BULLETINS

OF

AMERICAN

PALEONTOLOGY

VOL. XXVII

1942 - 1943

Paleontological Research Institution
Ithaca, New York
U. S. A.

CONTENTS OF VOLUME XXVII

BULLETINS
OF
AMERICAN PALEONTOLOGY

VOL. XXVII

NUMBER 101

1941

Paleontological Research Institution
Ithaca, New York
U. S. A.

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 27

No. 101

NEW MOLLUSCA FROM THE PLEISTOCENE OF SAN PEDRO, CALIFORNIA—II

By

S. Stillman Berry

October 7, 1941

Paleontological Research Institution

Ithaca, New York

U. S. A.

NEW MOLLUSCA FROM THE PLEISTOCENE OF SAN PEDRO, CALIFORNIA—II

By

S. Stillman Berry
Redlands, California

This is the second (the first appeared as No. 94A of these Bulletins, Berry, 1940) of the preliminary papers incident to my study of certain Pleistocene biotas of the San Pedro district in southern California. Diagnoses of seven more species and one subspecies of mollusks from Hilltop Quarry, believed hitherto undescribed, are here advanced for the consideration and criticism of other students. All are gastropods, five being members of the family *Turridæ,* which contributes many species and genera to this fauna and comprises one of its more important and interesting constituent groups. The generic position of most of these can only be taken as in a high degree provisional, pending the time when some careful student will undertake far more extensive investigations of the living animals as well as the shells of this family than are now anywhere available to us. Until this is done even the most careful analysis of turrid genera and subgenera can be little more than tentative, while some forms now placed there may well prove not to belong to the family at all.

I am deeply indebted to my friend, Mr. Tom Craig, of Los Angeles, for his kindness in supplying the drawings used in the accompanying plate, wherein six of the species described are, we hope, recognizably figured. Illustrations of the two remaining species must unfortunately await a subsequent occasion.

Actæon (Microglyphis) schencki, new species

Diagnosis.—Shell small, somewhat barrel-shaped, with a rapidly tapering conoid spire; whorls about 5; apex smooth, polished, rounded; later whorls convex, somewhat flattened on the sides, ornamented by fine growth striations and numerous fine, fairly sharp, not very regularly spaced, incised, spiral lines, of which about 20 can be counted from suture to suture on the penultimate whorl; suture distinct, appressed, but deepening to an ultimately strong shouldering of the whorl in many of the fossils through the peculiar susceptibility to decortication of this part of the shell. Aperture broadly auriform; outer lip simple, sharp; inner lip covered by a well-developed callus continuing past the pillar to cover the umbilical region; columella in general perpendicular, but weakly biarcuate in a greater or less degree and twisted in front to form a moderately strong fold bordering the canal, with varying traces of a small secondary fold just posterior to this; canal very short, open, truncate, hardly recurved.

Measurements of holotype.—Alt., 4.9; diam., 3.2; alt. aperture, 3.2 mm.

Holotype.—Cat. No. 10,409, Berry Collection.

Paratypes.—Cat. No. 10,410, Berry Collection; others to be deposited in the collections of the Paleontological Research Institution, Stanford University, and the United States National Museum.

Type locality.—Lower Pleistocene—"Hilltop Quarry" (the fine-grained upper beds), San Pedro, California; S. S. Berry, 1935-36.

Remarks.—The *Microglyphis* group of *Actæon* is poorly represented in Recent collections, but is not at all rare in the soft, fine-grained upper layers of Hilltop Quarry. In the somewhat extended series of shells referable to this subgenus now before me, in addition to the species just described, I strongly suspect the presence of a second species of possibly greater frequency, characterized by a sparser spiral striation, strong duplex fold of the pillar, and a narrow, more strongly curved canal; but decortication of the shells is so prevalent that only a few of the specimens are in first-class condition, and it is difficult to be sure how many of these apparent characters are really critical without a better knowledge of their normal range of variation. I hope a little later to supply figures of both forms, but shall not attempt formally to name the second without a more prolonged study.

Two species from the living fauna alone require comparison with the fossils. *A.* (*M.*) *estuarinus* Dall (1908a:238) from 92 fathoms, off Estero Bay, California, is materially larger (5 5x3.7 mm.) than *schencki,* and apparently possesses a relatively lower spire ("spire above the last whorl 1.0 mm."). It seems not to have been figured. *A.* (*M.*) *breviculus* Dall (1902, p. 512; 1908a, p. 237,238, pl. 15, fig. 12) from 48-53 fathoms, off Santa Rosa Id., California, is a thinner-shelled yet stubbier species, with a more cylindric body whorl and a lower spire than *schencki,* and only about half as many spiral striæ.

It is a pleasure to associate with this very interesting species the name of an unfailingly interested and helpful friend, Dr. Hubert G. Schenck of the Department of Palæontology of Stanford University.

Oenopota turrispira, new species Plate 1, fig. 1

Diagnosis.—Shell small, solid, fusiform, high-spired, with about 8 high-shouldered, narrowly sloping tabulate whorls, which are almost straight below the shoulder but tend to overhang the deeply cut suture. Embryonic shell mammillate, the first turn, or a little more, smooth, with rounded whorls, which shortly become subcarinate and then almost at once develop two strong spiral cords, the uppermore of which is on the shoulder, while the lower appears to arise from the peripheral angle, although the suggested homology is soon obscured by the flattening of the whorls; crossing the spirals and forming strong squarish depressions with and between them are fine axial threads running across the shoulder and thence down the outer slope to the lower suture, which shortly develop into about 12 massive ribs (strongly retractive on the shoulder and weakening and narrowing into the suture above) which increase to about 18 on the body whorl, with interspaces somewhat narrower than the ribs, and become obsolescent on the base of the shell approaching the canal; the two spiral threads previously mentioned after about two turns rather abruptly increase to four and eventually to five intersuturally, and a total of perhaps 15 on the body whorl, where those nearest the canal become indistinct and difficult to count accurately, while in form they are strongly flattened, with the rather sharply cut grooves between them hardly half as wide. Underlying the major sculpture is a very fine minor sculpture of microscopic axial threads and spiral lines visible only under high magnification. Aperture subperipheral, narrowed, distinctly less than half as long as the shell; canal rapidly narrowing, moderately long; columella weakly arcuate, flattened, and bounded outwardly by a distinct furrow.

Measurements of holotype.—Alt., 13.6; diam., 5.5; alt. aperture, 6.1 mm.

Holotype.—Cat. No. 10,400, Berry Collection.

Paratypes.—Cat. No. 10,401, Berry Collection.

Type locality.—Lower Pleistocene—"Hilltop Quarry" (a shelly pocket in the fine-grained upper beds), San Pedro, California; 1 nearly perfect shell and 2 broken spires, S. S. Berry and E. P. Chace, 1936.

Remarks.—This species is large for an *Œnopota* and peculiarly high-spired, but exhibits obvious similarities to the Recent *fidicula* (Gould, 1849, p. 141) described from Puget Sound, and a nearly allied form has in fact already been reported under that name from a higher level in the San Pedro Pleistocene. It differs distinctly from *fidicula,* however, in the relatively shorter aperture, narrower form, produced spire, less numerous and strongly flattened spiral threads, and wide shoulder spiral.

Grant and Gale (1931, p. 514) offer a very elaborate synonymization of the forms of this group, and *fidicula* is one of the submerged species, but until there has been offered a much more convincing assembling of evidence for so extreme a view, I find myself little tempted to follow them. On the contrary it appears to me quite as likely from present data that a thoroughgoing analysis will reveal the number of distinct species in this group to be appreciably larger than is now recognized as that it will justify so sweeping a recombination. Meanwhile it is surely wise to move slowly. Even in the works of Sars, who figures the North Atlantic forms of *Œnopota* in wide variety, I have been successful in finding no variant which appears even closely comparable to the present form.

The specific name is derived from the L. *turris,* tower, + *spira,* spire.

Moniliopsis chacei, new species Plate 1, fig. 2

Diagnosis.—Shell small, moderately heavy; spire tall and acute, with a smooth submammillate nucleus of about 1½ deeply sutured whorls, which are at first smoothly rounded, later subcarinate; postnuclear whorls 5+ to nearly 6, at first with a strongly threaded carina, shortly supplemented by a slightly weaker thread between the carina and the lower suture, and with the shoulder ornamented by about 16 low axial ridges which form nodes where they join the carina; on the later whorls these axial ribs increase in both strength and number to about 23 on the body whorl, and from the second postembryonic whorl onward they extend completely across the whorl, fading out only in the region of the canal, and becoming strongly retractive above the fasciole, more weakly protractive below it; the early carination diminishes steadily to the body whorl, the outlines of which are quite smoothly convex, while at the same time the number of spiral threads steadily increases both in number and equality of development until on the final whorls there are found in addition to the two major spirals another between them nearly as strong, a fourth just posterior where the axial ribs make their bend, a fifth anterior to these which tends to thread the suture, and about 13 or 14 of diminishing strength extending to the canal, besides often a thread or two just below the suture in the fasciolar area; all these threads save in the region of the canal are more or less strongly noded where they are intersected by the axial ribs. Suture of first whorl strongly oblique, subsequently normal in character; channeled on the early whorls, less so on the later ones. Aperture narrow, not quite half so long as the shell, terminating in a rather long, open, slightly recurved canal; outer lip thin, sharp, simple except for the fasciolar notch, which is imperfect in all my specimens; columella at first nearly perpendicular, then smoothly arcuate into the canal, without plications.

Measurements.—Largest specimen—alt., 11.5+; diam., 4.6; alt. aperture, 5.6 mm. Holotype—alt., 10.1; diam., 3.8; alt. aperture, 4.9 mm.

Holotype.—Cat. No. 10,395, Berry Collection.

Paratypes.—Cat. Nos. 10,396 and 10,399, Berry Collection; others to be deposited in the collections of the Paleontological Research Institution, Stanford University, California Institute of Technology, Pomona College, San Diego Museum of Natural

History, United States National Museum, and the private collection of Emery P. Chace.

Type locality.—Lower Pleistocene—"Hilltop Quarry" (fine-grained upper beds), San Pedro, California ; S. S. Berry, R. K. Cross, and E. P. Chace, 1934 to 1939.

Remarks.—This characteristic and rather common species in the horizon studied apparently represents an undescribed race close to *fancheræ* (Dall, 1903, p. 172; 1919, p. 28, pl. 8, fig. 3), having the same large nipplelike nucleus but with the sculpture, especially the axial, of the later whorls notably sparser and coarser than in either *fancheræ* or *rhines* (Dall, 1908, p. 248; 1919, p. 28, pl. 8, fig. 5). It may conceivably lie in the direct ancestral line of the first-mentioned species. The form and sculpture of the early whorls as well as the peculiar larval shell strongly suggest those found in the associated Clathurellas, a circumstance perhaps more deeply significant than mere coincidence. Both this species and *fancheræ* differ too strongly in nuclear character from (*e. g.*) *ophioderma* (Dall, 1908, p. 247) to be properly considered as subspecies or races of the same specific complex.

The species is named for the well-known collector and field-worker, Mr. Emery P. Chace of San Pedro, who has helped me greatly in securing abundant material from the Quarry.

Clathurella (Glyphostoma) tridesmia, new species Plate 1, fig. 3

Diagnosis.—Shell small, moderately heavy; spire tall and acute, with a smooth submammillate nucleus of a trifle less than two rounded strongly sutured whorls, the first steeply descending; postnuclear whorls 5½, at first simply angular at the periphery, then with a spiral cord developing below the carina, followed shortly by other spirals and further by the axial sculpture to take on the character of the mature ornamentation hereinafter described. Suture of first whorl strongly descending, of subsequent whorls normally aligned, appressed, the fasciolar region below it on the later whorls slopingly shouldered and bearing 5 to 6 low, close-set, threaded spirals, with interspaces narrower than the threads, followed below by a heavier cord just above the very heavy nodular band which emphasizes the peripheral angle; whorl below the periphery rounded, bearing usually about 20 or 21 strong spiral ribs, the upper ones more or less nodulose, of which only 3 or 4 remain exposed on the spire, thence on the last whorl becoming gradually weaker toward the canal; second cord below the periphery much larger than its companions, and sometimes almost as strong as the peripheral cord, forming a secondary angle to the whorls, though this may vary considerably in strength in different specimens; in a few examples the next cord, or next cord but one below this, is likewise emphasized to some extent; threads between the 2 or 3 major cords sometimes reduced to mere intercalaries, at other times as large as those on the lower part of the whorl. Axial sculpture comprising 17 to 19 (count on penultimate whorl) low, rounded, slightly protractive ribs, which are usually most in evidence on the spire, becoming nearly obsolete on the anterior part of the body whorl, and in some specimens so reduced as to be little in evidence save insofar as they produce the previously mentioned nodulations of the major spirals. Lines of growth inconspicuous. Aperture subovate, with a short, open, slightly recurved canal, produced at the columella, and a deep rounded anal sulcus terminating close to the suture with a strong subsutural callus; outer lip strongly arcuately produced, somewhat thickened just back of the sharp, slightly crenulated margin, with usually a moderately strong varix behind it; apertural denticles wanting so far as noted; inner lip smooth, sharply sloping at first, but the rather long columella nearly straight.

Measurements of holotype.—Alt., 10.0; alt. last whorl, 4.6; diam., 4.0 mm.

Holotype.—Cat. No. 10,393, Berry Collection.

Paratypes.—Cat. No. 10,394, Berry Collection; others to be deposited in the collections of the Paleontological Research Institution, California Institute of Technology, Stanford University, Pomona College, San Diego Museum of Natural History, United States National Museum, and the private collection of Emery P. Chace.

Type locality.—Lower Pleistocene—"Hilltop Quarry" (pit in quarry floor), San Pedro, California, (also frequent in the upper beds); S. S. Berry, R. K. Cross, and E. P. Chace, 1934 to 1939.

Remarks.—This is a very beautifully sculptured little species of a beautiful group, the double angulation of the whorls causing the spire to appear almost turreted. Grant and Gale (1931) rightly bring to question the taxonomic exuberance of Dall, yet it seems clear that in this as in many other instances they hasten to the other extreme. Although forms such as the selected holotype are very different from anything else in the group known to me, it is admittedly true that the fossil series is an exceedingly variable one, so variable indeed that one might well ponder whether it itself may not include more than one form. Also the tendency of this variation is very definitely in the direction of the living *cymodoce* (Dall, 1919, p. 54, pl. 17, fig. 6), but at no point does the gap at present seem quite bridged, whether or no at some later day we find it so. The latter species, as evidenced by one of Woodworth's original specimens before me, is very close to *tridesmia,* but the smooth nucleus is smaller, the axial ribs begin almost immediately, they are both more distinctly knobby and fewer in number, the periphery is much less angular, especially on the early whorls, the postlabial varix is much stronger, and the outer lip is both heavier and much less strongly produced.

C. conradiana (Gabb, 1866, pl. 1, fig. 12; 1869, p. 73) is larger, with a wider body whorl and much heavier ribbing.

C. canfieldi (Dall, 1871, p. 101; 1872, pl. 15, fig. 9) is a smaller, heavier, more strongly ribbed species, with a denticulate aperture and less produced spire.

The specific name chosen is derived from the Gr. *tri-*, thrice, + *desmios,* bound, and has reference to the triplicate major spiral sculpture.

Mitromorpha barbarensis woodfordi, new subspecies Plate 1, fig. 4

Diagnosis.—Shell large for the genus, spindle-shaped, biconic; whorls convex; suture channeled, a slender thread visible in the channel; heavily sculptured with a series of very even, flattened, spiral cords, about 4 to a whorl between the sutures, and 17 on the body whorl, their interspaces generally about equal to them in width, but rather wider at the summit and narrower at the base of the whorl, the uppermost channel especially wide; axial sculpture wanting on the final whorl, but on the earlier postnuclear turns represented by about 12 low, but quite massive and narrowly spaced ridges. Aperture narrow, elongate, a little less than half as long as the shell; columella sinuous, biarcuate, the columellar folds two in number, but low and usually quite obsolete or perhaps immersed in most of the specimens examined; anterior canal moderately defined and at maturity slightly recurved.

Measurements of holotype.—Alt., 11.4; diam., 4.2; alt. aperture, 5.6 mm.

Holotype.—Cat. No. 7705, Berry Collection.

Paratypes (all smaller than the holotype or immature).—Cat. No. 7706, Berry Collection; others to be deposited in the collections of Stanford University, the Paleontological Research Institution, Pomona College, California Institute of Technology, San Diego Museum of Natural History, and the United States National Museum.

Type locality.—Lower Pleistocene—"Hilltop Quarry" (pit in quarry floor), San Pedro, California; S. S. Berry, R. K. Cross, and E. P. Chace, 1934 to 1939.

Remarks.—The closest affinity of this, by far the largest member of the genus yet to be described, is clearly with *M. barbarensis* Arnold (1907, p. 438, 446, pl. 57, fig. 1; cf. also topotypes from Bathhouse Cliff, Santa Barbara, California, in Berry Coll., Cat. No. 8958), but it is very much larger, narrower, with a more produced spire, and the axial ribbing becomes nearly or quite obsolete on the final whorl at maturity. One of my immature shells would quite resemble Arnold's figure were it not for the heavier and wider axial ribs and their smaller number. It is the difficulty encountered in the separation of such specimens which lead me for the present at least to withhold full specific rank from *woodfordi*. Compared with *gracilior* "Hemphill" (Tryon, 1884, p. 317, pl. 25, fig. 62) the present form differs in its much larger size, more produced spire, fewer and coarser axial ribs, convex whorls, and deeper suture. *Interfossa* (Carpenter, 1856, p. 429) is interpreted by Grant and Gale (1931, p. 598) to include *barbarensis*, but I have seen on specimens from Neah Bay (the type locality) or its vicinity, and can not presume as to the correctness of their interpretation. Certainly no other Recent shells of the genus seen by me check at all closely with the fossils.

Grant and Gale find *interfossa* (+*barbarensis*) uncomfortably near to *aspera* (Carpenter), but I fail to understand why they prefer comparison with this species rather than with *gracilior*. Recent specimens from San Pedro which I can not separate from *gracilior* are really very close to Arnold's figure above cited, although, on the other hand, they seem clearly distinct from the Hilltop Quarry race. Compare also Arnold, 1903 p. 223, pl. 4, fig. 10.

The name proposed is in salutation to Prof. A. O. Woodford of the Department of Geology, Pomona College, and denominates an exceedingly beautiful little shell, the finest of its group.

Mitromorpha galeana, new species

Diagnosis.—Shell small, spindle-shaped, biconic; whorls weakly convex, the suture channeled, with a slender thread visible in the channel; heavily sculptured by a series of even spiral cords, numbering 5 between sutures on the spire, and a total of about 18 on the final whorl, separated by smoothly grooved channels narrower than the cords; axial sculpture wanting; aperture narrow, elongate, about half as long as the shell; columella sinuous, biarcuate, bearing two weak folds just below the center; anterior canal weakly defined.

Measurements of holotype.—Alt., 7.3; maj. diam., 3.3 mm.

Holotype.—Cat. No. 10,397, Berry Collection.

Paratypes.—Cat. No. 10,398, Berry Collection; others to be deposited in the collections of the Paleontological Research Institution, Stanford University, Pomona College, California Institute of Technology, San Diego Museum of Natural History, and the private collection of Emery P. Chace.

Type locality.—Lower Pleistocene—"Hilltop Quarry" (pit in quarry floor) San Pedro California; S. S. Berry, R. K. Cross, and E. P. Chace, 1934 to 1939.

Remarks.—This species stands near *filosa* Carpenter (1864. p. 658; 1865a, p. 182), but is more slender, the aperture is shorter, the suture is conspicuously threaded and channeled, and the relative proportions are different, lacking the curious hunched appearance which is peculiarly characteristic of *filosa.* Likewise none of the specimens I have examined show any denticulation of the outer lip or even the thickening and beveling off seen in the lip of the latter species.

The species is named for Dr. Hoyt Rodney Gale, to whom, for his part in the monumental monograph already cited repeatedly in this paper, every student, and particularly an isolated student like myself, must ever remain indebted.

Margarites (Lirularia) aresta, new species Plate 1, fig. 5

Diagnosis.—Shell small, thin, conic, rather high; whorls $5\frac{1}{2}$, rounded, strongly bicarinate, the carinæ acutely threaded, one carina on the shoulder, the other about equal to it and peripheral, entering the suture[1]; slope of shoulder strong, weakly arcuate; slope between carinæ nearly vertical; base typically ornamented by three spiral cords, the lowest of which strongly angulates the umbilical margin, with usually an additional lesser cord enclosed within it; axial sculpture wanting except for the fine but quite sharp growth lines. Embryonic shell mammillate, at first rounded and sculptureless as far as can be made out, but becoming shouldered after the last turn. Umbilicus open and of moderate width, well reamed out. Aperture rounded but angulated to some extent by the carinæ; lip thin, sharply beveled, simple, unreflected.

Measurements of holotype.—Alt., 4.7; diam., 4.4; alt. aperture, 2.9 mm.

Holotype.—Cat. No. 10,402, Berry Collection.

Paratypes.—Cat. No. 10,403, Berry Collection; others to be deposited in the collections of the Paleontological Research In-

[1] In some specimens a third weaker carina develops about midway of the shoulder, but this is more often represented by a mere thread or entirely obsolete. In the holotype there is a minor supplemental keel so closely subtending the peripheral one as to give almost the appearance of a single wide riblet in this region; it requires careful inspection to discover that the apparent rib is mostly an interspace.

stitution, Stanford University, United States National Museum, San Diego Museum of Natural History, and the private collection of Emery P. Chace.

Type locality.—Lower Pleistocene—"Hilltop Quarry" (from pit in quarry floor), San Pedro, California; S. S. Berry, 1934, also S. S. Berry and E. P. Chace, 1937 to 1939.

Remarks.—I know no species, living or fossil, with which *M. aresta* requires special comparison. It is clearly a *Lirularia* as that group is at present understood, but even amid this lovely assemblage its beautiful sculptural plan appears unique. In general it somewhat suggests a particularly elegant *Valvata*. Some shells show traces of rounded spots of color strung along the shoulder-carina. Several adult shells were obtained, but the great majority taken are quite juvenile. Possibly the fragility of the shell has something to do with this.

The specific name is the L. *arestus,* pleasing.

Skenea (?) cyclostoma, new species Plate 1, figs. 6, 7

Diagnosis.—Shell minute, simple, cyclostomoid; spire depressed, flattened; umbilicus open, widely funiculate; whorls rounded, rapidly expanding, the suture deeply impressed. Whorls 3½. Aperture almost perfectly circular, large. Sculpture wanting except for the very fine and numerous lines of growth.

Measurements of holotype.—Max. diam., 1.76; alt., .92; alt. aperture, .72 mm.

Holotype.—Cat. No. 10,407, Berry Collection.

Paratype.—Cat. No. 10,408, Berry Collection.

Type locality.—Lower Pleistocene—"Hilltop Quarry" (fine-grained upper beds), San Pedro, California; one mature shell, the holotype, and one minute juvenal, thought to be conspecific and used as a paratype, S. S. Berry, 1937, 1940.

Remarks.—I am by no means sure that this trim and inconspicuous vitrinellid is really a *Skenea,* but its lack of spiral sculpture appears suggestive of this genus rather than of *Delphinoidea,* while the well-known *S. planorbis* Fabricius (Berry Coll. 2286, taken at Provincetown, Mass., by C. W. Johnson) has seemed the nearest thing to it, available to me, for close comparison. From the latter the present shell differs in (1) the planulate spire; (2) the lower, much more rapidly expanding whorls; (3) the more evenly rounded aperture; (4) the finer and less irregular growth lines; (5) the smaller initial embryonic whorl; (6) the more polished surface (especially that of the embryonic whorls) and somewhat thinner shell, even though so alterable a character as texture is admittedly difficult to use as a basis of comparison between a fossil and a living shell; and (7) the possession of about one-quarter whorl less in shells of corresponding size. The differences in the embryonic shells as noted may indicate that the relationship between the two is not so close, but if properly allocated, this is perhaps the first Pacific record for the genus *Skenea*.

The specific name proposed has been chosen because of the marked resemblance in form of shell to the land-operculate genus *Cyclostoma,* which in turn derives its name from the Gr. *cyclos,* circular, + *stoma,* mouth, and has reference to the shape of the aperture.

LITERATURE CITED

Arnold, R.

1903. *The Paleontology and stratigraphy of the marine Pliocene and Pleistocene of San Pedro, California,* Memoirs California Academy Sciences, 3, June, 1903, pp. 420, pls. 1-37.

1907. *New and characteristic species of fossil mollusks from the oil-bearing Tertiary formations of Santa Barbara County, California,* Smithsonian Miscellaneous Collections (Quarterly Issue), 50 (4), Dec., 1907, pp. 419-447, pls. 50-58.

Berry, S. S.

New Mollusca from the Pleistocene of San Pedro, California —I, Bulletins American Paleontology, 25 (94A), Sept., 1940, pp. 1-18, pls. 1-2.

Carpenter, P. P.

1864. *A supplementary report on the present state of our knowledge with regard to the Mollusca of the West Coast of North America,* Report British Association Advancement Science, 1863. Aug. 1864. pp. 517-686. [Repr. in Smiths. Misc. Coll., pp. 1-172, Dec., 1872.]

1865. *Diagnoses of new forms of Mollusca from the Vancouver District,* Annals and Magazine Natural History, ser. 3, 14, Dec., 1864; pp. 423-429; 15, Jan., 1865, pp. 28-32. [Repr. with preceding in Smiths. Misc. Coll., pp. 233-246, Dec., 1872.]

1865a *Diagnoses of new forms of Mollusca from the West Coast of North America, first collected by Col. E. Jewett,* Annals and Magazine of Natural History, ser. 3, v. 15, March, 1865, pp. 177-182 [Repr. with preceding in Smiths, Misc. Coll., pp. 277-284, Dec. 1872.]

Dall, W. H.

1871-72. *Descriptions of sixty new forms of mollusks from the West Coast of North America and the North Pacific Ocean, with notes on others already described,* American Journal Conchology, 7 (2), Nov., 1871, pp. 93-160; (3), Mar., 1872, pls. 13-16.

1902. *Illustrations and descriptions of new, unfigured, or imperfectly known shells, chiefly American, in the U. S. National Museum,* Proceedings United States National Museum, 24 (1264), 1902, pp. 499-566, pls. 27-40.

1903. *Diagnoses of new species of mollusks from the Santa Barbara Channel, California,* Proceedings Biological Society Washington, 16, Dec., 1903, pp. 171-176.

1908. *Descriptions of new species of mollusks from the Pacific Coast of the United States, with notes on other mollusks from the same region,* Proceedings United States National Museum, 34 (1610), June, 1908, pp. 245-257.

1908a. *Reports on the dredging operations off the West Coast of Central America. . . by the U. S. Fish Commission Steamer "Albatross" . . . XXXVII. Reports on the scientific results of the expedition to the eastern tropical Pacific . . . by the . . . Albatross", etc. XIV. The Mollusca and the Brachiopoda,* Bulletin Museum Comparative Zoölogy Harvard College, 43 (6), Oct., 1908, pp. 205-487, pls. 1-22.

1919. *Descriptions of new species of mollusks of the family Turritidæ from the West Coast of America and adjacent regions,* Proceedings United States National Museum, 56 (2288), 1919, pp. 1-86, pls. 1-24.

Gabb, W. M.

1866. *Tertiary and invertebrate fossils,* Geological Survey of California, Palæontology, 2 (1), Feb., 1866, pp. 1-38, pls. 1-13.

1869. *Cretaceous and Tertiary fossils,* Geological Survey of California, Palæontology, 2, 1869, pp. 1-299, pls. 1-36.

Gould, A. A.

1849. *. . . descriptions of . . . species of shells from the collection of the U. S. Exploring Expedition,* Proceedings Boston Society Natural History, 3, 1849, pp. 140-144.

Grant, U. S. IV, and Gale, H. R.

1931. *Catalogue of the marine Pliocene and Pleistocene Mollusca of California and adjacent regions, etc.,* Memoirs San Diego Society Natural History, 1, Nov., 1931, pp. 1-1036, diag. A.-D. tab. 1-3, text figs. 1-5, pls. 1-32.

Tryon, G. W., Jr.

1884. Manual of Conchology, ser. 1, v. 6, 1884.

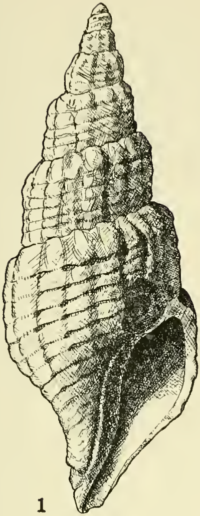
Note: Gabb, 1869 and Tryon, 1884 are inaccessible to me, so are cited perforce from the works of other authors.

PLATE

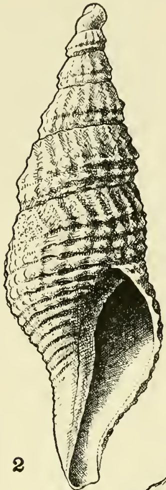
PLATE I (I)

EXPLANATION OF PLATE 1 (1)

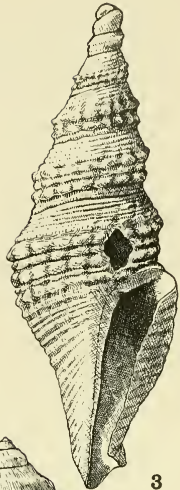
All figures on this page are from original drawings by Tom Craig



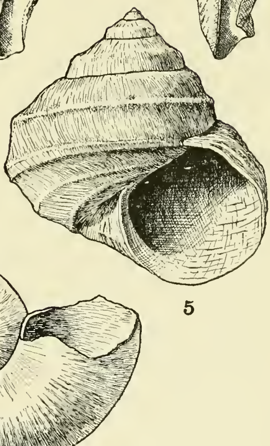
1



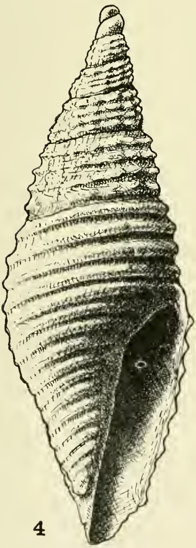
2



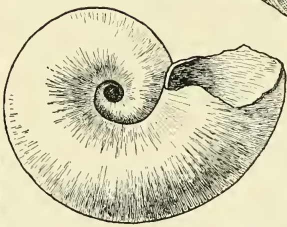
3



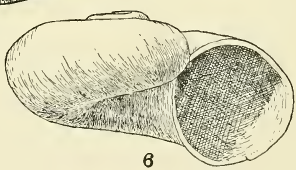
5



4



7



6

BULLETINS

OF

AMERICAN PALEONTOLOGY

VOL. XXVII

NUMBER 102

1941

Paleontological Research Institution

Ithaca, New York

U. S. A.

Condensed Table of Contents of Bulletins of American Paleontology and Palæontographica Americana*

BULLETINS OF AMERICAN PALEONTOLOGY

Volume I.	(Nos. 1-5). 354 pp., 32 pls. Mainly Tertiary Mollusca.	$ 8.00
II.	(Nos. 6-10). 347 pp., 23 pls. Tertiary Mollusca and Foraminifera, Paleozoic faunas.	10.00
III.	(Nos. 11-15). 402 pp., 29 pls. Mainly Tertiary Mollusca and Paleozoic sections and faunas.	8.00
IV.	(Nos. 16-21). 161 pp., 26 pls. Mainly Tertiary Mollusca and sections of Paleozoic sections and faunas.	5.00
V.	(Nos. 22-30). 437 pp., 68 pls. Tertiary fossils mainly Santo Domingan, Mesozoic and Paleozoic fossils.	8.50
VI.	(No. 31). 268 pp., 59 pls. Claibornian Eocene pelecypods.	6.00
VII.	(No. 32). 730 pp., 90 pls. Claibornian Eocene scaphopods, gastropods and cephalopods.	12.00
VIII.	(Nos. 33-36). 357 pp., 15 pls. Mainly Tertiary Mollusca.	5.00
IX.	(Nos. 37-39). 462 pp., 35 pls. Tertiary Mollusca mainly from Costa Rica.	7.00
X.	(Nos. 40-42). 382 pp., 54 pls. Tertiary forams and mollusks mainly from Trinidad and Paleozoic fossils.	8.00
XI.	(Nos. 43-46). 272 pp., 41 pls. Tertiary, Mesozoic and Paleozoic fossils mainly from Venezuela.	5.00
XII.	(Nos. 47-48). 494 pp., 8 pls. Venezuela and Trinidad forams and Mesozoic invertebrate bibliography.	6.00
XIII.	(Nos. 49-50). 264 pp., 47 pls. Venezuelan Tertiary Mollusca and Tertiary Mammalia.	6.00
XIV.	(Nos. 51-54). 306 pp., 44 pls. Mexican Tertiary forams and Tertiary mollusks of Peru and Colombia.	6.50

* Complete titles and price list of all numbers may be had on application. All volumes available.

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 27

No. 102

CEPHALOPODS FROM THE SEWARD PENINSULA OF ALASKA

By

Rousseau H. Flower

December 8, 1941

Paleontological Research Institution

Ithaca, New York

U. S. A.

CEPHALOPODS FROM THE SEWARD PENINSULA OF ALASKA

by

Rousseau H. Flower

The three species of cephalopods described in the following pages were collected from the York District, Seward Peninsula, Alaska, by J. B. Mettie, Jr., of the U. S. Geological Survey. They were sent to the writer through the kindness of Dr. Josiah Bridge. The specimens have been of exceptional morphological interest, but serve only to establish approximate correlations of the beds from which they came. Two of the species belong to *Ellesmeroceras,* a genus known only from the Ozarkian of America and the equivalent Wanwanian of Manchuria. The Alaskan forms are much closer to the Manchurian forms than to the single species thus far described from the Western Hemisphere, *Ellesmeroceras scheii* Foerste. The two species of *Ellesmeroceras,* collected from float, indicate the presence of Ozarkian strata.

The remaining species, a coiled cephalopod, is Canadian in aspect. Externally, the form is one which shows no essential difference from *Plectoceras* of the Ordovician. The siphuncle, however, shows a thickening of the connecting ring which is peculiar to certain Canadian cephalopods, including *Tarphyceras* and *Eurystomites.* It remained to determine whether the external form or the internal structure was the more significant feature to be used in classification. Other investigations indicate strongly that two distinct groups are involved in early Paleozoic coiled cephalopods. One of these, characterized by a thick connecting ring of complex structure, is known only from the Canadian. This includes *Tarphyceras* and *Eurystomites,* and it seems desirable to restrict the Tarphyceratidæ to such forms. Another group, thus far known definitely only from the Ordovician, is characterized by thin connecting rings which show no differentiation of structure. This group includes *Plectoceras* of the Plectoceratidæ and a number of genera formerly assigned to the Tarphyceratidæ, including *Barrandeoceras.* Further, Chazyan coiled cephalopods externally typical of such Canadian genera as *Aphetoceras, Pycnoceras,* and probably *Falcilituites* belong in this group. Unsettled problems of phylogeny make it impossible to revise the classification of the genera involved at the present time. It is conceivable that a simplification may have taken place in a single genetic line, producing Ordovician types from Canadian ones. On the other hand, the internal structure suggests very strongly that, instead, two lines may be involved which illustrate one of the most remarkable cases of homeomorphy to be found among the cephalopods. Which of these possibilities contains the true solution cannot be determined until more thorough investigations have been undertaken. Happily this is now being accomplished by Miller and Furnish, in the completion of the studies of Ozarkian and Canadian cephalopods.

Genus **ELLESMEROCERAS** Foerste

Revised description.—(Ulrich and Foerste, 1936, pp. 275-6.)

"Conchs orthoconic, slowly enlarging, laterally compressed. Sutures of septa curving downward laterally, rising almost as high dorsally as ventrally, but a little straighter on approaching the ventral saddles. Closely similar to *Ectenolites,* but regarded as orthoconic rather than cyrtoconic.

Siphuncle in flattened contact with one of the more narrowly rounded sides of the conch; structure probably holochoaniodal. Differing from *Cotteroceras* chiefly in the downward curvature of the septa laterally.

Genotype: *Ellesmeroceras scheii* Foerste (Denison Univ. Bull., Sci. Lab. Jour., vol. 19, p. 265, pl. 27, fig. 3A-c; pl. 33, fig. 3 (1921)."

The above description differs mainly from the original one, which is combined with the description of the genotype and is too long to be reproduced here, in the recognition of dorsal saddles of sutures. The illustration did not show the dorsal sutures clearly, and no mention of them was made in the original description. The Alaskan species are atypical mainly in that the dorsal saddle is better developed than is the ventral saddle. This is, however, a feature which may be expected to vary among the species. Such sutures are not known in any described orthoconic genus of the early Paleozoic, though they are characteristic of the genus *Ectenolites* Ulrich and Foerste (1936, p. 272) which possesses truncated endocones within the siphuncle and is slightly cyrtoconic in the adapical part of the shell. One of the Alaskan species shows a very slight cyrtoconic tendency, but this appears to be variable within the species.

The only described species of *Ellesmeroceras* consist of the genotype and several forms from the Wanwanian of Manchuria. The forms discussed in this paper are most closely allied to *Ellesmeroceras foerstei* Kobayashi (1933, p. 268, pl. 1, figs. 1, 11), a species of rather strongly compressed section and well-developed lobes, the dorsal saddles of which are quite conspicuous, at least anteriorly. This species appears to connect the Alaskan forms with the genotype, at least insofar as the condition of the sutures is concerned. Other described Manchurian species are broader in section and have straighter sutures.

The structure of the siphuncle has not been closely studied in any species of *Ellesmeroceras*. The siphuncle is made up of concave segments which are oblique, being strongly inclined orad on the ventral (?) side, where the siphuncle is practically in contact with the wall of the shell. The concave outline of the segments seems to be the only basis for classifying the genus as holochoanitic. The siphuncle is illustrated adequately in my plates. Exfoliated siphuncles, exposed on the ventral side of the conch (Pl. 1, figs. 1-2), present the aspect of cyrtochoanitic segments. In section (Pl. 1, fig. 19) this aspect is retained. However, close examination shows that the septa join the siphuncle at a point orad of the greatest width of the segment and apicad of the least width and are not located at the apparent septal foramen at all. Dorsally (Pl. 1, fig. 9; Pl. 2, fig. 6) the segments are concavosiphonate, but again the septa do not join the siphuncle at the point where they would normally be expected to be found. Septa were generally elusive, as were the fine points of the structure of the siphuncle wall, because of extensive replacement and recrystallization of the white calcite that filled the phragmocone for the most part. However, one section (Pl. 2, fig. 6) showed the course of the septa clearly and gave in addition good indication of the original structure of the siphuncle wall. At the base of the specimen, septa could be seen passing through areas of dark matrix and joining the siphuncle. The septal necks are bent before attaining the wall of the siphuncle itself.

Further, they seem to terminate shortly beyond the bend and to be discontinuous with the wall of the siphuncle. The nodes of the siphuncle lie shortly apicad of the bend of the neck. Also, there is indication that the walls are thickened, being widest apicad of the middle and shaped somewhat like a crescent or a meniscus. The interpretation of the structure of the siphuncle wall here can be seen by comparing Plate 2, fig. 6 with text figure 1A. Segments lying slightly farther orad in the same specimen furnished additional evidence of the ellipochoanitic structure. Here the cameræ are filled with white calcite and the free part of the septum is not visible. However, dark calcite lying close to the siphuncle marks in part the exterior of the siphuncle wall and preserves the bent portion of the septal necks (text fig. 1B). Owing to recrystallization of the material, particularly the white cal-

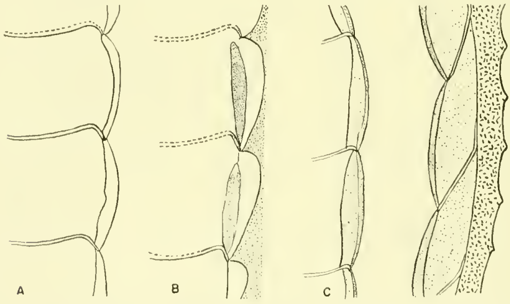


Fig. 1. Internal structure of siphuncle walls of Alaskan cephalopods.
A. Dorsal wall of siphuncle of *Ellesmeroceras bridgei,* from basal part of Plate 2, fig. 6. Cavity of siphuncle on right.
B. Showing appearance and restoration (broken lines) of dorsal wall of *E. bridgei* farther orad in the same specimen.
C. Siphuncle in *Plectoceras sewardense,* showing differentiation of connecting rings. Oblique course of septal foramen indicated by dotted line across the siphuncle.

cite, no further structures could be seen in the material. Investigation of the structure by thin section did not seem warranted by the present condition of all specimens observed and was further undesirable in view of the small amount of material available for study.

The thickening of the connecting ring is not a unique feature, confined to this genus, but is known in a considerable number of other cephalopod genera, including *Bathmoceras*, a number of Canadian genera formerly supposed to be holochoanitic, including *Protocameroceras* and several other forms. The significance of this structure will be discussed at another time.

According to Ulrich and Foerste (1936, p. 260) the Holochoanites are represented in the Ozarkian by three genera: *Ellesmeroceras, Walcottoceras*, and *Pachendoceras*. The present observations make it necessary to remove *Ellesmeroceras* from this list. Other genera have not been examined sufficiently closely to remove all doubt as to whether the condition may not be identical with that of *Ellesmeroceras*.

From the original descriptions, *Walcottoceras* appears to be little more than an annulated edition of *Ellesmeroceras*, while *Pachendoceras* is differentiated from it on the basis of its depressed section.[1]

Certainly the first forms which can be considered as holochoanitic beyond all possible doubt are younger than the Ozarkian. Further, rather desultory observations on supposedly holochoanitic Canadian forms have thus far failed to reveal other than ellipochoanitic structure, suggesting that the oldest of the true Holochoanites may be Ordovician.

Ellesmeroceras bridgei Flower, n. sp. Plate 1; Plate 2, fig. 6

Conch straight, compressed, expanding slowly, the height about 3 mm. greater than the width; section compressed with the ventral (?) or siphonal side very slightly more narrowly rounded than the antisiphonal side. Expansion is gradual. The largest form observed increases from 14 mm. and 17 mm. to 17 mm. and 20 mm. in the basal 30 mm., and to 21 mm. and 24 mm. in the next 20 mm. The rate of expansion is uniform in the specimens observed. The sutures bear lateral lobes which rise to a relatively

[1] *Pachendoceras* apparently possesses true endocones and is therefore included in the Endoceroidea. While probably ellipochoanitic, it is not closely related to *Ellesmeroceras*.

low and broad ventral saddle, not fully observed because of the tendency for the wall to break away at this region exposing the siphuncle. The dorsal saddle is relatively high and narrow.

Cameræ occur four and a half in 10 mm., where the adoral shell width is 15 mm.; six probably occuring in a length equal to the adoral width of the shell over the region measured. The siphuncle indicates that the cameræ become more closely spaced adorally, eight and a half segments occuring in a length equal to a width of 20 mm. in another individual.

The siphuncle lies close to the venter. In general, it lies in contact with the ventral wall at an early stage, later becoming free and separated from it by a short interval At a shell height of 19 mm., the siphuncle is faintly depressed in section, measuring 3 mm. by 4 mm. and is in contact with the wall (Pl. 1, fig. 5). Farther on in the same specimen, where the height is 23 mm., the siphuncle is 1 mm. from the venter, essentially circular, with a diameter of 4 mm. The appearance of the siphuncle segments as exposed on exfoliated specimens is adequately shown by our figures and has been discussed, along with the structure of the siphuncle, in connection with the description of the genus. The siphuncle is clearly without any internal organic deposit other than that supplied by the thickening of the connecting rings. Several specimens show the adapical portion of the siphuncle filled with calcite, and often the margin between the calcite and the matrix is such as to suggest the presence of diaphragms in the siphuncle. However, comparison of a number of specimens shows that the form of the contact is variable. In Plate 1, fig. 9, the calcite extends farthest orad on the ventral side. Other specimens have been observed in which the calcite slopes orad on the dorsum and even laterally. A laterally inclined contact is shown in cross section in Plate 1, fig. 5. The variation in orientation seems to be a clear indication that the contact is merely the junction of matrix forming an incomplete internal mold within the siphuncle and the complemental filling of calcite. Kobayashi (1935, p. 22, text fig. 2) has illustrated the Ellesmeroceratidæ as holochoanitic and as possessing diaphragms.[2] Our forms are clearly not holochoanitic and show no trace of organic dissepiments.

The surface of the shell is smooth and is preserved in several individuals. It is void of striations or any visible lines of growth. It does, however, show faint color markings which are sufficiently uniform in several individuals to suggest strongly that they represent an original color pattern. The markings form lateral lobes which rise steeply orad on the dorsum, much more steeply than the sutures, and are nearly transverse on the venter. Similar markings are also shown on the following species.

Discussion.—The prominence of the dorsal saddles, together with the slender form of the species and the separation of the siphuncle from the ventral wall at a shell height of 21 mm., will serve to distinguish this from all other species. The associated form differs in having the siphuncle separated from the ventral wall at a much earlier stage, possibly throughout the entire shell, and in being a smaller and a relatively rapidly expanding species.

Types.—This species is based upon a series of four syntypes, all the property of the U. S. Geological Survey, to be deposited in the U. S. National Museum.

Occurrence.—From the York District, Seward Peninsula, Alaska. All of the specimens are from a single piece of float from the bed of Cassiterite Creek, about 1.3 miles northeast of Cassiterite Mine. The beds from which these forms came are presumably Ozarkian, as the genus is known only from that period.

Ellesmeroceras expansum Flower, n. sp. Plate 2, figs. 3-5

This species is represented in our material by a single specimen which differs radically from *E. bridgei* in the more rapidly expanding section, a siphuncle that is separated from the venter at a much earlier stage, and the relatively narrowly rounded condition of the venter. The extant portion of the phragmocone has a maximum length of 25 mm. and expands from a

[2] This conclusion seems to be based on the presence of rather dubious dissepiments within *Sinocremoceras* and *Multicameroceras* which Kobayashi had formerly placed in the Ellesmeroceratidæ. He later removed them properly to the family Plectronoceratidæ. He occasionally speaks of both families as "ellesmeroceroids."

height of 12 mm. and a width of 9 mm. near the base to a height of 17 mm. and a width of 14 mm., in a length of 20 mm. At the base the siphuncle is 1 mm. wide, 1.4 mm. in height, and about .8 mm. from the ventral wall. Adorally the siphuncle is 2 mm. wide, 2.8 mm. high, and 1 mm. from the venter.

The sutures, shown only at the adoral end of the specimen, have only faint lateral lobes and rise equally on the dorsum and venter. The depth of the cameræ is not noted. The septum, shown at the adoral end of the specimen, is uniformly curved.

The lateral surface of the holotype shows color bands similar to those already mentioned in connection with *E. bridgei*. Unfortunately they are too faint to be illustrated clearly by natural photographs of the specimen.

Type.—Holotype, U. S. Geological Survey, to be deposited in the U. S. National Museum.

Occurrence.—Found associated with the above species in float from the bed of Cassiterite Creek, 1.3 mi. northeast of Cassiterite Mine, York District, Seward Peninsula, Alaska.

Genus PLECTOCERAS Hyatt

Genotype.—*Nautilus jason* Billings.

Plectoceras Hyatt, 1884, Proc. Boston Soc. Nat. Hist., vol. 22, p. 268; Hyatt, 1894, Amer. Phil. Soc., Proc., vol. 32, p. 499; Miller, S. A., 1897, North American Geol. Pal. 2d App. p. 776; Whiteaves, 1906, Geol. Surv. Canada, Pal. Foss., vol. 3, pt. 4, p. 299; Ruedemann, 1906, New York State Museum Bull. 90, p. 482; Grabau and Shimer, 1910, North American Index Fossils, vol. 2, p. 72; Troedsson, 1926, Meddelelser om Grönland, vol. 71, p. 41; Foerste, 1933, Denisen Univ. Bull., Sci. Lab. Journ., vol. 28, p. 119; Foerste, 1935, Denison Univ. Bull., Sci. Lab., Journ., vol. 30, p. 90.

The genotype of *Plectoceras* is from the Chazyan of the Mingan Islands, Quebec, but has also been identified from the Chazyan of the Champlain Basin, where it is represented by larger and more abundant specimens. The genus is erected for costate coiled cephalopods, the costæ sloping from the dorsum to a hyponomic sinus on the venter. The sutures are straight and transverse or may develop lateral lobes, though this does not apply to the genotype. Foerste has separted the genus *Metaplectoceras* (Foerste, 1935, p. 91), which differs mainly from *Plectoceras* in the tighter coiling and the development of an impressed zone, with *Inachus undatus* Hall of the Black

River limestone of Watertown, New York as the genotype. Curvature of the genotype of *Plectoceras* is known to be quite erratic and variable, with the whorls sometimes free, sometimes in contact, and sometimes so closely appressed that the dorsum is flattened as much as in *Plectoceras occidentale, P. lowi,* and *P. halli.* For this reason it does not seem advisable to recognize *Metaplectoceras* Foerste as a distinct genus. This leaves, included in *Plectoceras,* the following species:

Plectoceras jason (Billings), Chazyan, Mingan Islands and the Champlain Valley.

P. tyrans (Billings), Chazyan, Mingan Islands.

P. undatum (Conrad), Black River limestone, New York and Ontario.

P. halli (Foord), Black River limestone, New York and Ontario.

P. carletonense Foerste, Black River limestone, Ottawa Valley, Ontario.

P. foerstei Troedsson, Cape Calhoun series, Greenland.

P. lowi Foerste, Black River limestone (?) Pt. Burwell, Labrador.

P. occidentale (Hall), Platteville.

P. landerense (Foerste), Bighorn dolomite.

The siphuncle lies close to the ventral side of the shell. The septal necks are straight and short, and the connecting rings are thin and without differentiation of structure. The siphuncle has been studied in detail by Troedsson for *Plectoceras foerstei,* for which he has illustrated the structure in thin section (1926, pl. 2, fig. 1), and the writer has been able to study well-preserved specimens of *P. halli* (Foord) which shows similar structure. While material has not been adequate to study the structure thoroughly in the genotype, such material as was available indicates that there also the connecting ring is probably thin and simple.

The specimen described here from the Seward Peninsula of Alaska differs from Ordovician species of *Plectoceras* in the structure of the siphuncle, but the other features of the shell supply only minor differences which do not seem to be adequate for setting the species apart in a different genus. The umbilical perforation is larger than in other species of *Plectoceras,* and the conch seems to expand relatively slowly The exterior is typical of *Plectoceras*. The best difference is perhaps supplied in the course of the sutures, which lack lateral lobes but are inclined forward on the dorsal side of the shell. Nevertheless all of these differences are more or less closely approached in one or another species of typical Ordovician *Plectoceras*.

The wall of the siphuncle, however, differs in structure, not only from all known *Plectoceras*, but from all post-Canadian cephalopods so far studied in detail. The structure, illustrated in text figure 1C, consists of very short septal necks, scarcely recurved on the doral side, and essentially straight and continuous with the oblique septum on the venter. The remainder of the segment is composed of thick connecting rings which are differentiated into an outer light-colored layer and a thin, darker inner layer. Differentiation of the two layers is clear on the venter, but rather obscure on the dorsal side of the siphuncle. This condition is almost identical with that observed in *Eurystomites kellogi* of the Beekmantown of New York, and is similar to structures found in related species both of this genus and of *Tarphyceras*.[3]

The study of a number of genera formerly placed in the Tarphyceratidæ indicates that coiled Ordovician cephalopods are sharply divisible into two groups on the basis of the structure of the connecting ring. It remains to be determined whether these two groups are actually related, or whether they only exhibit a remarkable degree of homeomorphy. To determine this it is necessary that the details of siphuncular structure be studied for all genera of the Tarphyceratidæ and Plectoceratidæ. Further, it is eminently desirable that as many species as possible be investigated, particularly for genera which apparently pass from the Canadian to the Ordovician. It is believed that this matter will be dealt with very adequately in the study of Ozarkian and Canadian cephalopods now being completed by Dr. Miller.

[3] Ulrich and Foerste (1936) have subdivided these genera, particularly *Tarphyceras*, on the basis of section and rate of coiling. The genera are used here in their older and broader usage. This is partly because the descriptions now available leave considerable doubt as to the best place to set the boundaries between the new genera and the old ones as restricted, and partly because the proposal of these new genera seems to be a procedure of doubtful benefit in expressing the relationships between species.

The species here referred, with misgivings, to *Plectoceras* have been placed there so as not to interfere with the study now in progress. The structure of the connecting ring shows that it should properly be placed in the Tarphyceratidæ, or, if such separation seems desirable, in a new family related to the Tarphyceratidæ but grouped with it and not with the Ordovician forms. Possibly it will prove to belong to the inadequately known *Deltoceras* or to a genus as yet undescribed.

There are other cases known of a strong resemblance in gross features between Canadian and Ordovician cephalopods, but there is not enough information published as yet to determine whether there is a similar discordance in the structure of the connecting ring. *Barrandcoceras*, formerly placed in the Tarphyceratidæ, but Ordovician and not Canadian in range, has simple and very thin connecting rings. In the Chazyan, *Trocholites* has a siphuncle of Ordovician aspect. Also, species of the Chazyan, which are otherwise apparently typical of *Aphetoceras* and *Pycnoceras*, possess simple siphuncles of the type found commonly in the Ordovician. It is not known as yet whether the Canadian genotypes possess simple or thickened connecting rings. Further, the simple connecting ring is found in the species described as *Tarphyceras multicameratum* Ruedemann of the Chazyan.[4]

Much more study is necessary to establish the value of these structures in classification. Certainly there is abundant evidence of strong superficial resemblance between Canadian and Ordovician coiled cephalopods. Present facts show that Canadian coiled cephalopods have siphuncles very different from Ordovician coiled forms, suggesting that two major groups are involved, with no good evidence at the present time of intergradation despite the strong external similarity between the two groups. While it is not unlikely that some forms with simple connecting

[4] These species, which are to be described in my long-delayed study of the Chazyan cephalopods of the Champlain Valley, include some undescribed forms. Although curvature is such as to permit these associated forms to be placed in different genera, it is believed that here is a case in which such generic definitions have already been carried too far. The species are similar in section, exterior, and spacing as well as the course of the sutures. They differ in no essential respect except the rate of coiling. It is strongly felt that they represent a single Chazyan genus, though referable to *Aphetoceras, Pynoceras, Falcilituites,* and *Tarphyceras* on the basis of the extant description of those genera.

rings may be found in the Canadian, there is no evidence as yet to suggest that the complex connecting rings ever penetrated the Chazyan, nor is there any reason to believe that the two groups intergrade.

"Plectoceras" sewardense Flower, n. sp. Plate 2, figs. 1-2

Conch coiled, with the early whorls in contact, the later part of the last whorl free when mature. The holotype has a maximum disc of 105 mm. and consists of two and a half preserved volutions. Quite probably about half a volution is missing from the adapical end. The whorls are circular in section in the early stages, but the venter becomes flattened in the last whorl and the greatest width comes to lie close to the ventral surface, the sides converging from the abdominal to the umbilical shoulders. The mid-dorsal region has not been observed where the whorls are in contact; probably it is slightly flattened, as it retains this condition at the base of the mature living chamber where the whorl is free. Coiling is not tight enough to produce an impressed zone. Near the aperture the whorl becomes slightly compressed, and the abdominal shoulders become more rounded and the ventral face less distinct. The height of the whorl increases more gradually than in most *Plectoceras*. The apparent umbilical perforation has a minimum diameter of 6 mm. The whorl at the base has a height of 6 mm., which increases at intervals of a half volution to 9 mm., 16 mm., 23 mm., and 29 mm. In the first volution the width of the shell lies halfway between the dorsum and the venter, but it moves ventrad rapidly in the next half volution. The height and width increase from 17 mm to 20 mm. in the basal fourth of the last volution in a ventral length of 50 mm. The next half volution shows an increase of the height to 28 mm., with the width apparently the same. At the aperture, slightly more than a quarter of a volution farther, the height is 30 mm., with the width estimated at between 26 mm. and 28 mm.

The course of the sutures, not shown clearly on the specimen, is known only from the base of the living chamber. The suture is without lateral lobes, is essentially straight but inclined strongly forward from venter to dorsum, the inclination apparently being about equal to that of the lateral portion of the costæ, though less inclined than the costæ as they approach the extreme ventral portion. The cameræ, of which the last three are preserved on the paratype, are variable in depth, measuring 1 mm., 2 mm., and 1.5 mm., progressing orad.

The siphuncle lies in contact with the venter at least in the last whorl. Its structure is shown in fig. 1C. The connecting rings present slightly concave vertical outlines. The septal necks are short, scarcely attaining the cavity of the siphuncle, being overlaid by the tip of the connecting ring of the next adoral segment. The connecting rings are relatively thick. On the venter the connecting ring is divided into two portions, an inner dark-colored band, relatively thin, and a thick lighter outer band which occupies all of the space up to the wall of the shell. On the dorsum, the differentiation between the layers is not so clear. One segment shows a faint trace of differentiation of the tip of the connecting ring, producing the eyelet structure described in another paper, but it is so obscure that I have not attempted to reproduce it in the drawing.

The surface of the shell is not clearly preserved in the early portion, though incipient costæ are indicated there. In the last whorl costæ become prominent laterally, strong ventrolaterally, decreasing in strength gradually as the umbilical shoulder is approached and disappearing abruptly on the ventral surface. The costæ are inclined apicad from dorsum to venter, and are slightly curved with the convex side directed orad, the slope increasing as the venter is approached. About two costæ occur in a length equal to the adoral height of the shell. Near the mature living chamber the costæ are lost internally and are expressed externally only as thickened liræ. Transverse liræ mark the entire shell surface. These follow the course of the costæ and continue over the venter forming a deep rounded hyponomic sinus. The living chamber, which is complete on the holotype, has a basal height of 25 mm., taken normal to the shell rather than the oblique septum, and a ventral length of 85 mm., including about a quarter of a volution. The shell is free from the base of the living chamber.

Discussion.—Insofar as the gross features of the shell are concerned, it is relatively simple to distinguish this species from all that have been described previously. It is distinctive mainly in its umbilical perforation, which is large in comparison to *Plectoceras* species of a comparable size, followed by relatively slender whorls, gradually expanding, with the width and height about equal up to the mature living chamber where the whorl becomes faintly compressed and the greatest width no longer lies close to the ventral surface, where it moved in the second whorl. The Chazyan species of *Plectoceras*, including the genotype, are relatively broad in section, the early stages expand very rapidly, subsequent expansion of the shell is more rapid, and the section tends to become depressed. Most species can be separated by the oval section, for even where the venter is flattened, as in *P. lowi* Foerste, the greatest width never lies far ventrad of mid-height of the section. In this respect our species resembles only *Plectoceras halli* (Foord) of the Black River limestone of New York and Ontario, in which the expansion of the shell is more rapid. Strangely enough, the species which is closest to this one geographically, *P. foerstei* Troedsson (1926, p. 42, pl. 2, fig. 1; pls 11-12), is very different in section, being strongly compressed from a relatively early stage, with the greatest width consistently at mid-height of the whorl. A feature in which our species agrees with the Chazyan genotype and differs from all younger species is the extreme proximity of the siphuncle to the ventral wall of the shell. Our species has the siphuncle exposed at two places in the paratype. In one, at the base of the last whorl, it is apparently separated from the venter, though this is partially accounted for by the fact that the section does not penetrate the center of the shell. On the other section, a quarter of a volution farther, the siphuncle is close to the venter as described above. The condition of the siphuncle also recalls the condition found in *Deltoceras vaningeni* Ruedemann (1906, p. 480, pls. 25-28). Comparison with typical *Deltoceras* is not possible because the genotype is inadequately described and has never been figured. The Chazyan species, which is essentially a compressed edition of *Plectoceras* with relatively rapid vertical expansion, and which shows costæ similar to those of *Plectoceras* under favorable conditions of preservation, is probably most closely related to the smaller *Plecto-*

ceras tyrans (Billings) of the same horizon of the Mingan Islands.

The structure of the wall of the siphuncle indicates that this Alaskan species is not a *Plectoceras*. The significance of the structures has been discussed in connection with the genus and is here considered adequate to indicate the Canadian age of the species, regardless of its final resting place generically.

Types—Holotype and paratype, U. S. Geological Survey, to be deposited in the U. S. National Museum.

Occurrence.—York District, Seward Peninsula, Alaska. The holotype is labeled "On crest of ridge between Cassiterite Creek and Lost River, about 5000′ N.12W. of Cassiterite Mine." The paratype, a specimen polished from a weathered lateral surface, was found "in place, in bed of Rapid River, about 3500′ from mouth of River."

ACKNOWLEDGMENT

The cost of photography and illustration has been met by the Faber Publication Fund of the University of Cincinnati Museum. Many of the photographs are the work of Mr. Clifton Smith, student assistant in the museum.

ADDENDUM

In order to avoid confusion, it is necessary to call attention to the relationship of this work with a paper entitled "Notes on Structure and Phylogeny of eurysiphonate Cephalopods," appearing in vol. 3, No. 13 of the Palæontographica Americana. The present study was completed first and contains evidence of structure which is only summarized in the Palæontographica paper. The views here presented tentatively concerning the significance of the structures within the complex connecting rings have found further support in the investigation of additional material, and indeed, have been carried much further, tracing relationships not only of the Ellesmeroceratidæ and the Tarphyceratidæ, but the Endoceroidea and Actinoceroidea.

REFERENCES

Flower, R. H.

Notes on structure and phylogeny of eurysiphonate cephalopods, Palæontographica Americana, vol. 3, No. 1, Nov. 1941.

Foerste, A. F.

Notes on arctic Ordovician and Silurian cephalopods chiefly from Boothia Felix-King William Land, Bache Peninsula, and Bear Harbour, Denison Univ. Bull., Sci. Lab., Jour., vol. 19, 1921, pp. 247-306, pls. 27-35.

Kobayashi, T.

Faunal study of the Wanwanian (Basal Ordovician) series with special notes on the Ribeiridæ and the Ellesmeroceroids, Imp. Univ. Tokyo, Fac. Sci., Jour., Sec. II, vol. 3, 1933, pp. 249-328, pls. 1-10.

———— *On the phylogeny of the primitive nautiloids, with descriptions of Plectronoceras liaotungense, new species, and Iddingsia (?) shantungensis, new species*, Japanese Jour. Geol., Geogr., vol. 12, 1935, pp. 17-28, pl. 6.

Miller, A. K., and Thompson, M. L.

Beiträge zur Kenntniss tropisch-amerikanischer Tertiarmollusken. VI. Some Tertiary nautiloids from Venezuela and Trinidad. Ecologæ geologicæ Helvetiæ, vol. 30, 1937, pp. 59-73, pls. 7-10, text figs. 1-3.

Ruedemann, R.

Cephalopods of the Champlain Basin, New York State Museum Bull. 90, 1906, 611 pp., 38 pls., 57 text figs.

Ulrich, E. O., and Foerste, A. F.

New genera of Ozarkian and Canadian cephalopods, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, 1935, pp. 259-290, pl. 38.

PLATES

PLATE 1 (2)

EXPLANATION OF PLATE 1 (2)

Figure		Page
1-10.	**Ellesmeroceras bridgei** Flower, n. sp. .... Syntypes, float in Cassiterite Creek, York district, Seward Peninsula, Alaska.	7
1.	Ventral view of specimen, showing exfoliated siphuncle.	
2-4.	Ventral, lateral and dorsal views of specimen retaining sutures.	
5-6.	Cross sections of specimen at intervals of 28 mm.	
7.	Venter of broken specimen, showing annulated interior of siphuncle. (Same sp. as Pl. 2, fig. 6.)	
8-9.	Longitudinal section of specimen X1, and enlarged, showing siphuncular structure and inorganic deposit simulating dissepiments.	
10.	Venter of apical half of same specimen figure 1, ground to show siphuncular outline.	

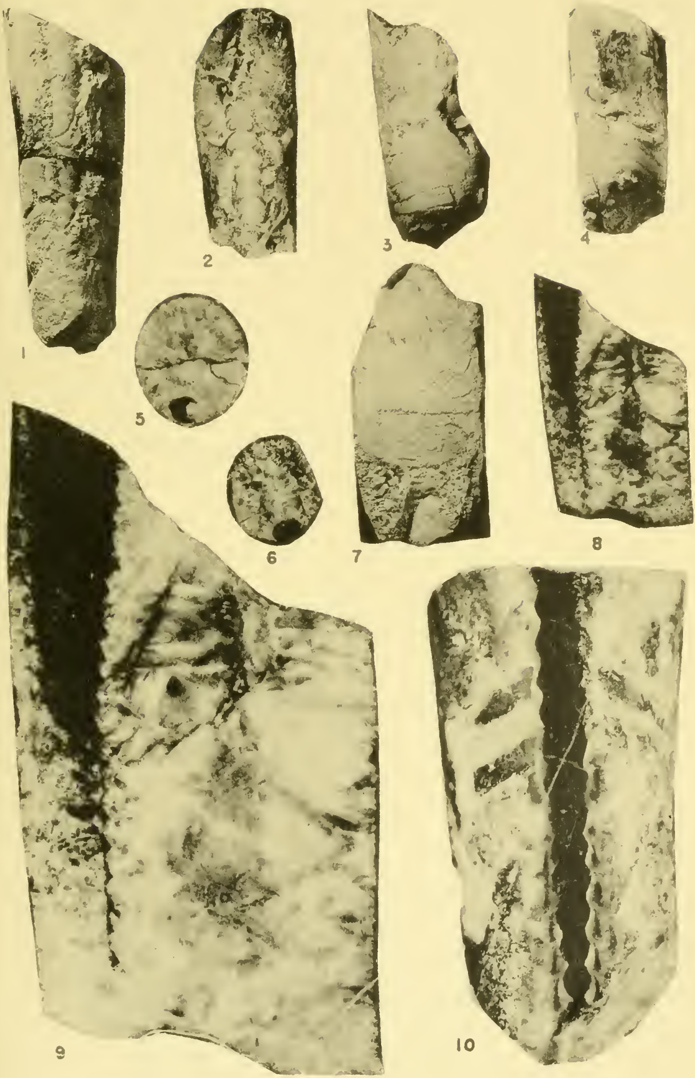
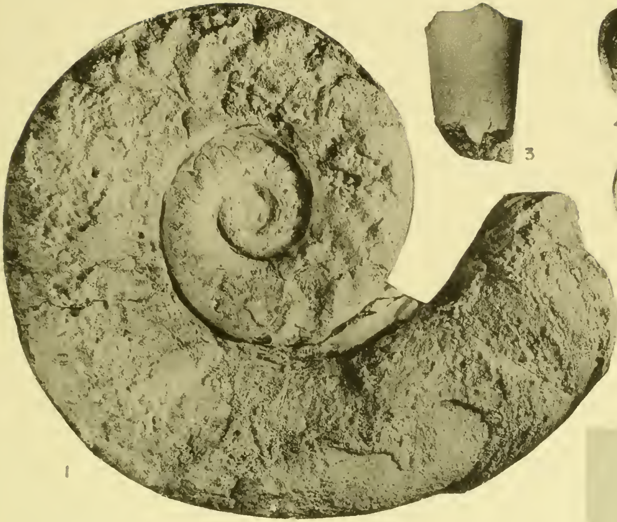


PLATE 2 (3)

EXPLANATION OF PLATE 2 (3)

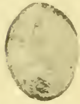
Figure		Page
1-2.	**Plectoceras sewardense** Flower, n. sp.	14
	1. Holotype X1, lateral.	
	2. Paratype, longitudinal section. Cassiterite Creek, Seward Peninsula, Alaska.	
3-5.	**Ellesmeroceras expansum** Flower, n. sp. Lateral, apical and adoral views of holotype. Float of Cassiterite Creek, Seward Peninsula, Alaska.	10
6.	**Ellesmeroceras bridgei** Flower, n. sp. Dorsal wall of siphuncle showing relation of necks and thickened siphuncle wall.	7



1

3

4



5

2

6

XV. (Nos. 55-58). 314 pp., 80 pls. 6.00
Mainly Ecuadoran, Peruvian and Mexican Tertiary forams and mollusks and Paleozoic fossils.

XVI. (Nos. 59-61). 140 pp., 48 pls. 5.00
Venezuela and Trinidad Tertiary Mollusca.

XVII. (Nos. 62-63). 283 pp., 33 pls. 6.00
Peruvian Tertiary Mollusca.

XVIII. (Nos. 64-67). 286 pp., 29 pls. 6.00
Mainly Tertiary Mollusca and Cretaceous corals.

XIX. (No. 68). 272 pp., 24 pls. 5.00
Tertiary Paleontology, Peru.

XX. (Nos. 69-70C). 266 pp., 26 pls. 6.00
Cretaceous and Tertiary Paleontology of Peru and Cuba.

XXI. (Nos. 71-72). 321 pp., 12 pls. 5.00
Paleozoic Paleontology and Stratigraphy.

XXII. (Nos. 73-76). 356 pp., 31 pls. 7.00
Paleozoic Paleontology and Tertiary Foraminifera.

XXIII. (Nos. 77-79). 251 pp., 35 pls. 5.00
Corals, Cretaceous microfauna and biography of Conrad.

XXIV. (Nos. 80-87). 334 pp., 27 pls. 6.00
Mainly Paleozoic faunas and Tertiary Mollusca.

XXV. (Nos. 88-94B). 306 pp., 30 pls. 7.00
Paleozoic fossils of Ontario, Oklahoma and Colombia, Mesozoic echinoids, California Pleistocene and Maryland Miocene mollusks.

XXVI. (Nos. 95-100). 420 pp., 58 pls. 7.00
Florida Recent marine shells, Texas Cretaceous fossils, Cuban Cretaceous corals, and geology and paleontology of Ecuador.

PALÆONTOGRAPHICA AMERICANA

Volume I. (Nos. 1-5). 519 pp., 75 pls. $12.00
Monographs of arcas, Lutetia, rudistids and venerids.

Volume II No's 6-12 **$12.00**

Volume III
Number
13

BULLETINS

OF

AMERICAN PALEONTOLOGY

VOL. XXVII

NUMBER 103

1942

Paleontological Research Institution

Ithaca, New York

U. S. A.

Condensed Table of Contents of Bulletins of American Paleontology and Palæontographica Americana*

BULLETINS OF AMERICAN PALEONTOLOGY

* Complete titles and price list of all numbers may be had on application. All volumes available.

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 27

No. 103

AN ARCTIC CEPHALOPOD FAUNULE FROM THE CYNTHIANA OF KENTUCKY

By

Rousseau H. Flower

March 30, 1942

Paleontological Research Institution

Ithaca, New York

U. S. A.

CONTENTS

AN ARCTIC CEPHALOPOD FAUNULE FROM THE CYNTHIANA OF KENTUCKY

By

Rousseau H. Flower

University of Cincinnati

INTRODUCTION

The cephalopods described in the following pages are known only from a lens exposed on the southeast side of the Poindexter quarry (Dunn, 1930), at the outskirts of Cynthiana, Kentucky, on the west side of the main road leading to Paris and Lexington. The faunule occurs high in the wall of the quarry among dense and relatively barren limestones and underlies fossiliferous beds carrying abundant *Orthorhynchula.* The entire series of beds lies within the Nicholas limestone (Foerste, 1909, pp. 209, 210), which is properly referred to the Greendale member of the Cynthiana limestone (McFarlan, 1938, pp. 992-995, also *fide litt*).

The cephalopod association is remarkable in many of its features. Faunally, it is quite distinct, consisting of new species which have not been found elsewhere in the Cynthiana. More remarkable is the fact that few of the species have close relatives in the remainder of the Cynthiana or in any of the Ordovician strata of the Cincinnati arch. Instead, there are represented here, genera which have been previously known largely, if not entirely, from the arctic region of North America, and which have come to be considered diagnostic of the post-Trenton, and even Richmond, age of the strata in which they occur. The present study adds to the list of supposedly late Ordovician genera which are now definitely established as occurring in the Trenton. The association is unusual, also, in the vertical position of most of the cephalopods, a condition which is attributed to burial of the conch while some gas was still retained in the phragmocone, as discussed below.

The material which forms the basis of this study was collected by the writer and is deposited in the Museum of the University of Cincinnati. The Faber Publication Fund of the University Museum has defrayed the cost of illustrations.

PRESERVATION

The mode of preservation of the cephalopods shows several features of unusual interest which make possible a reconstruction of the conditions under which the shells were buried. The lens, now exposed in the wall of the quarry, is only a section across a channel filling, about one and a half feet thick and four feet in width. Conversation with the quarrymen revealed that the cephalopods had been encountered extending far out into the quarry in rock now long since removed, but the band in which they occurred remained narrow. This supports the belief, founded upon the appearance of the lens in its present condition, that it represents a section across a linear channel filling.

The lower part of the lens contains pelecypods and gastropods in some abundance, but its upper three-fourths is occupied almost exclusively by cephalopods. Cyrtoceracones of the genus *Oonoceras* are the dominant element, and nearly all of the shells occur in a vertical position with the apex directed upward. This evidently has nothing to do with the fact that cyrtoceracones normally held the shell in this position during life, as has been demonstrated by color bands reported for a great variety of genera ranging from Ordovician to Mississippian. Cephalopods could hardly be preserved in a natural vertical position unless they were burrowers; pelecypods are not infrequently found in their life position, particularly in the Upper Devonian of New York and Pennsylvania, but these are forms which have lived beneath the surface of the sea bottom. The cephalopods of the Cynthiana lens are orthoceracones, cyrtoceracones and brevicones; forms which were not only motile, but were probably not greatly dependent upon a substratum. The prevalent invasion of matrix into the living chambers shows conclusively that the association is a thanatocœnose, and that the shells not only were dead, but free of the body mass of their former occupants when buried.

The vertical position of the shells can be explained only by the presence of gas in the cameræ at the time of burial. Gas in sufficient quantity will cause a cephalopod shell to float, but if only a small quantity is present the shell will come to rest on the bottom with the camerated portion of the shell directed upward as is seen here. This is quite possible from the condition of the shells. Apparently they were buried while the phragmocone was intact, or very largely so, for it is always free from sediment, though filled by crystalline calcite which was evidently deposited there subsequent to burial and the removal of the gas by solution. Quite possibly the shells were transported some distance before sinking to the bottom and being washed to their present location; certainly the complete absence of conspecific forms outside of the lens suggests that the shells did not live in the immediate vicinity. On the other hand, it seems improbable that such shells could have been carried any considerable distance without showing more breakage of the aperture and some loss of surface features as a result of solution or abrasion.

Subsequent to the burial of the shells, a considerable interval of time must have elapsed, after which the strata in which they were deposited were worn down, probably by current and wave action. In this interval, calcite was deposited inorganically in the cameræ of the shells. When the upper part of the bed was removed, the uppermost parts of the cephalopod shells were removed also, but sediment failed to penetrate the cameræ, showing that the calcite deposition occurred prior to the deposition of sediments on the abraded surface of this lens. This feature is probably of no major significance as a diastemic break, but was probably only an extremely local phenomenon. It is important, however, in showing that, very soon after burial, calcite may be deposited inorganically in a marine shell in cavities not occupied by sediment. An even more startling example of this phenomenon has been found by the writer in reef associations of the Valcour limestone, upper Chazy, of the Champlain Valley, New York, where the condition of the shells shows conclusively that they were buried, filled with calcite, then excavated by waves, washed about and broken, and finally buried in a black lime mud. Here typical specimens terminate in irregular surfaces of calcite, which clearly represent broken surfaces and have no connection with any organic structures.

FAUNAL RELATIONSHIPS

The species of cephalopods which have been found in the Cynthiana limestone in the faunule described above have not been found elsewhere in the Ordovician of Kentucky. Their significance, however, lies not so much in the fact that they are apparently confined to this single locality and horizon, but in their strong affinities with cephalopods from quite distant regions, in various aspects of the arctic Ordovician fauna. This is to be found in the Cape Calhoun beds of Greenland, various localities in the Arctic Archipellago, the Nelson River and Shamattawa limestones of Hudson Bay, the Liskeard limestone of Lake Timiskaming, the Whitehead formation of Gaspé, and some of the Ordovician strata of Anticosti, particularly the Vaureal limestone, the Red River series of Manitoba, the Bighorn formation of Wyoming, and the Fremont limestone of Colorado. There is still much uncertainty concerning the age of these formations. They have been considered Trenton, Richmond, and Covington equivalents, and the suggestion has been put forward that they may represent deposits ranging from the Trenton through the Richmond. A number of cephalopod genera which are characteristic of these beds have come to be considered diagnostic of the Richmond, or, at least, of the post-Trenton age of the strata, for many are absent in the typical Richmond. Several of these genera have subsequently been found in the Stewartville dolomite of Minnesota (Kay, 1935, p. 587), including *Lambeoceras, Westonoceras, Diestoceras, Charactoceras* and *Ephippiorthoceras.* The Cynthiana faunule adds to the list of supposedly diagnostic Richmond genera which are now known to occur in the Trenton, *Neumatoceras* and *Oonoceras,* while representatives of more widespread genera show closest affinities with species of the arctic association.

This is significant, also, in that it demonstrates a connection between the east-central embayment in late Trenton time and the arctic embayment, a connection which does not seem to have been previously suspected. Foerste (1932, p. 54) quotes Ulrich, apparently concurring in his view, that the Cathys[1] of Tennessee and Kentucky, the Fairview, and the Arnheim carry faunas which invaded the continent from the south, while the underlying strata, the Bigby and Lexington, the Eden and lower Maysville, and the Belleview-Mt. Auburn sequence of the upper Maysville, carry a fauna of north Atlantic origin. The cephalopods described here show evidence of a close relationship between the arctic embayment and the Cynthiana. This suggests strongly that the evidence leading to the conclusion stated above might be reëxamined with profit.

Of the cephalopod genera found in the Cynthiana faunule, only *Treptoceras* appears to be indigenous to the Cincinnati-Jessamine region. The genus is the one most commonly encountered from the Cynthiana to the top of the Richmond; it is developed in the Richmond of southern Ontario and in the Lorraine of western New York. Three species are described from the faunule considered here. Of these, two species, *T. perseptatum* and *T. prænuntium,* appear to be closely related to forms from the Cincinnatian strata. The third, *T. perseptatum,* is a form with exceedingly shallow cameræ and a markedly eccentric siphuncle. The eccentric siphuncle distinguishes it from *T. milleri* (Foerste, 1910, pl. 1, fig. 5), but it appears to differ less from some Richmond forms not known to occur below the Waynesville in the Cincinnati area.

Oonoceras is the dominant genus of the Cynthiana lens faunule, being represented by six species and one variety. The genus, as revised below, contains species which have formerly been placed in *Beloitoceras* and *Richardsonoceras.* As pointed out under the discussion of the genus, it may represent a form group rather than a genetic unit and does not appear to be set off sharply from *Cyrtorizoceras* or *Beloitoceras.* The only species of the genus known elsewhere from the Cynthiana is one which is relatively

[1] The Cathys is typically developed in Tennessee, but that name is no longer applied to the Kentucky region. The Cathys is the equivalent of the Cynthiana, both being uppermost Trenton in their respective areas. Until relatively recently the name Bigby, which typically underlies the Cathys in Tennessee, was applied to the Lexington of Kentucky.

rapidly expanding, and, as a result, actually not typical of the genus in form. As this form is known only from the phragmocone, it might be placed as easily in *Beloitoceras* or *Cyrtorizoceras.*

Cyrtoceracones typical of *Oonoceras* in form are known only from faunas of arctic affinities in America. *Oonoceras obstructum* (Foerste, 1928, p. 307, pl. 52, figs. 2-3) was described from the Vaureal formation of Anticosti Island as a species of *Beloitoceras.* This species agrees with *O. multicameratum,* described below, in the dorsal constriction of the interior of the mature living chamber, a feature not noted in other species of the genus. The Anticosti species is much larger than that of the Cynthiana and has considerably deeper cameræ. Nevertheless the two forms are so strikingly similar as to suggest a much closer relationship than is expressed by the inclusion of both in a single rather large genus.

The Ordovician strata of Hudson Bay supply other species referable to *Oonoceras. Oonoceras shamattawense* (Foerste and Savage, 1927, p. 78, pl. 15, figs. 2a-b), originally placed in the actinosiphonate genus *Oocerina,* is typical of *Oonoceras* in form and siphuncle, but differs from other species in that the sutures rise farther orad on the dorsum than on the venter. Two Silurian species were referred to the genus *Oocerina* in the same paper, both from the Attawapiskat limestone. One of these (Foerste and Savage, 1927, p. 80, pl. 14, fig. 4) appears, from the illustration and description, to be a typical member of the genus. If so, it is the only Silurian representative of the genus known in America. The other (Foerste and Savage, 1927, p. 79, pl. 14, fig. 2A-C) has a very broad siphuncle suggesting an actinoceroid cephalopod and is apparently not related to *Oonoceras.*

The Bighorn formation has yielded two representatives of the genus, both originally referred to *Richardsonoceras.* The reason for the change of generic references is given under the discussion of *Oonoceras* below. They are strikingly similar to two of the species of the Cynthiana. *Oonoceras wyomingense* (Foerste, 1935, p. 40, pl. 3, fig. 1) is quite similar to *Oonoceras planiseptatum* in section and general aspect, though it is a much larger species, and the cameræ are slightly deeper in proportion to the size of the conch. *Oonoceras subcuneatum* (Foerste, 1935, p. 41, pl. 7, figs. 3-4) is comparable in section and in its very shallow cameræ to *O. acutum* of the Cynthiana, but the section is even more compressed and subangular on the venter.

