la Coquille * *, Zoologie, vol. 2, pt. 1, p. 369, pl. 11, figs. 1, 1′, 1830 (Recent, Perú).

Natica bonplandi Valenciennes, in Humboldt and Bonpland, Voyage aux régions equinoxiales du nouveau continent, pt. 2, Recueil d'observations de zoologie, vol. 2, p. 264, pl. 57, figs. 3*a*, 3*b*, 1832 (Recent, Acapulco, Mexico; not seen).

?*Neverita nereidis* Maury, Olsson, Bull. Am. Paleontology, vol. 9, no. 39, p. 158, 1922 (Miocene, Costa Rica).

Polinices (*Neverita*) *glauca* Humboldt, Olsson, idem, vol. 27, no. 106, p. 20 (list), 1942 (Pliocene, Costa Rica).

Polinices helicoides (Gray), Hertlein and Strong, Am. Mus. Natural History Bull., vol. 107, art. 2, p. 287, 1955 (Recent, Baja California to Perú; see this publication for other citations).

Of medium size. Microscopic spiral lineation of fresh Recent shells not apparent, presumably due to slight wear. Umbilical rib narrow, slowly enlarging; unfilled umbilical space wide.

Height (incomplete) 16 mm, diameter (incomplete) 34 mm (figured specimen).

The Gatun formation yielded three incomplete fossils that closely resemble Recent shells of *Neverita helicoides* of medium size. The largest fossil, if it were complete, would have a diameter of about 45 millimeters. The largest Recent shells of *N. helicoides* in the U. S. National Museum collections have a diameter of between 55 and 60 millimeters. Slightly worn Recent shells do not show the very fine slightly wavy microscopic lineation of fresh shells.

Neverita nereidis Maury (1917, p. 137, pl. 23, figs. 17, 18), which occurs in the Cercado formation of the Dominican Republic, is closely allied to *N. helicoides*. Like the Gatun fossils, it is smaller than *N. helicoides* (diameter 35 mm). Moreover it has a wider umbilical rib than the Recent species. However remarkable it may be to recognize two very closely related species of *Hypterita* in the Miocene of the Caribbean region, the Gatun fossils are identified as *N. helicoides* on the basis of their narrow umbilical rib.

The fragment from the Miocene of Banana River, Costa Rica, identified by Olsson as *N. nereidis*, is not accessible at the present time. A fragment from that area, however, in the collections of the U. S. National Museum has a narrow umbilical rib and is doubtfully identified as *N. helicoides*.

Gray's name is far from satisfactory. He cited it as Barnes' manuscript name, a name that was still-born so far as Barnes' mention of it is concerned. Unfortunately the name, as Gray's name, is nomenclaturally available and therefore, as pointed out by Hertlein and Strong, replaces the well known name *Neverita glauca*.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 136a. Middle part, eastern area, locality 155b; western area, locality 161c. Middle Miocene, eastern Costa Rica (identification doubtful). Pliocene, western Costa Rica. Recent, Magdalena Bay, Baja California, and Gulf of California to Perú.

Subfamily SININAE

Genus Sinum Röding

Röding, Museum Boltenianum, pt. 2, p. 14, 1798.

Type (logotype, Dall, U. S. Natl. Mus. Bull. 90, p. 109, 1915): *Helix haliotoidea* Linné (cited by Röding as *Helix haliotoidea* Gmelin), Recent, western Pacific(?).

The collections from the Gatuncillo formation, the marine member of the Bohio(?) formation, and the Caimito and Culebra formations include unidentified species of *Sinum*, represented by poorly preserved specimens. The Culebra *Sinum* may be the species from the Anguilla formation, of the island of Anguilla, recorded as *Sinum chipolanum* (Dall) (Cooke, 1919, p. 124, pl. 5, figs. 6a, 6b), but the species so identified is smaller and more depressed than *S. chipolanum*.

A species from the Gatun formation, *Sinum gatunense* (Toula) (1909, p. 697, pl. 28, figs. 3a, 3b, 3c) is not represented in the collections examined. It was compared by Toula with the Recent West Indian *S. perspectivum* (Say) and, according to his illustrations, is closely related to that species and the Recent Panamic *S. noyesi* Dall. Toula's species is greatly depressed and has a very narrow base. *S. gatunense* has been recognized in the Cercado formation of the Dominican Republic (Maury, 1917, p. 138, pl. 24, fig. 2) and in the Bowden formation of Jamaica (Woodring, 1928, p. 390, pl. 31, figs. 3, 4). *S. dodonum* Gardner (1926–47, p. 554, pl. 59, figs. 37, 39, 1947), of the Oak Grove sand member of the Shoal River formation of Florida, probably is a large form of *S. gatunense*. Though Toula's illustration shows no faint spirals on the base, some specimens of the species from the Dominican Republic and Jamaica identified as *S. gatunense* have faint basal spirals like those on the type of *S. dodonum*.

Sinum euryhedra Woodring, n. sp.

Plate 21, figures 4, 7, 10

Sinum species, Woodring, Carnegie Inst. Washington Pub. 385, p. 390, 1928 (Miocene, Jamaica).

Of medium size, moderately depressed, base relatively very wide. Protoconch consisting of about 1½ smooth whorls. Spire whorls and body whorl between periphery and suture sculptured with spiral bands, separated by grooves that, for the most part, are of about same width as the bands, but near suture are twice as wide as the bands. Base smooth except for exaggerated growth lines. A narrow groove lies behind posterior part of everted columellar lip.

Height (incomplete, spire crushed) 11 mm, diameter (incomplete) 27 mm (type).

Type: USNM 561441.

Type locality: 137a (Stanford University locality 2655, Transisthmian Highway, 1.7 kilometers northwest of Sabanita, Panamá; same as USGS 16911), lower part of Gatun formation.

The type, an incomplete and somewhat crushed specimen collected from the lower part of the Gatun formation by T. F. Thompson, is the only representative of this species. It is characterized by moderate depression, wide base, and strong sculpture. Owing to crushing, the spire is too low in apertural aspect (pl. 21, fig. 4).

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There are no known close allies of this species in Caribbean and Panamic waters. *S. maculatum* (Say), a Recent Floridian and West Indian species, has a narrower base, thinner columellar lip and parietal callus, and weaker sculpture.

The small incomplete *Sinum* from the Miocene of Jamaica, so far as it goes, has the characters of *S. euryhedra*.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 137a. Bowden formation (middle Miocene), Jamaica.

Sinum gabbi (Brown and Pilsbry)

Plate 21, figures 3, 6

Sigaretus (Eunaticina) gabbi Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 64, p. 509, pl. 22, fig. 13, 1913 (Miocene, Canal Zone).

?*Sinum quirosanum* F. Hodson, Bull. Am. Paleontology, v. 13, no. 49, p. 67, pl. 36, figs. 10, 12, 1927 [Miocene (Oligocene-Miocene of Hodson), Zulia, Venezuela].

Reaching a large size, not depressed, body whorl strongly inflated. Spire low or relatively high. Protoconch of 2½ smooth slowly enlarging whorls. Sculpture of narrow closely spaced spiral threads of two or three orders. Spirals of early whorls variably crinkled by growth lines. A very narrow umbilical groove lies behind posterior part of everted columellar lip of adult shells. Immature shells umbilicate.

Height 23 mm, diameter 23 mm (figured specimen). Height 27 mm, diameter 24 mm (largest complete specimen). Estimated diameter 35 mm (largest specimen, incomplete).

Type: Acad. Nat. Sci. Phila. 3845.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

The type is a very small shell 6.5 millimeters high. The largest complete specimen (height 27 mm), collected at locality 175, has a higher spire than the others, but is associated with a smaller low-spired shell. That this species reaches a considerably larger size is shown by half of a body whorl (locality 176), which indicates a diameter of about 35 millimeters. The Venezuelan *S. quirosanum* is small, agreeing with *S. gabbi* in outline and sculpture, and may represent a small early Miocene race of *S. gabbi*. *S. nolani* Maury (1917, p. 139, pl. 24, fig. 1), a species that occurs in the Gurabo formation of the Dominican Republic, is more inflated than *S. gabbi*.

S. gabbi is a nondepressed species related to the Recent Peruvian *S. concavum* (Lamarck), the largest species of the genus (height 48 mm). The fossils, except the high-spired specimen, have a similar outline, but have spirals of less uniform width. No similar species is living in the western Atlantic.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 147*b*, 155, 155a, 155b, 155c (very small), 157. Upper part, eastern area, localities 175, 176, 177c.

Subfamily GLOBULARIINAE

Data concerning the anatomy of *Cernina fluctuata* (Sowerby), the only surviving globularine, are desirable as a basis for consideration of the subfamily or family status of that species and its numerous fossil allies.

Wrigley (1946, p. 88) has proposed a useful terminology for features in the umbilical region and on the columellar lip of globularines. The sheath (the limbe of French authors and the callus or fasciole of American authors) is the shell layer emerging from the umbilicus of umbilicated species. Its outer edge is designated the rim. The downward extension of the parietal callus, overlapping the sheath, is designated the lobe of the columellar border, or simply the lobe. The outer edge of the lobe, where it overlaps the sheath below the umbilicus, is either fairly sharp or indefinite. The sheath of some nonumbilicated species, such as *Globularia sigaretina* (Lamarck), is as well defined as that of umbilicated species, but the umbilicus is represented only by a slight depression at the posterior end of the sheath, formed by the outer edge of the lobe. On other nonumbilicated or narrowly umbilicated species a sheath is not recognizable. If present, it is concealed by the lobe, which forms an everted columellar lip that has an outer edge as sharp as a rim.

Genus Globularia Swainson

Swainson, A treatise on malacology, p. 345, 1840.

Type (logotype, Herrmannsen, Indicis generum malacozocrum, v. 1, p. 480, 1847): *Natica sigaretina* Lamarck, Eocene, Paris basin.

Subgenus Globularia s.s.

Globularia (Globularia) aff. G. fischeri (Dall)

Plate 15, figures 9, 17, 18

Moderately large, weakly shouldered, greatly inflated. Spire low, turreted. A narrow sloping shelf lies between suture and shoulder. Aperture greatly expanded. Sheath moderately wide on immature specimens. Posterior part of lobe well defined on immature specimens. Umbilicus closed.

Height (almost complete) 35.5 mm, diameter 31 mm (large figured specimen). Height 18.5 mm, diameter (incomplete) 15.5 mm (small figured specimen).

This greatly inflated *Globularia*, represented by more or less incomplete and poorly preserved specimens from the middle member of the Caimito formation of the Gatun Lake area and the Culebra formation, is closely related to *Globularia fischeri* (Gardner, 1926–47, p. 556, pl. 59, fig. 28, 1947). *G. fischeri* occurs in the Chipola

formation of Florida. Young shells of *G. fischeri*, up to a height of 13 millimeters, are narrowly umbilicated. With further growth the umbilicus is closed and the outer edge of the lobe is less well defined. A large incomplete specimen (diameter 60 mm) of *G. fischeri* has a very wide sheath, apparently almost completely covered by the thin lobe. Characters distinguishing the moderately large *G. anguillana* (Cooke) (1919, p. 123, pl. 4, figs. 9a, b; Anguilla formation, Anguilla) from *G. fischeri* are not evident. The type of *G. anguillana* has a very wide sheath; the umbilicus apparently is closed. *G. streptostoma* (Heilprin) (Dall, 1915, p. 107, pl. 12, fig. 27), from the Tampa limestone of Florida, like young shells of *G. fischeri*, is narrowly umbilicated. The umbilicus persists, however, on the largest available specimen (height 30 millimeters).

G. fischeri is the youngest *Globularia* in southeastern United States. In the Caribbean region the last representatives of the genus are found in slightly older strata: the Anguilla formation and its equivalents, which are correlated with the Tampa limestone.

Occurrence: Middle member of Caimito formation (late Oligocene), Gatun Lake area, localities 56, 57, 57a. Culebra formation (early Miocene) Gaillard Cut, localities 99g (*Globularia?* cf. *G. fischeri*), 100b.

Subgenus Ampulella Cox

Cox, Royal Soc. Edinburgh Trans., v. 57, p. 38, 1931.
Type (orthotype): *Ampullaria depressa* Lamarck, Eocene, Paris basin.

Ampulella, typical *Ampullina* of former usage, lacks the greatly expanded aperture and body whorl of *Globularia* s.s.

Globularia (Ampulella) species

Plate 15, figure 13

Small, weakly shouldered, strongly inflated. Spire low, turreted. A narrow sloping to slightly concave shelf lies between suture and shoulder. Faint microscopic lineation visible on some specimens. Aperture moderately expanded. Umbilicus narrow. Sheath moderately wide. Lobe narrow, its outer edge indefinite below umbilicus.

Height (incomplete) 21 mm, diameter (modified by dorso-ventral crushing) 19.3 mm (figured specimen).

This small *Globularia*, evidently a new species, is represented by poorly preserved fossils from the marine member of the Bohio(?) formation of the Gatun Lake area. The umbilicus is not exposed on the figured specimen and the upper part of the sheath is missing. The outline suggests the Eocene Paris basin species *Globularia parisiensis* (d'Orbigny), which occurs also in the late Eocene and early Oligocene of England (Wrigley, 1946, p. 92, figs. 6, 9). *G. parisiensis*, however, has a wider sheath and axially arranged microscopic punctae.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene) Gatun Lake area, localities 40a, 40d, 41.

