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GUELPH FAUNA IN THE STATE OF NEW YORK

BY

JOHN M. CLARKE AND RUDOLF RUEDEMANN

ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1903

University of the State of New York

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PREFACE

During the prosecution of the study herewith given of a fauna essentially new to the New York series of geologic formations, I have been under special obligation to Professor Albert L. Arey, of Brooklyn, the first to discover and record the presence of a Guelph fauna at Rochester, for the use of his collections, of which many specimens are here figured. In this place, also, I desire to make acknowledgment for courtesies received from Colonel C. C. Grant of Hamilton Ont. This work has, further, been essentially aided by the fine collections from the tough dolomites at Shelby, made by D. D. Luther, who has also contributed important stratigraphic details.

John M. Clarke
State Paleontologist

GUELPH FAUNA IN THE STATE OF NEW YORK

INTRODUCTION

TYPICAL GUELPH DOLOMITES OF ONTARIO AND THEIR FAUNA

The Guelph formation of Canada has been regarded by geologists as a local stratigraphic development succeeding the Niagara or Lockport limestone and antedating the desiccation of the sea which precipitated the deposits of the Salina stage. The formation in central Ontario, the region of its typical and highest development, has the aspect of a great lentil thinning to the southeast toward the Niagara river and to the northwest at Manitoulin island in Lake Huron, in the interval attaining a thickness of not less than 200 to 300 feet. Whether it is interrupted at this northern point is not determined, but it has recently been shown that certain characteristic fossils of the fauna occur in the territory of Keewatin about James's bay (Equan river); Dr Whiteaves has described two species of Trimerella from this region and these seem to indicate the presence of the formation.[1] The actual amount of deposit has however not been accurately measured, and the exposed sections have for the most part proved to be along the quite uniformly northwest strike of the strata. The entire formation is quite completely dolomitized, and this pervading alteration, together with the distinctly fragmental and sandy character of much of the deposit, indicates substantial deviation from the static conditions under which the normal Niagaran fauna was laid down. To the probable origin of these dolomites attention will be directed in a later paragraph. The fauna accompanying this formation has peculiarities of composition which separate it from any earlier manifestation of the Upper Siluric or at least from the Wenlockian fauna of the Niagaran (Rochester) shales and the modified continuation of that fauna into the Lockport limestones of New York.

It is striking for several of its peculiarities both positive and negative. These may be itemized briefly: (1) The prevalence of holostomatous, probably opercle-bearing gastropods of the genera Coelocaulis, Pycnom-

[1] Ottawa Naturalist [Oct. 1902], p. 139.

phalus, Euomphalus and Polytropis (*auct.*) and of schizostomatous genera of the style of Murchisonia, Pleurotomaria, Loxoplocus, etc. These are all often of notable size and are more abundant individually and in species than at any other Siluric date in American sections. (2) Abundance of cephalopods of cyrtoceran genera, of Phragmoceras, Trochoceras, etc. (3) Presence and special life period of the heavy-shelled, edentulate brachiopods, Monomerella, Trimerella and Rhinobolus. (4) Immense abundance at certain localities of the ponderous shelled clam Megalomus. (5) Paucity of other lamellibranchs and of brachiopods, bryozoans and trilobites. (6) Existence of corals and coral-making stromatoporoids, for the most part in an incomplete and semimacerated condition. Their abundance in the fauna is unquestionable, but their present condition is no true indication of their original state.

A fauna of such composition is distinctly late Siluric, at the same time quite as distinctly unlike any other element of the Appalachian Siluric sections.

The term Guelph, then, indicates both a faunistic and, in its typical province, a lithologic element of distinctive significance in the Siluric succession. In no sense is it a late presentment of the Niagaran fauna as expressed in the shale beds beneath the Lockport limestone. It is true and natural that species of the preceding fauna should present themselves in the Guelph congeries, and though this is not carried to great extent, yet we may always expect to find therein some well known and widespread survivors of the lower fauna.

GUELPH FAUNA OF NEW YORK AND ITS STRATIGRAPHIC RELATIONS

Historical

During the construction of the Erie canal, 1817–25, the rock cuttings near Newark in Wayne county brought to light an impure light colored dolomite. Some fossils were obtained from this rock by Dr G. W. Boyd, assistant to Professor James Hall, geologist in charge of the fourth district of the State, and this occurrence was first noted with woodcuts and names of the fossils in the final report on the geology of that district [1843, p. 137[1]]. As it was evident that the horizon of these few and inconspicuous though significant species (Loxonema boydi, Avicula triquetra, Euomphalus sulcatus, Orthoceras laeve, Atrypa, Delthyris, Cornulites) was above that of the Niagaran fauna, known best then, as now, from its development in the lower beds or Rochester shales, though recognized as continuing into the overlying Lockport limestone, Professor Hall regarded them as appertaining to the life of the Onondaga Salt group — the Salina formation of present usage. A few years later Professor Hall's attention was directed by Sir William Logan to the profuse occurrence of similar fossils in dolomites at Guelph and Galt Ont., and in 1848 he visited these localities, collected freely, and, in 1852, he described and illustrated a considerable number of species obtained by him at that time.[2] In regard to the stratigraphic position of the beds bearing this fauna, he states his view as follows [p. 340]:

> A simple inspection of the plates . . . will show that these fossils are typical of a distinct period from that of the Niagara group, and, though the few species yet known from the base of the Onondaga salt group in New York seem scarcely sufficient to indicate a well marked period or to claim positive identity in age with those of the Galt limestone, yet we are compelled to regard them thus or to rank the latter as a group entirely distinct from any yet recognized. . . Whether we regard them (the Galt and New York fossils) as of the age of the Onondaga Salt group or not, we know that they lie above the strata typified by the numerous fossils already described as belonging to the Niagara group and strictly should form no part of that group.

This opinion was expressed long before Robert Bell, now acting director of the Canadian Geological Survey, proposed to distinguish the formation in Ontario by the term *Guelph;* Hall's term "Galt limestone" being a dangerous approach to the better known and older stratigraphic name,

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[1] Professor Hall, in a subsequent reference to this discovery [N. Y. State Cab. Nat. Hist. 20th an. Rep't. 1868. p. 305 (rev. ed. p. 347)] mentions the origin of the rock exposure, though nothing is said of it in the fourth district report.

[2] Pal. N. Y. 2:341 *et seq.*

"Gault." It is clear from the expressions above quoted that Hall was the first to recognize the faunistic distinction of this association from the Niagaran;[1] but the discriminating observations of the Canadian geologists, Logan, Bell and Murray, aided notably in elevating Guelph sedimentation to the dignity of an event separable from the Niagaran. Professor Hall, after extending his studies of the Upper Siluric dolomites over the area of their distribution in Wisconsin, Illinois and Iowa, was inclined, in subsequent expressions, to caution in respect to the separation of Niagaran and Guelph faunas;[2] and to these we shall have occasion to refer in bringing the data here presented into harmony with facts previously known.

The Wayne county, N. Y., locality for "Onondaga Salt group" fossils was long ago lost. Nothing more is known of it than was given by Hall in 1843; and no examination of the region in later years has given any clue to exposures of this horizon, but some remarks on the horizon there presented are given in a subsequent paragraph.

The Lockport or Niagaran dolomite in western New York makes a very clearly defined topographic feature, specially where transected by drainage ways. As is well known it is the rock which is the cap and occasion of the falls at Niagara and of the upper falls of the Genesee river at Rochester, and, though modifying the contour between these points, only its lower parts project freely as exposure or lie under slight drift cover. This mass of dolomites, which is not less than 100 feet in thickness between Niagara Falls and Rochester, is at bottom at first comparatively pure and hard, but becomes more and more dolomitic and less resistant[3] toward the top. The overlying soft shales, gypsum beds and "platten" limestones of the true Salina have been so worn down by obsequent drainage that south of the Niagara escarpment, which is largely constituted of only the lower layers of the Lockport dolomite series, the

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[1] See also Pal. N. Y. 1859. 3:30.

[2] N. Y. State Cab. Nat. Hist. 20th Rep't. 1868. p. 306 (rev. ed. p. 348).

[3] That is, more yielding to meteoric agency, because the purer the dolomite, in this section, the more completely is it of fragmental origin.

ground is continuously low, much filled with detritus and specially swampy. The northern reaches of the Oak Orchard swamp, extending from near Churchville, Monroe co. on the east, across Orleans county, are excavated in the Salina shales and have the dolomite series (Guelph and upper Lockport) for a floor. Hence it is not altogether strange that, during the years of geologic study which have elapsed since 1843, extremely little has been seen of the strata buried in this almost undissected region.

In 1892 Albert L. Arey brought to the attention of the geologic section of the American Association for the Advancement of Science in session in the city of Rochester, his discovery of a fine series of fossils from this horizon at the top of the Lockport dolomites in and about that city. Some of these were obtained from the uppermost layers in a quarry then being worked in the southwest part of the city and known as the Nellis quarry; at present writing these workings are abandoned. More were derived from occasional excavations for municipal improvements made in the southern part of the city, affording an opportunity for collecting which may sometime recur but which is beyond the control of the geologist. This fauna was subsequently the subject of study by its discoverer, who published a brief account of it in the *Proceedings* of the Rochester Academy of Science [1892. 2:104–7].

These organisms proved to be for the most part preserved in nodules of white chert, of which they have frequently formed the nuclei, but in which more often they had become irregularly involved in the process of segregation. The shells themselves are largely replacements in chalcedonic silica and preserve with fine accuracy and in a manner altogether unusual for paleozoic fossils the important exterior surface ornament. This mode of preservation makes them extraordinarily interesting subjects. In the brief paper cited Mr Arey has brought the fauna as then known to him into comparison with the species of the Canadian Guelph and the published lists of fossils from the Chicago and Racine limestones, and elicits therefrom the very close similarity in general composition of the Rochester and Guelph faunas and the striking contrast between the former and the faunas of the Rochester shale and Lockport limestone. The paper concluded with a list of 15 species identified by the author as common to the Canadian and Rochester Guelph.

It would be impracticable for any investigator to obtain access to these species except by such personal consideration as that shown us by Mr Arey who has availed himself of transitory opportunities not likely to return. As the Nellis quarry is no longer productive, and the student can hardly wait for possible further city excavations into this interesting horizon, we have endeavored, with the important Arey collection as a nucleus, to further exploit this interesting fauna throughout western New York.

The natural sections of the dolomite series in Monroe county are very few, incomplete and unsatisfying. To the series of sections made as a result of searching all the water courses and trenchings, we shall presently refer; as none of them expose the strata with which we are now concerned, we can correlate them most satisfactorily after consideration of the developments given in the following.

Section of the dolomites at Shelby, Orleans county

While zigzagging across the Niagara cuesta in 1901 in the search for this Guelph horizon, the writers discovered a finely extended outcrop of the dolomite series along Oak Orchard creek, from 1 to 1¾ miles south of Shelby village, in Shelby, the southwestern township of Orleans county. Oak Orchard creek, a few miles to the south of this place, receives the Erie canal feeder or drainage channel from Oak Orchard swamp, and from that point the artificial and natural water courses are combined. To effect this function, the bed of the creek has been depressed by excavation of the natural rock section to a depth of 8 to 10 feet, and an immense amount of material thrown on the banks in most favorable situation for examination. The stratigraphic section here stretches along the creek for about 2 miles, and has been briefly sketched in a previous publication.[1]

At the base of the falls at Shelby are

[1] N. Y. State Paleontol. Rep't 1901, p. 521.

1 An exposure of normal Rochester shales, above which lie

2 Sixty feet of hard, dark gray dolomites, full of small cavities bearing druses of dolomite and calcite, but with few or no fossils; only parts of this series are exposed (Lockport limestone);

3 Two feet of porous dolomite, the cavities being vermicular or having the aspect of small tubes (Lockport limestone);

4 Three feet of dark gray dolomite. This is the *lower Guelph bed.* It contains a fairly profuse fauna, of which Trematonotus alpheus is the leading element, but Monomorella noveboracum the more exclusive species (Monomorella bed). Both are highly abundant and occur in extraordinarily fine specimens. Of other species the stratum contains: Poleumita crenulata, Coelidium macrospira, Lophospira bispiralis, Cyrtoceras orodes, Poterioceras sauridens, Protophragmoceras patronus, Trochoceras desplainense, T. costatum, etc.;

5 Eight feet of gray dolomite with few fossils, and these characterizing the Lockport fauna: Zaphrentis bilateralis, Enterolasma caliculus, Stropheodonta profunda, Orthothetes subplanus and a few others. This mass is capped by a thin bed of shaly limestone containing a profusion of small fossils, among which are: Cladopora multipora, Halysites catenularius, Lichenalia concentrica, Dalmanella elegantula, Orthothetes subplanus, Leptaena rhomboidalis, Camarotoechia neglecta, Rhynchotreta cuneata americana, Whitfieldella nitida oblata, Spirifer crispus (typical Rochester shale form), Cornulites arcuatus, Dalmanites sp., Calymmene cf. niagarensis, Proetus sp. This association is characteristic of the Rochester shale and lower Lockport limestone. Over this bed lies a thin layer of chert nodules without fossils.

6 Twenty-four feet of similar dark gray dolomite with fossils extremely rare and of the same character as those below (Lockport limestone).

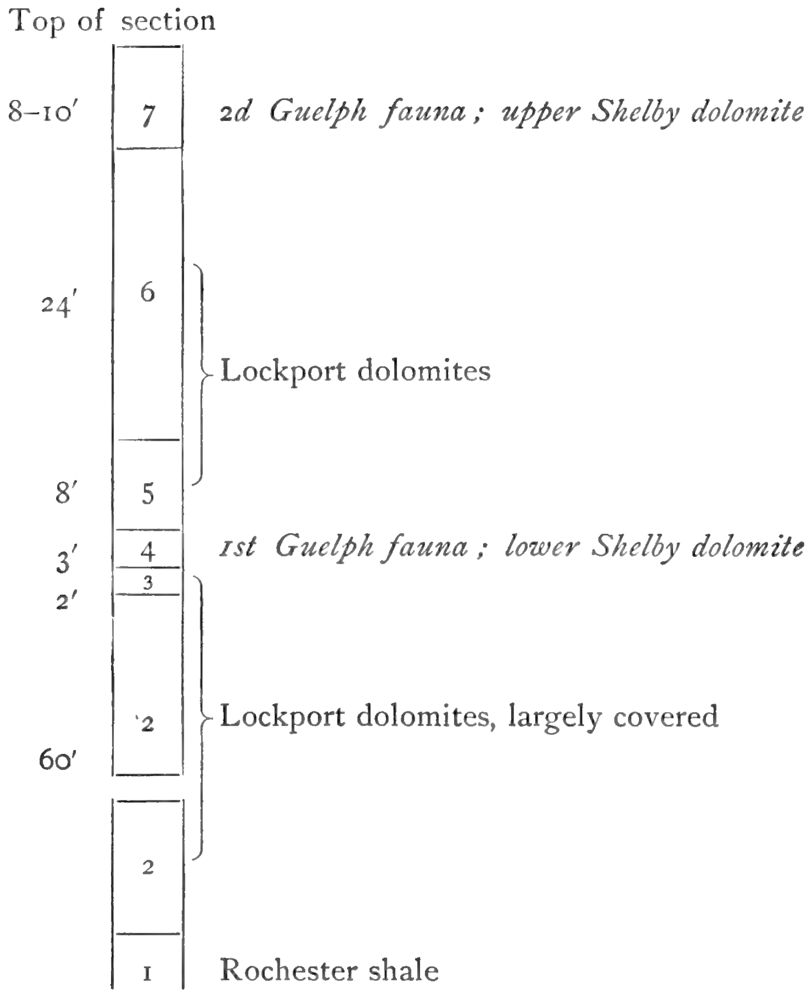
7 Eight to 10 feet of gray dolomite, bearing white chert nodules most

abundant in the lower part and containing *inter alia,* Trochoceras desplainense, Orthoceras trusitum, Coelidium macrospira, Trochonema cf. fatuum, Trematonotus alpheus, Cornulites arcuatus, Poleumita scamnata, P. sulcata, Eotomaria galtensis, Spirifer crispus, Leptaena rhomboidalis, Pterinea subplana, P. undata, Stromatopora galtensis, Diaphorostoma niagarense, Calymmene niagarensis, Proetus sp. This we shall term the *upper Guelph bed,* and shall have occasion to observe that its fauna is more nearly parallel to that at Rochester than the lower or earlier appearance of the Guelph in this section.