Neumatoceras carlsoni furnishes the first record for the genus in southeastern North America and also the first occurrence of the genus in beds of undisputable Middle Ordovician age. The genus is typically developed in the Bighorn formation of Wyoming and the Fremont limestone of Colorado (Foerste, 1935, pp. 31-32), and is also well represented in the Whitehead formation of Gaspé (Foerste, 1936, p. 380). It is doubtfully represented in the Shamattawa limestone of Hudson Bay by *Westonoceras* (?) *contractum* Foerste and Savage (1927, p. 55, pl 16, figs. 2A-B). Foerste has pointed out the possible connection of this form with *Neumatoceras* and with several other inadequately known species, including *Winnipegoceras*, sp. from the Red River formation of Manitoba and *Oncoceras tumidum* Schuchert from the Ordovician of Baffin Land (Foerste, 1935, p. 32). In addition, the genus is doubtfully represented in the Gonioceras Bay formation by *Maelonoceras reclinatum* Troedsson (1926, p. 91, pl. 55, figs. 1-3). This is a species which exhibits the strong lateral contraction of the mature part of the shell which is typical of the genus and shows a siphuncle very similar to that of *N. carlsoni*. It fails, however, to attain the extreme vertical gibbosity which is such a conspicuous feature of typical members of the genus. The exact correlation of the Gonioceras Bay formation has not been determined, but much of the evidence suggests early Trenton age.

Diestoceras, while represented only by a specifically undeterminable fragment, suggests again the northern faunas, being well developed in the Fremont limestone, the Bighorn formation, the Red River, Shamattawa limestone, Cape Calhoun beds, the Whitehead formation of Gaspé, and the Ordovician of Anticosti. The genus is an exceedingly wide ranging one, however. It has been reported from beds of Middle Ordovician age (Foerste, 1933, pp. 145-146) and also from the Lower Ordovician of the Mingan Islands[2] (Foerste, 1938, pp. 103-104, pl. 20, fig. 9; pl. 21, figs. 1-3).

2 The two Chazyan species are not quite typical of the genus in form and may eventually prove to be unrelated to *Diestoceras*. Nothing is known of their internal structure.

The presence of two species of *Rizoceras* again indicates strongly a connection with the arctic fauna. Previously only two species of *Rizoceras* have been reported from the American Ordovician. One is *Rizoceras carletonense* Foerste (1932, pl. 34. fig. 4; 1933, p. 118) of the Black River limestone of the Ottawa Valley. This does not show any close relationship to either of our species. The other is *R. coronatum* Foerste and Savage (1927, p. 50, pl. 5, fig. 7) of the Shamattawa limestone of Hudson Bay. This species is quite similar to *R. graciliforme* in proportions. While the relationship of the Ordovician species of *Rizoceras* to one another seems fairly certain, their connection with the Silurian genotype remains to be established. A new genus, still undescribed, has been found by the writer in the Chazyan of the Champlain Valley, which differs from *Rizoceras* in the orthochoanitic siphuncle and the absence of a hyponomic sinus. The Cynthiana forms and the other Ordovician forms may prove to be closer to this genus than to typical *Rizoceras* when their internal structure has been made known, but the presence of a well-defined hyponomic sinus indicates that they are different enough to be set apart from the Chazyan genus.

SYSTEMATIC DESCRIPTIONS

Class **CEPHALOPODA**

Order **NAUTILOIDEA**

Suborder **EURYSIPHONATA**[3]

Superfamily **ACTINOCEROIDEA**

Family **SACTOCERATIDÆ**

Because of confusion as to exactly what constitutes the genus *Loxoceras* McCoy (a problem which has not yet been solved), Troedsson (1926, p. 79) proposed the family Sactoceratidæ for orthoceracones with small cyrtochoanitic siphuncles. He referred

[3] The Eurysiphonata, originally proposed by Teichert and subsequently used by him, was given the rank of a subclass. It is treated here as a suborder of the Nautiloidea, largely because it is felt that the subclasses Tetrabranchiata and Dibranchiata and the orders Ammonoidea and Nautiloidea of the Tetrabranchiata are too widely known to be discarded. There appears at the present time to be as good justification for the recognition of the Eurysiphonata and Stenosiphonata as major divisions, but the rank given to such divisions is unfortunately a matter of opinion upon which it is difficult to come to any very wide agreement.

to it *Sactoceras* Hyatt and *Eskimoceras* Troedsson. However, the genotype of *Sactoceras* is clearly an actinoceroid, and therefore Foerste and Teichert (1930, p. 208) correctly placed the family in the Actinoceroidea, a new superfamily with essentially the scope of the Actinoceratidæ of Hyatt. They redefined the family and placed in it the genera *Sactoceras, Eskimoceras, Troedssonoceras, Ormoceras* and *Deiroceras.* Miller, Dunbar, and Condra (1933, p. 77) referred *Pseudorthoceras, Mooreoceras* and *Euloxoceras* to the family. These genera were later made the nucleus of a new family, Pseudorthoceratidæ Flower and Caster (1935, pp. 29-30), which was subsequently shown to be unrelated to the Actinoceroidea, but, derived, instead, from orthochoanitic orthoceracones of the "Orthoceratidæ" (Flower, 1939, pp. 165-180). Restudy of the genus *Troedssonoceras* (Flower, 1939, pp. 481-484) showed that it is a typical member of the Sactoceratidæ closely allied to *Deiroceras*, although the Greenland species which have been referred to it are not congeneric and cannot even be placed in the Actinoceroidea (Teichert, 1934, pp. 40-42) and must therefore be assigned to a different genus, for which a new name had already been provided by Shimizu and Obata (1935) along with a great many others, most of which seem to have no good use. The writer subsequently discussed the Sactoceratidæ briefly (1940, pp. 442-443), pointing out the probable relationship of *Rayonnoceras* and urging that the form of the radial canals might serve as a better criterion of the group than the form of the siphuncular segments.

Several grave problems remain, particularly in the matter of determining generic boundaries. The writer (1939, p. 24; 1940, p. 443) has several times mentioned the difficulites involved in the placing of some Ordovician species which obviously belong to a single generic group and which are prevalent in the Cincinnatian. The main difficulty lies in the various ontogenetic stages encountered in a single individual, each of which is characteristic of a described genus. The early segments are very similar to those of *Armenoceras.* These become more slender, the necks less strongly recurved, and they thus attain the condition typical of *Ormoceras.* Subsequently, the siphuncle becomes more slender, approximating the condition of typical *Deiroceras,* and further simplification of the outline results in the outline typical of *Leurorthoceras.* Such changes in the ontogeny are nothing new. A problem arises from the fact that species which have been referred to these genera in the past are represented by fragments of the conchs *Leurorthoceras* is known only from adoral portions of large individuals. It cannot be determined what type of siphuncular outline occurs in earlier stages, because such earlier stages are unknown for the genotype. The same applies to *Deiroceras.* It is likewise not definitely known whether the early stages of *Ormoceras* are *Armenoceras*-like in siphuncular outline. Silurian and Devonian species, in which the genotype of *Ormoceras* is included, are known to retain siphuncular segments typical of *Ormoceras* throughout life, without the appearance of *Deiroceras* or *Leurorthoceras* stages. In this respect, it offers a sharp contrast to the Ordovician species, which retain a high degree of plasticity of siphuncular outline during life. It seems highly desirable that the group of plastic species should be placed in a separate genus rather than in *Ormoceras.*

Paractinoceras Hyatt (1900, p. 528, see also Foerste, 1929, pp. 209-210) of the Ordovician shows an adoral simplification of siphuncular outline, but it cannot be used for the species under consideration because the early siphuncular stages are those of *Actinoceras* rather than of *Armenoceras.* The conch shows an adoral contraction which is essentially a feature of the Actinoceratidæ, not known in any of the Sactoceratidæ.

The differentiation between *Sactoceras* and *Ormoceras* seems to be a matter which has not been adequately treated. *Ormoceras* has frequently been compared with other actinoceroids, in particular with *Armenoceras* and *Actinoceras,* but descriptions of *Sactoceras* rarely mention any genus other than *Loxoceras* by way of comparison. In the opinion of the writer, there is really no good distinction between *Sactoceras* and *Ormoceras.* The genotype of *Sactoceras* shows the necks to be somewhat shorter and the brims somewhat better developed than in *Ormoceras,* but there is variability in both genera in this respect which supplies complete intergradation. The segments of the siphuncle in the two genera are almost identical in form, and neither shows any close resemblance to the *Armenoceras*-like segments of the Ordovician species. The position of the siphuncle in both genera may vary from subcentral to a position close to the ventral wall. The sutures may be straight and transverse or slightly inclined apicad on the venter. Only lack of access to specimens of the genotype of *Sactoceras* causes the writer to refrain from formally reducing *Sactoceras* to synonymy and proposing a new family name based upon *Ormoceras*.

The separation of the plastic Ordovician species into a new genus distinct from *Sactoceras* and *Ormoceras* is clearly desirable. However, there is no certainty that this new genus, named *Treptoceras* below, may not eventually prove to be a synonym of *Leurorthoceras* or of *Deiroceras*. It is even possible, though not probable in the opinion of the writer, that these two genera may not be distinct when their genotypes are known from reasonably complete specimens. However, it seems that there is a real advantage at the present time for the proposal of a genus for these numerous Ordovician species, which can be fully defined and recognized easily. If subsequent study should show that it is a synonym of *Deiroceras* or *Leurorthoceras*, or both, the transfer will be a relatively simple one.

Only one more obstacle to the proposal of this genus need be considered. This is the fact that Shimizu and Obata (1935A, pp. 27-35) have already proposed not only a genus, but a whole family including several genera, which might possibly embrace these forms. The genera are based upon intricacies of siphuncular outline of supposedly mature individuals depending upon features which, in the opinion of the writer, are probably not greater than specific in rank. Further, they take no account of the variation of the siphuncular outline in ontogeny and cannot be demonstrated to be congeneric with *Treptoceras* until they are at least adequately described and much more fully illustrated.

Genus **TREPTOCERAS** Flower, n. gen.

Genotype.—*Orthoceras duseri* Miller

Conch orthoceraconic, circular or slightly depressed in section, with sutures straight and either transverse or sloping slightly apicad from dorsum to venter. The septa are normally very shallowly curved, the cameræ are usually shallow, though this is not uniform. The siphuncle is located some distance ventrad of the center in mature positions of the shell, but may be central or subcentral in the young stages The siphuncular outline is highly plastic. The earliest segments are *Armenoceras*-like in outline, broader than long and frequently heart-shaped, being broadest at the adoral end, sloping gradually and converging adapically with a relatively small area of adnation between the adapical end of the connecting ring and the septum. The necks at this stage are strongly recurved and recumbent or nearly so; the connecting ring adjacent to the brim is frequently in contact with the septum. Segments farther orad become more slender, with the brim free, the segment subglobular, as is typical of *Ormoceras*, though the necks are usually shorter and more sharply recurved at this stage than is typical of *Ormoceras*. Farther orad the segments take on the slender outline of *Deiroceras* and finally of *Leurorthoceras*, though that condition is not attained in the gerontic stage of all species.

Deposits within the siphuncle are typical of the Sactoceratidæ, and the radial canals are straight and perpendicular to the central canal. Apparently the radial canals are few in number, for many sections fail to show them at all, but show instead the appearance of a continuous lining as in the Pseudorthoceratidæ. The perispatium is always developed, however, and serves to distinguish *Treptoceras* under such circumstances.

Discussion.—The salient features and the problems of nomenclature have been discussed above. The genus is one which is very widespread in the Upper Ordovician of the Cincinnati region, and one also represented in the Middle Ordovician. Quite probably it contains a number of species formerly placed in *Ormoceras* and *Deiroceras*. These include *Deiroceras dismukense* Foerste and Teichert (1935) of the Richmond of Tennessee, *Ormoceras* (?) *covingtonense* Foerste and Teichert of the Maysville of Kentucky, *Deiroceras curdsvillense* Foerste and Teichert of the Curdsville member of the Trenton of Tennessee, *Ormoceras cannonense* Foerste and Teichert of the Cannon member of the Trenton of Nashville, Tennessee, *Ormoceras troosti* Foerste and Teichert of the Cathys of Tennessee, *Ormoceras lindsleyi* Foreste and Teichert of the Trenton of Tennessee. To these should be added practically all of the smooth-shelled species of "*Orthoceras*" described from the Cincinnati region from the Cynthiana to the top of the Richmond. Also are included many of the straight-shelled cephalopods of the Lorraine group of New York, which were largely referred to *Paractinoceras* and *Actinoceras* by Ruedemann (1926) and are closely related to species of the same age in the Cincinnati region. The species selected as a type, *Orthoceras duseri* Miller, is one of the more abundant and better known forms of the Waynesville formation of the Richmond of the Cincinnati area.

Treptoceras persiphonatum Flower, n. sp. Plate 4, figs. 1-2

This species is represented only by the holotype. The section is circular, expanding from 25 mm. to 32 mm. in the 75 mm. of the phragmocone, and to 39 mm. in the 60 mm. extent of the living chamber. The sutures are straight and transverse. The cameræ occur uniformly four and a half in a length equal to the adoral diameter of the shell. The septum is shallow, the depth of curvature being 3.6 mm. at a conchial diameter of 30 mm., or approximately one-ninth the diameter. The siphuncle is markedly eccentric. At the apical end of the type, it is 4 mm. in diameter within the camera and 3 mm. from the ventral wall of the shell. At the adoral end, it is of uncertain diameter, but its center lies 7 mm. from the venter. The segments are slightly longer than broad, as is to be expected from the growth stage represented. A segment, 7 mm. long, expands from 4 mm. to 6 mm. within the cameræ. The septal neck is one-seventh the length of the segment, the brim is slightly less than the neck, and the area of adnation is vestigial. Deposits are present in the siphuncle throughout; those at the adoral end are not fully developed. Deposits are not developed in the cameræ so far as can be determined from the recrystallized condition of the specimen. The internal mold is smooth. None of the shell surface is preserved.

Type.—Holotype, Univ. of Cincinnati, No. 22695.

Occurrence.—From the Greendale member of the Cynthiana limestone, Cynthiana, Kentucky.

Treptoceras perseptatum Flower, n. sp. Plate 1, fig. 1; Plate 3, fig. 6

Section circular throughout, with straight transverse sutures. The conch expands from 16 mm. to 21 mm. in a length of 40 mm., the rate being 5 mm. in a length of 40 mm. throughout the phragmocone. The sutures are straight and transverse. Cameræ occur twelve in a length equal to the adoral diameter of the shell, but the last two or three may be even shallower in a mature shell. The septa have a depth of 3.6 mm at a conchial diameter of 30 mm., approximately one-ninth the diameter and equal to the depth of one and a half cameræ. The siphuncle is central at a diameter of 14 mm.,, but becomes eccentric rapidly, lying with its center 7 mm. from the venter and 9 mm. from the dorsum at a diameter of 16 mm., and only 2 mm. from the venter at a conchial diameter of 21 mm. The siphuncular segments are broader than high, a condition which often accompanies very shallow cameræ. At a conchial diameter of 15 mm., a segment is 1.5 mm. long and expands from 2 mm. to 4 mm. within the cameræ. Adorally the segments become more slender, so that, where the length is 2 mm., the siphuncle expands from 2 mm. to 3 mm. Deposits within the siphuncle are typical of the genus. Cameral deposits are largely mural, but circuli appear outside the septal necks.

A paratype supplies information concerning the mature living chamber which has a basal diameter of 22 mm. and is 56 mm. in length. Expansion is normal nearly to the middle of the living chamber, where the vertical outline becomes convex, at least on the preserved dorso-lateral surface. The apertural diameter is estimated as 24 mm.

Discussion.—The apical siphuncular segments of this species are very suggestive of *Armenoceras*, with the brim considerably better developed than the neck. Adorally, the condition becomes more similar to that of *Ormoceras*. The species shows a strong similarity to *Treptoceras milleri* (Foerste, 1910, p. 76, pl. 1, fig. 5), a slightly larger form, but one with similar shallow cameræ. *T. perseptatum* differs strikingly from this form in the rapid movement, in ontogeny, of the siphuncle from the center to a position close to the ventral wall. At a later stage, than that ever attained in *T. perseptatum*, judging by conchial diameters, *T. milleri* shows a much less eccentric siphuncle than does our species.

Both species, in their very shallow cameræ developed at a relatively early stage of growth, offer a contrast to other species known from the Trenton and Cincinnatian strata of the Cincinnati arch The next occurrence of comparable forms is in the Waynesville shales of the Richmond.

Types.—Univ. of Cincinnati, holotype, No. 22697, paratype, No. 22698.

Occurrence.—From the Greendale member of the Cynthiana limestone, from Cynthiana, Kentucky.

Treptoceras prænuntium Flower, n. sp. Plate 1, fig. 2

Conch circular in section, expanding from 19 mm. to 25 mm. in a length of 40 mm. The sutures are straight and transverse; seven cameræ occur in a length equal to an adoral diameter of 20 mm., and this proportion is constant throughout the known portion of the shell. The septa are 4 mm. deep at a conchial diameter of 19 mm., with the depth of curvature slightly greater than the depth of the camera. As in *T. perseptatum*, the siphuncle moves rapidly from a central position to a ventral one, but is not as eccentric as in that species, moving from a subcentral position at a conchial diameter of 11 mm., to one halfway between the center and the venter at a conchial diameter of 25 mm. The siphuncular segments are usually faintly expanded, a segment 2.8 mm. in length increasing in diameter from 1.5 mm. to 2.1 mm. The maximum size of the species is not definitely known, as neither gerontic cameræ nor living chambers have been observed, but the condition of the siphuncular segments suggests that the phragmocone did not continue very much further orad than is shown on the type.

Discussion.—The very slender siphuncular segments serve to distinguish this species from its associates. It may also be readily distinguished by the proportions of the conch; *T. perseptatum* has much shallower cameræ and a more eccentric siphuncle. *T. perisiphonatum* shows a similar position of the siphuncle. Not only are the segments broader in proportion to the conch, but the cameræ are also much deeper.

Types.—Univ. of Cincinnati, holotype, No. 22696; paratype, No. 22697.

Occurrence.—From the Greendale member of the Cynthiana limestone, at Cynthiana, Kentucky.

Suborder STENOSIPHONATA

Family RIZOCERATIDÆ Hyatt

Genus RIZOCERAS Hyatt

Conch compressed, expanding with moderate rapidity, the apex usually slightly curved exogastrically. The sutures are straight and transverse. The siphuncle is placed close to the venter, which is the more convex side of the conch; its segments slender but clearly expanded within the cameræ, and free of any organic deposit.

The conch is particularly characterized by the continuation of the rather rapid rate of expansion to the aperture of the mature shell. A hyponomic sinus is present throughout life, but the aperture is otherwise unmodified. The surface markings are transverse and retain the markings of the hyponomic sinus.

The relationship of the two species here described from the Trenton of Kentucky has been adequately treated in the section dealing with the faunal affinities of the Cynthiana lens and need not be repeated. *Rizoceras* is apparently a long-ranging genus, the oldest species being from the Black River of the Ottawa Valley and persisting to the close of the Middle Silurian. It is better represented in the Silurian of Bohemia than anywhere else; certainly the two species previously known from the American Ordovician and the few American Silurian species, some of which are inadequately known and rather atypical in form, do not make as imposing an array as one might expect for a genus of such generalized aspect. The taxonomic relationship of *Rizoceras* is still uncertain; quite probably it is, as Hyatt believed, a relatively straight expression of the curved *Cyrtorizoceras*, but enough is not known of the internal structure of the Ordovician species to make this certain.

Rizoceras graciliforme Flower, n. sp. Plate 2, fig. 7

This is a relatively small and slender *Rizoceras* showing only vestigial curvature in a faint concavity of the dorsum. The section is circular at the base of the holotype where the diameter is 8 mm. This increases in a length of 7 mm. to a height of 12 mm. and a width of 11 mm. at the base of the living chamber. In 12 mm., the conch increases to 15 mm. and 17 mm. The aperture is not clearly preserved except ventrolaterally, where faint indication of the sinus is found.

The sutures bear very slight lateral lobes and are faintly inclined orad from dorsum to venter. The cameræ increase in the length of the phragmocone from 1 mm. to 1.8 mm. No trace of the siphuncle is preserved. The surface bears numerous fine and closely spaced transverse markings. At regular intervals these are thickened and elevated into vestigial annuli which are spaced seven to eight in a length of 5 mm.

Discussion.—The slender form distinguishes this from the following species and gives it proportions somewhat similar to those of *R. coronatum* Foerste and Savage of the Shamattawa limestone of Hudson Bay. It may be distinguished readily from that species by the smaller size, the development of slight lateral lobes, and the faint obliquity of the sutures, those of that form being straight and transverse.

Type.—Holotype, Univ. of Cincinnati, No. 22693.

Occurrence.—From the Greendale member of the Cynthiana limestone, from Cynthiana, Kentucky.

Rizoceras conicum Flower, n. sp. Plate 1, figs. 7-8

Conch compressed, venter and dorsum equally rounded. Venter uniformly convex in vertical outline, dorsum concave adapically, nearly straight adorally; sides diverging uniformly. Height and width equal adapically, the section later becoming compressed. The earliest stage observed has the height and width both 6 mm. The holotype expands from 11 mm. and 11.5 mm. to 25 mm. and 23 mm. in a length of 20 mm. The phragmocone terminates at a height of 13 mm. and a width of 12 mm. The sutures are straight and transverse; ten cameræ occur in a length of 10 mm. on the adoral part of the phragmocone. The cameræ increase orad in depth from .6 mm. to 1.5 mm. The living chamber has a ventral length of 16 mm. to the middle of the hyponomic sinus which is broad and well developed. No trace of the siphuncle is retained. The surface bears rather coarse transverse markings which retain the outline of the hyponomic sinus on the venter.

Discussion.—This species is represented by two individuals in the collection studied. In both, the phragmocone is filled with calcite which is so extensively recrystallized that all internal features are lost. The species is apparently a typical member of the genus in form, but does not seem to be closely similar to either of the previously described Ordovician species of North America. *R. carletonense* Foerste is a larger and more rapidly expanding form with coarser ornament. *R. coronatum* Foerste and Savage is more slender and is more comparable to *R. graciliforme* described above. The only other cephalopods of *Rizoceras*-like appearance in the Ordovician of America is an undescribed genus and species of the Chazyan of New York which is orthochoanitic and lacks a hyponomic sinus.

Types.—Univ. of Cincinnati, holotype, No. 22692, paratype, No. 22693.

Occurrence.—From the Greendale member of the Cynthiana limestone, at Cynthiana, Kentucky.

Family **ONCOCERATIDÆ**

Genus **NEUMATOCERAS** Foerste

Genotype.—*Neumatoceras gibberosum* Foerste

This genus is a compressed exogastric cyrtoconic brevicone clearly allied to *Oncoceras* and *Beloitoceras* from which it differs mainly in its unusual form. The conch attains its maximum width at a relatively early stage, after which it contracts laterally to the aperture. While contracting laterally the greatest height of the shell is attained, which is so strongly developed as to produce a highly characteristic humped appearance. The ventral siphuncle is described as being composed of slightly expanding segments. The species described below appears to be a typical member of the genus in this respect. However, the only species for which the siphuncle has been illustrated, *N. nutans* Foerste (1935, pl. 2, fig. 1), shows a large orthochoanitic siphuncle instead.

The genus is developed in the Bighorn formation, the Fremont limestone, and the Whitehead formation of Gaspé. Quite possibly *Maelonoceras* (?) *reclinatum* Troedsson (1926, p. 91, pl. 55, figs. 1-3) is a member of the genus, though a rather generalized one. It certainly lacks the adoral contraction over the adoral surface of the living chamber figured for the genotype of *Maelonoceras* and shows no features inconsistent with regarding it as an early *Neumatoceras* which is not as gibbous as are the younger forms.

Neumatoceras carlsoni Flower, n. sp. Plate 3, figs. 3-5; Plate 4, fig. 9

Conch exogastric, cyrtoconic, compressed, the venter much narrower than the dorsum. Venter uniformly curved adapically with radius of curvature of 40 mm., becoming greater just before attaining the living chamber and then nearly straight adorally. The maximum width is attained about 5 mm. below the base of the mature living chamber, where the width is 22 mm. Beyond this point, the height increases for a short distance, while the width steadily and gradually decreases to the aperture, so that 6 mm. farther, the width is 20 mm. and the height 23 mm ; in the next 12 mm. the width becomes 16 mm. and the height 18 mm.

Seven cameræ are attached to the living chamber of the type. The last three are considerably shortened. The sutures bear prominent lateral lobes and rise farther orad on the venter than on the dorsum. The siphuncle has a diameter of 2 mm. and is 2 mm. from the venter. A fragment from the earlier part of the conch of the same individual shows that the segments are relatively short and broad, but are only very slightly expanded within the cameræ and are empty. The living chamber is apparently not quite complete ventrally, but the dorsal margin, which is straight, is clearly preserved.

Discussion.—In form, this is a typical *Neumatoceras*, though it is not as gibbous vertically as are some of the previously described species. In this respect, it is somewhat closer to *Beloitoceras,* but in that genus the maximum height and width are attained at about the same point, but the greatest shell height is never found at a region where the conch is contracting laterally orad.

Type.—Holotype, Univ. of Cincinnati, No. 22694.

Occurrence.—From the Greendale member of the Cynthiana limestone, at Cynthiana, Kentucky.

Family OONOCERATIDÆ

Genus OONOCERAS Hyatt

Genotype.—*Cyrtoceras lentigradum* Barrande

Oonoceras Hyatt, 1884, Boston Soc. Nat. Hist., Proc., vol. 22, p. 280.
Ooceras Foord, 1884, Cat. Foss. Cephalopoda British Mus., vol. 1, p. 262.
Oonoceras Hyatt, 1894, Amer. Phil. Soc., Proc., vol. 32, pp. 447, 520.
Ooceras Hyatt, 1900, Cephalopods, in Zittel-Eastman Textb., Paleont., vol. 1, 1st ed., (Reprinted in later editions.)
Ooceras Ruedemann, 1906, New York State Mus., Bull. 90, p. 495.
Ooceras Grabau and Shimer, 1910, North American Index Fossils, vol. 2, p. 195.
Oonoceras Foerste, 1926, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, p. 321.

Conch longiconic, cyrtoconic, only gently curved, compressed in section with the venter more narrowly rounded than the dorsum and often subangulate. Expansion is very slow, and the mature part of the conch is essentially tubular. Sutures with slight lateral lobes, the ventral saddles rising slightly higher than the dorsal saddles. Siphuncle close to the venter, the segments very slender in the genotype, being suborthochoanitic rather than cyrtochoanitic. Species with broader segments are connected, however, by intermediate types. The shell surface bears transverse markings, normally thickened at intervals, sometimes simulating the appearance of annuli as in the genotype. The surface markings are not reflected upon the interior of the shell. A hyponomic sinus is developed throughout life.

Discussion.—The early spelling of this name, *Oonoceras*, was changed to *Ooceras* by Foord, a form which is consistent with the proper usage of the original Greek. The early form of the generic name is not to be regarded as a *lapsus calami* (Knight, 1941). Although Hyatt (1900) subsequently recognized the shorter form as correct and proposed the family *Ooceratidæ*, it appears necessary to retain the original spelling.

The genus was first erected for slender compressed cyrtoceracones, but has come to be much more restricted in scope. Foerste regarded *Oonoceras* (reëstablishing the original spelling) as characterized by the development of annuli, a hyponomic sinus, and a ventral empty siphuncle composed of slender segments. The annulated appearance is more apparent than real. This is shown by the absence of any trace of the "annuli" on the interior, and also by the species, which show a transition between the genotype and forms with relatively smooth exteriors, marked only by transverse liræ and striæ which are thickened at periodic intervals. The ornament of the genotype represents only an extreme development of the periodic thickening of the surface markings. Foerste proposed the genus *Oocerina*, based upon *Cyrtoceras lentigradum* Barrande, for species which differ from *Oonoceras* in possessing broadly expanded siphuncular segments which are occupied by actinosiphonate deposits.

Actually three groups are recognizable among the Silurian species of *Oonoceras* and may be summarized as follows:

I. Forms with empty ventral siphuncles composed of slender segments. Expansion is so slight within the cameræ that the condition is suborthochoanitic. The surface markings are thickened at rhythmic intervals, often producing the effect of annuli. This is to be regarded as *Oonoceras, sensu stricto.*

II. Forms with empty ventral siphuncles which differ from the condition outlined above in being definitely cyrtochoanitic and markedly expanded within the cameræ. The surface markings show the same thickening as in the above group, but are usually less prominent. This group, although different enough in siphuncular outline, does not seem to constitute a valid generic group, inasmuch as it is connected with *Oonoceras, sensu stricto,* by numerous species showing all gradations between the two types of siphuncular outlines.

III. Forms with cyrtochoanitic ventral siphuncles which are occupied by actinosiphonate deposits. The surface features of the type are not known; other species show surface markings similar to those of the other two groups. Foerste regarded this group as lacking a hyponomic sinus. While no sinus is figured for the genotype, it is present in other species, and it is to be feared that the drawing of the type is incorrectly restored at the region of the aperture. This is the group for which the generic name *Oocerina* was proposed by Foerste.

There is reason to believe that *Oocerina*, itself, may not be as distinct as a casual inspection of its features seems to indicate. It is distinguished from certain species of group II only by the presence of actinosiphonate deposits in the siphuncle. Such deposits have been used by Teichert as sufficient basis for the recognition of the Actinosiphonata as a major group within the cyrotochoanitic nautiloids. However, enough is not known of the occurrence, mode of growth, or function of these deposits to warrant their use alone as a basis for the erection of major taxonomic groups. The observations of the writer on Ordovician and Devonian forms indicate that actinosiphonate deposits may be very erratic in their occurrence. In some instances, they do not appear before the gerontic stage of the individual and are absent in individuals lacking such other indications of late maturity as the shallowing of the adoral cameræ and the development of incipient cameral deposits in the phragmocone. In a Chazyan genus, soon to be described, it was further noted that actinosiphonate deposits were to be found only in the larger species; mature and gerontic individuals of the smaller species consistently lacked any trace of the structures. The same has also been found to be true of the Devonian genus *Brevicoceras*, which can be traced to an origin in actinosiphonate cephalopods of the Devonian and Upper Silurian. This suggests that the puzzling condition found in the Chazy genus is also not connected with the development of the deposits in the large forms, but rather with the suppression of the structures in the small forms. Until more is known of the significance of the structures, however, it is at least highly convenient to retain *Oocerina* for the *Oonoceras*-like forms which possess actinosiphonate deposits. It may eventually be shown that actinosiphonate forms are genetically distinct from nonactinosiphonate cephalopods throughout the greater part of the Paleozoic. If, however, the writer's suggestion is correct that actinosiphonate deposits represent the secretion of excess calcium carbonate in the interstices of the siphonal vascular system, it is highly probable that actinosiphonate deposits may have arisen independently in many different genetic lines (Flower, 1938, p. 9; 1939, pp. 55-56).

Forms closely similar to the complex of Silurian species discussed above make up the dominant element in the fauna described in the present paper. They are slender cyrtoceracones, unquestionably *Oonoceras*-like in form, and cannot be distinguished from the species in group II as outlined above, which are characterized by broadly expanded siphuncles which lack actinosiphonate deposits. Closely related forms are found in the Ordovician of the Arctic, in strata which have been variously regarded as Trenton and Richmond. These include *Oonoceras obstructum* (Foerste, 1928, p. 307, pl. 52, figs. 2-3) of the Ordovician of Anticosti Island, originally described as a species of *Beloitoceras*. Subsequently, relatively slender forms were separated as *Richardsonoceras* Foerste, and related species from the Bighorn formation and the Fremont limestone were described as *Richardsonoceras wyomingense* Foerste and *Richardsonoceras* (?) *subcuneatum* Foerste, (1935, pp. 40-42, pl. 3, fig. 1; pl. 7, figs. 3-4). Both appear to be typical representatives not only of *Oonoceras*, but of the same species group as that containing the Kentucky forms. Foerste and Savage (1927, pp. 78-80, pl. 15, figs. 2-3) described two forms from the Shamattawa limestone of Hudson Bay as *Oocerina shamattawense* and *Oocerina* (?), sp. Neither is typical *Oocerina,* but rather of the Ordovician species of *Oonoceras*.

In the Middle Ordovician there are no forms which are strikingly similar to *Oonoceras*, but probably the ancestral radical is found in typical *Richardsonoceras* Foerste (1933, p. 91). This genus, based upon *Cyrtoceras simplex* Billings of the Black River limestone of the Ottawa Valley, differs from group II of *Oonoceras* mainly in superficial features; nevertheless the types appear to be very distinct in aspect and can be distinguished at a glance. *Oonoceras* is very slightly curved, very slender, and has the septa closely spaced and very flat. *Richardsonoceras,* on the other hand, is more strongly curved, more rapidly expanding, and has relatively distant septa which are not greatly flattened. In both groups, the siphuncles are essentially similar; a hyponomic sinus is developed. A difference of apparently minor importance is found in the faint rhythmic recurrence of thickened surface markings on Ordovician *Oonoceras*. Although *Richardsonoceras* shells are marked by fine transverse markings, periodic thickening of the lines has not been noted.

Richardsonoceras is known from the Black River and Trenton of New York, southern Ontario, Wisconsin, and Minnesota. Foerste has referred the following species to the genus:

Richardsonoceras clarkei Foerste, Black River of Wisconsin.

Richardsonoceras falx (Billings), Uppermost Black River, Paquette Rapids, Ottawa River, Ontario.

Richardsonoceras romingeri Foerste, Black River, St. Joseph Island, Lake Huron.

Richardsonoceras schofieldi (Clarke), Platteville, Wisconsin.

Richardsonoceras simplex (Billings), Leray limestone of the Ottawa Valley, Ontario.

Possibly Trenton species are related which have been referred by Foerste to *Cyrtorizoceras*, but, as is shown below, generic boundaries are dubious here also.[4] These species appear to expand vertically too slowly to represent typical *Cyrtorizoceras*. As the siphuncles are not known, it is possible, however, that they represent the genus *Paquettoceras* Foerste, which is essentially a smooth-shelled form of the orthochoanitic cyrtoconic genus *Centrocyrtoceras*.

In attempting to carry *Richardsonoceras* farther back and to connect it with related forms, difficulties of generic boundaries are again encountered. There appears to be no fundamental difference between *Richardsonoceras* and *Cyrtorizoceras*, at least as that genus is developed in the Ordovician, except the greater rate of vertical expansion of *Cyrtorizoceras*. There are species which might be placed in either genus with equal justification as far as our knowledge of them extends at present.

Slender cyrtoceracones with uncontracted apertures, compressed section, and cyrtochoanitic siphuncle are unknown in the Chazy. However, related forms are known which differ only in the slightly gibbous condition of the living chamber. These species, forming a fairly uniform form group extending from the Chazyan to the Richmond, constitute the genus *Beloitoceras*. Some species very closely approach *Richardsonoceras* and also

[4] In particular *Cyrtorizoceras filosum* (Conrad) of the Trenton and *Cyrtorizoceras camurum* (Hall) of the basal Trenton, both of New York. See Foerste, 1928, pp. 186-189, pl. 42, figs. 3-4.

Cyrtorizoceras. A slight increase in gibbosity, located high on the mature living chamber, produces the type of form diagnostic of the much older genus *Oncoceras*, from which *Beloitoceras* was separated for species of more generalized aspect. The form fails to correlate with specific differences of the siphuncular outline between the two genera. This suggests strongly that the genera are only form groups, and that actual genetic relationships are probably more complex than the external form indicates. Chazyan species are undeniably primitive, as is indicated by the simple siphuncles which are suborthochoanitic at least in the early stages. Most of these forms are in process of description by the writer.

It has generally been considered that a contracted living chamber is a phylogerontic condition, but the stratigraphic range of the genera discussed entirely fails to support such a view. Instead, *Beloitoceras*, with a faintly contracted living chamber, appears to be the oldest member of this series so far recognized. No uniformly slender cyrtoceracones are yet known from the Chazyan which might provide evidence of the antiquity of the supposedly simpler type.

Beloitoceras varies in many ways, but variations in gibbosity produce extreme types which have been separated as genera. In Black River and Trenton times *Oonoceras* develops as an expression of extreme gibbosity, while more slender forms with parallel sides or expanding living chambers constitute *Maelonoceras, Cyrtorizoceras* and *Richardsonoceras.* Later on, variations within *Beloitoceras* probably led to the development of the genera *Winnipegoceras* and *Neumatoceras* in the arctic faunas.

Richardsonoceras of the Black River-Trenton seas of eastern North America probably gave rise to *Oonoceras* of the late-Trenton and arctic faunas. This type appears to persist essentially unchanged into the Silurian of Bohemia, where form deviation again occurs, producing the three form groups noted above, which are based primarily on the variation of the siphuncular outline and structure. The further tracing of the history of this remarkable complex is obscure. There is indication that *Oxygonioceras* is more probably related to Silurian *Cyrtorizoceras,* than

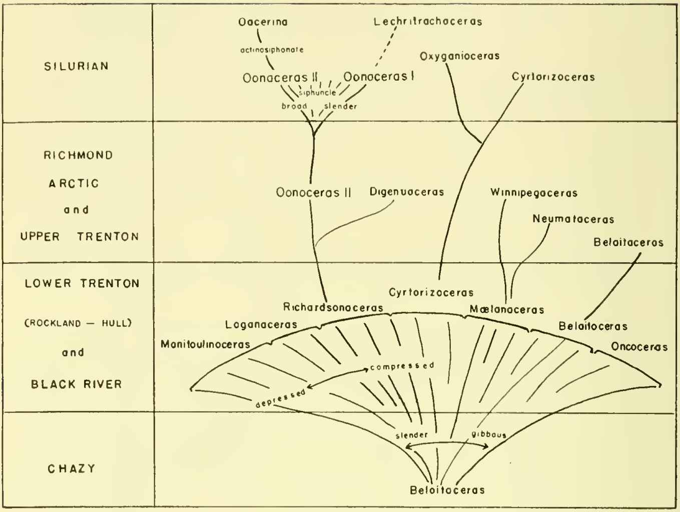


Fig. 1. Diagrammatic representation of the development of *Oonoceras* and its allies. *Beloitoceras*, the simplest of the Oncoceratidæ, appears in the Chazyan. Variation in gibbosity results in a variety of forms ranging from *Oncoceras* to *Cyrtorizoceras*, with the generic boundaries largely arbitrary. Variation in section in nongibbous forms produces a similar range of genera from the compressed *Cyrtorizoceras* and *Richardsonoceras* to the circular *Loganoceras* and the depressed *Manitoulinoceras.* Late Trenton to Richmond types represent continuation of only a few of these genetic lines and seem to lack the wide variation, form-genera being few in number and fairly distinct. Wide variation in the form of the siphuncle again occurs in the two divisions of the genus *Oonoceras* in the Silurian, while the development of actinosiphonate deposits results in the genus *Oocerina.* The relationship of *Lechritrochoceras* to *Oonoceras,* as indicated by the broken line, is not thoroughly established. *Oxygonioceras* appears to be related to *Cyrtorizoceras* on the basis of siphuncular structure. Many genera, largely the relatives of *Loganoceras* and *Manitoulinoceras,* are omitted for the purpose of simplification. In the present state of our knowledge, the most startling break in the faunal record occurs in the middle of the Trenton, making necessary the rather unusual grouping of the Ordovician strata used here.

to group II of *Oonoceras*. Further, it is probable that typical *Oonoceras* gave rise to the costate trochoceroids which are particularly characteristic of the Silurian of both America and Europe.

Further ramifications of form and section in the Ordovician probably led to such genera of circular section as *Loganoceras* and *Kentlandoceras* and to forms of depressed section of which *Manitoulinoceras* is probably the best known example. While there is considerable variation in the details of the siphuncular outline of all of these Ordovician genera, all apparently agree in having relatively small and usually slender siphuncles which are ventrally located and devoid of any organic deposits. While it is not impossible that some forms, in particular those of depressed section, may be connected to the ancestral radicle which gave rise to the Mixochoanites upon the appearance of natural truncation, there is likewise no good structural basis for distinguishing these forms from the evidently related compressed longiconic forms of the Oncoceratidæ. The probable relationships within this group are indicated in the accompanying diagram, which is designed to emphasize particularly the dependence of the genera on form.

Oonoceras planiseptatum Flower, n. sp. Plate 1, figs. 9-10; Plate 2, fig. 6

Conch compressed, with the venter only slightly more narrowly rounded than the dorsum and with the greatest width occuring at the middle of the section. The conch is slightly and uniformly curved throughout the earlier portion, the radius of curvature being 90 degrees, but it becomes straighter on the mature living chamber, where the radius is increased to 110 degrees. The section on the mature living chamber becomes more strongly compressed. A phragmocone expands from 33 mm. and 37 mm. to 38 mm. and 44 mm. in a length of 45 mm. A complete living chamber increases from 37 mm. and 43 mm., at the base, to 38 mm. and 47 mm., at the aperture, in a length of 35 mm.

The sutures are straight and transverse dorsally and dorsolaterally. They slope slightly orad upon approaching the venter. The septa are very flat, having a lateral curvature of 4 mm. where the diameters are 33 mm. and 37 mm. The cameræ are very shallow, sixteen to eighteen occurring in a length equal to an adoral shell height of 44 mm. The siphuncle is not shown in any representative of this species.

The aperture is slightly inclined orad from dorsum to venter with reference to the plane of the last septum. The aperture is straight dorsally and laterally, but shows indication of a hyponomic sinus on the venter. The surface of the shell is not exposed. The internal molds sometimes show longitudinal markings over the phragmocone which represent incipient cameral deposits in gerontic individuals.

Discussion.—From the slender rate of expansion, this species must have attained a length of at least a foot when complete. Its slender form distinguishes it from the only associated species which attained comparable diameters. Other diagnostic features are found in the dominantly transverse course of the sutures, the very shallow cameræ, and the extreme compression of the mature living chambers. The species is represented by only two good specimens in our collection. One consists of a phragmocone of a mature individual, the other is a living chamber which shows the gerontic compression and reduction of curvature, but has not yet attained the internal thickening of the shell wall.

Types.—Holotype, Univ. of Cincinnati Museum, No. 22680; paratype, No. 22681.

Occurrence.—From the Greendale limestone member of the Cynthiana limestone, Middle Ordovician, at Cynthiana, Ky.

Oonoceras acutum Flower, n. sp. Plate 2, figs. 3-5

Conch only faintly curved, with radius of curvature for venter 120 degrees in the basal portion, but reduced adorally on the mature living chamber to about 90 degrees. The section is strongly compressed, the venter subangulate. At the base, the height is 30 mm. and the width 25 mm. This increases at the base of the living chamber to 29 mm. and 36 mm. in a length of 35 mm. The living chamber has a maximum (dorsal) length of 37 mm. and is incomplete adorally. It attains a width of 27 mm. and a height of 37 mm.

The sutures slope slightly and uniformly orad from dorsum to venter, but become slightly more inclined as the venter is approached. The cameræ are shallow, with a maximum depth of

3 mm., so that there are approximately fifteen in a length equal to the adoral height of the shell. The siphuncle is located close to the venter. The form of its segments has not been observed.

The living chamber is constricted internally on its dorsal side, indicating that the type is a gerontic individual. The aperture is not preserved. No trace of the original shell surface remains.

Discussion.—The length of the living chamber of this form is very similar to that of *O. brevidomum*, but the conch is uniformly more slender, less rapidly expanding, and the diameters attained are not so great. The extreme subtriangular form suggests *O. triangulatum*, but, in addition to the larger size, the conch of this species differs in being much more strongly compressed and in possessing the region of greatest width well dorsad of the center of the shell.

Types.—Holotype, Univ. of Cincinnati Museum, No. 22682; paratype, Univ. of Cincinnati Museum, No. 22683.

Occurrence.—From the Greendale member of the Cynthiana limestone at Cynthiana, Kentucky.

Oonoceras (?) brevidomum Flower n. sp. Plate 2, figs. 1-2

This species is represented by a single crushed individual. Though clearly related to the other species here placed in *Oonoceras*, the general aspect of this form is rather that of a *Beloitoceras*. In size, it approximates *Oonoceras planiseptatum*, but differs in the more rapid expansion, the shorter living chamber and the more oblique sutures. The specimen is 34 mm. high and 32 mm. wide at the base and expands to 38 mm. and 46 mm., in a ventral length of 38 mm. at the base of the living chamber. The living chamber has a ventral length of 23 mm. and attains a height of 50 mm. and a width of 40 mm. The ventral outline is slightly convex throughout, with an average radius of curvature of about 75 degrees. The dorsum is faintly concave.

The sutures are uniformly oblique, sloping orad strongly on the venter. The cameræ are shallow, attaining a maximum depth of 4 mm., while the earliest preserved camera has a depth of 2 mm., and the last two are gerontically contracted. The siphuncle is not preserved.

The living chamber is short, the internal mold somewhat constricted before attaining the aperture. The aperture is less oblique than the last septum, straight dorsally and laterally and with a small and not very sharply defined hyponomic sinus.

Discussion.—This species is easily confused only with *O. planiseptatum*, which it most closely approximates in size. Even allowing for the increase in rate of expansion, which might be produced vertically in the specimen by flattening, the rate of expansion is obviously greater in this form, as is also the curvature. In both features, the condition of *Beloitoceras* is approached. More diagnostic are the markedly oblique sutures and the shortness of the living chamber.

Type.—Holotype, Univ. of Cincinnati Museum, No. 22684.

Occurrence.—From the Greendale member of the Cynthiana limestone at Cynthiana, Kentucky.

Oonoceras multicameratum Flower, n. sp. Plate 3, figs. 1-2

Conch gently curved, radius of curvature of venter 100 mm. over the mature portion. Section compressed, the venter more broadly rounded than in *O. graciliforme*, and with greatest width located at the center of the height. The shell expands from 21 mm. and 23 mm. to 23 mm. and 25 mm. in the 22 mm. of the phragmocone. In the 36 mm. of the living chamber, the height becomes 28 mm. and the width 24 mm.

The sutures bear slight lateral lobes, but are scarcely inclined orad on the venter. The septa are very flat, having a maximum depth of curvature at the base of the specimen of 3 mm., one-seventh the width at that point. The cameræ are shallow, between eleven and twelve occurring in a length equal to an adoral shell height of 25 mm. The siphuncle is close to the venter. As exposed at the apical end of the specimen, it has a diameter of 2.5 mm. and is slightly less than 2 mm. from the ventral wall of the shell.

The surface is not preserved on any representative of this species. The internal mold bears a dorsal constriction near the adoral end of the living chamber found in no other species of this association, but strongly reminiscent of *Oonoceras obstructum* (Foerste) of the Vaureal limestone of Anticosti. The aperture is not preserved except possibly on the extreme dorsal portion of the shell.

Discussion.—The shallow cameræ, nearly transverse sutures, broader venter, and the development of the gerontic internal thickening of the shell on the dorsum distinguish this from *O. gracilicurvatum.* The rate of curvature is somewhat less in this species, and the living chamber is slightly shorter in proportion to its basal dimensions. A further difference is found in the proportions of the living chamber, which is essentially parallel-sided in *O. graciliforme,* but is faintly expanded in this species. The gerontic constriction is found only on the dorsum of *O. multicameratum;* in *O. graciliforme* it extends onto the venter.

Type.—Holotype, Univ. of Cincinnati Museum, No. 22685.

Occurrence.—From the Greendale member of the Cynthiana limestone, at Cynthiana, Kentucky.

Oonoceras gracilicurvatum Flower, n. sp. Plate 4, fig. 3-5

Conch slender, slightly and uniformly curved, with radius of curvature of venter 85 degrees. The section is compressed, with the venter much narrower than the dorsum, the greatest width lying scarcely dorsad of the center. The holotype expands from 22 mm. and 20 mm. to 25 mm. and 23 mm. in the 30 mm. of the phragmocone. The living chamber has a ventral length of 45 mm. and at the apertural end measures 25 mm. and 23 mm. as at the base. The aperture is not preserved. The internal mold is constricted near the anterior end, indicating a gerontic condition, also showing, by its position, that the living chamber was probably very nearly complete.

The sutures bear very shallow lateral lobes and are inclined orad from dorsum to venter. Seven to eight cameræ occur in a length equal to an adoral shell height of 23 mm. The last cameræ show no evidence of gerontic shortening. The septa are not clearly exposed, but are evidently very flat as in related species. The siphuncle is located close to the venter and is cyrtochoanitic, apparently more broadly expanded transversely than vertically. A segment 3 mm. long expands from 1.5 mm. to 3 mm. No trace of deposits can be found in the siphuncle.

The shell wall is marked by numerous transverse striæ and liræ which are rather irregularly thickened, giving the shell a rugose appearance. On the venter, a well-developed hyponomic sinus is indicated by these markings.

Discussion.—This is the smallest of the species of *Oonoceras* in the fauna and may be further distinguished from its associates by the relatively deep cameræ. The species which most closely approximate this one in the proportion of the exterior of the shell and in section differ in having shallower cameræ. Other minor differences are found in the section of the conch and in the expression of the gerontic internal thickening of the shell near the aperture. In this species a zone of thickening extends entirely around the shell. In the preceding species it is found only on the dorsum, as in the related Anticosti form, *Oonoceras obstructum* (Foerste).

Type.—Holotype, Univ. of Cincinnati Museum, No. 22686.

Occurrence.—In the Greendale limestone member of the Cynthiana, Middle Ordovician, at Cynthiana, Kentucky.

Oonoceras triangulatum Flower, n. sp. Plate 4, figs. 6-8

Conch slender and very gently curved, with radius of curvature for venter of 105 degrees over the mature part of the shell. The section is subtriangular, the venter subangulate, although the greatest width of the shell is located scarcely dorsad of mid-height.

The holotype retains 28 mm. of the phragmocone in which the height increases from 20 mm. to 24 mm. and the width from 18 mm. to 21 mm. In the 42 mm. of the complete living chamber, a height of 28 mm. and a width of 26 mm. are attained.

The sutures are slightly inclined orad from dorsum to venter and bear very slight lateral lobes. Only the adoral two cameræ are exposed. The last measures 2 mm. in depth, the preceding one 3 mm. The siphuncle is not preserved on the specimen.

The aperture is not clearly preserved, and there is only an obscure suggestion of a small hyponomic sinus. The surface bears numerous fine alternating transverse liræ and striæ. At regular intervals the liræ are thickened, producing a costate aspect. The costæ are spaced from three to four mm. apart.

Discussion.—The subtriangular section, slender form, the poor development of the lateral lobes, and the very slight curvature serve to distinguish this species from all associated forms. It does not appear to have any close relatives in other faunas.

Type.—Holotype, Univ. of Cincinnati Museum, No. 22687.

Occurrence.—In the Greendale member of the Cynthiana limestone, at Cynthiana, Kentucky.

Oonoceras triangulatum var. cylindratum Flower, n. var. Plate 1, figs. 3-4

This form differs from *O. triangulatum* mainly in its much more gradual rate of expansion. Radius of curvature of the venter is about 105 degrees. The section is subtriangular, the dorsum broad, the venter narrow and subangulate, though slightly broader than typical *triangulatum*. The conch expands from 19 mm. and 21 mm. to 22 mm. and 25 mm. in 35 mm. in the earliest stage represented. In the holotype, the phragmocone shows an increase from 21 mm. and 24 mm. to 25 mm. and 29 mm. in 30 mm., while the living chamber changes in 45 mm. to 29 mm. and 27 mm. A second living chamber shows almost identical proportions.

The sutures are somewhat oblique and bear slight lateral lobes and agree essentially with those of typical *triangulatum*. The cameræ occur between ten and twelve in a length equal to an adoral height of the shell. The siphuncle is very close to the venter, measuring 3 mm. in diameter as exposed at the base of the holotype, and 1 mm. from the venter.

The shell surface is marked by faintly rugose transverse striæ and liræ, somewhat less strongly developed than in *O. gracilicurvatum*. The aperture is not clearly preserved in any specimen, but the lines of growth show the development of a well-defined hyponomic sinus on the venter.

Discussion.—This form differs from *O. triangulatum* mainly in the less rapid expansion. The curvature of the venter of the two species and the size and proportions of the living chamber are very similar, as is the depth of the cameræ. The venter is slightly more rounded in this form. It is not impossible that the differences involved might represent sexual dimorphism, but the present material is not adequate to warrant any definite conclusion on this subject.

Types.—Holotype, No. 22688, paratypes, Nos. 22689, 22690, University of Cincinnati Museum.

Occurrence.—From the Greendale limestone member of the Cynthiana, at Cynthiana, Kentucky.

Oonoceras suborthoforme Flower, n. sp. Plate 1, fig. 11

A fragment of a phragmocone with a maximum length of 24 mm. represents still another species of *Oonoceras*. Curvature is so slight that the lateral view is hardly sufficient to determine that the venter is located at the left side as the specimen is oriented in our illustration. The section is scarcely higher than wide, the greatest width, however, occuring slightly dorsad of the center so that the venter is very slightly more narrowly rounded than the dorsum. The conch expands from 20 mm. and 19.5 mm. to 23 mm. and 22.5 mm., in the length of 25 mm. The sutures bear prominent lateral lobes, but rise adorally about equally on dorsum and venter. Nine cameræ occur in the length of 20 mm. The adoral cameræ are slightly shallower than the others, suggestive of the approach of a gerontic condition. The siphuncle is close to the venter, but is not clearly marked. The specimen is remarkable for the development of a series of grooves upon one side of the internal mold. They represent molds of cameral deposits not elsewhere preserved on the conch; they have not been noted in other species of the genus. The surface, living chamber, and aperture are unknown.

Discussion.—In spite of the fragmentary nature of the type this form may be readily recognized by the straight condition of the shell and the marked development of lateral lobes which is not accompanied, as is usual in the genus, by the development of oblique sutures extending farther orad on the venter than on the dorsum.

Type.—Holotype, Univ. of Cincinnati Museum, No. 22762.

Occurrence.—From the Greendale member of the Cynthiana limestone, from Cynthiana, Kentucky.

Family DIESTOCERATIDÆ

Genus DIESTOCERAS Foerste

Diestoceras ? sp. Plate 1, figs. 5-6

Among the material from the Cynthiana lens are fragments of a moderately large breviconic form which appears to fall in the genus *Diestoceras* on the basis of the compressed section, slight contraction of the shell near the aperture, the straight and transverse sutures and the scalariform siphuncle. Three specimens of this form were encountered, but all of them contained a geodic filling of coarse calcite crystals in the living chamber making suitable extraction impossible. The phragmocone of the best preserved individual is compressed throughout, having a basal width of 22 mm., a basal height of 24 mm., increasing in 37 mm. to a width of 37 mm. and a height of 40 mm. The venter is slightly convex, the dorsum is straight. The sutures are straight and transverse. The cameræ average 2 mm. in depth, with variation of less than .5 mm. in the known portion of the phragmocone. The siphuncle lies close to the venter. A segment, 2 mm. long, has a diameter at the septal foramen of .7 mm., and expands to 2.2 mm. In vertical outline the segment is scalariform, being adnate dorsally on the adoral end and ventrally on the adapical end. No trace of organic deposits is preserved in the cameræ.

The living chamber is known only from inadequate fragments. The largest fragment of a living chamber has a height of 50 mm. and a width of 46 mm. In this specimen there is no definite trace of apertural contraction, though this has been observed in a lateral fragment of a slightly larger individual.

Discussion.—The rapid rate of expansion of the phragmocone distinguishes this from the associated species of *Oonoceras*, from which it is further distinguished by the scalariform outline and broadly expanded condition of the siphuncular segments. Enough is not known to make possible any close comparison with the described species referred to *Diestoceras*. The preservation may in part account for the absence of actinosiphonate deposits in the one siphuncle sectioned; it is also true that this is an immature individual, as shown by the lack of evidence of adoral contraction of the shell and by the absence of adoral shallow cameræ and also by the absence of the longitudinal markings on the internal mold of the phragmocone generally present in mature individuals of this genus.

Type.—Univ. of Cincinnati Museum, No. 22699.

Occurrence.—From the Greendale member of the Cynthiana limestone (Trenton), at Cynthiana, Kentucky.

REFERENCES

Dunn, P.

Geological map of Harrison County, Kentucky, Kentucky Geol. Surv., ser. 6, 1930.

Flower, R. H.

Devonian brevicones of New York and adjacent areas, Palæontographica Americana, vol. 2, No. 9, 1938, 84 pp., 4 pls., 10 figs.

——— *Study of the Pseudorthoceratidæ*, Palæontographica Americana, vol. 2, No. 10, 1939, 214 pp., 9 pls., 22 figs.

——— *Some Devonian Actinoceroidea*, Jour. Paleont., vol. 14, 1940, pp. 442-446, pl. 61.

Flower, R. H., and Caster, K. E.

The stratigraphy and paleontology of northwestern Pennsylvania. Part II, *Paleontology*. Sec. A: *The cephalopod fauna of the Conewango series of the upper Devonian of New York and Pennsylvania*, Bull. Amer. Paleont., vol. 22, No. 75, 1935.

Foerste, A. F.

Preliminary notes on Cincinnatian fossils, Denison Univ. Bull., Sci. Lab., Jour., vol. 14, 1909, pp. 209-232, pl. 4.

——— *Preliminary notes on Cincinnatian and Lexington fossils*, Denison Univ. Bull., Sci. Lab., Jour., vol. 16, 1910, pp. 17-100, pls. 1-6.

——— *Cephalopoda*, in Twenhofel, *Geology of Anticosti Island*, Canada Geol. Surv., Mem. 154, 1928, 480 pp., 60 pls.

——— *Black River and other cephalopods from Minnesota, Wisconsin, Michigan and Ontario*, Part I, Denison Univ. Bull., Sci. Lab., Jour., vol. 27, 1932, pp. 47-136, pls. 7-37.

——— *Black River and other cephalopods from Minnesota, Wisconsin, Michigan and Ontario*, Part II, Denison Univ. Bull., Sci. Lab., Jour., vol. 28, 1933, pp. 1-146.

——— *Bighorn and related cephalopods*, Denison Univ. Bull., Sci. Lab., Jour., 1935, pp. 1-96, pls. 1-22.

——— *Cephalopods from the Upper Ordovician of Percé, Quebec*, Jour. Paleont., vol. 10, 1936, pp. 373-384, pls. 54-57.

——— *Cephalopoda* in Twenhofel, *Geology and paleontology of the Mingan Islands, Quebec*, Geol. Soc. Amer., Special Paper, No. 11, 1938, pp. 76-105, 24 pls.

Foerste, A. F., and Savage, T. E.

Ordovician and Silurian cephalopods of the Hudson Bay area, Denison Univ. Bull., Sci. Lab., Jour., vol. 22, 1927, pp. 1-108, pls. 1-24.

Foerste, A. F., and Teichert, C.

The actinoceroids of east-central North America, Denison Univ. Bull., Sci. Lab., Jour., vol. 25, 1930, pp. 201-296, pls. 27-59.

Hyatt, A.

Cephalopoda, in Zittel-Eastman Textbook of Paleontology, vol. 1, 1st ed., 1900, pp. 502-595. (Reprinted, 2d edition, 1913, pp. 583-616.)

Kay, G. M.
Ordovician Stewartville-Dubuque problems, Jour. Geology, vol. 43, 1935, pp. 561-590, 10 figs.

Knight, J. B.
Are corrections to the original spelling of generic names advantageous? Amer. Jour. Sci., vol. 239, 1941, pp. 312-315.

McFarlan, A. C.
Stratigraphic relationships of Lexington, Perryville and Cynthiana (Trenton) rocks of central Kentucky, Geol. Soc. Amer. Bull., vol. 49, 1938, pp. 986-996, 1 pl., 1 fig.

Miller, A. K., Dunbar, C. O., and Condra, G. E.
The nautiloid cephalopods of the Pennsylvanian system in the mid-continent region, Nebraska Geol. Surv., ser. 2, Bull. 9, 1933, 240 pp., 24 pls., 32 figs.

Ruedemann, R.
The Utica and Lorraine formations of New York. Part II, *Systematic paleontology*, No. 2, *Molluscs, crustaceans and eurypterids*, New York State Museum Bull. 272, 1926.

Shimizu, S., and Obata, T.
Three new genera of Ordovician nautiloids belonging to the Wutinoceratidæ (nov.) from east Asia, Jour. Shanghai, Sci. Inst., sec. 2, vol. 2, 1936, pp. 27-35.

Teichert, C.
Untersuchungen an actinoceroiden Cephalopoden aus Nordgrönland, Medelelser om Grönland, Bd. 92, Nr. 10, 1934, pp. 1-48, 22 figs.

Troedsson, G. T.
On the middle and upper Ordovician faunas of northern Greenland, I, *Cephalopods*, Meddelelser om Grönland, Bd. 71, 1926, pp. 1-157, pls. 1-65.

PLATES

PLATE I (4)

EXPLANATION OF PLATE I (4)

Figure Page

1. **Treptoceras perseptatum** Flower, n. sp. 18
Horizontal section of holotype, Univ. of Cincinnati, No. 22679.

2. **Treptoceras prænuntium** Flower, n. sp. 19
Horizontal section of holotype, Univ. of Cincinnati, No. 22696.

3-4. **Oonoceras triangulatum var. cylindratum** Flower, n. sp. 37
Paratype, (3) left lateral and (4) dorsal aspects. Univ. of Cincinnati, No. 22690.

5-6. **Diestoceras** ? sp. 38
(5) Ventral aspect of fragmentary phragmocone (6) vertical section of the same specimen. Univ. of Cincinnati, No. 22699.

7-8. **Rizoceras conicum** Flower, n. sp. 21
Holotype, (7) ventral and (8) left lateral aspects. Univ. of Cincinnati, No. 22691.

9-10. **Oonoceras planiseptatum** Flower, n. sp. 31
Holotype, (9) dorsal (10) right lateral aspects. Univ. of Cincinnati, No. 22680.

11. **Oonoceras suborthoforme** Flower, n. sp. 38
Holotype, left lateral aspect, showing unusual development of longitudinal furrows on internal mold representing camerai deposits. Univ. of Cincinnati, No. 22762.

All specimens are from a lens in the Greendale member of the Cynthiana limestone, Middle Ordovician, from the Poindexter quarry, Cynthiana, Kentucky. Illustrations natural size.


1
2
3
4
5
6
7
8
9
11
10

PLATE 2 (5)

EXPLANATION OF PLATE 2 (5)

Figure		Page
1-2.	**Oonoceras brevidomum** Flower, n. sp. Holotype, (1) left lateral and (2) dorsal views. Univ. of Cincinnati, No. 22684.	33
3-5.	**Oonoceras acutum** Flower, n. sp. Holotype, (3) left lateral (4) dorsal and (5) septate views. Univ. of Cincinnati, No. 22682.	32
6.	**Oonoceras planiseptatum** Flower, n. sp. Paratype, septal view. Univ. of Cincinnati, No. 22681.	31
7.	**Rizoceras graciliforme** Flower, n. sp. Holotype, lateral aspect, venter on right. Univ. of Cincinnati, No. 22693.	21

All specimens are from a lens in the Greendale member of the Cynthiana limestone from the Poindexter quarry, Cynthiana, Kentucky. Illustrations natural size.

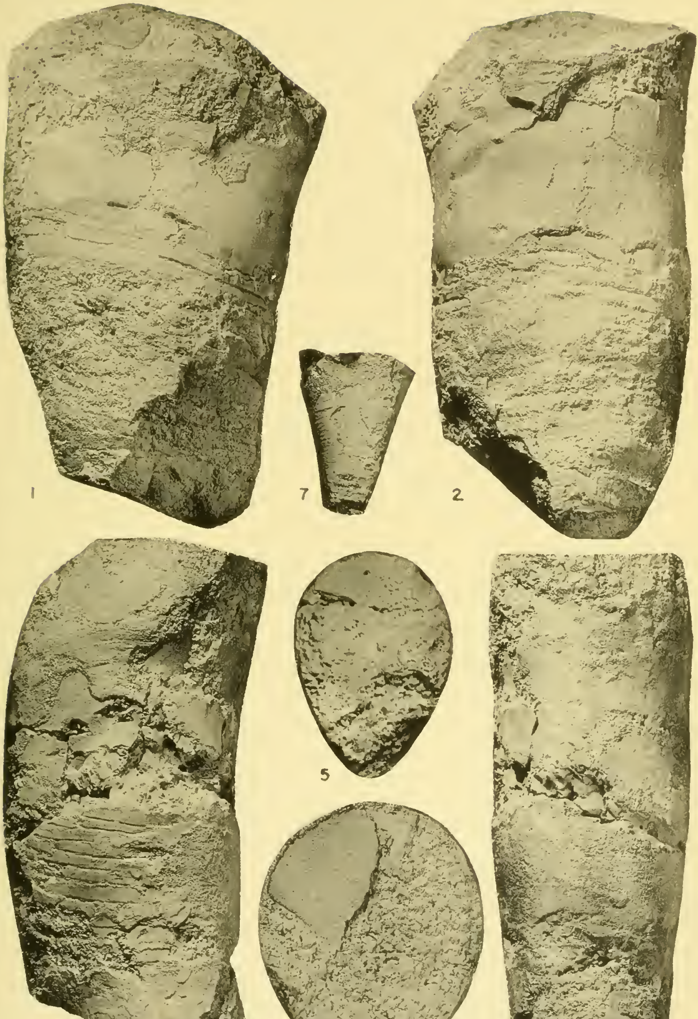

1
7
2
5
3
6
4

PLATE 3 (6)

EXPLANATION OF PLATE 3 (6)

Figure Page

1-2. **Oonoceras multicameratum** Flower, n. sp. 34
Holotype, (1) right lateral and (2) dorsal aspects. Univ. of Cincinnati, No. 22685.

3-5. **Neumatoceras carlsoni** Flower, n. sp. 23
Holotype, (3) ventral, (4) right lateral and (5) dorsal. Univ. of Cincinnati, No. 22694.

6. **Treptoceras perseptatum** Flower, n. sp. 18
Paratype, Univ. of Cincinnati, No. 22698.

7-8. **Oonoceras triangulatum** var. **cylindratum** Flower, n. sp. 37
Holotype, (7) ventral and (8) lateral aspects. Univ. of Cincinnati, No. 22688.

9. **Oonoceras planiseptatum** Flower, n. sp. 31
Holotype, dorsal aspect. Univ. of Cincinnati, No. 22680.

All specimens are from a single lens in the Greendale member of the Cynthiana limestone, from the Poindexter quarry, Cynthiana, Kentucky. Illustrations natural size.

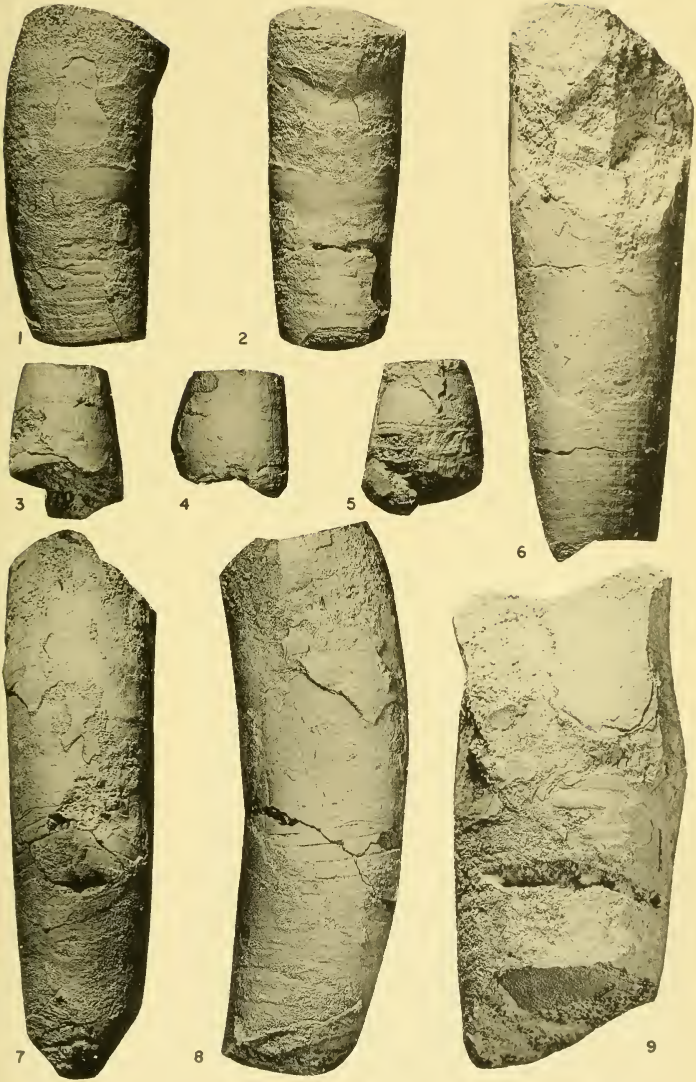

1
2
3
4
5
6
7
8
9

PLATE 4 (7)

Explanation of Plate 4 (7)

Figure		Page
1-2.	**Treptoceras persiphonatum** Flower, n. sp. Holotype, (1) exterior of phragmocone (2) horizontal section. Univ. of Cincinnati, No. 22695.	17
3-5.	**Oonoceras gracilicurvatum** Flower, n. sp. Holotype, (3) ventral aspect (4) lateral aspect (5) dorsal aspect. Univ. of Cincinnati, No. 22686.	35
6-8.	**Oonoceras triangulatum** Flower, n. sp. Holotype, (6) ventral (7) right lateral (8) dorsal aspect. Univ. of Cincinnati, No. 22687.	36
9.	**Neumatoceras carlsoni** Flower, n. sp. Holotype, vertical section of portion of phragmocone. Univ. of Cincinnati, No. 22694.	23

All specimens are from a lens in the Greendale member of the Cynthiana limestone, Middle Ordovician, from the Poindexter quarry, Cynthiana, Kentucky. Illustrations natural size.


1
3
4
5
2
9
6
7
8

XV. (Nos. 55-58). 314 pp., 80 pls. 6.00
Mainly Ecuadoran, Peruvian and Mexican Tertiary forams and mollusks and Paleozoic fossils.

XVI. (Nos. 59-61). 140 pp., 48 pls. 5.00
Venezuela and Trinidad Tertiary Mollusca.

XVII. (Nos. 62-63). 283 pp., 33 pls. 6.00
Peruvian Tertiary Mollusca.

XVIII. (Nos. 64-67). 286 pp., 29 pls. 6.00
Mainly Tertiary Mollusca and Cretaceous corals.

XIX. (No. 68). 272 pp., 24 pls. 5.00
Tertiary Paleontology, Peru.

XX. (Nos. 69-70C). 266 pp., 26 pls. 6.00
Cretaceous and Tertiary Paleontology of Peru and Cuba.

XXI. (Nos. 71-72). 321 pp., 12 pls. 5.00
Paleozoic Paleontology and Stratigraphy.

XXII. (Nos. 73-76). 356 pp., 31 pls. 7.00
Paleozoic Paleontology and Tertiary Foraminifera.

XXIII. (Nos. 77-79). 251 pp., 35 pls. 5.00
Corals, Cretaceous microfauna and biography of Conrad.

XXIV. (Nos. 80-87). 334 pp., 27 pls. 6.00
Mainly Paleozoic faunas and Tertiary Mollusca.

XXV. (Nos. 88-94B). 306 pp., 30 pls. 7.00
Paleozoic fossils of Ontario, Oklahoma and Colombia, Mesozoic echinoids, California Pleistocene and Maryland Miocene mollusks.

XXVI. (Nos. 95-100). 420 pp., 58 pls. 7.00
Florida Recent marine shells, Texas Cretaceous fossils, Cuban Cretaceous corals, and geology and paleontology of Ecuador.
Cuban and Peruvian Cretaceous, and Peruvian Eogene corals, and geology and paleontology of Ecuador.

XXVII. (Nos. 101-103, other numbers in preparation). 90 pp. 7 pls. 2.00
San Pedro, California Pleistocene Mollusca and early Paleozic cephalopods from Alaska and Kentucky.

PALÆONTOGRAPHICA AMERICANA

Volume I. (Nos. 1-5). 519 pp., 75 pls. $12.00
Monographs of arcas, Lutetia, rudistids and venerids.

Volume II No's 6-12 .... $12.00

Volume III. (No. 13, other numbers in preparation). 56 pp. 3 pls. . 1.25
Eurysiphonate cephalopod structure and phylogeny.

BULLETINS

OF

AMERICAN PALEONTOLOGY

VOL. XXVII

NUMBER 104

1942

Paleontological Research Institution

Ithaca, New York

U. S. A.

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 27

No. 104

Type Fossil Cypræidæ of North America

By

William Marcus Ingram
Mills College, California

August 11, 1942

Paleontological Research Institution
Ithaca, New York
U. S. A.

CONTENTS

TYPE FOSSIL CYPRÆIDÆ OF NORTH AMERICA

By

William Marcus Ingram

Mills College, California

INTRODUCTION

This paper is a product of an attempt to gather information dealing with holotypes of the fossil Cypræidæ of North America. Many holotype numbers and holotype depositories are here listed for the first time. Type localities are included and the geological age of the holotypes is cited. The first illustrations of many of the holotypes by the photographic method are included. Questions which have been referred to the writer concerning the above points have prompted a publication of such a paper.

No worker has yet attempted to make such a survey. Schilder (1932) published a list including many of the forms which come within the scope of this paper, but he made no attempt to include information about holotypes. He had no opportunity to examine the many type specimens housed in the United States, and, from erroneous data included in his "Fossilium Catalogus," he has not studied many of the species included here. Vredenburg (1920) listed a number of fossil species from localities in North America in his interesting consideration of the classification and antiquity of the Cypræidæ. His work, though not complete, is a world-wide, general consideration of this group, with great emphasis placed upon systematic relationships of many species. Schilder (1926), who later examined and corrected Vredenburg's (1920) work, included relative data concerning some of the species dealt with here.

The writer believes that the Cypræidæ included here represent a fairly complete assemblage of the species described from North America, although some species may have been unavoidably overlooked.

CLASSIFICATION OF THE CYPRÆIDÆ CONSIDERED

Five genera are recognized here as belonging to the North American Cypræidæ. These are: *Cypræa* Linnæus, *Cyprædia* Swainson, *Sulcocypræa* Conrad, *Siphocypræa* Heilprin and *Gisortia* Jousseaume. The greatest number of species is assigned to the genus *Cypræa.* The writer has not attempted to subdivide the Linnæan genus *Cypræa* further, believing that it is best to wait until anatomical relationships of Recent forms are known and can serve as a possible guide in correlating fossil affinities. Numerous European writers, notably Schilder,[1] have attempted to divide the original genus *Cypræa* into innumerable genera that intergrade one into the other. The genera recognized here are natural ones; they show no intergradations from one to the other. The variability in the family Cypræidæ and intergradations of generic characteristics in this group are well known by one who has studied them to even a small extent; many of the characters used to separate the so-called genera seem to be relative and not specific. In this connection it is well to quote Sowerby (1870) in his reference to living species.

> In attempting to arrange the *Cypræa* in groups according to their affinities, it is difficult to find any leading principle of association or separation, because shells associated by one set of characters are disassociated by others. Thus, *C. capensis* and *C. Adamsonii* have been placed by some authors under the name "*Cypræaovulum*" on account of their resemblance in their system of dorsal striation, but in all other characters their affinities are widely apart.
>
> Neither can the species be well separated according to their general forms, or the degree of thickening of their sides by superdeposited enamel, because, in these respects, the species pass from one to the other by imperceptible gradations, and because widely different forms are found in the same species. Thus, the common short *C. carneola,* with thickened sides, would, in arrangement depending upon forms or lateral expansion, be placed in a group with *C. arenosa,* which it greatly resembles, while the cylindrical form of the same species would range with *C. testudinaria* and *C. argus.*

[1] *op. cit.*

GENERAL DISCUSSION

Certain of the genera of Cypræidæ are restricted in their stratigraphic ranges. The genus *Cyprædia,* represented in North America by three species, is confined to the Eocene, and all have limited geographic ranges. Two species, *Cyprædia gilberti* Palmer and *Cyprædia subcancellata* (Johnson) are from the Claiborne, middle Eocene; the former species was described from the Gosport sand, Monroe County, Alabama, and the latter from the Claiborne Eocene of Smithville, Bastrop County, Texas. *Cyprædia fenestralis* (Conrad) is from the Jackson, upper Eocene of Jackson, Mississippi. Olsson (1931) described a *Cyprædia chira* from the lower Oligocene, Peru. This occurrence seems to be the only one in the South and Central American area. Trechmann (1923) described *Cyprædia elegans* (Trechmann), and listed *Cyprædia elegans* (Defrance) from the "Yellow limestone" of Jamaica, which probably represents a middle Eocene occurence. Schilder (1939) described *Cyprædia vistabellensis* and *Cyprædia kugleri* from the upper Eocene of Trinidad. With the exception of Olsson's (1931) species, the *Cyprædia* in our hemisphere are of Eocene occurrence.

The genus *Sulcocypræa* Conrad, represented at this time by only the genotype, *Sulcocypræa lintea* (Conrad), is confined to North America, occuring in the Jackson Eocene and Vicksburg Oligocene in Mississippi. Schilder (1932), disregarding the characters of the genotype, erroneously placed numerous North American species in this genus.

Siphocypræa Heilprin occurs exclusively in the Pliocene of Florida, and is represented only by its genotype, *Siphocypræa problematica* Heilprin. Schilder (1932) incorrectly included other hemispheric species of Cypræidæ in this genus, *i. e.*, *Cypræa amandusi* Hertlein and Jordan, *Cypræa henekeni* Sowerby, *Cypræa mus* Linnæus, *Cypræa carolinensis* Conrad, etc.

Only one specimen of the genus *Gisortia* has been collected in North America. Reference to this specimen was first published by Clark and Vokes (1936) ; it was described by Ingram (1940) as *Gisortia clarki,* from the Capay stage, Llajas formation, lower zone, Simi Valley, Ventura County, California.

The genus *Cypræa* is the most widely distributed in the fossil record, extending from the Cretaceous through Pleistocene and Recent. Geographically, fossil species extend from coast to coast in North America. Thirty-three species and subspecies of *Cypræa* are found in the fossil state in North America.

AGE OF CYPRÆIDÆ.

Present data would indicate that the Cypræidæ had a Jurassic or possibly even an earlier origin. At that time the center of dispersal seems to have been in Europe; the two Jurassic occurrences are from the Tithon stage in Sicily. The two species, *Cypræa gemmellaroi* and *Cypræa tithonica,* were described by Stefano (1882). If available stratigraphic records are reliable, data included here would indicate that a radiation from this possible Jurassic center of origin soon occurred, since three so-reported Cretaceous species, *Cypræa suciensis* Whiteaves[2] from British Columbia, *Cypræa squyeri* Campbell from Montana and *Cypræa mortoni* Gabb[2] from New Jersey, are found in North America. Since the peak of production of numbers of species occurred in the Eocene of North America, it is possible to assume that the Cypræidæ were well established and on a decline before the family was well established in the West Indies and South and Central America, where the maximum number of species thus far reported are of Miocene occurrence.

SOME RELATIONSHIPS BETWEEN FOSSIL AND RECENT CYPRÆIDÆ OF THE WESTERN HEMISPHERE

This section discusses generally the relationships between some of the living and fossil species of the Western Hemisphere. A number of included species do not occur in fossil or living states in North America, but the discussion seems pertinent since some of the South and Central American and neighboring island species are related to the North American Cypræidæ.

[2] Although these ''species'' possibly belong to the Cypræidæ, their generic rank is doubtful (see text).

Ten species, found as fossils in the Western Hemisphere, are still present in the living state. Three fossil species have traceable living descendants. The former species are *Cypræa spurca* Linnæus, *Cypræa spadicea* Swainson, *Cypræa cinerea* Gmelin, *Cypræa arabicula* Lamarck, *Cypræa sowerbyi* Kiener, *Cypræa albuginosa* Mawe, and *Cypræa isabella* Linnæus, *Cypræa nigropunctata* Gray, *Cypræa cervinetta* Kiener, and *Cypræa cervus* Linnæus. The latter species are *Nuclearia gabbiana* (Guppy), *Cypræa trinitatensis* Mansfield, and *Cypræa henekeni* Sowerby.

Nuclearia gabbiana (Guppy) has been reported by Maury (1917) and listed by Ingram (1939e) from the lower Miocene of Santo Domingo. It has a Miocene occurrence in Haiti, Trinidad, and Columbia. A living representative is the Indo-Pacific species, *Nuclearia nucleus* (Linnæus). This latter species is now abundantly found throughout the tropical and temperate waters of the Pacific. A probable descendant of *N. nucleus* in the Hawaiian Islands is *N. madagascariensis* (Gmelin), Ostergaard (1928), Ingram (1939d). Available fossil evidence thus indicates that the Santo Domingo area was possibly the center of origin for the present-day widely distributed *N. nucleus* (Linnæus).