Globularia (Ampulella?) nana Woodring, n. sp.

Plate 15, figures 3, 4

Very small, strongly inflated. Spire high, faintly turreted. Upper part of body whorl sculptured with faint microscopic spirals, lower part with widely spaced spiral grooves. Umbilicus practically closed. Sheath not recognizable. Lobe forming a very wide everted columellar lip.

Height (not quite complete) 7 mm, diameter 5 mm (type).

Type: USNM 561361.

Type locality: 42 (USGS 17692, northeast coast of Trinidad Island, Canal Zone), marine member of Bohio(?) formation.

This minute globularine is fairly common in the Bohio(?) formation of Trinidad Island and occurs in the same formation near Palenquilla Point. The very wide everted columellar lip—that is, very wide for the size of the shell—widely spaced spiral grooves on the lower part of the body whorl, and minute size indicate that it represents an unnamed minor subdivision of *Globularia* or *Ampulella*.

Amaurellina garzaensis Vokes (1939, p. 173, pl. 22, figs. 9, 12, 16), a middle Eocene species from California, is of comparable size, but has a narrower columellar lip and relatively strong, evenly spaced spiral grooves.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), Gatun Lake area, localities 41, 42.

Genus Amaurellina Fischer?

Fischer, Manuel de conchyliologie, p. 766, 1885.
Type (monotype): *Ampullina spirata* (Lamarck) (*Ampullaria spirata* Lamarck), Eocene, Paris Basin.

Amaurellina? species

Plate 14, figure 4

Molds from limestone of the Gatuncillo formation are doubtfully referred to *Amaurellina*. They are large, strongly inflated, shouldered, and have a moderately high turreted spire. The wide space between the shoulder and the preceding whorl indicates a wide shelf or channel adjoining the suture.

Height (incomplete) 53 mm, diameter 52 mm (largest specimen). Height (incomplete) 46 mm, diameter 38 mm (figured specimen).

If these molds represent an *Amaurellina*, it is an exceptionally large species.

Occurrence: Gatuncillo formation (late Eocene), Madden basin, localities 9, 12, 15.

Genus Pachycrommium Woodring?

Woodring, Carnegie Inst. Washington Pub. 385, p. 391, 1928.
Type (orthotype): *Amaura guppyi* Gabb, Miocene, Dominican Republic.

Pachycrommium? solenaeum Woodring, n. sp.

Plate 14, figure 1

Of medium size, shouldered, moderately inflated. Spire high, turreted. A narrow channel adjoins suture. Aperture short. Sheath narrow, rim low. Posterior part of sheath overlapped by narrow lobe, which becomes low and unrecognizable anteriorly. Umbilicus closed.

Height (not quite complete) 32.5 mm, diameter (somewhat crushed) 22 mm (type).

Type: USNM 561364.

Type locality: 38 (USGS 17166, Río Casaya area, Quebrada de Oro, a northwestward-flowing tributary of Río Casaya, 3.3 kilometers southeast of east end of Gamboa bridge, Canal Zone), Gatuncillo formation.

The type (and only specimen) of this species is a silicified fossil from the Gatuncillo formation. The outline of body whorl and aperture is somewhat distorted by lateral crushing. The replacing silica is granular.

The generic assignment of this species is doubtful. The type of *Pachycrommium* has a gently sloping shelf between the suture and the shoulder, and a more elongate aperture. Moreover, sheath and lobe can be distinguished only on immature specimens, the lobe of mature shells forming a wider and more strongly edged everted columellar lip than that of *Pachycrommium? solenaeum*. Nevertheless a species that appears to be properly referred to *Pachycrommium* has a channel adjoining the suture and separation of sheath and lobe evidently depends on growth stage. *"Amauropsis" burnsii meridionalis* Pilsbry (1922, p. 387, pl. 34, figs. 23, 24; Miocene, Dominican Republic), which is discussed under *Pachycrommium?* cf. *P. trinitatensis* (p. 97), has a channel adjoining the suture. Lobe and sheath are well defined on the posterior part of the sheath on the only specimen in the U. S. National Museum, but not on the type, according to Pilsbry's illustration.

Eocene high-spired globularines from America and other regions have been referred to *Pachycrommium*. It is doubtful, however, how many of them—including species mentioned when the generic name was proposed, as noted by Palmer (1937, p. 136–137)—are closely related to *Pachycrommium guppyi*.

Occurrence: Gatuncillo formation (middle Eocene), Río Casaya area, locality 38.

Pachycrommium? proinum Woodring, n. sp.

Plate 15, figure 12

Lupia perovata (Conrad), Dall *in* Hill, Mus. Comp. Zool. Harvard College Bull., v. 28, p. 273, 1898 (list; Eocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 360, 1911 (Dall's record).

Of medium size, shouldered, strongly inflated. Spire high, turreted. Whorls sloping from suture to shoulder. Aperture elongate. Sheath narrow, for most part not preserved. Lobe narrow, imperfect. Umbilicus closed. Very faint microscopic spiral lineation visible on some specimens on and near shoulder. Type and two other specimens show narrow retractive dark axial bands.

Height (incomplete) 26 mm, diameter 19 mm (type). Height (not quite complete) 35 mm, diameter 22 mm.

Type: USNM 135200.

Type locality: 40a (USGS 2683, Vamos Vamos, off Palenquilla Point, Canal Zone, now submerged), marine member of Bohio(?) formation.

Though this globularine is represented by 15 specimens collected at Vamos Vamos and at locality 41 near Placnquilla Point, none completely shows the columellar lip. The lobe is shown on five specimens, on all of which it is narrow, and an imperfect narrow sheath is visible on the type. Dark axial bands are well shown on the body whorl of three specimens. They may possibly indicate axial bands differing in shell texture rather than color bands.

Incomplete as these fossils are, they suggest a *Pachycrommium* that is less inflated than *P. guppyi* and has whorls characterized by a steeper slope between the suture and the shoulder.

Dall identified this globularine as the Claiborne (middle Eocene) species *"Lupia" perovata* (Conrad), an identification that doubtless had much influence on his conclusion that the strata at Vamos Vamos, and by inference at Gatun, are Eocene. *"Lupia" perovata* has a higher less turreted spire. In outline of whorls *Pachycrommium? proinum* is more similar to the Jackson (late Eocene) species *"Amauropsis" jacksonensis* Harris, which, like *"Lupia" perovata*, has a higher spire. Mansfield's (1940, p. 222, pl. 27, fig. 44) late Oligocene *Pachycrommium* sp., from the lower part of the Chickasawhay marl of Alabama, is less inflated than the species from Panamá and has a higher spire.

Pachycrommium? proinum is closely related to *Pseudocrommium gabrielensis* Clark (Clark and Durham, 1946, p. 19, pl. 16, figs. 14, 15), from the late Eocene of Colombia, but is smaller and has a more turreted spire. The paratype of *Pseudocrommium gabrielensis* has indistinct alternating dark and light axial bands. *Pseudocrommium carmenensis* Clark (Clark and Durham, 1946, p. 19, pl. 16, fig. 7) evidently is conspecific with *P. gabrielensis*.

Both *"Lupia" perovata* and *"Amauropsis" jacksonensis* have been considered high-spired species of *Crommium* (Palmer, 1937, p. 136, pl. 14, figs. 5, 9; Harris and Palmer, 1946–47, p. 256, pl. 30, fig. 5, 1947). Should the names *Euspirocrommium* or *Pachycrommium* prove to be inappropriate for these high-spired species that evidently are related to *Crommium*, *Pseudocrommium* (Clark, in Clark and Durham, 1946, p. 18; type (orthotype): *Pseudocrommium carmenensis* Clark), based on a late Eocene species from Colombia, is available for them and has recently been used for them (Richards and Palmer, 1953, p. 27).

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), Gatun Lake area, localities 40a, 40b, 40d, 41.

Pachycrommium? cf. P.? trinitatensis (Mansfield)

Plate 16, figure 11

Large, shouldered, strongly inflated. Spire high, turreted. Aperture moderately elongate. Other apertural features unknown.

Height (incomplete) 50 mm, diameter (exaggerated by crushing) 39 mm (figured specimen).

Molds of a large high-spired globularine, which occur in the middle member of the Caimito formation in the Gatun Lake area and in the Culebra formation, resemble the type of *"Amauropsis" trinitatensis* (Mansfield, 1925, p. 58, pl. 10, figs. 4, 5). The type of that species is a mold from early Miocene strata in Trinidad. Mansfield's (1937, p. 177, pl. 9, fig. 7) *"Amauropsis"* aff. *"A." burnsii meridionalis* Pilsbry, a late Oligocene form represented by molds from Georgia and Florida, also resembles the type of *"Amauropsis" trinitatensis*. *"Amauropsis" burnsii meridionalis* (Pilsbry, 1922, p. 387, pl. 34, figs. 23, 24) occurs in the Miocene of the Dominican Republic. Despite its wide deep channel adjoining the suture, it appears to be a *Pachycrommium*. Mansfield's (1940, p. 223, pl. 27, fig. 8) late Oligocene *Pachycrommium?* sp., a mold from the lower part of Chickasawhay marl, has a similar sutural channel, but is larger and has a higher spire. Though *"Amauropsis" burnsii meridionalis* has a sutural channel like that of the Chipola species *"Polinices (Amauropsis)" burnsii* Dall (Gardner, 1926–47, p. 557, pl. 59, fig. 12, 1947), a close relationship between the two forms is doubtful. The Chipola species has a wide expanded aperture and thickened outer lip. It is a remarkable globularine.

If the unknown apertural features of both *"Amauropsis" trinitatensis* and the fossils from Panamá could be ignored, the fossils from Panamá would be unequivocally identified as the Trinidad species. The outline of the figured mold is distorted by dorso-ventral crushing. Should *"Amauropsis" trinitatensis* prove to be a *Pachycrommium*, it would be the largest species of the genus. *"Natica" phasianelloides* d'Orbigny [1852(?), p. 9, pl. 1, fig. 7] may be an earlier name for it.

Occurrence: Middle member of Caimito formation (late Oligocene), Gatun Lake area, locality 60. Culebra formation (early Miocene), Gaillard Cut, locality 108c.

Pachycrommium? cf. P. guppyi (Gabb)

Plate 16, figure 12

Of medium size, strongly inflated, strongly shouldered. Spire high, strongly turreted. Gently sloping shelf extends from suture to shoulder. Apertural features unknown.

Height (not quite complete) 27 mm, diameter 21.5 mm (figured specimen).

The Culebra formation yielded three incomplete high-spired globularines. The most nearly complete specimen, which is figured (and probably also the other two) is comparable in outline to the strongly shouldered form of *Pachycrommium guppyi* (Pilsbry, 1922, p. 386, pl. 34, figs. 25–27). *P. guppyi* occurs in the early Miocene Baitoa formation of the Dominican Republic and also in the middle Miocene Cercado and Gurabo formations. Mansfield (1937, p. 174) considered *"Amauropsis" floridana* Dall (1915, p. 108, pl. 5, fig. 11), a small *Pachycrommium* from the early Miocene Tampa limestone of Florida, to be indistinguishable from *P. guppyi*. *P. floridanum*, however, has a more expanded aperture and correspondingly more inflated body whorl. The middle Miocene Oak Grove form, *P. dodonum* Gardner (1926–47, p. 557, pl. 59, figs. 4, 13, 1947), agrees with the strongly shouldered form of *P. guppyi*.

Though *Pachycrommium guppyi* occurs in formation correlated with the Gatun formation, the genus has not been found in the Gatun formation. *Pachycrommium?* cf. *P. guppyi* is the youngest of the high-spired globularines in the Canal Zone.

Occurrence: Culebra formation (early Miocene), Gaillard Cut, localities 112, 115a.

Family TURRITELLIDAE

Genus Turritella Lamarck

Lamarck, Soc. Histoire Nat. Paris Mém., p. 74, 1799.
Type (monotype): *Turbo terebra* Linné, Recent, tropical western Pacific.

Turritella occurs in all marine formations of the Canal Zone and adjoining parts of Panamá, except the Chagres sandstone proper. The number of forms therefore is large: 17 species and 3 subspecies. The Gatun formation, which contains 6 species and 2 named minor forms, has the largest number of species. Not more than 4 species, however, were found in the Gatun formation at any one locality.

The importance of the sculpture of the early whorls and the growth line in a study of the affinities of turritellas was emphasized by Merriam in his monograph of fossil turritellas from the Pacific coast of North America. His term "growth-line angle" (Merriam, 1941, p. 59) is adopted for the angle between the axis of the shell and a line extending from the posterior end of the growth line to the anterior end on spire whorls, or to the apex of the forward bend, if such a bend is present near the anterior suture.