This is the southernmost exposure on Oak Orchard creek; and it appears that in the general planing of the country by ice and water any harder beds above would have in some degree at least, resisted erosion and left some trace of themselves in the well channeled way of this stream to the south.

It seems fair to conclude, therefore, from this section supplemented by similar evidence in Monroe county, that overlying beds, with the possible exception of a few feet of dolomite, were the soft shales and thin "platten" limestones of the Salina, and hence that the upper Guelph horizon, lithologically, topographically and faunistically here terminates the dolomite period.

This section is represented in the following diagram.



A significant feature of this occurrence is the double appearance of the Guelph fauna. Its earlier manifestation is after the lapse of 63 feet of Lockport dolomite ; it retreated and reappeared after 32 feet more of these Lockport dolomites with their characteristic species, had been deposited. Here it closes the dolomite episode, and the Lockport species have finally withdrawn. We designate these appearances of the fauna as the lower and upper Guelph faunas or, as the local development of the fauna is predicable and carries an impress of distinctive nature, as the *lower* and *upper*

Shelby faunas, contained in the *lower* and *upper Shelby dolomites*. It is furthermore specially noteworthy that of these two manifestations of the fauna, the lower is the purer Guelph, that is, is freer from complications with species occurring in the Lockport dolomites. In the upper bed, however, the presence of such Lockport species is much more pronounced. On the other hand, the intervening Lockport dolomites are wholly free from any evidences of the Guelph species; though decidedly meager in fossils, yet these are all proper to the horizon in which they occur. Thus the overlapping faunas are relatively free of complication and intermixture. We note again, as just stated above, that it is not the lower and purer Guelph congeries that appears in the Rochester section; on the other hand, it is the later association, containing a number of Lockport limestone species, that agrees better in composition with this more eastern development.

We are thus presented with conclusive evidence of an invasion of the Guelph fauna from the west into western New York, while the Lockport dolomites were being deposited and at about the middle of the period of their formation; this immigration was of brief duration, failed to acquire a lasting foothold, withdrew without reaching far if at all east of Orleans county; it thereafter returned with some unimportant modification in composition, penetrated as far east as Monroe and Wayne counties, while the previous occupant of the field withdrew, not to return.

At the close of the descriptions of the New York Guelph species we have given tables showing the distribution of the fossils and bringing out the difference in the composition of the early and late appearance of the fauna in the Oak Orchard creek section and the relation of these manifestations to the fauna in Monroe county. For that place we reserve all further discussion of the affinities of the congeries to extralimital expressions of the Guelph fauna.

Niagara county

The rock exposures at Niagara Falls show 120 feet of limestone and dolomite currently referred to the Niagaran formation. We have been unable to determine the existence of the Guelph fauna in the vertical section here afforded, though the unfavorable exposure may still veil its presence, but we are satisfied that the careful analysis of this section recently made by Mr Luther locates with precision the horizon which at Shelby so much more favorably expresses its contents. To elucidate these stratigraphic relations we here give the detailed section of the dolomites presented in the cut of the Gorge Railway, ½ mile north of the east end of the bridge, supplemented at the top by a temporary exposure made by the Ontario Power Co. on the Canada side.

25′	7	Brown dolomites exposed at Goat island and Three Sisters islands with summit near head of rapids. Full of cavities and with Stromatopora, Halysites. Weathers very scraggy. Uppermost bed (4′) sandy
10′	6	Car barn of Gorge Railway; not exposed
8′	5	Brown, thin bedded dolomites with rough surface and black partings
12′ 6″	4	Thin bedded dolomite, fine grained and very hard. Continuous bed of chert nodules near top; *probable horizon of upper Shelby fauna*
19′	3	Compact drab dolomite; few cavities. *Horizon of lower Shelby dolomite near top*
17′ 6″	2	Smooth, thin bedded dolomites with Stromatopora; at top, Enterolasma, Favosites
28′	1	Compact light brown dolomite
		Rochester shale

The basal layer of the series (1) is quite homogeneous, though the lower part is schistose. The same stratum is seen at Lockport along the banks of the canal beginning a little west of the locks in the city and extending continuously toward the southwest for a mile. Farther west near Gasport it is quarried at the top of the banks of the ravine south of the village and in a ravine south of Middleport. The layer may be differentiated at the falls in Oak Orchard creek.

Stratum 2 is composed of varying proportions of hard, dark gray, subcrystalline limestone and irregular beds of unstratified bluish hydraulic material, giving the whole a dappled appearance. It is dark blue when fresh but weathers a very light gray. It is also known in the canal south of Lockport and in the creek 2½ miles southwest of Gasport. Stromatoporas are common in it. The horizon can be recognized at Shelby from the piles of material just west of the village.

Stratum 3 is a compact, light brown dolomite of uniform texture. At Niagara Falls there are small corals (Enterolasma caliculus, Favosites) in the lower part. From the character of the rock and that of the overlying stratum we regard this as the horizon of the lower Guelph fossils at Shelby. There the subdivision into separate beds is more pronounced and the fossils are restricted to a 3 foot layer; this subdivision of the stratum is also shown at Lockport where the layer is the highest and most southern one exposed on the canal.

Stratum 4 is finer, harder and lighter colored than the layers above and below and is filled with cavities. Near the top is a continuous row of chert nodules which are bluish when fresh but become white on long exposure. This layer is nearly in a plane with the crest of the American and Horseshoe falls. Fossils are extremely scarce but the exposure is unfavorable for examination. Poleumita scamnata occurs here, a species not elsewhere found except in the chert nodules of the upper Shelby and Rochester horizon. This fact indicates that this chert layer represents the *upper Guelph horizon* which would, thus, be separated from the lower horizon by an interval of 20–25 feet, considerably less than at Shelby.

Above stratum 5, consisting of brownish dolomites in thin layers having black partings, there is a covered interval of 10 feet (6), which is followed by a 25 foot mass (7) of rough geodiferous dolomite in thick and thin layers. This is exposed in the cut of the Gorge road south of the car barn, at the south of Goat island and on the Three Sisters. This rock contains numerous fossils; Stromatopora, Halysites, Favosites (diffusely branching form) Spirifer crispus, Trematospira (which is common in the Guelph of Iowa), Coelidium macrospira, Pterinae subplana.[1]

The association indicates a mixture of Lockport and Guelph species, though there is nothing in it which militates against its construction as a Guelph fauna, as, in fact, a facies of the fauna somewhat removed in space from the reefs about which the true Guelph was centered. We may note that Professor Hall[2] described and figured specimens from "limestone below the cliff at Niagara Falls"—evidently loose—as Cyrtoceras? subcancellatum and Gomphoceras? sp. Both are identified with specimens from the Rochester shale but this identification seems erroneous in the former and dubious in the latter case. These fossils are quite distinctly of Guelph habit and it is probable that both were derived from this upper layer. We may properly regard the layer of chert nodules below as presenting the first appearance of the Guelph (i. e. the upper) fauna in this section and in this case may conceive the thickness of 45 feet of dolomite above this layer as imperfectly or not at all represented at Shelby.

The actual measurement of the dolomite section at Niagara Falls is 13 feet more than on Oak Orchard creek and this difference is largely if not wholly at the top of the former. It is not now possible to say how much of the section has been planed off in either place or what part of the difference is to be ascribed to the thinning of the formation eastward. That a portion of the top of the section throughout this region is concealed, is indicated by borings. Deep wells in the Niagara region are stated to show about 100 feet of limestones above the exposure,[3] but it is altogether uncertain that this is to be accepted as correct or what part of such alleged increase can be ascribed to the dolomite series.

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[1] These fossils have been chiefly collected on Goat island by Gilbert van Ingen.

[2] Pal. N. Y. 2: 290, pl. 61.

[3] Grabau. N. Y. State Mus. Bul. 45, p. 114.

Other manifestations in Orleans county

In the townships of Barre and Clarendon lying between Shelby township and the west boundary of Monroe county, outcrops of the dolomites are seldom shown. Except at Clarendon village almost the entire surface of the dolomites has been planed down and forms the floor of the basin in which lie detached northern parts of the Oak Orchard swamp. The lower element of the series is exposed at several places near the northeast corner of Barre. At Clarendon village the exposure shows the lowest layers (1, of the Niagara section) in and above the falls; in the ridge south of the village strata 2 and 3 are exposed. No trace, however, of Guelph fossils has appeared here. About 40 feet above the base of the dolomites there appears a cherty layer, similar to, perhaps identical with that in Niagara county; in the latter section the elevation of the layer above the Rochester shale is 75 feet.

One and one half miles east of Barre Center and on the ridge south of Clarendon are found the rough layers appertaining to division 7 of the Niagara section, and the more even grained, sandy dolomites which cap the section near the rapids of the Niagara river, are quarried at Honest Hill, 3 miles south of Clarendon.

In all the section exposed at Clarendon no trace has been found of Guelph fossils; the lower Guelph fauna as expressed at Shelby is absent and the horizon of the upper fauna is not clearly exposed. South of the line of outcrop of these upper rough dolomites the country is dotted with boulders of this origin, made rougher and more jagged by the action of decomposing agencies.

Monroe county

Allen creek section. Directly south of Rochester, an interrupted section of the dolomites is made by Allen creek, a stream of many branches, traversing the town of Pittsford, flowing north and discharging into the Irondequoit river. (1) The lowest exposure is beneath the large culvert through which the stream passes under the New York Central Railroad (Direct road), where 20 feet of rough dolomites are shown. The bottom of this exposure is 350 feet A.T. After a covered interval estimated at about 10 feet, another exposure (2) is seen at Lincoln's Mills, near the crossing of the East avenue road; 25 feet of dark bluish gray dolomite, with drusy cavities and showing specimens of Stropheodonta profunda, are exposed. Estimating a covered interval of 20 feet, a third outcrop (3) occurs on the premises of John Balder, consisting of 5 feet of evenly bedded dolomites overlain by 8 to 10 feet of darker rock with Stromatopora. Above are 2 feet of a peculiarly concretionary layer with many corals of the Lockport limestone and similar to a layer in the Pike quarry section, Rochester. Continuous with this exposure, farther up the creek are (4) 10 feet of dark dolomite with corals; 5 feet of finer, harder and thin bedded rock; 12 feet of dark brown dolomite with Stromatopora, Halysites and Favosites. The summit of the outcrop is about 8 rods east of the Erie canal. Above this section is a covered interval estimated at about 15 feet, and herein probably lies the Guelph horizon of the Nellis quarry, which, as we shall presently note, is above the dolomites in Pike quarry. The exposure next following on the stream (5) is 5 to 6 rods long in the low banks and covers about 8 feet of thin "platten" limestones of the Salina. In the bottom of the Erie canal, 2 miles northwest of Pittsford, 470 feet A. T., and ¾ of a mile from the last named exposure are black shales with interbedded gray "platten" limestones abounding in Salina crustaceans. Exposure 5 has an elevation at the bottom of 485 feet and hence lies above the Salina shales referred to. We may fairly conclude that these Salina black shales lie immediately above the covered Guelph horizon.

The total thickness of the dolomites here according to the section given, is about 120 feet.

Brighton. At a rock cut, 1 mile east of Brighton on the Direct road (New York Central Railroad) are 15 feet of brown dolomites with Stromatopora and Favosites. The exact horizon of this layer in the Lockport dolomites is not altogether clear.

Rochester and vicinity: *Pike quarry*, Frost avenue and Summer street. The section where best exposed is as follows, beginning at the bottom, which is the surface of the water in the quarry:

1	Brownish gray to black scraggy dolomite with drusy cavities. Stromatopora and Favosites abundant. (*See* Allen creek section, no. 4)	2 feet
2	Compact unbroken dolomite	5 "
3	Dark brown dolomite like 1	3 "
4	Dark bluish gray dolomite, weathering brown; compact	10 "
5	Brown sandy dolomite in layers 2 to 4 inches thick. Heavier layer at top. Stromatopora and Zaphrentis bilateralis	6 "

This section is clearly all of Lockport dolomite.

Nellis quarry, McLean street. The highest part of this locality is 1200 feet west and 600 feet south of Pike quarry, and this rock section runs 15 feet higher than in that section. The white chert nodules from which Mr Arey obtained many of the Guelph species before workings here were abandoned, are all in the upper part of this additional thickness.

The rapids, Genesee river. The exposure here is 25 or 30 rods long and includes about the same section as Pike quarry. The Guelph horizon with white chert is not exposed.

Lauer quarry, town of Gates, 2 miles west of the Rochester city line. The lower part of the section exposes 15 feet of dolomite with Favosites, Stromatopora and Enterolasma caliculus (Lockport). The highest part of the quarry gives 3 feet additional, which may rise to the Guelph horizon, but no satisfactory evidence is at hand. The elevation here is 550 feet A. T. The quarry is not now operated.

Newman quarry, 1¼ miles north of Lauer quarry and 3 miles west of Rochester city line; town of Gates; 30 to 35 feet above the preceding. At the south end of the quarry the section is from the bottom.

1 Compact bluish dolomite, with Enterolasma caliculus (Lockport) - - - - - - - - - - - 4 feet

2 Dark grayish brown dolomite with white chert nodules. This layer has furnished Trematonotus alpheus, but fossils are very scarce. (Guelph or upper Shelby horizon) - -

Wayne county

The original occurrence of Guelph fossils in New York, was, as we have already noted, from the bottom of the Erie canal near Newark. Professor Hall has stated that these remains (a mere handful of depauperated shells) were thrown out with the Salina marls, the rock containing the fossils preserving "the celluliferous structure and characteristic color of the argilaceous limestone of that formation."[1] Newark lies on the Salina shales which are shown to a depth of not less than 200 feet in well sections in the city.[2] The canal (9 feet deep) passes through the city in an east-west course which it retains for several miles. The nearest outcrop of the dolomite is at Fairville, 6 miles due north. This outcrop may be near the middle of the series and the dip of the beds is south 30–50 feet to the mile. It would thus appear that Professor Hall's specimens must have come from a high horizon, even within the Salina shales wherein was represented a brief, ill conditioned return of Guelph species.

Southern Ontario — the section at Hamilton

The composition of the Niagara escarpment, which is finely continued along Lake Ontario (Hamilton bay) just south of the city of Hamilton, has been carefully studied by Colonel C. C. Grant of that place, who has published various data in regard to it. Dr J. W. Spencer also some years ago studied this region stratigraphically and described some of the fossils therefrom. From these sources we gather that the section here is the following, beginning at the top.

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[1] N. Y. State Cab. Nat. Hist. 20th An. Rep't, p. 305 (rev. ed. p. 347).

[2] The section of a well put down at Alloway, 3 miles south of Newark, showed 580 feet of Salina shales to the top of the dolomites. [*See* Prosser. Am. Geologist, June 1900, p. 353]

1 The Barton beds (Spencer). Summit formation, mostly dark dolomite with interbedded shale and soft hydraulic layers, the latter considerably employed in the manufacture of cement - -	87	feet
2 Magnesian silicious beds filled with irregular nodules of light or white chert - - - -	20	feet maximum
3 Blue dolomite - - - - - - - -	5–6	feet
4 Rochester shale - - - - - - - -	17.6	feet

For our immediate use we need not carry the section further down, though the outcrop of the cuesta extends well into the Medina, as on the Niagara river. To return to 1: these heterogeneous strata, consisting of shales, soft waterlimes and hard dolomites (Barton beds[1]) contain discrete faunas. In the hydraulic layers are Atrypa reticularis, Enterolasma caliculus, while the dark dolomites bear a distinct association. With the aid of Colonel Grant and by the study of his collection and that of the Hamilton Scientific Association, we are able to cite these as characteristic species: Orthothetes subplanus, Leptaena rhomboidalis, Orthoceras bartonense Spencer, a Dawsonoceras identical with D. annulatum. More important however are the following, each of which has been seen by Colonel Grant in but a single specimen: Pleurotomaria perlata,[2] Coelidium macrospira, Trochoceras like T. waldronense from the Waldron. The first two of these are of distinctively Guelph character, and P. perlata has not been found outside of that fauna. Colonel Grant finds that the upper layer of these Barton beds, whenever stripped of soil, is everywhere deeply scored by glacial shearing and believes that some part of the dolomites has been thus carried away. Hence we get in these Barton beds, a clue to or suggestion of the true Guelph fauna, which we may well believe

[1] The employment of this term, so well known and long established in the English Tertiary nomenclature, recalls how nearly Professor Hall came to duplicating the same English nomenclature by introducing the terms Galt and Ludlowville.

