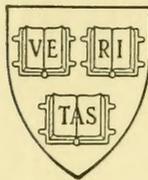




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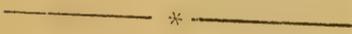
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**No. 109**

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- II. WERNEROCERAS IN THE DEVONIAN OF NEW YORK
- III. A GONIOCERAS FROM VIRGINIA
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- VII. ANNULATED ORTHOCERAONIC GENERA OF PALEOZOIC NAUTILOIDS

By

Rousseau/H. Flower  
University of Cincinnati Museum

*August 10, 1943*

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

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# I. TISSUE REMNANTS IN THE PHRAGMOcone OF RAYONNOCERAS

## ABSTRACT

A small *Rayonnoceras* from the Chester of Indiana which was buried in its normal life position is described. Study of sediments entering the shell indicate barriers which have since disappeared and are represented by calcite. Thin bands of calcite mark a peculiar but characteristic pattern in the phragmocone and are interpreted as calcified remnants of the partially distorted cameral mantle. The specimen represents a new species and is the first record of the genus east of the Mississippi. Other American species of *Rayonnoceras* are briefly reviewed.

## INTRODUCTION

A specimen representing a new species of *Rayonnoceras* from the Chester of Indiana is mainly of interest for the evidence which it presents of tissue in the cameræ at the time of burial of the shell and the infiltration of inorganic materials. This tissue affected the invasion of sediments and influenced the deposition of calcite in the shell cavities to which the sediment failed to penetrate. Previously the writer (Flower, 1939, pp. 45-51) came to the conclusion that the cameral deposits of orthoceracones were secreted by a cameral mantle, and traced the probable origin and development of that tissue. At the same time a specimen on which the cameral mantle was preserved in place (pp. 164-165, pl. 7, fig. 8; pl. 8, fig. 19) was figured and described and mention was made of the specimen described here (p. 46) in connection with the evidence of cameral tissue present at the time of burial of the shell. Subsequently the study of a unique specimen of *Leurocyloceras* (Flower, 1941) presented a remarkable case of the preservation of the large blood tubes which were developed in the cameral mantle of that genus, thereby demonstrating that the vascular system may pass directly from siphonal to cameral tissue. The present study is significant mainly in recording a rather different mode of preservation of cameral tissue and indicates strongly that hitherto unexplained structures in nautiloids may be the result of the retention of cameral tissue in a more or less altered state.

In order to demonstrate the effect of tissue upon the invading sediments it is first necessary to consider briefly the orientation and history of preservation of the specimen concerned. The shell came into my hands in a block of limestone showing good bedding planes. Study of a section through the protruding adapical end of the shell showed that the conch lay with the ventral surface close to one plane, the dorsum close to the other. Closer inspection revealed that sediment was confined to the ventral portion of the shell, while the dorsal portion was occupied by calcite representing a complement to the incomplete internal mold formed by the sediment. Further, this was adequate to show that the conch had come to rest upon its ventral surface, as is common among actinoceroids, as the result of the concentration of heavy cameral and annulosiphonate deposits on the ventral side of the shell.

The sagittal section of the specimen (text fig. 1, and Pl. 1, fig. 1) reveals more of the history of this shell. The living chamber is lost, the adoral septa are somewhat broken and the connecting rings are completely destroyed except where they are reinforced by heavy annulosiphonate deposits. These facts indicate that the shell was subjected to considerable damage, probably by wave action, previous to its burial. After it came to rest on its ventral surface, sediments entered through the siphuncle, and settled into the ventral portion of the camerae. The siphuncle is not filled completely by sediments. Close inspection reveals that the sediments do not quite attain the septal necks on the dorsal side. The dorsal line of contact of sediment and calcite is somewhat irregular, but approximately parallel to the bedding plane, and the upper portion of the siphuncular cavity is not filled. As a result, casual inspection of the section fails to give a correct impression of the strongly cyrtochoanitic condition of the siphuncular segments on the dorsum.

Were this all, the specimen would be an interesting but extremely typical example of the development of an incomplete internal mold in an orthoceracone. However, at one point a clear break is shown in the dorsal wall, which has permitted sediments to enter a single camera from above. Under normal circumstances the sediment entering from above would be expected to sink and mingle with that entering through the siphuncle, but here

something has happened to keep the two masses of sediment apart, for they are widely separated by a mass of calcite. This calcite, by its position must represent the inorganic filling of a space formerly occupied by some substance, now missing, which obstructed the invading matrix. A tissue is at once suggested, subsequently decaying and leaving a cavity to be filled in geodically by calcite. Further, from what is known of the presence of tissue in the cameræ of cephalopods from other sources, this conclusion seems the only logical one which can be drawn from the present specimen. It is not improbable that cameral tissues, being somewhat protected in location, might persist in the shell after the removal of the visceral mass and the siphonal tissues. They would not be found unaltered, as was noted in *Geisonoceras teichertii* (Flower, 1939) but would probably be more or less subject to decay which would cause them to separate from the shell entirely or in part, and might produce some very marked modifications in their original form, thickness, and areal extent.

If cameral tissue is present in a camera which has been invaded by matrix, it is quite possible that it may be found in a better state of preservation in less exposed cameræ of the same shell. Inspection of more adapical cameræ which are not open to the exterior through breaks in the shell wall, reveals structures to which no other explanation seems to be applicable.

In the inspection of these cameræ four types of calcite can be observed. First, there is a dark, fine-grained calcite which has replaced original organic calcareous deposits of the shell. On the ventral side this has replaced the siphonal deposits, seen clearly about the three adapical septal necks and less clearly on the fourth. Also, close to the ventral wall, it has replaced the original cameral deposit, episeptal in this species. Equally definite in the specimen, though somewhat more obscure in the photograph, are the cameral deposits close to the dorsal wall in the adapical two cameræ. The appearance of the original calcareous deposits in this section is very different from that of any of the following types of calcite, which are therefore to be attributed to other sources.

The second type of calcite consists of fine-grained, possibly cyrtocrystalline material, which forms a series of thin white lines. These lines occupy approximately similar positions in the adapical two cameræ on the dorsum, and traces of them in a somewhat distorted condition can be noted in the next two dorsal cameræ. Adjacent to the lines of white cryptocrystalline calcite are broad bands of white calcite, clearly crystalline, though composed of relatively small crystals. These separate the white bands noted above from the fourth type of crystal, and in places grade into the last type, which consists of darker colored coarse crystals of calcite.

The last two types of calcite represent the geodic filling of cavities in the shell; here, as is usual in such cases, crystallization begins with numerous fine small crystals around the periphery of the cavity and ends with the deposition of coarse and rather irregular crystals at the center. However, the thin white lines remain to be explained, and must represent the position of some substance which controlled the pattern of calcite deposition. The course of these lines is shown in text figure 1, though no attempt has been made to differentiate the two types of calcite which together make up the geodic filling. It is apparent from the condition of the specimen that the white lines must represent a structure which was present before calcite was deposited in the cameræ. Further, the form of the line suggests that it was a thin tissue, which, if stretched out, would approximately line the cameræ. The conclusion seems unavoidable that this represents a portion of the original cameral tissue which has become separated in part from the septa, to which it was originally attached, and was lying in a somewhat distorted condition in the cameræ.

The course of the line suggests this explanation more strongly when its details are examined and compared with conclusions reached on the form of the tissue from other data. At the adapical end of the specimen (text fig. 1) the mantle line lies close against the septum, and continues along the cameral deposit and the dorsal wall of the camera. On the adoral surface a portion of this line has broken loose, and has slipped downward a little. Further, there is to be noted here a peculiar arching of the mantle away from the ventral surface, also seen more clearly in the next camera orad. Continuing the line, a slight break is to be seen at the tip of the septal neck, also seen more clearly in the

next camera. Inasmuch as this is the point at which the connecting ring and enclosing tissue were attached, the break is to be expected precisely here. The tissue then continues around the septal neck into the next camera. It follows the margin of the camera to the tip of the next septal neck at which a break is again seen, this time a more conspicuous one. In the third camera the tissue remnant is less completely preserved, and its position is clearly modified by the sediment penetrating from above. Only a faint remnant is preserved in the next adoral camera.

The course of the white lines is not precisely that postulated previously for cameral tissue, but it must be remembered that in this specimen not only have most of the soft parts been removed, permitting the entry of sediment through the siphuncle, but the shell had suffered breakage, indicating some transporta-

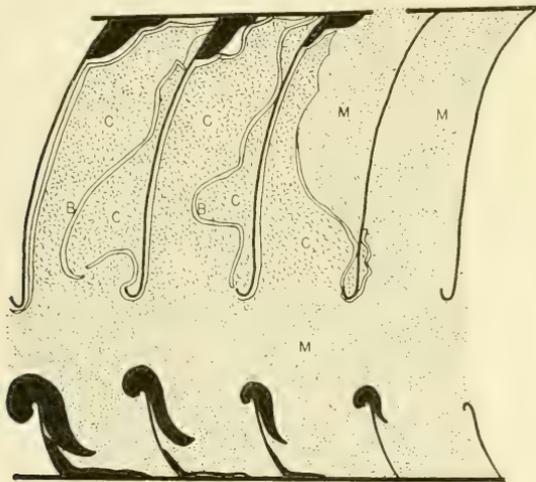


Figure 1. Sagittal section of *Rayonnoceras malotti* Flower, n. sp. oriented with the dorsum up, the position in which it was buried. Original shell parts are in solid black. M—Matrix which has entered both from the adoral end of the siphuncle and from the break in the dorsal wall. C—Calcite occupying portions of shell not filled by matrix; infiltrated inorganic material. B—Cryptocrystalline calcareous bands representing position of cameral mantle at time of burial and solidification.

tion previous to burial. There is certainly ample opportunity for dissolution of cameral tissue in this interval, and the retention of any trace of cameral tissue under these circumstances is remarkable. Apparently previous to calcification the mantle has been pulled loose from the adoral surface of the camera, and the lobe thus formed has tended to slump downward slightly. The behavior of the mantle in this way seems to be characteristic; not only is there indication of such folding, but there is a similar arching of an inorganic mineral deposit, though this time of chalcidony, in the holotype of *Harrisoceras orthoceroides* (Flower 1939A) which appears to represent the same phenomenon.

Quite possibly the retention of cameral tissue is a much more common factor in nautiloids than has hitherto been supposed. Its presence has been suspected by the writer in the region surrounding the siphuncle in several pseudorthoceroids, also in the cameræ of holocoanites, where it has a somewhat different distribution. The field is largely an unexplored one, and one rich in possibilities.

#### Genus **RAYONNOCERAS** Croneis

The Actinoceroidea are essentially an early Paleozoic group, attaining their maximum expression in the Ordovician. Some new types appear in the Silurian, but only two genera are known in the Devonian, *Ormoceras* Stokes and *Metarmenoceras* Flower, of which only *Ormoceras* is known to extend from the Lower to the Middle Devonian. (Flower, 1940.)

It is surprising, therefore, to find in the Mississippian and Pennsylvanian a new type of actinoceroid which appears both in Europe and America, the genus *Rayonnoceras* Croneis, which contains the largest known actinoceroids. The genus was formerly referred to the Actinoceratidæ, but the writer has suggested (1940) that it might be placed in the Sactoceratidæ instead, a change which is supported by some structural features and which is overwhelmingly suggested by the range of the genera involved.

Schindewolf (1933) has differentiated *Carbactinoceras* which

was proposed as a new genus, though the author remarked that it might possibly be regarded as a subgenus of *Rayonnoceras*. The two groups are distinguished on the basis of the following characters:

<i>Rayonnoceras</i>	.	<i>Carbactinoceras</i>
Siphuncle broad, ventral		Siphuncle narrower, subcentral
Necks relatively long, not less than brims		Necks shorter than brims
Cameral deposits episeptal and hyposeptal		Cameral deposits episeptal only

The status of *Carbactinoceras* as a subgenus seems more in keeping with the instability of these characters which vary considerably among the species and which strongly suggest complete intergradation between the two extreme types.

*American species of Rayonnoceras.*—*Rayonnoceras bassleri* Foerste and Teichert (1930) is unfortunately based upon a specimen the label of which is lost. It is believed from the lithology and the resemblance to *R. solidiforme* Croneis to be from the Fayetteville of the Upper Mississippian of Arkansas. Indeed, these two species, both probably from the same horizon and region, are very similar. *R. solidiforme* possesses septa which "extend horizontally out for a certain distance from the dorsal side of the septal foramina, whereas in *R. bassleri* they rise immediately upward from the foramen." (Foerste and Teichert, 1930, p. 210.) It might be noted that the remarkable course of the septa in *R. solidiforme* is almost certainly the result of distortion of the specimen under pressure, as the same effect has been observed in numerous other cephalopods, always attributed to flattening. The other characters by which the species are separated are such as might possibly vary among different parts of the conch of the same species, and it is probable that the two forms may be conspecific.

*R. buffaloense* Foerste and Teichert is a small form, the holotype obviously somewhat distorted by pressure but with strongly oblique sutures which are apparently original. It is from the Caney shale of Oklahoma.

*R. girtyi* Foerste and Teichert is a larger form with nearly straight sutures, and closely resembles *R. vaughanianum* in size, but that species possesses more oblique sutures and siphuncular segments which are longer in proportion to their width. *R. vaughanianum* (Girty) (see Foerste and Teichert, 1930) is a large species with a strongly eccentric siphuncle and oblique sutures. Both species are from Oklahoma in boulders of the Caney shale regarded as of St. Louis age.

A new species from the Chester of Indiana is described below.

**Rayonoceras malotti** Flower, n. sp.

Plate 1, fig. 1; Text fig. 1

The conch is orthoceraconic, slightly depressed in section. A fragment of a living chamber has a width of 25 mm. and a height of 23 mm. The holotype, consisting of a portion of a mature phragmocone, expands vertically from 16 mm. to 18 mm. in a length of 15 mm. There are seven cameræ in a length equal to the adoral shell height of 18 mm., but in the adoral portion of the region measured the cameræ decrease in depth from 3 mm. to 2.5 mm., showing that this represents a mature phragmocone. The depth of the cameræ in the ephebic portion would be somewhat greater, and their number in a similarly measured length slightly less. The sutures are not exposed, but are evidently oblique, as can be determined from the vertical section, the obliquity being equal to the depth of an ephebic camera. Where the height of the shell is 17 mm., the siphuncle is 5 mm. in diameter at the septal foramen, and is 2.5 mm. from the ventral wall. The connecting rings are destroyed, but their outline can be traced in the adapical part of the shell by the external outline of the better developed of the annulosiphonate deposits. The brim is twice the neck, the neck being .5 mm. in length. The area of adnation can be seen on the ventral side only, where it is much greater than the brim, and extends halfway to the ventral wall of the shell.

Mural deposits are present in the cameræ of the holotype. Deposits of the siphuncle are typical of the genus, but not far enough developed in the fragmentary specimen to show the course of the vascular system.

The species was evidently small, for the gerontic portion of the cameræ is retained in the holotype. The markedly ventral siphuncle and the obliquity of the sutures separate this species from all others. The closest relative appears to be *R. buffaloense* Foerste and Teichert, of the Caney shale, but in that species the septa are deeper, the siphuncle more central, and the cameræ much deeper. Our species is further distinctive for its small size.

*Type*.—University of Cincinnati Museum, No. 24078, holotype.

*Occurrence*.—From the Chester of southern Indiana. Exact locality and horizon are unknown. The specimen came into my hands unlabeled, among miscellaneous material collected by Dr. E. A. Logan and his students, and was nearly thrown out. Dr. C. A. Malott has kindly examined the specimen and the block from which it was cut, and on the basis of lithology has tentatively assigned it to the Paoli member of the Chester. In spite of its fragmentary nature the specimen is of interest not only for the features of morphology and preservation discussed above, but in being the only specimen of a *Rayonnoceras* so far recognized in the Chester group of Indiana.

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## II. WERNEROCERAS IN THE DEVONIAN OF NEW YORK

### ABSTRACT

On the basis of an exceptionally large and well-preserved specimen, the description of *Werneroceras plebiforme* is revised. The species is regarded as occupying the uppermost beds of the Union Springs member of the Marcellus instead of the Cherry Valley member.

### INTRODUCTION

The oldest ammonoid known from the Devonian of New York is *Werneroceras plebiforme* (Hall) which was previously reported only from a single locality, Cox's ravine, at Cherry Valley, New York. The same exposures constitute the type section of the Cherry Valley limestone, though extending also into underlying and overlying formations. During the summer of 1939 two exceptionally well-preserved specimens were found at Stockbridge Falls, Oneida Creek, Madison County, New York. These specimens were in loose pieces, which were obviously from one of several thin limestone bands in the upper part of the Union Springs member of the Marcellus shale. In the spring of 1941 additional specimens were obtained, this time in place, in the uppermost of these thin limestone bands at the same locality.

This discovery establishes a new locality for the species, and suggests that actually it is probably much wider ranging than was formerly believed. That it has not been reported previously is probably due in part to the fact that the shales underlying the Cherry Valley limestone are usually exposed in cliffs, not suitable for extensive collecting. Further, the attention of fossil hunters is more generally directed to the more difficult but richer collecting of the Cherry Valley limestone rather than to the relatively barren layers beneath, which have a smaller and a not very spectacular fauna.

The new material is of further interest in that it supplies not only the largest representative of the species known, but also shows better surface features than any other known specimen, and indicates that the umbilical spines increase in prominence in the mature part of the shell, and are not confined to the early whorls as all previous descriptions would lead one to believe.

The find is of further interest in that it involves a minor but intriguing stratigraphic problem, as there is some question as to whether the "*Anarcestes* bed" should be placed in the Cherry Valley or in the Union Springs member of the Marcellus shale.

### STRATIGRAPHIC POSITION

It may be safely assumed that *Werneroceras* occurs at equivalent horizons at Stockbridge Falls and at Cherry Valley. In both localities the species is limited to a horizon certainly not more than 4 inches in thickness. Further, it occurs in a type of lithology, in fine-bedded limestones and very thin-bedded black shales, which are notable for the retention of fine stratigraphic divisions over relatively wide areas. The Cherry Valley locality has yielded a considerable suite of specimens from a single bed, sometimes so abundantly as to retain four individuals on a slab slightly less than a foot square. The Stockbridge locality has a less imposing record, but has yielded a total of eight specimens, of which five were little better than impressions, but all except two were collected from limestones in place, and are sufficient evidence to indicate that here also the *Werneroceras* is a good horizon marker, though certainly less abundant.

On a strictly lithological basis the *Werneroceras* bed occurs in the limestone mass which overlies the basal shales of the Marcellus and which constitutes the type section of the Cherry Valley limestone. However, as is shown below, this section is atypical and differs from all other sections of the limestone in carrying a great mass of calcareous material which is elsewhere represented by Union Springs shales with thin interbedded limestones.

On a similar lithological basis the *Werneroceras* bed occurs at Stockbridge Falls in the upper part of the Union Springs shales. The limestone layer which it occupies, there about three inches in thickness though varying from 1 inch to 5 inches and quite concretionary, is lithologically identical with at least six other beds of limestone occurring at intervals farther down in the section for a distance of about fifteen feet. Farther down, limestone bands become less concretionary and gradually increase in thickness until they blend gradually with the top of the Onondaga. Although

*Werneroceras* has not been found in the type section of the Union Springs shale, its horizon is doubtless represented there as at Stockbridge by the final limestone band of the Union Springs member.

The discrepancy in lithology between the type section and more westerly sections of the Cherry Valley limestone is largely responsible for the apparent difference of opinion between the writer (Flower, 1936) in citing *Werneroceras* from the Union Springs member, and Miller (1938) in citing it from the Cherry Valley member of the Marcellus. Clearly faciological changes are such that it is not possible to draw a precise boundary at the base of the Cherry Valley limestone on the basis of lithology which will be exactly equivalent in all sections. The matter is largely of academic interest, inasmuch as only a very small interval of the section is involved. More important, however, is the possibility of recognizing restricted horizons in this part of the section by means of the fauna.

The lower part of the Union Springs shale has never been subjected to sufficiently systematic collecting to permit any conclusions as to the possibilities of faunal segregation of minor elements. The lowest part of the section which has come to the attention of the writer consists of the upper eight feet of the shale as known from Cherry Valley and more western localities. The fauna here is that generally considered typical of the Union Springs shale. *Styliolina fissurella* is dominant, *Lunulicardium marcellense* is abundant in all sections, though it extends over a considerable vertical thickness and is clearly useless as a precise horizon marker. A Bellerophon-like gastropod occurs, which attains considerable size particularly in the Cherry Valley section, and may readily be mistaken for the unfortunately little known *Tornoceras* which occurs in this part of the section at the three localities which I have collected most closely, Cherry Valley, Stockbridge and Union Springs. Less common is a large *Pan-enka*, aff. *P. ventricosa*, one of the few species which appears to continue into the overlying Cherry Valley limestone. All of these forms are found in association with the *Werneroceras* at Stockbridge Falls, where the fauna as well as the lithology suggests the Union Springs and not the Cherry Valley.

The thin shale band between the *Werneroceras* layer and what I propose to regard as the base of the Cherry Valley limestone, accepting momentarily the lithological boundary as developed from Stockbridge Falls west to Union Springs, seems to contain no diagnostic species. In it occur large concretions, though they are never continued to form a band of limestone in these regions. The Cherry Valley section is exceptional in this respect.

The lower member of the Cherry Valley is a massive block of limestone which rarely contains cephalopods. Lithologically it is identical to the upper layer, though inclined to be finer grained and less crystalline at the base. This layer I have found to contain *Aulopora*, sp. in great numbers, which I have never observed anywhere in the upper layer. It also contains abundant *Proetus haldemani* Hall, *Leiorhynchus limitare*, and several small gastropods. *Marcrochilina ononagaensis* Clarke, I have found only in this layer, but the species is not common and may occur in the overlying cephalopod beds. The *Aulopora*, abundant *Proetus* and small gastropods seem to be excellent criteria of this layer. It also contains a large thick-shelled *Coleolus*, which is apparently closer to the *C. crenatocinctum* Hall of the Onondaga than to the species which he described from the Cherry Valley limestone, *C. aciculatum*, a smaller form with a curved apex, and no known surface ornament. The only cephalopods which I have found in this bed consist of inadequate fragments of *Agoniatites*. The shaly partings which separate this from the overlying mass of the Cherry Valley limestone sometimes contain poorly preserved *Agoniatites*. Although these specimens have been carefully examined with a comparison with *A. nodiferis* in mind, they fail to show any trace of the nodes which characterize that species.

The fauna of the upper half of the Cherry Valley limestone consists largely of cephalopods. These are confined to a few layers near the middle of the bed. Extraction along bedding planes is exceedingly difficult except under propitious conditions of weathering. In general three cephalopod horizons can be recognized, each marked by a bedding surface, though occasionally the shells are packed so thickly and so deeply that the beds are

not distinct. The lowest bed, and the poorest, usually contains only fragments of the characteristic *Agoniatites vanuxemi*. It has yielded some of the rarer and more interesting of the smaller forms, including *Acleistoceras jonesi* at Stockbridge, *Verticoceras erectum* at Stockbridge, *Ovoceras oviforme* at Stockbridge and Union Springs, and *Michelinoceras swarthi*.

The overlying bed appears to lack most of the rarer nautiloids, and consists largely of *Agoniatites*. *Striacoceras typum* (Saemann) is present. The highest bed contains the best preserved of the species of this orthoceracone, as well as the most abundant ones. *Agoniatites* still persists, though it is not uncommon to open large slabs at this layer without exposing a single specimen of this form. This bed has yielded all of the gyroceracones which I have collected, as well as *Centroceras marcellense* and the large brevicones. The absence of *Agoniatites* in this layer is characteristic of the Stockbridge locality, but is less marked at Union Springs and at Manlius is nonexistent. It is this layer which is exhibited in the New York State Museum bearing numerous ammonoids, orthoceracones, and two specimens of the rare large brevicones of the Cherry Valley. (See Miller 1938, frontispiece.)

With these horizon markers in mind, it is possible to turn to the type section of the Cherry Valley limestone and by recognizing the same layers, to determine the point in the section which is represented farther west as the lithological base of the Cherry Valley limestone. Clarke (1901, p. 121) records 328 feet 2 inches of shale below the appearance of limestone in the section. The next measured interval, of 1 foot 5 inches consists of a series of limestones separated by shale beds, of which the lowest carries *Werneroceras*. The overlying shale, 4 feet 9 inches is noted for an abundance of *Agoniatites nodiferis* (Hall). Above this I have found the section to differ from that of Clarke, and find it possible to recognize the two main divisions of the Cherry Valley proper, the lower containing *Proetus*, *Aulopora*, but only rare and fragmentary cephalopods, the upper bearing the cephalopod layers, in which *Agoniatites* is more abundant at the base and *Striacoceras* at the top. The remainder of the section can be ignored. The overlying shales belong to the Chittenango member. When followed upstream the crest of a low fold is encountered as a result of which

this section is repeated down to the *Agoniatites nodiferis* bed at the base of the Cherry Valley. Reëxamination of the section has shown that the writer was probably in error in correlating this bed with the middle shaly parting between the coral and cephalopod members of the Cherry Valley limestone in more western areas. (Flower, 1936.)

**Werneroceras plebiforme** (Hall)

Plate 1, fig. 3

This species has been redescribed with complete bibliographic references by Miller (1938) and the present description is restricted to such supplementary and revisionary data as are supplied by our specimens. The largest and most complete individual consists of the internal mold of the outer whorl and a small portion of an inner whorl, and an impression of the exterior to which adhered numerous small fragments of the shell as well as a part of the internal mold of the earlier whorls. Most of the shell fragments and interior were so badly weathered that they could not be retained, and crumbled under cleaning. However, the external mold showed remarkably clear surface features. For purposes of illustration an artificial rubber cast was made from the external mold and applied to the natural internal mold of the outer portion of the conch.

The disc attains a maximum of 130 mm. in diameter. Portions of four whorls are preserved, and comparison with other specimens indicates that within the apparent umbilical gap of 19 mm. there were originally at least four additional volutions not indicated on the present individual. The section of the outer whorl is slightly distorted; apparently the arching of the ventral wall has been exaggerated by slight lateral flattening. In its present state the apertural end of the specimen shows a whorl height of 50 mm., and the width, which is much greater than the height even in the present compressed specimen, must have been at least 80 mm. The impressed zone has a depth of 20 mm.

The surface is marked by a pair of prominent lateral spines which are seen on typical internal molds only as nodes. The series of specimens from Cherry Valley fail to show the nodes on the lower part of the shell. Although in the mature whorls the spines tend to be somewhat more completely filled by shell material, exfoliation is largely responsible for the condition of

the figured specimens. The nodes shown on our specimen are stronger than was previously suspected, and increase rather than decrease in prominence on the later whorls. The nodes increase in size on the last two volutions, but decrease in prominence. There are twelve on the next to the last volution, and only eight, not all of which are preserved, on the final whorl. The nodes of this whorl are preserved only basally, but even on the internal mold they projected markedly, and are broken just beyond their bases. The large size of the nodes, the last of which is 9 mm. in width and 11 mm. in length, suggests that the spines of the surface may have approached in prominence the nodes of *Hercoceras* Barrande. However, in *Werneroceras* the nodes are uniformly solid projections, hollow only at the base, and have no relation to the spoutlike nodes of the *Hercoceratidæ*.

The lines of growth are very clearly shown in some of the inner whorls, though naturally only the lateral portion is shown. These consist of closely spaced striæ and liræ, generally fine and threadlike, but occasionally thickened at irregular intervals giving the surface an obscurely fasciculate appearance. These lines slope apicad from dorsum to venter over the entire exposed surface. As often happens in nodose ammonoids, the lines of growth are modified where they come in contact with the spines. Apicad of each spine the lines of growth are more markedly oblique than elsewhere, and are relatively transverse after a node is passed.

*Discussion.*—Comparison of the Stockbridge material with the types and with a fine suite of specimens in the New York State Museum from the type locality shows that while there is some variation within the species, there does not seem to be justification for dividing it. Variations noted have to do with the ratio of height to width of the whorl, and also with the closeness of coiling. In neither respect does the Stockbridge material differ from specimens from the type locality of the species. There variation is accompanied by so many specimens expressing intermediate conditions between the extremes that the conclusion was reached that a single variable species is involved.

*Type.*—University of Cincinnati Museum, No. 22866, hypotype.

*Occurrence.*—From the *Werneroceras* zone at Stockbridge Falls, Oneida Creek, Madison County, New York. The syn-

types, and all previously known representatives of the species are from Cox's ravine, Cherry Valley, New York.

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## III. A GONIOCERAS FROM VIRGINIA

### ABSTRACT

A new species of *Gonioceras* from Virginia represented by an exceptionally large specimen is described and figured. Comparison with other *Gonioceras* indicates that while knowledge of that genus is unsatisfactory, the beds yielding the specimen are regarded as probably lower Trenton in age.

### INTRODUCTION

A large *Gonioceras* in the collections of the University of Cincinnati Museum is remarkable both for its unusual size and for its affinities. The specimen is exceeded in size by only one other known to the writer, a specimen figured by Troedsson (1926, pl. 65) of *Gonioceras groenlandicum* Troedsson, of the Cape Calhoun series of northern Greenland. Further, the species is closely related only to *Gonioceras holtedahli* Troedsson of the Gonioceras Bay limestone of northern Greenland. There is some question as to the exact age of the Gonioceras Bay limestone, Troedsson (1926) originally regarded it as Black River in age, but Teichert (1937, pp. 14-18,) has shown that it is probably best regarded as lower Trenton in age. The Chickamauga limestone has generally been recognized as containing several distinct horizons, but has been considered to be older than Trenton, and has been referred to the Blount group, believed to be intermediate in age between the Chazy and the Black River.

## DISTRIBUTION OF GONIOCERAS IN AMERICA

*Gonioceras* first appears in the Chazyan of the Champlain Valley, where it represented by *G. chaziense* Ruedemann (1906) in the Crown Point limestone, middle Chazyan. The writer has subsequently found a different but related species in the upper Chazy Valcour limestone of the same region. Practically contemporaneous with these occurrences in the north, is the appearance of *Gonioceras* in the lowermost Ordovician strata exposed in the Nashville dome. An as yet undescribed *Gonioceras* appears in the Murfreesboro limestone, a species which appears to be closely allied to the Chazy species of the Champlain Valley. The overlying Pierce limestone is a bryozoan facies which has not yielded cephalopods, but *Gonioceras* reappears in the next formation, the Ridley limestone, where it was identified by Galloway (1919) as *G. anceps* Hall. It is very doubtful whether it is actually conspecific with the Black River species of New York, which is not only widely separated geographically, but considerably younger. Precise correlation of the Lower Ordovician of the Nashville Basin with the Chazyan of New York is not very certain. The Murfreesboro limestone contains in addition to the *Gonioceras*, *Ruedemannoceras stonense* (Safford, 1869, p. 290, pl. 4, fig. 2) and a *Centrocyrtoceras*. *Ruedemannoceras* and *Gonioceras* occur together in both the Crown Point and Valcour limestones of the Champlain Valley. *R. stonense* is the only known occurrence of that genus in any region other than that in New York. *Centrocyrtoceras* is known in the Champlain Valley from only one small undescribed species from the Valcour limestone. The Murfreesboro limestone may on this basis be regarded as equivalent to the middle or upper Chazyan, the *Centrocyrtoceras* apparently favoring the latter correlation. However, middle Chazyan cephalopods are not very abundant in the Champlain basin, and are probably not completely known.

The Pamela limestone of western New York occasionally yields *Gonioceras*, though the species has not yet been studied closely. This formation was at one time regarded as Chazyan,

then placed in the Stones River group, and has more recently been regarded as basal Black River, though on the basis of the presence of the thinning edge of the formation overlapping strata regarded as Chazyan in the Ottawa Valley, and it does not seem that the evidence thus far presented necessitates or justifies this change, proposed by Wilson and later accepted by Kay.

*Gonioceras* is abundant in the Watertown limestone of the Black River group in western New York, but is unknown in the Black River of the Champlain Valley. The Watertown species is *Gonioceras anceps*, but restudy will probably show that more than one species is actually present, as specimens of comparable width show marked variation in the rate of expansion. *Gonioceras occidentale* Hall and *G. occidentale* var. *homerense* Foerste characterize the Platteville of Black River age in Wisconsin. *G. kayi* Foerste was described from the Trenton Decorah formation. Foerste (1932-33) later recognized both *G. occidentale* and *G. kayi* from the Platteville member at Mineral Point, Wisconsin. *G. occidentale* has been found by the writer in beds of probably Platteville age in the cryptovolcanic structure of Kentland, Indiana.

In southern Ontario Kay (1937, pl. 9) has found an undescribed *Gonioceras* to be characteristic of the Rockland formation, basal Trenton. Kay also includes in the Rockland the limestones of the Paquette Rapids which contain a *Gonioceras* close to *G. occidentale*. These beds have been formerly regarded as Black River in age, but Kay regards them (1942, p. 604) of higher Rockland age, though the basis for this conclusion is not made clear. These beds carry a distinctive fauna, including many species absent from the typical Rockland, and also a few species, notably *Receptaculites occidentalis* Salter and *Maclaurina logani* (Salter) which were originally described from these beds, and which Kay (1937) regards as diagnostic of the Rockland. Available sections illustrate that the Paquette Rapids fauna occurs above massive beds bearing *Actinoceras* which appear to be the equivalent of the Watertown member of the Black River. However, the possibility that the fauna may be older than Rockland has not received adequate consideration as yet. Certainly its occurrence above the Watertown member of the Black River is not adequate proof of its Trenton age.

While it is not possible to discuss the intricacies of correlation and nomenclature of the Ordovician of Ontario at the present time, it should be pointed out that the Trenton age of the Paquette Rapids beds was stated categorically by Kay but not proved. Further, the present boundary between the Black River and the Trenton is not a natural one. Kay has arbitrarily selected the top of the Chaumont formation, which includes the Leray and Watertown members where they cannot be differentiated, as the top of the Black River, and has arbitrarily used the strata regarded in Ottawa as Trenton as the type section of that formation. The "Trenton" beds which contain *Gonioceras* in southern Ontario are Rockland in age. They are absent in the type section of the Trenton at Trenton Falls, and likewise in the type section of the Black River. As such, they are intermediate in age, and only close faunal study can determine in which group they should be placed.

The remaining important occurrence of *Gonioceras* is that of northwestern Greenland. *G. holtedahli* Troedsson occurs in the *Gonioceras* Bay formation which Troedsson (1926) originally regarded as Black River in age, largely because he saw in the overlying Cape Calhoun formation fossils of Black River affinities, and felt that that formation might embrace the Black River in part also. Teichert (1937) has subsequently reviewed the problem of the age of these beds, and came to the conclusion that they were probably not older than basal Trenton, apparently accepting the Rockland as Trenton. The overlying Cape Calhoun beds contain *Gonioceras wullfi* Troedsson, *G. groenlandicum* Troedsson, *G. angulatum* Troedsson, and *G. cf. groenlandicum*. Troedsson believed that these beds may range from Black River to Richmond. Teichert (1937) also regards the Cape Calhoun as probably comprising several distinct horizons. The formation is thick, and it was not possible to collect the fossils with regard to their stratigraphic relationship. Teichert (1937) regards the formation as Trenton, at least in part. S. K. Roy (1941) refers the Cape Calhoun to the Richmond without question, but treats the Red River series of Manitoba in the same

summary fashion, and, even more surprisingly, regards the Viola limestone of Oklahoma as Richmond, considering the presence of a species from Mt. Silliman related to *Westonoceras deckeri* of the Viola limestone as evidence of Richmond age. Teichert points out that of the Cape Calhoun cephalopods, only three genera are not known to occur in strata of pre-Richmond age. These are *Apsidoceras*, *Huronina* and *Danoceras*. The writer has recently found *Apsidoceras* among upper Trenton material from Montreal.

From the above summary it is evident that *Gonioceras* has a very considerable vertical range. In the Champlain Valley it is confined to the Chazyan, and is not known from the Black River. In the Tennessee Basin it occurs in the Chazyan Murfreesboro and again in the Black River Ridley limestone. Though generally regarded as an arctic genus, the earliest *Gonioceras* are not boreal, at least in their known distribution. It is significant that the genus has not been found in the Chazyan of the Mingan Islands, formerly regarded as very closely allied to the New York Chazyan. Re-study of the Champlain cephalopods shows that while a strong resemblance remains, practically none of the cephalopod species of New York and the Mingan Islands are identical, and there is more in common between the Murfreesboro fauna and the Chazyan than the present published data would indicate, suggesting a dominance of austral over true boreal elements in the faunas of the type Chazyan.

In Black River time *Gonioceras* is an essential component of the faunas which have been regarded as boreal. The Black River fauna continues on into strata now regarded as lower Trenton with specific changes, but without any major appearance of new genera or the disappearance of old ones. Possibly the Cape Calhoun formation may contain the youngest of the known species of *Gonioceras*, but it is not certain that even these strata are younger than lower Trenton. However, in this region there may reasonably be expected to be preserved faunas of Black-River and Richmond affinities, for it is generally known that in Trenton time the Black River fauna disappeared from eastern North America, retreating northward, where it developed gradu-

ally into the Richmond fauna. Formerly it was thought that the boreal fauna did not invade eastern North America again until Richmond time, but Kay (1935) has clearly demonstrated the presence of this fauna in the upper Trenton of Minnesota, New York and Ontario.

*Gonioceras hubbardi* is clearly not related closely to any of the Chazyan species, and the condition of its sutures suggests only *Gonioceras holtedahli* Troedsson of the Gonioceras Bay limestone. It appears safe to conclude that the stratum which yielded the specimen is probably to be correlated with that formation, but this is not very satisfactory, since the age of the Gonioceras Bay limestone is not established upon a very firm basis. Further, two other unsettled problems make the matter very uncertain. First, it has not been demonstrated that species of *Gonioceras* evolve in any orthogenetic series in strict accordance to the occurrence of the species in the stratigraphic column. Second, it is by no means certain where the best place may be to draw a boundary between the Black River and the Trenton. The Cape Calhoun species of *Gonioceras* and also *G. cf. groenlandicum* of the Rockland of Ontario, seem to have the lateral portion of the sutures more strongly recurved than any Black River species, or than *G. hubbardi* or *G. holtedahli*. However, as seen from the above summary, much still remains to be learned about *Gonioceras* in America.

***Gonioceras hubbardi*** Flower, n. sp.

Plate 3, fig. 7

The holotype is a natural horizontal section consisting only of the phragmocone, 370 mm. in length. At the adoral end one side is embedded in the rock and not exposed; the other side at the opposite end is lost by weathering, as the plane of weathering is irregular, and slightly oblique to the plane of the specimen. The rate of lateral expansion is moderate, much less than is considered normal for the genus. The conch expands from 98 mm. to 100 mm. in a length of 100 mm. in the middle portion. Although the sides are not clearly exposed adorally, the condition of the sutures suggests that the same expansion continues to the adoral end of the specimen.

The section of the conch is not clearly shown, but certain of its features can be inferred from the holotype and also from the

paratype. Adapically the siphuncle clearly lies very close to the lower wall of the shell, which is apparently very slightly convex. The other wall is apparently more strongly arched. Near the middle of the specimen practically the entire width of the shell is preserved at a region slightly dorsad of the siphuncle.

The sutures must be nearly straight vertically, though strongly curved laterally, showing the pattern typical of the genus. The details of the lobation of the suture vary slightly from dorsum to venter, presenting variations in different parts of the shell which compare with differences which have been used elsewhere for specific criteria in *Gonioceras*. The mid-ventral lobe of the suture is more transverse at the center than is the mid-dorsal lobe.

The siphuncle which lies close to the ventral wall, appears to be quite typical of the genus in the form of the segments. At the base of the specimen a segment expands from 8 mm. to 18 mm. and is 2.6 mm. in length. The vertical dimensions of the segment have not been determined, but as in most *Gonioceras*, the width is probably considerably greater than the height.

At the adoral end of the specimen the cameræ appear to have become slightly crowded, but no trace of the living chamber remains. There is no evidence of the fusiform outline shown in the mature portion of *Gonioceras groenlandicum* Troedsson. At the base, the specimen appears to be expanding at the same slow rate as the central portion. The adoral end may be contracted very slightly, but the present evidence fails to show this conclusively.

The sutures are closer to those of *Gonioceras hottedahli* Troedsson than to any other described species. They are shown clearly in the accompanying illustration.

*Discussion.*—The slender form is perhaps the most salient feature of this species. Comparison with previously described species of *Gonioceras* serves for the most part to show that they have been inadequately described and figured. The Chazyan species, *G. chaziense*, is not only smaller, but also has proportionately broader lateral zones, though the sutures do not extend so far apicad at their lateral extremities. The same differences serve to distinguish this from an undescribed Valcour limestone species. The Murfreesboro form is known to me only

from incomplete specimens, not showing the lateral portion of the conch clearly. However, there is good indication that this form agrees in general with the Chazyan types in not having the sutures very strongly recurved, and also is peculiar in that the height is larger in proportion to the width than in any other species.

The suture pattern is closer to that of *Gonioceras holdedahli* Troedsson (1926, p. 83, pl. 48, figs. 1-2; pl. 49, fig. 1; pl. 50, fig. 1) than to any other known species. The lateral saddles of the suture are rounded, and the suture becomes straighter though oblique, on approaching the lateral margin. In *G. wulffi* the sutures are more broadly rounded laterally, and do not become straight near the edge of the conch. In *G. angulatum* and *G. kayi* the lateral saddles are more angular, the sutures straighter in the lateral zone. In *G. groenlandicum* the sutures extend much farther apicad laterally than in this species, and remain more curved as in *G. wulffi*. In *G. anceps* and *G. occidentale* the conch expands more rapidly. Typical *G. anceps* does not have the sutures so strongly recurved laterally. Our species is distinguished from *G. holdedahli*, seemingly its closest relative, in that the lateral flanges of the sutures do not extend so far apicad. The type shows this clearly, owing to the mode of preparation. The natural section showed a little relief, and to bring out the precise course of the sutures it was necessary to black in every other camera. In this way the distinction of the sutures is retained, even where they come very close together, a phenomenon which makes the tracing of sutures in strongly lobed species of *Gonioceras* sometimes very difficult.

*Types*.—Holotype and paratype, University of Cincinnati Museum, Nos. 22846-7.

*Occurrence*.—From the Chickamauga limestone, north side of Buckeye Mt., Giles County, Virginia. The section has been given by Hubbard and Croneis (1924).

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#### IV. INVESTIGATIONS OF ACTINOSIPHONATE CEPHALOPODS

##### ABSTRACT

Previous treatment and investigations of actinosiphonate cephalopods are briefly reviewed. Evidence is offered to show cases in which actinosiphonate structure has appeared independantly in several distinct genetic lines, and more cases are suspected of having undergone similar development. As a structure of polyphyletic origin, actinosiphonate structure is too broad a generalization to have any genetic significance. However, various types of actinosiphonate structure occur. Early Ordovician cephalopods, *Falcouroceras* and *Minganoceras* show some distinctive structural features and ontogenetic anomalies. *Actinomorpha* is described as an example of bipectinate rays of deposits in the Ordovician. The deposits of *Archioceras* are described in detail on the basis of serial sections. Those of the *Brevicoeratidae* are briefly described.

##### INTRODUCTION

Actinosiphonate deposits within the siphuncles of cephalopods are differentiated from annulosiphonate deposits by the development of numerous processes extending from a thin lining of the siphuncle radially toward the center. Such structure was taken by Hyatt (1900) as the criterion of one of the two divisions which he made in the *Cyrtocoanites*. In the *Actinosiphonata*, as opposed to the *Annulosiphonata*, were placed, in addition to genera known to possess actinosiphonate deposits, practically all breviconic shells such as were once placed in the too-inclusive genus *Gomphoceras*. Foerste (1926) reinvestigated the *Actinosiphonata* and pointed out for the first time the perplexing problem of the peculiar and seemingly erratic distribution of actinosiphonate structure. Not all of the genera formerly placed in the *Actinosiphonata* were actinosiphonate. In fact, a very considerable group of genera appear to be completely devoid of such deposits. Hyatt had recognized that actinosiphonate structure did not hold throughout his *Actinosiphonata*, while not all of the *Annulosiphonata* were annulosiphonate. He believed that each type of structure was developed in its own group. Annulosiphonate cephalopods have been treated by various recent investigators, and at least two types of structure are involved, to which Strand (1934.) applied the names of lunettes, for the deposits of actino-

ceroids, and bulettes for the deposits of other forms. The bulettes he regarded as derived from the connecting ring, and probably rather closely related to actinosiphonate deposits. Flower (1942) has proposed that the annulosiphonate deposits of the actinoceroids may be also derived from the connecting ring, though indirectly by growth of a part of the ring which was specialized first into an eyelet (Flower, 1942) and which was presumably nonporous.

Among the simpler genera assigned to the Actinosiphonata are the Oncoceratidae, which lack all trace of actinosiphonate structure. Attempting the removal of such forms from the group, Teichert (1933) proposed to substitute the name *Cyrtoceroidea*, and later (1939) presented a classification of the known actinosiphonate genera into families which were based largely upon the form of the shell. The scheme which he proposed is a logical and a convenient one, but it is to be greatly feared that it is not natural. The present evidence suggests strongly that actinosiphonate structure developed several times independantly in different lines of descent within the Nautiloidea. Further, additional studies have lead to the belief that true genetic relationships can be traced among various genera, and that such relationships show little constancy in the form of the shell, upon which Teichert has based his familous divisions.

Actinosiphonate structure is not as yet known from any cephalopods older than the Chazyan. There two genera occur, *Minganceras* Foerste and *Valcouroceras* Flower, n. gen. *Diestoceras* has also been reported from the Chazyan of the Mingan Islands, (Foerste, 1938) but it is not certain that this is a true *Diestoceras*, and the single Chazyan species is not known to have actinosiphonate structure. *Valcouroceras* gives rise to those Upper Ordovician cephalopods which are currently assigned to *Wetherbyoceras* Foerste,\* and is very closely related to species which

\* Unfortunately *Wetherbyoceras* is based upon *Cyrtoceras conoidale* Wetherby of the Cincinnati. That species cannot be recognized unless the original type is found. According to Foerste, (in correspondance) types of this and other Cincinnati cyrtoceracones have been lost. Under the circumstances, it will not be possible to recognize *Wetherbyoceras* Foerste.

have been described and figured in connection with this generic name. It is not certain that *Diestoceras* is closely allied to this stock, nor is it certain which if any of the Silurian and Devonian actinosiphonate cephalopods may be traceable to this early beginning of the Actinosiphonata proper.

However, in tracing the development of *Oncoceras* and *Oonoceras*, (Flower, 1942, p. 24, fig. 1, p. 30) it appears that in the Silurian *Oonoceras* attains a second period of form modification resulting in new generic types. One of these is *Oocerina* Foerste which can be separated from *Oonoceras* only by the development of actinosiphonate deposits. In all other differences, which involve the surface markings and the width and expansion of the segments of the siphuncle, these two genera intergrade. From this it is necessary to infer either a degree of convergence in contemporaneous species almost too remarkable to be credited, or that *Oocerina* is nothing more than an *Oonoceras* which developed actinosiphonate deposits.

A second and even more startling case of the development of actinosiphonate deposits is encountered in another line of descent probably traceable to the Oonoceratidæ. In cyrtoceracones of the Silurian probably best placed in *Cyrtorizoceras*, increase in coiling resulted in the development of a low-spired trochoceroid. This is *Oxygonioceras* Foerste. A considerable number of species from the Middle Silurian of Bohemia described by Barrande suggest this relationship because they are so nearly intermediate between the two genera that there is some doubt in which they are best placed. *Oxygonioceras* in turn seems to be the ancestor of *Mitroceras* and *Foersteoceras* of the Upper Silurian, in which actinosiphonate deposits appear. These genera form the first of the Brevicoceratidae, which in Middle Devonian time developed into degenerate loosely coiled trochoceroids, two distinct gyroceraconic genera which appear to have developed independently from trochoceroid ancestors, and a variety of breviconic genera. This family, treated in more detail in a work by the writer on Middle Devonian cephalopods of New York to be published by the New York State Museum, shows not only a third line of actinosiphonate cephalopods which cannot be placed with

either of the first two as a genetic group characterized by actinosiphonate deposits, but also two other features of interest. First, the actinosiphonate deposits within this family are highly distinctive in form, and show that actinosiphonate structure is too broad a generalization. There are various types of actinosiphonate structure, and one type is highly characteristic of this family. Perhaps further study of other actinosiphonate cephalopods will yield morphological features by which other independent groups characterized by such structure can be recognized. Second, this family shows that not only can actinosiphonate structure appear in a line in which such structure was originally absent, but that it can give rise to new forms in which the structure may be lost. This was shown strikingly by the breviconic genera. *Brevicoceras* Flower, (1938,) which is typically actinosiphonate, may give rise to *Exocyrtoceras* and *Verticoceras*, also possibly *Ovoceras*, in which the structure is never developed. This is shown by the fact that the genera are so closely allied in all other features, that it is necessary to set arbitrary limits for their separation. If the presence or absence of actinosiphonate structure were used, some species placed in *Brevicoceras* on the basis of section and sutures and the hyponomic sinus would have to be removed to *Exocyrtoceras*. Still another division of species between these two genera would be effected if the sutures were considered diagnostic, and still another if the presence or absence of the hyponomic sinus is used. As this last character has the dubious sanction of long usage, and seemed to be no worse at least than the others, it was retained as the diagnostic feature, species with a sinus being placed in *Brevicoceras*, while those without it were placed in *Exocyrtoceras*. In the Brevicoceratidae relationship was largely based upon the presence of species which bridged the gap between genera erected on the customary basis of shape, section, sutures, and which, except for the ultimate loss of actinosiphonate deposits, appear to be quite uniform in the structure of the siphuncle. It is largely upon the strength of this family, which contains brevicones, trochoceroids and gyroceracones, that it has seemed necessary to reject Teichert's families based upon the form of the shell.

There are other cases which it has not been possible to investigate adequately in which actinosiphonate structure may have appeared in other lines of descent. One of the most striking is found in the phragmoceroids. Two Silurian genera, *Phragmoceras* and *Conradoceras* lack actinosiphonate deposits. In the Middle Devonian of Bohemia they are replaced by two actinosiphonate genera, *Bolloceras* and *Paraconradoceras* (Foerste, 1926). Indeed, Foerste placed some Devonian species in *Phragmoceras* but these differed from all known Silurian species in being actinosiphonate. Further, the features of the aperture upon the basis of which Foerste placed these species in *Phragmoceras*, and placed others associated with them in *Bolloceras*, did not appear to be constant, (Flower, 1938, p. 61-63) therefore the writer proposed that the better division between these genera would be the presence or absence of actinosiphonate structure, thereby placing all Devonian species formerly included in *Phragmoceras*, in *Bolloceras*. The Silurian *Phragmoceras* and *Conradoceras* are stratigraphically isolated from the Middle Devonian *Bolloceras* and *Paraconradoceras*. From what has been learned of homeomorphy in other fossil groups, it may be that the Silurian and Devonian forms represent merely a remarkable case of form convergence, and that they are not closely related at all. However, there is still the possibility that *Bolloceras* and *Paraconradoceras* may represent yet another case of development of actinosiphonate structure within distinct lines of descent. Certainly no other origin for these genera has yet been suggested.

Another problem, which was first noted by Foerste (1926) was the apparent erratic distribution of actinosiphonate deposits. Sometimes they did not appear in all members of a group which seemed to be a good genus on the basis of all other features. Sometimes Foerste used actinosiphonate structure to divide such form-genera, as in the separation of *Oocerina* from *Oonoceras*.\*

\* This remains at present as the only good difference. Foerste used in addition the presence of annuli on *Oocerina*, but the transverse ridges of the surface are not true annuli (Flower 1942, p. 24-31) and Bohemian species show a gradation between the ridged surface of the genotype of *Oocerina* and typical *Oonoceras*.

However in cases where no other support could be found for separating extant genera, division on the basis of actinosiphonate structure was not attempted. *Amphicyrtoceras* for example, is not known to be actinosiphonate in the genotype, but Foerste referred to it *Amphicyrtoceras ? penultimum* Barrande which is actinosiphonate but it is otherwise typical of the genus. Other examples are cited by Foerste (1926, p. 298) who also called attention to the fact that nothing was known of the constancy of actinosiphonate structure within a species. In some, as in *Wetherbyoceras*, it appears to be uniformly present. In some other species, it is shown in some individuals but not in others. Teichert (1939, 1940) proposed that conditions of preservation might account for this difference. This may and almost certainly does apply to many cases, but there are examples known in which the preservation of all other features is excellent, and there seems to be no good reason why actinosiphonate deposits, if originally present, should not be retained. Flower (1938, p. 8-10, 1939, p. 63-66) suggested that actinosiphonate deposits might be structures which appeared late in the life of the organism, probably gerontic. The two explanations are not mutually exclusive.

## STRUCTURE OF ACTINOSIPHONATE DEPOSITS

In general those deposits which have been classed as actinosiphonate apparently begin as a thin organic lining within the siphuncle. From this lining processes develop which converge toward the center of the shell. Sometimes these are essentially tabular, and may pass from one segment to the next without any apparent break. In tracing the individual rays from segment to segment, they are normally obscured at the septal foramen, but in many cases pass it unmodified. As the rays of deposits are traced orad through a series of cameræ they may increase in number. This may be the result of either the appearance of new rays between older ones, or the division of any of the rays. Striæ on shells behave similarly.

Rays of actinosiphonate deposits may be simple lobes, or they may be complexly divided, usually alternately and somewhat ir-

regularly bipectinate, as noted in *Actinomorpha*, described below, and as also shown by Teichert (1940) in *Danoceras*. Both simple and bipectinate rays are known from the Ordovician through the Devonian. The published information is completely inadequate at the present time to show whether such differences are constant within a genus, as seems very probable, and if so, what types characterize the known actinosiphonate genera.

In some cephalopods continuous rays are not formed, but from the thickening of the siphuncle lining at the septal foramen in a manner sometimes recalling *Westonoceras* which is not properly actinosiphonate, more or less regular ray like processes may extend not only centrad toward the axis of the siphuncle, but also orad and apicad into the expanded part of the segments. Such deposits are quite distinct from those which form a continuous lining. They are characteristic of the genus *Diestoceras* of the Ordovician, and are known in the Devonian only in the family Brevioceratidæ. No Silurian examples of this type of structure have yet been encountered.

Actinosiphonate deposits are in one instance clearly a modification of the connecting ring. Thin sections of *Archiacoceras* under most favorable conditions of preservation show no differentiation of the deposit from the original connecting ring. They agree with the connecting ring in conditions of replacement and texture, and differ in both from the true shell structures of the septal necks. Opaque sections suggest strongly that the same applies to the other genera which have been studied here, *Valcouroceras*, *Actinomorpha*, *Herkimerocheras*, as well as to Middle Devonian brevicones from the Eifel region too incomplete for certain generic diagnosis.

Probably the most peculiar feature of actinosiphonate structure is its frequent absence in early portions of the siphuncle. Recapitulatory significance of such a phenomenon seems dubious, for if any ontogenetic progression is to be found in such parts, which can be altered by further secretion, the most advanced condition would be expected in the older part of the shell. It may be that other factors, possibly mechanical, are involved.

As has been noted above, actinosiphonate structure is a gener-

alization, rather too broad, to cover a variety of superficially similar structures which seem to have appeared several times in the history of cephalopods independently. Further statements concerning the morphology of these deposits are best confined to the individual types studied.

#### CHAZYAN ACTINOSIPHONATE CEPHALOPODS

The oldest actinosiphonate cephalopods thus far recognized are Chazyan in age. They fall into two genera, probably closely related, *Minganoceras* Foerste and *Valcouroceras*, Flower, n. gen. *Minganoceras* is known only from the genotype, *M. subturbinatum* from bed A5 of the Mingan formation of the Mingan Islands, and the species is apparently upper Chazyan, to be correlated with the Valcour limestone of the Champlain Valley. Apparently this species is known only from the holotype. The genus is depressed in section and faintly curved exogastrically, and is rather generalized in form. The sutures are essentially straight and transverse, the shell is not contracted at the aperture. Foerste (1938, p. 104, pl. 24, figs. 1-4) has supplied a very adequate description and illustration of this species and genus. *Valcouroceras* is best developed in the Valcour limestone of the Champlain Valley, but is also known from the lower Chazyan. The Valcour limestone material is fortunately abundant, though too often fragmentary, and usually preserves the internal structure clearly. It is exclusively from this genus that the following observations have been drawn. There is, however, no reason to believe that the siphuncular structure of *Minganoceras* is not similar in all essential features.

*Valcouroceras* is represented in the upper Chazyan by a considerable number of species. These differ from *Minganoceras* in form. The section is compressed in the early stages, the venter narrowly rounded so that the section is subtriangular. In later stages the shell may become broader than high. Over the living chamber the shell is slightly inflated and contracts toward the aperture. Usually the venter loses its narrowly rounded condition here and the shell as a consequence loses its subtriangular aspect.

Within the series of contemporaneous upper Chazyan species which make up the genus *Valcouroceras* as established on the basis of form and section, there exists an almost bewildering variation of internal structure, having to do with the form of the segments of the siphuncle and also with the actinosiphonate deposits within the siphuncle. However, further examination of this genus in the light of associated forms has made possible an explanation of some of these variations.

*Form of siphuncular segments.*—It has been previously noted by the writer (1941, p. 524-5) that the Chazyan cephalopods do not appear amenable to the usual division into orthochoanitic and cyrtochoanitic cephalopods. Instead, five groups were proposed for (1) orthochoanitic tubular siphuncles (2) suborthochoanitic siphuncles (3) cyrtochoanitic siphuncles which are suborthochoanitic in early stages (4) siphuncles which are cyrtochoanitic in the early stages later becoming suborthochoanitic, and (5) siphuncles which are broadly cyrtochoanitic throughout. *Valcouroceras* clearly belongs in the third of these groups. Early stages of the siphuncle are essentially tubular. Later stages show expansion of the siphuncle within the cameræ to an extent which can be roughly correlated with the growth stage. Some of the species are small, and these commonly fail to attain broadly expanded segments at all. Only in the larger species are very broad segments attained. It is apparent from this that those individuals which underwent a longer period of development, and which were long lived, attained a more advanced condition than did their smaller and presumably shorter lived relatives. This correlation is not perfect. The smaller and more primitive species may, as one can readily see, also produce large species which may agree with them in internal structure, while dwarfing of some of the large species may give rise to small species in which the siphuncle attains an advanced stage of cyrtochoanitic development. We have no examples of the former, but several of the latter, one in the Chazyan, and others in the closely related *Wetherbyoceras* of the Upper Ordovician.

The explanation of the plasticity of the siphuncle is relatively

simple. It applies not only to *Valcouroceras*, but also to a greater or lesser degree to the Oncoceratidæ, *Oncoceras*, *Beloitoceras* and *Richardsonoceras* of the Chazyan, and also to *Allumettoceras* which, together with *Tripteroceras* and an undescribed genus, seem to constitute a natural family of straight depressed cyrtochoanitic shells with empty siphuncles. That Chazyan specimens show this phenomenon more strikingly than younger Ordovician cephalopods which have been studied is believed to be attributable to a combination of two factors: 1. Chazyan species are nearer in time to the development of cyrtochoanitic structure. Consequently if, as appears likely, it developed tachygenetically, the suborthochoanitic stage should be more conspicuous in Chazyan species than in those of the Black River and Trenton. Ulrich and Foerste (1933) have remarked that there seems to be no good division between orthochoanitic and cyrtochoanitic structures in the Canadian, and presumably cyrtochoanitic structure must have been developed in the interval between the Chazyan and the Canadian, except, of course, in the case of the Actinoceroidea, which underwent a completely independent development. As a consequence it is to be expected that even in the upper Chazyan, cyrtochoanitic structure has not become thoroughly established in genera and families which it characterizes in Middle Ordovician and later horizons. 2. Further, the apparent wide discrepancy between the Chazyan and the younger cyrtochoanitic cephalopods in this respect may be more apparent than real. It must be remembered that in most Black River and Trenton formations early stages are exceedingly rare, and internal structure is not usually well preserved. In the upper Chazyan, however, abundant early stages have been found which can be studied by means of sections.

The very earliest stages of *Valcouroceras* have been encountered only in apical fragments which cannot be assigned to any of the several species with certainty. In fact, except for the broad dorsum, they are very difficult to distinguish from similar stages in *Beloitoceras*. The segments of the siphuncle have essentially straight septal necks, very short and often obscure, and the connecting ring is suborthochoanitic. The next stage in expansion

results in segments which are still slender, but in which the septal necks are recurved, and the siphuncle begins to show indication of a scalariform condition in vertical section, although the connecting rings are still only slightly expanded within the camerae (fig. 2A). The next stage (fig. 2B) shows an increase in the scalariform condition, the neck being straight on the venter, recurved on the dorsum, and with the connecting ring broadly adnate at its adapical end on the venter but not on the dorsum.

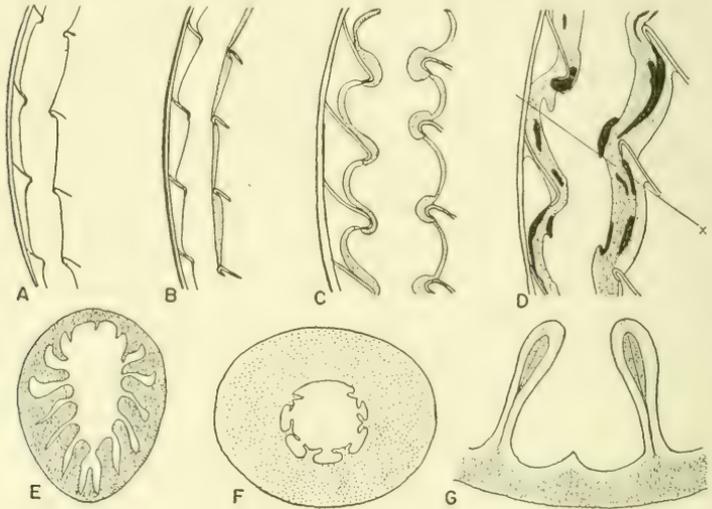


Figure 2. Structure of actinosiphonate deposits. A. Early segments of siphuncle of *Valcouroceras* lacking deposits. B. Later stage, showing beginning of thickening of ring on dorsum. C. Segments of adoral end of *Valcouroceras bovinum*. Actinosiphonate structure is not evident, and is only slightly developed in cross sections. D. Vertical section of *Valcouroceras cyclops* in which three distinct types of calcification are shown. This cannot be seen in cross sections. Same specimen as is illustrated by other sections in Plate 2, figs. 5-6. X denotes plane of section of Plate 2, figure 5. E. Cross section of typical *Valcouroceras* siphuncle. Generalized after a series of sections of *V. cyclops*. F. Cross section through septal foramen of *Brevioceras pompyense* Flower. G. Detail of cross section of siphuncle of *Archiacoceras ventricosum*, showing structure of rays and layers of the siphuncle lining.

This figure shows on the dorsal side of the siphuncle an organic lining which, as will be shown below, appears to develop

as a thickening of the connecting ring itself. The outline of the original connecting ring may be taken to be the outer or cameral surface of this deposit.

The next stages (fig. 2C-D) show progressive expansion of the segments of the siphuncle. The connecting rings become more recurved on the dorsum, the area of adnation becomes more pronounced on the venter, and the connecting rings are more strongly curved. In both figures the outline of the connecting ring is complicated by the presence of actinosiphonate deposits. In the last figure, 1D, the connecting ring has apparently not only grown by the addition of material to its inner siphonal surface, but also by the addition of material to its outer or cameral surface. Yet such deposits, by their origin and texture are similar to the connecting ring and contrast sharply with the septa and other true shell structures. They are not properly cameral deposits, except in that they lie outside of the original boundary of the siphuncle. In origin they agree with the connecting ring and contrast strongly with the true cameral deposits which are secretions of a true mantle surface.

*Actinosiphonate deposits.*—Well-developed actinosiphonate deposits in *Valcouroceras* have been studied by serial sections, both cross and longitudinal sections being used. In cross section the siphuncle is compressed. The thick lining of the siphuncle is well shown, and cannot be distinguished from the original connecting ring. From it rays project toward the center of the siphuncle. In a section which was essentially parallel to the plane of the septum, the lobes were thicker on the ventral than on the dorsal surface. Massive lobes flank a small pointed ventral process, and become less massive and also shorter as the dorsum is approached. On another specimen, the reverse was found to be true, and the explanation was found in the discrepancy between the plane of the section and the plane of the septum. Wherever the ground section came closest to the septum the siphuncle tended to be narrower, and the lobes of the deposits tended to become reduced. However, the significant fact seemed to be the bilaterally symmetrical arrangement of the lobes of the deposit within the siphuncle. Two cross sections are figured here, Plate 2, figure 5, and Plate 3, figure 7.

The appearance of longitudinal sections varies greatly depending upon the level to which such sections are ground. Plate 2, figure 4 shows one which has been ground parallel to the axis of the siphuncle attaining its center. Here a thin continuous lining is seen which is thickened at the septal necks in such a way as to appear annulosiphonate. The same condition is shown in text figure 1C. Such a section resembles *Westonoceras* so strongly that cross sections of that genus were made to determine whether actinosiphonate structure was developed there. None was found.

A section not attaining the center will cut some of the rays of the actinosiphonate deposit. In such a section in *Minganoceras* (Foerste, 1938, pl. 24, fig. 5) the rays may be seen projecting orad into each segment from the region of the septal foramen, but not attaining continuity from segment to segment. However, the same sort of section may be achieved in *Valcouroceras* by a section taken at the correct level, while a section nearer the wall of the siphuncle will show that these rays are essentially vertical partitions. They extend farther toward the center of the siphuncle at the adapical end of the segment than at the adoral end, but can be traced from segment to segment, though very short and poorly developed at the septal foramen when they are all but lost in the thickened siphuncle wall from which they arise. This is shown by the two sections on Plate 2, figures 5, and 6. Figure 5 is a cross section taken at the apical end of a fragment of shell, showing the deposits of the siphuncle. The deposits are thicker on the dorsum than on the venter here because the plane of the section cuts the middle of the siphuncle segment on the venter, but on the dorsum lies just apical of the septal neck, where the siphuncle is greatly expanded. The position of this section is shown in figure 1D by the line x. In order to study the siphuncle further, this specimen was sectioned obliquely, the plane of section attaining the center of the siphuncle adorally, while it passed obliquely away from the center adapically so as to preserve the entire cross section shown in Plate 2, figure 5. In the middle of the three segments shown, rays similar to those of *Minganoceras* are seen; they do not appear to at-

tain the adoral end of any segment. However, a more eccentric section, shown in the next adapical camera, shows the rays extending from one end of the segment to the other, and fused at each end with the lining of the siphuncle. When this same specimen was ground parallel to the axis of the siphuncle, a condition such as shown in figure 1D was found. The most perplexing phenomenon here is the apparent differentiation of structure within the actinosiphonate deposits. This was not observed clearly in any cross section. It is probable that, instead of any real differentiation of layers in the original organic deposit, the structures are here complicated by areas of dark calcite, often difficult to distinguish from the real deposits, which do not represent original calcareous structures, but which owe their dark color to substances from decayed tissues. It was not possible to make enough sections of the specimen from which this drawing was taken to trace out the structure in detail, or to be certain that actinosiphonate deposits have been properly differentiated from tissue remnants. Whether by tissue remnants or real organic calcareous deposits, there is clearly here some addition of material on the outside of the original connecting ring as well as on the inside.

Differentiation of various parts of the deposit in *Valcouroceras* is highly problematical. The cross section of Plate 2, figure 5 shows the margin of the lobes of the deposit to be darker than the remaining part, and the cavity is filled with light calcite. However, other specimens have failed to show similar phenomena, suggesting that it may be adventitious.

Genus **VALCOUROCERAS** Flower, n. gen.

Genotype.—*Valcouroceras bovinum* Flower, n. sp.

The shell is an exogastric cyrtococone which varies in section among species, and also among growth stages. The early part of the shell is compressed, with the venter more narrowly rounded than the dorsum, so that the section may be subtriangular. At the base of the mature living chamber the height and width may become equal, and in later portions the sides converge orad so that the section assumes a compressed condition again. On the

gibbous living chamber the venter is usually as broadly rounded as the dorsum.

The sutures may be straight and transverse in the young, but generally slope forward on the ventral side of the shell, forming rounded lateral lobes and broad rounded ventral saddles. The siphuncle is close to the ventral wall, and varies in ontogeny from suborthochoanitic to broadly cyrtochoanitic.

The surface of the shell bears coarse rather distant transverse markings. No hyponomic sinus is developed.

The siphuncle has already been described in some detail for this genus. The outline of the segments is variable, and actinosiphonate structure is only well developed in later portions of the phragmocones of larger individuals.

*Discussion.*—This genus is erected upon the basis of a considerable suite of specimens representing various species from the Valcour limestone of the Chazyan. While it is evident that more species are represented among our material than are described at present, some are represented by material too fragmentary to justify the application of new names. Unfortunately among such specimens are included the fragments representing the largest of all the species, which has supplied the best examples of actinosiphonate structure here. Such species of this sort as I have had occasion to figure, are designated simply as *Valcouroceras*, sp.

The genus, although an exceedingly plastic one, does not lend itself to further division, largely because the known species fail to fall naturally into smaller and more restricted groups.

*Valcouroceras* differs from its contemporary, *Minganoceras*, in the more compressed section, more rapid expansion, and the gibbous living chamber, as well as in the more subtriangular section of the shell. Outside of the Valcour limestone only one other species is known to the writer, an undescribed one from the Platteville limestone. *Wetherbyoceras* has been applied to Upper Ordovician cephalopods which are closely related to *Valcouroceras*. They represent more advanced types, in that actinosiphonate deposits appear in earlier stages of the shell, and differ

further in the possession of a hyponomic sinus. In form they are rather typical of *Valcouroceras* except for these details, and exhibit the ontogenetic modification of section from compressed to depressed, that characterizes the Lower Ordovician genus.

*Valcouroceras bovinum* Flower, n. sp.

Plate 4, figs. 2-3; 9-10

Conch strongly cyrtoconic, rapidly expanding, the living chamber contracting in the mature portion and becoming slightly compressed gerontically. The species is represented in our material by two specimens illustrating different stages of growth.

The holotype consists of an essentially complete mature living chamber and a portion of the phragmocone retaining the siphuncle. The living chamber has a basal height and width of 39 mm. In a dorsal length of 25 mm. and a ventral length of 52 mm., the aperture is attained which is considerably oblique from the axis of the last septum, which was nearly transverse, and also from the axis of the shell. The height across the aperture is 45 mm., the width, 37 mm. The radius of curvature of the ventral profile is variable over the living chamber, but averages 50 mm. The phragmocone has sutures which in the mature shell slope only slightly forward on the ventral side. The siphuncle, close to the mature living chamber, is made up of broadly rounded segments, somewhat scalariform in vertical section. A well-defined organic lining is seen within the siphuncle, quite typical of actinosiphonate deposits in a median vertical section. It was not possible to make a cross section to determine the presence or number of rays, but they are obviously not strongly developed.

The paratype is a slightly younger specimen( expanding from a compressed section of 22 mm. and 24 mm. at the base to a circular section of 32 mm. at the base of the living chamber. The 25 mm. of phragmocone on the venter contains six camerae. The shell attains a height of 42 mm. and a width of 39 mm. in the basal 15 mm. of the living chamber. The living chamber is incomplete, and has a maximum lateral length of 35 mm. Just beyond the base the sides become convex and the shell apparently assumes a compressed condition.

*Discussion.*—This is a large relatively rapidly expanding shell. By this it can be differentiated from not only smaller rapidly ex-

panding species, but also from the more slender *V. lativentrum* (Ruedemann).

*Types*.—Holotype, University of Cincinnati Museum, No. 24169; paratype, No. 24170.

*Occurrence*.—Valcour limestone, upper Chazyan, Little Monty Bay, southeast of Chazy, N. Y.

*Valcouroceras obesum* Flower, n. sp.

Plate 4, fig. 5

Conch strongly curved, faintly depressed in earliest part, with diameters of 18 mm. and 22 mm., expanding in 40 mm. ventrally to 30 mm. and 32 mm., where the conch is faintly compressed at the base of the living chamber. In the basal third of the living chamber, the diameters increase to their maximum of 32 mm. and 36 mm., contracting toward the aperture which measures 28 mm. and 34 mm., and is 50 mm. from the base of the living chamber as measured ventrally. Radius of curvature about 40 mm. for the ventral outline, but with curvature slightly greater on adoral half of living chamber.

Sutures rising adorally on venter, with shallow lateral lobes. Ephebic cameræ at a transverse diameter of 30 mm. measure 3 mm. in length. Siphuncle close to venter, compressed at septal foramen, its structure in section not observed in this species.

Aperture incomplete, but definitely transverse to axis of conch and without hyponomic sinus. The surface bears transverse lines of growth. Section with the venter obscurely subangulate in basal half of living chamber and adoral part of phragmocone.

*Discussion*.—Enough of this species is known to justify a reconstruction of the form, and indicates clearly a breviconic cyrtoceracone rapidly expanding apically, subcircular in earliest stage, faintly depressed in early ephebic portion, becoming more and more compressed over the living chamber which contracts slightly toward the aperture, contracting more laterally than vertically. An earlier portion of the specimen is preserved, which is too imperfect for accurate measurement and consists of a portion of the phragmocone filled with calcite, which was impossible to extract from the limestone matrix.

The species is larger than *V. seeleyi*, and is much more strongly curved. The dorsum is concave in portions of *V. obe-*

sum comparable in size to those of *V. scelleyi* in which it is definitely convex. The dorsum becomes very faintly convex in *V. obesum* only along the living chamber.

*Type*.—Holotype, University of Cincinnati Museum, No. 22172.

*Occurrence*.—From the Valcour limestone near Little Monty Bay, Chazy, New York.

**Valcouroceras cyclops** Flower, n. sp.

Plate 2, figs. 4-6; Plate 3, fig. 7; Plate 5, figs. 11-12

This species, the largest in the Valcour limestone, may be distinguished from all others by its large size. All specimens so far encountered are fragmentary, but two living chambers, both very poorly preserved are known, and a number of fragments from the adoral part of the phragmocone have supplied excellent actinosiphonate deposits. Because of the fragmentary nature of the specimens, it has been considered necessary to describe them separately. The large living chambers are so poorly preserved that they are not figured.

The shell is compressed and the venter subangular in the early stages of growth. The section becomes depressed at a shell width of 75 mm., at the base of the mature living chamber. Two nearly complete living chambers are known. One preserves only one lateral surface. It has a ventral length of 120 mm., a uniform radius of curvature of the venter of about 120 mm., and increases vertically from 60 mm. to 80 mm. in height in the basal two-thirds. The dorsum is missing adorally, but apparently expansion continues to the aperture. This suggests that the specimen may not be mature.

A second living chamber, somewhat flattened vertically by pressure, increases in its present condition from a height of 85 mm. to 90 mm., in a ventral length of 80 mm., and a dorsal length of 50 mm. This specimen preserves the shell surface in part, and shows a broadly banded appearance, with the coarsest markings 5 mm. apart, but with finer ones irregularly spaced between.

The sutures are relatively simple, and essentially straight and transverse, failing to slope forward on the venter as in most other species.

One early stage which is placed in this species because of the simple sutures and the rugose surface, a portion of a shell with a maximum length of 70 mm., shows the siphuncle in the basal portion. In this region the shell expands from 13 mm. and 15 mm. to 26 mm. and 27 mm., and the siphuncle, though cyrtocoanitic, is much more slender than in representatives of other species of comparable size.

*Discussion.*—In spite of the fragmentary nature of all shells so far encountered, it seems desirable to apply a name to this species which can readily be distinguished from its associates by its large size. Apparently early portions of the shell show a more gradual expansion of the siphuncle than do those of smaller and more accelerated species, nevertheless, extremely early stages still remain as undeterminable. This species, with *Montyoceras titaniforme* Flower and the endoceroids, largely *Vaginoceras opletum* Ruedemann, are the dominant Valcour species, at least in regard to size. The species is apparently not uncommon, but the extreme hardness of the rock makes it difficult to obtain. I have not figured the larger representatives of the species. All have very poor surfaces, and are of such a nature that they could not be photographed successfully. Further, reduced figures of such specimens are usually not satisfactory. The form can be reconstructed by the measurements given above, and the later portions of phragmocones may be readily recognized by examination of the siphuncle which is compressed at the septal foramen and equipped with good actinosiphonate deposits which are amply illustrated here.

*Types.*—Syntypes, University of Cincinnati Museum, Nos. 24174-9.

*Occurrence.*—From the Valcour limestone near Little Monty Bay, southeast of Chazy, New York.

**Valcouroccras** cf. **seelyi** (Ruedemann)

Plate 4, fig. 11

*Oonoceras seelyi* Ruedemann, 1906, New York State Museum, Bull. 90, p. 496-7, fig. 51, pl. 38, figs. 7-11.

One specimen figured here is referred to this species with doubt. It agrees with the original description in the short rapidly expanding and only slightly cyrtocoanitic shell, but represents

a younger stage than the known figured specimens and has a considerably simpler siphuncle. The phragmocone expands vertically from 14 mm. to 27 mm. in a ventral length of 20 mm. and a dorsal length of 9 mm. The shell is faintly compressed in section, the width being 1 mm. less than the height at both ends of the phragmocone, though the venter is not much more narrowly rounded than the dorsum. There are seven camerae in the phragmocone, and in the adapical five the siphuncle is seen in vertical section. The segments are similar in form and structure to those shown in text figure 2b. Deposits form a thickening of the connecting ring, but fail to show any actinosiphonate rays.

*Figured specimen.*—University of Cincinnati Museum, No. 24190.

**Valcouroceras**, sp. 1

Plate 4, figs. 4, 6

Under this designation are figured two specimens representing small phragmocones of *Valcouroceras*, which cannot be connected with any mature living chambers. The maximum size of this species is unknown. One of the specimens is relatively complete for the length of 25 mm. on the venter. The shell is compressed, the venter more narrowly rounded than the dorsum. It expands from 7 mm. in width and 8 mm. in height at the base to 17 mm. in height normal to the septum and a width estimated at 15 mm. The adoral six camerae occupy a length of 14 mm. The siphuncle is close to the venter. Its structure has not been studied in section, but the aspect of the shell at the adoral end of the specimen indicates clearly that some organic lining is developed which is a darker gray than the calcite which occupies the rest of the shell.

Similar in all respects but slightly smaller is a second specimen which has been sectioned vertically. This increases in height from 4 mm. to 14 mm. in a ventral length of 26 mm. The siphuncle lies close to the ventral wall. The segments are slightly convex on the ventral side and are nearly angular and sculariform on the dorsal side. The dorsal side of the siphuncle is thickened by an accessory deposit, some of which seems to be on the outside of the original connecting ring instead of exclusively on the interior. The earliest segments are more slender than the others, and approached very closely the suborthochoanitic pattern shown in text figure 2A.

*Figured specimens.*—University of Cincinnati Museum, Nos. 24180, 24173.

*Occurrence.*—From the Valcour limestone, upper Chazyan, from Little Monty Bay, southeast of Chazy village, New York.

**Valcouroceras**, sp. 2

Plate 4, fig. 1

This specimen, included to show the diversity of early portions of *Valcouroceras*, a considerable number of which were encountered, is more rapidly expanding than the above form, more arcuate, and has the sutures much less strongly inclined to the axis of the shell. The specimen is nearly circular at its base, 2 mm. in diameter, and increases in a ventral length of 32 mm. and a dorsal length of 22 mm., measured not quite to the adoral end, to 17 mm. and 15 mm. The venter becomes markedly narrower than the dorsum and the section is strongly subtriangular at the adoral end of the specimen. The sutures are nearly straight and transverse. Laterally they are only very faintly curved, the convexity directed apicad. The shell surface is preserved in part, and shows only vestigial lines of growth.

The radius of curvature is about 30 mm. for the venter.

The siphuncle at the adoral end of the specimen shows essentially the developmental stage illustrated in text figure 2B. No deposits are preserved. Apparently they were originally absent as the shell is well preserved and both camerae and siphuncle are filled with white calcite which would be expected to retain traces of the organic deposits. The deposits in these Valcour limestone specimens appear as a very dark-gray calcite which contrasts strongly with the white infiltrated material.

*Discussion.*—This specimen, which approaches very close to the initial part of the shell, is clearly distinct from the two specimens described above as *Valcouroceras*, sp. 1, by the greater curvature, less inclined sutures, more rapid expansion and more strongly triangular section. Nevertheless, it is obviously not a specimen which shows any indication of an approach to maturity, and the absence of a lining within the siphuncle suggests in addition that it may represent the phragmocone of an immature shell. It has not been possible to connect this specimen with any

mature living chamber, which is considered necessary for the proper identification of a species. As a consequence it is considered wisest not to propose a new specific name for this form.

*Figured specimen.*—University of Cincinnati Museum, No. 24189.

*Occurrence.*—From the Valcour limestone, upper Chazyan, from Little Monty Bay, southeast of Chazy, New York.

### BIPECTINATE ACTINOSIPHONATE DEPOSITS

Only two genera and species of cephalopods are thus far known to have actinosiphonate deposits in which the rays are typically alternately bipectinate, that is, in which they are branched, and in which normally secondary branches are thrown off at regular intervals, first from one side of the main ray and then from the other. Teichert (1940) has figured such structure, though rather irregularly developed, for *Danoceras subtrigonum* of the Buchan limestone of Victoria, Australia. This species I have not seen, and all that is known of its structure is contained in Teichert's description and figures. The rays of this form are branched, sometimes with alternative secondary branches, but often the secondary branches are as long as the main stipe, and like it may be divided. Bifurcation of the main stipe into two equal branches may also occur.

The single Ordovician cephalopod thus far known to have similar deposits, at least insofar as the cross section of the shell is concerned, is described below as *Actinomorpha pupa*. The siphuncle has been studied by means of a longitudinal section ground normal to the vertical axis of the shell, and two cross sections taken from near the adoral end of the siphuncle.

The longitudinal section, shown in Plate 3, figure 5, and enlarged in Plate 3, figure 2, is represented here by a section which does not attain the very center of the siphuncle; therefore the rays cut across it obliquely. The rays in these sections are represented by the dark lines, while the remainder of the siphuncle is filled by buff-colored matrix. The longitudinal sections show that while the rays are often crowded at the region of the septal foramina, and some disappear there, enough can be traced

through this critical region to indicate beyond doubt that these deposits are essentially continuous throughout the length of the siphuncle. The apparent disappearance of some of the rays at this region is quite easy to understand in view of the nature of the rays as seen in cross section. The section may easily pass through some of the short branches, and even the main rays may shorten occasionally at the septal foramina so that they appear to vanish there in sections cut to the right level.

The longitudinal section is not in itself very revealing of the nature of the rays. This can be seen better in cross sections. Two such sections were made, that shown in Plate 3, figure 4 lying at the adapical end of the small piece near the base of the living chamber which can be clearly identified in Plate 3, figures 5 and 6, lying just orad of the portion of the phragmocone on which the siphuncle has been exposed by grinding of the venter. The section shown in Plate 3, figure 3 lies at the adoral end of the same piece. Here the structures have been considerably distorted as the result of the distortion which has affected the adoral end of the shell of this specimen, while the adapical end is relatively unmodified in form.

The cross sections show that the siphuncle wall, here consisting apparently of a connecting ring, is relatively thin. There is no differentiation of an organic lining of the siphuncle from the ring, and the two are almost certainly one and the same structure, as has been found to be the case in other actinosiphonate cephalopods studied here.

The rays are formed of material darker than the matrix, and are essentially uniform in texture throughout. There is no indication of a central axial structure as in *Archiacoceras*, and as also indicated in *Danoceras subtrigomum* (Teichert, photograph, also 1940). The rays are variable in form but are essentially described as bipectinate, being branched first on one side and then on the other. The rays vary in form. Sometimes secondary branches may be lengthened so that they penetrate as far into the siphuncle cavity as the main stipe, and sometimes they may be branched. However, generally the bifurcation of the main stipe is not encountered, and secondary branching of a

branch from the main stipe of the ray is not usually carried very far. One phenomenon which seems to be quite characteristic of the siphuncle of this genus is the presence of one or more short simple rays on the dorsal side and again on the ventral side of the siphuncle. In the two cross sections both of which are slightly distorted, as can be seen by the slightly irregular shape of the sections, the simple short rays are not perfectly aligned, and are difficult to make out as they are shorter and smaller than other rays. They appear, however, to be a constant feature, and the only indication of a rough bilateral symmetry which can be seen in the siphuncles of this genus. These sections are adequate to show the mode of branching of the other rays of the deposit, and the two together seem to show all possible variations from the simplest type in which short rays arise at regular intervals on alternate sides of a main stipe, like the mode of branching in some of the more generalized of the axonolipous graptolites.

From the structural similarity between *Actinomorpha* and *Danoceras* it might appear that the genera may be related. This is a conclusion which is, however, unsafe, at least until more is known about the siphuncle of *Danoceras*, as it is not demonstrated there, though it seems likely from Teichert's figures, that the deposits are continuous from segment to segment. In form the genera are both compressed cyrtocones, with the siphuncle marginal, but one is exogastric and the other is endogastric. According to Teichert's (1940) classification these genera would be placed in different families. While it is not impossible that apparently exogastric and endogastric genera may be very closely related, as sometimes seems to be the case of some of the cyrtocones of the Silurian of Bohemia, the evidence is not strong enough in the present instance to suggest that the similarity of the actinosiphonate deposits of these two genera represents more than an accidental convergence.

Genus **ACTINOMORPHA** Flower, n. gen.

Genotype.—*Actinomorpha pupa* Flower, n. sp.

Shell strongly compressed in section, the venter slightly more

narrowly rounded than the dorsum. The shell is breviconic, expanding to a point just before the base of the mature living chamber and then contracting toward the aperture. In the early part of the shell the venter is faintly convex, the dorsum and the sides are essentially straight in profile until the maximum diameters are attained. Where the maximum width is attained the sides converge gradually, but remain only slightly convex to the aperture. The curvature of the venter remains fairly uniform. The dorsal profile has not been observed but probably assumes a convex condition.

The sutures are essentially straight and transverse. The siphuncle lies close to the venter, and is made up of rather broad segments which are cyrtochoanitic but expand relatively slightly within the cameræ. The interior of the siphuncle contains well-developed actinosiphonate deposits which are continuous throughout the length of the siphuncle, and in which branched or pectinate processes extend inward from the margin toward the center of the siphuncle.

The aperture appears to be straight and transverse dorsally and laterally, but on the venter a conspicuous hyponomic sinus is developed. The surface bears frequent low rounded ridges, rather irregular, which function as lines of growth, preserving the course of the sinus.

*Discussion.*—Superficially the holotype and only known species is faintly suggestive of the genus *Neumatoceras* in form, particularly in the increasing convexity of the ventral profile near the aperture, giving the shell a slightly humped appearance. However, the earliest stage fails to show that the shell was truly and strongly cyrtoconic as in *Neumatoceras*, but instead was straight or nearly so to the apex. *Neumatoceras* is described as having a ventral siphuncle in which the segments are "faintly expanded," a condition which I have found to be true of some species which are typical of *Neumatoceras* in external form. However, Foerste (1935, pl. 2, fig. 1) has shown in *N. nutans* Foerste a siphuncle which is broad but tubular and orthochoanitic. No other genus seems to resemble this one closely. Perhaps the only other one similar in aspect is the nearly straight compressed breviconic

*Dowlingoceras* Foerste (1928) which is similar in the profiles of dorsum and venter and differs further in the absence of a hyponomic sinus. The siphuncle is similar to that of this genus in form, but no actinosiphonate deposits have been recognized.

**Actinomorpha pupa** Flower, n. sp.

Plate 3, figs. 2-6

The holotype, preserving the greater part of a mature shell, is a faintly exogastric brevicone 80 mm. in length. The section is compressed, the venter narrower than the dorsum, expanding in the greater part of the length of the phragmocone from a height of 21 mm. and a width of 18 mm. to a height of 40 mm. and a width of 33 mm. This occurs in a ventral length of 34 mm., and attains the greatest width of the shell. Over the next two cameræ, 7 mm. in length, the sides become markedly convex, and in the remaining 40 mm. of the living chamber, the sides converge to a width of 20 mm., which was probably originally greater as there is clear evidence of compression of the living chamber after death. The ventral profile increases in curvature as it approaches the aperture. The dorsal profile is unknown beyond the adoral portion of the phragmocone. It probably became slightly convex as the aperture was approached. The sutures are straight and transverse. The cameræ are nearly uniform in depth throughout, varying only from 3.5 mm. to 4 mm. on the venter as shown by the length of the segments of the siphuncle. The sutures are not, for the most part, preserved on the type; the only ones being clearly shown are those near the base of the living chamber.

The siphuncle lies close to the venter. It is made up of rather broad segments which expand within a camera from 3 mm. to 5 mm. where the length of a segment is 4 mm. The septal necks are very short and recurved. The connecting rings are evenly convex in longitudinal section. Actinosiphonate deposits are well developed in the siphuncle. These are described in detail following the description of this species.

The aperture bears a prominent hyponomic sinus on the convex siphonal ventral side of the shell. The surface is marked by low rounded distant transverse ridges which follow the course of the hyponomic sinus throughout the early growth stages. Four ridges occur in a length of 10 mm., but there is some variation in their spacing. They do not appear to be preserved at all on the internal mold.

*Discussion.*—Although in form this species is remotely similar to *Neumatoceras*, it can be distinguished not only by the structure of the siphuncle, but also by the form of the shell. The greatest height of the shell is not attained, as in that genus, considerably apicad of the base of the living chamber. The sutures do not rise strongly orad from dorsum to venter, and the early part of the shell is not strongly cyrtconic as in *Neumatoceras*. Nevertheless, *Actinomorpha* is probably closer to *Neumatoceras* in form than to any other genus. The only other comparable genus is *Dowlingoceras* Foerste (1928, p. 43) which is a compressed straight brevicone, somewhat similar in the outline of the segments of the siphuncle, but lacking two important features of *Actinomorpha*, the hyponomic sinus and the actinosiphonate deposits.

This remarkable species has been known to me for some years, but I have delayed its description largely because of uncertainty as to its origin, in the hope of obtaining additional material which might settle this problem. It has suffered all the vicissitudes which can come upon a specimen from an old collection. When first discovered in the collections of the University of Cincinnati Museum, it was labeled and catalogued as "*Gonioceras anceps* (Hall), Black River." The manifest absurdity of the determination made it seem likely that the approximate horizon data might be equally wild. However, inspection of the catalogue showed that the next specimen was labeled "*Gomphoceras*, Black River" and proved to be a good *Gonioceras occidentale*. It is quite evident that prior to cataloguing the labels of these two specimens were interchanged. Further, it makes it reasonably certain that both are from approximately the same horizon and locality. *G. occidentale* is a Platteville species, known from Wisconsin and Minnesota, and it seems probable that *Actinomorpha pupa* is from the

same horizon and region. The two agree in lithology to the extent that both are preserved in a light yellow dolomite. *A. pupa*, however, is preserved in fine-grained material, probably higher in calcium content, and lacks the saccharoidal texture of most Platteville specimens.

*Holotype*.—University of Cincinnati Museum, No. 8969.

*Occurrence*.—Uncertain, as noted above, probably Platteville of Wisconsin or Minnesota.

#### ACTINOSIPHONATE DEPOSITS OF ARCHIACOCERAS

Two specimens of *Archiacoceras subventricosum* from the Middle Devonian have supplied the basis of the following observations. One specimen was studied by means of camera lucida drawings of serial sections in the New York State Museum, and a second specimen was procured for a similar study at the University of Cincinnati.