Merriam pointed out that among the several hundred described species of *Turritella*, groups of closely allied species are as distinctive as groups of species in other families—groups that are given generic and subgeneric rank in other families. Nevertheless he was reluctant to assign superspecific names to the groups of species he recognized, as suitable material for consideration of many of the superspecific names proposed for turritellids was not available to him. He therefore grouped his species into stocks named for a typical species (Merriam, 1941, p. 33–55). At an earlier date Guillaume (1924) classified European Tertiary species in groups, also named for a typical species. Merriam's stocks, however, are more restricted than Guillaume's groups and afford a much better basis for a satisfactory classification. Guillaume relied on the growth line, ignoring the development of the sculpture and other features.

Though no exhaustive study has been attempted, only one subgenus of turritellas from the Canal Zone and adjoining parts of Panamá appears to have a suitable name: *Torcula;* in fact, two names (*Torcula* and *Bactrospira*) are available for that subgenus, which corresponds to Merriam's *T. altilira* stock.

Subgenus? (?Guillaume's T. hybrida group, in part)

Turritella cf. T. carinata Lea

Plate 14, figure 2

Moderately large, moderately slender. Whorls slightly concave, the profile modified by a spiral forming a basal carina immediately adjoining anterior suture. Remainder of late whorls apparently smooth; remainder of intermediate whorls apparently smooth or sculptured with a low spiral at anterior third. Poorly preserved early whorls show a spiral at about anterior third, but no other sculpture apparent. Growth line not known.

Height (incomplete, 7+ whorls) 41.5 mm, diameter 16 mm (figured specimen).

The figured specimen and fragments consisting of several intermediate and late whorls are silicified fossils from the Gatuncillo formation in the Río Casaya area. The basal carina suggests affinity with the Claiborne (middle Eocene) species *Turritella carinata* (Palmer, 1937, p. 189, pl. 24, figs. 5, 6, 8, 9, 12). The last few whorls of some large specimens of *T. carinata* have no macroscopic spirals other than the basal carina, like the figured fossil from Panamá. On other large specimens of *T. carinata*, however, the last few whorls have one to several additional spirals. Though the figured specimen reaches a greater diameter than *T. carinata*, even the last whorl tightly clasps the preceding whorl, whereas the last few whorls of large shells of *T. carinata* gradually withdraw from the carina. *T. carinata* has microscopic spiral lineation, but such sculpture would not be reproduced by the granular silica of the fossils from Panamá. The early whorls of *T. carinata* are sculptured with three spirals; the growth-line sinus is very deep and the growth-line angle very narrow.

The middle Eocene Peruvian *T. bosworthi* Woods (Woods and others, *in* Bosworth, 1922, p. 80, pl. 8, figs. 8–10) is more strongly carinate.

T. carinata evidently represents, in part, Guillaume's *T. hybrida* group (Guillaume, 1924, pp. 286–290).

Occurrence: Gatuncillo formation (middle Eocene), Río Casaya area, locality 38.

Subgenus?

Turritella cf. T. collazica Maury

Plate 16, figure 13

Large, late whorls rapidly enlarging. Whorls slightly concave, the profile dominated by a wide swollen basal carina occupying anterior third, or a little more, of whorl. Other sculpture obscure or absent. Sculpture of early whorls and growth line unknown.

Height (incomplete, 4+ whorls) 56 mm, diameter (exaggerated by crushing) 25 mm (figured specimen).

The basal limestone of the La Boca marine member of the Panamá formation on Río Masambí yielded a poorly preserved crushed *Turritella* characterized by a wide swollen basal carina. The Oligocene Puerto Rican *T. collazica* has a similar basal carina (Maury, 1920, p. 51, pl. 8, fig. 5). According to Maury's illustration, the basal carina bears a groove and the remainder of the whorl is sculptured with six low spiral threads.

A fragment from the Culebra formation at locality 5857, listed as *Turritella* sp., resembles the La Boca species, but its preservation is too poor to permit identification.

Occurrence: Limestone at base of La Boca marine members of Panamá formation (early Miocene) Río Masambí, locality 123.

Subgenus? (?Merriam's T. buwaldana stock)

Turritella cf. T. samanensis Olsson

Moderately large, slender. Whorls slightly convex or flat, sculptured with about 10 subequal low spirals. On at least some intermediate and late whorls the basal

spiral and another near middle of whorl are slightly stronger than others. Sculpture of early whorls and growth line unknown.

Height (incomplete, 3+ whorls) 25 mm, diameter 15 mm.

This species is represented by poorly preserved fragments from calcareous sandstone in the Gatuncillo formation of the Río Fríjol area. The slightly convex or flat whorls and the subequal spirals resemble features of the late Eocene Peruvian *Turritella samanensis* (Olsson, 1928, p. 65, pl. 14, figs. 3, 4, 6–8; 1931, p. 74), which is recorded from the late Eocene of Colombia (Clark, *in* Clark and Durham, 1946, p. 26, pl. 23, figs. 1, 4). *T. masinguiensis* Clark (*in* Clark and Durham, 1946, p. 24, pl. 23, figs. 3, 5–7, 9, 10), also from the late Eocene of Colombia, appears to be *T. samanensis*.

According to Olsson, the early whorls of *T. samanensis* have three spirals. Therefore it is unlikely that it is related to *T. uvasana* Conrad, of the Eocene of California, the early whorls of which have two spirals (Merriam, 1941, p. 89.) Probably it is a representative of Merriam's *T. buwaldana* stock (Merriam, 1941, p. 42).

Occurrence: Gatuncillo formation (late Eocene), Río Fríjol area, locality 34.

Subgenus?

Turritella species

Large, slender. Late whorls slightly concave, a narrow carina lying near anterior suture and a wider carina near posterior suture. Intermediate whorls sculptured with a spiral at anterior third, one or two spirals at posterior third, and microscopic minor spirals. Sculpture of early and late whorls and growth line unknown.

Height (incomplete, 3 whorls) 43 mm, diameter 24 mm.

The affinities of this species, which occurs in the Gatuncillo formation, are undetermined. Late whorls are represented only by molds.

Occurrence: Gatuncillo formation (late Eocene), Madden basin, localities 12, 15; Río Fríjol area, localities 32, 34.

Subgenus? (Merriam's T. uvasana stock)

Turritella adela Woodring, n. sp.

Plate 15, figures 5, 6

Turitella gatunensis Conrad, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 310 (part, not pl. 17, fig. 10=*T. atacta* Dall), 1892 (Miocene, Vamos Vamos, Panamá). Dall, in Hill, Mus. Comp. Zool. Harvard College Bull., v. 28, p. 273 (part), 1898 (list; Eocene, Vamos Vamos, Panamá).

Of medium size, slender. Whorls moderately convex. Sculpture of late whorls consisting of 9 or 10 primary spirals, the 3 or 4 on anterior half of whorls slightly stronger than those on posterior half. Minor spirals of unequal strength lie between primaries. Earliest preserved whorls sculptured with two spirals: One at middle of whorl, the other midway between it and anterior suture. Spirals persist as the posteriormost and third (numbered anteriorly from middle of whorl), respectively, of the strong spirals on anterior half of late whorls. Base sculptured with numerous minor spirals of unequal strength and two stronger spirals adjoining periphery. Growth-line sinus moderately deep, the apex at middle of whorl; growth-line angle narrow.

Height (incomplete) 25 mm, diameter 7.5 mm (type). Height (incomplete, 3 whorls) 22.5 mm, diameter 12 mm (paratype).

Type: USNM 561370; paratype, USNM 561371.

Type locality: 41 (USGS 17716, east side of promontory 375 meters southeast of Palenquilla Point, Canal Zone), marine member of Bohio(?) formation.

Turritella adela is abundant in the marine member of the Bohio(?) formation near Palenquilla Point and at the nearby submerged Vamos Vamos locality. All the specimens, however, are incomplete. In general features it resembles *T. galvesia* Olsson (1931, p. 78, pl. 14, figs. 2–7), of the Oligocene of Perú, but has more inflated whorls and a deeper growth-line sinus. The lower limb of the sinus of *T. galvesia* is practically vertical. The sculptural pattern and growth line of the Oligocene Venezuelan *T. andreasi* Hodson (1926, p. 37, pl. 24, figs. 7–9, 12, pl. 25, fig. 2) suggest relationship. Though the early sculpture of *T. andreasi* is unknown, intermediate whorls do not have the two strong spirals characteristic of *T. adela* at the same diameter.

The early sculpture, the subsequent sculptural pattern, and the growth line indicate that *T. adela* is a medium-sized late Eocene or early Oligocene species of Merriam's *T. uvasana* stock, which reached its acme in the Eocene of the Pacific coast of North America and continued through the Oligocene (Merriam, 1941, p. 42–44). Dall identified *T. adela* as *T. gatunensis* Conrad. If he had specimens from Vamos Vamos in mind, he was justified in claiming that his *T. gatunensis* is closely related to *T. uvasana*.

Occurrence: Marine member of Bohio(?) formation (late Eocene or early Oligocene), Gatun Lake area, localities 40, 40a, 40d, 41.

Turritella meroensis Olsson

Plate 15, figure 19

Turritella gatunensis Conrad, Joukowsky, Soc. Phys. Histoire Nat. Geneva Mém., v. 35, p. 163 (list), pl. 6, figs. 26, 27, 1906 (Oligocene, Panamá).

Turritella meroensis Olsson, Bull. Am. Paleontology, v. 17, no 63, p. 76, pl. 13, figs. 1–4, 1931 (Oligocene, Perú, Ecuador).

Moderately large, slender. Whorls strongly inflated, sculptured with strong subequal spirals, 5 on intermediate whorls, 5 or 6 on late whorls. Late whorls bearing a gradually enlarging secondary spiral between anteriormost primary and suture, and between posteriormost and suture. Well-preserved whorls showing microscopic spirals between primaries. Sculpture of early whorls and growth line not known.

Height (incomplete, 3+ whorls) 39 mm, diameter 21 mm (figured specimen).

Type: Paleontological Research Institution, Ithaca, N. Y., 2051.

Type locality: Caleto Mero, Perú, Heath formation (late Oligocene).

Turritella meroensis occurs in the middle member of the Caimito formation in the Gatun Lake area and in the Quebrancha limestone member of the same formation in the Quebrancha syncline. Preservation of the specimens from the Quebrancha limestone member is poor. This species has already been recorded by Olsson (1942, p. 239) from strata in the Canal Zone now assigned to the Caimito formation, and he thought also that Joukowsky's *T. gatunensis* is *T. tristis* or *T. meroensis* (Olsson, 1942, p. 241). Wherever *T. meroensis* has been found, in Perú, Ecuador, and Panamá, it occurs in formations of late Oligocene age.

The later whorls of this *Turritella* are *Mesalia*-like, as pointed out by Olsson. The specimens from the Caimito formation closely agree with the form from the type locality shown in Olsson's figure 1 and with Joukowsky's illustrations of his *T. gatunensis* from late Oligocene strata in the Santiago area, Panamá, and also with specimens from that region. The growth line is not shown on specimens from the Caimito formation. On specimens from the type locality the sinus is of moderate depth and its apex is near the middle of the whorl; the growth-line angle is narrow. Also on specimens from the type locality the growth lines form threads on unworn primary spirals.

T. vientoensis Clark (in Clark and Durham, 1946, p. 27, pl. 23, figs. 2, 11–13, 17, 18), a late Eocene species from Colombia, is closely allied to *T. meroensis*, but the later whorls of *T. vientoensis* have more numerous spirals. *T. saltoensis* Clark (in Clark and Durham, 1946, p. 26, pl. 23, fig. 28) evidently is a form of *T. vientoensis* differing in details of sculpture.

There are no known descendents of *T. meroensis*. Though this well-defined species was identified by Joukowsky as *T. gatunensis*, it needs no comparison with that species. According to the growth line and the early sculpture of two spirals (Olsson, 1931, p. 76), *T. meroensis* is a representative of Merriam's *T. uvasana* stock, which is not known to have survived the Oligocene. The heavy spirals and strongly inflated whorls suggest affinity with *T. variata lorenzana* Wagner and Schilling (Merriam, 1941, p. 99, pl. 18, fig. 3, pl. 19, figs. 9, 12–14), of the Oligocene of California.

Gabb's illustrations of his *T. gatunensis* (Gabb, 1881, p. 342, pl. 44, fig. 10, 10a), which does not even remotely resemble *T. gatunensis* and was named *T. tristis* by Brown and Pilsbry (1911, p. 358, footnote), suggest a species resembling *T. meroensis*, but more slender. Three incomplete specimens are in the type (and only) lot (Acad. Nat. Sci. Philadelphia 3532). The largest, which has a height of 28 millimeters and a diameter of 8 millimeters, evidently is the original of Gabb's freely drawn figure 10 and is herewith designated the lectotype. The whorls enlarge very slowly. The earliest whorls are bicarinate, but also have a weak posterior spiral; at the same stage *T. meroensis* has similar sculpture. A fragment of late whorls has five primary spirals, the third from the base being carinate. The third specimen, also a fragment of late whorls, is sculptured with five primary spirals and very fine secondaries; that is, the sculpture is much like that of late whorls of *T. meroensis*. On the basis of this inadequate material *T. tristis* may be a very slender ally of *T. meroensis*. The stratigraphic relations of the black shale on Oronli Creek, in southern Costa Rica—the type locality of *T. tristis*—are unknown, but, according to the fossils Gabb found there, its age probably is Oligocene. Apparently no geologist has seen it since Gabb's visit.