[2] It is apparently this species that has been described by Spencer as P. clipeiformis from this upper horizon at Hamilton. [Univ. Mo. Bul. 1. 1884. p. 57, pl. 7, fig. 6]

was more fully developed in the later deposits removed by glacial erosion.

Summary

We may briefly summarize the evidence from these sections thus:

The more prolific development of the Guelph fauna in the lower Shelby dolomite on Oak Orchard creek does not extend so far eastward as Monroe county and has as yet been observed only at the original locality.

The Guelph fauna of the upper Shelby dolomite, which is largely involved in chert nodules, appears under similar conditions both at Shelby, about Rochester, and in the Niagara Falls section.

It is to be noted that, while the white chert segregations are in some measure an index of the upper Guelph horizon, those which contain fossils have proved to be in an exceedingly small ratio to the number present. The experience of Mr Arey in the exposures about Rochester showed that these fossils were to be had only by very great diligence and watchfulness, and it seems probable that they will always be of rarity. The dolomite containing these silicious nodules weathers freely to sand, retreating from about the nodules, which thus become loosened and set free, so that the rough, scraggy dolomitic blocks with which the surface of the country is freely covered, specially in the towns of Ogden and Sweden, Monroe co., seem to us to be in part at least derived from this upper Guelph horizon.

We conclude that the episode of the Lockport dolomites, which was virtually the closing sedimentation phase of the true marine Siluric, embraces representations of two quite distinct faunas; (1) the essential or normal fauna of the time and place, the immediate successor of, and derivative from the profuse Rochester shale (Niagaran) fauna, that is to say, the peculiar and appropriate fauna of the Lockport stage; (2) at least two, perhaps three manifestations of the typical Guelph fauna which has entered this province from the west. These are embedded in the dolomites and interbedded with the layers containing the other fauna. They represent a distinct organic facies from the other, and the relations of both are those of mutually encroaching faunas of adjoining provinces without alteration of sediment and sea.

In New York, therefore, both Lockport and Guelph faunas pertain to the period of the Lockport-Shelby dolomites.

FAUNA OF THE GUELPH DOLOMITE IN WESTERN NEW YORK

ANTHOZOA

TETRACORALLA (HEXACORALLA?)

ZAPHRENTIS Rafinesque. 1820

Zaphrentis cf. racinensis Whitfield

Plate 1, fig. 2, 3

Cf. Zaphrentis racinensis Whitfield, Geology of Wisconsin. 1882. 4:277, pl. 14, fig. 1, 2

Four casts of the interior of the calyx of a supposedly turbinate coral were found among the Rochester material, one of which had been identified by Mr Arey with Zaphrentis racinensis. We have a few specimens also from the upper horizon at Shelby. Professor Whiteaves records[1] that he had corals from various Canadian localities in a similarly poor state of preservation, and these he regarded as possibly identical with Z. racinensis Whitf. That species itself was founded on internal casts of cups only, from the Racine limestone, and, while our specimens show the same number of septal impressions as those and also agree therewith in the development of the septal fossette and the mode of contraction of the calicular cavity, they uniformly attain only about half the size of Z. racinensis, the latter having a calyx twice as deep as that from Rochester. While it would be hazardous to identify these corals from such casts only, dissimilarity in size does not impugn their usefulness for correlation. It is not probable that the casts represent specimens of Z. (Polydilasma) turbinata Hall,[2] from the Lockport limestone of New York, as that species is characterized by the duplication of its septa about the outer walls and the abrupt depression of the cup about half way from the outer margin to the center, which would give to the casts a cylindric interior and a saucer-shaped superior part.

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[1] *Op. cit.* 1895. p. 49.

[2] Pal. N. Y. 1852. 2:112, pl. 32, fig. 2a-h.

In the upper Guelph of Shelby was collected a single specimen which possesses a rapidly widening corallum, narrow, thin septa and a deep cup; on account of these characters, it has also been referred to Zaph. racinensis rather than to Zaph. turbinata.

ENTEROLASMA Simpson. 1900

Enterolasma cf. **caliculus** Hall (sp.)

Plate 1, fig. 1

Streptelasma calicula Hall, Paleontology of New York. 1852. 2:111, pl. 32, fig. 1a-k

Of somewhat more frequent occurrence than the foregoing in the Guelph at Rochester are casts of a smaller turbinate, rapidly expanding zaphrentid, slightly curved toward the apex. These in exterior appearance suggest identity with Streptelasma caliculus Hall. Unfortunately in nearly all specimens the internal structure has been destroyed by dolomitization, but a single specimen has afforded in thin section, evidence of a pseudolamella consisting of the involved vermiform projections of the septa suggesting the convolutions of the intestines. Simpson[1] has united under the generic name Enterolasma, species presenting this peculiar divergence from the structure of Streptelasma, assuming the S. strictum Hall, of the Helderbergian, as the type of the genus. Two other species of Niagaran age have been referred by this author to the genus, viz Petraia waynensis Safford and Streptelasma radicans Hall, the former from Perry county, Tenn., the latter from Waldron Ind. Enterolasma waynense differs from E. caliculus in the coarser and more prominent costae and the sharper concentric striae. It is also proportionally more slender. These are but slight differences, which are not pronounced in the Guelph species. Enterolasma radicans has a more irregular growth and a broad base of attachment.

This characteristic dwarfed coral has not been observed in either the lower or upper Guelph beds at Oak Orchard creek, while it was found to be

[1] N. Y. State Mus. Bul. 39. 1900.

abundant in the dark crystalline limestone directly underlying the upper Guelph chert nodules.

DIPLOPHYLLUM Hall. 1852

Diplophyllum caespitosum Hall

Diplophyllum caespitosum Hall, Paleontology of New York. 1852. 2:115, pl. 33, fig. 1a-r

Cyathophyllum pelagicum Billings, Geol. Sur. Canada. Paleozoic Fossils. 1862. 1:108; Catalogue of the Silurian Fossils of Anticosti. 1866. p. 34

Diphyphyllum caespitosum Nicholson, Paleontology of the Province of Ontario. 1875. p. 59

Diphyphyllum caespitosum Lambe, Ottawa Naturalist. 1899. 12:240

Diphyphyllum caespitosum, Geol. Sur. Canada. Contrib. Canadian Paleontology. 1901. v. 4, pt 2, p. 158

Several fragments of coral stocks from Rochester show aggregate simple, cylindric coralla of somewhat varying diameter. Most of these coralla are so weathered or dolomitized that the interior structure is lost; one stock which was better preserved, afforded sections showing that the coral has the internal structure described by Hall for the Niagaran species D. caespitosum, viz a deep calyx; below this an internal zone with tabulae and septa, and a wide marginal zone with septa and numerous dissepiments, which give this zone a cellular appearance. In mode of growth also this form agrees with D. caespitosum. It is not common in the chert nodules of the Guelph horizon.

Observations. The generic relations of this species have been variously interpreted by different writers. Hall erected for it the genus Diplophyllum, citing as differentials the characters of the distinctly separated central and marginal areas of the cell, and mentioned its apparent relationship to Diphyphyllum Lonsdale, without stating the differences between the two. Latterly, Diplophyllum has been considered a synonym of Diphyphyllum; and Rominger,[1] who has been followed by Lambe, united under Diphyphyllum both Eridophyllum and Diplophyllum, because of

[1] Geol. Sur. Michigan. 1876. 3:120.

similarity in mode of growth, admitting however three different modifications in their structure. In the first of these, consisting exclusively of Siluric forms, the demarcation of the outer and inner area is very obscure, and the septa reach to the center of the cells; in the second the septa are confined to a narrow outer zone, and the zones are not separated by an intermediate wall; and the third has a distinct secondary wall separating the inner and outer zones, and this the septa never transgress. Diplophyllum caespitosum, by the development of the septa which reach the center, falls under the first group; the second is that comprised under the generic term Diphyphyllum; and the third is equivalent to Eridophyllum. The last two genera have usually been recognized by European writers, and Frech has stated that Diphyphyllum was based on corals of the Carboniferous limestone, quite distinct from Eridophyllum, and a question may therefore arise as to the propriety of employing the term Diphyphyllum so as to include Diplophyllum.

Diphyphyllum has been considerably misunderstood. Edwards and Haime[1] united it with Lithostrotion, at the same time creating the similar genus Eridophyllum, which on account of its internal wall was compared with Acervularia. De Koninck and Dybowski, however, later defined the genus Diphyphyllum as characterized by the presence of an internal wall with regular tabulae within it and by the feeble development of the septa. The group defined by these characters is identical with Rominger's second modification except that this author describes this group as without internal wall. Other writers on Diphyphyllum contend that the internal wall is never but slightly developed. Frech[2] states that, on account of the internal walls in Diplophyllum caespitosum, Hall's comparison of that species with Diphyphyllum was erroneous, and that it is much more nearly related to Acervularia. It is also distinctly stated that the septa in Diphyphyllum are feebly developed, while in Diplophyllum they are quite strong and reach the center.

[1] Polyp. Foss. Terr. Paleoz. 1851. p. 446.

[2] Lethaea Palaeozoica, 1: 350.

Mr Lambe, who has undertaken a revision of the Canadian corals, united Diplophyllum and Eridophyllum under Diphyphyllum, which is characterized as possessing no "inner wall"; and Diplophyllum caespitosum is said to have "dissepiments arching upward, between the septa, against the outside wall, generally in a single series, their outer edges, as seen in transverse section, assuming the appearance of an inner wall situate less than 1 mm from the wall proper." This appears to us to confirm the presence of an inner wall in D. caespitosum, as the inner wall of the other genera, where it can be said to be typically developed, such as Lonsdaleia and Acervularia, consists also of a single or terminal series of strongly developed upward arching dissepiments. We must, therefore, as long as the term "inner wall" is used loosely, consider D. caespitosum as possessing this structure. It would seem to us that the term should be restricted to that inner wall which is often formed by the lateral thickening of the septa, in like manner as the pseudotheca.

From sections of Diplophyllum caespitosum, of Eridophyllum verneuilianum, the type species of that genus, and of E. simcoense, given by Lambe in the paper above cited, it becomes apparent that the internal wall of Eridophyllum, or walls (for in E. verneuilianum occur two series of dissepiments) are also constructed as in Diplophyllum, and that the difference between the two genera can at present be based only on the different development of the septa, while the difference assumed to consist in the failure of the septa to transgress beyond the inner wall in Eridophyllum is not valid. To this difference may be added the presence of the characteristic radiciform expansions in Eridophyllum. Diphyphyllum differs from the two latter genera by its very feebly developed septa, which do not reach the internal wall, and by its different geologic range. While these distinctions in the three genera may be only of degree, the groups denoted by them differ also in geologic age, Eridophyllum being essentially a Devonic and Diphyphyllum entirely a Carbonic genus.

Diphyphyllum caespitosum occurs, according to Billings, as early as the Anticosti group of Anticosti; it is common in the Lockport dolomite of New York, and is reported from the same horizon in Ontario (Thorold); in Wisconsin it ranges from the Mayville beds, through the coral and Racine beds into the Guelph horizon.

HELIOPHYLLUM Hall. 1849

Heliophyllum sp. indet.

Plate 1, fig. 4, 5.

A single internal cast of a small calyx found in the Guelph of Rochester shows distinctly the impression of the denticulations on the septa, which in the present state of our knowledge are regarded as characteristic of Heliophyllum. Though a considerable number of Siluric species have been referred to this genus, the specimen in hand is not sufficiently complete for identification.

TABULATA

FAVOSITES Lamarck. 1816

Coral stocks of Favosites belong to the most common fossils of the Guelph dolomite. The different coralla show considerable variation, indicating the presence of several species.

Favosites niagarensis Hall

Favosites niagarensis Hall, Paleontology of New York. 1852. 2:125, pl. 34A bis, fig. 4a-h

Favosites gothlandica Whiteaves (in part), Paleozoic Fossils. 1895. v. 3, pt 2, p. 50

Favosites niagarensis Lambe, Contrib. Canadian Paleontology. 1899. v. 4, pt 1, p. 71

This is one of the commonest of the species in the white chert nodules at Rochester and the upper Guelph of Oak Orchard creek. The specimens are for the most part subspheric, attain the size of the fist and are composed of corallites which are seldom larger than 2 mm in diameter, and average considerably less, specially in immature growth. The tabulae are regular and flat, but vary in the intervals between them in different specimens, from .3 mm in one to 1.5 mm. On account of the incrustation of thickened walls, the pores and spines can rarely be observed; one was found to possess two rows of alternating pores on the sides. The presence of numerous spines is indicated by pits on the internal casts of cells. These spines are arranged in three or four rows corresponding to as many septa on each side.

It is safe to consider forms with these characters as identical with F. niagarensis.

Observations. Whiteaves,[1] in his description of Favosites gothlandicus from the Guelph at Galt, Hespeler, Elora and Fergus, regards Favosites niagarensis Hall as a synonym of that species, but remarks that there are no examples of the typical form of F. gothlandicus with large corallites, among the Guelph organisms of the survey museum, and that he has seen but a single specimen thereto. On the other hand Mr Lambe, in the *Revision of the Madreporaria Perforata and the Alcyonaria*[2] describes F. niagarensis and F. gothlandicus separately, but only F. gothlandicus as occurring in the Guelph of Ontario. Milne-Edwards and Haime also regard F. niagarensis as synonymous with F. gothlandicus, but at the same time give a diameter for the corallites which is greater than that of the Guelph specimens. Hall expressly stated that his species was distinguished by the size of the cells, and also usually formed small spheroidal masses, characters with which these Guelph specimens are in accord.

Favosites hisingeri Edwards & Haime

Favosites hisingeri Milne-Edwards & Haime, Polypiers Fossiles des Terr. Paleoz. 1851. p. 240, pl. 17, fig. 2a, 2b

Astrocerium venustum Hall, Paleontology of New York. 1852. 2:120, pl. 34, fig. 1a-j

Astrocerium parasiticum Hall, Paleontology of New York. 1852. 2:122, pl. 34, fig. 2a-i

Astrocerium pyriforme Hall, Paleontology of New York. 1852. 2:123, pl. 34A, fig. 1a-e

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[1] Paleozoic Fossils, v. 3, pt 2.

[2] Contrib. Canadian Pal. v. 4, pt 1, p. 7.

Favosites venusta Nicholson, Paleontology Prov. of Ontario. 1875. p. 65.

Favosites venustus Rominger, Geol. Sur. Michigan. Fossil Corals. 1876. p. 22, pl. 5, fig. 3

Astrocerium venustum Whitfield, Geology of Wisconsin. 1882. 4:270, pl. 13, fig. 8–10

Favosites hisingeri Whiteaves, Paleozoic Fossils. 1882. v. 3, pt 2, p. 51

Several specimens from the dolomite at Rochester and the upper Guelph at Oak Orchard creek differ materially from other species in size of the corallites, and, while they are uniform in this regard, they vary among themselves. They form depressed, hemispheric or flat, though massive expansions. The cells vary from .5 mm to 1.5 mm in diameter, and are prismatic. Long septal spines, reaching nearly to the center of the corallites, are arranged in longitudinal rows. The number of rows of pores has not been positively determined. The tabulae are thin, flat, horizontal, closely arranged, from .5 to 1 mm apart.