*Archiacoceras* Foerste (1926, p. 346), based upon *Phragmoceratites subventricosus* d'Archiac and de Verneuil, is a compressed endogastric shell. The genotype is apparently known only from the phragmocones. The shell is cyrtconic, compressed, the sutures are curved on the sides, the convexity being directed apicad, and extend farther forward on the convex side than on the concave side. The position of the siphuncle on the concave side of the shell is responsible for the generally accepted interpretation of the shell as endogastric. However, this is very questionable as the siphonal side of the shell bears a very well-defined septal-furrow (Flower, 1939) which is known to be exclusively a dorsal feature in other cephalopods, including *Nautilus*. It should be noted that nothing is known of the aperture of the shell of this species. Apparently no other species than the genotype has been placed in *Archiacoceras*. Other presumably endogastric compressed shells are: *Protophragmoceras* Hyatt, a Silurian genus without known actinosiphonate structure; *Endoplectoceras* Foerste 1926, also Silurian, is more slender, and has a more broadly expanded siphuncle; *Danoceras* Foerste 1926, is typically slightly gibbous over the living chamber and less rapidly expanded. The Silurian genotype has a rather slender si-

phuncle, containing actinosiphonate deposits but Teichert (1940) has recognized the genus in the Middle Devonian of Victoria, Australia, where it is represented by a species with a considerably larger siphuncle. Probably more similar in form to *Archiacoceras* than any other genus is *Alpenoceras* Foerste based upon *A. ulrichi* Foerste of the Alpena limestone. Congeneric are several species from the Winnipegosis dolomite, of which only *A. occidentale* Whiteaves is described. Within this genus the siphuncle is close to the concave side of the shell and is made up of expanded segments. However, the siphuncle contains a continuous lining without the development of rays forming an actinosiphonate deposit. This condition has been found in both the genotype and *A. occidentale*.

The actinosiphonate deposits are shown best by cross sections of the siphuncle. There is a thick organic lining which cannot be differentiated from the connecting ring and which is believed to arise from it. From this lining toward the center of the siphuncle there project numerous radial processes. These are generally simple, their sides subparallel but irregular, and the tips rounded and slightly inflated. These are sometimes divided, but division is irregular and never attains the alternating bipectinate pattern of *Actinomorpha* or of *Danoceras* as reported by Teichert. In opaque section some structure can be detected in the rays. In thin section (Pl. 4, fig. 1) it can be seen that the outer part of the deposit is composed of finely granular material, which cannot be differentiated from the connecting ring. This composes three-fourths the width of the lining of the siphuncle, or may perhaps be more properly considered a thickening of the siphuncle wall itself. An inner thin band is clearer and a lighter yellow. Often this is not sharply set off from the thicker part of the lining, but in some places a definite line can be seen which represents a definite boundary between the two. This is not apparent in all cross sections, and often cannot be traced around the entire circumference of a single cross section. (Pl. 5, fig. 1).

The rays ordinarily show a clear differentiation of structure. There is an outer rim of clear material. This encloses a central rod as seen in cross section which may extend a variable distance at the base into the siphuncle lining. In the distal inflated part

of the ray the rod may continue to a point not far from the tip, but is always inclosed in the light-colored lining. The rod is not always clear as a distinct entity in this region from a menisciform or oval mass of darker, coarser grained material. This may often appear to consist of several concentric layers which are apparently original. The three rays shown in Plate 5, figure 1 show some of this variation. That at the left shows the inflated menisciform material within the broadened tip of the ray, but only a vestige of the central rod in this area. The central one shows the rod and several concentric layers in the menisciform structure before the outer thin lining which is continuous with the marginal clear layer of the siphuncle wall. The third shows the rod clearly but there is poor differentiation between the menisciform mass and the lining. (Fig. 2g.)

The number of rays appears to increase gradually orad in the siphuncle. However, the rays are generally continuous from segment to segment. Major rays remain fairly constant numerically in a suite of serial sections, although they are supplemented erratically by secondary rays which are not prolonged along the axis of the siphuncle for any distance, but instead are essentially short rodlike projections. However, in any one cross section it was not always possible to distinguish the major rays from the secondary ones, as they may upon occasion equal one another in length and structure. In general the shorter rays fail to show the inflation at their tips which is so well developed in the longer ones. Of the two specimens studied by a series of sections passing from one camera to another, the major rays appeared not only constant, but perfectly aligned from segment to segment. One showed 19 rays in most serial sections, though the number varied from 18 to 20. In the other specimens, that illustrated on Plate 6, the rays were more numerous, varying from 36 to 38. These sections were taken through two segments near the adoral end of a large individual. In the adapical portion of the same shell, the rays averaged only 18 in number. Clearly the rays increase in number orad. The increase in the number of rays is brought about in part by the interpolation of additional rays. It is not certain, however, that rays may not also be produced by bifurcation.

Cross sections show a uniformity of the number and arrangement of rays from segment to segment. Longitudinal sections, however, show commonly the appearance of discrete segmental series of rays which are massed about the septal foramen, and extend from there orad into the segment, but not apicad. This appearance was due to the nature of the longitudinal sections, which do not cut the rays parallel to their axes, but are slightly oblique to the plane of the rays, and cut them only near their tips. As the rays extend farther centrad in some regions of the siphuncle than in others, this presents the aspect of discrete segmental deposits (Pl. 6, figs. 2-3). However, a section which is markedly eccentric, will show that a single ray is continuous at least throughout the central part of each segment. (Pl. 6, fig. 1.) In order to determine the exact nature of the rays, it was necessary to secure a series of serial cross sections of the siphuncle. Selected sections from such a series are shown in Plate 6, figures 4-9.

Figure 4 is taken near the adoral end of a segment. The lining of the siphuncle is strongly developed and from it project a series of rays toward the center of the siphuncle. These belong to the segment in which the section was taken, as shown by the lowermost transverse line drawn on Pl. 6, fig. 3, which indicates the position of this section. However, on the right side of the section, which is very slightly oblique, extending farther orad on the left than on the right, the deposits of segment 1 lie in contact with deposits of segment 2. Farther orad, as shown on the left side, fusion is complete and the boundary between the two cannot be made out structurally, though it is evident on the basis of outline alone. Further, here the deposits of segment 2, the adoral segment, have expanded laterally to form a continuous ring of organic material within the deposits of segment 1.

Figure 5 shows a section only slightly farther orad. It differs from figure 4 mainly in that the central ring belonging to the adoral deposit is better formed. An intermediate section in which the ring is complete is omitted. As can be seen from figures 4 and 5, the rays of the two deposits, apparently of segmental origin, are perfectly aligned and continuous.

Figure 6 is taken at the adapical end of the septal foramen,

and shows the constriction of the siphuncle. On the right side there is a trace of the outer rays, because that side of the section as ground lies slightly farther apical than the left side, as was the case in figures 4 and 5.

Figure 7 passes through the septal foramen. The light area surrounding the siphuncle cavity marks the part of the section which cuts through the adnate connecting ring and the septal neck, which is essentially recumbent as can be seen in figures 1-3. These structures are not clearly differentiated in opaque sections,

Figures 8 and 9 are taken orad of the septal neck. The cavity of the siphuncle assumes its former proportions, though expanding on the upper side (probably ventral), which is farthest from the shell wall, as shown in figure 8. Figure 9 illustrates a condition which will persist orad from the position of the section early in the entire length of the segment of the siphuncle, as was ascertained by the grinding of further sections which are not illustrated here inasmuch as they failed to show additional morphological features.

In these cross sections, which are oriented with the dorsal side down, and are continued to the shell wall, an excellent check on differentiation of original structure against replacement phenomena was supplied by the variable mode of preservation shown within any single section. One side of the siphuncle, that on the right in figures 4-9, was filled with light calcite, which continued over the ventral part of the shell to the shell wall, and appears white in most of our sections. The left side of the shell, however, was filled with matrix.

From these sections it is necessary to conclude that the deposits of the siphuncle of *Archiacoceras* first of all are nothing more than projections from a much thickened connecting ring. As may be expected from their origin, their linear extent in the siphuncle is controlled by the arrangement of the serially repeated connecting rings. The deposit is heavy at the adapical end of the ring, where it may form an annulosiphonate ring fused with and supported by the rays belonging to the next adapical connecting ring. A remarkable feature is the continuity and alignment of the rays of adjacent metameric deposits.

This type of structure is much more complex than that of *Valcouroceras*, and there seems to be no parallel for it in the complex but continuous rays of *Actinomorpha*. It is not surprising to find that the Ordovician genera exhibit a simpler structure. The taxonomic significance of the structure of *Archiacoceras* is unfortunately a matter only for conjecture until similar studies have been made known the structure of some of the contemporary and possibly related genera.

#### DISCRETE ANNULOSIPHONATE DEPOSITS

The three genera discussed above are all examples of a type of actinosiphonate structure which extends from segment to segment. They are not uniform, and may not be homologous structures, for in *Archiacoceras* they are apparently the fusion of segmental types, even though they may have been formed about contemporaneously ontogenetically, while in *Valcouroceras* and *Actinomorpha* there is no reason to believe that the deposits are not truly continuous without any metameric origin.

Likewise the types of deposits grouped here as discrete actinosiphonate structures are diversified and almost certainly originated independently of one another. The earliest of these discrete deposits, which are differentiated from the continuous septal foramina, and rarely meet and never fuse, are found in ones mainly in that the rays are confined to the regions of the *Dicstoceras* Foerste. This genus is typically developed in the true Richmond, but is widespread and perhaps attains its maximum size as well as diversity of structure in the large series of disconnected deposits ranging from the Fremont limestone of Colorado and the Big Horn formation north through the Ordovician Liskeard formation of Lake Timiskaming, the Red River series of Hudson Bay, the Whitehead formation of Gaspé, numerous Ordovician outliers of the arctic archipelago, of which the more important are in Baffin Land, and the Cape Calhoun formation of Greenland. Teichert (1934, 1937) has already presented a summary of the essential features of this genus based upon a study of *D. pyriforme* Troedsson of the Cape Calhoun

formation, and *D. scalare* of the Richmond of Anticosti.

The structure is evidently very complex. Rays spring mainly from the region of the septal foramina, and extend orad and apicad into the expanded segments of the siphuncle. Some rays apparently also spring from the wall of the siphuncle within the expanded part of the segments. The structure is evidently complex, and must be approached by the use of carefully made serial sections.

In contrast to the structure of *Diestoceras*, the Breviocerataidæ of the Devonian show a much simpler deposit. This is best known for *Brevioceras* and for *Eleusoceras*, both of which have been illustrated in longitudinal sections by the writer (Flower, 1938, pl. 1, fig. 1; pl. 3, fig. 2). These genera show deposits which do not project so far orad and apicad of their origin as do those of *Diestoceras*, and they are obviously much simpler in form. Additional material of *Eleusoceras* has failed to preserve these structures properly for section, but several sections were taken from the holotype of *Brevioceras pompeyense* Flower at the region of a septal foramen. The actinosiphonate rays are attached to the siphuncle wall only at the foramen, as shown in text figure 2 F, and each is bifid. Sections farther away from the foramen show these deposits to extend orad and apicad, but where this occurs they are free from the siphuncle wall, and are rather irregular in structure. *Naedyceras* and its allies occasionally show structure which is similar but less complex, inasmuch as the deposits do not extend orad or apicad into the cameræ for any appreciable length. These forms are discussed and illustrated by the writer in another work, now submitted but unpublished. At the risk of creating *nomenes nuda* I note here that *Gyroneedyceras validum* (Hall) has yielded such deposits, which are also shown in various species of *Naedyceras*, though more poorly preserved, and similar rays are characteristic of *Stereotoceras* Flowers ms., in which they are particularly well developed.

## CONCLUSIONS

Actinosiphonate deposits have appeared at least three times independently in the history of nautiloid development: in the closely allied Chazyan genera *Minganoceras* and *Valcouroceras*, again in *Oocerina* in the Silurian and in the Brevicoceratidæ, which developed such deposits in Upper Silurian time. Probably other similar cases await discovery or confirmation. As polyphyletic structure, actinosiphonate deposits are not in themselves an adequate criterion for a major division of the nautiloids. However, there is much variation within actinosiphonate deposits, and some of these types seem to be characteristic of restricted genetic groups. It is highly unlikely that few types studied closely in the present work have exhausted the possibilities for morphological variation within those structures which have been lumped together under the term actinosiphonate. Briefly, the following types have been recognized here:

- I. Deposits consisting of a thickening of the connecting ring producing simple rays which are continuous from segment to segment. This is typical of *Minganoceras*, *Valcouroceras* and those Upper Ordovician species at present assigned to *Wetherbyoceras*. From the extant figures, many Silurian actinosiphonate cephalopods fall in this category.
- II. Deposits consisting of alternately bipectinate rays, apparently continuous. Only two examples of this type are known, probably unrelated, *Actinomorpha* Flower of the Ordovician, and *Danoceras* as reported by Teichert (1940) for a Devonian species. These are quite probably not closely related.
- III. Deposits of apparently segmental origin, but fused and perfectly aligned, as exemplified by *Archiacoceras*. What other genera show similar structure is as yet unknown.
- IV. A deposit consisting of a lining of the siphuncle and irregular complex processes. This is known only from *Diestoceras* of the Ordovician, which seems so different from contemporary actinosiphonate genera that it probably developed these structures independently.
- V. A deposit consisting of a lining of the siphuncle and shorter

simpler processes arising from the septal foramen, usually bifurcated, always discrete, and never markedly complex. This is characteristic of the Devonian *Brevicoceratidæ*, and has been observed in *Naedyceras* and its allies, *Brevicoceras*, *Eleusoceras*, and imperfectly in *Foersteoceras*, as well as in several related genera descriptions of which are in press.

From the polyphyletic origin and seemingly erratic distribution, it is evident that actinosiphonate deposits must be the result of excess calcification, resulting in form-types which are built in accordance with pre-existing structures in the soft parts of the siphuncles. The rough similarity of the form-types indicates approximate structural similarities of organization on the siphuncles of these various cephalopods, often not closely related, but differences exist which may be of great morphological and taxonomic significance when they are better known.

Actinosiphonate deposits fail to show the ontogenetic progression from one part of the shell to another which is to be expected in a series made up of similar repeated segmental parts, such as have been found in the annulosiphonate deposits of the Actinoceroidea, Pseudorthoceratidæ and orthochoanitic orthoceracones. This necessitates the conclusion that such deposits were formed during a relatively short and rapid period of growth. Otherwise such ontogenetic progression would certainly have been found. The absence of deposits in many shells of normally actinosiphonate species is to be explained in terms of growth stages. Actinosiphonate deposits appear only in gerontic or near gerontic shells, and are deposited rapidly within siphuncles. Specimens which represent neanic or early epebic growth stages may be expected to lack these features. This conclusion may require some slight emendation. It is doubtful whether there is any sharp demarcation between the growth stages. In some instances actinosiphonate structure is accompanied by other manifestations of the excess deposition of calcareous material within the shell. However, it is suspected that in some instances actinosiphonate deposits may precede most other types of gerontic calcification, at least in the genus *Herkimeroceras* Foerste of the Upper Silurian. It is eminently de-

sirable that this matter be investigated further. The present hypothesis, however, seems to be the only one which will explain adequately the absence of normal ontogenetic progression and the widespread though perhaps not universal correlation between actinosiphonate structure and other deposits which are clearly a manifestation of late maturity and old age.

Within the earliest stages of actinosiphonate species no true actinosiphonate deposits are developed. Further, some small mature species congeneric with a closely related to typically actinosiphonate species may lack the deposits throughout the entire phragmocone. There is not yet adequate evidence to explain this phenomenon. It might be that in *Valcouroceras* small species fail to attain actinosiphonate structure because they are phylogenetically more primitive than their larger and longer lived relatives. However, this hypothesis cannot be invoked to explain indential phenomena in the small species of the Devonian genus *Brevicoceras* which is developed from gyroceraconic and trochoceroid shells of considerable size which have well-developed actinosiphonate deposits.

Actinosiphonate deposits differ widely from the septa and other true shell structures in their color, and texture, and obviously have undergone a rather different history of preservation. This leads to the conclusion that they are not true shell structures, but like the connecting ring must have a different origin. Further, the deposits are believed to be developed by a thickening of the connecting ring itself, for while various structures may be differentiated in actinosiphonate deposits, the thin sections thus far examined fail to show a differentiation of the deposits from the connecting ring.

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## NEW ORDOVICIAN CEPHALOPODS OF EASTERN NORTH AMERICA

The descriptions brought together here include Chazyan and Black River cephalopods of the University of Cincinnati Museum. These include the following genera and species:

- Actinoceras arcuanotum* Flower, n. sp. Tyrone limestone, Kentucky.  
*Eorizoceras platyceroïdes* Flower, n. sp. Chazy limestone, Lake Champlain.  
*Eotripteroceras minutum* Flower, n. sp. Chazy limestone, Lake Champlain.  
*Graciloceras longidomum* Flower, n. sp. Chazy limestone, Lake Champlain.  
*Centrocyrtoceras mozolai* Flower, n. sp. Chazy limestone, Lake Champlain.  
*Trocholites ruedemanni* Flower, n. sp. Chazy limestone, Lake Champlain.  
*Trocholites gracilis* Flower, n. sp. Chazy limestone, Lake Champlain.

These descriptions are published at this time because it is felt that further delay in the appearance of these forms may seriously interfere with the progress of the study of the Paleozoic cephalopod. Originally it was intended to append to these descriptions a considerable number of new forms of the Cincinnati. However, the arrival of much additional material has made it desirable to place these together in a separate and a more comprehensive work devoted to the cephalopods of the Upper Ordovician of the Cincinnati region.

### Genus **ACTINOCERAS** Bronn

***Actinoceras arcuanotum*** Flower, n. sp.

Plate 2, fig. 7

The holotype represents a mature individual of a relatively small and slender species, consisting of a phragmocone 160 mm. long and living chamber 120 mm. long. The specimen expands from a width of 34 mm. and an estimated height of 25 mm. to 46 mm. and 34 mm. in a length of 90 mm.; in the remaining 60 mm. of the phragmocone the conch attains 58 mm. and 39 mm. The living chamber contracts gradually to the aperture, the venter being straight, but the dorsum and the lateral outlines slightly curved, so that the apertural end measures 30 mm. and 50 mm., and the living chamber has a fusiform appearance.

In section the venter is slightly more flattened than the dorsum. The siphuncle lies ventrad of the center, and is very close to the ventral wall in the apical part of the shell. Here it has a width of 15 mm. at the septal foramen, and a height of probably about 12 mm. The septa are nearly straight and steeply inclined as seen in section. The sutures are unknown ventrally but describe lobes on the dorsum adorally. The cameræ occur four in a length equal to an adoral height of the shell and between five and six in a length equal to the adoral width in the adapical portion. Adorally six occur in a length equal to the width and four in a length equal to the height where the section measures 38 mm. and 30 mm. The gerontic cameræ are markedly shortened.

The siphuncle at the apical end is exposed in natural section. A segment expands from 16 mm. to 22 mm. and is 8 mm. in length. Annulosiphonate deposits are markedly thicker at the adapical end than at the adoral end and serve to illustrate clearly that such deposits do not extend the length of the phragmocone, but that they must be absent in some of the more adoral cameræ.

*Discussion.*—This species is unlike any of the forms previously reported from this area. It can be readily distinguished from *Actinoceras kentuckiense* by the more gradual expansion of the shell and the more transverse sutures. It can be distinguished from *A. libanum* Foerste and Teichert (1930, p. 245, pl. 34, figs. 1-2; pl. 57, fig. 5) by the more slender form and the strongly depressed section. The exact horizon of this species is not known with certainty, but lithology suggests that it is probably from the Tyrone, which is known to carry actinoceroids in a layer considerably above the "Birds eye" horizon, possibly Lowville in age.

*Type.*—Holotype, University of Cincinnati Museum, No. 22580.

*Occurrence.*—High Bridge, Kentucky, probably from the Tyrone limestone.

Genus **EORIZOCERAS** Flower, n. gen.

Genotype.—*Eorizoceras platyceroides* Flower, n. sp.

Conch a rapidly expanding cyrtoceracone, moderately curved

adapically, becoming straighter adorally in the mature shell, the general aspect resembling that of a Devonian *Platyceras*. The section is faintly compressed in the early stage, with the dorsum and venter about equally rounded. This remains compressed ephibically but the section becomes subtriangular with the venter more elevated and more narrowly rounded than the dorsum. The sutures are straight, slightly oblique, sloping orad on the venter, the inclination increasing as the living chamber is approached. The siphuncle is small, close to the ventral wall, cylindrical, and empty. No cameral deposits are known. The surface bears well-defined transverse bands which continue across the venter with no indication of the usual hyponomic sinus. In addition, finer longitudinal markings are present on the genotype.

*Discussion.*—In form this genus closely approximates *Rizoceras* as conceived by Hyatt, but differs in the absence of a hyponomic sinus and in the cylindrical siphuncle. The genus is evidently not related to the great mass of Ordovician and Silurian cyrtocoenic cephalopods which are cyrtocoenic, but is an independent development of the orthocoenic line. No closely similar orthocoenic genera are known.

***Eorizoceras platyceroides*** Flower, n. sp.

Plate 5, figs. 2, 3

Conch cyrtocoenic apically, becoming straight before the end of the mature (?) living chamber. The holotype represents a nearly complete specimen which describes an arc of not over 70 degrees. The apex is oval, slightly compressed, venter and dorsum equally rounded, with a height of 3 mm. and a width of 2.8 mm. This increases to a width of 17 mm. and a height of 18 mm. at the aperture where the venter is subangulate, the dorsum transverse, and the section obscurely subtriangular. This occurs in a ventral length of 30 mm., and an actual length of 28 mm. The phragmocone is 15 mm. in length and contains thirteen camerae which increase only slightly in length when traced orad, from .5 mm. to .7 mm. The siphuncle is close to the venter, tubular, and apparently empty. The living chamber increases from a width of 8 mm. and a height of 9 mm. to 17 mm. and

18 mm. in a length of 18 mm. The last suture is inclined orad considerably on the venter, making an angle of about 20 degrees with the horizontal.

Surface with regular, distant rounded transverse liræ and fainter longitudinal liræ, the latter conspicuous only apically.

*Discussion.*—This species bears a superficial resemblance to some of the smaller associated species *Valcourceras*, but may be distinguished by the orthochoanitic siphuncle, the shorter phragmocone and the lack of apertural contraction of the shell.

*Type.*—Holotype, University of Cincinnati Museum, No. 24186.

*Occurrence.*—Valcour limestone, upper Chazyan, from Little Monty Bay, Chazy, New York.

Genus **EOTRIPTEROCERAS** Flower, n. gen.

Genotype.—*Eotripteroceras minutum* Flower, n. sp.

Conch orthoconic, depressed in section, the venter more flattened than the dorsum. The mature sutures bear dorsal and ventral lobes. The siphuncle is located well ventrad of the center of the shell, and is perfectly tubular in outline. No deposits are known in the cameræ or in the siphuncle. The surface of the shell appears to be smooth.

*Discussion.*—This genus resembles *Allumettoceras* very strongly externally, but the tubular siphuncle shows that the similarity is purely isomorphic, and that no real relationship exists between the two genera. Instead this genus is apparently a specialized *Michelinoceras*. The only known representative as present is the genotype, of upper Chazyan age.

***Eotripteroceras minutum*** Flower, n. sp.

Plate 5, figs. 13, 14

The conch is small, orthoconic, depressed in section, rapidly expanding. In the 9 mm. of the holotype, the width increases from 8.5 mm. to 10 mm. and the height from 6 mm. to 7.5 mm. The sutures rise to low lateral saddles, and bear lobes on dorsum and venter. Five cameræ occur in a length equal to the adoral height of the shell of 7.5 mm. However, the normal depth of

the cameræ may be somewhat greater, as the last two cameræ of the holotype appear to be slightly shorter than the others, which indicates that a mature condition is approached. If so, the mature shell did not attain dimensions much greater than those shown by the type.

The siphuncle is tubular. Adapically it lies 1.4 mm. from the venter, is .8 mm. in diameter and lies 4 mm. from the dorsum. Adorally it is the same in diameter, 1.8 mm. from the venter and 5 mm. from the dorsum.

*Discussion.*—The generic characters serve to distinguish this minute species. From early stages of *Allumettoceras*, it can be distinguished only by a study of the siphuncle in section. The siphuncle of *Allumettoceras* is still broadly expanded in a stage even earlier than that exhibited by the type of *E. minutum*. From most other orthoceracones the shell can be distinguished by the strongly depressed section and the rapid expansion.

*Type.*—Holotype, University of Cincinnati Museum, No. 24187.

*Occurrence.*—From the Valcour limestone, upper Chazyan, of Little Monty Bay near Chazy, New York.

Genus **GRACILOCERAS** Flower, n. gen.

Genotype.—*Graciloceras longidomum* Flower, n. sp.

Conch an exogastric cyrtoceracone of compressed section, expanding slowly and uniformly to the aperture. Living chamber very long, phragmocone in the known species much shorter than the living chamber. Sutures oblique, rising orad on the ventral side, developing slight lateral lobes. Septa shallow horizontally, deep vertically. Siphuncle close to venter, orthochoanitic, empty. Apical cameræ deeper than those following, slightly inflated, possibly representing a "protoconch".

*Discussion.*—This genus is erected for the reception of a single Chazyan species. Aside from the remarkable length of the living chamber and the shortness of the phragmocone, the genus can readily be distinguished by its other features. Indeed, there are

no Ordovician or younger orthochoanitic cyrtoceracones with which it is at all comparable. The genus seems to be comparable with some Canadian cyrtoconic genera which are little known internally. Compressed Canadian cyrtoceracones of exogastric curvature comprise *Bassleroceras*, *Dwightoceras*, and *Dyscritoceras*. Of these *Dwightoceras* possesses a very large siphuncle, and is almost certainly euryisiphonate in its affinities and is possibly an endoceroid. *Bassleroceras* is a slender compressed conch with a long phragmocone and a short living chamber which is very different from *Graciloceras* in aspect. *Dyscritoceras* which is more similar in the features of the phragmocone is breviconic, the living chamber contracted slightly at the aperture. The details of siphuncle structure of none of these genera are adequately known. The wall of the siphuncle of *Graciloceras* has not been studied in thin section, but appears to possess thin simple connecting rings of the stenosisiphonate pattern.

While the siphuncle wall is not clearly preserved it is evident that the connecting ring is thin. The segments of the siphuncle appear to be suborthochoanitic rather than tubular. The segments are extremely short in proportion to their diameter, and expansion is very slight.



Fig. 3. *Graciloceras longidomum* Flower, n. sp. A. Section of a specimen showing a deep initial chamber, but cutting obliquely through the siphuncle as shown by the siphuncle. B. Section from holotype. The adoral end of the specimen is a natural weathered section. The adapical end was ground parallel to the cylindrical siphuncle.

*Graciloceras longidomum* Flower, n. sp.

Plate 4, figs. 7, 8; text fig. 3

The holotype, the most complete specimen preserved, presents a natural longitudinal section, not quite attaining the center of the conch in the apical portion. The shell expands from 4 mm. and 5 mm. to 5 mm. and 6 mm. in the 10 mm. of the phragmone as measured ventrally. Expansion is continued in the 30 mm. of the living chamber to 15 mm. vertically and 12 mm. horizontally. The maximum length of the living chamber, which is incomplete adorally, is 45 mm. The adoral diameters are estimated at 18 mm. and 16 mm.

The camerae, of which eleven are preserved in the phragmone, are very shallow, six occurring in a length of 3 mm. The septum is slightly greater than the depth of the camera in vertical curvature, and is only slightly curved horizontally. Evidently the sutures must have shown faint lateral lobes. The siphuncle is minute, less than .2 mm. in diameter, and separated by about its own diameter from the venter. The necks are short, the rings thin. The segments are not clearly outlined in the holotype, being obscured by some dark calcite, but appear to present suborthochoanitic rather than cylindrical outlines.

*Discussion.*—The siphuncle lies very close to the venter in a stage closely approximating the apex of this species. It seems highly unlikely that it could become central in the apical chamber. The species can be distinguished from most other Chazyan forms by the generic characters. Fragments of a similar form, too incomplete for description and too poor to merit illustration, suggest the presence of a larger related species in the Chazyan.

A second specimen, retaining the adapical end of the shell, appears to agree sufficiently with the holotype to be referred to this species. The apical chamber has a vertical height of 3 mm. from dorsum to venter. It is 1.2 mm. deep, while the following camera is only .6 mm. deep. Unfortunately the section does not show the siphuncle in this camera, but it lies close to the venter in immediately succeeding camerae and it seems highly unlikely that it will move toward the center appreciably in the small distance

remaining. This is of interest in view of the obvious stenosphonate and elliphoanitic nature of the siphuncle wall, and in view of Kobayashi's hypothesis (1937, p. 20) according to which such a species should have a siphuncle which is central in the initial part of the shell.

The species is represented in our collections by three specimens and some additional fragments.

*Types*.—Holotype and four paratypes, University of Cincinnati Museum, Nos. 24181—24185.

*Occurrence*.—From the Valcour limestone, upper Chazyan, of Little Monty Bay, near Chazy, New York.

Genus **CENTROCYRTOCERAS** Foerste

*Genotype*.—*Cyrtoceras subannulatum* d'Orbigny (= *Cyrtoceras annulatum* Hall). Trenton limestone of New York.

*Centrocyrtoceras* Foerste, 1926, Denison Univ. Bull., Sci. Lab. Jour., vol. 21, p. 366, pl. 43, fig. 5; pl. 45, fig. 4A-C; 1933, *ibid.*, vol. 28, p. 45; 1935, *ibid.*, vol. 30, p. 27.

Conch cyrtoconic, possibly gyroceraconic in some species, subcircular in section. Sutures straight and transverse; siphuncle subcentral, composed of cylindrical or subcylindrical segments. Surface marked with transverse annuli which slope slightly apicad on the venter, and with finer liræ and striæ which are transverse and follow the same course.

*Discussion*.—The species which have previously been placed within the genus range from the Stones River through the Trenton of New York. Except for one species, *C. rotundum* Foerste of the Prosser of Iowa, the genus is confined, so far as is known at present to the east. The single species known from the Chazy limestone is atypical in its compressed form, the position of the siphuncle dorsad of the center as well as by its minute size. The characters do not seem to warrant setting the species apart in a distinct genus.

***Centrocyrtoceras mozolai*** Flower, n. sp.

Plate 5, fig. 8

Conch minute, gently curved exogastrically. The type, the only specimen so far encountered, is 9 mm. in length and ex-

pands from 1.6 mm. and 1.9 mm. to 2.5 mm. and 2.6 mm., the section being slightly compressed. Sutures transverse to the axis of the conch and straight. Depth of camerae not observed. The adoral 5 mm. of the specimen apparently represents a living chamber; the adapical 4 mm. is without clear septa, although one is exposed where the specimen is broken at the base of the living chamber. The siphuncle lies halfway between the center and the dorsal side. Ornamentation consists of transverse annuli which are distant, rounded, thickened slightly dorso-laterally, and are inclined very slightly apicad over the entire ventral surface.

*Discussion.*—The single minute specimen upon which the above description is based is not suitable for sectioning. The affinities of the species with *Centrocyrtoceras* is based upon the external form. The curvature is such that it cannot be considered an immature portion of a *Barrandeoceras*, which would be much more gradually curved, judging from the very large umbilical perforation. The species is unique in its slightly compressed form, the siphuncle dorsad of the center, and in the subtuberculate condition of the annuli dorso-laterally.

*Type.*—Holotype, University of Cincinnati Museum, No. 24188.

*Occurrence.*—Valcour limestone of Little Monty Bay, near Chazy, Clinton County, New York.

#### Genus **TROCHOLITES** Conrad

This genus, based upon *Trocholites ammonius* Conrad of the Trenton limestone of New York, was erected for coiled forms which expand gradually and consist of several volutions. The section is broadly rounded, and the siphuncle lies close to the dorsum. Hyatt (1894, p. 480) erected the genus *Trocholiticeras* for Canadian species which differ from *Trocholites* mainly in the more compressed form of the later volutions, and in the early stages of the shell, which differ from *Trocholites* in having a slightly wider umbilical perforation, but mainly in the position of the siphuncle, which does not attain a position close to the dorsum

until after the completion of the first whorl. The species previously placed in *Trocholites* range from the Beekmantown (Ft. Cassin) to the Richmond. However, the Beekmantown *Trocholites internastriatus* has been removed to another genus, *Curto-ceras*, Ulrich, Foerste, Miller and Furnish. No species have previously been known from the Chazyan, and the genus is yet to be recognized in the Black River. In the Trenton it is represented by several species: the genotype from New York, *Trocholites ammonius*, *T. canadensis* Hyatt from Montreal, and *T. faberi* Foerste from the Cynthiana limestone of Kentucky. Three Upper Ordovician species from Cincinnati have been described in terms of this genus, *T. dyeri* Hyatt from the Cincinnatian, *T. minusculus* Miller and Dyer from the Eden, and *T. circularis* Miller and Dyer which may be upper Maysville (Bassler, 1915, p. 1298) or Waynesville. *T. planorbiformis* occupies the Upper Ordovician of New York. This is a typical *Trocholites*. The species from Cincinnati are little known, and even their generic position is uncertain.

The two Chazyan species described below are of some interest in view of the problem raised by the writer (Flower, 1941) of the relationship between Canadian and Champlainian coiled cephalopods. Hyatt had assumed that the coiled Canadian and Champlainian species were not strikingly distinct from one another, and that the Trocholitidæ in particular represent a closely knit genetic group passing from Canadian to Champlainian and even Cincinnatian. The writer found in differences of the siphuncle wall evidence suggesting that two unrelated genetic stocks might be involved, although the similarities were so strong between some of these genera that it was recognized that the possibility must be considered that similar and contemporaneous changes might have occurred in the Trocholitidæ and in the Tarphyceratidæ, Deltoceratidæ and Plectocerotidæ. Subsequently more data on the structure of Canadian coiled cephalopods have been published by Ulrich, Foerste, Miller and Furnish, without, however, any recognition of this problem, and indeed without any discussion of Hyatt's views on phylogeny of these forms which

were based upon a very careful comparison of the species with special reference to the early ontogenetic stages. Their illustrations show that in every case in which thin sections have been made and illustrated in Canadian coiled cephalopods, the connecting ring is thick. In some cases this is interpreted as a deposit within the siphuncle. Deposits growing from the outer cameral surface of the ring are interpreted as cameral deposits. While correct enough from the point of view that they are formed outside of the original connecting ring, such an interpretation ignores the very obvious differences in structure and probably in composition of these deposits from aragonitic mantle secretions such as true cameral deposits. Only in one case, *Wichitoceras cecipiens* (1942, p. 85) are thin connecting rings shown. It is not certain that this was drawn from a thin section.

At the time when the writer first pointed out the structural differences in the connecting rings of Champlainian and Canadian coiled cephalopods, no thin sections of any of the Trocholitidæ were available for study. It now appears that a division occurs in genera assigned to this family similar to that noted in the coiled cephalopods with central or ventral siphuncles assigned currently to the Tarphyceratidæ, Deltoceratidæ and Plectoceratidæ. The Canadian *Curtoceras* has complex rings, as shown by the illustrations of Ulrich and his associates. Data are not supplied for other genera in that work. The Chazyan *Trocholites ruedemanni* has thin structureless connecting rings, in which they agree with other post-Canadian cephalopods thus far studied. However, according to Hyatt, there was a very close relationship between *Trocholites* and *Trocholitoceras*. The Chazyan species of *Trocholites* are typical of this genus in the dorsal positions of the siphuncle from the earliest known growth stages, but in section *T. gracilis* particularly approaches *Trocholitoceras*. Whether this resemblance is significant cannot be determined until the siphuncular structure of *Trocholitoceras* is made known.

Strand (1843) has figured thick rings in *Discoceras* and *Schroederoceras* which suggest that these Upper Ordo-

vician types may be directly descended from some such Canadian ancestor as *Curtoceras*, but apparently differ strongly in this respect from at least *Trocholites*.

***Trocholites ruedemanni*** Flower, n. sp.

Plate 5, figs. 6, 7

This is a small species with rather broad rounded whorls. The pragmocone of the holotype includes about five and a half whorls and represents a mature or nearly mature specimen. The greatest diameter is 28.5 mm. which is taken before the completion of the fifth whorl as the remainder of the shell is incomplete. The section is depressed throughout. The earliest known portion is a broadly depressed oval in section, with no true impressed zone. Half a volution farther, the venter is broadly rounded, but the dorsum is straight and transverse, the sides strongly rounded. Farther orad an impressed zone develops, which in the outer whorls becomes half the height of the whorl. The venter is broadly rounded, the sides more strongly rounded, with the greatest curvature at the umbilical shoulders. The following dimensions taken at intervals of a half whorl will show the proportions and the habit of growth:

Width	Whorl height	Front venter to impressed zone
2.4	.8	.8
2.8	1.0	1.0
3.	1.5	1.4
3.5	2.5	1.6
4.5	3.2	2.0
6.5	4.0	2.5
9.0	5.0	5.8
11.0	6.0	4.0
14.0	9.0	5.8

The sutures bear shallow lateral lobes, umbilical and ventro-lateral saddles, and a faint ventral lobe in the mature whorl. The impressed zone is marked by a deep lobe, so that a cross section of the shell shows the plane of the suture as oblique. The septa are evenly curved, and are less than one camera in depth. Four camerae occur along the venter in a length equal to an adoral diameter of 9 mm.

The siphuncle is cylindrical, small, and in contact with the dorsal wall except in the first half whorl, where it is nearly three

times as far from the venter as from the dorsum. In the last whorl the siphuncle is about .8 mm. in diameter. It is orthochoanitic with very short straight septal necks which scarcely complete the turn so that they lie parallel to the shell axis. The connecting rings are thin and show no differentiation of structure.

Only a portion of the living chamber is known. It describes one quarter of a volution and shows indication of being geronically uncoiled adorally, the dorsum coming to be slightly separated from the earlier whorl.

The surface of the shell, though poorly preserved, shows traces of transverse markings. On the last two whorls there are small rounded nodes on the umbilical shoulders, about eight on the last half volution of the holotype. Ventrad of these are faint traces of costæ which slope apicad as they approach the venter, and apparently fade out before attaining the broad ventral zone.

*Discussion.*—This species is represented by a single complete specimen, but there are numerous fragments, indicating that the species is not uncommon in the Valcour limestone, and that its small size, indicated by the type, is uniform. In coiling it is in some respects more similar to *Trocholiticeras* as than to *Trocholites*. As might be expected if the two genera are related, as is indicated by the form though not by the internal structure, this species is intermediate between Middle Ordovician *Trocholites* so far studied and the Beekmantown *Trocholiticeras* in the position of the siphuncle in the early stage of the shell.

The species can be readily distinguished by its small size, broad whorl, and the presence of nodes on the umbilical shoulders. From the associated *T. gracilis* it may be distinguished by the broader more rounded whorls, the greater dimensions of the whorls in specimens comparable in the diameter of the disc, and the more involute condition.

*Holotype.*—University of Cincinnati Museum, No. 24193.

*Occurrence.*—Valcour limestone, upper Chazy, Little Monty Bay, southeast of Chazy, New York.

**Trocholites gracilis** Flower, n. sp.

Plate 5, figs. 4, 5

This is a small shell, the maximum disc known being 24 mm. but differs from *T. ruedemanni* in the narrower whorls, the arched venter in the mature shell, the looser coil, and the absence of lateral nodes on the shell. The species is known from two fairly complete specimens as well as a number of fragments. The holotype, the most complete shell known, fails to retain the surface of the lateral portions of the early whorls. Fortunately this information is supplied by a paratype. The umbilical perforation is very small, and the shell is in contact at the first volution. The impressed zone begins early as in *T. ruedemanni* but is never so deep as in that species. The early whorls are circular or nearly so except for the development of the impressed zone. Farther orad the greatest width comes to lie dorsad of the center of the shell though the venter is still slightly flattened though narrow. In the last volution the venter becomes more elevated and develops an obscure keel. Here the whorl is 6.5 mm. broad and 7 mm. high. The preceding whorl is 6 mm. broad and 5 mm. high.

The sutures lack clearly defined lobation, but slope adapically toward the venter. Three cameræ occur in a length on the venter equal to an adoral diameter of 5.5 mm. The siphuncle is orthochoanitic and similar to that of *T. ruedemanni*. From the third whorl it is in contact with the dorsum. Its position in earlier whorls is unknown. The last half whorl of the paratype consists of a living chamber which is apparently complete adorally. The surface of the shell is marked by rugose lines of growth which slope apicad toward the venter. The internal mold shows traces of these markings in the form of obscure lateral costæ.

*Discussion.*—This species is presumably considerably rarer than *T. ruedemanni*. Calcite filled specimens have proved difficult to extract as the limestone matrix is harder than the calcite and ordinarily specimens lack the lateral portion of the inner whorls. However, the paratype shows an almost undamaged lateral surface. The species may be readily distinguished from

*T. ruedemanni* by the narrower whorl, the elevated venter in the mature part of the shell, and the different habit of growth. The whorls are much narrower than in that species, and although it was not possible to study the species by cross sections, the impressed zone was evidently shallower. In the small size and narrowly elevated venter, no younger forms are comparable.

*Types*.—Holotype and paratype, University of Cincinnati Museum, Nos. 24191-24192.

*Occurrence*.—From the Valcour limestone, upper Chazy, from Little Monty Bay, southeast of Chazy, N. Y.

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## VI. SOME SILURIAN CYRTOCONIC CEPHALOPODS FROM INDIANA WITH NOTES ON STRATIGRAPHIC PROBLEMS

### ABSTRACT

Three new species and one new genus of cyrtoconic Silurian cephalopods from Indiana are described, with remarks on the occurrence and current problems of correlation. The new species are *Pentameroceras cumingsi*, *Tetrameroceras faberi*, and *Laureloceras cumingsi*, the last being also a new genus.

### INTRODUCTION

In the following pages long standing descriptions of a few cyrtoconic cephalopods of more than usual interest are brought together. *Tetrameroceras faberi* of the Osgood limestone is significant as the first record in America of this genus, which is prolifically developed in the Silurian of Bohemia. *Pentameroceras* has long been known to occur in the Silurian of northern Indiana, but has been identified in terms of the single Bohemian species. Restudy of this form shows that it is distinct from those which Barrande included under his name, and which apparently constitute in themselves several distinct species. Both of these genera are perhaps better known from the European Silurian. The third form discussed, *Laureloceras cumingsi*, represents one of three species of the new genus *Laureloceras* which is known only from the Laurel limestone.

### SILURIAN CEPHALOPOD FAUNAS IN INDIANA

Little is known concerning the cephalopods of the Osgood limestone, a relatively barren formation. Foerste has illustrated a *Dawsonoceras americanum* from it, which seems to be the only previous record of an Osgood cephalopod prior to the present description of *Tetrameroceras faberi*.

The overlying Laurel limestone contains a prolific cephalopod fauna but one which is generally widely scattered and quite sparsely distributed. One locality, two miles east of Westport, Indiana, has yielded a profusion of cephalopod shells from a sin-

gle layer. This association has been found to contain a number of undescribed or recently described species many of which are not known from the rest of the Laurel. This lens has yielded the following species:

- Harrisoceras reevesi* Flower
- Harrisoceras*, n. sp.
- Virgoceras cancellatum* Flower
- Protokionoceras*, n. sp.
- Leurocycloceras bucheri* Flower
- Dawsonoceras americanum* (Foord)\*
- Dawsonoceras*, n. sp.
- Laureloceras cumingsi* Flower, n. sp.
- Ormoceras*, n. sp.\*
- Elrodoceras indianense* (Miller)\*
- Elrodoceras*, n. sp.

Those marked with an asterisk are known from other localities in the Laurel not consisting of any marked concentration of cephalopods. Although the shells in this bed show a dominantly parallel arrangement, it is not regarded as an association of dead shells. Rather, the parallel arrangement of shells is due to reworking of the upper part at least of the bed after an initial period of deposition. This is shown clearly by the fact that some shells have been broken irregularly across inorganic infiltrated calcite which can be explained by supposing that the shells were initially buried, the cavities of the shell filled in with inorganic material. Then reworking of the sediment caused these shells to not only be uncovered and moved, but also broken. A similar phenomenon has been found in the Valcour limestone of the Chazyan, and may be much more widespread than has previously been supposed. Indeed, it may prove that many of the limestones which have been noted for cephalopod shells lying in parallel directions represent such phenomenon. If so, much that has been written about these beds, which have been regarded as containing an association of dead shells washed together by chance, perhaps far from their normal environments, will have to be rejected.

Another line of reasoning also suggests strongly that the association is a natural ecological one. In association with the

cephalopods in this bed were found few brachiopods, an *Atrypa* and a *Cyrtina*, but a great profusion of trilobites, largely *Dalmanites*, *sensu lato*, and *Bumastus*. Also there were a considerable though smaller number of gastropods, and a profusion of echinoderm remains, largely unidentifiable, but certainly containing some forms identifiable as cystidians. The association of cephalopods, trilobites and gastropods in abundance in hard limestones is a phenomenon so widely distributed in the Paleozoic that it is obviously a natural association. It has been dealt with elsewhere as the cephalopod facies.\*

The generalized cephalopod fauna of the Laurel contains species for the most part distinct from those found in the lens at Westport, but the same genera are involved. The species known to the writer, some undescribed, are included in the following list:

- Harrisoceras laurelense* Flower
- Leurocyloceras franklinense* (Miller)
- Dawsonoceras americanum* (Foord)
- Protokionoceras*, n. sp.
- Ormoceras*, n. sp.
- Elrodoceras indianense* (Miller)
- Laureloceras howardi* (Miller)
- Laureloceras nashvillense* (Miller) (Not known in Indiana)
- Heracloceras clodi* (White)†
- Heracloceras abruptum* (Hall)
- "*Nautilus*" *oceanus* Hall

The Laurel fauna is one dominantly of orthoceracones, as can be seen from the above list. Phragmoceroid shells and brevi-

\* Flower, R. H.: *Environment of early Paleozoic nautiloids*, Nat. Res. Council, Rept. committee on marine geology as related to Paleontology, 1941-42, pp. 37-40.

† This and the following species are probably not actually *Heracloceras* Teichert, a new name proposed for *Gigantoceras* Hyatt which was preoccupied. The genotype of *Gigantoceras* is *Gyroceras inclegans* Meek of the Middle Devonian. The Silurian species can be distinguished on the basis of lateral lobes of the sutures, but both Devonian and Silurian species are so little known that further division of this genus does not seem advisable at the present time. Silurian species are probably closely related to *Uranoceras*. The relationship of the single described Devonian species is uncertain, but it is suspected that it may be a compressed derivative of the Rhadinoceratidæ.

cones are unknown, and the only curved and coiled genera are *Laureloceras* and *Heracloceras*, though a third genus may have to be added for the reception of *Nautilus oceanus* Hall when that species is made better known from additional material. At present it is known only from the type.

The overlying Waldron shale has yielded few cephalopods. There is a smooth orthoceracone, *Orthoceras simulator*, of unknown structure and therefore uncertain taxonomic position. *Dawsonoceras*, more abundant in the Waldron of Tennessee than in Indiana, shows wide variation in surface features, and probably more than one form is involved (Flower, 1942). The only other Waldron cephalopod is *Lechritrochoceras waldronense* Hall. *Orthoceras amycus* Hall is a little known annulated species possibly from the Waldron, the generic position of which is uncertain.

The overlying Louisville limestone is relatively barren of cephalopods in Indiana. Doubtfully reported from it is *Harrisceras ignotum* Flower (1939). This species was found by the writer in the summer of 1941 in Silurian limestones rich in cephalopods near Olive Hill, Tennessee at the southern end of the Sequatchie anticline. The associated species were not conspecific with any known from the Laurel of Indiana.

Correlation of the Silurian of southern Indiana and northern Indiana has been complicated by an intervening area covered by drift in which no exposures are available. The lowermost of the exposed Silurian beds of northern Indiana, the Missinewa shale is correlated with the Osgood by Cumings and others. It has yielded only a few flattened orthoceracones, mostly undeterminable species of *Protokionoceras*. The Liston Creek limestone, regarded as the probable equivalent of the upper Clinton beds of southern Indiana and Tennessee, including the Laurel to the Louisville and probably also overlying formations, and of the Manistique in the north, has a large but mainly undescribed cephalopod fauna. Orthoceracones are abundant, and though many of the Laurel genera reappear none of the Laurel species

are duplicated. The following list indicates the affinities of many of the undescribed species.

- Harrisoceras obstructum* (Newell)
- Harrisoceras monocameratum* Flower
- Protokionoceras*, sp., aff. *P. myrice* (Hall)
- Kionoceras* cf. *scammondi* (McChesney)
- Kionoceras* cf. *strix* (Hall and Whitfield)
- Leurocycloceras*, n. sp.
- Leurocycloceras* cf. *niagarensis* (Hall)
- Armenoceras*, n. sp.
- Bickmorites bickmoreanum* (Whitfield)
- Bickmorites marshi* (Hall)
- Oxygonioceras wabashense* Foerste
- Phragmoceras angustum* (Newell)
- Phragmoceras projectum* (Newell)
- Tubiferoceras lineare* (Newell)
- Tubiferoceras gilberti* (Kindle and Breger)
- Gomphoceras*, sp.
- Hexameroceras*, sp.
- Lechritrochoceras*, sp.

It is believed that the orthoceracones, from their widespread occurrence in the Silurian of southern Indiana and Tennessee, were indigenous to this area, while the phragmoceroids represent a faunal incursion, probably from the north. If this is so, the Liston Creek limestone might be expected to show some zonation of the fossils, and the phragmoceroids might be expected to put in a relatively late appearance. However, at two localities at which it was possible to determine the relative position of the various species in the beds, it was found that the phragmoceroids and the *Oxygonioceras* occurred low in the section, somewhat below the bed which has yielded the great profusion of orthoceracones, many of which show Laurel affinities.

The Huntington limestone cephalopod fauna is very inadequately known. There can be little question, however, but what it is a typical Racine association, and the first of the Silurian faunas of Indiana which can be placed in the Lockport, using the term in its broader sense, as the upper of the two major divisions of the American Middle Silurian. Its large orthoceracones are clearly in a large part identical with those of the Racine, and some species are involved which seem to have escaped description thus far. Kionoceroids are abundant and essentially Racine

in affinities. Some of these species may appear in the Liston Creek dolomite. *Dawsonoceras* occurs here, and includes types similar to *nodocostatum* and *granti*. *Phragmoceras* attains a greater abundance and variation in size than in the Liston Creek, and one of the largest *Hexameroceras*, *H. cacabiforme* (Newell) occurs here. *Mandaloceras wabashense* (Newell) and *Pentameroceras cumingsi* Flower, n. sp. represent the appearance of genera new to this region. *Lechritrochoceras desplainense* (McChesney), a Racine species, occurs here in abundance. The genus is one found in the Clinton, being present both in the Waldron shale of Indiana and the Irondequoit limestone of New York (Flower, 1942). The brevicones of depressed section, *Amphicyrtoceras* and *Worthenoceras* which characterize the Racine and Cedarville are not yet known from northern Indiana, nor are *Cyrtorizoceras* or other of the numerous cyrtocone genera of the Racine and Port Byron faunas.

In general, it appears from their prolific development in the east central area, that either, most of the large orthoceraconic types characteristic of the earlier part of the Middle Silurian must have developed here indigenously, while in contrast, two distinct northern faunas developed. One is an early one, found in formations of Clinton age, and characterized above all else by *Discosorus* and its allies. This fauna is an arctic one, and only a few stray members of the Discosoridae passed south of the northern Michigan region, *Kayoceras* appearing in the Hopkinton of Iowa, and *Discosorus* itself penetrating the New York Clinton. Wherever in the series of northern Silurian outliers this horizon is capped by another it is very likely to be a bioherm association in which breviconic cephalopods are conspicuous, and orthoconic types are absent. It is from this direction that most of the breviconic genera common to the American and European Silurian entered, for the most part. *Inversoceras*, *Pentameroceras*, *Mandaloceras*, *Phragmoceras*, *Hexameroceras*, *Cyrtorizoceras* and many other cyrtoconic and breviconic genera apparently mark this invasion. Some of these penetrate Indiana in

pre-Racine time, as they clearly occur in the Liston Creek limestone, but failed to penetrate farther south into the Laurel. Possibly the Cincinnati-Chicago axis was an important barrier at this time, as was the contemporaneous Cattaraugus axis of Ontario. However, as there is no evidence that this axis was a definite barrier to deposition, it is more likely that climatic and environmental factors harder to reconstruct may have been the determining factors.

If the Liston Creek limestone derived some of its exotic elements, such as *Phragmoceras*, *Tubiferoceras* and *Gomphoceras* from an arctic invasion, it must be at least in part younger than the beds carrying the *Discosorus* fauna, and may be equivalent of the Attawapiskat limestone and related formations. Further, if the Liston Creek is, as is now coming to be accepted, Clinton in age, the *Discosorus* faunas must be relatively early Clinton. This is consistent with the known facts, for *Discosorus* itself penetrates the New York Clinton only in the relatively early Reynales limestone; the related *Kayoceras* invades the Hopkinton, the lowermost Middle Silurian formation of Iowa. In Anticosti the discosorids are best developed in the lowermost of the Silurian formations, the Gun River, where they are joined by a few orthoceracones *Kionoceras bellatulum*, *Ormoceras morrisoni*, and *Spyroceras tenuiclystratum* which are faintly reminiscent of the orthoceraconic fauna of the east central interior.

Genus **PENTAMEROCERAS** Hyatt

Genotype.—*Gomphoceras mirum* Barrande.

Conch erect, breviconic, the shell closing over the adoral end in a domelike manner, leaving for an aperture a long hyponomic sinus, and five shorter sinuses which radiate from a central point.

The shell is erect, and shows no clear traces of either exogastric or endogastric origin. The sutures are straight and transverse, the siphuncle is ventral, marginal, and is composed of elongate-oval rather slender segments which are free from any trace of organic deposits.

In section the genus is variable, being sometimes compressed, sometimes depressed, and again circular in section.

Unfortunately some confusion attends the use of *Pentameroceras mirum* as a genotype, inasmuch as Barrande included two and possibly three species under that name. To eliminate this difficulty it is necessary to select a type for the species. In making this selection, the original of Barrande's figures 10 to 14 on plate 91 are selected. This selection is made rather than using the first specimen to be figured, because it is much better known and much more adequately illustrated. Not only are all necessary views of the specimen shown, but the phragmocone has been sectioned to reveal the outline of the segments of the siphuncle.

The new name *Pentameroceras depressum* is here proposed for the original of Barrande's figures shown on plate 82, figures 20-25. In this species the section is markedly depressed, the dorsal sinus is shorter and slightly broader than any of the others. Barrande also included in *Gomphoceras mirum* a diminutive specimen illustrated on his plate 82, figures 17-20. This specimen is differentiated from the others readily by its small size. No apertural view is shown, and the details of the aperture are unknown. There is no certainty from his figures whether the section is compressed, depressed or circular. Without these data it seems unwise to propose a name for this specimen.

In placing individuals embracing a wide size range within a single species, Barrande seems to have been accepting the belief later expressed by Hyatt, that many brevicones attained a perfect contracted aperture in immature individuals, which was resorbed periodically in growth. An alternate explanation is that maturity was attained within a species over a remarkable size range. This applies today in certain gastropod species which attain peculiar apertural features upon maturity. Still a third explanation which must be considered is the possibility of sexual dimorphism. The problems attending the recognition of such dimorphism in extinct organisms, such as the brevicones, have been discussed by Flower

(1939, p. 7) and Teichert (1940, p. 60) and were first suggested by Ruedemann (1921, p. 317). Possibly this tiny specimen figured by Barrande might be a diminutive male of one of the other species. If so, sexual dimorphism is here responsible for considerable difference in size as was suggested by Ruedemann and by Teichert, instead of the relatively slight differences attributed to this cause by the writer. The two are not mutually exclusive.

In the opinion of the writer, the more conservative course in a situation of this kind, is the proposal of distinct specific names for the two specimens, which might be sexual variations of the same species. To include both under a single name should require a definite knowledge which can never be obtained for an extinct organism and is justified only in such peculiar cases as that noted by Ruedemann in first proposing the application of sexual dimorphism to breviconic cephalopods. Ruedemann found a large number of specimens in association within which two size groups could be discerned. It does not seem advisable in dealing only with two or three specimens, as in the present instance, to attempt any conclusions of this sort.

*Pentameroceras* has been recognized in the Middle Silurian of America, but no very critical study has been made of the forms with the view of determining specific boundaries and differences. Foerste (1930, p. 380) noted the presence of *Pentameroceras* in the Racine dolomite at Milwaukee and Wauwatosa, in the equivalent Huntington dolomite at Delphi, Indiana, and the Peebles dolomite, of Guelph age, of Ohio. He illustrated the Peebles specimen under the name of *Pentameroceras* cf. *mirum* (Barrande) and considered that "it is not likely that the Bohemian species succeeded in migrating as far as the central states without recognizable changes, but no special attempt has been made as yet to discriminate the different forms." He pointed out certain differences between the Bohemian forms, but stated that the specimen from Peebles was too incomplete to serve as a type.

The differences cited by Foerste consist of the following features: (1) a shorter body chamber (2) a less erect form (3) a compressed rather than a depressed section. In noting the last

Terence Foerste had in mind the specimen figured by Barrande . . . which the name *Pentameroceras depressum* is here proposed. The other differences, however, serve very well to distinguish this form from the type here selected. In addition, the lectotype of *Pentameroceras mirum* has a long living chamber in which the the greatest diameters are attained considerably above the base, and the contraction from the point of greatest diameter to the aperture is much more gradual than in any known American species.

The differences between the Peebles specimen and the one from Port Byron, Illinois, which Foerste subsequently named *Pentameroceras byronense* (Foerste 1930, p. 117, pl. 23, figs. 5A-C,6) are less evident. In both the five lobes of the dorsal part of the aperture are relatively short and broad, and are rounded lobes rather than linear slits. The Peebles specimen is inflated at the base of the living chamber and contracts gradually to the aperture, the convex sides converging slowly but uniformly. In the Port Byron specimens the conch expands to a point two-thirds the distance from the base of the living chamber to the aperture, and then contracts more abruptly orad. The differences seem to be sufficient to warrant considering the Peebles and the Port Byron forms as distinct species, though the two Port Byron specimens figured by Foerste suggests that a larger series might show more gradation between these two forms. Possibly in the development of broad rounded lobes instead of slitlike apertures, there are features which may indicate a close relationship between these two forms, both of Guelph age, and which might be explained as apertural imperfections in the last phylogerontic members of *Pentameroceras*. This hypothesis will require further investigation, however. Evidence is meagre, and the possibility remains that in the few Guelph specimens known, the aperture may not have been completely formed. This explanation is probably not the true one. The internal molds of the Port Byron specimens show the same gradation of the vertical outline and a slight flaring of

the aperture beyond, which indicate a thickening of the interior of the shell around the aperture found only in fully developed gerontic individuals. The development of the basal zone is another indication of this stage of growth (Foerste 1930, pl. 23, fig. 5B).

Two other specimens of *Pentameroceras* from the Silurian of Hudson Bay have been figured. The precise horizon of both is uncertain. They came either from the Ekwan or the Attawapiskat limestones, of which the former underlies the latter. *Pentameroceras rarum* Parks (see Foerste and Savage, 1927, p. 102, pl. 23, fig. 7A-C) is the only *Pentameroceras* known which is clearly exogastric in its affinities, as is *Mandaloceras* for the most part. The five rays of the dorsal aperture are slitlike, subequal in length, the hyponomic sinus is long, straight when seen in vertical section instead of curved with the convexity orad as in all other known species, and the section of the shell is faintly compressed. *Pentameroceras* (?), sp. (Foerste and Savage, p. 103, pl. 23, fig. 6A-C) is a minute specimen, recalling in vertical outline the Peebles specimen, but with five lobes of the dorsal part of the aperture rounded, very poorly developed, and surrounding a wide circular space. The section is faintly compressed, and is more narrowed ventrally than dorsally.

***Pentameroceras cumingsi*** Flower, n. sp.

Plate 2, figs. 1-3

(?) *Pentameroceras mirum* Newell, 1888, Proc. Boston Soc. Nat. Hist., vol. 23, p. 483.

Conch erect, small, breviconic, but with the earlier portion expanding very gradually; attaining the point of gibbosity slightly above the middle of the mature living chamber, from which the shell contracts rapidly over the apertural end leaving only the restricted lobate aperture characteristic of the genus. The venter appears faintly concave in the early part of the shell, becoming straight over the base of the living chamber. The dorsum is straight to the point at which convexity appears. The section is circular. The conch expands in the holotype from a diameter of

7 mm. at the base of the specimen, increasing in a length of 17 mm. to 12 mm. The aperture closes over the adoral end at a length of 23 mm.

The type preserves seven cameræ in a length of 10 mm., the last camera subequal to the preceding in length. The siphuncle is not exposed on the basal septum of the specimen.

The hyponomic sinus, 8 mm. in length, is inflated at its tip, but narrow basally. The five arms of the main part of the aperture about 6 mm. in length, are likewise slightly inflated at their tips. The median lobe is slightly broader than the others. When viewed laterally, the hyponomic sinus presents a slightly curved outline, the convexity being directed orad. The surface of the shell is not preserved.

*Discussion.*—The type upon which this species is based is from the same locality as the specimens which Newell (1888) identified as *Pentameroceras mirum*. It is not possible to tell from Newell's brief description whether or not his forms were conspecific with this one, as seems highly likely. *P. cumingsi* is the only *Pentameroceras* so far known in which the section is circular in the mature state. It is differentiated from the compressed *P. mirum*, *P. rarum*, *P. byronense* and the Peebles specimen attributed to *P. cf. mirum* by the compressed section common to all of those species. *P. depressum* is markedly depressed in section. In having slender slitlike sinuses to the dorsal part of the aperture this species is allied to *P. mirum* and the two Bohemian species, but is separated from the remaining American forms, including the Peebles specimen and the unnamed one from Hudson Bay. From *P. rarum* this form is distinguished by the circular section, the curved condition of the hyponomic sinus when viewed in vertical section, and the somewhat longer lateral sinuses.

*Type.*—Holotype, University of Cincinnati Museum, No. 23095.

*Occurrence.*—From the Huntington dolomite, of Racine age, (Lockport), Middle Silurian, from Delphi, Indiana.

Genus **TETRAMEROCERAS** Hyatt, 1884Genotype.—*Phragmoceras bicinctum* Barrande, 1867

*Tetrameroceras* Hyatt, 1884, Boston Soc. Nat. Hist., Proc., vol. 22, p. 277; Hyatt, 1900, Cephalopoda, in Zittel-Eastmann Textbook of Palaeontology, vol. 1, 1st ed, p. 612; Foerste, 1926, Denison Univ. Bull. Sci. Lab., Jour., vol. 21, p. 360, pl. 50, fig. 1A-C.

Shell compressed, phragmoceroid in aspect, the living chamber swollen and generally convex in both dorsal and ventral profiles. The venter, as marked by the hyponomic sinus and the siphuncle, is concave in the early stages and the dorsum convex. The genus is characterized mainly by the form of the aperture which develops a long hyponomic sinus and four smaller sinuses giving the main part of the aperture a quadrate aspect. The siphuncle is made up of convex segments which contain actinosiphonate deposits.

*Discussion.*—The first known American species of *Tetrameroceras* is described below. Curiously this genus, which one might expect to appear in America in the latter half of Middle Silurian time, along with other genera which are common to the Middle Silurian of America and Bohemia, instead, appears in the Osgood limestone which is Clinton and probably relatively early Clinton. The following Bohemian species, all described by Barrande as members of the genus *Phragmoceras*, are properly placed in *Tetrameroceras*. All forms from the Middle Silurian, étage E of Bohemia: *T. rimosum*, *T. loveni*, *T. discrepans*, *T. insolitum*, *T. vetus*, *T. problematicum*, *T. infaustum*, *T. deshayesi*, *T. bellatum* and *T. bicinctum*.

***Tetrameroceras faberi*** Flower, n. sp.      Plate 1, fig. 1; Plate 3, fig. 1

This species is represented in our collections by a single specimen of a mature shell which is probably slightly compressed by pressure. The shell is 90 mm. in length and increases in height from 21 mm. at the base to 62 mm. slightly above the base of the living chamber. The dorsal outline is strongly and uniformly convex at the base of the specimen, having a radius of curvature of 80 mm. The curvature becomes stronger at the adoral part of the living chamber, its radius decreasing to 40 mm. The venter

is straight from the initial part of the known shell to the adoral portion of the living chamber, where it becomes slightly convex. The sutures develop slight lateral lobes adorally, but rise only slightly orad on the venter. The siphuncle is scalariform, close to the venter, and without any known deposits. The eleven preserved cameræ of the phragmocone increase in depth from 3 mm. to 9 mm., the maximum depth being attained at the fifth camera before the living chamber. Beyond that point the cameræ grow progressively shorter. Traces of vestigial cameral deposits are found at the base of the specimen, but the surfaces fail to show circumferential lobation. They are strongest ventrally, absent dorsally, and form a groove of the internal mold parallel to the suture slightly orad of midheight of each camera. Were they not deeply incised and rather irregular, these markings might be interpreted as the adoral end of the mural part of the septum.

The living chamber has a basal height of 60 mm., a width of 30 mm. The height increases to its maximum of 62 mm., one-third the distance to the aperture, while the width remains the same. Beyond this point the shell contracts vertically and horizontally to the aperture. The hyponomic sinus is 38 mm. long, and slightly inflated. The main aperture is marked by a pair of fingerlike lobes projecting obliquely dorsad, and a shorter more rounded pair projecting ventrad. The lateral pressure which has slightly distorted the shell has made these seem asymmetrical.

*Discussion.*—This species is of interest in that while it is a relatively early appearance of this genus in the Middle Silurian, it fails to show features which are generalized. The endogastric condition of the apical part of the shell is not so marked as in many Bohemian species of *Tetrameroceras*, and the aperture is more strongly contracted than in many of these previously described species, where it is relatively open and the lobes are short and rather broadly rounded. In this species, however, the lobes are essentially linear slits, slightly rounded at the ends, and they

form the main part of the aperture of the shell. The form of the segments of the siphuncle is typical of the genus, but the apparent absence of actinosiphonate structure is not. This may be attributed either to poor preservation or to the fact that the specimen has not attained a gerontic condition as is shown by the absence of a basal zone, and the absence of any trace of thickening of the shell near the aperture. Cameral deposits are, however, slightly developed, but can be discerned only in the apical part of the specimen.

*Holotype*.—University of Cincinnati Museum, No. 22532.

*Occurrence*.—From the Osgood limestone, Madison, Indiana. The Osgood is the lowermost formation of the Clinton of Indiana, overlying the Brassfield of Medinan, Lower Silurian age.

Genus **LAURELOCERAS** Flower, n. gen.

Genotype.—*Laureloceras cumingsi* Flower, n. sp.

Conch cyrtoconic or more probably gyroceraconic when complete, expanding very gradually, and slender. The section is a compressed oval, the venter considerably more narrowly rounded than the dorsum. The sutures are essentially transverse to the axis of the shell, and may or may not develop broad lobes over the lateral surfaces. The siphuncle is close to the venter. The septal necks are straight and orthochoanitic, the connecting ring somewhat expanded. No deposits are known in the interior.

This genus is erected for the reception of three species, the genotype, *L. cumingsi*, which is described and illustrated here, and the two previously described forms, *L. howardi* (Miller, 1893, p. 326, pl. 12, fig. 1) of the Laurel limestone of Indiana, and *L. nashvillense* (Miller, 1891, p. 697, pl. 16, fig. 1), from the Laurel limestone of Tennessee.

Although very simple in external aspect, there are few described genera which are at all similar in aspect. Other compressed cyrtoconic smooth-shelled genera are largely cyrtochoa-

itic. This applies to *Oonoceras* Hyatt and its allies including *Richardsonoceras* and *Cyrtorizoceras*. The only Ordovician genus at all similar in aspect is *Graciloceras* Flower, described in an earlier paper in this series, but the aspect of the two genera is very distinct, *Graciloceras* being a cyrtocoene, with a short phragmocone of very closely spaced septa. Silurian cyrtocoenic cephalopods which resemble *Laureloceras* only remotely are cyrtocoenitic. No comparable younger forms are known.

***Laureloceras cumingsi*** Flower, n. sp.

Plate 5, figs. 9, 12

This species is based upon a single specimen which describes about three-eighths of a revolution, in which the radius of curvature of the venter increases from 65 mm. to 117 mm. in a ventral length of 160 mm. and an actual length of 125 mm. The shell is compressed about uniformly throughout, the height being 27 mm. with the width of 20 mm. The venter is considerably more narrowly rounded than the dorsum. The height of the type increases in 100 mm. as measured on the venter from 21 mm. to 38 mm.

The sutures are nearly transverse, but slope slightly orad on the venter. The cameræ are deep, four and a half in a length equal to an adoral shell height of 25 mm., and five in a length equal to an adoral shell height of 35 mm. The septum is normal in curvature, equal to the depth of a camera in vertical section, being 5 mm. deep at a shell height of 26 mm. The siphuncle is located about 1 mm. from the ventral wall. It is 1.2 mm. across the septal foramen and expands within the cameræ to 2 mm. The septal necks are inclined parallel to the axis of the shell and are properly orthocoenitic. The connecting rings are convex in section. No organic deposits are noted in the siphuncle. The section illustrated has the structure somewhat complicated by adventitious pyrite.

The surface of the shell is not clearly preserved. Enough of the shell is preserved to indicate, however, that the surface must have been essentially smooth. There is no indication of a

hyponomic sinus, but it is not certain whether one was present or not.

*Discussion.*—This species is differentiated from *Laureloceras nashvillense* (Miller, 1891, p. 697, pl. 16, fig. 1) by the somewhat closely spaced septa, five occurring in a length equal to the height of the shell in *L. cumingsi*, and only four in an even later stage of *L. nashvillense*. These two species are quite similar in curvature, *L. nashvillense* being perhaps slightly less coiled, and slightly less rapidly expanding. Although the siphuncle of that species is not known there can be little doubt but that it is congeneric with *L. cumingsi* which it resembles very strongly. This species, from the Laurel limestone of Nashville, Tennessee, appears to be known only from Miller's original specimen and description.

Very similar also is *Laureloceras howardi* (Miller, 1893, p. 326, pl. 12, fig. 1) from the Laurel limestone of St. Paul, Indiana. This species is considerably more strongly curved than *L. cumingsi* and more rapidly expanding. The septa are more closely spaced and the sutures are evidently more inclined to the axis of the shell, sloping orad strongly on the venter. The lateral lobes shown in the holotype are probably not diagnostic but appear to be a phenomenon attendant upon the weathering of a lateral surface.

No other congeneric species are known. Members of the genus bear a superficial resemblance to the smooth-shelled genus *Oxygonioceras* Foerste of the Silurian. This genus is represented in the Liston Creek limestone, of which the Laurel is partially equivalent, though the Liston Creek limestone is probably equivalent also to higher formations of the Silurian of southern Indiana and probably also of Tennessee, by *Oxygonioceras wabashense* Foerste. All known specimens of *Oxygonioceras* can fortunately be distinguished from *Laureloceras* species by their much more closely spaced septa, a superficial but highly convenient criterion. *Oxygonioceras* differs from *Laureloceras* in the strongly cyrtochoanitic structure of the siphuncle, a fact which it has been pos-

sible to confirm on the basis of *O. wabashense* of the Liston Creek limestone, as well as upon the basis of specimens and Barrande's figures of Silurian species of Bohemia, and one species to be described elsewhere from the Silurian of Arisiag, Nova Scotia.

*Type*.—Holotype, University of Cincinnati Museum, No. 24194.

*Occurrence*.—From the Laurel limestone, two miles east of Westport Indiana. This specimen is one of several from a single layer in the Laurel limestone which, at this locality, has yielded an abundance of cephalopods including a number of new species. It is associated with *Leurocyloceras bucheri* Flower, *Virgoceras cancellatum* Flower, *Dawsonoceras*, n. sp. *Protokionoceras*, n. sp. *Elrodoceras indianense* (Miller), *Elrodoceras*, n. sp., *Harrisoceras reevesi* Flower and *Ormoceras*, n. sp. which occur there in profusion. The only associated fossils are trilobites, *Dalmanites* and *Bumastus*, two brachiopods, *Atrypa reticularis* and a *Cyrtina*, and fragments of cystoids. Gastropods occur but are too poorly preserved for identification. The parallel arrangement of many of the cephalopod shells suggests a thanatocenose, which, however, is opposed by the occurrence here together of abundant cephalopods, trilobites and gastropods, three groups which commonly occur together in massive limestones and which, by the accumulated evidence of many such occurrences, are regarded as indicative of a natural ecological association which will be discussed elsewhere as the cephalopod facies.

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## VII. ANNULATED ORTHOCERA CONIC GENERA OF PALEOZOIC NAUTILOIDS

### ABSTRACT

A survey of Paleozoic annulated orthoceracones reveals that they are a homeomorphic and not a genetic group. The generic names which have thus far been proposed for such shells are reviewed. Some genera are so little known that they are practically useless until the types can be restudied. Nomenclature has been complicated by the proposal of generic names based upon superficial features of no genetic value. Restudy of genotypes makes some of these genera available.

### INTRODUCTION

Annulated orthoceracones are numerous in the Paleozoic, and those of North America alone comprise over a hundred described species. Such shells first appear in the Cambro-Ordovician beds, approximately of Gasconade age, and representatives of the form-group continue upward as far as the Pennsylvanian. Sixty years ago all such species were placed in the too-inclusive genus *Orthoceras* along with all other straight cephalopods. Subsequent study has not only made it necessary to distinguish generically between annulated and nonannulated cephalopods, but has shown that the annulated cephalopods are in themselves polyphyletic, for annuli have clearly developed many times independently in straight cephalopods.

At the present time thirty-two generic names have been proposed for annulated orthoceracones. Some were proposed long ago before the structural features of cephalopods were well understood. Some of these are useless, while others are not only valid but useful genera. Others have been proposed as morphological investigations showed the need for new names, and a third group, based upon superficial features of the shell surface, are of value only because the types have been restudied and are found to fall into natural groups to which no earlier name could be properly applied.

## PROPOSED GENERIC NAMES

*Cycloceras* McCoy was the first generic name to be proposed for annulated straight cephalopods. Unfortunately the genotype, by subsequent designation (Bassler, 1915), is a species which is little known. It is not even certain whether the genus should be used for orthochoanitic or cyrtochoanitic cephalopods. Miller, Dunbar and Condra (1933, p. 45) have shown that the genotype from the Mississippian of Europe is so little known that until it is restudied, no additional species can be placed in the genus with certainty. Previously Foerste (1924, p. 224) proposed the genus *Perigrammoceras*, based upon *Orthoceras rugosum* Fleming, for species of quite similar external aspect, but Foerste (1932, p. 83) recognized that this genus could not be distinguished from *Cycloceras* and regarded it as a synonym. The same conclusion was reached by Miller, Dunbar and Condra (1933, p. 45). The siphuncle of the genotype of this genus is likewise unknown, and it is uncertain whether it is orthochoanitic or cyrtochoanitic. Subsequently Miller and Furnish (1938, p. 50) have used *Perigrammoceras* for a species from the Mississippian of America, and Miller and Furnish (1940) have subsequently described American Mississippian annulated shells in terms of the genus *Cycloceras*. The reasons for these changes of view have not been stated.

Hyatt (1884, 1900) recognized several genera of annulated cephalopods and placed them in two families. *Protocycloceras* Hyatt, *Cycloceras* McCoy and *Dawsonoceras* Hyatt made up, with the little known *Ctenoceras*, the family Cycloceratidæ of Hyatt, while *Spyroceras* was placed in the family Kionoceratidæ. Both families were placed in the Orthochoanites, and indeed, it was not recognized at that time that there were any cyrtochoanitic annulated cephalopods.

At the present time these genera are very differently treated. *Protocycloceras* Hyatt, based upon the Canadian species *P. lamar-*

*cki* (Billings), was regarded as holochoanitic by Ruedemann (1906) a view of which is certainly supported by the aspect of the siphuncle wall as seen in opaque section. Thin sections, however, show that the septal necks are very short and that the wall of the siphuncle is made up of very thick connecting rings (Flower, 1941).

*Dawsonoceras* Hyatt based on *Orthoceras annulatum* Sowby, is a valid genus characteristic of the Silurian of America and Europe in which the shell is annulated and its surface marked by transverse ridges which are festooned. The siphuncle is sub-orthochoanitic and the cameræ contain mural deposits, while small annuli develop in the siphuncle.

*Spyroceras* Hyatt, based upon *Orthoceras crotalum* Hall, long used for all annulated orthochoanitic orthoceracones with longitudinal markings, has been shown to have the internal structure of a *Dolorthoceras* (Flower, 1939) and as such is greatly restricted in scope. No species older than the Middle Devonian has been demonstrated to have this structure. The genus is at present restricted to Middle and Upper Devonian species of America and Europe. Other generic names must be employed for orthochoanitic shells which resemble *Spyroceras* externally and also for cyrtochoanitic Ordovician species of this same general aspect which are of uncertain relationship but are clearly not Pseudorthoceratidæ.

Grabau and Shimer (1910) proposed *Cyclendoceras* based upon *Endoceras annulatum* Hall of the Trenton limestone of New York for species which have the essential structure of an *Endoceras* but which have annulated shells.

Foerste and others have used *Spyroceras* and *Cycloceras* of Ordovician and Silurian species with the surface patterns regarded formerly as diagnostic of those genera, including within them species which were orthochoanitic, cyrtochoanitic, and sometimes intermediate between the two in the form of the segments of the siphuncle. He proposed *Leurocycloceras* for conchs with annuli but without longitudinal or transverse markings. That genus, based upon *L. raymondi* Foerste (1928, p. 272), was revised by

the writer (Flower, 1941A) and found to contain all Silurian species of America formerly placed in *Cycloceras*. In the genus connecting rings are absent, and cameral deposits, episeptal and hyoseptal, may fuse within the septal foramina in advanced stages of growth. In the Silurian of Bohemia, however, there are shells of the aspect of *Cycloceras* with simple tubular siphuncles and no known deposits of the phragmocone, typified by *Orthoceras bohemicum* Barrande. No generic name is available for such species.

*Metaspyroceras* Foerste (1932), based upon *Spyroceras ruedemanni* Foerste (1921) of the Cedarville dolomite, Middle Silurian, was proposed for shells similar in aspect to *Spyroceras* but with annuli sloping orad on one side of the shell and the sutures sloping orad on the opposite side. Happily the siphuncle of the genotype is known to be orthochoanitic (Foerste, 1928, pl. 61, fig. 3A-G). This is the first genus proposed for shells similar externally to *Spyroceras* but with an orthochoanitic siphuncle. Similar orthochoanitic species but with transverse sutures and septa are placed in another genus, *Anaspyroceras*, as noted below, but the two may be very closely related.

Troedsson (1926) was the first to deliberately propose a name for cyrtochoanitic annulated orthoceracones. This is *Eskimoceras*, based upon *E. boreale* Troedsson of the Cape Calhoun series of the Ordovician of Greenland. The segments of the siphuncle are nummuloidal and no deposits are known within the camerae or siphuncle. Similar siphuncles are known in Ordovician cephalopods with the exterior pattern of both *Cycloceras* and *Spyroceras*, as formerly used in the broad sense, and as the surface of the genotype is not known, it is uncertain to which of these groups, if either, *Eskimoceras* can be applied. No species other than the genotype have yet been placed in the genus.

Kobayashi (1927) described *Tofangoceras* for Ordovician annulated cephalopods with relatively narrow but crytochoanitic siphuncles. The genus was subsequently divided by its author (1936) so that *Tofangoceras* included only those species that lacked deposits in the siphuncle, though having cameral deposits,

while *Tofangocerina* contained all species which showed a continuous lining within the siphuncle. A similar division was made at the same time between the smooth-shelled *Stereoplasmoceras* and *Stereoplasmocerina*. Unfortunately the Manchurian species which supply the basis of this work are largely fragmentary and none embrace any appreciable portion of the conch. Such differences might appear in different parts of the shell of a single specimen. They may also result from the examination of commensurate parts of the shell of individuals within a species representing various growth stages. Adoral parts of the conch of any cephalopod bearing organic deposits may be expected to lack such structures. Portions farther apicad in the *Stereoplasmoceratidæ* and *Pseudorthoceratidæ* may show cameral but no siphonal deposits. This is because these deposits show a constant and specific relationship to the growth of the shell in their appearance. In many cephalopods cameral deposits may appear over a very considerable interval of the phragmocone without any trace of siphonal deposits, which are frequently much more delayed in their appearance. These cameral deposits in a species may appear first in the tenth camera from the living chamber, while siphonal deposits may be delayed until the eighteenth or even later. Thus adoral and adapical parts of the same species may show the features characteristic of *Tofangoceras* and *Tofangocerina*. This is in itself no criticism of the genera, as shown by the relationship of growth stages to the biogenetic law in the *Pseudorthoceratidæ*, but where, as in the case of *Tofangoceras*, all known specimens are fragmentary, it presents an objection and a possible alternate explanation of the known phenomena. Until the matter can be investigated further, it seems unwise to regard *Tofangoceras* and *Tofangocerina* as distinct genera. The surface features are not well known in *Tofangoceras* but such markings as have been observed are fine transverse lines as in *Cycloceras*. Sections of some Black River species from Watertown, N. Y., closely allied to species which Foerste placed in *Cycloceras* show siphuncles and cameral deposits similar to the Manchurian species of *Tofangoceras*, and are properly placed in that genus.

Miller, Dunbar and Condra (1933) erected the genus *Brachycycloceras*, based upon *Brachycycloceras normale* Miller, Dunbar and Condra of the Pennsylvanian of central North America, for orthochoanitic conchs of cycloceroid aspect in which the sutures slope orad on one side of the shell and the annuli forward on the opposite side. Flower and Caster (1935) erected *Neocycloceras*, based upon *Neocycloceras obliquum* Flower and Caster, for Upper Devonian annulated orthoceracones with fine transverse markings, usually more or less oblique, slightly oblique sutures, and a subcentral nummuloidal siphuncle. The internal structure is not adequately known, as no specimens have been found showing the structure of any deposits in the siphuncle. The only cyrtchoanitic cephalopods in that part of the column are the actinoceroids, which have considerably larger siphuncles, and the Pseudorthoceratidæ. Therefore *Neocycloceras* is believed to belong to the Pseudorthoceratidæ (Flower, 1939, p. 180) though the problem still requires investigation on the basis of better preserved material than has yet been found.

Also worthy of mention is *Cyrtospyroceras* Flower (1938), based upon *C. reimanni* Flower of the Hamilton, a cyrtconic shell with a marginal siphuncle similar to that of *Dolorthoceras* in outline. No deposits have been observed within the phragmocone. The genus may be a curved development from *Spyroceras* or may be only homeomorphic with it. No other possible origin of the genus has, however, been suggested.

*Geisonoceroides* Flower (1939) is a Middle Devonian development of the Pseudorthoceratidæ in which the very slender shell bears low, rounded annuli and fine transverse markings.

Two annulated genera have been proposed among those of the Ozarkian and Canadian by Ulrich and Foerste (1935, pp. 266, 289). *Catoraphiceras*, based upon *C. lobatum* Ulrich and Foerste of the Canadian of Tennessee and described as holochoanitic, is a slightly depressed annulated shell characterized by sutures which form a narrow conspicuous lobe on the ventral (siphonal) side of the shell.

*Walcottoceras* based upon *Endoceras? monensis* Walcott, is a compressed annulated shell with a large marginal siphuncle regarded as holocoanitic. In view of the elliphoanitic or rather aneuchoanitic nature of many such siphuncles in the early Paleozoic (Flower, 1942) the holocoanitic nature of both of these genera is regarded with doubt. *Catoraphiceras* is Canadian. *Walcottoceras* is listed as Ozarkian. The writer has found typical representatives of that genus, however, in association with *Lecanospira*, *Bassleroceras*, *Clitendoceras*, *Hystricurus* and shells probably best placed in *Pachendoceras*, in a faunule which is largely a typical Canadian assemblage in the Ft. Ann quadrangle of eastern New York.

#### GENERA PROPOSED BY SHIMIZU AND OBATA

The above genera are those proposed up to the present with the exception of those proposed by Shimizu and Obata. Their work is best treated separately because of the special problems involved. Thus far all except a very few of the genera have been based upon species which were well enough known so that they could be easily recognized. Indeed, the only exceptions to this at the present time are the Mississippian genotypes of *Cycloceras* and *Perigrammoceras*. Foerste, and most other authors, had applied *Spyroceras* and *Cycloceras*, broadly to include species which together ranged fairly well through the lower part of the Paleozoic, though conscious of their error in doing so. This procedure was apparently adopted because it was felt that the alternate step, the proposal of new generic names, should await a more thorough study of the species involved, and in particular, the use of adequately known genotypes. Shimizu and Obata (1935, 1936) displayed none of these inhibitions. Basing their observations almost completely upon the published works of Foerste, Kobayashi and Endo, they have proposed a large number of generic names, and quite a few family names, based largely upon minor differences in the surface features of the shell, in conjunction with fine distinctions between various types of siphuncular segments. In both respects their statements are often misleading and sometimes deliberately false. The generic names

which they have proposed have thus far not been employed to any considerable extent by other authors. Were the differences, which they mention the criteria for the recognition of their genera, their work might well be consigned to the oblivion which it so richly deserves. However, a generic name, if proposed under certain conditions, chief among which is the use of a genotype, is valid from a nomenclatorial point of view however absurd its description may be. When such names are proposed for a group of organisms in which new generic divisions are needed, they must be considered, for subsequently described genera run the danger of being reduced to synonymy. It should be noted that there are no generic names among those so far considered for the following types of annulated cephalopods:

1. Annulated species with longitudinal markings and an orthochoanitic siphuncle, and simple transverse sutures.
2. Annulated cephalopods with longitudinal markings and a cyrtochoanitic siphuncle, lacking deposits of the Pseudortho-*ceratidæ*, and either empty or with annular deposits.
3. Orthochoanitic shells with the aspect of *Cycloceras*.
4. Cyrtochoanitic shells with the aspect of *Cycloceras* but with simple sutures.

Such species are abundant in the Ordovician and Silurian, and generic names are needed for them. It is necessary to determine first whether any of the generic names already proposed can be used for such species.

In the following pages the genera proposed by Shimizu and Obata are analysed in as far as the resources available to the writer permit. Some genera are based upon species which are so inadequately known that no other species can be assigned to the genus with certainty.\* In other cases the genotypes have yielded adequate structural information.

Before proceeding to a detailed analysis of the genera, a brief survey of the results of this investigation is presented.

\* In some instances the genotypes are known only from single specimens. The rarity of the species and the poor preservation of internal structure characteristic of the beds in which they occur (as in parts of the Trenton of New York) makes it improbable that they will ever be well enough known to serve as useful genotypes.

Family **SPYROCERATIDÆ** Shimizu and Obata

This name is abandoned. It was proposed for orthochoanitic genera of the external aspect of *Spyroceras*, ignoring completely that the genotype of *Spyroceras*, *S. crotalum* (Hall 1876) has a cyrtochoanitic siphuncle. Subsequently the writer (1939) has demonstrated that *Spyroceras* is properly placed in the Pseudorthoceratidæ. The genera which Shimizu and Obata placed in the Spyroceratidæ are as follows:

*Eospyroceras*.—A subjective synonym of *Metaspyroceras* Foerste.

*Hypospyroceras*.—Inadequately known. The genotype is apparently known only from the type, which does not show the necessary internal structure.

*Subspyroceras*.—Until the siphuncle of the genotype is made known, no other species can be placed in this genus.

*Anaspyroceras*.—The genotype is orthochoanitic. The genus must be used for orthochoanitic shells of the external aspect of *Spyroceras*, with transvers annuli and sutures. It may, however, grade into *Metaspyroceras*.

*Gorbyoceras*.—Sections of the genotype yielded a cyrtochoanitic siphuncle, contrary to the exception of Shimizu and Obata who placed it in the orthochoanitic Spyroceratidæ by faith alone. The segments of the siphuncle are similar in form to those of relatively early stages of *Treptoceras*. It is uncertain whether this genus, like *Treptoceras*, is an actinoceroid, or whether it belongs to some other group.

Family **HAMMELLOCERATIDÆ**

This name is dropped because the type genus is not recognized. It was proposed for cyrtochoanitic shells externally like *Spyroceras*.

*Hammelloceras*.—A subjective synonym of *Gorbyoceras*.

*Cedarvilloceras*.—A subjective synonym of *Dawsonoceras* Hyatt. The siphuncle is not properly cyrtochoanitic.

Family **CYCLOCERATIDÆ** Hyatt

As emended by Shimizu and Obata, this family is confined to orthochoanitic annulated shells with transverse markings. That the siphuncle of *Cycloceras* itself is unknown is a fact which they treat with an indifference amounting to apathy. Besides *Cycloceras* they place in it:

*Paleocycloceras*.—A subjective synonym of *Protocycloceras*.

*Foersteoceras*.—A homonym of *Foersteoceras* Ruedemann. Properly, the family Cycloceratidæ can contain only the type genus until *Cycloceras* itself is more adequately known.

Family **ESKIMOCERATIDÆ** Shimizu and Obata

As the genotype is not known to have transverse markings, the family cannot be used for such shells. Two new genera are placed here with *Eskimoceras*.

*Pseudeskimoceras*.—A subjective synonym of *Tofangoceras*.

*Kogenoceras*.—A subjective synonym of *Tofangoceras*.

GENERA PROPOSED BY SHIMIZU AND OBATA FOR  
SHELLS OF THE EXTERNAL ASPECT OF SPYRO-  
CERAS (SPYROCERATIDÆ AND HAMMELL-  
OCERATIDÆ OF SHIMIZU AND OBATA)

Genus **EOSPYROCERAS** Shimizu and Obata

Genotype.—*Orthoceras arcuoliratum* Hall (1847, p. 198, pl. 42, fig. 7).

*Original description*.—"Genotype *Orthoceras arcuoliratum* Hall from the Middle Ordovician of North America. The extremely arching or undulating annulations and fine longitudinal striae of this genus serve to distinguish it from the other known

representatives of *Spyroceratidæ*. Although the siphuncular structure of the genotype is unknown, it is provisionally included in *Spyroceratidæ*."

It is obviously impossible to use this generic name until the condition of the siphuncle is known for the genotype. Happily, a hypotype in the collection of the University of Cincinnati Museum, No. 10452, from the Trenton limestone near Theresa, New York, has revealed a portion of the siphuncle, sufficient to show that it was orthochoanitic and perfectly tubular. This generic name can therefore be used for orthochoanitic annulated cephalopods with longitudinal markings. Unfortunately, however, the slope of the annuli in the genotype is very close to that of *Metaspyroceras* Foerste (1932). No specimens of the genotype are known which preserve the sutures clearly enough to show whether they slope in a direction opposite to that of the oblique annuli or not. Even if the sutures are straight and transverse, there is no clear dividing line between such species and those in which the sutures as well as the annuli are oblique. Therefore, I tentatively regard *Eospyroceras* as a subjective synonym of *Metaspyroceras* Foerste. Foerste (1928, 1932) placed *Orthoceras arcuoliratum* Hall in *Spyroceras* while in the same work he placed some other species in *Metaspyroceras*. The distinction applied by Foerste is not altogether clear. Apparently only those species with markedly oblique sutures and annuli were placed in *Metaspyroceras*, while those with oblique as well as transverse annuli but with sutures which were either relatively straight and transverse, or poorly shown, were placed in *Spyroceras, sensu lato*. The problem of the generic distinction in such species is one to which there seems to be more than one possible nomenclatorial solution. However, in view of the present restriction of *Spyroceras* to members of the Pseudorthoceratidæ, the question is no longer what species may be placed in *Spyroceras*, but what ones can properly be included in *Metaspyroceras*. *Spyroceras* cannot properly be applied to any known pre-Devonian cephalopod. *Metaspyroceras* is the first genus proposed for orthochoanitic shells

of the external aspect of *Spyroceras*, and as such might possibly be extended to include all such shells which range from Ordovician though the Silurian and possibly even higher. In the present work, however, *Metaspyroceras* is confined to shells in which the annuli are oblique, though more latitude is allowed the condition of the sutures than was done by Foerste, largely because it is believed that no natural distinction can be made on this basis.