Occurrence: Middle member of Caimito formation (late Oligocene), Gatun Lake area, locality 56. Quebrancha limestone member of Caimito formation (late Oligocene), Quebrancha syncline, locality 62. Late Oligocene, Santiago area, Panamá. Late Oligocene, Posorja, Ecuador. Heath formation (late Oligocene), Perú.

Subgenus?

Turritella cf. T. caleta Olsson

Plate 15, figures 14–16

Small, slender, more or less bicarinate. Early whorls sculptured with three equally spaced spirals. Anterior and posterior spirals emphasized on intermediate whorls, producing a bicarinate outline, and generally emphasized on late whorls. Intermediate and late whorls also sculptured with unequal minor spirals, including original middle spiral. Primary and some minor spirals of well-preserved specimens slightly noded by growth lines. Growth-line sinus deep, apex slightly back of middle of whorl; growth-line angle very narrow.

Height (incomplete, 2+ whorls) 13.5 mm, diameter 9.5 mm (figured fragment of large specimen). Height (incomplete, 4 whorls) 13 mm, diameter 6.5 mm (figured fragment of specimen of intermediate size).

Variation affects the strength of the spirals and therefore the whorl profile. Though late whorls are typically bicarinate, the bicarinate outline is somewhat obscured on some specimens by weakening of one or both primaries, or by development of posterior minor spirals that are almost as strong as the posterior primary (pl. 15, fig. 16).

Turritella cf. *T. caleta* occurs in the marine member of the Bohio(?) formation. It is represented by numerous fragments and immature specimens, or shell tips, in collections from Vamos Vamos and Trinidad Island, and was found near Palenquilla Point. Apparrently it is related to the Oligocene Peruvian *T. caleta* Olsson (1931, p. 79, pl. 12, figs. 9, 11, 12, 15), but the early sculpture of that species is unknown. The late whorls of *T. caleta* have a weak posterior primary spiral.

The bicarinate outline and growth line suggest relationship to *T. altilira* Conrad. That suggestion, however, is not supported by the sculpture of the early whorls. The bicarinate outline and growth line also suggest relationship to *T. olssoni* Clark (Clark and Durham, 1946, p. 25, pl. 23, figs. 14–16, 22), a late Eocene Colombian species, which has less strongly beaded late whorls. *T. olssoni* was claimed to be an early member of the *T. altilira* group. Specimens that show the early sculpture, available through the kindness of J. Wyatt Durham, substantiate that claim, the earliest sculptured whorls bearing an anterior spiral, a weaker posterior spiral appearing later. *T.* cf. *T. caleta* therefore is not related to *T. olssoni*.

Occurrence: Marine member of Bohio(?) formation (late Eocene or Oligocene), Gatun Lake area, localities 40, 40a, 40b, 40d, 41, 42, 42c.

Subgenus Torcula Gray

Gray, Proc. Zool. Soc. London, p. 155, 1847.
Type (orthotype): *Turbo exoletus* Linné, Recent, Florida and West Indies.

The subgenus *Torcula* is characterized by an anterior spiral on the earliest sculptured whorls, an intermediate sculpture of two widely spaced spirals, typically a similar mature sculpture of two primary carina-forming spirals, and also a deep growth-line sinus and a narrow growth-line angle. The intermediate sculpture of the type species is weak, five or six whorls sculptured with two weak spirals following the first two whorls sculptured with a stronger anterior spiral. The intermediate sculpture of *T. altilira* and its close allies is much stronger.

Most of the lots of *T. exoleta* in the U. S. National Museum collections are from depths of 35 to 85 fathoms. A few lots, however, were dredged at shallower depths; one lot from Conch Key, Fla., at a depth of 1 to 5 feet. As orally pointed out by R. T. Abbott, it is remarkable that a species almost unobtainable except by dredging was available to Linné.

Bactrospira Cossmann (1895–1924, pt. 9, p. 129, 1912; type [orthotype], *Turritella perattenuata* Heilprin, Pliocene, Florida) is available as a name for a minor group under *Torcula*, including *T. altilira* and its close allies. *T. altilira* has more rapidly enlarging early whorls than *T. perattenuata*. *Eurytorus* Gardner (1926–47, p. 596, 1947; type [orthotype], *Turritella mixta* Dall, Miocene, Florida), proposed as a section of *Torcula*, has the growth line and early and intermediate sculpture of *Torcula*. The whorls enlarge so rapidly, however, and on mature whorls two or three original secondary spirals are so strong that subgeneric rank may be justified.

T. amaras is by no means a typical species of *Torcula* in plan of mature sculpture. It is somewhat comparable to *Eurytorus* in divergence from the basic pattern of *Torcula*, but diverges in a different direction.

Turritella (Torcula?) amaras Woodring, n. sp.

Plate 16, figures 4–7, 10

Large, rapidly enlarging. Whorls typically flat; suture typically obscured by overhanging anterior spiral. Intermediate and late whorls of some specimens carinate at the anterior spiral, the suture being exposed. Sculpture consisting of three strong subequal primary spirals. Earliest preserved whorls sculptured with two spirals, anterior one at about anterior third of whorl, posterior one at about posterior third; anterior spiral slightly stronger. These spirals are middle and posterior spirals of subsequent whorls. Anterior spiral, adjoining suture, appearing at early stage and gradually increasing in size. Middle and posterior spirals farther apart than middle and anterior, the middle spiral lying in front of middle of whorl. One to three weak secondary spirals generally present between middle and posterior primaries, and between posterior primary and suture. Well-preserved shell surfaces show microscopic spiral striae. Primary and secondary spirals of some whorls obscurely noded by growth lines. Growth-line sinus deep, the apex at about middle of whorl between middle and posterior spirals; growth-line angle narrow.

Height (incomplete) 47 mm, diameter 14.5 mm (type, a specimen of intermediate size). Height (incomplete, 3+ whorls) 43 mm, diameter 24.5 mm (figured fragment of large specimen).

Type: USNM 561373.

Type locality: 116 (USGS 5853, west side of Gaillard Cut, Canal station 1863, Canal Zone, Culebra formation.

The only important variation affects the whorl profile. Carinate whorls owe their profile to loose clasp-

ward columellar lip. Growth-line sinus deep, its apex a little behind middle of whorl; growth-line angle narrow.

Height (incomplete, 6 whorls) 43.5 mm, diameter 17.5 mm (topotype). Height (incomplete 7+whorls), 63 mm, diameter 19 mm (figured fragment of large specimen). Height (incomplete) 73 mm, diameter 13 mm (figured almost complete large specimen).

Type material: Lectotype, Acad. Nat. Sci. Phila. 3513.

Type locality: Gatun, Canal Zone. Locality of topotype: 150a (USGS 10997, Panama Railroad, high cut about 0.4 mile (650 meters) southeast of Gatun railroad station, Canal Zone), middle part of Gatun formation.

In February, 1957, Ellen James Trumbull, of the Geological Survey, found at the Academy of Natural Sciences of Philadelphia a poorly preserved 4-whorled specimen of *Turritella altilira* that was collected by Newberry. It is all that is left of the type lot and is an obligatory lectotype, if not the remains of the 7-whorled type illustrated by Conrad. The specimen shown on plate 23, figure 7, was collected close to, if not at, the type locality. In 1855, when Newberry gathered a few fossils on his way to California, Gatun was located on the banks of the Chagres at the west end of the bluffs formed by the Quebrancha Hills. Presumably he found his fossils, including *T. altilira*, in a railroad cut. In the French literature on the geology of the present Canal Zone, *T. altilira* is designated *T. tornata* (*T. tornata* Guppy=*T. guppyi* Cossmann, a subspecies of *T. altilira*).

The typical form, which has flangelike strongly noded primary spirals, is rare in the lower part of the Gatun formation, but is widespread and abundant in the middle and upper parts in the Canal Zone. The posterior primary is almost invariably wider than the anterior on late whorls and, with few exceptions, is unequally doubled. Details of sculpture and the degree of whorl constriction between the posterior primary and the suture are variable. No specimens of the typical form are in the U. S. National Museum collections from the lower part of the Gatun formation, but T. F. Thompson collected from the lower part three specimens identified as *T. altilira altilira*. Only one specimen (from locality 138a), however, is really typical. One of the other two—a large specimen from locality 137a—has anterior and posterior primary spirals of equal width. The other (from locality 138a) has a nonflanged posterior primary; that is, it combines characters of the typical form and *T. altilira praecellens*, with which it is associated. On specimens from about the lower half of the middle part of the Gatun, including strata in the type region, one of the minor spirals in the concave area between the primaries is stronger and more coarsely noded than the others, and the suture is deeply impressed, as the result of strong whorl constriction (pl. 23, fig. 7). On specimens from about the upper half of the middle part, no minor spiral dominates the others and the suture is not so deeply impressed (pl. 23, fig. 12). On specimens from still higher strata in the upper part of the formation, however, a minor spiral is dominant on about half of the specimens, and most of them have a deeply impressed suture. Shells from a U. S. Geological Survey locality representing the upper part of the formation near Mount Hope (locality 175) have been illustrated by Merriam (1941, pl. 24, figs. 3, 4). Plate 23, figure 13 shows one of the few shells that have a simple posterior primary. On this specimen the posterior face of the posterior primary is not deeply concave. The shell was damaged and repaired while the second preserved whorl was being formed and after the repair the posterior primary is farther from the suture. This specimen therefore is abnormal, but the posterior primary is not doubled preceding the repair.

Maturity, as indicated by suppression of the nodes, is reached at a diameter of 15 to 20 millimeters. Healed breaks are conspicuous on the body whorl of mature shells and are not unusual on spire whorls. About 200 perfectly preserved shell tips from locality 147b and a considerable number from several other localities show the protoconch and early sculptured whorls (pl. 23, fig. 1).

In the Canal Zone and adjoining parts of Panamá the earliest forms of *Turritella altilira* appear in the upper Oligocene part of the Caimito formation and in the lower Miocene Emperador limestone member of the Culebra formation; the last in the Toro limestone member of the Chagres sandstone. The Caimito and Emperador fossils are discussed under the next heading. The earliest occurrence of the typical form is in the lower Miocene part of the Caimito formation in Madden basin. A poorly preserved small specimen from Madden basin, probably from the calcareous sandstone member of the Caimito formation, and molds (including one of a large specimen) from the overlying Alhajuela sandstone member are referred to the typical form. Though some details of the sculpture are partly or completely lacking, the identification is made with considerable confidence, for the primaries are flangelike, and the posterior primary is wider than the anterior and is unequally doubled. Other specimens from the Miocene part of the Caimito formation are too small or too imperfect for identification, other than in the unrestricted sense. A subspecies (or variety), discussed under a separate heading, is represented in the lower part of the Gatun formation and apparently occurs in

the middle part. The acme of the typical form is reached in the middle and upper parts of the Gatun. The typical form is less abundant in the middle part west of the canal than east of the canal, and no form was found in the upper part in the coastal area west of the Canal Zone. Most of the lots collected in the middle part west of the canal are small specimens identifiable only in the unrestricted sense. A mold of a small specimen records the presence of the species in the Toro limestone member of the Chagres sandstone. According to current age assignments, *Turritella altilira*, in the unrestricted sense, therefore ranges from late Oligocene to early Pliocene; the typical form from late early Miocene to middle Miocene.

T. altilira and its immediate close allies are widely distributed in the upper Oligocene deposits of Puerto Rico, Antigua, Trinidad, Venezuela, and Panamá; the lower Miocene of Haiti, Dominican Republic, Puerto Rico, Anguilla, Brazil, Trinidad, Venezuela, Colombia, Panamá, and Costa Rica; the middle Miocene of Jamaica, Dominican Republic, Trinidad, Venezuela, Colombia, Panamá, Costa Rica, southeastern Mexico, Florida, Ecuador, and Perú; the upper Miocene of Trinidad, Venezuela, Colombia, Panamá, Costa Rica, the Colorado Desert of southern California; and the lower Pliocene of Panamá. Nineteen names have been proposed for forms of the *T. altilira* group. Some doubtless are superfluous, but many are to be regarded as subspecies of *T. altilira;* indeed six were described as subspecies or varieties. A study of the stratigraphic and geographic grades would be certain to yield valuable results, but would be a lengthy diversion. Only a few of the described forms combine flange-like, strongly noded primary spirals and a posterior primary wider than the anterior. Nevertheless middle Miocene fossils from southwestern and northern Colombia and Venezuela have flange-like, strongly noded primary spirals, and some have a posterior primary wider than the anterior. They so closely approach the typical form that they are referred to it. That is, the typical form occurs in the central Panamá area, along the south border of the Caribbean Sea, and at the south end of the Miocene Atrato Valley strait.