This form is well known from the Niagaran and Guelph formations and has a wide distribution.

Favosites gothlandicus Lamarck

Favosites gothlandica Lamarck, Histoire des Animaux sans Vertèbres. 1816. 11:206

Favosites favosa? Hall, Paleontology of New York. 1852. 2:126, pl. 34A bis, fig. 5a-e

Favosites gothlandica Billings, Geology of Canada. 1863. p. 305, fig. 302; Catalogue of the Silurian Fossils of Anticosti. 1866. p. 32

Favosites gothlandica and favosa Nicholson, Paleontology Prov. of Ontario. 1875. p. 51, 52

Favosites gothlandica Nicholson, Paleontology of Ohio. 1872. 2:224

Favosites favosus Rominger, Fossil Corals. 1876. p. 20, pl. 4, fig. 1–4*a*, pl. 5, fig. 2

Favosites gothlandica Whiteaves (in part), Paleozoic Fossils. 1895. v. 3, pt 2, p. 50

Favosites gothlandica Lambe, Contrib. Canadian Paleontology. 1899. v. 4, pt 1, p. 3, pl. 1, fig. 1

With this species has been identified a fragment of a very coarse type of Favosites from Rochester. The calyxes of this specimen average between 2 and 3 mm in width, the tabulae are in the main closely arranged and the cell walls strong; the mural pores are provided with a distinct rim, as observed by others, are much larger than those of specimens referred to F. niagarensis, are arranged in three rows and set closer together than in other species. The marginal depressions of the tabulae observed in F. gothlandicus by Mr Lambe are also easily observable in this specimen. Septa have not been noticed. The walls of the corallites are striated concentrically in several places, indicating the growth lines.

To all appearances this is the same form as that described and figured by Hall as F. favosa? Goldf. from the Niagara limestone at Milwaukee [*op. cit.*]. F. favosus has been currently considered as a synonym of F. gothlandicus. Whiteaves, Lambe and Milne-Edwards and Haime do not recognize that species.

Favosites forbesi Edwards & Haime

Favosites forbesi Edwards & Haime, Polypiers Fossiles des Terr. Paleoz. 1851. p. 238

Favosites forbesi Edwards & Haime, British Fossil Corals. 1855. p. 238, pl. 60, fig. 2a–g

Favosites forbesi Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 50

Favosites basaltica Lambe (in part), Contrib. Canadian Paleontology. 1899. v. 4, pt 1, p. 8

Both at Rochester and at Shelby fragments have been obtained which differ noticeably from the other specimens in the small size of the corallites, which average not quite 1 mm in diameter. Interspersed between these are less numerous, almost circular, somewhat larger corallites. The walls are rather thin, the tabulae irregularly disposed, the pores apparently arranged in two rows and the interior of the cells provided with horizontal scales or squamulae.

It would seem to be a specimen of like character that was identified by Nicholson[1] as coming from Hespeler. In regard to the occurrence of this species, Dr Whiteaves remarks that it is not included in any of the

[1] Pal. Ontario. 2d Rep't. p. 56.

lists of fossils from the Guelph formation in the *Geology of Canada* and that he has failed to recognize it in any of the later collections received by the survey.

A comparison of the specimens from New York with the original description and figures by Edwards and Haime leaves no doubt that, if their species is valid, these may appropriately be referred to it, for they show the difference in size of cells and the average cell diameter given by those authors.

Mr Lambe, however, has lately[1] expressed the view that the specimens determined by Nicholson as F. forbesi are identical with F. basalticus Goldfuss, from which Edwards and Haime had separated it first. These authors themselves, state that there occur all transitions between the two sizes of cells, and, as this difference in our specimens is much less marked, there seems to be good reason for doubting the validity of that species (F. forbesi). In fact, Mr Lambe describes F. basalticus Goldfuss as subject to many variations in outward form and in the size and shape of the corallites. As, however, the dimensions for the corallites are given by him as varying from 2 mm, or even less, to 4 or 5 mm, while in the Guelph specimens, as in those described by Edwards and Haime, the diameter of the two kinds of cells does not quite average 1 and 2 mm; and as Mr Lambe does not cite F. basalticus from the Guelph beds but only from the Onondaga limestone of Ontario, it seems preferable still to refer these specimens to F. forbesi E. & H. Both Nicholson [*op. cit.*] and Frech[2] mention as an additional descriptive feature of this species the less sharply subcylindric form of the cells, a very marked feature of the specimens from Rochester and Shelby. The difference in the size of the cells is reported as most marked in young specimens, but becomes obliterated with progressing growth.

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[1] Contrib. Canadian Pal. v. 4, pt 1, p. 8.

[2] Lethaea Palaeozoica, 1:422.

CLADOPORA Hall. 1852

Cladopora multipora Hall

Cladopora multipora Hall, Paleontology of New York. 1852. 2:140, pl. 39, fig. 1a-g

Favosites? multipora Nicholson, Paleontology of Ontario. 1875. p. 53

Cladopora multipora Lambe, Contrib. Canadian Paleontology. 1899. v. 4, pt 1, p. 29

This form, with the characters assigned to it by Hall and by Lambe, is quite common in the upper Shelby layer, occurring in casts in the compact dolomite which present only the tube fillings, while in the nodules the cell walls are retained. Hall reports the species from the lower part of the Lockport limestone at Lockport, and Lambe from the Niagaran of Lake Temiscamingue, Quebec; it has not been cited from the Canadian Guelph. Whitfield lists an undetermined species of Cladopora from the Guelph of Wisconsin.

The lower Shelby bed frequently contains indistinct masses of a Cladopora, which may be also referable to this species.

HALYSITES Fischer. 1813

Halysites catenularius Linne (sp.)

Tubipora catenularia Linné, Systema Naturae, ed. 12. 1767. p. 1270

Catenipora labyrinthica Goldfuss, Petrefacta Germaniae. 1826. 1:75, pl. 25, fig. 5

Halysites catenularia Edwards & Haime, British Fossil Corals. 1855. p. 270, pl. 64, fig. 1a-c

Catenipora escharoides Hall, Paleontology of New York. 1852. 2:127, pl. 35, fig. 1a-i

Halysites catenulatus Billings, in Logan's Geology of Canada. 1863. p. 305, fig. 303

Halysites catenularia Nicholson, Paleontology Prov. of Ontario. 1875. p. 51, fig. 24a, b

Halysites catenularia Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 47

Halysites catenularia Lambe, Contrib. Canadian Paleontology. 1899. v. 4, pt 2, p. 68

Specimens of this species occur in the white flint nodules at Rochester, and also in the dark dolomite, the latter in a condition altogether similar to that in which they are abundantly found throughout the upper layers of the Lockport dolomite series. The species is also common at the upper Guelph horizon near Shelby falls. In the size of the corallites and shape of the meshes the forms approach that described by Goldfuss as Catenipora labyrinthica, but the latter is considered by Whitfield[1] as a variety of Halysites catenulatus, while Whiteaves regards it as synonymous with the latter, and Lambe asserts that transitions are observable to the forms with large corallites and meshes.

Halysites catenularius, with its varieties has a very wide vertical and horizontal distribution and in Canada occurs both in the Guelph and Niagara beds.

Halysites agglomeratus Hall (sp.)

Catenipora agglomerata Hall, Geology of New York; report on fourth district. 1843. table 22, fig. 2

Catenipora agglomerata Hall, Paleontology of New York. 1852. 2:129, pl. 35 bis, fig. 2a-g

Halysites agglomerata Nicholson, Paleontology Prov. of Ontario. 1875. p. 51, fig. 24c, d and p. 66

Halysites agglomeratus Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 48

Numerous fragments consisting of rather long straight chains composed of nearly round, rather large corallites have been observed at Rochester and in the upper Shelby dolomite. Hall termed forms with this character Catenipora agglomerata. Nicholson reports the species from the Guelph of Ontario; while Lambe [*op. cit.* p. 67, 68] believes that the corallum of H. catenularius adopted the agglomerata mode of growth when its lateral expansion was interfered with or restricted, and asserts that both oval and circular corallites are found in the same corallum. These fossils are too scantily represented in the Rochester material to permit any conclusion in regard to the relation of the species in question.

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[1] Geol. Wisconsin. 1882. 4:271.

There have also been observed in this material a few fragments consisting of alternating rows of large corallites with smaller rectangular ones. This variation has been reproduced by Lambe [pl. 3, fig. 2] and is regarded by him as belonging to Halysites catenularius, his specimen coming from the Niagaran of Ontario.

SYRINGOPORA Goldfuss. 1826

Syringopora infundibulum Whitfield

Plate 1, fig. 6–9

Syringopora infundibula Whitfield, Geol. Sur. Wisconsin. Annual Report. 1877. p. 79

Cystostylus infundibulus Whitfield, Geology of Wisconsin. 1882. p. 274, pl. 14, fig. 7

Cystostylus infundibulus Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 1, p. 2

Cystostylus infundibulus Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 49

Syringopora infundibula Lambe, Contrib. Canadian Paleontology. 1899. v. 4, pt 1, p. 53

A considerable number of nodules of the upper Shelby Guelph are composed of a Syringopora, identical with the above species originally described by Whitfield from the Racine limestone at several points in the vicinity of Wauwatosa and Milwaukee Wis. Whiteaves subsequently reported the species from the Guelph of Hespeler, Elora and Durham.

The material in hand consists of medium sized, apparently irregular coralla, aggregations of subparallel, straight or somewhat flexuous corallites, which have an average diameter of 3 mm and are from 3 to 6 mm apart. The corallites appear externally as transversely wrinkled, sometimes abruptly thickened tubes, which multiply by lateral budding and are connected by transverse, hollow connecting processes, three or four of which are often given off radially in different directions at the same level.

The spiniform septa and funnel-shaped tabulae, characteristic of the genus, are distinctly shown in natural sections.

The writers share Mr Lambe's doubt whether this species will prove distinct from the longer established species, S. verticillata Goldfuss, the more as Rominger, in his very elaborate description of the latter,[1] points out that it is very variable in the size of the tubes and their mode of growth. The dimensions of the two species, as given by these authors, do not differ materially; the critical difference therefore rests only in the more verticillate arrangement of the connecting tubes of the one species, which, as the Shelby material suggests, may take place at the same level in one place and at different levels in other portions of the corallum, so that the latter species may be based on an extreme variation.

Should Syringopora infundibulum prove to be a synonym of S. verticillata, the form is not restricted to the Guelph but also extends down into the Lockport limestone, from which S. verticillata was described, Goldfuss's types having come from the Niagaran of Drummond island.

The only Syringopora which is described from the Niagaran of New York is S. multicaulus Hall, which is said to occur in the Lockport limestone. It appears from the original drawings of that species, that its corallites are smaller than those of S. infundibulum, and the connecting processes must have been very far apart.

HYDROZOA

STROMATOPORA Goldfuss. 1826

Stromatopora galtensis Dawson (sp.)

Plate 1, fig. 13

Coenostroma galtense Dawson, Life's Dawn on the Earth. 1875. p. 160

Coenostroma galtense Dawson, Quart. Jour. Geol. Soc. 1879. 35:52

Cf. Stromatopora constellata Hall, Paleontology of New York. 1852. 2:324

Stromatopora galtensis Nicholson, Monograph on British Stromatoporidae. 1891. p. 173

Stromatopora galtensis Whiteaves, Paleozoic Fossils. 1895. v. 2, pt 3, p. 52

Both at Rochester and in the upper horizon at Shelby occur broad, flat masses with distinct astrorhizae on the surface but with the interior mostly dolomitized. These fossils are very similar to Stromatopora

[1] Geol. Sur. Michigan. 1876. v. 3, pt 2, p. 80.

constellata Hall of the Coralline (Cobleskill) limestone, but the latter has the astrorhizae on monticules, a feature not shown in the Rochester specimens.

Sir William Dawson, in *Life's Dawn on the Earth*, p. 160, describes and figures a form from the Guelph which shows such astrorhizae without monticules, and the same closely laminated interior. Sections obtained from the Rochester specimens show that the mass is first divided into "latilaminae," then again in closely arranged laminae, through which pillars pass continuously. On the basis of these structures the specimen is considered a true Stromatopora, and as showing no noticeable differences from Dawson's Coenostroma galtense. The latter was regarded by Nicholson as probably identical with Str. typica Rosen. This author also states that Coenostroma constellata (Hall) Spencer[1], from the upper Niagaran of Hamilton Ont., does not appear distinguishable from C. galtense Daws.

This species forms numerous large concentric masses in the upper Guelph of Oak Orchard creek. A good specimen exhibiting the astrorhizae in fine preservation was also obtained from the dark crystalline limestone directly underlying this layer and associated with Enterolasma caliculus in abundance. In the lower bed occur very frequently cavities of large size, which are either entirely vacant or filled with a more or less loose mass of small, white, dolomite crystals. The shape of these cavities and the occasional retention of one or two concentric layers indicate that they originated from the dissolution of masses of Stromatopora.

CLATHRODICTYUM Nicholson & Murie. 1878

Clathrodictyum ostiolatum Nicholson

Plate 1, fig. 10-12

Stromatopora ostiolata Nicholson, An. and Mag. Nat. Hist. 1873. ser. 4. 12:90, pl. 5, fig. 1, a

Stromatopora ostiolata Nicholson, Paleontology Prov. of Ontario. 1874. pl. 1, fig. 1, 1a; 1875, p. 63

[1] Univ. State of Missouri. Bul. 1. 1884. p. 48.

Clathrodictyon (Stromatopora) ostiolatum Nicholson, Monogr. British Stromatoporidae. 1886. pt 1, p. 14

Clathrodictyon ostiolatum Nicholson, An. and Mag. Nat. Hist. 1887. ser. 5. 19: 11, pl. 3, fig. 1-3

Clathrodictyon ostiolatum Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 52

The great majority of the stromatoporoid bodies found in the dolomite of Rochester and in the upper Shelby horizon are small, often incrusting nodular masses with very fine and close lamination, a smooth or finely granulate surface and conic oscula, the latter a characteristic feature of Clathrodictyum ostiolatum. In the specimens under observation they are however not arranged distinctly, as described by Nicholson. Where the specimens are weathered, they display the characteristic nipple-shaped prominences of botryoidal appearance. Thin sections show that the specimens belong to the genus Clathrodictyum as defined by Nicholson and Murie, specially clear being the succession of calcareous laminae with intermediate vertical props or dissepiments, which do not penetrate the laminae, and the "marked off cellular compartments."

This species has hitherto been recognized only in the Guelph of Ontario.

A section presenting the same structure was observed among the museum collection of slides from a specimen ticketed as coming from the Coralline limestone at Schoharie. This section also displays distinctly "the internal cylindrical masses, each composed of laminae concentric with a long axis," observed by Nicholson in C. ostiolatum, as the internal continuation of the conic oscula. It seems, therefore, that this species is common to both the Guelph and the Coralline (Cobleskill) limestone.

BRACHIOPODA

CRANIA Retz. 1781

Crania (sp.)

Plate 4, fig. 6

An imperfect upper valve with subcentral beak and squamose concentric striae has been obtained in the white chert at Rochester but is not specifically identifiable.

MONOMERELLA Billings. 1871

Monomerella noveboracum sp. nov.

Plate 2, fig. 1-6; plate 3, fig. 1-7; plate 4, fig. 38

Shell large, thick; brachial valve subovate; pedicle valve elongate, subovate in marginal outline, the greatest width at midlength or sometimes a little in front of it, thence tapering with convex sides to a bluntly triangular erect umbo; the brachial valve broader, blunter and more curved than the pedicle valve. Pedicle valve gently convex, almost straight in profile; brachial valve strongly convex, with the greatest prominence posterior to the middle. The surface ornamentation consists of conspicuous growth lines.