Genus **HYOSPYROCERAS** Shimizu and Obata

Genotype.—*Orthoceras teretiforme* Hall

*Original description*.—“*Hyospyroceras*, gen. nov. Genotype; *Orthoceras teretiforme* Hall . . . from the Ordovician of North America. This genus is characterized by its slightly undulating broad annulations marked with coarse longitudinal striae.”

*Orthoceras teretiforme* Hall (1847, p. 198, pl. 42, fig. 8) (see also Foerste, 1932, p. 98-100, pl. 11, fig. 5A-B) is the genotype. There is no such described species as *Orthoceras teretiforme* Hall which is obviously a misprint. The nature of the siphuncle is unknown in this species. Consequently until it is known, the generic name cannot be applied to either orthochoanitic or cyrtchoanitic annulated shells. Foerste (1932) figures only a part of the original type specimen. The remainder is apparently lost. Insofar as the writer has been able to determine, this species seems to be known only from this small specimen. It is inadequate as the basis of a genus, which in the last analysis, it is. The annuli are slightly oblique as in *Metaspyroceras* Foerste and its synonym *Eospyroceras* Shimizu and Obata. The annulations are not so broad as indicated in Hall's original drawing, and the surface features noted by Shimizu and Obata are not adequate for the recognition of the genus which is not only unrecognizable in its present state but is regarded tentatively as a subjective synonym of *Metaspyroceras* Foerste.

Genus **SUBSPYROCERAS** Shimizu and Obata (1935, p. 4)

Genotype.—*Spyroceras middlevillense* Foerste (1928, Denison Univ. Bull., Sci. Lab., Jour., vol. 23, p. 178, pl. 40, fig. 3A-B).

*Original description*.—“This genus is similar to typical *Spyro-*

*ceras* but with more prominent annulations and coarser, stronger, longitudinal striæ. *Orthoceras olorus* Hall [1847, p. 201, pl. 43, fig. 5] and *O. clathratum* Hall [*Ibid.*] from the middle Ordovician of North America, assigned by Foerste to *Spyroceras*, may belong to *Subspyroceras*. Beside it *Spyroceras orientale* Kobayashi [1934, p. 425, pl. 21, fig. 8-11] from the Middle Ordovician of Korea and *Spyroceras*, sp. indet. [in Endo, 1932, p. 73, pl. 38, fig. 5] from the Ordovician of Shensi, China are referred to *Subspyroceras*."

In the above only the method of citation of the species mentioned has been changed to make it intelligible without the bibliography of Shimizu and Obata.

The siphuncle is unknown. Until it has been studied in the genotype, it cannot be said for certain whether the genus is orthochoanitic or cyrtochoanitic. Similar species, with prominent transverse annuli and coarse surface markings, in the Chazyan, Black River and Cincinnati, which have been studied by the writer, are both orthochoanitic, having perfectly tubular siphuncles, and cyrtochoanitic, having considerably expanded siphuncles. Obviously two genera are involved, but in the present state of ignorance of *Subspyroceras*, that name which should never have been proposed upon such meagre data, cannot be applied to either group of species.

Genus **ANASPYROCERAS** Shimizu and Obata (1935, p. 4)

Genotype.—*Orthoceras anellum* (Conrad, 1843, (see also Foerste, 1928, p. 177, pl. 40, fig. 4). Beloit member, Black River formation, Mineral Point, Wisconsin.

*Original description*.—"This genus is readily distinguished from *Spyroceras* by its more crowded, stronger annulations. *Dawsonoceras* ? *aequilonare* Troedsson [1926, p. 79, pl. 9, fig. 2-4, incorrectly included by Foerste (13, p. 162) in *Spyroceras*] from the Ordovician of Greenland, and *Spyroceras fritzi* Foerste (13, p. 163, pl. 37, fig. 2) from the middle Ordovician of North America probably belong to *Anaspyroceras*."

The criteria upon which this genus was based by Shimizu and Obata seem even more absurd when it is remembered that such species as *Spyroceras lima* and *S. thestor*, typical members of the genus from the Hamilton of New York might be included here as easily. As usual, Shimizu and Obata have selected as a genotype of a new genus in their presumably orthochoanitic Spyroceratidæ a species for which the form of the siphuncle is unknown. Study of a specimen in the collections of the University of Cincinnati Museum revealed the presence of straight septal necks in the species, but failed to show connecting rings. The genus can, then, be used for orthochoanitic conchs of the aspect of *Spyroceras*. Its use seems a necessary step. Unfortunately there is no certainty that future study may not show that it is not distinct from the inadequately known genus *Subspyroceras* which precedes it in the descriptions of Shimizu and Obata. Should this occur, that genus would have to be considered as having page priority.

Genus **CEDARVILLOCERAS** Shimizu and Obata

Genotype.—*Dawsonoceras nodocostatum* (McChesney) Foerste (1928, p. 276, pl. 58, fig. 3, pl. 59, fig. 1) Silurian of North America.

*Original description*.—"This genus differs from the typical *Dawsonoceras* chiefly in having narrow but distinct equidistant longitudinal ridges crossing the annulations. We believe it to be a derivative of the Ordovician anaspyroceratid stock, which has much finer longitudinal ridges. The specimen figured by Patte as *Orthoceras pseudocalamiteum* (not Barrande) from the Gotlandian of Yunnan, China, has not the same form as the species of Barrande. It appears to be referable to *Cedarvilloceras*."

Study of American species of *Dawsonoceras* shows, however, that *D. nodocostatum* represents one of two extremes in the modification of the ornament. Internally it is typical of *Dawsonoceras*, and grades into it through such allied forms as *D. hyatti* Foerste and *D. bridgeportense* Foerste. As I am unable to find any good point of division between this and typical *Dawsonoceras*, this new generic name is one for which it does not seem possible to find any good use. Therefore *Cedarvilloceras* is regarded as a

subjective synonym of *Dawsonoceras*. The genus is common in the Silurian of America, and it is represented by a considerable number of species which are very closely related. (Flower, 1942, p. 12-17.) It is also well developed in the European Silurian.

Genus **GORBYOCERAS** Shimizu and Obata

Genotype.—*Orthoceras gorbyi* Miller, 1894. (See also Foerste, 1928, p. 283, pl. 41, fig. 4a-c.) Richmond. Upper Ordovician, Ohio and Indiana.

*Original description*.—"This genus is characterized by possessing peculiar annulations and distinct longitudinal striae; the annulations sloping downward and weakening toward the venter."

Although this genus is placed among the *Spyroceratidæ* by Shimizu and Obata and is therefore presumably regarded as orthochoanitic by them, no description had up to that time included any mention of the structure of the siphuncle of the genotype. That species has been restudied on the basis of a good suite of specimens from the collections of the University of Cincinnati and of Dr. W. H. Shideler of Miami University. The siphuncle is found to be cyrtochoanitic, made up of broadly oval segments with strongly recurved short septal necks, and is indistinguishable in outline from the siphuncle of early epehebic *Treptoceras* Flower. Further, the earliest part of the shell sectioned shows small annulosiphonate deposits. These facts suggest strongly that *Gorbyoceras* may be a member of the *Sactoceratidæ* of the *Actinoceroidea*. The cyrtochoanitic nature of the siphuncle is all that preserves the name of *Gorbyoceras*, for it happens to be the first generic name proposed in connection with a cyrtochoanitic shell of the aspect of *Spyroceras* with broadly rounded siphuncular segments and small annulosiphonate deposits. Such species are widespread in the Ordovician, ranging from the Chazyan *Spyroceras clintoni* (Miller) (see Ruedemann, 1906) to the genotype and allied species of Richmond age. It has page priority over *Hammelloceras* Shimizu and Obata, discussed below and *Porteroceras* Shimizu and Obata. These generic names are proposed for cyrtochoanitic conchs of very similar aspect, but distinguished, as noted below, upon the basis of details of the surface sculpture. The perpetuation of *Gorbyoceras* rests upon the rules of zoological nomenclature and upon page priority and not upon a single one of

the features mentioned in the above quoted description of Shimizu and Obata. Oblique annuli are found in other conchs of spyroceroid aspect, even in *Spyroceras, sensu stricto* in the Devonian. *Spyroceras oppletum* Flower (1939) of the Tully limestone, a typical *Spyroceras* internally, has low annuli which may fade out on one side of the shell. Equally oblique annuli are to be found in both orthochoanitic and cyrtochoanitic shells with the ornament of *Spyroceras*. Indeed, externally, the oblique annuli and sutures makes *Gorbyoceras* an almost perfect homemorph for *Metaspyroceras* Foerste, the only difference shown on the exterior of typical specimens being the tendency for the annuli to weaken and disappear on the ventral side of *Gorbyoceras*. This is a feature not constant even in the genotype, as shown by the study of a considerable series of specimens.

*Revised description.*—Conch orthoceraconic, rarely slightly curved, with annuli and longitudinal markings. In the genotype the siphuncle is broadly cyrtochoanitic, with very short septal necks and segments of rounded outline, similar to those of early ephelic *Treptoceras*. The obliquity of the annuli and sutures is not a constant feature, nor is the low rounded condition of the annuli. Such general and obvious differences in the shells have failed to show any stratigraphic or paleogeographical uniformity and I can discover no good reason for subdividing the genera as at present established on the basis of such features. The segments of the siphuncle are broader than in *Spyroceras* and siphonal deposits do not line the siphuncle as in the Pseudorthoceratidæ.

Genus **HAMMELLOCERAS** Shimizu and Obata

*Genotype.*—*Dawsonoceras hammelli* Foerste. (1910, p. 74, pl. 1, fig. 4). Richmond, Ohio and Indiana.

*Original description.*—"Externally this genus is somewhat similar externally to *Kionoceras* except that it has prominent annulations and an ormoceratoid siphuncle."

Shimizu and Obata are correct in attributing to the genotype of this genus a cyrtochoanitic siphuncle. However, such a siphuncle is also to be found in *Gorbyoceras*, a fact of which they were ignorant when placing that genus in the supposedly or-

thochoanitic *Spyroceratidæ*. *Dawsonoceras hammelli* is very closely related to *Orthoceras gorbyi* with which it is associated in the upper Richmond of Indiana and Ohio. In the same association are found other species which are intermediate between these two in the features of the annuli, surface markings, and sutures. Further, the early stages of *gorbyi* and *hammelli* are so similar that I am not certain that they can always be distinguished. With such close relationship between the genotypes, two generic names in such a group of closely allied species are things for which I can discover no good use. Therefore *Hammelloceras* Shimizu and Obata is suppressed as a synonym of *Gorbyoceras* Shimizu and Obata.\*

Genus **PORTEROCERAS** Shimizu and Obata

Genotype.—*Spyroceras porteri* Schuchert. (See Foerste, 1928, p. 37, pl. 7, fig. 2A-B; pl. 23, fig. 4.) Trenton or Upper Ordovician, Baffin Land.

*Original description*.—"Genotype: *Spyroceras porteri* (Schuchert) Foerste from the Upper Ordovician? of Canada. This genus although related to *Hammelloceras* differs from it in possessing more prominent ornamentation and sactoceroid siphuncle. *Orthoceras bilineatum* Hall 13, p: 200, pl. 43, fig. 3 = *O. annallum* Hall 6, pl. 43, fig. 6d-f only, incorrectly assigned by Foerste [7, (1928) p. 180, pl. 40, fig. 5A-B] to *Spyroceras*, and *Spyroceras bilineatum* var. *alpha* (Hall) Foerste [7 (1928) p. 180, pl. 40, fig. 7] from the Middle Ordovician of North America, probably belongs to *Porteroceras* although the structure of the siphuncle is unknown."

The "more prominent ornament" by which this genus is set apart from that based upon *Orthoceras hammelli* is a difference

\* In the revision of the Cincinnati nautiloids of the Cincinnati region, a work which is now more than half completed, *G. gorbyi*, *G. hammelli* and associated and closely related species are described and illustrated. One undescribed form is clearly intermediate between *G. gorbyi* and *G. hammelli* so that the recognition of two genera based upon these species is not only manifestly absurd, but impossible.

not well supported by Foerste's photographs of the type, and one which disappears when more and better preserved material of *O. hammelli* is studied. The sactoceroid rather than ormoceratoid siphuncle, a distinction of which Shimizu and Obata appear to be fond, is of very dubious merit and validity. The relatively narrow siphuncle which they consider "sactoceratoid" rather than "ormoceratoid" may so easily be due to a section which does not quite attain the center of the siphuncle, that its use as a generic feature seems unwise. Further, the difference between the form of the segments of the siphuncle as shown by the two genotypes is not, in the opinion of the writer, great enough to serve as a basis of generic separation. Therefore *Porteroceras* is here regarded as a synonym of *Gorbyoceras* of which *Hammelloceras* is also a synonym.

GENERA OF ANNULATED CEPHALOPODS WITH  
TRANSVERSE MARKINGS PROPOSED BY  
SHIMIZU AND OBATA

Family **CYCLOCERATIDÆ** Hyatt

Shimizu and Obata (1936, p. 19) emend this family to "orthochoanitic annulated orthoceracone and cyrtoceracone with transverse striae and without longitudinal ridges or striae." Inasmuch as *Cycloceras* is so little known that only the genotype can be placed in it, the family Cycloceratidæ can not contain any other genus than the inadequately known *Cycloceras*, and is at the present time of no real value in the scheme of cephalopod classification. Shimizu and Obata place two new genera in this family which have been previously commented upon by the writer (Flower, 1941, p. 475-477). *Paleocycloceras* Shimizu and Obata was erected on the basis of a supposition and was believed to be ellipochoanitic, whereby it is distinguished according to Shimizu and Obata, from *Protocycloceras*. However, thin sections of the siphuncle of the genotype of *Protocycloceras* show that it is ellipochoanitic and eurysiphonate in the complex thick connecting ring (Flower, 1941A). Therefore, if Shimizu and Obata

are correct in their supposition, there is still no good difference between *Protocycloceras* and *Paleocycloceras*. In any case, the new name should not have been proposed on the basis of a supposition.

*Foersteoceras* Shimizu and Obata, as pointed out independently by Teichert (1941) and Flower (1941), is a homonym of *Foersteoceras* Ruedemann (1926). Further, both authors agree that until more is known about orthochoanitic Ordovician conchs of the general aspect of *Cycloceras*, there is no virtue in proposing a new name for this group of species.

#### Family **ESKIMOCERATIDÆ** Shimizu and Obata

The family Eskimoceratidæ was erected by Shimizu and Obata (1936, p. 22) for "Cyrtochoanitic annulated orthoceracone and cyrtoceracone without longitudinal ridges or striae." In it were placed besides *Eskimoceras* Troedsson (1926) two new genera. Little is known of the surface of *Eskimoceras*, and there is no information as to the nature of any deposits of the interior of the phragmocone, and there is no certainty that it forms a natural family with any other annulated cephalopods. The two new genera are summarized below.

#### Genus **PSEUDESKIMOCERAS** Shimizu and Obata

"Genotype: *Cycloceras ? manchuriense* Endo (1932, p. 68, pl. 14, fig. 8, 9, 12.) Diagnosis: Annulated orthoceracone, sub-circular in cross section, annulation oblique and less numerous than number of septa. Siphuncle moderate in size, subcentral and ormoceratoid.

"Remarks: This genus is close to *Eskimoceras*, from which it is distinguished by having oblique test annulation and by its septa outnumbering the annulation."

The surface of the shell of the genotype is so poorly preserved that Endo was not certain that it fell into the broad group to which Foerste and others applied the name *Cycloceras* in a broad sense. Similar species from the Black River of New York and Ontario have been studied by the writer (unpublished) and are regarded as typical of *Tofangoceras*, which Shimizu and Obata

incorrectly regard as orthochoanitic. *Pseudskimoceras* is here regarded as a subjective synonym of *Tofangoceras* Kobayashi.

Genus **KOGENOCERAS** Shimizu and Obata

"Genotype.—*Tofangoceras huroniforme* Kobayashi (1934, p. 435, pl. 27, fig. 9-11, 14.)

"Diagnosis: Cyrtchoanitic annulated orthoceracone, circular in cross section, with narrow eccentric siphuncle, characterized by *Huronia*-like segments.

"Remarks: The genotype of this genus, which was erroneously referred by Kobayashi to *Tofangoceras*, differs sufficiently from the latter true *Tofangoceras* belonging to the orthochoanites to justify the creation of a new genus, *Kogenoceras*, gen. nov.

"This genus resembles *Pseudskimoceras*, but has *Huronia*-like siphuncular segments instead of the sactoceratoid siphuncular segments of the latter."

The segments of the siphuncle are not nearly so similar to those of *Huronia* as this description would lead one to believe. They are expanded segments in which expansion is more abrupt at the adoral end, at the septal neck, than at the adapical end. The deposits of the camerae are typical of the Stereoplasmoderata and of *Tofangoceras*. The deposits of the siphuncle are of the type for which Kobayashi has erected the genus *Tofangocerinia*. As noted above, it is very possible that this genus may not be distinct from *Tofangoceras* but shows an apparent difference owing to examination of individuals representing different growth stages of fragmentary shells.

There is no basis for the recognition of *Kogenoceras* as distinct from *Tofangoceras*.

## SUMMARY OF PALEOZOIC ANNULATED CEPHALOPOD GENERA

I. Early Paleozoic pre-Champlainian genera. Internal structure where known shows euryisiphonate connecting rings.

*Ivalcottoceras* Ulrich and Foerste, 1935. Small compressed annulated shells with a marginal and reputedly holochaoanitic siphuncle. Regarded by Ulrich and Foerste as Ozarkian, but

found by the writer in the Canadian in association with *Bassleroceras*, *Clitendoceras*, *Lecanospira*, *Hystricururus* and a cephalopod regarded as the supposedly Ozarkian genus *Pachendoceras* Ulrich and Foerste in the Fort Ann quadrangle, eastern New York.

*Clitendoceras* Ulrich and Foerste, 1935. Circular to depressed annulated shells readily recognized by the small narrow lobe formed on the venter. Canadian.

*Protocycloceras* Hyatt. Circular to depressed annulated cephalopods with simple sutures and a large submarginal siphuncle, apparently holochaoanitic, but made up of aneuchoanitic necks and complex thick rings. Canadian, North America.

*Peleocycloceras* Shimizu and Obata.—Synonym of *Protocycloceras*. Canadian of Manchuria.

II. Stenosiphonate annulated genera of the external aspect of *Spyroceras*.

*Metaspyroceras* Foerste. Ordovician and Silurian orthochoanitic forms. Typically the sutures slope forward on one side, the annuli on the other. Such typical species grade into others in which the annuli are oblique but the sutures essentially transverse.

*Eospyroceras* Shimizu and Obata. Here regarded as a subjective synonym of *Metaspyroceras* Foerste.

*Hypospyroceras* Shimizu and Obata. Inadequately known. No species other than the genotype can be assigned to it.

*Subspyroceras* Shimizu and Obata. Inadequately known.

*Anaspyroceras* Shimizu and Obata, emend. Flower. This is the first generic name which has been proposed with a genotype known definitely to have the external aspect of a *Spyroceras* with simple transverse sutures and an orthochoanitic siphuncle. As such it is being employed elsewhere by the writer. It is probably related to *Metaspyroceras* and may, it is feared, grade into that genus.

*Gorbyoceras* Shimizu and Obata, emend. Flower. This genus was inadvertently applied by its authors to a cyrtchoanitic species. It is the proper receptacle for shells with the external

aspect of *Spyroceras* but with nummuloidal siphuncles. Cameral deposits are developed. Small annulosiphonate deposits are known, suggesting that this genus may be an actinoceroid. The internal structure is quite similar to that of *Treptoceras*, but no portions of the shell are known showing the siphonal deposits in a growth stage sufficiently advanced to show whether they are actinoceroid in their structure. Ordovician, Chazyan through Richmond.

*Hammelloceras* Shimizu and Obata. A subjective synonym of *Gorbyoceras*.

*Portroceras* Shimizu and Obata. A subjective synonym of *Gorbyoceras*.

*Spyroceras* Hyatt. Middle and Upper Devonian.\* Annulated shells with longitudinal markings. The siphuncle is similar to that of *Dolorthoceras* Miller. The deposits of the siphuncle are typical of the subfamily Dolorthoceratinae of the family Pseudorthoceratidae. In the broad sense *Spyroceras* was formerly used for nearly all annulated cephalopods with longitudinal ornament. III. Surface markings not definitely known.

*Eskimoceras* Troedsson. A valid genus of annulated cyrtochoanitic cephalopods. It is uncertain whether the surface is smooth, or whether originally longitudinal markings were present as in *Spyroceras*, *sensu lato*, or transverse markings such as in *Cycloceras*, *sensu lato*. Ordovician. Thus far recognized only in Greenland.

*Tofangoceras* Kobayashi. Annulated cephalopods with a cyrtochoanitic siphuncle, rather variable in the form of the segments, variation apparently having much to do with the growth stage examined. Cameral deposits are well developed. Species showing parietal deposits within the siphuncle are placed here by the writer. Ordovician.

\* Possibly also Lower Devonian. Nothing, however, is known of the internal structure of *Spyroceras*-like Lower Devonian shells and their generic position is uncertain.

*Tofangocerina* Kobayashi. Regarded here as not distinct from *Tofangoceras*. The genus was erected for species of *Tofangoceras* showing clear deposits within the siphuncle.

*Kogenoceras* and *Pseudeskimoceras* Shimizu and Obata. — Synonyms of *Tofangoceras* Kobayashi.

IV. Annulated orthoceracones with transverse marking.

*Cyclendoceras* Grabau and Shimer. Holochoanitic endoceroids with low annuli. Ordovician.

*Foersteoceras* Shimizu and Obata.—Homonym of *Foersteoceras* Ruedemann.

*Leurocycloceras* Foerste.—Confined to species with specialized internal structure. Annuli may be low and flat, interspaces appearing as narrow grooves. Silurian, North America and Europe.

*Dawsonoceras*.—Silurian. Transverse markings scalloped and festooned. Secondary longitudinal markings sometimes developed.

*Cedarvilloceras* Shimizu and Obata.—Synonym of *Dawsonoceras*.

*Neocycloceras* Flower and Caster. Cyrtchoanitic, with oblique annuli and sutures. Upper Devonian and Mississippian. Internal structure poorly known, probably best placed in Pseudorthoceratidæ.

*Brachycycloceras* Miller, Dunbar and Condra. Orthochoanitic rapidly expanding annulated shells of the aspect of *Cycloceras*, *sensu lato*, with sutures and annuli slightly inclined in opposite directions. Pennsylvanian.

*Cycloceras* McCoy. Annulated cephalopod. Mississippian. Genotype inadequately known; no other species can be placed in the genus properly.

*Perigrammoceras* Foerste. A subjective synonym of *Cycloceras*. The siphuncles are not known in the types of either genera.

*Geisonoceroïdes* Flower. Slender pseudorthoceroids with low frequent annuli and fine transverse markings. Middle and Upper Devonian of New York.

## PHYLOGENETIC NOTES

Annulations on straight shells are clearly no good mark of relationship of genera, as shown by the exceedingly diverse internal structures. In the early Paleozoic the euryisiphonate line, characterized by thick connecting rings, gave rise at least to one annulated shell, *Protocycloceras*, and probably to *Walcottoceras* and *Catoraphiceras*, two genera which are not well enough known structurally to permit the tracing of their precise relations. There is no reason to believe that they form a natural group among early Paleozoic cephalopods with *Protocycloceras*.

In the Champlainian shells of sphyroceroid aspect but with cyrtochoanitic siphuncles appear. Such forms, believed to be best placed tentatively in the Stereoplasmoceratidæ, form a natural group ranging from the Chazyan (*G. clintoni* S. A. Miller) to the Richmond, and among the various generic names previously proposed, *Gorbyoceras* is the only one which can legally be applied to them in accordance with the rules of zoological nomenclature and the present knowledge of cephalopod genotypes.

Orthochoanitic shells of the external aspect of *Sphyroceras* are found in association with these forms. Sometimes it is impossible to distinguish between the two groups without the aid of sections. Such species are placed in *Anasphyroceras* Shimizu and Obata and in *Metasphyroceras* Foerste.

Shells of sphyroceroid aspect in the Silurian are little known. A few orthochoanitic species are found in this part of the column which are probably best placed in *Anasphyroceras*. The genotype of *Metasphyroceras* is Silurian, but more Ordovician than Silurian species are known in the genus.

In the Middle Devonian the genus *Sphyroceras* developed within the secondary cyrtochoanitic family Pseudorthoceratidæ. No species are known except in the Middle and Upper Devonian which can be assigned to *Sphyroceras* in the strict sense. Higher in the column no shells of sphyroceroid aspect are known.

The Middle Ordovician of Manchuria contains annulated cephalopods of the Stereoplasmoceratidæ belonging to the genus *To-*

*fangoceras* Kobayashi. Some Middle Ordovician species of America, formerly placed in *Cycloceras*, *sensu lato*, show the features of this genus. The siphuncle is cyrtochoanitic, though variable in form with the growth stages, the early segments being more expanded than the later ones, which approach and may even attain a suborthochoanitic condition. *Eskimoceras* is generally considered with shells of cycloceroid aspect, although the surface is unknown. It is cyrtochoanitic, but no deposits are known and it is therefore uncertain whether it is related to *Tofangoceras* or whether it represents an independent development. No generic name is available for Ordovician and Silurian orthochoanitic species of the external appearance of *Cycloceras*. Such forms exist in the upper Ordovician of North America and in the Silurian of Europe.

*Leurocycloceras*, proposed for shells presumably without transverse markings, is found to be the dominant cycloceroid genus of the American Silurian. It is orthochoanitic, and peculiar in the mode of growth of the deposits of the phragmocone as well as in the absence of connecting rings. (Flower, 1941A.)

The next cycloceroid conch found is *Neocycloceras* Flower and Caster, a cyrtochoanitic shell doubtfully assigned to the Pseudorthoceratidæ, largely because no other family is known in that part of the column which develops small cyrtochoanitic siphuncles in straight cephalopods. *Neocycloceras* ranges from the Upper Devonian (Conewango) into the basal Mississippian.

Mississippian annulated cephalopods which have been assigned to *Cycloceras* and *Perigrammoceras* are essentially cyrtochoanitic, though no deposits have been made known in the siphuncles, and their relationship is therefore still obscure. It is not even certain that deposits are naturally absent in these forms, as the American Mississippian is an unfavorable medium for preservation of internal structure of cephalopods in most instances.

The next occurrence of cycloceroid conchs, and the last, is found in the orthochoanitic *Brachycycloceras* of the Pennsylvanian.

From the above summary it can be seen that annulated ceph-

alopods have developed in many different structural groups. Some are still very inadequately known, but it is clear that such a shell form has developed several times in the pre-Champlainian euryisiphonate cephalopods, once in the true Holochoanites which as defined by Hyatt, is a part of the Endoceroidea, and many times among the elliphochoanitic stenosisiphonate forms which dominate from the Champlainian to the close of the Paleozoic. Annuli have appeared in the Pseudorthoceratidæ, in the Stereoplasmoceratidæ, and in orthochoanitic orthoceracones. A number of cyrtochoanitic genera of uncertain origin remain to be traced which are isolated either by the form of the segments of the siphuncle, deposits or absence of deposits, and stratigraphic range, all three frequently contributing.

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## PLATES

The cost of illustrative materials for this series of papers has been met by the Faber Publication Fund of the University of Cincinnati Museum.

PLATE I (I)

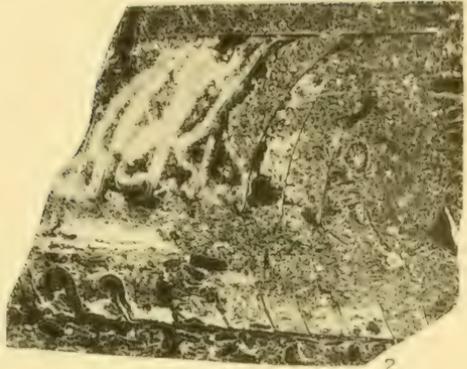
## EXPLANATION OF PLATE 1 (1)

(Tetrameroceras, Rayonoceras and Werneroceras)

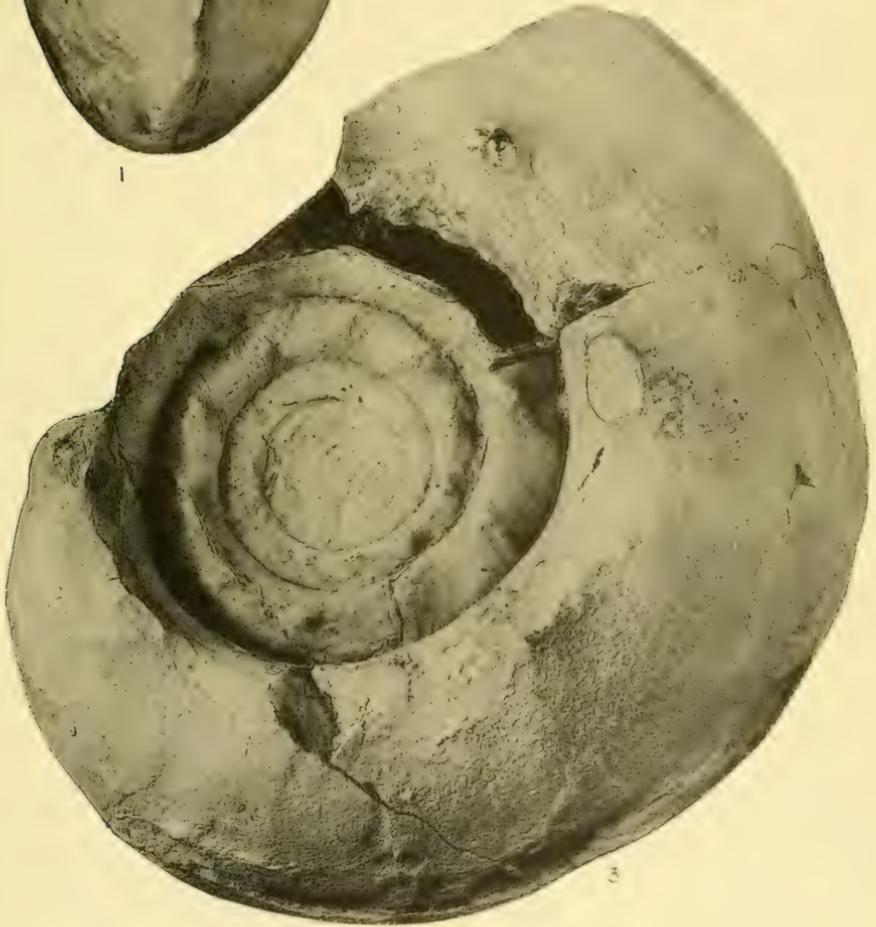
Figure	Page
1. <b>Tetrameroceras faberi</b> Flower, n. sp. . . . .	95
Holotype, adoral aspect, venter beneath. Univ. of Cincinnati Museum, No. 22532. Osgood limestone, Madison, Indiana.	
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Holotype, a vertical section, oriented with the ventral side beneath as in position of burial, and as shown in text fig. 1. About X2½. Univ. of Cincinnati Museum, No. 24078. Chester group, southern Indiana. (Not fig. 1 as indicated in text.)	
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Hypotype. Univ. of Cincinnati Museum, No. 22866. From the uppermost beds of the Union Springs member of the Marcellus, Stockbridge Falls, Oneida Creek, Madison County, New York.	



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PLATE 2 (2)

EXPLANATION OF PLATE 2 (2)  
(Ordovician and Silurian nautiloids)

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1-3. <i>Pentameroceras cumingsi</i> Flower, n. sp. ....	93
Holotype, Univ. of Cincinnati Museum, No. 23095. 1— adoral, 2—lateral, and 3—ventral views, X 1. Huntington dolomite, Delphi, Indiana.	
4. <i>Valcouroceras cyclops</i> Flower, n. sp. ....	47
Vertical section through center of siphuncle, X2½. Univ. of Cincinnati Museum, No. 24177. Valeour limestone, Little Monty Bay, southeast of Chazy, N. Y.	
5-6. <i>Valcouroceras cyclops</i> Flower, n. sp. ....	47
Sections of siphuncle, about X2½. 5—adapical end of speci- men ground to show cross section. 6—oblique section from same specimen, attaining the center of the siphuncle ador- ally, but cutting only the margin adapically. Univ. of Cin- cinnati, No. 24178. Valeour limestone, Little Monty Bay, Chazy, New York.	
7. <i>Gonioceras hubbardi</i> Flower, n. sp. ....	26
Holotype, about X½. University of Cincinnati Museum, No. 22846. Chickamauga limestone, north side of Buckeye Mt., Giles County, Virginia.	
8. <i>Actinoceras arcuanotum</i> Flower, n. sp. ....	68
Holotype, X1. Univ. of Cincinnati Museum, No. 22580. Tyronne limestone, High Bridge, Ky. (Not fig. 7 as indicated in text.)	



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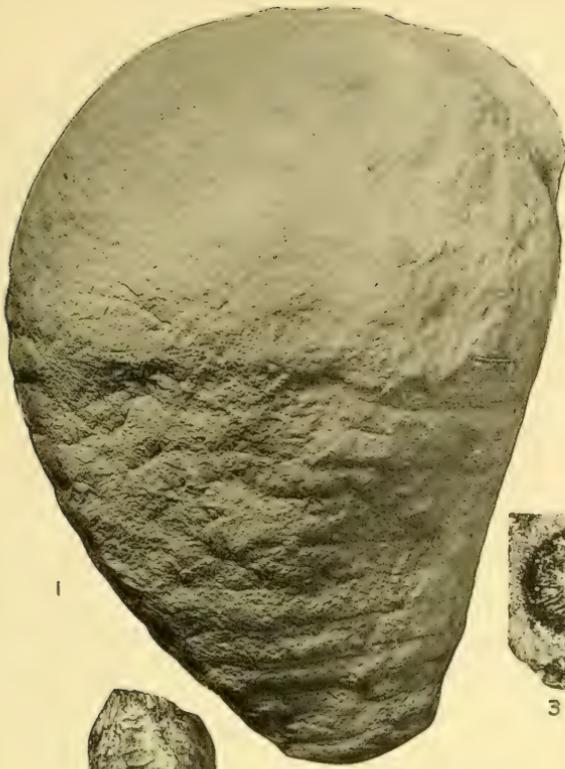
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PLATE 3 (3)

EXPLANATION OF PLATE 3 (3)  
(Ordovician and Silurian nautiloids)

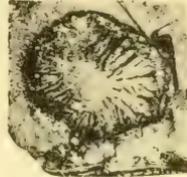
Figure	Page
1. <i>Tetrameroceras faberi</i> Flower, n. sp. ....	95
Holotype, X1, lateral aspect, Univ. of Cincinnati, No. 22532. Osgood limestone, Madison, Indiana.	
2-6. <i>Actinomorpha pupa</i> Flower, n. sp. ....	55
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7. <i>Valcourceras cyclops</i> Flower, n. sp. ....	47
Cross section of siphuncle, X2½. Univ. of Cincinnati Museum, No. 24177. Valcour limestone, Little Monty Bay, south-east of Chazy, N. Y. (Note—For <i>Goniceras hubbardi</i> see Plate 2, fig. 7.)	



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PLATE 4 (4)

EXPLANATION OF PLATE 4 (4)  
(Chazyan (Ordovician) nautiloids)

Figure	Page
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Lateral view of an immature fragment. Univ. of Cincinnati Museum, No. 24189. Valcour limestone, Little Monty Bay, southeast of Chazy, N. Y.	
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Lateral view of an immature fragment, Univ. of Cincinnati, Museum, No. 24180. Same locality and horizon.	
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Holotype, lateral aspect, X1, Univ. of Cincinnati Museum, No. 24172. Same locality and horizon.	
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Early stage in vertical section, X1, showing slender suborthochoanitic siphuncle. Univ. of Cincinnati Museum, No. 24173. Same locality and horizon.	
7-8. <b>Graciloceras longidomum</b> Flower, n. sp. ....	74
Sections of two fragments of phragmocones, about X2½. 7—Retains deep apical chamber. Univ. of Cincinnati Museum, No. 24183. 8—Paratypes. Univ. of Cincinnati Museum, No. 24184. Upper Chazyan, Little Monty Bay, Chazy, New York.	
9-10. <b>Valcouroceras bovinum</b> Flower, n. sp. ....	45
Holotype, X1, 9—lateral, 10—Ventral aspects. Univ. of Cincinnati Museum, No. 24169. Same locality and horizon.	
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Vertical section, X1. Shows siphuncle in stage very close to that of text fig. 1 b. Univ. of Cincinnati Museum, No. 24190. Same locality and horizon.	

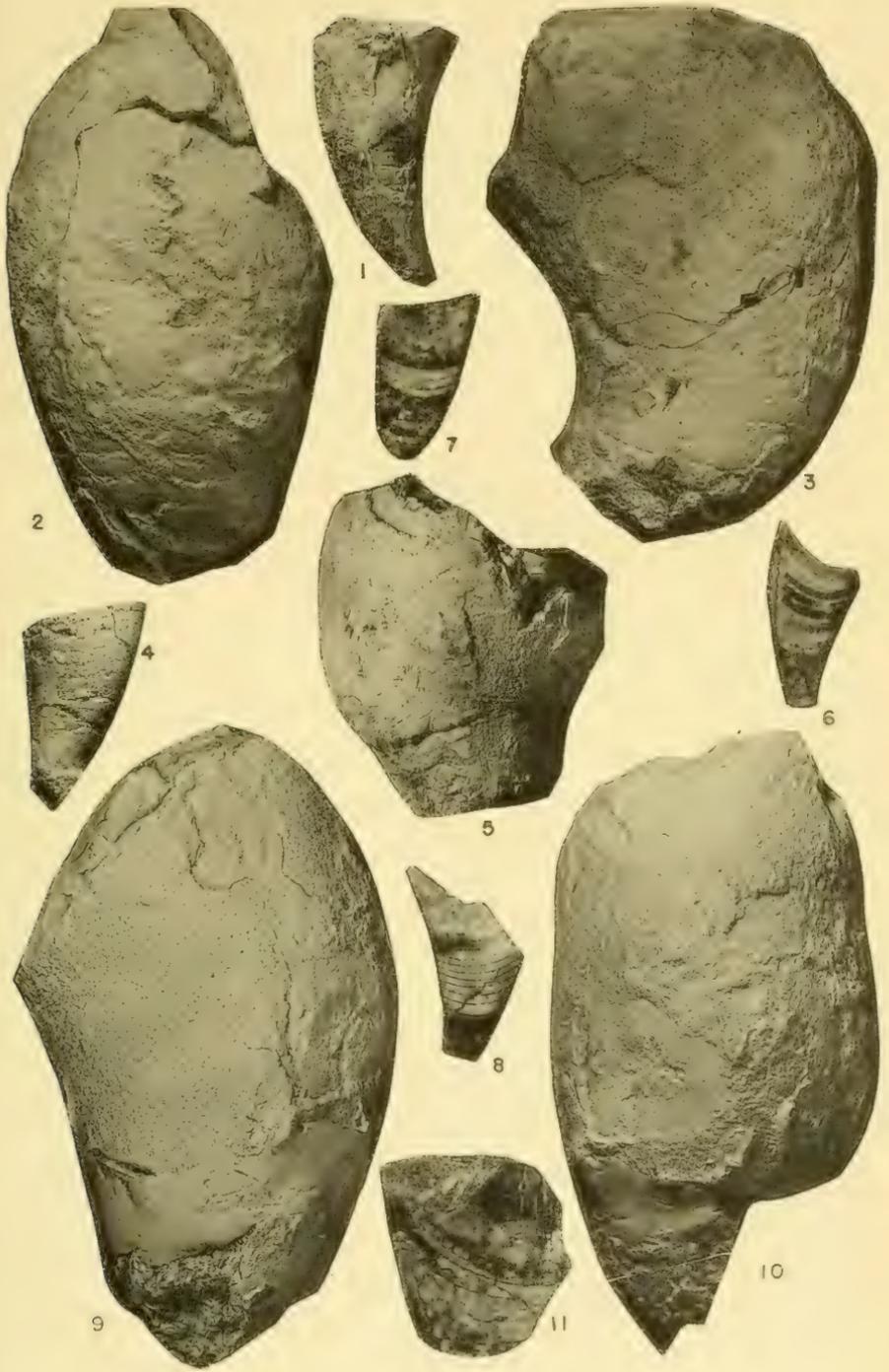




PLATE 5 (5)

EXPLANATION OF PLATE 5 (5) -  
(Paleozoic nautiloids)

Figure	Page
1. <i>Archiacoceras subventricosum</i> (d'Archiac and de Verneuil) . . . . .	53
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4—paratype, slightly greater than X1, Univ. of Cincinnati Museum, No. 24186. 3—ventral (convex) sides. Univ. of Cincinnati Museum, No. 24186. Valeour limestone, Little Monty Bay, Chazy, New York.	
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4—paratype, slightly greater than X1, Univ. of Cincinnati Museum, No. 24192. 5—holotype, slightly greater than X1, Univ. of Cincinnati Museum, No. 24191, Valeour limestone, Little Monty Bay, Chazy, New York.	
6-7. <i>Trocholites ruedemanni</i> Flower, n. sp. . . . .	79
Holotype, Univ. of Cincinnati Museum, No. 24193. 6—cross section of shell. 7—lateral aspect, one-half of the specimen sectioned longitudinally. Slightly greater than X1. Valeour limestone, Little Monty Bay, Chazy, New York.	
8. <i>Centrocyrtoceras mozolai</i> Flower, n. sp. . . . .	75
Holotype, lateral aspect, about X2½. Univ. of Cincinnati Museum, No. 24188. Valeour limestone, Little Monty Bay, Chazy, New York.	
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Holotype, Univ. of Cincinnati Museum, No. 24194. 9—vertical section, enlarged, from adapical portion of type showing suborthoceranitic siphuncle. 12—lateral surface of holotype, somewhat weathered. Laurel limestone, Westport, Indiana.	
10-11. <i>Valcouroceras cyclops</i> Flower, n. sp. . . . .	47
10—ventral and 11—lateral aspects. Paratype, Univ. of Cincinnati Museum, No. 24179. Valeour limestone, Little Monty Bay, Chazy, New York. (Not figs. 11-12 as indicated in the text.)	
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Holotype, Univ. of Cincinnati Museum, No. 24187. 13—apical view; showing septum, with venter oriented to the right. 14—vertical section. Valeour limestone, Little Monty Bay, Chazy, New York. X2½.	

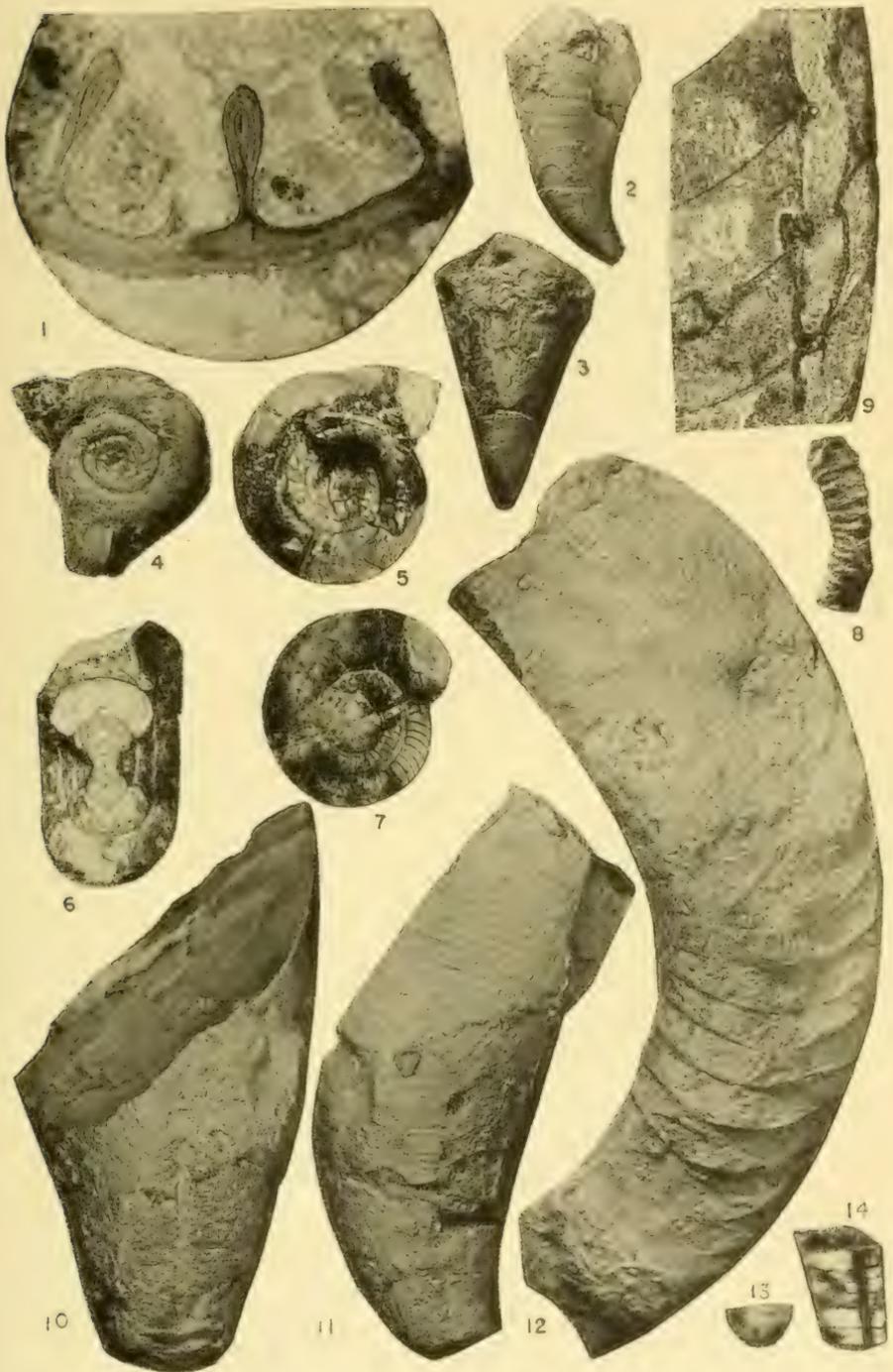
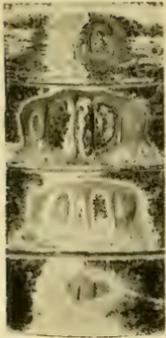




PLATE 6 (6)

EXPLANATION OF PLATE 6 (6)  
(Actinosiphonate cephalopods)

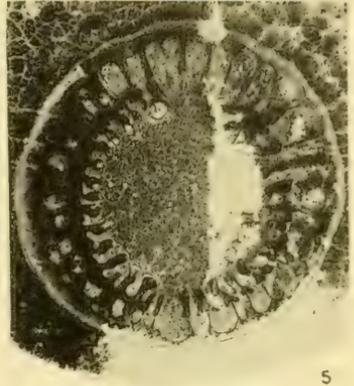
- | Figure  | Page |
|---|------|
| 1-9. <i>Archioceras subventricosum</i> (d'Archiac and de Verneuil)<br>Sections through siphuncle. Univ. of Cincinnati Museum, No. 22506. Gerolstein, Eifel, Germany; Middle Devonian.   | 60   |
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| 4-9. Selected photographs taken from a series of serial sections progressing orad in the shell. 4—Selection showing partial fusion of rays of an adapical and an adoral series, the adoral ones appearing on the inside, and not being continuous all around the siphuncle. 5—Farther orad, the adoral series forms a complete ring, shown only partially here, on the left side, while aligned with rays of the adapical series. 6—Cross section essentially at region of septal neck. 7—Section still in region of neck, slightly farther orad. 8—Section just orad of septal foramen. The siphuncle enlarges more rapidly orad from the neck on the side farthest from the shell wall. 9—Section farther orad showing condition which is typical up to the adoral end of the segment where a condition like fig. 4 would be encountered.<br>In all sections the shell wall is oriented beneath the siphuncle. In most sections this is more or less completely filled by light calcite, which also occupies the right side of the siphuncle as oriented in fig. 4.—9. Sections are approximately X2. |      |



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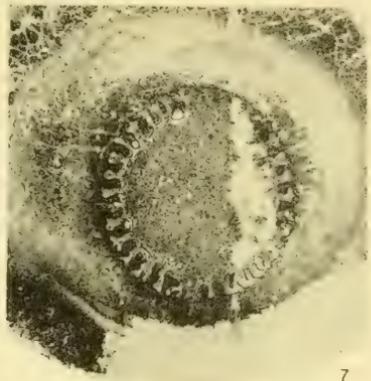
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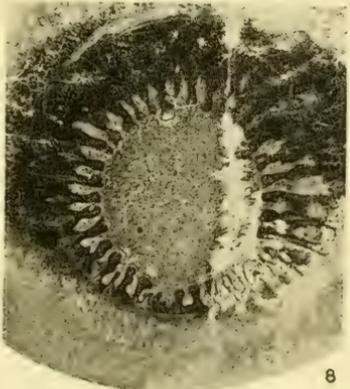
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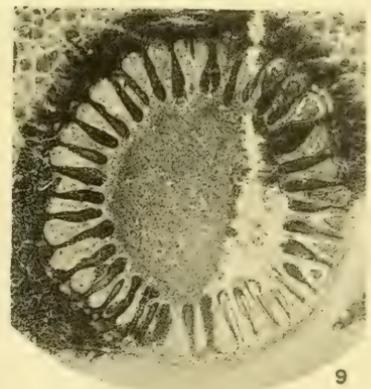
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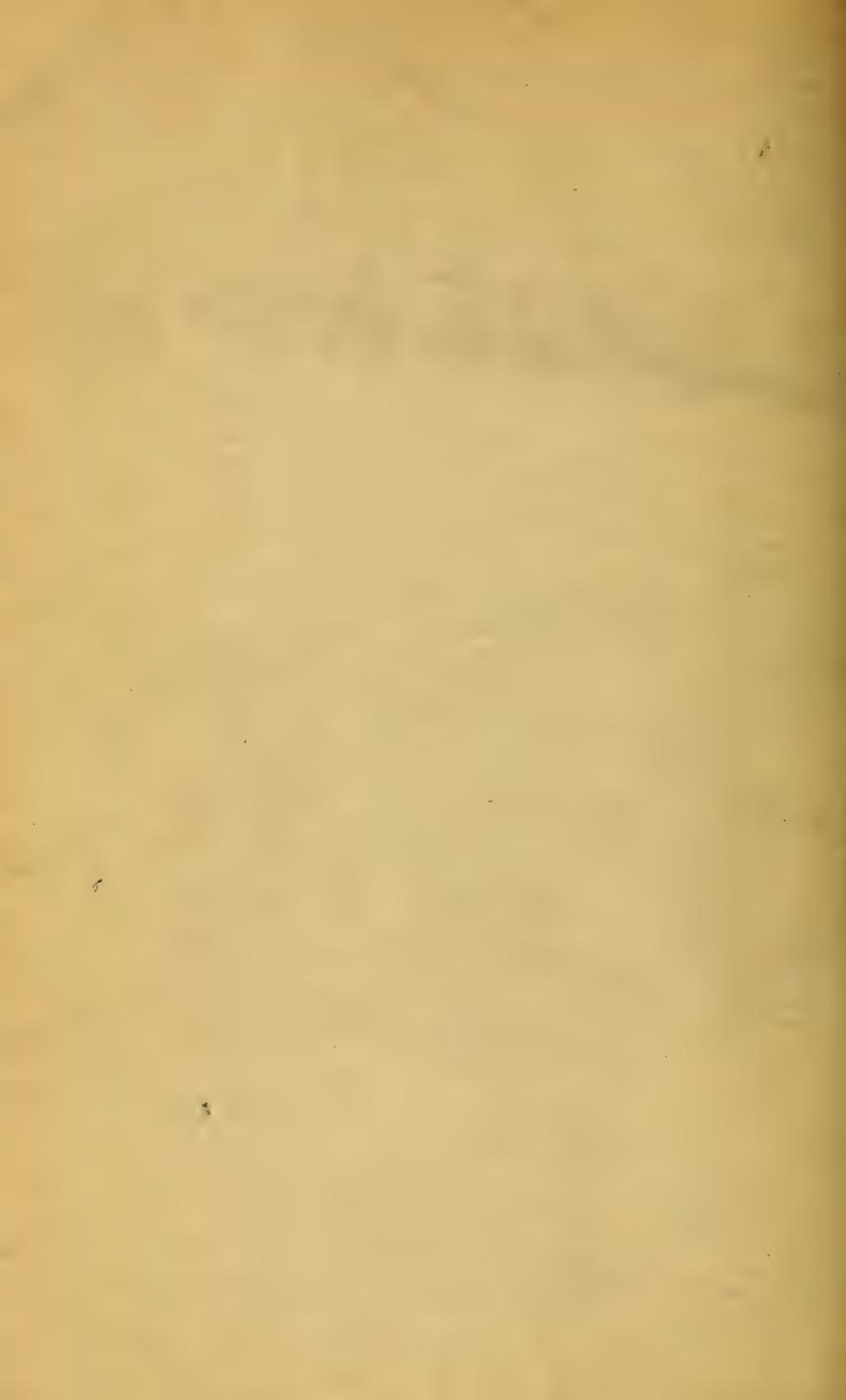
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Three Forks Fauna in the Lost River Range, Idaho

By

Ewart M. Baldwin

*September 6, 1943*

Paleontological Research Institution  
Ithaca, New York  
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# THREE FORKS FAUNA IN THE LOST RIVER RANGE, IDAHO

By Ewart M. Baldwin

## INTRODUCTION

The Lost River Range forms a prominent topographic unit in south central Idaho. The range trends southeastward across the central portion of the Borah Peak quadrangle toward the Snake River Plains where it is covered by recent volcanics. The area discussed in this paper is confined to the northern half of the range in the Porah Peak quadrangle (U. S. Geol. Survey topographic sheet, 1932).

During the summer of 1941 and 1942, field work in the Lost River Range disclosed a shaly limestone which contained an abundant fauna in places. This formation was correlated with the Three Forks formation, Three Forks, Montana, on the basis of similarity of faunas. The Three Forks has not been previously reported in south central Idaho, although Richardson (1913), Piper (1924) and Mansfield (1927) have reported the Three Forks in southwestern Idaho and neighboring regions in Utah.

The Three Forks formation was described by Peale (1893) at Three Forks, Montana. It has been called the Three Forks shale and the Three Forks limestone, depending upon lithology. Berry (1943) redefined the type section and removed an upper yellow sandstone member, which contained a *Syringothyris* fauna, and proposed the name Sappington sandstone for it. The name Three Forks formation was restricted to the shaly limestone between the Jefferson formation and the Sappington.

Previous work on the fauna of the Three Forks has been done by Raymond (1907, 1909, 1912) who discovered the occurrence of certain Upper Devonian ammonoid forms. Haynes (1916) worked out a detailed stratigraphic section and an excellent report on its fauna.

Earlier geologic work in the Lost River Range has been of a broad reconnaissance nature. More detailed work has been done in the neighboring Wood River District and Bayhorse region by Ross (1930, 1937). He summarized the stratigraphy of a thick Paleozoic section in a report on south central Idaho. Although he did not recognize the Three Forks formation, he listed a collection from the uppermost Devonian strata at Elbow Canyon, east of Mackay, Idaho, which was collected by Umpleby and Girty and examined by Kindle. Kindle (in Umpleby, 1917) regarded the strata, which contained the following species, "as a calcareous facies of the Threeforks shale fauna, although it is not a typical fauna of this horizon."

Productella, sp.	Reticularia, sp.
Camarotoechia, sp.	Spirifer utahensis
Schizophoria striatula, var.	Spirifer whitneyi
australis	Meristella cf. M. barrisi
Athyris parvula	Euomphalus eurekensis

This locality corresponds in stratigraphic position with the Three Forks beds some 30 miles to the northwest in the Borah Peak quadrangle, but several of the above forms were not recognized by the writer in his collections.

Kirk and Cooper (in Cooper *et al.*, 1942) reported the following locality in the Borah Peak quadrangle:

"The lower part of the Milligen is shaly and contains species of the Threeforks formation. In a ravine southwest of Freighter Spring, on the east side of Double Spring Canyon . . . Cooper identified the following species: *Cyrtospirifer monticola* (Haynes), *Camarotoechia* cf. *C. nordeggi* Kindle, globular *Athyris*, and *Cleiothyridina devonica* Raymond."

## ACKNOWLEDGMENT

Acknowledgment is made to Dr. K. V. W. Palmer under whose direction the identification of the fauna was made and for suggestions during the preparation of this report. This study was made possible largely through the generous aid from the Charles Pean DeLong Graduate Research Fund of Cornell University, for which the writer is gratefully indebted.

## STRATIGRAPHY AND FAUNAL LISTS

A section, about one mile east of Freighter Spring, probably the same locality which was called the "lower part of the Milligen" by Kirk and Cooper, was measured and fossils were collected. The section is as follows:

	feet
Massive limestone containing <i>Productellas</i> and <i>Schuchertellas</i> .. .. .	40
Shaly limestone with interbedded thin limestone beds contain- ing <i>Cyrtospirifer</i> , <i>Athyris</i> , and <i>Camarotoechia</i> ; buff in color .....	75
Shaly limestone; buff color; and apparently unfossiliferous. ....	195
	310

The Three Forks is a lithologic unit easily separated from the overlying Milligen. No sandy phases were noted nor were any similar limestones found in the alternating shales and sandstones of the Milligen. The abundant fauna of the Three Forks formation stops abruptly at the apparently conformable appearance of sandstone.

The Three Forks is nonresistant and generally covered for considerable distances by talus slopes. However, it is found in places where the dip of the strata is favorable, and for this reason, it is concluded that the Three Forks is usually present. An abundant fauna was not found in many of the exposures of the Three Forks formation. Instead these exposures resembled the

lower 195 feet of the measured section. Some of these outcrops examined were in a belt along the mountain front well above Antelope flat and a locality about a mile above the powerhouse on Lower Cedar Creek near Mackay. Perhaps further search would have disclosed the fauna that is so abundant in the upper part of the formation.

The following collections were made:

Locality No. 4. In the upper 115 feet of the measured section, one mile east of Freighter Spring near Dickey, Idaho.

*Cyrtospirifer whitneyi* (Hall)  
*C. whitneyi* var. *animasensis* (Girty) (contains *C. monticola* (Haynes))  
*Spirifer raymondi* Haynes  
*Camarotæchia contracta* (Hall)  
*C. cf. C. shimeri* Warren  
*C. nordeggi* Kindle  
*Leiorhynchus madisonense* Haynes  
*L. madisonense* var. *gibbosum* Haynes  
*L. cf. L. dunbarensense* Haynes  
*L. cf. L. jeffersonense* Haynes  
*L. utahense* var. *ventricosum* Haynes  
*Pugnax*, sp.  
*Productella*, sp.  
*Productella* cf. *P. coloradensis* Kindle  
*Athyris vitatta* Hall  
? *Leptodesma chillensis*, n. sp.  
*Cleiothyridina devonica* Raymond  
*Schuchertella chemungensis* var. *areostriata* (Hall)  
*Schizophoria striatula* var. *australis* Kindle  
*Euomphalus*, sp.  
*Chætetes* ?, sp.  
"Orthoceras" ?, sp.  
Crinoid fragments

Locality No. 5. East side of Grouse Creek Canyon, about a mile below Mill Creek.

*Cyrtospirifer whitneyi* var. *animasensis* (Girty)  
*Schuchertella chemungensis* var. *areostriata* (Hall)  
*Chætetes* ?, sp.  
*Leiorhynchus*, sp.

Locality No. 6. Mountain top northeast of Grouse Creek. The lower part of the formation.

*Camarotæchia contracta* (Hall)  
*Cyrtospirifer whitneyi* var. *animasensis* (Girty)

## CORRELATION CHART OF THREE FORKS FAUNA

Lost River Range	Nev. <sup>1</sup>	Colo. <sup>2</sup>	Mont. <sup>3</sup>	Banff <sup>4</sup>
<i>Cyrtospirifer whitneyi</i> .....			X <sup>5</sup>	
<i>C. whitneyi</i> var. <i>animasensis</i> ? .....	S <sup>6</sup>	X	X	X
<i>Spirifer raymondi</i> .....			X	
<i>Camarotoechia contracta</i> .....		X <sup>7</sup>	X	
<i>C. cf. C. shimeri</i> .....				X
<i>C. nordeggi</i> .....				X
<i>Lciorhynchus dunbarensis</i> .....				X
<i>L. utahense</i> var. <i>ventricosum</i> .....				X
<i>L. cf. L. jeffersonense</i> .....				X
<i>L. madisonense</i> .....				X
<i>L. madisonense</i> var. <i>gibbosum</i> .....	S		X	S
<i>Pugnax</i> , sp. ....			S <sup>7</sup>	S
<i>Productella</i> cf. <i>P. coloradensis</i> .....	S	X	X	X
<i>Athyris vitatta</i> .....	S			S
? <i>Leptodesma ehllensis</i> n. sp. ....			S	
<i>Cleiothyridina devonica</i> .....		S	X	
<i>Schuchertella chemungensis</i> var. <i>arctostriata</i> .....	S	X	X	S
<i>Schizophoria striatula</i> var. <i>australis</i> .....	S	X	X	S
<i>Euomphalus</i> , sp. ....	S		S	S <sup>7</sup>

1. Devils Gate formation, Nevada, Merriam (1940)
2. Ouray formation, Colorado, Girty (1900); Kindle (1909)
3. Three Forks formation, Montana, Raymond (1907; 1909) and Haynes (1916)
4. Banff, Upper Minnewanka formation, Warren (1927)
5. Identical forms.
6. Related forms
7. Includes *Cyrtospirifer monticola* (Haynes)

## CORRELATION

The Three Forks formation in Idaho is at the top of the known Devonian. In this respect it is similar to Upper Devonian formations of the so-called "*Cyrtospirifer zone*", with whose faunas comparisons are made on the above chart.

A close correlation with the restricted Three Forks formation, Montana, is firmly established by a large number of species in common.

However, several striking differences were noted. *Camarotoechia nordeggi* Kindle, *C. cf. shimeri* Warren, *Athyris vitatta* Hall, and *Pugnax*, sp., are several of the forms which are abundant in the Lost River Range and unreported from the Three Forks, Montana area. The *Camarotoechias* have been reported from the Upper Devonian formations in the Canadian Rockies by Kindle (1924) and Warren (1927, 1937). They are associated in the Lost River Range with the abundant *Lciorhynchus* assemblage which is prominent in the type Three Forks section. A form which resembles *A. vitatta*, but identified as *Meristella*

*barrisi* Hall, is rare in the Montana section. The forms are similar in external features and it is probable that the specimens from Montana and Idaho are the same species.

The type Three Forks area contains an ammonoid fauna, a large pelecypod fauna, and numerous specimens identified as *Rhipidomella vanuxemi* Hall? Although ammonoids were not found in the Lost River Range, it is possible that they will prove to be present. Several poorly preserved pelecypods were noted in the field, and although only one form was collected, a larger fauna is probably present. Haynes (1916) doubtfully assigned numerous specimens to *Rhipidomella vanuxemi*. They were present in both the upper sandy portion which contained the *Syringothyris* fauna and in the Three Forks (restricted). Although the *Syringothyris* horizon was not recognized in the Lost River Range, no Rhipidomellas were found in the lower horizons.

The forms which are most numerous in the Three Forks of the Lost River Range are: *Cyrtospirifer whitneyi* var. *animasensis* (Girty), *Leiorhynchus madisonense* var. *gibbosum* Haynes, *Cleiothyridina devonica* Raymond, *Athyris vitatta* Hall, *Pugnax*, sp., *Camarotæchia nordeggi* Kindle, and Productellas.

Schindewolf (1934) pointed out that the occurrence of *Platyclymenia americana* and *P. polypleura*, at Three Forks, Montana indicated an affinity with the "Prolobites-Platyclymenia-Stufe", third from the base ammonoid zone of the European Upper Devonian. Miller (1938) correlated the "Prolobites-Platyclymenia-Stufe" with the Connewango ("possibly only the lower part"). The Connewango is placed in the lower Bradfordian by Schuchert (1943).

Cooper (1942, p. 1785) pointed out the apparent relationship of the Three Forks with the Ouray as follows:

"In the Threeforks proper occur a variety of fossils including large *Cyrtospirifer*, *Productella*, and *Leiorhynchus* suggesting affinity with the Pehcha shale of New Mexico and the Ouray limestone of Colorado. The pelecypods and goniatites . . . indicate a somewhat older age. Of the former the most important is *Loxopteria* which in New York is restricted to the Canadaway group."

On the basis of ammonoids, Cooper (p. 1785) placed the Three Forks in the Conneaut group of the Cassadaga stage.

The correlation between the Three Forks formation and the upper Devils Gate formation of Nevada is pointed out by Merriam (1940, p. 62) as follows:

“Forms showing a marked similarity are above all the abundantly occurring *Cyrtospirifer* and *Leiorhynchus*. Other analogies are noted (1) in the common occurrence of similar types of *Productella*, (2) presence of related forms of *Schizophoria*, though the species appear to be distinct, (3) occurrence in both faunas of schuchertellas of similar character, (4) absence or scarcity of *Atrypa*.”

The Three Forks may be younger than the upper Devils Gate because in the Lost River Range the moderately thick Grand View dolomite lies between the Jefferson, which contains *Pachyphyllum*, and the “*Cyrtospirifer* zone” of the Three Forks formation.

The relationship between the Idaho Three Forks and the upper Devils Gate is more general than specific for although there is a generic similarity, few of the species are in common as is the case with the Lost River Range and the type Three Forks area.

The Exshaw shale in the Canadian Rockies is tentatively correlated by Warren (1937) with the Three Forks formation in Montana, and by Cooper (1942) with the lower part of the “Milligen formation” (Three Forks formation) of the Lost River Range.

In conclusion, a correlation of the shaly limestone in the Lost River Range with the Three Forks formation of Montana appears to be justified, not only on the basis of lithology and stratigraphic position, but on the basis of a close similarity in faunal content.

## DESCRIPTION OF FOSSILS

Type and figured specimens have been deposited in the Paleontological Research Institution, Ithaca, New York. A duplicate collection is located in the paleontology laboratory, Cornell University.

The material described and figured in the following pages are all from localities in the Three Forks formation, Upper Devonian of Idaho.

## PHYLUM BRACHIOPODA

Genus **SCHUCHERTELLA** Girty

- Schuchertella chemungensis** var. **arctostriata** (Hall) Plate 1, fig. 21  
*Streptorhynchus chemungensis* var. *arctostriata* Hall, 1867, Pal. N. Y.,  
 vol. 4, pl. 9, figs. 1-12.

Specimens are common in the Three Forks formation. The usual size of shell is 32 mm. in width and 25 mm. in length. Fine intercalary plications are between fine plications which reach the length of the shell.

*Locality*.—Nos. 4 and 5.

Genus **CAMAROTÆCHIA** Hall and Clarke

- Camarotæchia contracta** (Hall) Plate 1, figs. 11, 12  
*Atrypa contracta* Hall, 1843, Geol. N. Y., Rept. of Fourth Dist., p. 66,  
 figs. 2, 3.  
*Camarotoechia contracta* (Hall) Hall and Clarke, 1893, Pal. N. Y., vol.  
 VIII, Pt. II, p. 192, pl. 57, figs. 28-32, 49.

The figured specimen is from the lower part of the Three Forks formation, and is slightly larger and more gibbous than specimens found in the shaly limestone members in the upper part of the formation at locality No. 4.

The specimens compare in description with *C. contracta* collected by Raymond (1909, p. 142, pl. 3, figs. 1-7) but tend to be smaller.

*Locality*.—Nos. 4 and 6. Figured specimen is from No. 6.

- Camarotæchia nordeggi** Kindle Plate 1, figs. 15-17, 22  
*Camarotoechia nordeggi* Kindle, 1924, Pan-Am. Geol., vol. 42, No. 3, p.  
 128, pl. 14, figs. 4-7.

The specimens are gibbous, and have from 40 to 72 fine plications which extend from umbo to commissure. The sinus is variable, but deep in the larger specimens. The number of plications appears to depend upon the size of the specimens.

Of 24 measured specimens, the average size is 24 mm. in width, 21 mm. in length, and 15 mm. in thickness.

*Locality*.—No. 4

- Camarotæchia cf. shimeri** Warren Plate 1, fig. 10  
*Camarotoechia shimeri* Warren, 1927, Geol. Survey Canada, Mem. 153,  
 p. 52, pl. 4, figs. 5, 6.

Specimens referred to *C. shimeri* are smaller than those identified as *C. nordeggi* Kindle. They have a shallow sinus and have a smaller number of similar fine plications.

There is no sharp break between the characters of the specimens and there is a possibility that those referred to *C. shimeri*

and immature specimens of *C. nordeggi*.

*Locality*.—No. 4.

#### Genus LEIORHYNCHUS Hall

**Leiorhynchus cf. dunbarens** Haynes Plate 1, figs. 3-5

*Leiorhynchus dunbarens* Haynes, 1916, Ann. Carnegie Mus., vol. 10, pp. 38, 39, pl. 8, fig. 8.

Of six specimens collected, three undamaged individuals average 19 mm. in width, 13 mm. in height, and 13 mm. in thickness. Five specimens have three angular sharp plications on the fold and two rounded plications in the sinus. One has two plications on the fold and one in the sinus. Concentric growth lines are prominent.

*L. dunbarens*, as figured by Haynes (plate 8, fig. 8), contains three rounded plications in the sinus and does not seem to be typical of the species as he described it. Those specimens from the Lost River Range compare closely with the description, but tend to be smaller, more gibbous, and have less width in proportion to height and thickness.

*Locality*.—No. 4.

**Leiorhynchus madisonense** var. **gibbosum** Haynes Plate 1, fig. 13

*Leiorhynchus madisonense* var. *gibbosum* Haynes, 1916, Ann. Carnegie Mus., pp. 39, 40, pl. 7, figs. 14-16.

Cf. *Leiorhynchus athabascense* Kindle, 1924, Pan-Am. Geol., vol. 42, pp. 217, 218, pl. 14, figs. 1-3.

Cf. *Leiorhynchus walcotti* Merriam, 1940, Geol. Soc. Am., Spec. Paper, No. 25, p. 82, pl. 9, figs. 4-8.

The pedicle valve is gibbous with a deep flattened sinus which becomes strongly curved toward the front of the shell. Brachial valve is more convex and has a broad, flattened mesial fold which becomes more accentuated toward the commissure.

About five plications are present on the fold and in the sinus. Shells are commonly 25 mm. in width, 18 mm. in length, and 19 mm. in thickness. Plications are indistinct on the lateral slopes.

*L. madisonense* var. *gibbosum* differs from *L. athabascense* in that it does not have the wedge-shaped lateral margins of the latter; otherwise there is a very strong resemblance. *L. walcotti* has more angular plications and in addition it has plications on the lateral slopes; otherwise, though, it corresponds in general shape.

*Locality*.—No. 4.

## Genus PUGNAX Hall and Clarke

**Pugnax**, sp.

Plate 1, figs. 18-20

- Cf. *Pugnax altus* (Calvin) Hall and Clarke 1893, N. Y., vol. VIII, pt. II, pl. 60, figs. 1-5.  
 Cf. *Pugnax pugnus* (Martin) Hall and Clarke 1893, N. Y., vol. VIII, pt. II, pl. 60, figs. 6-10.  
 Cf. *Pugnax minutus* Warren, 1927, Geol. Sur. Canada, Mem., 153, p. 55, pl. 4, figs. 2-4.

The average dimensions of over 50 specimens is approximately 14 mm. in width, 9 mm. in length, and 11 mm. in thickness. Generally two to three round, to subangular plications, which carry through to the umbo, are on the fold and one to two rounded plications are in the sinus. There is some variation in the depth of the sinus which begins about midlength of the shell and usually becomes deeply accentuated at the commissure. The lateral slopes are usually smooth but occasionally faint plications can be found.

The specimens resemble *P. altus* in trigonal outline and depth of sinus, but they are smoother on the lateral slopes. There is less resemblance to *P. pugnus* for the sinus of the specimens is deeper in proportion, and the lateral slopes are smoother. The specimens are universally larger than *P. minutus*, the sinus is deeper, and the plications reach the length of the shell, whereas they do not in *P. minutus*.

There is a possibility that the specimens from the Lost River Range, Idaho, represent a new species of *Pugnax*.

*Locality*.—No. 4.

## Genus CYRTOSPIRIFER Nalivkin

**Cyrtospirifer whitneyi** var. *animasensis* (Girty)

Plate 1, figs. 6, 7

- Spirifer disjunctus* var. *animasensis* Girty, 1900, 20th Ann. Rep., U. S. Geol. Survey, Pt. 2, pp. 48-55, pl. 4, figs. 1-10.  
*Spirifer whitneyi* var. *animasensis* Kindle, 1909, U. S. Geol. Survey, Bull. 391, pp. 25, 26, pl. 9, figs. 1-3a.  
*Spirifer whitneyi* var. *monticola* Haynes, 1916, Ann. Carnegie Mus., vol. 10, pp. 36-38, pl. 4, figs. 6-10; pl. 6, figs. 1-7.

*Cyrtospirifer* forms are common in the Upper Devonian of the Rocky Mountain region. Girty reported them from the Ouray District, Kindle from Colorado and New Mexico, Haynes from Three Forks, Montana, and Merriam (1940) from Nevada.

Girty, when studying the fauna of the Ouray District, Colorado, identified a form as *Spirifer disjunctus* var. *animasensis*.

Kindle, when restudying the area and New Mexico, concluded that these forms were more like *Cyrtospirifer whitneyi* (Hall) because of the radiating pattern on their plications. Although he noted differences in size and shape, he concluded that because of the variability of the *C. disjunctus* type, it would be inadvisable to create a new species. He did, however, restrict *S. whitneyi* var. *animasensis* to the smaller specimens with the high cardinal area and identified the rest as *S. whitneyi*.

Haynes, when studying the Three Forks, Montana area, found *Cyrtospirifers* which he concluded were identical with forms from Colorado identified as *S. whitneyi* by Kindle. He noted the differences enumerated by Kindle and considered them sufficient to name the new variety, *S. whitneyi* var. *monticola*. He designated as types seven specimens which showed a continuous variation in shape of the cardinal area from those with a narrow hinge line and incurved beak, to those with a wide, high cardinal area and straight beak. The latter are difficult to separate from *C. whitneyi* var. *animasensis* (Kindle).

Over 50 specimens of *Cyrtospirifers* were collected by the writer in the Lost River Range, Idaho. Their average dimensions were 32 mm. in width, 25 mm. in length, or a ratio of about 1 : .8. Most of the specimens were insufficiently preserved to show the surface markings, but the cardinal area varied within the limits of *C. whitneyi* var. *monticola* as was shown by direct comparison with the type specimens.

Comparison of the *Cyrtospirifers* from the Lost River Range, Idaho, was also made with a large collection obtained near Glenwood Springs, Colorado, by W. C. MacQuown. The Colorado specimens are similar in detail but larger than usual, and it appears that size, like shape of the cardinal area, may be variable in this form of *Cyrtospirifer*.

Because these forms of *Cyrtospirifer* cannot be conveniently separated on size, as did Kindle (1909), and because variability of cardinal area has been demonstrated by Haynes (1916), MacQuown<sup>1</sup> proposed that the name, *C. whitneyi* var. *animasensis*

<sup>1</sup>Unpublished thesis, Cornell University, 1943.

(Girty) be extended to include *C. whitneyi* var. *monticola* (Haynes) and the larger forms from Colorado which were identified as *S. whitneyi* by Kindle. The writer agrees with this classification.

*Locality*.—Nos. 4, 5, and 6.

Genus **SPIRIFER** Sowerby

**Spirifer raymondi** Haynes

Plate 1, fig. 23

*Spirifer raymondi* Haynes, 1916, Ann. Carnegie Mus., vol. 10, pp. 31-33, pl. 5, figs. 1-2; pl. 6, figs. 12, 13.

Several small specimens were collected. The best specimen, which is figured, is 28 mm. in width, 16 mm. in length, and 11 mm. in thickness. Specimens have a straight narrow hinge line and well-defined fold and sinus.

*Locality*.—No. 4.

Genus **ATHYRIS** McCoy

**Athyris vitatta** Hall

Plate 1, figs. 8, 9

*Athyris vitatta* Hall, 1867, Geol. Sur. N. Y., vol. 4, Pt. 1, pp. 289, 290, pl. 46, figs. 1-4.

*Athyris vitatta* Hall, Grabau, 1933, Pal. Sinica, p. 508, pl. 43, figs. 10 a-d.

The average size of 50 specimens is approximately 16 mm. in width, 17 mm. in length, and 13 mm. in thickness. Specimens show a deep sinus with a prominent fold on either side. Fine concentric growth striae are present. Some specimens show greater width than length.

They resemble *A. angelicoides* Merriam, but have a sharper, more upright beak and are less gibbous. They resemble *A. angelica* Hall in shape, but are uniformly smaller. Forms which resemble *A. vitatta* have been identified as *Meristella barrisi* Hall in the "Cyrtospirifer zone" in Colorado and New Mexico, (Kindle, 1909) and from Elbow Canyon in the Lost River Range (Kindle in Umpleby, 1917).

*Locality*.—No. 4.

Genus **CLEIOTHYRIDINA** Buckman

**Cleiothyridina devonica** Raymond

Plate 1, fig. 14

*Cleiothyridina devonica* Raymond, 1909, Ann. Carnegie Mus., vol. 5, Nos. 2, 3, pp. 143, 144, pl. 3, figs. 16, 17; pl. 4, figs. 1-11.

*Cleiothyridina devonica* is common in the upper part of the Three Forks formation. It resembles *Athyris coloradoensis* Girty, but is smaller in size.

*Locality*.—No. 4.

## PHYLUM MOLLUSCA

## CLASS PELECYPODA

Genus *LEPTODESMA* Hall? *Leptodesma chillensis*, n. sp.

Plate 1, figs. 1-2

Two left valves of a new species of a long inequivalve pelecypod were collected in the upper part of the Three Forks formation. The larger and more mature specimen (fig. 1) is hereby designated as the holotype (Pal. Res. Inst., No. 6048) and the smaller specimen, (fig. 2) is the paratype (Pal. Res. Inst., No., 6049).

The specimens show a short anterior and a long posterior end and an alignment of the valve very nearly parallel to the hinge line. The larger specimen is incomplete, but corresponds to the smaller specimen in detail. In the larger specimen there is a narrow rounded beak which extends slightly over the hinge line but flattens out and broadens toward the posterior end. There is a shallow depression between the hinge line and the rounded part of the valve along the posterior part. The shell is covered by concentric growth lines.

The specimens resemble species of *Leptodesma* in many respects, but differ in being aligned nearly parallel to the hinge line so that no posterior wing is developed. They are therefore questionably assigned to *Leptodesma*.

*Locality*.—No. 4.

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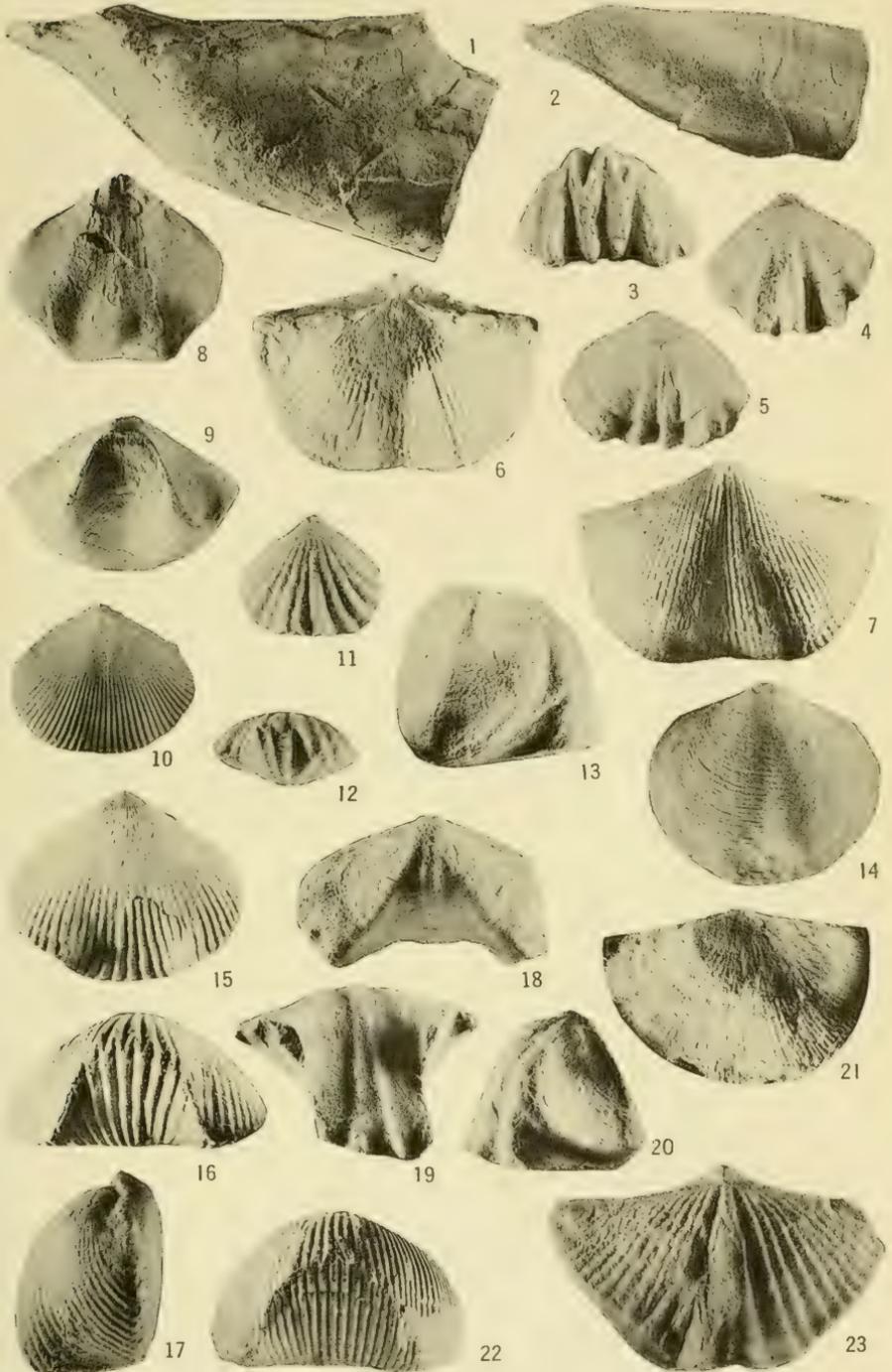
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PLATE

PLATE I (7)

## EXPLANATION OF PLATE 1 (7)

Figure	Page
1-2. ? <i>Leptodesma chillensis</i> , n. sp. Figure 1 is slightly enlarged. Holotype, Pal. Res. Inst., No. 6048. Figure 2, paratype; x 3; Pal. Res. Inst. No. 6049.	15
3-5. <i>Leiorhynchus</i> cf. <i>dunbarensis</i> Haynes Width, 18 mm.; length, 13 mm.; thickness, 12 mm. Pal. Res. Inst., No. 6041.	11
6-7. <i>Cyrtospirifer whitneyi</i> var. <i>auimansensis</i> Girty Width, 35 mm.; length, 25 mm.; thickness, 18 mm. Pal. Res. Inst., No. 6044.	12
8-9. <i>Athyris vitatta</i> Hall Width, 17 mm.; length, 13 mm.; thickness, 10 mm. Pal. Res. Inst., No. 6046.	14
10. <i>Camarotoechia</i> cf. <i>shimeri</i> Warren Width, 22 mm.; length, 18 mm.; thickness, 5 mm. Pal. Res. Inst., No. 6040.	10
11-12. <i>Camarotoechia contracta</i> Hall Width, 10 mm.; length, 8 mm.; thickness, 4 mm. Pal. Res. Inst., No. 6037.	10
13. <i>Leiorhynchus madisonense</i> var. <i>gibbosum</i> Haynes Width, 24 mm.; length, 17 mm.; thickness, 17 mm. Pal. Res. Inst. No. 6042.	11
14. <i>Cleiothyridina devonica</i> Raymond Width, 14 mm.; length, 12 mm.; thickness, 5 mm. Pal. Res. Inst., No. 6047.	14
15-17. <i>Camarotoechia nordeggi</i> Kindle Width, 20 mm.; length, 16 mm.; thickness, 10 mm. Pal. Res. Inst., No. 6038.	10
18-20. <i>Pugnax</i> , sp. Width, 18 mm.; length, 9 mm.; thickness, 10 mm. Pal. Res. Inst., No. 6043.	12
21. <i>Schuchertella chemungensis</i> var. <i>arctostriata</i> Hall Width, 32 mm.; length, 25 mm. Pal. Res. Inst., No. 6036.	10
22. <i>Camarotoechia nordeggi</i> Kindle Width, 29 mm.; length, 27 mm.; thickness, 18 mm.; more gibbous and larger than usual. Pal. Res. Inst., No. 6039.	10
23. <i>Spirifer raymondi</i> Haynes Width, 26 mm.; length, 16 mm.; thickness, 11 mm. Pal. Res. Inst., No. 6045.	14









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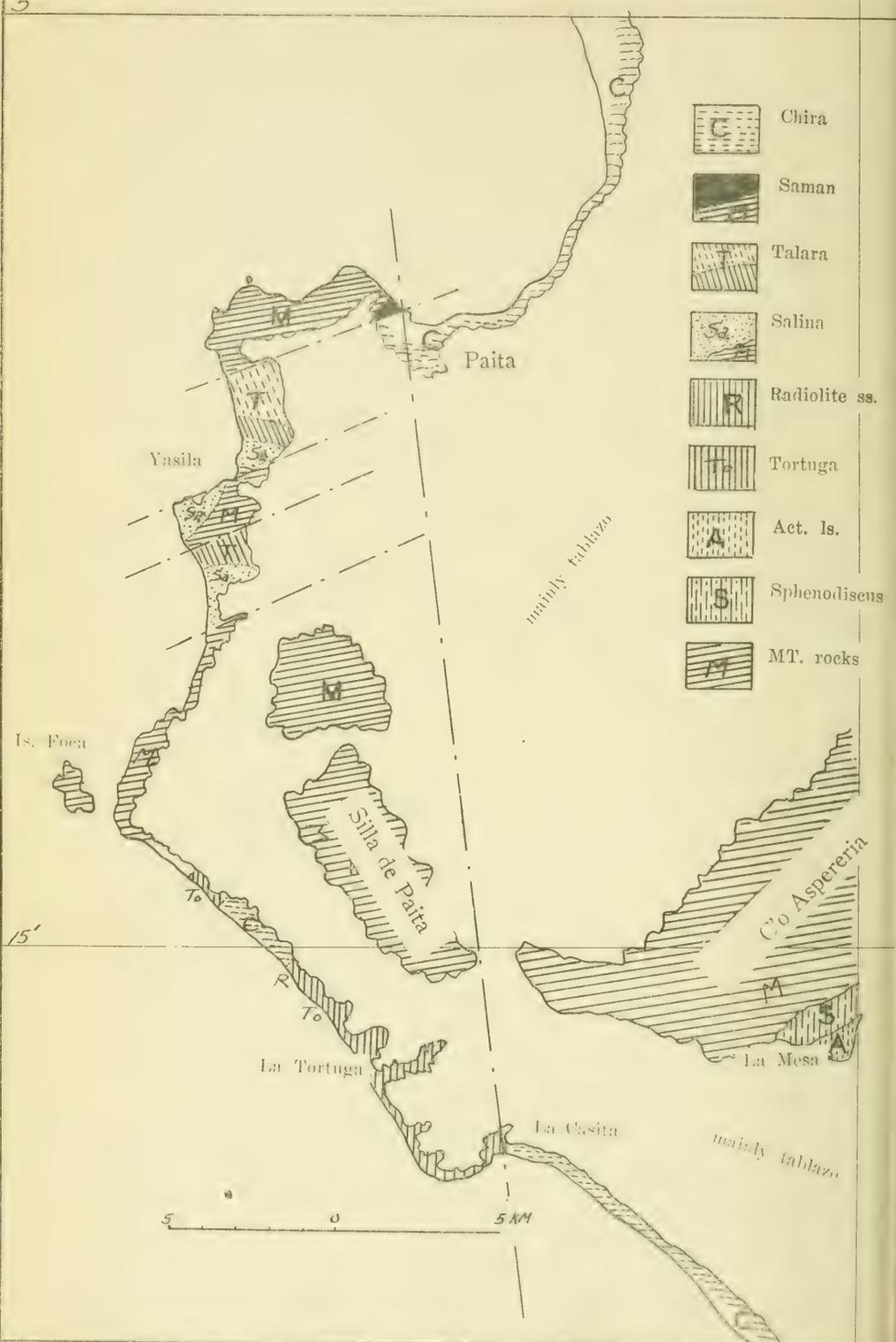
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U. S. A.





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- Chira
- Saman
- Talara
- Salina
- Radiolite ss.
- Tortuga
- Act. Is.
- Sphenodisens
- MT. rocks

SKETCH MAP OF THE PAITA PENINSULA

**BULLETINS  
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**Vol. 28**

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No. 111

Contributions to the Paleontology of  
Northern Peru  
Part VII. The Cretaceous of the Paita Region

By

A. A. Olsson

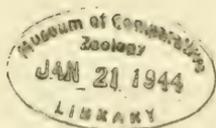
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CONTRIBUTIONS TO THE PALEONTOLOGY OF  
NORTHERN PERU:  
PART VII. THE CRETACEOUS OF THE PAITA REGION

By

A. A. OLSSON

FOREWORD

The principal purpose of this paper is the description and illustration of some Upper Senonian molluscan fossils from the Paita region of northwestern Peru. It supplements therefore to some extent our earlier contributions to the Cretaceous of the Amotape region, a short distance further to the north. Our collections were obtained mainly in 1937 and 1938 when several short reconnaissance trips were made to the localities along the south side of the Paita Mountains for Cretaceous fossils, first described by Gerth. I am deeply grateful to Mr. O. C. Wheeler, Chief Geologist for the International Petroleum Company, Toronto and to Mr. O. D. Boggs, formerly Chief Geologist in Peru, who accompanied me on these trips, for their most generous assistance in the field studies and in collecting.

As the Peruvian fauna differs so greatly from any other Cretaceous assemblage yet described from South America, it has been necessary to propose many new generic and subgeneric names for some species. These names are the following:

Genus <i>Sechuritella</i>	Type, <i>S. terebracincta</i> , n. sp.
Genus <i>Trocotaulax</i>	Type, <i>T. elegans</i> , n. sp.