The *T. altilira* group reached southeastern United States in middle Miocene time. Gardner's (1926–47, p. 595, pl. 57, fig. 17, 1947) *Turritella* cf. *T. altilira*, found in the Shoal River formation of Florida, represents a form of *T. altilira*, but like many Caribbean forms it lacks flangelike primaries. Merriam's (1941, p. 44–47) Pacific coast *T. altilira* stock consists of *T. inezana* Conrad and *T. imperialis* Hanna. *T. inezana* appears in the early Miocene of California as a migrant. Though the immediate predecessor of *T. inezana* has not been recognized, the presence of a subspecies of the closely related *T. altilira* in the late Oligocene of Panamá shows that tropical America was a potential reservoir for the lineage leading to *T. inezana*, as had been inferred. Merriam has pointed out that *T. imperialis*, of disputed Miocene or Pliocene age (preferably late Miocene) is practically indistinguishable from some forms of *T. altilira* that lack flangelike primaries. It presumably is to be treated as a subspecies of *T. altilira*.

T. altilira has living allies in the Caribbean Sea and in the Panamic region: *T. exoleta* (Linné) and *T. mariana* Dall, respectively. Neither closely resembles the typical form of *T. altilira*. *T. exoleta* is the type of *Torcula*.

Occurrence: Calcareous sandstone(?) member of Caimito formation (early Miocene), Madden basin, localities 77 (*T.* cf. *T. altilira*), 80. Alhajuela sandstone member of Caimito formation (early Miocene), Madden basin, localities 88 (*T. altilira* s. l.), 89, 92 (*T. altilira* s. l.). Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 137a, 138a, 139 (*T. altilira* s. l.). Middle part, eastern area, localities 141, 142, 143 (*T.* cf. *T. altilira*), 146, 147b, 147c, (*T.* cf. *T. altilira*), 147e (*T. altilira* s. l.), 147f, 147g, 147h, 150a, 151, 152 (*T. altilira* s. l.), 153, 153a, 154, 155, 155a, 155b, 155c, 157, 158, 159, 159a, 160 (*T. altilira* s. l.); western area, localities 161c, 161d (*T. altilira* s. l.), 162 (*T. altilira* s. l.). 162a (*T. altilira* s. l.) 165 (*T. altilira* s. l.), 166 (*T. altilira* s. l.), 168 (*T. altilira* s.l.), 170a. Upper part, eastern areas, localities 171, 173a, 174, 175, 176, 177, 177c, 177d (*T. altilira* s. l.), 178. Toro limestone member of Chagres sandstone (early Pliocene) locality 195 (*T. altilira* s. l.). Middle Miocene, Chocó, southwestern Colombia; northern Colombia. Middle Miocene, Falcón, Venezuela.

Turritella (Torcula) altilira Conrad, subspecies

Plate 15, figure 10

?*Turritella* aff. *T. perattenuata praecellens* Pilsbry and Brown, Mansfield, U. S. Natl. Mus. Proc., v. 66, art. 22, p. 55, pl. 9, figs. 7, 8, 1925 (Miocene, Trinidad).

Moderately large, moderately slender. Primary spirals relatively low, strongly noded. Posterior face of posterior primary slightly concave. Posterior primary wider than anterior, doubled or tripled. Minor spirals between primaries of unequal strength. Sculpture of early whorls unknown. Growth line like that of typical *T. altilira*.

Height (incomplete, 5+ whorls) 29.5 mm, diameter 13.3 mm (figured specimen). Height (incomplete, 7 whorls) 41.5 mm, diameter 17 mm.

The shell tapers more gently than that of the typical form of *Turritella altilira*. The most conspicuous difference, however, lies in the features of the primary spirals,

which are not flangelike. The difference is particularly marked on the wide posterior primary, the posterior face of which is only slightly concave. On most of the specimens the posterior primary is doubled—on a few it is tripled. Though the primaries are strongly noded, the nodes are not as conspicuous as on the typical form, possibly owing to slight wear.

Mansfield's *Turritella* aff. *T. perattenuata praecellens* Pilsbry and Brown, of the early Miocene at Machapure (or Machapoorie) Quarry, Trinidad, has similar heavy strongly noded primaries.

This unnamed subspecies of *T. altilira* is found in the middle member of the Caimito formation in the Gatun Lake area and in the Quebrancha limestone member of the Caimito in the Quebrancha syncline. The Quebrancha limestone fossils are poorly preserved. A mold of a small specimen from the Emperador limestone member of the Culebra formation evidently is more similar to the typical form, as intermediate whorls have high primaries.

Occurrence: Middle member of Caimito formation (late Oligocene), Gatun Lake area, locality 56. Quebrancha limestone member of Caimito formation (late Oligocene), Quebrancha syncline, locality 62. Emperador limestone member of Culebra formation (early Miocene), Gaillard Cut, locality 120 (*T. altilira* s. l.).

Turritella (Torcula) altilira praecellens Pilsbry and Brown

Plate 23, figures 2, 8

Turritella perattenuata praecellens Pilsbry and Brown, Acad. Nat. Sci. Phila. Proc., v. 69, p. 36, footnote, pl. 5, fig. 12, 1917 (Miocene, Dominican Republic).

Of medium size, slender. Primary spirals relatively low, moderately or weakly noded. Posterior face of posterior primary slightly concave. Posterior primary wider than anterior, generally doubled. Minor spirals between primaries of subequal strength. Sculpture of early whorls like that of typical *T. altilira*, but minor spirals appearing several whorls later. Growth line like that of typical *T. altilira*.

Height (incomplete, 8 whorls) 42 mm, diameter 12.5 mm (larger figured specimen). Height (incomplete, 4+ whorls) 30.5 mm, diameter 13 mm (smaller figured specimen).

Type: Acad. Nat. Sci. Phila. 2608.

Type locality: Dominican Republic, Miocene (presumably Baitoa formation, late early Miocene).

This form of *Turritella altilira*, like the subspecies in the Caimito formation, lacks flangelike primary spirals. It is more slender than the Caimito subspecies and its primaries are not as strongly noded. Suppression of the nodes at a diameter of 12 millimeters suggests that it does not reach a large size.

The fossils from Panamá may represent a local race of *T. altilira* not of the same genetic stock as *T. altilira praecellens*. Nevertheless the identification emphasizes the direction of differentiation from the typical form. Collections of *T. altilira praecellens* from the Baitoa formation of the Dominican Republic include larger specimens than those from Panamá and some that have more strongly noded primaries. Though *T. altilira praecellens* was described as a subspecies of *T. perattenuata* Heilprin, of the Pliocene of Florida, it apparently lacks the greatly attenuated whorls of that species and evidently is more closely related to *T. altilira*. *T. perattenuata*, however, also is a nonflanged member of the *T. altilira* group.

T. montserratensis (Mansfield, 1925, p. 53, pl. 9, figs. 5, 6), which occurs in the Telemaque sand member of the Springvale formation (late Miocene) of Trinidad and should be assigned subspecific rank under *T. altilira*, is very similar, but its posterior spiral is not doubled.

The form of *T. altilira* identified as *T. altilira praecellens* occurs in the lower part of the Gatun formation. It is, indeed, the only *altilira*-like *Turritella* in the U. S. National Museum collections from that part of the formation. A form comparable to *T. altilira praecellens*, but very weakly noded and less slender, is found in the middle part of the Gatun at locality 144. The lower Gatun subspecies (or variety) and the typical *T. altilira* are represented in Hill's Gatun collection labelled Vamos Vamos (locality 158).

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136a, 137, 138, 138a. Middle part, eastern area, localities 144 (*T. altilira* subsp., cf. *T. altilira praecellens*), 158. Baitoa formation (late early Miocene), Dominican Republic.

Subgenus? (Merriam's T. ocoyana stock)

Turritella cf. T. subgrundifera Dall

Plate 16, figure 3

Small, slender, strongly carinate at about anterior fourth of whorl. Sculpture consisting of 6 or 7 widely spaced spirals. Spiral immediately in front of and behind carina-forming spiral and 1 or 2 near posterior suture weaker than others. Sculpture of early whorls and growth line not known.

Height (incomplete, 3 whorls) 18 mm, diameter 5 mm (figured specimen). Height (incomplete, 3 whorls) 25 mm, diameter 15 mm (increased by crushing).

The whorl profile, slender outline, and widely spaced spirals of this species, represented by two poorly preserved fragments from the Culebra formation, strongly suggest *Turritella subgrundifera*, of the Chipola formation of Florida (Gardner, 1926–47, p. 590, pl. 57, fig. 1,

1947). Though the early whorls and growth line of the species from Panama are not known, it is without much doubt a close ally of *T. subgrundifera*, if not that species. The protoconch of *T. subgrundifera* is cylindrical, consisting of 1¾ strongly inflated whorls. Three spirals appear gradually and practically simultaneously on the first sculptured whorl: a strong middle spiral, a moderately strong anterior spiral (the carina-forming spiral of later whorls), and a weak posterior spiral. The growth-line sinus is very shallow and wide, and the growth-line angle very wide.

T. subgrundifera is recorded from the Miocene of Colombia (Pilsbry and Brown, 1917, p. 35).

Occurrence: Culebra formation (early Miocene), Gaillard Cut, locality 99d.

Turritella venezuelana Hodson

Plate 16, figures 8, 9

Turritella venezuelana Hodson, Bull. Am. Paleontology, v. 11, no. 45, p. 32, pl. 21, figs. 4, 8, pl. 22, figs. 1, 6, 1926 [Miocene (Oligocene-Miocene of Hodson), Venezuela].

Turritella venezuelana quirosana Hodson, idem, p. 34, pl. 22, figs. 9, 10, pl. 24, fig. 1, 1926 [Miocene (Oligocene-Miocene of Hodson), Venezuela].

Turritella venezuelana walkinsi Hodson, idem, p. 34, pl. 22, fig. 8, 1926. [Miocene (Oligocene-Miocene of Hodson), Venezuela].

Small, early whorls rapidly enlarging. Whorls moderately carinate at about anterior fourth or rounded. Sculpture consisting of 6 or 7 primary spirals. On some specimens a minor spiral is present in some interspaces. Earliest preserved whorls sculptured with three spirals, the posteriormost weak and the anteriormost forming the carina on later carinate whorls. Base sculptured with weak closely spaced minor spirals. Growth-line sinus very shallow and wide; growth-line angle very wide.

Height (incomplete, 6 whorls) 15.3 mm, diameter 5.4 mm (larger figured specimen). Height (incomplete, 4 whorls) 23.5 mm, diameter 9.5 mm.

Type: Paleontological Research Institution, Ithaca, N. Y.

Type locality: Locality 6, Oil seep at Mene de Saladillo, 1½ kilometers southwest of Quirós, District of Miranda, Zulia, Venezuela (Hodson and Hodson, 1931, p. 5), La Rosa formation (Sutton, 1946, p. 1694), early Miocene.

This small species occurs in the Culebra formation. It shows considerable variation in whorl profile, in width of primary spirals, and in presence or absence of minor spirals. According to Hodson, it is variable in Venezuela also. The types of the three forms named by him were found at the same locality.

Turritella venezuelana is closely related to *T. subgrundifera*, but evidently is not a small form of that species. *T. subgrundifera* is carinate (except the late whorls of a few specimens), its early whorls enlarge less rapidly, and the posteriormost of the three spirals of early whorls appear at an earlier stage. Both species are representatives of Merriam's *T. ocoyana* stock (Merriam, 1941, p. 47).

Occurrence: Culebra formation (early Miocene), Gaillard Cut, localities 99b, 107, 110, 111a, 112, 112a, 114. La Rosa formation (early Miocene), Zulia, Venezuela.

Turritella abrupta Spieker

Plate 23, figures 6, 15, 16

Turritella (*Haustator*) *robusta* Grzybowski, Neues Jahrb., Beilage-Band 12, p. 646, pl. 20, fig. 3, 1899 (Miocene, Perú). Not *T. robusta* Gabb, 1864.

Turritella robusta Grzybowski, Woods, *in* Bosworth, Geology of the Tertiary and Quaternary periods in the north-west part of Peru, p. 110, pl. 18, fig. 4, pl. 19, fig. 1, 1922 (Miocene, Perú). Spieker, Johns Hopkins Univ. Studies in Geology, no. 3, p. 84, pl. 4, fig. 5, 1922 (Miocene, Perú).

Turritella robusta var. *abrupta* Spieker, idem, p. 85, pl. 4, fig. 6, 1922 (Miocene, Perú).

Turritella charana Spieker, idem, p. 86, pl. 4, fig. 7, 1922 (Miocene, Perú).

Turritella supraconcava Hanna and Israelsky, Calif. Acad. Sci. Proc., 4th ser., v. 14, no. 2, p. 59, 1925 (new name for *T. robusta* Grzybowski).

Turritella robusta fredeai Hodson, Bull. Am. Paleontology, v. 11, no. 45, p. 13, pl. 5, figs. 1, 3, pl. 6, figs. 2, 5, pl. 7, figs. 1, 6, 7, pl. 9, fig. 7, pl. 29, fig. 6, 1926 (Miocene, Venezuela).

Turritella supraconcava var. *fredeai* Hodson, Weisbord, idem, v. 14, no. 54, p. 30, pl. 9, figs. 3, 4, 1929 (Miocene, Colombia).

Turritella fredeai Hodson, Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 119, pl. 17, fig. 1, 1929 (Miocene, Colombia).