The possible living descendants of *Cypræa trinitatensis* Mansfield are *Cypræa cervinetta* Kiener, *Cypræa zebra* Linnæus, and *Cypræa cervus* Linnæus. These species have a restricted Western Hemisphere distribution. In the fossil state *C. trinitatensis* has been reported from the lower Miocene of Trinidad.

Cypræa mus Linnæus is no doubt a living descendant of the Miocene "*Cypræa henekeni* group." This cowry group, made up of closely related forms, seems to have been the most widely spread of any Cypræidæ in Miocene time. *Cypræa henekeni* Sowerby has been reported from the Miocene of Santo Domingo by Maury (1925). The writer has examined specimens from the Miocene of Costa Rica and Panama. Other fossil forms of the Western Hemisphere which are closely related to the living *Cypræa mus* are: *C. henekeni* var. *poteronis* Ingram and *C. noulei* Maury from the Miocene of Santo Domingo, *C. merriami* Ingram from the Miocene of Panama, *C. henekeni amandusi* Hertlein and Jordan from the Miocene of Lower California, and *Cypræa* *cayapa* Pilsbry and Olsson from the Pliocene of Ecuador. Concerning the holotype of *C. cayapa,* Pilsbry and Olsson (1914) state: "Before being entombed in the sediments, the shell had been eaten into by boring organisms and partly encrusted with a growth of bryozoa so that it is possibly a shell derived from an older fossiliferous series."

The presence of *C. henekeni amandusi* in the lower Miocene of Lower California indicates that a western movement was made before the land bridge between North and South America was formed.

It seems likely, since the "*C. henekeni* group" was so well established in Miocene time, that some Eocene ancestor will possibly be found when collecting becomes more extensive in the Caribbean Region. This statement, of course, is based on present-day knowledge of fossil forms.

Today, *C. isabella* has a wide Indo-Pacific distribution, having been reported by Ingram 1937a, 1937b, 1938, 1939a, 1939b, from the Hawaiian Islands, Christmas, Washington, Palmyra, and Fanning Islands, Guam Island in the Mariana Group, American Samoa, and Makatea Island in the Tuamoto Archipelago, and from numerous localities by Schilder and Schilder (1939). *C. isabella* Linnæus has survived as a plastic species from Miocene time, and is one of the most common cowries in number of individuals throughout its present distributional range. It has been reported from the middle Miocene of Santo Domingo by Pilsbry (1921), Gabb (1873), Maury (1917), and Ingram (1939e). Woodring (1928) listed a subspecies, *Cypræa isabella patrespatriæ* Maury, from the Bowden fauna of Jamaica (middle Miocene). Pilsbry (1921) and Ingram (1939e) consider Maury's *patrespatriæ* to be a synonym of the species *C. isabella.* The distribution of the subspecies *C. isabella mexicana* Stearns, the apparent local descendant of the Miocene *isabella,* has been recorded by Hertlein (1937) . This worker listed the following localities where the subspecies is known to occur: Tres Marias and Revillagigedo Islands; Gulf of California; Cape San Lucas, Lower California; and Clipperton Island. Specimens listed as types are numbered 46581 in the United States National Museum and are from Tres Marias, Gulf of California. The Miocene collection from Santo Domingo is the oldest collection geologically and older than any fossil collections of *isabella* from the Indo-Pacific region. From present data, it seems likely that the living Indo-Pacific *isabella* originated in Miocene time in the Caribbean region. It then migrated eastward before the Canal Zone formed a barrier.

NONEXISTENT FORMS

The author believes as have others working with the Cypræidæ, notably Dall (1890), that the following species should be placed in a doubtful group. The doubtful or nonexistent species are *Cypræa annulifera* Conrad, *Cypræa lapidosa* Conrad, *Cypræa semen* Tuomey, and *Cypræa hemisphærica* Tuomey.

Dall (1890) stated that *C. annulifera* was merely a *C. annulus* Linnæus some Indian or trader may have dropped on the Yorktown Peninsula. The writer has examined this specimen in the Academy of Natural Sciences, Philadelphia, and also determined it to be, without doubt, *C. annulus* Linnæus. This species is a typical Indo-Pacific form, being one of the most common of Recent Cypræidæ. Concerning the remainder of the above species it is well to cite Dall (1890): "In Tuomey's Report on the Geology of South Carolina, 1848, among the Eocene fossils enumerated are *Cypræa lapidosa* Conrad, *C. semen* and *C. hemisphærica* Tuomey. These are mere names, never having been described or figured. The type of *C. lapidosa* is still to be found in the museum of the Academy of Natural Sciences. It is an unrecognizable internal cast which may not even be a *Cypræa*." The type of *C. lapidosa* in the above institution was examined by the writer, and is obviously an unrecognizable internal cast, doubtfully that of a *Cypræa*.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to the following individuals who have aided in the preparation of this work, and to the following institutions which have courteously offered their material for study: Prof. G. D. Harris and Dr. K. V. Palmer of the Paleontological Research Institution, Ithaca, New York; Dr. C. W.

Merriam of the Department of Geology of Cornell University, Ithaca, New York; Dr. Paul Bartsch, Dr. Harald Rehder, and Mr. F. S. MacNeil of the United States National Museum, Washington, D. C.; Dr. Henry A. Pilsbry, Dr. B. F. Howell, and Miss Anne Harbison of the Academy of Natural Sciences, Philadelphia, Pennsylvania; Dr. C. Weaver of the Department of Geology of the University of Washington, Seattle, Washington; Dr. G. Dallas Hanna and Dr. L. G. Hertlein of the California Academy of Sciences, San Francisco, California; Dr. Bruce L. Clark of the Department of Paleontology of the University of California, Berkeley, California; Dr. Charles T. Berry of the Johns Hopkins University, Baltimore, Maryland, and Mr. William T. Clark, Jr., of Cambridge, Massachusetts.

The United States National Museum, Washington, D. C.; the Academy of Natural Sciences, Philadelphia, Pennsylvania; Paleontological Research Institution, Ithaca, New York; California Academy of Sciences, San Francisco, California; the Wagner Free Institute of Science, Philadelphia, Pennsylvania; and the Geology Department of Cornell University, Ithaca, have extended every privilege to aid in the preparation of this paper.

Gratitude is expressed to Dr. W. E. Heming of Whittier College, Whittier, California, formerly of Cornell University, for checking the numerous early drafts.

LIST OF TYPE FOSSIL CYPRÆIDÆ OF NORTH AMERICA

Genus CYPRÆA Linnæus, 1758

Cypræa alabamensis de Gregorio[3]

C. alabamensis de Gregorio, 1890, Annales de Géologie et de Paléontologie, p. 59, pl. 9, figs. 8-10.

Holotype.—DeGregorio home, Via Mola 132, Palermo, Sicily.

Type locality.—Gosport sand, Claiborne, Alabama. Middle Eocene.

Cypræa ballista Dall Plate 1, figs. 1, 2

C. ballista Dall, 1915, United States National Museum Bulletin, 90, p. 85, pl. 6, figs. 9, 10, 11.

Holotype.—Numbered 165098 in United States National Museum.

Type locality.—Tampa silex beds at Ballast Point, Tampa Bay, Florida

[3] The specific description references are not repeated in the bibliography unless they are cited in discussions in the text.

Cypræa bayerquei Gabb

C. bayerquei Gabb, 1864, Geological Survey of California, Paleontology, vol. 1, pp. 129-130. Not *C. bayerquei* Gabb, 1869, Geological Survey of California, Paleontology, vol. 2, pp. 163-164, pl. 27, figs. 43a, 43b, 43c.

Holotype.—Numbered originally 31403 in the Museum of Paleontology, University of California, Berkeley, California; reported missing by Dr. Bruce L. Clark of the Department of Paleontology.

Type locality.—Clayton, Contra Costa County, California. Upper Eocene.

Cypræa carolinensis Conrad

C. carolinensis Conrad, 1841, Silliman's Journal, vol. 41, p. 346, pl. 2, fig. 6.

Holotype.—?

Type locality.—Natural Well, Duplin County, North Carolina. Upper Miocene.

Cypræa carolinensis floridanus Mansfield Plate 1, figs. 3, 4

C. carolinensis floridanus Mansfield, 1931, Proceedings of the United States National Museum, vol. 79, p. 6, pl. 1, figs. 2, 6, 7.

Holotype.—Numbered 371333 in the United States National Museum.

Type locality.—Tamiami Trail, 42 miles west of Miami, Florida. Upper Miocene.

Cypræa castacensis Stewart Plate 1, figs. 5, 6

C. bayerquei Gabb, 1869, Geological Survey of California, Paleontology, vol. 2, pp. 163-164, pl. 27, figs. 43a, 43b, 43c.

C. castacensis Stewart, 1926, Proceedings of the Academy of Natural Sciences, Philadelphia, vol. LXXVIII, p. 370, pl. 28, fig. 10.

Holotype.—Numbered 11690 in the Museum of Paleontology, University of California, Berkeley, California. Reported missing by Dr. Bruce L. Clark of the Department of Paleontology.

Type locality.—University of California locality 452, Grapevine Creek, Tejón, California. Upper Eocene.

Cypræa chilona Dall Plate 1, figs. 7, 8

C. chilona Dall, 1900, Transactions of the Wagner Free Institute of Science, vol. 3, pt. 5, p. 1195, pl. 39, figs. 1, 3.

Lectotype.—Numbered 498388 in the United States National Museum, Washington, D. C.

Type locality.—Chipola beds, Alum Bluff, Florida. Middle Miocene.

Cypræa eosmithii Aldrich

C. smithii Aldrich, 1886, Geological Survey of Alabama, Bulletin 1, p. 33, pl. 5, fig. 3.

C. eosmithii Aldrich, 1923, Proceedings of the Biological Society of Washington, vol. 36, p. 199.

Holotype.—Aldrich collection, not numbered. The Johns Hopkins University, Baltimore, Maryland.

Type locality.—Gregg's Landing, Alabama. Sabine, Eocene.

Cypræa estellensis Aldrich

C. estellensis Aldrich, 1921, Bulletin of American Paleontology, vol. 9, No. 37, pp. 14-15, pl. 2, fig. 1.

Holotype.—Alabama State Museum.

Type locality.—Sucarnoochee beds, Pursley Creek, Wilcox County, Alabama. Sabine (Wilcox) Eocene.

Cypræa fresnoënsis Anderson Plate 1, fig. 9

C. fresnoënsis Anderson, 1905, Proceedings of the California Academy of Sciences, third series, vol. 2, No. 2, p. 198, pl. 13, fig. 2.

Holotype.—Numbered 50, California Academy of Sciences, San Francisco, California.

Type locality.—Avenal sands, northwest of Coalinga, western Fresno County, California.

Cypræa healeyi Aldrich Plate 2, figs. 1, 2, 3, 4

C. healeyi Aldrich, 1923, Proceedings of the Biological Society of Washington, vol. 36, p. 199.

C. dalli Aldrich, 1894, The Nautilus, vol. 7, No. 9, p. 98, pl. 4, figs. 2, 2a.

Holotype.—Numbered 135157 in the United States National Museum.

Type locality.—United States National Museum number 319, Red Bluff, Chickasawhay railroad bridge, one and one-half miles south of Shubuta, Clark County, Mississippi. Oligocene.

Cypræa heilprini Dall Plate 2, figs. 5, 6

C. heilprinii Dall, 1890, Transactions of the Wagner Free Institute of Science, vol. 3, p. 166, pl. 11, figs. 2, 2a.

Holotype.—Numbered 114103 in the United States National Museum.

Type locality.—Ballast Point, Chipola beds, Florida. Lower Miocene.

Cypræa henikeni amandusi Hertlein and Jordan

C. amandusi Hertlein and Jordan, 1927, Proceedings of the California Academy of Sciences, fourth series, vol. 16, pp. 628-629, pl. 18, fig. 1, pl. 19, figs. 1, 4, 5.

Types.—Syntypes in Leland Stanford University type collection from locality 66 of Stanford University, California. Paratypes numbered 2663 and 2664 in the California Academy of Sciences, San Francisco, California.

Type locality.—San Ignacio Arroyo, 8 kilometers southwest of San Ignacio, Lower California. Insidro formation. Lower Miocene.

Cypræa jacksonensis Johnson Plate 2, fig. 7

C. jacksonensis Johnson, 1899, Proceedings of the Academy of Natural Sciences, Philadelphia, vol. 5, p. 77.

Holotype.—Numbered 7120 in the Academy of Natural Sciences, Philadelphia.

Type locality.—Jackson, Mississippi. Upper Eocene.

Cypræa kemperæ Nelson Plate 2, figs. 8, 9

C. kemperæ Nelson, 1925, University of California Publications in Geological Sciences, vol. 15, p. 424, pl. 56, figs. 9, 10; pl. 57, fig. 4.

Holotype.—Numbered 987 in the California Academy of Sciences San Francisco, California; Syntype, numbered 30541 in the Museum of Paleontology, University of California, Berkeley, California.

Type locality.—University of California locality number 3764 in the Martinez south of Simi Valley, Ventura County, California. Martinez Eocene. Lower Eocene.

Cypræa kennedyi Harris

C. kennedyi Harris, 1895, Proceedings of the Academy of Natural Sciences, Philadelphia, vol. 47, p. 78, pl. 8, figs. 12, 12a.

Holotype.—Texas State Museum (Harris 1895). Formerly in the Geology Department, University of Texas, Austin, Texas. Probably lost, Palmer (1937).

Type locality.—Dr. Collard's farm, Town Branch, Sparks Headright, Brazos County, Texas. Lower Claiborne Eocene.

Cypræa ludoviciana Johnson Plate 2, figs. 10, 11

C. ludoviciana Johnson, 1899, Proceedings of the Academy of Natural Sciences, Philadelphia, vol. 51, pp. 77-78, pl. 2, fig. 6.

Lectotype.—Numbered 13538 in the Academy of Natural Sciences, Philadelphia.

Type locality.—Montgomery, Grant Parish, Louisiana. Jackson Eocene. Upper Eocene.

Cypræa mathewsonii Gabb Plate 2, fig. 12

C. mathewsonii Gabb, 1869, Geological Survey of California, Paleontology, vol. 2, p. 164, pl. 27, figs. 44a, 44b.

C. kerniana Anderson and Hanna, 1925, Occasional Papers of the California Academy of Sciences, vol. 11, pp. 104-105, pl. 13, figs. 9, 10, 11.

Holotype.—Numbered 4217 in the Academy of Natural Sciences, Philadelphia, Pennsylvania.

Type locality.—Tejón group, Martinez, California. Upper Eocene.

Cypræa novasumma (Nelson) Plate 2, fig. 13

Ovula novasumma Nelson 1925, University of California Publications in Geological Sciences, vol. 15, No. 11, p. 425, pl. 57, fig. 2.

Holotype.—Numbered 30499 in the Museum of Paleontology, University of California, Berkeley, California.

Type locality.—Martinez, south side of Simi Valley. Martinez Eocene. Lower Eocene.

Cypræa nuculoides Aldrich Plate 2, fig. 19

C. nuculoides Aldrich, 1903, The Nautilus, vol. 16, No. 9, p. 98, pl. 3, figs. 4, 5, 6.

Holotype.—Geology Department of the Johns Hopkins University, Baltimore, Maryland. Specimens in the Aldrich collection are not numbered.

Type locality.—Dubose's Mill in west Alabama. Claiborne, middle Eocene.

Cypræa oakvillensis Van Winkle Plate 2, figs. 14, 15

C. oakvillensis Van Winkle, 1918, University of Washington Publications in Geology, vol. 1, No. 2, p. 88, pl. 7, fig. 19.

Holotype.—Numbered 7606 in the California Academy of Sciences, San Francisco, California.

Type locality.—University of Washington Paleontological locality number 161, about one mile west of Oakville on the Northern Pacific Railway. Lower Oligocene; *Barbatia merriami* zone.

Cypræa pilsbryi Ingram Plate 2, figs. 16, 17

C. pilsbryi Ingram, 1939, The Nautilus, vol. 52, No. 4, pp. 120-121, pl. 9, figs. 2a, 2b.

Holotype.—Numbered 781 in the Academy of Natural Sciences, Philadelphia, Pennsylvania.

Type locality.—Along the Cape Fear River, North Carolina. Miocene.

Cypræa pinguis Conrad

C. pinguis Conrad, 1854, in Wailes Report on the Agriculture and Geology of Mississippi, pl. 17 (corrected plate number); reprint 1939, Bulletin of American Paleontology, vol. 24, No. 86, p. 8, pl. 17, figs. 3a, 3b.

Holotype.—?

Type locality.—Jackson, Mississippi. Upper Eocene.

Cypræa simiensis Nelson Plate 2, fig. 18

C. simiensis Nelson, 1925, University of California Publications in Geological Sciences, vol. 15, p. 425, pl. 57, figs. 3a, 3b, 3c.

Holotype.—Numbered 30498 in the Museum of Paleontology, University of California, Berkeley, California.

Type locality.—Locality number 3818 of the Museum of Paleontology of the University of California. Martinez Eocene.

Cypræa sphæroides Conrad Plate 3, figs. 1, 2

C. sphæroides Conrad, 1847, Proceedings of the Academy of Natural Sciences, Philadelphia, vol. 3, p. 282.

Lectotype.—Numbered 13512 in the Academy of Natural Sciences, Philadelphia, Pennsylvania.

Type locality.—Vicksburg, Mississippi. Oligocene.

Cypræa squyerii Campbell Plate 3, figs. 3, 4

C. squyerii Campbell, 1892, The Nautilus, vol. 6, No. 5, pp. 50-51. (Named but not described.)

C. squyerii Campbell, 1893, The Nautilus, vol. 7, No. 5, p. 52, pl. 2, figs. 1, 2. (Described and figured.)

Holotype.—Numbered 13536 in the Academy of Natural Sciences Philadelphia, Pennsylvania.

Type locality.—Mingusville, Montana. Cretaceous.

Cypræa suciensis Whiteaves

C. suciensis Whiteaves, 1895, Proceedings and Transactions of the Royal Society of Canada, second series, vol. 1, section 4, No. 4, pp. 119-134,

Holotype.—In the Museum of the Geological Survey of Canada.

Type locality.—Sucia Islands, Vancouver, British Columbia. Cretaceous.

Cypræa tumulus Heilprin Plate 3, fig. 5

C. tumulus Heilprin, 1887, Transactions of the Wagner Free Institute of Science, vol. 1, p. 111, pl. 16, figs. 49, 49a.

Holotype.—Numbered 861 in the Wagner Free Institute of Science, Philadelphia, Pennsylvania.

Type locality.—Ballast Point, Hillsboro Bay, Florida. Lower Miocene.

Cypræa vaughani Johnson Plate 3, figs. 6, 7

C. vaughani Johnson, 1899, Proceedings of the Academy of Natural Sciences, Philadelphia, vol. 51, p. 78, pl. 2, fig. 7.

Holotype.—Numbered 9450 in the Academy of Natural Sciences, Philadelphia, Pennsylvania.

Type locality.—Hammett's Branch near Mt. Lebanon, Louisiana. Lower Claiborne Eocene.

Cypræa willcoxi Dall Plate 3, figs. 8, 9

C. willcoxi Dall, 1890, Transactions of the Wagner Free Institute of Science, vol. 3, pp. 166-167, pl. 11, figs. 2, 2a.

Holotype.—Numbered 112441 in the United States National Museum, Washington, D. C.

Type locality.—Two localities were cited by Dall (1890) in his description of this species; in the Chipola red sand, West Florida and at White Beach, near Osprey, Florida, at the northern part of Little Sarasota Bay, in a water-worn sandstone of yellowish-brown color. The holotype is from White Beach, near Osprey, Florida. Middle Miocene.

CYPRÆA OCCURING IN BOTH THE FOSSIL AND LIVING STATE IN NORTH AMERICA

Cypræa arabicula Lamarck

C. arabicula Lamarck, 1819, Suite du Genre Porcelaine, Annales Museum National d'Histoire Naturelle, Paris, vol. 16, p. 100.

This species occurs in the Pleistocene of Magdalena Bay, Lower California, (Jordan, 1936), and in the Pleistocene of Oaxaca, Mexico (Palmer and Hertlein, 1936), (Grant and Gale, 1931).

Cypræa sowerbyi Kiener

C. sowerbyi Kiener, 1845, Species General Iconographie Coquilles, Cypræa, pp. 38-39, pl. 7, fig. 5.

C. annettæ Dall, 1909, The Nautilus, vol. 22, p. 125.

This species occurs in the Pleistocene of Magdalena Bay, Lower California (Grant and Gale, 1931), (Jordan, 1936).

Cypræa spadicea Swainson

C. spadicea Swainson, 1823, Philosophical Magazine, vol. LXI, p. 376.

C. spadicea Gray, 1824, Monograph, Cypræidæ, Zoological Journal, vol. 1, pp. 500-501.

C. fernandoensis Arnold, 1907, Proceedings of the United States National Museum, vol. 32, p. 538, pl. 1, figs. 8, 8a.

This species has been reported from the Pleistocene and Pliocene of California, (Arnold, 1907), (Gabb, 1869), (Grant and Gale, 1931), (Ingram, 1938a) and from the Pleistocene of Magdalena Bay, Lower California, (Jordan, 1936).

* * *

Genus **SIPHOCYPRÆA** Heilprin, 1887

Heilprin (1887) proposed the name *Siphocypræa* as a subgenus. Here this name is given full generic rank. In establishing *Siphocypræa* Heilprin stated, "I propose this subgenus for a group of remarkable Cypræas, which differ from all other members of the family in the possession of a deep, comma-shaped sulcus or depression, occupying the apical portion of the shell, and which, as the posterior continuation of the aperture, is curved dextrally around the axis of involution . . . The other characters of the shell are those of the Cypræa generally." (Heilprin, 1887.) At this time the genotype is the only species included in the genus.

Siphocypræa problematica Heilprin Plate 3, figs. 10[4] 11

C. (*S.*) *problematica* Heilprin, 1887, Transactions of the Wagner Free Institute of Science, vol. 1, p. 87, pl. 4, figs. 12a, 12b.

Lectotype.—Numbered 915 in the Wagner Free Institute of Science. By personal communication, Mr. John G. Hope, Curator of the Wagner Free Institute of Science, Philadelphia, states by letter, " . . . there are three specimens in a tray from Caloosahatchie, Florida. These are marked "types," and agree with the three specimens figured by Heilprin in "Explorations in Florida, Transactions of the Wagner Free Institute of Science, Vol. 1." From these three specimens one should be selected as the lectotype; since the other two specimens were figured by Heilprin in the original description they would no doubt be designated as paratypes.

Type locality.—Caloosahatchie formation, below Fort Thompson, Florida. Pliocene.

Genus SULCOCYPRÆA Conrad, 1865

Conrad (1865) proposed the name *Sulcocypræa* as a subgenus. Here this name is given full generic rank.

Sulcocypræa lintea (Conrad) Plate 3, figs. 12, 13

C. lintea Conrad, 1847, Proceedings of the Academy of Natural Sciences, Philadelphia, vol. 3, p. 282.

Lectotype.—Numbered 13510 in the Academy of Natural Sciences, Philadelphia, Pennsylvania.

Type locality.—Vicksburg, Mississippi, Oligocene.

Conrad's (1847) description is included here since it apparently contained several errors which Aldrich (1894) corrected. Aldrich's (1894) corrections are also included.

Conrad's (1847) original description states, "Ovate, elevated, ventricose, with four approximate equal impressed lines; base ventricose, profoundly striated; labrum margin much thickened, profoundly striated; summit of labrum prominent; base slightly produced." Aldrich (1894) referring to the above description states, "Conrad's original description contains a misprint which seems to have been perpetuated in later publications. It should read "with *fine* approximate equal impressed lines," instead of "four . . lines." This writer examined the holotype and there is no doubt but that Conrad's original description should have read *fine* instead of *four.*

Genus CYPRÆDIA Swainson, 1840

Swainson (1840) in describing this genus stated, "Cypræform; the base contracted; the body-whorl not flattened beneath; shell

[4] Figure 10 is here designated as the lectotype.

cancellated; aperture of equal breadth throughout; a few thickened, short teeth on the pillar; lip at the base which is not internally concave." Three North American species belong to this genus. These are *C. gilberti* Palmer, *C. fenestralis* Conrad, and *C. subcancellata* (Johnson).

Cypraedia fenestralis Conrad — Plate 4, figs. 2, 3

C. fenestralis Conrad, 1854, in Wailes' Report on the Agriculture and Geology of Mississippi, pl. 17 (corrected plate number), figs. 3a, 3b, 3c; reprint, 1939, Bulletin American Paleontology, vol. 24, No. 86, p. 8, pl. 4, figs. 5a, 5b.

Lectotype.—Numbered 13197 in the Academy of Natural Sciences, Philadelphia, Pennsylvania.

Type locality.—Jackson, Mississippi. Upper Eocene.

Cypraedia gilberti Palmer — Plate 4, figs. 4, 5

C. gilberti Palmer, 1937, Bulletin of American Paleontology, vol. 7, pts. 1, 2, pp. 234-235, pl. 30, figs. 27, 28.

Holotype.—Numbered 2962 in the Paleontological Research Institution, Ithaca, New York.

Type locality.—Gosport sand, Monroe County, Alabama; Paleontological Research Institution, No. 104. Claibornian, middle Eocene.

Cypraedia subcancellata (Johnson) — Plate 4, figs. 6, 7

C. subcancellata Johnson, 1899, Proceedings of the Academy of Natural Sciences, Philadelphia, vol. 51, pp. 78- 79, pl. 2, fig. 9.

Holotype.—Numbered 7119 in the Academy of Natural Sciences, Philadelphia, Pennsylvania.

Type locality.—Smithville, Bastrop County, Texas. Lower Claiborne Eocene.

Genus GISORTIA Jousseaume, 1884

Coquille ovoide, déprimée en dessous, irrégulièrement arrondie et souvent tuberculeuse en dessus. Ligne d' intersection du manteau centrale; ouverture sinueuse dilatée en avant; bords peu ou point dentés, fossette antérieure du bord columellaire à peine sensible.

Gisortia clarki Ingram — Plate 4, fig. 1

G. clarki Ingram, 1940, Journal of the Washington Academy of Sciences, vol. 30, No. 9, pp. 376-377, fig. 1.

Holotype.—Numbered 14844 in the Museum of Paleontology, University of California, Berkeley, California.

Type locality.—Locality number 4052, Museum of Paleontology, University of California; Capay stage, Llajas formation, lower zone, Simi Valley, Ventura County, California. Eocene.

DOUBTFUL CYPRÆIDÆ

Two species of Cypræidæ, both of the genus *Cypræa,* are considered to be of doubtful specific rank. These are *Cypræa sabuloviridis* Whitfield, and *Cypræa mortoni* Gabb. *Cypræa mortoni* Gabb is of extremely doubtful rank. The writer has examined the holotype in the Academy of Natural Sciences, Philadelphia, and found that its generic character was questionable. This species probably belongs to the Cypræidæ, but since some of the cancellated genera of the family have a smooth interior, and would leave a smooth internal mold like a member of the genus *Cypræa,* it seems best to question the generic as well as the specific rank of this species until a topotype showing shell characteristics is found. No shell characters are preserved in the holotype. Only the holotype illustrations of *Cypræa sabuloviridis* Whitfield have been available to the writer; these show beyond doubt that this species was based on an internal mold, thus one can question the generic rank until topotype material is available. The illustrations indicate that this species may belong to the Cypræidæ.

Cypræa mortoni Gabb

C. mortoni Gabb, 1860, Journal of the Academy of Natural Sciences, Philadelphia, second series, vol. 4, p. 391, pl. 68, fig. 8 in text, 9 in plate.

Holotype.—Numbered 13535 in the Academy of Natural Sciences, Philadelphia, Pennsylvania.

Type locality.—Burlington County, New Jersey. Cretaceous.

Cypræa sabuloviridis Whitfield

C. sabuloviridis Whitfield, 1892, Monograph of the United States Geological Survey, vol. 18, p. 223, pl. 33, figs. 20, 21, 22.

C. sabuloviridis Whitfield, 1892, Geological Survey of New Jersey, vol. 2, pp. 1-402.

Holotype.—Rutgers University, New Brunswick, New Jersey.

Type locality.—''In the Upper layers of the Upper Green Marls at Shark River, and Farmingdale, New Jersey.'' (Whitfield, 1892.) Eocene.

Whitfield (1892) in both of the above references described this species as new. The above cited reports are word for word publications. Since two separate localities are cited it is questionable which should be chosen as the type locality.

BIBLIOGRAPHY

Aldrich, T. H.

New Tertiary fossils from Red Bluff, Mississippi, The Nautilus, vol. 7, No. 9, 1894, p. 98, pl. 4, figs. 2, 2a.

New species of Tertiary fossils from Alabama, Mississippi, and Florida, The Nautilus, vol. 16, No. 9, 1903, p. 98, pl. 3, figs. 4, 5, 6.

Arnold, R.

New and characteristic species of fossil mollusks from the oil-bearing Tertiary formation of southern California, Proc. U. S. Nat. Mus. vol. 32, 1907, pp. 525-546.

Conrad, T. A.

Observations on the Eocene formation, and descriptions of one hundred and five new fossils of that period, from the vicinity of Vicksburg, Mississippi, with an appendix, Proc. Acad. Nat. Sci., Philadelphia, vol. 3, No. 11, 1847, pp. 280-299.

———— *Catalogue of the Eocene and Oligocene testacea of the United States,* Amer. Journ. Conch., vol. 1, 1865, p. 31.

Clark, B. L., and Vokes, H. E.

Summary of marine Eocene sequence of western North America, Bull. Geol. Soc. Amer., vol. 47, 1936, pp. 851-878.

Dall, W. H.

Contributions to the Tertiary fauna of Florida, with especial reference to the Miocene silex-beds of Tampa and the Pliocene beds of the Caloosahatchie River, Trans. Wag. Free Inst. Sci., vol. 3, pt. 1, 1890, pp. 1-200.

Gabb, W. M.

On the topography and geology of Santo Domingo, Trans. Amer. Phil. Soc., vol. 15, new series (read 1872), 1873, pp. 49-259.

———— *Cretaceous and Tertiary fossils,* Geol. Surv. of Calif., Paleontology, vol. 2, 1869, pp. 1-299.

Grant, U. S., and Gale, H. R.

Pliocene and Pleistocene Mollusca of California and adjacent regions, Memoirs of San Diego Soc. Nat. Hist., Calif., vol. 1, 1931, pp. 1-1036.

Harris, G. D.

Tertiary paleontology of Texas, Proc. Acad. Nat. Sci., Philadelphia, vol. 47, 1895, pp. 45-88.

Heilprin, A.

Explorations of the West Coast of Florida in the Okeechobee Wilderness, Trans. Wag. Free Inst. Sci., vol. 1, 1887, pp. 1-134.

Hertlein, L. G.

A note on some species of marine mollusks occuring in both Polynesia and the western Americas, Proc. Amer. Phil. Soc., vol. 78, No. 2, 1937, pp. 303-312.

Ingram, W. M.

The family Cypræidæ in the Hawaiian Islands, The Nautilus, vol. 50, No. 3, 1937 (a), pp. 77-88.

———— *Cypræidæ from Christmas, Palmyra, Washington, and Fanning Islands,* The Nautilus, vol. 51, No. 1, 1937 (b), pp. 5-7.

——— *Cypræidæ from Guam*, The Nautilus, vol. 52, No. 1, 1938, pp. 5-7.
——— *Notes on the cowry, Cypræa spadicea Swainson*, The Nautilus, vol. 52, No. 1, 1938 (a), pp. 1-4.
——— *Cypræidæ from American Samoa with notes on species from Palmyra Island*, The Nautilus, vol. 52, No. 3, 1939 (a), pp 103-105.
——— *Cypræidæ from Makatea Island, Tuamotu Archipelago*, Occas. Papers, Bernice. P. Bishop Museum, vol. 14, No. 18, 1939 (b), pp. 323-325.
——— *Notes on Cypræa heilprini Dall and Cypræa chilona Dall with new species from the Pliocene of Costa Rica*, Bull. Amer. Paleontology, vol. 24, No. 84, 1939 (c), pp. 321-326.
——— *Endemic Hawaiian cowries*, Occas. Papers, Bernice P. Bishop Museum, 14, No. 19, 1939 (d), pp. 327-333.
——— *New fossil Cypræidæ from the Miocene of the Dominican Republic and Panama, with a survey of the Miocene species of the Dominican Republic*, Bull. Amer. Paleontology, vol. 24, No. 85, 1939 (e), pp. 329-340.

Jordan, E. K., and Hertlein, L. G.
The Pleistocene fauna of Magdalena Bay, Lower California, Cont. Dept. Geol. Stanford University, vol. 1, No. 4, 1936, pp. 107-173.

Jousseaume, F.
Étude sur la famille des Cypræidæ, Bull. Soc. Zool. France, t. 9, 1884, pp. 88-89.

Linnæus, C.
Systema Naturæ, Tomus 1, 1758.

Mansfield, W. C.
Miocene gastropods and scaphopods from Trinidad, British West Indies, Proc. U. S. Nat. Mus., vol. 66, No. 2559, 1925, pp. 1-65.

Maury, C. J.
Santo Domingo type sections and fossils, Bull. Amer. Paleontology, vol. 5, No. 29, pt. 1 1917, pp. 1-252.
——— *A further contribution to the Paleontology of Trinidad (Miocene horizons)*, Bull. Amer. Paleontology, vol. 10, No. 42, pp. 1-410.

Olsson, A. A.
Contributions to the Tertiary paleontology of Northern Peru, Part 4, The Peruvian Oligocene, Bull. Amer. Paleontology, vol. 17, No. 63, 1931, pp. 1-264.

Ostergaard, J. M.
Fossil marine mollusks of Oahu, Bull. Bernice P. Bishop Museum, No. 51, 1928, pp. 1-32.

Palmer, R. H., and Hertlein, L. G.
Marine Pleistocene mollusks from Oaxaca, Mexico, Bull. S. Cal. Acad. Sci., vol. 35, pt. 2, 1936, pp. 65 to 81.

Palmer, K.
The Claibornian Scaphopoda, Gastropoda, and dibranchiate Cephalopoda of the southern United States, Bull. Amer. Paleontology, vol. 7, No. 32, 1937, pp. 230-237.

Pilsbry, H. A.

Revision of W. M. Gabb's Tertiary Mollusca of Santo Domingo, Proc. Acad. Nat. Sci., Philadelphia, vol. 73, 1921, pp. 305-435.

Pilsbry, H. A., and Olsson, A. A.

The Pliocene fauna from western Ecuador, Proc. Acad. Nat. Sci., Philadelphia, 1941, p. 41, pl. 7, fig. 4.

Schilder, F. A.

Additions and corrections to Vredenburg's classification of the Cypræidæ, Rec. Geol. Sur. India, vol. 58, pt. 4, 1926, pp. 358-379.

——— *Fossilium Catalogus,* 1: *Animalia,* Pars 55: *Cypræacéa.* Published by W. Junk, Berlin, 1932.

——— *Cypræacca aus dem Tertiar von Trinidad, Venezuela, und den Antillen,* Abh. der Schweiz. Palæont. Gesell., Bd. 62, 1939, pp. 1-35.

Schilder, F. A., and Schilder, M.

Prodrome of a monograph on living Cypræidæ, Proc. Mal. Soc. London, vol. 23, pt. 4, 1939, pp. 119-231.

Sowerby, G. B.

Thesaurus Conchyliorum, Cypræa, pts. 26, 27, 28, 1870, pp. 1-58. London.

Stefano, G. di

Nuove spec. tithoniche, Natural. Siciliano, vol. 1, 1882.

Stearns, F. E. C.

On rare or little known mollusks from the West Coast of North and South America, with descriptions of new species, Proc. U. S. Nat. Mus., vol. 16, No. 941, 1893, pp. 341-352.

Swainson, W.

A treatise on Malacology, In the Cabinet Cyclopædia, edited by D. Lardner, 1823, p. 325.

Trechmann, C. T.

The yellow limestone of Jamaica and its mollusks, Geol. Mag., London, vol. 60, No. 8, 1923, pp. 337-367.

Tuomey, M., and Holmes, F. S.

Pliocene fossils of South Carolina, Russel and Jones, Publishers. 1857.

Vredenburg, E.

Classification of the Recent and fossil Cypræidæ, Rec. Geol. Sur. India, vol. 2, pt. 1, 1920, pp. 65-152.

Whitfield, R. F.

Gasteropoda and Cephalopoda of the Raritan clays and Greensand marls of New Jersey, Geol. Surv. New Jersey, vol. 2, 1892, pp. 1-402.

——— *Gasteropoda and Cephalopoda of the Raritan clays and Greensand marls of New Jersey,* Mon. U. S. Geol. Survey, vol. 18, 1892, pp. 1-402.

Woodring, W. P.

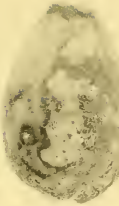
Miocene mollusks from Bowden, Jamaica, Part two, Carnegie Inst. Wash., Pub. No. 385, 1928, pp. 316-321.

PLATES

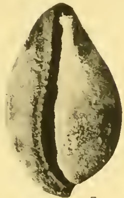
PLATE I (8)

EXPLANATION OF PLATE 1 (8)

1



2



5

6

3

4

7

8

9

PLATE 2 (9)

EXPLANATION OF PLATE 2 (9)

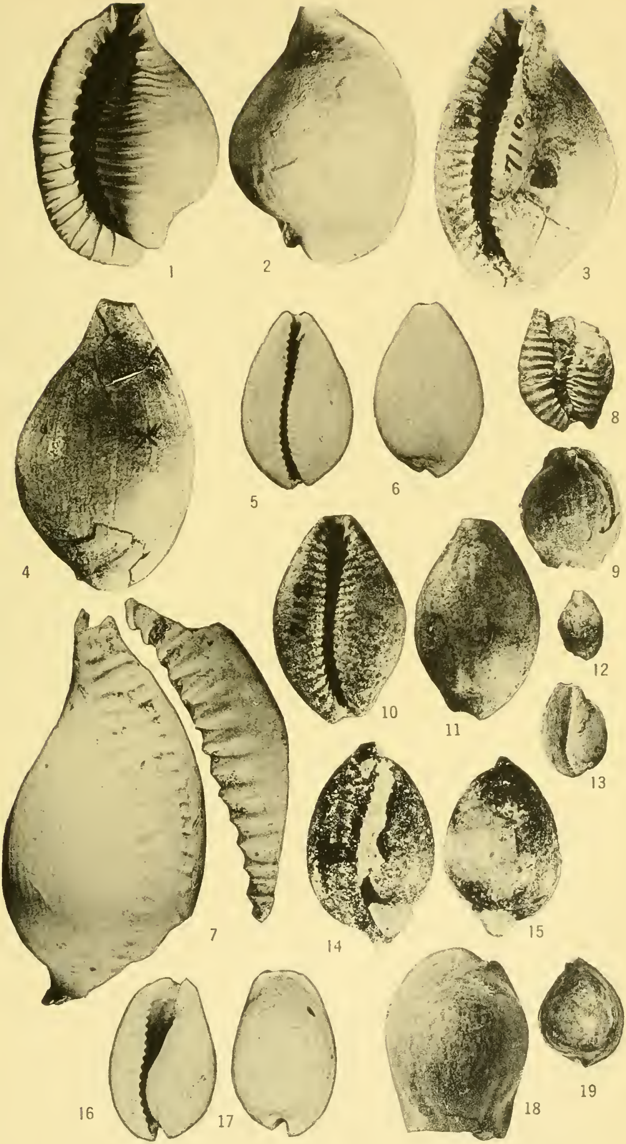

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

PLATE 3 (10)

EXPLANATION OF PLATE 3 (10)

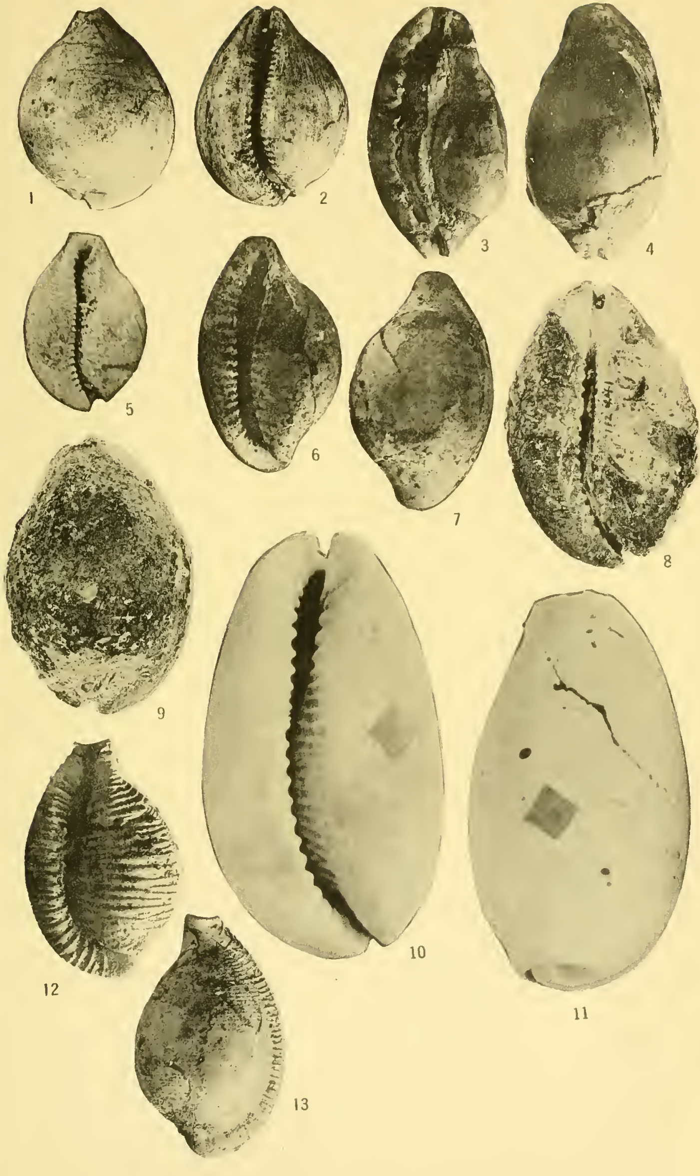
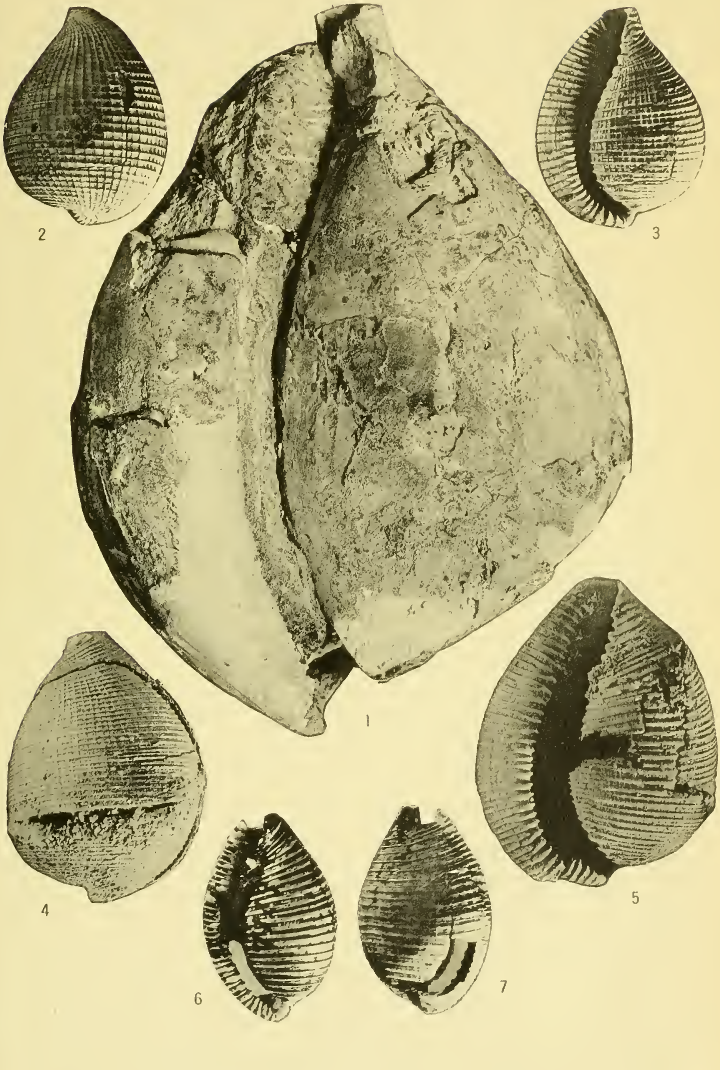

1
2
3
4
5
6
7
8
9
10
11
12
13

PLATE 4 (11)

EXPLANATION OF PLATE 4 (11)


2
3
1
4
5
6
7

BULLETINS

OF

AMERICAN PALEONTOLOGY

VOL. XXVII

NUMBER 105

1942

Paleontological Research Institution

Ithaca, New York

U. S. A.

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 27

No. 105

CEPHALOPODS FROM THE CLINTON GROUP OF NEW YORK

By

Rousseau H. Flower

University of Cincinnati

August 31, 1942

Paleontological Research Institution

Ithaca, New York

U. S. A.

CONTENTS

CEPHALOPODS FROM THE CLINTON GROUP OF NEW YORK

By

Rousseau H. Flower
University of Cincinnati

INTRODUCTION

The present study is largely concerned with the description of cephalopods from the Irondequoit limestone of the Clinton group, Middle Silurian, of western New York. This is based upon material collected by Ringueberg and Sarle and now deposited in the Buffalo Museum of Science. I wish to express my indebtedness to the Museum and to Dr. I. G. Reimann for an opportunity to study this interesting material.

Happily the cephalopods from the Clinton of New York described by Hall have been restudied by Foerste in various papers, and our knowledge of these forms is brought as near to completion as the scanty horizon data and the poor preservation of the types permit. The twelve described species are briefly listed below with the references to the more critical descriptions. One of these species may be Lockport in age rather than Clinton; the five described from the Rochester shale are known from flattened material; several others are inadequately known, and the precise origin of several in terms of present-day stratigraphy is uncertain. In view of the rather unsatisfactory condition of these known forms, the few cephalopods here described from the Irondequoit actually constitute a very considerable contribution to the nautiloid fauna, containing nine determinable new species, and the ubiquitous *Dawsonoceras americanum*. In addition, living chambers of smooth orthoceracones indicate the presence of at least two additional species which cannot be described until the phragmocones have been found and studied.

Faunally and systematically, the small group of cephalopods is of more than usual interest. The problem of the correlation of the Middle Silurian of New York with that of Indiana, Ohio, and Illinois is still very complex. Outside of New York, there has been no wide agreement as to the placing of the boundary between the Clinton and the Lockport. In New York, the limestones and shales of the Clinton in general furnish a sharp lithological contrast to the dolomites of the Lockport, but in the east-central area there seems to be great lithological similarity between the two divisions of the Middle Silurian. Further, no good faunal criteria have yet been found to mark the two divisions which can be regarded as infallible. It is probable that all pre-Racine beds in the east-central area may be safely referred to the Clinton. The present study offers some slight contribution to the support of this belief in that it establishes the presence of some supposedly characteristic Lockport genera in beds which are undisputably Clinton in age. As a consequence, the presence of such forms in pre-Racine strata in the east-central area cannot be considered as indicating Lockport age, as was formerly supposed.

CEPHALOPODS PREVIOUSLY REPORTED FROM THE CLINTON OF NEW YORK

The previously described species of cephalopods of the Clinton group of New York are few, and many of them are not adequately known at the present time. The largest number of species reported are from the Reynales limestone.

Armenoceras vertebratum Hall (1852, p. 94, pl. 29, figs. 1a-g; see also Foerste, 1928, p. 220, pl. 41, figs. 1-6). Described from the Reynales limestone of Reynales Basin, Niagara County, New York.

Michelinoceras (?) *virgulatum* Hall (1852, p. 95, pl. 29, figs. 2a-c; see also Foerste, 1928, pl. 45, fig. 5). This is reported by Hall as occuring in association with the preceding, and also at Lockport, New York, in the lower part of the Clinton. The species is very inadequately known. Apparently conspecific forms have been obtained from the Irondequoit limestone, but are thus far obtained only from silicified specimens inadequate for the necessary study of the internal structure.

Oncoceras (?) *subrectum* Hall (1852, p. 94, pl. 28, fig. 11a, b). This species is not adequately known for generic determination, the type consisting of a rapidly expanding phragmocone of some breviconic form. It is reported from the "lower silicious layers" of the Clinton group at Lockport. Possibly this is to be attributed to the Irondequoit rather than the Reynales limestone.

Discosorus conoideus Hall (1852, p. 99, pl. 28, figs. 13a-c). According to Hall, the species is from the green shale near the ridge road in the town of Ontario, Wayne County, and also in the "lower part of the group" at Lockport, Niagara County, New York. Foerste (1934, pp. 171-173) regards the horizon as probably Reynales.

Leurocycloceras clavatum Hall (1852, p. 104, pl. 31, figs. 4a-b; see also Foerste, 1928, p. 214, pl. 45, fig. 6). From the Herkimer sandstone, Herkimer County, New York. (Flower, 1941.)

Amphicyrtoceras (?) *abruptum* Hall (1852, p. 97, pl. 29, figs. 4a-b; see also Foerste, 1928, pp. 223-225, pl. 46, figs. 6a-b). Enough is not known of this species to determine its exact generic position. It might be referred to *Ectocyrtoceras* Foerste with equal justification. The horizon of this species is uncertain. Foerste's statement concerning the occurrence of this form is as follows: "This specimen was sent to Hall by Col. Jewett, of Lockport, New York, as coming from the upper limestone in the Clinton of that place, but for some unknown reason is referred by Whitfield and Hovey to some part of the Clinton at Reynales Basin. It is doubtfully listed by Chadwick from the Irondequoit, but in a letter to the writer he recognizes the possibility of its being Gasport age. If this species is properly placed in the Clinton, which seems doubtful, it is the earliest occurrence of depressed breviconic cyrtoceracones in pre-Lockport strata in America.

Dawsonoceras americanum (Foord) is listed as occurring in the Clinton in shales below the ore beds at Wolcott, Wayne County, New York. The specimen figured by Hall (1852, p. 96, pl. 29, fig. 3) is rather poorly preserved and considerably flattened. The surface markings, as represented here, lack the festooning characteristic of *Dawsonoceras americanum* or *D. an-*

nulatum. The location of this specimen does not seem to be known.

The Rochester shale carries a more abundant fauna than other members of the Clinton, but the species are rather inadequately known, owing largely to the poor state of preservation. The following are reported from the Rochester shale:

Dawsonoceras americanum (Foord). Though the original description was based upon several specimens from different localities and horizons in the Silurian of America, the type, selected by Foerste (1928, p. 35), is from the Rochester shale, and this form is therefore the typical one.

Leurocycloceras rochesterense Foerste (1928, p. 224, pl. 53, fig. 1). This is *Orthoceras imbricatum* Hall, 1851, not Hisinger.

Kionoceras subcancellatum (Hall). Originally figured as *Orthoceras cancellatum.* Known only from flattened portions of the shell.

Kionoceras rochesterense Foerste (1928, p. 307). Originally figured as *Orthoceras virgatum?* Sowerby (Hall, 1852, p. 291, pl. 63, figs. 2-3).

Amphicyrtoceras subcancellatum (Hall) (*Cyrtoceras ? cancellatum* Hall, 1852, p. 290, pl. 61, figs. 2a-c). This is a flattened brevicone of the general form of *Amphicyrtoceras,* but is known only from flattened specimens. This supplies the only authentic record of depressed breviconic cyrtoceracones in the Clinton of New York. The reference of *Amphicyrtoceras* (?) *abruptum* to the Irondequoit is highly questionable as noted above.

DESCRIPTION OF SPECIES

Genus ARMENOCERAS Foerste

Armenoceras subvertebratum Flower, n. sp. Plate 2, fig. 5

Conch orthoceraconic, depressed in section, expanding in the type from 14 mm. and 16 mm. to 30 mm. and 20 mm. in a length of 90 mm. The sutures are straight and probably slightly oblique, being slightly inclined orad on the dorsal side. The cameræ occur six in a length equal to the adoral conchial width throughout the known portion of the shell. The septa are deeply curved, having a depth of 8 mm. at a conchial width of 25 mm., which is equal to the depth of one and a half cameræ. The siphuncle is subcentral in the early portion of the shell, but rapidly moves to a position well ventrad of the center, so that at a shell width of 30 mm. the center of the siphuncle is located 4 mm. from the ventral wall. The segments of the siphuncle are slightly expanded for *Armenoceras* and are very similar to those of *A. vertebratum* (Hall) of the underlying Reynales limestone. The recurved portion of the neck is short, but at the adapical end of the segment a considerable area of adnation is developed. A typical segment at a conchial width of 25 mm. has a length of 6 mm. and expands from 4 mm. to 7 mm. The cameræ continue to the adoral end of the specimen without any trace of either the living chamber or any gerontic features. Within the siphuncle annulosiphonate deposits are developed; adapically traces of horizontal radial canals typical of the Sactoceratidæ and some *Armenoceras* can be seen. Episeptal and hyposeptal deposits are developed in the cameræ and as usual are markedly concentrated on the siphonal side of the shell.

Discussion.—This species agrees with *Armenoceras vertebratum* (Hall) (see Foerste, 1928, p. 220, pl. 41, figs. 1-6) in general aspect, particularly in the depth of the cameræ and the appearance of the siphuncle, but differs from it in the depressed section and the ventral position of the relatively small siphuncle in the mature portion. Although the siphuncle in *A. subvertebratum* is apparently subcentral in the earliest known stage, comparable stages of *A. vertebratum* have not been figured. Quite probably such stages alone would not be distinguishable.

A. subvertebratum is represented by two specimens, one of which has furnished the basis of this description. The other specimen is unsuitable as a basis for determination due to its distorted condition, but quite evidently it is conspecific with the first.

Type.—Holotype, Buffalo Museum of Science, No. E1077.

Occurrence.—From the Irondequoit limestone, at Gasport, New York.

Genus LEUROCYCLOCERAS Foerste

Leurocycloceras Foerste (1928, p. 272), based upon *Leurocycloceras raymondi* of the Racine dolomite of Wisconsin, was erected for the reception of annulated orthoceracones which differ from *Cycloceras* in lacking any fine transverse markings. The genus has been revised by the writer (Flower, Amer. Jour. Sci., 1941, vol. 239, No. 7) to include also forms which develop such broad flat annuli that the interspaces appear as narrow striæ on an otherwise smooth exterior. The genus contains most of the Silurian species of America which have been referred to *Cycloceras*, and also some which have been placed in *Geisonoceras*. The essential diagnostic features of the genus are internal, and although they are lacking in the species described below, which is known only from a living chamber, this form is so similar to several better known representatives of the genus that there is no doubt concerning its relationship.

Leurocycloceras ringuebergi Flower, n. sp. Plate 1, fig. 9

This species is known only from a living chamber, which is 130 mm. long, expanding from 28 mm. and 29 mm. to 35 mm. and 36 mm. Expansion is more rapid over the basal than on the adoral part, indicating the approach of maturity. The suture is straight and transverse. The septum has a depth of 7 mm. at a diameter of 28 mm. Half of the septum is preserved, but no trace of the septal foramen remains.

Surface features in the form of shallow distant impressed bands appear on the living chamber. Five to six bands occur in a length of 20 mm. As in other species, the bands are somewhat oblique.

Discussion.—The bands are much more closely spaced than in *L. bucheri* Flower (1941), and the rate of expansion is slightly greater. Further, that species attains a larger size while still lacking any trace of mature features. The surface features are also more closely spaced than in *L. clavatum* (Hall) of the Herkimer sandstone of the Clinton group of New York. The species is much smaller than *L. niagarense*, and the surface markings are more distant than in comparable portions of that form.

Type.—Buffalo Museum of Science, No. E10672

Occurrence.—Irondequoit limestone, Clinton group, Middle Silurian, from Lockport, New York.

Genus **KIONOCERAS** Hyatt

Kionoceras mutabile Flower, n. sp. Plate 1, figs. 1-4

This species, represented by several specimens from the Irondequoit, is characterized by the change of ornament which ranges from that of *Spyroceras* through *Protokionoceras* and finally *Kionoceras*. The earliest stage, represented by a slightly flattened silicified individual expanding from 2 mm. to 6 mm. in 24 mm., shows prominent longitudinal liræ spaced four in a width of 2 mm., crossed by slightly more prominent annuli which occur five in a length equal to an adoral diameter of 5 mm. near the adoral end of the specimen. The next stage, shown by an individual 22 mm. long expanding from 6 mm. to 9 mm., shows the longitudinal liræ becoming more widely spaced, four occurring in a width of 5 mm. at the adoral end. The annuli are reduced to transverse ridges, fainter than the longitudinal ones and spaced much more closely than before in relation to the diameter, occurring eight in a length equal to an adoral diameter of 8 mm. In addition, there appear at this stage fine longitudinal liræ in the interspaces between the stronger ridges, six or seven appearing in an interspace.

The latest stage shows the longitudinal ridges becoming more widely spaced and prominent, the areas between becoming slightly concave. Only faint traces remain of the longitudinal liræ, which apparently become more numerous; the transverse ridges, now as faint and nearly as frequent as the fine longitudinal ridges, produce a subcancellate surface pattern.

The cameræ are shown clearly only on one individual, which is slightly flattened. Here four cameræ occur in a length equal to the greater diameter of 17 mm.

Discussion.—The later stages of this species are comparable in proportions with the known parts of *Kionoceras rochesterense* Foerste and *Kionoceras subcancellatum* (Hall), both of the Rochester shale. *Kionoceras mutabile* differs from *rochesterense* in the presence of more prominent longitudinal ridges, and the development of fine longitudinal and transverse markings in the interspaces. From *K. subcancellatum*, it is distinguished by the equal and uniform strength of the prominent longitudinal ridges.

Types.—Syntypes, Buffalo Museum of Science, Nos. E10780, E10745, (three specimens) a-c.

Occurrence.—In the silicious bands of the Clinton, apparently Irondequoit limestone; Gasport and Lockport, New York.

Kionoceras perlineatum Flower, n. sp. Plate 2, fig. 6

The phragmocone of this species is unknown. The type consists of a portion of a living chamber 62 mm. in length and 32 mm. in basal diameter . The surface differs from that of *K. subcancellatum* (Hall) of the overlying Rochester shale in possessing an extra series of lines. In *K. subcancellatum* (Hall) only two series are developed. While the spacing of these lines is very similar in the two species, *K. perlineatum* possesses in addition a third series of alternating longitudinal liræ, weaker than the first two pairs. No transverse markings are developed. The internal mold is faintly constricted, producing an obscurely annulated appearance.

Discussion.—Of the described species the one most similar to *K. perlineatum* is probably *Kionoceras strix* (Hall and Whitfield) of the Liston Creek limestone, of Clinton age, of northern Indiana. In this species, which attains a much greater size than the fragment at hand from the Irondequoit limestone, the surface may possess three series of markings, which become progressively weaker, or the second and third may be subequal in strength.

In view of the lack of the phragmocone, the exact relationship of this species cannot be determined. *K. strix*, which is probably the most similar American form, is a *Virgoceras*, judging by its internal structure. No doubt a new generic name will have to be proposed for such longitudinally marked forms. The internal structure of the nearest neighbor, *Kionoceras subcancellatum* (Hall) of the Rochester shale of New York, is unknown. The species is known entirely from flattened individuals. *K. subcancellatum* shows very similar spacing of the primary and secondary longitudinal liræ, but lacks the third and finest series.

The ornament is faintly reminiscent of that of *Virgoceras cancellatum* Flower (1939, p. 162) in the series of alternating longitudinal markings, but there is no trace of the fine transverse markings which characterize that species. Whether or not there is any relationship cannot be determined until the phragmocone of this species has been studied.

Type.—Holotype, Buffalo Museum of Science, No. E10788.

Occurrence.—From the Irondequoit limestone, Clinton group, Middle Silurian, from Gasport, New York.

Genus **DAWSONOCERAS** Hyatt

Dawsonoceras Hyatt, 1884, Proc. Boston Soc. Nat. Hist., vol. 22, p. 276; Hyatt, in Zittel, 1900, Eastman Textb. Paleont., vol. 1, 1st ed., p. 518; 1913, 2d ed., p. 599; 1927, 3d ed., p. 599; Clarke and Ruedemann, 1903, New York State Mus., Mem. 5, p. 82; Grabau and Shimer, 1910, North American Index Fossils, vol. 2, p. 58; Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 225; Foerste, 1928, *ibid.*, vol. 23, p. 26.

Cedarvilloceras Shimizu and Obata, 1935, Jour. Shanghai Sci. Inst., sec. 2, vol. 2, p. 5.

Conch orthoceraconic, sometimes very slightly curved, with straight transverse sutures. The siphuncle is only slightly eccentric, orthochoanitic, with annulosiphonate deposits. Cameræ with mural deposits. The shell bears conspicuous annuli and transverse surface markings which typically consist of scalloped tranverse liræ. Ornamentation is variable, longitudinal liræ of secondary nature may appear, again the festoons may become vestigial, as may the annuli.

Discusion.—*Dawsonoceras* is a highly characteristic Silurian genus, being present in the Middle Silurian of Europe and also extending into both the Lower and the Upper Silurian of America.

Shimizu and Obata have proposed a new genus, *Cedarvilloceras,* based upon *Dawsonoceras nodocostatum* (McChesney). So gradual is the development of nodes and longitudinal liræ from the transverse festooned liræ that no line can be drawn between this genus and typical *Dawsonoceras.* Recognition of the genus serves no useful stratigraphic purpose and is opposed by the evidence of the close interrelationships existing among the various species involved. Therefore *Cedarvilloceras* is here regarded as a synonym of *Dawsonoceras.*

Formerly, only one species of *Dawsonoceras* was recognized in America, and this was considered conspecific with the European Silurian *Dawsonoceras annulatum* (Sowerby). An American species was later separated as a variety, *D. annulatum* var. *americanum,* which was subsequently given specific rank by Foerste (1928). Savage (1917, p. 156, pl. 9, fig. 22) described the only known Lower Silurian species, *Dawsonoceras tenuilineatum,* which approaches, in its surface features, the simple pattern popularly considered characteristic of *Cycloceras.* Foerste (1928) distinguished a number of other species of *Dawsonoceras* which range throughout the Middle Silurian. Specific criteria have been based almost entirely upon the details of the surface features of the shell. This limitation is essentially the result of the fragmentary nature and frequently poor preservation of the material and can be remedied only by a careful monographic treatment of the genus on the basis of much better material than is available at present. However, a brief review of the species serves to show that, inadequate as our knowledge is, considerable variation is evident in the recognized species as developed in various formations and localities, and that the recognized species are not so sharply set off from one another as one might wish.

Dawsonoceras americanum is discussed below, and specimens from the Irondequoit limestone are figured and described. The typical form is that found in the Rochester shales, where individuals are found in a flattened state. The greater number of *Dawsonoceras* of the Osgood limestone of Indiana appear to be identical, though with them there is associated an early form of *D. nodocostatum*. In a large suite of specimens from the Waldron shale of Tennessee, it is possible to recognize this species by the evenly spaced and relatively distant transverse markings, though some individuals show a tendency for the liræ to become crowded at the crests of the annuli. This feature is characteristic of *Dawsonoceras annulatum* (Sowerby) of the Silurian of Europe, but none of the Waldron specimens which I have seen show the crowding developed as strongly as is shown in the specimen from the Wenlock of England figured by Foerste (1928, pl. 5, figs. 1a-b).

In the Waldron and Osgood, there are discernible two types of *D. americanum,* one of which has the surface markings slightly more closely spaced than the other. The differences do not appear to be great enough to serve as a basis for the designation of these forms as distant species or even varieties at the present time, for enough material has not been gathered to preclude the possibility of intergradation in different parts of the same individual. However, it is interesting to note that there is an indication of variability here which points toward the different species which have been recognized from higher formations.

Forms with very closely spaced transverse markings, which tend to loose annuli and in which the festooning becomes extremely irregular, are present in the Osgood (Foerste, 1928, pl. 61, fig. 5) and are abundantly represented in the Waldron shale. These forms resemble *D. americanum* in the early stages, and there is demonstrable variability in the point at which the annuli are reduced, and fine, rather rugose, transverse markings predominate; nevertheless, they appear distinct enough to be set aside as a separate species for which the name *Dawsonoceras rugosum* is here proposed. This stock can be traced higher in the section, and the annuli are completely lost at a relatively early stage in a form from the Racine dolomite here described as *Dawsonoceras senescens*. A representative of this form was described by Foerste (1928, pl. 56, fig. 9) as *Geisonoceras wauwatosense*, a species which has typically much more regular surface features. Nevertheless, it is worth noting that in the ultimate development of this stock the essential features of the genus *Dawsonoceras* have been completely obliterated, and only the study of the intermediate Waldron species will show the actual relationship.

A second deviation from the stock of *annulatum* is characterized by the retention of regular festoons of transverse liræ, but the liræ become more distantly spaced. This is represented by *Dawsonoceras graftonense* Foerste (1928, p. 158, fig. 6) of the Racine dolomite, and fragments of a closely similar form, but one with even more distantly spaced liræ, occur in the Laurel limestone of southern Indiana.

Dawsonoceras hyatti Foerste is known only from portions of relatively late stages of large individuals and is characterized by broad rounded annulations and numerous finely festooned transverse liræ. The species was described from the "Lockport" of Hamilton, Ontario. Foerste referred specimens from other localities to it, none of which appear to be quite identical in surface features. Specimens from the Cedarville dolomite of Ohio (Foerste, 1928, pl. 58, figs. 1, 2, 4, 5) have the annuli less broadly rounded, and the transverse markings seem to be thickened at the middle of each of the shallow arcs making up the characteristic surface markings. Another specimen, this time from the Joliet limestone of Illinois (Foerste, 1928, pl. 59, fig. 2), is more typical, but in the later part of the shell the festoons are lost.

D. multiliratum (Foerste, 1928, p. 279, pl. 60, figs. 1-2) is the most distinctive form, bearing prominent longitudinal markings developed at the crest of the aligned festoons of the surface. It can be distinguished from *D. nodocostatum* by the broader and flatter annuli as well as by the more prominent longitudinal markings and the absence of nodes, features which are found to be rather variable.

The nodose forms are very close to those bearing longitudinal markings and are typified by *D. bridgeportense* and *D. nodocostatum*. *D. granti* Foerste of the Barton beds (Foerste, 1928, p. 29, pl. 4, fig. 1, pl. 28, fig. 5), which are probably to be classed as Rochester rather than Lockport, possesses marked longitudinal ornament but is not nodose. The dominant *Dawsonoceras* of the Liston Creek dolomite of northern Indiana is a form very close to typical *granti*. *D. nodocostatum* is represented by fragments from the Osgood limestone, and from the Laurel limestone, both of southern Indiana. The form was described from the Racine dolomite, where the species develops rather broader annuli than usual, and a form with narrower annuli has been reported by Foerste (1928, pl. 585, fig. 3) from the Cedarville dolomite of Ohio. *D. bridgeportense* is quite similar to *nodocostatum*, but has oblique annuli.

It is quite evident that the species, as now defined, are of little stratigraphic value. While typical *americanum* is not developed in the Lockport of New York or Ontario, and is apparently found in pre-Lockport strata in Indiana, it is probably unsafe to regard the form as confined to the Clinton. Further, many of the more complex species with more specialized ornament patterns, such as *nodocostatum*, are definitely known to make their appearance well below the development of the typical Racine. The specimens of the Guelph have not, as yet, been adequately studied. Foerste reported *D. hyatti* from the Port Byron (Foerste, 1928, p. 274, pl 48, figs. 2a-b), but the surface markings are not preserved and the annuli seem to be both much narrower and much lower than is typical of the species.

Dawsonoceras americanum (Foord) Plate 1, fig. 6

Orthoceras annulatum Hall, 1843, Nat. Hist. of New York, Geology, vol. 4, p. 110, fig. 1; table of illustrations, No. 14, p. 17, fig. 1.

Orthoceras undulatum Hall, 1852, Paleont. of New York, vol. 2, p. 293, pl. 64, fig. 1a-f; pl. 65, fig. 3.

Orthoceras annulatum Roemer, 1860, Silurian fauna western Tennessee, Breslau, p. 78, pl. 5, figs. 18a-b; Billings, 1866, Cat. Sil. Foss. Anticosti Geol. Surv. Canada, p. 83; Hall, 1868 (extras 1865), 20th Rep. New York State Cab. Nat. Hist., p. 351, pl. 20 (11) figs. 4-6, (see. expl. of plates, p. 393; rev. ed., 1870, p. 411, pl. 20, figs. 4-6; pl. 24, figs. 2-4, p. 433; Hall and Whitfield, 1895, Geol. Surv. Ohio, Pal., vol. 2, p. 147, pl. 9, fig. 1; Whitfield, 1882, Geol. Surv. Wisconsin, vol. 4, p. 298, pl. 19, fig. 1; Hall, 1882, 11th Ann. Rep. Indiana Dep. Geol. Nat. Res., p. 324; White., *ibid.*, 1882, p. 358, pl. 38, fig. 1; Chamberlin, 1883, Geol. Wisconsin, vol. 1, p. 194; Whiteaves, 1884, Pal. Fos., Geol. Surv. Canada, vol. 3, pt. 1, p. 38; Leslie, 1889, Geol. Surv. Pennsylvania, Rep. Progr., 4, p. 542, figs.; Grabau 1901, Buffalo Soc. Nat. Sci., Bull. vol. 7, p. 215, fig. 147; New York State Mus., Bull. 45, 1901, p. 215, fig. 147.

Orthoceras (Dawsonoceras) annulatum Kindle and Breger, 1904, 28th Rep. Dep. Geol. Nat. Res. Indiana, p. 472, pl. 19, figs. 3-4.

Orthoceras (Cycloceras) annulatum Foerste, 1899, Proc. Boston Soc. Nat. Hist., vol. 24, p. 282, pl. 8, fig. 5.

Dawsonoceras annulatum Grabau and Shimer, 1910, North American Index Fos., vol. 2, p. 58, figs. 1260, 1261.

Orthoceras (Dawsonoceras) annulatum var. *americanum* Kindle and Breger, 1904, 28th Rep. Dep. Geol. Nat. Res. Indiana, p. 472.

Dawsonoceras annulatum var. *americanum* Clarke and Ruedemann, 1903, New York State Mus., Mem. 5, p. 81, pl. 10, figs. 9-21; pl. 11, fig. 1; Grabau and Shimer, 1910, North American Index Fos., vol. 2, p. 58; Grabau, 1909, Michigan Geol. Surv., vol. 1, p. 196, pl. 28, fig. 8; pl. 29, fig. 1.

Orthoceras annulatum var. *americanum* Foord, 1889, Cat. Fos. Ceph. British Mus., p. 56; Whiteaves, 1895, Pal. Fos., Geol. Surv. Canada, vol. 3, pl. 2, p. 101.

Dawsonoceras americanum Foerste, 1928, Denison Univ. Bull., Sci. Lab. Jour., vol. 23, p. 34, p. 5, fig. 4; pl. 28, fig. 4; Foerste, 1928, *ibid.*, vol. 23, p. 279, pl. 61 fig. 5.

Although *Dawsonoceras americanum* (Foord), formerly the only species of *Dawsonoceras* recognized in the American Silurian, has been considerably restricted by Foerste, it still remains such a variable species that it is possible that more than one species is actually involved. The type, as selected by Foerste (1928, p. 35), is a specimen from the Rochester shale, and the Rochester forms can therefore be taken as typical. Unfortunately, the Rochester specimens are almost entirely flattened, and as a result little more can be used for species differentiation than the surface markings, which are somewhat variable even among specimens from the Rochester shale. The two specimens described below from the Irondequoit limestone appear to be identical with the Rochester form. The smaller one is of particular interest, for it is apparently the first unflattened representative which can be assigned here with absolute certainty. It shows the original section, condition of the phragmocone, and makes possible a closer study of the surface features with reference to the shell proportions.

Foerste figured a specimen from the Osgood limestone of Indiana which appears to be identical with the Rochester form (1928, pl. 5, figs 2-3). Some specimens from the Waldron shale appear to be identical, also, though, curiously enough, typical *americanum* has not been definitely established in the intermediate Laurel limestone.

Two specimens from the Irondequoit limestone appear to be not only well within the bounds of this rather variable species, but very similar to the type, which occurs in the overlying Rochester shales.

One of these is a small, undistorted shell, 95 mm. in length, expanding from 9 mm. to 16 mm. in a length of 90 mm. The sutures are straight and transverse. Slightly less than three cameræ occur in a length equal to an adoral diameter of 12 mm. The siphuncle is less than half a millimeter off center at the apex. The annuli are very faintly oblique, sloping apicad on the siphonal side. The annuli are spaced three in a length equal to an adoral diameter of 11 mm., and the same proportion is retained to the latest portion of this specimen. Festooned transverse liræ are uniformly spaced, slightly accentuated at the crests of the annuli but not crowded. Between six and seven liræ occur in the space between the crests of two annuli. The festooning is regular, about eight occurring on one-half of the shell.

The other, a much larger specimen, is somewhat flattened, but at a mean conchial diameter of 32 mm., five or six annuli occur in a length equal to that adoral diameter. The transverse liræ are slightly more closely spaced, varying from eight to twelve in the interval between the crests of two annuli.

Figured specimens.—Buffalo Museum of Science, No. 10784.

Occurrence.—In the Irondequoit limestone of Lockport, New York.

Dawsonoceras senescens Flower, n. sp.

Geisonoceras wauwatosense Foerste, 1928, Denison Univ. Bull. Sci. Lab., Jour., vol. 23, pl. 56, fig. 9.

Conch slender, with the annuli completely lost, at least in the later stages. Transverse markings show a complete loss of festooning, but in spacing and the irregular appearance of thickened liræ they are identical with those of *Dawsonoceras percostatum* Flower. The holotype expands from 14 mm. to 19 mm. in 40 mm. The coarser liræ average from 7 to 11 in a length of 10 mm.

Discussion.—The type of this species, which was figured by Foerste as *Geisonoceras wauwatosene* (Whitfield) differs from that species widely in the kind of surface markings, having the transverse markings closely and irregularly spaced, and lacking longitudinal markings entirely. In spite of the loss of the annuli and festooning, it is evident that this is the final expression of the stock represented in earlier strata by *Dawsonoceras percostatum.* In *D. senescens* practically all the features characteristic of *Dawsonoceras* are lost. Nevertheless its close similarity to *D. percostatum* leaves little doubt as to the relationship and origin of this form, and the erection of a new genus for this single anomalous species does not seem to be necessary. So far as is known at the present time, this species is the last member of the genetic line characterized by closely spaced markings within the genus *Dawsonoceras.*

Type.—Holotype, Museum of Comparative Zoology, No. 2303C.

Occurrence.—From the Racine dolomite, Middle Silurian, of Waumatosa, Wisconsin.

Genus **CYRTORIZOCERAS** Hyatt

Conch cyrtoconic compressed, rapidly expanding in contrast to the slender cyrtoconic *Ooceras.* The early stages are normally circular in section, but, relatively early, the greatest shell width appears dorsad of the center, and the height expands more rapidly than the width. On the mature living chamber, the lateral outlines become faintly convex, contracting toward the aperture. The aperture bears a hyponomic sinus which is usually clearly marked. The sutures are straight and transverse in the earliest stage, but in the adoral portion they tend to slope orad on the venter. Lateral lobes are variable in their occurrence and development, being best seen in the more strongly compressed species and rarely developed in the broader forms. The siphuncle is close to the venter. The segments in the genotype are described by Foerste as narrowly fusiform. In the Silurian species the segments are somewhat broader and are scalariform in vertical section. No deposits are known in the siphuncle or cameræ.

Discussion.—At the present time there seems to be insufficient justification for the separation of Ordovician and Silurian species. Any differences in the outline of the siphuncle appear to be minor and show too much variability in Silurian species to serve as a good basis for distinction. The genus is a large one, rather variable, and one which does not seem to be susceptible to further division, particularly when the known Bohemian as well as the American species are considered. It is very similar to the more slender *Richardsonoceras* Foerste of the Ordovician and appears to grade into *Ooceras,* both in form and surface features. Likewise the siphuncle seems to vary from slender segments, such as are found in the Ordovician genotype, some Silurian species, and the genus *Ooceras,* to broader segments, such as are found in the American Silurian species described below. Further expansion, of which there is evidence in some species, usually accompanied by a more compressed form, leads to, and apparently grades into, the condition found in *Oxygonioceras.* Indeed, the Silurian of Bohemia contains species, such as *Oxygonioceras simplex* (Barrande, pl. 19, figs. 8-11), which are transitional, both in outline and in the form of the siphuncle.

Lechritrochoceras and its allies appear to be more closely akin to typical *Ooceras* than to *Cyrtorizoceras,* being generally more slender in form and having suborthochoanitic siphuncular segments which vary in position from subcentral to ventral.

The taxonomic position of cyrtochoanitic cyrtoceracones with empty siphuncles is complex, and one to which there have been no recent contributions. It is quite evident that the genera are closely similar, varying somewhat in all features in section, ornament, sutures, expansion, and form of siphuncle. From the evidence of Barrande's abundant illustrations, it seems unlikely that any new morphological features await discovery. There is apparently a group of cyrtochoanitic cyrtoceracones ranging from slender to gibbous, probably becoming breviconic in part and also trochoceran in their mode of growth. This group will include several of Hyatt's families: the Rizoceratidæ; Oöceratidæ; and a new family which must be added for the reception of suborthochoanitic trochoceroids. A problem, still awaiting further information, is whether actinosiphonate genera, which differ but little from members of this group in other features, are actually related or merely isomorphic.

Cyrtorizoceras reimanni Flower, n. sp. Plate 2, figs. 1-4

This is a moderately large *Cyrtorizoceras* of rather slender form, moderately compressed section, and sutures which are transverse laterally. Holotype expands from 8 mm. and 8 mm. at apex, where the greatest width is dorsad of the center, to 34 mm. and 29 mm. at the base of the living chamber, in a ventral length of 75 mm. and dorsal length of 52 mm. Curvature is gradual in the apical half of the phragmocone, the radius of curvature of the venter being about 100 mm.; curvature increases orad so that its radius becomes about 80 mm. The living chamber becomes slightly straighter, more compressed, the lateral outlines becoming slightly convex. Its ventral length is 42 mm., its dorsal length, 38 mm. Height of aperture, 38 mm.; estimated width, 32 mm.

The phragmocone contains about 16 cameræ, increasing from 3 mm. to 6 mm. in depth. The sutures are without lateral lobes. The siphuncle, known from another specimen, is slightly convex, scalariform in vertical outline; the dorsal neck, recumbent; the free part of the connecting ring is in contact with the septum, then becoming free and straight adapically but faintly concave in the middle of more adoral segments, joining the preceding neck with no area of adnation. The ventral neck is orthochoanitic; the connecting ring convex in outline and broadly adnate to the preceding septum. As the sutures tend to become slightly oblique, passing orad on the venture, the siphuncle is separated from the venter by half its width, the septal foramen is markedly oblique, giving the siphuncular segments a most peculiar aspect. No deposits are known in either cameræ or siphuncle.

A paratype shows proportions which are sufficiently different from those of the holotype to suggest sexual dimorphism. The apical portion of the shell is more rapidly expanded, and curvature is more uniform over the phragmocone. The apex is blunt, increasing to a circular condition of 7 mm. diameter in a length of 4 mm. In a ventral length of 62 mm. and a dorsal length of 60 mm., the base of the living chamber is attained, where the height is 33 mm., and the width 28 mm. The living chamber has a dorsal length of 36 mm. and a ventral length of 44 mm., attaining a height of 36 mm. and a width of 29 mm. By the lateral convexity contraction of the living chamber, both specimens are mature.

The surface of the shell bears transverse liræ and striæ, often quite faint, but indicating the presence of a hyponomic sinus on the venter in every instance. The details of the ornament vary among individuals and also among parts of the same individual, those of the paratype illustrated being usually coarse.

Discussion.—An attempt to draw any telling comparisons between this and other species of *Cyrtorizoceras* has not been very successful. It belongs to a group of species in which the section is only moderately compressed, the compressed aspect being largely due to the occurrence of the greatest width of the shell well dorsad of the center and to the narrower condition of the venter than of the dorsum. Such species have been known abundantly in the Middle Silurian of the east-central area. The Clinton species is not closely similar in proportions or aspect to American forms, but recalls more strikingly many of the compressed cyrtoceracones of the Silurian of Bohemia, which are properly referred to the genus *Cyrtorizoceras* also.

Types.—Buffalo Museum of Science, Holotype, No. E10785; paratypes, E10785 (three specimens), E10787 (3 specimens included).