Pedicle valve. Cardinal area large, broad, flat, elongate triangular, slanting obliquely inward and divergent from that of the brachial valve; subdivided longitudinally into a broad, flat, depressed median area (pedicle groove) bounded by lateral ridges and broad, smooth areal borders. Median area higher than broad, crossed by coarse, lamellose growth lines. Supracardinal slope narrow, very oblique and incurved; cardinal faces narrowly triangular, curving outward, merging into a prominent and very broad cardinal buttress, which extends nearly the entire length of the platform. Hinge transverse, much depressed. Platform well developed, extending about half the length of the valve, linguate, widening slightly anteriorly; front obliquely and obtusely angular. Umbonal chambers in most specimens very deep, wide mouthed and broad. Platform vaults not developed. Crescent distinct below the hinge line; lateral and terminal parts readily distinguishable, the latter more impressed. Transverse scars forming an oval impression between terminal crescents and platform. Platform scars finely and obliquely striated; extending apparently the full length of the umbonal chamber. Umbo-lateral scars not distinguished. A broad, low ridge extends from the anterior edge of the platform to the front margin of the valve.

Brachial valve. Shorter by nearly one third than the pedicle valve, broadly ovate, with a low, rotund beak, and transverse hinge which is strongly raised in the middle. Umbonal cavity simple, deep and broad. Platform very large, moderately elevated, extending three quarters the length of the valve, with V-shaped anterior margin, and rounded, projecting antemedian point; slightly excavate on its anterior walls, often to the extent of forming shallow platform vaults. Anterior septum a low, broad ridge, more prominent than in the pedicle valve. Crescent appearing as a well defined impression on the cardinal slope, its sides and ends curving forward and being broader and less distinct. Transverse scars distinct, subcircular depressions. Umbo-lateral scars rather faint and small, lying at the sides of the umbonal cavities. Both median and anterior scars of the platform sharply defined, depressed below the lateral scars, which are obliquely striate.

Horizon. Lower Shelby dolomite, Oak Orchard creek.

This large and ponderous shell has been found only at the locality cited, but is there in very great abundance; it is surpassed in number of individuals only by Trematonotus alpheus and Poterioceras sauridens. Some of the specimens are impressions of the exterior of the shell.

This species is in many respects closely related to M. prisca Billings, whose characters have been described by several authors,[1] though nothing is yet known of its exterior. So obvious is this relationship that M. noveboracum is evidently a local, more prosperous development of that widespread Guelph species. It is, however, sufficiently different to necessitate distinction. It is larger, the specimens attaining a length of 80 mm and a width of 65 mm; the umbonal cavities are, in most specimens, absolutely and relatively much longer, some attaining a length of 35 mm; the umbo of the pedicle valve however is less acutely, but more broadly tapering; the cardinal area, pedicle surface and areal borders are therefore relatively broader. The platform of the brachial valve extends farther anteriorly, and the anterior septa of both valves extend as broad distinct

[1] *See* Billings, Paleozoic Fossils. Nicholson, Pal. Ontario. Whiteaves. Davidson. Hall & Clarke, Pal. N. Y. v. 8, pt 1.

ridges to the anterior margin. In size this form rivals M. durhamensis Whiteaves, which however is readily distinguished by its extremely large and prominent beaks in both valves. In some features the species is still more closely related to M. walmstedti Dav. & King than to M. prisca. Monomerella walmstedti is a species from the corresponding beds of Gothland, which has a similar development of the umbo and cardinal region, but possesses a more convex umbo in the pedicle valve. Davidson points out the close relationship of that species with M. prisca. Monomerella noveboracum shows relationship also, in the character of its brachial valve, with M. kingi Hall & Clarke, from the Niagaran dolomites of Hawthorne Ill.[1] This Shelby species is the only representative of the family Trimerellidae yet found in the State of New York.

DALMANELLA Hall & Clarke. 1892

Dalmanella cf. **elegantula** Dalman (sp.)

Plate 4, fig. 9

For synonomy of Orthis elegantula see Hall & Clarke, Paleontology of New York. 1892. v. 8, pt 1, p. 207, and Davidson, Monogr. British Silurian Brachiopoda.

Some small and incomplete specimens of immature individuals found at Rochester and in the upper Guelph at Shelby suggest affinity with the specific type of Dalmanella elegantula in the relative convexity of the two valves and the character of the surface sculpture so far as retained.

The presence of casts of the interior of two species of Orthis in the Guelph of Ontario is mentioned by Whiteaves; and it is also cited from the Guelph beds at Cedarburg Wis.[2]

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[1] *See* Pal. N. Y. v. 8, pt 1, pl. 4D, fig. 2.

[2] Geol. Wisconsin, 2: 379.

Dalmanella cf. **hybrida** Sowerby (sp.)

Plate 4, fig. 7, 8

Orthis hybrida Sowerby, in Murchison's Silurian System. 1839. p. 630, pl. 13, fig. 11

Orthis hybrida Hall, Paleontology of New York. 1852. 2: 253, pl. 52, fig. 4a-c; and authors generally

A single depauperated ventral valve with the characters of this species has been observed in the chert nodules at Rochester. Orthis hybrida is found at various outcrops of the Racine beds of Wisconsin, but has not been elsewhere identified in typical Guelph rocks.

LEPTAENA Dalman. 1828

Leptaena rhomboidalis Wilckens

For synonymy *see* Schuchert, United States Geol. Sur. Bul. 87, p. 240

Under the name L. depressa, Hall[1] reports this species as common in the Rochester shale and rare in the Lockport limestone. A single small specimen has been obtained from the lower Shelby dolomite. As this cosmopolitan shell is not mentioned from the Guelph of Canada or Ohio, in Wisconsin has been reported only from one locality of that formation, and is entirely absent from the upper horizon at Shelby and Rochester, it evidently found very uncongenial conditions in the Guelph basin.

SPIRIFER Sowerby. 1815

Spirifer crispus (Hisinger) Hall

Plate 4, fig. 10–20

Spirifer crispus Hall, Paleontology of New York. 1852. 2: 328, pl. 74, fig. 9a-h

The Spirifers occurring in the upper Shelby horizon both at Rochester and Oak Orchard creek present features of considerable interest and significance. They naturally fall into two groups, one of small and broad forms, of which numerous specimens have been observed, the other of larger and relatively longer form, occurring in but restricted number.

The smaller of these is identical in expression with the Sp. crispus described by Hall from the Coralline (Cobleskill) limestone. All the

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[1] Pal. N. Y. 2 : 258.

specimens before us from Rochester and Shelby, as well as those described from the Coralline limestone of eastern New York, agree in having the plications obsolete, while they distinctly show the fine concentric striae with minutely setose edges, characteristic of that species. Hall expressly states that these Coralline forms possess no distinctive features from the Niagaran specimens of this very variable species, and he therefore had "no hesitation in referring the specimens from the Niagara and the Coralline limestone to the same species." At the same time it seems that there is, in the progress of this species, a decided tendency toward the development of smooth forms, as is evinced by the replacing of the strongly plicated shells of the Rochester shales by the smooth forms in the Coralline and the Guelph dolomites.

In the upper horizon on Oak Orchard creek a few faintly ribbed specimens indicate the derivation of the smooth mutation from the typically costate form. But they also contrast strongly with the highly plicate forms found abundantly in a fossiliferous limestone layer in the Lockport limestone above the lower Shelby bed and among which there are found no smooth specimens. In the lower fauna Spirifer is entirely absent.

A similar smooth expression of Spirifer crispus in the dolomites of the Manlius horizon has been recently observed by A. W. Grabau in western New York and described as Spirifer eriensis.[1] Dr Grabau emphasizes the very close relation of his form with the Coralline (Cobleskill) limestone variety of Spirifer crispus for which he has proposed the varietal term corallinensis. These smooth varieties of the species thus extend to the top of the Siluric.

The larger form is too robust to be considered a variety of Sp. crispus. It is also distinguished by the subtriangular outline, and the long extended beak of the pedicle valve. The sinus is extremely shallow and can hardly be characterized as flanked by folds. Parts of the shell adhering to the cast exhibit concentric imbricating lines. A comparison with Sp. bicostatus at once suggests itself, but the form from the Guelph dolomite is still larger than the typical forms of that species, has the extremities

[1]Geol. Soc. Am. Bul. 11. 1900. p. 366. pl. 21, fig. 2a, b.

more angular and lacks the distinct folds on either side of the sinus. In these features, differential from Sp. bicostatus, it agrees with a large form which is described and figured by Hall from the Coralline limestone as "Spirifer sp."[1] and is stated to be closely allied to Sp. crispus but differing in size. This agreement extends even to four of the five very low costae observed on the casts from the Coralline limestone of Schoharie. The form from the Guelph dolomite [see plate 4, fig. 21, 22] unites the characters of Sp. bicostatus with this unnamed Spirifer. Sp. bicostatus in New York is only known from its original locality, Vernon Center in Oneida county, in the eastern extension of the Lockport limestone. It seems, therefore, probable that this group of forms is restricted to the Guelph dolomite, the eastern extension of the Lockport limestone in the center of the State, where the stratigraphic relations are not fully known, and to the Coralline limestone.

Whiteaves[2] states that the characters of two ventral valves from the Guelph at Durham Ont. are so similar to those of Sp. bicostatus, as described and figured by Hall, that it is possible these should be referred to that species rather than to Sp. plicatellus. This species and its variety, radiatus, replace Spirifer crispus in the western Racine and Guelph beds, from which the latter has not been reported.

WHITFIELDELLA Hall & Clarke. 1892

Whitfieldella nitida Hall

Plate 4, fig. 32-37

Atrypa nitida Hall, Geology of New York; rep't on fourth dist. 1843. table of organic remains 13, fig. 5

This is the most common brachiopod in the higher horizon of the Guelph dolomite at Shelby and at Rochester. Most of the examples are relatively small, in this feature approaching more nearly the New York Niagaran than the Waldron, Indiana, specimens. One exhibits lateral folds, an occurrence at times observable in the Waldron shell.

[1] Pal. N. Y. 2: 327, pl. 74, fig. 7, 8a-d.

[2] Paleozoic Fossils, v. 3, pt 2, p. 62.

Whitfieldella nitida Hall is not reported from the Guelph limestone of Canada. It is there replaced by W. hyale Billings (sp.) which is said to be abundant at all localities. The Rochester specimens are distinctively different from the latter, which is broader shouldered, has its greatest width more posteriorly and is less convex. The majority of them however have a broader outline than the typical Lockport specimens, a feature in which they approach W. nucleolata Hall, the Coralline limestone representative of the genus, but they still differ from the latter in not having a distinct sinus and indentation of the anterior margin. Hall[1] makes the interesting statement that these broader forms occur in the Lockport limestone of eastern Wayne county and in Cayuga county, that they have not the full development which the same species has in the shale at Rochester, and that they are not easily distinguished from the less characteristic specimens of W. nucleolata. The forms from the Guelph dolomite here considered seem to agree most closely with these eastern shells from the Coralline limestone.

Whitfieldella hyale is reported by Whitfield from the Wisconsin Racine and Guelph beds, while W. nitida is mentioned only from the Racine beds. As the latter species has not been cited from the Guelph of Ohio it appears to be present in that formation only in New York. It is entirely absent from the lower horizon at Shelby.

CAMAROTOECHIA Hall & Clarke. 1892

Camarotoechia (?) **neglecta** Hall (sp.)

Plate 4, fig. 28–31

Atrypa neglecta Hall, Paleontology of New York. 1852. 2:274, pl. 57, fig. 1a-p

Rhynchonella neglecta Hall, N. Y. State Mus. 28th An. Rep't. 1879. p. 162, pl. 26, fig. 1–6

Rhynchonella neglecta Beecher & Clarke, N. Y. State Mus. Mem. 1. 1889. p. 37, pl. 4, fig. 3, 6–8

Characteristic specimens of this species are quite common in the white chert of the Rochester and the upper Shelby dolomite. They seem to

[1] Pal. N. Y. 2:329.

agree more closely with the shell as it occurs in the Rochester shales of New York than with the representatives of the species at Waldron Ind., the latter having the plications less blunt and the sinus more pronounced.

The species has a wide distribution in the Niagaran beds, and is listed from some of the Guelph localities in Wisconsin. It has not been found in the Canadian Guelph. These specimens do not approach Rhynchonella pisa Hall & Whitfield, the only species of the genus recognized by Whiteaves in the Guelph fauna of Ontario [*op. cit.* 1895. p. 63].

Camarotoechia (?) indianensis Hall

Plate 4, fig. 26, 27

Rhynchonella indianensis Hall, Albany Institute. Trans. 1863. 4: 215

Rhynchonella indianensis Hall, N. Y. State Mus. 28th An. Rep't. 1879. p. 163, pl. 26, fig. 12–22

Rhynchonella indianensis Beecher & Clarke, N. Y. State Mus. Mem. 1. 1889. p. 42, pl. 3, fig. 17–28

This species is represented by a few specimens from the Rochester and Shelby horizons.

It, as well as C. (?) neglecta, is decidedly more common in the chert nodules of the upper Shelby dolomite than at Rochester. In the lower Shelby bed it is still less frequently observed.

Camarotoechia (?) indianensis occurs freely in the Niagaran at Waldron Ind., and at Louisville Ky., but has not been recorded in the Niagaran beds of New York.

RHYNCHOTRETA Hall. 1879

Rhynchotreta cuneata americana Hall

Plate 4, fig. 23–25

Atrypa cuneata Hall (non Dalman), Geology of New York; rep't on fourth dist. 1843. table of organic remains 13, fig. 3, 4

For synonomy *see* Hall & Clarke, Pal. N. Y. v. 8, pt 2, p. 185

In the upper Guelph of the Oak Orchard creek section a single normal specimen of this shell was obtained, exhibiting the cuneiform outline, concave cardinal slopes and angular plications curving outward toward the lateral margins. The plications are not quite as prominent as in the typical Rochester shale specimens.

This shell is widely distributed in the Niagaran of North America, where it occurs in the Rochester shale, Waldron and Osgood beds; but it seems to be absent from the higher beds of the Niagaran, and has not been observed before in the Guelph. Its appearance, though extremely rare, in the Guelph of Oak Orchard creek, is hence worthy of notice.

LAMELLIBRANCHIATA

MYTILARCA Hall. 1870

Mytilarca eduliformis sp. nov.

Plate 5, fig. 8–10

Shells rather small, valves ovate acuminate, very narrow at the beaks, with slightly concave anterior margins, broadly rounded at the base and at the postlateral extremity, the posterior cardinal margin being straight. Beaks narrow, subacute and directed forward. Surface elevated along the umbonal ridge which runs from the beaks to the antelateral curve. From this ridge the surface is abruptly incurved and almost vertical. Posteriorly the slope is very much more gradual, and the ridge loses its prominence over the basal region. The ornament is not well preserved, but patches of the shell show fine concentric lines without other modification.

Dimensions. This description is based on two specimens, one of which retains the valves in normal juxtaposition. The valves have a length of 20 mm and a width at three fourths their length of 15 mm.

Observations. This shell has a noteworthy resemblance in form and contour to a small example of the living Mytilus edulis. It is provisionally referred to the genus Mytilarca, though some generic distinction may eventually be found between this and the typical upper Devonic representative of the genus. The only American Upper Siluric species which has heretofore been referred to Mytilarca is the M. sigillum Hall from the Niagaran at Waldron Ind.

Mytilarca eduliformis is from the white chert at Rochester.

Mytilarca acutirostrum Hall

Plate 5, fig. 11, 12

Ambonychia acutirostra Hall. N. Y. State Cab. Nat. Hist. 20th An. Rep't. 1867. p. 336, pl. 14, fig. 2

Ambonychia acutirostra Hall. N. Y. State Mus. 28th An. Rep't. 1879. p. 171, pl. 7, fig. 12

Several internal casts of this shell, rather below medium size, were obtained from the lower bed at Shelby. They are characterized by their full, relatively long valves with produced, acute beaks, straight, short cardinal line, straight and slightly convex anterior margin which extends almost the whole length of the valve, very convex basal and less rounded, almost straight and oblique posterior margin, which forms an obtuse angle with the short wing of the posterior cardinal region. The umbo is very prominent and convex; from it a slightly elevated and distinct umbonal ridge extends to the anterobasal angle. Thence the valve slopes evenly toward the posterior margin, and more abruptly toward the anterior margin. No muscular impression has been observed on the somewhat incrusted casts. The impression of a distinct, narrow ligamental area, extending the full length of the cardinal line, and of two oblique lateral teeth at the extreme posterior end of the cardinal line are noticeable.