Turritella abrupta Spieker, Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 200, 1932 (Miocene, Perú). Merriam, Calif. Univ. Dept. Geol. Sci. Bull., v. 26, p. 48, pl. 29, fig. 4 ("cf."), pl. 30, fig. 6, pl. 31, figs. 2–4, 1941 (Miocene, Colombia, Venezuela). Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 99, 1951 (Miocene, Ecuador).

Moderately large, rapidly enlarging. Whorls very strongly and sharply carinate at about anterior fourth. Sculpture consisting of 8 or 9 widely spaced spirals. Protoconch of about 1¾ inflated whorls. Two strong spirals appear on first sculptured whorl: one at middle of whorl, the other halfway between it and anterior suture. A low narrow spiral adjoining anterior suture also appears on first sculptured whorl. Anterior of the two strong spirals gradually increasing in size until on about sixth sculptured whorl it is stronger than middle spiral and forms the carina. At about same stage weak spirals appear between middle spiral and posterior suture, and elsewhere. On late whorls a spiral adjoins anterior suture and a weaker spiral lies between it and carina. Anterior sutural spiral emerging on base as a strong spiral. Base between this spiral and columellar lip sculptured with weak spirals. Growth-line

sinus very shallow and wide, the apex just above carina; growth-line angle very wide.

Height (incomplete, 4 whorls) 39 mm, diameter 23 mm (largest figured specimen).

Type: Johns Hopkins University.

Type locality: Zorritos, Perú, Zorritos formation (early Miocene).

Turritella abrupta occurs in the middle part of the Gatun formation, but is rare. It is represented by the figured specimen of moderate size, collected in the eastern area, and by very small specimens from the western area. Adhering calcareous sandstone somewhat masks the strength and sharpness of the carina on the largest figured specimen.

This overnamed *Turritella*, which reaches a relatively gigantic size (height about 200 mm), is found in Perú, Ecuador, the Darién basin of Panamá, the Chiriquí area of Panamá, Colombia, and Venezuela, generally in formations of middle Miocene age. In Perú, however, it occurs both in the upper Zorritos and Cardalitos formations, dated as late early and middle Miocene, respectively, by Olsson (1932, fig. 2, p. 42). The occurrence of *T. abrupta* in the Miocene of the Isthmus of Tehuantepec (Woodring, 1928, pp. 66, 98) cannot be confirmed at the present time. The fossils on which that record was based have been mislaid or were misidentified.

On the basis of the characters of intermediate and late whorls, *T. abrupta* may be considered a large very strongly and sharply carinate subspecies of *T. ocoyana* Conrad, of the middle Miocene of California. Nevertheless these two forms show a considerable difference in development of sculpture. According to Merriam's (1941, pl. 31, fig. 1) illustration of the early whorls of *T. ocoyana*, fairly strong spirals, other than the middle and anterior spiral, appear at an early stage. On the early whorls of the Gatun specimens of *T. abrupta* such spirals are weaker and appear at a later stage. Until additional data on the sculpture of the early whorls are available, specific rank is retained for *T. abrupta*.

T. trinitaria Maury (1925, p. 230, pl. 42, fig. 10; Vokes, 1938, p. 26, fig. 29; Rutsch, 1942, p. 129), from the late Miocene Springvale formation of Trinidad, presumably is a less strongly carinate subspecies of *T. abrupta*. *T. abrupta trinitaria* and *T. matarucana*, representing different lineages, are the last survivors of the *T. ocoyana* group in the Caribbean and nearby areas.

T. ocoyana is widespread in the middle Miocene of California, but has no predecessors there. The inference that it is a migrant from tropical America is justified, for there are earlier closely related species in that region.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 144a; western area, localities 161c, 161d, 170a. Upper part of Zorritos formation (early Miocene) and Cardalitos formation (middle Miocene), Perú. Progreso formation (middle Miocene), Ecuador. Middle Miocene, Darién area, Panamá. Middle Miocene, Chiriquí area, Panamá. Middle Miocene, Bolívar, Colombia. Miocene, Falcón, Venezuela.

Turritella matarucana Hodson

Plate 22, figures 11, 12

Turritella matarucana Hodson, Bull. Am. Paleontology, v. 11, no. 45, p. 31, pl. 20, fig. 4, pl. 21, figs. 1, 9, 1926 (Miocene, Venezuela).

Turritella plebeia A-L-Owensi Hodson, idem, p. 31, pl. 20, figs. 1, 2, 5, 6, pl. 23, fig. 2, pl. 28, fig. 1, 1926 (Miocene, Venezuela).

Moderately large, early whorls rapidly enlarging, late whorls slowly enlarging. Intermediate whorls moderately convex, late whorls slightly convex. Late whorls narrowly beveled at posterior suture. Sculpture consisting of numerous closely spaced spirals, some of which are narrower and more closely spaced than others. Earliest preserved whorls sculptured with two spirals: one at middle of whorl, the other halfway between it and anterior suture. Base sculptured with very weak spirals disappearing toward columellar lip. Growth-line sinus very wide and shallow; growth-line angle very wide.

Height (incomplete, 5 whorls) 44.5 mm, diameter 16 mm (larger figured specimen).

Type: Paleontological Research Institution, Ithaca, N. Y.

Type locality: Locality 197, Río Matarucа, Buena Vista anticline, near La Vela, District of Colina, Falcón, Venezuela, La Vela formation (late Miocene).

Turritella plebeia alowensi,[3] also from the Miocene of Falcón, Venezuela, was based on specimens that have moderately inflated whorls. They are similar to *T. matarucana* in sculptural pattern and growth line, and evidently represent a form of that species having moderately inflated whorls even at a late stage.

Despite the absence of a carina and the presence of numerous closely spaced spirals, *T. matarucana* is allied to *T. abrupta* and other species of the *T. ocoyana* group, according to the sculpture of the early whorls and the growth line. In whorl profile and sculpture it more closely resembles the larger, more rapidly enlarging, and more convex-whorled Miocene European species *T. terebralis* Lamarck, which has similar early sculpture and growth line. The whorl profile and

[3] Though "the original orthography of a name is to be preserved unless an error of transcription, a lapsus calami, or a typographical error is evident" (International Rules of Zoological Nomencalture, Article 19), a name like "*A-L-Owensi*" is so objectionable that alteration to "*alowensi*" appears to be justified.

sculpture suggest *T. plebeia* Say, of the Miocene of Maryland. *T. plebeia* has similar early sculpture, but its growth-line sinus is narrower and deeper, and its growth-line angle is narrower.

T. matarucana occurs in the Gatun formation. It is locally abundant in the lower part of the formation and rare in the middle part.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 135 (identification doubtful), 136, 136a, 137, 137a, 138a. Middle part, eastern area, locality 144a (identification doubtful); western area, locality 161c. Uramaco (middle Miocene) and La Vela (late Miocene) formations, Falcón, Venezuela.

Subgenus?

Turritella gatunensis gatunensis Conrad

Plate 23, figures 4, 5, 9, 14

Turritella gatunensis Conrad, Pacific R. R. Expl., v. 6, Geol. Rept., p. 72, pl. 5, fig. 20, 1857 (Miocene, Gatun, Panamá). (Reprinted, U. S. Geol. Survey Prof. Paper 59, p. 178, 1909.) Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 310 (part, not pl. 17, fig. 10=*T. alacta* Dall), 1892 (Miocene, Gatun, Panamá). Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 358, pl. 27, figs. 4, 5. 9, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 148, pl. 14, figs. 12, 13, 1922 (Miocene, northwestern Panamá, Costa Rica). Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 120, 1929 (Miocene, Colombia). Li, Geol. Soc. China Bull., v. 9, p. 267, pl. 6, fig. 49, 1930 (Miocene, Panamá Bay; Miocene, Gatun, fide Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 83, p. 432, 1931). Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 100, 1951 (Miocene, Ecuador).

Turritella cf. *T. gatunensis* Conrad, Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 33, pl. 9, fig. 7, 1929 (Miocene, Colombia).

Turritella gatunensis lavelana Hodson, idem, v. 11, no. 45, p. 23, pl. 18, fig. 6, pl. 19, fig. 7, 1926 (Miocene, Venezuela).

Turritella conradi Toula, K. k. Geol. Reichsanstalt Jahrb., Band 58, p. 694, pl. 25, fig. 4, 1909 (Miocene, Canal Zone).

Not *Turritella gatunensis* Conrad, Gabb, Acad. Nat. Sci. Phila. Jour., 2d ser., v. 8, p. 342, pl. 44, figs. 10, 10a, 1881 (Oligocene(?), Costa Rica;=*T. tristis* Brown and Pilsbry). Joukowsky, Soc. Phys. Histoire Nat. Geneva Mém., t. 35, p. 163 (list), pl. 6, figs. 26, 27, 1906 (Oligocene, Panamá;=*T. merоensis* Olsson). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 229, pl. 42, fig. 12, 1925 (Miocene, Trinidad;=*T. caronensis* Mansfield, described as a subspecies of *T. gatunensis*). Mansfield, Washington Acad. Sci. Jour., v. 28, p. 102, figs. 1–3, 6, 1938 (Oligocene, Florida).

Moderately large, slender. Posterior part of whorls constricted, anterior part concave between primary spirals. Sculpture consisting of a primary spiral near, but generally behind, middle of whorl, a second primary at anterior third to fourth, and numerous minor spirals. Microscopic spirals generally visible on late whorls. A minor spiral lying behind, and close to, middle primary is almost, or quite, as strong as primaries on some specimens. On a few specimens a minor spiral in front of anterior primary or between primaries is accentuated. Primaries decreasing in strength on last whorl or two of some specimens. As they decrease, anterior part of whorl becomes more inflated. Spirals slightly undulated by axial waves on a few specimens. Protoconch cylindrical, of two inflated whorls. Early sculptured whorls attenuated. A very strong middle spiral, forming a strong median carina, a very weak spiral adjoining anterior suture, and a very weak spiral half-way between them appear on first sculptured whorl. The strong middle spiral is the middle primary of later whorls. The weak spiral adjoining the anterior suture gradually enlarges and becomes the anterior primary. Other weak spirals appear on third or fourth sculptured whorl. Base sculptured with numerous low minor spirals. Growth-line sinus wide and shallow, the apex between primaries; growth-line angle wide. Interior of late whorls smooth or bearing narrow spiral ridges of varying strength.

Height (almost complete) 58.5 mm, diameter 15 mm (largest figured specimen).

Type: Lost.

Type locality: Gatun, Canal Zone.

Turritella gatunensis, like *T. altilira*, was based on fossils collected by Newberry at Gatun. The type of *T. gatunensis* is lost. As Conrad's illustration is even cruder than his representation of *T. altilira*, the identification rests primarily on the brief and unsatisfactory description. The collection that furnished a topotype of *T. altilira* (locality 150a) includes the traditional *T. gatunensis*, but the preservation is not good enough for designation of a neotype. The specimens shown on plate 23, figures 4, 9, collected at the Gatun Locks site, 250 meters west of Gatun, are considered representative of the typical form.

The typical form of *T. gatunensis* probably is represented in the calcareous sandstone member of the Caimito formation in Madden basin. It is locally abundant in the lower part of the Gatun formation, widespread and locally abundant in the middle part, rare in the upper part in the eastern area, and probably occurs in the Toro limestone member of the Chagres sandstone.

Intermediate whorls are characterized by the two primary spirals and the concave space between them. Early sculptured whorls are attenuated and are very strongly carinate at the middle of the whorl. Late whorls, however, are variable in sculpture and whorl profile. Nevertheless the basic pattern of a middle and anterior primary is more or less discernible. This basic pattern, the constriction of the posterior part of whorls, and the growth line are the most reliable features for identification of late whorls. Most of the shells from the lower part of the Gatun formation are

relatively flat-whorled and have strong primaries (pl. 23, fig. 14). Strong minor spirals are less common in the lower part of the formation than in the middle part. Specimens that have axial waves were not found in the lower part and are not common in the middle part, except at localities where the subspecies (or variety), described under the next heading was collected. Some specimens in the collection from locality 150a, which is close to, if not at, the type locality, have weak axial waves.

The profile, sculpture, and growth line of late whorls indicate that the typical form, or closely related forms, occur in the Miocene of northwestern Panamá, Costa Rica, Colombia, Ecuador, and Venezuela. Confirmation, based on the sculpture of the early whorls, is desirable. Weisbord's *T.* cf. *T. gatunensis*, from the Miocene of Colombia, may be referred to the typical form, despite its wide primaries. The early sculptured whorls of *T. gatunensis caronensis* Mansfield (1925, p. 51, pl. 8, figs. 12–14), of the Miocene of Trinidad, are not attenuated; the first few sculptured whorls are weakly carinate; and later early whorls are not as strongly carinate as those of *T. gatunensis*. This Trinidad species of *Turritella* is closely related to *T. gatunensis*, but presumably is to be given specific rank.