Genus Thianassa	Type, <i>T. ciconia</i> , n. sp.
Genus Rhinotamides	Type, <i>R. rudis</i> , n. sp.
Genus Sympanotomus	Type, <i>S. muricatus</i> , n. sp.
Genus Nodifaunus	Type, <i>N. nodosa</i> , n. sp.
Genus Glorioclava	Type, <i>G. inca</i> , n. sp.
Genus Previcarya	Type, <i>P. peruviana</i> , n. sp.
Genus Tortucerithium	Type, <i>T. textilis</i> , n. sp.
Genus Parinana	Type, <i>Morgana magma</i> Woods (Eocene)
Genus Torgnellus	Type, <i>T. peruvianus</i> , n. sp.
Genus Perustrombus	Type, <i>P. wheeleri</i> , n. sp.
Subgenus Orthostrombus	Type, <i>Perustrombus toutu-</i> <i>gensis</i> , n. sp.
Genus Peruarca	Type, <i>P. pectunculoides</i> , n. sp.
Genus Incanopsis	Type, <i>I. acariformis</i> , n. sp.
Subgenus Tortucardia	Type, <i>Glossocardia stephen-</i> <i>soni</i> , n. sp.
Subgenus Perucardia	Type, <i>Cardium brüggeni</i> , n. sp.
Subgenus Incacardium	Type, <i>Cardium mellisum</i> , n. sp.
Subgenus Sechurina	Type, <i>Aphrodina australis</i> , n. sp.
Genus Mulinoides	Type, <i>Mulinoides chilca</i> , n. sp.
Genus Macrodonax	Type, <i>Macrodonax peruviana</i> , n. sp.
Subgenus Tellipiura	Type, <i>Tellidora peruana</i> , n. sp.
Subgenus Austrosphenodiscus	Type, <i>Coahuilites peruviana</i> Gerth
Genus Paciceras	Type, <i>P. pacifica</i> , n. sp.

I am using this occasion to change two, earlier generic names given to Peruvian fossils which have proved to be preoccupied:

*Peruvia* Olsson, 1934 changed to *Peruviella*, new name.

Preoccupied by *Peruvia* Malloek, 1929 in *Diptera*, *Ann. Mag. Nat. Hist.* (10) 4, 104.

*Iddingsia* Olsson, 1929, changed to *Iddingsella*, new name.

Preoccupied by *Iddingsia* Walcott, 1924 in *Trilobita*, *Smith. Misc. Coll.* 5, 58.

Gloversville, N. Y.

Aug. 1st, 1943.

## INTRODUCTION

The discovery of Upper Cretaceous beds with rudistids and *Roudaireia* at Monte Grande near Negritos in northwestern Peru was first announced by Iddings and Olsson(1) in 1928. This was followed by Gerth's (2) description of a small Upper Cretaceous fauna with rudistids, *Sphenodiscus* and other mollusks from exposures along the south side of the Paita Peninsula. These two localities have thus far furnished the only Upper Cretaceous or Maestrichtian molluscan fossils yet known in coastal Peru. Aside from these occurrences, the only other important development of late Cretaceous deposits along the west coast of South America are the fossiliferous beds on the island of Quiriquina and around the shores of the Bay of Concepción on the coast of Chile. The Quiriquina beds have assumed importance in geological literature through their early discovery and description in the writings of D'Orbigny and Darwin(3). The Chilian deposits and those of northern Peru were formed in relatively small, local embayments which barely touched the present coast. This late Cretaceous and purely Pacific transgression(4) was therefore completely distinct from the great Tethyan or Mediterranean invasions which flooded the earlier Cretaceous geosynclines within the Andes proper. In Venezuela, and more especially in Colombia, the Maestrichtian sea persisted for a time longer within the mountain zone although, except locally or in restricted horizons, its deposits are nonmarine and coal-bearing. The restriction of the Peruvian marine Upper Senonian to the coastal zone and its predominantly, coarsely clastic character is strong evidence of regional uplift towards the close of the Cretaceous period. This phase in the formation of the Peruvian Andes, only one of many, thus corresponds closely in time to the Laramide revolution of North America as pointed out by Steinmann, Stille(5) and many other students of South American geology.

## GEOLOGY

The region referred to in this paper as the Paita Peninsula is a portion of the northwest coast of Peru between  $5^{\circ} 4'$  and  $5^{\circ} 20'$  S. Lat. and lying between Paita Bay on the north and the Bay of Sechura on the south. In contrast with the smoothly curving shores and the sandy beaches of these deep bays, the coast line of the Paita Peninsula is very irregular, its jagged headlands and rocky islands being formed of hard, metamorphic and crystalline rocks of great complexity of structure and composition. This very great contrast in coastal development has resulted primarily from the condition that the Paita Peninsula is part of an old range of mountains which became dismembered by faulting in the Late Cretaceous and early Eocene times.

The geology of the Paita Peninsula is little known and has received but scant mention in the literature. Its principal rocks are slates, schists, gneisses or granites which form most of the Paita Mountains and the headlands along the coast at Punta Nermete and Foca Island. These formations were long believed to be Archean but a few Carboniferous rocks found near Paita, show that they are at least partly Carboniferous in age. A rich and varied Permo-Carboniferous fauna has also been known from the Amotapes for many years. It seems probable that the Paita Peninsula was once connected with the Amotape Range to the north of the Chira Valley and with the similar out-lying Cerros de Illescas and the Lobos Islands to the south. These groups of present-day mountains are composed of essentially similar rocks and their prevailing structural trends, if extended, would join to form a continuous range. Large areas in the eastern and central part of the peninsula have no rock outcrop, the generally flat, barren surface being floored by young, marine terrace deposits or by drifting desert sands. These level, uplifted, marine plains of deposition have a very extensive development in the coastal region of northern Peru where they are known as *tablazos*. In the Paita region, this tablazo plain has a mean elevation of about 200 feet but it lowers steadily southward into the Sechura desert. The Paita tablazo is formed principally of beach sands and gravels, marine marls and shell limestones which

locally may reach a thickness of 200 feet. Elsewhere these tablazo deposits may be very thin or entirely missing, the flat floor, generally on rock, being then the peneplained surface or uplifted sea-bottom of the tablazo sea.

Tertiary formations of Eocene, Oligocene and Miocene ages are found at several places in the Paita region. At the city of Paita, the Oligocene Chira shales form the lower part of the high, tablazo cliffs bordering Paita Bay. They are mainly black shales, weathering light-brown or chocolate color. Fossils are principally pteropods, Foraminifera and thin-shelled mollusks. Interesting exposures of Eocene rocks occur at several places, their principal area of development being found at Yasila and Jaquay Cunas on the coast between Foca Island and Nermete Point. These names refer to small, fishing camps, the nearby coves affording anchorage and some protection from the heavy ocean swell. At Yasila, the Eocene formations rest directly upon the crystalline basement. These slivers of Eocene sediments occur as small segments between faults which normally trend about N. 50° E. Cross faults are also present but of lesser importance. Aside from the richly fossiliferous character of these Eocene horizons, the Yasila and Paita sections give much interesting information as to the depositional history of Eocene times in northern Peru. The section at Yasila and Jaquay Cunas is as follows:

Talara	Mostly shale	Talara shale
	Basal sandstone.	
Salina	Chocolate shales and gredas	
	Fossiliferous concretionary sandstones	
	Basal sandstones and conglomerates	
Paleozoic or older	Slates, schists, etc.	

No rocks corresponding to the lower Eocene or Negritos formation have been found in the Paita region, the basement floor at Yasila being overlain by beds containing a Salina or lower middle Eocene fauna. The lower 50 to 100 feet of this section is composed of barren sandstones and conglomerates, the bed in contact with the basement being generally a coarse breccia

formed entirely of slate and quartz fragments. Overlying these basal beds are 50 feet or more of highly fossiliferous, concretionary shaly sandstones containing *Surcula* (*Andicula*) *occidentalis*, *Peruluta peruviana*, *Pseudoglauconia lissoni*, *Boggsia anceps* and many others. The chocolate shales which overlie the fossil beds are usually unfossiliferous and may be partly Pale Greda in age. Rocks of Salina age have not been found further south so the occurrence at Yasila along the north and west side of the Amotape-Paita Range may mark the southern shoreline of the mid-Eocene sea.

The Talaran or lower upper Eocene comprises two members, a lower zone (approximately 200 feet thick) of concretionary, bluish sandstones and an upper shale member. The lower sandstones are richly fossiliferous and have yielded a large fauna of small mollusks. The concretions contain pieces of fossil wood and are generally thickly seamed with calcite veinlets. The contact of the Talara sandstones with the Salina is in all places sharp and distinct while at some places where the Salina is missing, the Talara lies directly upon the older rocks.

The Saman sandstones outcrop in their typical Chira Valley facies at the west side of the City of Paita. They are yellowish, concretionary sandstones and are very fossiliferous. They lie directly upon the basement schists thereby proving the independent transgressive character of the late upper Eocene sea. It was from these Eocene exposures at Paita that the earliest Tertiary fossil to be described from South America by D'Orbigny had been obtained. Later, other collections were made by Raimondi and Orton which were described by Gabb. These outcrops of Saman sandstone are separated from the Chira shale exposures to the east of the city by a major fault.

The Sechura Miocene was previously known in outcrop only along the east side of the Illescas Mountains but a small area of Miocene exposures has since been found at Cerro Chocán near the northeast end of the Cerros de Aspereria [Olsson(6)]. Gerth showed Cretaceous outcrops at or near this locality on his small sketch map which may or may not refer to these Miocene beds. The exposures are limited in extent and consist mostly of a

yellowish shell limestone and concretionary shale which rests with a basal conglomerate upon a crystalline floor. The fossils, mostly molluscan, are badly wind eroded but amongst others, have the following forms: *Dosinia illesca* Olsson, *Cardita*, sp. *Corbula* cf. *acutirostra zorrutensis* Olsson, *Semele*, sp., *Conus bravoii* Spieker, *Conus multiliratus* Spieker, *Turritella*, sp., *Antillophos* sp., *Thanetia (Solenosteira) sechurana* Olsson.

East and southeast of the city of Paita are the small peaks of the Paita Mountains. They form two groups of mountains, the western set known as the Silla de Paita and the eastern set as the Cerros de Aspereria. The Silla de Paita is the higher and more rugged, its principal peaks in the northern part having an elevation of about 380 meters. The Cerros de Aspereria are much lower and in many places are completely smothered by dune sands. The trend of the Silla de Paita is northwesterly but a large part of its marginal area has been lowered or planed off by the tablazo sea. The Cerros de Aspereria have a north-easterly trend and are therefore parallel to the normal, structural grain of the Amotape Range some miles north of the Chira Valley. At the south, the Silla de Paita and the Cerros de Aspereria are weakly joined by a low pass or wind gap about six or seven kilometers north of the coast. Although these two mountain groups are similar in their rock formations, they are evidently parts of two major fault blocks, the fault separating them passing from the coast at La Casita "the end of the Cretaceous breccia sequence" northward along the east side of the Silla de Paita Mountains to the tablazo break and change in geology at the City of Paita. A fault with a similar trend borders the east side of the Illescas Mountains and separates the old mountain rocks on the west from the Tertiaries of the Sechura desert on the east. In both cases, upfaulting has occurred on the west side.

The Cretaceous outcrops at La Mesa along the south side of the Cerros de Aspereria are believed to be older than the beds at Tortuga. The La Mesa beds are relatively fine-grained rocks, in part limestones and represent deposits formed by a transgressive sea across a relatively flat, peneplained floor. The Cretaceous in the coast section at Tortuga is coarsely clastic and contains only

an occasional interbedded marine or fossiliferous layer. A marked change in the source of sedimentation has therefore occurred since the formation of the basal beds at La Mesa. The base of the Tortuga breccias has not been seen but they probably overlap to some extent upon the old rocks forming the core of the old Paita Mountains. The formation of these thick deposits of shingle beach accumulations can only be explained as the result of a lively erosion in nearby mountains in process of uplift. This period of orogeny, correlated with the change in character of the Cretaceous sediments, is probably connected with the formation of the Paita and Illescas fault system (probably also the Pananga fault of the Amotapes) which is therefore of Maestrichtian age although movements have occurred along these faults at intervals during the Tertiary. The Cretaceous sections at La Mesa and Tortuga therefore offer an excellent example of the close governing influence of tectonics(7, 8) in the petrographic character and mode of formation of a sedimentary deposit.

#### THE PAITA CRETACEOUS

The most complete section of Upper Senonian rocks yet known in northern Peru is found along the south coast of the Paita Peninsula from near Foca Island eastward through Tortuga to La Casita and in smaller patches at La Mesa near the south corner of the Paita Mountains. These outcrops were first found by the geologists of the Dutch Shell (the Bataafschen Petroleum Maatschappij) in 1925 and a small collection of fossils from these beds was briefly described by Gerth(2) in 1928. Gerth indicated several outcrop areas along the south side of the Cerros de Aspereria but only that at La Mesa itself has been seen by us. The locality at the northeast end of the Cerros de Aspereria or near Cerro Chocán is Miocene. It is quite possible that Cretaceous beds are exposed at points along the east side of these mountains but outcrops must be rare as the area is covered with deep and constantly shifting desert sands. The Cretaceous at La Mesa and in the sea cliffs at Tortuga are the shore-facies of more marine beds believed to underlie Sechura Bay.

What we believe to represent the lowest and oldest part of the Paita Cretaceous are the rocks exposed at La Mesa which is a small, flat-topped hill at the south end of the Cerros de Aspereria. Only at this place do we actually see the base of the Cretaceous series which lies with marked unconformity upon the much older, metamorphic and crystalline rocks of the Paita Mountains. These exposures consist principally of a yellowish sandstone and sandy shale, sometimes concretionary and generally fossiliferous. The sharply keeled ammonites (*Austrosphenodiscus* and *Pacificeras*) are common here, together with small gasteropods and bivalves, but the fauna as a whole is not well preserved because of severe wind-erosion. Gerth called these beds the *Sphenodiscus-Schichten*. The ammonite beds are overlain by a massive limestone formed mostly of rudistid remains but a few other fossils such as *Actæonella* are common in the lower layers. This horizon is Gerth's *Actæonellen-Rudistenkalkstein* and from it he described *Pironæ peruviana*. Although the limestone is highly fossiliferous, good specimens are very difficult to extract in fit condition for identification. Besides *Actæonellas*, our collection contains only a few fragments of a radiolite showing the forked vascular markings of a *Sauvagesia*.

The Cretaceous exposures at La Mesa and those in the coast section at Tortuga are separated by a wide area of flat tablazo without any rock outcrop so that the stratigraphic relations of the two sections cannot be observed. In contrast to the relatively fine-grained and typically marine beds at La Mesa, the rocks at Tortuga are composed mostly of coarse, breccia-conglomerates and contain fossils only in a few, and relatively thin horizons.

The coast between Foca Island at the west end of the peninsula and La Casita to the east, is bordered for most part by a tablazo escarpment about 65 meters in elevation. This tablazo plain extends inland to the foot of the Paita Mountains around which it overlaps in shore-line form. Along the coast, this tablazo overlies segments of Tertiary and Cretaceous formations which in the shore cliffs is distributed roughly as follows: at Foca Island and for a distance of about two miles east, the principal exposures are the Amotape slates; they are followed by a small

segment of Cretaceous sandstones with rudistid remains. The coastal zone immediately south of this block is formed by Tertiary shales which extend for a distance of about a mile and a half. No fossils are known from these Tertiary beds but in appearance the beds resemble the Chira. The base of the Tertiary is formed by beds of conglomerate and breccia which lie on Cretaceous sandstones. The main Cretaceous section begins at this point, about two miles north of the fishing village of Tortuga and continues without major interruption to La Casita which is merely a small indentation in the U. S. escarpment. The Cretaceous in this section is formed mostly of a slate breccia-conglomerate and more rarely sandstones. It is usually poorly consolidated, well bedded and dips fairly regularly northward at angles varying from 17 to 30 degrees. The uppermost part of this section is formed by the Radiolite sandstones which is exposed opposite the small guano rock known locally as "La Mina de Perico". It is a bluish-greenish-colored rock when fresh, rather massive, its bedding indicated mainly by lines of small concretions. The bedding is more regular towards the base and seams of conglomerate begin to appear as well as layers of fossils. Remains of *Sauvagesia peruviana* are common in the upper and main parts of the sandstones but most specimens are badly broken. Some of these fragments are from individuals of large size. A few bones, fossil wood and fragments of shells were observed.

Fossil layers begin to appear in the lower part of the Radiolite sandstones and form a transitional zone between the sandstones proper and the underlying breccias. In the paleontological part of this paper, these fossil beds will be referred to as the *Baculites* zone or the Upper Breccias. Fossils are very abundant here, most of the species are large, thick-shelled and many in excellent state of preservation. It is a typical Monte Grande faunal assemblage, most of the species known from Monte Grande occurring here. Prominent species in these beds are *Pseudocucullaea gregoryi*, *Trigonarca meridionalis*, *Trigonia gerthi* and *hopkinsi*, *Roudaircia peruviana*, *Cardium brüggeni* and *amotapensis*, *Perustrombus wheeleri*, *Torgnellus peruvianus* and many others. Ammonites are rare except *Baculites lyelli* which grows to a large

size. The thickness of the Radiolite sandstone, including the fossiliferous beds below it, is estimated as about 500 feet but careful measurements have not been made.

Under the Radiolite sandstones there is a very thick sequence of slate breccia-conglomerates, usually so coarse that when seen in small patches might be mistaken for basement rock in outcrop. The color is usually a limonite red but green and gray beds as well as layers of a pure white sandstone are interbedded. Near the middle of this sequence at the small fishing village of Tortuga, the breccias contain a few, relatively thin layers of fossiliferous, pebbly conglomerates and shaly sandstones. About three of these fossiliferous bands were found which for sake of convenience were called the lower, middle and upper fossil beds of Tortuga. The fauna is essentially the same in all layers. Beyond Tortuga, the breccia-conglomerates outcrop continually along the shore and at many places form high, impassable cliffs.

The Cretaceous at Tortuga and La Mesa is roughly divided as follows:

- A. The Radiolite sandstones with the *Baculites* zone at base. Thickness about 500 feet.
- B. Breccia-conglomerates with interbedded sandstones. Thickness not known but probably about 1000 feet.
- C. The Tortuga fossil beds. A zone of thin fossil beds within the breccias and probably together about 200 feet in thickness.
- D. Lower Breccias, unfossiliferous, thickness unknown.
- E. Interval without outcrop, unconformity possible.
- F. *Actæonella* limestones.
- G. *Austrosphenodiscus-Paciceras* shales and sandstones.
- H. Basement of complexly folded crystalline and metamorphic rocks.

## FOSSILS FROM THE MONTE GRANDE AND PAITA UPPER SENONIAN

Nuculana, sp. ....	Tor.	
Pseudocucullæa gregoryi Olsson .....	MG.	Bac.
Pseudocucullæa paitana, n. sp. ....	LMs	
Peruarea pectunculoides, n. sp. ....	Bac.	
Incanopsis acariformis, n. sp. ....	Tor.	
Breviarea peruviana, n. sp. ....	LMs.	
Mytilus signatus Olsson .....	Tor.	MG.
Volsella cerva, n. sp. ....	Tor.	
Volsella portuna Olsson .....	MG.	
Pedalion woodsii Olsson .....	Tor.	MG.
Gervillia incertans, n. sp. ....	Tor.	
Inoceramus, sp. A. ....	Bac.	
Inoceramus, sp. B. ....	Bac.	
Anomia, sp. ....	Tor.	
Ostrea palpa, n. sp. ....	Tor.	
Ostrea (Lopha) seelura, n. sp. ....	Bac.	
Ostrea (Lopha) stappenbecki Olsson .....	Tor.	MG.
Ostrea, sp. ....	LMs	
Pinna, sp. ....	Bac.	
Trigonia (Scabrotrigonia) gerthi, n. sp. ....	Bac.	
Trigonia hopkinsi, n. sp. ....	Bac.	
Anatmya, sp. ....	Tor.	
Periploma nermeta, n. sp. ....	Bac.	
Pholadomya houghti Olsson .....	MG.	
Spondylus hopkinsi Olsson .....	MG	
Plicatula harrisiana Olsson .....	MG	
Roudaireia peruviana Olsson .....	Bac. MG.	LMs
Roudaireia auressensis Coquand .....	MG	
Glossocardia (Tortueardia) stephensoni, n. sp. ....	Tor.	LMs.
Corbicula meridionalis, n. sp. ....	Tor.	
Venericardia weberbaueri Olsson .....	MG.	
Orbignya pacifica Olsson .....	MG.	
Sauvagesia peruviana, n. sp. ....	Bac.	MG.
Pironæa peruviana Gerth .....	Actæonella ls:	
Cardium ? abnormalis, n. sp. ....	Bac.	
Cardium (Perueardia) brüggeni, n. sp. ....	MG. Bac.	LMs.
Cardium amotapensis Olsson .....	Bac.	MG.
Cardium (Ineacardium) mellisum, n. sp. ....	Tor.	LMs.
Aphrodina pacifica, n. sp. ....	Bac.	
Aphrodina cf. auea d'Orbigny .....	Bac.	
Aphrodina speciosa, n. sp. ....	Tor.	
Aphrodina (Sechurina) australis, n. sp. ....	Bac.	
Legumen peruvianum, n. sp. ....	Tor.	
Icanotia pacifica, n. sp. ....	Tor.	
Mulinoides chilea, n. sp. ....	Bac.	
Mulinoides chicama, n. sp. ....	Tor.	
Macrodonax peruviana, n. sp. ....	Bac.	
Tellidora (Tellipiura) peruana, n. sp. ....	Tor.	

Tellina, sp. ....	MG.	
Linearia bomara Olsson .....	MG	
Panope frailia, n. sp. ....	Bac.	
Corbula tuma, n. sp. ....	Tor.	
Corbula montegrandensis Olsson .....	Bac.	
Corbula broggii, n. sp. ....	Bac.	
Tectus tseludi, n. sp. ....	Tor.	
Teinos oma, sp. ....	Tor.	
Pseudomelania simplex, n. sp. ....	Tor.	
Nerita jayanca, n. sp. ....	Tor.	
Desmiera peruviana Olsson .....	MG.	
Stalio agnia, n. sp. ....	Tor.	
Mesalia janja, n. sp. ....	Tor.	LMs.
Mesalia peruviana Olsson .....	MG.	
Mesalia inca Olsson .....	MG.	
Woodsalia paitana, n. sp. ....	Tor.	
Woodsalia paitana robusta, n. subsp. ....	Tor.	
Turritella ceiba, n. sp. ....	Bac.	
Turritella prechira, n. sp. ....	LMs.	
Turritella saposa, n. sp. ....	Tor.	
Turritella lama, n. sp. ....	Tor.	
Turritella desolata, n. sp. ....	Bac.	
Turritella inuya, n. sp. ....	Tor.	
Turritella prelissonii, n. sp. ....	Bac.	
Turritella bartsia, n. sp. ....	Pan de Azucar	
Sechuritella terebracineta, n. sp. ....	Bac.	
Sechuritella chaapoya, n. sp. ....	Bac.	
Pseudomalaxis ?, sp. ....	Tor.	
Melanatria medialis, n. sp. ....	Tor.	
Glauconia cordalis, n. sp. ....	Bac.	
Nodifaunus nodosus, n. sp. ....	Tor.	
Nodifaunus costatus, n. sp. ....	Tor.	
Glorioclava inca, n. sp. ....	Tor.	
Previcarya peruviana, n. sp. ....	Tor.	
Trococtaulax elegans, n. sp. ....	Tor.	
Thianassa coconia, n. sp. ....	Tor.	
Pyrazus peruvianus, n. sp. ....	Tor.	
Tortuercithium textilis, n. sp. ....	Tor.	
Sympanotomus muricatus, n. sp. ....	Tor.	
Rhinotamides rudis, n. sp. ....	Tor.	
Calyptraea aperta Solander .....	Bac. MG.	Tor.
Ampullina breccia, n. sp. ....	Bac.	
Ampullina tortuga, n. sp. ....	Tor.	
Ampullina cumara, n. sp. ....	Tor.	
Anchura pacifica, n. sp. ....	Bac.	
Calyptrophorus hopkinsi Olsson .....	MG. Bac.	
Torgnellus peruvianus, n. sp. ....	MG. Bac.	
Perustrombus wheeleri, n. sp. ....	Bac.	
Orthostrombus tortugensis, n. sp. ....	Tor.	
Orthostrombus cypræformis Olsson .....	MG.	
Pseudoliva, sp. ....	MG.	
Fasciolaria cf. bleicheri Thomas and Peron .....	MG.	

<i>Fasciolaria sechura</i> , n. sp. ....	Bac.
<i>Latirus tribulus</i> , n. sp. ....	Bac.
<i>Rhombopsis meridionalis</i> , n. sp. ....	Tor.
<i>Fusinus corbis</i> , n. sp. ....	Bac.
<i>Lissapiopsis ? calappa</i> Olsson .....	MG.
<i>Triton</i> , sp. ....	Bac.
<i>Voluta inca</i> , n. sp. ....	Bac.
<i>Volutocorbis meridionalis</i> , n. sp. ....	Bac.
<i>Lyria concha</i> , n. sp. ....	Tor.
<i>Baculites lyelli</i> d'Orbigny .....	Bac.
<i>Turrilites peruvianus</i> , n. sp. ....	Bac. MG.
<i>Parapachydiseus</i> , sp. ....	Bac.
<i>Coahuilites (Austrosphenodiseus) peruvianus</i> Gerth .....	LMS.
<i>Paciceras pacificum</i> , n. sp. ....	LMS.
<i>Paciceras gerthi</i> , n. sp. ....	LMS.
Small ostracods .....	Tor.
<i>Scalpellum</i> , sp. ....	Tor.
<i>Callianassa</i> , sp. ....	Tor.
<i>Montastrea parinasensis</i> Wells .....	Bac. MG.

The locality abbreviations refer to the following:

MG. Monte Grande near Negritos.

Bac. *Baculites* zone.

Tor. The Tortuga fossil zones.

LMS. La Mesa.

Pan de Azucar. Pan de Azucar near La Brea.

In the Negritos oil-field, a subsurface formation has been encountered in some deep wells containing a very late Cretaceous or post-Navarran microfauna. To these beds, the name Mal Paso was proposed by Wiedey and Frizzell in 1940 and more recently, the fauna, composed entirely of small Foraminifera, has been described by Frizzell(9). The Mal-Paso is not known in outcrop but in well-borings consists predominantly of shales which underlie with apparent conformity the main oil sand in the older part of the Negritos field and which may therefore mark the base of the Eocene Negritos shales. The formation has a thickness of about 7000 feet, below which lies a zone of conglomerate which in turn rests unconformably upon beds believed to belong to the Middle Cretaceous Copa Sombrero.

The Paita Cretaceous, because of its sandy and clastic character, has not yielded any microfossils aside from ostracods and small plates of a *Scalpellum* so that a paleontological comparison with the Mal Paso is at present not possible. As pointed out by Frizzell, the Mal Paso Foraminifera which comes mainly from the upper 3000 feet of the formation, are younger than the Navarro and hence must be younger than the Monte Grande and the

*Clavulina* shales. Such common Foraminifera as *Spiroplectamina grzybovskii* Frizzell and *Marssonella oxycona* Reuss certainly suggests a correlation with the Tamesi (Velasco) of Mexico and the Lizards Spring fauna of Trinidad, and referred by most authorities to the Danian. Whether the lower Mal Paso shales and the underlying conglomerate are the age equivalent of the Monte Grande and *Clavulina* shales cannot be decided at present without fossils. If these deep beds should eventually yield fossils of Maestrichtian or Navarro age, a correlation with the Monte Grande sequence would be indicated.

At Monte Grande and at Paita, the Tertiary formations which overlie the Cretaceous sediments belong either to the middle Eocene or still higher horizons and are strongly unconformable. It can be pointed out again that the Negritos field with its unusually thick and very complete Eocene section, is the very center of the Eocene sedimentary basin in northern Peru with the oldest Eocene occupying a very small area. If transitional Cretaceous and Eocene beds are found anywhere in South America we should expect them here.

The *Turritella bartsia* described in this paper comes from a series of coarse, shore-facies sandstones outcropping in the south bank of Quebrada Ancha near Pan de Azucar west of La Brea. These beds rest unconformably upon the Pananga limestones. Their age is not definitely known as no other fossils have been found in them. They may belong to the Monte Grande or to a lower Eocene horizon.

#### AGE OF THE PAITA CRETACEOUS

A late Cretaceous or Upper Senonian age for the Paita sequence is clearly indicated by its fauna. The presence of a large *Baculites* belonging to the *anceps-vagina* group, a typical Upper Senonian *Parapachydiscus*, large, rounded forms of *Trigonarca*, *Roudaireia*, *Pseudocucullaea*, members of the *Inoceramus* cf. *balticus* group; and rudistids closely allied to Upper Cretaceous species elsewhere is definite evidence of its late Cretaceous character. These fossils would seem to indicate a Maestrichtian age for the entire sequence but because of its great thickness and well-differentiated faunal zones, it is equally possible that the section may also include horizons somewhat older than the Maestrichtian.

In the Andes, the most widespread of the marine Cretaceous deposits are beds which extend from the Turonian into the Lower Senonian possibly as high as the Santonian. These formations contain a rich fauna with several ammonite zones in which species of *Coilopoceras*, *Barroisiceras*, *Tissotia*, *Heterotissotia*, *Peroniceras*, etc., are a few of the dominant and characteristic forms. These faunal elements are entirely absent from the Paita Cretaceous and show that no part of the section is as old as the Lower Senonian.

Gerth, without information as to the field sequence of beds, considered the ammonite locality at La Mesa or his *Sphenodiscus* Schichten as belonging to the Maestrichtian. This age assignment was based largely on his identification of these sharply keeled and more or less noded ammonites as a subspecies (*peruviana*) of the common Navarran *Sphenodiscus pleurisepta* Conrad. The beds at La Mesa belong to the lowest and hence the oldest part of the Paita Cretaceous and lie directly upon basement. The sharply keeled ammonites so abundant in this lower horizon belong to two genera and three species none of which are closely related to the Texan *Sphenodiscus pleurisepta*. They are associated with a relatively small *Roudaireia*, medium-sized *Pseudocucullæa*, small Trigonias, etc., a faunal assemblage which is very similar to that found in the basal Umir and the Mita Juan in Colombia and Venezuela. The rudistid, *Pironæa peruviana* Gerth, comes from the slightly higher horizon of the *Actæonella* limestone. The *Actæonella* was referred by Gerth to *Actæonella* (*Volvulina*) cf. *lævis* d'Orbigny but the material I have seen consists only of cross sections and cannot be closely determined.

The fossil zones at Tortuga village or in the middle Breccias contain a fauna which is largely confined to it and consequently does not yield much evidence as to its age. On a casual inspection and disregarding its obvious stratigraphic position below unquestionable Cretaceous, this fauna might easily be mistaken for lowermost Eocene. Some of the cerithids and potamidids, including *Melanatria*, the *Mesalia janja*, some of the Turritelias and the presence of true *Calyptrea*, might all be considered as Eocene forms. The cerithids and potamidids belong for the most part to

new genera and have no similar species in the Eocene so far as known. *Mesalia janja*, although somewhat similar to some Eocene species like *fasciata* Lamarck, is perfectly distinct and what is more important, the same species occurs at La Mesa associated with ammonites. The *Calyptrea* seems identical with *aperta* Solander, a common Eocene species in Europe and America, but it occurs both at Monte Grande and in the Upper Breccias or *Baculites* zone in company with ammonites, etc., so that its occurrence at Tortuga has no age significance. On the other hand, there are a few purely Cretaceous genera such as *Legumen* and *Anatimya* as well as several species which range upward to the *Baculites* zone or downward into the La Mesa. Of these we may mention, *Mytilus signatus*, *Pedalion woodsi*, *Cardium mel-lisum*, *Perustrombus* and *Mesalia janja*.

The fauna from the *Baculites* or Upper Breccia zone is most certainly Maestrichtian. It is essentially similar to that of Monte Grande. The *Sauvagesia peruviana* which occurs in the uppermost sandstone is very similar to "*Durania*" *curasavica* (Martin) from Curacao and Cuba. Most of the bivalves and gasteropods are characterized by large and solid shells or the highest stage of their evolution. This is certainly true for such species as *Roudaireia peruviana*, *Trigonarca meridionalis*, *Pseudocucullæa gregoryi*, *Trigonia hopkinsi* and the striking *Perustrombus wheeleri* and *Torgnellus peruvianus*. The ammonites are poorly represented in these upper beds but include two very important forms, the *Baculites lyelli* d'Orbigny and a *Parapachydiscus* allied to the *Parapachydiscus dossantosi* Maury from eastern Brazil.

In resumé, it seems probable that the *Austrosphenodiscus-Paciceras* beds at La Mesa are of Campanian age. The Tortuga breccias, including the *Baculites* and *Radiolites* sandstones, are Maestrichtian.

RELATED MARINE EQUIVALENTS OF THE  
PERUVIAN UPPER SENONIAN IN SOUTH AMERICA  
AND WEST INDIAN REGION

CHILE

Fossiliferous late Cretaceous rocks have been known for many years to occur on the Island of Quiriquina in the Bay of Concepción on the coast of Chile. The first fossils were described from here by D'Orbigny (10) in 1842 and although including a *Trigonia* (the widespread *Trigonia hanetiana*) were nevertheless considered as Tertiary. The age of the Quiriquina section was definitely established a few years later by Darwin (3) on the discovery of specimens of a baculite. Somewhat earlier Lieutenant Belcher (11) had found an ammonite near Tomé, so large that only a fragment could be removed. Darwin's fossils were described by Forbes (12) who correlated the fauna directly with the Pondicherry of India. A large number of Cretaceous fossils, many from Quiriquina and Tomé, were described by Philippi (13) but most of these so-called species are indeterminable, being based on casts and unrecognizable fragments. In 1895 Steinmann gave the name Quiriquina formation or Quiriquina-Schichten to the Cretaceous beds in this region and worked out the detailed geology and succession for the first time. The results of Steinmann's (14) work and fossil collecting is recorded in a series of papers in which Möricke and Deecke are co-authors. The Cretaceous at Quiriquina lies with a relatively flat dip upon a complexly folded, crystalline basement and is overlain by coarse Tertiary sandstones and conglomerates, a stratigraphic set-up similar to that seen at Paita and at Monte Grande. The most recent study of the Quiriquina fauna is by Wetzel (15) but which adds little of note to the earlier work of Steinmann and Wilckens (16). The fauna is relatively varied, especially in ammonites and besides other mollusks contains remains of plesiosaurian reptiles and one species of bird. Of mollusks alone, about 85 species are known.

Most students of the Quiriquina fauna, as well as Kossmat(17) and Uhlig, have called particular attention to the marked affinities of the Chilean ammonites to those from the Ariyalur and Pondicherry of India as well as with the Nanaimo beds on the Island of Vancouver and other localities in Puget Sound. The affinity of the Chilean Quiriquina fauna with the New Zealand Cretaceous(18) is even more marked and includes not only similar species of ammonites but extends to the other mollusks as well, the most striking forms being the *Trigonia hanetiana*, *Lahillia*, *Thyasira* and some allied types of gasteropods. To the southward, the Quiriquina fauna, through its ammonites, ties in with the beautiful assemblages described by Kilian and Reboul(19) from Seymour Island and Snow Hill in the Antarctic.

With northern Peru, the affinities of the Chilean Cretaceous is not nearly so close as we would have expected from the foregoing account of the widely distributed character of the Indo-Pacific ammonite fauna. This condition has been explained as due to a land barrier separating the two areas of deposition, but it is worthy of note that a similar distinction in faunal makeup between the Chilean and Peruvian provinces was true for the whole Tertiary. The north Peruvian Cretaceous is decidedly more tropical in character, as indicated, for instance, by the occurrence of rudistids, lacking in Chile and in New Zealand. The absence of *Trigonia hanetiana*, *Lahillia* and other characteristic Patagonian and Chilean types from north Peru is probably also due to climatic or zonal control. Only *Baculites lyelli* and more questionably the *Aphrodina* cf. *auca* are common to the two regions. If the ammonites were more abundantly represented in the Peruvian deposits, much closer ties would probably be shown.

The Quiriquina beds have been referred to the Upper Senonian or Maestrichtian. Stephenson(20) has noted the similarity of *Parapachydiscus quiriquinae* Philippi to *arkansasus* of the Nacatoch sand member of the Navarro as well as the presence in the fauna of *Discoscaphites constrictus* (Sowerby) which confirms their correlation with the European Maestrichtian.

## COLOMBIA AND VENEZUELA

No Upper Senonian rocks are yet known in Ecuador. In Colombia, some excellent Maestrichtian or at least Upper Senonian faunal assemblages have recently been collected from various localities but the fossils have not been described. The Colombian Maestrichtian shows close affinities with the Peruvian, the most remarkable of these are from localities in the upper Magdalena Valley. These beds have a rich fauna in which large, thick-shelled species of *Spondylus*, *Roudaireia*, *Pinna*, *Cardium*, *Pseudocucullæa*, etc., closely allied to Monte Grande forms, are the dominating elements. The relation of the fauna from these beds to the *Roudaireia-Pseudocucullæa-Sphenodiscus* Parahyba horizons of eastern Brazil seems equally as close; one of the most interesting ties being a large crab allied to *Xanthopsis brasiliانا* Maury.

The lower Umir and the Rio de Oro formations have yielded small faunules containing *Coahuilites*, *Inoceramus*, *Pseudocucullæa*, *Cardium brüggeni*, *Breviarca*, etc. As a rule, the fossils are not well preserved but would seem to indicate a possible correlation with the *Austrosphenodiscus-Paciceras* horizon of the Paita Cretaceous and may therefore be as low as the Upper Campanian. That these fossiliferous beds do not represent the topmost part of the Colombian Cretaceous, as is so often expressed, is quite evident.

The Mita Juan of western Venezuela is the correlative of the Umir. Its lowermost beds have yielded a meager molluscan fauna containing *Roudaireia* and sphenodiscid ammonites but the fossils are poorly preserved and critical comparison cannot be made at this time. They would seem, however, to belong to about the same level as the ammonite horizon of the Rio de Oro and the lower Umir. *Roudaireia* and fragments of very large *Pseudocucullæa* have been found at a few places in east central Venezuela. At many of these occurrences, the Cretaceous fossils are from boulders in Eocene conglomerates which serve to show that a definite erosional interval occurred before the deposition of the Eocene sediments.

A few Maestrichtian fossils, including *Roudaireia* have been recorded by Waring and Harris(21) from Trinidad. To this record, Rutsch(22) has more recently added *Hamulus* and *Sphenodiscus*. These fossils are derived from blocks or boulders from Eocene clastics or from the Mount Moriah boulder beds of upper Eocene age.

#### BRAZIL

A small but very interesting Upper Cretaceous fauna has been described by Maury(32) from the State of Parahyba do Norte in eastern Brazil. These fossils come mostly from a limestone quarry on the Rio Gramame, near the city of Parahyba. Two faunal zones are present but which are probably merely facies variants and do not differ importantly in age. The first zone is characterized by a rich ammonite fauna in which are numerous species of *Parapachydiscus*, *Pseudophyllites* and *Sphenodiscus*. Some of the *Parapachydiscus*, notably *dossantosi* seem very similar to the single fragmentary *Parapachydiscus* known from Paita. The second zone has a pelecypod fauna in which are large, thick-shelled species of *Roudaireia*, *Trigonarca*, *Pinna*, *Pseudocucullæa* (*Eusebia*), *Venericardia*, *Pholadomya*, etc. Many of these species, because of their solid, heavy shells adapted to a coastal environment, show relationship with the Monte Grande facies of northern Peru.

#### BONAIRE AND CURAÇAO

Upper Cretaceous rocks occur on the Dutch Island of Curaçao as well as Bonaire off the coast of Venezuela, but aside from a few rudists from Curaçao, the fauna has not been recorded. The Cretaceous formations of the islands are said to be dominantly volcanic in origin with diabases, porphyrites and tuffs in which are intercalated beds of chert and limestone. Two rudistids are described by MacGillavry(24) from the Seroe Teintje limestone on Curaçao, the most interesting of which is *Durania curasavica* (Martin), a sauvagesinid radiolite. This species belongs to the same, low, spreading type as our *Sauvagesia peruviana*, from the uppermost Cretaceous sandstone at Paita, and doubtless the two forms should be referred to the same genus.

The Curaçao species has also been identified by MacGillavry (26) from the Loma Yucatan limestone, north of Camaguey City in the east central part of Cuba. MacGillavry favored an Upper Campanian age for the Loma Yucatan limestone and a Maestrichtian age for the Havana formation, *s. str.*, or *Barrettia* beds. Some corals (Pijpers, 1933) and *Actæonella* have also been reported from the Dutch Islands which suggest a faunal assemblage similar to that known from beds immediately beneath the Eocene limestones of San Juan de los Morros in Venezuela.

#### JAMAICA

In Jamaica, an interesting Upper Senonian section has become known mostly from the field and paleontological studies of Trechmann (26). The rudistids and caprinids predominate in the fauna, many of the species are closely related to forms from Cuba, and some reach gigantic size. According to Trechmann all the Cretaceous or Rudistid limestones in Jamaica belong to one and the same high and vertically restricted horizon. This limestone overlies shales containing a fauna having a Campanian aspect. Shales are also found overlying the Rudistid limestones at a few places but have yielded only a small fauna. The rudistids contain amongst the Hippurites, such genera as *Orbigynya*, *Barrettia* and *Præbarrettia* while the Radiolites have reached the stage of their evolution in which the ligamental flexure has become lost. This stage, according to Douville, was reached amongst European species of the Radiolitidæ in the Dordonian (Maestrichtian) and during the Turonian for most species of the Biradiolitidæ.

The Cretaceous shales which underlie the Rudistid limestone have yielded a fauna comprising about 55 named forms, including five ammonites. This fauna like that of the Jamaican Eocene is decidedly European, north African and even Indian in affinities, a feature repeatedly emphasized by Trechmann. This characteristic is equally true for the Peruvian Eocene and Cretaceous as well. The Providence shales fauna shows some resemblance to the Peruvian Cretaceous. Thus *Roudaircia jamaicensis* is so nearly related to *Roudaircia peruviana* that from figures alone it is difficult to decide whether they should be separated. This group of high, sharply keeled forms, differing mainly from the more

typical African *Roudaireia auressensis* by its smoother sculpture, is a widespread type, being found, outside of Jamaica, in Colombia, as well as in Peru. *Roudaireia peruviana* commences in the basal Upper Senonian at La Mesa where it is comparatively small. It is not known from the middle zone at Tortuga, perhaps because of unfavorable environment but reappears in abundance and in large size in the Upper Breccia zone.

There has been some interesting discussions as to the age of the Jamaican Cretaceous sequence. Trechmann from his study of the mollusks considered the Rudistid limestones with *Barrettia* as Maestrichtian and the underlying Providence shales as Campanian with the possibility of the lowest beds as Middle Senonian. On the other hand, Hawkins(27) who studied the echinoids collected by Trechmann in the Rudistid limestone considered their age as low as the Cenomanian or Turonian. Douville(28) notes, however, that according to Lambert, some analogous forms of echinoids have been recorded from the Campanian of Persia. Trechmann's opinion as to the late Cretaceous age of the Jamaican beds received much support from Spath's(29) studies of the ammonites, comprising five species, collected from the lower part of the Providence shales, a considerable distance below the Rudistid limestone. This ammonite assemblage which contained amongst others, a *Parapachydiscus* allied to the European *gollevillensis*, Spath considered as Upper Senonian, not older than the Campanian and probably still younger. Most later writers who have had occasion to consider the Jamaican Cretaceous have followed Trechmann in his age assignment.

#### OTHER AREAS

Porto Rico, Haiti and Cuba, each have important developments of Upper Cretaceous beds but only in Cuba do these formations contain good fossils. The Cuban Cretaceous fauna is, however, mainly rudistid which has been described in part by Palmer, Douville, MacGillavry, Rutten and Vermunt. The Havana formation contains *Barrettia* amongst other rudistids and is therefore equivalent to the Rudistid limestone of Jamaica. Palmer and others consider its age as Maestrichtian. This formation in many places lies directly upon basement. As noted by Trech-

mann, beds corresponding to the Providence shales seem to be missing in Cuba. With the rich Navarro and Ripley faunas so beautifully monographed by Stephenson and Wade, there seems to be very little in common with Peru. The same is also true for the Mexican Cretaceous.

### RESUMÉ

From this brief review of the distribution of the known Upper Senonian fauna in South America and the West Indian region, a few generalities seem possible at this time.

1. In the most complete sections, two series of beds are present: (a) a lower series, usually more shaly and containing a fauna which is probably Campanian; (b) an upper series, more widely distributed, is usually formed of more shallow-water deposits, often reeflike or nonmarine in large measure or coarsely clastic. These beds are Maestrichtian.

2. The Upper Senonian transgression therefore commenced in the Campanian and reached its maximum expansion in the Maestrichtian but it was accompanied by uplift in the borderlands as is shown by the increasing coarseness of sedimentation in many areas. In other regions it was accompanied by volcanism.

3. The Peruvian Upper Senonian fauna is distinctly tropical in character and closely related to the North African. It seems also to be remarkably distinct from the Chilian and Patagonian faunas, the reasons for which are not yet clearly understood.

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## SYSTEMATIC DESCRIPTIONS

Phylum **MOLLUSCA**  
 Class **PELECYPODA**  
 Order **PRIONODESMACEA**  
 Superfamily **ARCACEA**  
 Family **ARCIDÆ**  
 Subfamily **NÆTINÆ**

Genus **PSEUDOCUCULLÆA** Solger

**Pseudocucullæa gregoryi** Olsson

Plate 2, figs. 1, 2

*Pseudocucullæa gregoryi* Olsson, 1934, The Cretaceous of the Amotape Region, Bull. Amer. Paleont., vol. 20, p. 22, pl. 3, fig. 1.

This remarkable species, first found at Monte Grande, is quite common in the Upper Breccia zone. It grew to a large size, the figured specimen measuring: length, 140 mm.; height, 134 mm., semidiameter, 47 mm. The hinge is known from several specimens but its finer details are generally obscured by a covering of matrix or damaged by breaks. The cardinal area is quite high, in the figured specimen it has a height of about 15 mm. just below the beak. It has a series of about eight, deep, ligamental grooves which are parallel to each side of the dorsal margin. The hinge plate is wide, solid, the central portion with a group of fine, narrow, lamellar teeth arranged transverse to the hinge margin and finely wrinkled or crenulated on their sides. The lateral teeth, two in number in each set, are large and solid, the sides of the bordering sockets crenulated. Muscle scars were evidently deep but are not well exposed on any of our specimens. The external surface is smooth and there are no indications of radial sculpture.

*Figured specimen.*—Paleontological Research Institution, No. 4820.

*Occurrence.*—*Baculites* zone.

**Pseudocucullæa paitana**, n. sp.

Plate 2, figs. 3-5

Shell of medium size, obliquely subovate in form, highest in the posterior-ventral portion; the small beaks are placed at the

anterior fourth and are separated from each other by the fairly wide, multivincular grooved, ligamental area; the anterior side is flatly rounded to subtruncate, the posterior side is obliquely rounded; the valves are moderately convex, when not crushed or distorted, with a fairly pronounced umbonal ridge extending from the beak to the junction of the ventral and posterior margins; surface nearly smooth or roughened only by coarse lines of growth; hinge as typical for the genus; cardinal area as may be seen from the figure, is quite long, its height about one-seventh of its length and carrying a series of eight or more parallel, ligamental grooves; lateral hinge teeth strong.

Length, 73 mm.; height, 71 mm.; diameter, 42 mm.

Length, 86.5 mm.; height, 79 mm.; diameter, 40 mm. (crushed)

Length, 76 mm.; height, 70 mm.; semidiameter, 25 mm.

This species is doubtless the fossil referred to by Gerth<sup>1</sup> as *Cucullæa*, *spec. nov.* It is quite common in the ammonite beds at La Mesa. From *Pseudocucullæa gregoryi* Olsson from Monte Grande and the Upper Breccia zone, this species differs by its smaller size and more oblique shell. Although abundantly represented in our collection, none of our specimens have the hinge fully exposed.

*Types*.—Paleontological Research Institution, Nos. 4821, 4822, 4823.

*Occurrence*.—*Sphenodiscus* beds of La Mesa.

Genus **PERUARCA**, new genus

Genotype.—*Peruarea pectunculoides*, n. sp.

The following is a description of the genus *Peruarca*:

Shell subcircular to squarish; beaks nearly central; the hinge plate is of moderate width and curves down strongly at both ends; hinge teeth forming a continuous series but divided almost equal-

<sup>1</sup>Gerth, H.: *op. cit.*, "Eine ganz neuartige Form für die wohl am besten eine neue Gattung geschaffen wird, da sie eine Art Mittelstellung zwischen *Cucullæa* und *Pectunculus* einnimmt. Die grosse Muschel besitzt den geraden, taxodonten Schlossrand mit ziemlich hoher Bandarea und etwas nach vorne verschobenem und gekrümmtem Wirbel der ersten Gattung. Aber der Schlossrand ist erheblich kürzer als die grösste Breite, die ungefähr in der Mitte der um 1/8 höher als breiten, stark gewölbten Klappe liegt., p. 239.

ly into an anterior and a posterior set; in the middle, the teeth are small and transverse to the hinge line, they number about four on the posterior side and four or five on the anterior side; the lateral teeth are much larger, elongated and placed at first oblique to the hinge line but later become nearly parallel to it; the entire anterior set has about 14 teeth and the posterior set about 15; the cardinal area is of medium width, depressed, bordered by raised edges on the sides; a small triangular-shaped area just above the middle of the hinge and below the beak is faintly indicated by two diverging grooves which may correspond to a single pair of ligamental furrows; external sculpture of close, concentric lines and fine radials which show most strongly on the umbos; margins entire.

*Remarks.*—This genus is proposed for a single left valve from the *Baculites* zone. The symmetrical hinge resembles that of *Glycymeris* but it differs from that genus by its plain cardinal area and externally by its form. From the members of the *Trigonarca* group, the main differences are the nearly complete absence of ligamental grooves and radial sculpture.

***Peruarca pectunculoides*, n. sp.**

Plate 3, fig. 6, 7

Shell of medium size, moderately convex with a nearly square form, the height and length being about equal; anterior side is widely rounded, the posterior side nearly straight; a well-marked umbonal angle extends from the beak to the posterior-ventral corner; anterior, of the umbonal angle, the valve is smoothly convex while the posterior-umbonal slope appears flattened; the surface sculpture is rather weak for the most part (partly the effects of weathering) except on the umbo and near the dorsal margin where it consists of fine, regular concentric ridges finely decussated by small, radial ribs; hinge as described above; interior filled with matrix but the exposed margin of the valve is smooth.

Length, 50 mm.; height, 49.5 mm.; semidiameter, 19 mm.

*Type.*—Paleontological Research Institution, No. 4817.

*Occurrence.*—*Baculites* zone.

Genus **INCANOPSIS**, new genusGenotype.—*Incanopsis acarifformis*, n. sp.The following is a description of the genus *Incanopsis*:

Shell small, convex with a sharply angled, umbonal ridge behind which the surface is strongly flattened or impressed; sculpture of fine ribs resembling that of *Barbatia*; beaks opisthogyrate, placed about one-third of the distance of the shell length from the anterior margins; cardinal area wide, the longer part lying on the posterior side of the beak; the ligamental portion of the cardinal area is triangular in form, nearly equally divided between the anterior and posterior sides and marked off from the smooth parts of the cardinal area by deep lines; posterior portion of the cardinal area smooth; the ligamental grooves vertical; hinge plate long, narrow, with a continuous series of small taxodont teeth, coarser at the ends; ventral margin smooth; muscle scars plain.

*Remarks.*—The vertically grooved ligamental area and small opisthogyrate beaks indicate a relationship of this small Cretaceous ark with the *Nœtinæ*. In the figured specimen, the ligamental area forms a small triangle with a broad base and with the posterior side only a little longer than the anterior. It is sharply delimited from the remaining parts of the cardinal area (which is smooth) by deeply incised lines. The ligamental grooves are variable in coarseness and in the figured specimen number about 24. There are indications of very fine, vertical lines on the ligamental area which may correspond to the secondary lines described by MacNeil<sup>2</sup> for some genera of the Tertiary *Nœtinæ*. In the differentiation of the cardinal area into two parts, that of the ligament with its vertical grooving and the smooth posterior part, is comparable to that shown by the Eocene genus *Scapularca* but in other characters there is little resemblance between them. Through its *Barbatia*-like sculpture, as well as sharing a vertically striated ligament, *Incanopsis* shows great similarity to *Striarca* Conrad (genotype *Arca centenaria* Say of the

<sup>2</sup> MacNeil, F. S.: *Species and genera of Tertiary Nœtinæ*, U. S. Geol. Survey, Prof. Paper No. 189-A, 1938, p. 7.

Chesapeake Miocene). *Striarca* has recently been discussed by Schenck and Reinhart<sup>3</sup> and assigned by them to the Arcinæ and not to the Nœtinæ as the transversely striated ligament and flanged muscle scars would seem to suggest. To this genus also, these authors have referred the *Arca* (*Barbatia*) *aquilateralis* Thiele (renamed *Striarca thielei* Schenck and Reinhart), a Recent species of the Dutch East Indies, although in that species, the ligamental area is reduced to a small triangular patch immediately below the beaks.

***Incanopsis acariformis***, n. sp.

Plate 4, figs. 1, 2; Plate 5, fig. 8

Shell small, strongly convex, quadrate in form with a sharply angled umbonal ridge; sculpture subreticulate with numerous small ribs, finely nodulated by the concentric lines; these ribs may be more or less regular in size over the whole surface or much finer on the umbonal angle and on the posterior-dorsal submargins; the valves sometime show a medial sulcation which is most strongly developed across the umbos; hinge and cardinal area as described above; ventral margin crudely crenulated.

Length, 17.75 mm.; height, 10.5 mm.; semidiameter, 6.25 mm.

Length, 23 mm.; height, 15 mm.; diameter, 14.5 mm.

*Types*.—Paleontological Research Institution, Nos. 4832, 4833.

*Occurrence*.—Lower zone at Tortuga; middle zone at Tortuga.

Genus **BREVIARCA** Conrad

***Breviarca peruviana***, n. sp.

Plate 3, figs. 2, 8, 9

Shell small, rather solid, moderately convex, trigonal; beaks central; surface smooth but on magnification shows a sculpture of fine, threadlike, radial riblets which on the anterior-dorsal angle are finely decussated by the concentric lines; cardinal area amphidetic with symmetrical sides with respect to the beak and striated with fine, vertical lines; hinge plate narrow in the central part, wider and arched on the ends; hinge teeth numerous, probably continuous, very small in the middle zone, much larger on

<sup>3</sup> Schenck, H. G. and Reinhart, P. W.: *The pelecypod genus Striarca from the Indo-Pacific Province*, Archiv für Naturgeschichte, Bd. 7, Hft. 2, 1938.

the sides; anterior set has about eight teeth and the posterior set about 15; ventral margin smooth.

Length, 18.75 mm.; height, 15 mm.; diameter, 10.5 mm.

Length, 18.5 mm.; height, 14 mm.; diameter, 9.25 mm.

Length, 23 mm.; height, 18.75 mm.; semidiameter, 7 mm.

There are six specimens in the type collection. The species will be recognized by its trigonal form, central beaks and with the subumbonal area slightly more flattened than the anterior side. In our specimens, the hinge and cardinal areas are poorly preserved but their chief characters are visible. The cardinal area is amphidetic, almost equally divided between the anterior and posterior sides. The ligamental portion is transversely grooved with fine lines which cover nearly the entire surface of the area except for narrow borders on the sides. The extent to which the ligament is developed to cover a small or a major part of the cardinal area is a variable feature amongst various species of *Breviarca* and consequently has small taxonomic value. In form, our shell resembles the more circular species of *Breviarca* such as *B. perovalis* Conrad and *B. subovalis* Stephenson<sup>†</sup>, but differs from them by its more trigonal, sharper beaks and longer, posterior end.

*Types*.—Paleontological Research Institution, No. 4814 (holotype;) paratypes, No. 4815-4816.

*Occurrence*.—La Mesa.

Superfamily MYTILACEA

Family MYTILIDÆ

Genus MYTILUS Linné

*Mytilus signatus* Olsson

*Mytilus signatus* Olsson, 1934, The Cretaceous of the Amotape Region, Bull. Amer. Paleont., vol. 20, p. 35, pl. 7, fig. 4.

This species is fairly common in the lower and middle fossil beds at Tortuga. It is characterized by its strongly flattened anterior side which is sharply separated from the rest of the surface by an angled ridge. The entire surface is sculptured with

<sup>†</sup> Stephenson, L. W.: *The Cretaceous formations of North Carolina*, North Carolina. Geol. and Econ. Survey, vol. 5, pt. 1, 1923, pp. 110, 111, pl. 20, figs. 1-8.

fine, close-set, simple riblets except on the anterior area which is smooth. *Septifer acutus* Trechmann<sup>5</sup> from Jamaica is very similar to our shell but is larger.

*Specimen*.—Paleontological Research Institute, No. 4872.

*Occurrence*.—Tortuga.

Genus **VOLSELLA** Scopoli

***Volsella cerva***, n. sp.

Plate 17, fig. 8

Shell small, elongated, highest at the posterior end; beaks are near the anterior end and from which there extends a strong, umbonal ridge obliquely across the surface to the posterior-ventral corner; the sculpture is formed by radial riblets divided into two sets by a line along the top of the umbonal angle; on the dorsal or posterior side of the umbonal ridge, there are 11 strong, primary ribs which near the margin and on the ventral half become smaller and increase in number through intercalation; on the anterior side of the umbonal angle, the ribs are more numerous and become progressively smaller towards the end; interior not known.

Length, 25.5 mm.; height, 16 mm.; semidiameter, 7 mm.

*Type*.—Paleontological Research Institution, No. 4863.

*Occurrence*.—Tortuga.

Superfamily **PTERIACEA**

Family **VULSELLIDÆ**

Genus **PEDALION** (Solander) Huddesford

***Pedalion woodsii*** Olsson

*Melina woodsii* Olsson, 1934, The Cretaceous of the Amotape Region, Bull. Amer. Paleont., vol. 20, p. 26, pl. 4, fig. 1.

Two specimens of this species were collected in the lower fossil bed at Tortuga. One has the following dimensions: length, 69 mm.; height, 90 mm. The species was originally described from Monte Grande.

*Specimen*.—Paleontological Research Institution, No. 4871.

<sup>5</sup> Trechmann, C. T.: *The Cretaceous shales of Jamaica*, Geol. Mag., vol. 64, No. 752, 1927, pp. 50-51, pl. 3, fig. 9.

*Occurrence*.—Tortuga.

Genus **GERVILLIA** Defrance

**Gervillia incertans**, n. sp.

Plate 6, fig. 4

Shell elongate, convex; the beaks are placed near the anterior end; dorsal margin straight, forming the edge of the posterior wing; the posterior wing is rather long and quite wide and is differentiated by its more depressed, flattened surface; the shell itself is rather convex, the maximum inflation about the middle zone; surface smooth; interior not exposed to view.

Length, 40 mm.; height, 17 mm.; semidiameter, 8 mm. (approximate)

It has been impossible to expose the hinge structure and consequently the generic reference of this species to *Gervillia* is not certain. Its narrow form is somewhat similar to certain elongated Gervillias such as *Gervillia aviculoides* Defrance and *Gervillia soleniformis* Defrance but is shorter and has a wider and longer wing. The contour of its anterior extremity is more suggestive of certain species of *Volsella*. *Gervillia aviculoides* has been figured by D'Orbigny in his Voyage of the Astrolabe (plate 7, fig. 37).

*Type*.—Paleontological Research Institution, No. 4845.

*Occurrence*.—Tortuga, lower zone.

Genus **INOCERAMUS** J. Sowerby

**Inoceramus**, sp. A.

Plate 1, fig. 2

This species is probably allied to the form figured by Stoliczka<sup>6</sup> as *Inoceramus Cripsianus* Mantell from the Arrialoor group, the uppermost part of the true Cretaceous of south India. Stoliczka considered his specimens as agreeing with the form figured by Zittel<sup>7</sup> as variety *typica* from the Gosau beds of central Europe. The Indian and Peruvian shells are characterized by their moderately large, strongly inflated, broadly subrhomboidal form with their greatest length lying in a zone extending through the middle and parallel to the dorsal and ventral margins. The

<sup>6</sup> Stoliczka, F.: *Cretaceous fauna of southern India*, Palaeontographica Indica, vol. 3, 1871, p. 405, pl. 27, figs. 1, 1a.

<sup>7</sup> Zittel, K. A.: *Die Bivalven der Gosaugebilde in den nordöstlichen Alpen*, Denkschr. Akad. Wiss. Wien, vol. 25, 1865-66, p. 98, pl. 14, figs. 1, 2.

umbos are prominent and end in recurved beaks situated close to the anterior side. The sculpture is formed by widely spaced, concentric folds which are best developed on the central and anterior portions but become obsolete elsewhere.

Inocerami of somewhat similar characters to species A and B are common in the Upper Senonian rocks throughout the world. By most older workers, such as Zittel, Whiteaves, Stoliczka and Pervinquière, these forms have been referred, as a group, to *Inoceramus cripsi* Mantell but since typical *cripsi* is a species of restricted Cenomanian range, recent authors have used other names such as *Inoceramus regularis* d'Orb., *balticus* Böhm, etc. The North African and European shells as well as most illustrations of the North American forms differ by their wider, less convex valves, lower umbos and by their more persistent ribs.

Our specimen is an internal cast of a right valve with a fragment of the original shell retained along the dorsal margin. This specimen measures as follows:

Length, 110 mm.; height, 76 mm.; semidiameter, 40 mm.

*Type*.—Paleontological Research Institution, No. 4809.

*Occurrence*.—*Baculites* zone.

***Inoceramus*, sp. B**

Plate 1, fig. 1

This form is represented by an incomplete specimen of the left valve lacking the dorsal margin so that the beak and hinge characters are unknown. It is moderately convex but less inflated than species A. The form is broadly subovate. The sculpture consists of strong, persistent ribs of which about 15 are preserved. The ribs and their wide interspaces are crossed by a set of sub-obsolete, radial lines which simulate small ribs. These radials are strongest in the middle zone, elsewhere they may be faint or absent.

Amongst illustrated Inocerami, our specimen can be compared with Pervinquière's<sup>8</sup> figure of a North African shell determined as *Inoceramus regularis* d'Orbigny, but it is noticeably higher. There is, however, no close resemblance to D'Orbigny's *regularis*

<sup>8</sup> Pervinquière, L., *Études de paléontologie tunisienne: Pt. 2, Gastropodes et lamellibranches des terrains Crétacés*, 1912, p. 117, pl. 8, figs. 5-9.

figured in the *Paléontologie Française, Terrains Crétacés*. Another form allied to the Peruvian is possibly the Egyptian shell called *Inoceramus cripsi* Mantell var. *radians* by Quass<sup>9</sup> which shows strong radial markings in the interspaces of the ribs over the entire shell.

Our specimen measures:

Length, 110 mm.; height, 90 mm.; semidiameter, 39 mm.

*Type*.—Paleontological Research Institution, No. 4810.

*Occurrence*.—*Baculites* zone.

Superfamily ANOMIACEA

Family ANOMIIDÆ

Genus ANOMIA (Linné) Müller

*Anomia*, sp.

There are several small *Anomias* in the lower fossil beds at Tortuga but our specimens are too imperfect for identification or illustration. They belong to three species. Some have a smooth surface and the free valve is nearly circular in form with the small beak removed slightly from the edge of the dorsal margin. Another form has a larger shell with widely spaced concentric lines while a third species has a sculpture of small raised pustules.

*Occurrence*.—Tortuga, lower fossil bed.

Superfamily OSTREACEA

Family OSTREIDÆ

*Ostrea palpa*, n. sp.

Plate 1, figs. 5, 6; Plate 4, figs. 8, 10

Shell small, irregular in form and sculpture but the left or attached valve is generally larger, more convex and more strongly ribbed than the right; the left valve is irregularly rounded to elongate in form with the sides generally impressed and the beaks turned to the left if not obliterated by the large attachment scar; the ribs of the left valve are typically large and strongly developed in the middle zone, absent from the sides and generally become obsolete on the older shells; right valve is smaller, more rounded,

<sup>9</sup> Quass, A.: *Die Fauna der Oberwegischichten und der Blätterthone in der libyschen Wüste*, in *Beitrag zur Kenntniss der Fauna der obersten Kreidebildungen in der libyschen Wüste*, *Paleontographica*, Band 30, Abteil 2, 1902, p. 170, pl. 20, figs. 9, 10.

flatter and unribbed but with more pronounced concentric markings; the posterior side of each valve is generally expanded or winged; interior of the left valve with a grooved, crenulated margin and a narrow, curved, ligamental furrow which ends in the tip of the beak; the interior of the right valve is less deep and the ligament furrow is wider and the margins of the valves have short ribs which form the crenulated pits in the grooved margins of the left valve.

Length, 19.5 mm.; height, 29 mm.; semidiameter, 14 mm. (left valve).

Length, 14 mm.; height, 25 mm.; diameter, 13 mm.

Length, 16 mm.; height, 20 mm.; diameter, 13 mm. (holotype).

This species is common in the lower zone at Tortuga. It is associated with larger, thinner shells which are probably *Anomias* but their interiors have not been seen. The crenulated margins of this small oyster recalls some early Eocene species.

*Types*.—Paleontological Research Institution, holotype, No. 4805; paratypes, Nos. 4806-8.

*Occurrence*.—Tortuga.

#### Subgenus **LOPHA** Bolten

***Ostrea (Lopha) sechura***, n. sp.

Plate 1, figs. 7, 8

Shell of medium size, solid, broadly sickle-shaped as figured; surface sculpture of the left valve is formed by 11 or 12 strong ribs which on the lower or ventral portion are enlarged and angular in form; posterior umbonal side deeply inflexed, its surface sculptured with fine, narrow riblets and its valve margin coarsely crenulated; interior of left valve is relatively shallow, its anterior and ventral margins coarsely fluted by the ends of the ribs; muscle scar of medium size and outlined by thickened margins.

Height, 88 mm.; width, 68 mm.; semidiameter, 29 mm.

Only the left valve is known but the species will be easily recognized by its sculpture and broad, sickle form.

*Ostrea (Lopha) stappenbecki* Olsson occurs at Tortuga but

only fragments are available in our present collections.

*Type*.—Paleontological Research Institution, No. 4804.

*Occurrence*.—*Baculites* zone.

Superfamily **TRIGONIACEA**

Family **TRIGONIIDÆ**

Genus **TRIGONIA** Bruguière

Subgenus **SCABROTRIGONIA** Deecke

**Trigonia (Scabrotrigonia) gerthi**, n. sp. Plate 3, figs. 4, 5, 10

*Trigonia crenulata Peruana* Gerth (not Paulcke), 1928, *Neue Faunen der Oberen Kreide mit Hippuriten aus Nordperu*, Leidsche geol. Mededeel, Deel 2, p. 234.

The shell is thick, moderately convex with a hatchet-shaped form and well-rounded, ventral margins; the umbones are small with incurved, opisthodontic beaks placed near the anterior end; the sculpture consists of a set of strong, coarsely scabrous ribs numbering about 23 which cross the surface of the valve from the ventral margin to the edge of a smooth zone extending from the beak to the posterior-dorsal margin; on the anterior side, the lunule is poorly defined by a shallow groove and by the more irregular form of the ribs; the escutcheon is outlined by its more depressed surface and by a sculpture of small, scabrous riblets trending transverse to the dorsal margin; between the escutcheon and the main sculptured disk, is an unribbed band extending from the beak to the posterior-dorsal margin; this band is divided by a groove into two equal parts; in the region of the umbo, this band is cordlike and sculptured by the end of the ribs extending from the shell disk and from the sides of the escutcheon, more posteriorly, the band widens and becomes smooth except for the coarse lines of growth.

Length, 52.5 mm.; height, 43 mm.; semidiameter, 13.75 mm.

Length, 56 mm.; height, 46 mm.; semidiameter, 17 mm. (type)

Length, 63 mm.; height, 57 mm.; semidiameter, 26 mm.

This species resembles *Trigonia scabra* Lamarck by its sharply scabrous, narrow ribs but differs greatly from that species by its

form and in the sculpture of its posterior-dorsal area in which respect it approaches the *Trigonia crenulata* Lamarck. In *Trigonia crenulata* and its allied subspecies *tocaimaana* Lea (*subcrenulata* d'Orb.), the ribs are corded or crenulated and in the South American forms fewer in number. Perhaps more closely allied to our shell, is the *Trigonia bartrami* Stephenson<sup>10</sup> from the *Exogyra ponderosa* zone in North Carolina but it seems to differ by its more widely spaced ribs. There are specimens of a small *Trigonia* at La Mesa but they are too poorly preserved to be identified.

*Types*.—Paleontological Research Institution, holotype, No. 4812; paratype No. 4813.

*Occurrence*.—*Baculites* zone.

*Trigonia hopkinsi*, n. sp.

Plate 3, fig. 1

Shell large, thick, subrhomboidal to hatchet-shaped; umbos high, projecting above the hinge line and sculptured with strong ribs; beaks small, nearly touching each other and situated a little in front of the middle axis of the valves; anterior side of the valves is widely rounded, the curve passing evenly into the ventral margin; posterior side is straight, appearing as if truncated, slightly oblique; convexity of valves moderate; the sculpture is mainly restricted to the umbos which have a series of strong, riblike folds which fade out on the middle zone of the valves and on the posterior area; the ribs on the posterior side are smaller, shorter, and curve sharply towards the margins; the main surface of the valves is smooth or roughened only by the lines of growth; a strong umbonal angle extends from the beak to the corner between the ventral and posterior margins; interior not known.

Length, 98 mm.; height, 92 mm.; semidiameter, 24 mm.

Length, 80 mm.; height, 71 mm.; diameter, 43 mm.

This unusual *Trigonia* is distinguished by its large, quadrate form and in having only the umbos and the adjacent portions of the posterior-dorsal submargins strongly sculptured, the remain-

<sup>10</sup> Stephenson, L. W.: *Cretaceous formations of North Carolina*, North Carolina Geol. Econ. Sur., vol. 5, pt. 1, 1923, p. 186, pl. 52, figs. 1-3; pl. 53, figs. 1-4.

ing area of the valves being smooth. The *Trigonia Sieversi* Steinmann<sup>11</sup> is somewhat similar to the young of this species but judging by the figure given by Steinmann in his *Geologie von Perú*, its sculpture is finer on the anterior portion and the form is even more quadrate. A very small *Trigonia*, only .7 cm. in length from the lower Senonian of Huallanca, Peru, was described by Brüggén<sup>12</sup> as *Trigonia parva*. This shell has the quadrate form and strong ribbed sculpture of *Trigonia sieversi* and may be the young of that species.

*Type*.—Paleontological Research Institution, No. 4819.

*Occurrence*.—*Baculites* zone.,

Order ANOMALODESMACEA

Superfamily ANATINACEA

Family LATERNULIDÆ

Genus ANATIMYA Conrad

*Anatimya*, sp.

Plate 6, figs. 5, 6

The material of this form from Tortuga is badly crushed but its reference to the genus *Anatimya* seems reasonably certain. The shell is very thin and in most specimens, only small pieces of the original shell remains. The form is elongate, the beaks placed slightly anterior of the middle. The internal cast shows a series of small ribs in the central zone but the sides are smooth.

*Specimens*.—Paleontological Research Institution, Nos. 4850, 4851.

*Occurrence*.—Tortuga middle zone.

Family PERIPLOMIDÆ

Genus PERIPLOMA Schumacher

*Periploma nermeta*, n. sp.

Plate 3, fig. 3

Shell of medium size, inequivalve, thin, subelliptical in form; anterior side is well rounded and twice as long as the posterior which is narrowed and was probably subtruncated at the end (broken in the type); the left valve is flat, depressed or flexed slightly in the central, anterior region; right valve is moderately convex, greatest in the zone extending from the beak to the anterior-ventral margin; surface is smooth, marked only with lines of growth with indications of resting marks which produce a

<sup>11</sup> Steinmann, G.: *Geologie von Perú*, Heidelberg 1929, p. 175, fig. 225.

<sup>12</sup> Brüggén, H.: *Die Gastropoden und Lamellibranchier des unteren Senons von Nord-Peru*, N. J. f. Min. etc., BB., vol. 30, 1910, taf. 25, fig. 7.

roughly banded appearance; granules or pustules are present on the posterior subzone in the left valve (this area is destroyed on the right valve); beaks destroyed on the type specimen but there are remains of a buttresslike structure which may have served as support for the chondrophore.

Length, 66.5 mm.; height, 44 mm.; diameter, 13 mm.

From the form of the valves alone, the fossil would appear to belong to *Periploma* without question. The beaks have been destroyed by weathering but reveal a sandy matrix filling the interior and the remains of a solid structure which was probably the support for the chondrophore. The anterior portions of the valves is largely destroyed but remains indicate a flexed zone such as is characteristic of most species of this genus. Coarse, irregular pustules are sparingly distributed over the whole surface and are strongly developed on the anterior subzone of the left valve.

*Type*.—Paleontological Research Institution, No. 4818.

*Occurrence*.—*Baculites* zone.

#### Order TELEODESMACEA

##### Superfamily CYPRICARDIACEA

##### Family PLEUROPHORIDÆ

##### Genus ROUDAIREIA Munier-Chalmas

#### *Roudaireia peruviana* Olsson

Plate 2, figs. 6, 7

*Roudaireia jamaicensis peruviana* Olsson, 1934, *The Cretaceous of the Amotape Region*, Bull. Amer. Paleont., vol. 20, p. 42, pl. 2, fig. 6.

Gerth recorded *Roudaireia Druï* (= *auressensis*) from the Paita region but in our collecting we have found only the larger and smoother *peruviana* which is common in the Upper Breccia zone. Our largest specimen, a right valve measures length, 91 mm.; height, 86 mm.; and diameter, 46 mm. The anterior side of the umbos are sculptured over a small area with strong ribs which fade out before reaching the umbonal angle. The general surface of the shell is smooth except where the concentric growth lines become coarse and crowded together during resting periods.

Specimens of *Roudaireia* from the *Austrosphenodiscus* beds are too much wind eroded to be specifically identified but their

shape and sharply angled, posterior ridge is more like *peruviana* than the ribbed *aurensensis*. Brüggén's *Roudaireia intermedia*<sup>13</sup> is a small shell of about 30 mm. in length and height and is listed from Otusca near Cajamarca together with Coniacian ammonites. A coarsely sculptured species resembling a small *aurensensis* has been described by Lisson<sup>14</sup> as *Roudaireia brüggéni*. Its age is Lower Senonian.

*Specimens figured*.—Paleontological Research Institution, Nos. 4824, 4825.

*Occurrence*.—*Baculites* zone. *Austrosphenodiscus* beds at La Mesa.

Genus **GLOSSOCARDIA** Stoliczka

Subgenus **TORTUCARDIA** new subgenus

Genotype.—*Glossocardia* (*Tortucardia*) *stephensoni*, n. sp.

The following is a description of the subgenus *Tortucardia*:

Shell elongate, of an irregular form, with an angled umbonal ridge, smooth except for irregularity in the lines of growth; hinge with three cardinal teeth in the left valve, two in the right; a distant posterior lateral tooth but no anterior lateral; ligament external.

*Remarks*.—From *Glossocardia* Stoliczka, genotype *Glossophora obesa* Reeve, a Recent species from Mauritius, this group differs in possessing three cardinal teeth in the left valve. The shape of the shell is very variable, perhaps due to a burrowing habit but most of our specimens have been strongly distorted.

***Glossocardia* (*Tortucardia*) *stephensoni***, n. sp. Plate 17, figs. 5-7

Shell of medium size, irregularly subrectangular in outline, equivalve and strongly inequilateral; beaks situated near the anterior end; a strong, angular umbonal ridge extends obliquely from the posterior side of the beak to the posterior-ventral margin; the beaks are small, prosogyrate, nearly touching each other and situated fairly close to the anterior side, above them the umbos are wide and bordered on the posterior side by an

<sup>13</sup> Brüggén, H.: *Die Gastropoden und Lamellibranchier des unteren Senons von Nord-Perú*, N. Jahrb. Min. etc., BB., vol. 30, 1910, p. 756, pl. 26, fig. 2.

<sup>14</sup> Lisson, C. I.: *Boletín de la Sociedad Geológica del Perú*, tomo 1, 1925, p. 28, lamina 3, figs. 6, 7, 8.

angle; medially, the shell develops a shallow, sometimes scarcely noticeable furrow which widens ventrally; sculpture consists of coarse, concentric growth lines which are strongest on the anterior side, smoother on the umbonal ridge; escutcheon narrowly linear; the hinge has three cardinal teeth in the left valve, two in the right; the posterior lateral is distant and there are no anterior laterals; the cardinal teeth are enlarged or nodulose at the end; a long lamellæ (which may be the nymph) lies above the cardinal teeth along the dorsal margin and above which is the external ligament.

Length, 28 mm.; height, 18 mm.; diameter, 14 mm.

Length, 31 mm.; height, 17.25 mm.; semidiameter, 9 mm.

Length, 30 mm. (broken); height, 20 mm.; semidiameter, 10 mm.

The shell is rather variable in form, perhaps the result of a burrowing habit, but most of my specimens have been distorted during fossilization.

*Types*.—Paleontological Research Institution, Nos. 4864, 4865, 4866.

*Occurrence*.—Tortuga.

Superfamily SPHÆRIACEA

Family CORBICULIDÆ

Genus CORBICULA Megerle von Mühlfeld

*Corbicula meridionalis*, n. sp.

Plate 4, figs. 3, 4

Shell is nearly circular in outline, moderately convex and relatively thin; the anterior, ventral and posterior sides form together a nearly complete circle, with the dorsal side narrower and more straight; umbos are prominent, ending in the small, opisthogyrate beaks, placed at the anterior third; interior cavity of the valves is not known, being filled with matrix in all specimens; the hinge of the right valve has the following characters: the hinge plate is narrow and elongated; beneath the beak, there are three, small, cardinal teeth, the middle one being double, the other two are long and narrow; the posterior lateral tooth is distant, long, narrow, bordered above by a groove for the insertion of the posterior, left lateral; anterior lateral not preserved in the specimen but in a left valve it is placed about half as far

from the beaks as the posterior lateral; surface smooth or marked with growth lines which are coarse and strong in the small area just below the beaks; in some specimens, faint, radial striæ, resembling those of some Diplodontidæ are present; no lunule.

Length, 37 mm.; height, 31.5 mm.; semidiameter, 9.5 mm.

Externally, this species resembles a *Cyclinella*, the shell being nearly circular in form and very thin. Most of the specimens are broken or crushed and molds of the interior show no markings of the pallial line. The hinge is quite similar to *Egetaria pullastra* Mörch but the anterior lateral is more distant.

*Types*.—Paleontological Research Institution, Nos. 4834, 4835.

*Occurrence*.—Tortuga, middle zone.

#### Superfamily RUDISTACEA

##### Family RADIOLITIDÆ

##### Genus SAUVAGESIA Bayle, *sensu lato*

##### *Sauvagesia peruviana*, n. sp.

Plate 8

*Sphaerulites* (*Lapeirousia*) cf. *nicholasi* Olsson, 1934, The Cretaceous of the Amotape Region, Bull. Amer. Paleont., vol. 20, pp. 49, 50, pl. 8, fig. 4. Not of Whitfield, 1897.

Fragments of this large rudistid from Monte Grande were referred provisionally to Whitfield's *Sphaerulites nicholasi* from the Upper Cretaceous of Jamaica, the forked, vascular markings of its separated wall plates being very similar. More perfect specimens from Tortuga, since available, show that the Peruvian form is a distinct species and may belong even to a different genus. All the specimens are fragments of the lower or attached valve. Our largest example, the holotype, consisting of two pieces, has a diameter of about 13½ inches. The smaller specimens are often colonial and may perhaps belong to a species different from the larger form. It appears as if the Peruvian species cannot be assigned to any described genus. Lacking perfect specimens, I am for the present referring the form to the genus *Sauvagesia* in a broad sense.

The lower valve is thick, ponderous and spread broadly upwards from a basal or apical attachment point, and as shown by some smaller colonial specimens, its spreading edges were lobed or star-shaped. The external surface is in most cases destroyed by weathering but in one small specimen it is seen to have

been coarsely striated or ribbed. The texture of the outer layer is very thick and composed of fine lamellæ with the surface of each thin layer marked with fine wrinkles or granules and crossed by large, forked vascular furrows; these vascular markings showing as elevated ridges on the lower side of each lamellar layer. The visceral cavity is a hollow cone, generally wide and shallow at the top but prolonged into a long, crooked tube below. The inner shell layer which forms the lining of the cone or visceral cavity is smooth or marked with fine, parallel lines conforming to the lamellar layers of the outer wall. Its color is brown or darker than that of the outer shell. The walls of the cone are smooth except where broken by fractures and show no internal rib or flexure indicating the position of the ligament and the channels for the siphons.

The most prominent characters of the Peruvian rudistid are its low, spreading form and simple visceral cone. A similar type of growth form is assumed by *Dania curasavica* Martin from the Seroe Teintje limestone of Curaçao and referred by MacGillavry<sup>15</sup> to the genus *Durania* Douville. The Curaçao species appears to attain great size, specimens about 300 mm. are said to be common. The species has also been recorded by the same author<sup>16</sup> from Loma Yucatan, Camaguey Province, Cuba, where it occurs with its characteristic flat form and large size in company with other rudistids. Both Trechmann and Mac Gillavry have noted the very flat cone of the Curaçao species and suggested the possibility that it constituted a new genus. *Durania*, as exemplified by its genotype, the *Hippurites cornuastoris* Des Moulins<sup>17</sup> has a high, stout form with a coarsely ribbed surface and the siphonal channels are marked by two strong, longitudinal

<sup>15</sup> MacGillavry, H. J.: *The rudist fauna of Seroe Teintje limestone (northern Curaçao)*, K. Akad. Wetens. Amsterdam., Pr. vol. 35, 1932, p. 385, pl. 1, figs. 7, 8; pl. 2, figs. 1-6.

<sup>16</sup> MacGillavry, H. J.: *Geology of the Province of Camaguey, Cuba with revisional studies in rudist paleontology*, Geog. en Geol. Meded., Phys-Geol. Reeks, vol. 14, 1937, p. 42

<sup>17</sup> For good figures see Toucas, Ar.; *Études sur la classification et l'évolution des Radiolides*, Soc. Geol. France, Mem. Paleon., n. 36, vol. 17, 1909, p. 94, pl. 3.

furrows. These characters are very different from any shown by *peruviana*. *Radiolites nicholasi* Whitfield is apparently considered a *Bournonia* by MacGillavry but further checking seems necessary. Fragments of a radiolite showing vermiculate markings were collected from the *Actæonella-Pironæa* limestone at La Mesa but are insufficient for identification.

*Types*.—Paleontological Research Institution, Nos. 4800-4803.

*Occurrence*.—Uppermost sandstones at Tortuga.

Superfamily **CARDIACEA**

Family **CARDIIDÆ**

Genus **CARDIUM** Linné

**Cardium** (?) **abnormalis**, n. sp.

Plate 17, fig. 3

The shell is of medium size with a *Fragum*-like form and a thick, solid texture; umbo high, wide, ending above in a small prosogyrate beak; umbonal ridge high, angled, the dorsal-posterior area well defined and divided by a groove in the middle, the outer portion being flattened while the inner or side next the hinge being arched or vaulted; a deep furrow or groove extends from the ventral margin upwards towards the beak but is only faintly indicated on the umbo; surface is smooth except for irregularly distributed growth lines which at intervals are grouped together in resting marks; ventral margin crenulated; hinge unknown.

Length, 32 mm.; height, 36 mm.; semidiameter, 17 mm.

The type of this species is a single left valve with the hinge completely covered with a hard, cemented matrix which cannot be removed. Although its form is so unusual, there are some features of the shell which suggest that the species belongs to the Cardiidæ. The strong, umbonal ridge and the well-differentiated medially divided, posterior-dorsal area are similar to *Fragum*. The surface appears to have been smooth or marked only with irregular growth lines which are occasionally crowded together to form resting marks, a type of surface ornamentation similar to *Pachycardium*. The ventral margin is strongly thick-

ened and internally crenulated. Whether the deep groove is a normal feature or merely a shell fracture cannot be determined from this specimen.

*Type*.—Paleontological Research Institution, No. 4862.

*Occurrence*.—*Baculites* zone.

Subgenus **PERUCARDIA**, new subgenus

*Genotype*.—*Cardium* (*Perucardia*) *brüggeni*, n. sp.

The following is a description of the subgenus *Perucardia*:

Shell large, inflated, subcircular; ribs numerous, their interspaces rectangularly grooved; ribs adorned with short spines and strong nodes or granules, their interspaces being smooth; ligament external, seated on a large, thickened, nymphal plate; hinge strong, the dentition normal; the right valve has two, strong cardinals which are fused and form the posterior side of a deep socket; in the left valve, the cardinal teeth are free, the anterior one very large, the posterior one much smaller, vertical and placed above the socket, its upper end almost touching the beak; lateral teeth strong, each situated at an equal distance from the cardinals.

*Remarks*.—*Perucardia* resembles *Trachycardium* Mörch but differs by the character of the nodes ornamenting its ribs which are simple granules, sometimes greatly enlarged and not the roofed, scalelike spines of the latter genus. From *Granocardium* Gabb, which it resembles by its rounded, inflated form, it differs in having the nodes seated on the summit of the ribs and not in their interspaces. These nodes are present over the entire shell and on the anterior ribs are greatly enlarged and closely crowded. They are generally small on the central ribs, only their bases being generally preserved. Over most of the surface, the nodes on each fifth rib are larger than the adjacent ones. The hinge is normal and amongst Recent species is most similar to that of *Mexicardia* Stewart, as illustrated by its West Coast species, *Cardium procerum* Sby.

**Cardium (Perucardia) brüggeni**, n. sp.

Plate 5, figs. 1, 3, 5, 7

*Cardium*, cf. *Lissoni* Olsson, 1934, The Cretaceous of the Amotape Region, Bull. Amer. Paleont., vol. 20, p. 52, pl. 5, fig. 3 (not of Brüggén, 1910).

Shell large, subcircular, ventricose, moderately thin in the umbonal portion, thicker elsewhere; the umbos are very wide, inflated, with beaks placed nearly centrally, coiled and nearly touching above the hinge line; the outlines of the valves is subcircular, the sides well rounded, the posterior, a little longer than the anterior; there is no defined dorsal area; the ribs are numerous, an exact count not being possible from the available material but probably number about 60; due to weathering and decortication of the surface, the ornamentation of the ribs is generally preserved only on a portion of the shell, the ribs being plain on most specimens; the ribs were originally adorned with large and small nodes or spines; these nodes on the anterior ribs form large knobs but on the central ribs are small, toothlike spines; there is a general tendency for these nodes or spines to be larger on each fourth or fifth rib, especially on the margins; hinge as described above; margins fluted in harmony with the ribs; approximate size of a large specimen would be: length, 102 mm.; height, 106 mm.; semidiameter, 45 mm.

Decorticated specimens of this species from Monte Grande were first referred to Brüggén's<sup>18</sup> *Cardium lissoni*, a species described from the Lower Senonian of Peru. The present species differs from *C. lissoni* by its ornamented ribs. *Cardium brüggeni* appears to be a widely distributed species in the Maestrichtian of South America. We have specimens from Colombia and Venezuela.

*Types*.—Paleontological Research Institution, Nos. 4827, 4828, 4829.

*Occurrence*.—*Baculites* zone. Monte Grande. La Mesa.

<sup>18</sup> Brüggén, H.: *Die Gastropoden und Lamellibranchier des unteren Senons von Nord-Perú*, N. Jahrb. Min., etc. BB., vol. 30, 1916, p. 756, pl. 26, fig. 1.

Subgenus **INCACARDIUM**, new subgenusGenotype.—*Cardium (Incacardium) mellisum*, n. sp.

The following is a description of the subgenus *Incacardium*:

Shell elongate-subcircular, the posterior side pointed, with a deeply impressed zone extending from the beak to the ventral margin; nymphal plate small; cardinals unfused and situated midway between the fairly distant laterals; ribs numerous, triangular in section and ornamented with scattered fluted or scalelike spines.

*Remarks.*—By its elongated and pouting posterior extremity, this *Cardium* resembles certain ribbed *Liopistas* but has a thicker shell and different hinge. The ribs on the middle area and on the anterior sides have a rasplike appearance because of the sharp, fluted or scalelike spines. The hinge is fairly normal and is generally similar to that of *Trachycardium* to which group, this subgenus is probably closest related. The cardinal teeth of the right valve, the only one well known, are perfectly free at their upper ends; and the anterior tooth, although smaller than the posterior, is still quite large and is placed obliquely to the direction of the hinge line. The laterals are quite strong and equidistant from the cardinals. *Cardium caudatum* d'Orbigny<sup>19</sup> as figured in the Voyage of the Astrolabe has a shape similar to *Incacardium* but the posterior-dorsal area is shown as smooth or unribbed. The species has not been recorded by subsequent workers and is possibly a *Liopista*.

**Cardium (Incacardium) mellisum**, n. sp.

Plate 5, figs. 2, 4, 6

Shell of medium size, convex and sculptured with scaled or spine-bearing ribs; the valves are moderately convex, the greatest inflation being located just posterior of the middle line; a deeply impressed zone extends from the beak to the posterior-ventral margin; it is bordered on the posterior side by the dorsal area which appears somewhat flattened and has a smoother, ribbed sculpture; the sculpture is formed by numerous ribs of triangular section, arranged as follows:—in the middle and an-

<sup>19</sup> d'Orbigny, A.: *Voyage au Pole Sud et dans l'Océanie sur les corvettes L'Astrolabe et La Zéélé*, Geologie Atlas, 1847, figs. 25, 26.

terior sides, the ribs number about 22, in the depressed zone about six and there are six or seven on the dorsal area; these ribs are largest in the central part and are adorned with scattered fluted or scalelike spines placed on the summits; the interspaces are triangular in form, smooth or etched with cross lines; the ribs of the depressed zone and the dorsal area are smaller and plain; a small area on each side of the beaks is smooth; hinge plate narrow, the right valve has two, unfused, cardinal teeth, the posterior one larger and bordering a V-shaped socket; lateral teeth strong and situated at an equal distance on each side of the cardinals; inner margins fluted by the ends of the ribs.

Length, 34 mm.; height, 29.5 mm.; semidiameter, 13 mm. (holotype).

Length, 37.5 mm.; height, 30.5 mm.; semidiameter, 17 mm.

*Types*.—Paleontological Research Institution, Nos. 4830, 4831.

*Occurrence*.—Tortuga, middle zone. La Mesa.

Superfamily VENERACEA

Family VENERIDÆ

Genus APHRODINA Conrad

*Aphrodina pacifica*, n. sp.

Plate 7, figs. 1, 2

The shell is large, thick, subelliptical and moderately convex; beaks prosogyrate, approximate, situated about a fourth of the shell length from the anterior extremity; umbonal slope rounded; lunule cordate to subelliptical in form, in length about three-fourths of the distance between the tip of the beak and the anterior basal margin; right valve with a wide hinge plate on which are placed three cardinal teeth and a corrugated pit or socket for the anterior left lateral, the nymph is marked off above by a deep groove; the surface is smooth or irregularly wrinkled by the concentric growth lines; escutcheon is not defined.

Length, 66 mm. (imperfect); height, 61 mm.; semidiameter, 20 mm.

The holotype is a specimen of the right valve showing the hinge but the cardinal teeth are damaged. The hinge of the right valve has the anterior lateral socket strongly pitted or corrugated.

This hinge is similar to that figured by Stephenson<sup>20</sup> for the genotype of *Aphrodina*, the *Aphrodina tippiana* Conrad of the Upper Cretaceous of the Atlantic and Gulf coasts. Our species is most similar to *Aphrodina regia* Conrad from the Upper Cretaceous of North Carolina, differing principally by its more anteriorly placed beaks.

*Type*.—Paleontological Research Institution, No. 4857.

*Occurrence*.—*Baculites* zone.

***Aphrodina* cf. *auca* d'Orbigny**

*Antigona*, sp., Olsson, 1934, The Cretaceous of the Amotape Region, Bull. Amer. Paleont., vol. 20, No. 69, p. 54, pl. 5, fig. 6.