Observations. This form differs from the foregoing both in size, and in its slightly convex anterior margin. We have identified these shells with Ambonychia acutirostrum, a species which was described by Hall from the limestone of the age of the Niagaran group, near Milwaukee. In the 28th report of the New York State Museum it is said to be associated, in Wisconsin and Illinois, with Ambonychia aphaea, described from Wauwatosa Wis. and Bridgeport Ill. Professor Whitfield[1] cites the species from the Racine beds of Racine, Greenfield, Waukesha and Wauwatosa, and from the Guelph beds of Cedarburg, it being the only Guelph lamellibranch mentioned besides Megalomus canadensis. It has not been reported from the Canadian Guelph.

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[1] Geol. Wisconsin, 2: 372–79.

Hall referred his species with doubt to Ambonychia. Ulrich[1] refers the form to Mytilarca, a view which is verified by the evidence of lateral teeth.

Mytilarca acutirostrum is, as indicated by Hall, very similar to Myalina mytiliformis Hall from the gray Clinton limestone of New York. From the latter species M. acutirostrum was said to differ in its more acute beak and relatively greater width. In regard to width our specimens are intermediate between the two species, but in the character of its beak it is more like the western Guelph form. Foerste[2] has described still another Clinton form as Mytilarca mytiliformis, but as Hall's Ambonychia mytiliformis is a Mytilarca [p. 560 of same paper] the species should be renamed (Myt. foerstei *nom. propos.*).

PTERINEA Goldfuss. 1826

Pterinea subplana Hall (sp.)

Plate 5, fig. 4

Avicula subplana Hall, Paleontology of New York. 1852. 2:283, pl. 59, fig. 3a, 3b, 3c

Internal casts from the Rochester chert and the upper horizon at Shelby indicate a depressed right valve with long straight hinge line, beak subanterior and not prominent, slightly projecting above the hinge line. The ear is short and apparently rounded, the posterior wing is much extended, obliquely truncated and set off from the body of the valve by a low and broad depression. A long narrow cartilage pit extends from the beak three fourths the length of the posterior cardinal line and parallel to it. Surface with concentric lines.

The left valve shows a greater convexity and similar outline.

Avicula subplana is a Rochester shale species which has not been reported from the Guelph of Canada or the Interior.

[1] Geol. Sur. Minnesota, v. 3, pt 2, p. 494.

[2] Geol. Ohio, 7:559.

Pterinea undata Hall (sp.)

Plate 5, fig. 6

Avicula undata Hall, Paleontology of New York. 1852. 2:283, pl. 59, fig. 2

A single cast of the left valve. This, in its oblique form, short hinge line, prominent umbo, and much elevated, rounded umbonal ridge, agrees closely with this shell as described by Hall from the Rochester shale. The concentric undulations are also indicated on the cast.

We are not aware that this species has been obtained in either the Canadian or western Guelph. The specimen described is from the upper Shelby dolomite.

CONOCARDIUM Bronn. 1835

Conocardium sp.

Plate 5, fig. 7

Several small Conocardia, poorly preserved, have been noted in the Guelph at Rochester. These indicate a shell somewhat similar to the little known C. ornatum Winchell & Marcy[1] from the Niagaran dolomites of Illinois, but seem to lack the sharp ornamentation of the umbonal ridge. This ridge is greatly elevated, and the body of the shell is short, so that both anterior and posterior slopes are steep, but the former is much the more abrupt and is concave. The surface of the posterior slope bears nine to 10 ribs with five to six on the anterior.

Whiteaves mentions the frequent occurrence of a small Conocardium in the Guelph at Durham and thinks it probably an undetermined species, but gives no clue to its characters.

MODIOLOPSIS Hall. 1847

Cf. **Modiolopsis subalata** ? Hall

Modiolopsis subalatus? Hall, Paleontology of New York. 1852. 2:285, pl. 59, fig. 7

A somewhat incomplete cast of both valves, from the upper Guelph at Oak Orchard creek, exhibits the characteristics of the Rochester shale

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[1] Boston Soc. Nat. Hist. Mem. 1. 1866. p. 111, pl. 2, fig. 15.

specimens, which were identified with qualification by Hall with the Clinton form of his species. It differs to some extent in possessing a slight depression extending forward from the umbo, which is not mentioned in the description of M. subalata.

GASTROPODA

BELLEROPHON Montfort. 1808

Bellerophon shelbiensis sp. nov.

Plate 5, fig. 13–19

Bucania stigmosa? (Hall) Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 1, p. 34, pl. 5, fig. 3, 3a; pl. 8, fig. 4

Not Bucania stigmosa Hall, Paleontology of New York. 1852. 2:92, pl. 28, fig. 8, 8a-e

Dr Whiteaves has figured from the Guelph of Galt internal casts of a symmetric shell which he refers to as Bucania stigmosa? Hall. With regard to these he says:

> These agree perfectly with similar but better preserved casts from the Niagara formation at Grimsby Ont., in the museum of the survey, which have been identified with B. stigmosa by E. Billings, but in the absence of any knowledge of the shell of the Galt specimens their determination must be regarded as doubtful.

A considerable number of similar casts from Shelby leaves no doubt that this form is well distinguished from Hall's Clinton species, Bucania stigmosa, for, besides attaining a size thrice as large, it distinctly differs in the cross section of its whorls, which are more convex on the dorsal and more deeply concave on the ventral side, the whorls embracing somewhat more than in the Clinton species.

Diagnosis. Shell somewhat below medium size, having an average diameter of 15 mm and rarely attaining more than 25 mm; consisting of about three volutions which increase but slowly in size; whorls embracing about one third of the hight, lowly subtriangular in cross section, with a dorsal carina which, bearing the slit-band, becomes more prominent as growth advances. The sides are convex, full or evenly rounded in young stages, becoming more gently convex in later growth, abruptly sloping to the umbilicus, which appears relatively large on internal casts but as indicated by casts of the exterior was actually very small, the shell being considerably thickened along the umbilical edge. Aperture but little expanded laterally, broadly triangular reniform, outer lip with a shallow sinus, inner lip not observed. Surface ornamentation not sufficiently known, apparently consisting only of growth lines.

Horizon. Lower Shelby dolomite.

As Whiteaves reports this species from the Guelph at Galt and from the Niagaran formation at Grimsby Ont., it suggests itself that also in Canada this form may appear in an early manifestation of the Guelph fauna, as in New York. From B. tuber Hall, the only other species of Bellerophon described from the Niagaran, B. shelbiensis differs in the laterally more expanded aperture and the deeper sinus of the outer lip. We have no record of the occurrence of other species of true Bellerophon in the American Niagaran; and, in view of the large representation of the genus in the Lower Siluric and Devonic, it is evident that the facies in which this genus flourished in Niagaran time has not yet been brought to notice.

Though this shell was identified by Billings and Whiteaves with a species of Bucania, we feel justified in referring the form to Bellerophon. In the differentiation of Bellerophon and Bucania, the character of the surface sculpture is considered by various writers (de Koninck, Waagen, Koken) of critical importance; and this feature is not clearly exhibited in the Shelby material, but the character of the umbilicus, and of the section of the whorls is distinctly bellerophontid. The umbilicus has been described above; and the section is not flat on the dorsum and angulated at the edge, as in the generic type of Bucania, but rounded and embracing with the edges. All through the literature of paleozoic gastropods the distinction of Hall's genus Bucania from Bellerophon has been involved in much uncertainty and doubt. Professor Hall did not originally define the genus sufficiently to avoid misconception. It seems evident that, as suggested by Koken and Ulrich, Hall used B. expansa as type of his genus, but, as he described B. sulcatina as the first species of the genus, this had to be taken as typical, and B. expansa has been construed as a species of Roemer's later genus, Salpingostoma. De Koninck and Waagen, in the endeavor to define the genus more clearly, based it on the presence of revolving lines. Koken, who intimates that Hall when defining the genus evidently had before him species of the subsequently established genera, Salpingostoma and Trematonotus, bases the genus on B. sulcatina and defines it by its flat dorsum, wide umbilicus, slightly expanded peristome and coarse, wrinkled revolving lines, crossed and interrupted by transverse lamellae. He also includes in this genus the Devonic and Carbonic species bearing these characters, and is followed in this view by Clarke, who has described a Devonic Bucania.[1] Hall, on the other hand, states[2] that there are no Bucanias younger than the B. profunda (which is a Trematonotus) of the Helderbergian, so that there obviously exists a considerable difference between Hall's and Koken's conceptions of Bucania. Lindström, in his work on the Silurian Gastropoda of Gothland, does not recognize the genus at all, but unites it with Bellerophon, on the ground that it has the wide aperture in common with most of the Bellerophons, and that the wide umbilicus and the spiral striae are not of enough importance to be of value as generic distinctions. The claim of Fischer[3] and Lindström, that Hall ultimately abandoned the generic term Bucania and reunited the form with Bellerophon, seems to be based on a misconception, as Hall, in *Paleontology of New York*, v. 5, states only that the B. devonica is probably not Bucania, and that this genus does not enter the Devonic.

In contrast with Lindström's extreme conservatism, Ulrich places Bellerophon and Bucania in different families, the Bellerophontidae and Bucaniidae. He recalls Koken's observation as to the differences in the aperture and surface sculpture between the "Sulcatina typus" and the Devonic and Carbonic species, and holds the opinion that Bucania, in its restricted sense, is "strictly a Silurian genus and possibly not even repre-

[1] Paleozoic Faunas of Parà.

[2] Pal. N. Y. v. 5, pt 2.

[3] Manuel de Conchyliologie, p. 854.

sented in the upper Silurian." The spirally ribbed later species are united by this author under a new generic term, Bucanopsis. As these forms do not differ from Bellerophon in other features than the cancelation of the surface, the genus is placed among the Bellerophontidae. To Bucanopsis are referred the well known Hamilton species Bell. leda and B. lyra. If our Guelph species should prove to be ornamented with spiral lines, it would also be referable to Bucanopsis.

TREMATONOTUS Hall. 1868 (emend.)

Trematonotus alpheus Hall

Plate 5, fig. 20–23; plate 6, fig. 1–9

Tremanotus alpheus Hall, separately printed in advance for N. Y. State Cab. Nat. Hist. 18th An. Rep't. 1865. p. 43

Tremanotus alpheus Hall, N. Y. State Cab. Nat. Hist. 20th An. Rep't. 1867. p. 347, pl. 15, fig. 23, 24

Tremanotis alpheus McChesney, Chicago Acad. Sciences. Trans. 1859. v. 1, pl. 8, fig. 4a, b

Bellerophon (Bucania) perforatus Winchell & Marcy, Boston Soc. Nat. Hist. Mem. 1866. v. 1, no. 1, p. 108

Tremanotus alpheus Whitfield, Geol. Sur. Ohio. v. 2, Paleontology, p. 145, pl. 8, fig. 1

Tremanotus angustatus Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 70

Not Bucania chicagoensis McChesney, Description of New Species of Fossil from Paleozoic Rocks of Western States (advance extr. Chicago Acad. Sci. Trans. v. 1). 1859. p. 69, pl. 8, fig. 5a, b (plate published at a later date)

Probably Bucania angustata Hall, Paleontology of New York. 1852. 2: 349, pl. 84, fig. 7a-d

Of this remarkable type of symmetric gastropod structure, three specimens have been observed in the material from the Guelph horizon at Rochester, one from Newman's quarry, one among the fossils from the same horizon (upper Shelby) at Oak Orchard creek and not less than 100 internal and external molds in the collection from the lower Shelby bed. Two of the Rochester specimens are in a fair state of preservation, and most of the lower Shelby examples are excellently preserved, much better than are the originals of the species, as they retain the surface markings and the apertural expansion in neanic, ephebic and gerontic conditions. They permit, therefore, the addition of some important facts to the description of that species.

Description. Shell subdiscoid, involute; whorls three to four; in section subcircular to roundly elliptic, with inner groove, the outer whorl being impressed on the inner. The aperture has a flaring lip, which is turned outward by rather abrupt curvature till it stands at right angles to the axis of the body whorl and is then reflected. This lip attains, in one specimen, in its longer axis, a length of 65 mm, and in its minor one a length of 50 mm. The inner lip was folded back over the last whorl to such an extent that it covered about one third of it.

Most transverse sections of the shell show symmetric enrolment of the whorls, but a few, undisturbed in their growth, evince indications of asymmetry in early growth. This condition, however, has not been demonstrated a normal feature.

The degree of involution seems to have been subject to some variation, as there is some difference in the specimens in the width of the umbilicus at full growth. In the great majority, however, the volutions embrace sufficiently to make the umbilicus relatively small. The whorls are abruptly convex around the umbilicus.

The surface ornamentation consists of about 20 coarse flat topped revolving ridges, on each side from keel to umbilicus; these are separated by equally wide furrows with generally a smaller rib between them. The ribs have a somewhat irregular undulating course, periodically swelling and contracting, giving the surface a peculiarly irregular appearance. These irregularities are caused by intersection with incised concentric lines, beyond which the revolving ribs appear out of position. The ribs are also intersected by broad, transverse folds, which curve obliquely backward across the whorls. These are most distinct near the umbilicus and become faint near the dorsal keel. On the outside of the peristome the ribs become quite abruptly coarser; and in gerontic specimens they change, on the outer lip, into broader, less keeled ribs, and the smaller intercalated ribs disappear entirely, so that in such individuals the peristome bears a very distinct ornamentation. Casts of the interior surface of the shell demonstrate that the latter was almost entirely smooth, and bore no other traces of the highly sculptured surface ornament than occasional very faint, low, revolving undulations or obscure indications of the transverse ribs.

The transverse folds by which the surface sculpture is crossed, are apparently the results of the repeated production and absorption of the expanded mouth. The development of the latter at more or less frequent intervals is a noteworthy difference from the earlier Siluric forms referred by Ulrich to the genus Salpingostoma F. Roemer,[1] the fundamental distinction, however, being in the character of the perforations on the slit-band, which in Trematonotus are elliptic, with everted margins, while in Salpingostoma the perforation is a single long and continuous but inclosed slit.

In T. alpheus the perforations are located on an elevated, narrow, dorsal keel, which does not extend on the peristome, but is there followed by a depression extending to the margin of the outer lip. To the keel corresponded a deep groove on the inside of the shell. The groove and perforations disappear where the inner lip of the peristome reclines on the penultimate volution, and closes the perforations. The number of perforations left open varies from six to nine.

Dimensions. A large specimen with gerontic characters measures from the outer edge of the aperture to the dorsal side of the early part of the ultimate volution, 75 mm. The major diameter of the aperture was about 57 mm and the vertical diameter of the shell 51 mm.

Observations. The genus Tremanotus (*recte* Trematonotus Fischer) was erected by Hall as above cited for this species, the original specimens being from the Chicago limestone. Professor Hall had earlier described from the Guelph formation at Galt Bucania angustata,[2] a species

[1] The type of this genus, S. macrostoma, is a middle Devonic shell. It is yet to be demonstrated that the Trenton shells which have been referred to it are congeneric with this species.

[2] Pal. N. Y. 1852. 2:349, pl. 84, fig. 6a, b.

based on internal casts in a rather inferior state of preservation. Dr Whiteaves holds this fossil to be identical with T. alpheus, and while this is probably true, conclusive evidence of the exterior and apertural characters of the Canadian Guelph specimens still fails us, and we have no recourse except to continue the recognition of the term here adopted. It has been contended that McChesney's name, Bucania chicagoensis, has priority over T. alpheus, the description having been published in advance of that of the latter, but it was unaccompanied by illustration at its first description, and the original figure shows it to be a much larger and more widely umbilicated shell. On the same plate with this figure are others referred by McChesney to T. alpheus.