Cyrtorizoceras coralophilum Flower, n. sp. Plate 1, fig. 5

This is a moderately small species, only slightly curved adapically, and with the dorsum becoming straight over the mature living chamber. The venter is uniformly curved, the radius of curvature being 65 mm. The phragmocone expands from 22 mm. and 24 mm. to 25 mm. and 30 mm. in length of 25 mm. Four subequal cameræ occur in that length. The sutures rise orad on the venter, but the lateral lobes are scarcely developed. The siphuncle lies so close to the venter that its expanded portion is in contact with th ventral wall. The living chamber expands from 25 mm. and 30 mm. to 30 mm. and 34 mm. in a ventral length of 30 mm. Portions of the aperture are preserved. The lateral outlines are slightly convex over the living chamber, indicating a mature condition, although the last cameræ are not contracted. The surface bears fine, rather irregular, transverse liræ and striæ, which preserve the outline of the hyponomis sinus on the venter.

Discussion.—The broad section, the poor development of the lateral lobes of the sutures, and the straight dorsum should serve to distinguish this from all other species of *Cyrtorizoceras.*

Type.—Holotype, Buffalo Museum of Science, No. E10786.

Occurrence.—From a bioherm in the Irondequoit limestone at Lockport, New York.

Cyrtorizoceras filiferum Flower, n. sp. Plate 1, fig. 8

Conch relatively gibbous, expanding from a faintly compressed subcircular section of 13 mm. and 14 mm. to a strongly compressed condition of 38 mm. and 30 mm., where dorsum and venter are about equally rounded in the length of the phragmocone, which is 80 mm. ventrally and 20 mm. dorsally, with the radius of curvature of the venter increasing from 25 mm. at the apical third to 50 mm. at the adoral end. The living chamber has a ventral length of about 60 mm., the aperture being incomplete at that region; the dorsal length, 35 mm. The height of the aperture is 50 mm.; the estimated width, 38 mm. As in other *Cyrtorizoceras*, the lateral outline becomes faintly convex on the mature living chamber.

The sutures are straight and transverse adapically, but adorally they slope markedly orad on the ventral side, though without marked development of lateral lobes. The cameræ increase gradually in depth, measuring 6 mm. at the adapical end and 9 mm. at the adoral end of the phragmocone. The siphuncle is so close to the venter that the expanded segments are in contact with the ventral wall. In the plane of the septum, the foramen in 3 mm. and siphuncle expands to 5 mm., with a length of 5 mm. The outline of the segments is the same as in *C. reimanni*. As in that species, there is no evidence of organic deposits in either the cameræ or the living chamber.

Discussion.—This species is readily distinguished from its associate, *C. reimanni*, by its greater size, more rapid expansion, more oblique septa, and the siphuncle which is closer to the ventral wall. Forms of comparable proportions from the Silurian of America, all of which are considerably younger, show much better development of the lateral lobes of the sutures.

Type.—Holotype, Buffalo Museum of Science, No. E10806.

Occurrence.—In the Irondequoit limestone, Clinton group, Middle Silurian, at Gasport, New York.

Genus **LECHRITROCHOCERAS** Foerste

Lechritrochoceras Foerste 1926, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, p. 367, pl. 35, fig. 5; Foerste, 1930, *ibid.*, vol. 25, p. 46.

This genus was erected originally for the reception of simple trochoceroids with transverse but not longitudinal markings. However, Foerste later referred to the genus those species without transverse striæ and liræ which, by original definition, might better be placed in *Leurotrochoceras* Foerste. He drew the generic boundary at another point, placing in *Leurotrochoceras* only species which developed a strongly compressed section and a siphuncle which lies at least halfway between the venter and the center. Evidently in this case the disregard of the surface features as generic criteria is a matter of convenience and of necessity. The American species are largely preserved in dolomites, and it is not absolutely certain whether fine transverse markings might have been present originally, but were destroyed in all known specimens. It is further evident that the relationship between the genera is so close that the only justification for using two generic names is one of convenience in handling a large number of species, a practice that is to be seriously questioned.

Lechritrochoceras clintonense Flower, n. sp.

Plate 1, fig. 7; Plate 2, fig. 7

This is a small *Lechritrochoceras*, very slightly compressed in section throughout. The conch attains little more than one volution, though neither of the two known specimens retains clear gerontic features. In half a volution, the holotype expands from 4 mm. and 5 mm. to 9 mm. and 10 mm., in a ventral length of 35 mm. The living chamber follows, which describes a quarter of a volution and expands to 15 mm. and 16 mm. in a ventral length of 40 mm.

The sutures are straight and transverse. The cameræ occur about four to five in a length equal to an adoral diameter of 10 mm. The siphuncle lies slightly ventrad of the center of the conch and is suborthochoanitic in outline. At the base of the living chamber, it is 1 mm. in diameter and 3.5 mm. from the venter.

The surface bears rather narrow rounded costæ separated by wider concave interspaces. The fine liræ and striæ, usually seen in *Lechritrochoceras*, are lacking. The ribs occur about five in a length equal to an adoral diameter at diameters of 11 mm. and 15 mm. Adapically the ribs are very obscure and are probably completely absent on the first quarter volution. The aperture bears a broad hyponomic sinus, which is retained throughout, so that all costæ slope apicad on approaching the venter.

Discussion.—In the absence of fine surface markings, this species is closer to *Leurocycloceras* than to *Lechritrochoceras*, but in typical *Leurotrochoceras*, the section is strongly compressed and the siphuncle lies much closer to the venter. All of these features are exceedingly variable among species, however, and it is very questionable whether hard and fast boundaries can be found distinguishing these genera.

The species can be distinguished from many *Lechritrochoceras* by the absence of liræ and the faintly compressed section. *L. waldronense* (Hall) is known from specimens which are compressed, though it might be questioned whether they were originally so, as all specimens are somewhat flattened. *L. waldronense* has more closely spaced costæ. The rapid expansion and the completion of only one volution serve to distinguish this species from most of its relatives. *L. notum* (Hall) of the Racine dolomite is somewhat similar in aspect, but describes one and one-half volutions. *L. waldronense* (Hall) of the Waldron shale, *L. banisteri* (Hall) of the Racine dolomite, and *L. notum* of the Racine are most similar in proportions, being relatively rapid in their expansion, but all have much more closely spaced costæ.

Types.—Syntypes, Buffalo Museum of Science, No. E10794 (2 specimens).

Occurrence.—Irondequoit limestone, Clinton group, Middleport. N, Y.

REFERENCES

Flower, R. H.

Revision and internal structure of Leurocycloceras, Amer. Jour. Sci., vol. 239, No. 7, 1941, pp. 469-488, 3 pls.

Foerste, A. F.

American arctic and related cephalopods, Denison Univ. Bull. Sci. Lab., Jour., vol. 23, 1928, pp. 1-110, pls. 1-29.

——— *A restudy of American orthoconic Silurian cephalopods,* Denison Univ. Bull., Sci. Lab., Jour., vol. 23, 1928, pp. 236-320, pls. 48-75.

——— *A restudy of some of the Ordovician and Silurian cephalopods described by Hall,* Denison Univ. Bull., Sci. Lab., Jour., vol. 23, 1928, pp. 173-230, pls. 40-47.

Hall, J.

Paleontology, New York State Geol. Sur., vol. 2, 1852.

Savage, T. E.

Stratigraphy and Paleontology of the Alexandrian series in Illinois and Missouri, Illinois State Geol. Surv., Bull. 23, 1917.

PLATES

PLATE I (12)

EXPLANATION OF PLATE 1 (12)


1
2
3
4
5
6
7
8
9

PLATE 2 (13)

EXPLANATION OF PLATE 2 (13)

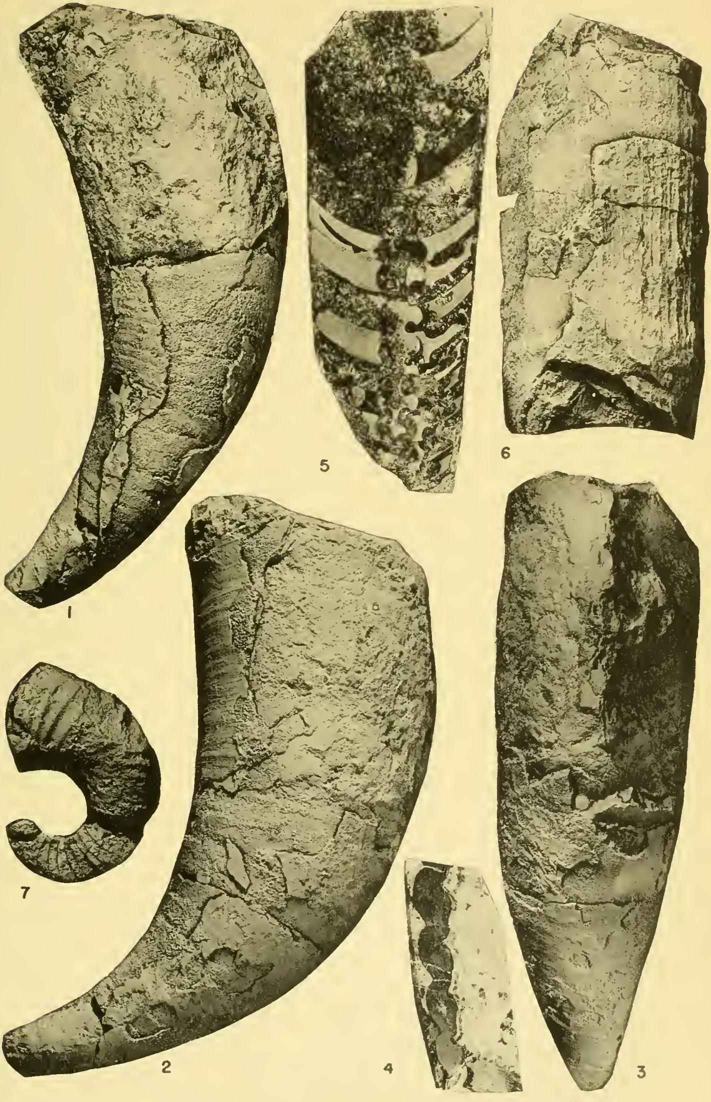
Figure Page

1-4. **Cyrtorizoceras reimanni** Flower, n. sp. 21
(1) Paratype, lateral aspect; (2) holotype, lateral aspect; (3) holotype, ventral aspect; (4) portion of siphuncle from a second paratype. Buffalo Museum of Science, E10785, (figs. 1-3). E10787 (fig. 4). Irondequoit limestone, Gasport, N. Y.

5. **Armenoceras subvertebratum** Flower, n. sp. 8
Section of adoral end of holotype parallel to bedding. The surface exposed is slightly oblique to the transverse plane of the specimen, being nearer the venter on th right than on the left. Buffalo Museum of Science, No. E1077. Irondequoit limestone, Gasport, N. Y.

6. **Kionoceras perlineatum** Flower, n. sp. 11
Holotype, Buffalo Museum of Science, No. E10788. Irondequoit limestone, Gasport, N. Y.

7. **Lechritrochoceras clintonense** Flower, n. sp. 25
Syntype, showing proportions of cameræ. Buffalo Museum of Science, No. E10794. Irondequoit limestone, Middleport, N. Y.


1
2
3
4
5
6
7

BULLETINS

OF

AMERICAN

PALEONTOLOGY

VOL. XXVII

NUMBER 106

1942

Paleontological Research Institution
Ithaca, New York
U. S. A.

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 27

No. 106

Tertiary and Quaternary Fossils from the Burica Peninsula of Panama and Costa Rica

By

A. A. Olsson

December 25, 1942

Paleontological Research Institution
Ithaca, New York
U. S. A.

CONTENTS

TERTIARY AND QUATERNARY FOSSILS FROM THE BURICA PENINSULA OF PANAMA AND COSTA RICA

By
A. A. Olsson

FOREWORD

In this paper,* the following new genera and subgenera are proposed:

Genus *Luciploma* of Veneridæ
Subgenus *Panacoma* of *Macoma* Leach
Subgenus *Buridrillia* of *Clathrodrillia* Dall
Subgenus *Charcolleria* of *Cancellaria* Lamarck
Subgenus *Longitrella* of *Mitrella* Risso
Subgenus *Cotonopsis* of *Strombina* Mörch

All the new species described in this paper are from the Burica Peninsula except:

Cancellaria (*Bivetopsis*) *charapota*, n. sp. Miocene of Ecuador
Cancellaria (*Charcolleria*) *perdiciana*, n. sp. Miocene of Colombia
Cancellaria colombiana, n. sp. Miocene of Colombia
Dalium ecuadoriana, n. sp. Oligocene of Ecuador
Dentalium (*Fissidentalium*) *esmeraldum*, n. sp. Oligocene of Ecuador

INTRODUCTION

The principal purpose of this paper is the description and illustration of certain new species of mollusks of late Tertiary and Pleistocene age from the Burica Peninsula of southwestern Panama and southern Costa Rica. Most of this material was collected by Mr. R. A. Terry during several years of extensive geologic studies on the Burica Peninsula and adjoining areas. Other collections were made by Mr. Terry and myself in 1938. I am also deeply indebted to Mr. Mark Trafton Jr. of the United Fruit Company, stationed at Puerto Armuelles, for much interesting Pleistocene, as well as Recent, material. A few new species of gasteropods from the Oligocene and Miocene of northern Colombia and western Ecuador have been included because of their special interest.

* Manuscript submitted, Oct. 1, 1942.

The Burica Peninsula forms the southwestern corner of the Republic of Panama and hence also the Pacific, or terminal, portion of the international boundary with Costa Rica. The peninsula itself is about 20 miles long with an average width of about 5 miles. It is for the most part covered with forest and only sparsely inhabited at a few places. In the north, where the peninsula widens and merges with the mainland, the interior portions are very rugged, and high cliffs of igneous rocks border the shore on the Costa Rican side. These heights give rise to a small mountain peak in the interior, known as Pico de Burica, with an elevation of about 700 meters. Immediately north of Pico de Burica is a belt of low lands between 15 and 20 miles wide and drained, in part, in Costa Rica by the Rio Coto flowing westward into the Gulf of Dulce, and in Panama by the Rio Chiriqui Viejo flowing southeast into the Bay of Charco Azul. The east shore of the peninsula is washed by the waters of Charco Azul, the deepest bay along the Panama south coast and the western part of the greater Gulf of Chiriqui.

The geology of the Burica Peninsula has been rather extensively investigated by Mr. R. A. Terry in connection with his broader regional studies in Panama. A short discussion of certain features of the geology of the region, accompanied by a sketch map of the areal geology and depth soundings in the Bay of Charco Azul, is given by Terry (1941) in his paper on "Submarine Valleys off the Panamanian Coast."

Pico de Burica, as well as the adjoining rugged parts of the peninsula, is principally formed of hornblende andesite, the common igneous basement rock in Panama, locally overlain by, or in fault block contact with, upper Eocene limestones. This zone of basement outcrop is part of an old uplift or structural trend along which are also located the older rocks exposed in the interior of the Peninsula of Osa in southern Costa Rica and in the island of Coiba off the coast of Veraguas. In a similar way, the low lands between Pico de Burica and the interior highlands lie in a parallel trough or geosyncline which also includes the present Gulf of Dulce, the Bay of Charco Azul and the Gulf of Chiriqui. This trough is filled with a thick section of normal

Tertiary sediments, including Eocene, Oligocene and Miocene beds of which exposures are found at David, Brenón and other localities along the north side.

In most parts of Panama, where Eocene beds are known to occur, they are normally overlain by thousands of feet of shales of Oligocene and Miocene age. These formations are missing, however, on the Burica Peninsula or the region immediately south of Pico de Burica, although well developed in the Rio Coto-Rio Chiriqui-Viejo syncline as previously noted. The Pliocene deposits of the peninsula overlap the older rocks of Pico de Burica so that this outpost mountain was an island during the formation of these beds. On the peninsula, the formational strike is normally northwest and southeast with the regional dip towards the north. Therefore, as we go south towards Burica Point, we encounter progressively older beds in the following manner. In the northern zone near Puerto Armuelles, the outcrops are of Pleistocene age and consist, for the most part, of sands and shales belonging to the Armuelles formation (Olsson, 1942). Fossils are plentiful in certain horizons. The basal portion of the Armuelles formation is formed by thick beds of conglomerate well exposed at Punta de Piedra a few miles south of Puerto Armuelles. This conglomerate marks an unconformity, and beneath it lies a great thickness of predominantly blue shales, rich in small Foraminifera, known as the Charco Azul formation (Olsson, 1942). This formation is of Pliocene age and outcrops extensively on both sides of the peninsula and in many rivers and quebradas in the interior. To the south, the lower beds of the Charco Azul become increasingly tuffaceous and sandy and grade down into the Burica sandstones (Olsson, 1942). These sandy beds represent the lowest rocks exposed at the southern end of the peninsula. Only a small fauna is known from the Burica sandstones and their age cannot be definitely fixed. The stratigraphy would seem to indicate that they belong to the same sedimentary cycle as the Charco Azul and consequently are tentatively referred to the uppermost Miocene or lowermost Pliocene. The thickness of the Burica sandstones is not known since they are only partly exposed, but both the Armuelles and Charco Azul formations have a maximum thickness of about 4000 feet. These formations have been strongly folded and faulted, and their structure bevelled by erosion.

The Burica Peninsula is the most active seismic region in present-day Panama, the continuation of the earth movements which have so strongly deformed the sedimentary formations. That the region has undergone great changes during the late Tertiaries is clearly revealed by its geology. The general northerly dip of the peninsular formations is partly an original depositional feature off an old land, the northern shoreline of which was near Burica Point. In Miocene times, this Pacific land included the peninsula as far north as the Rio Coto syncline, as the general overlap of the Pliocene beds on basement rocks indicate. The destruction of this land in the later Tertiary and during the Pleistocene was accompanied by violent volcanic activity, and consequently volcanic or tuffaceous materials become increasingly more important as a sedimentary constituent towards the south. The geology of the Burica Peninsula has an important bearing on the Tertiary history of Panama and on the larger regional problems dealing with the tectonic development of the Pacific coast of Central America and northern South America. A short discussion of the history of the region, based principally on the submarine topography of Charco Azul, has been contributed by Terry. The common occurrence of many fossils with deep-water characteristics, in the Pliocene formations in particular, is the most interesting feature of the entire fauna and fully supports the geologic interpretation of great changes in the Pacific region during the late Tertiary and Quaternary periods.

STRATIGRAPHY AND PALEONTOLOGY

THE ARMUELLES FORMATION (OLSSON, 1942)

This formation outcrops typically near Puerto Armuelles, and good sections are found in most streams in the vicinity, such as Rio Guanabanon, Rio Corotu, Quebrada Rabo de Puerco and Rio San Bartolome. The beds consist principally of gray, well-bedded, foraminiferal shales and soft sandstones. Some layers, particularly near the base, are lignitic, containing leaves and partially mineralized wood. The upper part of the formation is generally quite sandy. These upper beds, outcropping in Quebrada Rabo de Puerco and in Monte Verde Ravine, are rich in fossil mollusks, and most of the known species were collected from these horizons. The basal portion of the formation contains at least two prominent conglomeratic horizons separated by an interval of foraminiferal shale, their combined thickness being about 600 feet. The conglomerate at the base is generally strongly consolidated and is interbedded with blue sandstones. This conglomerate forms Punta de Piedra on the shore of Charco Azul about 4 miles south of Puerto Armuelles. At this place, it contains boulders of andesite, red jasperoids and other igneous rocks sometimes 6 feet or more in diameter. Its contact with the underlying blue shales of the Charco Azul formation is an unconformity, the upper layers of the Pliocene shales having been deeply brecciated and the fissures filled with fossiliferous sand. This zone of unconformity has yielded an exceptionally interesting faunule of small mollusks.

The molluscan fauna of the Armuelles formation comprises about 130 known species. It is a typical shallow-water assemblage, very similar to that living in near-shore waters along the present south coast of Panama. A few species appear to be new and are described in this paper. A few others, such as *Chione traftoni* and *Nœtia reversa magma*, occur in the Pliocene of Ecuador and elsewhere. The very high percentage of Recent species in the Armuelles beds and its close relation to the present fauna of Panama shows that the formation is not older than the early Pleistocene.

Fossils from Rabo de Puerco and Monte Verde Ravine.—

Arca (Scapharca) concinna Sby.
Arca (Scapharca) emarginata Sby.
Arca (Cunearca) nux Sby.
Barbartia (Acar) illota Sby.
Nœtia reversa magma MacNeil
Pinna, sp.
Ostrea, sp.
Pecten dentatus Sby.
Pecten ventricosus Sby.
Plicatula dubia Hanley
Crenella ecuadoriana Pils. and Olss.
Anomia peruviana d'Orb.

Placuanomia panamensis, n. sp.
Pandora (Clidiophora), sp.
Thracia (Cyathodonta) dubiosa Dall
Thracia (Cyathodonta) undulata Con.
Eucrassatella gibbosa Sby.
Crassinella, sp.
Chama corrugata Brod.
Chama (Echinochama) californica Dall
Diplodonta, sp.
Diplodonta (Felaniella), sp.
Cardium (Mexicardium) procerum Sby.
Cardium (Trachycardium) senticosum Sby.
Cardium (Trigoniocardia) graniferum Brod. and Sby.
Cardium (Lævicardium) elenense Sby.
Cyclinella, sp.
Macrocallista squalida Sby.
Macrocallista traftoni, n. sp.
Pitar lenis Pilsbry and Lowe
Pitar (Lamelliconcha) concinna Sby.
Chione (Chionopsis) amathusia Phil.
Chione (Chionopsis) traftoni Pils. and Olss.
Chione (Lirophora) mariæ d'Orb.
Tellina (Eurytellina), sp.
Tellina (Eurytellina) panamanensis Li
Tellidora burnetti Brod. and Sby.
Macoma lamproleuca Pilsbry and Lowe
Macoma (Psammacoma) panamensis Dall
Macoma (Cymatoica) undulata Hanley
Semele lævis Sby.
Semele jaramija Pils. and Olss.
Semele cf. californica Con.
Tagelus violaceus Carp.
Tagelus (Mesopleura) peruvianus Pils. and Olss.
Solecurtus broggii Pils. and Olss.
Solecurtus galapaganus Dall
Mactra (Micromactra), sp.
Labiosa undulata Gould
Corbula biradiata Sby.
Panopea, sp.
Bullaria punctulata A. Adams.
Terebra (Terebra) robusta Hds.
Terebra (Strioterebrum) panamillata, n. sp.
Conus zebra Sby.—(Smaller spire than most Recent specimens)
Conus arcuatus Sby.
Conus virgatus Rve.
Conus tornatus Brod.
Polystira oxytropsis Sby.
Polystira, sp.
Turricula tuberculata Brod. and Sby.
Clathrodrillia inequistriata Li
Clathrodrillia (Carinodrillia) halis Dall
Crassispira tapocana Dall
Nannodrillia nana Dall
Cancellaria (Cancellaria) urceolata Hds.
Cancellaria (Euclia) cremata Hds.

Cancellaria (Euclia) cassidiformis Sby.
Oliva araneosa C. B. Adams.
Oliva polypasta Duclos
Olivella, sp.
Marginella sapotilla Hds.
Marginella minor Hds.
Lyria (Enæta) harpa Barnes
Latirus castaneus Rve.
Galeodea patula Brod.
Hanetia anomala Rve.
Hanetia pallida Brod. and Sby.
Colubraria, sp.
Cymatium weigmani Anton
Distorsio decussatus Val.
Engina maura Sby.
Cantharus elegans Gray
Triumphis distorta Lam.
Nassa pagoda Rve.
Phos veraguensis Hds.
Metula amosi Vanatta
Columbella major Sby.
Cosmioconcha modesta Powis
Strombina recurva Sby.
Strombina gibberula Sby.
Murex recurvirostris Brod.
Phyllonotus radix Lam.
Thais biserialis Blv.
Semicassis centiquadratus Val.
Ficus decussata Wood
Cypræa, sp.
Strombus gracilior Sby.
Turritella tigrina Kiener
Architectonica granulata Lam.
Crepidula onyx Sby.
Crepidula aculeata Brod.
Crucibulum (Crucibulum) umbrella Desh. (rudis Brod.)
Crucibulum (Crucibulum) spinosum Sby.
Crucibulum (Dispotæa) imbricatum Brod.
Calyptræa conica Brod.
Calyptræa mamillaris Brod.
Natica broderipiana Reclus
Natica macrochiensis Gmelin
Polinices (Polinices) uber Val.
Neritina, sp.
Circulus occidentalis Pils. and Olss.
Dentalium (Fissidentalium) buricum, n. sp.

FOSSILS FROM THE ZONE OF UNCONFORMITY AT PUNTA DE PIEDRA

The basal conglomerate of the Armuelles formation, outcropping at Punta de Piedra about 4 miles south of Puerto Armuelles, lies unconformably upon the Charco Azul. The zone of unconformity is indicated, in part, by a brecciation of the Charco Azul shales, with the blocks recemented by seams of fossiliferous sand. From this sand filling, was obtained a rich assemblage of small mollusks of which the following list is a partial determination. This fauna is probably Pleistocene and represents shells washed into the fissures in the shale during the initial flooding or transgression by the Pleistocene sea, although the overlying Punta de Piedra conglomerates are unfossiliferous. A few species from the Charco Azul shales may have become mixed during the collecting and washing of the samples, but this mixing is probably not important. Probably the most interesting species in this faunule is *Condylocardia panamensis,* the first record of this South Pacific genus in America.

Condylocardia panamensis, n. sp.
Nannodrillia nana Dall
Philbertia trichodes Dall (hirsutum de Folin)
Marginella minor C. B. Adams
Marginella margaritula C. B. Carp.
Hanetia elegans Dall
Nassa, sp.
Turbonilla (Strioturbonilla) aff. thyne Bartsch
Turbonilla (Pyrgiscus), several species
Triphoris, sp.
Triphoris alternatus C. B. Adams
Cæcum cf. suave de Folin
Seila, sp.
Eumeta, sp.
Rissoina cf. lauræ de Folin
Rissoina cf. gisna Bartsch
Rissoina cf. effusa Mörch
Alvania bartschi, n. sp.
Teinostoma, sp.
Circulus, sp.

THE CHARCO AZUL FORMATION (OLSSON, 1942) (PLIOCENE)

At Punta de Piedra, south of Puerto Armuelles, the Pleistocene conglomerates of the basal Armuelles formation is seen to be underlain by a series of blue to black shales which outcrop in typical form along the shores of Charco Azul nearly to Punta Burica. This formation has been called the Charco Azul and referred to the Pliocene mainly on the evidence of its fauna. The formation is also present on the Costa Rican side of the peninsula, outcropping in many streams and along the shore. At the mouth of Quebrada Peñitas, in the northern part of the peninsula on the Costa Rican side, the base of the Charco Azul is formed by a coarse, blue sandstone containing small concretionary nodules and seams of conglomerate. This sandstone lies directly upon the basement andesite. Its fossils are mostly near-shore forms, with such types as *Thais, Cantharus, Modiolus,* as well as rock barnacles. These basal beds are found at several other places in this zone as well as in the interior of the peninsula and prove the strongly transgressive character of the Pliocene sea in this region. The main part of the Charco Azul, exposed along Quebrada Peñitas, is a foraminiferal shale containing abundant limestone concretions, some of which have a tubular form. As usual, in shale formations of this type, molluscan fossils are scattered or occur only in a few, restricted horizons.

The typical exposures on the east coast of the Charco Azul belong to the upper part of the formation. They are rather soft, black shales and, as indicated by their fossils, were deposited in waters considerably deeper than the shales found along Quebrada Peñitas. Excellent outcrops of the lower and middle part of the Pliocene beds are found along the southwest coast of the peninsula and at low tide can be closely examined for miles. These beds, however, have a different facies development from the rocks exposed at Charco Azul and along Quebrada Peñitas in that they are tuffaceous. Fossils are rare in these tuffaceous shales, the commonest forms being scattered specimens of *Fissidentalium buricum* and *Buridrillia panarcia.* The lower beds become increasingly more sandy and grade down into the Burica sandstones proper. Although the separation is entirely artificial, the base of the Charco Azul formation is placed at a point in the section where sandstone beds predominate over the shale. According to Terry, the thickness of the Charco Azul is about 4000 feet.

The molluscan fauna of the Charco Azul varies according to the conditions under which these beds were formed, and, in order to show these differences, the fauna from each of the principal localities is listed separately. In the exposures at Charco Azul, many of the commonest species have deep-water affinities. These shells are often white in color, translucent or of glassy lustre; others, such as the turrids, show the effects of water corrosion. These deep-water forms are associated with others of a purely shallow-water habitat. Assuming that the topography of the sea-bottom at Charco Azul in Pliocene times was more or less similar to that prevailing along the present coast or that the Charco Azul shales were deposited on a steeply sloping or shelving bottom, considerable variation in depth would take place in comparatively short distances. Under these conditions, shallow-water or littoral shells might easily be washed into deep water by currents and storms where they would become mixed with other species which normally lived in the deeper waters. Our information on the distribution of the deep-water mollusks of the Panama region is based principally on the dredging conducted by the Albatross Expedition and reported upon by Dall (1908). Many species found in the Charco Azul shales, such as the turrids, naticids and others, have close affinities with species dredged by the Albatross in waters as deep as 1471 fathoms. It must be noted that dredging stations are generally so few and at such widely spaced stations that it is not possible to obtain a comprehensive conception of the composition and distribution of the deep-water fauna. It is also true that most dredging expeditions have devoted their main efforts to very deep or very shallow waters, leaving unexplored the far richer, intermediate zone, lying between 100 and 400 fathoms. The shales at Charco Azul were probably deposited in this depth of water, an opinion also advanced by Coryell and Mossman (1942) from their recent studies on the Foraminifera of the Charco Azul shales.

In lithology, the Charco Azul shales, particularly along Quebrada Peñitas, are similar to the Uscari of northern Panama and Costa Rica and the tuffaceous shaly facies near Burica Point to the Esmeraldas of northern Ecuador. This similarity is further accentuated by the occurrence of large *Dentalium*, *Acila* and by some turrids. Closer inspection of the fauna, however, reveals that the great majority of shells are closely related to Recent species in the Panamic region, while the purely Miocene element is relatively slight and restricted to a few forms, such as *Acila*, *Antillophos* and certain cones. Relations with the recently described Pliocene of Ecuador are fairly intimate as illustrated by the common occurrence of such distinctive species as *Strombinophos loripanus* Pils. and Olss., *Nassa puntablancoenis* Pils. and Olss., *Strombina ecuadoriana* Pils. and Olss., *Scapharca wheeleri* Pils. and Olss. and *Macoploma.* Stratigraphically, the Charco Azul is overlain by the Armuelles formations with its unmistakable Pleistocene fauna. For these reasons, I am referring the Charco Azul directly to the Pliocene and correlating it broadly with the Jama and Canoa formations of western Ecuador. Future collecting will undoubtedly add many species to this very rich and interesting fauna.

CHARCO AZUL

This locality is approximately 10 kilometers south of Puerto Armuelles on the east coast. The following species are represented in our collections from this locality. Related species and their depth occurrence are indicated in parenthesis.

Nucula iphigenia azulensis, n. var. (*N. iphigenia* Dall, Gulf of Panama, 259 fathoms.)

Nuculana (*Jupiteria*) *chiriquiana*, n. sp. (*N. agapea* Dall, Gulf of Panama, 1672 fathoms.)

Nuculana (*Jupiteria*) *davidana*, n. sp.

Yoldia (*Orthoyoldia*) *quiba*, n. sp. (*Y. panamensis* Dall, Gulf of Panama, 182-322 fathoms.)

Scapharca charcoazulensis, n. sp.

Pseudamusium terryi, n. sp. (*P. panamensis* Dall, Gulf of Panama; Galapagos; Mexico, 141-855 fathoms.)

Lucina (*Lucinoma*) *chiripanicus*, n. sp. (*L. heroicus* Dall, *L. æquizonatus* Stearns.)

Macoma (*Panacoma*) *chiriquiensis*, n. sp.

Sanguinolaria azulensis, n. sp.

Corbula (*Varicorbula*) *granti*, n. sp.

Polystira panamensis, n. sp.

Fusiturricula woodringi, n. sp. (*F. fusinella* Dall, Gulf of Panama, 153 fa.; Mexico, 58 fathoms.)

Clathrodrillia (*Buridrillia*) *panarica*, n. sp.

Leucosyrinx nicoya, n. sp. (*L. persimilis* Dall, Gulf of Panama, 1020 fathoms.)

Leucosyrinx buricana, n. sp. (*L. galapagana* Dall, Galapagos, 634 fathoms.)

Ancistrosyrinx cedonulli reevei, n. var. (*A. cedonulli* Reeve, Gulf of Panama, 10-153 fathoms.)

Borsonella adamsi, n. sp. (*B. agassizi* Dall, Gulf of Panama, 1471 fathoms.)

Borsonella harrisi, n. sp.

Pleurotomella (*Phymorhynchus*) *agina*, n. sp. (*P. argeta* Dall, Galapagos, 812-855 fathoms.)

Cancellaria (*Cancellaria*) *penita*, n. sp.
Hanetia (*Fusinosteira*) *alternata* Nelson
Strombinophos loripanus Pils. and Olss.
Nassa (*Uzita*) *armuella*, n. sp.
Nassa (*Uzita*) *terryi*, n. sp. (*N. miser* Dall, Gulf of Panama, Mexico, 182-322 fathoms.)
Strombina (*Cotonopsis*), sp.
Mitrella (*Longitrella*) *vespertina*, n. sp.
Epitonium (*Ferminiscala*) *ferminianum* Dall, (*E. ferminianum* Dall, Panama, Gulf of California, 24-153 fathoms.)
Natica scethra burica, n. var. (*N. scethra* Dall, Gulf of Panama, 153 fathoms.)
Metula, sp.
Harpa, sp.

The most interesting feature of this fauna is the deep-water characteristics shown by some species. It is perhaps best illustrated by the turrids, amongst which we have such normally deep-water genera as *Leucosyrinx*, *Borsonella*, and *Phymorhynchus*. The Recent species of these genera closely allied to forms from the Charco Azul as indicated in the above list, are recorded from depths of 600 to 1500 fathoms. It is quite possible that some of these fossils are drift shells brought into somewhat shallower waters by upwellings. An interesting occurrence at Charco Azul is the *Ancistrosyrinx cedonulli reevei*. The Recent representative of this elegant shell was first dredged by Cumings in the Bay of Panama at a depth of about 10 fathoms, the type being an immature individual. It was later dredged in some abundance by the Albatross Expedition in the same region at depths ranging from 30 to 153 fathoms. Another striking member of the faunal assemblage is *Hanetia* (*Solenosteira*) *alternata* Nelson. This species was first described from the Tumbez beds of northern Peru. Until the discovery of this species in Panama, Nelson's types from Peru (preserved in the Peabody Museum at New Haven) remained the only specimens known. It is probably a species of intermediate depth range which may account for its general rarity as a fossil.

QUEBRADA MELLISA

This stream flows into the Bay of Charco Azul about 1 kilometer south of the last locality. The fossils, in the list below, were collected by Terry from exposures along Quebrada Mellisa about $3\frac{1}{2}$ miles upstream. The fauna, as may be seen, contains a high percentage of Recent species.

Arca (Scapharca) charcoazulensis, n. sp.
Ostrea megadon Hanley
Cardium (Fragum) magnificum (Desh.)
Dosinia (Dosinidia) grandis Nelson
Pitar (Lamelliconcha) mellisa, n. sp.
Chione (Chione) vaca, n. sp.
Chione (Lirophora) ebergenyi Böse
Chione (Lirophora) kelletti Hds.
Cardita laticostata Sby.
Conus arcuatus vacuanus, n. subsp.
Crassispira, sp.
Turricula dulcia, n. sp.
Turricula (Knefastia) andesita, n. sp.
Oliva angulata Lam.
Oliva (Agaronia) testacea Lam.
Marginella, n. sp.
Fusinus mellissus, n. sp.
Hanetia anomala burica, n. subsp.
Strombinophos loripanus, Pils. and Olss.
Phos (Antillophos) rutschi, n. sp.
Strombina recurva Sby.
Strombina fusiformis penita, n. subsp.
Phyllonotus brassica Lam.
Malea ringens Swains.
Ficus ventricosus Sby.
Architectonica nobilis Roeding
Natica broderipiana Recluz

RIO GUANABANON

This river flows into Charco Azul about $3\frac{1}{2}$ kilometers south of Puerto Armuelles. Fossiliferous exposures of the Armuelles formation occur in its lower courses. The following species belong to the Charco Azul formation and were collected by Terry from exposures about 4 kilometers upstream from the mouth.

Nucula iphigenia azulensis, n. subsp.
Arca (Cunearca) nux Sby.
Arca (Argina) brevifrons Sby.
Periploma planiuscula Sby., var.
Phacoides liani Pilsbry
Cardium (Trigoniocardia) obovale Sby.
Chione (Lirophora) kelletti Hds.
Pitar (Lamelliconcha) anona, n. sp.
Terebra (Terebra) elena Pils. and Olss.
Terebra (Strioterebrum) aspera Hds.
Terebra (Strioterebrum) guanabana, n. sp.
Clathrodrillia (Buridrillia) panarica, n. sp.
Conus arcuatus vacuanus, n. subsp.

Conus cf. patriceus Hds.
Nassa (Arcularia) puntablancoensis Pils. and Olss.
Strombinophos loripanus Pils. and Olss.
Phos (Antillophos) rutschi Pils. and Olss.
Metula pilsbryi, n. sp.
Strombina ecuadoriana Pils. and Olss.
Bursa nana jamanensis Pils. and Olss.
Turritella tigrina Kiener

MOUTH OF QUEBRADA PENITAS

This locality occurs on the Costa Rican side of the peninsula slightly south of the latitude of Puerto Armuelles. The fossils were collected in the basal part of the Charco Azul formations only a short distance above the basement andesite.

Modiolus cf. purpuratus Lam.
Eucrassatella gibbosa Sby.
Pitar (Lamelliconcha) rosea Brod. and Sby.
Cardium (Mexicardia) procerum Sby.
Terebra (Strioterebrum) cracilenta Li
Conus arcuatus vacuanus, n. subsp.
Conus regularis Sby.
Polystira, sp.
Crassispira, sp.
Turricula dulcia, n. sp.
Turricula (Knefastia) andesita, n. sp.
Cancellaria (Cancellaria) penita, n. sp.
Cancellaria (Cancellaria) ventricosa Hds.
Cancellaria (Peruclia) bulbulus Sby.
Oliva spicata Rod.
Oliva (Agaronia) testacea Lam.
Strombina recurva Sby.
Strombina ecuadoriana Pils. and Olss.
Strombinophos loripanus Pils. and Olss.
Typhis (Talityphis) costaricensis, n. sp.
Thais cf. biserialis Blainville
Cantharus elegans Gray
Bursa nana jamanensis Pils. and Olss.
Distorsio decussatus Val.
Vitularia cf. salebrosa King
Natica broderipiana Recluz
Polinices (Polinices) cf. panamensis Recluz

QUEBRADA PENITAS

These fossils come from the shale beds lying about 300 feet stratigraphically above the basal sandstones. The fauna occurs rather sporatically and good fossils are common only at a few places.

Nuculana (Jupiteria) davidana, n. sp.
Acila isthmica burica, n. subsp.

Arca (Scapharca) wheeleri Pils. and Olss.
Arca (Cunearca) esmeralda Pils. and Olss.
Periploma cf. stearnsi Dall
Tellina (Eurytellina) panamanensis Li
Tellina (Macaliopsis) frontera, n. sp.
Macoma (Macoploma) medioamericana, n. sp.
Corbula ovulata Sby. var.
Ringicula (Ringiculella) costaricensis, n. sp.
Clathrodrillia (Buridrillia) panarica, n. sp.
Clathrodrillia harrisi, n. sp.
Conus (Leptoconus) arcuatus vacuanus, n. subsp.
Conus (Leptoconus) cacuminatus Spieker
Cancellaria (Cancellaria) penita, n. sp.
Cancellaria (Charcolleria) terryi, n. sp.
Cancellaria (Calcarata) peninsularis, n. sp.
Mitra cyclica, n. sp.
Latirus penitus, n. sp.
Hanetia (Fusinosteira) alternata Nelson
Tritiaria (?) ecuadoriana Pils. and Olss.
Nassa (Arcularia) puntablancoensis Pils. and Olss.
Cymatophos galerus Pils. and Olss.
Phos (Antillophos) rutschi, n. sp.
Strombina fusiformis penita, n. subsp.
Murex recurvirostris Brod.
Malea ringens Swainson

RIO LA VACA

This locality is situated in the upper part of Rio La Vaca in Costa Rica, about 20 kilometers N. 45° W. of Puerto Armuelles. The collection was made by Mr. Terry.

Nucula iphigenia azulensis, n. subsp.
Arca (Scapharca) obesa Sby.
Arca (Cunearca) nux Sby.
Arca (Argina) brevifrons Sby.
Nœtia reversa magma MacNeil
Crenella ecuadoriana Pils. and Olss.
Placuanomia, sp.
Pecten tumbezensis d'Orb.
Periploma planiuscula Sby., var.
Periploma, undet. sp.
Eucrassatella gibbosa Sby.
Crassinella, sp.
Divaricella lucasana Dall and Ochsner
Cardium (Mexicardia) procerum Sby.
Pitar (Pitarella), n. sp.
Pitar (Lamelliconcha) concinna Sby.
Chione (Chione) cf. amathusia Philippi
Chione (Chione) vaca, n. sp.
Chione (Lirophora) mariæ d'Orb.
Chione (Lirophora) kelletti Hds.
Dosinia grandis Nelson
Macrocallista, sp.
Strigilla, sp.

Tellina (Eurytellina) ecuadoriana Pils. and Olss.
Chama (Echinochama) californica Dall
Tagelus (Mesopleura) peruvianus Pils. and Olss.
Labiosa undulata Gould
Corbula ovulata Sby.
Terebra (Terebra) robusta Hds.
Terebra (Terebra) lingualis Hds.
Terebra (Strioterebrum) aspera Hds.
Terebra (Strioterebrum) vaca, n. sp.
Terebra (Strioterebrum) cracilenta Li
Conus emarginatus Reeve
Conus arcuatus vacuanus, n. subsp.
Conus pyriformis Reeve
Conus puncticulatus Hwass
Cancellaria (Cancellaria) urceolata Hds.
Cancellaria (Euclia) pacifica Pils. and Olss.
Oliva araneosa Lam.
Marginella, sp.
Latirus, sp.
Nassa (Arcularia) puntablancoensis Pils. and Olss.
Cymatophos panamensis, n. sp.
Strombinophos loripanus Pils. and Olss.
Metula pilsbryi, n. sp.
Strombina ecuadoriana, n. sp.
Bursa nana jamanensis Pils. and Olss.
Distorsio decussatus Val.
Aesopus (Glyptæsopus), sp.
Turritella tigrina Kiener
Architectonica nobilis Roeding
Crucibulum (Crucibulum) hispidium Brod.
Crepidula onyx Sby.
Polinices (Neverita) glauca Humboldt
Natica broderipiana Recluz
Circulus, sp.
Dentalium, sp.

RIO BLANCO

Rio Blanco is a large stream flowing into the Bay of Charco Azul about 6 kilometers northeast of Puerto Armuelles. The following species of the Charco Azul formation were collected by Terry from the headwaters of the north fork of the Rio Blanco near the Costa Rican border. This locality lies on the northeastern slopes of Pico de Burica about 18 kilometers northwest of Puerto Armuelles.

Nuculana iphigenia azulensis, n. subsp.
Nuculana (Jupiteria) davidana, n. sp.
Acila isthmica burica, n. subsp.
Periploma planiuscula Sby. (large form)

Cardium (Trigoniocardia) spiekeri Hanna and Israelsky
Pitar, sp.
Macoma (Macoploma) medioamericana, n. sp.
Corbula ovulata Sby.
Terebra luctuosa Hds.
Conus cf. patriceus Hds.
Conus regularis Sby.
Conus pyriformis Reeve
Cancellaria (Cancellaria) cf. decussata Hds.
Oliva venulata Lam.
Oliva (Agaronia) testacea Lam.
Olivella, sp.
Marginella sapotilla Hds.
Phos (Antillophos) rutschi, n. sp.
Nassa (Arcularia) puntablancoensis Pils. and Olss.
Columbella major Sby.
Strombina ecuadoriana Pils. and Olss.
Strombina recurva Sby.
Malea ringens Swainson
Cypropterina pustulata Lam.
Natica broderipiana Recluz
Polinices aff. reclusiana Deshayes
Polinices panamensis Recluz

BURICA SANDSTONES (OLSSON, 1942)

Excluding the upper Eocene limestones of the north portions of the peninsula and always structurally associated with the basement rocks, the oldest formation exposed on the peninsula proper, is the Burica sandstones. These rocks form the southern end of the peninsula and the small islands nearby. As previously indicated, the Burica sandstones are transitional with the overlying tuffaceous shales of the lower Charco Azul. This relationship suggests that they are the lower portion of the sedimentary series of which the Charco Azul shales are the higher and deeper water facies. The actual base of the Burica sandstones and the basement on which they rest, are not known. The lowest beds exposed at the Point are certain coarse, gritty sandstones and pebbly conglomerates, but large boulders of a very coarse conglomerate, derived from still lower beds, occur on the beach. At Burica Point, we are evidently close to the base of the sedimentary section and near the margins of an old land which once laid in the Pacific to the south. The majority of the pebbles in the conglomerates belong to a black andesite and they may be well rounded or angular; others are quartzitic.

Fossils are generally rare in the Burica sandstones except as small fragments of shells which are scattered throughout the beds. Our best collection of mollusks was obtained in the lowest beds exposed at Burica Point, the fossils occurring in a small pebbly conglomerate interbedded with blue sandstones. The commonest fossils in this horizon are the shells of *Calyptogena*, both as closed and free valves. With them were associated *Thyasira, Solemya* and most of the species listed below. The type of *Solemya burica* was nearly perfect when found with both valves tightly closed. The other specimen of *Solemya* likewise had both valves closed, but it is rather poorly preserved. The other forms are ordinary shallow-water types and many are badly broken and worn. The fauna of the Burica sandstones, as represented in our collection, is as follows:

Dentalium (Fissidentalium) buricum, n. sp.
Terebra (Strioterebrum), sp. (A large species but represented by fragments only.)
Architectonica, sp. (Poorly preserved.)
Cancellaria, sp.
Hanetia pelicana, n. sp.
Cantharus amycus n. sp.
Phos (Antillophos) gatunensis Toula
Fusinus, sp.
Siphonalia?
Turritella cf. gatunensis Conrad
Polinices, sp.
Nucula iphigenia Dall group.
Arca, (A large, thick-shelled species, badly worn.)
Pecten, cast only (Perhaps P. tumbezensis d'Orb.)
Chione (Chione) araneosa, n. sp.
Chione, sp.
Luciploma panamensis, n. sp.
Thyasira bisecta Conrad
Solemya burica, n. sp.

The fauna of the Burica sandstones, as far as known from rather meager collections, appears to be, in the main, distinct from that in the overlying beds. The presence of *Fissidentalium buricum* and *Nucula iphigenia* show that these beds are probably not a great deal older than the tuffaceous shales of the Lower Charco Azul. Relations with the Miocene is indicated by the presence of *Phos gatunensis* and *Turritella cf. gatunensis.* These two species are represented each by a single imperfect specimen. Hence their identification is somewhat questionable. Until the paleontology of the Burica sandstones is better known, the age of these beds is tentatively considered as lower Pliocene or uppermost Miocene.

REFERENCES

Coryell, H. N., and Mossman, R. W.
Foraminifera from the Charco Azul formation, Pliocene, of Panama, Jour. Paleont., vol. 16 No. 2, 1942, pp. 233-246.

Dall, W. H.
The Mollusca and the Brachiopoda (Albatross Rept.), Bull. Mus. Comp. Zoöl., vol. 43, No. 6. 1908.

Olsson, A. A.
Tertiary deposits of northwestern South America and Panama., Proc. Eighth Amer. Sci. Congress, vol. 4, Geol. Sciences, 1942 pp. 248-250.

Terry, R. A.
Notes on submarine valleys off the Panamanian Coast, Geog. Review, vol. 31, No. 3, 1941, pp. 377-384.

SYSTEMATIC DESCRIPTIONS

Class **PELECYPODA**

Order **PRIONODESMACEA**

Family **SOLEMYIDÆ**

Genus **SOLEMYA** Lamarck

Subgenus **ACHARAX** Dall

Solemya (Acharax) burica, n. sp. Plate 2, fig. 1

The shell is large, rather solid for the genus, broadly elongated in form and strongly rayed; anterior side wider than the posterior and, originally, probably about 3 times as long; dorsal and ventral margins parallel, shape of the two extremities not known except through inference from the course of the lines of growth; the surface is marked with strong, rayed bands which extend from the beaks toward the ventral margins, defined by grooves; these rays have the appearance of being alternately raised and depressed with respect to each other; on the anterior submargins, there are 5, raised rays, separated from each other by wide furrows, nearly as wide as the rays themselves; they are followed by 15 or 16 rays, separated only by grooves which cover the middle of the valves (where they are widest) and the adjacent parts of the posterior side, leaving the submargin itself nearly smooth; the ligament is external, its remains forming a knoblike mass behind the beaks.

Length of fragment, 58 mm.; height, 47 mm.; diameter, 36 mm.

The type is a fragment, measuring about 60 mm. in length. It shows the middle portion of both valves originally closed, and filled with a pebbly sandstone matrix. The original length of the perfect shell is estimated as about 115 mm. The substance of the shell is fairly thick, about 2 to 3 mm. near the dorsal margin. Along the anterior-dorsal margin is a knoblike mass which appears to be the remains of a wholly external ligament. Dall[1] records 2 species of *Acharax* in the Recent Panamic fauna, both from deep water, (*S. agassizii* Dall and *S. johnsoni* Dall) but which differ from the fossil by their longer form and by their sculpture. *S. ventricosa* Conrad, from the Oligocene and Miocene beds of Oregon and Washington, seems nearer to *A. agassizii* Dall of the Recent fauna than to our fossil. The species of *Solemya* found in the Oligocene of Peru are likewise quite different.

Type.—Paleontological Research Institution, No. 4076.

Occurrence.—Burica sandstones, Burica Point.

Family NUCULIDÆ

Genus NUCULA Lamarck

Nucula iphigenia azulensis, n. subsp. Plate 4, figs. 2, 5, 7

cf. *Nucula iphigenia* Dall, 1895, Proc. U. S. Nat. Mus., vol. 18, p. 15.
cf. *Nucula iphigenia* Dall, 1908, Bull. Mus. Comp. Zoöl. vol. 43, p. 369, pl. 7, figs. 1, 4.

Shell large, solid, moderately convex; beaks opisthogyrate, placed at the posterior one-third; the anterior end is produced and is only a little more rounded than the posterior; surface of the shell is smooth over the larger part, but with a series of fine, narrow, irregular wrinkles present on the umbos but which fade out and are replaced elsewhere by fine radial lines which are a part of the internal-rayed structure of the shell itself; lunule narrow, linear; posterior area flattened except at the valve margins

[1] Dall, W. H.: *The Albatross Report*, Bull. Mus. Comp. Zoöl., vol. 43, No. 6, 1908, p. 364. Additional notes on Dall's specimens are given by Woodring, Lower Pliocene mollusks and echinoids from the Los Angeles Basin, U. S. Geol. Survey, Prof. Paper, 190, 1938, p. 27 .

which are elevated or slightly arched; the escutcheon is weakly defined by a change in sculpture or the abrupt ending of the concentric wrinkles; interior brilliantly nacreous with a strong pallial line connecting the muscle scars; margins of the valve coarsely crenulated; hinge has a large, obliquely set chondrophore; and has approximately 15 teeth in the posterior set and 28 in the anterior.

Length, 34 mm; height, 23.5 mm.; semidiameter, 7 mm.

Length, 31 mm.; height, 21 mm.; diameter, 13.5 mm.

Our shell, although related to Dall's species, differs in being less *Iphigenia*-like in form, the anterior extremity being more pointed and the posterior side more narrowly rounded. Dall's specimens were dredged from 259 fathoms of water in the Gulf of Panama.

Type.—Paleontological Research Institution, No. 4074; other specimen, No. 4075.

Occurrence.—Charco Azul.

Genus **ACILA** H. and A. Adams

Acila isthmica burica, n. subsp. Plate 1, figs. 2, 6, 8, 9

Shell subovate, the posterior side 3 to 4 times the length of the anterior, the beaks placed at the posterior three-fourths; the sculpture consists generally of a single or primary bifurcation which extends from the beaks obliquely backwards to the middle line of the ventral margin, but in some specimens a secondary bifurcation is present in the rostral sinus; the sculpture is generally normal in character in shells up to about 17 mm. in height but in larger examples, the sculpture of the ventral area becomes more or less crowded, discontinuous and often with many small bifurcations as well as a crowding of the lines of growth in a coarse manner; escutcheon and lunule absent or very poorly defined; the dorsal area is sculptured with the continuation of the ends of the ribs which in the younger shells extend to the hinge margin but in the older ones is replaced by a zone of crowded lines; in some specimens, the deep, interspaces between the ribs is crossed by a series of fine, close, elevated, concentric threads.

Length, 32 mm.; height, 24 mm.; diameter, 15.5 mm.

Length, 29 mm.; height, 20.5 mm.; diameter, 15 mm.
ally smaller and more trigonal in shape, the beaks being situated less posteriorly than in this form. A lunule and escutcheon is also generally present, sculptured similarly to the rest of the dorsal margin as may be seen in the figures of *A. isthmica* given by Schenck.[3] On *A. burica*, a lunule and escutcheon seem to be absent and the sculpture of the dorsal area is simpler.

It is of interest to record a species of *Acila* in Panama from formations younger than the Gatun. Schenck has given the range of *Acila isthmica* as occurring throughout the Miocene but this extended range is not based on any records of the species in beds of upper Miocene age. In Panama, typical *A. isthmica* is known only from the Gatun, the original specimens coming from the rock excavated during the construction of the locks or from the quarries to the east of the Chagres Spillway. This horizon belongs to the lower beds of the Gatun formation. *Acila isthmica* is also found in the Las Perdices shales near Puerto Colombia in northern Colombia. As first shown by Anderson[4] and later by Olsson,[5] the Las Perdices horizon is much older than the true Gatun and is correlated with the Upper Uscari of Costa Rica. The known range of typical *A. isthmica* in Panama and Colombia is therefore in the lower and middle Miocene.

Type.—Paleontological Research Institution, No. 4077; other specimen, No. 4078.

Occurrence.—Quebrada Peñitas, Costa Rica.

Family **NUCULANIDÆ**

Genus **YOLDIA** Möller

Subgenus **ORTHOYOLDIA** Verrill

Yoldia (Orthoyoldia) quiba, n. sp. Plate 3, figs. 5

Shell of medium size, equivalve, inequilateral, the two ends of

In typical *A. isthmica* Brown and Pilsbry,[2] the shell is gener-

[2] Brown, A., and Pilsbry, H. A.: Proc. Acad. Nat. Sci. Phila., vol. 63, 1911, pp. 361, 362, pl. 27, figs. 11 12.

[3] Schenck, H. G.: *Nuculid bivalves of the genus Acila*, Geol. Soc. of America, Special Paper No. 4, 1930, p. 87, pl. 12, figs. 1, 3, 5, 6.

[4] Anderson, F. M.: *Marine Miocene and related deposits of north Colombia*, Proc. Calif. Acad. Sci., 4th series, vol. 18, 1929, p. 91.

[5] Olsson, A. A.: *The Peruvian Miocene*, Bull. Amer. Paleont., vol. 19, 1932, p. 29. See also note by Hedberg in Schenck, *Nuculid pelecypods of the genus Acila in the Tertiary of Venezuela, northern Colombia and Trinidad* Eclogæ Helvetiæ, vol. 28, No. 2, 1935, p. 504 (footnote).

nearly equal length but with the posterior side slightly narrower and bluntly pointed at the end; umbos low, wide, nearly centrally located with the small, scarcely coiled beaks touching each other; surface smooth, polished and ornamented in the middle zone by strong, regular, concentric lines; escutcheon narrowly linear, defined by a slightly elevated ridge; lunule similar but wider anteriorly; ligament apparently wholly internal.

Length, 27 mm.; height, 14 mm.; diameter, 8 mm.

This species is perhaps related to Dall's[6] unfigured *Orthoyoldia panamensis,* described from the Bay of Panama, and dredged from a depth of 322 fathoms. The measurements of *O. panamensis* indicate a much smaller shell than the fossil.

Type.—Paleontological Research Institution, No. 4079.

Occurrence.—Charco Azul.

Genus **NUCULANA** Link

Subgenus **JUPITERIA** Bellardi

Nuculana (Jupiteria) chiriquiana, n. sp. Plate 1, fig. 7

Shell of medium size, plump and rather finely sculptured; the beaks are nearly central or situated a little posterior of the middle; posterior side comparatively short, pointed at the end, the anterior side only a little wider, narrowly rounded at the end; posterior-dorsal area widely lanceolate, finely sculptured and limited by a foldlike ridge from the rest of the surface; lunule present, narrowly lanceolate, depressed with two limiting folds on the side; surface sculptured with fine, regular, concentric ridges separated from each other by deeply incised lines; these ridges are of nearly equal strength over the general surface of the shell but become finer on the umbos and coarser on the posterior-dorsal area since there they represent the continuation of each 3d or 4th ridge only; interior deep, smooth, glassy with well-marked muscle scars; pallial line faint, with a small, hardly visable pallial sinus; margins entire; resiliary pit deep, directly under the beaks, separating about 26 teeth in the anterior set and 18-20 in the posterior set.

[6] Dall, W. H.: *The Albatross Report*, Bull. Mus. Comp. Zoöl., vol. 43, No. 6, 1908, p. 380.

Length, 20 mm.; height, 11.5 mm.; semidiameter, 5 mm.

This species has some resemblance to Dall's *Leda agapea* from the Gulf of Panama but has a shorter and narrower, posterior side.

Type.—Paleontological Research Institution, No. 4080.

Occurrence.—Charco Azul.

Nuculana (Jupiteria) davidana, n. sp. Plate 1, fig. 3

Shell large, plump, with the small beaks placed nearly central and closely adjacent; posterior end, narrowly produced, pointed, the anterior side wider and rounded; ventral margin rounded but bulging a little just anterior of the middle; posterior-dorsal area lanceolate, flattened but with a small rise or bulge in the middle; no lunule; sculpture consists of strong, concentric ribs which are fairly large and regular, decreasing in size towards the beaks; the ribs are separated by wide grooves; surface of the shell, under a glass, may appear smooth, porcellaneous or there may be a series of small, concentric lines covering both the ribs and the interspaces; the posterior-dorsal area sculptured similarly with riblets but which are smaller and lie parallel to the hinge line; hinge not exposed on the type specimen but in another fragmentary shell, the posterior set of teeth number about 20.

Length, 27 mm.; height, 14 mm.; diameter, 12 mm.

The type is a complete shell of both valves, closed so that the interior is not exposed. Another fragmentary specimen is represented by a broken left valve showing only the posterior side of the hinge. This valve has a coarser sculpture and has about 20 teeth in the posterior set. The species resembles the *Leda balboæ* Brown and Pilsbry[7] of Gatun but is larger and more coarsely sculptured. *Nuculana gibbosa* Sowerby, in the Recent fauna is also similar but is even larger and has a finer sculpture.

Type.—Paleontological Research Institution, No. 4081.

Occurrence.—Charco Azul.

[7] Brown, A., and Pilsbry, H. A.: Proc. Acad. Nat. Sci. Phila., vol. 63, 1911, p. 362, pl. 27, fig. 8.

Family ARCIDÆ

Genus ARCA Linné

Subgenus SCAPHARCA Gray

Arca (Scapharca) charcoazulensis, n. sp. Plate 3, figs. 7, 8

Form transversely elongate, the dorsal and ventral margins nearly parallel, the posterior side strongly oblique and the shell moderately thin in texture; the right valve has about 32 ribs, the left with about 31, including in this count, the ribs forming the edge of the dorsal margins; umbos wide, slightly depressed or sulcated in the middle zone with the small beaks coiled a little over the cardinal area; the beaks are placed at the anterior one-third; the shell is only moderately convex; in the left valve the ribs are double in part over the anterior portion, simple elsewhere, noded or beaded in the middle or umbonal section; on older shells, the ribs of the left valve become narrow and subtriangular in section, heavier and stronger on the posterior submargins; the ribs of the right valve are similar; interval between the ribs is etched with evenly to irregularly spaced lines; hinge straight with numerous small teeth arranged in two series, nearly continuous, there being about 28 in the anterior set and 35 in the posterior; muscle scars well marked, the ventral margin fluted in harmony with the external ribs; cardinal area narrow with 3 chevron-shaped lines.

Length, 35 mm.; height, 18.5 mm.; semidiameter, 7.5 mm. (right valve).

Compared with its most similar species, the *Arca dariensis* Brown and Pilsbry of the Gatun Miocene and *Arca concinna* Sowerby of the Recent fauna, this species differs by its more transverse outlines, less convex, thinner shell and by its sculpture. In *Arca dariensis*, the ribs on the posterior-umbonal slope are double while in this species as in *A. concinna*, they are simple or have only a faint, dividing line in the middle.

Type.—Paleontological Research Institution, No. 4082; other specimens, No. 4083.

Occurrence.—Charco Azul.

Genus NŒTIA (Gray) H. and A. Adams

Nœtia reversa magma MacNeil

Nœtia magma MacNeil, 1938, U. S. Geol. Sur., Prof. Paper 189-A, p. 38, pl. 6, figs. 20, 21.

Nœtia (Nœtia) reversa magma Pilsbry and Olsson, 1941, Proc. Acad. Nat. Sci. Phila., vol. 93, p. 50.

This large *Nœtia* is common as a Pliocene fossil along the West Coast of northern South America. One specimen, measuring, length, 65 mm.; height, 61 mm.; and diameter, 32 mm., was collected by Terry from the Pleistocene of Quebrada Rabo de Puerco. When young, this subspecies cannot be readily separated from typical *N. reversa* except that in *N. magma*, the ribs (counting the flutings along the inner margins) are generally more numerous and the form tends to be longer or more regularly rectangular. An imperfect specimen of *N. magma* from the Pliocene of Rio Guanabanon measures length, 80 mm.± ; height, 75 mm.± ; semidiameter, 40 mm. Our largest specimen of true *N. reversa*, collected at Puerto Callo near Jipijapa, Ecuador, has the following measurements, length, 51 mm.; height, 45 mm.; semidiameter, 24 mm.

Occurrence.—Pliocene. Rio La Vaca. Pleistocene. Rabo de Puerco.

Family PECTINIDÆ

Genus PSEUDAMUSIUM (Klein) Mörch

Pseudamusium terryi, n. sp. Plate 2, figs. 5, 6, 7

Shell small, translucent, very thin, both valves only slightly convex; beaks small, low, hardly projecting beyond the hinge line; ears small, subequal in the left valve; in the right valve, the anterior ear is a little larger than the posterior and with a wide fasciole corresponding to the byssal sulcus, above which are 6, radial, scabrous threads separated by wide, unequal interspaces; on the right valve, the posterior ear is smooth, the anterior one has a few to several, radial threads which fade out above; sculpture of the right valve is variable, the umbonal portion is smooth, below it, the surface is generally ornamented by widely spaced, radial threads, numbering about 14 or very numerous, more closely spaced threads numbering about 46; in addition, fine but distinct "*Camptonectes*" striations are present; the right valve is typically smoother with the radials numbering about 8, confined to the anterior submargins in some valves, faint indications of the radials may spread over the rest of the shell; the "*Camptonectes*" striations are finer in the left valve but are visable with a lens especially on the posterior submargins; interior with a micalike lustre showing radially impressed lines corresponding to the external sculpture.

Height, 15 mm.; diameter, 13.5 mm.; semidiameter, 1.25 mm.

This species resembles *P. panamensis* Dall[8] but differs by its nearly smooth right valve. The shell is very thin and delicate. It is locally common in the clays at Charco Azul.

Type.—Paleontological Research Institution, No. 4084; other specimens, No. 4085.

Occurrence.—Charco Azul.

Family **ANOMIIDÆ**

Genus **PLACUNANOMIA** Broderip

Placuanomia panamensis, n. sp. Plate 1, figs. 1, 4, 5

Shell of moderate size, thin to slightly thickened, *Anomia*-like in texture; lower valve widely adherent to the object to which it was fixed; the upper valve concavely flattened to slightly convex, sometimes developing an irregular fold along the margin; the surface of the upper valve is smooth, sometimes with irregular, wormlike markings in some parts; under the lens, the growth lines are seen to be irregularly arranged and wrinkled, with very fine, scarcely visible, radial lines and near the margin occasionally small, appressed, spinelike scales can be noted; in the lower valve, the surface is irregularly folded and shows fine irregular, radial threads sometimes pustular, tubed and crowded, irregular growth lines; lower valve with a well-developed V-shaped, crural process, fitting into deep sockets in the opposite valve; the byssal foramin, large, filled with a plug, showing externally as a long, wedge-shaped area extending to the beak and with a single muscle scar set obliquely below; in the upper valve there are two muscle scars set obliquely to each other.

[8] Dall, W. H.: *The Albatross Report*, Bull. Mus. Comp. Zoöl., vol. 43, No. 6, 1908, p. 404, pl. 6, figs. 8, 10.

Length, 60 mm.; width, 60 mm., upper valve.
Length, 53 mm.; width, 54 mm., upper valve.
Length, 34 mm.; width, 42 mm., lower valve.

From *Placuanomia cumingii* Broderip, the only other known species along the West Coast, the fossil differs by its flat, feebly plicated valves and in its more *Anomia*-like habitus of growth and general sculpture. There are three valves in our collection, the smallest being that of the lower or sessile valve. The crural process is large and strong in the lower valve, fitting into corresponding deep sockets in the upper valve.

Type.—Paleontological Research Institution, No. 4086; other specimen, No. 4087.

Occurrence.—Quebrada Rabo de Puerco.

Order **ANOMALODESMACEA**
Family **PERIPLOMATIDÆ**
Genus **PERIPLOMA** Schumacher

Periploma lucina, n. sp. Plate 3, fig. 4

Shell of medium size, nearly circular in outline, the posterior side somewhat shorter and narrower; the texture of the shell is thin, formed by a pearly inner layer and an outer layer which is paper thin and white or gray in color; both valves are of moderate but nearly equal convexity with no noticeable flexing; the surface markings consists mainly of fairly coarse, concentric lines and very minute pustules or granules arranged concentrically, strongest and crowded most on the posterior submargins; interior and hinge unknown.

Length, 38.5 mm.; height, 34.5 mm.; diameter, 17.5 mm.

We have two specimens but only the holotype is fairly well preserved. In shape, the shell resembles a small *Loripinus*. The granules are very small or submicroscopic in size and arranged in a concentric series.

Type.—Paleontological Research Institution, No. 5007.

Occurrence.—Rio Guanabanon.

Periploma planiuscula Sby. subsp.

Our collection has 2 large Periplomas from Rio Blanco which measure respectively, 70 and 75 mm. in length. This is larger than most Recent specimens of this species. They should perhaps be separated as a subspecific form but the fossils are too badly crushed for description and figuring.

Periploma aff. stearnsii Dall

Periploma stearnsii Dall, 1896, Proc. U. S. Nat. Mus., vol. 18, p. 9.
Periploma stearnsii Dall, 1908, Bull. Mus. Comp. Zoöl., vol. 43, No. 6, p. 426, pl. 16, fig. 5.

In form, the shell is subcircular to suborbicular with the beaks placed at the posterior third; the texture is relatively thin with an internal pearly layer, covered by a thin skin of a dull, white color. The surface is thickly covered with minute or submicroscopic granules or pustules arranged in radial lines. The right valve is a little more inflated than the left. Valves slightly flexed.

Length, 42 mm.; height, 37 mm.; diameter, 14 mm.

From the *P. planiuscula* group this species is distinguished by its fine, radially arranged granules. In these characters, definite affinities with *P. stearnsii* Dall is indicated. Dall's figure of his species shows only the interior of a right valve which makes a specific determination uncertain. Our only specimen is imperfect.

Occurrence.—Quebrada Peñitas.

Order **TELEODESMACEA**
Family **VESICOMYACIDÆ**
Genus **CALYPTOGENA** Dall

Calyptogena panamensis, n. sp. Plate 2, figs. 2, 3

Form elongate-ovate, moderately convex, thick-shelled, with a coarse sculpture of crowded growth lines; anterior side about ½ the length of the posterior side with the low beaks curved forward; anterior and posterior ends nearly equally rounded; no lunule but apparently a long, narrow, excavated escutcheon is present; texture of shell is solid; interior shows a deep, muscle scar and a wide, simple pallial line; margin entire; teeth more or less worn or obsolete in the only specimen showing the hinge but with the remains of a large central and an anterior cardinal present; ligament external.

Length, 44 mm.; height, 24 mm.; semidiameter, 6 mm.

Calyptogena panamensis is the commonest and best preserved fossil in the Burica sandstones. The shell is solid, generally somewhat chalky and the surface coarsely sculptured. The hinge appears to be that of typical *Calyptogena* but the teeth are worn or imperfectly preserved in the few specimens showing the hinge.

In a few specimens, the external ligament is still preserved. Perhaps some of the species described as *Pleurophopsis* and *Vesicomya* from the Oligocene of Peru may belong to *Calyptogena* as suggested by Woodring but their hinge is not known while their more *Unio*-like shape and flexed valves is more like *Pleurophopsis*. The rock in which these fossils occur at Punta Burica is a coarse, gritty or pebbly sandstone. They are associated with *Solemya, Thyasira, Fissidentalium, Luciploma* and other forms. In a recent discussion of the depth range of *Calyptogena pacifica* Dall on the basis of the material preserved in the National Museum, Woodring[9] notes that most of the examples were dredged in quite deep waters ranging from 322 to 680 fathoms and a single corroded pair of valves from a depth of 30 to 41 fathoms. Some of the specimens of *Calyptogena* from Burica Point occur as free valves but the majority have closed valves, some still retaining remains of the external ligament. Under these circumstances, it appears unlikely that these shells could have drifted far from their original habitat station.

Type.—Paleontological Research Institution, No. 4088; other specimen, No. 4089.

Occurrence.—Punta Burica.

Family CONDYLOCARDIIDÆ

Genus CONDYLOCARDIA Bernard

Condylocardia panamensis, n. sp. Plate 3, figs. 9, 10

Shell very small, generally glassy and solid in texture, equivalve and strongly inequilateral; externally the valves are broadly subtrigonal, the posterior side produced, pointed with a wide excavated, escutcheonlike area which gives to the shell the appearance of a small *Tridacna* or a *Verticordia;* umbos prominent, surmounted by the platelike, embryonic shell encircled by thickened, raised margins; sculpture consists of strong, radial ribs, heaviest in the middle, smaller on the sides and nearly absent from the posterior extremity; these ribs on a typical shell number about 8; they are separated by rather wide interspaces, tra-

[9] Woodring, W. P.: *The Lower Pliocene mollusks and echinoids from the Los Angeles Basin, California*, U. S. Geol. Sur., Prof. Paper 190, 1930, p. 51.

versely grooved or striated by the growth lines; hinge as normal for the genus, in the right valve it has a strong knob or hook-shaped anterior cardinal tooth and a socket for the left posterior cardinal tooth, between which lies the ligamental pit, also a strong anterior lateral tooth and a smaller, rudimentary posterior lateral tooth; body cavity deep, the ventral margins fluted by the ends of the ribs which usually show through the glassy or translucent shell.

Length, 1.75 mm.; height, 1.50 mm.; diameter, 1.25 mm.

It is extremely interesting to discover a species of this genus in the American fauna. Although at present known only as fossil, it is doubtless present in the Recent Panamic fauna. The headquarters of the genus *Condylocardia*[10] lie in the southern Pacific with several known species in New Zealand and Australia.[11] One fossil species has been described from the Parisian Eocene. The genus is characterized by its peculiar hinge and by the persistant prodissoconch or embryonic shell which sits as a small cap on the summit of the umbos. Our species differs strikingly from the known Recent species by its stronger ribs and deep, excavated escutcheonlike area.

Type.—Paleontological Research Institution, No. 4090; other specimens, No. 4091.

Occurrence.—Zone of unconformity at base of Pleistocene at Punta Piedra.

Family THYASIRIDÆ

Genus THYASIRA (Leach) Lamarck

Thyasira bisecta Conrad Plate 2, fig. 4

Venus bisecta Conrad, 1849, U. S. Expl. Exped. (Wilkes), vol. 10, Geol., p. 724; Geol. Atlas, pl. 17, figs. 10, 10a.

Thyasira bisecta Dall, 1901, Proc. U. S. Nat. Mus., vol. 23, pp. 789, 790.

Thyasira bisecta Grant and Gale, 1931, Mem. San Diego Soc. Nat. Hist., vol. 1, pp. 281, 282, pl. 13, fig. 15.

For additional synonymy see Grant and Gale's paper noted above.

10 Bernard, F.: Jour. de Conch., vol. 44, 1897, p. 174.

11 For Australian species see, Cotton and Godfrey, *Handbook of the Molluscs of South Australia*, South Australian Branch British Science Guild, 1938, pp. 191-196.

Our specimen is an internal cast composed of a pebbly sandstone matrix with small fragments of the original shell preserved on the umbos and along the dorsal margins. The fossil measures, length, 70 mm.; height, 70 mm.; semidiameter, 32 mm. It agrees well with the figure of *Thyasira bisecta* Conrad, var. *nipponica* Yabe as given by Grant and Gale of a specimen from the Pliocene of Japan. The geological range as given by those authors extends from the Oligocene to the Pleistocene, its most southerly known occurrence being in the Pleistocene of San Pedro. Its Recent American range is given as off the Alaskan peninsula south to the coast of Oregon. The occurrence of this species in Panama is therefore of considerable interest. A large *Thyasira* was described by VanWinkle from the Oligocene of Trinidad as *T. adocassa* which appears to differ mainly in being somewhat more elongated. Large Thyasiras are not uncommon in the Oligocene of northern Colombia but have not been critically studied.

Figured specimen.—Paleontological Research Institution, No. 4092.

Occurrence.—Burica sandstones, Burica Point.

Family LUCINIDÆ

Genus LUCINA Bruguière

Subgenus LUCINOMA Dall

Lucina (Lucinoma) chiripanica, n. sp. Plate 4, figs. 1, 4

Shell subquadrate to subcircular in form, only moderately convex with a fairly thick texture; beaks small, pointed, recurved; dorsal area indicated by a depressed, ever widening zone, extending from the beaks to the posterior side, which is straight or subtruncate; the ventral side is widely rounded, the anterior side a little produced, pointed, appearing slightly depressed; lunular side, rather long; sculpture of fine growth lines and concentric, sharp, distant, elevated lamellæ continuous over the whole shell. The elevated lamellæ are spaced, 3.5 to 4 mm., apart on the middle of the shell disk; the lunule is long, narrow, darker colored than the rest of the shell; hinge of right valve shows two strong, cardinal teeth, the posterior one being the heaviest and bifid; anterior and posterior laterals visible but not strongly developed; pallial line continuous; the anterior adductor scar, long, narrow.

Measurements of the type, length, 54 mm.; height, 46 mm.; semidiameter, 11.5 mm.

This species is nearest *L. heroicus* Dall from western Mexico and to *L. æquizonatus* Stearns from Santa Barbara channel, California but differs from both by its form and in details of sculpture. *L. acutilineata* Conrad (*annulatus* Reeve) has a more circular, convex shell.

Type.—Paleontological Research Institution, No. 4099; other specimens, No. 5000.

Occurrence.—Charco Azul.

Family **VENERIDÆ**

Genus **PITAR** Roemer

Subgenus **LAMELLICONCHA** Dall

Pitar (Lamelliconcha) mellisa, n. sp. Plate 5, fig. 4

Shell broadly subelliptical in form, ventral margin well rounded, posterior end more narrowly rounded; the shell is only moderately convex, its surface ornamented with numerous, equal or subequal, concentric ribs which are generally thin or lamellose and separated by somewhat wider, flat interspaces; there is a tendency for each 4th or 5th concentric rib to become enlarged or lamellose and the interspaces, as well as the ribs, are covered with fine, submicroscopic striæ; escutcheon very narrow; interior concealed in our specimen.

Length, 47 mm.; height, 40 mm.; semidiameter, 12 mm.

The holotype, from Quebrada Mellisa, is the only specimen known. It differs most strikingly from the members of the *Pitar circinata* group by its more regularly elliptical form and wider, more rounded posterior side.

Type.—Paleontological Research Institution, No. 4095.

Occurrence.—Quebrada Mellisa.

Pitar (Lamelliconcha) anona, n. sp. Plate 5, fig. 1

Shell subovate, plump, ventral margin regularly rounded; posterior side narrowed with a tendency to become obliquely truncated at its end; surface ornamented with prominent, subequal, concentric ribs which are thin or lamellar and separated by deeper and wider interspaces; these ribs are thin and high but they are generally not well preserved over the whole surface; finer concentric striæ overrun the concentric ribs and their interspaces; lunule small, cordate, marked with lower ribs; escutcheon narrow, ridgelike; interior is concealed in our specimen.

Length, 35.5 mm.; height, 28.5 mm.; diameter, 20 mm.

Known only from the holotype which is a perfect shell with closed valves and consequently the interior cannot be seen. From *P. circinata* the species differs in being longer and by its more strongly truncated posterior side as well as by its thinner and higher riblets. A weak sinal depression extends from the posterior-ventral side towards the umbos.

Type.—Paleontological Research Institution, No. 4096.

Occurrence.—Rio Guanabanon.

Genus MACROCALLISTA Meek

Macrocallista traftoni, n. sp. Plate 5, figs. 2, 3

Shell medium-sized, subelliptical in form and moderately convex; texture subsolid, porcellaneous with a smooth external surface which is generally polished but originally was covered with a brownish-colored epidermis of which remnants persist on some specimens; the posterior side is twice the length of the anterior, oblique and obtusely rounded at its end; muscle scars prominent, united by the pallial line with a wide sinus reaching past the middle line; hinge normal; lunule narrow, slightly impressed.

Length, 33 mm.; height, 21 mm.; semidiameter, 6.5 mm. (type.)

Length, 39.5 mm.; height, 28.5 mm.; semidiameter, 8.75 mm.

Although common, it has not been possible to identify this fossil with any known species. From the young of the Recent West Coast species of *Macrocallista,* such as *M. aurantiaca* Sby., *M. squalida* Sby., and *M. pannosa* Sby., the present shell differs by its longer form. Some shells have remains of a brown epidermis but show no trace of a color pattern.

Type.—Paleontological Research Institution, No. 4093; other specimen, No. 4094.

Occurrence.—Pleistocene, Rabo de Puerco and Rio Guanabanon.

Genus LUCIPLOMA, new genus

Genotype.—*Luciploma panamensis*, n. sp.

The following is a description of the genus *Luciploma*.

Shell subovate, longer than high, solid and with an external concentric sculpture; no lunule or escutcheon; hinge venerid with a set of 3 cardinal teeth but no laterals; resilium scar very high and wide, not bordered above by a groove for the insertion of the external ligament; dorsal edge of the valve sharp, flangelike; nymphs if present much reduced in size; ventral margins smooth.

Remarks.—The type of this interesting genus is a fragmentary right valve. Its hinge structure agrees best with *Cyclina* and *Cyclinella*, the right valve having no anterior lateral and 3 typical venerid cardinal teeth of which the middle one is strongest. Both *Dosinia* and *Cyclina* have broad nymphs and the resilium scar is bordered dorsally by a deep groove for the insertion of the external ligament. In the type of this new genus, the nymphs are not recognizable, the whole area above the cardinal teeth forming the resilium scar. There is no dorsal ligament groove as in *Dosinia*, the external edge of the shell forming a sharp, flangelike margin. The anterior muscle scar is deep as in all thick, solid shells. The ventral margin is smooth. Lunule and escutcheon are absent.

Luciploma panamensis, n. sp. **Plate 3, figs. 1, 2**

Shell subovate, solid and of medium convexity; external sculpture formed by concentric riblets which are quite regularly spaced on the umbo but become crowded and irregular ventrally; inner margins smooth; hinge as described above, the most striking feature being the high, wide resilium scar which forms a sharp, flangelike edge to the dorsal margin of the shell; anterior muscle scar prominent.

Partial length, 38 mm.; height, 36 mm.; semidiameter, 11 mm.

Although it has been necessary to base a new genus and species on a single, fragmentary specimen, its characteristics are so unusual that its naming appears justifiable. The hinge structure as indicated above is typical venerid, the relations of the shell being clearly with *Dosinia* and *Cyclina*. It differs principally from these and other venerid genera by its wide resilium scar. The external sculpture is suggestive of certain species of *Astarte* and *Crassatellites*.

Type.—Paleontological Research Institution, No. 5009.

Occurrence.—Burica sandstones, Burica Point.

Genus **CHIONE** Megerle von Mühlfeld

Subgenus **CHIONE**, s. s.