Shell is small or medium-sized, solid, rounded and moderately convex; the small beaks are placed at the anterior one-third and are closely adjacent and curved over the small, flattened or feebly arched lunule; umbos are wide and full, and appear somewhat flattened; posterior-dorsal slope curved and strongly arched in the middle; the margin along the base and at the anterior and posterior sides is well rounded; lunule is large, flattened, limited by a groove; left valve has a heavy hinge plate on which is placed an anterior lateral tooth, wrinkled or corrugated on the sides, together with three cardinal teeth, the upper one bordered by a shallow, slightly rugose furrow; surface of shell sculptured with strong, even, concentric ribs which cover the entire surface or become reduced to irregular wrinkles on the sides. The size is rather variable, an average measurement is length, 37 mm.; height, 32 mm.

On the basis of Wilcken's<sup>21</sup> figure of *Cytherea auca* d'Orbigny, 1847,<sup>22</sup> I am referring our fossil to the Chilean Cretaceous species currently identified by this name, with the reservation that an actual comparison of specimens might reveal differences not at present evident from the figures alone. True *Venus auca*

<sup>20</sup> Stephenson, L. W.; *Invertebrate fossils of the Upper Cretaceous formation*, North Carolina Geol. Econ. Sur., vol. 5, 1923, p. 314, pl. 71, figs. 4 and 6.

<sup>21</sup> Wilckens, O.: *Revision der Fauna der Quiriquina-Schichten*, N. Jahrb. Min. etc., BB. vol. 18, 1904, pp. 243-248, pl. 19, figs. 12-14.

<sup>22</sup> d'Orbigny, A.: *Voyage au Pole Sud et dans l'Océanie sur les corvettes L'Astrolabe et La Zéléé*, Geologie Atlas, 1847, pl. 5, figs. 9, 10.

d'Orbigny, 1842,<sup>23</sup> as noted by several authors (Stoliczka,<sup>24</sup> Wilckens) is a Tertiary *Tapes*-like shell and the name *auca* should not be used for the Cretaceous species. Through various mutants of the fossil, many based on casts, the species has often been renamed by Philippi according to the extensive synonymy given by Wilckens. Therefore a decision as to the proper designation of this common Chilean Cretaceous species must be reserved for some student working directly with Chilean collections.

*Occurrence*.—*Baculites* zone. Tortuga.

***Aphrodina speciosa*, n. sp.**

Plate 4, figs. 5-7

Shell small or medium-sized, with convex whorls and a sub-ovate form; umbos wide, prominent ending in small, slightly coiled beaks placed at the anterior one-fourth; sculpture is formed by quite strong, concentric ribs which have a subequal spacing on the center of the disk but become irregular near the ventral margin and are much smaller, closer spaced on the umbos; no escutcheon, the umbonal slope being strongly convex; lunule cordate, quite large and defined by an incised line across which the concentric sculpture passes with no change; interior and hinge not known.

Length, 21 mm.; height, 19 mm.; diameter, 13 mm.

Length, 18.5 mm.; height, 16.5 mm.; diameter, 11 mm.

Length, 16 mm.; height, 15 mm.; diameter, 11 mm.

This species is usually small, the average size being about 18 mm. but an occasional individual may reach 24 mm. The shell is strongly convex, its texture solid and the surface sculptured by strong, subequal ribs which have a convexly curved form con-

<sup>23</sup> d'Orbigny, A.: *Voyage dans l'Amerique meridionale*, Pal., 1842, p. 122, pl. 12, figs. 17, 18.

<sup>24</sup> Stoliczka, F.: *Cretaceous faunas of southern India*. *Pelecypoda*, 1865-70, p. 165, No. 184.

centric to the strongly rounded ventral margin. Interior and hinge have not been seen.

*Types*.—Paleontological Research Institution, holotype, No. 4836; paratypes, Nos. 4837, 4838.

*Occurrence*.—Tortuga, lower fossil bed.

Subgenus **SECHURINA**, new subgenus

Genotype.—*Aphrodina* (*Sechurina*) *australis*, n. sp.

The following is a description of the subgenus *Sechurina*:

Shell large, solid and with a hinge structure essentially similar to that of *Aphrodina* but differs in having a well-marked escutcheon defined by a change in sculpture and by a deeply impressed line.

***Aphrodina* (*Sechurina*) *australis*, n. sp.**

Plate 7, figs. 3, 5, 6

Shell large, thick, convex, subovate to subelliptical in form; umbos wide and prominent, the beaks prosogyrate, approximate and situated about a fourth of the distance from the anterior extremity; posterior extremity subtruncated; escutcheon narrowly elliptical, marked off by a strongly angled ridge and bordered ventrally by a deeply incised line; lunule broadly cordate, smoothish, limited by an impressed line; surface smooth or irregularly wrinkled by growth lines; right valve with a wide hinge platform on which are placed three cardinal teeth and a socket for the anterior left lateral; the nymph is limited above by a deep groove.

Length, 87 mm.; height, 73 mm.; diameter, 53 mm.; type.

Length, 67 mm.; height, 61 mm.; diameter, 47 mm.

*Remarks*.—From the *Aphrodina pacifica*, this species is distinguished by its deeply excavated area of the escutcheon and greater convexity of its valves. The hinge is preserved in a specimen of the right valve, but its details are obscured by grains of matrix. Its structure is essentially similar to that of *Aphrodina pacifica* except that it is heavier and the posterior nymph is much stronger. The posterior right cardinal appears to have been bifid. The escutcheon is well marked and clearly differentiated by a deeply impressed line. Possibly related to this spe-

cies is *Venus subsulcata* Philippi<sup>25</sup> from Algarrobo, Chile. *Callista pseudoplana* Yabe and Nagao<sup>26</sup> from the Upper Cretaceous of Saghalin Island may also be related.

*Types*.—Paleontological Research Institution, Nos. 4858, 4859.  
*Occurrence*.—*Baculites* zone.

Genus **LEGUMEN** Conrad

**Legumen peruvianum**, n. sp.

Plate 6, fig. 12

Shell thin, compressed or slightly convex, similar in form and sculpture to *Legumen planulatum* Conrad but is proportionally shorter and higher; posterior side is well rounded and about twice as long as the more narrowly rounded, anterior side; umbos very low and compressed; the external surface is marked with close-set, concentric lines, stronger and more irregular on the anterior-ventral subzone, smoother and more irregular on the posterior side; a smoothish ray, extending from the umbo to the posterior-ventral margin, is sometimes evident; ventral margins generally broadly flexed in the middle; interior and hinge not known.

Length, 47 mm. (approximate); height, 21.5 mm.

Although this species is quite common at Tortuga, our specimens are fragmentary or merely surface impressions. The species is closely related to *Legumen planulatum* Conrad,<sup>27</sup> the genotype, the Peruvian form being shorter, higher and with a more expanded posterior side.

*Type*.—Paleontological Research Institution, No. 4846.

*Occurrence*.—Tortuga, lower and middle zones.

Genus **ICANOTIA** Stoliczka

**Icanotia pacifica**, n. sp.

Plate 2 fig. 8

Shell elongate, soleniform, slightly convex, rather thin; dorsal margin long, straight, the ventral margin parallel to it except near

<sup>25</sup> Philippi, R. A.: *Die Tert. und Quart. Versteinerungen Chiles*, 1887, p. 115, pl. 17, fig. 7.

<sup>26</sup> Yabe, H., and Nagao, T.: *New or little-known Cretaceous fossils from North Saghalin (Lamellibranchiata and Gastropoda)*, Science Reports of the Tôhoku Imperial University, 2d series, vol. 7, No. 4, 1925, p. 120, pl. 29, figs. 1, 1a, 1b, 1c.

<sup>27</sup> Wade, Bruce: *The fauna of the Ripley formation on Coon Creek, Tennessee*, U. S. Geol. Survey, Prof. Paper No. 137, 1926, pp. 90-91, pl. 29, figs. 1.

the anterior end where it is smoothly curved; umbo and beak not differentiated; surface is sculptured with radiating riblets or lines which are fine over the greater part of the shell surface but become coarse on the posterior-dorsal portion; hinge and interior not exposed.

Length, 76 mm; height, 21 mm.; semidiameter, 4 mm.

Our single specimen is very fragmentary but it agrees closely in general characters with *Icanotia impar* Zittel,<sup>28</sup> the genotype from the Gosau Cretaceous of Europe. *Icanotia elicita* Stoliczka<sup>29</sup> from the *Ariyalur* group of India is wider posteriorly.

*Type*.—Paleontological Research Institution, No. 4826.

*Occurrence*.—*Baculites* zone.

Superfamily **MACTRACEA**

Family **MACTRIDÆ**

Genus **MULINOIDES**, new genus

Genotype.—*Mulinoides chilca*, n. sp.

The following is a description of the genus *Mulinoides*:

The shell is solid, strongly convex and with a well-differentiated posterior-dorsal area; hinge has strong, lateral teeth and a wholly internal ligament and resiliary pit; the hinge of the right valve has a deep resiliary pit which is placed immediately below the beak and directed obliquely backwards, and it is bordered posteriorly by a narrow groove which separates it from the dorsal edge of the valve; the anterior side of the resiliary pit is lamellar which united with an upper arm forms an inverted V-shaped cardinal tooth; anterior and posterior lateral teeth are large, solid, bordered above by a groove in which the laterals of the opposite valve are received; a lumularlike area is present, marked off by a line or groove and by a change in sculpture.

*Remarks*.—The majority of the Cretaceous Mactridæ have been referred by authors to the genus *Cymbophora* Gabb, based on *Mactra ashburnerii* Gabb of the Californian Cretaceous. The hinge of the genotype has been figured by Packard<sup>30</sup> and by

<sup>28</sup> Zittel, K. A. von: *Die Bivalven der Gosaugebilde*, Denkschr. Akad. Wiss. Wien, vol. 25, 1865-66, p. 120, pl. 2, fig. 4; same figure in Dall, Zittel Text-book of Paleontology, 1913, fig. 814.

<sup>29</sup> Stoliczka, F.: *Cretaceous fauna of southern India. The Pelecypoda*, Mem. Geol. Surv. India, vol. 3, 1871, p. 168, pl. 4, fig. 16.

<sup>30</sup> Packard, E. L.: *Mesozoic and Cenozoic Mactrinae of the Pacific Coast of North America*, Bull. Dept. of Geol., Univ. Calif., vol. 9, No. 16, 1916, p. 298, pl. 26, figs. 4, 5.

Stephenson<sup>31</sup> for several other species from the Coastal Plain of the United States. As noted by Stewart,<sup>32</sup> the *Maetra araucana* d'Orb.<sup>33</sup> from the Cretaceous of Quiriquina is probably a member of this genus. Dall<sup>34</sup> considered *Cymbophora* merely a subgenus of *Spisula*, stating that it differed chiefly from the typical genus by the elevated edges of the chondrophore pit and by a posterior slit or sinus above it. Stephenson elevated *Cymbophora* to the rank of a genus, and this procedure was followed by Stewart.

Our specimens from the Upper Breccia zone have the valve cavity filled with a cemented matrix so that it has not been possible to clean or uncover the hinge structures thoroughly. Its main features, however, are determinable. The hinge is solid with strong, enlarged lateral teeth and in these characters it resembles many species of *Mulinia*. The edges of the resiliary pit or chondrophore are prominent, lamellarlike and a deep groove or slit borders the posterior side. Whether the resiliary pit forms a more or less, independent, spoon-shaped structure as figured by Packard for *Cymbophora ashburnerii* cannot be determined but in *Mulinia* as well as in other Maetras, the edges of the resiliary pit are often thin, raised and free. The typical species of *Cymbophora* are shown as having, narrow, lamellarlike laterals and the form of the shell is trigonal and often elongated as common to many *Spisulas*. The slit or groove, which borders the posterior side of the pit or the adjacent under surface of the dorsal edge of the valve probably served for the attachment of the ligament.

Although the Peruvian species agrees in its hinge structure with that described or figured for *Cymbophora*, there are obvious differences which seem important. These characters are the more

<sup>31</sup> Stephenson, L. W.: North Carolina Geol. Econ. Sur., vol. 5, pt. 1, 1923, pp. 335-339.

<sup>32</sup> Stewart, R. B.: Acad. Nat. Sci. Philadelphia, Spec. Pub. No. 3, 1930, p. 211.

<sup>33</sup> Wilckens, O.: *Revision der Fauna der Quiriquina-Schichten*, N. Jahrb. f. etc. BB., vol. 18, 1904, pp. 251-260, pl. 20, figs. 5-7.

<sup>34</sup> Dall, W. H.: Trans. Wagner Free Institute of Science, vol. 3, pt. 4, 1898, p. 879.

solid, rounded or convex shell, stronger, less lamellar, lateral teeth and a resiliary pit which is more typically mactroid in form. The posterior-dorsal area is well marked and, as in *Mulinia*, is limited from the rest of the surface by an angled ridge. A large, lunular area is present, covering the whole of the anterior side and it is marked off by a groove and a change in sculpture. This genus is represented by two species in the Peruvian Cretaceous.

**Mulinoides chilca**, n. sp.

Plate 7, figs. 4, 7-9

Shell of medium size, solid, subovate to subtriangular in form and strongly convex; sculpture is formed by concentric riblets which are strongest on the central portion and on the anterior side, with the beaks and umbonal portions generally smoother; a wide, flattened, posterior-dorsal area is present and defined by a keel or angular line extending from the umbo to the posterior, basal angle of the valve; the anterior side has a large lunular area, defined by a grooved line extending from the beak to the anterior, basal corner at which line, there is a change in sculpture, the concentric riblets becoming much coarser, since only the alternate ones are retained; hinge as described above; interior filled with matrix.

Length, 51 mm.; height, 45 mm.; semidiameter, 21 mm.

*Types*.—Paleontological Research Institution, Nos. 4854, 4855, 4856.

*Occurrence*.—*Baculites* zone.

**Mulinoides chicama**, n. sp.

Plate 6, fig. 7

Shell small, subtriangular, the umbos nearly central; valves subequilateral, the anterior and posterior dorsal margins almost straight or weakly arched and meet above the beaks to form an approximate right angle; the valves are strongly convex, the maximum inflation situated near the middle of the disk; a well-marked umbonal angle extends from the beak to the posterior-ventral margin, above it the dorsal area is wide but set off from the rest of the surface by its stronger sculpture; surface is smooth in the middle and on the umbos but with strong, regular, concentric riblets in the central portion and on the lunular and

posterior-dorsal areas; hinge and interior not exposed.

Length, 22 mm.; height, 18.5 mm.; diameter, 13.25 mm.

Agreeing generally with *Mulinoides chilca* in form but much smaller.

*Type*.—Paleontological Research Institution, No. 4852.

*Occurrence*.—Tortuga, lower fossil bed.

Superfamily **TELLINACEA**

Family **DONACIDÆ**

Genus **MACRODONAX**, new genus

*Genotype*.—*Macrodonax peruviana*, n. sp.

The following is a description of the genus *Macrodonax*:

Shell large, solid, donaciform, the posterior side longer than the anterior and sharply truncated marginally; sculpture is discrepant on the two sides, the posterior portion being strongly ribbed, nodose, while that of the anterior portion is concentric; ligament external; the hinge is strong but known only from the right valve which has the following characters:—hinge plate stout with two cardinal teeth,—the posterior one being heavier, and two strong lateral teeth placed distantly; sockets for the insertion of the laterals of the opposite valves border the superior side of the right laterals; valve margins plain; pallial sinus not known.

**Macrodonax peruviana**, n. sp.

Plate 1, figs. 3, 4

Shell large, solid with a *Donax* or *Chion*-like form; valves only moderately convex, appearing externally as if somewhat flattened; the beak is very small, touching the hinge line and lying just above the angle between the cardinal teeth; anterior side is somewhat longer than the posterior and both are narrowly rounded at the ends; the posterior side has a sharply flattened or truncated submargin; the surface sculpture is divided between two areas, that of the posterior side which consists of small and large radial riblets decussated by concentric lines, and that of the anterior side ornamented with coarse, more or less waved, concentric ridges only; there are three or more rows of large, double-

based spines as indicated in the figures; characters of interior and pallial line not known.

Length, 118 mm.; height, 72 mm.; semidiameter, 21 mm.

*Type*.—Paleontological Research Institution, No. 4811.

*Occurrence*.—*Baculites* zone.

Family **TELLINIDÆ**

Genus **TELLIDORA** (Mörch) H. and A. Adams

Subgenus **TELLIPIURA**, new subgenus

Genotype.—*Tellidora (Tellioura) peruana*, n. sp.

The following is a description of the subgenus *Tellioura*:

Generally similar to *Tellidora* in form and in possessing strongly dentated, dorsal margins but differs in being equivalved and in having a sculpture of strong, closely spaced, concentric riblets.

***Tellidora (Tellioura) peruana***, n. sp.

Plate 6, figs. 13-16

Shell of medium size, equivalve, subtrigonal to subrounded in outlines, the length being slightly greater than the height; the valves appear to be nearly flat but in reality are slightly convex as may be seen when viewed from above; the hinge margins, particularly on the posterior side is strongly dentated by a series of sharp, toothlike projections similar to those found on Recent species of *Tellidora*; the beaks are small, sharply pointed and curved forward, there being no clearly differentiated umbos; the sculpture is formed by a series of regularly spaced, concentric riblets which are persistent over the whole shell and overrun by finer concentric threads; most examples of the right valve show a weakly differentiated posterior-dorsal area either by a smoothing of the sculpture or by a faint furrow; in the left valve this area is slightly flexed.

Length, 25.5 mm.; height, 22 mm.; diameter, - - - - .

Length, 21.5 mm.; height, 22.5 mm.; diameter, 4.5 mm.

Length, 26 mm.; height, 19.5 mm.; diameter - - - - .

A rather poor impression of the hinge of the left valve shows the dentition and the immersed ligament to be essentially similar to that of *Tellidora burneti* Broderip and Sowerby of the West

Coast Recent. The latter it also resembles closely by its shape, toothed dorsal margins and the slight but distinct posterior-dorsal flexure.

The *Astarte*-like form and strong sculpture is also similar to that of *Astartemya* Stephenson<sup>35</sup>, recently described from the Navarro group of Texas but differs in shape and by its toothed margins.

*Types*.—Paleontological Research Institution, Nos. 4847, 4848, 4849.

*Occurrence*.—Lower fossil zone, Tortuga.

Superfamily SAXICAVACEA

Family SAXICAVIDÆ

Genus PANOPE Menard

**Panope frailia**, n. sp.

Plate 4, fig. 9

The shell is medium-sized, broadly subelongate, equivalve, convex and its texture rather thin; umbos wide, placed at the anterior one-third with the maximum inflation a little above the middle; ventral margin straight in the middle zone, becoming roundly curved towards the ends; dorsal and ventral margins not quite parallel, the dorsal side sloping somewhat towards the posterior end which appears somewhat produced and bluntly pointed; shell widely gaping at both ends; surface smooth except for growth lines which are sometimes crowded together forming irregular wavelike undulations; internal characters not known.

Length, 98 mm.; height, 48.5 mm.; diameter, 33 mm

The unique specimen is not well preserved, having lost the greater part of the umbonal portion. The subelongated form recalls that of *Panope goldfussii* (Wagner) of the Floridian and lower Chesapeake Miocene. *Panope simplex* Hüpe from the Quiriquina beds has a similar form but the beaks are more central.

<sup>35</sup> Stephenson, E. W.: *The larger invertebrate fossils of the Navarro group of Texas*, The University of Texas Pub., No. 4101, 1941, pp. 173, figs. 1-3.

*Type*.—Paleontological Research Institution, No. 4839.

*Occurrence*.—*Baculites* zone.

Superfamily **MYACEA**

Family **CORBULIDÆ**

Genus **CORBULA** Lamarek

***Corbula tuma***, n. sp.

Plate 6, figs. 8-11

Shell of average size, strongly convex, with a subovate outline, sharply constricted in the posterior region and produced to form a long, narrow snout at the end; the left valve is only slightly smaller than the right, partly embraced by it and with approximately the same degree of convexity; umbos wide, full with the beaks nearly central; the sculpture is formed by close-set, concentric lines, a trifle weaker in the left valve; hinge and interior not seen.

Length, 10.5 mm.; height, 6.25 mm.; diameter, 6.5 mm. (type).

This species will be recognized by its generally small size, form and long, beaklike posterior end. It is common in the lower and middle fossil bed at Tortuga.

*Types*.—Paleontological Research Institution, Nos. 4841, 4842, 4843, 4844.

*Occurrence*.—Tortuga.

***Corbula broggii***, n. sp.

Plate 6, figs. 1-3

The shell is large for the genus with nearly equal and similar valves and of a subelliptical form; the left valve is somewhat smaller than the right but otherwise very similar in form and sculpture; umbonal area wide, passing upward into the small, adjacent beaks which are placed a little back or posterior of the middle line; the anterior side is longer, broadly rounded at the end, the posterior side shorter, narrower and somewhat pointed at the end; posterior-dorsal area well defined, somewhat smaller in the left valve and bordered by a rib or small keel; surface sculptured with coarse, closely spaced concentric riblets; interior and hinge not known.

Length, 31.5 mm.; height, 20.5 mm.; diameter, 13 mm. (type).

Length, 38 mm.; height, 25 mm.; diameter, 16 mm.

Perhaps to be referred to *Carycorbula*, this species differs from most other *Corbulas* by its unusually large size. Three specimens are known.

*Type*.—Paleontological Research Institution, No. 4840.

*Occurrence*.—*Baculites* zone.

Class **GASTROPODA**

Subclass **STREPTONEURA**

Order **ASPIDOBRANCHIA**

Suborder **DOCOGLOSSA**

Superfamily **TROCHACEA**

Family **TROCHIDÆ**

Genus **TECTUS** Montfort

**Tectus tschudi**, n. sp.

Plate 9, fig. 9

The shell is rather solid with a high, conic form and a sculpture formed by two rows of individual nodes, the smaller or inferior row placed closer to the suture than the superior is to the upper suture; base flattened to somewhat impressed, smooth; no umbilicus.

Height, 18.5 mm. (imperfect); diameter, 19 mm.

Only one specimen is known of this interesting species. It is named for Dr. J. J. von Tschudi, who as a naturalist travelled extensively in Peru between the years 1838 and 1842.

*Type*.—Paleontological Research Institution, No. 4874.

*Occurrence*.—*Baculites* zone.

Superfamily **SUBULITACEA**

Family **PSEUDOMELANIIDÆ**

Genus **PSEUDOMELANIA** Pictet and Campiche

**Pseudomelania simplex**, n. sp.

Plate 12, fig. 17

Length of shell about 18 mm., with a high spire of flat-sided whorls and a smooth surface; suture lines distinct; last whorl with a sloping base; aperture incomplete in type specimen, the columellar area appearing to be excavated and with a thin ridge of callus on the parietal wall.

Length, 18 mm.; diameter, 6.75 mm.

A small, plain shell with a fairly long spire of about seven,

flat-sided whorls preserved on the type. Lacking any distinctive characters, the present assignment of this species to *Pseudomelania* is provisional.

*Type*.—Paleontological Research Institution, No. 4873.

*Occurrence*.—Tortuga, lower fossil bed.

Superfamily **NERITACEA**

Family **NERITIDÆ**

Genus **NERITA** Linné

*Nerita jayanca*, n. sp.

Plate 9, figs. 6, 7

Shell small, subglobose or ovate with a very small, low spire and large, convex, embracing body whorl; whorls about three, the suture quite distinct; aperture crescentic; outer lip with an inner, marginal border, slightly more thickened within and bordered by a zone of small pustules; inner lip straight, the columellar area large, flattened, its edge bordered by four or five small teeth; surface smooth or marked with lines of growth which near the lip may be grouped in narrow bands.

Height, 8 mm.; diameter, 9 mm. (holotype).

Height, 11 mm.; diameter, 12 mm.

This species resembles *Nerita umzambiensis* Woods<sup>36</sup> from the Cretaceous of Pondoland but is smaller and has a less expanded body whorl and somewhat higher spire.

*Types*.—Paleontological Research Institution, Nos. 4875, 4876.

*Occurrence*.—Tortuga, lower fossil bed.

Order **CTENOBRANCHIATA**

Suborder **TÆNIOGLOSSA**

Superfamily **RISSOACEA**

Family **MICROMELANIIDÆ**

Genus **STALIOA** Brusina

*Stalioa agnia*, n. sp.

Plate 12, figs. 5, 15, 16

Shell very small, rissoid, with a medium length, conic spire;

<sup>36</sup> Woods, H.: *The Cretaceous fauna of Pondoland*, Annals of the South African Museum, vol. 4, No. 12, 1906, p. 311, pl. 37, figs. 14, 15.

body whorl about two-thirds of the total length; base imperforate or with a small chink present in some cases; surface smooth; sutures distinct, generally with a bordering band; aperture semi-lunate, with a continuous peristome; outer lip heavily thickened, strongly impressed on the back.

Length, 3 mm.; diameter, 1.8 mm. (type).

The measurements given above are of the holotype but most of the specimens are much smaller. A narrow cord borders the lower side of the suture in most specimens and the body whorl immediately behind the heavily thickened lip is generally deeply impressed. The general contours of this shell and its thickened lip are similar to *Stalioa Deschiensi* (Deshayes)<sup>37</sup>, an Eocene species from the Paris Basin.

*Types*.—Paleontological Research Institution, Nos. 4877, 4878.

*Occurrence*.—Tortuga, upper zone.

Superfamily **CERITHIACEA**

Family **TURRITELLIDÆ**

Genus **MESALIA** Gray

**Mesalia janja**, n. sp.

Plate 10, figs. 1-3

Shell of medium size with the rapid taper common to most species of the genus; whorls convex and in the adult stage with two strong, spiral keels; nucleus is not known; the earliest spire whorls preserved on our specimens are unicarinate or provided with a single, large, revolving keel placed just below the middle; a smaller spiral is introduced on the sloping shoulder above and which increases rapidly in size and soon becomes nearly equal in strength to that of the lower or primary spiral keel; the main whorls are double keeled and the spiral interspaces are practically smooth; on the body whorl, a third keel less strong than the other two borders the base; growth lines have a deep sinistral inflexion in the middle and in the adult become coarse and crowded on the back of the last whorl.

Length, incomplete 25.50 mm.; diameter, 13 mm.

<sup>37</sup> Cossmann, M. and Pissarro, G.: *Iconographie complete des Coquilles Fossiles de l'Eocene des environs de Paris*, 1910-1913, pl. 14, figs. 90-2.

Length, incomplete 25 mm.; diameter, 11.75 mm.

This beautiful species is plentiful at Tortuga and in the ammonite beds at La Mesa. It resembles closely the figures of the Persian Cretaceous forms referred by Douville<sup>38</sup> to *Mesalia fasciata* Lamarck. *Mesalia fasciata* is a Calcaire Grossier species of the Paris Basin and the figures given by Cossmann and Pissarro<sup>39</sup> do not resemble closely either the Persian or Peruvian fossils. Specimens of *Mesalia fasciata* from Grignon, France are in the Harris collection at the Paleontological Research Institution. These specimens are similar to the figures commonly published for this species in having a sculpture formed of three or more spiral cords. The earliest spire whorls of *Mesalia fasciata* are smooth, flat-sided, their lower edge somewhat angled or keeled over the suture. This smooth stage includes eight or more whorls. The lower angle of the whorl later forms the first spiral but it is soon followed by a second spiral between it and the upper suture. In the bicarinate forms of *Mesalia fasciata* these two primary spirals may continue to form the dominant sculpture of the main whorls but the commonest types have three or more spiral cords of nearly equal strength. In *Mesalia janja* the early postnuclear whorls are more strongly keeled at a much earlier stage than in *Mesalia fasciata* indicating that the two species are not closely related.

*Types*.—Paleontological Research Institution, Nos. 4879, 4880, 4881.

*Occurrence*.—La Mesa. Tortuga beds, lower horizon.

Genus **WOODSALIA** Olsson

**Woodsalia paitana**, n. sp.

Plate 11, fig. 5

Shell is of medium size, robust, composed of relatively few and fairly rapidly tapering spire whorls; nucleus and earlier whorl

<sup>38</sup> Douville, H.: *Mission Scientifique en Perse par J. de Morgan*, tome troisieme, Etudes Geologiques, pt. 4, Paleontologie. 1904, pp. 329, 330, pl. 47, figs. 23-27.

<sup>39</sup> Cossmann, M. and Pissarro, G.: *Iconographie complete des Coquilles Fossiles de l'Eocene des environs de Paris*, 1910-13, pl. 21, figs. 126-9.

of spire not known; the first whorls preserved on our specimens have two subequal spiral cords situated just above the lower suture; on the following whorls, the upper spiral enlarges more rapidly than the other and becomes a sharp, narrow keel while the lower spiral is much less pronounced; area above the keel is concave and smooth; base of last whorl convex but sculpture details not known; growth lines, as in *Woodsalia*, have a wide, inward curve or sinus which lies along the peripheral keel.

Length, 47 mm. (spire incomplete); diameter, 24 mm.

*Type*.—Paleontological Research Institution, No. 4882.

*Occurrence*.—Tortuga, lower fossil bed.

***Woodsalia paitana robusta*, n. subsp.**

Plate 11, figs. 3, 9

The shell is wider and of more conic form with the periphery of the whorls sharply edged or keeled and the lower spiral is nearly absent; surface of whorl above peripheral keel is flat, sloping and smooth; growth lines with a wide sinus in the peripheral zone.

This form is possibly a distinct species but our material is not decisive in this respect. From *Woodsalia negritensis* Woods of the Eocene Negritos beds, these Cretaceous species differ most strongly in having the upper spiral cord enlarging and forming the peripheral keel while in the Eocene species, it is the lower cord that enlarges to form the periphery of the mature whorls.

*Types*.—Paleontological Research Institution, Nos. 4883, 4899.

*Occurrence*.—Tortuga, lower fossil bed.

Genus **TURRITELLA** Lamarek, *sensu lato*

***Turritella lama*, n. sp.**

Plate 10, figs. 5, 8, 10

Shell of medium size; spire slender in youth, later increasing more rapidly in diameter; sutures linear but with a concave sutural zone so that the profile of the whorl appears more or less convex; nucleus and apical whorls not known but the earliest spire whorls preserved in any of our specimens, have three, primary, revolving spirals, equally separated from each other and from the sutures; smaller spiral threads appear in the interspaces;

the three, primary spirals decrease steadily in size and in the adult are no stronger than the others; in the adult, the lower edge of the whorl which overhangs the base, has generally stronger spirals; pattern of growth lines like those of *saposa*.

Length, 23.5 mm.; diameter, 10 mm.

Length, 24.5 mm.; diameter, 8.75 mm.

Length, 20 mm.; diameter, 8 mm.

Length, 18.25 mm.; diameter, 8.15 mm.

Estimated length of average specimen when perfect about 35 mm.

From *Turritella saposa* with which this species occurs, it is distinguished by its more rapid taper, wider, more convex whorls and finer sculpture in the adult stage.

*Type*.—Paleontological Research Institution, No. 4884; other specimens, Nos. 4885, 4886.

*Occurrence*.—Tortuga, lower zone.

***Turritella saposa***, n. sp,

Plate 10, figs. 4, 7, 9, 11, 12

Shell relatively small, with a slender, tapering spire; whorls numerous, appearing flat-sided or only slightly convex between linear and only slightly excavated sutures in the adult stage; nucleus and apical whorls unknown but the earlier observed whorls have three primary, revolving cords or liræ, equidistant from each other and from the lower suture; they are typically finely nodulated by the growth lines, their interspaces smooth; a fourth, smaller, nodulated spiral borders the upper sutures; on the later turns, the spiral liræ increase in numbers through the addition of new threads between the primaries and still finer spirals occur in their interspaces; growth lines sinuous, with the axis of the inflexion placed just above the middle or at the posterior third.

Dimensions of figured specimens as follows:

Length, 20.5 mm.; diameter, 7.75 mm.

Length, 26.5 mm.; diameter, 7.50 mm.

Length, 20.75 mm.; diameter, 7 mm.

Length, 18.75 mm.; diameter, 8.75 mm.

Length, 21.5 mm.; diameter, 8 mm.

*Type*.—Paleontological Research Institution, No. 4887; other specimens, Nos. 4888-4891.

*Occurrence*.—Tortuga, lower zone.

***Turritella prechira*, n. sp.**

Plate 10, fig. 13

Shell of medium size, slender; whorls 10 or more; nucleus and apical whorls unknown; the spire whorls have two strong, primary spirals separated from each other by a concave band; sutures indistinct, bordered on the superior side by a small cord; on the last whorl, this sutural cord becomes enlarged and forms the periphery; fine spiral threads occur in the space between the primaries on well-preserved specimens.

Length, 31 mm.; diameter, 8.5 mm.

This species resembles *Turritella chira* Olsson of the Saman sandstones and the Chira shales but the primaries are stronger and the form is more slender. It also resembles the *Turritella soaresana* Hartt<sup>40</sup> from Maria Farinha of eastern Brazil. White's figure shows three strong spirals although in his description only two are mentioned. Our specimens are wind eroded but the species can be easily distinguished by its slender form and strong sculpture.

*Type*.—Paleontological Research Institution, No. 4892.

*Occurrence*.—La Mesa.

***Turritella ceiba*, n. sp.**

Plate 11, figs. 6, 15

Shell large, solid, with a rapid taper; protoconch unknown; the earlier known whorls have a convex profile caused by two strong, primary cords which encircle the middle zone; on the following turns additional spirals appear above the two, primary ones; half-grown shells have an irregular sculpture with one or more cordlike spirals around the lower quarter and smaller spirals above; when well preserved, very fine spiral threads cover the primary sculpture and impart to the surface, a coarse, clothlike texture; in large specimens the mature whorls are generally smooth but whether normal or due to erosion cannot be deter-

<sup>40</sup> White, C. A.: *Cretaceous invertebrate fossils from Brazil*, Archivos do Museu Nacional, vol. 7, 1888, pp. 160-161, pl. 18, figs. 8, 9.

mined.

Length, 114 mm. (incomplete); diameter, 32.75 mm.

This is the largest *Turritella* in the Cretaceous of the Paita region. The earlier whorls of the spire are strongly bicarinated, later the sculpture becomes irregular and weaker.

*Types*—Paleontological Research Institution, Nos. 4893, 4894.

*Occurrence*.—*Baculites* zone.

***Turritella inuya***, n. sp.

Plate 13, figs. 10, 11

Shell of medium size and rather stout; spire conic with a fairly rapid taper, the mature whorls appearing flat-sided or only slightly convex; nucleus not known; earlier spire whorls observed are strongly sculptured and have one, primary spiral keel placed just above the lower suture; a second spiral appears shortly at the upper third and rapidly increases in size and on the more mature whorls nearly equals the lower spiral in strength; these two spirals give the sculpture of the mature whorls a bicarinate character; small but coarse spirals cover the remaining surface; the primary spirals, as well as the larger ones of the secondary series, are nodulated by the lines of growth; the periphery of the last whorl has a double keel and the flattened base below it, is covered with fine spirals.

Length, 32 mm. (imperfect); diameter, 14 mm.

*Types*.—Paleontological Research Institution, Nos. 4895, 4896.

*Occurrence*.—*Tortuga*, lower zone.

***Turritella prelissoni***, n. sp.

Plate 16, fig. 2

Shell of medium size with a fairly rapidly tapering spire; nucleus and earlier spire whorls are not known; the first spiral whorl preserved on the type has two strong spiral cords, the lower one is the heavier; there is a small thread between the two primaries and one thread borders each suture; on the following turns, the spirals increase in number and on the last turn there are about seven in all; with exception of the slightly larger peripheral cord the spirals are approximately equal in strength; finer spiral threads are present in the interspaces; the growth lines become rather coarse on the last whorl so as to resemble a ribbed sculpture.

Length, 44 mm. (imperfect); diameter, 21 mm.

The type specimen is imperfect and has four whorls preserved. Its shape and sculpture is similar to that of *Turritella lissoni* Woods<sup>41</sup> from the Negritos Eocene. In the Cretaceous species, the spire whorls have two, primary, spiral cords while in *lissoni* there are generally three. On a former occasion, I referred *Turritella lissoni* to the genus *Woodsalia*<sup>42</sup> of which *Turritella negritosensis* Woods is the genotype but the species apparently belongs to a different group.

*Type*.—Paleontological Research Institution, No. 4964.

*Occurrence*.—*Baculites* zone.

*Turritella desolata*, n. sp.

Plate 15, figs. 4, 5

Shell of moderate size, turrilled with a regularly tapering spire and numerous whorls; nucleus and earlier spire whorls unknown, the following ones have a slightly convex form resulting from the strength of the spiral cords; sculpture is formed by three strong, spiral cords separated by fairly wide, grooved intervals; base flattened to slightly rounded.

Length, 31.5 mm.; diameter, 13.25 mm. (4½ whorls)

Length, 33 mm.; diameter, 11 mm. (5 whorls)

Although common, all our specimens are poorly preserved, worn or thickly encrusted with matrix. Nearly complete specimens have about 10 whorls and a length of 45 to 50 mm. and a diameter of about 13 mm. Fragments indicate, however, that the shell sometimes became much larger. There are several, described species of Cretaceous *Turritellas* having three or four strong, primary spirals but which differ generally from the Peruvian by their more strongly convex whorls. In view of the poor preservation of our material, a careful comparison from published figures alone is impossible.

*Types*.—Paleontological Research Institution, Nos. 4900, 4901.

*Occurrence*.—*Baculites* zone.

<sup>41</sup> Woods, H., in Bosworth, T. O.: *Geology of the Tertiary and Quaternary periods in the north-west part of Peru*, 1922, p. 79, pl. 8, figs. 4, 5.

<sup>42</sup> Olsson, A. A.: *Contributions to the Tertiary paleontology of northern Peru, Pt. II, Upper Eocene Mollusca and Brachiopoda*, Bull. Amer. Paleont., vol. 15, 1929, pp. 79, 80.

**Turritella bartsia**, n. sp.

Plate 15, fig. 9

Shell large, coarse; spire long, with a very gradual taper; in the type only the three last whorls are preserved; the whorls have a bipartite sculpture which is formed by a central ridgelike spiral dividing the surface of each whorl in two, nearly equal parts, each of which has a concave profile; in the upper zone, the sculpture is formed by a strong, keeled ridge or spiral bordering the lower side of the suture and three or more, weak spiral threads lying just above the middle ridge; in the lower zone, the surface is concave, smooth and bordered near the suture by a keeled spiral less strong than the one bordering the upper suture; base of whorl is rounded, the peripheral side bordered by a double keeled spiral.

Length, 80 mm. (imperfect); diameter, 30 mm.

The strong, medial spiral, dividing the sculpture of each whorl into two, nearly equal parts, is the most striking feature of this unusual species. The single specimen was collected loose near Pan de Azucar, east of La Brea. Its stratigraphic derivation is not positively known. The whorls are filled with a coarse, gritty matrix, unlike the Middle Cretaceous rocks outcropping in the vicinity. These Cretaceous rocks, mostly limestones, are overlain by massive, barren sandstones which either represent shore deposits of the lower Eocene or Negritos formation or they may belong to Upper Cretaceous rocks equivalent in age to the Monte Grande.

*Type*.—Paleontological Research Institution, No. 4902.

*Occurrence*.—Pan de Azucar.

**Turritella parinensis**, n. sp.

Plate 11, figs. 1, 2, 12

Shell rather large, stout, the mature whorls with a strong, basal or peripheral keel and spire with a fairly rapid taper; earlier nuclear whorls are not known but the later ones have two spirals which are placed on the lower half; the lower or more anterior of these nuclear spirals increases more rapidly in size and develops into the strong, peripheral cord or keel of the later whorls while the upper spiral becomes obsolete and eventually

disappears; the surface of the mature whorls is deeply concave and smooth; base flattened and ornamented with six scabrous cords, the upper three are much stronger than the anterior ones; growth lines and the shape of the outer lip strongly sinuous and as figured; our most perfect shell measures about 80 mm. in length and 25 mm. in diameter.

Length, 52 mm. (apex missing); diameter, 25 mm. (type).

This species is common and characteristic of the Parinas sandstones occurring generally with *Carolia* (*Parinomya*) *parinensis* Olsson. It differs by its smoother whorls from *Turritella bosworthi* Woods of which it is obviously the descendant. The growth lines have typically a very deep sinus which lies almost in the middle of the whorl between the upper suture and the peripheral keel. A smaller, shallower sinus is generally developed on the edge of the base just below the keel.

*Types*.—Paleontological Research Institution, Nos. 4897, 4898.

*Occurrence*.—Parinas sandstones. Parinas Point (holotype); Cabo Blanco; Parinas outcrops south of Talara. (Eocene).

Genus **SECHURITELLA**, new genus

Genotype.—*Sechuritella terebracincta*, n. sp.

The following is a description of the genus *Sechuritella*:

Shell turritelloid in form, with numerous whorls, each with a prominent, revolving cord or keel bordering the posterior edge; surface generally smooth at maturity; growth lines sinuous, strongly antecurrent, indicating an obliquely inclined outer lip; a deep, anal sinus in the posterior keel.

*Remarks*.—This genus will be distinguished from *Turritella* by its solid, posterior keel and strongly antecurrent lines of growth. Specimens more perfect than those now available may show other distinguishing characters such as the possibility of an anterior sinus in the outer lip and an anterior canal. The genus is represented by two Peruvian species: the genotype, *terebracincta* and *chacapoya*. In the latter, the spire whorls are spirally sculp-

tured but the surface of the following whorls soon become smooth. *Sechuritella terebracincta* is an accelerated species and the spire whorls are smooth at an early stage and the posterior cord is early developed. In species of *Turritella* with a strong, posterior keel, such as the group of *Turritella praecincta* Conrad and *Turritella dickersoni* Woods, the keel is relatively thin, flangelike and sharp-edged while in *Sechuritella*, this structure is an enlarged cord which thickens and becomes more solid with growth, its upper surface being relatively wide, flat, sloping, its edge smoothly rounded while its lower surface is narrow and often grooved. The aperture was longer and more produced than in *Turritella* and may have possessed an anterior canal.

***Sechuritella terebracincta*, n. sp.**

Plate 11, figs. 7, 8, 10, 11, 14

The shell is large and solid, each whorl with a massive cord-like keel near the upper suture and separated from it by a sloping shoulder, while the lower or anterior side of the keel is sharply limited, sometimes by a groove; the surface of the whorl is smooth except for irregularities in the lines of growth; body whorl is higher than wide with a sloping or nonflattened base; growth lines antecurrent.

Measurements of the fragmentary examples in our collection give only an incomplete idea of the actual size of the species. The specimen illustrated by figure 10 on Plate 11 has a diameter of about 26 mm. The taper of the spire was very gradual so that the original length of this specimen was probably between 90 to 100 mm. Cross sections show that the columella was unarmed and the walls of the whorl chambers heavily thickened in a concentric fashion. The keel is often hollow.

*Types*.—Paleontological Research Institution, Nos. 4903 to 4907.

*Occurrence*.—*Baculites* zone.

***Sechuritella chacapoya*, n. sp.**

Plate 11, figs. 4, 13

Shell is large, solid, with a fairly rapidly tapering spire; whorls numerous (about six are preserved on the holotype), wider than

high; the majority of the whorls have a sharply carinated keel on the posterior side; nucleus is not known; the earlier whorls preserved on our specimens are spirally sculptured, the uppermost spiral soon enlarging to form the keel while the other spirals decrease in strength and the surface of the whorls becomes smooth; aperture and base not preserved in available material; growth line pattern, like that of *Sechuritella terebracincta*, is strongly antecurrent.

Length of imperfect specimen, 54 mm.; diameter, 23.25 mm.

From *Sechuritella terebracincta* with which this species occurs, it is separated by its more rapidly tapering spire, sharper keel and spirally sculptured spire whorls.

*Types*.—Paleontological Research Institution, Nos. 4908, 4909.

Family MELANIIDÆ

Genus MELANATRIA Bowdich

*Melanatria medialis*, n. sp.

Plate 12, figs. 8, 11

Shell of medium size, stout, with a high spire of six or more whorls; the spire tip or nucleus is lost on the type specimen; whorls of the earlier portions of the spire appear to have been smooth or marked only with very fine lines visible with a lens; on the succeeding whorls there is a single row of spinelike tubercles on the posterior side of the suture; these tubercles number about six to a whorl; on the last whorl, there are two rows of spined tubercles, the lower row placed on the edge of the base or periphery of the whorl with its tubercles arranged alternately with those of the upper row; aperture incomplete, the inner lip with a spread of callus; basal part of shell is smooth.

Length, 28.5 mm. (imperfect); diameter, 16.25 mm. (holotype).

This species resembles *Melanatria dimorphica* Woods<sup>43</sup> from the Negritos formation at Negritos and La Brea but differs by the smooth apical whorl and in its fewer, spinelike tubercles of the body whorl.

<sup>43</sup> Woods, H.: In Bosworth, *Geology of the Tertiary and Quaternary periods in the north-west part of Peru*, 1922, p. 83, pl. 9, figs. 11a, 11b.

*Type*.—Paleontological Research Institution, No. 4910.

*Occurrence*.—Tortuga, middle fossil bed.

Genus **GLAUCONIA** Giebel

***Glauconia cordalis***, n. sp.

Plate 15, fig. 13

Shell rather solid, in form like *Turritella* with a long spire formed of numerous whorls; apex and earlier whorls unknown, the later ones having a flat-sided profile and sculptured with two, very strong, spiral cords which are divided medially by a deep groove; these cords are rounded on the anterior or lower side, flaring and thin-edged on the upper side; a deep, spiral groove forms the lower edge of each spire whorl, the suture being concealed by the overlapping edge of the next whorl; last whorl rounded, the sculpture becoming less pronounced; growth lines slightly sinuous in the middle; aperture with a continuous peristome which becomes free-edged in the adult.

Length, 33.75 mm. (imperfect); diameter, 15.75 mm.

Length, 27.25 mm.; diameter, 14 mm.

The reference of this fossil to *Glauconia* is provisional pending the discovery of more perfect specimens. The shell is very solid and the sculpture is formed by two strong, broad, spiral cords. The aperture appears to have been rounded with a continuous and free-edged peristome.

*Type*.—Paleontological Research Institution, No. 4918.

*Occurrence*.—*Baculites* zone.

Family **POTAMIDIDÆ**

Genus **TROCOTULAX**, new genus

Genotype. — *Trocotulax elegans*, n. sp.

The following is a description of the genus *Trocotulax*:

Shell small or medium-sized with a high spire and regularly enlarging whorls; sutural area excavated; sculpture of noded spirals on the upper surface and plain spirals only on the base; mouth round with a thickened, continuous and free-edged peristome; a small potamid sinus at the end of the columella.

*Remarks*.—In referring this genus to the Potamididæ, I have been guided by its general resemblance to some species of *Ceri-*

*thidea* and by its circular mouth bordered by a thickened and continuous peristome which anteriorly is slightly reflexed to form a small siphonal sinus. The flattened basis is sculptured with plain spirals only. The sutural zone is deeply excavated which gives to each whorl a convex form.

**Trocotaulax elegans**, n. sp.

Plate 13, figs. 6-8

Shell small with a lengthened spire composed of eight whorls plus the missing nucleus; sutures lie in a smooth, excavated band so that each whorl is convex in form, the suture itself is indistinct or shows only as a thin line; sculpture of each whorl is formed by three strong cords which are coarsely noded by ribs which extend across from the edge of each sutural band; these ribs number about 14 on an average specimen; base flattened to slightly convex, sculptured by two strong spiral cords in the outer zone and three smaller ones in the inner zone; aperture circular, edged by a thickened peristome; a small potamid sinus at the end of the columella.

Length, 14 mm.; diameter, 7 mm.

Length, 15 mm.; diameter, 7 mm.

*Types*.—Paleontological Research Institution, Nos. 4911, 4912, 4913.

*Occurrence*.—Tortuga, middle fossil bed.

Genus **THIANASSA**, new genus

*Genotype*.—*Thianassa ciconia*, n. sp.

The following is a description of the genus *Thianassa*:

Shell small, nassoid with a high and broad spire; sculpture is formed by straight narrow ribs and smaller, finely wrinkled spirals; ribs are more or less noded at their upper ends thus giving to each whorl a narrowly shouldered form; last whorl is high with a gently sloping base ending in a short but straight anterior canal provided with a small, slightly reflexed siphonal sinus.

These shells resemble somewhat *Elimia* H. and A. Adams but differ by their generally shorter form and in some other features. For the present, the genus may be classed with the Potamididæ.

**Thianassa ciconia**, n. sp.

Plate 13, fig. 5

Shell small with a broad, stout spire composed of five or more

whorls, the nucleus not included; early portion of the spire more rapidly enlarging than the latter; each whorl appears narrowly shouldered by the ends of the straight, narrow ribs which are more or less sharply noded at the ends adjacent to the upper suture; these ribs are almost in a direct line across each spire whorl, numbering about seven to each turn; finer, wrinkled spiral bands cover the ribs and the wider interspaces, the spiral adjacent to the upper suture being the largest; last whorl is rather high with a gently sloping base ending in a short, straight anterior canal; inner lip with a thick coat of callus on the columella and parietal wall.

Length, 15.75 mm.; diameter, 8 mm.

This peculiar species is represented by several specimens in varying degrees of preservation. Two species may be present, some examples are longer and have more numerous ribs than the form here figured. The straight, narrow ribs and finely wrinkled or decussated spirals are characteristic of all the specimens.

*Type*.—Paleontological Research Institution, No. 4914.

*Occurrence*.—Tortuga, middle fossil bed.

Genus **RHINOTAMIDES**, new genus

Genotype.—*Rhinotamides rudis*, n. sp.

The following is a description of the genus *Rhinotamides*:

Shell cerithid with an elongate-conic spire of numerous, flat-sided whorls and a hexagonal section formed at first by scarcely differentiated ribs; on the later whorls, these riblike angles become nodose and form into two rows of sharp tubercles; one row, that bordering the upper suture is the stronger, the other encircles the peripheral angle; base strongly flattened and sculptured with spirals; columella with a single fold.

**Rhinotamides rudis**, n. sp.

Plate 13, figs. 9, 13

Shell of medium size, stout with nine or more spirally sculptured whorls; early portion of spire has a hexagonal section, the corners of which form low ribs at first scarcely discernible but later becoming more pronounced; the ends of these ribs develop

into rows of strong tubercles or spines; rest of surface has fine and more or less alternating beaded spirals; base flattened with three or more rows of beaded spirals; aperture not known.

Length, 31 mm. (imperfect); diameter, 21 mm. (holotype).

Length, 27 mm.; diameter, 15.5 mm.

A perfect example of this interesting shell is not known. Remains of the outer lip suggest that of *Tympanotonos* Schumacher to which this genus seems most closely related. As may be seen from the figure, a sinus or channel was presented at the posterior end of the lip. The spire whorls have a hexagonal cross section, the angles of which become ribs and bear strong, spiniform tubercles on the mature whorls. Judging by associated fragments, the spines are very large and strong in old shells.

*Types*.—Paleontological Research Institution, Nos. 4915, 4916.

*Occurrence*.—Tortuga, middle and lower fossil beds.

Genus **SYMPANOTOMUS**, new genus

Genotype.—*Sympanotomus muricatus*, n. sp.

The following is a description of the genus *Sympanotomus*:

Shell cerithid with a long spire ornamented with two rows of pointed tubercles, the lower row stronger than the other; base flattened; inner lip with a thick, calloused platform.

***Sympanotomus muricatus***, n. sp.

Plate 13, fig. 4

Shell of medium size with a medium length, pointed spire of 10 or more whorls; nucleus not known; the earlier spire whorls have two, equally noded, spiral cords, the nodes of which connect across the intervening groove in riblike manner; on the following whorls, the lower cord gains rapidly in strength and becomes large and sharply noded on the mature whorl while the upper cord remains small and only feebly noded; on the last whorl, the nodes of the spiral cord average about 12 in number; base flattened and spirally sculptured; aperture in all specimens is poorly preserved but has a callus growth which forms an appressed platform; a potamid, anterior sinus is present.

Length, 30 mm.; height, 16.25 mm.

*Type*.—Paleontological Research Institution, No. 4917.

*Occurrence*.—Tortuga, middle fossil bed.

Genus **PYRAZUS** Mentfort**Pyrazus peruvianus**, n. sp.

Plate 13, fig. 12

Shell small or medium-sized, with a long, slender spire of eight or more whorls, the tip being broken away in all our specimens; the whorls have a pentagonal section formed by five strong ribs; on the spire, the ribs are nearly in line, straight, but tend gradually to revolve towards the left as growth proceeds and on the later turns, the ribs are more widely separated and stronger individually; spirals overrun the whole surface and consist of two sizes, a primary set of strong, finely noded spirals, about five in number on the spire whorls and about eight on the body whorl, and very minute spiral threads between the larger ones visible only with a lens; aperture rounded produced forward but the tip of the canal is broken in all our specimens.

Length, 27 mm.; diameter, 12.5 mm.

The genus *Pyrazus* is based on *Cerithium ebinius* Bruguière, a Recent species but several Upper Cretaceous and Eocene forms have been referred to it by Cossmann, Douville and other European workers. Among described species, *Pyrazus peruvianus* may be compared with *Pyrazus pentagonatus* (Schlotheim) from the upper Eocene of Italy, good figures of which are given by Cossmann<sup>44</sup>, both species having the ribs in fives and arranged in nearly straight lines. Douville<sup>45</sup> records *Pyrazus pyramidatus* Deshayes,<sup>46</sup> which is an Eocene species in the Paris Basin (Cuisian), from the Maestrichtian of Persia.

*Type*.—Paleontological Research Institution, No. 4959.

*Occurrence*.—Tortuga.

Genus **NODIFAUNUS**, new genus

*Genotype*.—*Nodifaunus nodosus*, n. sp.

The following is a description of the genus *Nodifaunus*:

<sup>44</sup> Cossmann, M.: *Essais de Paléonochologie Comparée*, vol. 7, 1906, p. 120, pl. 10, figs. 3, 9, 10.

<sup>45</sup> Douville, H.: *Mission scientifique en Perse par J. de Morgan*, vol. 3, Etudes Géologiques, pt. 4, Paléontologie, 1904, p. 306, pl. 42, figs. 5, 6.

<sup>46</sup> Cossmann, M., and Pissarro, G.: *Iconographie complète des Coquilles fossiles de l'Eocène des environs de Paris*, tome 2., 1910-1913, pl. 42, figs. 5, 6.

Shell solid, with numerous whorls and a high spire; the early whorls are smooth, flat-sided to slightly convex, later ones developing a row of large knobs or ribs on the superior side; on the mature whorl, the base becomes rounded, sloping; growth lines straight or only slightly sinuous in the middle; anterior canal short with no distinct siphonal sinus; aperture semilunate, the parietal wall with a thick coat of callus.

*Remarks.*—To this group belong two characteristic species which are common in the fossil zones in the Lower Breccias at Tortuga. The spire whorls are smooth, resembling *Faunus*, but in the later stages are ornamented by a row of large, spinelike knobs or coarse ribs, most strongly developed just below the upper suture. In form, the shell resembles the figures given for *Pseudobellardia* Cox<sup>47</sup>, 1931 based on *Faunus auriculatus* Schlotheim from the upper Eocene, Ronca beds of northern Italy. *Pseudobellardia* has the spire whorls ribbed and a definite spiral sculpture.

**Nodifaunus nodosus**, n. sp.

Plate 12, figs. 6, 7, 10, 12

Shell solid, melanoid of an average length of about 34 mm., the spire is long, formed for the most part of flat-sided, smooth whorls, the apical portion slender, the middle part wider or more inflated; sutures linear, distinct; the surface is smooth except for a row of strong spinelike nodes on the upper side of the penultimate and mature whorls; these nodes number about seven to the turn; last whorl rather high with a smooth, sloping or rounded base; aperture semilunar with the inner lip or parietal wall covered by a thick coating of callus; lines of growth straight or slightly curved in the middle.

Length, 34 mm.; diameter, 15.5 mm.

*Types.*—Paleontological Research Institution, Nos. 4920, 4921, 4922.

*Occurrence.*—Tortuga, lower and middle fossil zones.

<sup>47</sup> Wenz, W.: *Handbuch der Paläozoologie, Gastropoda*, Teil, 3, 1939, p. 697, fig. 2003.

**Nodifaunus costatus**, n. sp.

Plate 12, figs. 9, 14

Shell solid, like *Nodifaunus nodosus* in general characters but with a more slender spire and the smooth stage confined to the earlier whorls; axial sculpture somewhat variable in strength and stage of development but in most specimens begins quite early and consists of coarse, riblike folds which do not quite reach the lower suture; on the type, the ribs number about eight on the last turn and are placed alternately with those of the adjacent whorl; last whorl rather high with a smooth, slightly convex, sloping base; aperture melanoid, a strong covering of callus on the parietal wall and a short canal without a siphonal sinus.

Length, 31 mm.; diameter, 14 mm.

The typical forms of these two species are very distinct but some intermediate specimens occur which are more difficult to classify. *Nodifaunus nodosus* is generally a larger and stouter shell, the smooth spire whorls noticeably wider and the axial nodes appear later and are more spinelike. The young shell has an angled periphery and a flattened base sculptured with feeble spirals. In *Nodifaunus costatus*, the form is more slender and the axial nodes are more riblike in appearance. The youngest shells seen have a sloping and smooth base.

*Types*.—Paleontological Research Institution, Nos. 4923, 4924.

*Occurrence*.—Tortuga, lower and middle fossil zones.

Genus **GLORIOCLAVA**, new genus

Genotype.—*Glorioclava inca*, n. sp.

The following is a description of the genus *Glorioclava*:

Shell of medium size, solid, with a rather long, smooth spire; spire whorls eight or more (apex unknown), slightly convex in profile; surface smooth except for very faint spiral threads; parietal wall with a thick coating of callus; growth lines straight or showing only a slight inflexion in the middle.

*Remarks*.—The aperture and anterior canal are seldom well preserved amongst the fossil cerithids and the relation and classification of many fossil groups are consequently doubtful. In form,

*Glorioclava* resembles *Clavocerithium* Cossmann<sup>48</sup> but the spire whorls are entirely smooth and judging by the shape of the growth lines, the outer lip was without a sinus. In these characters the Cretaceous shell differs from *Iddingsella* Olsson<sup>49</sup> as well as in size. The nucleus and earliest spire whorls are not preserved in our specimens but as far as can be determined the surface was smooth except for very minute spiral threads.

***Glorioclava inca*, n. sp.**

Plate 12, fig. 13

Shell of medium size, solid, with a rather longish spire of seven or more whorls (apex unknown); in profile, the spire whorls are slightly convex between well-marked sutures; surface smooth; inner lip with a thick callus on the parietal wall.

Length, 37 mm. (incomplete); diameter, 15.5 mm.

*Type*.—Paleontological Research Institution, No. 4925.

*Occurrence*.—Tortuga, middle zone.

Genus **PREVICARYA**, new genus

Genotype.—*Previcarya peruviana*, new species

The following is a description of the genus *Previcarya*:

The shell is stout, with a pointed spire of numerous whorls; earlier whorls with three strong cords, the upper one being regularly noded, the others smooth; on the later whorls, the nodes of the superior cord enlarge to form strong tubercles, the other cords remain smooth or become obsolete; base flattened and sculptured with strong spirals; aperture with a continuous peristome, the posterior end of the outer lip with a small sinistral groove; columella with a small fold.

*Remarks*.—This genus resembles *Vicarya* d'Archiac and Haime<sup>50</sup> (genotype *Vicarya verneuli* d'Archiac) but is smaller and has the posterior sinus reduced to a groove at the junction of the outer lip with the body whorl while in true *Vicarya*, the

<sup>48</sup> Wenz, W.: *Handbuch der Paläozoologie, Gastropoda*, Teil 4, 1940, p. 762, Abb. 2208.

<sup>49</sup> Olsson, A. A.: *Contributions to the Tertiary paleontology of northern Peru, Pt. 2, Upper Eocene Mollusca and Brachiopoda*, Bull. Amer. Paleont., vol. 15, No. 57, 1929, p. 81, pl. 4, figs. 1-4. (See also foreword to this paper.)

<sup>50</sup> Wenz, W.: *Handbuch der Paläozoologie*, Band 6, Teil 6, 1940, p. 741 Abb. 2145.

posterior sinus is placed in the middle of the lip and forms a deep inflexion in the lines of growth. The aperture of *Vicarya* is also calloused. The genus *Previcarya* appears to have representative species in the Cretaceous rocks in many parts of the world. The *Cerithium hispidum* Zekeli<sup>51</sup> from the Cretaceous of Gosau together with *Cerithium (Fibula?) inauguratum* Stoliczka<sup>52</sup> may belong to it. These species were referred by Cossmann<sup>53</sup> to *Cimolithium* Cossmann with *Cerithium belgicum* d'Orbigny, a Cenomanian species as type. Cossmann's figure of *Cimolithium belgicum* differs too greatly from *Previcarya peruviana* for the Peruvian species to belong to the same genus. *Previcarya* may also occur in eastern Brazil (Maria Farinha) from which White<sup>54</sup> has figured a fragmentary specimen as *Nerinæa inauguratum* Stoliczka.

***Previcarya peruviana*, n. sp.**

Plate 12, figs. 1, 2, 3

Shell of medium size, stout, with a moderately long, nearly flat-sided and sharply conic spire; whorls numerous, 13 or more; nucleus unknown; the earlier whorls are sculptured with three strong cords, the upper cord being strongly and regularly noded, the other two are smooth with the lowest cord a little larger than the middle one; on the later whorls the simple nodes of the posterior cord increase in size to become coarse and rather widely spaced sharp tubercles which on the largest specimens number about nine to the turn; the other two cords which are smooth persist on the later whorls but remain small or become faint to subobsolete; in addition there is a fine, submicroscopic spiral lining over the whole surface; young shells have a strongly flattened base with a bordering carina; on more mature shells, the base becomes more rounded and sculptured with three or

<sup>51</sup> Zekeli, F.: *Die Gastropoden der Gosaugebilde*, Kh. geol. Reichsan-Wien. Abh., Band 1, 1852, pp. 115, 116, pl. 24, figs. 1, 2.

<sup>52</sup> Stoliczka, F.: *Cretaceous faunas of southern India*, Palæontologia Indica, Mem., 1865-70, p. 193, pl. 15, figs. 15, 19, 20.

<sup>53</sup> Cossmann, M.: *Essais de Paléoconchologie Comparée*, vol. 7, 1906, p. 57.

<sup>54</sup> White, C. A.: *Cretaceous invertebrate fossils*, Archivos do Museu Nacional, vol. 7, 1888, p. 141, pl. 13, fig. 9.

more strong spirals; aperture, when perfect, has a continuous peristome with a strong posterior sinal groove at its upper end; the complete outer lip is not known; columella with a small, oblique fold.

Height, 35 mm.; diameter, 16.75 mm. type.

Height, 34.5 mm.; diameter, 16 mm.

A common and characteristic species in the middle zone at Tortuga.

*Types*.—Paleontological Research Institution, Nos. 4926, 4927, 4928.

*Occurrence*.—Middle zone at Tortuga.

Family **CERITHIIDÆ**

Genus **TORTUCERITHIUM**, new genus

*Genotype*.—*Tortucerithium textilis*, n. sp.

The following is a description of the genus *Tortucerithium*:

Shell cerithid with a long, tapering spire of numerous whorls at first sculptured with narrow, foldlike ribs and spirals; on the later turns the ribs become stronger and on the last divide into two rows of stout tubercles; aperture not known.

**Tortucerithium textilis**, n. sp.

Plate 13, figs. 1-3

Shell of medium size to large, with a long, tapering spire of eight or more whorls; the nucleus is unknown; the whorls of the spire have a flat profile and are separated by distinct but waved sutures and their sculpture consists of strong, close-set, foldlike ribs which number about 11, at first straight but later become oblique and overrun by fine spiral threads; the axial ribs on the later turns are strongly thickened and more widely separated and on the last turn are divided into two rows of sharp tubercles, the upper set bordering the suture and the other encircling the periphery; base slightly convex and ornamented with fine spirals; aperture incomplete, with a coating of callus on the parietal wall.

Length, 49.5 mm. (imperfect); diameter, 25 mm.

This is the largest and commonest cerithid at Tortuga and will readily be recognized by its slender form and characteristic sculpture. I have found no described species to which it appears at all closely related.

*Types*.—Paleontological Research Institution, Nos. 4931, 4932, 4933.

*Occurrence*.—Tortuga, middle fossil bed.

Genus **PARINANA**, new genus

Genotype.—*Morgana magma* Woods, Plate 15, fig. 14

The following is a description of the genus *Parinana*:

Shell with pupoid outline, rather solid; spire long, composed of numerous smooth whorls except the earlier ones which may be sculptured with ribs and spirals; aperture with a thickened, continuous peristome and a *Clava*-like anterior canal; outer lip appressed, thickened with only a shallow sinistral inflexion in the lines of growth; the base sloping and sculptured with strong spirals.

*Remarks*.—In 1904, Douville<sup>55</sup> gave the name *Irania* to a group of species common in the Maestrichtian of Persia, the selected genotype being the *Vicarya fusiformis* Hislop. The type species also occurs at Rajamandii, India, in beds variously referred to the late Cretaceous and Eocene. It is a smooth shell with a very deep, narrow sinus in the outer lip. The name "*Irania*" being preoccupied in birds, was changed to *Morgana* by Cossmann<sup>56</sup> who classed the genus in the Melanopsidæ. Wenz<sup>57</sup> places *Morgana* with the Potamididæ. Woods<sup>58</sup> in his study of the Bosworthian collection described two species from Peru as *Morgana magma* and *costata*. *Morgana costata* was later selected by Olsson<sup>59</sup> as the genotype of *Hopkinsiana* and because of its well-developed cerithid aperture and canal, referred the species to the Cerithiidæ. *Parinana magma* is a common and characteristic fos-

<sup>55</sup> Douville, H.: *Mission Scientifique en Perse par P. de Morgan*, Études Géologiques, pt. 4, Paléontologie, 1904, pp. 319-322, pl. 44, figs. 1-18.

<sup>56</sup> Cossmann, M.: *Paléocœnch. comparée*, vol. 8, 1909, p. 164, pl. 3, figs. 14, 15.

<sup>57</sup> Wenz, W.: *Handbuch der Paläozoologie*, 1940, pp. 741, 742, Abb. 2146.

<sup>58</sup> Woods, H.: In Bosworth, *Geology of the Tertiary and Quaternary periods in the north-west part of Peru*, 1922, p. 82, pl. 9, figs. 5, 6.

<sup>59</sup> Olsson, A. A.: *Contributions to the Tertiary paleontology of northern Peru, Pt. 2, Upper Eocene Mollusca and Brachiopoda*, Bull. Amer. Paleont., vol. 15, No. 57, 1929, p. 84, pl. 6, figs. 8, 10, 11.

sil in the Parinas sandstones. As noted by Woods this species bears much resemblance to *Morgana fusiformis* but differs by its larger size and more importantly in having only a shallow sinus in the outer lip. The anterior canal, although seldom preserved, has a long, somewhat recurved beak similar to that of *Clava* and other related cerithids. These characters show that the Peruvian *magma* cannot belong to the true genus *Morgana*. The *Vicarya* ? *sappho* White and *Vicarya* ? *daphne* White from Brazil may belong to this genus.

***Parinana americana***, n. sp.

Plate 12, fig. 4

Shell small, pupoid and rather solid; spire long with eight whorls preserved on type (apex is broken); the spire whorls are strongly sculptured with four spiral cords of which the two outer ones are the strongest; these cords are coarsely and regularly noded; on the last whorl, the spiral sculpture has become obsolete and the surface is nearly smooth; aperture ovate, the inner lip thickened, its edge generally free; growth lines indistinct on the type but appear weakly sinuous in the middle.

Length, 15 mm.; diameter, 6.5 mm.

The type material of this small species comprises four specimens, none of which is perfect.

*Type*.—Paleontological Research Institution, No. 4929.

*Occurrence*.—Tortuga, middle fossil bed.

Superfamily CALYPTRÆACEA

Family CALYPTRÆIDÆ

Genus CALYPTRÆA Lamarck

***Calyptrea aperta*** Solander

Plate 9, figs. 10-13

*Calyptrea* is typically a Tertiary and Recent genus but some authors, such as Stoliczka, have recorded species from several Cretaceous localities but most of these records are based on casts or otherwise questionable material. The Peruvian examples from the Cretaceous of Tortuga and the *Baculites* zone belong not only to typical *Calyptrea* but they are apparently specifically identical with *Calyptrea aperta* Solander (sometimes known as *C. trochiformis* Lamarck) common in the Eocene of Europe and North America. The Claibornian forms of this species have recently

been illustrated by Palmer.<sup>60</sup> Internal molds of a *Calyptrea* from the Roca beds of the Argentine are mentioned by Von Ihering<sup>61</sup> under the name of *C. cf. pileolus* d'Orb. and were first referred to *C. aperta* Solander by Boehm.<sup>62</sup>

In our collections, *Calyptrea aperta* is abundant in the middle fossil bed at Tortuga and one specimen was also found in the *Baculites* zone. Representative examples are figured. As typical of the genus, young shells are very variable in form and sculpture. The sutures are generally distinct (except on the apical portion) and the individual whorls vary from flat to moderately convex. Many shells have the sutural zone strongly shouldered or it may be flattened and depressed, thus accentuating the apparent convexity of the whorls. The older portion of the conch tends to become smooth but elsewhere the sculpture is formed by a series of close, irregular radial wrinkles and small, ventrally directed, scalloped frills or pustules. The specimen from the *Baculites* zone has a high, conic spire and several rows of obliquely ascending pustules.

For comparison with the Cretaceous forms, I have also figured a specimen from the Eocene Parinas sandstones of Keswick Hills east of Negritos.

Our shells measure as follows:

Height, 18.5 mm.; diameter, 34 mm. Tortuga.

Height, 22 mm.; diameter, 26 mm. Tortuga.

Height, 25.5 mm.; diameter, 37.5 mm. Tortuga.

Height, 34 mm.; diameter, 37 mm. *Baculites* zone.

*Figured Specimens*.—Paleontological Research Institution, Nos. 4934, 4935, 4936. Eocene specimens (Parinas ss.), No. 4937.

*Occurrence*.—Tortuga, middle zone. *Baculites* zone. Also at Monte Grande.

<sup>60</sup> Palmer, K.: *The Claibornian Scaphopoda, Gastropoda and dibranched Cephalopoda of the southern United States*, Bull. Amer. Paleont., vol. 7, No. 32, 1937, p. 145, pl. 16, figs. 1, 2, 3, 5.

<sup>61</sup> von Ihering, H.: *Les Mollusques Fossiles du Tertiaire et du Crétacé Supérieur de l'Argentine*, Anales del Museo Nacional de Buenos Aires, serie III, tomo 7, 1907, p. 28.

<sup>62</sup> Boehm, J.: *Zeitschr. Deut. Geol. Ges.*, 1903, p. 72.

Superfamily **STROMBACEA**Family **APORRHAIÐÆ**Genus **ANCHURA** Conrad*Anchura pacifica*, n. sp.

Plate 14, fig. 1

Shell of medium size, fusiform with a slender, turritid spire; four whorls are preserved on the type, the apical whorls being missing; the body whorl is about half the length of the shell and is ornamented with a single, strong, knoblike rib situated near the left side; the sculpture is cancellated on the spire whorls and formed by nearly equal ribs and spirals, the intersection of which is slightly noded; the ribs have vanished on the last whorl (except for the single one placed near the left side), only the spiral sculpture remains which is formed by a series of few widely spaced stronger spirals and intermediate smaller ones; the spirals are more or less nodulated by the lines of growth; the outer lip has a long, narrow, spurlike form, the end of which has been broken away in the type; anterior canal straight; columella not exposed.

Length of specimen (tip of spire and canal missing), 31 mm.

Diameter of specimen (wing incomplete), 17.5 mm.

This is the only species of *Anchura* known from Peru. It is characterized by its cancellated spire whorls.

*Type*.—Paleontological Research Institution, No. 4943.

*Occurrence*.—*Baculites* zone.

Family **STROMBIDÆ**Genus **TORGNELLUS**, new genus

*Genotype*.—*Torgnellus peruvianus*, n. sp.

The following is a description of the genus *Torgnellus*:

In form, the shell is like *Pugnellus* Conrad (genotype *P. typicus* Gabb=*P. densatus* Conrad) but more massive and the external surface is smooth or without definite sculpture; sutures covered with callus except perhaps in extreme youth; young shells are fairly regularly fusiform with a pointed spire, a long, straight anterior canal and with an upward pointed hook at the posterior end of the outer lip; with maturity and senility, the shell becomes thick, massive and irregular, the outer lip developing

a massive lobe ending posteriorly in a blunt spur; the anterior canal is broadly appressed and turns sharply towards the left; spire in the adult is merely a small knob, appressed on the ventral side; aperture in the middle is quite wide with parallel sides.

**Torgnellus peruvianus**, n. sp.

Plate 14, figs. 7, 8

*Pugnellus*, sp., Olsson, 1934, The Cretaceous of the Amotape Region, Bull. Amer. Paleont., No. 69, p. 66, pl. 9, fig. 5 (young specimen).

Shell of adult large or medium-sized, solid, completely covered with callus and with a thick, expanded outer lip; no ribbed sculpture is developed at any stage, the surface of the whorls being essentially smooth; in the very young, the shell has a prominent spire and quite evenly convex whorls; in the succeeding stages, a cover of callus is spread over the whole surface and with age becomes very thickly developed in certain areas, particularly on the outer, posterior surface of the winged lip; the spire is completely submerged by the callus and usually develops into a small, lateral compressed, hooklike snout similar to that found at the posterior end of the outer lip; anterior beak turned sharply to the left.

Length, 46 mm.; greater diameter, 39 mm. (across lip); lesser diameter, 22.25 mm. (transverse to lip).

*Torgnellus* is clearly allied to *Pugnellus* but differs by its heavier shell, more thickly covered with callus, absence of a ribbed sculpture and more importantly in having the anterior canal bent sharply to the left in the adult. Young shells have the straight anterior canal of *Pugnellus*. An interesting species described by Gabb as *Pugnellus tumidus* occurs in the Cretaceous of the island of Quiriquina, Chile and has been well figured by Wilckens.<sup>63</sup>

Stewart<sup>64</sup> has referred this species, together with the Californian *P. hamulus* Gabb to *Conchothyra* but true *Conchothyra* of the New Zealand Cretaceous has no anterior canal. Marwick<sup>65</sup>

<sup>63</sup> Wilckens, O.: *Revision der Fauna der Quiriquina-Schichten*, N. Jahrb. fur Min. etc. BB. vol. 18, 1904, p. 205, pl. 18, figs. 2a, 2b.

<sup>64</sup> Stewart, R.: *Gabb's California fossil type gastropods*, Proc. Acad. Nat. Sci. Philadelphia, vol. 78, 1926, p. 358.

<sup>65</sup> Marwick, J.: *The Wangaloan and associated molluscan faunas of Kaitangata-Green Island subdivision*, Geol. Sur. N. Zealand, Pal. Bull., No. 15, 1937, p. 63.

places *Conchothyra* among the Struthiolariidæ.

*Type*.—Paleontological Research Institution, No. 4938.

*Occurrence*.—*Baculites* zone.

Genus **PERUSTROMBUS**, new genus

Genotype.—*Perustrombus wheeleri*, n. sp.

The following is a description of the genus *Perustrombus*:

Shell large, solid, thickened by a heavy deposit of callus; adult with the spire completely concealed, the area of the spire is flattened and bordered by a massive, circling keel of callus which extends from the posterior end of the outer lip and is most strongly developed on the dorsal surface; outer lip massive, straight and thickened by a wide band of callus clearly marked off from the rest of the surface; surface smooth; anterior canal long, straight.

***Perustrombus wheeleri***, n. sp.

Plate 14, figs. 1-3

Shell of large size, solid; the spire is completely concealed in the adult, the area covering the spire being flattened and bordered by a high, massive keel of callus; body whorl subcylindrical in form, convex and smooth but there are faint indications of former ribs showing through the callus; a massive cord-like keel of callus is formed at the posterior end of the outer lip and on the dorsal side assumes a high, humplike form; outer lip straight, long and strongly thickened by a wide band of callus; aperture sublinear of uniform width throughout; anterior canal long, straight, the end broken in the type specimen.

Length (tip of anterior canal broken), 77 mm.; greater diameter (ventral side), 40 mm., (with hump); lesser diameter (transverse to aperture), 32.5 mm.

Two specimens of this interesting species are known, the large holotype measuring 77 mm. in length and a smaller, more fragmentary specimen which if complete would be about 50 mm. in length. This second shell although so much smaller than the holotype has the same heavily thickened lip, humped shoulder and flattened concealed spire. The keel which is so strongly formed on the dorsal side continues as a low fold across the ventral side as well. The form of the shell is decidedly *Cypræa*- or

*Gisortia*-like best seen in the younger specimen which is strongly compressed dorsal-ventrally.

*Type*.—Paleontological Research Institution, No. 4939.

*Occurrence*.—*Baculites* zone.

Subgenus **ORTHOSTROMBUS**, new subgenus

*Genotype*.—*Perustrombus* (*Orthostrombus*) *tortugensis*, n. sp.

The following is a description of the genus *Perustrombus*:

Shell of medium size, solid, with a short, pointed spire; the spire whorls are ribbed in the early stages; the sculpture and sutures later become covered with a continuous coat of callus; aperture is broadly linear with parallel walls, the outer lip strongly thickened by a band of callus, heaviest at the posterior end; anterior canal straight.

***Perustrombus* (*Orthostrombus*) *tortugensis*, n. sp.** Plate 14, figs. 5, 6

Shell of medium size, solid and completely covered with a callus of variable thickness; spire is short, pointed at the end, and composed roughly of six whorls; young specimens are not available but the holotype has a series of small, oblique riblets, showing faintly through its covering of callus; the upper side of the whorls are impressed; growth lines showing faintly through the coat of callus are sinuous, retractive above towards the suture as in *Pugnellus*; aperture is broadly linear, with the inner and outer lips parallel; outer lip is strongly thickened by a wide belt of callus, especially so at the posterior side; anterior canal broken in the specimens available but was apparently straight.

Length, 40 mm. (imperfect); diameter, 24 mm. (holotype).

Length, 41.5 mm. (imperfect); diameter, 26 mm.

This elegant shell is represented in our collections by two specimens. The species will be easily recognized by its short, conic spire and callus which covers the entire shell, including the sutures in the adult. Short, obliquely set ribs are visible through the callus on the spire whorls. On the back of the body whorl, the growth lines are seen to be sinuous, strongly retractive above towards the suture as in *Pugnellus*. The outer lip has a broad band of callus on the back as in *Perustrombus wheeleri*

which assumes its greatest thickness at the posterior end where it forms the side of the deep, anal channel. A knoblike growth of callus is found at the edge of the parietal wall. The anterior canal is broken in our specimens but it was apparently straight.

*Pugnellus* ? *cypræformis* Olsson from Monte Grande can now be referred to *Orthostrombus*. This species was originally based on two specimens. The holotype, which is larger and has an exposed spire, will carry the name *cypræformis*. It differs from the Tortuga species in being much larger. The second Monte Grande specimen, that illustrated by figure 4, plate 9 of our Amotape report, is perhaps a new species of *Peruostrombus* but being poorly preserved is best left unnamed until better material is found.

*Type*.—Paleontological Research Institution, No. 4940.

*Occurrence*.—Tortuga, lower fossil bed.

#### Genus CALYPTRAPHORUS Conrad

*Calyptrophorus hopkinsi* Olsson Plate 15, figs. 8, 12

*Calyptrophorus hopkinsi* Olsson, 1934, *The Cretaceous of the Amotape Region*, *op. cit.*, p. 68, pl. 10, fig. 2.

As near as can be determined from available material, this species appears to be a true *Calyptrophorus* although as pointed out recently by Palmer,<sup>66</sup> the exact systematic position of the few Cretaceous forms referred to this genus will remain doubtful until specimens with the anterior canal and outer lip perfectly preserved are known. Even in case *Calyptrophorus hopkinsi* should not prove to belong to the typical genus, it is most certainly its direct precursor. The specimens here figured are from the *Baculites* zone at Tortuga and although fragmentary, serve to supplement our knowledge of this species, first described from Monte Grande.

Young specimens or those deprived of their covering of callus have a *Faunus*-like shape, tapering spire and close, linear sutures. The earlier whorls of the spire are ribbed but this sculpture soon disappears and the surface becomes smooth. The ribbed stage

<sup>66</sup> Palmer, K.: *The Claibornian Scaphopoda, Gastropoda and dibranchiate Cephalopoda of the southern United States*, Bull. Amer. Paleont., vol. 7, 1937, p. 242.

may cover about six whorls and the smooth stage about six turns or more. The anterior canal although broken in all our specimens was long and narrow.

*Figured specimens.*—Paleontological Research Institution, Nos. 4941, 4942.

*Occurrence.*—*Baculites* zone.

Superfamily NATICACEA

Family NATICIDÆ

Genus AMPULLINA Lamarck, *sensu lato*

*Ampullina breccia*, n. sp.

Plate 9, figs. 2-4

Shell large, thick, ovate, imperforate, the spire slightly less than half the total length; whorls 5+, (nucleus not preserved), those of the spire are slightly convex, that of the body whorl is well rounded to slightly angulated in the middle; sutures distinct, the bordering area is not flattened so that the spire is not scalar in form; aperture ovate, the inner lip with a thick spread of callus on the parietal wall which extends down as a band into the anterior portion of the outer lip; surface smooth but where well preserved, shows faint spirals; growth lines are retractive, oblique to the axis of the shell about 20 degrees and have a slight flexure in the middle.

Height, 57.5 mm.; diameter, 44.5 mm. (type).

This species closely resembles Stewart's<sup>67</sup> figure of *Ampullina oviformis* Gabb from the Chico Cretaceous of Tuscan Springs, California. As Stewart notes, this Californian species is at least subgenerically removed from typical *Ampullina*. From the associated *Ampullina tortuga*, the present species is distinguished by its form, and convex, nonscalar, spire whorls. The holotype belongs to the *Baculites* zone but smaller and otherwise identical forms occur in the lower zone at Tortuga.

*Type.*—Paleontological Research Institution, Nos. 4944, 4945, 4946.

*Occurrence.*—*Baculites* zone. Lower Tortuga zone.

<sup>67</sup> Stewart, R. B.: *Gabb's California fossil type gastropods*, *Proc. Acad. Nat. Sci. Philadelphia*, vol. 78, 1926, p. 333, pl. 21, fig. 10.

**Ampullina tortuga**, n. sp.

Plate 9, fig. 1

The shell is fairly large, thick, imperforate, ovate with a moderately elevated spire about half the total length; nucleus not known; whorls about six; in the small shells, the sutural area is simply rounded but with growth becomes narrowly flattened and the profile of the spire becomes shouldered; small shells have a narrow umbilicus which later becomes covered by the spreading callus; aperture holostomous, subovate in outline; inner lip with a thick spread of callus over the parietal wall; outer lip imperfect on our specimens but judging from the shape of the lines of growth, was only slightly oblique in the adult; surface smooth except for the faint lines of growth.

Length, 56 mm., diameter, 47 mm.

Young shells have a narrow, well-formed umbilicus which is soon covered by the encroachment of the callus of the inner lip. Mature shells have a strongly shouldered spire profile and the body whorl is large and subovate in form.

*Type*.—Paleontological Research Institution, No. 4947.

*Occurrence*.—Tortuga, lower zone.

**Ampullina cumara**, n. sp.

Plate 9, fig. 5

Shell of medium size, nonumbilicate, with a short spire and a large, convex body whorl; nucleus not preserved on our specimens; spire formed of about six or more, convex whorls between well-marked sutures; body whorl inflated, its greatest convexity lying opposite the upper third of the aperture; general surface of the shell is smooth, polished, but showing faint impressions of the growth lines and often still weaker indications of minute, irregular spirals; aperture semilunar, the outer lip not well preserved on any of our specimens, was somewhat oblique as indicated by the growth lines; inner lip with a spread of callus on the parietal wall; anterior end of the aperture with a short, reflexed canal.

Length, 29.5 mm., diameter, 25 mm.

This species of which we have four specimens, differs strikingly from the other forms by its shorter, smaller spire and pro-

portionately larger body whorl. Its general shape is similar to that of *Ampullina willemeti* (Desh.),<sup>68</sup> which is the genotype of *Crommium*, except that it has no umbilicus and the spread of callus is therefore wider.

*Type*.—Paleontological Research Institution, No. 4948.

*Occurrence*.—Tortuga, lower zone.

Superfamily **BUCCINACEA**

Family **GALEODIDÆ**

Genus **RHOMBOPSIS** Gardner

**Rhombopsis meridionalis**, n. sp.

Plate 15, figs. 1, 2

Shell of medium size, fusiform with a high spire and fairly long anterior canal, strongly sculptured with ribs and spirals; nucleus missing on available specimens, the spire whorls remaining on type numbering about  $4\frac{1}{2}$ ; the body whorl is rather large with a rounded shoulder ornamented with about 10 ribs which fade out across the base and upwards towards the suture; sutural zone impressed, concave; in addition to the ribs, the surface is elaborately sculptured with strong, alternating spiral threads; aperture incompletely preserved in type but shows a long, twisted anterior canal ending in a small but distinct canal; growth lines sinuous.

Length, 25.5 mm.; diameter, 17.75 mm.

In essential characters, this species resembles the *Rhombopsis orientalis* and *microstriatus* Wade<sup>69</sup> from the Ripley Cretaceous of Tennessee differing principally by its broader form and more strongly curved anterior canal. The western species figured by Meek are less similar. *Rhombopsis* was proposed by Gardner, 1916, as a substitute name for *Neptunella* Meek, 1876, preoccupied by Gray, 1853. The group *Neptunella* was used as a subgenus of *Pyrifusus* Conrad by Meek with *Fusus newberryi* as the genotype.

*Types*.—Paleontological Research Institution, Nos. 4953, 4954.

*Occurrence*.—Tortuga, lower zone.

<sup>68</sup> Cossmann, M., and Pissarro, G.: *Iconographie complete des Coquilles fossiles de L'Eocene des environs de Paris*, tome 2e, 1910-1913, pl. 11, 64-17.

<sup>69</sup> Wade, Bruce: *The fauna of the Ripley formation on Coon Creek, Tennessee*, U. S. Geol. Survey, Prof-paper, 137, 1926, p. 142.

Family **FASCIOLARIIDÆ**Genus **LATIRUS** Montfort**Latirus tribulus**, n. sp.

Plate 15, fig. 11

Shell fusoid with a spire about equal to the aperture in length; whorls shouldered and sculptured with strong, knobbed ribs which number about eight on the last whorl; above the shoulder, the face of the whorls is constricted and concave, its sculpture smoother; the shoulder and the surface of the whorls are covered by a series of strong spirals evenly distributed and separated by wide intervals; two or three of these spirals cross the top of the ribs on the shoulder angle which they render somewhat nodose with 10 or more placed on the base and over the anterior canal; aperture and columellar area imperfect and covered with matrix.

Length, 42 mm: (imperfect); diameter, 28 mm.

The type specimen is poorly preserved with the columella covered by matrix. The generic reference to *Latirus* is therefore provisional until better material permits more certain identification.

*Type*.—Paleontological Research Institution, No. 4949.

*Occurrence*.—*Baculites* zone.

Genus **FASCIOLARIA** Lamarck**Fasciolaria sechura**, n. sp.

Plate 15, figs. 3, 10

Shell ovate with a high spire and a moderately convex body whorl; apex missing in the type specimens, there being three whorls of the spire preserved; these spire whorls have a slightly convex profile between lined, distinct sutures; the surface is smooth with a faintly impressed band bordering the edge of the upper suture; trace of the lines of growth show a wide, backward curve or shallow sinus in the middle zone of the body whorl; aperture is subovate, the end of the anterior canal broken: columellar area covered.

Length, 43.75 mm. (imperfect); diameter, 28 mm.

This species is based on two imperfect specimens, both with the anterior canal broken and their aperture so filled with matrix that the columella cannot be seen. The generic position of

these shells is therefore uncertain and will remain so until better material is known. In form the shell strongly resembles certain smooth *Fasciolaria* such as the Recent Atlantic *tulipa* and *distans*. It is also possible that the species is a volutid comparable to the genus *Ptychoris* Gabb based on *Voluta purpuriformis* Forbes<sup>70</sup> from the Indian Cretaceous. From the *Fusus difficilis* d'Orbigny<sup>71</sup> of the Cretaceous of Quiriquina, referred by Wetzel<sup>72</sup> to *Leiostoma* Swainson, the Peruvian species differs by its longer, straighter canal and less convex body whorl.

The *Fasciolaria* ? *calappa* Olsson from Monte Grande should probably be referred to the genus *Lissapiopsis* Imlay<sup>73</sup> based on *Lissapiopsis unicarinata* Imlay from the Upper Cretaceous, Difunta formation of Mexico. Imlay considered this genus of large, shouldered gasteropods as related to *Melongenina* but the group shows equally close resemblance to some members of the Strombidæ.

*Types*—Paleontological Research Institution, Nos. 4950, 4951.  
*Occurrence*.—*Baculites* zone.

#### Genus FUSINUS Rafinesque

*Fusinus* ? *corbis*, n. sp.

Plate 9, fig. 15

Shell of medium size, solid, the spire longer than the canal; apex lost, the remaining whorls of the spire numbering about four; sculpture is formed by nine knoblike ribs which are strongly developed on the middle zone of each whorl and on the shoulder of the last whorl but fade out below on the base; in addition the entire surface is covered with coarse, cordlike spirals, fairly regular in size except in the sutural zone where they are somewhat

<sup>70</sup> Forbes, E.: Trans. Geol. Soc. London, vol. 7, 1846, p. 130, pl. 12, fig. 2; also Stoliczka, F.: *Cretaceous fauna of southern India*, vol. 2, 1868, *Gastropoda*, p. 91, pl. 8, figs. 4, 5, 6, 7.

<sup>71</sup> d'Orbigny, A.: *Voyage dans l'Amérique meridionale*, 1842, *Paleontologie*, p. 118, pl. 12, figs. 11, 12.

<sup>72</sup> Wetzel, W.: *Die Quiriquina Schichten als Sediment und Palaontologisches Archiv.*, Paläontographica, vol. 78, 1930, p. 69, pl. 11, figs. 3, 4.

<sup>73</sup> Imlay, R. W.: *Stratigraphy and paleontology of the Upper Cretaceous beds along the eastern side of Laguna de Mayran, Coahuila, Mexico*, Bull. Geol. Soc. America, vol. 48, 1937, p. 1843.

smaller; anterior canal is long and straight but the end is broken in type.

Length, 49 mm. (imperfect); diameter, 25 mm.

Since the columella is covered, the generic position of this fossil is uncertain but its form and straight canal is similar to many species of true *Fusinus*. It also resembles a figure of a fusinid shell from the Maestrichtian of Persia referred to *Lathyrus*, sp., by Douville<sup>74</sup>.

*Type*.—Paleontological Research Institution, No. 4952.

*Occurrence*.—*Baculites* zone.

Superfamily **VOLUTACEA**

Family **VOLUTIDÆ**

Genus **VOLUTOCORBIS** Dall

*Volutocorbis meridionalis*, n. sp.

Plate 9, fig. 14

Shell subovate, the spire and aperture of about equal length; nucleus lost on the type, the remaining whorls of the spire number about four; the sculpture is sharply subcancellate, formed by a series of narrow, ridgelike ribs which extend from the anterior canal to the suture and are crossed by strong spirals separated by wider interspaces; the ribs number 9 or 10 on the last whorl; sutures bordered on the anterior side by a strong cord or ridge; columella covered in the type.

Length, 35.5 mm.; diameter, 21.5 mm.