There seem to be no close relatives of *T. gatunensis* in the Miocene of southeastern United States. Though intermediate and late whorls of *T. gatunensis blountensis* Mansfield (1935, p. 41, pl. 4, figs. 1, 2), from deposits of middle Miocene age in western Florida, are practically indistinguishable in sculpture and growth line from specimens of *T. gatunensis* that have a strong posterior minor spiral, they enlarge less rapidly. The earliest preserved whorls (not quite the earliest sculptured whorls) are not carinate and are sculptured with 6 or 7 spirals. *T. blountensis* therefore is not a subspecies of *T. gatunensis*. The small specimens from the Shoal River formation of Florida doubtfully recorded as *T. gatunensis blountensis* (Gardner, 1926–47, p. 592, pl. 57, figs. 11, 12, 1947) are less like *T. gatunensis* in whorl profile. The earliest preserved whorls are not carinate and are sculptured with three strong spirals.

Mansfield's *T. gatunensis*, from the late Oligocene of Florida, has the sculptural pattern of that species, but late whorls are more or less uniformly convex. The earliest preserved whorls have two spirals. One specimen shows a suggestion of a moderately deep growth-line sinus, with the apex a little behind the middle of the whorl, and a narrow growth-line angle. This species of *Turritella* is without much doubt related to the species from Vamos Vamos, *T. adela:* the species mentioned by Mansfield as *T. gatunensis*, following Dall's identification. According to Mansfield, a form of *T. gatunensis* from the "lower faunal zone" of the Gatun formation has early whorls like those of the species of *Turritella* from Vamos Vamos. That observation, however, evidently was based on some misunderstanding, for no specimen of *T. gatunensis* from the Gatun formation that shows the early whorls has such sculpture. The affinities of Mansfield's (1940, p. 218, pl. 27, figs. 56, 57) *Turritella* cf. *T. gatunensis*, from the late Oligocene Chickasawhay marl, are uncertain. The growth line is unknown and the early whorls of the only specimen that shows them are too poorly preserved to reveal the sculpture.

Occurrence: Calcareous sandstone member of Caimito formation (early Miocene), Madden basin, locality 82 (mold, identification doubtful). Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136a, 137, 137a, 138, 138a. Middle part, eastern area, localities 140, 141, 144, 144a (identification doubtful), 147a, 147d, 147e, 147i, 150a, 153, 155, 155b, 155c, 156, 157, 158, 159, 159a, 159b, 160; western area, localities 161, 161a, 169. Upper part, eastern area, localities 163, 172. Toro limestone member of Chagres sandstone (early Pliocene; molds, identification doubtful), localities 194, 196. Late Miocene, Water Cay, Panamá. Middle Miocene, Costa Rica. Middle Miocene, Bolívar, Colombia. Miocene, Falcón, Venezuela. Subibaja formation (early Miocene) and Progreso formation (middle Miocene), Ecuador.

Turritella gatunensis rhytodes Woodring, n. subsp.

Plate 23, figures 10, 11, 17

Moderately large, slender. Protoconch and early whorls like those of typical form. Posterior part of intermediate and late whorls strongly constricted. On intermediate whorls minor spirals, particularly one or more between primaries, increase in strength until on late intermediate and late whorls they are as strong as primaries, the whorls losing the typical *T. gatunensis* profile. Spirals of intermediate whorls more or less undulated by axial waves on most specimens. Growth line like that of typical form.

Height (incomplete) 66 mm, diameter 16.5 mm (type).

Type: USNM 561395; paratypes, Stanford Univ.

Type locality: 162a (USGS 8359, lower trail on west side of Río Chagres northwest of Gatun Dam, Canal Zone), middle part of Gatun formation.

Turritella gatunensis rhytodes is abundant in the middle part of the Gatun formation at localities 162 and 162a on the west side of Río Chagres northwest of Gatun Dam. Presumably it is a local subspecies or variety. The typical form occurs in the middle part of the Gatun at nearby localities, but is not represented

in the collections from localities 162 and 162a. As shown by the illustrations, the sculpture is variable. On some specimens the axial waves are so strong that the sculpture has a cerithid appearance; on a few they are absent or practically absent. The strong constriction of the posterior part of the whorls and the strong minor spirals are characteristic features. In whorl profile *T. gatunensis rhytodes* closely resembles *T. gatunensis willistoni* Hodson (1926, p. 25, pl. 18, figs. 2–4), which, however, has strongly differentiated primary and secondary spirals on late whorls. Axial waves were cited as the characteristic feature of *T. gatunensis taratarana* Hodson (1926, p. 25, pl. 18, figs. 5, 7). The posterior part of the whorls of that form are not strongly constricted. The presence or absence of axial waves evidently is a variable character in different forms of *T. gatunensis*, including the typical form. *T. gatunensis willistoni* and *T. gatunensis taratarana* appear to be varieties of *T. gatunensis*. They are found together at some localities in Miocene strata in Falcón, Venezuela, and at a few localities are recorded in association with *T. gatunensis lavelana*, which, as indicated by the synonomy citation under *T. gatunensis*, is considered the typical form.

The typical form of *Turritella subannulata* Heilprin (1887, p. 89, pl. 8, fig. 17), a Pliocene species from Florida, has cerithid axial sculpture, two primary spirals on intermediate and late whorls, and a growth line similar to that of *T. gatunensis*. The development of the sculpture, however, indicates that it is not closely allied to *T. gatunensis*.

"Turritella gatunensis" tarataranoides Haas (1942, p. 315, figs. 3, 4), and also *"Crepitacella" altispira* Haas (idem, p. 315, figs. 5, 6) and *"Crepitacella"* n. sp. indet. aff. *"C." altispira* Haas (idem, p. 316), are fresh-water snails, as the editor of the Journal of Paleontology was informed when Haas' manuscript and illustrations were received. The type material of these species is so poorly preserved that their affinities are uncertain, but the *"Turritella"* seems to be a *Pachychilus*. Not only is the type material poorly preserved, these species also were collected at an unknown Costa Rican locality (Idem, p. 310). Despite these deficiencies, they were given an unqualified middle Miocene age. Specimens of these fresh-water snails, collected in 1910 in a tunnel at Brasil (in the Meseta Central west of San José), are in the collections of the U. S. National Museum. They were presented to W. H. Dall by Don Anastasio Alfaro, Director of the Museo Nacional at San José, during a visit to Washington.

Occurrence: Middle part of Gatun formation (middle Miocene), localities 162, 162a.

Subgenus?

Turritella cf. T. berjadinensis cocoditana Hodson

A whorl fragment from the Culebra formation has a strong carina-forming spiral at the anterior fourth, two primary spirals near the middle, two weaker spirals between the carina and the anterior suture, and closely spaced fine minor spirals over the entire whorl.

Though its middle spirals are of subequal strength, this fragment is comparable to the Miocene Venezuelan *Turritella berjadinensis cocoditana* (Hodson, 1926, p. 29, pl. 19, fig. 5, pl. 20, figs. 3, 7, 10).

Occurrence: Culebra formation (early Miocene), Gaillard Cut, locality 115b.

Subgenus? (Merriam's T. broderipiana stock)

Turritella mimetes Brown and Pilsbry

Plate 22, figures 6–9

Turritella mimetes Brown and Pilsbry, Acad. Nat. Sci. Phila. Proc., v. 63, p. 357, pl. 27, fig. 1, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 149, pl. 14, fig. 5, 1922 (Miocene, Canal Zone).

Turritella (*Haustator*) aff. *T. hanleyana* Reeve, Toula, K. k. Geol. Reichsanstalt Jahrb., Band 61, p. 498, pl. 30, fig. 6, 1911 (Miocene, Canal Zone).

?*Turritella mimetes* Brown and Pilsbry, Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 120, 1929 (Miocene, Colombia; not described, possibly *T. lloydsmithi* Pilsbry and Brown).

Not *Turritella* cf. *T. mimetes* Brown and Pilsbry, Merriam, Calif. Univ. Dept. Geol. Sci. Bull., v. 26, no. 1, pl. 38, fig. 7, 1941 (Miocene, Colombia; = *T. lloydsmithi* Pilsbry and Brown).

Moderately large, slender. Whorl profile flat or slightly concave. Late intermediate and late whorls generally loosely clasping, producing a weak basal carina. Protoconch cylindrical, of 1¾ inflated whorls. Early sculptured whorls attenuated, strongly inflated. A middle spiral, forming a weak carina, and minor spirals appear on first sculptured whorl. Middle spiral decreasing in strength on next whorl and lost among minor spirals covering entire whorl. Second and succeeding sculptured whorls therefore not medially carinate. On some specimens a median spiral again attains slight prominence on sixth or seventh sculptured whorl. Late whorls sculptured with spirals roughly representing three ranks, the third rank being microscopic. Base sculptured with numerous spirals. Growth-line sinus wide and shallow; growth-line angle wide. Interior of late whorls smooth or bearing narrow spiral ridges.

Height (incomplete) 73 mm. diameter 17.5 mm (largest figured specimen).

Type: Acad. Nat. Sci. Phila. 1734.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Turritella mimetes is widespread in the middle part of the Gatun formation, fairly common in the upper part in the western area, and probably occurs in the Toro limestone member of the Chagres sandstone. The whorl profile, determined by clasping of the succeeding whorl, and the sculpture are variable. The shells from the upper part of the Gatun, all collected in the western area, are relatively small. Their early whorls are not preserved, but their early intermediate whorls are like those of specimens from the middle part of the formation.

T. mimetes is related to the Recent Caribbean *T. variegata* (Linné). In fact, the marked similarity of late whorls in profile, sculpture, and growth line suggests that it is a subspecies of *T. variegata*. The early and early intermediate whorls of *T. variegata*, however, are medially carinate and rapidly enlarging. Allies of *T. variegata* are widespread in the Miocene of the Caribbean region. It is not known whether any of them are closely related to *T. mimetes*. *T. lloydsmithi* Pilsbry and Brown (1917, p. 35, pl. 5, fig. 11), a middle and late(?) Miocene Colombian species, has more crowded spirals separated by very narrow grooves. Its early intermediate whorls are medially carinate and rapidly enlarging. It therefore is a close ally of *T. variegata*, possibly a subspecies. *T. planigyrata* Guppy (Mansfield, 1925, p. 55, pl. 9, figs. 1, 9; Rutsch, 1942, p. 131, pl. 8, fig. 5), the first of these Miocene Caribbean allies of *T. variegata* to be named, was based on fossils from the late Miocene Springvale formation of Trinidad. Its medially carinate and rapidly enlarging early intermediate whorls link it closely with *T. variegata*. Its sculpture is uniformly fine like that of some specimens of *T. variegata*.

T. mimetes is also related to the Recent Panamic *T. leucostoma* Valenciennes, as identified by Kiener. The Recent species has attenuated early whorls, which, however, are medially carinate and have fewer spirals.

Occurrence: Middle and upper parts of Gatun formation (middle and late Miocene). Middle part, eastern area, localities 141 (identification doubtful), 150, 154 (identification doubtful), 155, 155a, 155b, 157, 159; western area, localities 161, 161b, 161c, 162, 165 (identification doubtful), 170. Upper part, western area, localities 182, 182a, 183, 184, 185. Toro limestone member of Chagres sandstone (early Pliocene), locality 196 (identification doubtful).

Turritella bifastigata Nelson

Plate 22, figure 10

Turritella bifastigata Nelson, Conn. Acad. Arts Sci. Trans., v. 2, p. 189, 1870 (Miocene, Perú). Spicker, Johns Hopkins Univ. Studies in Geology no. 3, p. 63, pl. 3, fig. 1, 1922 (Miocene, Perú). Hodson, Bull. Am. Paleontology, v. 11, no. 45, p. 48, pl. 30, fig. 1, 1926 (Miocene, Perú). Olsson, idem, v. 19, no. 68, p. 198, 1932 (Miocene, Perú).

Turritella gothica Grzybowski, Neues Jahrb., Beilage-Band 12, p. 645, pl. 20, fig. 10, 1899 (Miocene, Perú). Woods, *in* Bosworth, Geology of the Tertiary and Quaternary periods in the north-west part of Peru, p. 110, 1922 (Miocene, Perú).

Moderately large. Intermediate whorls rapidly enlarging; late whorls slowly enlarging. Last whorl or two loosely clasping. Early intermediate whorls medially carinate; late intermediate whorls slightly convex; late whorls slightly concave between a faint collar adjoining posterior suture and a more distinct, but narrower, collar adjoining anterior suture. Anterior collar forming a carina on whorls preceded by a loosely clasping whorl and on body whorl. Sculpture of early whorls not known. Early intermediate whorls sculptured with three subequal primary spirals (a median spiral forming a carina, a spiral adjoining anterior suture, and another halfway between them) and minor spirals. Anterior spiral developing into anterior collar, the other two gradually weaken. Late whorls sculptured with faint minor and microscopic spirals, the strongest of which corresponds to the second (from anterior suture) primary of intermediate whorls. Base sculptured with low wide spirals, between which and on which are fine minor spirals. Growth-line sinus moderately deep, the apex at middle of whorl; growth-line angle wide.

Height (not quite complete) 66 mm, diameter 18.5 mm (figured specimen).

Lectotype: Peabody Museum, Yale Univ. 534.

Type locality: Zorritos, Perú, Zorritos formation, late early Miocene.

Late whorls are characterized by the sutural collars, producing a slightly concave profile, and faint spiral sculpture between the collars.