Whiteaves was inclined to believe that all three may be found identical with T. dilatatus Sowerby, because Billings had identified a specimen from the Niagaran of L'Anse á la Vieille on the Bay of Chaleurs, and another from "Division 2" of the Anticosti group, with that species. A comparison of our material with Sowerby's excellent figures and McCoy's more complete description convinces us that the form in hand is distinct from the Ludlow and Wenlock species, for, while the dimensions and the surface sculpture appear to be alike in the two, the whorl section is markedly distinct. This is evinced by the flat dorsum of the whorls and the broad but low cast of the aperture in Sowerby's figure, and by McCoy's statement[1] that the section of each whorl is twice as wide as long. In the specimens of T. alpheus from Shelby, the proportion of width to hight is, in the inner volutions, as 3 : 2, in the ephebic volution however, only as 5 : 4. This volution is, therefore, relatively much higher than in the English form. In this character our material agrees fully with Hall's type of T. alpheus. On the other hand, the single specimen which served as representative of this species in Hall & Whitfield's description of its occurrence in Ohio,[2] possesses lower volutions, it being described as having the lateral diameter of its whorls nearly double that of the dorsoventral

[1] British Paleozoic Fossils, p. 309.

[2] Pal. Ohio, 2 : 145.

diameter. It is also much more widely umbilicated and the outer volutions embrace the inner ones for about one half their width. As the large series of New York specimens are quite uniform in their relatively high volutions, it seems to us that the specimen from Genoa O., represents another type and approaches Trematonotus chicagoensis McChesney, which (in its restricted definition) possesses only low volutions and a very wide umbilicus.

Trematonotus alpheus is very nearly related to T. longitudinalis Lindström, which has cylindric volutions, a like surface ornamentation and an equal degree of umbilication. It differs however in having a relatively much greater expansion of the lateral peristome and shorter outer lip; and T. alpheus does not exhibit the distinct dorsal ridge of the outer lip in continuation of the slit band, and the corresponding sinuation of the margin of the outer lip. Lindström regarded his species most nearly related to T. trigonostoma Hall & Whitfield, evidently because only incomplete casts of the more closely related T. alpheus, had been figured at the time of his study.

The peculiar preservation of the majority of the specimens as molds is evidently the same as in the Gothland material, for the principal figure given by Lindström illustrates the same mode of preservation. Failure to properly interpret this figure led Koken to the misconception that it represents the inside of the aperture, and he has stated,[1] in his elaborate research *Ueber die Entwickelung der Gastropoden vom Cambrium bis zur Trias*, that Trematonotus has on the aperture internal folds, which show no relation to the outside sculpture. Our material shows how easily this misconception could arise. The wrinkled sculpture is actually that of the outside of the aperture, and the inside of the aperture was nearly smooth.

We need not emphasize here the significance of the discovery of this species in New York at a horizon corresponding to its occurrence in Canada and Illinois. We fail to find the form cited among the Guelph fossils of Wisconsin; among the Racine fossils, however, there is listed

[1]Neues Jahrb. Beilagebnd. 1888–89. p. 386.

Bucania angusta[1] (in error for angustata), which probably is a synonym of T. alpheus, as stated above. Hall also[2] mentions the occurrence of Bucania angustata at Racine, stating that the specimen is indistinguishable from the species occurring at Galt. The early appearance of this form in the Racine beds of Wisconsin seems to us quite significant in view of the abundant appearance of T. alpheus in the lower Shelby dolomite.

DIAPHOROSTOMA Fischer. 1885

Diaphorostoma niagarense Hall (sp.)

Plate 10, fig. 14–16

Platyostoma niagarensis Hall, Paleontology of New York. 1852. 2: 287, pl. 60, fig. 1a–v

Two very young specimens from Rochester and four equally small ones from the upper Guelph at Shelby, exhibit in profile, shape of volutions, aperture and surface markings, the characteristic features of D. niagarense. The largest of these specimens possesses a broad, shallow depression on the middle of the body whorl, where the growth lines are distinctly sinuate.

This form occurs in various exposures of the Rochester shale within the State of New York, and also in more robust development at Waldron Ind. It is not reported from the Guelph formation, nor has it been recognized from the Coralline limestone of eastern New York.

POLEUMITA nom. nov.

In 1876 Munier-Chalmas introduced[3] the generic term Oriostoma (=Horiostoma) for certain French Lower Devonic shells which have been more fully explicated by Oehlert and Barrois. Lindström,[4] after comparison of the Gothland shells with the French species regarded both congeneric, admitting however a dissimilarity in the abundant presence

[1] Geol. Wisconsin, 2:375.

[2] N. Y. State Cab. Nat. Hist. 20th An. Rep't. 1867. p. 346.

[3] Jour. de Conchyliologie, 16 : 103.

[4] The Silurian Gastropoda and Pteropoda of Gotland.

of opercula among the Swedish shells, which have not been observed with typical species of Horiostoma — an argument to which little weight can be given. Horiostoma, however, was described as having the final whorl free about the aperture though only for a short distance, a feature which is not specifically noted by Lindström for the Siluric species. Koken has expressed[1] the belief that there is a palpable difference in the typical Horiostoma (H. konincki Oehlert) and the species referred by Lindström to that genus, and regards the former as related to the capulids, while the latter are derivable by easy stages from Euomphalus. Koken has proposed to denominate the Swedish Horiostomas by the term Polytropis de Koninck, introduced for Carbonic shells in 1881. As this name however was employed by Sandberger in 1874 for an entirely different group of Gastropods, its use is not permissible.

Koken has not made out a very forcible argument for the distinction of these genera; and our impulse is to array the species from the Guelph which we are about to discuss, under Munier-Chalmas's genus. Admitting however the dependability of Koken's inferences, there remains no place here for the term Polytropis which he has applied to the Swedish species and which Whiteaves, following that proposition, has also employed for species of the Guelph of Ontario. Hence we have introduced the name Poleumita, basing its characters as a genus on the species which is most abundant in the Guelph horizon at Rochester, P. scamnata.

Poleumita scamnata sp. nov.

Plate 9, fig. 1–8, 10, 12–15

Shell turbinate, with spire more or less depressed, there being in this respect a notable variation among the individuals; whorls five to six, subcircular to subovate in section, very slightly overlapped by succeeding volutions, on the contrary separated by a broad and deep suture, above which the whorls stand up prominently. The form of the whorl does not vary materially with growth, but the suture and its excavated or flattened outer slope become more conspicuous though relatively no larger on the later

[1] Neues Jahrb. für Mineral. Beilageband 6. 1889. p. 425, 477.

whorls. Near the aperture the last whorl is distinctly free from the preceding. Aperture circular, not thickened; umbilicus round and deep. Surface bearing a series of about 20 fine, elevated, flat topped and continuous ridges, of which about 15 are on the outer and upper slope of the whorl. These are separated, except near the suture, by flat grooves of subequal size and wider than the ridges.

The excavated slope to the suture occupies the width of two or three of these intervals, and on this faint traces of the revolving lines may sometimes be observed. On the umbilical surface the revolving ridges are more prominent than elsewhere and more widely separated. At times these ridges appear to be faintly grooved at their summits. All these ridges are crossed by fine, imbricating or tilelike, concentric striae which are caught back at the summits and are most sharply evident in the intervening furrows. These lines are specially noticeable over the sutural slope where they are faintly festooned by the obsolete revolving lines, and again toward the umbilicus. At the aperture of adult shells they are closely crowded.

Dimensions. A typical example of the species measures as follows: hight (apex to lower margin of aperture) 28 mm; basal diameter 31 mm, i. e. a ratio in these dimensions of nearly 1:1. Another example has a hight of 20 mm, basal diameter of 35, a ratio of 4:7, indicating a very depressed spire.

Observations. This beautiful species is the most common of all the gastropods of the Rochester fauna, and also occurs in the upper horizon at Shelby, but has not been found in the lower bed. All the specimens before us indicate remarkable uniformity except in the degree of elevation of the spire. The species is probably related to the shell Whiteaves has identified with Euomphalus (1884),[1] Polytropis (1895) macrolineatus Whitfield, from the Guelph at Elora and Durham, Ont., but differs therefrom in proportions of the whorls, depth of suture and apparently in the character of the ridges of the surface. While we are unable to find closer agreement in the Canadian and New York species, we are disposed

[1] *Op. cit.* v. 3, pt 1, pl. 3, fig. 6.

to believe that the former could hardly with safety be referred to the large, very coarsely ridged shell which Whitfield described[1] as Euomphalus macrolineatus from the dolomites at Manitowoc Wis. In size and surface characters P. scamnata approaches very closely Lindström's Horiostoma lineatum,[2] having the same sculpture throughout, but the latter has its spire greatly depressed and the body whorl attached at the aperture.

Poleumita (?) sulcata Hall (sp.)

Plate 10, fig. 1-4

Cyclonema sulcata Hall, Paleontology of New York. 1852. 2:347, pl. 84, fig. 1a-d

Trochonema (Pleurotomaria) pauper Hall, New York State Cab. Nat. Hist. 20th An. Rep't. 1867. p. 343, pl. 15, fig. 5, 6, 9

Cyclonema sulcatum Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 1, p. 18, pl. 3, fig. 5

Polytropis sulcatus Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 89, pl. 13, fig. 9, 9a

The original of this species was a shell from the "Onondaga Salt group, Newark, Wayne co., N. Y." With it were described other specimens obtained by Professor Hall on his visit to the Canadian Guelph localities in 1848. The early illustrations, which are not altogether satisfactory for the requirements of identification among so many similar shells, have been supplemented by the figures given by Whiteaves as above cited. The species appears to be among the rarer gastropods of the Guelph formation, but in the Rochester material we find several examples of it, some of them preserving the detail excellently, and we also have the same species from the dolomites of the upper Guelph at Shelby. Whiteaves has redescribed the species in full, and we find no pronounced disagreement therewith among our shells. Characteristic of it are (1) the notable elevation of the spire, which is considerably greater than the basal diameter

[1] Geol. Wisconsin, 4 : 294, pl. 18, fig. 5, 6.

[2] Silurian Gastropoda, p. 173, pl. 20, fig. 42–44.

and gives the shell the aspect of a true Cyclonema, (2) the deep suture, with broadly excavated outer slope, (3) the differentials of the surface sculpture, which over the body or outer convexity of the whorl consists of fine, subequal, elevated, revolving lines, increasing by intercalation. Near the suture two of these are stronger and wide apart, and on the umbilical surface four are specially emphasized, being larger and more distant than any of the rest. In all, the mature shell carries 20 to 25 revolving lines, which are crossed by fine, crowded and rather indistinct concentric growth lines, most palpable on the final whorl. The final whorl is apparently slightly detached at the aperture as in P. scamnata, but the aperture itself is not well retained in any of our specimens.

There is certainly very little difference in the characters of this species as we now apprehend it and the shell figured by Hall as Trochonema (Pleurotomaria) pauper from the Racine limestone at Racine. There is a striking discrepancy between the description of that species and its illustration which may be due wholly to the fact that the drawing was made from material not accessible when the description was printed. S. A. Miller,[1] for reasons not evident, has ranked this species as a synonym for Pleurotomaria halei Hall, but this is unquestionably erroneous.

Notwithstanding the resemblance of this shell to Cyclonema, we find that it is kept from that association by the presence of a deep though narrow umbilicus, and perhaps also by the coexistence of opercula which Whiteaves has discovered but which have not yet been recorded as occurring in Cyclonema. The apparent detachment of the final whorl at the aperture and the loose coiling evinced by the very deep suture in all these shells constitute another difference from Cyclonema in which the whorls distinctly embrace each other.

[1] Cat. Paleozoic Fossils, p. 422.

Poleumita crenulata Whiteaves (sp.)

Plate 9, fig. 9, 11, 16–24

Straparollus crenulatus Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 2, p. 21, pl. 3, fig. 8a, b

Polytropis crenulatus Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 91

Dr Whiteaves states that he had but two specimens of this species in the collections from the Guelph at Durham, and from these he drew his description. In the Arey collection are upwards of 30 specimens, which show that the species is specially characteristic of this eastern development of the Guelph. About half as many have been collected in the lower bed at Shelby but none at all obtained from the upper Guelph horizon, where P. scamnata was found in considerable number. This abundant material does not qualify the very clear and full description of the species given by Whiteaves, which we here reproduce. Our larger series, however, shows that wider variations exist in the elevation of the spire and surface sculpture, as the few specimens from Durham would indicate.

Shell turbinate, compressed vertically, hight one third less than the maximum breadth; whorls three to four [5]; spire short, about one third the entire hight, somewhat conical, its volutions being obliquely rounded; suture excavated; body whorl compressed vertically both above and below, ventricose and inflated in the middle; umbilicus about one third the diameter of the base, very deep and exposing all the inner whorls up to the apex; mouth nearly circular but narrower above and very slightly emarginated or indented by the penultimate whorl; outer lip apparently thin and simple, convex above and obliquely convex below. Surface marked by a few narrow and not very prominent spiral ridges which are crossed obliquely by numerous flexuous crenulated raised ridges or lamellae. On the outer half of the body whorl there are about seven or eight of these spiral ridges, four above and either three or four below the middle. The upper ones, one of which is placed very close to the periphery, are distant and rather clearly defined, but the lower ones are close together and extremely indistinct. These latter two are exclusively confined to the outer portion of the base, and disappear altogether before reaching the umbilical margin. The crenulated raised lines, however, which cross the whorls obliquely, are as strongly marked in and around the umbilicus as they are on the central and upper portions of the body whorl, and they are much more numerous as well as more closely disposed than the spiral ridges.

While a few examples show the same ratio of spire to body whorl (2:3) as that given by Whiteaves, many of the specimens from Rochester have a decidedly more elevated spire, which sometimes nearly equals in hight the diameter of the body whorl. The surface sculpture oscillates between the entire development of the revolving ridges and the suppression of the transverse ridges, and the reverse, but mostly consists of quite regular, coarse, sinuous and squamose transverse ridges.

Dimensions. An average well preserved shell has a hight of 30 mm and a basal diameter of 39 mm.

Observations. There is no likelihood of confounding this with any other described form. The general type of surface is of the same plan as that of P. scamnata, but the sparseness of the revolving ridges and the greater prominence of the concentric markings are pronounced. The species is clearly of the same generic character as P. scamnata, but here we fail to observe on any specimen evidence of the detachment of the body whorl at the aperture.

COELIDIUM nom. nov.

Coelidium macrospira Hall (sp.)

Plate 7, fig. 2-8; Plate 10, fig. 13

Murchisonia macrospira Hall, Paleontology of New York. 1852. 2:346, pl. 83, fig. 5

Murchisonia loganii Hall, Paleontology of New York. 1852. 2:346, pl. 84, fig. 4a, 4b

Murchisonia macrospira Billings in Logan's, Geology of Canada. 1863. p. 339, fig. 334

Murchisonia macrospira Nicholson, Paleontology Prov. of Ontario. 1875. p. 70, pl. 3, fig. 9

Murchisonia macrospira Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 1, p. 27, pl. 4, fig. 7, 7a

Murchisonia logani Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 80

Murchisonia macrospira Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 81

In describing the fossils which he had collected from Galt and vicinity, Professor Hall applied the name Murchisonia loganii to a turritiform specimen of the internal cast, showing in part the rounded whorls, 11 or 12 in number, and partly exposing the inner surface of the whorls. At the same time he applied the name M. macrospira to an external mold of moderately large size and of similar angle to M. loganii but presenting whorls simply and rather sharply angulated by the peripheral slit band. It has been questioned by Whiteaves whether any distinction between such bodies can or should be made. On consideration of the material representing these shells in the Rochester and Shelby collections, in most cases clear cut internal casts present rounded whorls save in the mature growth of the shell, such casts of the later volutions preserving the angularity at the periphery. At times however this obscurity of angulation on the cast is manifested on all whorls. It therefore seems probable that but a single species is represented by these two names, and of these it is M. macrospira which should be employed, as this is the name given to the external mold on which the species characters are best expressed. The species is represented by a number of specimens from Rochester, a large example from the upper Shelby dolomite and several small specimens from the lower horizon.