Chione (Chione) vaca, n. sp. Plate 5, fig. 7

Shell of medium size, subtrigonal, very solid, depressed to strongly convex; the form is subtrigonal; the umbos surmounted by the slightly recurved beaks, are placed a little in front of the middle, and the posterior and anterior sides are straight, sloping and of nearly equal length; ventral side evenly rounded; sculpture is formed of strong, steplike, concentric folds, widening ventrally, and strong, radial riblets or cords which tend to be regular near the ventral margins but which dorsally are paired or formed by the division of earlier simple cords; escutcheon and lunule well marked, without ribs; hinge normal with a strong, central cardinal tooth; ventral margin crenulated.

Length, 27.5 mm.; height, 26 mm.; semidiameter, 8.75 mm.

Length, 28 mm.; height, 30.5 mm.; semidiameter, 12 mm.

Allied to the Recent West Coast, *C. subimbricata* Sby., this species is readily distinguished by its peculiar step or platform-like ribs and trigonal form. In the young of *C. subimbricata*, the concentric ribs have raised, thin edges so that the shell resembles *C. cancellata*. This stage, if present in *C. vaca*, must be restricted to a very early age as the shoulders of the ribs are rounded even in very small shells.

Type.—Paleontological Research Institution, No. 4097.

Occurrence.—Rio La Vaca. Quebrada Melissa.

Chione (Chione) araneosa, n. sp. Plate 3, fig. 6

The shell is of medium size, solid, obliquely subtrigonal and of medium convexity; posterior-dorsal side appears nearly straight with the edge, bordering the excavated, flattened escutcheon, angled; ventral side well rounded; the surface sculpture is rather subdued and is formed principally by radial cords crossed by weak concentric ridges; the radial cords are rather coarse and regular over major part of the surface and appear slightly curved as they cross from the beaks to the ventral margin; on the dorsal-posterior slope, the radials are much finer; the concentric ridges are subobsolete for the most part and are well marked only on the umbos; on perfect specimens, they were probably lamellose to a degree on the posterior-dorsal submargins, particularly near the end; lunule subelliptical, defined by an impressed line; interior not exposed.

Height, 32 mm.; length, 33 mm.; semidiameter, 7 mm.

The species resembles an eroded *Chione cancellata* but the shell is higher, more trigonal, solid and the primary radials are simple cords.

Type.—Paleontological Research Institution, No. 4098.

Occurrence.—Burica sandstones, Burica Point.

Subgenus **LIROPHORA** Conrad

Chione (Lirophora) kelletti (Hinds)

Venus kellettii Hinds, 1844, Zool. Voy. Sulphur, Moll., p. 65, pl. 19, fig. 5.
Chione (*Lirophora*) *kelletti* Pilsbry and Olsson, 1941, Proc. Acad. Nat. Sci. Phila., vol. 93, p. 64, pl. 16, fig. 2.

This species was described by Hinds from the island of Quibio, off the coast of the Province of Veragua, Panama. It is apparently a rare species in the Recent fauna. As fossil, it is common at several localities on the Burica Peninsula. It is quite variable, some individuals being much longer than high, while in others, the height is nearly the same as the length. The solid coalescent ribs tend to form a smooth, even surface on the middle of the disk with a bordering band of high, leaflike expansions on the ends, often broken away. These thick, solid shells resemble species of *Anomalocardia* but differ in possessing the foliaceous areas on the anterior and posterior sides. The pallial sinus is very short. Some of our specimens measure as follows:

Length, 48.5 mm.; height, 40.0 mm.; diameter, 15.0 mm.
Length, 42.5 mm.; height, 38.0 mm.; diameter, 27.5 mm.
Length, 34.0 mm.; height, 27.5 mm.; diameter, 9.0 mm.

Occurrence.—Rio La Vaca. Quebrada Mellisa.

Chione (Lirophora) ebergenyi Böse

Venus (*Chione*) *Ebergenyii* Böse, 1906, Bol. Inst. Geol. Mexico, Num. 22, lám. II, figs. 4-17.

A specimen of *Lirophora* from Quebrada Mellisa is evidently the *Chione ebergenyi* Böse from Paso Real near Tuxtepec, State of Oaxaca in Mexico. The shells figured by Böse are slightly longer and the costæ are narrower and hence more numerous. Most species of *Lirophora* are variable and consequently these differences are not considered of much importance.

Occurrence.—Quebrada Mellisa.

Family **PSAMMOBIIDÆ**

Genus **SANGUINOLARIA** Lamarck

Subgenus **SANGUINOLARIA**, s. s.

Sanguinolaria (Sanguinolaria) azulensis, n. sp. Plate 5, fig. 8

Shell small, subelliptical, thin and slightly convex; the umbos are nearly central ending above in the small, pointed beaks; posterior side slightly narrower than the anterior, its dorsal margins somewhat flattened and smooth, there being no well-marked posterior flexure; sculpture is formed by evenly spaced, concentric lines, strongly developed on the anterior side, nearly absent from the posterior, while in the middle zone they are slightly oblique and cross the concentric growth lines; no radials; interior featureless, the pallial sinus and muscle scars scarsely showing because of the thinness of the shell; hinge of the right valve with 2 cardinal teeth, the posterior one being double, 2 laterals, the anterior one placed near the cardinals, the other one more remote.

Length, 35.5 mm.; height, 21 mm.; semidiameter, 4.25 mm.

Our material of this interesting form consists of two specimens, one badly broken. From the Recent West Coast, *S. tellinides* C. B. Adams, it is distinguished by its smaller, thinner shell and absence of any radial sculpture.

Type.—Paleontological Research Institution, No. 5008.

Occurrence.—Pliocene. Charco Azul.

Family **TELLINIDÆ** Linné

Genus **TELLINA** Linné

Subgenus **MACALIOPSIS** Cossmann

Tellina (Macaliopsis) frontera, n. sp. Plate 4, figs. 3, 6

Shell suborbicular, *Semele*-like in form; the valves are moderately convex, that of the left being a little more inflated than the right which has a shallow flexure extending across the posterior-middle section; beaks placed a little posterior of the middle are small, adjacent and project but little above the hinge line; anterior side, nearly twice the length of the posterior, is widely rounded at the end, its dorsal margin sloping downward; posterior-dorsal side sloping more rapidly than the anterior, joining with the ventral side to form a well-rounded end; ventral margin straight in the middle, oblique to the longer axis of the shell, rounding into the side; the valves are weakly flexed, resulting in the formation of a shallow, broad, depressed zone in the posterior-middle section of the right valve; there is a narrow, linear, posterior-dorsal area in each valve; surface sculptured by moderately coarse and evenly spaced growth lines; interior unknown.

Length, 44 mm.; height, 36.5 mm.; diameter, 15 mm.

In the holotype the two valves are tightly closed so that the interior and the hinge are not visible. The shape and sculpture are quite *Semele*-like but the presence of a well-marked posterior-dorsal area and the distinct but slight flexing of the valves indicate tellinid rather than semelid affinities.

Type.—Paleontological Research Institution, No. 5001.

Occurrence.—Quebrada Peñitas. Costa Rica.

Genus **MACOMA** Leach

Subgenus **PANACOMA**, new subgenus

Genotype.—*Macoma (Panacoma) chiriquiensis*, n. sp.

The following is a description of the subgenus *Panacoma.*

Valves thin, broadly subovate, moderately inflated and subequal; the posterior side a little narrower and longer than the anterior; sculpture of strong, raised, concentric threads and a sprinkling of small, *Thracia*-like granules; no differentiated posterior flexure; hinge normal; pallial sinus wide, confluent below.

Macoma (Panacoma) chiriquiensis, n. sp. Plate 5, figs. 5, 6

Shell thin, broadly subovate. subequal; the anterior side is somewhat shorter and more widely rounded than the posterior; there is no posterior flexure so that the two sides appear more or less subequal; the sculpture is formed by fairly regular, small, raised threads which are weakly flexed in the middle by a slightly depressed band extending from the beaks to the middle portion of the ventral side; in addition, the surface has a sprinkling of small granules recalling some species of *Thracia;* body cavity deep with a wide pallial sinus reaching a little beyond the middle, below, it is confluent with the pallial line which reaches nearly to the posterior muscle scar; hinge of the left valve with normal *Macoma*-tooth formula, 2 cardinal teeth, the anterior one larger, no laterals.

Length, 34 mm.; height, 27 mm.; (estimated) semidiameter, 7 mm. (type).

This species is based on two imperfect specimens but with very distinctive characters. The valves are moderately inflated, thin with no posterior flexure. The surface sculpture is peculiar and consists of a series of strong, concentric, raised threads separated by wide, flat interspaces, the whole being covered with small granules sometimes fusing with the coarse threads of growth.

Type.—Paleontological Research Institution, No. 5002; other specimen, No. 5003.

Occurrence.—Charco Azul.

Subgenus **MACOPLOMA** Pilsbry and Olsson

Macoma (Macoploma) medioamericana, n. sp. Plate 4, fig. 8

Shell of medium or large size, elongate, delicate; the valves are subequal, the left being slightly larger and more convex than the right which is somewhat flexed or depressed in the middle; beaks, placed at the posterior one-third, are small and pointed; anterior side nearly twice the length of the posterior, obliquely rounded at the end; posterior side somewhat narrowed, obliquely truncated at the end; surface is marked with lines of growth, smoother in the middle, coarse and more or less granulose on the sides; each valve has a narrow, submarginal zone at the posterior end, its surface earthy in appearance and bordered anteriorly by a line of coarse granules; hinge unknown.

Length, 62 mm.; height, 30 mm.; diameter, 12 mm.

Length, 52 mm. (imperfect); height, 27 mm.; diameter, 12 mm.

The type of this subgenus is *Macoma ecuadoriana* Pilsbry and Olsson, recently described from the Pliocene of Ecuador. The Panama species is proportionately longer. It differs also by its coarser, more earthy, or *Thracia*-like granulation of the surface on the posterior submargins. Although common at Quebrada Peñitas, the species is seldom well preserved. Fragments indicate that the shell in some cases reached 80 to 85 millimeters in length.

Type.—Paleontological Research Institution, No. 5004.

Occurrence.—Pliocene. Quebrada Peñitas, Costa Rica.

Family **CORBULIDÆ**

Genus **CORBULA** Bruguière

Subgenus **VARICORBULA** Grant and Gale

Corbula (Varicorbula) granti, n. sp. Plate 2, figs. 8, 9

Shell of medium size, subtrigonal, moderately convex and with nearly central beaks; valves unequal, that of the right being about a fourth larger, both are quite convex; right valve is bluntly rostrate posteriorly, and its surface sculptured with strong, concentric riblets which pass into crowded irregular lines on the posterior area; left valve smaller, its posterior half more or less impressed, its anterior side rounded to convex and its surface marked with subobsolete to irregular, smoothish concentric riblets, no radial lines; the left valve is rostrated, its posterior area marked with 3, low riblike folds, most distinct at the ends; interior of valve deep, the right valve with a strong cardinal tooth, fitting into a socket in the left.

Length, 11.5 mm.; height, 10 mm.; semidiameter, 4.5 mm. (right).

Length, 10.5 mm.; height, 9 mm.; semidiameter, 4 mm. (left).

Our specimens are all rather poorly preserved, some of the valves being deeply weathered and chalky. From the majority of Corbulas of this group, the present species differs in the absence of radial lines on its left valve. Both valves are moderately convex and marked with concentric riblets, those of the right valve being stronger

Type.—Paleontological Research Institution, No. 5005; other specimen, No. 5006.

Occurrence.—Quebrada Peñitas. Charco Azul.

Corbula (Varicorbula) cf. bradleyi Nelson

Corbula bradleyi Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 200.
Corbula (*Aloidis*) *bradleyi* Spieker, 1922, Johns Hopkins Univ., Studies Geol. No. 3, p. 171, pl. 10, figs. 13, 14.
Corbula (- - - -) *bradleyi* Olsson, 1932, Bull. Amer. Paleont., vol. 19, p. 137.

Shell large, the right valve larger and more convex than the left; umbos wide, convex, with the beaks near the anterior one-third, incurved over the hinge, the posterior side bluntly rostrate and marked off from the rest of the surface by a weak ridge; the surface sculpture of the right valve consists of strong and nearly regular, concentric riblets; the left valve is smaller and more elongated in form and less convex; its surface sculpture is formed by irregularly spaced, narrow, radial riblets.

Nelson described this species from a single, somewhat weathered right valve from the Tumbez beds of northern Peru. The type was subsequently studied and figured by Spieker. This specimen measures length, 20 mm., and height, 18.5 mm., a size rather large for the genus.

A *Varicorbula* probably belonging to Nelson's species occurs in our collections from Quebrada Mellisa. We have 5 right valves and 1 left valve. Two valves have the following measurements: right valve, length, 16 mm.; height, 12.5 mm.; semidiameter, 6.5 mm.; left valve, length, 11 mm.; height, 8 mm.; semidiameter, 4 mm.

A relatively large *Varicorbula* from the Pliocene of California has been described as *V. gibbiformis* by Grant and Gale.[12] The figures seem to indicate a higher form than the Panamanian specimens.

Class **GASTROPODA**

Order **CTENOBRANCHIATA**

Family **TEREBRIDÆ**

Genus **TEREBRA** Bruguière

Subgenus **STRIOTEREBRUM** Sacco

Terebra (Strioterebrum) guanabana, n. sp. Plate 11, fig. 4

Shell large, slender with about 12 whorls preserved in the type (apex missing); the sculpture of the earlier whorls is rather strong with a prominent fasciolar band defined below by a deep spiral groove which appears punctate in the spaces between the ribs; on the lateral whorls, the fasciolar band becomes wider and the limiting groove below it is less strong; the spirals overrun the whole surface including the fasciolar band, at first strong and regular on the spire whorls they soon become more numerous and irregular on the later turns; on the whorl of the spire about

[12] Grant, U. S. IV, and Gale, H. R., San Diego Soc. Nat. Hist., Mem., vol. 1, pp. 420-421, pl. 19, figs. 4-6. Also Woodring, 1938, U. S. Geol. Surv., Prof. Paper 190, 1931, p. 55, pl. 6, figs. 8, 9.

12 mm. from the tip, the ribs are strong, slightly bowed and number about 23 with about 6 or 7 spirals in their interspaces; on the succeeding turns, the ribs gradually become more numerous and less pronounced, and on the last turn appear scarsely stronger than crowded growth lines; the spirals on the mature whorls numerous, irregular and rather weak; anterior canal fairly long, twisted, the columella armed with 2 low folds.

Length, 69.00 mm.; diameter, 14.25 mm. (type).

Type.—Paleontological Research Institution, No. 4026.

Occurrence.—Rio Guanabanon, Sta. 18.

Terebra (Strioterebrum) aspera Hinds

Several poorly preserved *Terebra* in our collections have been tentatively identified with this Recent species. They are quite similar to specimens of *T. aspera* from the West Coast of South America but differ in a few minor characters, the constancy of which cannot be determined from the material at hand.

Occurrence.—Rio La Vaca and Rio Guanabanon.

Terebra (Strioterebrum) cracilenta Li — Plate 11, fig. 5

Terebra cracilenta Li, 1930, Bull. Geol. Soc. China, vol. 9, No. 3, p. 274, pl. 8, fig. 67.

Terebra cracilenta Pilsbry, 1931, Proc. Acad. Nat. Sci. Phila., vol. 83, pp. 434, 439, text figs. 1, 1a, 2.

Terebra (*Strioterebrum*) *cracilenta* Pilsbry and Olsson, 1941, Proc. Acad. Nat. Sci. Phila., vol. 93, p. 14.

Of this beautiful species, we have 3 specimens, none quite perfect. The columellar folds are weak and sometimes scarsely developed, the superior one being generally broad and flattened. The spiral sculpture predominates and consists typically of alternating bands nodulated by the ribs, this noding extending to the spiral bands on the base.

Specimen figured.—Paleontological Research Institution, No. 4027.

Occurrence.—Rio La Vaca.

Terebra (Strioterebrum) vaca, n. sp. — Plate 11, figs. 6, 7

Shell acute-acuminate, the taper being rather rapid; whorls about 10 or more (apex lost on type) straight with the fasciolar band projecting slightly above the general surface; each spire whorl is rather wide with noticeably inclined sutures; the sutural fasciole is pronounced and strongly noded, especially on the upper half, there being on the last turn about 24 nodes present; below the sutural fasciole, the face of the whorl has 4 spiral bands with a 5th just visible in the lower suture on some whorls, these spirals increase in strength upward; the ribs are weak and mainly indicated by the noding of the spirals and in the spiral interspaces are scarsely shown; on the outer face of the last whorl, there are altogether about 13 spirals, the lower 4 or 5 encircling the base, are slightly smaller and plain; anterior canal twisted, the columella with 2 strong folds, the upper one continuous with the sharp, external keel.

Length, 42.00 mm.; diameter, 10.50 mm.

Type.—Paleontological Research Institution, No. 4028.

Occurrence.—Rio La Vaca.

Terebra (Strioterebrum) panamillata, n. sp. Plate 11, fig. 3

Shell of moderate size with about 7½ whorls preserved in the type (apex missing); fasciolar band is strongly noded and about one-third of the width of each spire whorl; it projects slightly above the general surface, otherwise the surface profile is nearly straight; although the ornamentation consists of both ribs and spirals, the sculpture as a whole appears smoothish; the spirals cover the entire surface, including the fasciole and are mainly flat bands somewhat stronger in the middle of the whorl but decrease in strength on the base; in the interval below the sutural fasciole and the suture, the spiral sculpture falls into two series, a lower set formed by 4 flattened bands, quite regular and an upper set of lower, narrower and more irregular ones; the ribs are weaker than the spirals except on the fasciole which they strongly nodulate; on the last whorl, the ribs are narrow, sinuous, widely spaced and number about 12 but they do extend over the base; the twisted anterior canal rather short and the columella folds are weakly developed, only the superior one being at all recognizable.

Length, 32 mm.; diameter, 9 mm.

This species resembles *T. armillata* Hinds of the Recent fauna as well as its subspecies *sheppardi* Pilsbry and Olsson from the Ecuadorian Pliocene but differs in its smoother sculpture, weaker columellar folds and other characters. It also resembles *T. ligyrus* Pilsbry and Lowe but is larger and the fasciolar groove is more strongly defined.

Type.—Paleontological Research Institution, No. 4029.

Occurrence.—Rabo de Puerco.

Family **CONIDÆ**

Genus **CONUS** Linné

Subgenus **LEPTOCONUS** Swainson

Conus (Leptoconus) arcuatus vacuanus, n. subsp. Plate 6, figs. 11, 12

Shell of medium size with a sharply angled shoulder and broadly conic, high spire; the nucleus was very small but is lost on all our specimens, it was followed by 10 or more spire whorls, the earliest of which are ornamented by small ribs which are quickly lost on the succeeding turns; the surface of the spire whorls is concave or excavated, leaving the edge of the shoulder sharply angular; the last whorl is rather wide at the shoulder, tapering rapidly forward into the anterior canal which is slightly twisted at the end; the sculpture, in the young stages, consists of strong, spiral grooves which cover the whole surface except the spire and possibly a narrow band adjacent to the shoulder; these spiral bands are separated by strong grooves and generally average about 22 in number; these bands may be regular in size and width or they may be divided by medial lines; in older shells, a wide zone bordering the shoulder may be smooth or it may have only faint indications of the spiral bands remaining visible; columella straight, the anterior canal with a slight twist or fold at its end.

Length, 46 mm.; height, 22 mm. (type).

Length, 36 mm.; height, 18 mm.

This cone recalls some Miocene species as *C. planiliratus* Sby. and *C. imitator lius* Woodring.[13] Like other members of this group, the cone shows much variation in sculpture according to age and size. Amongst Recent forms, the present shell is closely allied to *Conus arcuatus*[14] Sowerby. *Conus gradatus,* as figured by Reeve,[15] is possibly the same as Sowerby's species. In the

[13] Woodring, W. P.: *Miocene mollusks from Bowden, Jamaica,* Carnegie Inst. Washington, Pub. No. 385, 1928, p. 209, pl. 10, figs. 5, 6.

[14] Sowerby, G. B.: The Conchological Illustrations, *Conus,* 1841, fig. 9.

[15] Reeve, L.: Conchologia Iconica, 1843, fig. 140.

series before me, the fossil differs by its wider form and shorter, more evenly conic spire, the tip of which is scarcely attenuated. A cone from the Pleistocene of the Rio Guanabanon identified as *C. arcuatus* is figured for comparison. This shell is immature but is very similar to the form figured by Reeve as *C. gradatus*. (Plate 6, figs. 13.)

Type.—Paleontological Research Institution, No. 4030.

Occurrence.—Quebrada Peñitas, Quebrada Mellisa and Rio Guanabanon.

Family TURRIDÆ

Genus POLYSTIRA Woodring

Polystira panamensis, n. sp. Plate 12, fig. 4

Shell of medium size, fusoid, the aperture and spire of about equal length; nucleus unknown, about 8 whorls remaining on the type specimen; the spire whorls have a strong, spiral cord placed a little below the middle and sculptured with double-knobbed ribs, which lie at the apex of the anal sinus; above and below this central or peripheral cord, the growth lines curve forward as strong, raised threads; the upper suture is bordered by a raised thread and in the area between it and the central cord, the surface has 4, small but well-marked, spiral threads but no primaries; the last whorl has 5 primary spirals between the peripheral cord and the base, these are more widely spaced above, their interspaces carrying 2 or more fine threads; below the base, there are 10 or more spirals which extend over the anterior canal; aperture wide above, narrowed forward; axis of anal sinus in the middle following the peripheral cord.

Length, 23 mm.; height, 8 mm.

A single specimen only of this finely sculptured species was found.

Type.—Paleontological Research Institution, No. 4032.

Occurrence.—Charco Azul.

Genus CLATHRODRILLIA Dall

Clathrodrillia harrisi, n. sp. Plate 9, fig. 10; Plate 11, fig. 8

Shell of medium size, slender, the spire half again as long as the aperture; apex acute, originally with a very small nucleus (lost on our specimens); the subsequent whorls number about

10, are convex in profile and separated by distinct but somewhat wavy, appressed sutures; sculpture, formed by spirals and ribs, is rather weak and subdued; the short ribs are restricted to the middle of the whorl (absent from the concave sutural fasciole and the base); these ribs on the last whorl number about 14; spiral threads have a variable development, on some specimens as illustrated by figure 8, Plate 2, they are quite strong and cover the ribs, in others they are nearly absent from the top of the ribs and are strongly developed on the base only; very fine spiral threads cover the entire surface and may be seen with a hand lens; aperture subovate, terminating forward in a rather wide, slightly recurved canal; outer lip thickened by a humped rib on the back and with a small, narrow anal sinus lying in the sutural fasciole; columella with a spread of callus.

Length, 34 mm.; diameter, 11.75 mm.

Length, 32.5 mm.; diameter, 11 mm.

This species is referred tentatively to *Clathrodrillia*. In form and thickened lip it recalls *Glyphostoma* or *Clathurella* but differs in other characters.

Type.—Paleontological Research Institution, No. 4033.

Occurrence.—Quebrada Peñitas.

Subgenus BURIDRILLIA, new subgenus

Genotype.—*Clathrodrillia panarica*, n. sp.

The following is a description of the subgenus *Buridrillia*.

The shell is rather large, slender, fusiform with a long spire and anterior canal; anal sinus like that of *Drillia* is placed in an excavated fasciolar band bounding the upper suture; pillar straight, generally with a large, thick fold on the columella; anterior canal long, wide, nearly straight; sculpture of straight axial ribs and spirals, the surface with a waxy lustre.

To this group, we should probably also refer the *Borsonia ephigona* Von Martins[16] described from deep-water stations in the Indian Ocean and from off the coast of Sumatra (depths 614 to 677 meters in depth). The type of the Indian Ocean spe-

16 Von Martens, Ed., und Thiele, J.: *Die beschalten Gastropoden der deutschen Tiefsee Expedition*, 1898-99, Wissen. Erg. Deutsch. Tiefsee Exp. Dampfer "Valdivia," Band, 1904, p. 91, taf. 2, fig. 2.

cies is very similar in form and sculpture and the columella has a large, thick fold. The known specimens are small (the largest measuring but 28 millimeters) and may not be mature but the columellar fold is large and in an advanced stage of development. The genus *Darby*, recently proposed by Bartsch[17] for *D. lira* of the Puerto Rican deep, has a similarly large, thickened columellar fold but differs in other respects.

Clathrodrillia (Buridrillia) panarica, n. sp. Plate 7, figs. 4, 5 7.

Shell quite large, fusiform, rather coarse and solid; whorls 8 or more; nucleus not known; sculpture consists (a) of narrow, foldlike ribs which are strongest on the spire whorls where they extend from the lower suture to the edge of the anal fasciole but on the last whorl are mainly restricted to the portion immediately adjoining the fasciole, and (b) faint, subobsolete spirals; on the holotype, the ribs number 12 or 13 on the last turn; the spirals are flattened, smoothish or irregular cords, a little coarser on the anterior canal, absent from the surface of the fasciole; the spirals number about 8 on the penulimate whorl and about 30 on the last whorl; outer lip sinuous, curved forward in the lower portion and with a moderately deep sinus lying in the anal fasciole; aperture elongate, ending in a fairly wide, anterior canal; columella with a large, thick, lumplike fold, its upper or posterior side, flattened or excavated.

Length, 72.0 mm.; diameter, 20.5 mm.; aperture, 31.0 mm.

This peculiar species is characterized by its large size, waxy surface luster, and especially by the large columellar fold. This fold is not equally developed on all shells and its size is probably not entirely a result of mature growth. Some specimens from Quebrada Peñitas, as large as the average shell from Charco Azul, may have a plain columella or one showing only a slight swelling while other shells from the exposures along the beach on the west side of the Burica Peninsula have developed a large, thick fold at the same stage of growth. The axial sculpture is formed by strong, narrow, ribs which commence on the base and extend to the edge of the sutural fasciole. The spirals form subobsolete, flattened bands separated by fine lines.

[17] Bartsch, P.: *New mollusks of the family Turritidæ*, Smith. Misc. Coll., vol. 91, No. 2, 1934, p. 22, pl. 6, figs. 4, 5; pl. 7, figs. 6, 8.

Type.—Paleontological Research Institution, No. 4034; other specimens, No. 4035.

Occurrence.—Quebrada Peñitas, Costa Rica; Charco Azul, Panama. Beach exposures on the west side of the Burica Peninsula, Costa Rica.

Genus ANCISTROSYRINX Dall

Ancistrosyrinx cedonulli reevei, n. subsp. Plate 10, fig. 4

cf. *Pleurotoma cedonulli* Reeve, 1843, Proc. Zoöl. Soc. London, p. 185.
cf. *Pleurotoma cedonulli* Reeve, 1845, Conch. Icon. *Pleurotoma*, sp. 117.
cf. *Ancistrosyrinx cedonulli* Dall, 1908, Albatross Report, p. 273.

Shell broadly fusiform, with a high, tabulated spire, elegantly coronated with a row or crown of triangular, flattened, scalelike spines; surface generally smoothish and polished, in places malleated or showing a series of wrinklelike, spirally arranged threads and a set of strong spirals on the anterior canal; in the area between the shoulder and the suture, the surface is flattened with a strong central carina and sculptured with a series of oblique growth lines on the outer portion, smoother on the inner side; anal sinus deep, lying next to the suture; the scalelike spines decorating the shoulder, number about 19 on the last whorl.

Length, 43 mm.; diameter, 20 mm; aperture, 27 mm.

The type of *Pleurotoma cedonulli* was dredged by Cummings in the Bay of Panama at a depth of 10 fathoms. It is an immature specimen. Reeve's figure shows a narrow, slender shell with relatively few spines on the shoulder angle. Our fossil specimens are wider and have more shoulder spines. The fossil is quite common at Charco Azul, the delicate shell having a high surface polish and a white to cream color.

Type.—Paleontological Research Institution, No. 4036.

Occurrence.—Charco Azul. Rio Guanabanon.

Genus FUSITURRICULA Woodring

Fusiturricula woodringi, n. sp. Plate 7, fig. 2

Shell quite large, slender, fusiform; spire and anterior canal very long and of equal length; nucleus not preserved, subsequent whorls 10 or more in number; sutures indistinct, appressed, in front of which the whorl is deeply constricted to form a pronounced sutural fasciole; on the last whorl, the sculpture has 10, short, axial ribs developed principally on the shoulder with the last rib forming the back of the lip being the largest and strongest; in addition there are spiral threads arranged in an alternating series of primary, secondary and tertiary size and extend from the tip of the anterior canal to the sutural fasciole; on the fasciole itself, the spirals are much finer; aperture subovate, with a long slender, anterior canal; outer lip, widely expanded forward, retractive above into a deep sinus lying in the sutural fasciole.

Length, 62.0 mm.; diameter, 18.5 mm.; aperture, 34.0 mm.

This species resembles the *Turris* (*Surcula*) *fusinella* Dall[18] which is the type of Woodring's *Fusiturricula*.[19] The holotype of *T. fusinella* is an immature specimen having a length of only 17 mm., dredged in the Gulf of Panama at a depth of 153 fathoms.

Type.—Paleontological Research Institution, No. 4037.

Occurrence.—Charco Azul.

Genus TURRICULA Schumacher

Turricula dulcia, n. sp. Plate 7, figs. 3, 6

The shell is similar to *Turricula flammea* Schumacher but is more slender with a less strongly contracted body whorl; solid, fusiform with a long, pointed, sharp spire having a strongly contracted or concave anal fasciole, nearly ½ the spire whorl in width, less wide in proportion on the penultimate whorl; sutures appressed; the surface is generally smooth, except on the whorls of the spire which show a series of ribs on the fasciolar angle to the number of about 11 on each turn but fade out so that they are practically lacking from the last whorl; on the body whorl, the surface is nearly smooth except for fine spiral lines which appear on magnification, much stronger on the base of the last whorl and on the canal; aperture narrow, elliptical produced forward into a long canal, slightly bent; pillar, thick, solid and smooth; outer lip arcuate in the lower part, with a deep, anal sinus lying in the sutural fasciole.

[18] Dall, W. H.: *The Albatross Report*, 1908, p. 261, pl. 14, fig. 7.

[19] Woodring, W. P.: *Miocene mollusks from Bowden, Jamaica*, Carnegie Inst. Washington, Pub. No. 385, 1928, p. 165.

Length, 47 mm.; diameter, 16 mm.; aperture, 24 mm.

This shell is quite similar to *Turricula flammea* Schumacher,[20] the type of the genus *Turricula,* but is more slender with a less strongly contracted body whorl. The *Turricula libya* Dall[21] from San Lucas is a stouter and shorter shell with stronger sculpture. Another similar species is the *Surcula nelsoni* Olsson[22] from the Tumbez beds of northern Peru but that species is larger and entirely lacking in ribs.

Type.—Paleontological Research Institution, No. 4038.

Occurrence.—Quebrada Peñitas.

Subgenus KNEFASTIA Dall

Turricula (Knefastia) andesita, n. sp. Plate 7, fig. 8

Shell rather large, coarsely sculptured, principally with spirals, the ribs being practically absent; nucleus unknown, about 8, post-nuclear whorls preserved; sutures very indistinct; the whorls are moderately convex, with the sutural fasciole hardly differentiated, this part of the whorl being merely constricted and without any marked change in sculpture; in the sculpture, the axial ribs are practically absent but with slightly irregular undulations marking former stages of rest; the spiral sculpture is strongly developed and consists of spiral cords, heaviest about the periphery, weaker in the zone of the sutural fasciole and separated by wide intervals carrying finer, secondary threads; on the spire whorls, there are about 5, principal spirals, increased to about 20 on the body whorl; the principal spirals begin at the lower margin of the sutural fasciole and extend to the tip of the anterior canal; spiral interspaces have generally 4, fine spiral threads; anal sinus, deep, lying in the middle of the sutural fasciole; aperture and canal imperfect but apparently the canal was moderately long, *Fusus*-like.

20 In Grant, U. S. IV, and Gale, H. R.: *Pliocene and Pleistocene Mollusca of California,* Mem. San Diego Soc. Nat. Hist., vol. 1, 1931, p. 486, pl. 25, figs. 9a, 9b.

21 Dall, W. H.: Proc. U. S. Nat. Mus., vol. 56, 1919, p. 2, pl. 2, fig. 5.

22 Olsson, A. A.: *The Peruvian Miocene,* Bull. Amer. Paleont., vol. 19, 1932, p. 150, pl. 16, fig. 10.

Length, 47.0 mm.; (imperfect), diameter, 19.5 mm.; aperture, 16.0 mm. (imperfect).

Related to *Turricula lavinia* Dall[23] from the West Coast of Mexico, this species differs by its stronger sculpture and less well-defined sutural fasciole. The sculpture of strong spiral cords, their intervals sometimes finely etched by the lines of growth, resembles that of the more finely sculptured species of *Polystira* but the retral sinus is that of *Turricula* and lies in the middle of the sutural fasciole. The ribs are practically absent but there is a series of irregularly spaced undulations, the larger ones marking stages of rest in the growth of the shell.

Type.—Paleontological Research Institution, No. 4039.

Occurrence.—Charco Azul formation, basal sands, mouth of Quebrada Peñitas.

Genus **PLEUROTOMELLA** Verrill

Subgenus **PHYMORHYNCHUS** Dall

Pleurotomella (Phymorhynchus) agina, n. sp. Plate 10, fig. 10

Shell of small or medium size, elongate-fusiform or columbelloid in form, smooth, polished; upper part of spire broken; sutures appressed, the whorl in front of it slightly constricted forming a shallow sutural fasciolar band; surface appearing smooth but on magnification showing fine, more or less, irregular spiral lines covering the anterior canal and the face of the body whorl except the sutural fasciole which is entirely smooth or marked with much finer, spiral lines; aperture semielliptical, the outer lip thin, arched forward in the middle, retractive towards the suture to form a shallow anal sinus adjacent to the suture; canal of moderate length, a little recurved at the tip.

Length, 27.50 mm.; diameter, 13.50 mm.; aperture, 15.00 mm.

This species is quite similar to the *Pleurotoma* (*Surcula*) *dissimilis* Watson,[24] dredged off the southeast side of the Philippines in 500 fathoms. The Philippine shell is larger (2.65 inches or about 67.50 mm.) and the sculpture is somewhat coarser but the shape is very similar. The Panama shell may also be com-

23 Dall, W. H.: Proc. U. S. Nat. Mus., vol. 56, 1919, p. 4, pl. 1, fig. 6.

24 Watson, R. B.: *Report on the Scaphopoda and Gasteropoda,* II, Report on the Scientific Results of the Voyage of the H. M. S. Challenger, Zoöl. vol. 15, 1885, p. 298, pl. 26, fig. 3.

pared with the *Pleurotomella* (*Phymorhynchus*) *argeta* Dall[25] dredged in 812 fathoms of water, near the Galapagos.

Type.—Paleontological Research Institution, No. 4040.

Occurrence.—Charco Azul.

Genus **LEUCOSYRINX** Dall

Leucosyrinx nicoya, n. sp. Plate 12, fig. 2

Shell thin, with a high, conic spire of 7 or more whorls, the apex and nucleus eroded; sutures appressed to slightly channelled; the whorls are strongly carinated at a point about one-third the whorl interval above the lower suture; above the peripheral carina, the surface is flattened, sloping, marked with fine spirals and the deeply arcuated growth lines of the anal sinus lying in about the middle of this area; below the peripheral angle, the surface has coarse, spiral cords or threads, somewhat alternating in strength; canal and lower part of the aperture not known.

Length, imperfect about 21 mm.; diameter, 17 mm.

We have fragments of 2 specimens of this species, both lacking the anterior portion. *L. persimilis* Dall[26] dredged from a depth of 1020 fathoms in the Gulf of Panama, is more slender.

Type.—Paleontological Research Institution, No. 5013.

Occurrence.—Charco Azul.

?Leucosyrinx buricana, n. sp. Plate 12, fig. 3

Shell of medium size, thin, volutiform, the spire and canal of about equal length; nucleus unknown, subsequent whorls 4 or more; sutures appressed; the whorls are narrowly shouldered, bearing a series of small, curved riblets which begin at about the middle zone of the body whorl but do not reach the upper sutures; on the body whorl, the riblets number about 14; besides the axial riblets, the sculpture on the body whorl consists of about 19, flat, spiral bands between impressed lines which begin on the canal and continue to the shoulder or edge of the sutural fasciole which is smooth; aperture elliptical, the outer lip thin; the anal sinus is very broad and shallow; anterior canal is moderately wide and nearly straight.

[25] Dall, W. H.: Proc. U. S. Nat. Mus., vol. 12, 1889, 307, pl. 6, fig. 5; Dall, W. H., *The Albatross Report*, 1908, p. 283, pl. 19, fig. 8.

[26] Dall, W. H.: *The Albatross Report*, Bull. Mus. Comp. Zoöl., vol. 43, No. 6, 1908, p. 271, pl. 12, fig. 2.

Length, 38.00 mm.; diameter, 20.00 mm.; aperture, 24.50 mm.

This species is not a typical *Leucosyrinx* but is referred to that genus tentatively because of its likeness to *?Leucosyrinx galapagana* Dall. The shell is poorly preserved and eroded but has the appearance of a deep-water species.

?Leucosyrinx galapagana Dall[27] dredged in 634 fathoms off the Galapagos Islands by the U. S. Bureau of Fisheries steamer Albatross is somewhat like our species but is smaller and more slender.

Type.—Paleontological Research Institution, No. 5014.

Occurrence.—Charco Azul.

Genus **BORSONIA** Bellardi

Subgenus **BORSONELLA** Dall

Borsonia (Borsonella) adamsi, n. sp. Plate 12, fig. 1

Shell of medium size, biconic, the aperture and spire of about equal length; apex eroded but with about 6 remaining whorls; the whorls are white or faun colored, polished but generally somewhat corroded; sutural fasciole well marked but not deep, forming a sloping or excavated band, a little more than half the width of the spire whorls and ornamented with flattish, spiral bands; shoulder with sloping, oblique ribs which on the last whorl number about 15; these ribs are absent from the sutural fasciole and from the base; whole surface covered with low, smoothish, spiral bands, the lined interspaces of which may be beaded; anal sulcus lying at the anterior side of the fasciole is moderately deep; aperture wide, the pillar with a single, obscure fold, the anterior canal slightly twisted.

Length, 27 mm.; diameter, 17 mm.; aperture, 14.5 mm.

This species is like *Borsonella agassizii* Dall[28] dredged from a depth of 1471 fathoms in the Gulf of Panama by the Albatross but has a longer canal and stronger axial sculpture. Like most of the other turrids from Charco Azul having deep-water characteristics, our shells are somewhat corroded and imperfect. It is possible that they had drifted some distance to their present

[27] Dall W. H.: Proc. U. S. Nat. Mus., vol. 56, 1919, p. 5, pl. 3, fig. 2.

[28] Dall, W. H.: *The Albatross Report*, Bull. Mus. Comp. Zoöl., vol. 43, No. 6, 1908, p. 275, pl. 1, fig. 5.

station but many deep-water mollusks show naturally the effects of water corrosion.

Named for C. B. Adams, pioneer student of Panama shells.

Type.—Paleontological Research Institution, No. 5010.

Occurrence.—Charco Azul.

Borsonia (Borsonella) harrisi, n. sp. Plate 12, figs. 6, 7

Shell small, biconic, the aperture and canal of about equal length; nucleus unknown, the remaining whorls 6 or 7 in number; the sutural fasciole forms a well-marked, sloping or excavated, smooth band which is about half the width of the spire whorl; surface below the fasciole is strongly sculptured with oblique riblets and spirals; the ribs are strongest just below the shoulder and number about 21 on the last whorl; the spirals form strong, flattened cords, separated above by incised lines only, and by deeper grooves on the base and canal; anal sulcus lying in the fasciole is quite wide; aperture wide, the pillar nearly straight, unarmed; anterior canal slightly twisted.

Length, 14.5 mm.; diameter, 6.8 mm.

Length, 15 mm.; diameter, 6.75 mm.

This is a smaller species than *B. adamsi*, the columella being unarmed in our two specimens.

Type.—Paleontological Research Institution, No. 5011; other specimen, No. 5012.

Occurrence.—Charco Azul.

Family CANCELLARIIDÆ

Genus CANCELLARIA Lamarck

Subgenus CANCELLARIA, s. s.

Cancellaria (Cancellaria) penita, n. sp. Plate 8, figs. 4, 8

Shell of medium size, ovate to subpyriform, the body whorl usually large, with the earlier whorls forming a smaller, conic, pointed spire; the nucleus is small, eroded on our specimens, followed by 6 or 7, postnuclear whorls; sutures excavated to narrowly channelled; sculpture consists of equal, spiral cords separated by much wider interspaces and a series of somewhat finer, longitudinal riblets which feebly nodulate the spirals at their intersections; on the penultimate whorl, the principal spirals number 6 between the sutures, in addition to a smaller spiral thread about the upper suture; on the last whorl, there are about 19 principal spirals, somewhat wider spaced above, and a little crowded on the anterior canal; umbilicus absent, the anterior canal produced, sometimes slightly perforate with a small, external cordlike fold; aperture semielliptical, the outer lip not thickened, toothed or dentated by the spiral sculpture, internally with a series of long, slender liræ which extend deeply into the throat of the shell; inner lip with a thin wash of callus which does not entirely conceal the sculpture, the columella straight, provided with 3 folds, the posterior one being the largest; small, varices, scarsely distinguishable, are developed on the back of some turns as small swellings.

Length, 27.00 mm.; diameter, 18.00 mm.; aperture, 18.50 mm.

From *Cancellaria dariena* Toula, this species differs by its larger body whorl, smaller spire so that the shape is pyriform. *Cancellaria cominella* Pilsbry and Olsson which is based on a young shell from the Pliocene of Ecuador is quite similar but has a higher spire.

Type.—Paleontological Research Institution, No. 4041; other specimens, No. 4042.

Occurrence.—Quebrada Peñitas.

Subgenus **BIVETOPSIS** Jousseaume

Cancellaria (Bivetopsis) charapota, n. sp. Plate 8, fig. 3

Shell of medium size, solid, sculptured with scabrous ribs and spirals; aperture ovate, the outer lip somewhat thickened, appearing as if widely fluted just below the middle and closely lirated within; inner lip with a callus shelf, irregularly pustulated on the outer portion and with strong liræ in the interior; the spire is rather short, of about 5 whorls (apex lost) and only about half the length of the rest of the shell; sculpture consisting of narrow, retractive axial ribs which are rendered scabrous by the spirals and on the shoulder become somewhat spiniferous; on the last whorl, these ribs number about 10, the last one on the outer lip becoming greatly enlarged; there are 12 spiral threads between the shoulder angle and the fasciolar cord, and there are 3 or 4 more on the area above the shoulder; columella excavated, with 3 plaits, the middle one being the smallest; siphonal canal short and strongly recurved, developing into a prominent cord on the back.

Length, 22 mm.; diameter, 17 mm.

This small species is quite common in the middle Miocene silty sandstones at Punta Charapota about midway between Manta and Bahia on the west coast of Ecuador.

Type.—Paleontological Research Institution, No. 4043.

Subgenus CHARCOLLERIA, new subgenus

Genotype.—*Cancellaria perdiciana*, n. sp.

The following is a description of the subgenus *Charcolleria.*

The shell is fusiform having the spire and aperture of about equal length, narrowly umbilicate, the base of the body whorl somewhat contracted at a point opposite the upper part of the aperture; anterior canal a little curved backwards, the siphonal sinus giving rise to an angled ridge forming the upper side or edge of the umbilicus; columella with 2 plaits, the upper one the larger ; sculpture evenly reticulated; the outer lip with a shallow, stromboid notch.

Cancellaria (Charcolleria) perdiciana, n. sp. Plate 8, fig. 5

Shell large, fusiform, solid; spire high of about 5 or more strongly convex whorls, the spire and aperture being of about equal length; anterior canal with a narrow, deep umbilicus, bounded above by a sharp keel, beginning at the upper columellar fold; the sculpture is finely reticulate, resulting from the intersection of fine, spiral threads and small wrinklelike, axial riblets; on the spire whorls, the spirals number about 11, their interspaces being wider; on the last whorl, there are about 22 spirals counting from the umbilical angle to the upper suture; aperture semi-elliptical, with a slightly recurved, anterior canal at its tip; pillar straight, callused and with 2 strong plaits, the upper one being the larger.

Length, 60.00 mm.; diameter, 28.50 mm.; aperture, 30.00 mm.

The present species is found in the Las Perdices shales of northern Colombia and is described in this place for comparison with *Cancellaria terryi* from Panama. The Colombian shell is perfect and has a well-developed umbilicus and it differs mainly from the Panamanian species by its finer reticulate sculpture.

Type.—Paleontological Research Institution, No. 4044.

Occurrence.—Las Perdices shales, Puerto Colombia. Lower Miocene.

Cancellaria (Charcolleria) terryi, n. sp. Plate 8, fig. 1

Shell fusiform, solid, with a high spire of about 6, strongly convex whorls; the nucleus is missing; body whorl relatively small, convex, extended forward into the fusiform anterior canal; sculpture is coarsely reticulate, formed by strong, spiral cords between wider interspaces and a series of small, axial riblets of the same strength as the spirals; on the spire whorls, there are about 9 spiral cords while on the body whorl they number between 17 or 18; the shell was perhaps umbilicate or became so at maturity, but the tip of the anterior canal is broken; aperture semicircular, the columella straight, strong, with 2 heavy plaits, the upper one being the larger.

Length, 41.00 mm. (imperfect); diameter, 23.00 mm., aperture, 18.00 mm.

The holotype is imperfect, having lost the tip of the anterior canal so that the above measurements should be increased by 5 or 6 millimeters. The shell appears to have had a small, narrow umbilicus.

Type.—Paleontological Research Institution, No. 4045.

Occurrence.—Charco Azul formation, Quebrada Peñitas. North fork of Rio Guanabanon.

Subgenus **CALCARATA** Jousseaume

Cancellaria (Calcarata) peninsularis, n. sp. Plate 11, fig. 9

Shell muriciform, solid with 5 whorls preserved, nucleus lost; spire subtabulated, pointed, the whorls shouldered and strongly sculptured; the sculpture of the spire whorls consists of 4, spiral cords, the 2 lower being strongest, leaving the band next to the shoulder angle smooth, and a series of strong, varixlike ribs, sometimes becoming spiniferous on the shoulder; on the body whorl, there are 13 or 14 spirals, somewhat alternating in strength and about 8 ribs; on the space above the shoulder, the surface is smooth but with the ribs continuing across to the suture generally in a sinuous course; aperture wide, subtriangular, the outer lip apparently smooth within, the columella bearing 3, strong plaits and small irregular pustules.

Length, 31 mm.; diameter, 19 mm.; aperture, 17 mm.

Our shell is imperfect, somewhat weathered and is not fully mature. It is apparently related to *Cancellaria centrota* Dall[29] described from near Cocos Island, Bay of Panama. It differs from Dall's figure and description of *C. centrota* in being imperforate, has a higher spire, less spiniferous shoulder varices and in having a greater number of spiral cords on the body whorl.

Type.—Paleontological Research Institution, No. 4046.

Occurrence.—Quebrada Peñitas.

Cancellaria colombiana, n. sp. **Plate 9, fig. 4**

Shell of medium size, stout; nucleus not preserved, succeeding whorls number 5 or more; the spire is elevated, scalar, with a deeply excavated sutural zone; the sculpture is sharply or nodosely reticulated and is formed by the intersection of strong, narrow, oblique riblets and coarse spirals; on the last whorl, the ribs number about 12, these are fairly uniformly developed over the greater part of the shell but tend to become enlarged and irregular on the back of the last whorl; spiral sculpture is formed by relatively few, strong cords; on the spire whorls, one of these cords forms the sharp angle of the shoulder, with 2 spirals below it and 2 smaller ones along the edge of the deeply excavated, sutural zone; on the last whorl, there are about 12 spirals below the shoulder; a narrow umbilicus is developed but it is not bordered by any noticeable keel or cord; aperture semilunate; the outer lip not strengthened in type (shell may not be quite mature) and with about 14, long, deeply entering liræ; columella straight with 3 folds of which the posterior one is the strongest; anterior canal short, ending in a straight, siphonal canal.

Length, 33.5 mm.; diameter, 23 mm.

The subgeneric relations of this interesting species is not known. It is characterized by its straight and not recurved siphonal canal deeply excavated sutural zone and a reticulated

[29] Dall, W. H.: *The Albatross Report*, Bull. Mus. Comp. Zoöl., vol. 43, No. 6, 1908, p. 295, pl. 1, fig. 8.

sculpture rendered sharply nodose by the intersection of the narrow, strongly oblique ribs and coarse spirals. Only the type specimen is known which comes from the Upper Las Perdices shales at Puerto Colombia Its age is probably lower Miocene.

Type.—Paleontological Research Institution, No. 4047.

Family **MITRIDÆ**

Genus **MITRA** Martyn

Mitra cyclica, n. sp. Plate 7, fig. 1

Shell of medium size, rather solid and strongly sculptured: the spire, with 7 whorls (apex lost) preserved on our specimen, is pointed and about the same length as the aperture and anterior canal; sutures are well marked and deeply grooved with the surface of the whorl between flattened to slightly convex; the sculpture is formed by strong, spiral cords between deep, encircling grooves; on the holotype, these grooves are mainly smooth except on the spire whorls where they are etched by deep, longitudinal lines; on the penultimate whorl there are 4 spiral cords; on the last whorl, there are 12 spiral cords and about 4 more on the canal; aperture narrow, the outer lip solid but not thickened, frilled by the ends of the spiral cords; columella with 4 plaits, the anterior one being quite small.

Length, 50 mm.; diameter, 16 mm.

Only the type specimen is known. The shell is solid and strongly sculptured with large, prominent spiral cords separated by deep spiral grooves. The fossil appears to be closely related to the rare *Mitra belcheri* Hinds from the Gulfs of Nicoya and Papagayo. Judging by Reeve's figure, *Mitra belcheri* is a more slender species with a longer spire and shorter, stouter body whorl. In *Mitra belcheri*, 5 cords are fully visible on the penultimate whorl while in the fossil there are but 4.

Type.—Paleontological Research Institution, No. 4048.

Occurrence.—Quebrada Peñitas.

Family **FASCIOLARIIDÆ**

Genus **LATIRUS** Montfort

Latirus penitus, n. sp. Plate 8, fig. 10

Shell of medium size, fusoid, the spire and aperture of equal length; nucleus unknown, the succeeding whorls of the spire numbering about 7, are convex and provided with knobbed ribs, strongest in the middle; the ribs number about 8 on the last turn, progressively less on the earlier ones, these ribs are strongly developed in the middle but are absent from the base and from the zone bordering the suture; on the whorls of the spire, the ribs are crossed by 3 prominent spirals, separated by very wide interspaces which generally carry a single, secondary thread and occasionally smaller tertiary ones, especially in sutural interspace; in addition, the whole surface of the shell is sculptured with fine, longitudinal threads; on the base of the last whorl, the spirals are more irregular and cannot be classified easily into primaries and secondaries; aperture semilunate above, drawn-out and narrowed below; outer lip with 7 long, entering liræ; columella with 3, small plaits; anterior canal, long, slightly twisted.

Length, 53 mm.; diameter, 21 mm.; aperture, 28 mm.

This species resembles *Latirus varicosus* Reeve but is distinguished by its slender form and in having the spire and anterior canal of nearly equal length.

Type.—Paleontological Research Institution, No. 4049.

Occurrence.—Quebrada Peñitas.

Genus FUSINUS Rafinesque

Fusinus mellisus, n. sp. Plate 9, fig. 7

Shell rather large, solid; the specimen is broken but originally the spire and aperture (including the anterior canal) was probably of equal length; 6 whorls are preserved but the nucleus and earliest spire whorls are lost; axial sculpture of the whorls of the spire is formed by 6, prominent rounded ribs with about equal interspaces; on the last whorl, the ribs have increased to 10; on the spire whorls, the ribs cross from suture to suture but later become more confined to the periphery and on the last whorl are obsolete in the sutural zone and from the base; suture is somewhat appressed; spirals cover the entire surface and consist of the usual threads of slightly different strength, a set of primaries, widely spaced with a central secondary which is bordered on each side by still smaller tertiary threads; on a whole, the spirals are quite uniform over the entire surface and the peripheral one does not become noticeably stronger than the others; outer lip simple, broken in our specimen; inner lip with a thin spread of callus; anterior canal long, broken in specimen.

Partial measurements are as follows:

Length, 82 mm.; diameter, 35.5 mm.

Dall[30] has described *Fusinus panamensis* from the Gulf of Panama, depth 153 fathoms, but the species has remained unfigured and we have had no opportunity of examining the type. The descriptions and measurements of *F. panamensis* indicate a shell of quite different characters.

Type.—Paleontological Research Institution, No. 4050.

Occurrence.—Quebrada Mellisa.

Fusinus, sp.

This record is based on a single fragment of about 3 whorls. Each turn has 8 ribs further marked with 8 primary spirals and smaller secondaries.

Occurrence.—Burica Point.

Family **BUCCINIDÆ**

Genus **HANETIA** Jousseaume

Hanetia pelicana, n. sp. Plate 3, fig. 3

Shell solid, muricid, with a sculpture of thick ribs and coarse spirals; spire high, conic, about one-half the total length; whorls about 5½ (tip missing); axial sculpture is formed by 5, strong, thick ribs between wider interspaces; on the spire whorls, the ribs extend from suture to suture but on the last turn do not pass much below the upper quarter of the aperture, except the last rib which forms the back of the outer lip; spirals consist of coarse, alternating threads, there being about 9 primary threads on the penultimate whorl in the space between the sutures; aperture oval, outer lip bowed with about 18 liræ within, inner lip smooth; canal short, wide, recurved at the end.

Length, 38 mm.; diameter, 21 mm.; aperture, 21 mm.

This species is nearest to *H. elegans* Dall[31] but has a higher spire and fewer ribs. Known only from the holotype which is imperfect.

Type.—Paleontological Research Institution, No. 4051.

Occurrence.—Burica sandstones, Burica Point.

[30] Dall, W. H.: Bull. Mus. Comp. Zoöl., vol. 43, No. 6, 1908, p. 301.

[31] Dall, W. H.: *The Albatross Report*, 1908, Bull. Mus. Comp., Zoöl. vol. 43, No. 6, 1908, pp. 300, 301.

Hanetia anomala burica, n. subsp. Plate 11, fig. 2

Shell of medium size, solid, subfusiform with a conic spire equal to the aperture in length; whorls 5+ (tip missing), the last whorl strongly angled or shouldered in the middle; sculpture is formed by thick, foldlike ribs, strongest on the middle or shoulder, and numbering about 7 on the last whorl, crossed by strong, spiral cords (which are generally formed by 3, finer, spiral threads) separated by deeply concave interspaces; these cords number 6 on the penultimate whorl; on the last whorl, there are 4 of these spirals on the area between the suture and the shoulder, 10 or 11 on the area between the shoulder and the umbilical keel; a strong keel rising in the notch of the anterior sinus surrounds the umbilical area which is sculptured principally by irregular growth lines; aperture subelliptical, the outer lip denticulated by the ends of the spiral cords and lirated within.

Length, 49 mm.; diameter, 36 mm.; aperture, 31 mm.

From the Recent species, this form differs by its fewer ribs and more strongly ribbed shoulder.

Type.—Paleontological Research Institution, No. 4052.

Occurrence.—Quebrada Mellisa.

Subgenus **FUSINOSTEIRA** Olsson

Hanetia (Fusinosteira) alternata Nelson Plate 10, fig. 1

Cuma alternata Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 198, pl. 7, figs. 3, 4.

Solenosteira alternata Spieker, 1922, Johns Hopkins Univ. Studies Geol., No. 3, p. 45, pl. 1, figs. 10, 11.

Solenosteira (Fusinosteira) alternata Olsson, 1932, Bull. Amer. Paleont., vol. 19, p. 181.

This large and perhaps the finest of the described species of *Hanetia* was previously known only from the type specimens collected in the Tumbez beds of northern Peru. Nelson's types in the Peabody Museum, Yale University, were loaned to me for study through the kindness of Dr. Dunbar. The Peruvian specimens differ in no way from the Panamanian except that the latter are more perfectly preserved. The shell is large, fusiform, shouldered and strongly sculptured with ribs and spirals. On the last whorl, the ribs number about 8. They are strongest on the angle of the shoulder, fade out above and extend below only as greatly reduced, wavelike folds to about the middle of the base or about halfway from the shoulder angle to the ridge bordering the umbilicus. Spirals are more or less alternating in character. They usually consist of a primary set between which there are 3 smaller ones so that the spiral sculpture as a whole appears banded. The umbilicus is deep and narrow, bounded above by a sharp, keel-like fold. Aperture subovate, produced anteriorly into a strongly recurved canal. The outer lip is thin, smooth or lirated feebly within, slightly sinuous in profile.

Length, 74 mm.; diameter, 47 mm.; aperture, 46 mm.

This species is common at Charco Azul where several beautiful specimens were obtained. It is rare in Quebrada Peñitas associated with *Acila isthmica burica* and *Strombina fusiformis penita*.

Figured specimen.—Paleontological Research Institution, No. 4053.

Occurrence.—Charco Azul; Quebrada Peñitas.

Hanetia elegans Dall

Solenosteira elegans Dall, 1908, Albatross Report, p. 300, pl. 5, fig. 6.

Our shell is not quite mature, the outer lip being scarsely thickened and only weakly lirated within. Dall's type was dredged in Panama from a depth of 153 fathoms off mud bottom.

Our fossil was collected from the zone of unconformity immediately beneath the basal Armuelles conglomerate at Punta de Piedra. The underlying Charco Azul shales are deeply brecciated and their fissures filled with fossiliferous sand which was introduced during the initial advance of the Pleistocene sea.

Occurrence.—Punta de Piedra.

Genus CANTHARUS (Bolten) Reading

Cantharus amycus, n. sp. Plate 11, fig. 1

Shell of medium size, solid with strongly shouldered whorls; apex of the shell is lost but with 3½ whorls remaining; the sharply angled shoulder is ornamented by small but strong ribs numbering about 14 on the last whorl; these ribs are practically confined to the shoulder or only feebly developed in the sutural area above; strong spirals cover most of the surface of the shell; there are about 19, primary spirals between the shoulder angle and the weak fasciolar fold at the tip of the anterior canal; between the primaries, there are finer secondary and tertiary threads; the interior of the shell is filled with a pebbly matrix so that the columella cannot be seen; anterior canal of medium length, slightly recurved at the end and with a weak fasciolar cord.

Length, 44 mm.; diameter, 29 mm.

The question as to the true generic position of this species will remain unsolved until specimens showing the interior are known.

Type.—Paleontological Research Institution, No. 4073.

Occurrence.—Burica sandstones, Burica Point.

Genus **METULA** H. and A. Adams

Metula pilsbryi, n. sp. Plate 9, fig. 8

Shell relatively large, stout, with the aperture more than half its length and with a coarse but regular cancellated sculpture; the spire whorls number about 6 (tip missing), slightly convex in profile; the last whorl is produced forward to form the moderately long, stout anterior canal; sculpture coarsely and regularly cancellated by nearly even ribs and spirals, their intersections being slightly nodose; the spiral cord adjacent to the upper suture is somewhat larger than the others; on the penultimate whorl, the spiral number about 12; lip thickened on the outside, slightly sinuous and feebly denticulated within; a thin wash of callus is spread over the columellar wall; anterior canal wide at its end.

Length, 45 mm.; diameter, 18 mm.; aperture, 26 mm.

This is a large, coarsely cancellated species. From the Recent species, *M. amosi* Vanatta, also found in the Pleistocene of Panama, this species differs by its wider shell and in having the aperture more than half the length of the entire shell. Our specimen shows faint traces of the original color, in the form of broad white and brown bands.

Type.—Paleontological Research Institution, No. 4062.

Occurrence.—Rio LaVaca and Rio Guanabanon.

Metula amosi Vanatta Plate 9, fig. 9

Metula amosi Vanatta, 1913, Proc. Acad. Nat. Sci. Phila., vol. 65, p. 22, text figs. 1, 2.

This Recent Panamic species is quite common in the Pleistocene dredgings from the Panama Canal at Thatcher's Ferry from which a specimen is here figured for comparison with *M. pilsbryi.* On the Burica Peninsula it occurs as a Pleistocene fossil at Rabo de Puerco and at the mouth of the Rio Guanabanon. The figured specimen measures, length, 44 mm.; diameter, 14 mm.; length of aperture, 23 mm. The largest specimen from Thatcher Ferry has a length of 46 mm. and is proportionately a little narrower than the one figured.

Figured specimen.—Paleontological Research Institution, No. 4063.

Family NASSIDÆ

Genus NASSA Lamarck

Subgenus UZITA H. and A. Adams

Nassa (Uzita) terryi, n. sp. Plate 8, figs. 2, 7, 9

Shell of medium size, generally white or glassy in color; nucleus (eroded on the type), is followed by 5 whorls which are strongly sculptured with cordlike spirals, coarsely beaded by longitudinal riblets; on the whorls of the spire, the spiral sculpture is formed by 3 strong, equal cords separated by deep, wide intervals, sometimes with a 4th spiral showing in the lower suture and a small secondary thread borders the upper one; on the body whorl, there are 7 spiral cords between the fasciole and the upper suture; axial sculpture consists of about 21 riblets which extend from the fasciolar sulcus to the upper suture and strongly nodulate the spiral cords at their points of intersection; aperture broadly subelliptical, the outer lip thickened by the last rib, strongly crenulated within by about 10 teeth or slender liræ which extend deeply into the throat of the shell; inner lip with a platform of callus, smooth or with a few, small, scattered pustules; beak rather long, encircled by a shallow sulcus; anterior canal is moderately long, wide, slightly recurved, its edge bounded by a strong keel-like plait.

Length, 22.5 mm.; diameter, 13.5 mm.; aperture, 10.5 mm.

Some of the shorter specimens resemble the *Nassa miser* Dall (Albatross Report, p. 307, pl. 4, fig. 1) from the Gulf of Panama but the fossils are generally longer, the anterior beak is less stubby and is encircled by a shallower, fasciolar sulcus. They also differ notably in sculpture. This species is the commonest fossil at Charco Azul.

Type.—Paleontological Research Institution, No. 4054; other specimens, No. 4055.

Occurrence.—Charco Azul.

Nassa (Uzita) armulla, n. sp. Plta 8, fig. 6

Shell of medium size with about 9, reticulately sculptured whorls; nucleus small, pointed, its surface being eroded on the type specimen; the postnuclear whorls, a little convex in form, except the last which is strongly convex; sutures well marked; the sculpture consists of strong, cordlike spirals numbering about 6 on the spire whorls, the lowest one being almost concealed in the suture; on the body whorl, the spirals number about 13 from the anterior fasciole to the suture; in addition to the spirals, there is a series of narrow riblets which are strongly developed over the whole shell; these riblets number about 21 on the body whorl in addition to a stronger rib which thickens the outer lip; beak small, encircled by a deep, sulcuslike fasciole; aperture broadly elliptical, with a well-marked posterior sinus and a deep, recurved anterior canal; outer lip thickened by an external rib, lirated within by fine, alternating threads, the primary ones, 13 in number; inner lip with a cover of callus bearing a set of small plaits or liræ on the parietal wall; a strong keel is placed at the edge of the anterior canal.

Length, 21.5 mm.; diameter, 10 mm.; aperture, 11 mm.

This is a strongly sculptured species. The spire is about half the length of the shell which has a pointed, conical spire and a moderately large, convex body whorl.

Type.—Paleontological Research Institution, No. 4056.

Occurrence.—Charco Azul.

Genus **CYMATOPHOS** Pilsbry and Olsson

Cymatophos panamensis, n. sp. Plate 9, fig. 1

Shell rather large, fusoid with a spire somewhat longer than the aperture; nucleus small, pointed of 3, smooth whorls; change from the smooth, nuclear stage to the adult sculpture is gradual by the introduction of small, threadlike lines which later develop into the ribs; these early ribs are crossed by 2, spiral threads;

whorls of the spire shouldered; the sculpture consists of straight ribs which commence on the base and extend upward to the suture, crossed by spiral threads, alternate in strength; the ribs are heaviest on the whorls of the spire, extend from suture to suture and average about 10 to each turn; spirals consist of strong threads of primary strength, widely spaced, the interspaces usually with a smaller or secondary thread; on the spire whorls, the primaries number about 6, increase to about 12 on the last whorl above the fasciolar keel; spiral interspaces finely etched with longitudinal growth threads; aperture suboval, the outer lip internally lirated; inner lip smooth, bordered by an oblique, spiral cord; siphonal fasciole bordered by a keel-like spiral and a moderately deep furrow.

Length, 44 mm.; diameter, 19 mm.; aperture, 21 mm.

From *Cymatophos galerus* Pilsbry and Olsson, this species differs by its smaller size and coarser spirals. A single worn specimen from the coast of Ecuador shows that the species is living in the Recent fauna.

Type.—Paleontological Research Institution, No. 4057.

Occurrence.—Rio La Vaca.

Genus **PHOS** Montfort

Subgenus **ANTILLOPHOS** Woodring

Phos (Antillophos) gatunensis Toula

Phos gatunensis Toula, 1909, Jahrb. der K-K. Geol. Reichsantalt, Wien, vol. 38, p. 701, pl. 28, fig. 6; pl. 25, fig. 11.
Phos gatunensis Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 349, pl. 25, figs. 1, 2.
Phos gatunensis Olsson, 1922, Bull. Amer. Paleont., vol. 9, p. 289, pl. 9, figs. 4, 5.
Tritiaria (*Antillophos*) *gatunensis* Woodring, 1928, Carn. Inst. Washington, Pub. No. 385, pp. 260, 261.

One imperfect specimen of this species was collected associated with *Solemya* near Burica Point. A comparison with typical *P. gatunensis* shows only minor differences which may not be constant in a larger series. The Burica shell is stouter and there are some slight differences in the character of the secondary sculpturing.

Occurrence.— Burica formation, Burica Point.

Phos (Antillophos) rutschi, n. sp. Plate 9, fig. 5

Shell of medium size, rather stout, the spire and aperture of about equal length and a coarse, even, reticulated sculpture; nucleus unknown; postnuclear whorls about 6; on the spire whorls, there are 5, spiral cords, slightly coarser below, and finely noded by the crossing of the longitudinal riblets which are of about the same strength as the spirals themselves; in the spiral intervals, there is one or two, fine threads; on the last whorl, the spiral cords number 13 or 14 between the upper suture and the fasciolar sulcus; on the penultimate whorl, the longitudinal riblets number about 27, they are more numerous on the body whorl where they are occasionally rather closely crowded; aperture narrow, elliptical, the outer lip somewhat thickened, bearing a series of about 10, long liræ; columella with 3 small folds or plaits, the lower one a little stronger than the others; a small tooth or ridge sits on the parietal wall near its posterior edge.

Length, 30 mm.; diameter, 15 mm.; aperture 1 6 mm.

Differs from *P. gatunensis* Toula and *P. mexicanus* Böse by its stouter shell and more regular sculpture, the riblets being a little stronger than the spirals. A somewhat similar but larger, undescribed species is found in the La Perdices shales at Puerto Colombia, Colombia.

Type.—Paleontological Research Institution, No. 4058.

Occurrence.—Quebrada Peñitas, Costa Rica.

Genus **MITRELLA** Risso

Subgenus **LONGITRELLA**, new subgenus

Genotype.—*Mitrella (Longitrella) vespertina,* n. sp.

The following is a description of the subgenus *Longitrella.*

Shell of medium size to small, slender, nearly smooth except for basal spirals; spire high; anterior canal of medium length, quite wide and slightly recurved at end; outer lip moderately thickened and with a series of small, irregular denticles within.

Remarks.—Differs from *Mitrella* in possessing a true anterior canal and from *Cosmioconcha* by its more slender form, longer canal and in sculpture.

Mitrella (Longitrella) vespertina, n. sp. Plate 10, fig. 9

Shell of medium size, with a slender spire about twice the length of the aperture; nucleus unknown, subsequent whorls 8 or more; the general surface is smooth except on the base of the last whorl and on the anterior canal which has strong spirals; the earliest spire whorls have also a strong, central impressed line; aperture broadly elliptical merging forward into a rather wide, anterior canal which is slightly recurved at the end; outer lip moderately thickened and with a series of irregular denticles within; inner lip and pillar smooth.

Type.—Paleontological Research Institution, No. 5014.

Occurrence.—Charco Azul.

Genus **STROMBINA** Mörch

Strombina fusiformis peñita, n. subsp. Plate 10, figs. 3, 6, 8

Shell slender, fusiform, with a long, slender, attenuated spire of 10 or more whorls; the first 7 whorls of the spire are finely, longitudinally ribbed, the following become shouldered, smooth or have a series of fine spiral lines encircling the whorl around the shoulder angle; last whorl subtriangular in transverse section, with a strong node on the left side and a dorsal hump near the suture or on the almost vanished shoulder; surface of body whorl smooth except for a series of spirals on the back of the anterior canal; aperture narrow, with a large, thickened outer lip carrying a deep notch near the posterior end, crenulated below; anterior canal produced, somewhat recurved at its end.

Length, 34 mm.; diameter, 13.0 mm.; aperture, 9.75 mm.

Length, 34 mm.; diameter, 13.5 mm.; aperture, 9.5 mm.

This species belongs with the group of *S. prisma* Pilsbry and Johnson and *S. cyphonotus* Pilsbry and Johnson of the Santo Domingan Miocene and *S. lessepsiana* Brown and Pilsbry of Gatun but is nearest related to *S. fusiformis* Hinds[32] described from an unknown locality in the Mollusca of the Voyage of the Sulphur. The figures of Hinds and Reeve show a shell more slender than ours, the diameter being about one-third of its length. In the three Miocene species, enumerated above, the dorsal hump is smaller and is bordered by small, longitudinal folds, absent in ours.

[32] Hinds, R. B.: *Zoölogy, Voyage of the Sulphur, Mollusca*, 1844, p. 38, pl. 10, figs. 17, 18; Reeve, L., Icon., *Columbella*, sp. 17.

Type.—Paleontological Research Institution, No. 4060; other specimens, No. 4061.

Occurrence.—Shales of Quebrada Peñitas, Costa Rica.

Subgenus **COTONOPSIS**, new subgenus

Genotype.—*Strombina* (*Cotonopsis*) *panacostaricensis*, n. sp.

The following is a description of the subgenus *Cotonopsis*.

Shell of medium size, solid; sculpture is smooth except for the longitudinal ribbing of the spire whorls (later becoming subobsolete) and fine, irregular spiral threads; anterior canal rather long, strongly recurved at the tip; outer lip moderately thickened and feebly lirated within; pillar straight, smooth with a single, strong or weak inner fold about midway; posterior sinus directed upwards, bordered by a small tooth on the parietal wall; nucleus small of 2 to 3 smooth, convex whorls.

Remarks.—This subgenus is represented by 2 species in the Tertiary beds of the Burica Peninsula, only one being described in this paper. From typical *Strombina* (genotype, *S. lanceolata* Sowerby), the group differs by the circular section of the body whorl, less thickened lip (which is not strongly denticulated within) and in the more strongly recurved anterior canal. In the undescribed species, the columella fold is very strong but in the genotype it is rather small. A strong tooth borders the parietal side of the posterior sinus.

Strombina (Cotonopsis) panacostaricensis, n. sp. Plate 10, fig. 5

Shell relatively large, with a high, sharply pointed spire about equal to the aperture in length, polished, solid; nucleus small, of about 2½ smooth whorls; postnuclear whorls about 8, the first being sculptured with longitudinal folds or ribs which gradually become obsolete on the later turns; sutures distinct, linear; the sculpture as noted, is formed at first by a series of straight, regular, foldlike ribs but these become subobsolete on the later turns leaving the surface nearly smooth, except for spirals extending from the middle of the body whorl to the tip of the anterior canal; on magnification, a series of faint, irregular lines can be seen covering the entire surface; aperture narrowly lanceolate, produced forward into the anterior canal which is recurved backward at its tip; outer lip somewhat thickened, feebly crenate within, with a posteriorly directed anal sinus at its junction with the body whorl; inner lip with a spread of callus bearing a tooth adjoining the posterior sinus.

Length, 32 mm.; diameter, 13 mm.; aperture, 16 mm.

Type.—Paleontological Research Institution, No. 4059.

Occurrence.—Tuffaceous shale, west side of the Burica Peninsula, about 5 miles north of Punte Burica.

Family **MURICIDÆ**

Genus **TYPHIS** Montfort

Subgenus **TALITYPHIS** Jousseaume

Typhis (Talityphis) costaricensis, n. sp. Plate 12, figs. 5, 8

Shell of medium size, solid; each whorl has 4 main varices which are extended upward on the shoulder into short, stout and somewhat appressed spines and between them also placed on the shoulder but closer to the preceding varix, are tubes directed upwards; the varix on the outer lip, strongest, expanded, forming a wide wing which extends from the upper suture and forward along the anterior canal which it encloses; the surface is smooth or shows only faint, spiral wrinkles; aperture circular, continuous, its edge raised above the adjacent surface.

Length, 22 mm.; diameter, 13 mm.

This species resembles the *T. martyria* Dall[33] from the Gulf of California, but it is more slender and the final varix is less expanded.

Type.—Paleontological Research Institution, No. 4064.

Occurrence.—Mouth of Quebrada Peñitas.

Family **EPITONIIDÆ**

Genus **EPITONIUM** (Bolten) Roeding

Subgenus **FERMINOSCALA** Dall

Epitonium (Ferminoscala) ferminianum Dall Plate 9, fig. 6

Epitonium (*Ferminoscala*) *ferminianum* Dall, 1908, Bull. Mus. Comp. Zoöl., vol. 43, No. 6, p. 316, pl. 8, fig. 8.

The fossil shell from Charco Azul seems identical with Dall's figure and description of this species. Our shell is slightly

[33] Dall, W. H.: *The Albatross Report*, Bull. Mus. Comp. Zoöl., vol. 43, No. 6, 1908, p. 314, pl. 15, fig. 11.

larger, measuring about 41 millimeters in length (Dall's specimen, length, 38 millimeter). The sculpture is evenly reticulated by sharp spirals and axial lamellæ, while the spiral intervals and the basal disk is covered with close-set, very fine, spiral threads.

Figured specimens.—Paleontological Research Institution, No. 4065.

Occurrence.—Charco Azul; Quebrada Peñitas.

Family **CASSIDIDÆ**

Genus **DALIUM** Dall

Dalium ecuadoriana, n. sp. Plate 9, figs. 2, 3

Shell broadly bucciniform with a blunt spire and whorls sculptured with strong, circular or spiral ridges; whorls 7 or more; nucleus unknown; sculpture consists of strong, spiral ridges between channeled interspaces; a wide, concave band encircles the posterior side of each whorl, but it is spaced from the suture by a band ornamented with 3 spiral cords; on the body whorl, there are 21 spiral ridges between the beak and the edge of the fasciolar band and 3 above; on the penultimate whorl, there are 4 ridges below the fasciole and 3 above; the top of the circular ridges are smooth or lined with faint spiral threads; the surface of the whorls is polished and colored either white or brown; aperture subelliptical, attenuated forward, ending in a short, slightly twisted canal; outer lip generally thin, smooth within; inner lip with a rather thick callus spread over the parietal wall; the surface of the fasciole and the spiral interspaces have very fine striations paralleling the growth lines.

Length, 43 mm.; diameter, 20 mm.; aperture, 27 mm.

Length, 39 mm. (imperfect); diameter, 23.5 mm.; aperture, 23 mm.

Length, 36 mm.; diameter, 21 mm.; aperture, 23 mm.

The genus *Dalium* was proposed by Dall[34] for *D. solidum* Dall dredged by the Blake off Granada Station in the West Indies in 576 fathoms. The Ecuadorian species resembles the figure of *D. solidum* very closely and there is no doubt that they belong to the same genus. Our shells are relatively thin and easily

[34] Dall, W. H.: *Report on the Mollusca, Pt. 2. Gastropoda and Scaphopoda (The Blake Report)*, Bull. Mus. Comp. Zoöl. vol. 18, 1889, p. 230. pl. 19, fig. 10d.

broken while *D. solidum* as its name implies is solid. None of our specimens are perfect or have the nucleus preserved. The surface of the whorls are chalky and deeply corroded on some specimens.

Dalium ecuadoriana occurs with *Dentalium esmeraldum* and various turrids in the Esmeraldas shales of upper Oligocene age at Punta Gorda, a few miles west of the mouth of the Rio Esmeraldas in northern Ecuador where it is fairly common.

Type.—Paleontological Research Institution, No. 4066.

Occurrence.—Esmeraldas tuffaceous shales. Punta Gorda a few miles west of the mouth of Rio Esmeraldas, Province of Esmeraldas, northern Ecuador. Age: upper Oligocene.

Family RISSOIDÆ

Genus ALVANIA Risso

Alvania bartschi, n. sp. Plate 11, fig. 10

Shell minute, broadly ovate with convex, cancellated whorls; nucleus of about 1½ well-rounded, smooth whorls; postnuclear whorls number about 2½, these are convex and sculptured with strong, slender ribs and spiral cords enclosing squarish pits; the last whorl has about 14 ribs (not counting the thickened lip) which extend from the region near the columella to the upper suture; these ribs are crossed and rendered nodose by 6 strong, spiral cords on the last whorl and 3 on the whorls of the spire; suture bordered by a sloping zone wider than the interspiral spaces; base well rounded, nonumbilicate; aperture subcircular, outer lip strongly thickened by a narrow varix; inner lip stout, peritreme complete.

Length, 1.25 mm.; diameter, .8 mm.

This small species resembles *A. oldroydæ* Bartsch[35] in form but is nonumbilicate and differs importantly in sculpture, having fewer ribs and spirals. It is named for Dr. Paul Bartsch, Curator of Mollusks in the United States National Museum, who has done so much work on the smaller species of West Coast mollusks.

Type.—Paleontological Research Institution, No. 4067.

Occurrence.—Zone of unconformity at the base of the Pleistocene at Punta Piedra.

[35] Bartsch, P.: Proc. U. S. Nat. Mus., vol. 41, 1911, p. 360, pl. 32, fig. 3.

Family **NATICIDÆ**

Genus **NATICA** Scopoli

Natica scethra burica, n. subsp. Plate 10, figs. 2, 7

Shell of medium size, with a moderately elevated spire and evenly convex body whorl; whorls about 4, exclusive of the smooth, polished nucleus of 2½ turns; sutures distinct; color white, hyaline to yellowish with no indication of color bands; surface nearly smooth, except around the anterior side of the suture where there is a zone of strong, tangential, very obliquely retractive, incised lines or wrinkles which on the type number about 33 on the last turn; in addition there are very faint growth lines and faint revolving lines, irregularly disposed; aperture ovate to semicircular with a spread of callus on the parietal side; umbilicus narrow, with an obscure rib of callus within and sometimes a second rib borders the external edge; outer lip thin, somewhat oblique; operculum calcareous with a strong, narrow, marginal rib bordered on both sides by a deep groove and on the inner side by a second, wider rib.

Length, 27.5 mm.; diameter, 27 mm.; aperture, 21 mm.

From *Natica scethra* Dall[36] (dredged in the Gulf of Panama from a depth of 153 fathoms), the fossil differs by its larger size, somewhat higher spire and in the sculpture of the operculum. Dall's figure of the operculum shows two marginal ribs of nearly equal size while in our shell, the outer lip is smaller.

Type.—Paleontological Research Institution, No. 4068.

Occurrence.—Charco Azul.

Order **OPISTOBRANCHIATA**

Family **RINGICULIDÆ**

Genus **RINGICULA** Deshayes

Subgenus **RINGICULELLA** Sacco

Ringicula (Ringiculella) costaricensis, n. sp. Plate 6, figs. 7, 8

Shell small, solid, globose, white, composed of 4, convex whorls forming a medium-height spire with obtuse apex; sutures distinct; surface is completely smooth, generally polished or showing only faint, longitudinal, narrow lines or markings in some specimens; last whorl large, terminating in a very thick, wide,

[36] Dall, W. H.: *The Mollusca and the Brachiopoda* (*Albatross Rept.*), Bull. Mus. Comp. Zoöl., vol. 43, No. 6, 1908, p. 333, pl. 11, fig. 5.

lip varix; outer lip is thickest in the middle which gives rise to a prominent, elevated bulge; aperture ovate, widest forward; columella with 2 strong plaits; parietal callus thick, resembling a fold and often carrying a small tooth at its anterior end.

Length, 2.5 mm.; diameter, 2.2 mm.

This species is easily recognized by its relatively large size and smooth, solid shell.

Type.—Paleontological Research Institution, No. 4025.

Occurrence.—Quebrada Peñitas.

Class SCAPHOPODA

Genus DENTALIUM Linnæus

Subgenus FISSIDENTALIUM Fischer

Dentalium (Fissidentalium) esmeraldum, n. sp. Plate 6, figs. 1, 2, 10

Shell large, solid and very long, gently curved with a slow taper; tips missing, but at a diameter of 2 millimeters, its cross-section is circular; surface sculptured with strong, longitudinal riblets which are fairly regular in the middle section, become irregular or alternating towards the tip; near the ventral aperture, the ribs begin to fade out and the surface becomes smooth; at a diameter of 7 millimeters, the ribs generally number about 23 and about 14 at a diameter of 3 millimeters; on the earlier parts of the shell, the ribs are narrow and are separated by very wide intervals, beautifully etched by the raised lines of growth; on the mature parts of the shell, 2 or 3 secondary ribs are present in the interspaces which increase slowly in size and are separated from the older set by narrow lines only.