This seems to be a true *Volutocorbis*, characterized by its fairly low spire and strongly cancellated sculpture. *Volutilithes* cf. *crenulifera* Bayan figured by Douville<sup>75</sup> from the Maestrichtian of Persia is quite similar to the Peruvian but has a longer spire and more numerous ribs. *Volutilithes crenulifera* Bayan is an Eocene species referred to *Volutocorbis* by Cossmann<sup>76</sup>. A

<sup>74</sup> Douville, H.: *Mission Scientifique en Perse par J. de Morgan*, Études Géologiques, pt. 4, Paléontologie, 1904, p. 288, pl. 40, fig. 4.

<sup>75</sup> Douville, H.: *Loc. cit.*, p. 290, pl. 40, figs. 8, 9.

<sup>76</sup> Cossmann, M.: *Essais de Paléoconchologie comparée*, vol. 3, 1899, p. 138.

*Volutocorbis* figured by White<sup>77</sup> and referred to the Indian species *Volutilithes radula* Forbes from Pernambuco, eastern Brazil is perhaps a lower Eocene form.

*Type*.—Paleontological Research Institution, No. 4955.

*Occurrence*.—*Baculites* zone.

Genus **VOLUTA** Linné

***Voluta inca***, n. sp.

Plate 9, fig. 8

The shell is rather large, solid, with a shouldered body whorl and a medium high, conic spire; nucleus is missing, the spire whorls are sculptured with about 10 ribs which extend as low, narrow folds between the sutures; on the body whorl, these ribs occur on the shoulder angle only where they are large and prominent; general surface of shell smooth except for a few faint spirals bordering the upper suture; outer lip broken and columellar pillar concealed by matrix.

Length, 72.75 mm. (imperfect); diameter, 50.30 mm.

The type, the only specimen known, has a broken lip and the columella is covered with a film of rock matrix which cannot be removed. In form, however, the shell is distinctly volutid and there is little doubt that it belongs to this family.

*Type*.—Paleontological Research Institution, No. 4956.

*Occurrence*.—*Baculites* zone.

Genus **LYRIA** Gray

***Lyria concha***, n. sp.

Plate 15, figs. 6, 7

Shell relatively small, solid, fusiform with a high spire and long aperture and canal; nucleus not preserved; spire whorls (five remaining on the type) have a low, convex form between strong, sinuous sutures; the surface texture appears solid, smooth, except for a series of strong ribs which number about eight on the last whorl; the ribs begin at the upper suture and extend across the base fading out on the canal; anterior canal, long, solid, the growth lines at the end becoming crowded and by their sinuous course show that the tip of the canal carried a small but

<sup>77</sup> White, C. A.: *Contributions to the paleontology of Brazil*, Arquivos do Museu Nacional do Rio de Janeiro, vol. 7, 1888, p. 126, pl. 10, figs. 15, 16, 17.

strong, siphonal sinus; columella straight with three small folds.

Length, 17.5 mm.; diameter, 9.1 mm.

Although fairly common, our specimens are all imperfect. One small shell shows three small, but distinct folds on the columella. The axial sculpture is formed by a series of slightly curved fold-like ribs, but the surface of the shell as a whole is smooth.

*Types*.—Paleontological Research Institution, Nos. 4957, 4958.

*Occurrence*.—Tortuga.

Class **CEPHALOPODA**

Subclass **TETRABRANCHIATA**

Order **AMMONOIDEA**

Suborder **EXTRASIPHONATA**

Family **BACULITIDÆ**

Genus **BACULITES** Lamarck

**Baculites lyelli** d'Orbigny

Plate 16, figs. 3-5

*Baculites Lyelli* d'Orbigny, 1847, Voyage au Pole Sud et dans l'Océanie sur les corvettes L'Astrolabe et La Zélee pendant les années 1837-1838-1839-1840 sous le commandement de M. Dumont-d'Orville capitaine de vaisseau. Geologie Atlas, pl. 4, figs. 3-7.

Fragments of a large baculite are common in the Upper Breccia or *Baculites* zone and this notice is probably the first record of the occurrence of species of this genus in Peru. *Baculites* has been repeatedly recorded from the Upper Cretaceous of Chile and Argentina. Darwin obtained specimens from Tomé in the Bay of Concepción which were figured by Forbes<sup>78</sup> in the Appendix to Darwin's Geological Observations who referred them to the Indian species, *Baculites vagina*. About the same time other specimens, which were collected by members of a French expedition, were beautifully figured by D'Orbigny as *Baculites Lyelli* and *ornatus* in the plates of the Voyage of the Astrolabe but without accompanying description and their exact locality is not known. The Chilian species has been carefully studied

<sup>78</sup> Forbes, E.: *Descriptions of secondary fossil shells from South America*, Appendix to Part 2 of Darwin's, *Geological Observations*, 1846, pl. 5, fig. 3.

by Steinmann<sup>79</sup> and later by Wilckens<sup>80</sup>, both authors followed Forbes in referring the South American forms to the Indian species. This view was also shared by Kossmat<sup>81</sup>. The most recent studies of this group is by Paulcke<sup>82</sup> who separated two species mainly from characters of the suture lines, referred one form to the European *Baculites* cf. *anceps* Lamarck and described the other as *Baculites vagina* var. *cazadorianus*. Another baculite has been described by Weaver<sup>83</sup> as *Baculites argentinicus*. Weaver's two specimens were very fragmentary and are said to have been collected together with a typical Roca molluscan fauna containing *Cardita beaumonti*. Weaver considered his species most closely related to *anceps* but made no comparison with the other described South American forms. Gerth<sup>84</sup> considered Weaver's collection as containing a mixed Roca and Malargue fauna.

D'Orbigny's beautiful figures of *Baculites lyelli* and *ornatus* are apparently restorations. *Baculites ornatus* differs from *lyelli* by its stronger sculpture, each rib being binodal and the siphonal side is wider or more flangelike. There are also differences in the sutures, the most striking being a lower, wider or more spreading siphonal saddle and narrower first lateral lobe. These differences would seem sufficient to establish these two forms as good species. Sutures of the Chilean baculite figured by Steinmann<sup>85</sup> as *Baculites vagina* are essentially similar to *lyelli* and to

<sup>79</sup> Steinmann, G.: *Die Cephalopoden der Quiriquina-Schichten*, N. Jahrb. Min., BB. vol. 10, 1895, p. 89, taf. 6, figs. 4a, 4b, 4c, 4d, and 4e; also text figures 8-12.

<sup>80</sup> Wilckens, O.: *Revision der Fauna der Quiriquina-Schichten*, N. Jahrb. Min., BB. vol. 18, 1904, p. 188.

<sup>81</sup> Kossmat, F.: *The Cretaceous deposits of Pondicherry*, Records, Geological Survey of India, vol. 30, 1897, pt. 2, p. 73.

<sup>82</sup> Paulcke, W.: *Die Cephalopoden der oberen Kreide Südpatagoniens*, Berichten der Naturforschenden Gesellschaft zu Freiburg i. Br. Band 15, 1906, pp. 10, 11, pl. 16, figs. 5, 5a, 5b, 6, 6a.

<sup>83</sup> Weaver, P.: *Roca formation in Argentina*, Amer. Jour. Sci., ser. 5, vol. 13, pp. 429-434, figs. 2a-c; also 1931, *Paleontology of the Jurassic and Cretaceous of west central Argentina*, Univ. of Washington, Mem., No. 1, 1927, pp. 466-467, pl. 62, figs. 401, 402, 403.

<sup>84</sup> Gerth, H.: *Geologie Südamerikas*, vol. 2, 1935, p. 327.

<sup>85</sup> Steinmann, G.: *Loc. cit.*

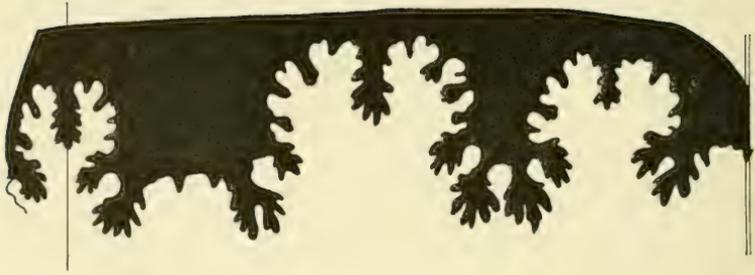


Fig. 1. Sutures of *Baculites lyelli* d'Orbigny. Drawn from specimen on Plate 16, figure 2.

our specimens from Peru, and it is evident that they all belong to the same species. Both the Chilian and Peruvian forms have a long narrow medially divided siphonal saddle bordered by a wide lateral lobe. The sutures of typical *Baculites vagina* from India as figured by Forbes and Kossmat, taking into account minor differences probably due to age, show a general likeness to the South American species and thus indicate a real relationship between these widely separated forms. However, there are definite differences in sculpture. Although Kossmat<sup>86</sup> considered the Indian and South American forms as one species, he also noted these differences as may be seen from his quotation: "The Chilian *Baculites vagina* is recognizable by the fact that the swellings of the ribs are a little nearer to the siphonal part of the shell than in the Indian type, for this reason the section appears to be more oval. This peculiarity may be constant as I observed it also in Chilian *Baculites* of this species in the British Museum but I did not attach much value to it then as the specimens in question were not adults," (p. 73). Until abundant material from South America and India are available for detailed study and evaluation of all characters, it seems best to consider these differences as specific and to restrict the use of the name *vagina* to the Indian forms. The South American forms must therefore take D'Orbigny's name *lyelli*.

Our specimens are mostly fragments of the living chamber with a pebbly matrix filling the interior. Two fragments of the

<sup>86</sup> Kossmat, F.: *Loc. cit.*

same individual when united have a length of 330 millimeters and a diameter of 40 millimeters at the larger end. The section of the conch is subtrigonal, the immature portion has more convex sides than the adult. The antisiphonal side is flattened to depressed in the middle but as the result of compression the sides are usually distorted. The surface sculpture consists of strong, foldlike ribs or swellings on the siphonal side of the middle, over which the lines of growth cross in an oblique, coarse fashion. These characters in our specimens seem to be constant.

*Figured Specimens.*—Paleontological Research Institution, Nos. 4960, 4961.

*Occurrence.*—*Baculites* zone.

Family **TURRILITIDÆ**

Genus **TURRILITES** Lamarck

*Turrilites peruvianus*, n. sp.

Plate 17, fig. 4

*Helicoceras*, sp., Olsson, 1934, *The Cretaceous of the Amotape Region*, *op. cit.*, p. 73, pl. 10, fig. 6.

A single specimen from the *Baculites* zone is a fragment preserving the last turn. It is the same species as previously recorded from Monte Grande as *Helicoceras*, sp. Coiling sinistral, loose; sculpture consisting of two rows of spinelike nodes, the superior set placed a little above the middle, the lower set on the outer border of the base; above and between these rows, the surface is smooth; there are a few irregular ribs which near the aperture cross the face of the whorl but they are generally present only in the umbilical area.

Height of fragment, 25 mm.; diameter, 31 mm.

*Type.*—Paleontological Research Institution, No. 4870.

*Occurrence.*—*Baculites* zone.

Family **DESMOCERATIDÆ**

Genus **PARAPACHYDISCUS** Hyatt

*Parapachydiscus*, sp.

Plate 16, fig. 1

Our single specimen, a fragment of the last whorl, has a diameter of 89 mm. The shell is strongly compressed, its thickness

being only about 20 mm. The ornamentation consists of ribs of two sizes; a primary set extends from the umbilical angle to the middle of the venter and numbers about 10 to a half turn and a shorter secondary set, usually one, sometimes two in each primary interspace strengthen the sculpture in the peripheral portion.

The form and sculpture of this *Parapachydiscus* are similar to certain species from the *Sphenodiscus* beds of eastern Brazil described by Maury<sup>87</sup> amongst which may be mentioned the *Parapachydiscus dossantosi* and *endymion*. No trace of the suture lines are preserved on our specimen.

*Specimen figured*.—Paleontological Research Institution, No. 4962.

*Occurrence*.—*Baculites* zone.

Family **ENGONOCERATIDÆ**

Genus **COAHUILITES** Böse

Subgenus **AUSTROSPHENODISCUS**, new subgenus

*Genotype*.—*Sphenodiscus pleurisepta* Conrad var. *peruviana* Gerth

The following is a description of the subgenus *Austrosphenodiscus*:

Shell sphenodiscoid with a sharply keeled venter; suture is like *Coahuilites* in having the external saddle divided into two

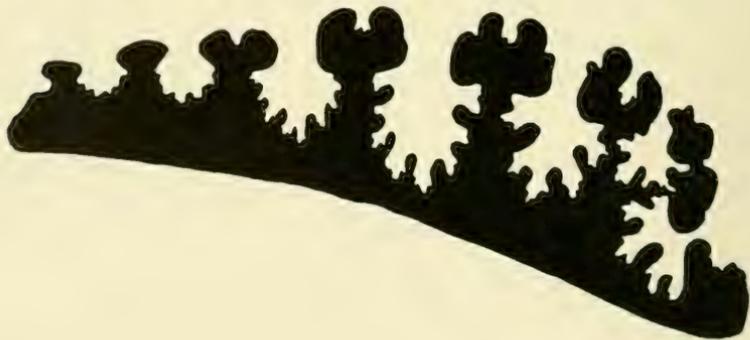


Fig. 2. Sutures of *Coahuilites* (*Austrosphenodiscus*) *peruviana* Gerth.  
Taken from specimen figured on Plate 17, figure 1.

<sup>87</sup> Maury, C.: *Cretaceo da Parahyba do Norte*, Serviço Geológico e Mineralógico do Brasil, Monographia No. 8, 1930.

(not three) branches by an adventitious lobe which is nearly as deep as the lateral lobe; in addition, the first branch or adventitious saddle is again subdivided into two secondary branches; saddles with phylloid ends.

*Remarks.*—The suture, here figured, was drawn from the specimen illustrated on Plate 17, fig. 1. Its pattern is essentially similar to that shown in Gerth's drawing (fig. 4, p. 238). The external saddle is divided into two branches by a deep lobe which nearly equals the lateral lobe in width and depth. This character is typical of *Coahuilites*<sup>88</sup> (genotype *Coahuilites sheltoni* Böse) from the lower Escondido of northern Mexico while in true *Sphenodiscus* Meek there are three adventitious branches in the external saddle. In addition, this species shows the peculiarity of having the first branch further subdivided by a smaller sub-adventitious lobe into two smaller branches, the ventral arm of which is sharply inclined towards the venter. This character is not only constant for the Peruvian species but is shared by an undescribed species in our collection from the Lower Umir of Colombia and consequently has more than specific value. The different branches of the external saddle are indented by several short lobes, the saddles having phylloid outlines.

Typical *Coahuilites* is known from several localities in beds of lower Maestrichtian or Campanian age in Colombia and Venezuela. According to Hedberg<sup>89</sup>, *Coahuilites* on basis of specimens identified by Spath, occurs in the Rio de Oro formation of north-eastern Colombia. An undescribed species has been collected from the Mito Juan of Tachira and several crushed specimens which may belong to *Coahuilites* are known from the lower Umir of the Magdalena Valley.

**Coahuilites (Austrosphenodiscus) peruviana** Gerth Plate 17, figs. 1, 2  
*Sphenodiscus pleurisepta* Conrad var. *peruviana* Gerth, 1928, Leidsehe  
 geol. Mededeel., deel 2, pp. 237, 238, text fig. 4.

This species is represented in our collection by two specimens,

<sup>88</sup> Böse, E.: *Cretaceous ammonites from Texas and northern Mexico*, Univ. of Texas, Bull. No. 2748, 1927, pp. 279-283.

<sup>89</sup> Hedberg, H. D., and Sass., L. C.: *Synopsis of the geologic formations of the western part of the Maracaibo Basin, Venezuela*, Boletín de Geología y Minería, Caracas, Venezuela tomo 1, 1938, p. 86.

the larger and more perfect one being here figured. This shell measures as follows:

Greater diameter, 86 mm. (partly restored)

Lesser diameter, 66 mm.

Thickness in umbilical region, 15 mm.

Height of whorl, 53.5 mm.

The shell is discoidal, laterally compressed, very involute and with a sharply angled or keeled venter. The surface is smooth with no indication of nodes or ribs. Cross section of the last whorl is narrowly lenticular, a little wider on the umbilical side of the middle; umbilical region is not noticeably impressed; suture as described above.

*Remarks.*—Gerth in his discussion of this species stated that his collection contained 80 specimens, represented mostly by fragments of the living chamber but also included a few perfect individuals. Gerth considered *peruviana* as a variety of the Texan *Sphenodiscus pleurisepta* Conrad basing his opinion largely from the ribbed sculpture of many specimens. According to our studies on material from the same locality, the ribbed forms belong entirely to the new genus described here as *Paciceras*. Eliminating these forms, the few remaining specimens belong to a smooth species with a narrow cross section. The sutural pattern of this species agrees with that described by Gerth for *peruviana*. It is obvious that *peruviana* is not closely related to *Sphenodiscus pleurisepta*.

*Specimen.*—Paleontological Research Institution, No. 4867.

*Occurrence.*—Basal or *Sphenodiscus* beds, La Mesa.

Genus **PACICERAS**, new genus

Genotype.—*Paciceras pacificum*, n. sp.

The following is a description of the genus *Paciceras*:

Sphenodiscoid, involute with a sharply keeled venter and small umbilicus; umbilical region impressed, bordered by a circle of small nodes or stronger ribs; sutural pattern relatively simple; the umbilical saddles are fairly numerous with flattened to rounded summit outlines, the separating lobes shallow and weakly toothed; the lateral saddle wide, bipartite, divided by an ad-

ventitious lobe; lateral lobe moderately deep and strongly toothed.

*Remarks.*—This genus is closely related to *Lybicoceras*<sup>90 91</sup> (genotype *Sphenodiscus Ismaeli* Zittell)<sup>92</sup> from the Maestrichtian of the Libyan desert and of which two species are known. The main differences are in the sutural pattern. In *Paciceras* the siphonal saddle is less deeply divided by the adventitious lobe and the series of umbilical saddles are more flattened. The form and external sculpture are similar.



Fig. 3. Sutures of *Paciceras pacificum*, n. sp.

*Paciceras pacificum*, n. sp.

Plate 17, figs. 9, 10

Adult shell of medium size, strongly involute and thickly lenticular; umbilicus small, deep with the surrounding area strongly impressed and bordered by a circle of small nodes numbering about 14 or 15 to each turn; these nodes may be quite strong or only faintly indicated; a second circle of nodes is sometimes present nearer the venter but otherwise the surface is smooth; venter is sharply angled or keeled; in cross section the outer whorl is broad, its width about half its height as measured from the umbilical center to the ventral edge; sutural pattern as

<sup>90</sup> Hyatt, A.: *Pseudoceratites of the Cretaceous*, Monograph of the U. S. Geol. Survey, vol. 44, 1903, p. 57.

<sup>91</sup> Roman, F.: *Les Ammonites Jurassiques et Crétacées*, Essai de Genéra, 1938, p. 494, pl. 51, figs. 473, 474.

<sup>92</sup> Quass, A.: *Beitrag zur Kenntnis der Fauna der obersten Kreidebildungen in der libyschen Wüste*, Palæontographica, vol. 30, 1902, pp. 302-307, taf. 29, figs. 3-7, and taf. 30, figs. 1, 1a-b.

described for the genus is relatively simple, its most characteristic feature being the low, flat-topped, umbilical saddles and toothed lobes; the inner portion of the suture is not exposed on available material but in the figured pattern, there are six umbilical saddles shown; the lateral lobe is moderately deep and strongly toothed; the lateral saddle is wide and medially divided by a shallow adventitious lobe; siphonal saddle broad, flat.

Greater diameter, 73 mm.; thickness of last whorl, 22 mm.

This is the commonest ammonite in the *Austrosphenodiscus* beds at La Mesa and will be recognized by its form, sculpture and pattern of its suture.

*Type*.—Paleontological Research Institution, No. 4868.

*Occurrence*.—La Mesa.

***Paciceras gerthi***, n. sp.

Plate 16, figs. 6, 7

Adult shell of medium size, involute, more thickly lenticular than *pacificum* and more strongly ribbed venter sharply keeled; umbilical region flatly impressed; the sculpture is formed by a set of medium strength ribs which are developed in the middle zone between the impressed umbilical area and a narrow, smooth band bordering the keeled venter; the ribs would number about 14 to a complete turn and are nodose at the ends; sutural pattern essentially similar to *pacificum*.

Since no perfect specimen is available, the following measurements are partly estimated:

Greater diameter,  $\pm 65$  mm.; height of last whorl, 40.5 mm.; width of last whorl, 21 mm.

*Type*.—Paleontological Research Institution, No. 4963.

*Occurrence*.—La Mesa.

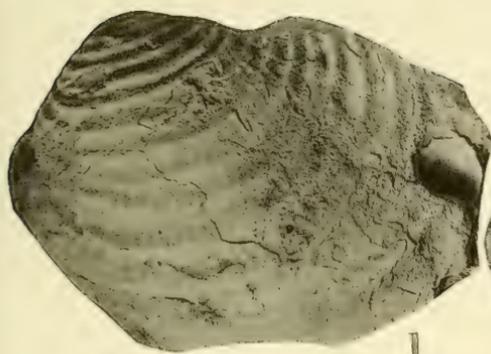
# PLATES

PLATE I (8)

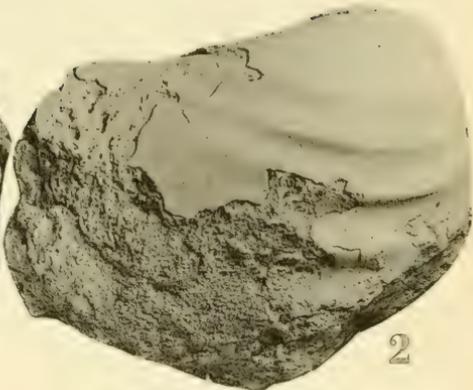
Plates furnished *gratis* by the author ready for insertion.

## EXPLANATION OF PLATE 1 (8)

Figure	Plate
1. <i>Inoceramus</i> , sp. B. ....	39
Length, 110 mm.	
P. R. I., No. 4810.	
<i>Baculites</i> zone.	
2. <i>Inoceramus</i> , sp. A. ....	38
Length, 110 mm.	
P. R. I., No. 4809.	
<i>Baculites</i> zone.	
3. <i>Macrodonax peruviana</i> , n. sp. ....	62
Holotype, length, 118 mm.	
P. R. I., No. 4811.	
<i>Baculites</i> zone.	
4. <i>Macrodonax peruviana</i> , n. sp. ....	62
Drawing of hinge of holotype.	
5. <i>Ostrea palpa</i> , n. sp. ....	40
Holotype, left valve, length, 16 mm.	
P. R. I., No. 4805.	
Tortuga.	
6. <i>Ostrea palpa</i> , n. sp. ....	40
Holotype, right valve.	
Tortuga.	
7. <i>Ostrea (Lopha) sechura</i> , n. sp. ....	41
Holotype, length, 88 mm.	
P. R. I., No. 4804.	
<i>Baculites</i> zone.	
8. <i>Ostrea (Lopha) sechura</i> , n. sp. ....	41
Interior of holotype.	



1



2



3



4



5



7



6



8



PLATE 2 (9)

## EXPLANATION OF PLATE 2 (9)

Figure	Plate
1. <i>Pseudocucullæa gregoryi</i> Olsson .....	31
Length, 140 mm.	
P. R. I., No. 4820.	
<i>Baculites</i> zone.	
2. <i>Pseudocucullæa gregoryi</i> Olsson .....	31
Same specimen as last, figured to show hinge.	
3. <i>Pseudocucullæa paitana</i> , n. sp. ....	31
Holotype, length, 79 mm.	
P. R. I., No. 4821.	
La Mesa.	
4. <i>Pseudocucullæa paitana</i> , n. sp. ....	31
Paratype, length, 71 mm.	
P. R. I., No. 4822.	
La Mesa.	
5. <i>Pseudocucullæa paitana</i> , n. sp. ....	31
Paratype, length, 62 mm.	
P. R. I., No. 4823.	
La Mesa.	
6. <i>Roudaireia peruviana</i> Olsson .....	45
Length, 94 mm.	
P. R. I., No. 4824.	
<i>Baculites</i> zone.	
7. <i>Roudaireia peruviana</i> Olsson .....	45
Length, 72 mm.	
P. R. I., No. 4825.	
<i>Baculites</i> zone.	
8. <i>Icanotia pacifica</i> , n. sp. ....	58
Holotype, length, 76 mm.	
P. R. I., No. 4826.	
<i>Baculites</i> zone.	

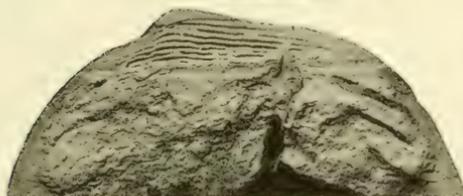
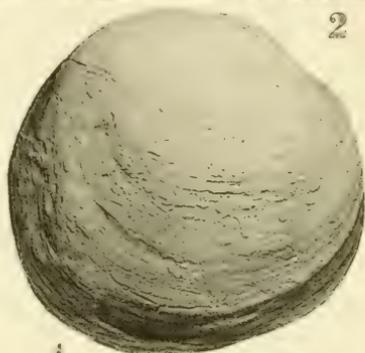
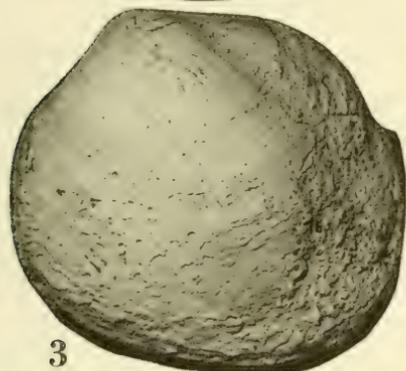




PLATE 3 (10)

## EXPLANATION OF PLATE 3 (10)

Figure	Plate
1. <i>Trigonia hopkinsi</i> , n. sp. ....	43
Holotype, length, 83 mm.	
P. R. I., No. 4819.	
<i>Baculites</i> zone.	
2. <i>Breviarca peruviana</i> , n. sp. ....	35
Paratype, length, 23 mm.	
P. R. I., No. 4815.	
La Mesa.	
3. <i>Periploma nermeta</i> , n. sp. ....	44
Holotype, length, 66.5 mm.	
P. R. I., No. 4818.	
<i>Baculites</i> zone.	
4. <i>Trigonia (Scabrotrigonia) gerthi</i> , n. sp. ....	42
Holotype, length, 56 mm.	
P. R. I., No. 4812.	
<i>Baculites</i> zone.	
5. <i>Trigonia (Scabrotrigonia) gerthi</i> , n. sp. ....	42
Paratype, length, 54 mm.	
P. R. I., No. 4813.	
<i>Baculites</i> zone.	
6. <i>Peruarca pectunculoides</i> , n. sp. ....	33
Holotype, length, 50 mm.	
P. R. I., No. 4817.	
<i>Baculites</i> zone.	
7. <i>Peruarca pectunculoides</i> , n. sp. ....	33
Same specimen as last.	
8. <i>Breviarca peruviana</i> , n. sp. ....	35
Holotype, length, 18 mm.	
P. R. I., No. 4814.	
La Mesa.	
9. <i>Breviarca peruviana</i> , n. sp. ....	35
Paratype, length, 18 mm.	
P. R. I., No. 4816.	
La Mesa.	
10. <i>Trigonia (Scabrotrigonia) gerthi</i> , n. sp. ....	42
Same specimen as figure 5.	

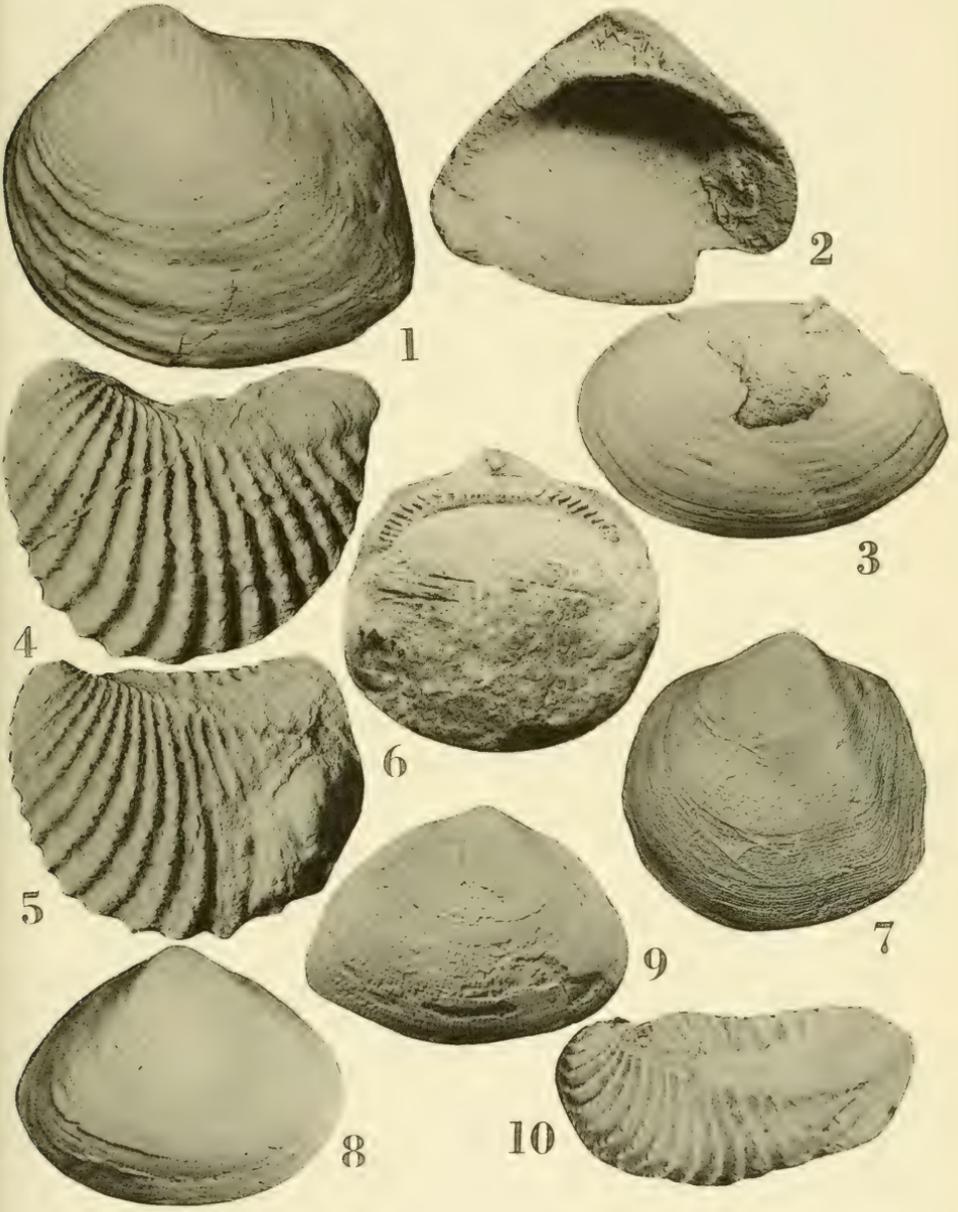




PLATE 4 (II)

## EXPLANATION OF PLATE 4 (11)

Figure	Plate
1. <i>Incanopsis acariformis</i> , n. sp. ....	35
Paratype, length, 17 mm.	
P. R. I., No. 4833.	
Tortuga.	
2. <i>Incanopsis acariformis</i> , n. sp. ....	35
Holotype, length, 17.75 mm.	
P. R. I., No. 4832.	
For exterior of same specimen see Plate 5, fig. 8.	
3. <i>Corbicula meridionalis</i> , n. sp. ....	47
Holotype, length, 37 mm.	
P. R. I., No. 4834.	
Tortuga.	
4. <i>Corbicula meridionalis</i> , n. sp. ....	47
Paratype, figured to show hinge, length, 34 mm.	
P. R. I., No. 4835.	
Tortuga.	
5. <i>Antigona speciosa</i> , n. sp. ....	56
Holotype, length, 21 mm.	
P. R. I., No. 4836.	
Tortuga.	
6. <i>Antigona speciosa</i> , n. sp. ....	56
Paratype, length, 16 mm.	
P. R. I., No. 4838.	
Tortuga.	
7. <i>Antigona speciosa</i> , n. sp. ....	56
Paratype, length, 18 mm.	
P. R. I., No. 4837.	
Tortuga.	
8. <i>Ostrea palpa</i> , n. sp. ....	40
Paratype, length, 34 mm.	
P. R. I., No. 4806.	
Tortuga.	
9. <i>Panopea frailia</i> , n. sp. ....	64
Holotype, length, 98 mm.	
P. R. I., No. 4839.	
10. <i>Ostrea palpa</i> , n. sp. ....	40
Paratype, height or length, 18 mm.	
Figured to show the crenulated margins adjacent to the hinge.	
Tortuga.	

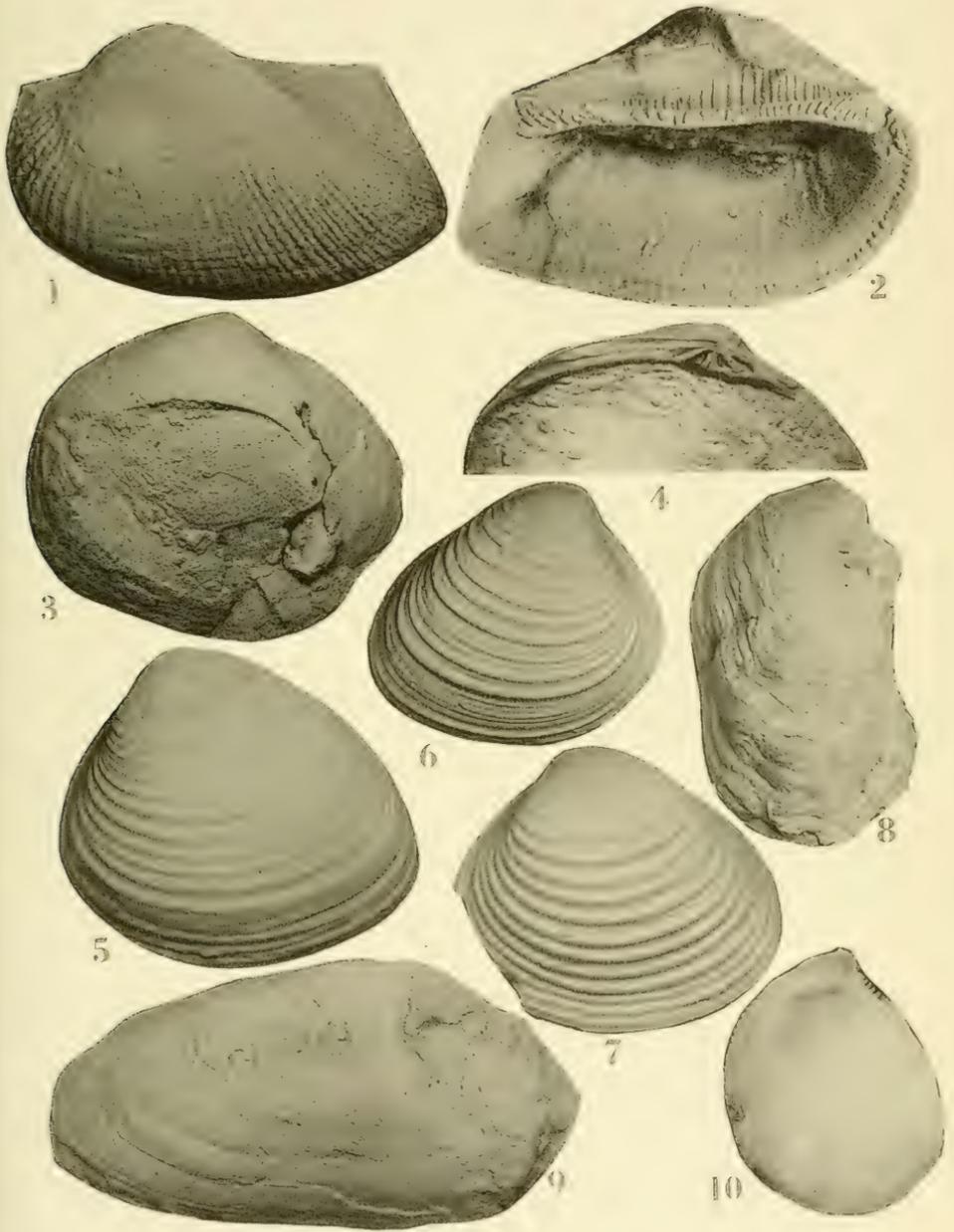




PLATE 5 (12)

## EXPLANATION OF PLATE 5 (12)

Figure	Plate
1. <i>Cardium</i> ( <i>Perucardia</i> ) <i>brüggeni</i> , n. sp. ....	52
Holotype, height, 106 mm.	
P. R. I., No. 4827.	
<i>Baculites</i> zone.	
2. <i>Cardium</i> ( <i>Incardium</i> ) <i>mellisum</i> , n. sp. ....	53
Holotype, length, 34 mm.	
Showing hinge of right valve.	
P. R. I., No. 4830.	
Tortuga.	
3. <i>Cardium</i> ( <i>Perucardia</i> ) <i>brüggeni</i> , n. sp. ....	52
Paratype, length of hinge fragment, 50 mm.	
The broken hinge of the right valve shows only the roots and	
stumps of the strong cardinal and posterior lateral tooth.	
P. R. I., No. 4827a.	
<i>Baculites</i> zone.	
4. <i>Cardium</i> ( <i>Incardium</i> ) <i>mellisum</i> , n. sp. ....	53
Paratype, length, 37.5 mm.	
P. R. I., No. 4831.	
Tortuga.	
5. <i>Cardium</i> ( <i>Perucardia</i> ) <i>brüggeni</i> , n. sp. ....	52
Fragment of shell showing position of spines.	
P. R. I., No. 4828.	
<i>Baculites</i> zone.	
6. <i>Cardium</i> ( <i>Incardium</i> ) <i>mellisum</i> , n. sp. ....	53
Holotype, length, 34 mm.	
P. R. I., No. 4830.	
Tortuga.	
7. <i>Cardium</i> ( <i>Perucardia</i> ) <i>brüggeni</i> , n. sp. ....	52
Paratype, height, 103 mm.	
P. R. I., No. 4829.	
<i>Baculites</i> zone.	
8. <i>Incanopsis</i> <i>acariformis</i> , n. sp. ....	35
Holotype, length, 17.75 mm.	
Same specimen as Plate 4, figure 2.	
P. R. I., No. 4832.	
Tortuga.	

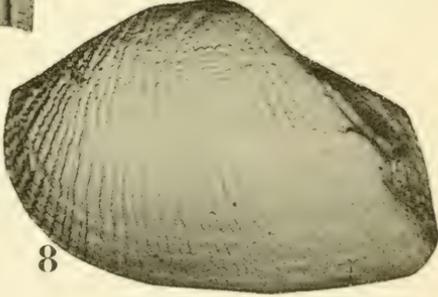
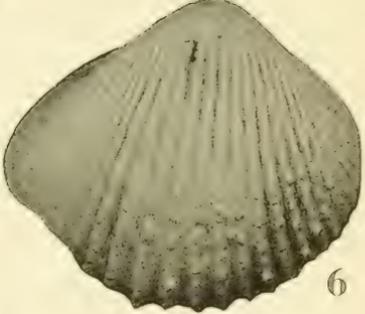
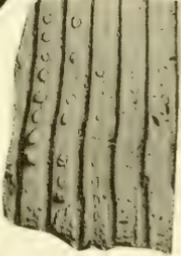
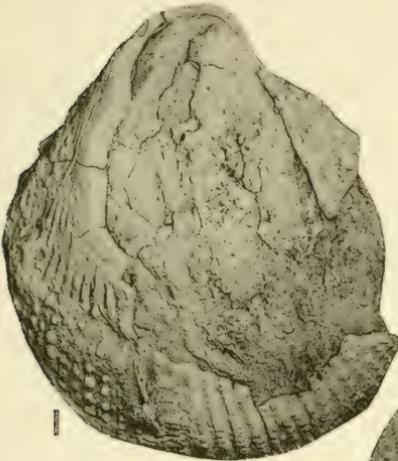




PLATE 6 (13)

13. *Tellidora (Tellipiura) peruana*, n. sp. ----- 63  
Holotype, length, 26 mm.  
P. R. I., No. 4847.  
Tortuga.
14. *Tellidora (Tellipiura) peruana*, n. sp. ----- 63  
Tortuga.
15. *Tellidora (Tellipiura) peruana*, n. sp. ----- 63  
Paratype, length, 22 mm.  
P. R. I., No. 4849.  
Tortuga.
16. *Tellidora (Tellipiura) peruana*, n. sp. ----- 63  
Paratype, length, 25 mm.  
P. R. I., No. 4848.  
Tortuga.

## EXPLANATION OF PLATE 6 (13)

Figure	Plate
1. <i>Corbula broggii</i> , n. sp. ....	65
Holotype, length, 31.50 mm.	
P. R. I., No. 4840.	
<i>Baculites</i> zone.	
2. <i>Corbula broggii</i> , n. sp. ....	65
Same specimen as last.	
3. <i>Corbula broggii</i> , n. sp. ....	65
Same specimen, dorsal view.	
4. <i>Gervilia incertans</i> , n. sp. ....	38
Holotype, length, 30 mm.	
P. R. I., No. 4845.	
Tortuga.	
5. <i>Anatimya</i> , sp. ....	44
Length, 25 mm.	
P. R. I., No. 4850.	
Tortuga.	
6. <i>Anatimya</i> , sp. ....	44
Length, 18 mm.	
P. R. I., No. 4851.	
Tortuga.	
7. <i>Mulinoides chicama</i> , n. sp. ....	61
Holotype, length, 22 mm.	
P. R. I., No. 4852.	
Tortuga.	
8. <i>Corbula tuma</i> , n. sp. ....	65
Paratype, length, 10.5 mm.	
P. R. I., No. 4841.	
Tortuga.	
9. <i>Corbula tuma</i> , n. sp. ....	65
Paratype, length, 10 mm.	
P. R. I., No. 4842.	
Tortuga.	
10. <i>Corbula tuma</i> , n. sp. ....	65
Holotype, length, 11 mm.	
P. R. I., No. 4843.	
Tortuga.	
11. <i>Corbula tuma</i> , n. sp. ....	65
Paratype, length, 10 mm.	
P. R. I., No. 4844.	
Tortuga.	
12. <i>Legumen peruvianum</i> , n. sp. ....	58
Impression of the left valve.	
Holotype, length, 41 mm.	
P. R. I., No. 4846.	
Tortuga.	

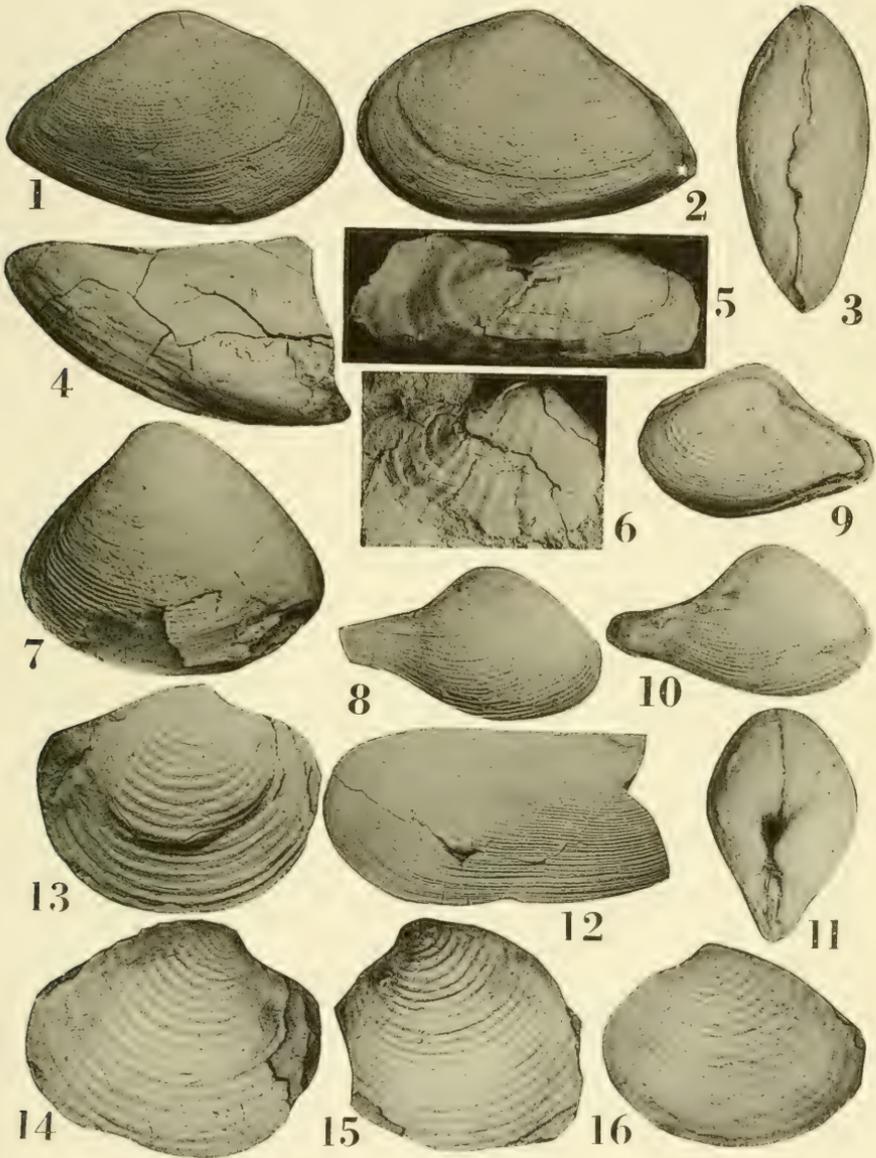




PLATE 7 (14)

## EXPLANATION OF PLATE 7 (14)

Figure	Plate
1. <i>Aphrodina pacifica</i> , n. sp. ....	54
Holotype, length, 68 mm.	
P. R. I., No. 4857.	
<i>Baculites</i> zone.	
2. <i>Aphrodina pacifica</i> , n. sp. ....	54
Same specimen as last.	
3. <i>Aphrodina</i> ( <i>Sechurina</i> ) <i>australis</i> , n. sp. ....	57
Paratype, length, 86 mm.	
P. R. I., No. 4859.	
<i>Baculites</i> zone.	
4. <i>Mulinoides chilca</i> , n. sp. ....	61
Paratype, figured to show lunule.	
P. R. I., No. 4856.	
<i>Baculites</i> zone.	
5. <i>Aphrodina</i> ( <i>Sechurina</i> ) <i>australis</i> , n. sp. ....	57
Holotype, length, 68 mm.	
P. R. I., No. 4858.	
<i>Baculites</i> zone.	
6. <i>Aphrodina</i> ( <i>Sechurina</i> ) <i>australis</i> , n. sp. ....	57
Same specimen as figure 3.	
7. <i>Mulinoides chilca</i> , n. sp. ....	61
Holotype, length, 51 mm.	
P. R. I., No. 4854.	
<i>Baculites</i> zone.	
8. <i>Mulinoides chilca</i> , n. sp. ....	61
Paratype, length of hinge portion figured, 32 mm.	
P. R. I., No. 4855.	
<i>Baculites</i> zone.	
9. <i>Mulinoides chilca</i> , n. sp. ....	61
Paratype, length of hinge portion figured, 34 mm.	
P. R. I., No. 4856.	
<i>Baculites</i> zone.	

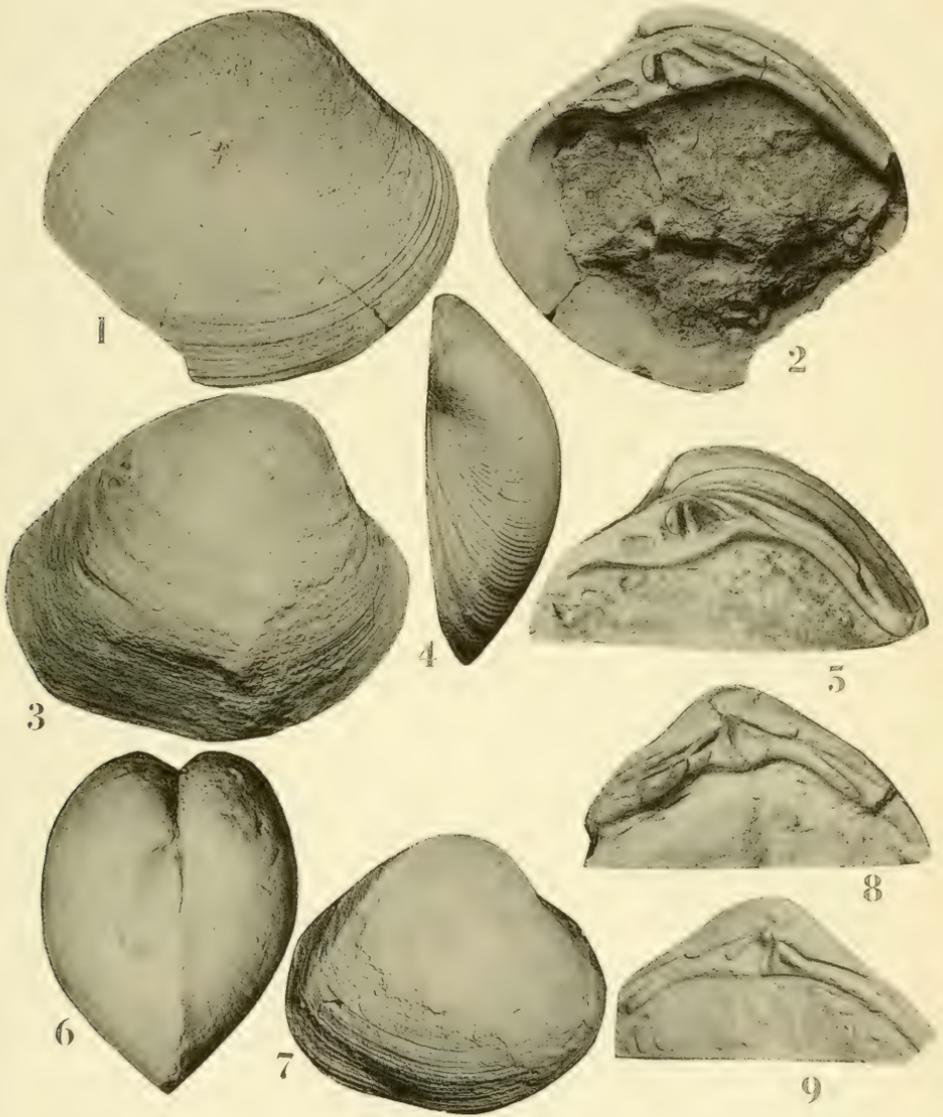
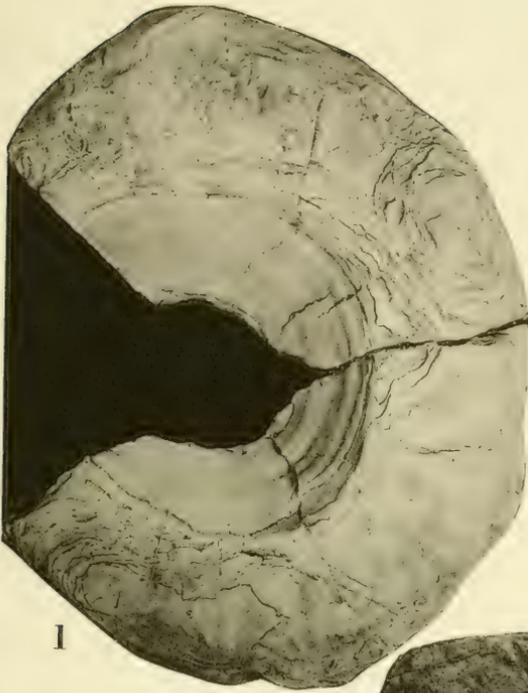




PLATE 8 (15)

## EXPLANATION OF PLATE 8 (15)

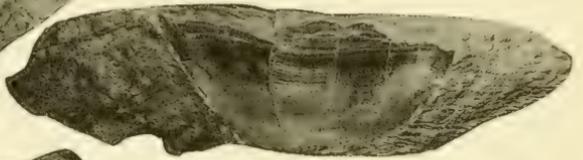
Figure	Plate
1. <i>Sauvagesia peruviana</i> , n. sp. ....	48
Holotype, greater diameter, 340 mm.	
P. R. I., No. 4800.	
Radiolite sandstone, Tortuga.	
2. <i>Sauvagesia peruviana</i> , n. sp. ....	48
Lower side of a separated plate from the outer wall, length,	
170 mm.	
P. R. I., No. 4801.	
Same locality.	
3. <i>Sauvagesia peruviana</i> , n. sp. ....	48
End view of lower fragment of the holotype showing the	
low growth form and section of body cavity.	
4. <i>Sauvagesia peruviana</i> , n. sp. ....	48
Paratype, length, 165 mm.	
A smaller, colonial form.	
P. R. I., No. 4802.	
5. <i>Sauvagesia peruviana</i> , n. sp. ....	48
Separated individual, probably once colonial, length, 115 mm.	
P. R. I., No. 4803.	
Radiolite sandstone, Tortuga.	



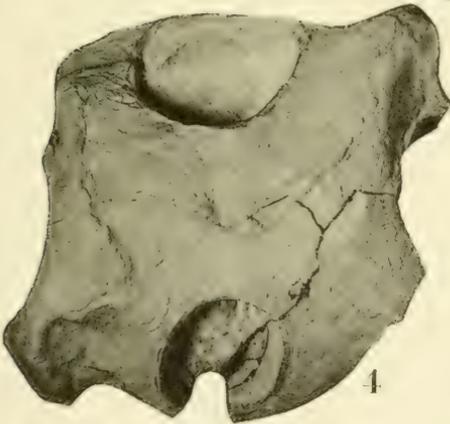
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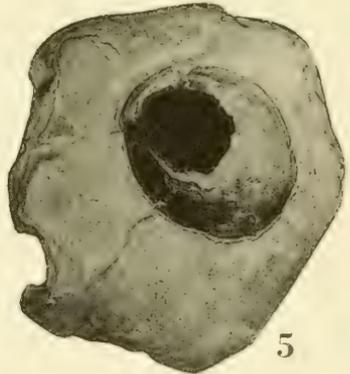
2



3



4



5



PLATE 9 (16)

12. *Calyptræa aperta* Solander ..... 90  
Greater diameter, 25.5 mm.  
P. R. I., No. 4935.  
Tortuga.
13. *Calyptræa aperta* Solander ..... 90  
Greater diameter, 35 mm.  
P. R. I., No. 4936.  
Tortuga.
14. *Volutocorbis meridionalis*, n. sp. .... 102  
Holotype, length, 35.5 mm.  
P. R. I., No. 4955.  
*Baculites* zone.
15. *Fusinus? corbis*, n. sp. .... 101  
Holotype, length, 49 mm.  
P. R. I., No. 4952.  
*Baculites* zone.

## EXPLANATION OF PLATE 9 (16)

Figure	Plate
1. <i>Ampullina tortuga</i> , n. sp. ....	97
Holotype, length, 56 mm.	
P. R. I., No. 4947.	
Tortuga.	
2. <i>Ampullina breccia</i> , n. sp. ....	97
Holotype, length, 58 mm.	
P. R. I., No. 4944.	
<i>Baculites</i> zone.	
3. <i>Ampullina breccia</i> , n. sp. ....	97
Paratype, length, 41 mm.	
P. R. I., No. 4945.	
Tortuga.	
4. <i>Ampullina breccia</i> , n. sp. ....	97
Paratype, length, 47 mm.	
P. R. I., No. 4946.	
Tortuga.	
5. <i>Ampullina cumara</i> , n. sp. ....	98
Holotype, length, 29.5 mm.	
P. R. I., No. 4948.	
Tortuga.	
6. <i>Nerita jayanca</i> , n. sp. ....	67
Paratype, height, 8.25 mm.	
P. R. I., No. 4876.	
Tortuga.	
7. <i>Nerita jayanca</i> , n. sp. ....	67
Holotype, height, 8 mm.	
P. R. I., No. 4875.	
Tortuga.	
8. <i>Voluta inca</i> , n. sp. ....	103
Holotype, height, 72.75 mm.	
P. R. I., No. 4956.	
<i>Baculites</i> zone.	
9. <i>Tectus tschudi</i> , n. sp. ....	66
Holotype, height, 18.5 mm.	
P. R. I., No. 4874.	
<i>Baculites</i> zone.	
10. <i>Calyptrea aperta</i> Solander .....	90
Greater diameter, 24 mm.	
P. R. I., No. 4934.	
Tortuga.	
11. <i>Calyptrea aperta</i> Solander .....	90
Greater diameter, 24 mm.	
P. R. I., No. 4937.	
Eocene, Parinas sandstones, Keswich Hills, Negritos.	

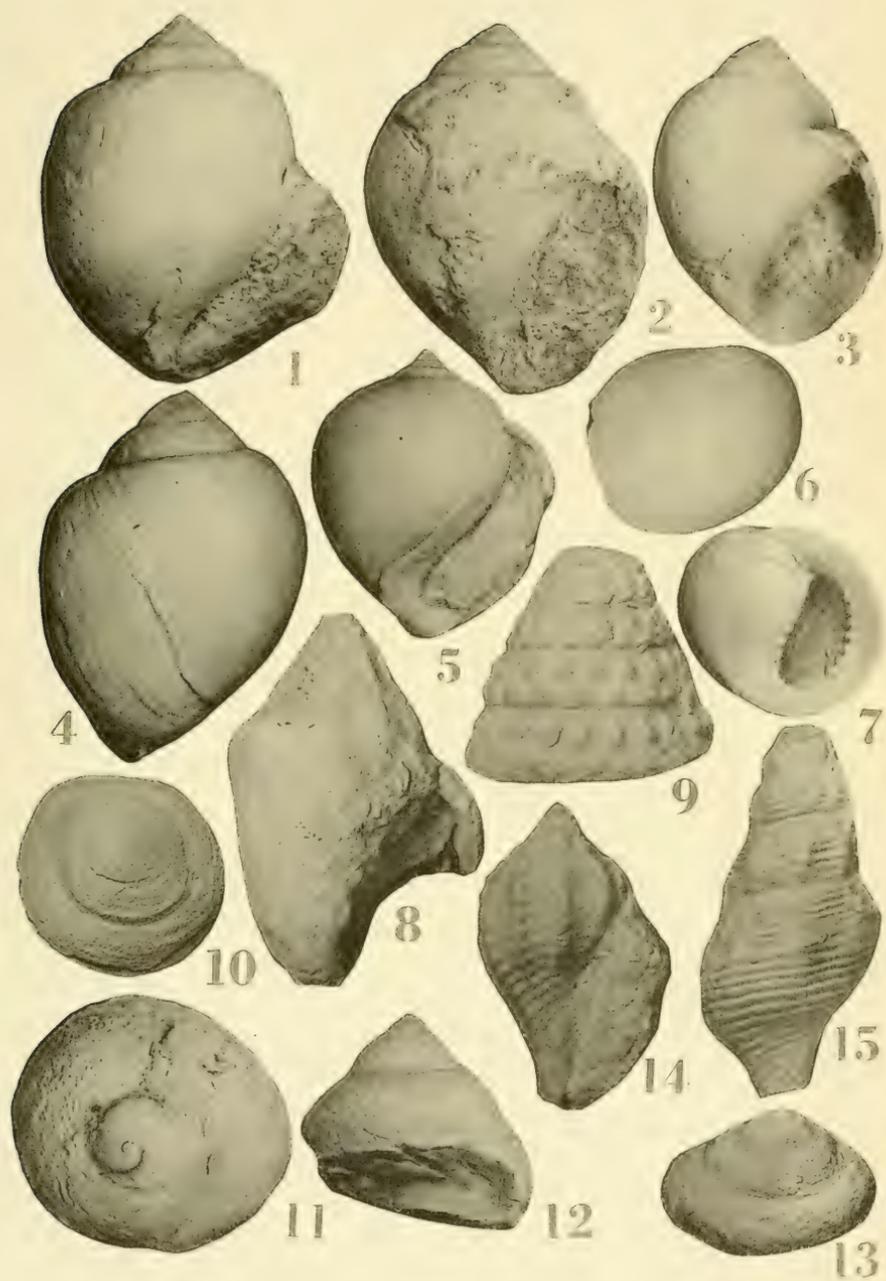




PLATE 10 (17)

12. *Turritella sapos*, n. sp. .... 71  
Paratype, length, 19.75 mm.  
P. R. I., No. 4891.  
Tortuga.
13. *Turritella prechira*, n. sp. .... 72  
Holotype, length, 31 mm.  
P. R. I., No. 4892.  
La Mesa.

## EXPLANATION OF PLATE 10 (17)

Figure	Plate
1. <i>Mesalia janja</i> , n. sp. ....	68
Holotype, length, 25 mm.	
P. R. I., No. 4879.	
Tortuga.	
2. <i>Mesalia janja</i> , n. sp. ....	68
Paratype, length, 25.5 mm.	
P. R. I., No. 4880.	
Tortuga.	
3. <i>Mesalia janja</i> , n. sp. ....	68
Paratype, length, 27 mm.	
P. R. I., No. 4881.	
Tortuga.	
4. <i>Turritella sapos</i> a, n. sp. ....	71
Holotype, length, 26 mm.	
P. R. I., No. 4887.	
Tortuga, lower zone.	
5. <i>Turritella lama</i> , n. sp. ....	70
Holotype, length, 25 mm.	
P. R. I., No. 4884.	
Tortuga.	
6. <i>Turritella sapos</i> a, n. sp. ....	71
Paratype, length, 24.5 mm.	
P. R. I., No. 4888.	
Tortuga.	
7. <i>Turritella sapos</i> a, n. sp. ....	71
Paratype, length, 21 mm.	
P. R. I., No. 4889.	
Tortuga.	
8. <i>Turritella lama</i> , n. sp. ....	70
Paratype, length, 19.5 mm.	
P. R. I., No. 4885.	
Tortuga.	
9. <i>Turritella sapos</i> a, n. sp. ....	71
Paratype, length, 18.5 mm.	
P. R. I., No. 4891a.	
Tortuga.	
10. <i>Turritella lama</i> , n. sp. ....	70
Paratype, length, 18 mm.	
P. R. I., No. 4886.	
Tortuga.	
11. <i>Turritella sapos</i> a, n. sp. ....	71
Paratype, length, 21 mm.	
P. R. I., No. 4890.	
Tortuga.	

PLATE 11 (18)

12. *Turritella parinensis*, n. sp. ----- 75  
Holotype, same specimen as figure 2, slightly different view  
to show the form of the growth lines.
13. *Sechuritella chacapoya*, n. sp. ----- 77  
Paratype, length, 41 mm.  
P. R. I., No. 4909.  
*Baculites* zone.
14. *Sechuritella terebracincta*, n. sp. ----- 77  
Paratype, length, 62 mm.  
P. R. I., No. 4907.  
*Baculites* zone.
15. *Turritella ceiba*, n. sp. ----- 72  
Holotype, length, 114 mm.  
P. R. I., No. 4894.  
*Baculites* zone.

## EXPLANATION OF PLATE 11 (18)

Figure	Plate
1. <i>Turritella parinensis</i> , n. sp. ....	75
Paratype, length, 46 mm.	
P. R. I., No. 4898.	
Cabo Blanco (Parinas sandstones).	
2. <i>Turritella parinensis</i> , n. sp. ....	75
Holotype, length, 52.5 mm.	
P. R. I., No. 4897.	
Parinas sandstones, Parinas Point.	
3. <i>Woodsalia paitana robusta</i> , n. subsp. ....	70
Paratype, length, 42.5 mm.	
P. R. I., No. 4899.	
Tortuga.	
4. <i>Sechuritella chacapoya</i> n. sp. ....	77
Holotype, length, 54 mm.	
P. R. I., No. 4908.	
<i>Baculites</i> zone.	
5. <i>Woodsalia paitana</i> , n. sp. ....	69
Holotype, length, 47 mm.	
P. R. I., No. 4882.	
Tortuga.	
6. <i>Turritella ceiba</i> , n. sp. ....	72
Paratype, length, 33 mm.	
P. R. I., No. 4893.	
<i>Baculites</i> zone.	
7. <i>Sechuritella terebracincta</i> , n. sp. ....	77
Paratype, length, 60 mm.	
P. R. I., No. 4903.	
<i>Baculites</i> zone.	
8. <i>Sechuritella terebracincta</i> , n. sp. ....	77
Paratype, length, 35 mm.	
P. R. I., No. 4904.	
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9. <i>Woodsalia paitana robusta</i> , n. subsp. ....	70
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P. R. I., No. 4883.	
Tortuga.	
10. <i>Sechuritella terebracincta</i> , n. sp. ....	77
Holotype, length, 43 mm.	
P. R. I., No. 4905.	
<i>Baculites</i> zone.	
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Paratype, length, 28 mm.	
P. R. I., No. 4906.	
<i>Baculites</i> zone.	

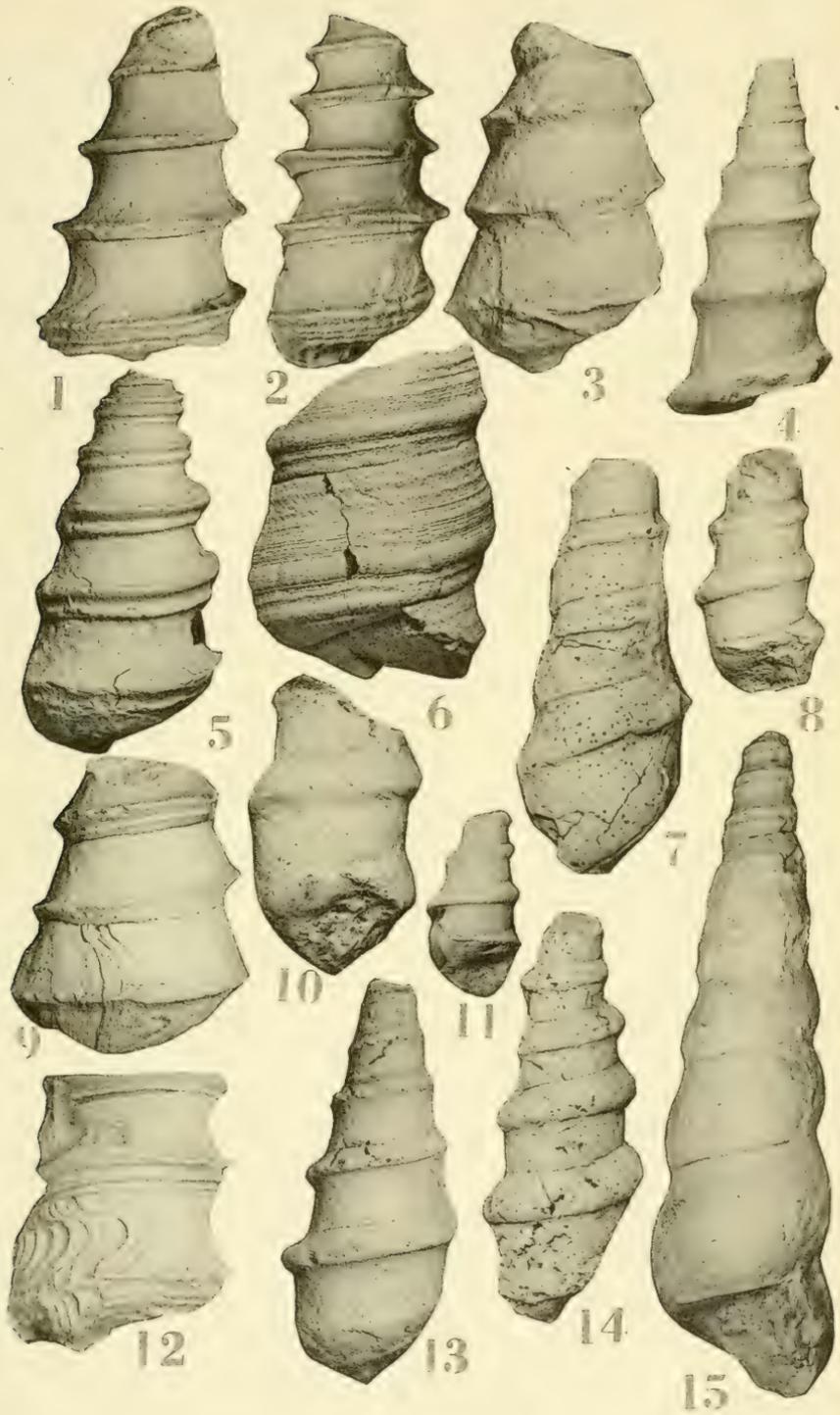




PLATE 12 (19)

13. *Glorioclava inca*, n. sp. ----- 86  
    Holotype, length, 37 mm.  
    P. R. I., No. 4925.  
    Tortuga.
14. *Nodifaunus costatus*, n. sp. ----- 85  
    Holotype, length, 31 mm.  
    P. R. I., No. 4923.  
    Tortuga.
15. *Stalioa agnia*, n. sp. ----- 67  
    Paratype, length, 3 mm.  
    P. R. I., No. 4877.  
    Tortuga.
16. *Stalioa agnia*, n. sp. ----- 67  
    Holotype, length, 3 mm.  
    P. R. I., No. 4878.  
    Tortuga.
17. *Pseudomelania simplex*, n. sp. ----- 66  
    Holotype, length, 18 mm.  
    P. R. I., No. 4873.  
    Tortuga.

## EXPLANATION OF PLATE 12 (19)

Figure	Plate
1. <i>Previcarya peruviana</i> , n. sp. ....	87
Holotype, length, 35 mm.	
P. R. I., No. 4926.	
Tortuga.	
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Paratype, length, 36.5 mm.	
P. R. I., No. 4927.	
Tortuga.	
3. <i>Previcarya peruviana</i> , n. sp. ....	87
Paratype, length, 24 mm.	
P. R. I., No. 4928.	
Tortuga.	
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P. R. I., No. 4929.	
Tortuga.	
5. <i>Stalioa agnia</i> , n. sp. ....	67
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P. R. I., No. 4877.	
Tortuga.	
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P. R. I., No. 4920.	
Tortuga.	
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P. R. I., No. 4910.	
Tortuga.	
9. <i>Nodifaunus costatus</i> , n. sp. ....	85
Paratype, length, 23 mm.	
P. R. I., No. 4924.	
Tortuga.	
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Paratype, length, 26 mm.	
P. R. I., No. 4921.	
Tortuga.	
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12. <i>Nodifaunus nodosus</i> , n. sp. ....	84
Paratype, length, 11.25 mm., young.	
P. R. I., No. 4922.	
Tortuga.	

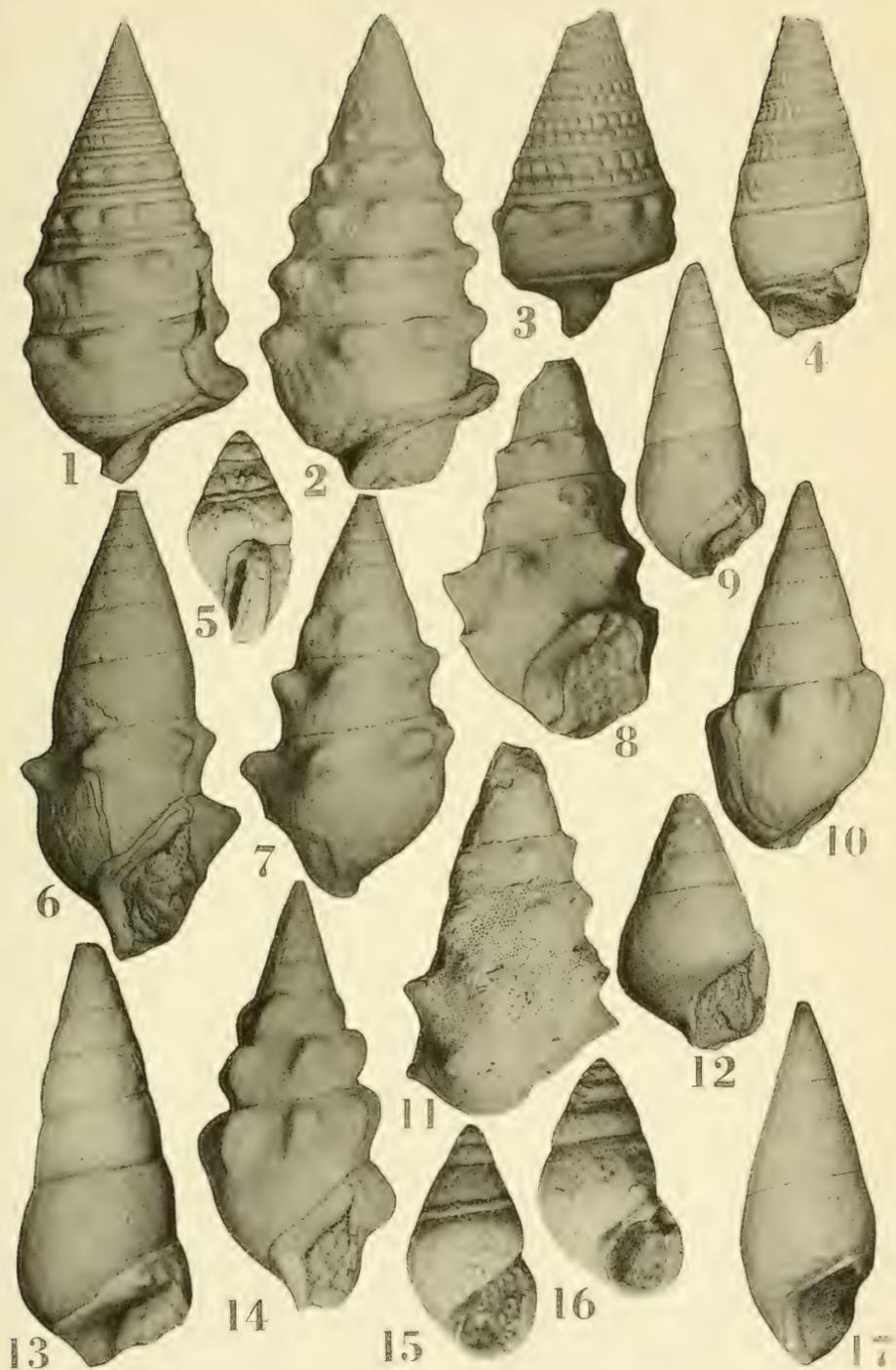




PLATE 13 (20)

12. *Pyrazus peruvianus*, n. sp. ----- 83  
Holotype, length, 27 mm.  
P. R. I., No. 4959.  
Tortuga.
13. *Rhinotamides rudis*, n. sp. ----- 81  
Paratype, length, 27 mm.  
P. R. I., No. 4915.  
Tortuga.

## EXPLANATION OF PLATE 13 (20)

Figure	Plate
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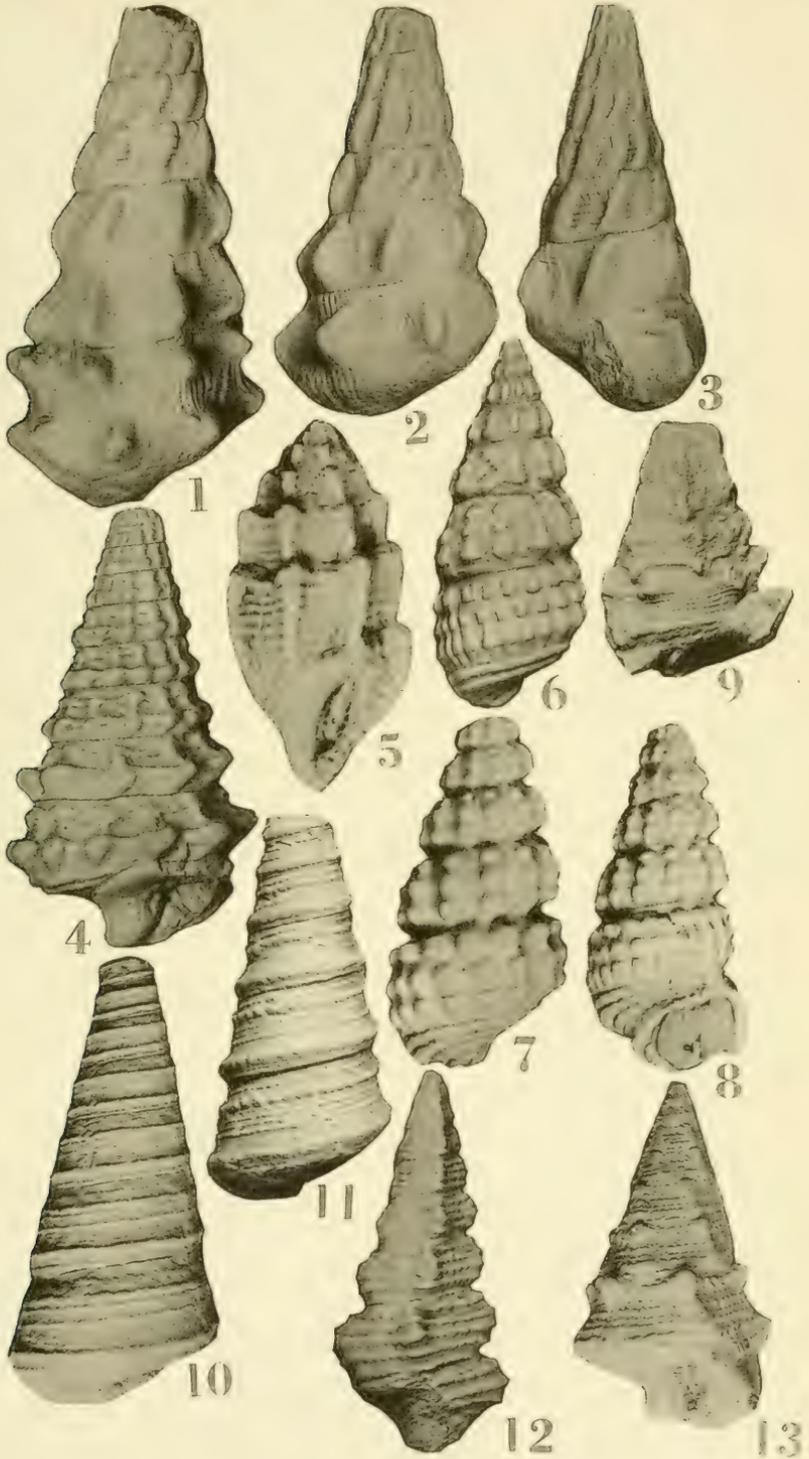




PLATE 14 (21)

## EXPLANATION OF PLATE 14 (21)

Figure	Plate
1. <i>Perustrombus wheeleri</i> , n. sp. .... Holotype, length, 77 mm. P. R. I., No. 4939. <i>Baculites</i> zone.	94
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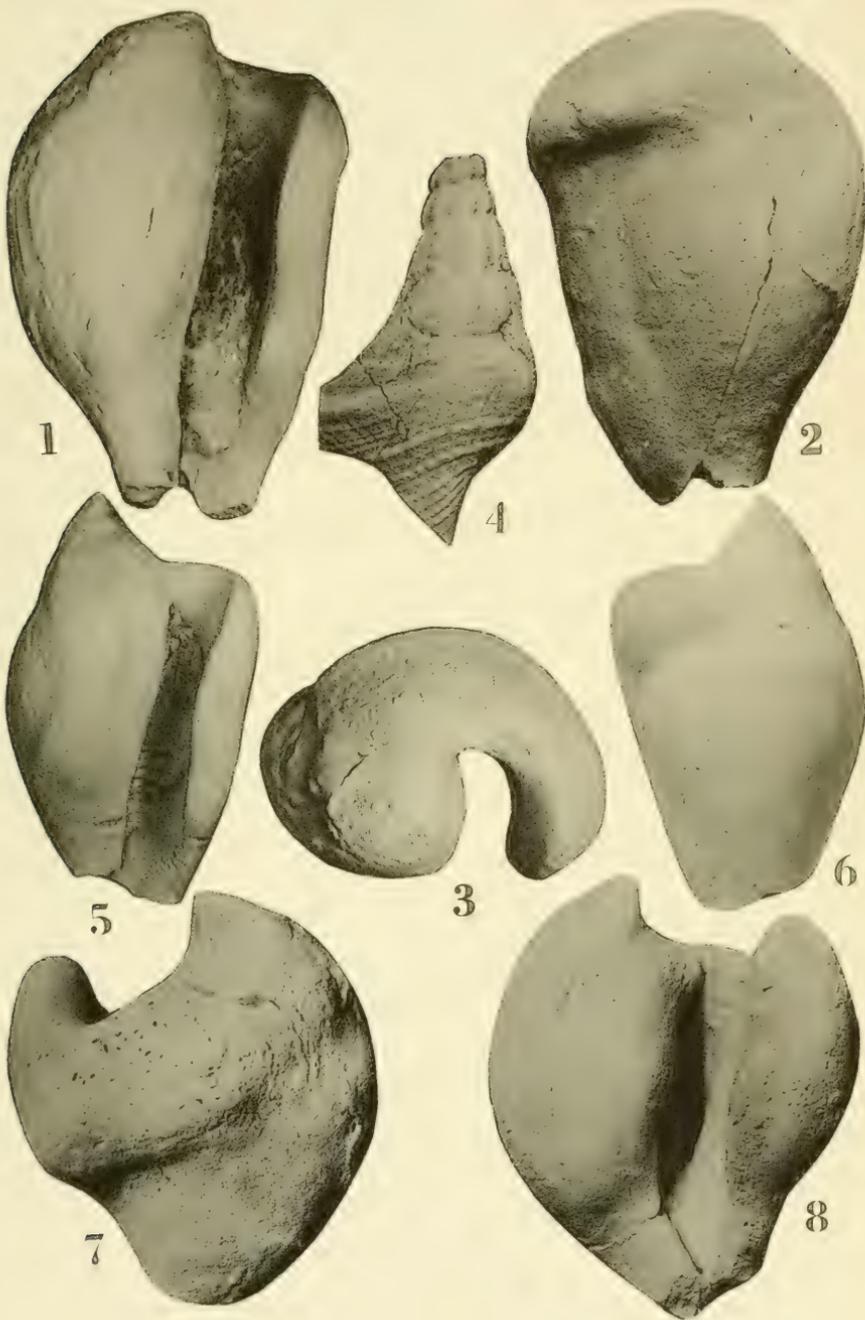




PLATE 15 (22)

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*Baculites* zone.
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Paratype, length, 32 mm.	
P. R. I., No. 4951.	
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Holotype, length, 42 mm.	
P. R. I., No. 4949.	
<i>Baculites</i> zone.	

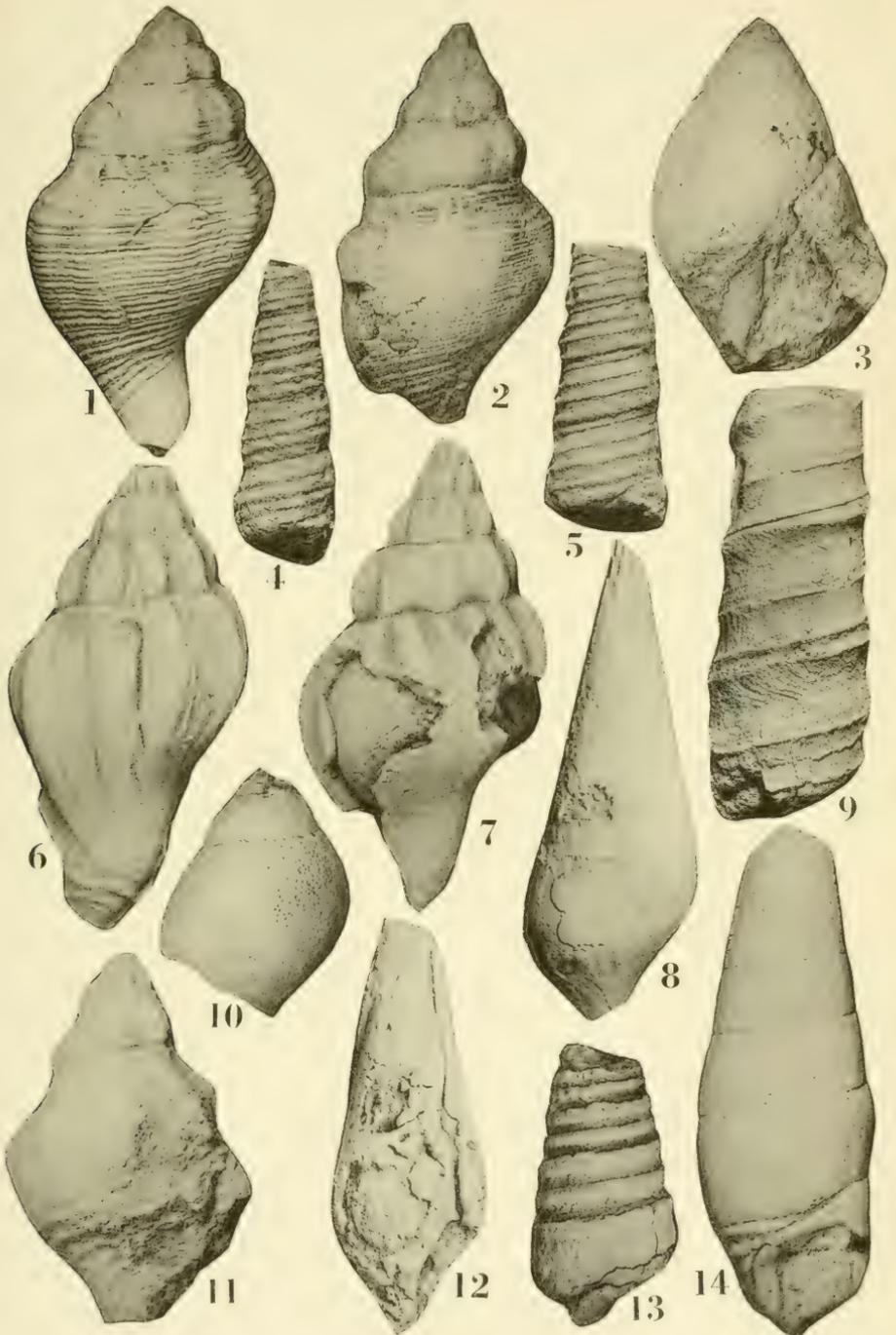




PLATE 16 (23)

## EXPLANATION OF PLATE 16 (23)

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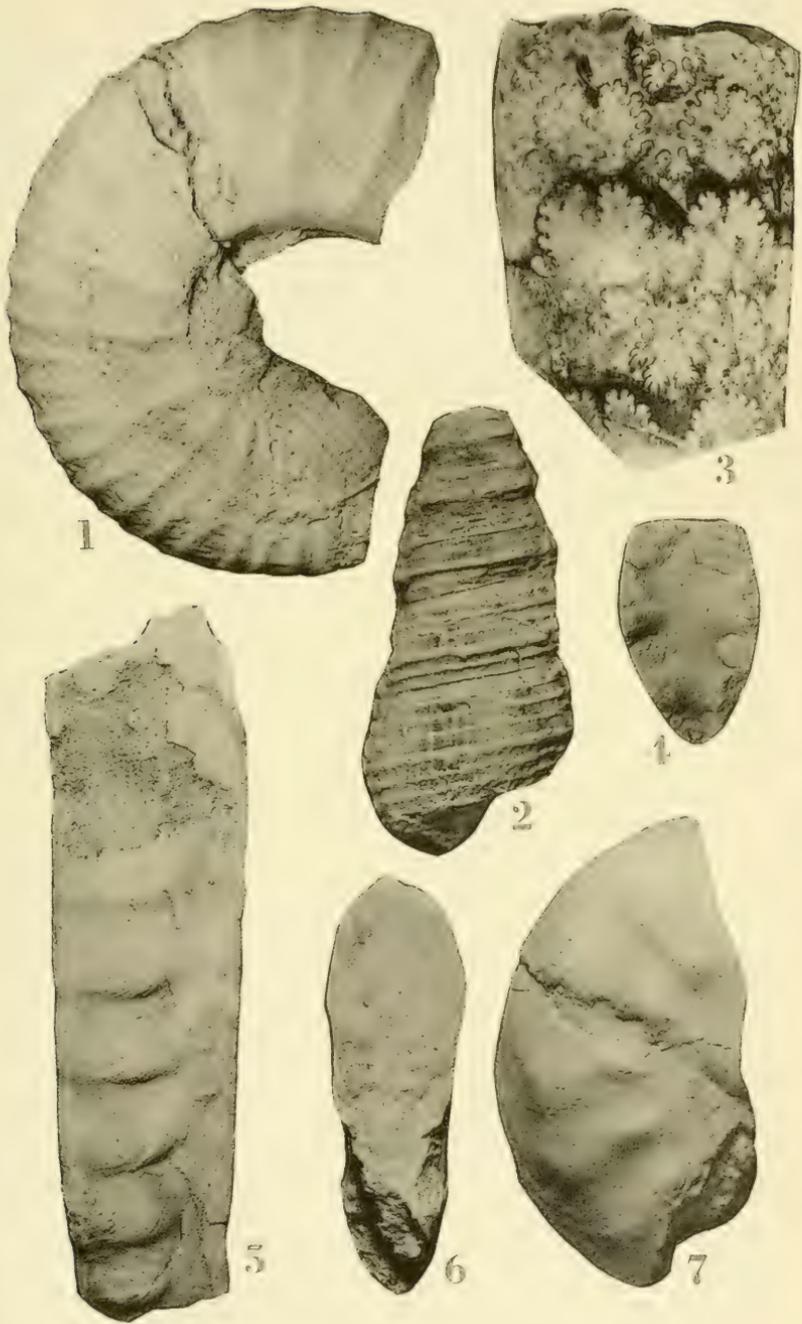
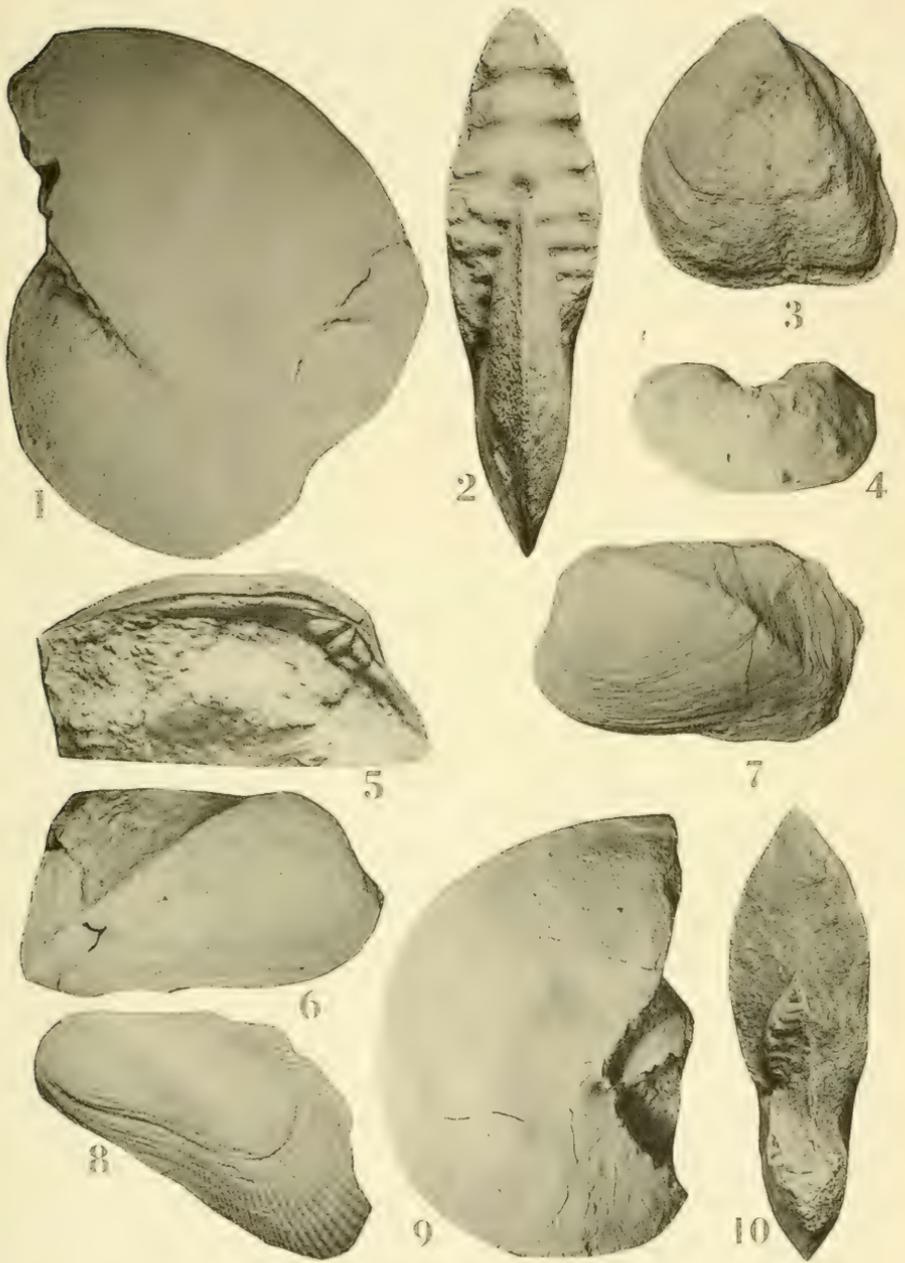




PLATE 17 (24)

## EXPLANATION OF PLATE 17 (24)

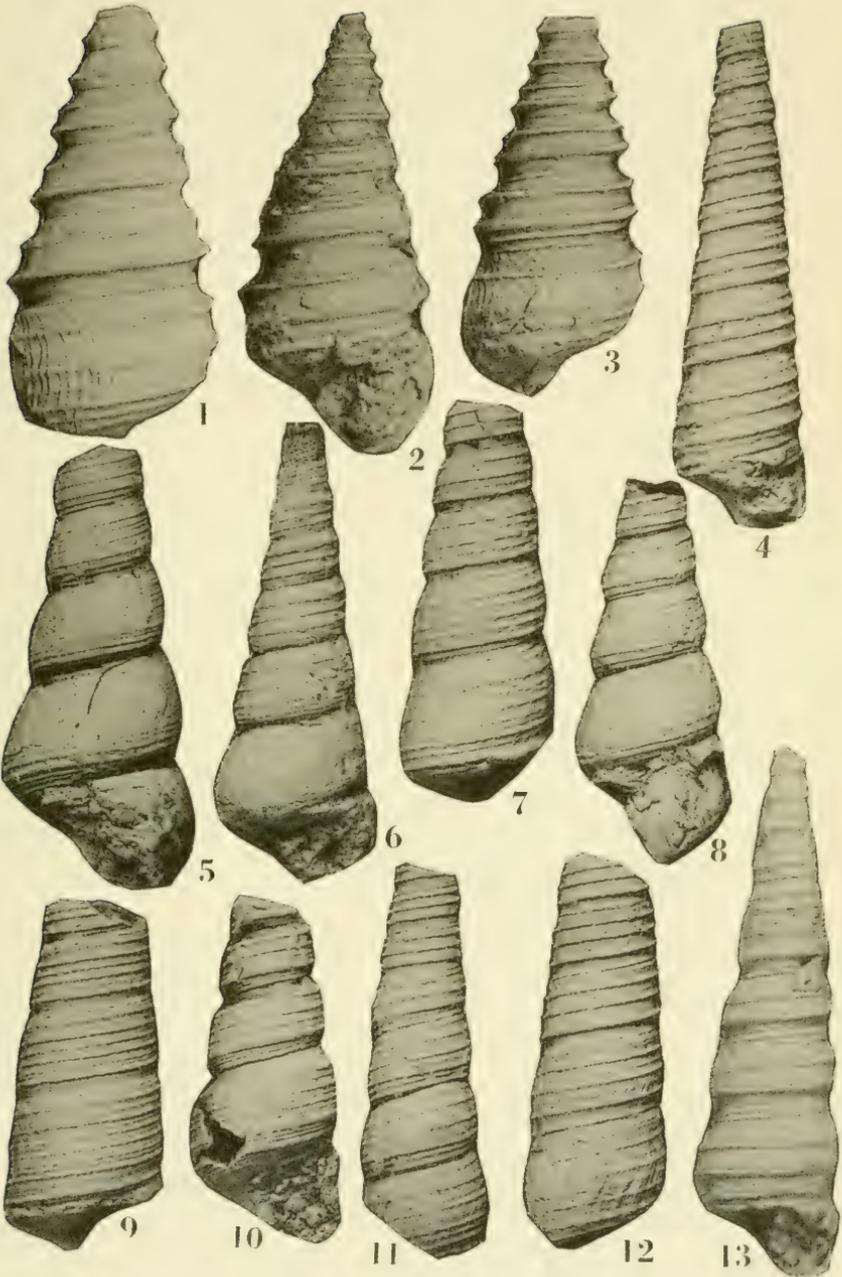
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1. <i>Coahuilites (Austrosphenodiscus) peruviana</i> Gerth .....	110
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P. R. I., No. 4864.	
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P. R. I. No., 4865.	
Tortuga.	
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P. R. I., No. 4863.	
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P. R. I., No. 4868.	
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Same specimen as last.	

