Several names have been proposed for Miocene Caribbean allies of *Turritella bifastigata*, all of which probably are to be assigned subspecific rank under that species or the Recent *T. broderipiana*. The Colombian *T. cartagenensis* Pilsbry and Brown (1917, p. 34, pl. 5, fig. 13; Weisbord, 1929, p. 30, pl. 9, figs. 1, 2) has stronger spirals. The Costa Rican *T. oreodoxa* Olsson (1922, p. 152, pl. 14, fig. 1) has a wide posterior collar, no anterior collar, and stronger spirals. Hodson (1926, pp. 48–50, pl. 29, fig. 3, pl. 30, figs. 2–6) described fossils from the Miocene of Falcón, Venezuela, as *T. bifastigata maracaibensis* and *T. bifastigata democraciana*. They are recorded together at numerous localities and evidently represent a variable form that probably is to be identified as *T. bifastigata cartagenensis* which also is recorded from the Miocene of Trinidad (Maury, 1925, p. 233, pl. 42, fig. 13).

T. bifastigata was found only in the lower part of the Gatun formation. Though it has no living allies in the Caribbean Sea, it is closely related to *T. broderipiana* d'Orbigny, a living Panamic species that lacks sutural collars or has greatly subdued collars. The early intermediate whorls of *T. broderipiana* are like those of *T. bifastigata*, but the middle spiral and the spiral adjoining the anterior suture are stronger, and the spiral midway between them is weaker. The early whorls of *T. broderipiana* enlarge rapidly. A middle spiral and one on both sides of it appear on the first sculptured whorl, and an anterior sutural spiral on the next whorl. With further growth the middle and anterior sutural spirals increase in strength, the others diminish. The middle spiral strongly carinates the early whorls, except the first. The first three whorls bear slightly arcuate exaggerated growth lines above the carina.

T. bifastigata and *T. mimetes* represent Merriam's *T. broderipiana* stock (Merriam, 1941, pp. 50–51).

Occurrence: Lower part of Gatun formation (middle Miocene), localities 137, 137a. Upper part of Zorritos formation (late early Miocene), Perú.

LOCALITIES AT WHICH FOSSILS WERE COLLECTED

The localities at which fossils were collected are described in the following list and the numbers used for them in the present report are correlated with the permanent numbers recorded in the Geological Survey's Cenozoic invertebrate register. The list includes not only localities that yielded fossil mollusks, but also some important localities where only other kinds of fossils were collected. Unless otherwise specified, the report locality numbers are plotted on the general geologic map (pl. 1). As noted in the list, localities in the Gaillard Cut area are plotted on the large-scale geologic map of that area (pl. 2). Some early collections have such inadequate data that they cannot be plotted, and other localities are not plotted to avoid congestion of the map. Early localities that are now submerged are shown on plate 1 and plate 2 by a special symbol, even though the plotted location may be only approximate. Some submerged localities, however, cannot be plotted even approximately.

Before the construction of the canal, Río Chagres flowed southwestward to the present site of Gamboa and there turned northwestward to the Caribbean Sea. It was first dammed near Gatun to form Gatun Lake and later was dammed upstream from Gamboa to form Madden Lake. The course of the river and the location of the Panama Railroad before the canal was built are shown on the map accompanying the publication cited under Bertrand and Zürcher (1899). The relocated line of the Panama Railroad, cited in the following list, is the present line constructed in 1911–13.

No. used in this report	USGS Cenozoic No.	Field No.	Description of locality
			GATUNCILLO FORMATION
1	--------	131	Madden basin, Panamá. South side of Río Pequení near head of Madden Lake, 120 meters west of former Canal Zone Pequení Police Substation. Thin-bedded limestone, 2.5 meters above base of Gatuncillo formation. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera (Cole, 1952 [1953]).
1a	--------	131a	Same locality. Thin-bedded nodular-weathering limestone, 5.5 to 7 meters higher stratigraphically. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera (Cole, 1952 [1953]). Not plotted.
2	--------	132	Madden basin, Panamá. West shore of Madden Lake at abandoned Salamanca Gaging station. Fairly soft limestone. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera (Cole, 1952 [1953]).
3	8400	------	Madden basin, Panamá. San Juan de Pequení, on Río Pequení about 1 kilometer upstream from junction with Río Chagres. Fragmental limestone. E. R. Lloyd, 1919. Now submerged. Topotypes of *Lepidocyclina chaperi* and other larger Foraminifera (Vaughan, 1926). For location of San Juan de Pequení see Reeves and Ross, 1930, pl. 5.
4	--------	150	Madden basin, Panamá. Trail west of Madden Lake, 4.8 kilometers north of Madden Dam. Limestone. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera (Cole, 1952 [1953]).
5	--------	118	Madden basin, Panamá. Trail north of Río Puente, 2 kilometers northeast of Natural Bridge (Puente Natural). Thin-bedded limestone. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera.
6	17433	114	Madden basin, Panamá. Lumber road north of Río Puente, 1.7 kilometers east-southeast of Natural Bridge. Limestone. T. F. Thompson and W. P. Woodring, 1949.
7	17432	115	Madden basin, Panamá. Lumber road north of Río Puente, 1.6 kilometers east-southeast of Natural Bridge. Limestone. T. F. Thompson and W. P. Woodring, 1949.

No. used in this report	USGS Cenozoic No.	Field No.	Description of locality
			GATUNCILLO FORMATION—continued
8		116	Madden basin, Panamá. Trail south of Río Puente, 800 meters southeast of Natural Bridge. Limestone. T. F. Thompson and W. P. Woodring, 1949. Corals.
9	17161	113	Madden basin, Panamá. Lumber road south of Río Puente, 1.5 kilometers southeast of Natural Bridge. Marly limestone. T. F. Thompson, 1948. Also a collection by T. F. Thompson and W. P. Woodring, 1949.
10		108	Madden basin, Panamá. Road to Madden Airfield, 650 meters northeast of Casa Larga. Marly limestone. T. F. Thompson, 1948. Also a collection by T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera (Cole, 1952 [1953]).
11	16889	15	Madden basin, Panamá. Madden Airfield, about 300 meters north of north end of paved runway, 1.7 kilometers east of Casa Larga. Limestone. J. R. Schultz, T. F. Thompson, and W. P. Woodring, 1947. Also larger Foraminifera (Cole, 1952 [1953]), corals, and echinoids (Cooke, 1948).
12	1762	107	Madden basin, Panamá. Lumber road south of Río Puente, 4 kilometers east of Casa Larga. Marly limestone. T. F. Thompson, 1948. Also a collection by T. F. Thompson and W. P. Woodring, 1949. Also corals.
13		106	Madden basin, Panamá. Road from Casa Larga to Laguna, 1 kilometer south-southeast of Río Chilibrillo bridge. Marly limestone. T. F. Thompson, 1948. Also a collection by T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera.
14		105	Madden basin, Panamá. 325 meters east of road from Casa Larga to Laguna, 1.1 kilometers southeast of Río Chilibrillo bridge. Limestone. T. F. Thompson, 1948. Also a collection by T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera.
15		129	Madden basin, Panamá. Road from Casa Larga to Laguna, 1 kilometer west of Laguna. Limestone. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera.
			GATUNCILLO FORMATION—continued
16	17434	128	Madden basin, Panamá. Road from Casa Larga to Laguna, south side of Río Limón immediately south of Laguna. Limestone. T. F. Thompson and W. P. Woodring, 1949. Also corals.
17		147	Quebrancha syncline, Panamá. Stream about 50 meters west of trail on east side of Río Gatuncillo, 4.5 kilometers northeast of Transisthmian Highway bridge across Río Gatuncillo. Mudstone and siltstone. W. P. Woodring, 1949. Smaller Foraminifera.
18		146	Quebrancha syncline, Panamá. Trail on east side of Río Gatuncillo, 3.3 kilometers northeast of Transisthmian Highway bridge across Río Gatuncillo. Limestone. W. P. Woodring, 1949. Larger Foraminifera.
19		145	Quebrancha syncline, Panamá. Trail on east side of Río Gatuncillo, 2 kilometers northeast of Transisthmian Highway bridge across Río Gatuncillo. Soft limestone. W. P. Woodring, 1949. Larger Foraminifera (Cole, 1952 [1953]).
20		19	Quebrancha syncline, Panamá. North side of Transisthmian Highway, 50 meters east of bridge across Río Gatuncillo. Limestone. J. R. Schultz and W. P. Woodring, 1947. Larger Foraminifera.
21		20	Quebrancha syncline, Panamá. East bank of Río Quebrancha about 100 meters northeast of Transisthmian Highway bridge. Mudstone. J. R. Schultz and W. P. Woodring, 1947. Smaller Foraminifera.
22		124	Quebrancha syncline, Panamá. Road to Nuevo San Juan, 0.5 kilometer southwest of junction with Transisthmian Highway. Fairly soft limestone. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera (Cole, 1952 [1953]).
23		125	Quebrancha syncline, Panamá. Road to Nuevo San Juan, 2 kilometers southwest of junction with Transisthmian Highway. Fairly soft limestone. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera (Cole, 1952 [1953]).

No. used in this report	USGS Cenozoic No.	Field No.	Description of locality
			GATUNCILLO FORMATION—continued
23a			Río Agua Sucia area, Panamá. About 30 meters southeast of trail, 2 kilometers southwest of Nuevo San Juan. Limestone. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera, not collected.
24		21	Río Agua Sucia area, Panamá. Transisthmian Highway, 3.5 kilometers northwest of Río Gatuncillo bridge. Silty mudstone. J. R. Schultz and W. P. Woodring, 1947. Smaller Foraminifera.
25		139	Río Agua Sucia area, Panamá. Half a kilometer northeast of Transisthmian Highway and 5.5 kilometers northwest of Transisthmian Highway bridge across Río Gatuncillo. Limestone. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera.
26		23	Río Agua Sucia area, Panamá. Transisthmian Highway, 5.7 kilometers northwest of Río Gatuncillo bridge. Calcareous mudstone. J. R. Schultz and W. P. Woodring, 1947. Larger Foraminifera (Cole, 1952 [1953]) and corals.
27	16931	22	Río Agua Sucia area, Panamá. Transisthmian Highway, 6.5 kilometers northwest of Río Gatuncillo bridge. Siltstone. J. R. Schultz and W. P. Woodring, 1947.
27a		22a	Same locality, calcareous sandstone 0.5 to 1 centimeter thick, about 6 meters lower stratigraphically. J. R. Schultz and W. P. Woodring, 1947. Larger Foraminifera (Cole, 1952 [1953]). Not plotted.
28		140	Río Agua Sucia area, Panamá. Transisthmian Highway, 7.3 kilometers northwest of Río Gatuncillo bridge. Poorly sorted gritty sandstone. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera (Cole, 1952 [1953]).
29			Río Agua Salud area, Canal Zone. Core hole SL–84, 5.7 kilometers north-northwest of Frijoles station on Panama Railroad and 300 meters south of head of Quebrada La Chinilla arm of Gatun Lake. Depth 22.5 meters, silty limestone. Drilled in 1947. Also outcrop float limestone at same locality. Larger Foraminifera (Cole, 1949).
30			Río Agua Salud area, Canal Zone. Core hole SL–99, 2.2 kilometers southeast of Frijoles station on Panama Railroad. Mostly siltstone. Drilled in 1947. Foraminifera.
31			Río Agua Salud area, Canal Zone. Core hole SL–100, 3.3 kilometers southeast of Frijoles station on Panama Railroad. Depth 40.5 to 40.8 meters, siltstone. Drilled in 1947. Foraminifera.
32	17163	136	Río Fríjol area, Canal Zone. Río Fríjol 6 kilometers northwest of west end of Gamboa bridge. Sandstone. T. F. Thompson, 1948. Also a collection by W. P. Woodring, 1949.
33		137	Río Fríjol area, Canal Zone. Pipe-line road, 6.5 kilometers northwest of west end of Gamboa bridge. Fairly soft limestone. W. P. Woodring, 1949. Larger Foraminifera (Cole, 1952 [1953]).
34	17165		Río Fríjol area, Canal Zone. Río Fríjol, 6.5 kilometers northwest of west end of Gamboa bridge. Sandstone. T. F. Thompson, 1948.
35	17700	135	Río Fríjol area, Canal Zone. Pipe-line road, 5 kilometers northwest of west end of Gamboa bridge. Silty mudstone. W. P. Woodring, 1949. Also smaller Foraminifera.
36		134	Río Fríjol area, Canal Zone. Pipe-line road, 3.3 kilometers northwest of west end of Gamboa bridge. Limestone. W. P. Woodring, 1949. Larger Foraminifera.
37		138a	Gamboa area, Canal Zone. 1.9 kilometers north-northwest of west end of Gamboa bridge, on road to core holes SL–94 and SL–96, 15 meters south of bridge across drainage ditch. Fairly soft limestone. T. F. Thompson and W. P. Woodring, 1949. Larger Foraminifera (Cole, 1952 [1953]).
38	17166	119	Río Casaya area, Canal Zone. Quebrada de Oro, a northwestward-flowing tributary of Río Casaya, 3.3 kilometers southeast of east end of Gamboa bridge. Partly silicified sandy limestone. R. H. Stewart, 1948. Also collections by T. F. Thompson, 1948, and W. P. Woodring, 1949.