The following measurements are from fragments only.

Length, 61 mm.; diameter, 10 mm.
Length, 60 mm.; diameter, 12 mm.
Length, 39 mm.; diameter, 7.5 mm.

Large Dentalia are common in certain Tertiary formations in tropical America and in some shale deposits are frequently the only fossils. Perfect specimens are rare, the apical portion being invariably lacking so that their identification must be based largely on size and the surface ornamentation. Most *Fissidentalium* are considered deep-water forms.

Dentalium granadanum Anderson[37] from the Las Perdices shales of northern Colombia and *Dentalium uscarianum* Olsson[38] from the Upper Uscari of Costa Rica are nearest related to *esmeraldum*. The *Dentalium solidissimum* Brown and Pilsbry[39] is based on a single fragment from Colombia, the locality not stated. This species is probably distinct from *D. granadanum* with which it was united by Weisbord.[40] The primary ribs on the form, numbering about 28, are narrow and separated by wide intervals. In *D. granadanum*, of which I have a good series from Puerto Colombia, the ornamentation is persistent, the shell remaining strongly sculptured throughout life while in *D. esmeraldum*, the mature sections of the shell are smooth. From *Dentalium buricum*, the Ecuadorian species is distinguished by its straighter shell, less curved apical portion and fewer ribs.

Type.—Paleontological Research Institution, No. 4069; other specimens, No. 4070.

Occurrence.—Esmeraldas formation (upper Oligocene) of Punta Gorda, Province of Esmeraldas, Ecuador.

Dentalium (Fissidentalium) buricum. n. sp. Plate 6, figs. 3, 4, 5, 6, 9

Shell large, solid, tapering gradually in the lower part, more rapidly near the tip which is also more strongly curved; tips missing in our specimens but at a diameter of 2 millimeters or more, the cross-section is circular; surface is sculptured with numerous, irregular, low, rounded, longitudinal ribs which fade out ventrally and are practically missing from the lower part of mature shells; lines of growth oblique, becoming more crowded towards the tip where the longitudinal ribs are also separated by wider or deeper interspaces; at a diameter of about 7 millimeters, the longitudinal ribs number about 38 and at a diameter of 3½ millimeters there are about 15 primary ribs and an equal number of secondary ones.

37 Anderson, F. M.: Proc. California Acad. Sci., 4th series, vol. 18, 1929, p. 144, pl. 13, fig. 3

38 Olsson, A. A.: Bull. Amer. Paleont., vol. 9, 1922, pp. 338, 339, pl. 15, fig. 1.

39 Brown, A., and Pilsbry, H. A.: Proc. Acad. Nat. Sci. Phila., vol. 69, 1917, p. 37, pl. 5, fig. 8.

40 Weisbord, N. E.: *Miocene Mollusca of northern Colombia*, Bull. Amer. Paleont., vol. 14, 1929, p. 26, pl. 5, figs. 10, 11.

Length, 56 mm.; diameter, 13.5 mm.
Length, 47 mm.; diameter, 10.0 mm.
Length, 45 mm.; diameter, 12.0 mm.

The above measurements are of fragments only but a full-grown shell would have a length of about 100 millimeters. One piece in our collection has a diameter of 15 millimeters although broken off considerably above the ventral aperture.

This species is common in the tuffaceous shales exposed along the beach on the west side of the Burica Peninsula associated with *Buridrillia panarica.* Another large *Dentalium,* perhaps allied to this species, occurs in the Pleistocene of Rabo de Puerco and Monteverde ravines near Puerto Armuelles. These Pleistocene shells are usually badly weathered so that the surface is chalky but in one specimen the surface is smooth over the greater part of the shell.

Type.—Paleontological Research Institution, No. 4071; other specimens, No. 4072.

Occurrence.—Tuffaceous shales, west side of the Burica Peninsula, Costa Rica.

PLATES

Plates furnished *gratis* by the author

PLATE 1 (14)

EXPLANATION OF PLATE 1 (14)

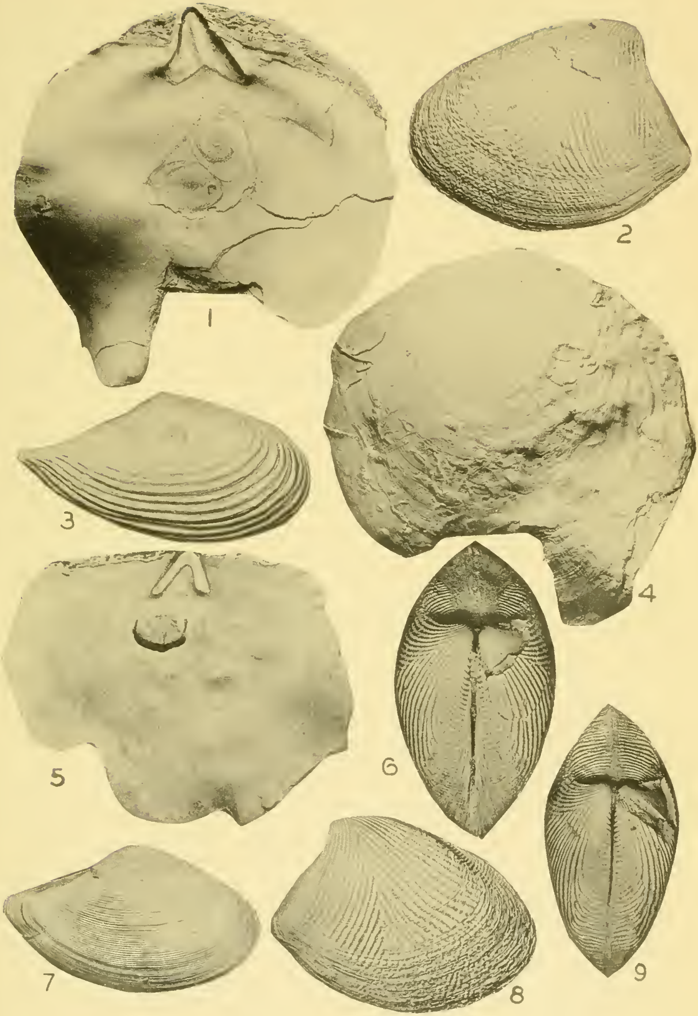

1
2
3
4
5
6
7
8
9

PLATE 2 (15)

EXPLANATION OF PLATE 2 (15)

Figure		Page
1.	**Solemya (Acharax) burica**, n. sp. Holoytpe; length of fragment, 58 mm. Burica sandstones, Burica Point.	23
2.	**Calyptogena panamensis**, n. sp. Paratype; length, 26 mm. Burica sandstones, Burica Point.	33
3.	**Calyptogena panamensis**, n. sp. Holotype; length, 45 mm. Burica sandstones, Burica Point.	33
4.	**Thyasira bisecta** Conrad Cast of a left valve; length of fragment, 70 mm. Burica sandstones, Burica Point.	35
5.	**Pseudamusium terryi**, n. sp. Paratype; height, 14 mm. Charco Azul.	30
6.	**Pseudamusium terryi**, n. sp. Holotype; height, 15 mm.; specimen whitened with ammonium chloride. Charco Azul.	30
7.	**Pseudamusium terryi**, n. sp. Same specimen as last, unwhitened.	30
8.	**Corbula (Varicorbula) granti**, n. sp. Holotype; length, 11.5 mm. Charco Azul.	45
9.	**Corbula (Varicorbula) granti**, n. sp. Paratype; length, 10.5 mm. Charco Azul.	45


1
2
3
4
5
6
7
8
9

PLATE 3 (16)

EXPLANATION OF PLATE 3 (16)

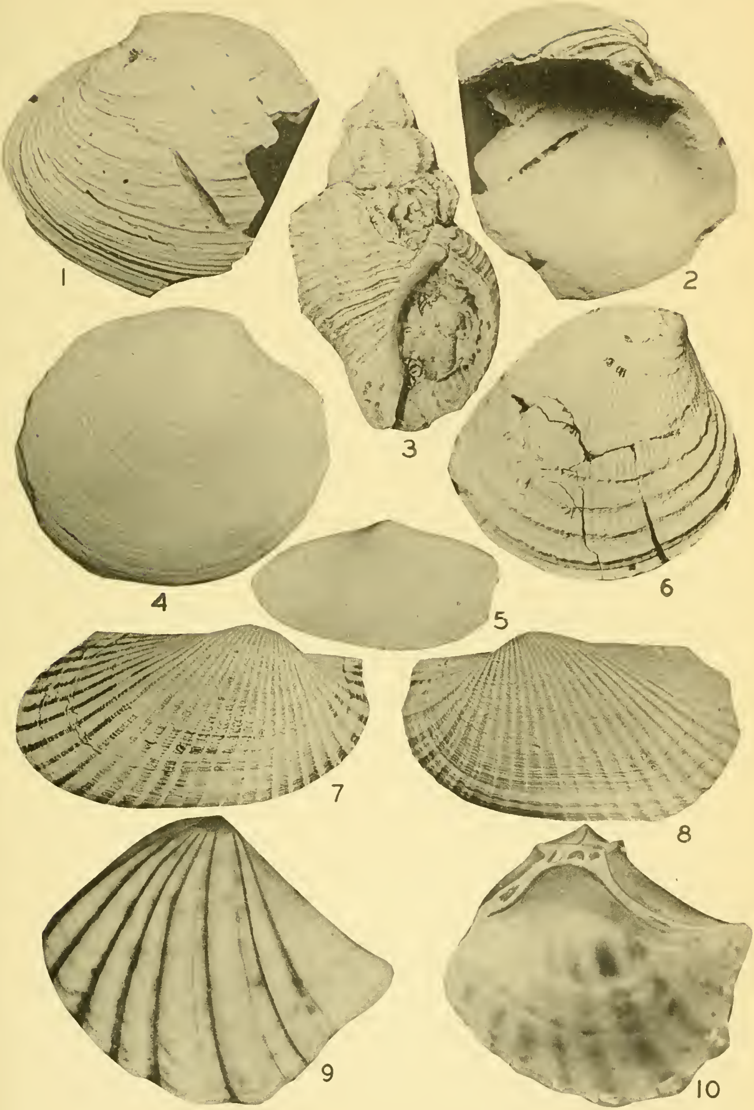

1
2
3
4
5
6
7
8
9
10

PLATE 4 (17)

EXPLANATION OF PLATE 4 (17)

Figure	Page
1. **Lucina (Lucinoma) chiripanica,** n. sp. Holotype; length, 54 mm. Charco Azul.	36
2. **Nucula iphigenia azulensis,** n. subsp. Paratype; length, 30.5 mm. Charco Azul.	24
3. **Tellina (Macaliopsis) frontera,** n. sp. Holotype; length, 44 mm. Quebrada Peñitas.	42
4. **Lucina (Lucinoma) chiripanica,** n. sp. Paratype; length, 35 mm. Charco Azul.	36
5. **Nucula iphigenia azulensis,** n. subsp. Holotype; length, 35 mm. Charco Azul.	24
6. **Tellina (Macaliopsis) frontera,** n. sp. Holotype; same specimen as fig. 3.	42
7. **Nucula iphigenia azulensis,** n. subsp. Paratype; length, 30 mm. Charco Azul.	24
8. **Macoma (Macoploma) medioamerciana,** n. sp. Holotype; length, 62 mm. Quebrada Peñitas.	44


1
2
3
4
5
6
7
8

PLATE 5 (18)

EXPLANATION OF PLATE 5 (18)

Figure	Page
1. **Pitar (Lamelliconcha) anona,** n. sp. Holotype; length, 35.5 mm. Rio Guanabanon.	37
2. **Macrocallista traftoni,** n. sp. Holotype; length, 33 mm. Rabo de Puerco.	38
3. **Macrocallista traftoni,** n. sp. Paratype; length, 29 mm. Rabo de Puerco.	38
4. **Pitar (Lamelliconcha) mellisa,** n. sp. Holotype; length, 47 mm. Quebrada Mellisa.	37
5. **Macoma (Panacoma) chiriquiensis,** n. sp. Holotype; length, 34 mm. Charco Azul.	43
6. **Macoma (Panacoma) chiriquiensis,** n. sp. Paratype; length, 37 mm. Charco Azul.	43
7. **Chione (Chione) vaca,** n. sp. Holotype; length, 27.5 mm. Rio La Vaca.	40
8. **Sanguinolaria (Sanguinolaria) azulensis,** n. sp. Holotype; length, 35.5 mm. Charco Azul.	42


1
2
3
4
5
6
7
8

PLATE 6 (19)

EXPLANATION OF PLATE 6 (19)

Figure	Page
1. **Dentalium (Fissidentalium) esmeraldum**, n. sp. Paratype; length, 60 mm. Punta Gorda, Ecuador.	80
2. **Dentalium (Fissidentalium) esmeraldum**, n. sp. Paratype; length, 39 mm. Punta Gorda, Ecuador.	80
3. **Dentalium (Fissidentalium) buricum**, n. sp. Paratype; length, 44 mm. West side of Burica Peninsula.	81
4. **Dentalium (Fissidentalium) buricum**, n. sp. Holotype; length, 57 mm. West side of Burica Peninsula.	81
5. **Dentalium (Fissidentalium) buricum**, n. sp. Length, 61 mm. Rabo de Puerco.	81
6. **Dentalium (Fissidentalium) buricum**, n. sp. Paratype; length, 48 mm. West side of Burica Peninsula.	81
7. **Ringicula (Ringiculella) costaricensis**, n. sp. Holotype; length, 2.6 mm. Quebrada Peñitas.	79
8. **Ringicula (Ringiculella) costaricensis**, n. sp. Paratype; length, 2.6 mm. Quebrada Peñitas.	79
9. **Dentalium (Fissidentalium) buricum**, n. sp. Paratype; length, 44 mm. West side of Burica Peninsula.	81
10. **Dentalium (Fissidentalium) esmeraldum**, n. sp. Holotype; length, 61.5 mm. Punta Gorda, Ecuador.	80
11. **Conus (Leptoconus) arcuatus vacuanus**, n. subsp. Holotype; height, 46 mm. Quebrada Mellisa.	49
12. **Conus (Leptoconus) arcuatus vacuanus**, n. subsp. Paratype; height, 36 mm. Quebrada Mellisa.	49
13. **Conus arcuatus** Sowerby Height, 39 mm. Rio Guanabanon.	50

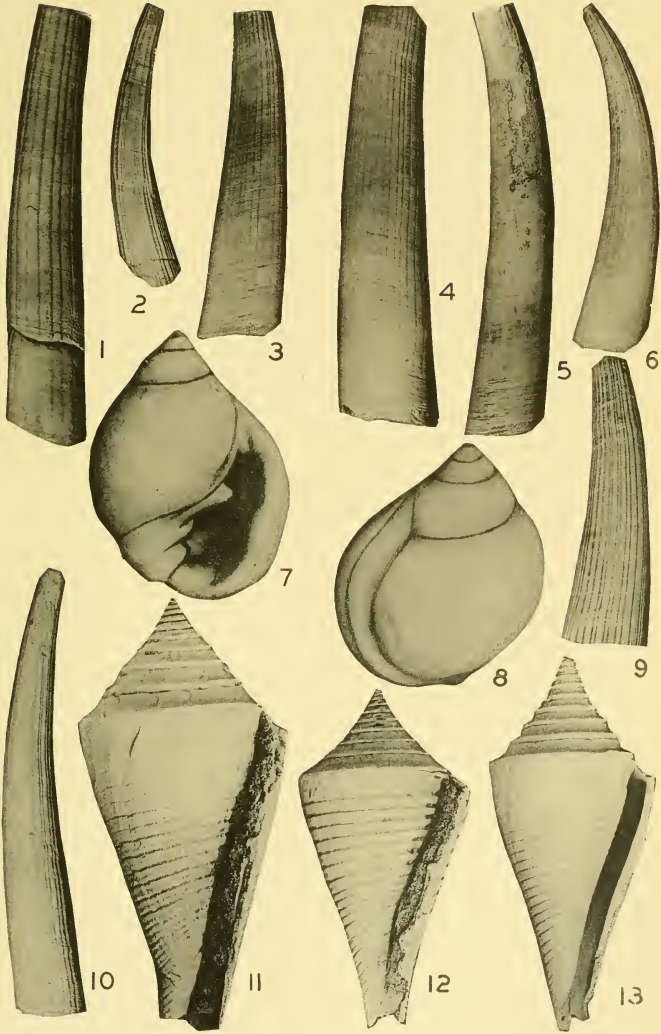

1
2
3
4
5
6
7
8
9
10
11
12
13

PLATE 7 (20)

EXPLANATION OF PLATE 7 (20)

Figure		Page
1.	**Mitra cyclica,** n. sp. Holotype; length, 50 mm. Quebrada Peñitas.	64
2.	**Fusiturricula woodringi,** n. sp. Holotype; length, 62 mm. Charco Azul.	53
3.	**Turricula dulcia,** n. sp. Holotype; length, 47 mm. Quebrada Peñitas.	54
4.	**Clathrodrillia (Buridrillia) panarica,** n. sp. Holotype; length, 72 mm. Charco Azul.	52
5.	**Clathrodrillia (Buridrillia) panarica,** n. sp. Paratype; length, 51 mm. Charco Azul.	52
6.	**Turricula dulcia,** n. sp. Paratype; length, 41 mm. Quebrada Peñitas.	54
7.	**Clathrodrillia (Buridrillia) panarica,** n. sp. Paratype; length, 54 mm. Tuffaceous shales, west side of Burica Peninsula.	52
8.	**Turricula (Knefastia) andesita,** n. sp. Holotype; length, 46 mm. Mouth of Quebrada Peñitas.	55

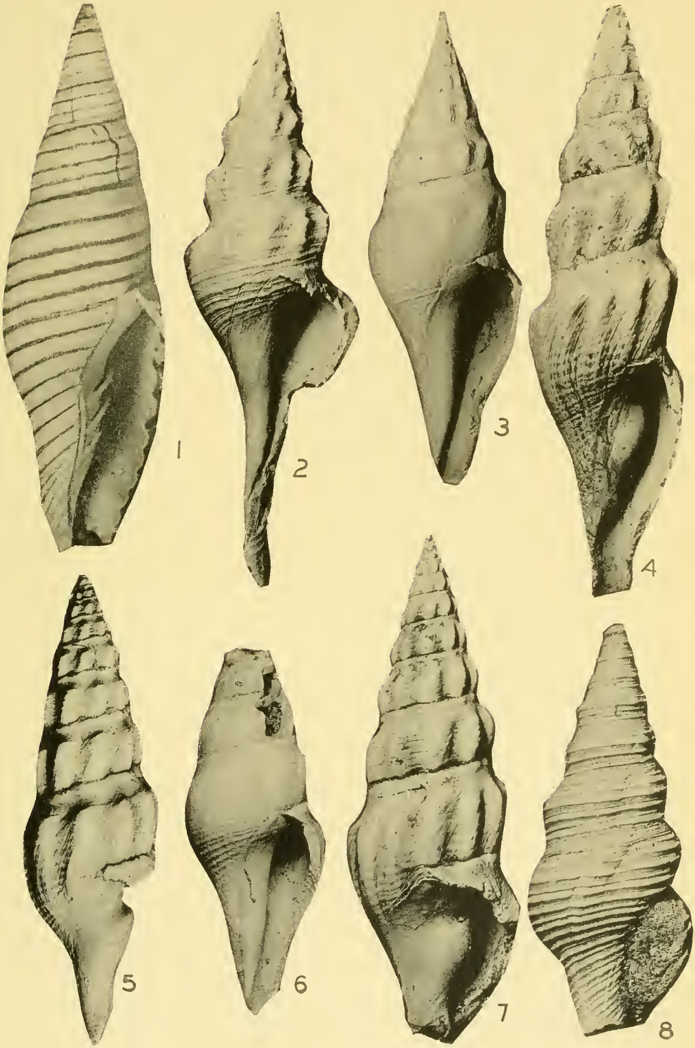

1
2
3
4
5
6
7
8

PLATE 8 (21)

EXPLANATION OF PLATE 8 (21)

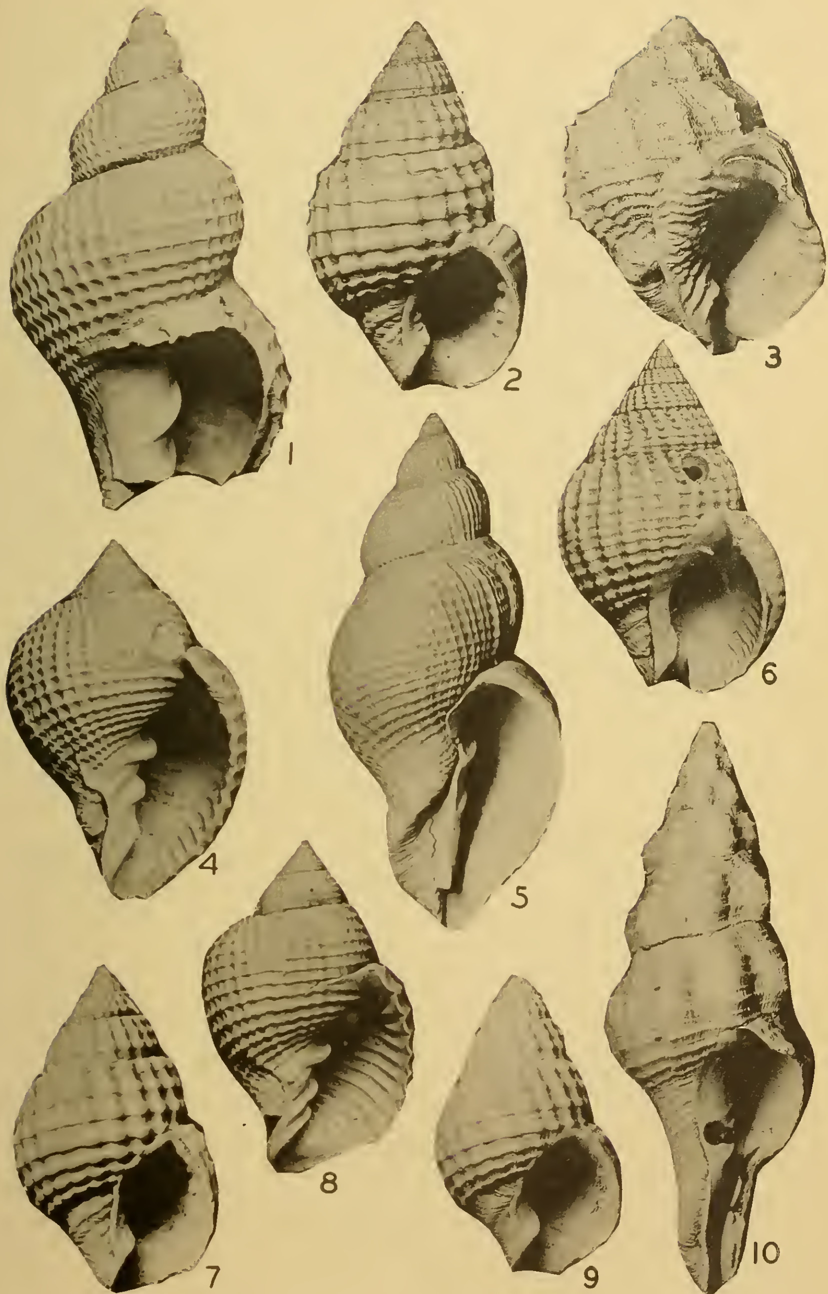

1
2
3
4
5
6
7
8
9
10

PLATE 9 (22)

EXPLANATION OF PLATE 9 (22)

Figure		Page
1.	**Cymatophos panamensis,** n. sp. Holotype; length, 44 mm. Rio La Vaca.	71
2.	**Dalium ecuadoriana,** n. sp. Paratype; height, 39 mm. Punta Gorda, Ecuador.	77
3.	**Dalium ecuadoriana,** n. sp. Holotype; height, 43 mm. Punta Gorda, Ecuador.	77
4.	**Cancellaria colombiana,** n. sp. Holotype; height, 33.5 mm. Las Perdices shales, Puerto Colombia, Colombia.	63
5.	**Phos (Antillophos) rutschi,** n. sp. Holotype; height, 30 mm. Quebrada Peñitas.	73
6.	**Epitonium (Ferminoscala) ferminianum** Dall Height, 41 mm. Charco Azul.	76
7.	**Fusinus mellisus,** n. sp. Holotype; height, 82 mm. Quebrada Mellisa.	65
8.	**Metula pilsbryi,** n. sp. Holotype; height, 45 mm. Rio La Vaca.	69
9.	**Metula amosi** Vanatta Height, 44 mm. Pleistocene, Thatcher's Ferry, Canal Zone.	69
10.	**Clathrodrillia harrisi,** n. sp. Holotype; height, 32.5 mm. Quebrada Peñitas.	50

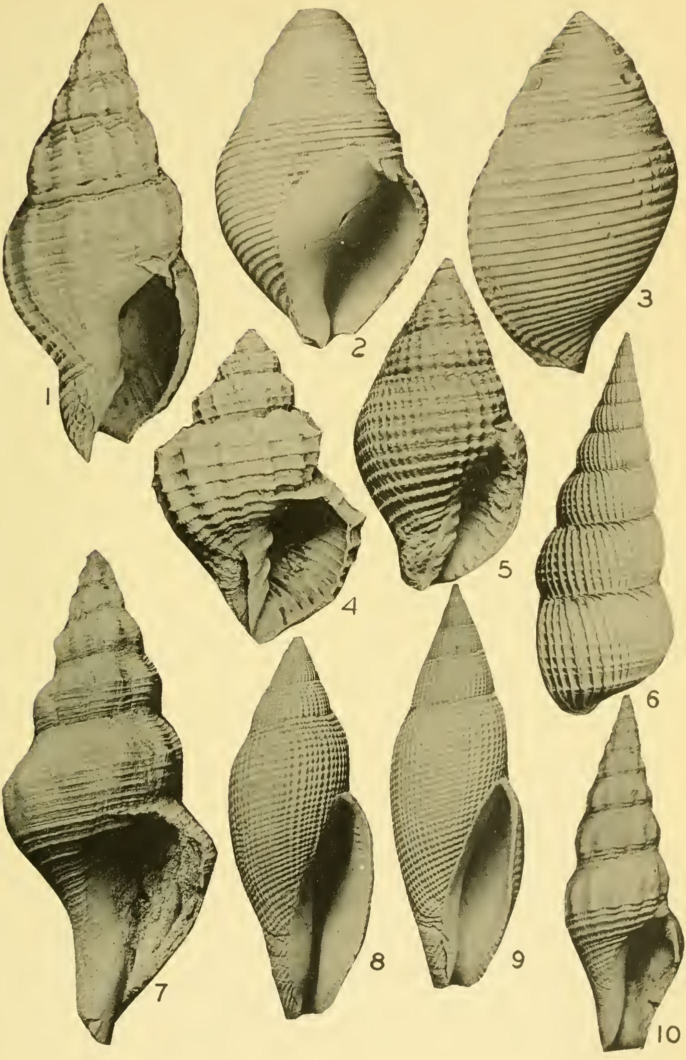

1
2
3
4
5
6
7
8
9
10

PLATE 10 (23)

EXPLANATION OF PLATE 10 (23)

Figure		Page
1.	**Hanetia (Fusinosteira) alternata** Nelson Length, 70 mm. Charco Azul.	67
2.	**Natica (Natica) scethra burica,** n. subsp. Holotype; length, 27.5 mm. Charco Azul.	79
3.	**Strombina fusiformis peñita,** n. subsp. Paratype; length, 34 mm. Quebrada Peñitas.	74
4.	**Ancistrosyrinx cedonulli reevei,** n. subsp. Holotype; length, 43 mm. Charco Azul.	53
5.	**Strombina (Cotonopsis) panacostaricensis,** n. sp. Holoytpe; length, 32 mm. West side of Burica Peninsula.	75
6.	**Strombina fusiformis peñita,** n. subsp. Holotype; length, 34.5 mm. Quebrada Peñitas.	74
7.	**Natica scethra burica,** n. subsp. Charco Azul.	79
8.	**Strombina fusiformis peñita,** n. subsp. Paratype; length, 26 mm. Quebrada Peñitas.	74
9.	**Mitrella (Longitrella) vespertina,** n. sp. Holotype; length, 25 mm. Charco Azul.	73
10.	**Pleurotomella (Phymorphynchus) agina,** n. sp. Holotype; length, 27.50 mm. Charco Azul.	56


1
2
3
4
5
6
7
8
9
10

PLATE 11 (24)

EXPLANATION OF PLATE 11 (24)

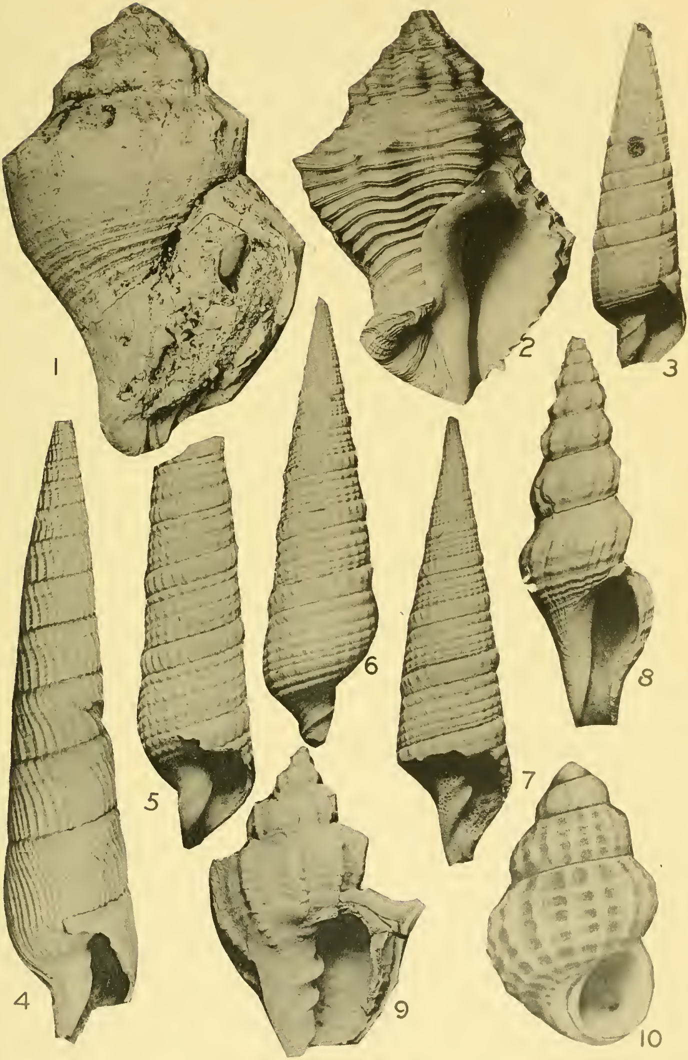

1
2
3
4
5
6
7
8
9
10

PLATE 12 (25)

Explanation of Plate 12 (25)

Figure		Page
1.	**Borsonia (Borsonella) adamsi**, n. sp. Holotype; length, 27 mm. Charco Azul.	58
2.	**Leucosyrinx nicoya**, n. sp. Holotype; length, 21 mm. Charco Azul.	57
3.	**?Leucosyrinx huricana**, n. sp. Holotype; length, 38 mm. Charco Azul.	52
4.	**Polystira panamensis**, n. sp. Holotype; length, 23 mm. Charco Azul.	50
5.	**Typhis (Talityphis) costaricensis**, n. sp. Holotype; length, 22 mm. Quebrada Peñitas.	76
6.	**Borsonia (Borsonella) harrisi**, n. sp. Holotype; length, 15 mm. Charco Azul.	59
7.	**Borsonia (Borsonella) harrisi**, n. sp. Paratype; length, 14.75 mm. Charco Azul.	59
8.	**Typhis (Talityphis) costaricensis**, n. sp. Holotype; same specimen as figure 5.	76

BULLETINS

OF

AMERICAN

PALEONTOLOGY

VOL. XXVII

NUMBER 107

1943

Paleontological Research Institution
Ithaca, New York
U. S. A.

Condensed Table of Contents of Bulletins of American Paleontology and Palæontographica Americana*

BULLETINS OF AMERICAN PALEONTOLOGY

* Complete titles and price list of all numbers may be had on application. All volumes available.

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 27

No. 107

A Median Dorsal Plate of Holonema from the Upper Devonian of New York

By

John W. Wells

February 1, 1943

Paleontological Research Institution
Ithaca, New York
U. S. A.

A MEDIAN DORSAL PLATE OF HOLONEMA FROM THE UPPER DEVONIAN OF NEW YORK

By

John W. Wells

The Ohio State University

INTRODUCTION

Recently I described a large median dorsal plate[1] from the Enfield formation (Naplesian) of central New York (1924). It was identified with a ventral plate, originally described as *Glyptaspis abbreviata* by Eastman (1907, p. 147, pl. 13), and placed in a new genus, *Deirosteus,* of the arthrodiran family Holonemidæ (*rect.* Holonematidæ). At that time the only certain distinction between this new form and *Holonema.* Newberry was the surface ornamentation of the plates. Now, through the fortunate discovery of a small but nearly complete example of the median dorsal plate of *Holonema rugosum* (Claypole)—one of the many heretofore unknown plates of this curious fish[2]—direct comparison can be made between two corresponding parts of *Deirosteus* and *Holonema.* This comparison, as will be shown, serves to confirm my separation of the two genera.

I am under obligation to Dr. K. V. W. Palmer, who noted the specimen in the geological collections at Cornell University and recognized its significance, and to the Department of Geology of Cornell University which has generously defrayed the cost of the illustrative plate. Credit for the discovery (in 1940) of the specimen is due Mr. G. E. Bentley of Jamestown, N. Y., who kindly donated it to Cornell.

[1] Pal. Res. Inst. Cat. No. 5945.

[2] The hinder portion of an MD of *H. rugosum* was collected several years ago from the Oneonta formation in Chenango County, N. Y., but only the interior surface with the posterior process can be discerned.

LOCALITY AND HORIZON

The specimen is an external mold on the surface of an irregular block of thoroughly leached sandstone packed with molds of invertebrates. It was found as float in a field a mile east of the village of Maine, in western Broome County, southern New York. The bedrock in this area, according to the Watkins Glen Catatonk atlas map (1909), is near the lower (paleontologic) boundary of the Chemung formation, but the specimen may be erratic, derived from a lower formation, probably the next older, the Enfield. The lithology is that of the Chemung, but in this area Chemung lithology extends below the base of that formation into the Enfield. The only recognizable significant invertebrate fossil in the block is *Spirifer mesacostalis* which suggests either a Chemung horizon or the Enfield not far below the base of the Chemung.

This association of a plate of *Holonema* with a marine invertebrate assemblage does not necessarily imply a marine life environment for this fish, for its remains are more commonly found in continental deposits indicative of fresh-water environments, not only in this country but in Russia (Obruchew, 1933, p. 113) and Spitsbergen (Heintz, 1935).

Genus **HOLONEMA** Newberry

Holonema rugosum (Claypole) Plate 1

Description of the MD

The median dorsal plate (Cornell Univ. Geol. Coll., No. 38766) is represented by an external mold which is complete posteriorly but lacks about one-fourth of the anterior end. The left side of the fore part also is missing. Compared with other known plates of *H. rugosum*, such as the ventral shield, it represents a rather small individual, probably less than half size.

Dimensions.—	Length (preserved)	14.4 cm.
	Length (estimated original[3])	17.5

[3] This length is arrived at on the assumption that the center of ossification lies about four-fifths of the distance from the anterior to the posterior end, as in most arthrodires.

Maximum width (at center of ossification)	7.9
Width at posterior end	5.4
Maximum convexity (anteriorly)	1

Outline elongate-rectangular, narrow, proportions about 2.3:1, convex anteriorly, nearly flat behind the center of ossification. Sides nearly straight, gently tapering forwards, with a slight reëntrant anteriorly and a strong one posteriorly and a strong bulge opposite the center of ossification. Posterior corners truncated; posterior margin slightly convex.

External ornamentation, in general plan, like that of *Deirosteus abbreviatus* (*vide* Wells, 1942, p. 652, pl. 95), in five zones: a central "club", a lateral and posterior concentric broad ridge and narrow interspace system, a lateral and posterior submarginal reticulate area, a marginal zone of parallel ridges at right angles to the margin, and a fan-shaped antero-central reticulated zone. A sensory canal groove on either side of the central "club" about two-thirds of the distance from the anterior to the posterior end, commencing at the inner edge of the marginal zone of parallel ridges, curving backwards across the submarginal reticulate zone and well into the central concentric ridge system, but not extending back so far as the center of ossification nor joining across the middle.

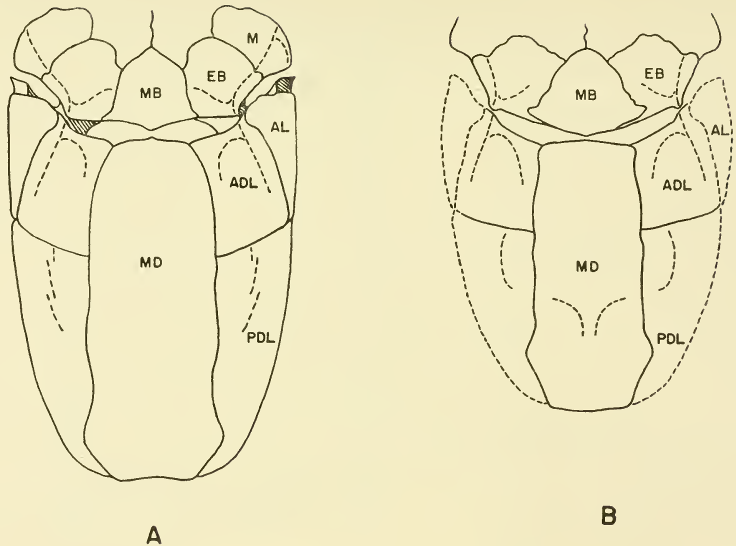
DISCUSSION

Comparison of the figure of this MD of *H. rugosum* with that of *Deirosteus abbreviatus*, previously cited, reveals very close similarity in general shape and in the surface sculpture plan, and at the same time indicates two outstanding differences between the two genera: the difference in detail of sculpture and presence of sensory canals in the former. In *Deirosteus*, the central sculpture consists of narrow ridges with broad tuberculated interspaces; in *Holonema*, the ridges are at least equal to, and usually broader than the interspaces. In *Deirosteus*, the marginal sculpture consists of rows of fine granulations; in *Holonema*, of parallel ridges. No sensory canals occur on the MD of *Deirosteus,* and this is perhaps a more significant generic distinction than that based upon ornamentation. Their curvature is contrary to that of the same canals on MD's of most arthrodirans which are curved backwards rather than forwards, but is the same as that of the canals on the MD of another holonematid, *Megaloplax marginalis* (Eichwald) (Obruchew, 1933, pl. 7, fig. 2) from the lower Upper Devonian of Russia.

The MD of the other fairly well-known species of *Holonema, H. radiatum* Obruchew (1933, p. 100), from the lower Upper Devonian of Russia, has been described (*ibid,* p. 103). It corresponds very closely in shape (especially posteriorly) and ornamentation with the new MD, except that no sensory canals have been noted. The condition of preservation of the external surface of the Russian plate, however, is bad and they may not have been preserved. The MD of *H. radiatum* is proportionally longer (2.6:1 compared with 2.3:1), suggesting that *H. rugosum* was a somewhat plumper fish.

Only two species of *Holonema* are at present even moderately well known[4]: the genotype, *H. rugosum* of the Naplesian and Chemungian of New York and Pennsylvania (and apparently the Erian of Michigan and Wisconsin), and *H. radiatum* of the lower Upper Devonian of Russia and Spitsbergen. Previously I suggested (1942, p. 654, pl. 97, fig. 4) that the *Holonema* plates described from the Traverse series of Michigan by Case (1931, p. 173, pl. 4, figs. 1, 2) indicated a new species, but further study of the Michigan Devonian specimens and specimens of undoubted *H. rugosum* from the Upper Devonian of New York does not yield any criteria for species discrimination. The ornamentation is the same and the only plates known in common between the two, the right externo-basals, are exactly the same, even to their

[4] Others, known from more or less imperfect fragments, are: *H. horridum* Cope (Chemungian, Pennsylvania), *H. ornatum* Traquair (Upper Devonian, Great Britain), and *H. eifeliense* (Kayser) (Middle Devonian, Germany). Neither of the last two belongs to *Holonema* and *H. ornatum* is probably not an holonematid.



Reconstruction of dorsal aspect of dorsal and part of cranial shields of *Holonema*.

A. *H. radiatum* Obruchew, Upper Devonian, Russia. (Modified from Obruchew, 1933); X3/16.

B. *H. rugosum* (Claypole), Middle and Upper Devonian, U. S. A.; X1/4.

dimensions. Fragments of the antero-dorso-lateral are known from both areas, but not of the same parts of the plates. For the present, then, *H. rugosum* appears to range from the Middle (Erian) well into the Upper (Chemungian) Devonian.

It may be premature to attempt reconstruction of the plan of the cuirass of this fish, but I believe I am taking no great liberties in presenting the tentative sketch shown in the text figure (B), wherein Obruchew's plan of *H. radiatum*, redrawn and slightly modified, has been used as a guide. The plan of *H. rugosum* is based upon the MD just described and upon others (EB, MB, ADL) from the Oneonta (Naplesian) formation of Chenango County, N. Y., and upon Case's material (EB, MB, ADL) from the Traverse (Erian) series of Michigan (Univ. Mich. Coll. Nos. 13040, 13043).

REFERENCES

Case, E. C.
Arthrodiran remains from the Devonian of Michigan, Contr. Mus. Paleont., Univ. Mich., 3, 1931, pp. 163-182, 5 pls., 13 figs.

Eastman, C. A.
Devonic fishes of the New York formations, New York State Mus., Mem., 10, 1907, 235 pp., 15 pls., 35 figs.

Heintz, A.
Holonema-Reste aus dem Devon Spitzbergens, Norsk geol. Tids., 15, 1935, pp. 115-121, 1 pl.

Obruchew, D.
Holonemidæ des russischen Devons, Acad. Sci. U. S. S. R., Inst. Paléozool., Trav. 2, 1933, pp. 97-115, pls. 5-8, 27 figs.

Wells, J. W.
Arthrodiran fish plates from the Enfield formation (Upper Devonian of New York), Jour. Paleont., 16, 1942, pp. 651-656, pls. 95-97.

Williams, H. S., Tarr, R. S., and Kindle, E. M.
Watkins Glen-Catatonk Folio, U. S. Geol. Surv., Geol. Atlas, 1909, Folio 169.

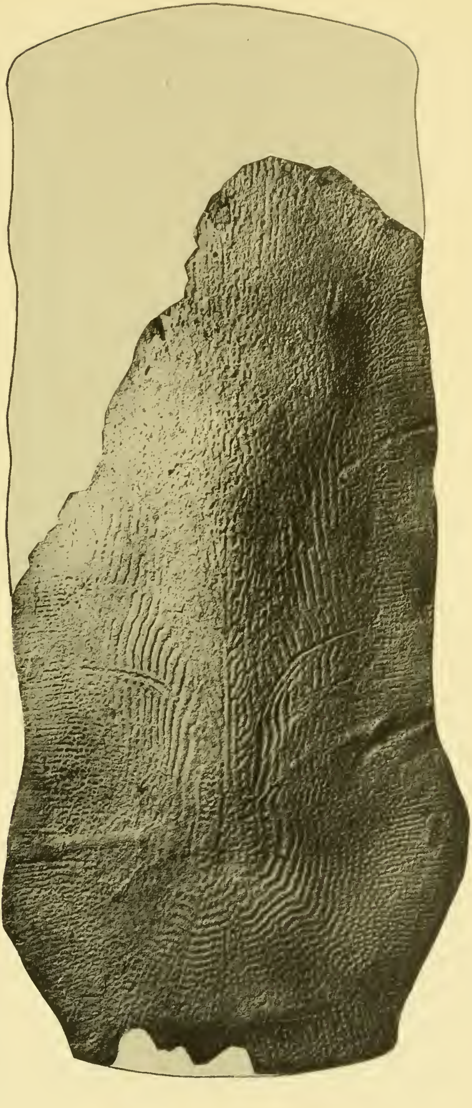
PLATES

PLATE I (26)

EXPLANATION OF PLATE 1 (26)

Figure Page

1. **Holonema rugosum** (Claypole) 4
   From the upper Enfield (?) formation near Maine, Broome County, N. Y. External surface of a nearly complete median dorsal plate (rubber cast), Cornell Univ. Geol. Coll., No. 38766. Natural size.



XV. (Nos. 55-58). 314 pp., 80 pls. 6.00
Mainly Ecuadoran, Peruvian and Mexican Tertiary forams and mollusks and Paleozoic fossils.

XVI. (Nos. 59-61). 140 pp., 48 pls. 5.00
Venezuela and Trinidad Tertiary Mollusca.

XVII. (Nos. 62-63). 283 pp., 33 pls. 6.00
Peruvian Tertiary Mollusca.

XVIII. (Nos. 64-67). 286 pp., 29 pls. 6.00
Mainly Tertiary Mollusca and Cretaceous corals.

XIX. (No. 68). 272 pp., 24 pls. 5.00
Tertiary Paleontology, Peru.

XX. (Nos. 69-70C). 266 pp., 26 pls. 6.00
Cretaceous and Tertiary Paleontology of Peru and Cuba.

XXI. (Nos. 71-72). 321 pp., 12 pls. 5.00
Paleozoic Paleontology and Stratigraphy.

XXII. (Nos. 73-76). 356 pp., 31 pls. 7.00
Paleozoic Paleontology and Tertiary Foraminifera.

XXIII. (Nos. 77-79). 251 pp., 35 pls. 5.00
Corals, Cretaceous microfauna and biography of Conrad.

XXIV. (Nos. 80-87). 334 pp., 27 pls. 6.00
Mainly Paleozoic faunas and Tertiary Mollusca.

XXV. (Nos. 88-94B). 306 pp., 30 pls. 7.00
Paleozoic fossils of Ontario, Oklahoma and Colombia, Mesozoic echinoids, California Pleistocene and Maryland Miocene mollusks.

XXVI. (Nos. 95-100). 420 pp., 58 pls. 7.00
Florida Recent marine shells, Texas Cretaceous fossils, Cuban and Peruvian Cretaceous, and Peruvian Eogene corals, and geology and paleontology of Ecuador.

XXVII. (Nos. 101-105, other numbers in preparation.) 152 pp., 13 pls. 3.25
San Pedro, California Pleistocene Mollusca, type fossil Cypræidæ of North America and early Palezoic cephalopods from Alaska, Kentucky and New York State.

PALÆONTOGRAPHICA AMERICANA

Volume I. (Nos. 1-5). 519 pp., 75 pls. $12.00
Monographs of arcas, Lutetia, rudistids and venerids.

II. (Nos. 6-12). 531 pp., 37 pls. 12.00
Heliophyllum halli, Tertiary turrid illustrations, Neocene Spondyli, Paleozoic cephalopods, Tertiary Fasciolarias and Paleozoic and Recent Hexactinellida.

Volume III. (Nos. 13-14, other numbers in preparation.) 90 pp., 5 pls. 2.25
Eurysiphonate cephalopod structure and phylogeny and Paleozoic siphonophores.

BULLETINS

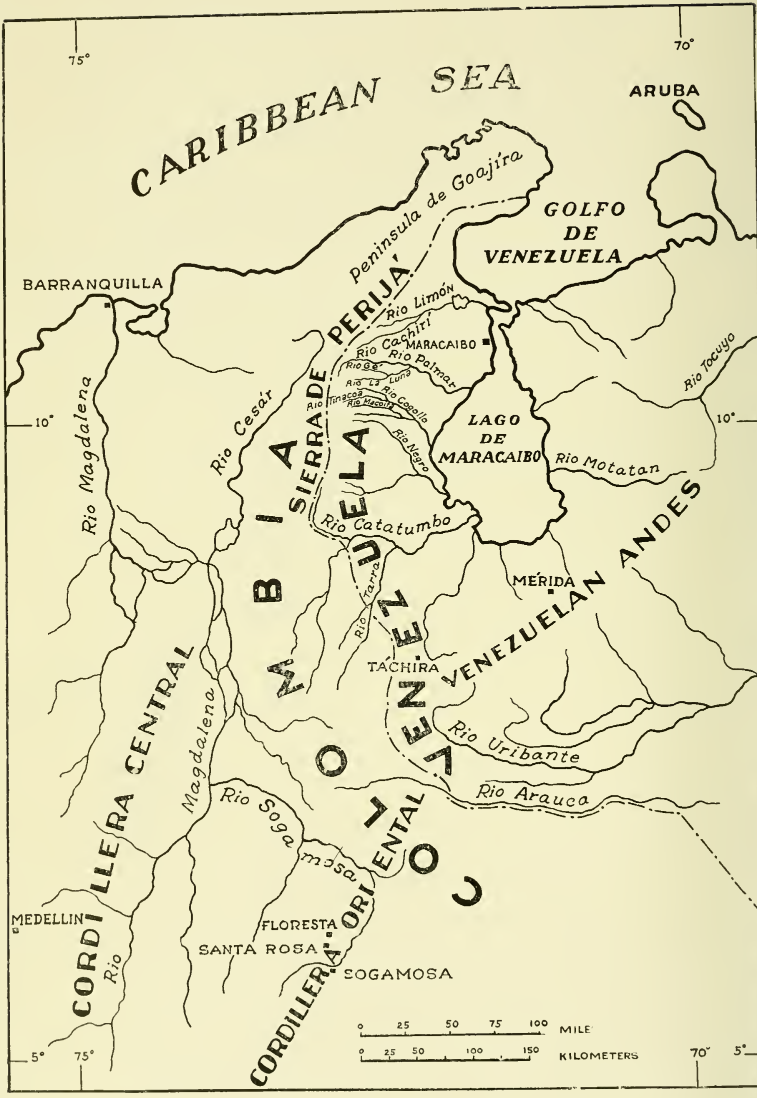
OF

AMERICAN PALEONTOLOGY

VOL. XXVII

NUMBER 108

Paleontological Research Institution
Ithaca, New York
U. S. A.


CARIBBEAN SEA
ARUBA
GOLFO DE VENEZUELA
Peninsula de Goajira
BARRANQUILLA
SIERRA DE PERIJÁ
Rio Limón
Rio Cachiri
MARACAIBO
Rio Palmar
Rio Cesár
LAGO DE MARACAIBO
Rio Motatan
Rio Tocuyo
Rio Catatumbo
Rio Negro
Rio Magdalena
COLOMBIA
VENEZUELA
VENEZUELAN ANDES
MERIDA
TACHIRA
Rio Tarra
Rio Uribante
Rio Arauca
CORDILLERA CENTRAL
Magdalena
Rio Soga mosa
CORDILLERA ORIENTAL
FLORESTA
SANTA ROSA
SOGAMOSA
MEDELLIN
Rio
75°
70°
10°
5°
MILES
KILOMETERS
0 25 50 75 100
0 25 50 100 150

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 27

No. 108

The Rio Cachiri Section in the Sierra de Perija, Venezuela

By

R. A. Liddle, G. D. Harris and
J. W. Wells

April 6, 1943

Paleontological Research Institution
Ithaca, New York
U. S. A.

CONTENTS

THE RIO CACHIRI SECTION IN THE SIERRA DE PERIJA, VENEZUELA

PART I. GEOLOGY

By

R. A. Liddle

LOCATION AND ACCESSIBILITY

Rio Cachirí rises in the high, cloud-capped mountains of the Sierra de Perijá along the boundary between Venezuela and Colombia. It flows northeastward to join Rio Socuy in forming Rio Limón whose waters reach the Gulf of Maracaibo, an arm of the Caribbean Sea, through Lago Sinamaica. The first 20 kilometers of its course are amid wild, rugged, forest-clad peaks from which it descends over falls, down boulder-choked gorges and narrow, densely forested valleys until it breaks through the frontal barrier at the eastern edge of the range to meander northeastward across semiarid lowlands.

West of the frontal barrier there are no human habitations, and few people have undertaken the arduous climb to the upper reaches of the river because all food, with the exception of meat, and equipment must be carried by man. Furthermore, the ascent may be made only near the end of the dry season, during the last half of February and the first half of March, when the river is at its lowest stage, for the river bed affords the only way of access. Even at the end of the dry season trails must be cut around some gorges and falls like those just west of Playa La India where the river has worn a narrow, vertical-walled canyon through sandstone and shale of the Misoa-Trujillo formation of lower and middle Eocene age that makes up the frontal barrier ridge of the mountains. Where the river cuts through soft shale no gorges or waterfalls are found but the stream bed is difficult to traverse because it is choked by fallen trees interlaced with vines.

Playa La India may be reached by mule in one day from Rancho Rio Viejo farther down on the east bank of Rio Cachirí. In the dry season Rancho Rio Viejo is accessible from Maracaibo, with difficulty, by automobile in about five hours.

From Playa La India to Campo Las Tres Bocas game is plentiful. Around the *playa*, are *havolina, danta, paujíl,* and *pavo.* Farther west the amount and variety of game diminish and above Campo Las Dos Bocas even *paujíl* and *pava* disappear, only parrots and monkeys being found. In the mountains where the river is clear and cold a species of vegetable-eating fish called *boca chica* is abundant but it does not take a lure. As pools in the river are fairly shallow at the end of the dry season a seine can be used effectively. The fish travel in schools of 200 to 500 and weigh uniformly from one and one-half to two pounds each.

INTRODUCTION

In the early part of 1924 C. W. Yeakel, P. W. McFarland, and R. A. Liddle traversed Rio Cachirí from its mouth westward into the Sierra de Perijá almost to the source of its north fork, now referred to as Caño del Norte. Fossils were collected from the Eocene, the Cretaceous, the "Old Red series" which was provisionally placed in the Permian, and from the Lower and Middle Devonian. Some of this Devonian fauna was described by Weisbord[1], and some of it was listed by Liddle[2].

In 1926 Joe Netick, G. A. Weaver, and Malcom Madera made a plane-table survey and systematic collections of fossils and rock samples westward from Rancho Cachirí into the Devonian section on the Caño del Norte and Caño del Oeste branches of Rio Cachirí. They did not, however, examine Caño Grande, the main branch of the river beyond Campo Las Tres Bocas.

In later years a few expeditions up Rio Cachirí have been reported but no one has made public the results obtained. The pur-

[1] Weisbord, N. E.: *Venezuelan Devonian fossils*, Bull. Amer. Paleont., vol. XI, No. 46, 1926.

[2] Liddle, R. A.: *The geology of Venezuela and Trinidad*, 1928, pp. 97-101, Forth Worth, Texas.

poses of the expedition up Rio Cachirí by Liddle in 1942 were:

1. To traverse westward far enough to pass through the section and discover the nature of the rocks forming the core and the highest peaks of the Sierra de Perijá.
2. To learn if sediments older than Devonian are present in the mountains.
3. To collect systematically from the entire pre-Cretaceous section.
4. To determine positively the age of the "Old Red series", (thought to be Permian) and its relation to the Devonian below and to the Cretaceous above.
5. To ascertain the relation of the black and red crinoidal limestone exposed near the mouth of Caño del Norte to the red-bed section that extends from the limestone outcrop farther northwest up the Caño; and to find out the relation of the crinoidal limestone to the Rio Negro formation of Lower Cretaceous age which is at the surface just east of the limestone.
6. To establish with certainty the age of the crinoidal limestone, believed to be Permo-Carboniferous.

The results of this expedition are contained in the following pages.

No attempt has been made to discuss in detail the Cretaceous and lower Eocene sediments which outcrop in the area examined. Their presence is briefly recorded merely to indicate their proper position in the geologic section.

ACKNOWLEDGMENTS

The success of this expedition into the Sierra de Perijá was due in a great measure to the assistance provided by Mr. R. W. McIlvain, Vice-President and Mr. Theron Wasson, Chief Geologist of The Pure Oil Company. Upon their instructions all arrangements for my entering Venezuela were made by Dr. J. M. Travieso Paúl of Caracas, Venezuela. To obtain the necessary permits in time of war was no small task. Mr. Wasson also fur-

nished me with the traverse of Rio Cachirí made by Netick, Weaver, and Madera in 1926. This survey enabled me to reëxamine the lower course of the river more rapidly than would have been possible otherwise, thus permitting me to spend more time in its upper branches.

Dr. W. H. Hegwein, Chief Geologist of the Caribbean Petroleum Company, Maracaibo, Venezuela, furnished me with a map covering much of the upper portion of Rio Cachirí. This map, made by Dr. J. Krebs, enabled me to study and collect rapidly from the Devonian section, thus leaving time enough to penetrate to the core of the Sierra de Perijá.

I am especially indebted to Mr. H. L. Patterson, General Manager, and to Mr. Joe Netick, Chief Geologist, of the Orinoco Oil Company, Maracaibo, Venezuela. Without their help I could not have completed my work during the short, dry season of the Sierra de Perijá. Mr. Netick also gave liberally from his knowledge of Venezuelan geology, acquired during the past 20 years, and made available to me all his collections. Some fossils from these collections are figured in this work.

My wife, Pearle Goolsby Liddle, has assisted in preparing the manuscript and Dr. K. V. Palmer has supervised its progress through the press. To both I am deeply grateful.

STRATIGRAPHY

IGNEOUS ROCKS

Two complementary types of igneous rocks have been found on Rio Cachirí east of the main core of the Sierra de Perijá. Their areal extent, however, is small because they occur only as intrusives into sedimentary beds—the acidic and basic types on Caño del Norte, and the basic type on Caño Grande. Acidic igneous rocks only, in association with metamorphics, have been discovered in the core of the mountains.

ACIDIC GROUP

One hundred meters above the junction of the Caño del Norte branch of Rio Cachirí with the Caño del Oeste branch is a fairly large pluglike mass which is well exposed in the east bank of the river. It is composed of quartz syenite, or aplite, and quartz diorite which are extremely hard to fracture, and are highly resistant to erosion. It protrudes from the heavily forested mountain slope into outcropping limestones that lie at the top of the red-bed section of probable Permian age and immediately below the Rio Negro formation,—a conglomeratic sandstone of Lower Cretaceous (Barremien) age. Slight alteration of the limestone beds adjacent to this igneous mass, notable mineralization and red staining by iron, indicate clearly the intrusive nature of the mass. Some of the limestone beds into which the intrusion was forced are full of large crinoid stems. In one bed, in association with a multitude of crinoid stems, is the hinge area of a *Spirifer*, and a large bryozoan form. Other beds of limestone that are quite similar in character to the crinoidal limestone contain no fossils although both types are in contact with each other. The quartz syenite and the quartz diorite are closely related in the mass,—the only difference being that in the quartz syenite the grayish ground-mass of dense, amorphous silica has crystals of glassy quartz embedded in it, whereas, the quartz diorite contains, in addition, specks of hornblende and traces of iron. In both types the grayish ground-mass is splotched with pale pink and light green.

Samples: "A" and 17.

Reddish and greenish quartz syenite and quartz diorite intrude red shales of probable Permian age higher up on the Caño del Norte branch of Rio Cachirí than the locality of Sample "A". They resemble somewhat the rock in Sample "A" but have larger quartz crystals and angular fragments of greenstone. Some places in the intrusion, represented by Sample OI-J-65, look like igneous breccia.

In the core of the Sierra de Perijá, in association with metamorphic rocks, chiefly quartzite and schist, are moderately soft, creamy-gray, mica-hornblende granite, and veins and dikes of vitreous, white, igneous quartz that cut both the metamorphic rocks and the granite.

Samples: parts of 78 and 79.

BASIC GROUP

On the Caño del Norte branch of Rio Cachirí dense, greenish-black diorite forms the contact zone between red beds of the Permo-Carboniferous and underlying dark-gray limestones and shales of the Devonian. The limestones are shattered and cut by calcite veins; the Permo-Carboniferous shales above the diorite are deep red and impregnated with iron.

Samples: 3, 4, 5, 6, and OI-J-69.

On the Caño Grande branch of Rio Cachirí a sill of basalt has penetrated the bedding of dark-gray shales of the Caño del Oeste formation of Upper Devonian age baking them to glossy black and indurating them considerably. Some mineralization by iron has taken place. The sill is a typical, dense, very hard, black diorite. The time at which it intruded the Devonian beds is not known, but since on Rio Gé not far away in the same mountain range similar basic rock has intruded Lower Cretaceous beds, it is probable that the sill on Rio Cachirí is no older than Cretaceous; possibly it is much younger.

Sample 61 is from this sill.

METAMORPHIC ROCKS

The only true metamorphic rocks in Rio Cachirí occur in its headwaters where they constitute the core of the Sierra de Perijá. Mica-hornblende schist and quartzite are the only types found. They occur in association with quartz-feldspar granite, both the granite and the metamorphic rocks being intruded by dikes and veins of vitreous quartz.

PRE-DEVONIAN: PROBABLY ARCHEOZOIC

Sierra de Perijá Series

Name.—Sierra de Perijá series is here used to designate grayish-tan, very hard quartzites cut by dikes and veins of white igneous quartz, together with mica schists and gneissoid schists intruded by granite found in place in the headwaters of the Caño Grande branch of Rio Cachirí, districts of Mara and Maracaibo, State of Zulia, and evinced by abundant float in the Caño del Oeste branch of Rio Cachirí, and in Rio Tinacoa. In Rio Gé quartzite boulders were found in float but no schist was seen.

Stratigraphic position.—The Sierra de Perijá series lies below and in faulted contact with beds of Devonian age on the Caño Grande branch of Rio Cachirí. There is no doubt of the relation as the contact can be located within a few feet. This series which doubtless embraces rocks of several ages, origins, and sources comprises the high mountain peaks of the Sierra de Perijá.

Physical character.—Grayish-tan, mauve, massively bedded, hard quartzite cut by veins and dikes of white quartz; greenish-gray, micaceous schists intruded by cream-colored granite; and greenish-yellow, gneissoid schists comprise the Sierra de Perijá series. Some of the quartz dikes are two and one-half feet in width and were traced across rock faces for 20 feet. The quartzite and the schistose rocks are interbedded.

Extent and thickness.—From rocks *in situ*, and from float, it is evident that the Sierra de Perijá series comprises the core of Sierra de Perijá and forms the high peaks, at least between Rio Apón on the south and Rio Cachirí on the north. Only 1,000 feet of the series were penetrated in the Caño Grande branch of Rio Cachirí because of lack of time, but it can be stated confidently that there are several thousand feet of this heterogeneous series.

Age and correlation.—The Sierra de Perijá series is definitely pre-Devonian, but a more exact age cannot be ascribed. Probably it includes rocks of several ages as is suggested by the character of the rocks themselves. It is believed to be pre-Paleozoic,—probably Archeozoic since unmetamorphosed Middle Ordovician has been found in the Venezuelan Andes, and Lower Ordovician and Upper Cambrian sediments are present in the Cordillera Oriental of Colombia about 300 kilometers south of Rio Cachirí. In both regions, which are in the Andean system, they are underlain by metamorphic and igneous rocks similar in character to those forming the core of the Sierra de Perijá on Rio Cachirí.

Topographic expression and local details.—Only in the headwaters of the Caño Grande branch of Rio Cachirí have rocks of the Sierra de Perijá series been found in place, but float has been picked up in several of the other larger rivers which drain eastward from this mountain range,—notably Rio Socuy, Rio Guasare, and Rio Palmar. Rocks of this series form the high peaks of the central area of this mountain chain.

Samples 78 and 79 were collected from the Sierra de Perijá series.

SEDIMENTARY ROCKS

From the core of the Sierra de Perijá eastward to its foothills where Rio Cachirí debouches from the mountains there are exposed along the river Devonian, Permo-Carboniferous, Cretaceous, and lower Eocene sediments. The Devonian is represented by the Rio Cachirí series which has been divided from base to top into the Caño Grande formation of fossiliferous, dark-gray, micaceous shales of Lower and Middle Devonian age; the Caño del Oeste formation of grayish-black, micaceous shales intercalated with some grayish-brown, micaceous, quartzitic sandstones of probable Upper Devonian age; and the Campo Chico formation of micaceous, quartzitic sandstones, gray, calcareous, micaceous shales, and a few dark-gray, calcitic limestones of probable Upper Devonian age. No fossils, either megascopic or microscopic, have been found in the beds that are thought to be Upper Devonian.

The Permo-Carboniferous, separated from the Devonian by a conglomerate made up of red shale in which angular fragments of limestone are embedded, consists of red, micaceous shales; at the top of these are dark-gray to black, locally red-stained limestones, some beds of which are full of large crinoid stems. In one bed a *Spirifer* and a large, tubular Bryozoa are associated with the crinoid stems,—all the stems being calcitized.

The Cretaceous, lying unconformably on the Permo-Carboniferous, is represented by a basal conglomeratic sandstone,—the Rio Negro formation of Barremien age, conformably overlain by massive, grayish-white limestones and minor gray shales of the Cogollo formation of Aptien and Albien ages. Conformably on the Cogollo formation is La Luna formation of black, petroliferous limestone and shale carrying discoidal and ellipsoidal masses of fossiliferous, petroliferous limestone. La Luna formation is Vraconnien in age and grades imperceptibly upward into the Guayuta shale of the Guayuta group. This shale is grayish black and of Cenomanien and Turonien ages. To date the only evidence of Cretaceous that is younger than Turonien in the region north of Rio Negro is the reference by Gerhardt[3] to Lower Senonien at Hato Nuevo, in the Sierra de Perijá, District of Maracaibo, Venezuela. This locality, however, is not in Venezuela but is a short distance to the west in the Department of Magdalena, Colombia. At Rio Negro, though, Maestrichtien Cretaceous is represented by coarse, gray sandstone in Quebrada del Mene, a branch of the river. This *quebrada* parallels on the west the frontal ridge of the mountains which, at this place, is made up of La Sierra sandstone, the *quebrada* extending along the contact between the sandstone on the east and Upper Cretaceous shales on the west. Faulting has narrowed the shale valley so that it is not known how much of the Guayuta or Colon is missing. Fossils indicating this occurrence of Maestrichtien are *Cucullæa perijana* F. and H. Hodson, and *Pseudocucullæa perijana* Harris, F. and H. Hodson[4].

The Eocene, which seems to rest with structural, as well as stratigraphic unconformity, on the Upper Cretaceous, has at its base the Rio Guasare formation. It is a marly, calcitic, redsplotched, fossiliferous, impure limestone (in places an oyster reef) that grades upward into coal-bearing shales and sandstones of the Third Coal horizon or Paso Diablo formation which comprises the basal portion of the Misoa-Trujillo formation of lower Eocene age. Resistant sandstones and lignitic shales of the Third Coal horizon form the frontal barrier or ridge of the mountains on Rio Cachirí at Playa La India but the formation extends much farther eastward into the great syncline which lies between the foothills of the Sierra de Perijá on the west and Cerros Los

[3] Gerhardt, K.: *Beiträge zur Kenntniss der Kreideformation in Venezuela und Peru*, Neues Jahr. Min., Beil. Bd. XI, 1897-98, pp. 69-70.

[4] Hodson, F. Hodson, H. K. and Harris, G. D.: *Some Venezuelan and Caribbean mollusks*, Bull. Amer. Paleont., vol. XVIII, No. 49, 1927, pp. 1-2.

Guineos on the east. It also outcrops to the southwest in Arroyo Cerrejon in the Valley of Rio Rancheria, Department of Magdalena, Colombia.

PALEOZOIC

Lower and Middle Devonian: Rio Cachirí Series

Caño Grande Formation

Name.—In 1928 Liddle[5] referred to his Rio Cachirí series all sediments below the red beds on the Caño del Norte branch of Rio Cachirí as far as the locality of his deepest penetration into the Devonian section. His expedition of 1942, in which a detailed study of the Devonian was made, and a systematic collection of samples secured, clearly indicates that although all sediments here referred to the Devonian have a distinct lithological relationship they can be divided into three formations,—the oldest of which is highly fossiliferous in places.

Stratigraphic position.—In the headwaters of the Caño Grande branch of Rio Cachirí the fossiliferous Caño Grande formation is in fault contact with the core of the Sierra de Perijá. Extremely hard, slaty shale and quartzitic sandstone (Samples 77 and 77½) which contain imprints of Lower Devonian fossils comprise the oldest Devonian beds found. They rest with distinct unconformity on schists, quartzites, granite, and quartz of the Sierra de Perijá series that may be Archeozoic in age. The Caño Grande formation grades upward into the Caño del Oeste formation which constitutes the middle portion of the Rio Cachirí series,—the contact being placed between the localities of Samples 62 and 63. At this stratigraphic level there is a notable though gradual lithologic change, and an abrupt termination of an abundant and varied fauna.

Physical character.—The Caño Grande formation is a distinct lithologic and biologic unit. Gray, micaceous, nodular, limonitic, calcareous, sandy shales containing mud pellets, microscopic particles of lignitic matter, and breaking with a shattery fracture, carry a prolific Lower and Middle Devonian fauna. In the ex-

5 Liddle, R. A.: *op. cit.*, pp. 97-99.

treme basal portion are some evenly bedded, fine-grained, dark-gray, micaceous, quartzitic sandstones, and a few more shaly sandstones which contain imprints of Spirifers and corals.

Extent and thickness.—The Caño Grande formation of the Rio Cachirí series has been found in place in the Sierra de Perijá only in the headwaters of Rio Cachirí. It is present in all branches of the river. Float from this formation has been collected at the mountain front in Rio Socuy and in Rio Guasare which, like Rio Cachirí, flow eastward down from the northern end of the Sierra de Perijá.

The thickness of the Caño Grande formation is calculated to be at least 2,500 feet. Accurate measurement is impossible because of faulting and intervals that are concealed by dense forests.

Age and correlation.—The prolific, well-preserved fauna of the Caño Grande formation is positive proof of its Lower and Middle Devonian age,—ranging from Helderbergian through Oriskanian and Hamiltonian. It can be correlated with the Floresta fauna of Colombia described by Caster[6] even though there are some differences that may be accounted for by facies changes, since the localities are 300 kilometers apart in the same mountain system. The Floresta fauna seems to more nearly represent the Helderbergian and Oriskanian, and to have less of a Hamiltonian character, whereas, in the Caño Grande fauna the Hamiltonian is well represented. There is a close lithologic and faunal relation between the Rio Cachirí series and Lower and Middle Devonian sediments of New York State. However, as would be expected in areas so far apart, some of the fauna is quite different. Lithologically the Rio Cachirí series bears little resemblance to the Floresta beds.

Fossils identified by Harris and Wells from the Caño Grande formation are:

Heliophyllum halli Milne Edwards and Haime
Heterophrentis venezuelensis (Weisbord)
Synaptophyllum vermetum (Weisbord)
Zonophyllum, sp.
Crinoid stems

[6] Caster, K. E.: *A Devonian fauna from Colombia*, Bull. Amer. Paleont. vol. XXIV, No. 83, 1939, pp. 1-218.

Fenestella venezuelensis Weisbord
Polypora cachirita Weisbord
Actinopteria subulrichi, n. sp.
Aviculopecten yeakeli Weisbord
Aviculopecten, sp. (fragment)
Ctenodonta?, sp.
Edmondia sylvana Hartt
Limoptera tenuis, n. sp.
Nucula?, sp.
Schizodus venezuelanus, n. sp.
Platyceras gibralteri, n. sp.
Platyceras sinistrum, n. sp.
Platyostoma ventricosum (Conrad)
Platyostoma ventricosum var. permudum, n. var.
Acrospirifer olssoni Caster
Amphigenia elongata var. weisbordi, n. var.
Athyris spiriferoides (Eaton)
Atrypa reticularis var. harrisi Caster
Camarotœchia, sp.
Chonetes stübeli Ulrich
Chonetes venezuelensis Weisbord
Dalmanella cf. nettoana Rath
Dictrostrophia cooperi Caster
Elytha colombiana Caster
Elytha? plana, n. sp.
Eodevonaria imperalis Caster
Eodevonaria subhemispherica Weisbord
Leptæna rhomboidalis, (Wilkens) vars.
Leptostrophia caribbeana Weisbord
Leptostrophia concinna (Morris and Sharpe)
Meristella, sp.
Meristella wheeleri Caster
Pentagonia? gemmisulcata Caster
Productella, sp.
Rhipidomella liddlei, n. sp.
Schellwienella goldringæ Caster
Spirifer kingi Caster
Spirifer olssoni Caster
Spirifer, sp. (fragments)
Spirifer weisbordi, n. sp.
Stropheodonta (Cymostrophia) casteri, n. sp.
Stropheodonta kozlowskii Caster
Strophonella? meridionalis (Caster)
Tropidoleptus carinatus Conrad
Shark tooth

Topographic expression and local details.—Actual outcrops of the Caño Grande formation in the several branches of Rio Cachirí, and brief glimpses of the mountains which it sustains, that can be seen occasionally from the river, comprise our general knowledge of the topographic influence of this formation. In the river the harder calcareous shales form vertical cliffs in places over 100 feet high, as well as narrow, vertical- and overhanging-walled canyons, and low waterfalls. Narrow, sharp valleys have been cut into the softer shales. A surprising feature is the hardness of the shale in cliff faces, considering the readiness with which it shatters after exposure, and the rapidity with which it weathers when soaked in water.

Samples: OI-J-97 (float), OI-J-113 (float), 31 (float), 34 (float), 37, 38 (float), 39, 40, 41, 42, 43, from the Caño del Oeste branch of Rio Cachirí, and

Samples: 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 77½, from the Caño Grande branch of Rio Cachirí.

The Caño Grande formation was not reached on Caño del Norte by the 1942 expedition of Liddle. It was examined in 1924 by the expedition of Yeakel, McFarland, and Liddle and some of the fossils collected by them were described by Weisbord[7].

Upper Devonian

Caño del Oeste Formation

Name.—The Caño del Oeste formation is named from the Caño del Oeste branch of Rio Cachirí where it is well exposed between traverse stations 32 and 42. It was thought, at first, that sediments comprising this formation could be referred directly to the Rio Tinacoa formation which is an established name but since no fossils have been found in either formation it is more advisable to introduce a local name and suggest a correlation between the two formations.

Stratigraphic position.—The Caño del Oeste formation, where the Devonian is in normal sequence, separates the Caño Grande formation from the Campo Chico formation. There seems to be a perfect gradation from base to top of the entire Devonian section. However, there is enough difference between the three

[7] Weisbord, N. E.: *op. cit.*, pp. 1-52.

parts to warrant separate formational names.

Physical character.—On Rio Cachirí the Caño del Oeste formation is composed of bluish-black, fine-grained, micaceous, ferruginous quartzite; dark-gray, micaceous, nodular, limonitic, unfossiliferous shale which has a shattery fracture and contains microscopic particles of lignite; black, micaceous, slaty shale having a splintery nature, and some black, unctuous, twisted unfossiliferous shale. Local induration of the shale in the basal part of the formation is caused by a 30-foot sill of basalt. On either side of it the shales are slaty.

In the type section of the Rio Tinacoa formation on Rio Tinacoa the shale which comprises most of the formation is squeezed, twisted, and crumpled more than the shale of the Caño del Oeste formation on Rio Cachirí, or shale of the same horizon on Rio Macoita. On Rio Tinacoa the Rio Tinacoa formation is predominantly black, nodular shale which breaks conchoidally or splintery. There is much slickensiding, and in some places the black shale appears to be graphitic. In the lower one-third of the section are some thinly bedded, hard, quartzitic sandstones, and in the basal part some thinly bedded, black, hard limestones.

Extent and thickness.—The Caño del Oeste formation and the Rio Tinacoa formation are known to reach, in the Sierra de Perijá, at least from Rio Macoita on the south to Rio Cachirí on the north, although they are not exposed locally in the intervening area on rivers like La Luna which do not penetrate deep enough into the section. They are present, only in part, on some other rivers because of faulting. On account of the terrific crumpling and twisting which accompanies the faulting in the Rio Tinacoa formation on Rio Tinacoa, an accurate estimate can not be made of its thickness, but on Rio Cachirí where the section is less disturbed there are about 3,500 feet of the Caño del Oeste formation.

Age and correlation.—No fossils have been found yet in the Caño del Oeste formation, but it is known to lie with gradational conformity above the Caño Grande formation of Lower and Middle Devonian age and consequently is thought to be Upper Devonian. It is believed to correlate with the Rio Tinacoa formation which has been described by geologists of the Caribbean Petroleum Company from the section on Rio Tinacoa already mentioned.

Topographic expression and local details.—Thinly bedded, quartzitic sandstones and a few, thin limestones of the Caño del Oeste formation protect the intercalated, softer shales but where they are not present and the shales stand at steep angles, landslides are common. In general, the formation supports high, rugged mountains.

Samples: 57, 58, 59, 60, 62, on the Caño Grande branch of Rio Cachirí, and

Samples: 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, on the Caño del Oeste branch of Rio Cachirí.

Campo Chico Formation

Name.—The Campo Chico formation is named from the locality of an overnight camp on the Caño Grande branch of Rio Cachirí. There is no particular topographic or drainage feature within the area of outcrop of these sediments so the camp site was utilized as a name although it may not meet the exact requirements of nomenclature.

Geologists of the Caribbean Petroleum Company use the term Rio Macoita formation to designate thinly bedded, sandy, micaceous, gray shales and dark-gray, evenly bedded, quartzitic, fine-grained sandstones which are well exposed on Rio Macoita, in the Sierra de Perijá, State of Zulia. To date no fossils have been found in these beds, but on lithology they are correlated with the Campo Chico formation. Hedberg and Sass[8] have used the term "Macoita series" to replace the term "Old Red series" of the Sierra de Perijá area, but unfortunately the type section which they designate for their "Macoita series" on Rio Macoita con-

[8] Hedberg, H. D., and Sass, L. C.: *Sinopsis de las formaciones geologicas de la parte occidental de la Cuenca de Maracaibo, Venezuela*, Bol. Geol. y Min., t. 1, Nos. 2, 3, y 4, 1937, p. 79.

tains no beds previously known as the "Old Red series". On Rio Macoita there is an unconformity which places the Rio Negro formation directly in contact with the Rio Macoita formation, the red-bed section apparently being cut out by the unconformity. For this reason Hedberg and Sass' usage is dropped and that in use by geologists of the Caribbean Petroleum Company is adopted.

Stratigraphic position. On Rio Cachirí the Campo Chico formation lies below Permo-Carboniferous, probably Permian, red beds from which it is separated by a conglomerate composed of deep-red, micaceous shale in which are embedded angular fragments of bluish-gray limestone. Although it is not possible to determine with certainty, it is believed that an unconformity of magnitude separates the Campo Chico formation from the overlying red beds. This is confirmed by the absence of the Mississippian and probably much of the Pennsylvanian. There is complete conformity between the Campo Chico formation and the Caño del Oeste formation which directly underlies it.

Physical character.—Dark-gray, hard, evenly bedded, quartzitic sandstones intercalated with dark-gray, hard, micaceous shales comprise most of the Campo Chico formation. There are also, a few thin, hard, black, calcitic limestones.

Extent and thickness.- Because of intense disturbances in the type section of the Rio Macoita formation on Rio Macoita, and in its outcrop on Rio Tinacoa, its thickness cannot be determined accurately. On Rio Cachirí, where less disturbance has taken place, there are, at least, 2,000 feet of the Campo Chico formation. On other rivers, between Rio Tinacoa on the south and Rio Cachirí on the north, only parts of the Rio Macoita formation or the Campo Chico formation are present. This is particularly true of Rio Gé, where a diorite intrusion is in contact with the Rio Macoita or the Campo Chico formation on the east; in fact, it occupies all the area between this horizon and the Cogollo formation of the Lower Cretaceous. Similar igneous rocks separate the Rio Macoita or Campo Chico formation from sediments exposed farther west.

On most rivers in the northern part of the Sierra de Perijá, which cut deeply enough into the mountains to reach the Campo Chico or Rio Macoita formation, there is some portion of this formation exposed. Of the rivers in this region which have been examined, the best exposures were found on Rio Cachirí and Rio Macoita.

Age and correlation.—The Campo Chico formation is thought to belong in the Upper Devonian because on Rio Cachirí there is no visible structural or lithologic break between it and the Caño del Oeste formation below, or between the Caño del Oeste formation and the underlying Caño Grande formation,—the Lower and Middle Devonian age of which is definitely established by fossil remains. However, there is sufficient lithologic change to substantiate the three parts into which the Devonian is separated. From base to top these are: Caño Grande formation, Caño del Oeste formation, and the Campo Chico formation. The Campo Chico formation is correlated with the Rio Macoita formation on lithology only as no fossils have been found in either formation.

Topographic expression and local details.—The resistance of the Campo Chico or Rio Macoita formation to erosion enables it to support many vertical bluffs along rivers where it outcrops. Mountains at a distance from the rivers have the same characteristic bluffs and steep slopes.

Samples: 53, 54, 55, 56, on the Caño Grande branch of Rio Cachirí;

Samples: 20, 21, 22, 24, 25, 26, 27, on the Caño del Oeste branch of Rio Cachirí, and

Samples: 1, 2, "C," on the Caño del Norte branch of Rio Cachirí.