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**Vol. 28**

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No. 112

**NOTES ON EOCENE GASTROPODS, CHIEFLY  
CLAIBORNIAN**

By

Katherine VanWinkle Palmer

*April 19, 1944*

PALEONTOLOGICAL RESEARCH INSTITUTION  
ITHACA, NEW YORK  
U. S. A.

13,961



NOTES ON EOCENE GASTROPODS, CHIEFLY  
CLAIBORNIAN

By

KATHERINE VAN WINKLE PALMER

INTRODUCTION

After completing my report on the Gastropoda of the Claibornian<sup>1</sup> middle Eocene embayment of the southern United States, a study of the Jacksonian upper Eocene univalves of the same area was undertaken. In the prosecution of this work certain corrections, additional notes and photographs of type specimens pertaining to the earlier Eocene faunas have accumulated. Such materials would seem to be more convenient for future reference if published as a unit and not interpolated in our forthcoming Jackson report.

The descriptions of several unusual species, mostly Claibornian may be noted. Some of the specimens of the species described were sent to the author by the late T. H. Aldrich of Birmingham, Alabama. Those of one species were collected by Winnie McGlamery of the Geological Survey of Alabama.

The writer wishes to thank Miss McGlamery and the authorities of the Alabama Museum of Natural History for the privilege of publishing the descriptions of the new species, the specimens of which are in the cabinets of that museum.

<sup>1</sup> Palmer, K. Van W.: *The Claibornian Scaphopoda, Gastropoda and dibranchiate Cephalopoda of the southern United States*, Bull. Amer. Paleont., vol. VII, No. 32, 1937, pt. 1, 548 pp.; pt. 2, 549-730 pp., 90 pls.

## SYSTEMATIC DESCRIPTIONS

Phylum **MOLLUSCA**Class **GASTROPODA**Family **TROCHIDÆ**Genus **CALLIOSTOMA** Swainson, 1840

Swainson, Treatise on Malacology, 1840, p. 351.

Genotype by subsequent designation, Hermannsen (Ind. Gen. Malac., I, 1846, p. 154), *Trochus conulus* Linnæus="conula Mart. 166. f. 1588" in Swainson (*vide* Hanley, *Ipsa* Linn. Conch., 1855, p. 322). Living. Mediterranean and Adriatic Seas; Atlantic at Canary Isls., Madeira and Azores.

Subgenus **EUTROCHUS** A. Adams, 1863

Adams, Proc. Zool. Soc. London, 1863, p. 506.

Genotype by monotypy, *E. perspectivus* Adams, *loc. cit.*=*E. adamsi* Pilsbry (Man. Conch., vol. XI, 1889, p. 402). Living. Tasmania.

**Calliostoma (Eutrochus) claibornianum**, n. sp.

Plate 2, figs. 4-6

Shell medium in size; nucleus of about one and one-half smooth whorls, very slightly constricted between the nuclear and post-nuclear whorls. The sculpture of the postnuclear whorls begins gradually with three strong revolving ribs which maintain their primary strength for several whorls. Secondary spiral ribs arise and increase in strength until on the body whorl there are about five revolving ribs of equal size from the suture to the broad border of the whorl. Spiral ribs crenulated; peripheral margin of the body whorl broad, carinated above and below; finer spiral ribs are interpolated between the two margins. Basal area covered with close-set revolving ribs; umbilicus deep, narrow; columellar area long and somewhat straight; labrum broken.

This species seems to be the first *Eutrochus* described from the southern Eocene.

*Dimensions*.—Height, 6.4 mm.; greatest diameter, 6 mm. (holotype).

*Holotype*.—Alabama Museum of Natural History, University, Ala.

*Occurrence*.—Gosport sand. Claiborne, Ala., collected by T. H. Aldrich. Species known by the holotype only.

## Family EPITONIDÆ

Genus EPITONIUM Roeding in Bolten, 1798

Roeding in Bolten, Museum Boltenianum, 1798, pt. 2, p. 91.

Genotype by subsequent designation, Suter (Man. New Zealand Moll., 1913, p. 319, *vide* Woodring Carnegie Inst. Washington, Pub. 385, 1928, p. 394), *Turbo scalaris* Linnæus (= *S. pretiosa* Lamarek). Living. Western Pacific.

Subgenus CRISPOSCALA de Boury, 1886

De Boury, Mon. Scelidæ vivantes et fossiles, Pt. 1; *Crisposcala*, fasc. I, 1886, Paris.

Genotype by original designation, "*C. (Scalaria) crispa*" (Lamarek), *op. cit.*, p. 1, pl. 1, figs. 1-5. Eocene. Paris Basin.

**Epitonium (Crisposcala) failianum**, n. sp.

Plate 2, figs. 9, 10

Shell medium in size; spire not complete; whorls rounded; sculpture of curved longitudinal lamellæ which have well-developed spines below the suture; about 18 such costæ on the body and penultimate whorls; whorls with incipient or what might be obsolete spiral ribs; the whole surface of the whorls between the lamellæ covered with microscopic revolving striæ; basal cord incipient, seen only with the binoculars; base of lamellæ back of the columellar and apertural margins united into a flare with a slight concavity before the callus; aperture auriculate.

This species differs from the known Claibornian and Jacksonian species of *Epitonium* in the absence of a well-developed basal cord, the presence of the flare in the umbilical region and in having finer spinous scalariform lamellæ.

The form is described from the holotype only.

*Dimensions*.—Height, 12 mm. (incomplete); greatest diameter, 7 mm. (holotype).

*Holotype*.—Alabama Museum of Natural History, University, Ala.

*Occurrence*.—Jacksonian or Claibornian. "One and one-half miles east of Fail, Alabama, in marl bed, just under prairie rock and above clays."

Subgenus **GYROSCALA** de Boury, 1910

De Boury, J. Conchyliol., vol. 58, 1910, p. 228.

Genotype by original designation (*loc. cit.*, pl. XI, fig. 1) *Scalaria commutata* Monterosato. Living. Mediterranean.

**Epitonium** (*Gyroscala*) *meclameriæ*, n. sp.

Plate 2, figs. 11-13

Shell large; whorls rounded; apical whorls broken and worn; the immediate surface of the whorls between the lamellæ smooth; sculpture consists of large, projecting lamellæ continuous from whorl to whorl because of the fused overlap of each lamella at the suture; varices irregular; basal cord conspicuous; labrum thickened; slight concavity below the columellar area; auricle fairly well developed.

This species differs from the other species of *Epitonium* in the southern Eocene by the presence of the thinner projecting lamellæ and by the smoothness of the surface of the shell between the lamellæ.

*Dimensions*.—Greatest diameter, 14.5 mm. (largest specimen). Specimens not complete.

*Syntypes*.—Alabama Museum of Natural History, University, Alabama.

*Occurrence*.—Lower Claiborne. Lisbon formation,<sup>2</sup> two miles south of Gilbertown, highway 29, Choctaw County, Alabama, collected by Winnie McGlamery, June 10, 1936.

Family **HIPPONICIDÆ**

Genus **HIPPONIX** Defrance, 1819

Defrance, J. Chim. Hist. nat., t. 88, 1819, p. 217, figs. 1, a-f.

Genotype by subsequent designation, Gray (Proc. Zool. Soc. London, pt. XV, 1847, p. 157), *Patella cornucopia* Lamarck. Eocene. Paris Basin.

**Hipponix** *vagus*, n. sp.

Plate 2, figs. 1-3

Shell large, aperture round, apical end constricted, forming a beaklike prominence; horseshoe-shaped muscular scars well developed; surface covered with moderately coarse radiating striæ. The type is worn but the radiating ribs are plainer than they appear in the photograph.

The species is known from a large unique specimen, the size

<sup>2</sup> Applied because it is used in common nomenclature but according to Lexicon of Geologic Names, Bull. U. S. G. S., No. 896, p. 1189, the name for the Eocene formation is preoccupied by usage in the Paleozoic.

of which is extraordinary for a southern American *Hipponix*, about four times the size of the largest specimens of *H. pygmaeus* found in the Gosport sand.<sup>3</sup> *H. vagus* equals in size individuals of the genotype in the Paris Basin Eocene. There is such a large gap between the common size of tiny *H. pygmaeus* and this shell that it does not seem that the present specimen could even be a gerontic individual of *H. pygmaeus*.

*H. sylværupis* Harris (Bull. Amer. Paleont., vol. III, No. 11, 1899, p. 83, pl. 11, fig. 10, a) of the Sabine (Wilcox) Eocene is about twice the size of *H. pygmaeus* but about half the dimensions of *H. vagus*.

*Dimensions*.—Height, 10 mm. (from apex to margin of shell beneath); 22 mm., greatest diameter.

*Holotype*.—Alabama Museum of Natural History, University, Ala.

*Occurrence*.—Gosport sand, Claiborne, Ala., collected by T. H. Aldrich.

Family THIARIDÆ (MELANIDÆ)

Genus THIARA Roeding in Bolten, 1798

(*Melania* Lamarek, 1799)

Roeding in Bolten, Museum Boltenianum, pt. 2, 1798, p. 109.

Genotype by monotypy<sup>4</sup> *Helix amarula* Linnæus. The same by subsequent designation, Hermannsen (Ind. Gen. Malac., II, 1849, p. 576 *Tiara* emend.) Living. Madagascar, Comoros, Mauritius and Réunion.

*Thiara aldrichi*, n. sp.

Plate 2, figs. 7, 8

Shell medium size; thin; apex broken; on the lower part of the whorls are coarse spiral ribs which decrease in size toward the body whorl; the whole surface of the shell is covered with microscopic striations which are most conspicuous over the basal

<sup>3</sup> The specimen, 8.5 mm., greatest diameter, mentioned in the Claiborne report (Palmer, 1937, p. 149) is, on additional examination, found to be probably a broken individual of *Calyptrea aperta* (Solander). The remnant is a ring of the lower margin of a shell, the middle and apical areas have been destroyed. A spiral line is preserved which suggests that the specimen is more likely *Calyptrea* than *Hipponix*.

<sup>4</sup> Remaining species mentioned by Bolten are *nomina nuda* fide Pilsbry and Bequaert (Amer. Mus. Nat. Hist., Bull. 53, 1927, p. 250).

part of the body whorl; whorls with 10 to 12 tuberculous longitudinal folds which extend from above the middle line downward and are less sharply developed on the body whorl; aperture entire; callus thin. There are a few brownish spots and splashes of coloration preserved.

This species is unusual in the southern Eocene. It represents a fresh-water species accidentally brought into a typically marine fauna.

The form resembles somewhat the general appearance in sculpture of *T. scabra* (Müller) (Martin, Foss. v. Java, Bd. 1, 1905, pl. 36, figs. 572-573) of the East Indies, the species which has been used by authors as the type of *Plotia* Roeding in Bolten<sup>5</sup>. The Claiborne species is not, however, applicable within the limits of the valid genotype of the subgenus. The figures of *Melania winteri* von dem Busch in Reeve, Icon. Conch., *Melania*, 1860, pl. XXII, fig. 157, suggest also the characters of this shell.

*Dimensions*.—Height, 17.3 mm.; greatest diameter, 8.1 mm. (holotype).

*Holotype*.—Alabama Museum of Natural History, University, Ala.

*Occurrence*.—Gospport sand, Claiborne, Ala., collected by T. H. Aldrich.

#### Family ARCHITECTONICIDÆ

##### Genus ARCHITECTONICA Roeding in Bolten

Roeding in Bolten, Museum Boltinianum, 1798, pt. 2, p. 78.

Genotype by subsequent designation, Gray (Proc. Zool. Soc. London, pt. XV, 1847, p. 151, "*Architectoma*"), *Trochus perspectivus* Linnæus. Living. Indo-Pacific.

##### Subgenus GRANOSOLARIUM Sacco, 1892

(*Non Solariaxis* Dall, December, 1892, Trans. Wagner Free Inst. Sci., vol. III, pt. II, pp. 323, 324, genotype *S. elaboratum* Conrad.)

Sacco, Boll. Mus. Zool. Anat. comp., vol. VII, April, 1892, p. 56; I Molluschi dei Terreni terziarii del Piemonte e della Liguria, pt. XII, June, 1892, p. 59.

<sup>5</sup> Roeding in Bolten, *op. cit.*, p. 95, did not list *T. scabra* [= *T. spinulosa* (Lamarek, 1882)] or its equivalent. Pilsbry and Bequaert, *Nautilus*, vol. 37, No. 1, 1923, p. 36, designated *Plotia lineata* [Bolten] as the genotype.

Genotype by original designation, *Solarium millegranum* Lamarck (Ann. s. Vert., VII, 1822, p. 6). Miocene, Pliocene. Italy. Sacco, June, 1892, *op. cit.*, pl. II, fig. 18.

If one follows Dall (1892) and Cossmann (Essais Paléoconch. comparée, 10 liv., 1915, p. 169), as I did in 1937, in uniting *A. elaborata* (Conrad) and *A. ornata* (Lea), then *Granosolarium* Sacco and *Solariaxis* Dall are synonymous. *Granosolarium* has priority.

However, observing the continuation of the Claibornian stocks of Architectonicas into the Jackson Eocene, one feels that *A. elaborata* and *A. ornata* do belong to two different types of shell, even though they may be related and there are troublesome variations in the Lower Claiborne. Consequently Dall's name and that of Sacco may stand for separate subgenera.

*A. canaliculata* (Lamarck) (Ann. Mus. nat. Hist. nat., Paris, t. 4, 1804, p. 53) represents the subgenus in the Paris Basin and English Eocene.

*A. elaborata* and *A. acuta* are representatives of *Solariaxis* in the southern Eocene.

#### **Architectonica (*Granosolarium*) *ornata* (Lea)**

*Solarium ornatum* Lea, 1833, Cont. Geol., p. 120, pl. 4, fig. 108; H. C. Lea, 1848, Acad. Nat. Sci. Philadelphia, Proc., vol. 4, p. 106; d'Orbigny, 1850, Prodrome de Paléontologie, vol. 2, p. 348; Heilprin, 1879, Acad. Nat. Sci. Philadelphia, Proc., vol. 31, p. 224; de Gregorio, 1890, Ann. de Géol. et Paléont., 7 liv., p. 136, pl. 12, figs. 53 a, b; Harris, 1895, Bull. Amer. Paleont., vol. 1, No. 1, p. 31. *non S. ornatum* Sowerby in Fitten, 1836, Trans. Geol. Soc. London, ser. 2, IV, App. p. 336.

*Solarium canaliculatum* Conrad, 1834, Appendix to Morton, Synopsis Org. Remains Cret. Group, p. 3 *non S. canaliculatum* Lamarck, 1804, Ann. Mus. nat. Hist. nat., t. 4, p. 53.

*Architectonica ornata* (Lea), Conrad, 1865, Amer. Jour. Conch., vol. 1, p. 30; Conrad, 1866, Smith. Misc. Coll., vol. VII, No. 200, p. 13.

*Solarium elaboratum ornatum* (Lea), Dall, 1892, Trans. Wagner Free Inst. Sci., vol. III, pt. II, p. 324 section *Solariaxis*.

*Solarium elaboratum* Conrad, Cossmann, 1893, Ann. Géol. et Paléont., 12 liv., p. 27.

*Solarium (Solariaxis) elaboratum* Conrad, Cossmann, 1915, Essais de Paléoconch. comparée, 10 liv., p. 169 *partim*, pl. VII, figs. 19, 20 *non* 18.

*Architectonica elaborata* (Conrad), Palmer, 1937, Bull. Amer. Paleont., vol. VII, No. 32, p. 164 *partim*, pl. 18, figs. 15, 16, 19; pl. 81, figs. 9-11 section *Granosolarium*.

Shell convex above, flattened below, furnished with many granular transverse lines, three of which, on the superior part of the whorl, are larger than the others, furrowed on both sides of the carina which is

crenulate, longitudinally striate; substance of the shell rather thick; suture furrowed; umbilicus very wide, perspective, beautifully crenate at the edge, furrowed within and longitudinally striate; whorls six; mouth suborbicular.

Length, 2,

Breadth 9-20ths, of an inch.

*Observations.* This species is very like Brander's figure of *Turbo canaliculatum*, and Sowerby's figure of the same species, *Solarium canaliculatum*, plate 524. On comparison, however, with a specimen from Hampshire, sent to me under that name, I find them very different; the umbilicus being much wider in the species from Claiborne, which is also more carinate, and has smaller and more numerous granulate lines.—[Lea, 1833.]

The ornamentation pattern of the adult is based on a tripriary plan. On the young or postnuclear whorls the whorl is bicarinate. On the adult there is one pronounced nodose spiral rib or primary just below the suture and another just above the suture. Between the upper and middle primaries there are two or three finer nodose secondary lines with diminutive tertiary threads. The interspace between the middle primary and the basal carina is prominently excavated. The dorsal and ventral surfaces are conspicuously covered with longitudinal coarse striations. The base is convex and covered with five or six (not including the peripheral carina) nodose revolving ribs with finer intercostal lines, varying in coarseness away from the umbilical margin.

In photographs of the ventral surface, the convexity of the shell hides the excavation of the area just in front of the marginal carina. The ventral surface therefore takes on an appearance more like *A. elaborata* (Conrad) which is deceiving. Lea's original figure of the ventral surface probably does not show the true character of the ventral margin. The Meyer drawing of type material produces a flatter perspective of the ventral surface and hence shows more of the excavated area. Otherwise Lea's figure and the Meyer drawing do not seem to represent the same species. Comparing the Meyer drawings (Palmer, 1937, pl. 81, figs. I, II) of *A. meekana* and *A. ornata*, one can see the close relationship between the two species.

In respect to the coarse radiating striæ *A. ornata* exhibits a relationship more with *A. meekana* than with *A. elaborata*. *A. ornata* differs from *A. elaborata* in having a convex base, as well as having a furrowed area above the peripheral carina. The

major difference between the two Gosport sand species is the adult triprimary pattern of revolving ribs of *A. ornata* which *A. elaborata* lacks. This difference in the sculpture places each of the two species in a different subgenus.

Dall thought of *A. ornata* as a variety of *A. elaborata* (Conrad). In 1937, I decided that *A. ornata* might be the young of *A. elaborata* and so followed Dall in grouping the two species. Because of such a union, *A. elaborata* was included in that group of *Architectonica* which is typified by *A. millegrana* (Lamarck) of the Miocene and Pliocene of Europe and represented by *A. canaliculata* (Lamarck) of the Eocene of the Paris Basin and England. The group is well developed in the southern Eocene. To this subgenus *A. ornata* belongs. The first clue to such a relationship is in the comparisons of Lea, Conrad and Heilprin of *A. ornata* with *A. canaliculata* (Lamarck). The sculpture of *A. ornata* is close-set and it is in this fact that the species has been probably correlated with *A. elaborata*. It is in some of the varieties of *A. meekana* where the margin is more acute and flaring and the intermediate revolving ribs are more subdued that the triprimary pattern of sculpture is most conspicuous and most easily observed.

*A. ornata* is fairly well represented in the Gosport sand. As far as collections which I have studied are concerned, the shells of *A. ornata* are smaller than *A. elaborata*. One specimen in our collection from the Lower Claiborne, Cook Mountain formation, at Big Branch of Cedar Creek, NW of Stone City, Texas, is very much like typical *A. ornata*. In the Jackson the species is developed in a varietal stage.

*Dimensions*.—Height, 7.7 mm.; greatest diameter, 13 mm. (largest specimen).

*Lectotype*.—No. 5600 (not 5500 as given in 1937), Academy of Natural Sciences, Philadelphia, Pa.

*Occurrence*.—Lower Claiborne. Cook Mountain formation, loc. 766, "Big Branch of Cedar Creek, east of Mr. Pollard's (deceased) farm, three miles NW of Stone City, Burleson County, Texas," collected by J. W. Wells; Gosport sand, Claiborne, Ala. (type).

Architectonica (*Granosolarium*) *meekana* Gabb

Plate 1, figs. 4-7

*Architectonica meekana* Gabb, 1860, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. IV, p. 385, pl. 67, fig. 40; Conrad, 1865, Amer. Jour. Conch., vol. 1, p. 30; Conrad, 1866, Smith. Misc. Coll., vol. VII, No. 200, p. 13.

*Solarium Meekannum* (Gabb), Heilprin, 1891, Acad. Nat. Sci. Philadelphia, Proc. for 1890, vol. 42, p. 400.

*Solarium acutum Meekianum* (Gabb), Dall, 1892, Trans. Wagner Free Inst. Sci., vol. III, pt. II, p. 324 under section *Solariaxis*.

*Architectonica acuta meekiana* Gabb, Palmer, 1937, Bull. Amer. Paleont., vol. VII, No. 32, p. 168 *partim*, pl. 81, figs. 1, 2; *non* pl. 20, figs. 9, 11, 13. Section *Granosolarium*.

Diseoid, whorls five, strongly carinate on the edge and somewhat rounded below; mouth subrhomboidal; umbilicus wide; surface above marked on the edge and on the middle of the whorl by two large, revolving nodose lines, and on the rest of the top by five smaller ones; between the two large ones there are numerous cross lines passing from one to the other; below, besides the "keel" on the edge of the whorl, there are seven ribs, one large one bordering the umbilicus and six smaller alternating ribs; in the umbilicus there is one rib on the middle of the whorl, besides the one on the edge.

*Dimensions*.—Height .1 in., diameter of the disc .32 in., width of umbilicus .15 in.

This beautiful species, under a glass, looks as if covered with "beading", all the ribs having that peculiar structure. Four specimens from Caldwell Co., in my collection. One very fine one from Wheelock, in the collection of the Smithsonian Institution.—[Gabb, 1860.]

Dall in 1890 included *A. meekana* under *A. acuta* Conrad, a Jackson Eocene species. The original figures of *A. meekana* and *A. acuta* are poor. In 1937 in the Claibornian gastropod report, I followed Dall in grouping *A. meekana* and *A. acuta*. In studying the Jackson gastropods one becomes aware that that which I called *A. acuta* in 1937 does not display the characters of the Jackson species.

Through the courtesy of the Academy of Natural Science at Philadelphia, photographs of the types of *A. acuta* and *A. meekana* were supplied. The illustrations of *A. acuta* will be included in the forthcoming paper on the Jackson fauna and those of *A. meekana* are reproduced herein. The present type material of *A. meekana* consists of two small specimens which are still not adequate to give a complete impression of the typical species. Without topotype material it is impossible to explain the exact characters of the species, *sensu stricto*, and hence it is prema-

ture to define the variations from type which the species may exhibit. But it is worthwhile to place on record additional pictures of the type material. The Meyer drawing of a specimen in the Gabb collection from Wheelock, Texas which Meyer compared with the type is very well drawn and shows the details of the sculpture better than the photographs. The specimen is small (Palmer, 1937, pl. 81, fig. 1).

Suffice it to say that that which I illustrated in 1937 as *A. acuta* is not the true *A. acuta*. The true *A. acuta* is a Jackson species and belongs to the *A. elaborata* (Gosport sand) stock which is of a different subgeneric development than *A. meekana*. The *A. acuta* of 1937 is named *A. meekana splendida* in this paper.

The specimen figured in 1937, pl. 20, figs. 9, 11, 13 as "*A. acuta meekiana*" is not *A. meekana* Gabb. The specimen is from the Lower Claiborne (Weches formation) at Smithville, Texas. It was from an early Texas collection and labelled "*S. acutum* var. *meekanum*". The specimen actually represents a member of the *A. elaborata* stock and may be nearest to *A. vespertina* Gabb. Since the sofar available figures of *A. vespertina* are too poor to identify *A. vespertina* Gabb (Acad. Nat. Sci., Philadelphia, Jour., 2d ser., vol. IV, 1860, p. 384, pl. 67, fig. 39; Palmer, 1937, pl. 82, figs. 2, 4) further naming is left until topotype material is identified.

*A. meekana* and its variations represent an important stock in the Lower Claiborne-Jackson beds. The predominate character of the stock is the presence in the adult of the three major revolving ribs—one on the edge of each margin of the whorl and one about the midline. Between the three large revolving ribs are finer spiral lines and the whole spiral sculpture is crossed by fine conspicuous radiating bifurcating threads. The spiral ribs are pronouncedly beaded. The minor threads vary on specimens from different localities. The earlier postnuclear whorls are bicarinate.

Dall's *A. textilina* (Trans. Wagner Free Inst. Sci., vol. III,

pt. II, 1892, p. 328, pl. 22, figs. 1, 2, 3) from Wautubbee, Mississippi, Lower Claiborne, appears to be of this line. The basal sculpture according to the illustration varies considerably from the typical *A. meekana*. *A. ornata* Lea of the Gosport sand (not *A. elaborata*) belongs to the *A. meekana* stock instead of to the *A. elaborata* group. At certain Lower Claiborne localities, such as Hammett's Branch, Louisiana and Hickory, Mississippi, the surface of the shells of the *A. meekana* stock tends to be smoother than typical and many of the spiral ribs are not present. Specimens from a locality about "2 miles northeast of Newton, Mississippi" have the very fine revolving ribs and an acute margin.

*Syntypes*.—No. 13291 (two specimens), Academy of Natural Sciences, Philadelphia, Pa.

*Occurrence*.—Lower Claiborne. Stone City formation (Cook Mountain), Caldwell "Co." Texas (type).<sup>6</sup>

*Architectonica* (*Granosolarium*) *meekana splendida*, n. var.

*Architectonica acuta* Palmer, 1937, Bull. Amer. Paleont., vol. VII, No. 32, p. 167 *partim*, pl. 20, figs. 12, 14-17.

*Non Architectonica acuta* Conrad, 1854, in Wailes, Rept. Agr. and Geol. Mississippi, p. 289, pl. 17, figs. 1a, 1b; Conrad 1855, Acad. Nat. Sci. Philadelphia, Proc., vol. 7, p. 261. Reprint 1939, Bull. Amer. Paleont., vol. XXIV, No. 86, pp. 7, 19, pl. 4, figs. 1a, 1b.

The details of the young and adult stages of this form are illustrated in the 1937 Claiborne bulletin where the species was confused with *A. acuta* Conrad.

On the earlier postnuclear whorls, the two posterior crenulated carinae predominate exhibiting a bicarinate appearance of the whorl. The area below the anterior nodose carina to the suture

<sup>6</sup> The word "Co." is probably a misstatement and means "town of Caldwell" (Roemer, Amer. Jour. Sci., 2d ser. vol. VI, 1848, p. 23). For map of the Caldwell-Wheelock area see Renick and Stenzel, Univ. Texas Bull., No. 3101, 1931, p. 75. Stenzel and Turner (Type Invertebrate Fossils of North America, Eocene Gastropoda 57, card No. 85) suggested that the type locality of *Turritella nasuta* Gabb, described in the same work with *A. meekana* from Caldwell "Co." and Wheelock, Texas, probably is "Stone City (Moseley's Ferry), bluff on right bank of Brazos River at bridge of State highway 21 and bridge of Southern Pacific Railroad, Burleson County, Texas."

is deeply excavated. Shortly the excavated area enlarges and the fine crenulated spiral rib just above the suture becomes conspicuous, developing the characteristic sculpture which consists pre-eminently of three large nodose spiral ribs—one above the suture, one below the suture and one in about the midline of the whorl. This pattern is the motif of the decoration of *A. meekana* Gabb of the Lower Claiborne as well as of *A. ornata* (Lea) of the Gosport sand. The stock is also present in the Jackson Eocene.

This particular variety differs from typical *A. meekana* in the greater acuteness of the periphery. That area as it spreads may contain several fine spiral threads between the peripheral and middle carinæ or the spiral striæ may be lacking. The ventral margin is also more extended with a wide space between the peripheral margin and the previous spiral rib which rises above like a shelf. The whole surface of the shell is delicately covered with divaricating radiating lines. This is a feature characteristic of the species.

The variety was abundantly developed at Lapinière Landing on the Ouachita River, Louisiana where the shells are exquisitely adorned like filigree.

*Dimensions*.—Height, 6 mm.; greatest diameter, 15 mm. (holotype).

*Types*.—Holotype, No. 2856; paratype, No. 2854; figured specimen, No. 2855, Paleontological Research Institution.

*Occurrence*.—Lower Claiborne. Cook Mountain formation. loc. 725, Sabine River, Texas side, opposite SW corner of SE  $\frac{1}{4}$  sec. 35, T. 5 N., R 13 W., field No. 21 (A. C. Veatch, Geol. Sur. La., Rept. for 1902, No. 3, p. 129, map pl. XXXIII), (type); loc. 724, Columbus, Sabine Parish, La. (A. C. Veatch, *op. cit.*, p. 130, map XXXIII); loc. 741, east bank of the Ouachita River, Lapinière Landing, Ouachita Parish, La. (A. C. Veatch, *op. cit.*, No. 4, pp. 155, 160, map pl. XXXVIII).

**Architectonica** (*Granosolarium*) *texcarolina*, n. sp. . . . Plate 1, figs. 8-11.

Shell small; the whole surface of the shell covered with beaded spiral ribs. Beginning with the first postnuclear whorl and continuing for about two whorls the sculptural pattern consists of two

primary nodose ribs with two secondary nodose ribs between. The upper rib is just below the suture and slightly overhangs it. The lower rib is above the suture with a fine spiral nodose rib between the primary rib and the suture. Between the two large ridges are two smaller nodose revolving ribs. On the later whorls a third primary nodose revolving rib develops which eventually becomes the peripheral carinate margin and it, together with the first two primary ribs, form the triprimary pattern of the sculpture of the mature shells. On the later whorls, tertiary nodose lines appear in the area between the upper primary ribs. A secondary rib is interpolated between the peripheral rib and the primary above. The sutures are impressed. The umbilical border and adjoining rib are enlarged. Three more smaller ribs with a finer rib cover the basal area between the periphery and the last secondary spiral. All are sharply nodose.

These shells described as new were included by me in 1937 under *A. elaborata*, var. because of the fact that *A. ornata* was not at that time separated from *A. elaborata*. This species differs from *A. elaborata* in the fundamental pattern of the sculpture, that of biprimary spirals on the young whorls with a triprimary pattern in the adult. Such sculpture is the major pattern of *A. ornata* of the Gosport sand and *A. meekana* of the Lower Claiborne. *A. texcarolina* differs from both *A. ornata* and *A. meekana* in having coarser ribs with the ribs closer together. The radiating, divaricating threads are conspicuous in *A. ornata* and *A. meekana* while in *A. texcarolina* the radiating lines have dissected the spiral ribs into coarser beads and hence have obscured themselves. The basal sculpture consists of about the same number of spirals in the three species. The secondary ribs are less conspicuous in *A. texcarolina* than in *A. ornata* and the spirals are more coarsely beaded and the umbilical ribs are larger in the former.

There is in the Gosport sand a variation of *A. ornata* which has coarser spiral ribs more tightly set than typical and somewhat as in *A. texcarolina*, but they are more subdued and the revolving ribs on the ventral surface are finer and more numerous than in both typical *A. ornata* and *A. texcarolina*.

The species is described from small, probably young specimens but since the shells from two widely separated localities exhibit similar characters which differ from immature individuals of known species, it seems as though they may represent a distinct species.

*Dimensions*.—Height, 2.3 mm.; greatest diameter, 5 mm. (holotype).

*Types*.—Holotype, No. 4457; paratype, No. 4456, Paleontological Research Institution.

*Occurrence*.—Lower Claiborne. Crockett formation (Cook Mountain), loc. 727, Little Brazos River, Brazos County, Texas,<sup>7</sup> collected by J. E. Adams (type). McBean formation, loc. 136, Orangeburg District, Orangeburg, S. C., collected by T. A. Caine and A. C. Veatch.

*Architectonica sabinia*, n. n.

*Solarium delphinuloides* Heilprin, 1880, Acad. Nat. Sci., Philadelphia, Proc., vol. 32, p. 375, pl. 20, fig. 13.

Non *Solarium delphinuloides* d'Orbigny, 1845, in Sagra, Hist. fis. pol. y nat. Cuba, t. V, p. 189.

Non *Solarium delphinuloides* Meyer, 1887, Ber. senckenb. naturf. Ges., p. 4.

This form requires a new name since its original name is pre-occupied by that of the Recent West Indian species of *Architectonica* described by D'Orbigny and also by that of a Jackson Eocene gastropod so named by Meyer.

Family **TURRITELLIDÆ**

Genus **TURRITELLA** Lamarek

Lamarek, Mem. Soc. Hist. nat. Paris, 1799, p. 74.

Genotype by monotypy, *Turbo terebra* Linnæus (Syst. Nat., 1758, p. 766). Living. Western Pacific.

**Turritella rina** Palmer

Plate 1, figs. 12-16

*Turritella rina* Palmer, 1937, Bull. Amer. Paleont., vol. VII, No. 32, p. 192, pl. 22, figs. 3, 4, 9; Bowles, 1939, Jour. Paleont., vol. 13, No. 3, p. 277, pl. 31, fig. 17; Stenzel and Turner, (1942), Type Invertebrate Fossils of North America, Eocene, Gastropoda 70, card No. 98.

*Turritella wechesensis* Bowles, 1939, *op. cit.*, p. 281, pl. 31, figs. 8, 14; Stenzel and Turner, (1942), *op. cit.*, card No. 108.

<sup>7</sup> The description (1937) of the locality was given as that of the original collector. This has been corrected by Stenzel (Univ. Texas Pub., No. 3945, 1940, p. 854, footnote) to that of Bur. Ec. Geol. Texas loc. No. 21-T-1.

The present occasion is taken to illustrate what some pronouncedly sculptured species can do in the matter of obliteration of that sculpture. Typical *T. rina* on the adult whorls has a strong overhanging carination of the whorls. The younger whorls are bicarinate, the spiral lines may be beaded. *Turritella wechesensis* Bowles was described as "differing from any of the other species [*Turritella*] of the Gulf Eocene in the obliteration of the sculpture on the adult whorls." It was compared with *T. rina* but was distinguished from that species by "the ultimate extinction of the carina and the disappearance of the secondary ribbing" in *T. wechesensis*.

*T. rina* is a prolific Lower Claiborne species and exhibits considerable variation. This can probably be illustrated best by figures of specimens from one locality. Those figures herein included are from Lapinière Landing<sup>s</sup>, on the Ouachita River, Ouachita Parish, Louisiana, Cook Mountain formation (where the species was abundant) and well illustrate the potentiality of the species. Many more from the same locality could be added to show intermediate stages between those specimens which are illustrated. Here one sees that *T. rina* develops into a form with a smooth shell with the connecting stages present. Therefore a distinction between *T. rina* and species which are like it except that in them the sculpture may become obliterated does not seem adequate to separate the forms. The connection of the two species mentioned is worth considering.

#### Family STROMEIDÆ

#### Genus ECTINOCHILUS Cossmann, 1889

Cossmann, Ann. Soc. roy. malac. Belg., t. XXIV, 4th ser., t. IV, 1889, p. 87.

Genotype by original designation, *Strombus canalis* Lamarek. Eocene. Paris Basin.

#### *Ectinochilus texanum cherokense*, n. n.

*Rimella texana* var. *plana* Harris, 1895, Acad. Nat. Sci. Philadelphia, Proc., vol. 47, p. 78, pl. 9, fig. 2.

*Ectinochilus texanus planus* (Harris), Palmer, 1937, Bull. Amer. Paleont., vol. VII, No. 32, p. 246, pl. 33, fig. 4.

*Non Rostellaria plana* Beyrich, 1854, Zeit. deutsch. geol. Gesell., vol. 6, p. 489, pl. 14, figs. 9, 9a=*Ectinochilus planum* (Beyrich), Wrigley, 1938, Proc. Malacol. Soc. London, vol. 23, pt. II, p. 69, figs. 21, 22.

<sup>s</sup> Veatch, A. C.: Rept. Geol. Louisiana, Pt. VI, No. 4, 1902, pp. 155, 160, map XXXVIII.

The name of the Lower Claiborne Texan stromboid species becomes preoccupied by that for a species in the Oligocene and Eocene of Europe.

Family CANCELLARIIDÆ

Genus COPTOSTOMA Cossmann, 1899

Cossmann, Essais Paléocœn. comparée, 3 liv., 1899, p. 34, as a section. Genotype by original designation, *Cancellaria quadrata* Sowerby. Barton Eocene. England. Wrigley, Proc. Malacol. Soc. London, vol. XXI, pt. VI, 1935, p. 357, pl. 32, fig. 1; pl. 35, fig. 46.

*Coptostoma rameum*, n. sp.

Plate 1, fig. 3

*Bonellitia ulmula* Palmer, 1937, Bull. Amer. Paleont., vol. VII, No. 32, p. 455, *partim* pl. 70, figs. 1, 7 *non* 8.

*Non Cancellaria ulmula* Harris, 1895, Acad. Nat. Sci. Philadelphia, Proc., vol. 47, p. 66, pl. 6, fig. 6. See *Bonellitia ulmula* (Harris), Palmer, 1937, *loc. cit.*, pl. 70, fig. 8.

Nuclear whorls large, tilted slightly to the axis of the spire; first nuclear whorl broken, last and next to the last with sharp longitudinal ribs extending the length of the whorl; nuclear and postnuclear whorls sharply demarcated; postnuclear whorls sculptured with about six primary spiral ribs with finer intermediate threads. There may be tertiary spiral lines over the body whorl. Well-developed longitudinal folds extend over the whorls of the spire and over the posterior area of the body whorl; two large columellar plications with a suggestion of a third; labrum coarsely denticulate; whorls rounded.

In 1937, I included under *Bonellitia ulmula* (Harris), [*Coptostoma ulmulum*] a specimen from Moseley's Ferry, Texas, which differs from *C. ulmulum* in the character of the protoconch, in the greater strength of the longitudinal folds over the whorls and in the presence of interstitial spiral ribs. Slight longitudinal folds occur on *C. ulmulum*.

It seemed when studying the Claibornian fauna that the Moseley's Ferry specimen might be grouped under the possible variation of the species. After finding in the Jackson Eocene the existence of *C. ulmulum* in which the shells exhibit less divergence from the typical species than that of the specimens in the Lower Claiborne, I am differentiating the Moseley's Ferry form specifically. Several specimens from a Lower Claiborne locality in Louisiana, the exact description of which has been lost, have the

same characters as on the individual from Moseley's Ferry, Texas. Such similarity would indicate that the specific characters were fairly constant.

*Dimensions*.—Height, 10.5 mm.; greatest diameter, 6 mm. (type).

*Holotype*.—No. 3307, Paleontological Research Institution.

*Occurrence*.—Lower Claiborne. Stone City formation (Cook Mountain), loc. 723, Moseley's Ferry, Brazos River, Burleson County, Texas (type). Cook Mountain formation, loc. 138, Louisiana.

#### Family SCAPHANDRIDÆ

##### Genus **ABDEROSPIRA** Dall, 1896

Dall, Proc. U. S. Nat. Mus., vol. 18, 1896, p. 32.

Genotype by original designation, *Bullina* (*Abderospira*) *chipolana* Dall (*loc. cit.*; Trans. Wagner Free Inst. Sci., vol. III, pt. 6, 1903, pl. 59, fig. 23). Chipola Miocene. Florida.

***Abderospira Aldrichi*** (Langdon)

Plate 1, figs. 1, 2

*Bulla* (*Haminea*) *Aldrichi* Langdon, 1886, Amer. Jour. Sci., 3d ser., vol. XXXI, No. 183, pp. 208, 209.

For complete synonymy, copy of the original description and additional notes see Palmer, 1937, Bull. Amer. Paleont., vol. VII, No. 32, p. 485, pl. 75, figs. 10, 11.

Through the courtesy of J. T. Singewald, Jr., Chairman of the Geological Department at the Johns Hopkins University, the type of Langdon's species has been loaned and photographs of the shell are included herein.

The Lower Claiborne, Lisbon formation specimen from near Newton, Mississippi, figured in 1937 has spiral lines with narrower interspaces and finer punctations than that of the type. Two specimens from Gopher Hill, Alabama represent, respectively, a mature and young shell. The larger has the spiral lines with interspaces equivalent to those of the type and the punctations are similar in size. The smaller specimen has interspaces and punctations finer than the Newton shell. Therefore it seems that the difference in the size of the interspaces between the spiral lines and size of the punctations may vary considerably with the age of the individuals. At least there are yet too few specimens

available to make specific distinctions on such differences of character.

*Holotype*.—Geology Department, The Johns Hopkins University, Baltimore, Md.

*Occurrence*.—Lower Claiborne. Lisbon formation, loc. 726 (see Palmer, 1937, p. 10); "Ferruginous sand" bed, 8 ft. above Gosport sand. Claiborne, Ala. (see Palmer, 1937, p. 486) (type). Loc. 1057, St. Stephen's, Gopher Hill, at water's edge, Washington County, Ala., collected by G. D. Harris, Oct. 3, 1940.

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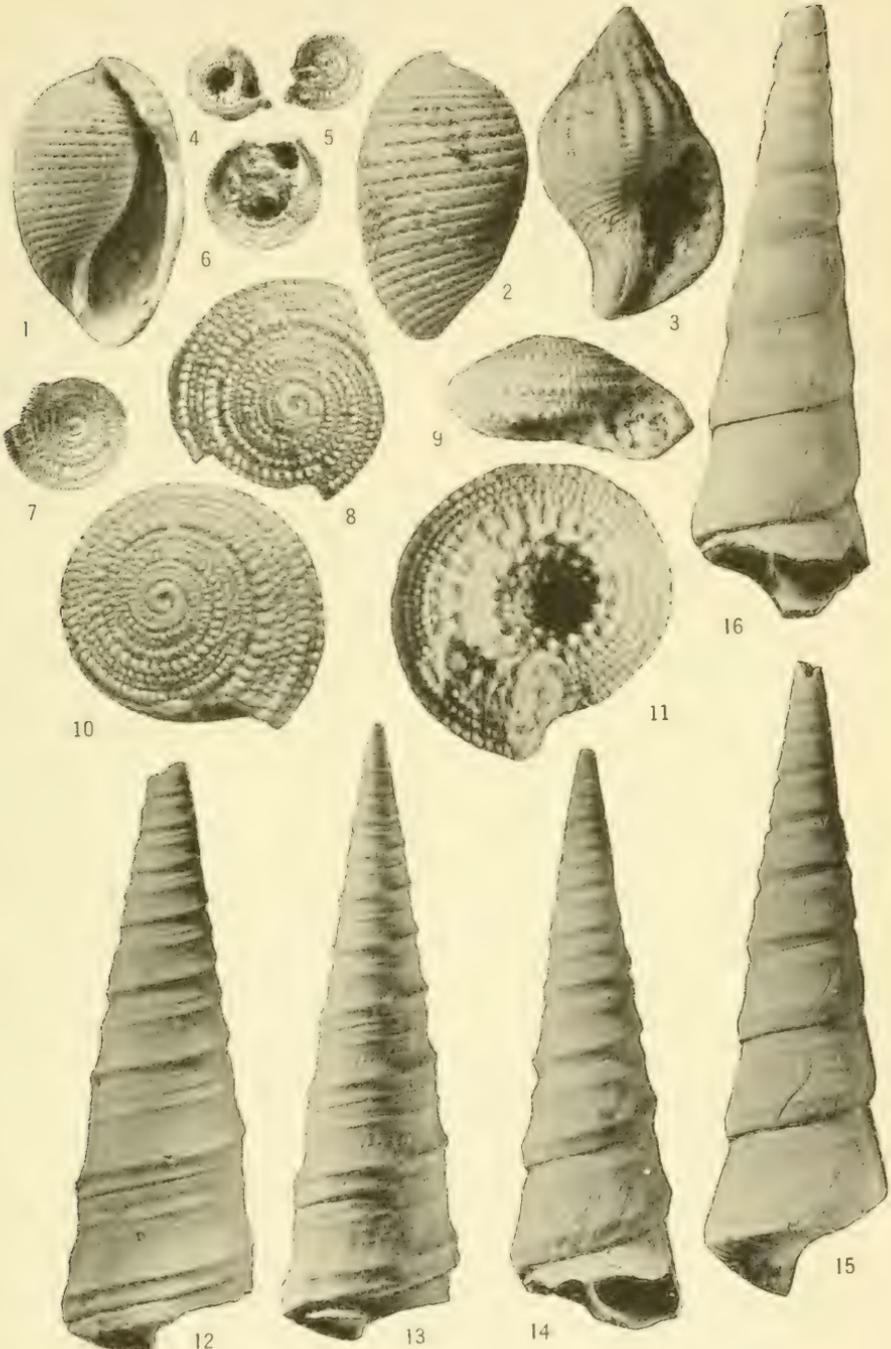
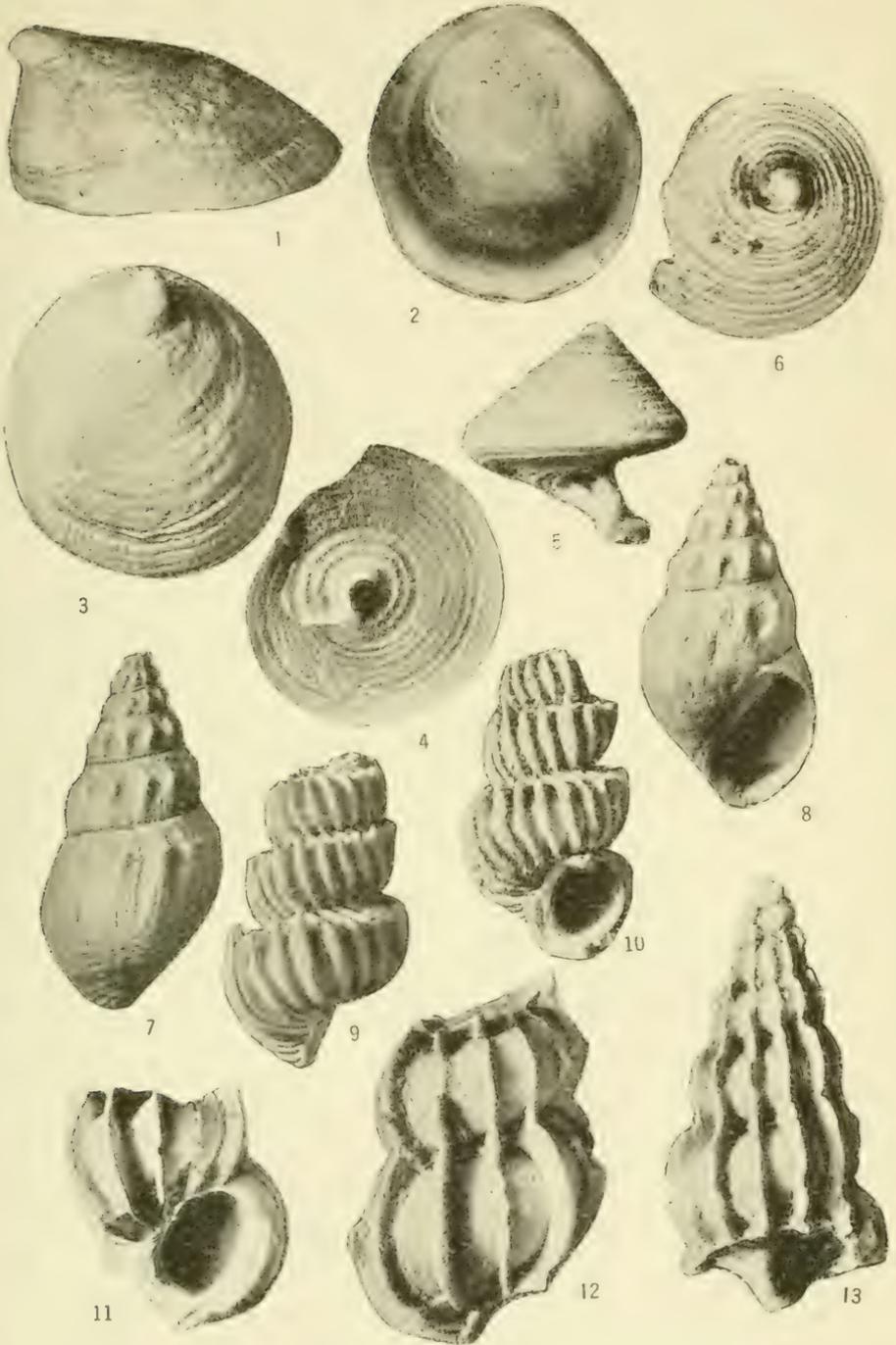




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No. 113

NEW FORAMINIFERAL GENERA FROM THE CUBAN  
MIDDLE EOCENE

By

W. Storrs Cole and Pedro J. Bermudez

*May 4, 1944*

PALEONTOLOGICAL RESEARCH INSTITUTION  
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NEW FORAMINIFERAL GENERA FROM THE CUBAN  
MIDDLE EOCENE

By

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Columbus, Ohio

and

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INTRODUCTION

Early in 1943 Bermudez sent Cole selected specimens from 10 stations in the Eocene of Cuba. The stations represented are:

1. Station 158—Southwest of Cayo Ballenatos, north of Camaguey Province.
2. Station 481—North of Grua 9, Ramal Juan Criollo of Central Jatibonico, Camaguey Province.
3. Station 222—Cut in road from Managuaco to Nazareno, Habana Province.
4. Station 464—Punta Brava, Habana Province.
5. Station 110—850 meters northwest of Penón, Matanzas Province.
6. Station 322—1 kilometer south of Central Saratoga, Matanzas Province.
7. Station 337A—4.5 kilometers west of Guanajay on the road to Mariel, Pinar del Rio Province.
8. Station 246—3 kilometers southeast of Hotel Saratoga, San Diego de los Baños, Pinar del Rio Province.
9. Station 261—Loma Candela, San Diego de los Baños, Pinar del Rio Province.
10. Station 527—East of Jicotea near Carretera Central, Santa Clara Province.

Cushman and Bermudez (1936a; 1936b; 1937) have described specimens of Foraminifera from three (Station 110, 261, 337A) of these localities. The only species discussed by Cushman and Bermudez (1936b, p. 59, pl. 10, figs. 27-30) in the present collection was *Pseudorbitolina cubensis* Cushman and Bermudez. Bermudez (1937, pp. 330-336) published a detailed list of the Foraminifera from Station 337A which he gave as one of the important faunal stations in naming the Jabaco formation which he correlated with the Tantoyuca formation of the Tampico Embayment area.

Cole (1941, pp. 22, 23, pl. 2, figs. 5-11; 1942, pp. 18, 19, pl. 3, fig. 4; pl. 5, fig. 1; 1944, pp. 35, 36, pl. 2, fig. 7; pl. 8, figs. 14, 15; pl. 13, figs. 1, 2) identified *Pseudorbitolina cubensis* in several wells in Florida. It is now apparent from this study that the Florida specimens are of the same species as those described from Cuba, but these specimens do not belong to the genus *Pseudorbitolina*. They represent a new genus which is named *Eodictyoconus*.

Bermudez (1937, p. 333) reports that *Gunteria floridana* Cushman and Ponton occurs with *Eodictyoconus cubensis* (Cushman and Bermudez) at Station 337A. In the present collection *Dictyoconus americanus* (Cushman) was found in association with *Eodictyoconus cubensis*. Cole (1942, pp. 7, 8; 1944, pp. 25, 36) has demonstrated that these species are characteristic of the middle Eocene Lisbon limestone which is a distinct subsurface unit in Florida. It is evident that a portion of the Jabaco formation of Cuba is middle Eocene in age rather than upper Eocene as the previous correlation with the Tantoyuca formation would suggest. The Tantoyuca formation has been correlated with the Jackson formation. Muir (1936, p. 118) has suggested "future study may show the basal part of the Tantoyuca to be a facies of the upper Tempoal". Cole (1927) believes that the upper Tempoal represents the Guayabal formation, a unit which is distinct from the underlying Tempoal.

## DESCRIPTION OF GENERA AND SPECIES

## Family VALVULINIDÆ

## Genus CAMAGUEYIA Cole and Bermudez, new genus

Genotype—*Camagueyia perplexa* Cole and Bermudez, new species

Test in the early stages with several chambers to the whorls with some reduction of the number of chambers in the adult portion of the test; wall finely arenaceous with considerable cement; chambers low, compressed, between thick roofs and floors; roofs and floors not extending to the center of the test which has pillar-like structures, particularly near the aperture; aperture located in the center of the truncate apertural face surrounded by inward projecting teeth.

The shape of the test and arrangement of the chambers in *Camagueyia* suggest the initial portion of *Tritaxilina* Cushman. Although numerous specimens were available, none of these showed the marked reduction in the number of chambers to a whorl which characterizes *Tritaxilina*. The aperture of *Tritaxilina* becomes terminal in the adult stage with a series of inward projecting teeth. In the initial stages the aperture is simple. The aperture of *Camagueyia* is similar to that of the adult stage of *Tritaxilina*, but occurs in a form of test which would be considered the initial stage in *Tritaxilina*. The development of the pillarlike structures below the aperture is not found in *Tritaxilina*. *Camagueyia* may be the ancestor of *Tritaxilina*.

*Camagueyia perplexa* Cole and Bermudez, n. sp.

Plate 1, figs. 2, 3

Test conical, the initial end tapering, the apertural face truncate or very slightly concave, early chambers indistinct, becoming more pronounced in the adult whorls; sutures in the initial portion indistinct, flush with the surface of the test, followed by rather distinct, depressed sutures between raised chamber walls; wall finely arenaceous with large amounts of calcareous cement; aperture large, in the center of the apertural end, surrounded by inward projecting teeth.

Axial sections show narrow, compressed chambers between very thick roofs and floors. The center of the test has a few pillars developed near the aperture below which the central area

may be open as the chamber walls do not extend to the center of the test. Horizontal sections were not very satisfactory, but these showed a clear central area into which several teeth projected.

An average specimen has a length of 0.8 mm. and a diameter at the apertural end of 0.8 mm. The largest specimen has a length of 1.0 mm. and a diameter at the apertural end of 0.7 mm.

*Localities.*—Stations 158; 246; 261; 337A.

Genus **DICTYOCONUS** Blanckenhorn, 1900

- Dictyoconus americanus** (Cushman) Plate 3, figs. 6-10  
*Conulites americana* Cushman, 1919, Carnegie Inst. Wash. Publ. 291, p. 43, text fig. 3.  
*Dictyoconus americanus* Cole, 1942, Florida Geol. Survey Bull. 20, pp. 21-24, pl. 3, figs. 12, 13; pl. 6, figs. 1-9; pl. 7, figs. 1-5; pl. 16, figs. 14, 15 (references and synonymy).

Specimens from Station 261 possess the essential features of this species.

Genus **EODICTYOCONUS** Cole and Bermudez, new genus  
 Genotype.—*Pseudorbitolina cubensis* Cushman and Bermudez

Test regularly or irregularly conical, some specimens with a deeply excavated umbilicus, others with the umbilical area completely filled with tiers of chamberlets. Specimens with the well-developed umbilicus are composed of a single layer of chambers, many of which contain a single horizontal plate. Specimens with the umbilical area filled with chamberlets have a plate, through which there are several large perforations, covering the umbilical area on the base of the test. The embryonic apparatus is composed of three subspherical chambers situated at the apex of the test.

**Eodictyoconus cubensis** (Cushman and Bermudez)

- Plate 1, fig. 1; Plate 2, figs. 1-12; Plate 3, figs. 1-5  
*Pseudorbitolina cubensis* Cushman and Bermudez, 1936, Contrib. Cushman Lab. Foram. Res., vol. 12, p. 59, pl. 10, figs. 27-30; Cole, 1941, Florida Geol. Survey Bull. 19, pp. 22, 23, pl. 2, fig. 5-11; Cole, 1942, *ibid.*, Bull. 20, pp. 18, 19, pl. 3, fig. 4; pl. 5, fig. 1; Cole, 1944, *ibid.*, Bull. 26, pp. 35, 36, pl. 2 fig. 7; pl. 8, figs. 14, 15; pl. 13, figs. 1, 2.

Douvillé (1910, p. 57) described the genus *Pseudorbitolina* as follows:

Coquille convexo-concave, constituée par un test sableux, finement ré-

tiolé sur face supérieure qui est ornée de fines lignes d'accroissement; la face inférieure présente sur son pourtour un limbe annulaire avec une seule rangée d'ouvertures correspondant à un canal principal annulaire; des canaux analogues se succèdent régulièrement jusqu'au sommet. Entre ces canaux et la surface externe se développent tout un système de canaux rayonnants tubulaires, disposés en couches successives correspondant aux bandes d'accroissement.

This genus was illustrated by four external views, two diagrams of the surface sculpture and one axial section. Unfortunately, all of these were drawings.

Cushman and Bermudez (1936, p. 59) referred Cuban specimens to this genus. Cole (1941, p. 22; 1942, p. 18; 1944, p. 35) recognized that specimens from Floridian wells were the same as those described from Cuba by Cushman and Bermudez. Bermudez (letter dated March 10, 1943) wrote Cole stating that he did not believe the Cuban specimens should have been referred to the genus *Pseudorbitolina*.

Cushman and Bermudez (1936, p. 59) presented an excellent description of the external features of the species they referred to *Pseudorbitolina*. Cole illustrated the internal features of the Floridian specimens assigned to the Cuban species. Inasmuch as the internal features of *P. cubensis* Cushman and Bermudez have not been described or illustrated, four axial sections and one horizontal section made from topotype specimens will be described and illustrated.

*Horizontal section.*—This section measures 1.46 mm. by 0.74 mm. The central open portion measures 0.74 mm. by 0.30 mm. The wall surrounding the umbilicus is divided into chambers having a length of 100 to 120  $\mu$  and a width of about 20  $\mu$  on the long sides of the test. The chambers on the short, curved ends of the test have a length of as much as 220  $\mu$  and a width of as much as 100  $\mu$ . Many of these chambers are subdivided by a vertical plate which extends from the peripheral side of the chamber one-half to three-quarters across the chamber opening. The radial chamber walls on the straight sides of the test end in an irregular wall which partially surrounds the umbilicus, but on the curved short ends the radial chamber walls bifurcate into two short processes which do not seem to be connected with each other nor with any wall of the umbilicus. Along one of the

straight sides on the peripheral edge there is a row of small chamberlets. The horizontal floors and roofs of the chambers are perforate. The perforations are of two types: small dark dots and large round openings of which about three occur to a chamber. Many of the radial chamber walls have a fine dark line through the center.

*Axial sections.*—The first section to be described has a diameter at the base of 1.1 mm. and a height of 0.66 mm. The umbilicus has a basal diameter of 0.5 mm. and a height of 0.4 mm. The test is composed of a single layer of chambers arranged so that the long axis of the chambers is parallel to the base of the test. These chambers have a length of about 260  $\mu$  and height of about 60  $\mu$ . A single horizontal plate projects about 80  $\mu$  into each chamber from the external wall. The most notable feature of this section is the fact that two of the three embryonic chambers are shown. The larger chamber has an internal length of 200  $\mu$  and an internal height of 140  $\mu$ ; the smaller chamber has an internal length of 80  $\mu$  and an internal height of 90  $\mu$ . The wall surrounding these chambers has a thickness of about 20  $\mu$ .

The second section represents a specimen with a basal diameter of 1.22 mm. and a height of 0.84 mm. The umbilicus has a basal diameter of 0.6 and a height of about 0.5 mm. The test is composed of a single layer of chambers arranged so that the long axis of the chambers is parallel to the base. Average chambers have an internal length of about 180  $\mu$  and an internal height of about 50  $\mu$ . The floors of the chambers bend downward as they leave the periphery of the test, then curve sharply so that they become parallel with the base of the test and finally as they approach the umbilicus they bend gently toward the apex of the test and touch the floor of the next chamber above. Some of the umbilical ends of the floors do not quite touch the floor of the next chamber in which case a narrow passage is left. These chambers are simple, without the projecting horizontal plate observed in the first section described.

The third section was made from a low, spreading individual with a basal diameter of 2+ mm. and a height of about 0.6 mm. The umbilicus has a basal diameter of about 0.6 mm. and a height

of about 0.4 mm. The structure of the chambers composing the test is irregular (see Plate 2, figure 7).

The fourth section was made from a much larger individual with a basal diameter of 3.2 mm. and a height of 2.9 mm. This specimen, viewed from the apex, had a triangular cross section. The umbilicus was covered by a plate in which there were several distinct openings. The test is composed of a peripheral layer of chambers similar to the ones observed in the other sections except that they are larger, but this specimen instead of having an open umbilicus has that area partially filled by small chamberlets.

Although the preliminary decision was made that this large specimen might represent a different genus, study of a large suite of specimens from Station 261 demonstrated that such was not the case. An analysis of the specimens from Station 261 follows.

The specimen illustrated on Plate 1, figure 1 has a basal diameter of 1.2 mm. and a height of 0.54 mm. The basal diameter of the umbilicus is 0.6 mm. and the height of the umbilicus is 0.36 mm. The test is composed of a single layer of chambers, some of which possess a single horizontal plate. At the apex a portion of a single embryonic chamber is shown.

A slightly larger specimen with a basal diameter of 1.46 mm. and a height of 0.8 mm. is illustrated on Plate 2, figure 3. The umbilicus of this specimen has a basal diameter of 0.6 mm. and a height of 0.5 mm. The structure of the test is similar to that observed in the first thin section described from this station.

The specimen illustrated on Plate 3, figure 5 demonstrates the connection between the specimens which are composed of a single layer of chambers and possess a deep umbilicus and those which have the umbilical area partially filled with chamberlets. This specimen which has a basal diameter of about 2 mm. and a height of 1.6 mm. has its test composed of a peripheral layer of chambers similar to those specimens which are composed of this layer alone. However, there is a mass of chamberlets developed at the base and extending into the umbilical area. The embryonic chambers observed in this specimen are similar to those previously described

from a topotype of "*Pseudorbitolina*" *cubensis*.

The specimens illustrated on Plate 2, figures 2, 4, 6 are a continuation of the series which proves that this genus contains specimens in which the test is composed of a peripheral layer of chambers enclosing a deep, well-developed umbilicus to those specimens which have the umbilical area completely filled with layers of chamberlets.

*Pseudorbitolina marthæ* Douvillé, the genotype of *Pseudorbitolina*, is similar to many of the Cuban specimens in that the test is concavo-convex, and is composed of a single layer of chambers. However, this similarity is superficial because the details of the internal structure are different.

As Douvillé indicates *Pseudorbitolina* is somewhat similar to *Orbitolina*, whereas *Eodictyoconus* is closely related to *Dictyoconus*, particularly through the specimens which have the umbilical chamberlets developed.

*Localities*.—Stations 110; 261; 337A.

#### Family AMPHISTEGINIDÆ

Genus **EOCONULOIDES** Cole and Bermudez, new genus

Genotype.—*Eoconuloides wellsi* Cole and Bermudez, new species

Test conical with an involute, trochoid, multichambered spire, the final chambers subdivided on the peripheral side into small chamberlets. The embryonic apparatus is bilocular, consisting of a subspherical initial chamber and a smaller second chamber. The spiral wall is thick initially and possesses irregularly developed pillars. The final spiral wall is thinner and lacks pillars.

*Eoconuloides* is related to *Helicostegina* Barker and Grimsdale (1936, p. 233). The embryonic apparatus in the two genera are the same. But, the most primitive species of *Helicostegina* has well-developed subsidiary chamberlets. These are not found in *Eoconuloides* although there is a suggestion of the development of this type of chamberlet. The axial sections of *Helicostegina* show biconvex forms, but *Eoconuloides* has a remarkable conical shape which produces triangular axial sections. *Eoconuloides* is

a specialization of the *Helicostegina* type by the axial elongation of the test.

*Eoconuloides wellsi* Cole and Bermudez, n. sp. Plate 1, figs. 4-10

Test conical, the base flat or very slightly convex, apex bluntly rounded, peripheral angle subacute, surface smooth, but in well-preserved specimens there is a mesh of clear shell material which outlines opaque areas. The mesh is composed of semicircular bands with the convex portion oriented toward the base of the test. The apical side of an individual unit of the mesh is formed by two intersecting convex sides of the succeeding row of units. The external dimensions of five specimens follow:

Specimen	1	2	3	4	5 (type)
Height	1.0 mm.	1.0 mm.	0.8 mm.	1.36 mm.	1.4 mm.
Diameter of					
base	0.96 mm.	1.16 mm.	0.88 mm.	1.26 mm.	1.14 mm.

The embryonic apparatus is bilocular, the initial chamber is subspherical with internal diameters of  $40 \times 60 \mu$ , the second chamber is smaller with internal diameters of  $30 \times 40 \mu$ . The distance across both chambers including the chamber walls is  $100 \mu$ . The division between the chambers is thin and straight. The outer chamber wall is relatively thick.

A horizontal section with a diameter of 1.02 mm. has  $3\frac{1}{8}$  coils with 25 chambers in the final volution. The chamber walls are straight, and many of them have a slight expansion on their proximal ends. There appears to be an aperture between this expanded portion of the radial chamber wall and the spiral wall, however, the preparations were not sufficient to be absolutely certain. One slightly oblique horizontal section indicates that the final chambers are subdivided into chamberlets in the peripheral portion.

Axial sections show the trochoid character of the test. The spiral wall has differences in thickness. The inner part has a thickness of  $100 \mu$  but the peripheral wall may be as thin as  $30 \mu$ . The thicker walls possess irregularly developed pillars. The heads of the pillars project above the surface of the walls. There is considerable difference in the strength of the pillars between in-

dividuals. The thin peripheral walls appear to lack pillars which would account for the absence of surface ornamentation.

This species is named in honor of Dr. John W. Wells.

*Locality*.—Station 222.

#### Family PLANORBULINIDÆ

Genus **EOANNULARIA** Cole and Bermudez new genus

*Genotype*.—*Eoannularia cocenica* Cole and Bermudez, new species

Test small, fragile, flat or concavo-convex, with or without a small umbo on the convex side. Embryonic apparatus bilocular; either a small, circular initial chamber slightly embraced by a larger chamber, or an ovoid initial chamber completely embraced by the second chamber. Equatorial chambers of two types, those of the annuli adjacent to the embryonic apparatus have curved outer walls and truncated inner ends, those in the final annuli are regularly rectangular with the radial walls in adjacent annuli alternating in position. The entire thickness of the test is composed of the equatorial layer, except a slight deposit of clear shell material over the embryonic apparatus.

*Eoannularia* has coarsely perforate, calcareous walls similar to *Linderina*. The embryonic apparatus, the shape and arrangement of the initial embryonic chambers are similar to those of *Linderina*. However, the equatorial chambers of the final annuli are similar to those of *Cycloclypeus*. *Linderina* has a very thick layer of clear shell material over the central portion of the test.

**Eoannularia cocenica** Cole and Bermudez, n. sp. Plate 1, figs. 11-16

Test small, fragile, circular, flat or concavo-convex, usually with a small, distinct umbo on the convex side, diameter from 0.6 to 1.32 mm. Many specimens have a thickened central area surrounded by a thinner portion from which the test slowly thickens toward the periphery. A typical specimen with this type of cross section has a thickness of 0.14 mm. at the center of the test, a thickness of 0.8 mm. at a distance of 0.14 mm. from the center, and a thickness of 0.12 mm. at the periphery. The surface of the test is ornamented by a regular mesh formed by the walls of the equatorial chambers, observed especially if the surface of the test is wet. Specimens with umbos have the mesh only on the pe-

ripheral portion of the test as the umbo is composed of clear shell material which effectively covers and conceals the equatorial layer.

The embryonic apparatus consists of two chambers. Two preparations have a small, circular initial chamber slightly embraced by a larger chamber; a single thin section has an ovoid initial chamber completely embraced by a larger chamber. The following table presents the measurements of these three embryonic apparatusi:

Specimen	1	2	3
Distance across both chambers including chamber walls	70 $\mu$	60 $\mu$	120 $\mu$
Internal diameter or diameters of initial chamber	20 $\mu$	20 $\mu$	45x50 $\mu$
Internal diameter of second chamber	22x40 $\mu$	20x50 $\mu$	40x110 $\mu$
Thickness of outer wall	7 $\mu$	6 $\mu$	15 $\mu$

At first the specimen with the larger embryonic apparatus was thought to represent another genus, but as the other characters are identical with the other specimens, it is included with them.

The embryonic apparatus is surrounded by about six annuli of equatorial chambers with curved outer walls and truncated inner ends. These equatorial chambers increase in size gradually. As this increase occurs the tangential diameter gradually becomes greater than the radial diameter and the curvature of the outer wall becomes less. There is a gradual change from the inner annuli to the outer which are composed of regular, rectangular chambers which have a radial diameter of about 40  $\mu$  and a tangential diameter of about 60  $\mu$ . The radial chamber walls of these rectangular chambers in adjacent annuli alternate in position.

The vertical sections show that the entire thickness of the test is composed of the equatorial chambers with the exception of a slight accumulation of shell material over the embryonic apparatus. The walls of the equatorial chambers as viewed in vertical

sections are strongly concave toward the periphery. Numerous stoloniferous apertures occur in the chamber walls.

*Localities.*—Station 322; 337A; 464; 481; 527.

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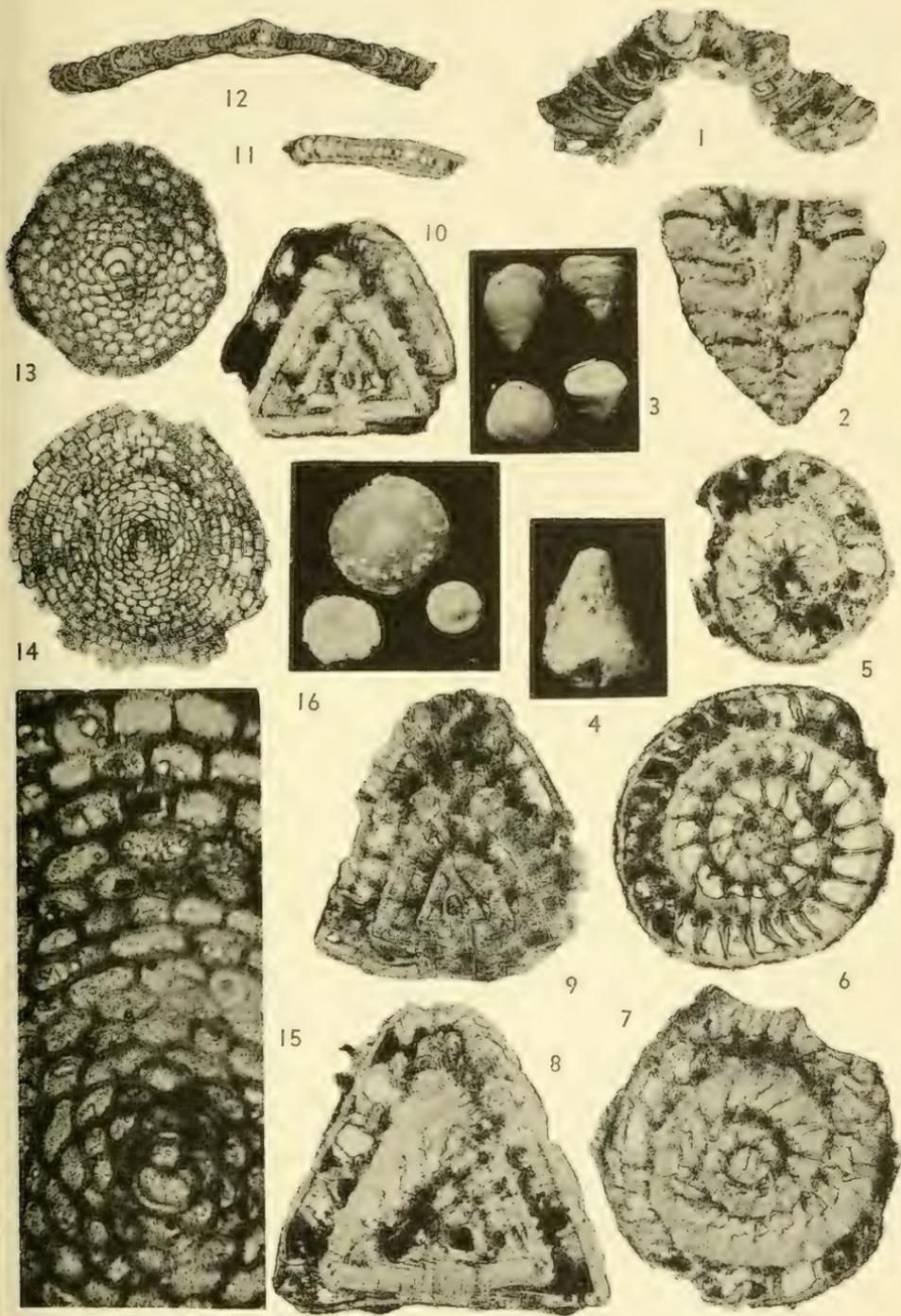




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## EXPLANATION OF PLATE 2 (28)

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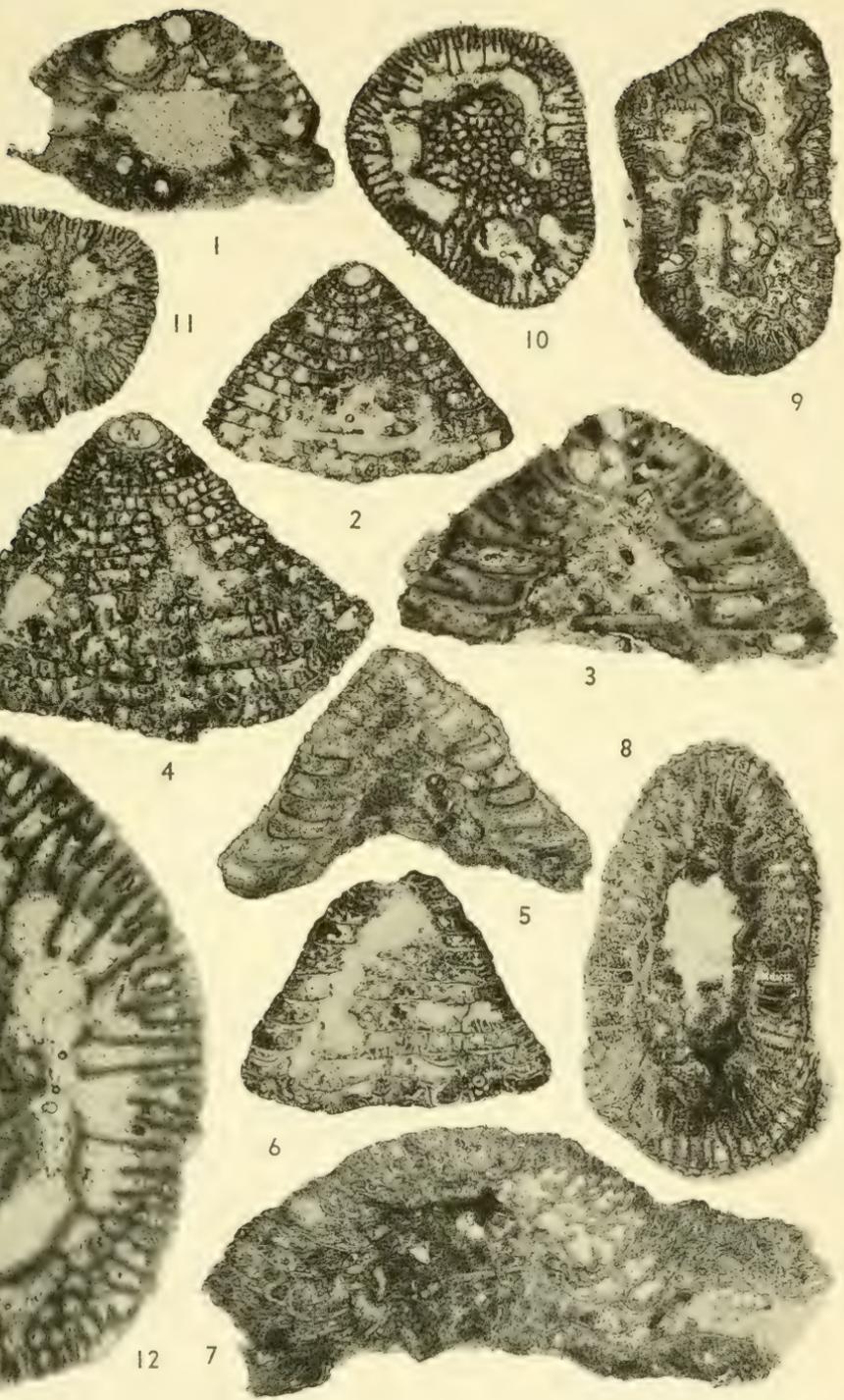
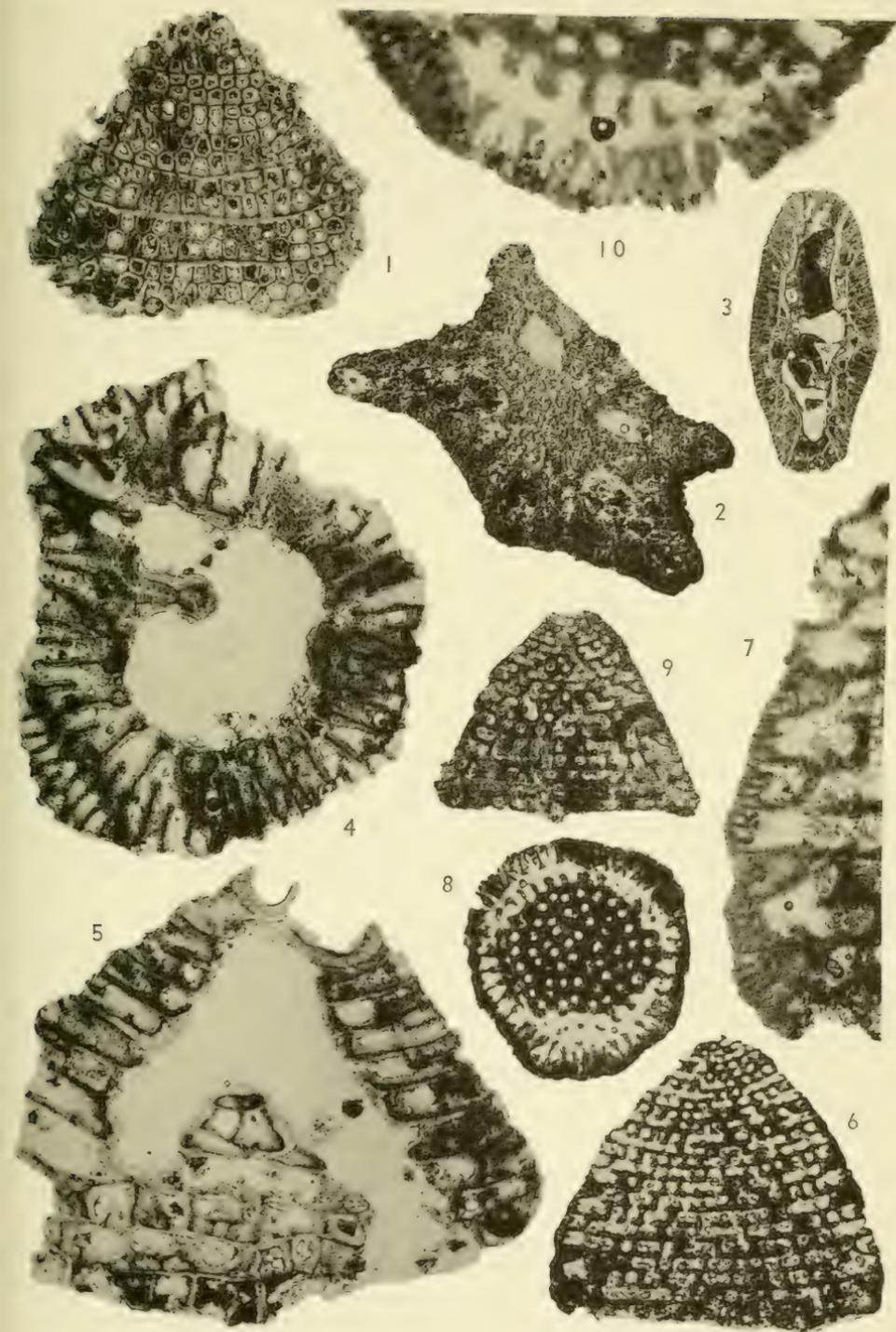


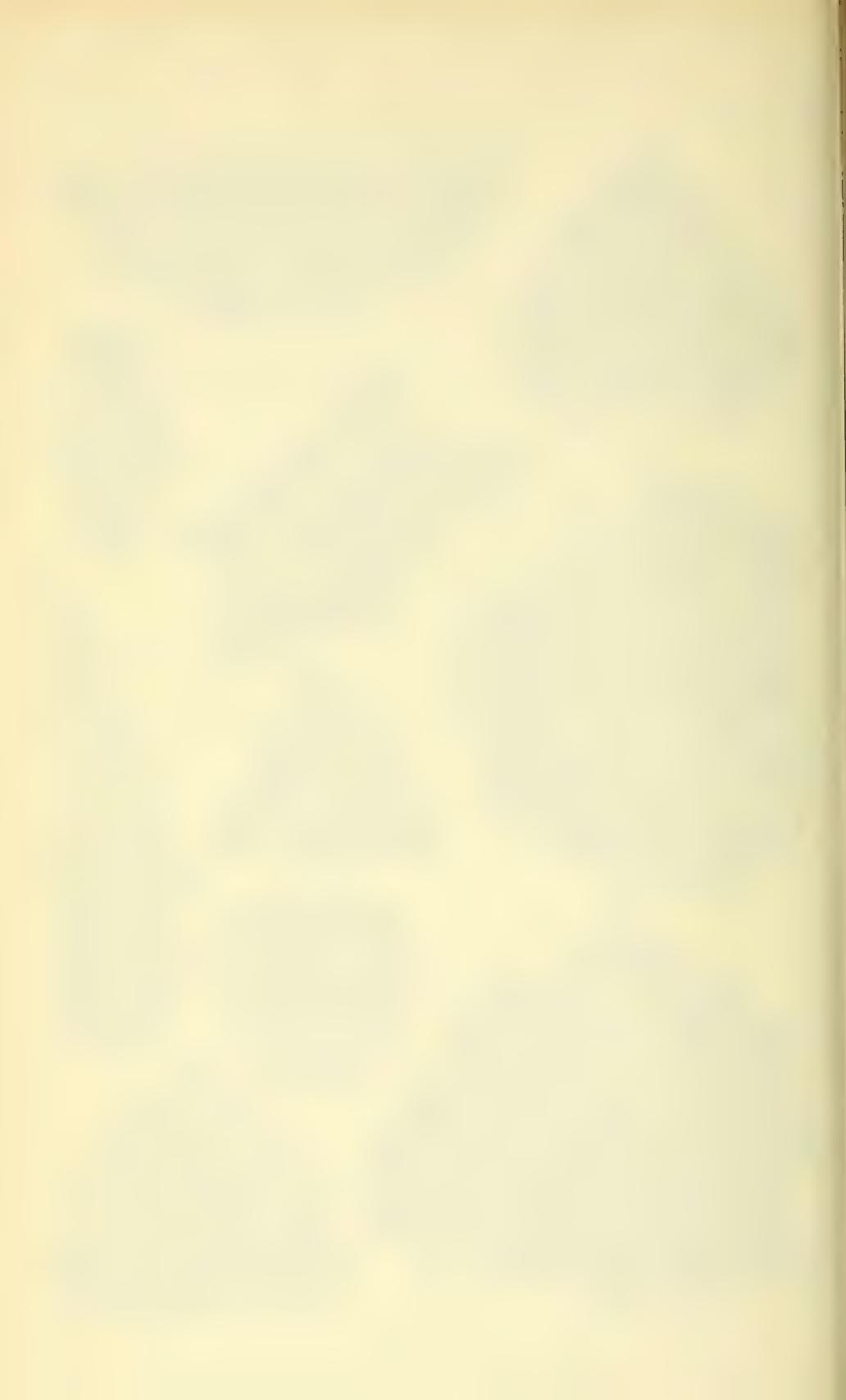


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## EXPLANATION OF PLATE 3 (29)

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**THE LARGER FORAMINIFERA FROM SAN JUAN DE LOS  
MORROS, STATE OF GUARICO, VENEZUELA**

By

C. M. Bramine Caudri

*July 16, 1944*

Palaeontological Research Institution  
Ithaca, New York  
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# THE LARGER FORAMINIFERA FROM SAN JUAN DE LOS MORROS

By

C. M. Bramine Caudri

## ABSTRACT

The fauna in limestone samples from San Juan de los Morros, State of Guarico, Venezuela, was found to be of Paleocene age. Seven species of larger Foraminifera are described, two of which are new (*Hexagonocyclina meandrica* and *Discocyclina aguerreverei*), two new generic names (*Hexagonocyclina* and *Kanikothalia*) are proposed and the nomenclature of the American "Miscellaneas" is discussed. A general discussion on the relative age of the Soldado formation and the vertical distribution of the Upper Cretaceous and lower Tertiary larger Foraminifera in this region concludes the paper.

## ACKNOWLEDGMENT

Early in 1941 Dr. S. E. Aguerrevere, geologist of the Ministerio de Fomento, Venezuela, presented a small collection of rock samples containing larger Foraminifera from San Juan de los Morros, State of Guarico, to Dr. H. G. Kugler at Pointe-a-Pierre, who assigned the examination to me.

After the preliminary results had turned out to be of general interest, it was decided that they should be worked out for publication. It is a privilege to acknowledge here the help from all those who made this work possible by their interest and assistance. S. E. Aguerrevere furnished the information on the stratigraphical position of the samples, H. Baggelaar, T. F. Grimsdale, U. Haanstra, H. G. Kugler and A. Senn lent me literature from their private libraries, whereas T. W. Vaughan sent us copies of a private correspondence between himself, L. M. Davies and S. Hanzawa on the subject of the nomenclature of the Miscellaneas. My special thanks go to H. H. Renz for his advice and help in supplying literature, to T. F. Grimsdale for many elucidative discussions and for supplying me with type specimens for comparison, and especially to A. Senn, of Barbados, who very kindly took the trouble of showing me the various localities in the Scotland District of that island, in order that I might gain some insight in the character of the highly interesting upper Scotland formation.

Mrs. Dorothy K. Palmer prepared for use in the Pointe-a-Pierre Geological Laboratory a carefully chosen collection of types from Cuba, for which I wish to express my gratitude. Circumstances did not, however, permit me more than a superficial examination of this material, so that all the remarks made on Cuba in the following pages have to be considered as based only on published literature and on a couple of Cretaceous types previously received from T. F. Grimsdale.

I am greatly indebted to Trinidad Leaseholds Limited for their permission to insert data obtained from their material for the purpose of comparison with the San Juan fauna.

Finally, I want to thank the Imperial College of Tropical Agriculture in Trinidad for generously offering me facilities for the completion of my manuscript and the preparation of the photographs.

#### DESCRIPTION OF THE MATERIAL

The material at my disposal consisted of 11 samples of hard foraminiferous limestone, collected at San Juan de los Morros, State of Guarico, Venezuela. These samples and many sections prepared from them are kept in the collections of the geological laboratory of Trinidad Leaseholds Ltd., Pointe-a-Pierre, Trinidad B. W. I., while duplicates of the samples are kept by the Servicio Tecnico de Minería y Geología in Caracas. The holotypes or syntypes of the new species and hypotypes including all the photographed specimens were sent to the U. S. National Museum, Washington, D. C.

The samples can be described as follows:

G.41. Locality.—Foot of Morro with lighthouse

*Discocyclina aguerreverei*, n. sp. (common)

*Athecocyclina* cf. *cookei* (Vaughan) (scarce)

*Lepidorbitoides* cf. *planasi* M. G. Rutten (common)

*Ranikothalia antillea* (Hanz.), *R. tobleri* (V. and C.)

and *R. soldadensis* (?) (V. and C.) (abundant)

- G.86. Locality.—Saddle to the south of the Morro with lighthouse (see fig. 1)  
*Discocyclina aguerreverei*, n. sp. (scarce)  
*Ranikothalia antillea* (Hanz.) (scarce)
- G.91a. Locality.—South slope of Morro de la Puerta  
*Ranikothalia antillea* (Hanz.) (abundant)  
*Ranikothalia tobleri* (V. and C.) (abundant)  
 Tubiform porous organisms, ind. (abundant) (fig. 2)
- G.91b. Locality.—as G.91a  
*Athecocyclina* cf. *cookei* (Vaughan) (abundant) (figs. 5, 6, 18, 20)  
*Lepidorbitoides* cf. *planasi* M. G. Rutten (abundant) (fig. 10)  
*Ranikothalia antillea* (Hanz.) (common) (figs. 5, 15)  
*Ranikothalia tobleri* (V. and C.) (abundant)  
*Ranikothalia* ? *soldadensis* (V. and C.) (scarce) (fig. 26)
- G.125c. Locality.—Small Morro NW. corner valley  
*Discocyclina aguerreverei*, n. sp. (abundant) (figs. 8, 11, 13, 17)  
*Athecocyclina* cf. *cookei* (Vaughan) (common) (fig. 12)  
*Lepidorbitoides* cf. *planasi* M. G. Rutten (abundant) (fig. 14)  
*Lepidorbitoides*, sp. ind. (scarce) (fig. 16)  
*Ranikothalia antillea* (Hanz.) (abundant) (fig. 23)
- G.128. Locality.—1 km. N. 50 E. from the hotel  
*Discocyclina aguerreverei*, n. sp. (abundant)  
*Athecocyclina* cf. *cookei* (Vaughan) (scarce)  
*Hexagonocyclina meandrica*, n. sp. (probably rather common) (figs. 7, 9)  
*Lepidorbitoides* cf. *planasi* M. G. Rutten (common)  
*Ranikothalia antillea* (Hanz.) (scarce)  
*Ranikothalia tobleri* (V. and C.) (common)
- G.153. Locality.—1 km. SE. of Granja  
*Discocyclina aguerreverei*, n. sp. (common)

- Athecocyclina* cf. *cookei* (Vaughan) (scarce)  
*Hexagonocyclina meandrica*, n. sp. (scarce)  
*Lepidorbitoides* cf. *planasi* M. G. Rutten (common)  
*Ranikothalia antillea* (Hanz.) (common) (fig. 25)  
*Ranikothalia* ? *tobleri* (V. and C.) (scarce)  
*Ranikothalia soldadensis* (V. and C.) (scarce) (fig. 19)
- G.164/165. Locality.—Eastward along strike from G. 91  
 ? *Discocyclina aguerreverei*, n. sp. (one bad fragment)  
*Athecocyclina* cf. *cookei* (Vaughan) (common)  
*Lepidorbitoides* cf. *planasi* M. G. Rutten (scarce) (fig. 3)  
*Ranikothalia antillea* (Hanz.) (abundant)  
*Ranikothalia tobleri* (V. and C.) (scarce) (fig. 3)
- G.174. Locality.—Along the Río Guárico, 1500 m. downstream from the mouth of Quebrada Pagüita  
 No larger Foraminifera
- G.219. Locality.—Quebrada de Agua, 2 km. SE. of San Juan  
 No larger Foraminifera
- G.s.s. Locality.—15 km. from San Juan on the road to San Sebastian  
*Discocyclina aguerreverei*, n. sp. (scarce)  
*Lepidorbitoides* cf. *planasi* M. G. Rutten (scarce, but unevenly distributed; in patches sometimes rather common)  
*Ranikothalia antillea* (Hanz.) (common) (figs. 4, 21)  
*Ranikothalia tobleri* (V. and C.) (abundant) (fig. 22)  
*Ranikothalia soldadensis* (V. and C.) (common) (fig. 24)

Among these samples ten represent one lithological unit. It is a partly pseudo-oölitic highly fossiliferous limestone with, generally spoken, a uniform fauna containing both Nummulitidæ and orbitoids. Only one piece from the locality G.91, distinguished for convenience as G.91a from the rest of the sample (G.91b), is slightly different.

1. *The pseudo-oolithic limestone.*—This is a grey to brownish-grey recrystallized limestone, in places micro-breccious (G.128, 153) and often of a definitely oolitic appearance, which is, however, caused by a peculiar kind of organisms that will be discussed below under the preliminary name of “tubiform ooliths” (Plate 1, figs. 1, 3, 5). In general, this limestone carries the following faunal and floral assemblage:

Discocyclina aguerreverei, n. sp.  
 Athecocyclina cf. cookei (Vaughan)  
 Hexagonocyclina meandrica, n. sp.  
 Lepidorbitoides cf. planasi M. G. Rutten, ? sp. ind.  
 Ranikothalia antillea (Hanz.)  
 Ranikothalia tobleri (V. and C.)  
 Ranikothalia soldadensis (V. and C.)  
 Amphistegina  
 Rotaliidae  
 Globigerinidae  
 Textulariidae  
 Miliolidae

Gastropods

Lamellibranchs

Bryozoa

Echinoids

Corals

“Tubiform ooliths”

Corallina

Lithothamnium

Archæolithothamnium

*Ranikothalia soldadensis* and *Hexagonocyclina meandrica* are only exceptionally found, but both species are to be considered as regular components of the assemblage, their scarcity being responsible for the fact that they are only occasionally showing up in the rock sections.

Of the accompanying organisms algæ (mostly *Corallina*) and the so-called “tubiform ooliths” are as a rule abundant, whereas

also echinoids and Bryozoa and in one case corals (G.125c) may play an important rôle as rock builders. Among the smaller Foraminifera only Miliolidae (G.s.s.) and Rotaliidae (G164/165) may be present in large amounts.

The samples G.174 and 219 have apparently no larger Foraminifera, but their fauna, although slightly different from the others in having a much larger quantity of shell material (lamellibranchs, small fragments), is closely linked with the rest by their abundance of "tubiform oöliths", particularly with the intermediate sample G.86, which has hardly any larger Foraminifera, that there is no doubt that they belong to the same rock as the samples that carry the complete fauna.

2. *The non-oölitic foraminiferal limestone G.91a.*—This is a typical *Ranikothalia*-limestone, containing both *R. antillea* and *R. tobleri* in large quantities and in the meantime lacking all kinds of "orbitoids". It is, furthermore, characterized by the abundance of a peculiar tubular organism of a much larger size than the above-mentioned "tubiform oöliths" and with coarsely porous walls (Plate 1, fig. 2). Echinoids and lamellibranchs are common in this rock and also some gastropods and corals were observed.

In a reef area like the one under consideration sudden changes of fauna and the occurrence of severely restricted colonies of certain organisms can be expected. For that reason, not too much stress should be laid on the difference in fauna between G.91a and the other samples. Most probably both kinds of rock belong to the same deposit.

#### PALÆONTOLOGICAL ANNOTATIONS

Hard rocks like the ones discussed here are, as a rule, an unfavorable starting-point for the detailed description of a fauna. It is true that the student can eventually get all the necessary information on the internal as well as on the external features of his species by means of orientated thin sections in addition to what he observed already in accidental rock sections and on the weathered surface of his samples, but this method requires so

much time that it can only be carried out for a very limited number of specimens. The following extensive and general remarks may, therefore, seem somewhat unbalanced if compared with the small collection of rock material on which they are based. As a matter of fact, the author would not have dared to write them down if she had not already been familiar with practically all the species in question through the study of loose specimens from Trinidad, Soldado Rock and Barbados. As this study was, for the greater part, carried out in the laboratory of Trinidad Leaseholds Limited for confidential reports, that material can not be included in our descriptions, but it has to be mentioned here to support the author's view on the systematic place of some of the forms and, at the same time, to furnish the indispensable data for the age determination of the San Juan fauna.

## SYSTEMATIC DESCRIPTIONS

Genus **DISCOCYCLINA** Gumbel, s. str.

**Discocyclina aguerreveri**, n. sp.

Plate 2, figs. 8, 11; Plate 3, fig. 13; Plate 4, fig. 17

This form is closely related to *D. grimsdalei* Vaughan and Cole. It is practically indistinguishable from that species externally and in vertical section, and also in horizontal section as far as the equatorial chambers are concerned. It should, however, be remembered that both species have up to now been found only in a recrystallized condition which may conceal original differences in the structure, especially in the vertical section. The only conspicuous difference between the two species lies in the nucleonch of the megalospheric form. *D. grimsdalei* has, in horizontal section, a "loose" initial chamber which does not touch the wall of the surrounding second chamber (it does, however, in the vertical section), whereas in *D. aguerreveri* the second chamber is kidney-shaped and embraces the first one only half or for three-quarters.

As in *D. grimsdalei*, the test of *D. aguerreveri* varies from discoid, sometimes with depressed center, to very flat with a thin edge. All the San Juan specimens are of the latter type; they

are well preserved in the hard rock and show a diameter of up to 5 mm. (Discoid specimens are known from other localities.)

*D. aguerreveri* shows a certain resemblance to Vaughan's *D. blanpiedi* from the lower Eocene of Alabama (1936, p. 254, pl. 41, figs. 1-7; see also Gravell and Hanna, 1938, pl. 7, figs. 1, 2, 3); but the latter seems to lack the thickened concentric walls which are so characteristic of the median layer of both *D. grimsdalei* and *D. aguerreveri*, it has smaller pillars and the lateral chambers have probably lower lumina and thicker walls in the vertical section.

*Syntypes*.—San Juan, G. 125c.

*Localities in San Juan*.—G. 41, 86, 125c, 128, 153, 164/165 (?), G. s. s.

*Distribution in other areas*.—Paleocene of Soldado Rock and Lizard Springs (Trinidad); Paleocene blocks from Point Bon-tour (Trinidad) (also *forma B*).

#### Genus **HEXAGONOCYCLINA**, n. gen.

*Genotype*.—*Discocyclina cristensis* Vaughan (1924, 1929)

*Characteristics of the genus*.—Test lenticular or discoid, of variable thickness, built up of a well-defined equatorial layer and lateral tissues. Embryonic apparatus small, consisting of two chambers which produce, in early development, two relatively large "auxiliary chambers" that in their turn give rise to four very short "nepionic spirals"<sup>1</sup> with two symmetric nepionic chambers over the middle of the embryonic ones. Early median chambers ogival, soon turning into the definite hexagonal shape with obtuse tops, very thin-walled (sometimes the concentric walls are locally thickened near the periphery so that the tops of the chambers are flattened and the chambers appear rectangular, but there is no doubt that the hexagonal shape is the normal one). Concentric stolons at the distal end of the radial walls (see description of *H. meandrica*). Radial walls alternating in subsequent rings of median chambers.

The place of the concentric stolons distinguishes *Hexagonocyclina* from *Discocyclina*, *s. str.*, in which they are at the prox-

<sup>1</sup> In the sense of Tan Hok for *Lepidocyclina* and *Miogyopsina*.

imal end. This peculiarity would point to relationship with *Pseudophragmina* (esp. *Proporocyclina*), but the alternating arrangement of the radial walls prevents us from including our form in that genus. The small size of the nucleoconch and the aspect of the first median chambers reminds one at first sight of of *Lepidorbitoides*, but the nepionic pattern is fundamentally different and the hexagonal shape of the later median chamber is also a marked difference. This nepionic arrangement and the shape of the median chambers are easily recognizable characteristics in *Hexagonocyclina*<sup>2</sup>.

Up to now, two or three species of *Hexagonocyclina* are already known: two flat forms (*Discocyclina cristensis* Vaughan from the Chicontepec formation in Mexico, which has been chosen as the genotype, and our San Juan species, *H. meandrica*, which may prove to be identical with it) and a small, robustly lenticular, as yet undescribed species that occurs in Trinidad and in Soldado Rock. The genus is, for the time being, considered as typical for the Paleocene.

***Hexagonocyclina meandrica*, n. sp.**

Plate 2, figs. 7, 9

Test very flat and thin, up to 3.6 mm. in diameter. Surface smooth or with small granulations; lateral chambers large, thin-walled, meandric (observed in tangential sections of the San Juan specimens in the rock, but even better on the surface of loose specimens from Soldado Rock).

Embryonic apparatus 100-120  $\mu$  (measured across both chambers), consisting of two practically equal subglobular chambers. Two large auxiliary chambers, nearly as big as the embryonic ones; four nepionic spirals, each consisting of 1-3 chambers. Median chambers at first small and ogival soon becoming isodiame-

<sup>2</sup> Both the nepionic pattern and the hexagonal chambers distinguish *Hexagonocyclina* from all other small-chambered orbitoids. A similar nepionic development is, up to now, only known from *Lepidocyclina*, s. l. and *Miogypsina*. Occasionally, hexagonal median chambers are also found in thin walled *Discocyclina*, s. str. (e. g., *Discocyclina blanpiedi* Vaughan 1936, *D. bullbrooki* V. and C., 1941, etc.) or *Asterocyclina* (e. g., the genus *Orthocyclina* Van der Vlerk, 1923; Caudri, 1934) but there is never such a distinct and constant feature as in *Hexagonocyclina*.

tric hexagonal; typical of the species seems to be that towards the periphery they become very much elongated radially and can attain a length of 85  $\mu$ . Stolons were not actually observed anywhere, but in several specimens from other localities, *e. g.*, Soldado Rock, a thinning-out and even complete obliteration of the radial walls towards the distal end occurred and a distal position of the concentric stolons can be deduced from that peculiar fact.

The vertical section can not be described from the San Juan material.

The species is very closely related to *Discocyclina cristensis* Vaughan (see description 1929, Mexico, pp. 8-9, pl. 2, figs. 1, 2) or it may be identical with it. According to the description, the Mexican species attains a diameter of only 2 mm. and its median chambers decrease in size towards the periphery. Moreover, its surface is described as "reticulate", which may indicate that the lateral chambers are polygonal like the ones in the small species from Trinidad; on the other hand, it may be that the typical meandric chambers have not yet developed in the small specimens from Mexico. This requires further investigation.

*Holotype*.—San Juan, G. 128<sup>3</sup>.

*Localities in San Juan*.—G. 128, 153.

*Distribution in other areas*.—Paleocene of Soldado Rock and Lizard Springs (Trinidad).

Genus PSEUDOPHRAGMINA H. Douvillé

Subgenus ATHECOCYCLINA Vaughan and Cole

**Pseudophragmina** (*Athecocyclina*) *cf. cooki* (Vaughan) Vaughan and Cole  
Plate 1, figs. 5, 6; Plate 3, fig. 12; Plate 4, figs. 18, 20

Comp. *Discocyclina cooki* Vaughan, 1936, Jour. Paleont., vol. 10, p. 256, pl. 42, figs. 1-6.

*Discocyclina cf. cooki* Cole, 1938, Florida Geol. Bull., 16, p. 31, pl. 12, figs. 4-5.

*Discocyclina cooki* Gravell and Hanna, 1938, Bull. A. A. P. G., vol. 22, pp. 1010, 1012, pl. 7, fig. 7.

*Pseudophragmina (Athecocyclina) cooki* Vaughan and Cole, 1941, Geol. Soc. Am., Special Paper 30, p. 62.

In 1914 Vaughan and Cole introduced the name of *Athecocyclina* for those members of the family of the Discocyclinidæ in

<sup>3</sup> Actually, the hard rock from San Juan is not a favourable material to furnish the type for this rare species. It would be better to choose the types from loose specimens found at other localities, which would offer more complete information.

which the radial walls of the medial chambers are only vaguely indicated or even totally obliterated, so that the median layer shows more or less continuous, mostly rather irregular, undivided concentric rings.

Up to now, data on the few known species of *Athecocyclina* are scanty. Vaughan and Cole, in describing their new species, *A. soldadensis*, in 1941, (pp. 25, 63), gave a short comparison with two other forms, *A. cookei* from the upper part of the Nanafalia formation in Alabama and *A. stephensoni* from the Chicontepec formation in Mexico, mentioning the ratio between diameter and thickness, the development of pillars and granulations and the shape and number of lateral chambers in vertical section. Loose specimens of *A. soldadensis* from Soldado Rock and Lizard Springs (Trinidad) showed recently that there may be quite a considerable variation both in this ratio and in the ornamentation, so that we may expect difficulties if we try to distinguish the species along those lines. On the other hand, the nature of the lateral chambers, which are rather spacious (12-24  $\mu$  high) and arranged in well-marked tiers in *A. stephensoni* (Vaughan, 1929, Mexico), but low-fissiform (8-12  $\mu$  high) and irregularly arranged in the two species, seems more promising for systematic purposes. The difference between *A. soldadensis* and *A. cookei* would lie chiefly in the number of lateral layers, the former having only 4-5 layers and the latter as many as 8-9. The specimens from San Juan, having about nine layers overlapping slitlike lateral chambers, would have to be determined as *A. cookei*. They do not, however, show the peculiar close setting of the radial "plate-like projections" across the rings in the horizontal section, which Vaughan described for that species and which he considered as probably being the remnants of median chamber walls. These plates would be only 15  $\mu$  apart and the chambers would thus be "very narrow, with the radial diameter as much as four and a half times the transverse diameter". In our specimens the "median chambers", as far as they can be distinguished, are approximately square. Careful comparison of the two materials will have to make out whether this is a really important difference or

whether perhaps a difference in crystallization has to be blamed for it.

Like some Lizard Springs specimens of *A. soldadensis*, many specimens of *A. cf. cookei* were observed to have a coarsely papillate surface. They often exceed in this respect the accompanying *Discocyclusina aguerreverci*, but the papillæ do not seem to correspond with equally heavy pillars in the vertical section.

*Localities in San Juan.*—G. 41, 91b, 125c, 128, 153, 164/165.

*Distribution outside San Juan.*—Alabama, Nanafalia formation; Florida, Salt Mountain limestone, Wilcox group; Texas, Polk County, in a deep well core 8722-8727 feet, age not mentioned (compare also the distribution in the Paleocene of the very closely related *A. soldadensis*, Soldado Rock, Trinidad, Barbados).

Genus **LEPIDORBITOIDES** A. Silvestri

**Lepidorbitoides cf. planasi** M. G. Rutten

Plate 1, fig. 3; Plate 2, fig. 10; Plate 3, fig. 14

*Lepidorbitoides planasi* M. G. Rutten, 1935, Jour. Paleont., vol. 9, p. 536, pl. 60, figs. 6-7.

The small "orbitoid" that is common in several of the San Juan samples is characterized as a *Lepidorbitoides* by its extremely fine mesh of thin-walled median chambers and by the spiral development of its nepionic stage. For the truncated, rounded shape of the median chambers it may be determined as *L. planasi* Rutten, but the determination must stay provisional until more exact data become available about this Cuban species.

The San Juan specimens correspond well with Rutten's figures both in horizontal and in vertical sections. They seem, however, different from the Florida material described by Cole (1941), especially in the vertical section. Although Rutten observed that the lateral chambers do not form regular tiers, his figure of the vertical section shows (like the specimens from San Juan) a much stronger tendency to tier formation than Cole's specimens which have fissiform chambers quite irregularly arranged in horizontal layers (1941, pl. 12, figs. 12-14; 1942, pl. 9, figs. 7-11.).

Rutten did not observe any pillars in his sections, but he admitted that his material was very unsatisfactory. The forms from

San Juan are variable in this respect but most of them are heavily pillared in the center as was observed both in sections and on the weathered surface of the samples.

*Localities in San Juan.*—G. 41, 91b, 125c, 128, 153, 164/165, G. s. s.

*Distribution in other areas.*—Habana formation of Cuba; Palaeocene blocks at Point Bontour, Trinidad; reworked in upper Eocene of Point Bontour and Soldado Rock.

**Lepidorbitoides**, sp. ind. ?

Plate 3, fig. 16

Among the large amount of *L.* cf. *planasi* in G. 125c there are a few sections in which the median chambers seem to be somewhat more pointed ogival, more like a gothic arch. It may be that they represent a different species.

Genus **RANIKOTHALIA**, n. gen.

Genotype.—*Nummulites nuttalli* (Nuttall, 1926), Davies, 1927.

In 1937 Col. L. M. Davies gave a general review of a peculiar group of nummulitic organisms in the upper Ranikot formation of India, of which *Nummulites nuttalli* is the central member.

This group is, according to Davies, characterized, in the first place, by the reticulation of the marginal cord and secondly, by the presence of transverse trabeculae branching from the septal filaments, which trabeculae, however, become apparent only under special conditions of weathering.

The present writer, who, through courtesy of the Sedgwick Museum, had the opportunity to study material of *N. nuttalli* from its type locality (1934, p. 58, pl. I, fig. 9), would like to add the following characteristics which can be even much more readily recognized in most sections because they are independent from the state of preservation:

1. The bluntly rounded chamber tops in horizontal section.
2. The thickness of the coarsely gutted supplementary skeleton as compared with the majority of other *Nummulites*.

Both characteristics suggest a close relation of the group to the genus *Pellatispira* Boussac which, for having a marginal plexus (although much less developed in ordinary nummulites) and a single foramen between adjacent chambers, should be in-

cluded in the family of the Nummulitidæ (Umbgrove, 1928; Barker, 1939, p. 309). *Pellatispira*, however, has an evolute spiral and a far stronger development of the secondary skeleton and vertical canals than the members of the *nutalli* group. On the other hand, the features of this group are sufficiently different from those of *Nummulites*, *s. str.* to distinguish it, for convenience, as a separate genus, for which I propose the name *Ranikothalia*, after the formation (Ranikot) and the locality (Thal), from where it was first adequately described (Davies, 1927).

The Indian representatives of this genus are:

*Nummulites nutalli* (Nuttall) Davies, *con var. kohaticus* Davies

*Nummulites thalicus* Davies, *con var. gwynæ* Davies (considered as the megalospheric form of *N. nutalli*)

*Operculina* (or *Nummulites*) *sindensis* Davies (1926), 1937

Ranikothalias have also been found in the Caribbean Region and Mexico, from where they were described under various generic names, *Operculina*, *Operculinoides*, *Camerina*, *Pellatispirella*, *Miscellanea*. A short discussion on their nomenclature may follow:

In India there occur in the Ranikot beds, side by side with *N. nutalli*, *c. s.*, a couple of very similar, strongly granulated forms that were originally described as *Nummulites* by d'Archiac and Haime (1853) and subsequently by H. Douvillé, Nuttall, Cotter and, at first, also by Davies considered as belonging to *Siderolites*. As this was not satisfactory, Pfender (Bull. soc. géol. de France, (5), vol. IV, 1934, pp. 225-236, pls. XI-XIII) created the new genus *Miscellanea* for this kind of organism. They are now known under the name of *Miscellanea miscella* (d'Archiac and Haime) and *Miscellanea stampi* (Davies).

Davies (1937, pp. 19-21, 40-42) discussed the relation between his *nutalli*-group (= *Ranikothalia*) and *Miscellanea*. In the latter, the supplementary skeleton is everywhere broken up into pillars and, in connection with this, there is no differentiation into compact lateral walls of the shell and a pillared marginal cord (see his text fig. 1). Davies came to the conclusion that *Miscel-*

*lanca* is nothing else than a pathologic form of the *Nummulites* of the *nuttalli*-group, but for practical morphologic reasons he treated it as a separate palaeontological genus.

After this was settled, a similar confusion started for the Caribbean forms. Here Hanzawa (1937) was the first to distinguish the Jamaican species, *Camerina* (= *Nummulites*) *matleyi* Vaughan from the true *Nummulites* on account of the canal system; he created the genus *Pellatispirella* for it and described in the same paper also a second species, *P. antillea*, from Haiti. Vaughan and Cole (1941, p. 32) discussed the validity of this genus and stated that *Pellatispirella* is a synonym of *Miscellanea* Pfender. This solution, although firmly based on comparison of the types, does not, however, satisfactorily cover all the details of the problem. There can hardly be any doubt that *Pellatispirella matleyi*, the genotype, belongs to the same genus as the Indian *Miscellaneas*, for it shows the peculiar development of the canals which "break up the entire supplementary skeleton into granules" as Davies put it, and it lacks a marginal cord. According to the rule of priority the name "*Pellatispirella*" has, therefore, to retreat before "*Miscellanea*". On the other hand, the second species, *P. antillea*, though it shows rounded chamber tops and vertical canals like a *Miscellanea*, definitely possesses a marginal cord and the walls are by no means broken up to the same extent as in *P. matleyi* or the Indian forms (comp. Vaughan and Cole's illustrations with our figures 21 and 23). Besides, it shows, in accurate equatorial sections, the conspicuous solid lining that separates the chamber cavity from the meshwork of canals in the margin and the thick double septa with a wide interseptal canal enclosed in them (fig. 25; see also Barker, 1939, pl. 20, fig. 10) as we know it from the *Nummulites* of the *nuttalli*-group, things that are not found in any of the figures of *Miscellanea* that I have ever seen. For these reasons, *Pellatispirella antillea* should be included in the genus *Ranikothalia*. The same applies to the later described species "*Miscellanea*" *tobleri* V. and C. and "*Miscellanea*" *soldadensis* V. and C. (figs. 19, 22, 24, 26) and to *Operculina bermudezi* Palmer from the Upper Cretaceous of Cuba (Palmer, 1934,

p. 238, pl. 12, figs. 3, 6-9; Hanzawa, 1937, p. 115; Thalmann, 1938, p. 331)<sup>4</sup>.

The confusion about the generic place of these forms kept Barker (1939) from including *Camerina pellatispiroides* Barker, n. sp. and *Operculinoides catenula* (Cushman and Jarvis) in the same group. In my opinion, we can safely consider these species as Ranikothalias; *Camerina pellatispiroides* seems to be identical with *R. antillea* and *Operculinoides catenula* possibly corresponds with our *R. tobleri* (V. and C.)<sup>5</sup>

The list of Carriibbean representatives of the new genus would thus be:

*Ranikothalia antillea* (Hanzawa) (including *Camerina pella-*

<sup>4</sup> The Sulcoperculinas ("Camerina" *äickersoni*, *cubensis* and *vermunti*) from the same deposits, of which Mr. T. F. Grimsdale kindly gave me some topotype material, do not definitely belong to the genus *Ranikothalia*. (See note 5. The name "*Sulcoperculina*" was introduced by Thalmann, 1938).

<sup>5</sup> *Operculina catenula* Cushman and Jarvis was originally described in 1932 from Lizard Springs, Trinidad, from the same area that also furnished the type of Vaughan and Cole's "*Miscellanea tobleri*" (1941). This description is very inadequate and can hardly interfere with the validity of the name "*tobleri*". Should, however, the Mexican species prove to be identical with the Trinidad one, then Barker's description would procure priority for the name "*catenula*" over "*tobleri*".

Recently, Cole (1942) identified the various Sulcoperculinas from the Cuban Maestrichtian (which he considered as actually belonging to one species) with both Cushman and Jarvis's *Operculina catenula* from Trinidad and Barker's *Operculinoides catenula* from Mexico, applying the name of *Miscellanea catenula* to the lot. There are serious objections to this generalization. In Thalmann's subgenus *Sulcoperculina* the margin has a definite groove which in perfect specimens may be concealed by its delicately fringed edges but shows up in worn fossils or at least causes the narrow edge of the test to be flattened, and is always very conspicuous in vertical sections. Both the groove and the fringed edges are quite characteristic. Cushman and Jarvis do not give a very clear picture of their *Operculina catenula*, but both from the description and from their figure 13 it may be understood that the periphery is "broadly rounded". Moreover, as Sulcoperculinas have never been found in Lizard Springs whereas *Ranikothalia* has, it seems more probable that the original *O. catenula* was a *Ranikothalia*. As for Cole's identification of the Mexican forms with *Sulcoperculina*: Barker never stated anything about a groove, but, to the contrary, remarked that his specimens have "a strongly developed rounded keel" and his figure 8 on plate 21 shows a good marginal cord. These forms, too, are rather Ranikothalias than Sulcoperculinas. The Cuban *Sulcoperculina* stands quite apart, probably as a separate genus, and should not be confused with "*Miscellanea*", neither with *Ranikothalia* nor with true *Miscellanea* Pfender.

*tispiroides* Barker)

*Ranikothalia tobleri* (V. and C.) (probably including *Oþerculinoides catenula* (Cushman and Jarvis)

*Ranikothalia soldadensis* (V. and C.)

*Ranikothalia bermudezi* (Palmer)

Summarizing, we see that in this peculiar group of the family of the Nummulitidae (= Camerinidae) we can distinguish the following genera:

*Ranikothalia* (*nuttalli*, *thalica*, *sindensis*, *antillea*, *tobleri*, *soldadensis*, *bermudezi*) (geographical distribution: India and central America)

*Miscellanea* (*miscella*, *stampi*, *matleyi*) (India and central America)

*Pellatispira* (*maderaszi*, *orbitoidea*, *rutteni*, *infata*, *glabra*, *irregularis*, *crassicolumnata* and others) (southern Europe and Indo-Pacific Region <sup>6</sup>)

In addition to these there is the still obscure genus *Biplanispira* (= *Heterospira* Umbgr., non Koken) (*mirabilis*, *absurda*) which is described from Borneo by Umbgrove (1936, 1938).

The close relation between the Indian and the Caribbean representatives of *Ranikothalia* accentuates the peculiar correlation between the upper Ranikot formation in India and the base of the Tertiary in the Caribbean Region that was already noted by Vaughan and Cole with reference to the genus *Miscellanea* (*loc. cit.*, p. 33).

The detailed description and systematic comparison of the Caribbean species are beyond the scope of the present paper. They cannot be based on specimens in hard rock, but require a careful study of loose material, such as that from Trinidad and Soldado Rock. A short preliminary characterization of the Tertiary forms, *R. antillea*, *tobleri* and *soldadensis*, which are all three present in the limestone from San Juan, will be given, however, below. The Cretaceous species, *R. bermudezi*, seems to be slightly different in having straighter septa in horizontal section.

<sup>6</sup> See remark on p. 37.

**Ranikothalia antillea** (Hanzawa)

Plate 1, figs. 4, 5; Plate 3, fig. 15; Plate 4, fig. 21; Plate 5, figs. 23, 25

?*Pellatispira*, sp., Gorter and van der Vlerk, 1932, Leidsche Geol. Meded., deel IV, p. 95, pl. 16, fig. 8.

*Pellatispiralia antillea* Hanzawa, 1937, Jour. Paleont., vol. 11, p. 116, pl. 20, figs. 8-10; pl. 21, fig. 1.

*Camerina pellatispiroides* Barker, 1939, Proc. U. S. Nat. Mus., vol. 86, p. 325, pl. 20, fig. 10; pl. 22, fig. 4.

*Miscellanca antillea* Vaughan and Cole, 1941, Geol. Soc. Am., Special Paper, No. 30, pp. 24, 33, pl. 4, figs. 1-4; pl. 6, figs. 3, 3a.

*Miscellanca*, sp. cf. *M. antillea*, loc. cit., pp. 24, 35, pl. 4, figs. 3-4.

*Miscellanca*, sp., robustly lenticular form, loc. cit., p. 25.

**Ranikothalia tobleri** (Vaughan and Cole) (compare footnote 5)

Plate 5, figs. 22, 26?

? *Operculina catenula* Cushman and Jarvis, 1932, Proc. U. S. Nat. Mus., vol. 80, p. 42, pl. 12, figs. 13a-b.

*Operculinooides catenula* Barker, 1939, Proc. U. S. Nat. Mus., vol. 86, p. 320, pl. 14, figs. 6, 8; pl. 18; fig. 5; pl. 21, figs. 7-8.

*Miscellanca tobleri* Vaughan and Cole, 1941, Geol. Soc. Am., Special Paper, No. 30, p. 35, pl. 4, figs. 5-7; pl. 7, fig. 1.

? *Miscellanca*, sp. cf. *M. soldadensis*, loc. cit., p. 36, pl. 4, fig. 10

? *Miscellanca*, sp. compressed lenticular form, loc. cit., p. 25.

*Non Miscellanca catenula* Cole, 1942, Jour. Paleont., vol. 16, p. 640, pl. 92, figs. 6-10 (see footnote 5).

*Ranikothalia antillea*, *tobleri* and *soldadensis* are very closely related to each other. *R. antillea* is a megalospheric form, *R. soldadensis* is a large microspheric form, and *R. tobleri* is somewhat intermediate in size between these two and its original description (Vaughan and Cole) comprises both the megalospheric and the microspheric generation.

From the study of detached specimens from Trinidad and Soldado Rock, the author got acquainted with the difficulties of separating these species in a satisfactorily objective way. In the extremes, the two types of megalospheric forms, which are far more common than the microspheric ones, may be very different, but in respect to every single characteristic which one tries to use for the distinction of the specimens in a population there is such a confusing variability that even in loose material it is not practicable to assign each individual to either one species or the other. Specific determination is, of course, still more uncertain in hard rock samples and it is better to take the two together in recording their occurrence in San Juan. Both types are present; typical examples of *R. antillea*, the robustly lenticular species

with a narrow coil and squarish-rounded chambers, are shown in figures 4, 5, 15, 21, 23 and 25, whereas our figures 22 and 26? represent *R. tobleri* which is as a rule flatter and has a wider spiral with accordingly higher, slightly curved chambers, the tops of which are more evenly rounded than in the former species.

*Localities in San Juan.*—G.41, 86, 91a, 91b, 125c, 128, 153, 164/165, G.s.s.

*Distribution in other areas:*

*R. antillea*—Cap Haitien, Haiti; upper Lizard Springs beds, Trinidad; Soldado formation on Soldado Rock; Chicontepec formation, Mexico; Misoa-Trujillo formation, Venezuela; Paleocene blocks at Point Bontour, Trinidad and (?) those in the Joes River mudflows in Barbados. Reworked in the transgressive upper Eocene of Point Bontour and Soldado Rock.

*R. tobleri*—Upper Lizard Springs beds, Trinidad, and in blocks in that vicinity; Soldado formation, Soldado Rock; Mexico, in beds of doubtful age, perhaps referable to the Chicontepec formation; (?) Paleocene blocks in the Joes River mudflows, Barbados; Paleocene blocks at Point Bontour, Trinidad. Reworked in the transgressive upper Eocene of Soldado Rock.

***Ranikothalia soldadensis*** (Vaughan and Cole)

Plate 4, fig. 19; Plate 5, figs. 24, 26?

*Pellatispirella*, sp., Hanzawa, 1937, Jour. Paleont., No. 11, p. 116, pl. 21, fig. 2.

*Miscellanea soldadensis* Vaughan and Cole, 1941, Geol. Soc. Am., Special Paper, No. 30, pp. 24, 25, 36, pl. 4, figs. 8-9.

The original description of this species was based on vertical sections in hard rock from Soldado Rock.

The San Juan limestone contains several specimens of this large flat form, likewise shown as vertical sections or cut in a somewhat obliquely horizontal direction. It is a wide-coiled microspheric form characterized by its particularly well-developed marginal cord. Quite possibly it is identical with the B-form of *R. tobleri*, representing the adult stage.

*Localities in San Juan.*—G.41?, 91b, 153, G.s.s. (common).

*Distribution in other areas.*—Paleocene of Soldado Rock (and reworked in the transgressive upper Eocene there); Paleocene blocks in the Joes River mudflows, Barbados; Cap Haitien, Haiti.

**"Tubiform oöoliths"**

Plate 1, figs. 1, 3, 5

Most of the samples in our collection have a definitely oöolithic appearance which shows best on the natural weathered surface or after polishing. In thin sections, too, these "oöoliths" can be very conspicuous. They are of an organic nature but their systematic place can not be determined.

The majority seem to be long, thin structures with a circular cross section; others are perhaps shorter and more or less rounded, but they all have approximately the same diameter. In many cases they enclose a small fossil (*Amphistegina*, *Rotalia*, a fragment of an orbitoid or frequently some remnant of the thallus of *Corallina*), which shows that at one time they must have been hollow or must have grown round a foreign body. Their wall is as a rule clear and structureless (resorbed in recrystallization) or sometimes iron-stained and with a definite indication of concentric growth. The filling of their cavities seems to be comparatively hard, so that in weathering the surface of the rock becomes granular just like in genuine "oöoliths."

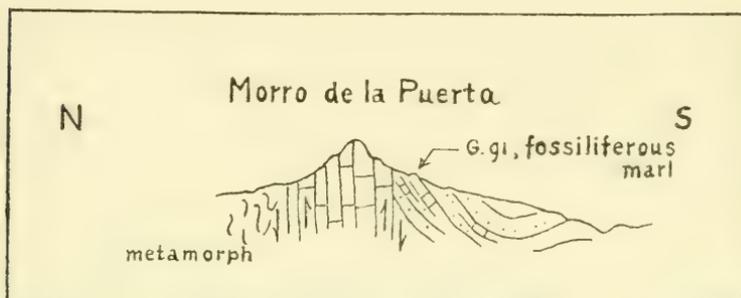
Apart from San Juan I have only once met with similar "tubiform oöoliths", viz., in a highly recrystallized reef limestone from Soldado Rock (K. 3876) which was found as a derived block in Kugler's upper Eocene "rubble bed". Lithologically this sample resembles to a certain extent the Paleocene "*Discocyclina* limestone" (type sample of *Athecocyclina soldadensis* V. and C.), which also occurred as a block in the basal bed of the transgressive upper Eocene of that islet (see Kugler, 1938, p. 216), but it does not contain any larger Foraminifera.

## THE AGE OF THE SAN JUAN FAUNA

The question of the age of the San Juan limestone is of considerable importance because it doubtless must be placed near the boundary between the Cretaceous and the Tertiary and here again we have to face the problem of the faunal changes

that mark the transition from one period to the other and of the value of various forms as index fossils.

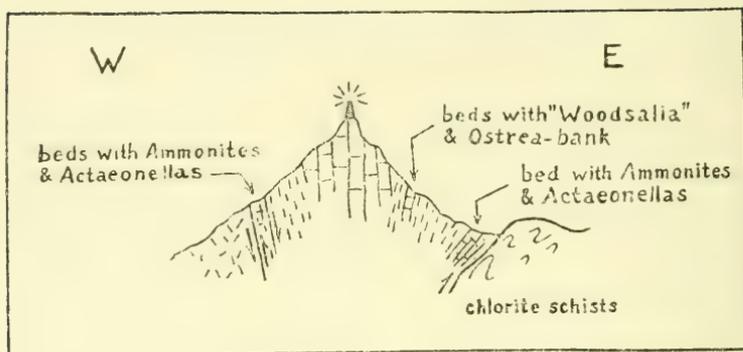
Dr. Aguerrevere was so kind as to give us in a letter, dated the 11th February 1941, some details about the local stratigraphy, especially indicating how the sample G.91, which was the first sample received for investigation, is linked with the important macrofauna found at this locality as there is no fundamental lithological or palæontological difference between G.91 and the other samples<sup>7</sup>, probably applicable to the whole of our "pseudo-oolithic limestone".



Section 1. The annotation on this section stated that no ammonites were found here but that in the macrofauna there occurred a gastropod that looked like *Woodsalia* and a large badly preserved "*Inoceramus*" and also fragments of hinge lines reminding one of *Inoceramus*. Probably there is not much vertical displacement in the fault between the morro limestone and the marls at G.91; the morro limestone was believed to be nothing but the reef facies of the same formation which includes the G.91 material and the sediments to the south as far as a certain distance south of the village of San Juan.

The state of preservation of the "*Inoceramus*" from G. 91 is bad and the "*Woodsalia*" is, according to a tentative determination by W. P. Woodring very similar to the lower Eocene or Paleocene, *Turritella mortoni* Conrad (comp. Kugler, 1938, p. 205), but if the identification should be correct, the occurrence of these two genera would indicate a Cretaceous age for G.91 and the "*Woodsalia*"-*Ostrea* beds.

<sup>7</sup> Neither the sample G.91a nor G.91b contains any *Discoeyclina*, *s. str.*, but as the frequency of this genus varies greatly even in the other samples where it is certainly present, there is no reason why this absence should be particularly emphasized.



Section 2.—From the field relations the zone including the sediments from the morro limestone down to the shale, which contains, on the east face, the beds with “*Woodsalia*” and the *Ostrea* bank, seemed to be contemporaneous with the section at G.91 but the ammonites and *Actaeonellas* come from a lower horizon. On the west slope of section 2 the ammonite beds were thought to be in fault contact with the neighboring lithology, the material at G.91 being, in all probability, younger than the ammonite beds.

From this we see that the age of our material, although it is considered as younger than the ammonite-bearing horizon, has nevertheless, for its mollusc contents, perhaps to be determined as Cretaceous. On the other hand, the microfauna shows too much affinity to the Tertiary to corroborate that conclusion.

Summarizing, the following seven species of larger Foraminifera have been found in our collection:

*Discocyclina aguerreverci*, n. sp. (closely related to *D. grimsdalei* V. and C.)

*Athecocyclina* cf. *cookei* Vaughan (closely related to *A. soldadensis* V. and C.)

*Hexagonocyclina meandrica*, n. sp. (very closely related to *Discocyclina cristensis* Vaughan)

*Lepidorbitoides* cf. *planasi* M. G. Rutten (specific determination probably correct)

*Ranikothalia antillea* (Hanz.) (= *Miscellanca antillea* (Hanz.) in Vaughan and Cole, 1941)

*Ranikothalia tobleri* (V. and C.) (= *Miscellanea tobleri* V. and C.)

*Ranikothalia soldadensis* (V. and C.) (= *Miscellanea soldadensis* V. and C.)

In order to obtain an idea about the relative age of this fauna we have to compare it with the following faunæ from this same region (Caribbean and around the Gulf of Mexico):

1. Upper Scotland formation (Murphys beds, Chalky Mount beds and Mount All beds), Barbados

Age: Between Paleocene and upper Eocene; according to Senn (1940), Renz (1942) and Vaughan (1942); middle Eocene

According to rough preliminary determinations made by Senn (*loc. cit.*, pp. 1554-1560):

*Discocyclina*, *s. str.*

*Asterocyclina*

*Nummulites*

*Operculina*

*Amphistegina* cf. *lopeztrigoii* Palmer

2. Nanafalia formation, upper part, Alabama

Age: Lower Eocene (Vaughan, 1936; Vaughan and Cole, 1941, p. 63)

*Discocyclina blanpiedi* Vaughan

*Athecocyclina cookei* (Vaughan)

3. Salt Mountain limestone, Florida

Age: Lower Eocene (Wilcox group) (Cole, 1938)

*Athecocyclina* cf. *cookei* (Vaughan)

4. Chicontepec formation, Mexico

Age: Lower Eocene (Vaughan, 1929; Barker, 1939)

*Discocyclina weaveri* Vaughan

*Discocyclina weaveri* var. *parvipapillata* Vaughan

*Hexagonocyclina cristensis* (Vaughan)

*Athecocyclina stephensoni* Vaughan

*Ranikothalia antillea* (Hanz.) (see Barker, 1939; *Camerina pellatispiroides*, n. sp.)

*Ranikothalia* (?) *tobleri* (V. and C.) (see Barker, 1939:

*Operculinoides catenula* (Cushman and Jarvis) )

5. Soldado Rock, off Trinidad, B. W. I., samples K. 2950 and K. 2951; type locality of the Paleocene (Soldado formation) in the central American region

Age: Paleocene, lower Eocene (Kugler, 1938; Vaughan and Cole, 1941)

*Discocyclina grimsdalei* V. and C.

*Discocyclina barkeri* V. and C.

*Discocyclina aguerreverei*, n. sp.

*Discocyclina "crassa"* (as figured by Vaughan and Cole, 1941, pl. 20, figs. 6, 7)

*Hexagonocyclina meandrica*, n. sp.

*Hexagonocyclina*, n. sp. (different species)

*Athecocyclina soldadensis* V. and C.

*Ranikothalia antillea* (Hanz.)

*Ranikothalia tobleri* (V. and C.)

*Ranikothalia soldadensis* (V. and C.)

NOTES.—The so-called "*Discocyclina* limestone", a Paleocene algal reef found as scattered blocks in the overlying upper Eocene deposits of this islet, contains:

*Athecocyclina soldadensis* V. and C. (abundant)

*Discocyclina aguerreverei*, n. sp. (extremely rare)

Among the numerous reworked Paleocene Foraminifera contained in the transgressive upper Eocene "rubble bed" (K. 2951B) one specimen of *Lepidorbitoides* cf. *planasi* was found, which suggests that this species must be present in the Soldado formation, although up to now not observed in place.

One of the samples collected on Soldado Rock is a limestone entirely built up by "tubiform oöoliths". The presence of this kind of rock in a place, where up to now no pre-Tertiary deposits have been found, is perhaps worth while mentioning although no premature conclusions should be drawn from it.

6. Lizard Springs beds, upper part. Type locality, Ravine Ampelu, Lizard Springs area, SE. Trinidad, B.W.I.

Age: Lower Paleocene (Renz, 1942, p. 531)

*Discocyclina*, sp. (closely related to *D. barkeri* V. and C.)

*Discocyclina grimsdalei* V. and C.

*Discocyclina "crassa"* (as figured by Vaughan and Cole, 1941, pl. 20, figs. 6, 7)

*Discocyclina aguerreverei*, n. sp.

*Hexagonocyclina meandrica*, n. sp.

*Athecocyclina soldadensis* V. and C.

*Ranikothalia antillea* (Hanz.)

*Ranikothalia tobleri* (V. and C.)

*Ranikothalia ? soldadensis* (V. and C.)

NOTE.—Vaughan and Cole's type material of *Miscellanca tobleri* (Lizard Springs, M.12) should, in comparison with this fauna, also be considered as of Paleocene age, although it does not come from exactly the same locality. Possibly it was found as reworked material in a surrounding of younger deposits. It is accompanied by *Discocyclina "crassa"*.

7. Paleocene algal reef limestone blocks at Point Bontour, near San Fernando, Trinidad, B.W.I. (Renz, 1942, p. 535)

*Discocyclina grimsdalei* V. and C.

*Discocyclina "crassa"* (as figured by Vaughan and Cole, 1941, pl. 20 figs. 6, 7)

*Discocyclina aguerreverei*, n. sp.

*Athecocyclina soldadensis* V. and C.

*Hexagonocyclina meandrica*, n. sp.

*Hexagonocyclina*, n. sp. (different species, same as in Soldado Rock)

*Lepidorbitoides* cf. *planasi* M. G. Rutten

*Ranikothalia antillea* (Hanz.)

8. Paleocene grit blocks embedded in the Joes River mudflows, Barbados. (Senn, 1940, p. 1574; Vaughan and Cole, 1941, p. 25; Renz, 1942, p. 535)

*Ranikothalia*, sp., robustly lenticular form (*R. antillea?*)

*Ranikothalia*, sp., compressed lenticular form (*R. tobleri?*)

*Ranikothalia soldadensis* (V. and C.)

*Discocyclina*, sp., aspect of *D. barkeri* V. and C.

*Discocyclina*, sp., apparently *D. grimsdalei* V. and C.

*Athecocyclina soldadensis* V. and C.

NOTE.—Senn's preliminary generic determination was: *Disco-*

*cyclina* (*Discocyclina*), *Nummulites* and *Operculina*.

9. Cárdenas beds, Mexico

Age: Upper Cretaceous (Maestrichtian) Barker and Grimsdale, 1937; Barker, 1939)

?*Camerina* (*Sulcooperulina*) *dickersoni* Palmer<sup>8</sup>)

*Borelis cardenasensis* B. and Gr.

*Lepidorbitoides minima* H. Douv.

?*Meandropsina ruttenei* Palmer

(*Vaughanina* in equivalent deposit elsewhere)

10. Habana formation, Cuba

Age: Upper Cretaceous (Maestrichtian) (Palmer, 1934; M. G. Rutten, 1935, 1936; Thiadens, 1937, both papers; Vermont, 1937; Voorwijk, 1937)

*Orbitoides browni* (Ellis)

*Orbitoides palmeri* Gravell

*Orbitoides apiculata* Schumb.

*Lepidorbitoides* (*Lepidorbitoides*) *minima* H. Douv.

*Lepidorbitoides* (*Lepidorbitoides*) *planasi* M. G. Rutten

*Lepidorbitoides* (*Lepidorbitoides*) *ruttenei* Thiadens

*Lepidorbitoides* (*Lepidorbitoides*) *ruttenei* var. *armata* Thiadens

*Lepidorbitoides* (*Lepidorbitoides*) *palmeri* Thiadens

*Lepidorbitoides* (*Lepidorbitoides*) *macgillavryi* Thiadens

*Lepidorbitoides* (*Cryptasterorbis*) *cubensis* (Palmer)

*Lepidorbitoides* (*Asterorbis*) *aquayoi* Palmer

*Lepidorbitoides* (*Asterorbis*) *rooki* V. and C.

*Lepidorbitoides* (? *Asterorbis*) *macci* Palmer

*Lepidorbitoides* (? *Asterorbis*) *havanensis* Palmer

*Pseudorbitoides israelskii* V. and C.

*Pseudorbitoides trechmanni* H. Douville

*Vaughanina cubensis* Palmer

*Omphalocyclus macropora* Brown

*Omphalocyclus*, sp. ind.

*Torreina torrei* Palmer

?*Meandropsina ruttenei* Palmer

See notes 4 and 5.

?*Camerina (Sulcoperculina) dickersoni* Palmer<sup>8</sup>

?*Camerina (Sulcoperculina) cubensis* Palmer

?*Camerina (Sulcoperculina) vermunti* Thiadens

*Operculina (Ranikothalia) bermudezi* Palmer

The above leaves no doubt as to the very close relationship between the San Juan fauna and the faunæ of the Soldado formation and its equivalents (Soldado Rock, Lizard Springs, Point Bontour block, Joes River mudflow block, Chicontepec formation in Mexico), but there is also a strong resemblance to the lower Eocene in Alabama and Florida and even to the middle (?) Eocene of Barbados, although it is striking that San Juan is lacking exactly in those forms that give the latter deposit its post-Paleocene appearance.

With the Maestrichtian of Cuba the similarity seems to be far less. It is true that the two faunæ have *Lepidorbitoides planasi* in common, while *Operculina bermudezi* is, if not identical, at any rate very closely related to the microspheric Ranikothalias we find in San Juan. But the general character is entirely different. The common and conspicuous Cretaceous forms like for instance *Asterorbis* and *Vaughanina* are completely absent in San Juan, and *Discocyclina* and *Athecocyclina* are not represented in the Habana formation.

So, although there are certain slight differences if the San Juan limestone is compared in detail with the classic Soldado Rock locality<sup>9</sup>, there can, in my opinion, be no doubt that this limestone is of the same age as the Soldado formation<sup>10</sup>.

<sup>9</sup> These differences are: 1. The absence of small *Discocyclina* of the group of *D. barkeri* 2. The abundance of *Lepidorbitoides* 3. The presence of *D. aguerreveri* instead of *D. grimsdalei* 4. The presence of *Athecocyclina* cf. *cookei* instead of *A. soldadensis*. The striking abundance of *Athecocyclina* can be explained by the facies. This genus seems to prefer compact algal reefs (comp. the "*Discocyclina* limestone" on Soldado Rock and the reef limestone block at Point Bontour).

<sup>10</sup> This is not necessarily the age of the formation that is exposed at the localities from whence the samples were collected. In the stratigraphical notes and sections Dr. Aguerrevere sent us, this information is, at G.91, called a "fossiliferous marl", whereas the sample G.91 was, like the rest, a hard limestone. Although the samples do not have the appearance of boulders, it should be kept in mind that there is a possibility that the limestone occurs at these localities as reworked material in a younger formation.

## THE CORRECT STRATIGRAPHICAL PLACE OF THE SOLDADO FORMATION

There has been a controversy about the correct designation of the Paleocene, a discussion of which can be found in papers by Barker (1936, p. 443), Rutsch (1939) and Vaughan and Cole (1941, p. 25). Some authors include the Paleocene in the Eocene as its lowermost member, but it seems to be more commonly accepted (*e. g.*, by the Committee on Geologic Names of the U. S. Geological Survey) that the Paleocene should be given the rank of a separate epoch preceding the Eocene. In the latter case there is, however, no complete uniformity of opinion as to where the boundary between Paleocene and lower Eocene should be drawn and there is some discrepancy between the use of the term in European and in American stratigraphy. For that reason Vaughan and Cole prefer to leave the question undecided and to speak in general of "lower Eocene" for all these deposits, including the Soldado formation as well as the Nanafalia formation or the Mexican Chicontepec. On the other hand, they admit that the Midway group would in any case belong to the Paleocene. As the Soldado formation was on account of many species of molluscs determined by Maury as the equivalent of the Midway Eocene of Mississippi and the Clayton of Alabama (see Kugler, 1938, p. 204 (3)), it seems logical to mark down the Soldado formation as Paleocene. The same applies to the Chicontepec formation (Barker, 1936, p. 443), to the upper part of the Lizard Springs beds (Renz, 1942, p. 531 and table), the fauna in the blocks of the Joes River mudflows (Vaughan and Cole, 1941, p. 25) and, consequently, that of San Juan.

Turning to another aspect of the question, we have to decide whether this American Paleocene (Midway) belongs to the Tertiary or whether it forms part of the Cretaceous. In general, it was always considered as Tertiary, but in recent years some doubt was expressed here and there. A thorough discussion of the subject has been given by Fox and Ross (1942, p. 672) in connection with the age of the Cannonball formation in North Dakota.

Their conclusion was that the Midway belongs to the Tertiary and not to the Cretaceous.

One of the data which evokes this doubt is offered by the mollusc fauna of the San Juan material itself, as has been cited above (p. 26). Not being specialized in molluscs, the author does not feel competent to take part in the discussion from that point of view, but judging from the larger Foraminifera there are certainly more arguments in favor of a Tertiary than of a Cretaceous age. There is far less resemblance between the Paleocene faunas and that of the Cuban Maestrichtian than there is between the Paleocene and the lower and middle Eocene. But what seems to me the strongest argument of all is that all the Paleocene (and "lower Eocene") localities mentioned above have yielded true *Discocyclus*, *s. str.*, for in spite of all the statements in literature about the find of so-called "Cretaceous *Discocyclus*" there are up to now no unchallengeable data about the first appearance of that genus earlier than in the Tertiary (see Caudri, 1937).

#### THE VERTICAL DISTRIBUTION OF THE UPPER CRETACEOUS AND LOWER TERTIARY LARGER FORAMINIFERA IN THE REGION AROUND THE CARIBBEAN AND THE GULF OF MEXICO

The San Juan fauna is a striking example of the overlap of the vertical range of *Lepidorbitoides*, which was up to now generally considered as typical of the Cretaceous, and such Tertiary forms as *Discocyclus* and *Athecocyclus*, a phenomenon which has lately been noted at several other localities as well.

The position of such faunæ is highly important from a stratigraphic point of view and, although we need many more data before we can arrive at a final conclusion, a first attempt has, therefore, been made here to disentangle the problem by listing the Cretaceous and lower Tertiary faunæ of larger Foraminifera in this region and combining them into a tentative distribution chart.

This chart by no means claims to represent the condensation of established knowledge of the vertical range of the various

forms mentioned in it. First of all, it is incomplete because I had not access to all the literature on the subject (*e. g.*, all the papers by Douvillé, many of those by Cushman and the earlier ones by Vaughan are left out); second, the exact stratigraphic position of several of the localities is still uncertain; and third, reworking may have had its influence in more than one case where we find a somewhat astonishing assemblage. The chart is, therefore, meant only as a summary of my present information and as a guide for further investigation.

## ANNOTATIONS TO THE TENTATIVE DISTRIBUTION CHART

### 1. LITERATURE

The following publications were used in the compilation of our chart:

*Venezuela*—Gorter and Van der Vlerk, 1932; Gravell, 1933; Senn, 1935

*Trinidad and Soldado Rock*—Cushman and Jarvis, 1932; Kugler, 1938; Vaughan and Cole, 1941; Renz, 1942.

*Barbados*—Senn, 1940; Vaughan and Cole, 1941; Vaughan, 1942; Renz, 1942.

*Jamaica*—Vaughan, 1928, 1929.

*Haiti*—Hanzawa, 1937.

*Cuba*—Cushman, 1919, 1919, (1920); Palmer, 1934; M. G. Rutten, 1935, 1936; Thiadens, 1937, both papers; Vermunt, 1937; Voorwijk, 1937

*Florida*—Cushman, 1919, (1920); Cole and Ponton, 1934; Cole, 1938, 1941, 1942; Gravell and Hanna, 1938.

*Alabama*—Vaughan, 1936; Gravell and Hanna, 1938.

*Mississippi*—Gravell and Hanna, 1938, 1940.

(*Louisiana*)—Vaughan, 1936

*Mexico*—Cole, 1927; Vaughan, 1929; Barker and Grimsdale, 1936, 1937; Barker, 1936, 1939; Senn, 1940 (p. 1559).





## THE PROBLEM OF REWORKING

a. *Discocyclina*, s. str.—At present I am under the impression that *Discocyclina*, s. str. is, at least in the Caribbean Region, not a normal constituent of the upper Eocene fauna. There are several finds of *Discocyclina* in the upper Eocene on record but most of them have been determined previous to Vaughan and Cole's review of the family of the Discocyclinidæ (1941, p. 57) and refer either to *Proporocyclina* or *Asterocyclina* (Cushman, 1919, 1919 (1920); Gorter and Van der Vlerk, 1932; Vaughan, 1927; Barker, 1936).

As far as Trinidad and Soldado Rock are concerned true Discocyclinæ have actually been found in upper Eocene deposits on several occasions but it is remarkable that they represent, with the exception of one case, exactly the same four or five species that are constant and abundant constituents of the Paleocene faunæ in the neighborhood and that other Paleocene genera (e. g., *Hexagonocyclina*, *Ranikothalia*) are mostly also found in the same deposits, which in many cases show a definitely transgressive character ("rubble bed" on Soldado Rock, marl beds with Paleocene blocks and small fragments of limestones at Point Bontour, etc.). There is reason to assume that these specimens are all derived from the Paleocene.

The exception referred to is the fauna of the limestone K. 3878, mentioned by Vaughan and Cole. This sample, which was collected on Soldado Rock from a horizon slightly above the very rich beds containing a typical Mount Moriah fauna, yielded a pure assemblage of *Discocyclina* (*Discocyclina*) *bullbrooki* V. and C., n. sp. and *Pseudophragmina* (*Proporocyclina*) *tobleri* V. and C., n. sp., together with some probably also new Amphisteginæ. These larger Foraminifera have nothing in common either with the Paleocene or the typical upper Eocene of this very small islet, but their general character seems old: the *Discocyclina* is very similar to the Paleocene species and the *Proporocyclina* is more primitive than the species found in the underlying upper Eocene beds. The fauna of smaller Foraminifera, which was studied by H. H. Renz, has several species in common with the

typical Soldado Paleocene <sup>11</sup>. From a palæontological point of view it is highly improbable that this peculiar fauna should succeed the rich Mount Moriah fauna in normal sequence and the most acceptable explanation seems to be that it originated from a high-Paleocene (or perhaps lower or middle (?) Eocene) marl that was up to now never found *in situ* at this locality, and that it was re-deposited as a whole in a high, in itself barren, transgression niveau of the upper Eocene (Kugler's bed 11). Scattered specimens from this fauna are also found mixed with the upper Eocene fauna in the immediate neighborhood, especially in the upper part of the underlying bed 10 (*e. g.*, K. 3691, 3692).

Among the "upper Eocene" Discocyclinæ of the older literature (Cushman) only *Orthophragmina marginata* from S. Bartholomew and *O. crassa* and *cubensis* from Cuba may be true Discocyclinæ, but the descriptions are very unsatisfactory. The age of the S. Bartholomew deposit is doubtful (see p. 39). As to the Cuban species, the comprehensive fauna listed from the upper Eocene of this island shows such a peculiar mixture of characters (*Dictyoconus*, Oligocene-like Lepidocyclinæ, usually large *Nummulites*) that we can not dismiss the thought of the possibility of reworking without a careful revision of the individual fauna of each locality. *D. crassa* is also mentioned from the lower White Limestone of Jamaica (Vaughan, 1928), where it is found likewise in association with *Dictyoconus*.

For the above reasons, the range of *Discocyclina*, *s. str.* was tentatively not extended in the chart beyond the middle-upper Eocene boundary.

*b. Hexagonocyclina.*—Like *Discocyclina*, this genus is consid-

<sup>11</sup> Dr. Renz kindly gave me the following information on the smaller Foraminifera: Sample K.3878, Soldado Roek, contains the following Foraminifera which are also present in the type sample, *Pulvinulinella obtusa* (Burrows and Holland), *Quinquetoculina*, sp., *Eponides elevata* (Plummer), *Anomalina*, sp., *Robulus*, sp., *Gyroidina subangulata* Plummer *Cibicides praecursorius* (Schwager). Others are too badly preserved (re-crystallized) to be determined specifically. (Comp. Cushman and Renz, 1942)

ered as reworked when found in upper Eocene deposits.

*c. Lepidorbitoides*.—The overlap of this genus over the boundary between the Cretaceous and the Tertiary seems for the moment rather unchallengeable. The slightly breccious appearance of some of the San Juan samples (autoclastic breccia?) is not enough reason to suspect reworking and the presence of *Lepidorbitoides* in the algal reef at Point Bontour (block) seems perfectly normal (see p. 29).

*d. Ranikothalia*.—This genus is, for the time being, regarded as ranging from the Upper Cretaceous (Habana formation, Cuba) to the Paleocene or perhaps somewhat higher, but the specimens reported from the upper Eocene are considered as reworked for the same reasons that were given in connection with *Discocyclina*, *s. str.* Special attention should be paid, however, to the fact that the type locality of *R. antillea* (Cap Haitien, Haiti) is mentioned by Vaughan and Cole (1914) as supposedly of upper Eocene age (p. 33). Apart from that species, the locality yielded also *R. soldadensis* (*loc. cit.*, p. 36) and the authors admit "that the limestone from which the specimens were taken may belong to the lower Eocene." (*Loc. cit.*, p. 24). This record is, therefore, tentatively included in the Paleocene column of our chart, but it may be that this age determination does not apply to the locality as such (block ?, reworked specimens ?).

### 3. ODD REMARKS

*a. Pellatospira in the American Tertiary*.—A vertical section in a sample from the lower part of the Misoa-Trujillo formation in central Falcón, Venezuela, was determined by Gorter and Van der Vlerk as "? *Pellatospira*, sp." (1932, p. 95, pl. 16, fig. 8). Most probably this is a specimen of *Ranikothalia*, sp. (cf. *antillea*). Up to now, the genus *Pellatospira* has not been found in the New World.

*b. Nummulites and Operculina in Barbados*.—Senn (1940) included these two genera tentatively in the faunæ from the Paleocene blocks in the Joes River mudflows (p. 1574) and from the

upper Scotland formation (p. 1554, 1556, 1559), whereas he also mentioned a "*Nummulites*" from the lower Scotland formation which is supposed to be the lower Eocene age (p. 1553). On looking through material collected at his type localities I found that the only Nummulitidæ in these samples were *Ranikothalia* and, as Senn's faunal lists are based only on preliminary field determinations, I did, therefore, not insert the Barbados *Nummulites* and *Operculina* in the chart.

From this there appears to be a possibility that the range of *Ranikothalia* reaches as high as middle Eocene, but this question is left out of the discussion for the present.

*c. Spiroclypeus in the upper Eocene.*—The only data about the occurrence of *Spiroclypeus* in the American upper Eocene are given by Gorter and Van der Vlerk, who mention it from the Menegrande beds in central Falcón, Venezuela (1932, pp. 98, 99). The generic determination of the fossils in question seems doubtful. The figure, given to illustrate the find, shows a vertical section that just as well might represent the central part of a *Helicolepidina spiralis* (pl. 16, fig. 7). As far as America is concerned, *Spiroclypeus* characterizes, for the moment, a high horizon in the Oligocene and is left out, therefore, of the chart.

*d. Heterostegina.*—Well-developed *Heterosteginae* have been found in the upper Eocene of Cuba and Florida, but for the rest, the genus seems to have its main distribution in the Oligocene in America. The dotted line in the upper Eocene column of Trinidad refers to a precursory form, morphologically closely resembling the Recent species *H. operculinoides* in the Indo-Pacific Region (Hofker, *The Foraminifera of the Siboga Expedition*, part I, Amsterdam, 1937). It is a very primitive form without secondary septa, in which, however, the tendency to subdivision of the operculine chambers is indicated by short secondary canals branching from the interseptal canals at regular intervals.

*e. Helicostegina dimorpha, Polylepidina, Lepidocyclina aff. cedarkeysensis and Operculina, s. str.* have recently been found in the Mount Moriah silt near San Fernando, Trinidad (unpublished data).

f. *Helicolepidina spiralis*.—This species is known from Venezuela, Trinidad and Soldado Rock, Cuba and Mexico, but up to now not from the southern United States. From Louisiana, however, Vaughan described a very closely related species, *H. nortoni* (1936). Its age is probably upper Eocene. The dotted line in the Florida upper Eocene column refers to this find.

g. *Lepidocyclina in the pre-Jacksonian*.—From the middle Eocene two species of *Lepidocyclina* (not *Polylepidina*) are recorded, *L. claubornensis* Gravell and Hanna from Mississippi and *L. cedarkeysensis* Cole from Florida, both of which show in several features a less advanced character than the variable group of *L. pustulosa* H. Douv., which also includes *L. "trinitatis"* (see Vaughan and Cole, 1941, pp. 64-66). However, Gorter and Van der Vlerk (1932, p. 95) mention *L. cf. trinitatis* from a low horizon in the Misoa-Trujillo formation in central Falcón, Venezuela. This horizon is considered by Senn (1935, p. 57) as the base of the middle Eocene; Renz (1942, p. 533) mentions the fauna under "Paleocene and lower Eocene". As this find seems abnormal as compared with the generally accepted upper Eocene age of the species, this determination should be carefully checked. The record is tentatively left out of the chart.

h. *Dictyoconus in the upper Eocene*.—Apart from Cuba and Jamaica, *Dictyoconus* has been recorded from only one locality, the age of which is mentioned as upper Eocene, the Menegrande beds on the shores of Lake Maracaibo, Venezuela (Gorter and Van der Vlerk, 1932, p. 98). It forms part of Tobler's Rio San Pedro fauna (comp. Senn, 1935, p. 58). Furthermore it has been found in the St. Bartholomew (St. Barthélómy) in the Lesser Antilles, which deposit is considered by Senn as the lower part of the upper Eocene, by others, however, as middle Eocene (see Senn, 1940, p. 1593, 1581). There is still a great deal of uncertainty around the exact range of this genus, but its main distribution seems, at any rate, to lie in the middle Eocene.

i. *Meaning of the abbreviation "c.s."*.—The abbreviation "c.s." (lat.: *con sorte*) is used in the chart to indicate a group of very

closely related or in part perhaps identical species (e.g., *Helicolepidina spiralis* and *H. nortoni*, *Lepidocyclina pustulosa*, *L. trinitatis*, *L. tobleri*, etc., *Lepidocyclina subglobosa* and *L. yurnagunensis*, *Lepidocyclina undosa*, *L. favosa*, etc.).

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# PLATES

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R. A. Liddle contributed \$50.00 toward expense of plates.

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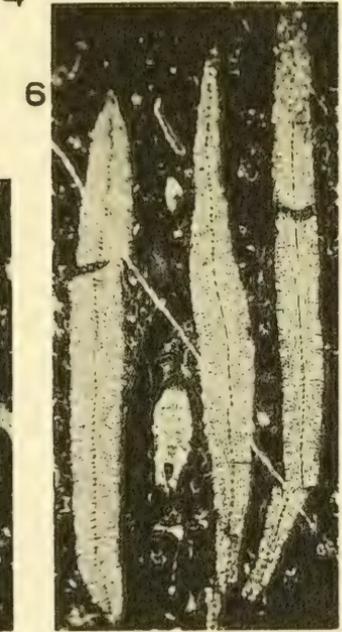
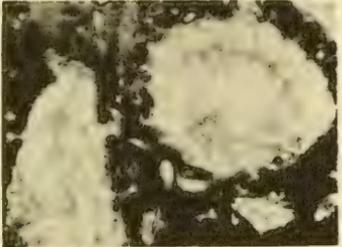
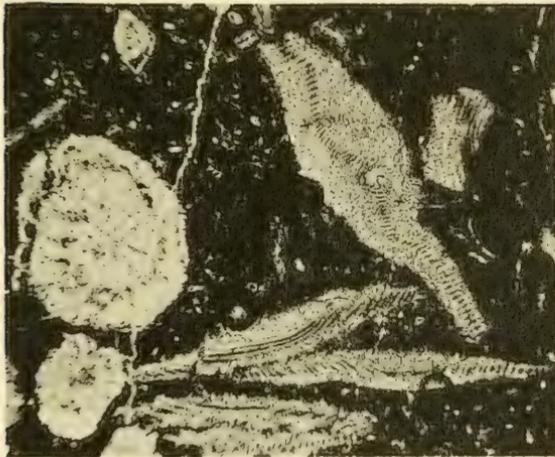
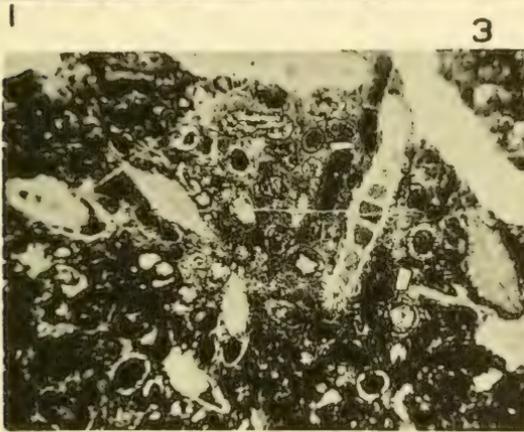
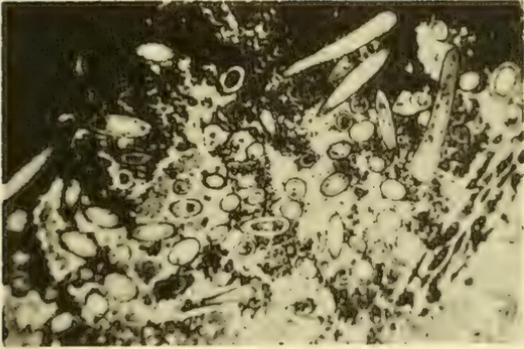


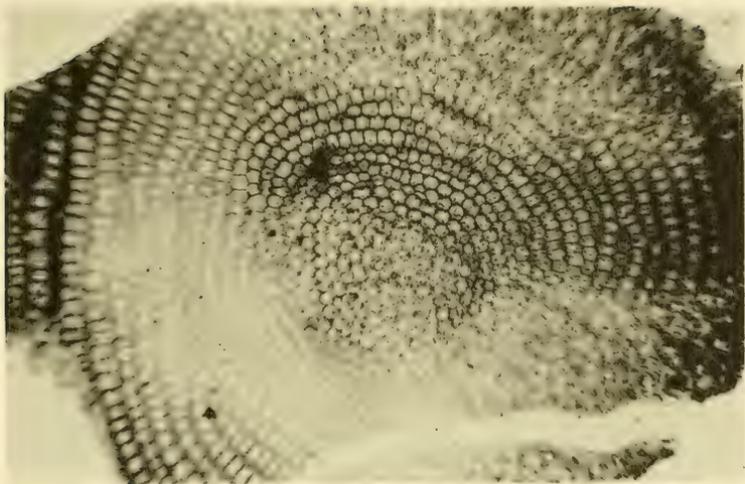


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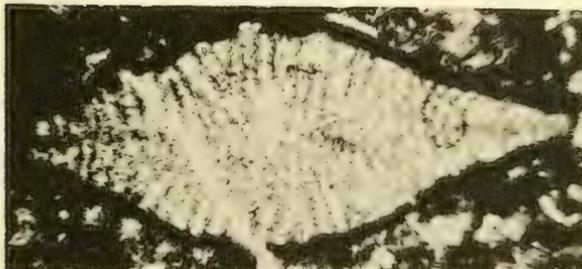
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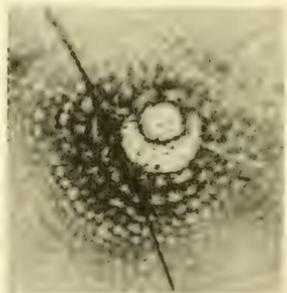


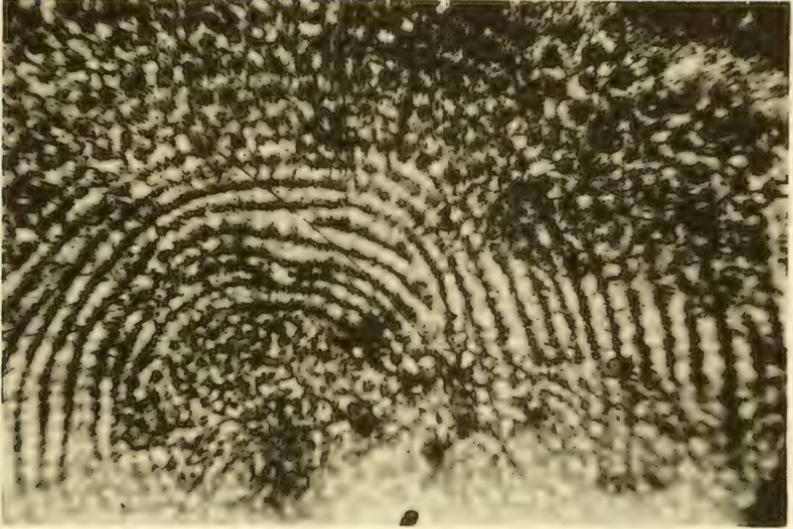


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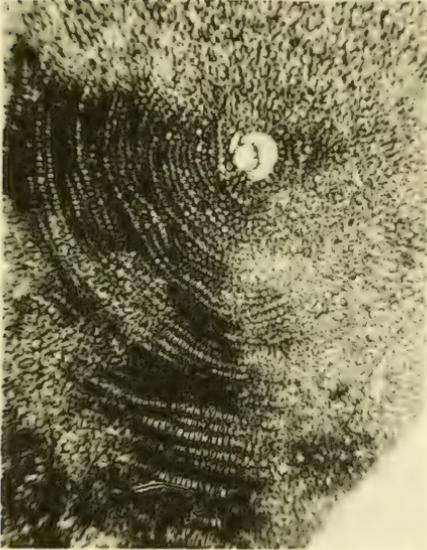
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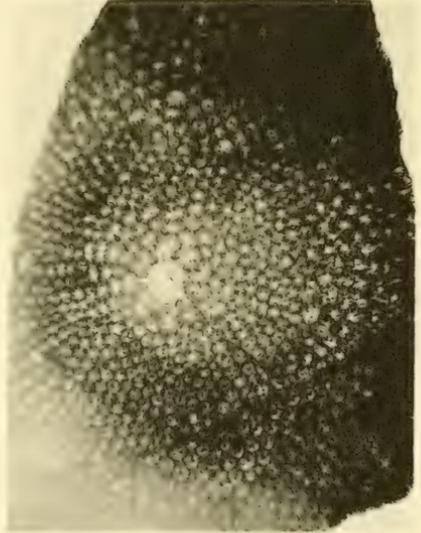
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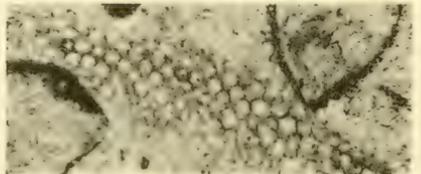




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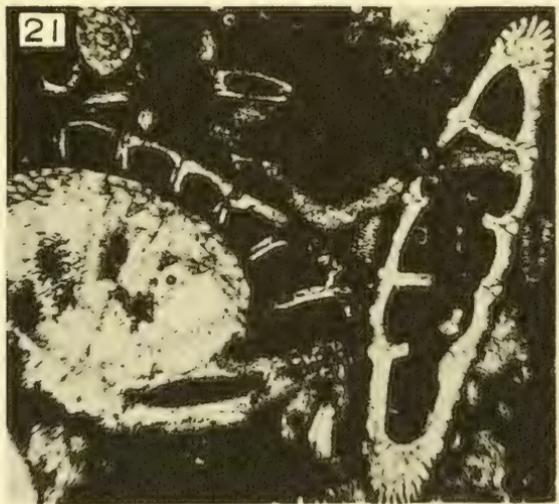
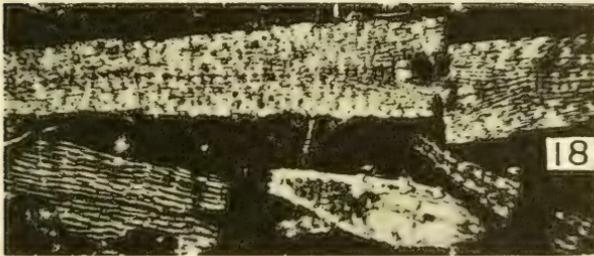
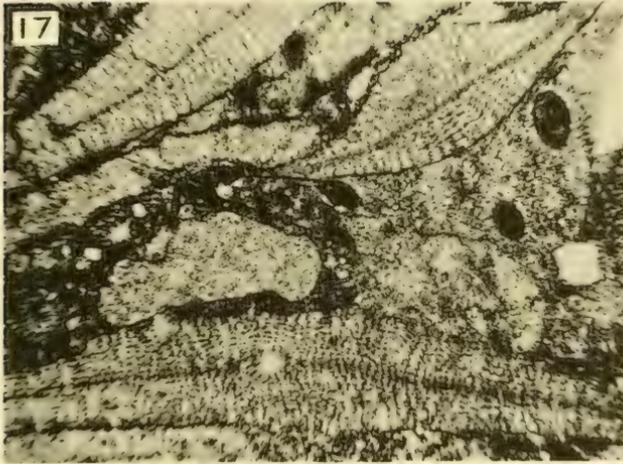
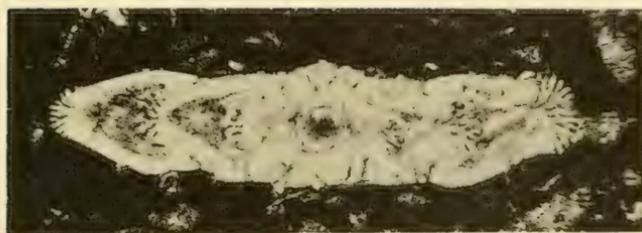




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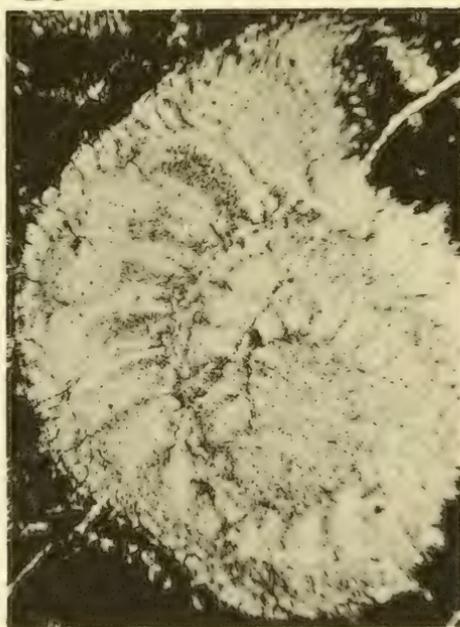


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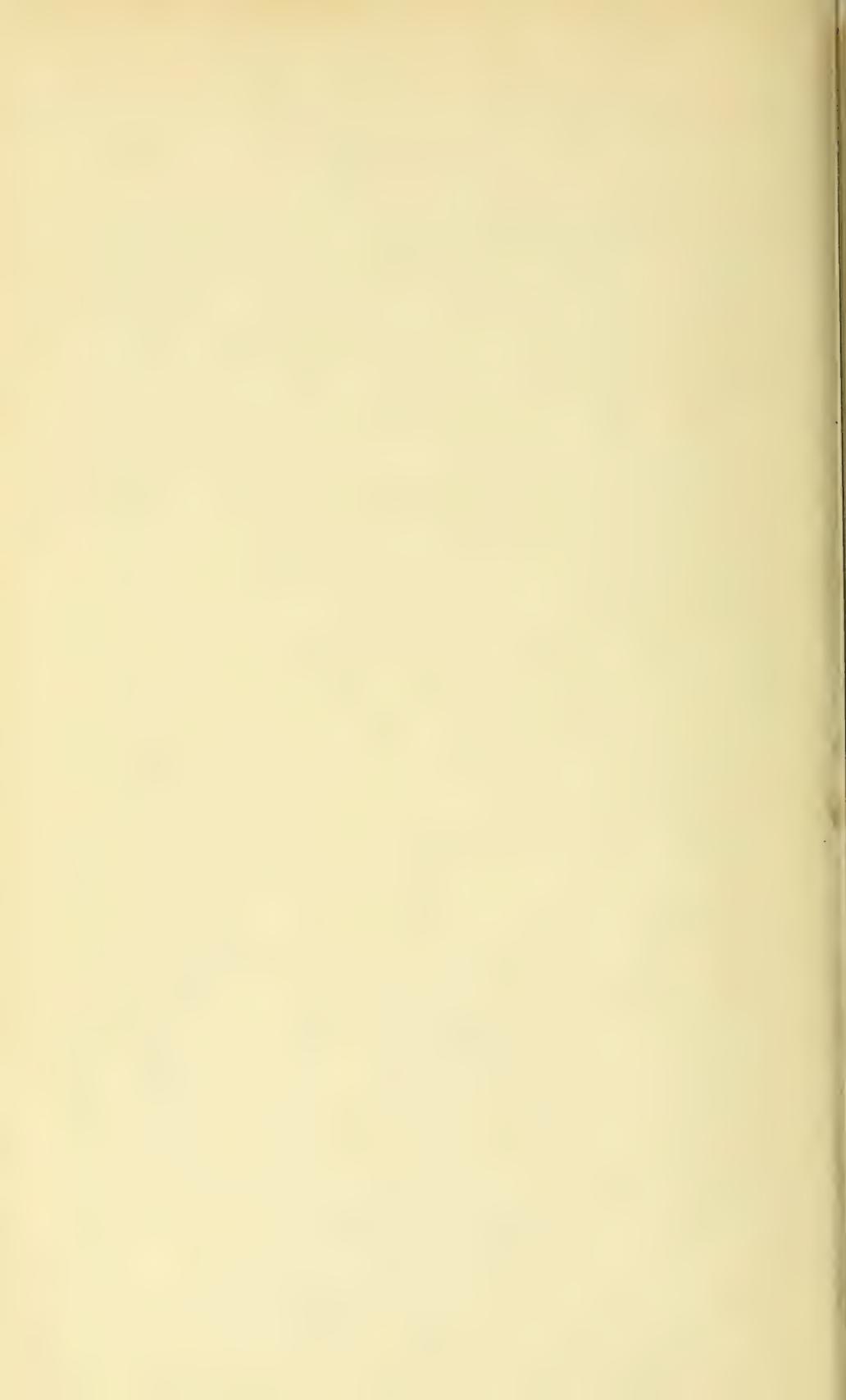
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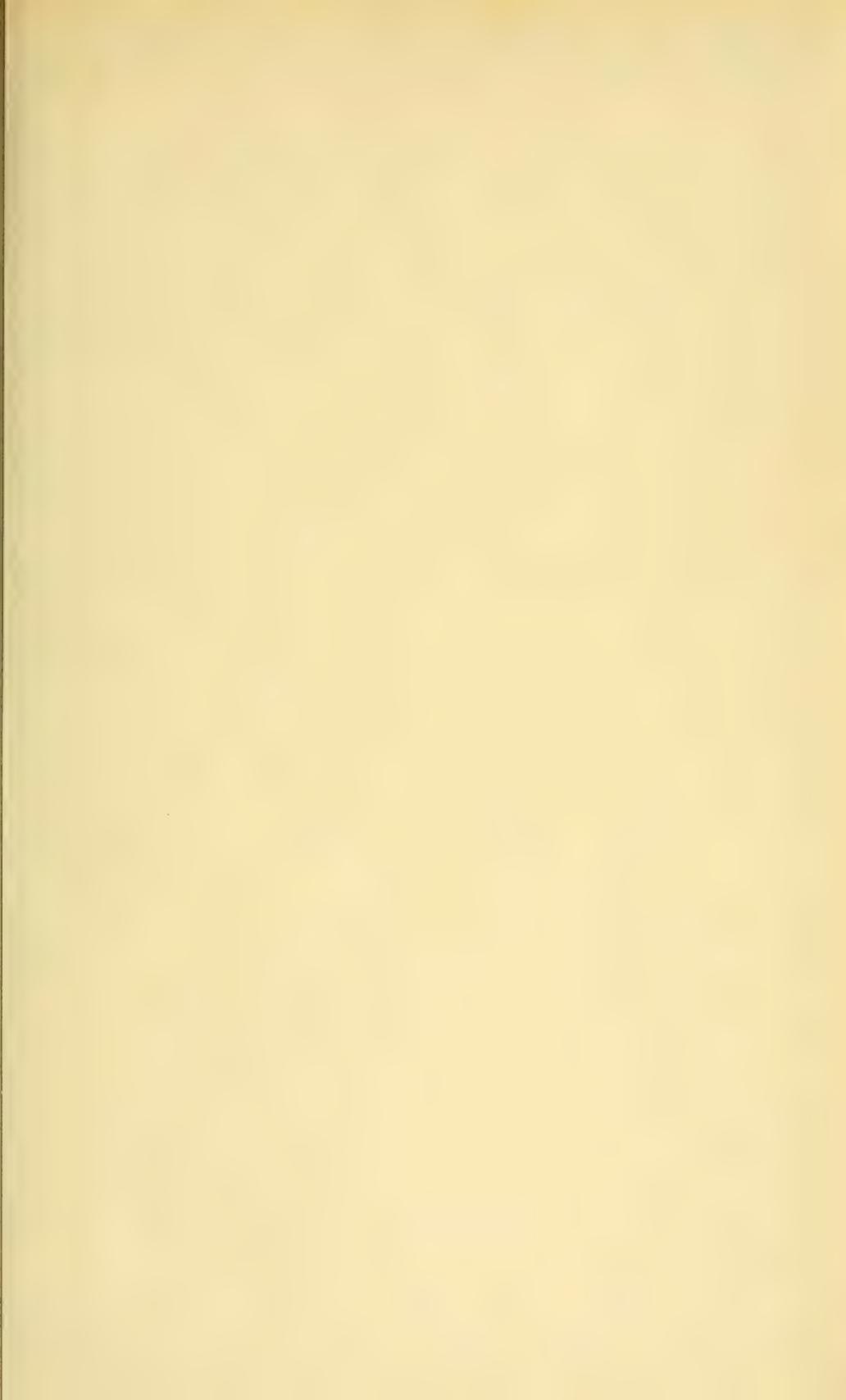


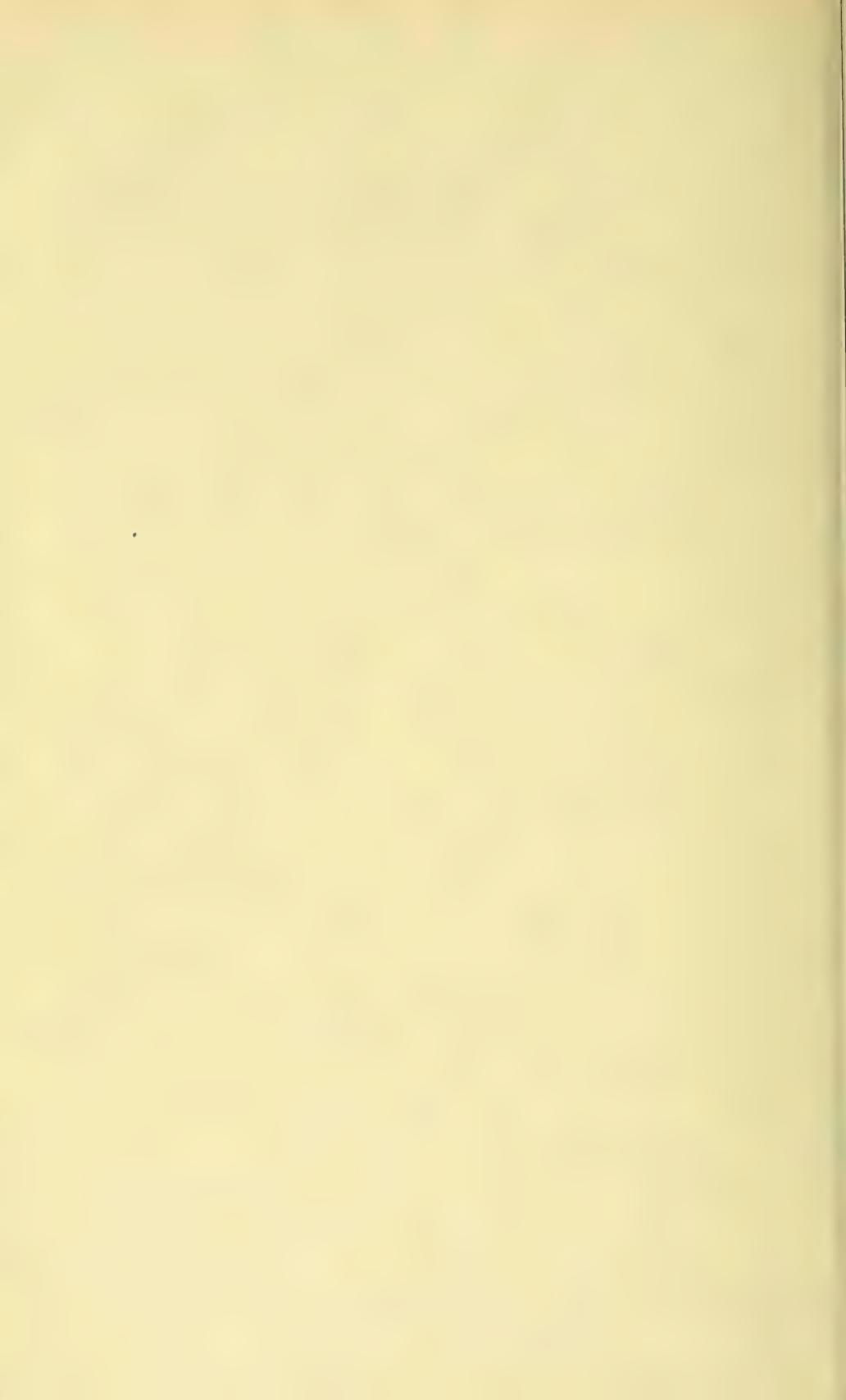
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