DEVONIAN—PERMO-CARBONIFEROUS RELATIONSHIP

No actual discordance of dip on Rio Cachirí was observed between the Devonian and the overlying red beds which are considered to be Permo-Carboniferous,—probably Permian in age.

However, in sediments standing at such high angles, where outcrops are separated by dense forests, divergence in dip, unless of magnitude, is difficult to detect. Unconformity is evinced, however, by the absence of some of the Carboniferous beds which are present in the Colombian and Venezuelan Andes, and by a 25-foot conglomerate at the base of the red-bed section at its contact with the Devonian below. This conglomerate has a matrix of red, micaceous shale in which are embedded angular fragments of light- and dark-gray limestone. The source from which this limestone was derived is not clear. Very little limestone was found in the Devonian, and it is surprising that sandstone fragments were not found in the conglomerate, since quartzitic sandstone is common in the Campo Chico formation just below the red beds. The limestone fragments may come from a horizon not present on Rio Cachirí, being cut out by the unconformity between the Devonian and the Permo-Carboniferous. Furthermore, as is indicated by fossiliferous float from Station OI-J-113, there appear to be Carboniferous beds within the drainage of Rio Cachirí which to date have not been found in place in the river itself. Fossils from the float are *Leptodomus ulrichi* Clark and *Productus liddlei*, n. sp.

Permo-Carboniferous

Palmarito Series

Name.—The Palmarito series was introduced by Christ[9] to include rocks of Permo-Carboniferous age in the Venezuelan Andes. Although only a part of the Permo-Carboniferous, probably just the Upper Permian, is present on Rio Cachirí it is assigned to the Palmarito series in order to avoid introducing a new name. Should it be learned later that a new name is desirable it can be introduced.

Stratigraphic position.—A basal conglomerate which lies at the bottom of the red-bed section constitutes the oldest rocks of

[9] Christ, P.: *La coupe geologique le long du chemin de Mucuchachí a Santa Barbara dans les Andes Vénézuéliennes*, Eclog. Geol. Helv., vol. XX, No. 3, 1927.

the Palmarito series on Rio Cachirí. It is well exposed at the localities of Samples 52 and 53-A on the Caño Grande branch of the river. On the Caño del Norte branch an intrusion of diorite separates the Palmarito formation from the Campo Chico formation. On the Caño del Oeste branch faulting and concealed section have obscured the contact of the Permo-Carboniferous and the Devonian. Even on the Caño Grande branch the actual contact of the two series was not seen, although the heavy forest which blankets the contact hides but a few feet of section. There does not appear to be much discordance in dip between the Devonian and the Permo-Carboniferous on Caño Grande although a small variation would be difficult to detect in beds which are so steeply inclined.

The contact of the crinoidal limestones, which constitute the upper member of the Palmarito series, and the Rio Negro formation of Lower Cretaceous (Barremien) age is likewise not exposed, although the two series are only a few feet apart. It is evident though, that the Cretaceous beds are much less inclined than are those of the Permo-Carboniferous. However, a mass of syenite and diorite which has intruded the crinoidal limestone horizon at the top of the Palmarito series probably is responsible for some of the disturbance in these Permo-Carboniferous limestones. But considering the divergence of dip between the two series, together with the fact that no Triassic or Jurassic is present although both are exposed not far distant in Venezuela and in Colombia, indicates an unconformity of great magnitude between the Permo-Carboniferous and the Cretaceous.

Physical character.—Deep-red, micaceous shale in which are embedded angular fragments of light- to dark-gray limestone comprises the basal conglomerate of the Palmarito series. Above it are deep-red, micaceous, well-bedded, unfossiliferous, brittle, sandy shales which in some places appear to have microscopic particles of lignitic matter; deep-red, unfossiliferous, unctuous, compact shales having greenish-white splotches and breaking with a shattery fracture; grayish-black, locally red-stained, calcitic limestone containing a profusion of large crinoid stems and roots, a *Spirifer,* and a large, branching, tubular Bryozoa. The crystalline texture of the limestone, its calcitization, and red staining may be due to it being intruded by a mass of quartz syenite and quartz diorite.

Extent and thickness.—The red-bed part of the Palmarito series outcrops on all branches of Rio Cachirí. Similar red beds have been examined on Rio Tinacoa where they are well exposed; at their top and in fault contact with them are black and red, highly shattered, silty, unfossiliferous shales which are locally slickensided. Where shattered, the shales carry abundant calcite veins. On Rio Tinacoa no fossils were found in any of the red-bed section and no trace of the limestones that occur at the top of the red-bed section on Rio Cachirí were discovered. On Rio Macoita the red beds and the limestones are missing in the unconformity between the Rio Negro formation of Lower Cretaceous age and the Rio Macoita formation of Upper Devonian age. On Rio Tinacoa there is a great fault between red beds of the Palmarito series and black shales of the Rio Tinacoa formation. It appears to have cut out most or all of the Rio Macoita formation.

The red beds of the Palmarito series are present throughout much of the northern part of the Sierra de Perijá, but limestones at the top of the series have been found only in one locality on Rio Cachirí. On Rio Cachirí there are at least 1,500 feet of red shales and from 50 to 75 feet of limestone at their top, all of which are considered to be Permo-Carboniferous.

According to Hedberg and Sass[10]:

> Rocks containing *Fusulina* of Carboniferous age have been reported from the upper course of Rio Palmar, District of Maracaibo.

These sediments also may belong in the Palmarito series and be related to the Permian rocks outcropping on Rio Cachirí.

Age and correlation.—Black and red crinoidal limestone beds and the associated, similar but unfossiliferous limestones which lie at the top of the red-bed section on the Caño del Norte branch of Rio Cachirí resemble the top of the Palmarito series that is exposed in the Venezuelan Andes.

The age of the Palmarito series on Rio Cachirí is not positive

[10] Hedberg, H. D. and Sass, L. C.: *op. cit.*, p. 79.

but the evidence (Samples "F", 15, and 16) is believed to warrant its assignment to the Permo-Carboniferous,—probably the Permian. The red and black limestone contains a large, branching form resembling *Rhombopora* or *Alveolites*, and the hinge area of a fairly large species of *Spirifer*. Thin-sections of some pieces of the limestone reveal a few *Textularia*-like Foraminifera.

Topographic expression and local details.—The black and red crinoidal limestones which lie at the top of the red-bed section and immediately below the Rio Negro formation in the Caño del Norte branch of Rio Cachirí were not found in place or in float in the Caño del Oeste branch which is very close by, or in the Caño Grande branch which is farther removed from Caño del Norte, although the localities at which they normally should outcrop were searched with care. They may be absent on these branches of Rio Cachirí because of a variable unconformity between the Cretaceous and the Permo-Carboniferous. The red-bed section is present on all branches of Rio Cachirí, although faulting has complicated it with the Campo Chico formation of Upper Devonian age on Caño del Oeste.

Kündig[11] makes the following reference to Permo-Carboniferous rocks on Rio Cachirí:

> Upper Carboniferous developed as a sandy shale-sandstone group containing typical Upper Carboniferous and possibly Lower Permian fossils (*Fenestella, Naticopsis, Orthotetes, Crenistria*) was described in a previous report a long time ago by J. Krebs from the Sierra de Perijá (Rio Cachirí).

A copy of Krebs's map was kindly furnished Liddle by Dr. Hegwein, Chief Geologist of the Caribbean Petroleum Company, Maracaibo, Venezuela, in order that Krebs's locality for the fossils mentioned might be found. His locality (Samples 63, 64, and 65) was identified but the fauna is not Permo-Carboniferous but is Lower and Middle Devonian.

Samples: "D", "E", "F", 7, 9, 10, 12, 13, 14, 15, 16, on the

[11] Kündig, E.: *Las rocas Pre-Cretaceas de los Andes Centrales de Venezuela con algunas observaciones sobre su tectonica*, Bol. Geol. y Min., t. II, Nos. 2, 3, y 4, 1939, p. 30.

Caño del Norte branch of Rio Cachirí,

Samples: 18, 23, 28, 29, on the Caño del Oeste branch of the river where the Permo-Carboniferous is complicated by having beds of the Campo Chico formation faulted into it, and

Samples: 51, 52, and 53-A, on the Caño Grande branch of the river.

PERMO-CARBONIFEROUS—CRETACEOUS RELATIONSHIP

There is a distinct structural disconformity between the crinoidal limestones which mark the top of the Permo-Carboniferous on the Caño del Norte branch of Rio Cachirí and the oldest (Barremien) Cretaceous which is represented by the Rio Negro formation. How much of this discordance of dip is due to local intrusion of quartz syenite and quartz diorite into the limestones is not known, for at no other place was this limestone horizon found,—the red-bed section being separated from the Lower Cretaceous by detrital from the surrounding mountains. However, since Barremien beds are the oldest Cretaceous on Rio Cachirí (but in Colombia Hauterivien and Valanginien together with Jurassic and Triassic have been found), it is reasonable to suppose that an unconformity of great magnitude separates the Rio Negro formation from the Palmarito formation on Rio Cachirí.

MESOZOIC

All Mesozoic sediments in the Sierra de Perijá on Rio Cachirí are Cretaceous in age. They are represented from base to top by: the Rio Negro formation of the Barremien; the Cogollo formation of the Aptien and Lower Albien; the Guayuta group of the Upper Albien, Cenomanien, and Turonien. This group includes in its basal part La Luna formation of the Albien and Cenomanien (Vraconnien) overlain by the Guayuta shale of the Cenomanien and ?Turonien.

The sandstones and conglomerates of the Rio Negro formation grade upward into massive, gray limestone and intercalated gray, sandy shales of the Cogollo formation. It, in turn, is conformably overlain by La Luna formation composed mainly of black, petroliferous limestone,—the limestone grading upward into grayish-black, locally nodular, poorly fossiliferous shales of the Guayuta group.

In that portion of the Sierra de Perijá which is north of Rio Negro no Cretaceous younger than Turonien has been found. It was probably deposited but has been cut out by faulting, unconformity, and overlap of younger beds. At Rio Negro coarse, gray sandstone of Maestrichtien age outcrops in Quebrada del Mene a branch of Rio Negro which joins that river just west of the frontal barrier near La Escalera, southwest of Machiques in the District of Perijá. *Cucullæa perijana* F. and H. Hodson and *Pseudocucullæa perijana*, F. and H. Hodson, in the sandstone indicate its age, and there is little doubt but that it once extended through the Sierra de Perijá region.

At approximately the contact of La Luna limestone with the Guayuta shale on Rio Gé are layers of bright-green glauconite which carries a very meager microscopic fauna and no megascopic fossils.

There is no evidence of Triassic or Jurassic on Rio Cachirí.

Lower Cretaceous

Rio Negro Formation

Name.—Hedberg and Sass[12] introduced the name Rio Negro conglomerate which they report was originated by geologists of the Venezuelan Gulf Oil Company to designate the thick sedimentary conglomerate lying conformably below the Cogollo limestone on Rio Negro in the west central part of the District of Perijá, State of Zulia. This is the same formation which Liddle[13] called Basal Cretaceous conglomerate.

Stratigraphic position.—The Rio Negro formation on Rio Cachirí, and, in fact, throughout its exposed area in the Sierra de Perijá, lies conformably below limestones and shales of the Cogollo formation. It rests, in all places observed, unconformably upon various older rocks. Locally in the Totumo region it lies directly upon grano-diorite of an old land mass, whereas

[12] Hedberg, H. D. and Sass, L. C.: *op. cit.*, pp. 79-81.
[13] Liddle, R. A.: *op. cit.*, pp. 119-120.

on Rio Cachirí, it rests unconformably upon black and red crinoidal limestones of Permo-Carboniferous age which are placed in the top of the Palmarito series. On Rio Tinacoa the Rio Negro formation of coarse, grayish-brown sandstone and intercalated black, calcareous shale lies above (east of) black, calcareous shale which is highly shattered and impregnated with calcite veins. Detrital material conceals the contact itself. A faulted and crushed zone in a bluff in the southeast bank of the river marks the contact of the black, calcareous shale and calcite-impregnated limestone with red, shaly limestone below,—the red limestone introducing a thick, red-shale section of probable Permian age.

On Rio Macoita the Rio Negro formation rests unconformably upon the Rio Macoita formation in the absence of intervening sediments.

Physical character.—The Rio Negro formation varies locally in character, depending upon its source. On Rio Cachirí it is a sandstone composed of fairly well-assorted quartz and feldspar but having less than the usual amount of conglomeratic matter. There are no black shales in it as there are on Rio Tinacoa. It is of moderate hardness and lacks the thin, quartzitic layers found in some other places. By way of contrast it should be mentioned that on Rio La Luna, the Rio Negro formation is composed almost entirely of small and large igneous fragments. Some of the large fragments are 3 to 4 inches in diameter. All of them are embedded in red shale and very fine, silty, red sandstone. On Rio Tinacoa the Rio Negro formation is a fairly fine, gray sandstone made up of angular quartz crystals and feldspar. Interbedded with the sandstone is some black shale. The sandstone contains considerable ferruginous matter.

Extent and thickness.—The Rio Negro formation is known to be present in the Sierra de Perijá, at least between Rio Guasare on the north and Rio Yasa on the south, though it probably exists farther north, and without doubt, farther to the south.

On Rio Cachirí it occupies a narrow belt below, or west of, the *cerro*-forming Cogollo limestone. It has no particular influence on topography.

As would be expected from a basal conglomerate, the Rio Negro formation, even in the rather limited area of the Sierra de Perijá, is extremely variable in thickness. On Rio Cachirí it is 200 feet thick.

Age and correlation.—The Rio Negro formation represents the oldest Cretaceous in the western part of Venezuela. No fossils have been found in the formation itself but as it lies conformably below the Cogollo formation of Aptien-Albien age, it is believed to be Barremien. It is considered to be an equivalent of, at least, a portion of the Barranquin formation of the eastern part of Venezuela, which in addition to conglomeratic sandstones, carries dark-gray shales and gray limestones that contain Lower Aptien and Barremien fossils.

Topographic expression and local details.—The small amount of the Rio Negro formation present on Rio Cachirí, and its relative resistance being about equal to that of the underlying Permo-Carboniferous sediments, gives it no particular influence on topography; in fact on the Caño Grande branch of the river it is difficult to find.

No samples were collected.

Cogollo Formation

Name.—The Cogollo formation, which is usually referred to as the Cogollo limestone because of the predominance of grayish-white limestone in it, is well exposed at the type locality on Rio Cogollo 40 kilometers south of Rio Cachirí but still in the Sierra de Perijá. It was described as the Cogollo limestone by Garner[14] in 1926.

Stratigraphic position.—The Cogollo formation lies with perfect conformity above the Rio Negro formation, and below La Luna formation of the Guayuta group. In places the contacts appear to be gradational; in others, though conformable, there

[14] Garner, A. H.: *Suggested nomenclature and correlation of geological formations in Venezuela*, Trans. Amer. Inst. Min. and Met. Engrs., 1926, pp. 677-684.

is a distinct lithologic change at the contact levels.

Physical character.—Massively bedded, gray limestones with which are intercalated minor, sandy, gray shales comprise the Cogollo formation, the limestones being so dominant that they give the impression that the formation is composed of limestone only. Cross-sections of fossils replaced by calcite are visible on weathered surfaces of the thicker limestone ledges. They are principally species of *Requienia, Ostrea, Homomya, Trigonia,* and *Isocardia.* From the sandy shale horizons casts of these fossils and ammonites have been secured. In weathering, the massive beds of limestone become pitted and cavernous, especially where they tower to high, vertical bluffs, and steep canyon walls.

Extent and thickness.—On Rio Cachirí the Cogollo formation is 1,400 feet thick and very prominent. Throughout its exposed area in the Sierra de Perijá, where not thinned by faulting, it is uniform in character and thickness.

Age and correlation.—The Lower Cretaceous, Aptien-Albien, age of the Cogollo formation is positively established by the fossils which it contains. Its correlation with El Cantil formation of the eastern part of Venezuela is exact.

Topographic expression and local details.—Vertical and overhanging, white-walled gorges choked with giant limestone boulders in Rio Cachirí, and prominent white-faced mountain peaks at distances from the river, characterizes the outcrop of the Cogollo formation. On all rivers in the Sierra de Perijá, which cut into the formation, its expression is similar. It is especially noticeable because of the less resistant Rio Negro formation below, and the soft Guayuta group above.

No samples were collected from this formation on Rio Cachirí, but a fair collection was made on Rio Gé.

Middle Cretaceous: Guayuta Group

La Luna Formation

Name.—In 1926 Garner[15] described La Luna limestone from Rio La Luna which is a small stream that emerges from the

[15] Garner, A. H.: *loc. cit.*

Sierra de Perijá at a little *hacienda* called Rancho La Luna.

Stratigraphic position.—La Luna formation lies with absolute conformity upon the Cogollo formation. In some places there is evidence of gradation, but in others the contact is fairly sharp, occurring at the upper limit of the massively bedded, gray limestones of the Cogollo, where they are overlain by dark-gray to black, petroliferous limestones and carbonaceous shales of La Luna. However, at the type locality on Rio La Luna the amount of beds included in La Luna formation is much greater than at other places in the Sierra de Perijá. It appears that the sea was deeper here than in other localities and as a result limestone deposition reached much higher in the section. Consequently, identification and correlation of similar black limestones and shales containing black, ellipsoidal or discoidal, petroliferous limestone masses in the Guayuta group are hazardous unless the contained faunas are confirmative. Furthermore, limestone horizons in the type section of La Luna are represented by shales in nearby areas.

A gradational relation exists between La Luna formation and the overlying Guayuta shale of the middle part of the Guayuta group which is composed mainly of dark-gray to black, locally nodular shales that carry few large fossils.

Physical character.—Black, thinly bedded, petroliferous, locally shaly limestones with which are intercalated black, sandy, carbonaceous shales containing black, discoidal and ellipsoidal, petroliferous, fossiliferous limestone masses of various sizes make up most of La Luna formation. The lenticular limestone masses are so well developed in horizons that they form continuous layers. Some contain many fossils,—chiefly pelecypods, and ammonites whose body cavities occasionally hold asphaltic oil. Irregular masses of black chert characteristically occur in the basal part of La Luna formation, especially on the Caño Grande branch of Rio Cachirí and on Rio Tinacoa.

In the type locality of La Luna formation on Rio La Luna the dark-gray shales grade upward into light-gray, ashy shales similar to gray, ashy shales of the upper part of the Guayuta group in the eastern part of Venezuela. In one horizon in the type locality these grayish-white, ashy shales carry perfectly spherical limestone balls that are not fossiliferous. The manner in which these ellipsoidal and discoidal limestone masses, as well as the spherical balls, were formed is but partially known. They are embedded in the shales,—the laminæ of the shales curving conformably about them suggest their origin in pockets in the sea floor around nuclei of fossils or foreign matter, the limestone deposition or growth taking place while the surrounding shales were being laid down. The lenticular masses vary from a few inches to several feet in diameter, the spherical balls from less than an inch to 10 inches in diameter. The upper part of La Luna formation carries a pelagic fauna; the lower part of the formation does not.

Extent and thickness—La Luna formation on Rio Cachirí is 600 feet thick. On most other rivers in the northern part of the Sierra de Perijá where it is exposed, with the exception of Rio La Luna, it varies from 200 to 600 feet. In the type section on Rio La Luna there are between 1,100 and 1,200 feet.

Age and correlation.—The fauna of La Luna formation indicates that the lowest beds are Upper Albien in age. Excluding the type locality, the upper range of the main limestones is Cenomanien. At the type locality the uppermost limestones and shales are poorly fossiliferous but the fauna indicates ?Turonien. La Luna is principally a Middle Cretaceous (Vraconnien) horizon.

In the Venezuelan Andes also, La Luna limestones form the basal part of the Guayuta group where the group is present.

In the eastern part of Venezuela La Luna formation comprises the basal part of the Guayuta group from which in some localities it has been separated into the Querecual formation. It readily correlates with a lithologically similar Middle Cretaceous horizon in Colombia, Ecuador, Peru, and Argentina.

Topographic expression and local details.—Although the lower portion of La Luna formation on Rio Cachirí contains resistant beds of limestone, their total thickness is so slight in comparison with the underlying Cogollo formation, that they have no marked influence on topography. The upper and more shaly portion of La Luna breaks down readily, and the resultant low relief grades imperceptibly into the narrow valleys which are underlain by shales of the overlying upper part of the Guayuta group.

On Rio La Luna, however, resistant limestones range so much higher in the section than in other places that the entire La Luna formation sustains rugged, fairly high mountains through which the river has cut a steep-walled channel.

Sample 50 was collected from La Luna formation on Rio Cachirí.

Guayuta Shale

Name.—The Guayuta formation was introduced in 1928 by Liddle[16] and in it he included what is now known in the eastern part of Venezuela, from base to top, as the Querecual, San Antonio, and the Santa Anita (lower part) formations,—the term Guayuta being retained as a group name to include all three formations. In the western part of Venezuela, in Sierra de Perijá, the same section is now designated, from base to top, as La Luna formation, Guayuta shale, Colon formation, and Mito Juan formation.

Stratigraphic position.—On Rio Cachirí the Guayuta shales are perfectly conformable on shales and limestones of La Luna formation; in fact the relation is almost a gradation. It is difficult to determine where the top of La Luna formation terminates and where the Guayuta shale begins because this part of La Luna is predominantly shale containing some thin limestone beds, and the basal Guayuta is made up of similar shale with almost no limestones. Furthermore, it is not known for certain if the steeply inclined, nodular, grayish-black shales which lie beneath the Rio Guasare formation with seeming unconformity are the upper part of the Guayuta or if they should be placed in the Colon formation. There is an interval on Rio Cachirí directly below the Rio Guasare formation which is concealed by detrital and in this

16 Liddle, R. A.: *op. cit.*, p. 154 ff.

interval, that is apparently underlain by shale, the Colon formation may be present.

Physical character.—Dark-gray to grayish-black, calcareous shales similar to those in La Luna formation comprise the basal part of the Guayuta shale section. These grade upward into grayish-black, nodular shales that are brittle when dry and unctuous when wet. There is very litttle sand but not infrequent thin seams of clay-ironstone. Upward in the Guayuta the shales become lighter gray, fracture readily, and contain 10-foot ledges of compact, dark-gray, micaceous shale that is slightly calcareous.

Extent and thickness.—There are about 1,800 to 1,900 feet of Guayuta shale exposed on Rio Cachirí. Heavy forests which conceal much of the outcrop render accurate measurements impossible. Furthermore, the dip is so steep that a slight change in rate in concealed areas would materially affect the results obtained. The Guayuta shale occurs in a narrow zone throughout the length of the Sierra de Perijá, but it varies widely in thickness from place to place because of faulting and possible unconformity at its top.

Age and correlation.—Megascopic fossils are rare in the Guayuta shale, and in the northern part of the Sierra de Perijá no microscopic study of the formation has been made. However, the upper part of the fossiliferous La Luna formation below, into which the Guayuta shale grades, is definitely fixed as Lower Cenomanien; consequently, the Guayuta shale is believed to be Upper Cenomanien and in part Turonien.

Topographic expression and local details.—Relatively low valleys mark the outcrop of the Guayuta shale in the Sierra de Perijá. It weathers rapidly, but where a bluff remains its face is usually scarred by landslides. The greater resistance of the Cogollo and the basal part of La Luna formations to the west, and the Rio Guasare and Misoa-Trujillo formations to the east, make valleys occupied on Rio Cachirí by the Guayuta shale and the upper, more shaly part of La Luna formation fairly conspicuous.

Sample OI-J-146+20 is from La Luna formation.

THE CRETACEOUS-EOCENE RELATIONSHIP

The soft, poorly exposed shales of the Upper Cretaceous on Rio Cachirí do not afford reliable observations of dip for comparison with the fairly steep, eastward dipping Rio Guasare formation of basal Eocene age. However, a short distance to the west of the outcropping limestones of the Rio Guasare formation that dip eastward at 60° are Upper Cretaceous shales which are highly inclined eastward, or are vertical. Some of this disturbance may be due to a strike fault observed in this horizon farther south in the Sierra de Perijá and suspected to be present on Rio Cachirí where the Upper Cretaceous section is thin.

CENOZOIC

Cenozoic sediments in the Sierra de Perijá on Rio Cachirí include only the lower Eocene. Unconformably on the Upper Cretaceous lies the Rio Guasare formation, a glauconitic, calcitic, reef-limestone of Midwayan age. It grades upward into the Third Coal horizon which constitutes the lower member of the Misoa-Trujillo formation, and is lower Eocene in age. The eastern foothills of the Sierra de Perijá, on Rio Cachirí, are made up of hard, sandy, lignitic shales and thinly bedded sandstones of the Third Coal horizon. This horizon extends eastward into the Inciarte coal basin, and seems to have an erosional unconformity marking its upper level, and to be unconformably overlain by Oligocene sandstones and sandy shales. It would not be surprising if this horizon of the Oligocene rests unconformably on the Third Coal horizon along most of the eastern foothills of the Sierra de Perijá, having overlapped the truncated edges of the intervening beds not removed by middle and upper Eocene erosion.

Lower Eocene

Rio Guasare Formation

Name.—Garner[17] in 1926 applied the name Rio Guasare formation to basal Eocene limestones that are well exposed on Rio Guasare above the Guayuta shale, in which may be included part

[17] Garner, A. H.: *loc. cit.*

or all of the Colon formation, of Upper Cretaceous age and below the Third Coal horizon of lower Eocene age.

Stratigraphic position.—On Rio Guasare the well-developed Rio Guasare formation, dipping eastward at 60°, lies on highly inclined to vertical shales of the Upper Cretaceous. Heavy forests, and detrital from the surrounding mountains conceal the actual contact, but the nearest exposures of the two formations have wide variation in dip. There is complete conformity between the Rio Guasare formation and the overlying Third Coal horizon which is also lower Eocene in age.

Physical character.—The Rio Guasare formation on Rio Cachirí, where the best exposures in the Sierra de Perijá are to be found, is a typical, impure, glauconitic, reef-limestone containing beds which are masses of closely packed oyster remains. The limestone is so hard and the shells so calcitized that identifiable specimens are difficult to extract. On weathering the glauconite makes red splotches over the grayish-yellow surface of the limestone. The individual beds of the limestone are regular and vary from three to four feet in thickness.

Extent and thickness.—On Rio Cachirí the Rio Guasare formation is from 350 to 1,000 feet thick depending upon where the contact with the overlying Third Coal horizon is placed. There are 350 feet of solid limestone which introduces the Eocene, but thin limestone beds, identical in character with the basal beds, occur at various levels upward through 1,000 feet of sediments which some place in the Third Coal horizon. The Rio Guasare formation of basal Eocene age, though variable in thickness over Venezuela and Trinidad, as would be expected from its character and nature of deposition, has wide distribution. It occurs in many localities in the eastern edge of the Sierra de Perijá, is exposed again on Rio Cachirí farther downstream at the eastern edge of the Inciarte coal basin where it reaches the surface in association with Cretaceous sediments, forms small outcrops on Isla Toas, reaches the surface at several localities across Venezuela, forms much of Isla Soldado in the Gulf of Paria between Venezuela and Trinidad, and has been uncovered in Marac

Quarry on the Island of Trinidad. It also outcrops on Arroyo Cerrejon in the valley of Rio Rancheria, Department of Magdalena, Colombia where it is known as the Arroyo Cerrejon limestone.

The Rio Guasare formation is thicker on Rio Cachirí than it is at any other place yet known in Venezuela. However, the section in Marac Quarry on the Island of Trinidad may be as thick.

Age and correlation.—*Turritella mortoni* Conrad, *Turritella negritosensis* Wood, *Venericardia planicosta* Lamarck, *Ostrea bellovacina* Lamarck, *Ostrea sellæformis* Conrad, and *Calyptraphorous trinodiferus* Conrad from the Rio Guasare formation indicate its lower Eocene age. Its unique physical character and fossil content readily identify the formation either on the surface or in the subsurface.

Topographic expression and local details.—The hard limestone beds of the Rio Guasare formation make prominent ledges in Rio Cachirí just east of the topographically low area occupied by soft shales of Upper Cretaceous age, but the thickness of the formation is not sufficient to give it much effect on general topography.

Sample OI-J-142+30 is from the Rio Guasare formation.

Misoa-Trujillo Formation: Third Coal Horizon

Name.—Liddle[18] in 1928 wrote:

> The Misoa-Trujillo formation receives its name from the Serrania de Trujillo and a spur of this range, called Sierra Misoa, both of which have a general northerly trend through the eastern parts of the districts of Sucre and Bolivar, State of Zulia. Over practically all parts of Venezuela where this formation, or its equivalents, is exposed two more or less distinct members are recognizable, though in all places they are not mappable divisions. These members, from below to above, are the Third Coal horizon and the . . . . sandstone. The Third Coal horizon is so firmly established in the nomenclature of western Venezuela that it is impracticable to ignore it or apply a new name. It was first used in the District of Colon, where it is the oldest of three coal-bearing horizons, the other two being in the Oligocene and Miocene.

Hedberg and Sass[19] in 1937 applied the name Paso Diablo formation to at least a part of the Third Coal horizon where it outcrops in Caño El Paso del Diablo, a tributary of Rio Guasare about 25 kilometers north of Rio Cachirí.

[18] Liddle, R. A., *op. cit.*, p. 181.
[19] Hedberg, H. D. and Sass, L. C., *op. cit.*, pp. 95-96.

Stratigraphic position.—The Third Coal horizon of the Misoa-Trujillo formation lies with perfect, and gradational conformity on the Rio Guasare formation. The contact is beautifully exposed in the banks of Rio Cachirí where massive limestones totaling 350 feet grade upward into sandy, carbonaceous shales and sandstones that carry beds of coal. The contact of the Third Coal horizon with the overlying sandstones and shales of Oligocene age occurs several kilometers east of the foothills of the Sierra de Perijá in the center of the geosynclinal coal basin which lies between the mountains on the west and Cerro Los Guineos on the east. These overlying sandstones and shales are considered to be Oligocene in age, and they transgress the eroded edges of the Third Coal horizon,—the unconformity between representing a great erosional interval.

Physical character.—Massive, and thinly bedded, fairly hard, grayish-brown, micaceous, locally calcareous sandstones intercalated with gray, sandy, micaceous shales containing scattered lignite and beds of sub-bituminous to bituminous coal which vary from a few inches to 30 feet in thickness comprise the Third Coal horizon. Large exposures of the thinly bedded sandstones and shales in the channel of Rio Cachirí have beautiful, regular ripple marks. Layers and isolated concretions of clay-ironstone are common.

Extent and thickness.—The Third Coal horizon occupies a wide belt in and to the east of the Sierra de Perijá on Rio Cachirí. It forms the foothills of the mountains, and extends eastward in the shallow geosyncline which reaches to Cerro Los Guineos.

Northward from Rio Cachirí it also makes up the foothills and the western rim of, as well as underlies, the geosyncline just referred to. Southward from Rio Cachirí it forms much of the eastern edge of the Sierra de Perijá but in places part of the horizon is truncated and overlapped by massive sandstones and shales of Oligocene age which comprise some of the foothills belt.

An estimated thickness of at least 3,000 feet of the Third Coal horizon is exposed on Rio Cachirí. Faulting of unknown magnitude renders accurate measurements impossible. There is some suggestion that the Third Coal horizon may reach an excessive thickness in this area.

Age and correlation.—No fossils have been found in the Third Coal horizon, but its close relation to the Rio Guasare formation below, whose lower Eocene age is positive, indicates that it too is lower Eocene. This lower Eocene horizon has wide distribution over Venezuela, is consistently coal-bearing, and in places furnishes valuable mines of coal.

Topographic expression and local details.—Rugged foothills in the eastern edge of the Sierra de Perijá are formed by the Third Coal horizon. On Rio Cachirí, where the river cuts through the eastern edge of the mountains, thinly bedded sandstones and intercalated sandy, coal-bearing shales form a gorge at the head of Playa La India.

Rocks exposed on Rio Cachirí between the core of the Sierra de Perijá on the west and the foothills of the mountains on the east, if minor structural disturbances are disregarded, form the eastward dipping flank of a great anticline whose axis trends north-south. Excepting local irregularities, some of which have considerable magnitude, there is a decrease in dip eastward from the axis of the anticline which coincides with the core of the mountains. This core is part of an old, deeply rooted land mass of probable Archeozoic age which has been called the Sierra de Perijá mass.[20].

Various periods of movement and intervals of erosion have occurred while these mountains were reaching their present form. Uplifts of magnitude, followed by marked erosion, took place between Archeozoic and Devonian, Devonian and Permo-Carboniferous, Permo-Carboniferous and Cretaceous, Cretaceous and Eocene, during middle and upper Eocene, and in the Miocene when the major Andean uplift occurred. Faulting and igneous activity accompanied some of these disturbances.

[20] Liddle, R. A., *op. cit.*, pp. 364-365.

DESCRIPTION OF SAMPLES FROM RIO CACHIRI

Localities of samples indicated on the accompanying map by numbers inside circles. All specimens are on file in the laboratory of the Paleontological Research Institution.

Samples from the Caño del Norte branch of Rio Cachirí

Sample "A".—Quartz syenite or aplite and quartz diorite having pink and green splotches on a mottled grayish-rose groundmass of pink feldspar and dense, amorphous silica in which are embedded transparent, glassy quartz crystals. There are some specks of hornblende, and a trace of iron.

Sample "B".—Dark-gray, dense limestone extremely shattered and containing veins and angular pockets of calcite. Both the limestone and the calcite are slickensided in places. Permo-Carboniferous, intruded by diorite.

Sample "C".—Dark-gray, hard, fine-grained sandstone formed by small, angular, and round quartz grains cemented together with a slight amount of calcite, and having much dark greenish-black mineral resembling hornblende and some tiny fragments of ferruginous matter. The rock appears to have been derived from an igneous or metamorphic source although it lacks mica which is present in quantity in most of the igneous, sedimentary and metamorphic rocks of the region. Upper Devonian.

Sample "D".—Deep-red, shattery-fracturing, unctuous, compact shales having greenish-white splotches. The matrix is fine, red silt that contains tiny particles of ferruginous matter. The shale is non-calcareous and unfossiliferous. Permo-Carboniferous.

Sample "E".—Same as Sample "D".

Sample "F".—Dark grayish-black, crinoidal limestone composed chiefly of calcitized crinoid roots, and stems ranging from one millimeter to one and one-half centimeters in diameter. The original rock and the replacement minerals are definitely slickensided. One rock fragment contains the hinge area of a fairly large *Spirifer* which indicates its Paleozoic age, and a large, tubular Bryozoa. These fossils might indicate Devonian age, since they are associated in Devonian shales farther west on Rio Cachirí and deeper in the stratigraphic section, but the small percentage of limestone in the Devonian raises considerable doubt about such a correlation. Furthermore, in order to reach its present position the crinoidal limestone, were it of Devonian age, would have to have been carried by the associated igneous intrusion through much Upper Devonian section and entirely through the red-bed section at the top of which the crinoidal limestone lies. It seems more probable that the crinoidal limestone is practically in its normal position in the stratigraphic section at the top of the red beds, and below the Rio Negro formation of basal Cretaceous age, and that its absence on other branches of Rio Cachirí is due to the great unconformity which exists at its level between the red-bed section below and the basal Cretaceous above. It is doubtful if the intrusion with which the crinoidal limestone is associated could have carried it up from the fossiliferous Lower and Middle Devonian several thousand feet below. Lithologically the crinoidal limestone does not resemble any Devonian beds seen in the region. Sample "F", like Samples 15 and 16, is abnormally heavy because of impregnation by iron. However, Samples 15 and 16, especially 16, are more reddish than black, either from original coloring or from ferruginous stain, because of their proximity to the igneous intrusion (Sample "A"). Permo-Carboniferous.

Sample 1.—Dense, dark-gray, sandy limestone slightly altered and cut by calcite veins; dense, dark, fine-grained, slightly micaceous, calcareous sandstone which carries small flakes of biotite. It is shattered and cut by calcite veins, and its weight suggests impregnation with iron. The Devonian at this locality forms a narrow gorge with overhanging walls. Steep slopes of the mountain sides descend to the rim of the gorge so that in order to continue upstream a trail must be cut high up on the mountain side. This was done by the 1924 expedition which collected fossiliferous Lower and Middle Devonian two kilometers upstream from the gorge. No metamorphic or igneous float was found in the Caño del Norte branch of Rio Cachirí so it is doubtful if this branch reaches the core of the mountains. For this reason more time was spent on the other branches of the river, which, judging from their westerly course, had more chance to cut to the core of the mountains. Upper Devonian.

Sample 2.—Identical in character with Sample 1, and with Sample OI-J-72. Upper Devonian.

Sample 3.—Dense, greenish-black diorite,—the same as Sample 5 and Sample OI-J-69.

Sample 4.—Same as Sample 3.

Sample 5.—Dense, greenish-black diorite.

Sample 6.—Very deep red, highly micaceous, sandy shale which has a blocky fracture. Its weight suggests impregnation with iron. Permo-Carboniferous.

Sample 7.—Same as Sample 6.

Sample OI-J-63.—Reddish and greenish quartz syenite or aplite and quartz diorite which have intruded and altered the associated red shales. Angular fragments of greenish-black igneous rock are present in the reddish groundmass. There is much clear quartz, and veins of calcite traverse the rock where it is fractured. Sample

OI-J-63 resembles Sample "A" to some extent; however, in Sample "A" the rock is homogeneous and aphanitic whereas in Sample OI-J-63 quartz crystals and greenstone fragments are common. Some parts of Sample OI-J-63 resemble igneous breccia in that it contains fragments of basalt one centimeter in diameter. Sample 8 is from same outcrop.

Sample 9.—Highly micaceous, dark-gray, sandy shale and highly micaceous deep-red shale. The red shale is similar to Samples 10, "D", and "E" but has more mica. There are neither megascopic nor microscopic fossils. Permo-Carboniferous.

Sample 10.—Deep-red, hard, shattery-fracturing shale having greenish-white splotches and carrying tiny flakes of mica. Not fossiliferous. Identical in character with Samples "D" and "E". Permo-Carboniferous.

Sample 11.—Same as Sample 10.

Sample 12.—Identical with Samples "B" and 13.

Sample 13.—Identical with Samples "B" and 12.

Sample 14.—A large bluff in the west bank of Caño del Norte composed of pinkish-gray aplite resembling the limestone which it has intruded; dense, hard, gray, unfossiliferous limestone containing no calcite; and pink to reddish, crystalline limestone that is full of calcite crystals. Both types of limestone appear in the same ledge, are unfossiliferous, and have the appearance of being slightly altered. Permo-Carboniferous, and igneous.

Sample 15.—Dark-gray to reddish-gray and red, crinoidal limestone similar to Sample 16. It contains a large, remose form similar to *Rhombopora* or *Alveolites;* the hinge area of a fairly large *Spirifer;* and a few *Textularia*-like Foraminifera which occur in some pieces of the dense limestone and are visible in thin-sections. Permo-Carboniferous.

Sample 16.—Reddish-black to black and red, crinoidal limestone in which crinoid remains comprise 50 per cent of the rock. There are many crinoid roots, and the abundant stems vary from one millimeter to one and one-half centimeters in diameter. All of the remains are replaced by calcite. The rock is unusually heavy because of impregnation with iron. It weathers gray. This crinoidal limestone lies with seeming unconformity, although the actual contact is concealed, below the Rio Negro formation of basal Cretaceous age. On its northwest this limestone is in contact, in the river bank, with the quartz syenite and quartz diorite of Sample "A". In the southwestern bank of the river the crinoidal limestone grades into a large bluff (Sample 14) of massive, reddish-black and black crystalline limestone intruded by aplite. The limestone lacks crinoid remains, and weathers pitted and cavernous. Farther northwest the massive limestone bluff appears to be in normal contact with the red-bed section that separates it from the Devonian. Evidence at present, although not final, indicates that the crinoidal limestone and the unfossiliferous, crystalline limestone are parts of the same deposition, as is the red-bed section. All are believed to be Permo-Carboniferous,—probably Permian. To date no fossils of any sort have been found in these beds. The crystalline character of some of the limestone is doubtless due to its proximity to the aplite intrusion. This intrusion contains almost no iron and is apparently not the source of the iron in some of the nearby limestones. They may have been enriched by waters and vapo: ascending along the contact. This aplite mass is complementary to the basalt dikes to the west and northwest.

Sample 17.—Quartz syenite or aplite and quartz diorite composed of quartz, feldspar, and a small amount of iron. In weathering some of the outer edges of the mass resemble sandstone, the quartz crystals standing out above the flakes of feldspar which are irregular-shaped white flecks.

Samples from the Caño del Oeste branch of Rio Cachirí

Sample 18.—Identical with Samples "D" and "E" in lithologic character, but the shale at Sample 18 is twisted, shattered, and crumpled by folding and faulting. Permo-Carboniferous.

Sample 19.—Dark-gray, dense, fine-grained, quartzitic sandstone composed of small, rounded and angular grains of quartz. There is considerable dark-green mineral resembling hornblende. The rock appears to have been derived from igneous material, but it has no mica. It is identical with Sample "C". Upper Devonian.

Sample 20.—"A": Quartzite composed of well-rounded, clear, fairly large quartz grains held together by siliceous cement. There is a slight amount of ferruginous matter.

"B":Quartzite composed of rounded, very small quartz grains held together by siliceous cement. In places the quartz crystals appear to be fused. Upper Devonian.

Sample 21.—Highly micaceous, questionably lignitic, irregularly bedded, limonitic, grayish-brown shale which is fairly well compressed. It appears to have been laid down in shallow water, as it is interbedded with thin, quartzitic layers. Upper Devonian.

Sample 22.—Gray, slightly calcitic, micaceous, hard quartzite composed almost entirely of interlocking, clear quartz crystals. There are a few black specks, and an occasional green one which may be hornblende, in addition to much mica. The outcrop forms a massive bluff in which the thinner layers are evenly bedded. Upper Devonian.

Sample 23.—Dull-red shale containing some fine, clear quartz sand and much mica. Permo-Carboniferous.

Sample OI-J-97.—Deeply weathered, highly fossiliferous, ferruginous,
(Float) gray clay shale containing much mica and some fine sand. Fossils identified are:

Spirifer kingi Caster

Spirifer, sp. (fragments)

These fossils indicate Lower and Middle Devonian age.

Sample 24.—Brown, quartzitic sandstone containing many particles of hematite and white flecks which are probably weathered feldspar. The quartz grains are fairly rounded. This ferruginous, quartzitic sandstone resembles parts of the Imataca series. Upper Devonian.

Sample 25.—Grayish-brown, micaceous, limonitic shale which shows that it has been fairly well pressed. It is similar to Sample 21 in character but is much more evenly bedded. Upper Devonian.

Sample 26.—Grayish-brown, fine-grained, ferruginous, quartzitic sandstone. The quartz grains are fairly well rounded and quite small. Highly limonitic and resembles parts of the Imataca series. Upper Devonian.

Sample 27.—Gray, evenly bedded, highly micaceous, quartzitic sandstone. The crystals of quartz are very small and among them are scattered small, dark specks resembling hornblende. Some beds are massive; others are thin. Upper Devonian.

Sample 28.—Deep-red, greenish-gray, splotched, micaceous shale. Identical with Samples ''D'', ''E'', 10, and 18. It immediately and conformably underlies the quartzitic sandstone of Sample 27 whereas in normal sequence it should overlie the sandstone. Permo-Carboniferous.

Sample 29.—Reddish-brown, dense, very fine-grained, silty sandstone. The quartz grains which make up the bulk of the rock are very small. This sandstone, like the shale above it (Sample 28), is not in normal position in the section. Permo-Carboniferous.

Sample 30.—Fairly soft, light-brown, white-flecked, medium coarse, quartzitic sandstone in which the quartz grains although variable in size are well rounded. The white flecks are weathered feldspar. There is a little ferruginous matter. Upper Devonian?

In the lower part of Caño del Oeste some portions of the red-bed section of the Permo-Carboniferous and some beds of the Upper Devonian are interposed. This is noticeable between the localities of Samples 18 to 31. It may account for our inability to find the conglomerate which marks the base of the Permo-Carboniferous and its contact with the Devonian on Caño Grande. A great amount of faulting has occurred between the localities of Samples 18 and 31. Not only have Upper Devonian and Permo-Carboniferous rocks been interposed but the rocks themselves are indurated, and well-developed slickensides exist in the shales and even in the quartzitic sandstones. Older beds in the Devonian show little evidence of such intense disturbance, and no evidence of induration by compression.

Sample 31.—Gray shale containing very little mica, and stained brown with limonite. Similar to Samples 21 and 25 but having less mica. The beds are vertical and overturned. Upper Devonian.

Sample OI-J-113.—Brown, soft, highly micaceous, very sandy, clay shale (Float) containing:

Edmondia sylvana Hartt
Leptodomus ulrichi Clarke
Nucula?, sp.
Tellinopsis venezuelana, n. sp.
Productus liddlei, n. sp.
Schellwienella goldringæ Caster

The character of the material composing the several fragments of this sample is very uniform but the fossils indicate that both Devonian and Carboniferous are represented. The *Producti* suggest Carboniferous whereas the other fossils are Devonian. No sediments in place, in the Permo-Carboniferous section which lies between the Devonian and the Cretaceous on Rio Cachirí, bear any resemblance to this Carboniferous float. Its source, though, must be in the watershed of this river which is relatively small. Careful search of the upper reaches of other rivers in this part of the Sierra de Perijá may reveal a more complete Carboniferous section than is now known. *Fusulina* from the upper course of Rio Palmar indicate the presence there of Carboniferous rocks not yet found in Rio Cachirí. Both Devonian and Carboniferous are represented in this sample.

Sample 31.—Grayish-black limestone containing some small crinoids that (Float) are replaced by calcite. Fossils identified are:

Fenestella venezuelensis Weisbord
Spirifer, sp.

Lower and Middle Devonian.

Sample 32.—Grayish, ferruginous, highly micaceous, compact sandy shale containing small, dark specks like hornblende. Sample 32 is 50 feet upstream from Sample 31. Upper Devonian.

Sample 33.—Hard, dark-gray, micaceous shale which is well bedded and full of very small flakes of mica. It contains no fossils but has calcareous concretions. Upper Devonian.

Sample 34.—Gray, micaceous, sandy shale which is highly weathered and (Float) stained brown in places by limonite. Fossils identified are:

Polypora cachirita Weisbord
Rhipidomella liddlei, n. sp.
Strophonella? meridionalis (Caster)

Lower and Middle Devonian.

Sample 35.—Same in character as Sample 33 but showing well-developed slip-planes due to squeezing. The shale is standing vertical. Not fossiliferous. Upper Devonian.

Sample 36.—Dark-gray, fossiliferous shale. Fossils identified are: (Float)

Heliophyllum halli Milne Edwards and Haime
Heterophrentis venezuelense (Weisbord)

Lower and Middle Devonian.

Sample 37.—Dark-gray, fossiliferous, calcareous shale and shaly limestone containing a few calcite crystals. It forms a deep, narrow gorge with one overhanging wall. There are many corals and some crinoid stems. Fossils identified are:

Heliophyllum halli Milne Edwards and Haime
Heterophrentis venezuelense (Weisbord)
Lower and Middle Devonian.

Sample 38.—Grayish, highly weathered, limonite stained, fossiliferous, (Float) calcareous shale or shaly limestone. Many of the fossils are casts filled with powdery limonite. Fossils identified are:

Fenestella venezuelensis Weisbord
Atrypa reticularis var. *harrisi* Caster
Elytha? plana, n. sp.

Lower and Middle Devonian.

Sample 39.—Gray, sandy, unfossiliferous, concretionary shale with infiltration and metalic stain from oxide of manganese. In this sample the stain is like burnished copper, whereas in other samples it has an irridescent purplish-black color. There are microscopic particles of lignite. Lower and Middle Devonian.

Sample 40.—Grayish-brown, micaceous, sandy clay carrying many clay pellets that are stained by limonite. These sediments appear to be shallow water deposits similar to Samples 21, 25, and 31. They contain very little mica. Lower and Middle Devonian.

Sample 41.—Dense, black, unctuous clay shale which is extremely twisted and contains many slip-planes. There is little mica, and the shale has a decidedly nodular character. Much of the exposed section is vertical. Lower and Middle Devonian.

Sample 42.—Gray, calcareous shale and darker gray shaly limestone and shale. The dark shales have well-developed slip-planes and show compression. At the localities of Samples 42 and 43 the outcropping beds are highly fossiliferous but the shale, and especially the black limestone, are so hard that the fossils can be extracted only where the rocks are extremely weatherd. Fossils identified are:

Fenestella venezuelensis Weisbord
Polypora cachirita Weisbord
Platyceras gibraltar, n. sp.
Spirifer, sp.
?*Aviculopecten yeakeli* Weisbord
Many fragments of corals and crinoids

Lower and Middle Devonian.

Sample 43.—Deeply weathered, dark-gray and light-gray shale in which the body cavities of fossils are filled with powdered limonite. The shale is highly fossiliferous. Fossils identified are:

Fenestella venezuelensis Weisbord
Polypora cachirita Weisbord
Pecten, sp. (fragment)
Acrospirifer olssoni Caster

Lower and Middle Devonian.

Sample 44.—Grayish, pink- and brown-stained, schistose, igneous quartz from a large boulder which blocks the narrow gorge of the river at this locality. The boulder is 30 feet in diameter and evidently has not been moved far, except possibly to roll down a steep mountain side. It is not possible to pass this place except by cutting a trail and climbing around the mountain side. There was not time for this. The boulder is from the Sierra de Perijá series of probable Archeozoic age.

There are many large quartz boulders and a number of smaller granite blocks in the river at this locality. Much of the granite is schistose, light in color, and contains much mica. The schist boulders and fragments are smaller than those of granite and quartz. These igneous and metamorphic rocks comprise much more of the stream detrital than do the Devonian sediments which form the walls of the canyon at this locality. It is believed that the base of the sedimentary section is not far upstream. At the locality of Sample 44 the Caño del Oeste branch of Rio Cachirí has decreased to about one-fourth of its size at Campo Las Dos Bocas. The water in the narrow channel averaged four feet in width and six inches in depth, except in a few deep holes.

Samples from the Caño Grande branch of Rio Cachirí

Sample 50.—Black, petroliferous, highly fossiliferous limestone in which the fossils are completely replaced by calcite. The sample is typical of the ellipsoidal and discoidal limestone masses embedded in black carbonaceous shale. These masses appear to have been formed in pockets or depressions in the sea floor in which calcium carbonate, possibly from the tests of fossils, accumulated while around them silt and mud were being laid down. The bed from which the sample was collected is a part of a La Luna formation which lies conformably between Guayuta shale above and Cogollo limestone below. The age is Middle Cretaceous or Vraconnien. The locality of the sample is at the downstream entrance to a boulder-choked gorge of Cogollo limestone whose walls rise 400 feet vertically above the river bed. The Cogollo limestone is massively bedded, bluish gray in color, weathers pitted or cavernous, and on exposed surfaces are many calcitized rudistids, *Ostrea*, sp., and *Trigonia*, sp., which show in cross-section but which can not be extracted. There is little evidence of the Rio Negro formation of basal Cretaceous age on Caño Grande. Beneath (upstream from) the outcrop of the Cogollo limestone is a narrow, debris-filled valley, and the first reliable outcrop (Sample 51) is red, brittle, micaceous shale. A few massive boulders of brown, fine to coarse, conglomeratic sandstone occurring just below the outcrop of the Cogollo limestone indicate the presence of the Rio Negro formation.

In Caño Grande, shale of the Guayuta is exposed for the first kilometer above its junction with the other part of Rio Cachirí. The shale underlies a low valley, but exposures are frequent enough in the river bed and banks to show that the shale is grayish black, nodular, concretionary, has a shattery fracture, and is standing vertical. In its lower part the nodular, gray, concretionary clay shale changes gradually into thinly bedded, black, petroliferous limestone and intercalated black shale in which are embedded ellipsoidal and discoidal, black, petroliferous limestone bodies. There are, also, thin bands of black chert. Where shattered, the limestone is cut by veins of white calcite.

Sample 51.—Well-bedded, micaceous, dull-red, brittle, unfossiliferous, sandy shale which is slightly lignitic. Sample 51 was collected one kilometer upstream from the base of the Cogollo limestone outcrop. The shale contains no megascopic or microscopic fossils. Permo-Carboniferous.

Sample 52.—Conglomerate having a matrix of deep, dull-red, micaceous, sandy shale in which are embedded large, angular fragments of light- and dark-gray limestone. The original gray of the limestone has in places been stained red with iron derived from the shale portion of the conglomerate which contains much ferruginous matter. There is a continuous exposure of red shale from the locality of Sample 51 to that of Sample 52. Permo-Carboniferous.

Sample 53.—''A'': Micaceous, ferruginous, dull-red shale which is nodular in character and appears to have been deposited in shallow water. Like Sample 52 the shale contains fragments of gray limestone. Sample 53 ''A'' and Sample 52 are a conglomeratic horizon that marks the base of the red-bed section. Permo-Carboniferous.

''B'': Gray, micaceous, very arenaceous, limonite-stained shale containing much finely disseminated lignitic matter that apparently was derived from leaf fragments. Intercalated with the evenly bedded shales are bluish-black, ferruginous, fine-grained, quartzitic sandstone. The ''B'' portion of the sample is considered to be the top of the Devonian section and is here referred to the Campo Chico formation, and correlated with the Rio Macoita formation. Upper Devonian.

Sample 54.—Dark bluish-gray, fine-grained, ferruginous, quartzitic sandstone shattered in places and having the fractures filled with calcite. Closely resembles the quartzitic sandstones lying below the red beds on Caño del Oeste. Upper Devonian.

Sample 55.—Gray, micaceous, thinly bedded, hard, sandy shale with which is intercalated hard, quartzitic sandstone that is shattered and has its fractures filled with calcite. The outcrop is continuous from the locality of Sample 54 to the locality of Sample 55. Upper Devonian.

Sample 56.—Dark bluish-gray, fine-grained, ferruginous, quartzitic sandstone more thickly bedded than Sample 55. Continuous outcrop from locality of Sample 55 to locality of Sample 56. Upper Devonian.

Sample 57. Thickly bedded, gray, nodular shale weathering brownish-gray from ferruginous matter. The shale is highly concretionary and breaks with a shattery fracture. There is finely disseminated lignitic matter which appears to have been derived from leaf fragments, but none are recognizable in the lignitic flakes. Upper Devonian.

Sample 58.—Dark-gray, micaceous, nodular shale weathering brownish and interbedded with black, micaceous, slaty shale. The dark-gray shale contains finely disseminated lignitic matter that appears to have been derived from leaf remains. Where the shale is shattered there has been replacement by calcite. Upper Devonian.

Sample 59.—Dark-gray, very dense, slaty shale which breaks with a splintery fracture that has been developed by compression. It is not micaceous, calcareous, or fossiliferous but has a slightly baked appearance due to its proximity to the diorite intrusion (Sample 61). In the bluffs formed by this outcrop, which are 100 feet high and over one kilometer in extent, there are thin layers of clay-ironstone. Upper Devonian.

Sample 60.—Identical with Sample 59 and Sample 61. Upper Devonian, and basalt.

Sample 61.—Dense, fine, bluish-black basalt sill 30 feet thick whose alternating thick and thin layers are evenly bedded and carry black, irregularly shaped masses of quartz. This igneous intrusion has followed the bedding of the sediments which it intrudes, its main effect being the baking of the adjacent shales.

Sample 62.—Identical with Sample 59. Upper Devonian.

Sample 63.—Gray, calcareous, micaceous, fossiliferous shale having a shattery fracture and being hard enough to form vertical bluffs 60 feet high. In weathering the shale becomes soft, and the casts of fossils are filled with powdery limonite. In places the shale is slightly nodular and contains finely disseminated lignitic particles that seem to have been derived from leaf fragments. The entire deposit appears to have been laid down in shallow water. Fossils identified are:

Synaptophyllum vermetum (Weisbord)
Platystoma ventricosum (Conrad)
Platystoma ventricosum var. *permudum*, n. var.
Leptæna boyaca Caster
Spirifer olssoni Caster
Spirifer weisbordi, n. sp.

Heliophyllum halli Milne Edwards and Haime
Heterophrentis venezuelense (Weisbord)
Meristella wheeleri Caster
Crinoid stems

The coral, *Synaptophyllum vermetum* (Weisbord), measured two feet in diameter. This fauna indicates Lower Devonian,—about the horizon of the Helderberg and Oriskany of New York State.

Sample 64.—Identical in character with Sample 63. Fossils identified are:

Stropheodonta (Cymostrophia?) casteri, n. sp.
Crinoid stems

Lower and Middle Devonian.

Sample 65.—Almost identical in character with Samples 63 and 64, except that there are more mud pellets. Fossils identified are:

Heliophyllum halli Milne Edwards and Haime
Crinoid stems (abundant)
Fenestella venezuelensis Weisbord
Polypora cachiriia Weisbord
Athyris spiriferoides (Eaton)
Atrypa reticularis var. *harrisi* Caster
Camarotæchia, sp.
Chonetes venezuelensis Weisbord
Dalmanella cf. *nettoana* Rath
Dictrostrophia cooperi Caster
Elytha colombiana Caster
Eodevonaria subhemispherica Weisbord
Leptæna rhomboidalis (Wilckens)
Leptostrophia concinna (Morris and Sharpe)
Pentagonia unisulcata Hall
Productella, sp.
Rhipidomella liddlei, n. sp.
Schellwienella goldringæ Caster
Stropheodonta kozlowskii Caster
Tropidoleptus carinatus Conrad
Actinopteria subulrichi, n. sp.
Amphigenia elongata var. *weisbordi*, n. var.
Ctenodonta?, sp.
Shark's tooth

This fauna indicates Lower and Middle Devonian age,—ranging from the Helderbergian through the Oriskanian and into the Hamiltonian.

Sample 66.—Grayish, nodular, micaceous, calcareous shale having a shattery fracture and containing many fenestelloid Bryozoa and crinoid stems, the latter being replaced by calcite. This shale forms bluffs 100 feet high on the south bank of the river. The only fossil identified is:

Fenestella venezuelensis Weisbord

Lower and Middle Devonian.

Sample 67.—Identical in character and containing practically the same fauna as Sample 66. Forms a high bluff on the south side of the river. Lower and Middle Devonian.

Sample 68.—Identical in character and fossil content with Samples 66 and 67. Lower and Middle Devonian.

Sample 69.—Grayish, micaceous, sandy, non-calcareous, nodular shale containing minute lignitic matter probably derived from fragments of leaves. Fossils identified are:

Fenestella venezuelensis Weisbord
Polypora cachirita Weisbord
Chonetes stübeli Ulrich
Eodevonaria imperalis Caster
Eodevonaria subhemispherica Weisbord
Leptostrophia caribbeana Weisbord
Meristella wheeleri Caster
Meristella, sp.
?*Spirifer,* sp. (fragments)
Limoptera tenuis, n. sp.

Lower and Middle Devonian.

Sample 70.—Quite similar in physical character to Sample 69, but differs in having more powdery limonite, well-developed slickensided surfaces, and in being nonfossiliferous. Weathers into convex-concave particles. At the locality of Sample 70 there is a crushed zone along a fault exposed in the south bank of the river. Black limestone on the east side of the fault is in contact with grayish-black, nodular shale on the west side of the fault. The strike of the fault is due north-south, and the angle of its dip is 85° west. The dip on the east side of the fault is 38° N. 45° W. but no reliable observation can be made of the dip in the crumpled shale on the west side of the fault. The convex-concave weathering shale of Sample 70 on the west side of the fault is believed to lie, when in normal position, above the fossiliferous, gray shale of Sample 69 but the fault has dropped it west of its regular position. These beds are thought to be Lower and Middle Devonian in age.

Sample 71.—Grayish-black, nodular, sandy, fossiliferous shale which forms a vertical walled gorge from 10 to 20 feet wide and from 100 to 200 feet high. The fossils, principally crinoid stems and cup corals, lie in layers and protrude from weathered surfaces. There are at least 500 feet of the shale exposed in this gorge. Fossils identified are:

Heliophyllum halli Milne Edwards and Haime
Heterophrentis venezuelensis (Weisbord)
Crinoid stems

Lower and Middle Devonian.

Sample 72.—Grayish-black, micaceous, calcareous, sandy, thinly bedded, fossiliferous shale forming the upper end of the gorge described in Sample 71. The shale contains lenses and seams of reddish-clay-ironstone. Intercalated in the shale are black, irregularly bedded limestone layers. Fossils contained in the shale lie in layers exposed along the walls of the gorge. They are almost exclusively corals and crinoids. Fossils identified are:

Heterophrentis venezuelensis (Weisbord)
Heliophyllum halli Milne Edwards and Haime
Platyceras sinistrum, n. sp.
Crinoid stems averaging two centimeters in diameter (abundant).
Rhipidomella liddlei, n. sp.

Lower and Middle Devonian.

Sample 73.—Lithologic character same as Sample 72. Fossils identified are:

Heliophyllum halli Milne Edwards and Haime
Heterophrentis venezuelensis (Weisbord)
Zonophyllum, sp.
Platyceras sinistrum, n. sp.

Lower and Middle Devonian.

Sample 74.—Similar in lithologic character to Sample 72 but not fossiliferous. Sample 74 was taken at a six-foot falls at the head of a large pool of water. Lower and Middle Devonian.

Sample 75.—Gray, micaceous, nodular, irregularly bedded shale having films of limonite along fractures. The shale forms a narrow gorge, and is not fossiliferous. Lower and Middle Devonian.

Sample 76.—Dense, evenly bedded, very fine-grained, dark-gray, micaceous, quartzitic sandstone which is not fossiliferous. With this quartzitic sandstone are intercalated a minor amount of more shaly sandstones which, although just as hard as the more massive sandstones, carry imprints of small and medium-sized Spirifers and corals. The quartzitic sandstones of Sample 76 lie conformably under the dark-gray, nodular shales of Sample 75. Between the stations at which Samples 75 and 76 were collected the dark-gray, nodular shale becomes extremely nodular, soft, and shattery in fracture. Lower and Middle Devonian.

Sample 77.—The quartzitic sandstones of Sample 77 are similar to those described in Sample 76, but they are interbedded with coarse, fairly soft, extremely micaceous, dark-gray sandstones made up of moderately rounded, clear quartz grains, large flakes of biotite, and small grains of hornblende. The more shaly members carry imprints of fossils mentioned in Sample 76, but they are impossible to extract because of the hardness of the rock. Lower and Middle Devonian.

Sample 77½.—Hard, dark-gray, slaty shale which is only 50 feet east (downstream) from the quartzite, quartz, schist, and granite of Sample 78. There may be a fault between the slaty shale of Sample 77½ and the metamorphic and igneous rocks of Sample 78 which form the core of the Sierra de Perijá. Lower and Middle Devonian.

Sample 78.—Moderately soft, mica-hornblende schist containing considerable white siliceous material disseminated throughout the rock, and some small, clear quartz grains. Medium-hard granite composed principally of feldspar and quartz. Sierra de Perijá series. Archeozoic.

Sample 79.—Gray, massive micaceous quartzite which is cut by thick dikes of pure, vitreous quartz. Sierra de Perijá series. Archeozoic.

At and upstream from the localities where Samples 78 and 79 were collected there are only igneous and metamorphic rocks exposed in the stream *in situ* or as float. A cursory examination of contact zones where quartz dikes and veins cut the older metamorphic and igneous rocks revealed no evidence of mineralization. However, a far more thorough examination must be made before an unqualified statement can be made.

Rio Cachiri Section and Stations.— *Liddle, 1942*

Fig. 1.—Photo 9 of fossiliferous, gray, Middle and Lower Devonian shale at the top of the Caño Grande formation on the Caño Grande branch of Rio Cachirí. The bluffs are vertical and 60 feet high.

Fig. 2—Photo 10 of calcareous, gray, fossiliferous shale which forms vertical bluffs 75 feet high on the Caño Grande branch of Rio Cachirí. Stratigraphically this locality is 200 feet lower in the section than the locality of Photo 9.

Fig. 1.—Photo 3 of gray, slaty shale and gray nodular shale that weathers brownish gray. Some dark-gray quartzitic sandstones are interbedded with the shales. The locality is about at the top of the Caño del Oeste formation on the Caño Grande branch of Rio Cachirí.

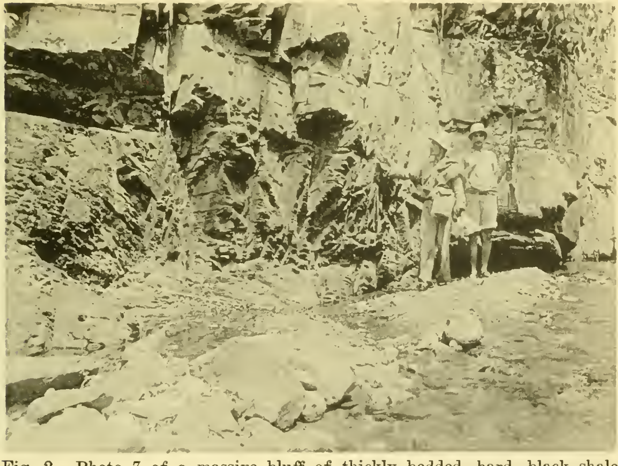


Fig. 2.—Photo 7 of a massive bluff of thickly bedded, hard, black shale containing a 30-foot layer of dense, black diorite. The locality is in the lower part of the Caño del Oeste formation on the Caño Grande branch of Rio Cachirí.

Fig. 1.—Photo 4 of nodular, grayish-black, clay shale having a shattery fracture. It is interbedded with black, slaty shale that contains thin layers of clay-ironstone. A large landslide occurs at this locality which is about the middle of the Caño del Oeste formation on the Caño Grande branch of Rio Cachirí.

Fig. 2.—Photo 6 of splintery, black shale of the Caño del Oeste formation on the Caño Grande branch of Rio Cachirí stratigraphically a little higher in the section than the diorite sill.

PART II. PALEONTOLOGY

A: BRACHIOPODA AND MOLLUSCA

By

G. D. Harris

At the request of Mr. R. A. Liddle, I have prepared the following brief statement relative to the collection of molluscs and molluscoids, mainly Devonian, he has recently made in western Venezuela.

Like the Cachirí River collection of Yeakel and Liddle, reported upon by Weisbord (1926), and the Floresta fauna of Olsson and Dickey, reported upon by Caster (1939), we have here a predominatingly brachiopod and bryozoan fauna with molluscs and trilobites playing subordinate rôles. We miss the usual South American developments of fair-sized modiomorphids, nuculids, Conularias, *et al.*, among the molluscs, as well as the most usual austral brachiopod types—Spirifers with few broad ribs, Leptocœlias, Orbiculoideas, and Rensellærias. *Stropheodonta* and *Chonetes* are fairly abundant and, with them, representatives of the far-ranging types—*Atrypa reticularis*, *Athyris spiriferoides*, *Tropidoleptus carinatus* and *Amphigenia elongata*.

In this particular collection we have found no traces of trilobites. This may be only accidental, however, since a few have been found in the Floresta and Cachirí collections mentioned above.

With the limited amount and imperfect state of preservation of the material at hand, it would be rash to attempt delimiting higher systematic units than species and subspecies at this time, though novel and interesting features may well be pointed out and illustrated. That these northwestern South American faunas are rich in old and new types there can be no doubt, and a great addition to the world's Devonian history will be made as soon as time and opportunity permit of making extensive collections, coupled with detailed stratigraphic observations over wide areas.

The general aspect of the collection inclines us to regard it as mainly representing approximately Onondaga time in North American geologic chronology.

The frequent occurrence of meristellids and platycerids may even suggest Oriskanian affinities at some localities. The absence of representatives of the far-flung cuboidal and pugnax-like rhynchonellids, *Stringocephalus, Buchiola* and *Grammysia* would seem to preclude definite relationships between this and upper boreal Devonian developments. The presence of rather large productids in "float" material raises the question of the possible presence of Carboniferous deposits about the Cachirí basin.

All specimens are deposited in the cabinets of the Paleontological Research Institution, Ithaca, N. Y.

NOTES ON BRACHIOPOD SPECIES

Genus **RHIPIDOMELLA** O'Ehlert, 1890
Jour. de Conch. 3d ser., vol. 38, p. 366

Genotype.—*Terebratula michelini* Léveillé, Fischer, (1887, p. 1288).

Illustration.—*Orthis* (*Rhipidomys*) *michelini* Fischer, Man'l de Conch., 1887, p. 1288, fig. 1057.

Rhipidomella liddlei, n .sp. Plate 4, figs. 1-3a

In the collection under consideration there are flat pedicle valves of *Rhipidomella* (outside and inside surfaces) and a large, very ventricose, brachial valve, all figured herewith. At first we had supposed these might be referred to *Orthis hartti* of Rathbun or perhaps to *Orthis subcarinata* (Hall) Knod. However, it appears from Rathbun's description that *hartti* is far more nearly equivalve than our species and has the ventral valve depressed longitudinally in the center. Knod's *subcarinata* shows a dorsal depression, as does ours, but the form is more pointed umbonally.

So far as cardinal process and crura are concerned, this Venezuelan species seems to be well represented by Hall and Clarkes' figure of *Rhipidomella penelope* (1892, pl. 6A, fig. 10). There is practically no cardinal area.

Locality.—Stations 64, 65, 72.

Genus **DALMANELLA** Hall and Clarke, 1892
Geol. Survey New York, Paleont. vol. 8, pt. 1, p. 205

Genotype.—*Orthis testudinaria* Dalman, K. svenska Vet.-Akad. Handl. 1828, p. 115, pl. 2, fig. 4.

Illustration.—Hall and Clarke, Geol. Survey New York, Paleont., vol. 8, 1892, pt. 1, pl. 5b, figs. 27-39.

Dalmanella, sp. Plate 4, fig. 5

A small specimen, seemingly quite close to the *Orthis nettoana* of Rathbun (1874, p. 247, pl. 10, figs. 7, 13), is represented in this collection from Sta. 65. Somewhat similar forms are represented by Knod (1908, pl. 26, figs. 9-11) as *Orthis subcarinata* Hall, a common form from the "Shaly limestone" of New York.

Genus **LEPTÆNA** Dalman, 1828

Genotype.—*Conchita rhomboidalis* Wilckens, Nachr. von selten Versteinerungen, 1769, p. 77, pl. 8, figs. 43, 44.—*Schuchert*

Illustration.—Geol. Survey New York, Paleont., vol. 8, pt. 1, 1892, pl. 8, figs. 17-31.

Leptæna rhomboidalis (Wilckens), sen. lat. Plate 4, fig. 4

That the material we have under consideration belongs to the species *rhomboidalis* in a broad sense, there can be no doubt. Specimens from the Floresta (Colombia) region are regarded by Caster as constituting a distinct form, *boyaca*. See his discussion of *boyaca* in volume 24 of these Bulletins, p. 119, 1939.

Locality.—Sta. 65.

Genus **LEPTOSTROPHIA** Hall and Clarke, 1892

Geol. Survey New York, Paleont., vol. 8, pt. 1, 1892, p. 288

Genotype.—*Stropheodonta magnifica* Hall, 10th Ann. Rept. New York State Cab. Nat. Hist., 1857, p. 54; so designated by Hall and Clarke, (1892, p. 288).

Illustration.—Hall, Geol. Survey New York, Paleont., vol. 3, 1859, pl. 93, fig. 4; pl. 94; fig. 2 a-d; Hall and Clarke, Geol. Survey New York, Paleont., vol. 8, pt. 1, 1892, pl. 13, figs. 27, 28.

Leptostrophia cf. concinna (Morris and Sharpe) Plate 4, fig. 6

Orthis concinna Morris and Sharpe, 1846, Quart. Jour. Geol. Soc. London, vol. 2, p. 275, pl. 10, figs. 2 a, b.

Leptostrophia concinna Clarke, 1918, Mon. Serv. Geol. e Min. Brasil, vol. 1, p. 285, pl. 23.

The specimen we have figured as figure 6, Plate 4 seems to be not far from Morris and Sharpe's *concinna*, in fact resembling the illustrations of that species more closely than it does the illustrations of New York Devonian members of this genus.

Locality.—Sta. 65.

Leptostrophia (Rhytistrophia) caribbeana Weisbord Plate 4, fig. 9

Leptostrophia caribbeana Weisbord, 1926, Bull. Amer. Paleont., vol. 11, p. 230, pl. 37, fig. 1.

Rhytistrophia caribbeana Caster, 1939, Bull. Amer. Paleont., vol. 24, p. 188.

In the material of this collection there is a large specimen undoubtedly of this species, but by no means so perfect as the specimens studied by Weisbord or Caster.

Locality.—Stations 65, 69.

Genus SCHELLWIENELLA Thomas, 1910

Mem. Geol. Survey Great Britain, Pal, 1, p. 92

Genotype.—*Spirifer crenistria* Phillips, 1836, originally so designated by Thomas, p. 92.

Schellwienella goldringæ Caster Plate 4, figs. 7-8a

Schuchertella aff. *sulivani* Weisbord, 1926, Bull. Amer. Paleont., vol. 11, p. 232, pl. 37, fig. 2.

Schellwienella goldringæ Caster, 1939, Bull. Amer. Paleont., vol. 24, p. 216, pl. 13, figs. 1-3.

For a detailed account of this species, see Caster (1939) as referred to above.

Its general appearance is very much like that figured by Rathbun (1874) for Hartt's *Streptorhynchus agassizi*. It will be noticed that the radii of figure 7 are much coarser and show more distinct alternation in size than do those of figure 8.

Locality.—Sta. OI-J-113, and Sta. 65.

Genus DICTYOSTROPHIA Caster, 1939

Bull. Amer. Paleont., vol. 24, p. 160

Genotype.—*Dictyostrophia cooperi* Caster, Bull. Amer. Paleont., 1939, vol. 24, p. 160, pl. 8, figs. 7-12; pl. 10, fig. 9; pl. 12, fig. 1.

The data used in describing this genus were practically all derived from the external and internal casts of one specimen from the Floresta collection. We now have what appear to be specimens of the ventral valve of this species and genus from the Cachirí district.

Dictyostrophia cooperi Caster Plate 4, figs. 10-12

For a very detailed description of the holotype (brachial valve), see Caster as above referred to.

The details of the sculpture of the ventral (pedicle) valve vary greatly in accordance with the layers exposed, as will be noted from figures 10-12.

Locality.—Sta. 65.

Genus STROPHEODONTA* Hall, 1852

Geol. Surv. N. Y., Paleontology, vol. 2, p. 63

Genotype.—*Leptaena (Strophomena) demissa* Conrad**. So designated by Hall (1852, p. 63).

*Hall says he proposed the name *Strophodonta* in 1850; see Hall in 10th Ann. Rept. St. Cab. Nat. Hist., 1857, p. 138.

**Conrad first described *demissa* under *Strophomena* and not *Leptaena* as given by Hall.

Illustration.—*Strophomena demissa* Con. Acad. Nat. Sci., Phila., Jr., first ser., vol. 8, 1842, pl. 14, fig. 14. Hall and Clarke, Geol. Surv. N. Y., Pal., vol. 8, pt. 1, 1892, pl. 14, figs. 7-12; Willard, Penn. Geol. Surv., Bull., G 19, 1939, pl. 17, fig. 1.

Stropheodonta (Cymostrophia?) casteri, n. sp. Plate 5, figs. 1, 2

Among our material there is an interior cast of a large stropheodontid. In some respects it would seem to belong to the assemblage Caster (1939, p. 148, pl. 7, figs. 14-17) has styled *Cymostrophia.* But it is larger than species so referred, more sharply geniculate and with muscular attachments very different from those of *C. schucherti* Caster (1939, pl. 8, fig. 6). The flabellate diductor impressions are widely separated anteriorly by anterior diductor scars within which are deep, elongated radial pits; posterior adductors are broadly expanded, and pits indicate a cardinal process of unusual dimensions. The cast shows fine papillæ radially distributed; the interior of the shell was accordingly punctate. A very limited area is so preserved as to show the exterior had radial lines of two sizes—heavy, with from two to five lighter ones between—and indicating the surface may have had the peculiar dimpled markings so characteristic of *Cymostrophia,* though this appearance may be due to lateral crushing.

The assignment of this form to a definite section of the stropheodontids must await more material, especially of the brachial valve.

Locality.—Sta. 14.

Genus **STROPHONELLA** Hall, 1879

28th Rept. N. Y. St. Mus. Nat. Hist., p. 154

Genotype.—*Strophomena semifasciata* Hall, 1863, p. 210, designated by Miller, N. A. Geol. and Pal., 1889, p. 383.

Illustration.—Hall and Clarke, Geol. Surv., N. Y., Pal. vol. 8, pt. 1, 1892, pl. 12, figs. 4, 5.

?Strophonella cf. meridionalis Caster Plate 5, figs. 3-5

?Strophonella meridionalis Caster, 1939, Bull. Amer. Paleont., vol. 24, p. 207, pl. 10, fig. 10.

We strongly suspect this large cast to be the brachial valve of Caster's *S. meridionalis.* Yet, with but one specimen to study, final conclusions cannot be made. The markings on the cast are well shown in figure 3, but the cardinal area seems most remarkable. This is unusually wide and seemingly without stropheodontid denticulation. The left half of the cardinal process is shown at c (fig. 4) and the left crura at p, but the right representatives of both are somewhat broken.

With only the material now in hand, we know of no genus to which this form can certainly be assigned. Further suggestions, however, will doubtless arise as new material is available for study.

Locality. Sta. 34. As the material from this station is designated as "float" its horizon is as yet undetermined.

Genus **TROPIDOLEPTUS** Hall, 1857

10th Ann. Rept. New York State Cab. Nat. Hist., p. 152

Genotype.—*Strophomena carinata* Conrad, 3d Ann. Rept. New York State Geol. Survey, 1839, p. 64; so designated by Hall (1857, p. 152, as given above).

Illustration.—Hall, Geol. Survey New York, Paleont., vol. 4, 1867, pl. 62.

Tropidoleptus carinatus (Conrad) Plate 5, fig. 6

We have an imperfect specimen of what appears to be a representative of *T. carinatus* (Conrad) as it has been interpreted in South American paleontology. The Morgan Expedition of 1871 obtained several specimens of this type from Ereré, and Rathbun described them in considerable detail, figuring three specimens (1874, p. 254, pl. 9, figs. 1, 9; pl. 10, fig. 26). Later (vol. 20, 1879, p. 34) he wrote: "The description of the Brazilian form, in the Bulletin of the Buffalo Society of Natural Sciences, referred to above, was made from a few specimens collected at Ereré in 1871. The collection made by the Geological Commission in 1876, however, contains many varieties resembling more closely the species as it is known in N. America. This last collection has also many very large specimens . . . " "Rare at the Ereré locality. (Morgan Ex. 1871; Geol. Comm., 1876.) Very abundant on the Rios Maecurú and Curuá. (Geol. Comm., 1876). This species was also found by Mr. A. Agassiz, associated with *Vitulina pustulosa*, in Devonian deposits on the island of Coati, Lake Titicaca, Bolivia."

Regarding Bolivian occurrences Ulrich remarks: "Die untersuchten Exemplare wurden von Stübel in einem Grauwacken-Sandsteine im Thale des Rio Sicasica zwischen La Paz und Oruro gefunden, wo sie, in gleicher Vergesellschaftung wie auf der Insel Coati, mit *Vitulina pustulosa* Hall zusammen vorkommen." (N. Jahr'b. Min., Geol. u. Paleont., B. B., vol. 8, 1893, p. 75.)

Katzer (Grundz. Geol. Unter. Amz. Geb., 1903, pl. 10, figs. 6, 7) shows forms from Ereré and the Maecurú resembling very closely the North American *carinatus* and the European *rhenanus;* to the latter he gives the varietal name *T. carinatus* var. *maecuruensis* (*op. cit.* p. 271).

Our specimen is by no means perfect enough to admit of referring to any special varietal form, but it does show that, like *Amphigenia elongata, Tropidoleptus carinatus, sensu lato,* it is represented in the Devonian fauna of Venezuela.

Genus **CHONETES** Fischer de Waldh., 1830-37

Oryct. du Gouv. de Moscou, pt. 2, p. 134

Genotype.—*Chonetes* sp.=*C. variolata* d'Orb., *fide*, De Koninck (1847, p. 209).

Illustration.—De Koninck (1847, pl. 19, fig. 5, pl. 20, figs. 2 a-l).

Chonetes (Eodevonaria*) subhemispherica Weisbord

Plate 5, figs. 7-9; Plate 6, figs. 1-4

Chonetes subhemispherica Weisbord, 1926, Bull. Amer. Paleont., vol. 11, p. 235, pl. 37, fig. 9.

Chonetes venezuelensis ? Weisbord, *Ibid.*, p. 234, pl. 37, fig. 8.

Chonetes subhemispherica ? Weisbord, *Ibid.*, p. 234, pl. 37, fig. 10.

Eodevonaria imperialis var. *parva* Caster, 1939, Bull. Amer. Paleont., vol. 24, p. 226, pl. 13, figs. 15, 16.

We have refigured Weisbord's holotype for convenience in reference here and, by referring to Hall's figures (1867, pl. 20, figs. 6a, b) of *C. hemispherica*, the appropriateness of the name *subhemispherica* is readily appreciated. To what extent less inflated and more circular forms like *C. venezuelensis* and varieties, as well as larger, more inflated, forms like *imperialis,* can be referred to one and the same species depends on the amount and character of material that will be found in the future. Rathbun says in describing his *C. freitasi* from Rios Maecurú and Curuá (1879, p. 20):

> In this species we have included a number of forms, which might have served for the formation of several species were not the material in our possession so abundant as to afford a complete series of variations, uniting the different forms closely together. The younger shells are proportionately the narrower, and in after growth they increase more rapidly in width than in length.

* *Eodevonaria*, Breger, Amer. Jr. Sci., vol. 22, 1906, p. 534. Genotype *C. arcuata* Hall.

Of the larger forms, this author states that the nearest New York representative "seems to be *C. acutiradiata* Hall." This, in turn, is not far from *C. hemispherica* Hall (1867, pl. 20, figs. 5, 6). All of which seems to suggest caution in giving new specific names, while at the same time the desirability of publishing as many figures as possible of the few and fragmentary specimens found thus far.

Locality.—Sta. 65 and 69.

Chonetes (Eodevonaria) venezuelensis Weisbord Plate 6, figs. 5, 6

Chonetes venezuelensis Weisbord, 1926, Bull. Amer. Paleont., vol. 11, p. 234, pl. 37, figs. 4, 5, 8?

One great difficulty in identifying the material in hand is that specimens are generally more or less coated over with a film not dissolvable in any ordinary acid solution. Such surfaces as are laid bare seem to indicate that there is a species less inflated than *subhemispherica* and with finer radii than characterize that species. These are called *venezuelensis* by Weisbord and are referred to several variations of *imperialis* Caster by Caster (1939).

Locality.— Sta. 65.

Chonetes stübeli Ulrich Plate 6, fig. 7

Chonetes stübeli Ulrich, 1892, Neues Jahrb. Min. Geol. u. Paleont., Beil.-Bd., vol. 8, p. 80, pl. 5, figs. 3, 4.

Chonetes zuliensis Weisbord, 1926, Bull. Amer. Paleont., vol. 11, p. 233, pl. 37, fig. 3.

Chonetes aff. *billingsi* Caster, 1939, Bull. Amer. Paleont., vol. 24, p. 232, pl. 13, figs. 7, 8.

Along with the larger, broader, chonetoid forms in the Liddle collection, there are smaller, higher, fewer-ribbed representatives that seem to be very close to Ulrich's *C. stübeli* and for the present may well be referred to that species, though the broad framing of some of Rathbun's lower Amazonian species may include varieties comparable to these Venezuelian types. With the material we now have in hand, positive specific assignments seem quite out of the question.

As regards the occurrence of this species, Ulrich (1882, p. 81) says:

> The species is found with *Vitulina pustulosa* Hall, *Tropidoleptus carinatus* Con. and *Tentaculites* sp. in shaly sandstone in the valley of Rio Sicasica between Oruro and La Paz (Stübel) possibly in the horizon of the Huamampampa sandstone.

Locality. Sta. 69.

"Eodevonaria imperialis Caster" Plate 6, figs. 8, 9

Eodevonaria imperialis Caster, 1939, Bull. Amer. Paleont., vol. 24, p. 222, pl. 13, fig. 13.

The very large cast we have in hand is probably conspecific with Caster's *imperialis* though it is about 50 per cent larger than his largest specimen (holotype). Hall and Clarke (1892, pl. 16, figs. 35, 36) illustrate a specimen from the Corniferous limestone near Williamsville, N. Y., which bears considerable resemblance to this species, in which the identification of the adductor and diductor muscular scars likewise seems uncertain.

Locality.—Sta. 69.

Genus **CAMAROTŒCHIA*** Hall and Clark, 1894

Geol. Survey New York Paleont., vol. 8, pt. 2, p. 189

Genotype.—*Atrypa congregata* Conrad, 5th Ann. Rept. New York Geol. Survey, 1841, p. 55, designated by Hall and Clarke, Geol. Surv. N. Y., Pal. vol. 8, 1894, p. 190.

Illustration.—Hall, Geol. Survey New York, Paleont., vol. 4, 1867, pl. 54, figs. 44-59.

Camarotœchia, sp. Plate 6, fig. 17

An imperfect specimen from Sta. 65 seems to belong to the rhynchonelloids of the Amazon region as described by Rathbun (1879, p. 33) rather than to the centronellids as described from Ponta Grossa by Clarke (1913, p. 211, pl. 22, figs. 1-7). We have nothing comparable to the large *"Rhynchonella" ererensis* of Rathbun, but in his discussion the forms he refers to as *Rhynchonella* (*Stenocisma*) *dotis* Hall (p. 33, *op. cit.*) seem to tally fairly closely with the fragment in our collection. However, comparing it with Hall's figures in volume 4 of the Paleontology of New York, our specimen seems to conform most closely with figures 21 and 22, Plate 54A named *Rhynchonella* (*Stenocisma*) *carica* from the Hamilton stage of the Devonian from Hamilton, N. Y. The fragmentary specimen figured by Caster (1939, pl. 13, fig. 21) from the Floresta fauna appears to be of the species in hand. Katzer's *Camarotœchia dotis* (1903, pl. 10, fig. 5) shows a specimen with 15 costæ while ours had at least twenty.

* In "An Introduction to the Study of the Brachiopoda," pt. 2, 1894, p. 826, (13th Ann. Rept. State Geologist), this genus is given as "*Camarotoechia* Hall, 1892," without references.

Genus **DICTYLOCLOSTUS** Muir-Wood, 1930
Annals and Mag. Nat. Hist. (10) vol. 5, p. 103

Genotype.—*Productus semireticulatus* (Martin) Petrif. Derbiensia, 1809, p. 7, pl. 32, figs. 1, 2; pl. 33, fig. 4.

Illustration.—See Martin, *supra;* Salter, Quart. Jour. Geol. Soc. London, 1861, vol. 17, pl. 4, fig. 1; Derby, Bull. Cornell Univ., Sci., No. 2, 1874, pl. 7, figs. 5-7, 15, 16; Hall and Clarke, Geol. Survey New York, Paleont., vol. 8, pt. 1, 1892, pl. 17A, figs. 16-18.

Dictyloclostus liddlei, n. sp. Plate 6, fig. 10

Although this specimen is imperfect in some details it appears to belong to a form of productid with distinct radial ornamentation, with comparatively few spines. The latter, however, show plainly on the ears exposed. The costæ tend to show a tripartite arrangement, most obvious where solution has taken place. A tendency toward this type of costation is shown in *P. costata* Sow. de Koninck (1847, pl. 8, fig. 3b; pl. 18, fig. 3) and by *P. scabriusculus* (Martin) Whidborne (1897, pl. 20, fig 1.6). *Productella arctirostrata* Hall (1867, pl. 26, figs. 22, 23) from the Chemung Devonian of southern New York bears some resemblance to this species, but *P. newberryi* Hall (1892, pl. 18, fig. 3) from the Waverly of Ohio makes a much closer approach.

Locality.—Sta. OI-J-113 "Float".

In general, the productids seem strangely rare in South American Devonian beds, though decidedly common in the Carboniferous. Rathbun described a single imperfect specimen of *P. maecuruensis* Rathbun (1878, p. 17), comparing it to Hall's figure of *P. navicella* from the Corniferous limestone of New York. One small specimen, *Productella* cf. *spinulicosta*, has been figured by Caster (1939, pl. 13, fig. 20) from the Floresta fauna of Colombia.

The holotype of this species has been crushed in by pressure, and solution has etched out in unnatural prominence the central disc portion; yet its size and most obvious characteristics seem to suggest affinities with forms considerably higher than the Devonian beds found in place on the Cachirí River.

Dictyloclostus ? sp. Plate 6, fig. 10a

Among the specimens recorded as "float," Sta. 38, we find a fair-sized productid with fine radiate markings cut by lamellose, transverse lines of growth, and with indications of scattered spines. The size and length of the latter are indicated in figure 10a, near the hinge margin. There can be no certainty in assigning this specimen to any particular group of productids, but it, as well as the preceding species, indicates that there are other, presumably higher, fossiliferous horizons in the Colombo-Venezuelan district not yet found in place.

Productella ? sp. Plate 6, fig. 11

A small, imperfect specimen of a productid is represented in this collection from Sta. 65. It is very probably of the same species as that figured by Caster as *Productella* cf. *spinulicosta* Hall (1939, p. 221, pl. 13, fig. 20).

Genus **AMPHIGENIA** Hall, 1867
Geol. Surv. New York, Paleont., vol. 4, p. 382

Genotype.—*Pentamerus elongatus* Vanuxem, 1842, Rept. 3d Dist. Geol. Survey New York, p. 132, so designated by Hall, (1867, p. 382).
Illustration.—Hall, *op. cit.*, 1867, pl. 59, figs. 1-11.

Amphigenia elongata var. **weisbordi**, n. var. Plate 6, figs 12-16

Amphigenia elongata Rathbun, 1878, Boston Soc. Nat. Hist., Proc., vol. 20, p. 34.

Amphigenia ? sp. indent., Weisbord, 1926, Bull. Amer. Paleont., vol. 11, pl. 38, fig. 1.

In Clarke's "Author's English Edition" of his Paleozoic Faunas of Pará, Brazil (1899, p. 89), he says:

> The abundance of typical specimens of *Amphigenia elongata* in both the Maecurú and Curuá sandstones is one of the most striking characters of these brachiopod faunas.

Rathbun notes that the Brazilian specimens are not radially striate (*op. cit.*, p. 35), but regards this as possibly due to coarseness of embedding rock. He, as well as Hall (*op. cit.*, p. 383), notes the extreme variability in form of this species. Regarding New York representatives, Hall says:

> This fossil is extremely variable in form; in the young state it is often as wide as long or wider, the hinge line extended, and the greatest width a little below the hinge, rapidly narrowing to the front. Other specimens of similar age are broadly ovate or oval, the dorsal valve depressed-convex, etc.

So far, in Venezuela, only the broad, *Athyris*-like forms have been found.

With only the imperfect specimen shown by Weisbord (*op. cit.*, pl. 38, fig. 1) its systematic position could only be guessed at, and certainly Weisbord made a good guess, for we have recently sectioned and polished the same in such a way as to make its characters evident. The illustrations herewith given show clearly the nature of the specimen. The surface of the shell is not sufficiently preserved to show distinctly whether radiating striæ are present or not. Weisbord (*loc. cit.*) believes he found traces of such striæ. On a very limited area there appear, when examined under the microscope, to be elongate radial pustules. The spondylium comes to a V-point at about one-half the depth of the shell where the point rests on a medial septum. Both are composed of exceedingly thin shell matter. The septum extends to the anterior edge of the shell, but shows little indication of a thickening posteriorly as indicated by Hall's figure 11, plate 59 (*op. cit.*).

Among the specimens discussed in this report, there is but one belonging to this genus, a brachial valve from Locality 65.

Though doubtless of the variety here discussed, it shows an enormous thickening of the rather flat dorsal valve, rather characteristic, we should suppose, of a fully mature form. Yet its outline is broad athyrid. The foramen, as indicated by Hall in his figure 7, plate 59 (*op. cit.*), is present, but the crural supports are broad and separated by a wide sinus.

Doubtless detailed study of the North and South American forms will bring out further distinctions, though whether of specific importance will depend on individual judgment. At any rate, here seems to be an important and most characteristic "Schoharie Grit" form, wide-spread and often abundant in northern South American Devonian beds.

Genus **ATRYPA**, Dalman, 1828

K. Vetens. Acad. Handl., Stockholm, 1827, vol. 93, p. 102

Genotype.—*Anomia reticularis* Linn. 1767, Syst. Nat., ed. xii, p. 1132.

Atrypa reticularis var. harrisi Caster — Plate 6, fig. 18

When we see these goodly-sized, expansive reticularid forms, we note at once a close relationship with the type long ago styled *A. desquamata* Sowerby (1840, pl. 56, figs. 19, 20). (See also Davidson, Paleont. Soc. London, 1864, pt. 6, British Dev. Brach., p. 58, pls. 10, 11). Hall (1867, expl. pl. 52, figs. 7-10) remarks regarding large forms from the Corniferous limestone of Albany and Schoharie counties:

The specimens present many features in common with the *A. desquamata* of Sowerby, but the shells are more gibbous and the beaks less elevated. The foramen and deltidial areas are not preserved in our species except in the young individuals. It is probable that they will eventually prove to be specifically distinct from the smaller forms referred to *A. reticularis.*

That the reticularid form before us is specifically identical with that illustrated by Weisbord from the headwaters of the Cachirí River, there can be no doubt. (See *Atrypa* cf. *reticularis* Weisb. Bull Amer. Paleont. vol. 11, 1926, p. 237, pl. 38, figs. 2, 3). In the same group, presumably belong the somewhat imperfect forms described by Caster from the Floresta district of Colombia (1939, vol. 24, p. 240, pls. 13, 16). All specimens thus far considered seem to be of the ventral valve only, which is not markedly gibbous; and one very imperfect impression before us of a brachial valve would suggest a similar conclusion regarding its form. At any rate we have here *desquamata*-like representatives of the reticularid stock rather indicative of an Onondaga horizon of the north Atlantic realm. The only objections to assigning them a new name, *harrisi*, as Caster has done, is that we still lack information regarding the deltidium of the pedicle valve, while the brachial valve is practically unknown. Again, new names at once obscure all relationships with well-known species.

For examples of the plasticity of this brachiopod type see the Fenton's article (1935, p. 369) "*Atrypae described by Clement L. Webster and related forms (Devonian, Iowa)*" and Stainbrook's (1938, p. 229) "*Atrypa and Stropheodonta from the Cedar Valley beds of Iowa.*"

Locality.—Sta. 65.

Genus **SPIRIFER** Sowerby, 1815

Mineral Conchology, vol. 2, 1815, p. 41

Genotype.—*Anomites striatus* Martin, Petr. Derb., 1809, pl. 23, figs. 1, 2; so designated by suspension of Rules of Zoöl. Nom. (See Procedure in Taxonomy, Schenk and McMasters 1936, p. 53).

Illustration.—*Spirifer striatus*. See Martin, above; Hall and Whitfield in King's Geol. Expl. 40th Par., vol. 4, 1877, pl. 5, figs. 13-15.

Spirifer weisbordi, n. sp. Plate 6, figs. 19, 20; Plate 7, fig. 1

In the collection under consideration, there are two large specimens of *Spirifer*, badly eroded but showing general shape and, locally, fine markings. One is figured herewith. Their most striking character is the depth and breadth of the mesial sinus. Ribs seem to be about 30 in number and are carried over the sinus area as well as laterally. One is at once reminded of *S. divaricatus* Hall from the Onondaga limestone of New York, though the sinus of the latter species is a little more acutely depressed centrally. The ribs are crossed by sharply marked concentric lines as in *antarctica* Morris and Sharp and *kingi* Caster, but the fine radiate markings sometimes shown in illustrations of these species are not preserved More specimens may show closer relationship with *kingi* than now seems evident. Others may indicate a relationship with the large cast referred to by Caster (1939, p. 262, pl. 18, fig. 9) as *Australospirifer* cf. *antarcticus*. Its size and bilobate appearance make this an outstanding species in this fauna.

Locality.—Sta. 65.

Spirifer kingi Caster Plate 7, figs. 2-4

Spirifer kingi Caster, 1939. Bull. Amer. Paleont. vol. 24, p. 251, pl. 18, figs. 1-4.

?*Conocardium?*, sp. indent. Weisbord, 1926, Bull. Amer. Paleont., vol. 11, p. 246, pl. 40, figs. 4, 5.

A few casts of the interior of the pedicle valves indicate the presence of Spirifers very closely allied to, if not identical specifically with, *kingi*. Rib subdivision seems less general and the "pustulate" appearance is less pronounced as the transverse striæ are less deeply incised than in the type specimen of *kingi*. Not enough specimens of *kingi* or of these similar forms have ever been collected to fully characterize them specifically. Hartt's *pedroanus* and *elizæ* (Rathbun, 1874, pl. 8, figs. 1-4) have similar outlines, but lack the mesial costation of *kingi*. A very small, young specimen is shown as figure 2 magnified about 6 times. An adult is shown as figure 3, while the fine radial striæ on the ribs are shown by figure 4.

It seems quite possible that the broken and laterally crushed specimen figured by Weisbord as *Conocardium*, *vide supra* may be the remains of an adult specimen of this species.

Locality.—Stas. OI-J-97, 65.

Spirifer olssoni Caster Plate 7, fig. 5

Acrospirifer olssoni Caster, 1939, Bull. Amer. Paleont., vol. 24, p. 256, pl. 18, figs. 10-13.

Among the *Spirifer* fragments in the collection in hand, some with few, strong costæ are certainly different from *kingi* or the *Elytha* groups illustrated by Caster. State of preservation does not admit of differentiating such forms positively from the allied *antarctica* or *murchisoni*, but they are probably referable to *olssoni* Caster. Allan (1935, pl. 2, figs. 4, 5) has referred to a somewhat similar form as "*Acrospirifer* cf. *hystericus* (Schlot.)"

from the "Lower Devonian" of New Zealand. The best specimen we have is crushed vertically as illustrated by figure 5, Plate 7, and if properly restored would be at least 50+ per cent wider from beak to base.

Locality.—Sta. 63.

Genus **ELYTHA** Fredericks, 1924

Bull. Com. Géol. Petrograd, vol. 38, p. 304,—*Nearc*

Genotype.—*Delthyris fimbriata* Con., Acad. Nat. Sci. Philadelphia, Jour., vol. 8, 1842, p. 263.

Illustration.—Hall., Geol. Survey New York, Paleont., vol. 4, 1867, p. 214, pl. 33.

Elytha? plana, n. sp. Plate 7, fig. 6a

A much crushed specimen of this reticularid form is in the material of the Liddle collection. Though wrinkled by pressure, there are no signs of true radial ribbing, save the medial fold or plication. Almost microscopically fine radiating lines are present over the shell surface, interrupted by concentric striæ or lamellæ. Such features recall those of *Spirifer pseudo-lineatus* Hall as shown by Hall and Clarke (1894, pl. 36, fig. 29) from the Keokuk limestone of Iowa. Having only an impression of the brachial valve of this species, it is quite impossible to assign it to any genus with certainty or satisfaction. Somewhat similar appearances have been recorded among the athyrids, as one styled *A. royssii* L'Eveillé by Walcott (1884, p. 280, pl. 18, figs. 9, 9a) in his paper on the Eureka District and referred to the Lower Carboniferous.

The fineness and lengths of the segments of radial striation seem to indicate that we have here quite a different type of ornamentation than that of the typical *fimbriatus* stock.

Locality.—Sta. 38, float material.

Elytha colombiana Caster Plate 7, fig. 7

Elytha colombiana Caster, 1939, Bull. Amer. Paleont., vol. 24, p. 246, pl. 19, figs. 1-8.

?*Delthyris fimbriatus* Conrad, 1842, Acad. Nat. Sci., Philadelphia, Jour. vol. 8, p. 263.

?*Spirifer meridioamericanus* Weisbord, 1926, Bull. Amer. Paleont., vol. 11, p. 238, pl. 38, figs. 4, 5.

Finer markings on the fragmentary specimens we have in hand correspond well with the better material figured by Caster, but the general shape of the shell is not shown. Further collecting will probably show the close relationship of all these forms and the Onondaga expression of Conrad's *fimbriatus*.

Locality.—Sta. 65.

Genus MERISTELLA Hall, 1860

13th Ann. Rept. N. York State Cab. Nat. Hist., 1860, pp. 74, 93

Genotype.—*Athyris laevis* Vanuxem, 1842; so designated by Hall and Clarke, see N. Y. Geol. Surv., Pal. p. 76, vol. 8, 1894.

Illustration.—Hall, Geol. Survey, New York, Paleont., vol. 3, 1861, pl. 39.

Meristella wheeleri Caster — Plate 7, fig. 8

Meristella wheeleri Caster, 1939. Bull. Amer. Paleont., vol. 24, p. 269, pl. 18, figs. 14, 15.

The specimen figured by Caster, as well as that herewith shown, indicates an unusually broad, deep medial sinus for members of this genus. The preservation of the former is somewhat better than in the latter, but that they may belong to one and the same species there can be little doubt.

Localiy.—Sta. 69.

Meristella, sp. — Plate 7, figs. 9, 9a

We herewith illustrate a specimen of what appears to be a *Meristella* with no indication of a medial fold or sinus, hence very different from *wheeleri* referred to above. In general appearance, this is intermediate between *nasuta* Conrad from the Onondaga of New York and *riskowskii* Ulrich from the "Iclaschiefer" of the Devonian of Peru. With only this one specimen in hand, it cannot be referred with assurance to *Meristella*, though it probably has affinities with the meristids.

Though *Meristella* ranges from the Coeymans to the Tully limestone in New York, it is most at home in beds not above the Onondaga limestone.

Locality.—Sta. 69.

Genus ATHYRIS M'Coy, 1844

Synop. Carb. Foss. Ireland, p. 146 (by Griffith)

Genotype.—*Terebratula concentrica* von Buch, *fide* Fisch. Man. Conch., 1887, p. 299.

Illustration.—Davidson, British Dev. Brach., 1864, pl. 3, figs. 11-18, pl. 4, figs. 1-3; Kayser's Lehrb. Geol., Bd. 3, 1923, p. 249, fig. 6.

Athyris spiriferoides (Eaton) — Plate 7, fig. 10

Terebratula spiriferoides Eaton, 1831, Amer. Jour. Sci., vol. 21, p. 137.
Athyris spiriferoides Hall, 1867, Geol. Survey New York, Paleont., vol. 4, p. 285, pl. 46.
Athyris aff. *spiriferoides* Weisbord, 1926, Bull. Amer. Paleont., vol. 11, p. 243, pl. 40, fig. 1 of the interior.

Though *A. concentrica*, a distantly related form, is characteristic of the Upper Devonian of Europe (Davidson, 1864, p. 16; Hall, 1867, p. 288), *A. spiriferoides* is an Onondaga-Hamilton, mid-Devonian species. Its occurrence in South America, first noted by Weisbord, is quite in harmony with the wide range of other virile stocks such as *Atrypa reticularis*, *Amphigenia elongata*, *Reticularia fimbriata*, *Tropidoleptus carinatus*, etc. To what extent these South American representatives should receive special names must await the results of more extensive investigations.

Locality.—Sta. 65.

Genus **PENTAGONIA** Cozzens, 1846

Ann. Lyceum Nat. Hist. New York, vol. 4, p. 158, pl. 10, fig. 3

Genotype. *Atrypa unisulcata* (*peersii* Coz.) Conrad, 5th Ann. Rep. Geol. Surv. N. Y., 1841, p. 56, so referred by monotypy.

Illustration.—*Meristella* (*Pentagonia*) *unisulcata* Hall, Geol. Surv., N. Y., vol. 4, 1867, p. 309, pl. 50, figs. 18-35.

Pentagonia? gemmisulcata Caster Plate 7, figs. 11, 11a

Pentagonia gemmisulcata Caster, 1939, Bull. Amer. Paleont., vol. 24, p. 272, pl. 16, figs. 16, 17.

For convenience in reference we have refigured Caster's type specimen but feel that more and better material is needed before finally assigning it to *Pentagonia* or any other brachiopod genus. May it not possibly belong to some unique aviculoid form. It is really a unisulcate form as the illustrations show while the gemmisulcate character applies only to the imprint (reversed) specimen.

As figure 13 we show another biplicate fragment from Sta. 65, vaguely suggesting a *Myophoria*-like form. Clarke (1909, p. 75, pl. 16, figs. 14, 15) has called attention to specimens from the Moosehead Lake region of Maine (Oriskanian, Coblentzian) closely resembling *Prosocoelus pes-anseris* Beiler and Wirtgen, a bicarinate European dimyarian. These fragments of unisulcate or bicarinate specimens, though scarcely now identifiable specifically or even generically are so characteristically marked that they will doubtless eventually serve a good purpose in paleontologic stratigraphy.

PELECYPOD SPECIES

Genus **LIMOPTERA** Hall, 1869

Prelim. Notice Lamellibranch Shells, etc., pt. 2, p. 15

Genotype.—*Lima macroptera* Con. Rept. New York State Geol. Survey, 1838, p. 117; original designation by Hall, 1869, p. 16.

Illustration. Hall, Geol. Survey New York, Paleont., vol. 5, pt. 1, 1884, pls. 24, 26-29.

Limoptera tennis, n. sp Plate 8, fig. 1

The general erectness of the specimen herewith figured at once suggests its relationship with the limopterids, though the thinness of shell and the divaricate radii seem features scarcely in harmony with those usual to this genus. The large wing shows clear-cut concentric striæ, while the body of the shell shows radii varying in size and extent of bifurcation. The confusion in sculpture above on the wing of the specimen figured seems due to the impression of the ornamentation of the right valve through the left valve.

We have seen no illustration of anything comparable to this form from South America or elsewhere. Vague resemblances may perhaps be found in comparing Hall's *L. pauperata* (1884, pl. 26, fig. 5) from the Onondaga of New York or Clarke's *L. rosieri* (1908, pl. 20, figs. 1, 2) from the St. Alban beds of New Brunswick, but the height and remarkable tenuity of test seem unique characters. A very indistinct impression, nearly smooth, is found in material from Sta. 65, quite probably the internal impression of this species; also an imperfect imprint of the exterior of a left valve.

Locality.—Sta. 65.

Genus ACTINOPTERIA Hall, 1883

Geol. Survey New York, Paleont., vol. 5, pt. 1, 1884, p. 107
(Issued as Plates and Explanations only, Jan. 1883)

Genotype.—*Actinopteria decussata* Hall, designated by Bassler, U. S. Nat. Mus. Bull. No. 92, 1915, p. 17.

Illustration.—Hall, Geol. Survey New York, Paleont., vol. 5, pt. 1, 1884, pl. 18, figs. 1-15.

Actinopteria subulrichi, n. sp. Plate 8, fig. 2

Among the specimens from Sta. 65, there is one referable to the genus *Actinopteria*, as usually understood, having the general form of *decussata* Hall and *ulrichi* Knod (1908, pl. 26, figs. 2, 3), but without the sharply defined concentric lines of the former and with very much finer radii than the latter. The radii vary somewhat in size and occasionally show a tendency to alternation. The concentric striation is very faint.

This is not far from Whidborne's *hirundella* from the Devonian of southern England as figured in the Palaeontographical Society of London for 1892 (Whidborne's monograph, vol. 2, pt. 2, pl. 6, figs. 5, 6). Comparison with Hall's *A. subdecussata* (1st. Ann. Rept., State Geologist, for 1882, dated 1884) pl. 3, fig. 9 may likewise be made to advantage.

Genus **AVICULOPECTEN** M'Coy, 1851

Ann. Mag. Nat. Hist., 2d ser. vol. 7, p. 171

Genotype.—*A. planoradiatus* M'Coy, so designated by Hind. Mon. British Carb. Lamell., vol. 2, 1903, p. 66.

Illustration.—St. Geol. Surv. Kan., vol. 10, 1937, pl. 5, figs. 12-15.

Aviculopecten yeakeli Weisbord Plate 8, fig. 3

Aviculopecten yeakeli Weisbord, 1926, Bull. Amer. Pal., vol. 11, pl. 5, fig. 3, p. 244, pl. 40, fig. 3.

Fragments of specimens undoubtedly referable to *Aviculopecten, sensu lato* are found in the present collection and in the Floresta material described by Caster, but so far, the most perfect specimen is the holotype of *yeakeli* here refigured for convenience in reference. Since this specimen is the imprint of the interior of one valve the surface markings cannot now be well defined. However, the early bifurcating of the ribs and the very fine ribbing on the ear seem to be noteworthy specific characteristics. For further details, see Weisbord, as referred to above.

Genus **TELLINOMYA** Hall, 1847

Geol. Survey New York, Paleont., vol. 1, 1847, p. 151

Genotype.—*Tellinomya nasuta* Hall, *vide supra.* The only species listed by Hall under the primal generic diagnosis.

Illustration.—Hall, Geol. Survey New York, Paleont., vol. 1, 1847, pl. 34, figs. 3 a-e.

Tellinomya ? sp. Plate 8, fig. 4

Owing to the apparent abundance of taxodonts indicated by Clarke's work on Brazil (1913, pl. 10), Méndez Alzola's on Uruguay (1939, pl. 10) and Ulrich's on Bolivia (1892, pl. 2), the Venezuelan fauna seems very poorly represented by this type of Mollusca. The fragment herewith figured appears to be the anterior end of a fairly large taxodont, showing very fine, but sharp, concentric striæ and unusually large taxodent teeth. Its true generic affinities can only be determined when better material is obtained. For similarly large dentition, see Whidborne (1896, pl. 7, fig. 10) *Ctenodonta* (*Koenenia*) cf. *obsoleta* Goldf.

Locality.—Sta. 65.

Genus **TELLINOPSIS** Hall, 1869

Prelim. Note Lamm. Shells; St. Cab. Nat. Hist., 1869, p. 80

Genotype.—*Nuculites subemarginata* Con. (Acad. Nat. Sci. Phila. Jr., 1st ser., vol. 8, 1842, p. 249, pl. 15, fig. 5) so designated by Hall, 1869, p. 80).

Illustration.—See Conrad, *supra*, 1842, pl. 15, fig. 5; Hall, New York Geol. Surv., vol. 5, Lamell. II, 1885, p. 464, pl. 76, figs. 21-31.

Tellinopsis? venezuelanus, n. sp. Plate 8, fig. 5

Hall figures, on Pl. 70 referred to above, several more or less elongated dimyarians with one or two ridges radiating out from the umbo, especially posteriorly, and with posterior portion of shell shorter than anterior. There is a somewhat *Tellina*-like appearance shown in some of these forms. Our shell is much shorter proportionally with less well-defined umbonal ridge and with a general *Macoma*-like appearance. On the shorter moiety of the shell (which we are assuming to be the posterior) the post-umbonal slope is rather narrow and shows signs of having a faint radiating ridge near the shell margin. The surface of the shell seems nearly smooth, though there are faint traces of concentric lines. As a temporary expedient this shell is being referred to *Tellinopsis?* though with more and better material a different generic assignment will doubtless be made.

Locality. Sta. OJ-J-113. "Float."

Genus **EDMONDIA** deKoninck, 1842

Desc. des Anim. fass. Carbon. Belg., 1842, p. 66.

Genotype.—*Isocardia unioniformis* Phillips (Geol. Yorkshire etc. 1836, vol. 2, p. 209, pl. 5. fig. 18); genotype, original designation by De Koninck, p. 67.

Illustration.—De Koninck (1842, pl. 1, fig. 4, a, b, c.), King, Perm. Foss. Eng., pl. 20, figs. 1-4; De Verneuil (1845, pl. 19, fig. 18).

Edmondia sylvana Hartt and Rathbun Plate 8, fig. 6

Edmondia sylvana Hartt and Rathbun, 1875, Ann. Lyceum Nat. Hist., New York City, vol. 11, p. 122.

Edmondia sylvana Clarke, 1900, Paleozoic faunas of Pará, Brazil, Author's English edition, p. 69, pl. 7, fig. 12.

Edmondia sylvana Katzer, 1903, Grundzüge der Geologie des unteren Amazonasgebietes, p. 206, pl. 14, fig. 12.

Since Hartt and Rathbun did not figure their Brazilian material, there is some doubt as to the true character of this species, but it seems probable that the small specimens we figure herewith from Venezuela may belong to the same species figured by Clarke and Katzer. However, the Amazonian specimens are from two to four times as large as the specimens we have in hand; they are comparatively narrower and less produced anteriorly.

Locality.—Sta. 65.

Genus NUCULA Lamarck, 1799
Mem. Soc. N. H., Paris, p. 87

Genotype.—*Arca nucleus* Lin. Syst. Nat. 10th ed., p. 695, *Nucula* Lam. by monotypy.

Illustration.—Grant and Gale, Mem. San Diego Soc. Nat. Hist., vol. 1, 1931, pl. 1, figs. 4, 5.

Nucula ?, sp. Plate 8, fig. 7

Clarke (1900, 1, pl. 8, figs. 9, 10) has illustrated a small *Nucula* as "*N. bellistriata* Con., var. *pervula*, var. nov. from "Rio Maecurú" that bears considerable resemblance to our specimen although it is much larger. So far, we have not discovered any trace of taxodont dendition in our specimen and hence it may not be a *Nucula*. It may be related to *Cardium gregarium* Beauschausen as illustrated by Clarke (1909, pl. 5, figs. 5-12) from the Dalhousie beds of New Brunswick.

Locality.—Sta. OI-J-113.

Leptodomus M'Coy, 1844

Leptodomus? ulrichi Clarke Plate 8, fig. 8

Leptodomus ulrichi Clarke, 1913, Foss. Dev. do Paraná, p. 196, pl. 16, figs. 19, 20.

The only specimen in hand seems to be very close to that shown by Clarke as fig. 20. Referring to the occurrence of his specimens he states:

Associated with *Leptocoelia* and other characteristic brachiopods in the shales of Ponta Grossa; also, in the yellow shale of Jaguariahyva; Sant' Anna da Chapada and Lagoinha, Matto Grosso.

Our specimen is likewise a yellowish, sandy shale, found lose at OI-J-113

With more perfect material in hand it will seem desirable to assign this species to a new or more appropriate genus as the name *Leptodomus* McCoy is preoccupied by Schoenhauer's name *Leptodomus*, 1843, according to Neave's Nomenclator Zoologicus, vol. 2, p. 911.

GASTROPOD SPECIES

Genus **PLATYOSTOMA** Conrad, 1842

Philadelphia Acad. Nat. Sci., Jour., 1st ser., vol. 8, p. 275

Genotype.—*Platyostoma ventricosum* Conrad, designated by Hall, 12th Ann. Rept. Regents Univ. State of New York, 1859, p. 20.

Illustration.—Conrad, Philadelphia Acad. Nat. Sci., Jour., 1861, pl. 17, fig. 5; Hall, Geol. Survey New York, Paleont., vol. 3, 1861, pl. 112, figs. 1-10; Knight, Geol. Soc. Amer. Spec. Paper, No. 32, 1941, pl. 85, fig. 3a-d.

Platyostoma ventricosum Conrad — Plate 8, figs. 9, 10

Platyostoma ventricosum Conrad, 1842, Philadelphia Acad. Nat. Sci., Jour., vol. 8, p. 275, pl. 17, fig. 5.

Platyostoma ventricosum Hall, 1861, Geol. Survey New York, Paleont., vol. 3, p. 469, pl. 112, figs. 1-10.

Diaphorostoma ventricosum Clarke, 1908, New York State Mus. Mem., pt. 1, p. 149, pl. 15, figs. 17-23.

The shell we are referring, temporarily at least, to the Conradian species *ventricosum* seems to agree generally with this form, though perhaps showing a little more definite flattening immediately below the suture and lacking all trace of undulatory ribbing. *P. ventricosum* is decidedly an Oriskany sandstone species.

Locality.—Sta. 63, No. 6029.

Platyostoma ventricosum, var. permundum, n. var.
Plate 8, figs. 11, 12; Plate 9, fig. 1

The specimen here so named is likewise from Station 63, and its general characters are well shown by the three different views. Its low spire and great mouth distinguish it at once from typical *ventricosum*.

Platyostoma neveritanum (Weisbord) — Plate 9, fig. 2

Diaphorostoma neveritanum Weisbord, 1926, Bull. Amer. Paleont., vol. 11, p. 247, pl. 41.

By consulting Weisbord's illustrations, it will be seen how very naticoid the spire of the species appears. Our specimen is somewhat more depressed, but seems closely related to Weisbord's. The fine markings appear to be the same.

Locality.—Sta. 42.

Genus **PLATYCERAS** Conrad, 1840

3d Ann. Rept. New York State Geol. Survey, p. 205

Genotype.—*Pileopsis vetusta* Sowerby, designated by Tate (1870, p. 34).

Illustration.—Knight (1941, pl. 88, figs. 1a-d).

Platyceras sinistrum, n. sp. Plate 9, figs. 3, 3a

Owing to the fact that the characters of the platycerids are greatly modified by the objects they adhere to, specific differentiation, as among the oysters, becomes a very difficult and uncertain matter. The forms we have before us are without spines, nodules or concentric undulations, and, upon the whole, seem rather Helderbergian than Hamiltonian in affinities. The form here styled *sinistrum* is practically without surface ornamentation; the slight ridges seen in figure 2 are due to a flattening by erosion. But there is a ridge shown by figure 3a marking off what seems to be a wide umbilical area. The upward turning, anastomate character of the aperture is an unusual feature.

Locality.—Sta. 72.

Platyceras? gibraltar, n. sp. Plate 9, figs. 4-6

Since the apex of this rather large specimen is broken away and the body of the shell lacks the more general irregularities of *Platyceras*, considerable doubt is felt as to its systematic status. The shell matter is much thicker posteriorly than anteriorly and seems to have been perforated by numerous tubes as shown in figure 6. The cast of the medial interior portion, as shown by figure 5, is covered by fine, curved, radiating markings—perhaps due to the work of parasites or marine organisms after the death of the animal. The cast of the interior suggests that there were larger, more or less *Hipponyx*-like, radii on the exterior of the shell. More perfect material must be obtained before this specimen can be properly classified.

Locality.—Sta. 42.

BIBLIOGRAPHY

Allan, R. S.

1935. *The fauna of the Reefton beds (Devonian), New Zealand.* New Zealand, Dept. Sci. and Indust. Res., Geol. Survey Branch, Paleont. Bull., No. 14, pp. 1-72, pl. 1-5, map.

Barrande, Joachim

1879. *Système silurien du centre de la Bohême*, pt. 1, Recherches paléontologique, vol. 5, Classes des Mollusques, Ordre des Brachiopodes, pls. 72-133.

Bassler, Ray
1915. *Bibliographical index of American Ordovician and Silurian fossils.* U. S. Nat. Mus. Bull., No. 92, pp. 1-1521, 4 pls. (in 2 vols.).
Butts, Charles
1941. *Geology of the Appalachian valley in Virginia, pt. 2, Fossil plates and explanations.* Virginia Geol. Survey, Bull., No. 52, pls. 64-135.
Caster, K. E.
1939. *A Devonian fauna from Colombia.* Bull. Amer. Paleont., vol. 24, pp. 101-318, pls. 7-20.
Chao, Y. T.
1927. *Productidae of China, pt. 1, Producti.* Geol. Surv. China, Palaeontologia Sinica, Ser. B, vol. 5, Fascicle 2, pp. 191, pls. 16.
1928. *Productidae of China, pt. 2, Chonetinae, Productinae, Richthofinae.* Geol. Surv. China, Palaeontologia Sinica, Ser. B. vol. 5, fasc. 3., pp. 88, pl. 6.
Clarke, J. M.
1900 (1). *The Paleozoic faunas of Pará, Brazil, pt. 1, The Silurian fauna of the Rio Trombetas, pt. 2, The Devonian Mollusca of the State of Pará.* Author's English edition extracted from the Archivos do Museu Nacional do Rio de Janeiro, vol. 10, pp. 1-174, 1899 ("submitted for publication, 1891"), pp. 1-127, pls. 1-8.
1900 (2). *The Oriskany fauna of Becraft Mountain, Columbia County, N. Y.* New York State Mus.. Mem., vol. 3, No. 3, pp. 1-128, pls. 1-9.
1908. *Early Devonic history of New York and eastern North America.* New York State Mus., Mem., 9, pp. 1-366, pls. 1-48.
1909. *Early Devonic history of New York and eastern North America.* New York State Mus., Mem. 9, pt. 2, pp. 1-250, pls. 1-34.
1913. *Fosseis Devonianos do Paraná.* Serv. Geol. e Min. Brasil, Mon., vol. 1, pp. 1-353, pls. 1-27.
Cleaves, A. B. See under Willard, Bradford
Cloud, Jr., P. E.
1942. *Terebratuloid Brachiopoda of the Silurian and Devonian.* Geol. Soc. Amer., Spec. Papers, No. 38, pp. 1-182, pls. 1-26.
Conrad, T. A.
1838. *Report of T. A. Conrad on the Palaeontological Department of the Survey.* State of New York, Assembly 200, Feb. 20, 1838, Communication from the Governor relative to the Geological Survey of the State, pp. 107-119.
1840. *Third annual report on the Palaeontological Department of the Survey.* New York-Geol. Surv., Ann. Rept., pp. 199-207.
1842. *Observations on the Silurian and Devonian systems of the United States with descriptions of new organic remains.* Acad. Nat. Sci. Philadelphia, Jour., 1st ser., vol. 8, pp. 228-280, pls. 12-17.
1859. *Observations on the genera Platyostoma and Strophostylus.* 12th Ann. Rept. Regents Univ. State of New York (Assembly Doc. No. 186), p. 20.
Davidson, Thomas
1864. *A monograph of the British Devonian Brachiopoda, pt. 6* (1st sec.). Palæontog. Soc. (London), Mon., pp. 1-131, pls. 1-20.
Derby, O. A.
1874. *On the Carboniferous Brachiopoda of Itaituba, Rio Tapajos, Prov. of Pará, Brazil.* Bull. Cornell Univ., Sci., vol. 1, No. 2, pp. 1-63, pls. 1-9.

Fenton, C. L., and Fenton, M. A.

1935. *Atrypa described by Clement L. Webster and related forms (Devonian, Iowa)*. Journ. Pal., vol. 9, pp. 369-381, pls. 37-43.

Fischer, Paul

1880-87. *Manuel de conchyliologie et de paléontologie conchyliologique*, pp. 1-1369, pls. 1-23.

Eaton, Amos

1831. Amer. Jr. Sci., 1st ser., vol. 21, p. 137.

Hall, James

1857. *Appendix C. Description of Paleozoic fossils.* New York State Cab. Nat. Hist., Ann. Rept,. No. 10, pp. 39-185, many text figs.

1859. *Descriptions and figures of the organic remains of the Lower Helderberg group and the Oriskany sandstone*, 1855-1859. Geol. Survey New York State, Paleont., vol. 3, pt. 1, Text, pp. 1-532.

1861. Part 2 (of the above), pls. 1-120.

1867. *Description and figures of the fossil Brachiopoda of the Upper Helderberg, Portage and Chemung groups*, 1862-1866. Geol. Survey New York State, Paleont., vol. 4, pt. 1, pp. 1-428, pls. 1-63.

1869. *Preliminary notice of the Lamellibranchiate shells of the Upper Helderberg, Hamilton and Chemung groups, with others from the Waverly sandstones, pt. 2*, pp. 1-97, pages 1-80, primarily printed edition of 100 copies, distributed in 1869, *fide* Hall; pp. 81-97, 1870. (For a discussion of these dates, see *Preliminary notice of the lamellibranchiate shells of the Upper Helderberg, Hamilton and Chemung groups*, pt. 1. 35th Ann. Rept. N. Y. St. Mus. Nat. Hist. by the Regents of the Univ. of the State of N. Y., 1884, pp. 215-216.)

1879. *The fauna of the Niagara group in Central Indiana.* New York State Mus. Nat. Hist., Ann. Rept., No. 28, pp. 99-210. pls. 3-37.

1884. *Descriptions and figures of the Monomyaria of the Upper Helderberg, Hamilton and Chemung groups.* Geol. Survey New York State, Paleont., vol. 5 pt. 1 (1), pp. 1-268, pls. 1-33, 81-92.

1885. *Dimyaria* (of the above), pt. 1 (2), pp. 269-561, pls. 34-80, 93-96.

Hall, James and Clarke, J. M.

1892. *An introduction to the study of the genera of Paleozoic Brachiopoda.* Geol. Survey New York State, Paleont., vol. 8, pt. 1, pp. 1-367, pls. 1-20.

1894. Part 2 (of the above), pp. 1-394, pls. 21-84.

Hind, Wheelton

1903. *Monograph of British Carboniferous Lamellibranchiata.* Palæont. Soc. (London) Mon., vol. 2, 216 pp., 25 pls.

Kätzer, Friedrich

1903. *Grundzüge der Geologie des untern Amazonasgebietes (des Staates Pará in Brazilien)*. pp. 1-296, pls. 1-16, map.

Kayser, Emanuel

1897. *Beiträge zur Kenntniss einiger paläozoischer Faunen Süd-Americas.* Zeits. der deut. geol. Gesel, bd. 49, pp. 274-317, pls. 7-12.

1878. *Atlas von 36 lithographischen Tafeln zur Abhandlung über die Fauna der ältisten Devon-Ablagerungen des Harzes.* Atlas zu den Abhandlungen zur geologischen Specialkarte von Preussen und den Thüringischen Staaten, pls. 1-36.

Keyes, C. R.

1894. *Paleontology of Missouri, pt. 2.* Missouri Geol. Survey, vol. 5, pp. 1-266, pls. 33-56.

King, Wm.
1850. *Monograph of the Permian fossils of England.* Paleontographical Society. London, 4 to. pp. 1-258, pls. 1-28.
Knight, J. B.
1941. *Paleozoic gastropod genotypes.* Geol. Soc. Amer., Spec. Papers, No. 32, pp. 1-510, pls. 1-96.
Keyserling, see De Verneuil
Knod, Reinhold
1908. *Devonische Faunen Boliviens.* Neues Jahrb. Min. Geol. u. Paleont., Beil.-Bd. 25, pp. 493-600, pls. 21-31.
Koninck, L. de
1842-1844. *Description des animaux fossiles que se trouvent dans le terrain carboniferè de Belgique* 4 to. Text pp. 1-716, pls. A-H and 1-55.
1847. *Monographie des genres Productus et Chonetes.* Recherches sur les animaux fossiles, pt. 1, pp. 1-246, pls. 1-20.
Lambert, R. and Méndez-Alzola, Rudolfo
1938. *Un nuevo yacimiento fosilífero devonico en el Departmaento do Durazno.* Inst. Geol. Uruguay, Bol., No. 24, pp. 169-174, pls. 3-15.
Liddle, R. A.
1928. *The geology of Venezuela and Trinidad.* Ft. Worth, Tex. Royal 8 vo., pp. 1-552, pls. 1-83.
M'Coy, Frederick
1844. *Synopsis of Carboniferous fossils of Ireland.* 4 to, Dublin.
1846. *Synopsis of the Silurian fossils of Ireland.* 4to, Dublin.
1851. *The British Paleozoic fossils added by Professor Sedgwick to the Woodwardian Museum,* 4to, London.
(M'Coys 4 to. works not seen.)
1851. *Description of some new Mountain limestone fossils.* Ann. and Mag. Nat. Hist., 2d ser., vol. 7, pp. 167-175.
Martin, W.
1809. *Petrificata Derbiensia, or figures and descriptions of petrifactions collected in Derbyshire.* 52 pls.
Méndez-Alzola Rudolfo
1938. *Fósiles Devonicos del Uruguay.* Inst. Geol. Uruguay, Bol., No. 24, pp. 1-115.
Miller, S. A.
1889. *North American geology and paleontology.* Roy. 8vo. 664, pp. 1194 text figs., Cincinnati.
Morris, J., and Sharpe, D.
1846. *Description of eight species of brachiopodous shells from the Paleozoic rocks of the Falkland Islands.* Geol. Soc. London, Quart. Jour., vol. 2, pp. 274-278, pls. 10, 11.
Muir-Wood, Helen
1930. *The classification of the British Carboniferous brachiopod sub family Productinae.* Ann. and Mag. Nat. Hist., 10th ser., vol. 5, pp. 100-108.
Murchison, R. I., see De Verneuil

Neave, Sheffield Airey
1939-1940. *Nomenclator Zoologicus*, A list of the names of genera and subgenera in zoology from the tenth edition of Linnaeus, 1758 to the end of 1935. 8vo, 4 vols. London.
Nettelroth, Henry
1889. *Kentucky fossil shells - a monograph of the fossil shells of the Silurian and Devonian rocks of Kentucky.* Kentucky Geol. Survey, pp. 1-243, pls. 1-36.
Newell, N. D.
1937. *Late Paleozoic Pelecypods: Pectinacea.* Kansas State Geol. Survey, vol. 10, pp. 1-123, pls. 1-20.
Phillips, John
1829. *Illustrations of the geology of Yorkshire, or a description of the strata and organic remains of the Yorkshire coast.* 4to, 15 pls. map, York (2d ed., London, 1836).
1836. Part 2 (of the above). *The Mountain limestone district.* 24 pls. London.
1841. *Figures and descriptions of the Paleozoic fossils of Cornwall, Devon and West Somerset, observed in the Ordinance Geological Survey of the district*, 8vo, 231 pp., 60 pls., London.
(Phillips articles, not seen)
Oehlert, D. P.
1890. *Note sur différents groupes établis dans le genre Orthis et en particulier sur Rhipidomella Oehlert (Rhipidomys Oehlert, olim).* Jour. de Conch., vol. 38, pp. 366-374., fig.
Reed, F. R. C.
1903. *Brachiopoda from the Bokkeveld beds.* S. African Mus., Ann., vol. 4, pp. 165-200, pls. 20-23.
1904. *Mollusca from the Bokkeveld beds.* S. African Mus., Ann., vol. 4, pp. 239-274, pls. 30-32.
1908. *New fossils from the Bokkeveld beds.* S. African Mus., Ann., vol. 4, pp. 381-406, pls. 47-48.
Salter, J. W.
1861. *On the fossils from the High Andes, collected by David Forbes.* Geol. Soc. London, Quart. Jour., vol. 17, pp. 62-73, pl. 4.
Schuchert, Charles
1897. *A synopsis of American fossil Brachiopoda, including bibliography and synonymy.* U. S. Geol. Survey, Bull., No. 87, pp. 1-464.
Schuchert, Ch. and LeVene, Clara M.
1929. *Brachiopoda, (Generum et Genotyporum index et Bibliographica)* Fossilium Catalogus 1: Animalia, Pars 42, pp. 1-140.
Sowerby, J. D. C.
1829. *The mineral conchology of Great Britain.* vol. 6.
Stainbrook, Merrill A.
1938. *Atrypa and Stropheodonta from the Cedar Valley beds of Iowa.* Jour. Pal., vol. 12, pp. 229-256, pls. 30-35.
Stoliczka, Ferd.
1871. *The Pelecypoda, with a review of all known genera of this class, fossil and recent.* Palæontologia Indica, Cret. Fauna S. India, vol. 3, pp. 1-537, pls. 1-50.
Swartz, F. M., see under Willard, Bradford

Tate, Ralph
1870. *Appendix to the Manual of Mollusca by S. P. Woodward.* 85 pp., no plates.
Thomas, Ivor
1905. *Neue Beiträge zur Kenntnis der devonischen Fauna Argentiniens.* Deutsche Geol. Gesell., Zeitschr., Bd. 57, pp. 233-290, pls. 11-14.
1910. *The British Carboniferous Orthotetinae.* Geol. Survey Great Britain, Paleont., Mem., vol. 1, pt. 2, pp. 83-134, pls. 13.
Ulrich, Arnold
1892. *Paleozoische Versteinerungen aus Bolivien.* Neues Jahrb. Min. Geol. u. Paleont., Beil.-Bd. 8, pp. 1-116, pls. 1-5.
Verneuil, Edouard de
1845. *Geologie de la Russie d'Europe et des montagnes de l'Oural,* par Roderick Impy Murchison, Edouard de Verneuil and le comte Alexandrie de Keyserling, 2 vols., vol. 2, Paleontologie, pp. 1-512, pls. 1-43, and A-G.
Walcott, C. D.
1884. *Paleontology of the Eureka District.* U. S. Geol. Survey, Mon., vol. 8, pp. 1-298, pls. 1-24.

PLATES

PLATE 4 (30)

Expenditure for engraving illustrations met by—
R. A. Liddle: 2 maps, 3 plates geologic views
G. D. Harris: 7 plates invertebrate fossils

EXPLANATION OF PLATE 4 (30)

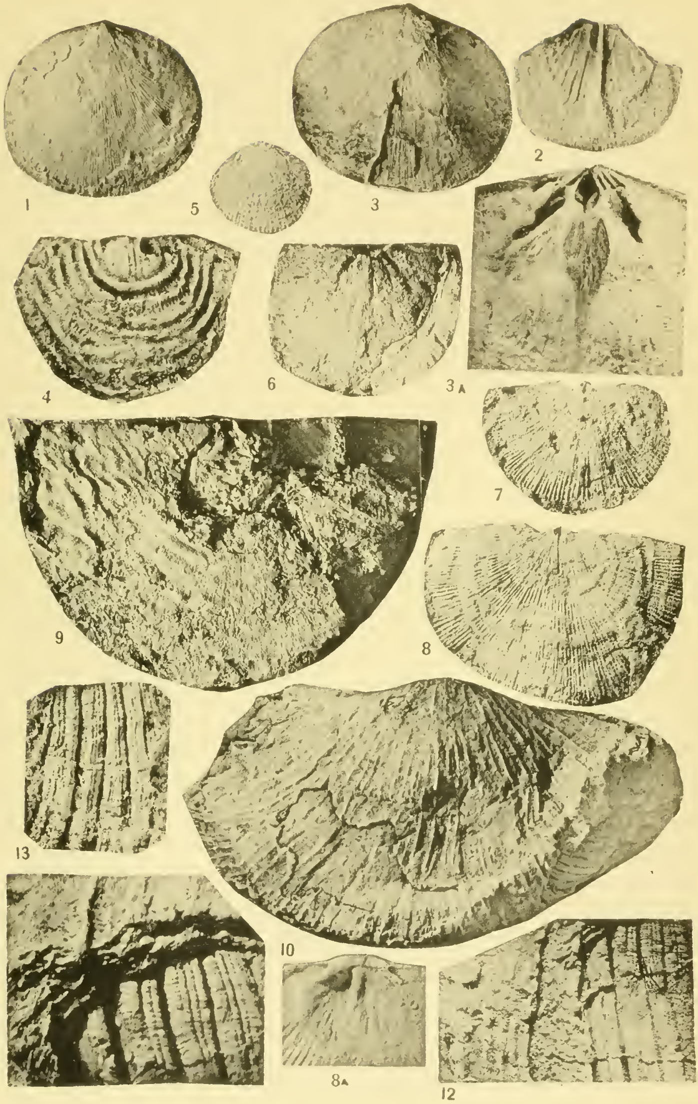

1
5
3
2
4
6
3A
7
9
8
13
10
8A
12

PLATE 5 (31)

EXPLANATION OF PLATE 5 (31)

Figure Page

1. **Stropheodonta (Cymatostrophia?) casteri**, n. sp. 59
Pedicle valve, cast: height, 50; width, 70; depth, 10 mm.; showing general form of the holotype; from Sta. 64. Pal. Res. Inst., No. 5990.

2. Same specimen as above, posterior area showing: a, remnants of original shell; b, interior striations of shell; c, molds made by cardinal processes of brachial valve; d, posterior adductor scars; e, flabellate diductor scars; f, anterior adductor scars; casts of radiate cavities.

2a. Punctate structure, anterior of fig. 1.

2b. Markings from left portion of fig. 1, cymostrophid?

3. **Strophonella? cf. meridionalis** (Caster) 59
Cast of interior of brachial valve: height, 40; width, 55; depth, 7 mm.; from Sta. 34. Pal. Res. Inst., No. 5991.

4. Cast of cardinal area of fig. 3; perfect crura and cardinal process on left; those on right somewhat broken.

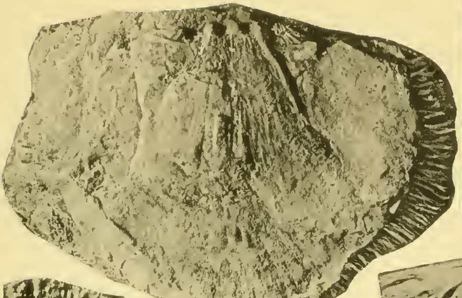
5. Details of central posterior portion of fig. 3.

6. **Tropidoleptus carinatus** (Conrad) 60
Internal cast of brachial valve: height, 16; width, 20; depth, 1 mm.; from Sta. 65. Pal. Res. Inst., No. 5992.

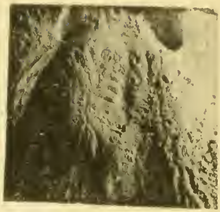
7. **Chonetes (Eodevonaria) subhemispherica** Weisbord 61
Weisbord's type specimen as figured in Bull. Amer. Pal., vol. 11, 1926, pl. 37, fig. 9.

8. **Chonetes (Eodevonaria) subhemispherica** Weisbord
Pedicle valve: laterally compressed, and radii generally obscured by a thick coating; height, 16; width, 12; depth, 9 mm.; from Sta. 65. Pal. Res. Inst., No. 5993.

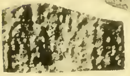
9. Vertically compressed specimen of **subhemispherica**: height 14; breadth, 20; depth, 5 mm.; Internal cast of valve; surface finely and highly papillate; from Sta. 69. Pal. Res. Inst., No. 5994.



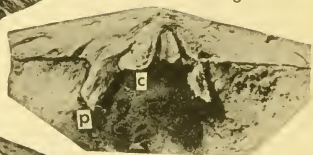
1



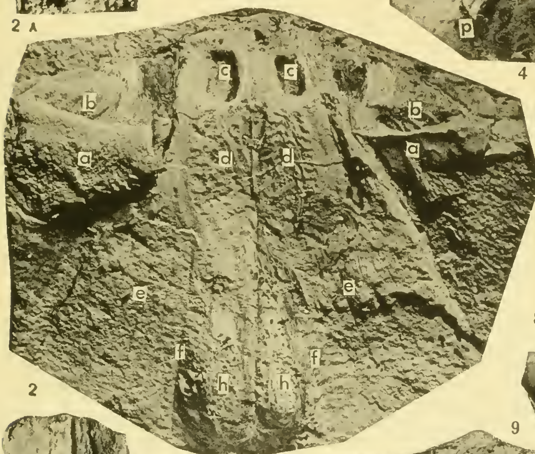
5



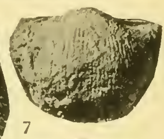
2 A



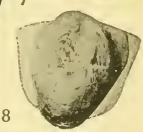
4



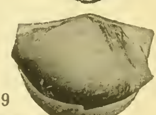
2



7



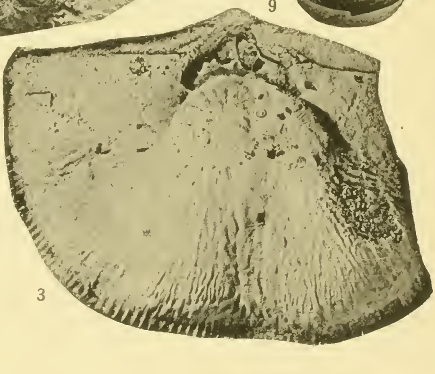
8



9

6

2 B



3

PLATE 6 (32)

Inst., No. 6006.

12. **Amphigenia elongata**, var. **weisbordi**, n. var. 65
    Pedicle valve: height, 25; width, 35; depth, 12 mm. The specimen figured by Weisbord (Bull. Amer. Pal., vol. 11, pl. 38, fig. 1).
13. The same specimen, showing one limb of spondylium intact, one broken.
14. The same showing median septum to the left, limb of spondylium to the right.
15. The same species: height, 35; breadth, 42; depth, 10 mm. Exterior of brachial valve; Station 65. Pal. Res. Inst., No. 6007.
16. The same specimen as fig. 15.
    Interior showing cardinal area where shell is very thick (but very thin anteriorly); anterior margin badly broken, when intact should be evenly rounded, not pointed as figured.
17. **Camarotœchia** sp. 63
    Height, 16; width, 16; depth, 3 mm. A specimen closely resembling *carica* Hall from the Middle Devonian of New York. Station 65. Pal. Res. Inst., No. 6008.
18. **Atrypa reticularis**, var. **harrisi** Caster 66
    Pedicle valve: height, 35; width, 34; depth, 4 mm; specimen is broader than appears from the figure herewith given; close to *A. desquamata* Sow. of the Devonian of England. Station 65. Pal. Res. Inst., No. 6009.
19. **Spirifer weisbordi**, n. sp. 67
    Pedicle valve, cardinal view: height, 35; width, 55; depth, 15 mm. See also Plate 4. Station 63. Pal. Res. Inst., No. 6010.
20. The same species; slightly magnified; anterior medial margin, showing type of costation; Station 63. Pal. Res. Inst., No. 6011.

EXPLANATION OF PLATE 6 (32)

Figure Page

1. **Chonetes (Eodevonaria) subhemispherica** Weisbord 61
   Pedicle valve: height, 12; width, 16; depth, 4 mm.; show-decoricated coarse ribbing; general contour and traces of muscular attachment; Station 65. Pal. Res. Inst., No. 5995.
2. The same species, brachial valve; showing radiate folds and muscular imprint of casts most commonly observed: height, 11; width, 20; depth, 3 mm.; Station No. 65. Pal. Res. Inst., No. 5996.
3. The same species; cast of interior of pedicle valve more deeply decorticated than shown in fig. 1, and showing muscular attachments more clearly. Station No. 65. Pal. Res. Inst., No. 5997.
4. Presumably the same species, young, pedicle valve: height, 7; width, 10 mm. Sta. 65. Pal. Res. Inst., No. 5998.
5. **Chonetes venezuelensis** Weisbord 62
   Imprint of exterior of brachial valve: height. 11; width, 15; depth, 2 mm. Station 65. Pal. Res. Inst., No. 5999.
6. The same species, showing exterior of brachial valve above and interior of pedicle valve below: height, 11; width, 14; depth, 4 mm. Station 65. Pal. Res. Inst., No. 6000.

6a. **Chonetes venezuelensis?** Weisbord
   Pedicle valve, interior: height, 5; width, 10; depth, 1 mm. Closely resembling some of the specimens figured by Clarke as *C. falklandensis* (Mor. & Sh.) and *C. Arcei* Ulrich from the Punta Grossa shales of southern Brazil. Station 38 "Float". Pal. Res. Inst., No. 6001.

7. **Chonetes stübeli** Ulrich 62
   Pedicle valve, cast of interior: height. 6; width, 7; depth, 2 mm. Station 69. Pal. Res. Inst., No. 6002.
8. **"Eodevonaria imperialis? Caster"** 63
   Internal cast of pedicle valve: height, 25; width, 30; depth, 10 mm. Station 69. Pal. Res. Inst., No. 6003.
9. The same specimen, cardinal view, showing arrangement of muscular scars.
10. **Dictyoclostus liddlei**, n. sp. 64
    Pedicle valve: height, 30; width, 30; depth, 10+ mm. Main portion flattened by pressure; ribs with tripartite markings; spine bases on ears only. Station OI-J-113, "Float". Pal. Res. Inst., No. 6004.

10a. **Dictyoclostus?**, sp. 64
    Pedicle valve, interior cast: height, 15; width, 15; depth, 5 mm. Specimen crushed in sub-centrally; spine bases not well shown. Station 38, "Float". Pal. Res. Inst., No. 6005.

11. **Productella?**, sp. 65
    Pedicle valve: height, 9; width, 9; depth, 2 mm. Compare fig. 19, pl. 13, vol. 24, Bull. Amer. Pal. Station 65. Pal. Res.

Continued on previous page


1
2
6 A
7
5
4
3
6
9
10
8
11
12
10 A
14
13
15
17
16
20
18
19

PLATE 7 (33)

EXPLANATION OF PLATE 7 (33)

Figure Page

1. **Spirifer weisbordi,** n. sp. 67
Holotype; same specimen as figured on pl. 3, fig. 19.

2. **Spirifer kingi** Caster 68
Pedicle valve, X5; from a rubber cast, showing early type of costation. Station OI-J-97 ''Float''. Pal. Res. Inst., No. 6012.

3. The same species, nearly adult form: height, 18; width, 30; depth, 5 mm. Station OI-J-97 "Float". Pal. Res. Inst., No. 6012.

4. Portion of fig. 3 magnified to show fine radial striation.

5. **Spirifer olssoni** Caster 68
Pedicle valve, vertically crushed, true height at least 16; width, 30 mm. Station 63. Pal. Res. Inst., No. 6013.

6. **Elytha? plana,** n. sp. 69
Holotype: brachial valve, rubber cast of exterior; height, 16; width, 23; depth, 6 mm. Station 38. Pal. Res. Inst., No. 6014.

6a. The same; portion of surface enlarged.

7. **Elytha colombiana** Caster 69
Brachial valve; height, 20 mm. Station 65. Pal. Res. Inst., No. 6015.

8. **Meristella wheeleri** Caster 70
Pedicle valve, cast of interior, somewhat worn; height, 30; width, 35 mm. Station 69. Pal. Res. Inst., No. 6016.

9. **Meristella** sp. 70
Pedicle valve original shell matter, exterior: height, 27; width, 28; depth, 9 mm. Station 69. Pal. Res. Inst., No. 6017.

9a. The same, interior showing umbonal characters.

10. **Athyris spiriferoides** (Eaton) 70
Pedicle valve: height, 30; width, 30; depth, 7 mm. Station 65. Pal. Res. Inst., No. 6018.

11. **Pentagonia? gemmisulcata** Caster 71
Rubber cast from type specimen (See Bull. Amer. Pal., vol. 24, pl. 16, figs. 16, 17), vicinity of Floresta, Colombia.

12,a. **Pentagonia unisulcata** Hall 71
After Hall. Here figured to show appearance of type of the genus.

13. An unidentified, myophora-shaped, somewhat eroded, specimen showing remarkable bi-plication as in figs. 11 and 12, but having more the appearance of a lamellibranch than of a brachiopod: height, 20; width, 16; depth, 4 mm. Station 65. Pal. Res. Inst., No. 6019 71


1
2
3
4
5
6
7
8
6 A
9
9 A
10
12
12 A
11 A
13

PLATE 8 (34)

EXPLANATION OF PLATE 8 (34)

Figure		Page
1.	**Limoptera tenuis**, n. sp. Holotype; left valve; height, 65; width, 45 mm.; Sta. 69; Pal. Res. Inst., No. 6021.	71
2.	**Actinopteria subulrichi**, n. sp. Holotype; left valve; height, 23; width, 35; depth about 4 mm. Wing evidently longer than shown. Sta. 65; Pal. Res. Inst., No. 6022.	72
3.	**Aviculopecten yeakeli** Weisbord	73
4.	**Tellinomya**, sp. Anterior portion of right valve: height, 11; width, 18 mm.; Sta. 65; Pal. Res. Inst., No. 6024.	73
5.	**Tellinopsis? venezuelanus**, n. sp. Holotype; right valve: height, 18; width, 21; depth from 2 to 3 mm.; Sta. OI-J-113, "Float"; Pal. Res. Inst., No. 6025.	74
6.	**Edmondia sylvana** Hartt Right valve; height, 6; width, 9; depth, 2 mm.; Sta. 65; Pal. Res. Inst., No. 6026.	74
7.	**Nucula**, sp. Left valve if a *Nucula*: height, 3.5; width or length, 5; depth, 1 mm.; Sta. OI-J-113, "Float"; Pal. Res. Inst., No. 6027.	75
8.	**Leptodomus? ulrichi** Clarke Left valve: height, 19; length, 62; depth, 4.5 mm.; Sta. OI-J-113, "Float"; Pal. Res. Inst., No. 6028.	75
9.	**Platyostoma ventricosum** (Conrad) Height, 25; width, 36 mm.; showing flattening of whorls above; Sta. 63; Pal. Res. Inst., No. 6029.	76
10.	**Platyostoma ventricosum** (Conrad) The same specimen showing shape of whorls and size of mouth.	
11, 12.	**Platyostoma ventricosum, var. permundum**, n. var. Holotype: height, 25; width, 50 mm.; Sta. 63; Pal. Res. Inst., No. 6030.	76


1
2
3
4
5
6
7
8
9
10
11
12

PLATE 9 (35)

EXPLANATION OF PLATE 9 (35)

Figure	Page

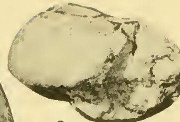
1. **Platyostoma ventricosum, var. permundum, n. var.** 76
   Same specimen as figs. 11 and 12 of Pl. 8.
2. **Platyostoma neveritanum** Weisbord 76
   Height, 20; width, 28 mm. Somewhat less spherical than the specimen by Weisbord (Bull. Amer. Paleont., vol. 11, pl. 41, figs. 1-3). Sta. 42; Pal. Res. Inst., No. 6031.
3. **Platyceras sinistrum,** n. sp. 77
   Holotype: greatest dimension as shown in fig. 3, 40 mm. Note how the beak, as viewed from above, seems to turn toward the right, while in fig. 1, the beak turns to the left. Sta. 72; Pal. Res. Inst., No. 6032.

3a. **Platyceras sinistrum,** n. sp.
   The same specimen viewed laterally, showing "umbilical" depression demarcated by a somewhat sharp ridge.

4. **Platyceras? gibraltar,** n. sp. 77
   Holotype: viewed from above; Sta. 42; Pal. Res. Inst. No. 6033.
5. **Platyceras? gibraltar,** n. sp.
   The same specimen as fig. 4; height, 30; length, 60 mm. Shell mostly removed, thicker posteriorly than anteriorly, fine irregular radiating markings shown on cast of interior.
6. **Platyceras? gibraltar,** n. sp. 77
   From the same specimen at "a," showing irregular tubules and perforations on what seems to be remnants of the innermost layer of the shell; perhaps a lichenalia-like growth on the inner surface of the shell after death of animal.
7. **"Foraminifera"** 25
   "Thin section X 10; Sta. 15, Permo-Carboniferous."—Liddle. Pal. Res. Inst., No. 6034.
8. **Spirifer** 25
   "Crystallized limestone showing abundance of crinoidal fragments and cardinal area of a *Spirifer*. Sta. 15; Permo-Carboniferous."—Liddle. Pal. Res. Inst., No. 6035.

1

4



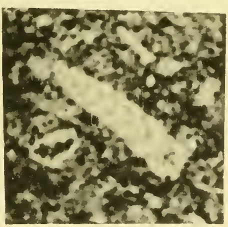
2

3

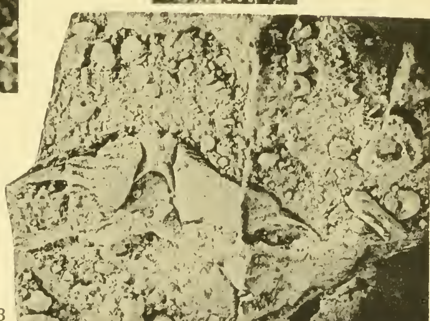
5

6

3 A



7



8

B: ANTHOZOA

By

John W. Wells

The Ohio State University

In 1926 Weisbord described and figured three species of corals from Devonian rocks in the upper course of Rio Cachirí, State of Zulia, northwestern Venezuela. More recently another small collection of corals was made by R. A. Liddle. These corals are of considerable interest because of their close relationships with the more or less well-known coral faunas of the Ulsterian and Erian stages, more particularly the former, of the eastern United States and Canada.

During the course of examining the new material, it became desirable to review the earlier material described by Weisbord, and these notes present the results of a study of both collections.

Five species, including as many genera, are recognized, probably representing a mere sample of the actual coral fauna of the Rio Cachirí beds. This fauna seems to be the homotaxial equivalent of the coral assemblages of the Ulsterian Onondaga-Columbus-Jeffersonville formations of the United States and Canada, but its facies, however, is not the more or less pure limestones with coral bioherms of these units but rather that of the Ludlowville formation (Erian) of central New York—arenaceous calcareous shales indicative of shallow, muddy bottoms, with corals rather thinly scattered, and rarely growing luxuriantly enough to build up bioherms or biostromes because of the influxes of mud.

Subclass RUGOSA

Heliophyllum halli Milne Edwards and Haime, 1850 Plate 10, figs. 1, 2
(For partial synonymy see: Fenton and Fenton, 1938, p. 211.)

Locality and material.—Nine specimens, one of them figured, from localities 36, 65, 72, 73, and 37.

Remarks.—The specimens appear to represent typical *H. halli*, with no notable variations from normal specimens from the

Ulsterian and Erian stages in New York, Ontario, and Ohio. One or two may represent an approach to *H. sciotoense* Stewart (1938, p. 39, pl. 7, figs. 3-5) although the distinctness of this species may be questioned. The specimen figured has 84 septa at the plane of the thin section about 15 mm. below the rim of the calice with a diameter of about 33 mm. The primary septa of the same specimen show only a very slight dilatation in the tabularium, but in another one of the same size they are sharply dilated in the tabularium and in nearly half of the dissepimentarium. In radial section the dissepimentarium consists of the usual dissepiments, while the tabularium, composed of weakly developed tabellæ, shows no distinct axial and periaxial zonation.

This species has already been reported from the Rio Cachirí series of Venezuela by Liddle (1928, pp. 98-99).

Synaptophyllum vermetum (Weisbord) Plate 10, figs. 3, 4

Diphyphyllum vermetum Weisbord, 1926, Bull. Amer. Paleont., vol. 11, p. 225, pl. 35, figs. 6, 7; pl. 36, fig. 1.

Localities and material.—Syntypes from upper course of Rio Cachirí, State of Zulia, northwestern Venezuela. One large colony, with nearly completely flattened corallites from locality 63.

Description.—Corallum phaceloid, with long, slender, flexuous cylindrical corallites with somewhat annulated sides, frequently touching each other but lacking radiciform processes. Diameter of corallites ranging from 2.5 to 4.5 mm., averaging about 3 mm. In transverse section there are about 44 subequal septa, with little or no differentiation into major and minor septa except in the early stages of rejuvenated corallites. They extend inwards less than one-half the radius, usually nearer one-third. The intersections of the dissepiments appear as a sort of wall near the periphery. Peripheral parts of the septa carinated, but the carinæ are often absent in parts of the corallum where the septa are very short. In longitudinal section the dissepiments are horseshoe-shaped and form a single peripheral series. The tabulæ are mostly complete, flat or slightly arched, with occasional incomplete tabulæ near the dissepimentarium. Calice and septal margins unknown.

Remarks. The foregoing is a revised description of this species based upon the new material and Weisbord's type specimens, from one of which transverse and longitudinal sections were cut (Pl. 10, figs. 3, 4). As thus redefined, this coral is seen to be very closely related to the North American Ulsterian species, *S. simcoense* (Billings), (*vide* Stewart, 1938, p. 43, pl. 8, figs. 5, 6) in almost every detail except for the much shorter and practically equal septa and lack of radiciform processes between the corallites.

Heterophrentis venezuelensis (Weisbord) Plate 10, figs. 7, 8, 9

Cyathophyllum venezuelense Weisbord, 1926 Bull. Amer. Paleont., vol. 11, p. 224, pl. 35, figs. 1-5.

Locality and material.—Syntypes from upper course of Rio Cachirí, State of Zulia, northwestern Venezuela. Seven specimens from localities 36, 37, 63, 72, and 73.

Description.—Solitary, corallum conical, nearly straight in early stages and strongly curved in large specimens. Epitheca moderately thick, ridged, with low growth annulations. Calice circular, slightly oblique, deep, with broad, nearly flat, raised tabular floor. Number of septa in ephebic stage uncertain but at least 100 in specimens 45 mm. in diameter. In a smaller one there are 76 at a diameter of 25 mm., in two orders: larger ones that extend more than two-thirds of the distance to the center, and shorter ones that exend less than one-third. Deep in the corallite the primaries extend to the center where they may be somewhat twisted together. Fossula well developed, apparently on the side of greater curvature. Tabulæ numerous, more or less complete in ephebic stages, convex, warped downwards sharply peripherally, somewhat as in *Siphonophrentis*, closely packed. In early stages they are very irregular and contorted. Dissepimentarium formed by a rather broad zone of concentric vesicular dissepiments. Peripheral stereozone well developed in practically all specimens, extending at least to the ends of the secondary septa and often beyond them to the inner margins of the primaries in some cases.

Remarks.—More than one species may be involved in the specimens included here, but no attempt to differentiate them is practicable until more material is available. The species is very closely allied to both *H. prolifica* (Billings) and *H. spissa* (Hall), both common North American Ulsterian species. The internal structure of these has not been described adequately, although sections of *H. prolifica* from the Columbus formation of central Ohio examined by the writer are practically identical with ephebic *H. venezuelensis.* There is also considerable similarity with *H. simplex* (Hall) of the New York Hamilton group, (Erian), (*vide* Hall, 1876, pl. 21, figs. 7, 11).

Zonophyllum, sp. Plate 10, figs. 5, 6

Locality and material.—One poorly preserved specimen from locality 73.

Remarks.—The single specimen of a cystiphyllid coral is too poorly preserved to be adequately described at this time, although it is probably new. The form of the corallum, which is apparently solitary, is irregularly cylindrical, about 12 mm. in diameter, with irregular constrictions, some of which are the effect of rejuvenation. In transverse section, there is an irregular outer zone of small dissepiments on which the septal rays (about 100) are highly developed and heavily thickened by stereothecal deposits. Centrally the cysts formed by coarse dissepimentlike tabulæ often bear some septal rays. In longitudinal section, the dissepimentlike tabulæ, which are usually thickened by sterome. form a central zone which in places extend nearly across the corallite.

The genus *Zonophyllum* Wedekind, 1924, occurs in the lower Middle Devonian of the Eifel region and has not hitherto been recognized in America, but among the American Devonian species of "*Cystiphyllum*" there occur forms very likely referable to it; for instance, *C. conifollis* Hall (1876, pl. 30, figs. 3-9) of the Hamilton group which has a growth form and structures (*vide* Fenton and Fenton, 1938, p. 232) similar to those of the Venezuelan specimen.

Subclass TABULATA

Thamnopora venezuelensis (Weisbord) Plate 10, fig. 10

Pleurodictyum venezuelense Weisbord, 1926, Bull. Amer. Paleont., vol. 11, p. 226, pl. 35, figs. 8, 9.

Locality and material.—Holotype from the upper course of Rio Cachirí, State of Zulia, northwestern Venezuela.

Remarks.—Weisbord's original description is inadequate, and the following is offered in amplification:

Corallum small, apparently nodular and similar in form to that of *Favosites forbesi*, the holotype being about 27 mm. in height with a maximum diameter of about 17 mm. Basal epitheca present, according to Weisbord. Corallites prismatic, diverging regularly from the axis of main growth, ranging in diameter from 1 to 1.5 mm. Calices only partially preserved, but apparently more or less circular rather than polygonal. Interior of corallites heavily thickened by stereotheca, through which the large (0.25-0.3 mm.) single series of mural pores persists. Tabulæ complete, flat, averaging slightly less than 1 mm. distant from each other.

The growth form of this species is not certainly nodular, and the holotype may not represent a single colony, but may, instead, be a stubby proliferation from a ramose corallum. In all other respects it is closely related to *T. limitaris* (Rominger) and *T. cariosa* (Davis) of the Ulsterian of the northeastern United States and Canada.

REFERENCES

Fenton, C. L. and Fenton, M. A.
Heliophyllum and "Cystiphyllum," corals of Hall's "Illustrations of Devonian corals." Carnegie Mus. Ann., vol. 27, 1938, pp. 207-250, pls. 17-24, 22 figs.

Hall J.,
Illustrations of Devonian fossils; corals of the upper Helderberg and Hamilton groups. Geol. Surv. New York, 1876, 39 pls. (with letterpress but no text).

Weisbord, N. E.
Venezuelan Devonian fossils. Bull. Amer. Paleont., vol. 11, 1926, pp. 223-268, pls. 35-41.

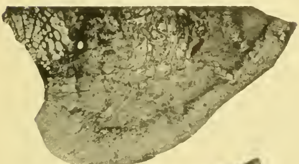
Stewart, G. A.
Middle Devonian corals of Ohio. Geol. Soc. Am., Special Paper, No. 8, 1938, 120 pp., 20 pls.

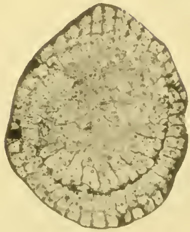
EXPLANATION OF PLATE 10 (36)

Figure		Page
1,2.	**Heliophyllum halli** (Milne Edwards and Haime) Fig. 1, transverse section, X1½; fig. 2, radial longitudinal section; X1½.	95
3,4.	**Synaptophyllum vermetum** (Weisbord) Figured syntype. Fig. 3, transverse section, X6 (inner wall and septa pertain to rejuvenated corallite); fig. 4, longitudinal section (slightly diagonal); X6.	96
5,6.	**Zonophyllum**, sp. Fig. 5, transverse section, X2; fig. 6, longitudinal polished section, X1½ (rejuvenated near middle).	98
7,8,9.	**Heterophrentis venezuelensis** (Weisbord) Fig. 7, longitudinal polished section of figured syntype, X1; figs. 8, 9, transverse sections of hypotype; X1½.	97
10.	**Thamnopora venezuelensis** (Weisbord) Longitudinal polished section of holotype; X2.	99

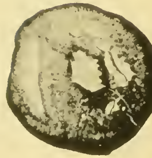
All specimens are in the Paleontological Research Institution


1


2

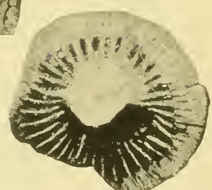

3

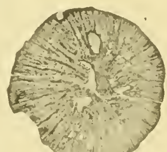

4


5


6


7


8


9


10

Index to Volume XXVII

Note:-Light face figures refer to the volume paging and not to the paging of the separate bulletins. Heavy face figures refer to the volume plate numbers.

End of Vol. XXVII