The illustrations here given show the angularity of the lower whorls, on which the slit band stands out prominently at the periphery, being narrowly convex, with elevated, thin margin not rising to the hight of the surface of the band. Of the whorls, which may be 10 in number, the last four show this angularity with increasing distinctness, but the earlier whorls even when well preserved present only a rounded surface. The slit band lies almost centrally on the whorl, but the overlap by later growth makes it appear below the middle except on the final whorl. The slope on the upper part of the whorl to the slit band is more direct and less convex than below. The concentric surface lines slope directly backward about the periphery but show a curvature on the umbilical surface. The apical angle is from 20° to 25°. The direction of the suture is quite transverse; form of aperture not observed. Umbilicus narrow but open to the apex of the shell.

The term Coelocaulus was introduced by Oehlert in 1888 for Devonic species of these Murchisonias; and Murchisonia logani has, on the basis of Hall's original figure, been referred to that genus by Ulrich.[1] The name was however preoccupied by Hall for a genus of Bryozoa; but recognizing the usefulness of the distinction intended, we have suggested the term here employed, Coelidium. Coelidium is pretty clearly distinguished from forms referred to Hormotoma by the more depressed whorls (when round), the less oblique suture and extended aperture and the perforate axis.

Coelidium macrospira, originally described from the Guelph of Ontario, has also been recognized among the fossils of the Guelph beds of Wisconsin.

Coelidium cf. **vitellia** Billings

Plate 7, fig. 9, 10

Murchisonia vitellia Billings, Paleozoic Fossils. 1865. 1: 156, fig. 138

Murchisonia vitellia Nicholson, Paleontology Prov. of Ontario. 1875. p. 3, fig. 6

Murchisonia vitellia Whiteaves. Paleozoic Fossils. 1895. v. 3, pt 2, p. 80

In the material from Rochester is a single incrusted shell of a rather large species of this genus with relatively short and stout spire presenting an apical angle of 45° to 50°. Through the incrustation of the surface the whorls show a low carination, and the vertical section which reveals the open axis of the shell also indicates the angularity of the whorls at the position of the slit band. This specimen bears six volutions. It is a shorter and stouter shell than C. macrospira, and, of the various species of Murchisonia with Coelidium characters which have been described from the Guelph fauna, this approaches most closely to Billings's species M vitellia from Galt, both in the angle of the spire and the number and form of the whorls.

[1] Geol. Sur. Minnesota. Paleontology. 1897. v. 3, pt 2, p. 1019.

EOTOMARIA Ulrich. 1897

Eotomaria durhamensis Whiteaves (sp.)

Plate 10, fig. 17

Pleurotomaria durhamensis Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 1, p. 24, pl. 4, fig. 2

Pleurotomaria durhamensis Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 77

Two internal casts in a not very favorable state of preservation, the larger composed of a spire of five whorls, have been found in the dolomites of this horizon at Rochester and are referred to this species on account of the slow increase of the whorls, the acuminate character of the apex, the obliquely flattened upper side of the whorls and the indication of the former presence of a deep umbilicus. The description of P. durhamensis was based on a single specimen, and that of P. galtensis, which is allied to it but differs in its more depressed spire, on not many more; Whiteaves has suggested that the former may prove to be only a variety of the latter. The difference is however a persistent one.

This and the P. galtensis are here referred to the genus Eotomaria, one of the divisions erected by Ulrich for forms heretofore comprised under Pleurotomaria, a genus which, it is asserted by that author, when restricted to forms agreeing closely with the original type is not found in the Paleozoic.

Eotomaria areyi sp. nov.

Plate 8, fig. 2

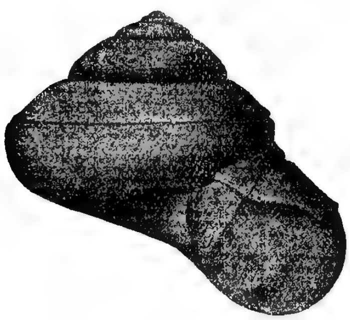
This is a large and robust shell bearing somewhat the expression of P. galtensis Billings,[1] but its proportions are larger, stouter and distinct in certain other details.

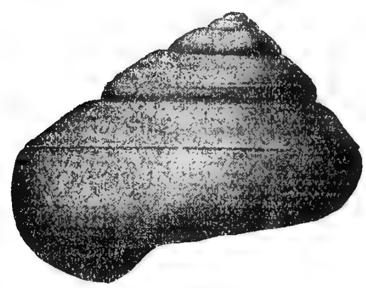
Shell depressed conic, broader than high, the thick spire being but slightly elevated; apical angle between 85° and 90°; whorls five, increasing slowly in size; suture not deeply impressed, as the upper surface of the whorls slopes gradually to the preceding ones; but on the casts there is a

[1] Geol. Sur. Canada. Paleozoic Fossils. 1862. 1:154, fig. 136. *See* Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 75, pl. 11, fig. 7.

deep furrow along the suture line. The upper slope of the early whorls is moderately convex, but assumes a gently sigmoidal contour on the body whorl, the upper part being gently convex, the lower concave, markedly so directly above the slit band. This band forms a rather narrow groove with projecting sides a little above the middle of the whorl; on the casts it appears as a quite prominent ridge, and passing on the spire a little above the suture line. Periphery of whorls slightly convex, nearly vertical, umbilical surface strongly convex; umbilicus small, only about one sixth of the diameter of the base of the shell; surface marked by fine crowded growth lines, which curve strongly backward at the slit band but on the under side converge directly toward the umbilicus; aperture not observed.

There is no satisfactory evidence of revolving ridges on the surface.





Dimensions. The best preserved example has a hight of 38 mm, basal width of 47 mm. Another, an incrusted specimen, has a hight of 43 mm, a basal width of 47 mm.

Our Rochester material has afforded but two examples of the shell, which we find to differ from the still imperfectly known P. galtensis, not alone in size, but also (1) in the thick and depressed spire, (2) in the profile of the whorls, which are less acute than in P. galtensis and have a different curvature of surface, (3) in the distinct umbilication of the shell, Whiteaves having stated that P. galtensis is imperforate. A still more depressed and broader shell of apparently this group of species is P. (Eotomaria) halei Hall[1] from Racine Wis. and Bridgeport Ill., and

[1] *See* N. Y. State Cab. Nat. Hist. 20th An. Rep't, p. 364.

in the opposite line of variation to an acuminate spire is P. (Eotomaria) laphami Whitfield[1] from the Niagaran at Ashford Wis.

Eotomaria kayseri sp. nov.

Plate 7, fig. 1; plate 8, fig. 1

The presence of still another species of the genus in the Guelph of Rochester is indicated by two internal casts, one of them pretty well preserved. These are of relatively large size, with stout whorls, apical angles about 75°, spire elevated, three whorls preserved. The suture is deeply impressed, the whorls overlapping not quite to the periphery. Surface of the whorls full, expanded, prominent on the slit band, which is narrow and elevated and bounded above by a similar ridge in close juxtaposition. On the outer whorl the surface slopes rather directly from suture to periphery or may be slightly concave between the peripheral ridge mentioned and another low ridge just outside of the suture. The lower or basal surface is evenly and moderately convex, not ventricose. The exposed parts of the earlier whorls are quite regularly convex, though showing evidence of the revolving ridges. The shell appears from the cast to have been distinctly umbilicate, though the umbilicus is quite narrow.

The hight of the best preserved shell (allowing for the apical whorls) is 53 mm; width across the base 48 mm.

Eotomaria galtensis Billings (sp.)

Plate 10, fig. 10-12

Pleurotomaria galtensis Billings, Paleozoic Fossils. 1862. 1:154, fig. 136

Pleurotomaria galtensis Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 75, pl. 11, fig. 7

Specimens referable to this species, were collected in the upper and lower Guelph of Oak Orchard creek.

Both show the characteristics of the internal and external casts on which Billings based the description of his species, viz depressed conic profile corresponding to an apical angle of about 100°, nearly flat upper side of

[1] Geol. Wisconsin. 1879. 3:296.

the volution, angular margins and the rather depressed lower side. The impression of the exterior verifies the observation of Whiteaves as to the external characters of this species and exhibits a nearly flat or only very gently convex upper slope, a vertical carination near the base of the upper whorls and a slit band, appearing as a spiral ridge which is concave on the apical and convex on the umbilical side. A difference from the exterior view given by Whiteaves exists in the position of the slit band, which lies below the mid-hight of the last volution. In the original drawing by Billings it lies at mid-hight, so that there is evidently slight variation of this feature. The surface is described by Whiteaves as having been apparently smooth; the specimen in hand shows only faint recurving growth lines on the shell fragments of the upper side of the whorls.

LOPHOSPIRA Whitfield. 1886

Lophospira bispiralis Hall (sp.)

Plate 10, fig. 6-9

Pleurotomaria bispiralis Hall, Paleontology of New York. 1852. 2:348, pl. 84, fig. 2a, 2b

Pleurotomaria bispiralis Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 74

This species was described from a single specimen obtained by Professor Hall at Galt; and Whiteaves reports that it is not otherwise known except in the reidentification of the species by Billings. The recorded examples are known to be poorly preserved, but the original, which was an external mold, shows quite distinctly features presented by three very good examples from the Rochester localities. The original description of the species is as follows: "Volutions about four or five, rapidly increasing from the apex, subangular, and marked above and on one side by thin, sharp carinae or spiral elevated lines." It is evident, on comparison with the better material in hand, that the spiral elevated lines here referred to represent the narrow slit band, which is very prominent on the periphery. The early whorls bear a sharp keel halfway between the suture and periphery, but on the final whorl this becomes quite obsolete. Present material allows a more precise definition of the characters of the species than could be given by its author.

Diagnosis. Shell of medium size, turbinate conic, a little higher than broad; spire elevated, hight greater than the basal diameter of the body whorl; apical angle 60°, base imperforate (?); suture deeply impressed, increasing outward in obliquity; earlier whorls overlapped by the later for one half the interval between the slit band and the base; volutions about five, subangular, slit band narrow with elevated margins, at or just above the middle of the whorl. The body whorl has a gently convex, almost direct slope from the suture to the slit band, but is convex and subventricose below the periphery. On the earlier whorls the depression of the upper surface is more pronounced, and the concavity is divided by a sharply developed keel or single ridge. A narrow, rather obscure and nearly vertical band runs along the suture. Surface marked by fine, irregularly concentric lines which cross the carina without interruption but are directed backward and are caught up at the slit band. On casts the carina and the slit band are indicated by rather low, rounded ridges.

Aperture unknown.

Observations. The angularity and prominence of the whorls in this species show its close approach to forms of Murchisonia having the expression of M. hespelerensis Whiteaves, and in this respect it is in harmony with Pleurotomaria durhamensis, these two species differing chiefly in the degree of elevation of the spire.

Besides the larger specimens from Rochester six smaller ones were obtained from the lower Shelby layer, and these distinctly exhibit the keel of the upper side of the whorl and the spiral elevated lines of the slit band. The upper Shelby dolomite has furnished no examples of the species.

HORMOTOMA Salter. 1859

Hormotoma whiteavesi sp. nov.

Plate 8, fig. 5-9

Shell long, slender, terete and acuminate, its entire length being nearly four times the diameter of the body whorl. Apical angle 18°–20°.

Volutions 9–10. These are but slightly overlapped, their exposed surfaces thus being quite regularly convex; the upper slope is slightly flattened or depressed to the obscure slit band. The sutural slopes are deep, the suture itself narrowly impressed, the edge of the lower whorl being slightly depressed against the whorl above. Umbilicus covered. Aperture oblique or subfusiform in outline. Inner lip somewhat thickened, outer lip with a deep linguiform emargination at its upper third. This is the edge of the slit band, which is a gently depressed sulcus without sharp margins, at which the surface lines are bent deeply backward. This band is evident on all whorls even on internal casts as an obscure flattening modifying the contour of the shell. The surface bears a multitude of fine and crowded, somewhat irregularly concentric lines, which are profoundly reflexed at the slit band but seem to be continuous over that area. On the lower slope of the body whorl is evidence of a second revolving band, which does not, however, effect any change in the direction of the concentric growth lines. This is a feature which is well defined only in a single specimen other examples, whether exteriors or internal casts, not showing it.

Dimensions. The most complete example before us has a length of 85 mm, a width at the base of 28 mm. A large specimen, incomplete at the apex, had a probable length of 100 mm and a basal diameter of 30 mm.

Observations. This graceful and striking species is one of the most abundant organisms in the Guelph horizon at Rochester. The Arey collection contains 25 or 30 specimens which are either internal casts in white chert or retain the shell more or less completely in pulverulent white silica with dolomitic interiors. The species has also been obtained in the upper Shelby horizon.

Shells of similar character to this have been already described from the Guelph fauna. Dr. Whiteaves has given figure and description[1] of an internal cast having similar outline and contour to H. whiteavesi though of smaller size, and this he has identified with the Loxonema magnum

[1] Paleozoic Fossils. 1884. v. 3, pt 1, p. 17; 1895. pt 2, p. 87.

Whitfield from the Guelph dolomites of Carlton township, Wisconsin.[1] This so called Loxonema, however, is a species of large proportions (Whitfield states that the probable length estimated from the two whorls which constitute the original specimen was fully 8 inches), rather square shouldered whorls and so far as known, smooth surface. The fine preservation of the Rochester specimens does not justify the reference of them to either Loxonema or to this species provided it prove a Loxonema. We have little doubt that the Guelph shell figured by Whiteaves (specimens are from Galt, Hespeler and Elora) as Lox. magnum is specifically identical with, if smaller, than the New York specimens of Horm. whiteavesi, and we propose therefore the change of name here adopted, taking however as the type specimens of the species those we have here figured.

The generic term Hormotoma which was introduced by Salter for Murchisonias of terete form and rounded whorls has been quite generally placed by authors back among the synonyms of Murchisonia. Lindström so treats it and at the same time employs the term Loxonema for shells in which among the longitudinal sinuous lines are extremely fine and crowded.

MACROCHILINA Bayle. 1880

Macrochilina sp. indet.

Plate 10, fig. 18

This is a very diminutive shell from the Rochester Guelph, with subequally rounded oblique whorls, three in number, the last rapidly increasing in hight, but all relatively narrow. In these respects it is unlike the various species described (mostly by Billings) as Holopea from various Canadian localities of the Guelph. The surface so far as preserved appears to be smooth and without slit band.

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[1] Geol. Wisconsin, 4:317, pl. 24, fig. 1.

TROCHONEMA Salter. 1859

Trochonema cf. fatuum Hall

Plate 10, fig. 5

Trochonema (Eunema) fatua Hall. N. Y. State Cab. Nat. Hist. 20th An. Rept. 1867. p. 345, pl. 15, fig. 7, 8

The upper Shelby dolomite has afforded a single imperfect example, comprising parts of the ultimate and penultimate whorls which bear the expression of the species cited above, showing a very broad peripheral band with raised margins and somewhat depressed surface, a direct slope above this band which is about as wide as the band itself, and a gently convex surface beneath. Faint concentric lines may be seen on the surface of this cast.

The original of this species is described from the Racine dolomites at Racine Wis. It is also cited[1] as occurring in the Guelph at Cedarburg Wis., but it is not recorded in the Canadian Guelph.

EUOMPHALUS Sowerby. 1812

Euomphalus fairchildi sp. nov.

Plate 8, fig. 3, 4

Shell of medium size, discoidal, with the apex of the spire depressed below the summit of the body whorl and lying almost in a horizontal plane. Volutions four to five; all in contact, but no impressed zone is formed, and at or near the aperture the body whorl seems to become almost detached. On the cast these volutions are free. Whorls oval in section, one third higher than wide; outer slope depressed convex and broad, upper side obscurely subangular, lower more broadly rounded; aperture apparently oval, not thickened, with a broad emargination on the upper side; umbilicus wide, exposing all the whorls.

Surface covered with sharp and fine, rugose concentric lines, which curve forward over the broad peripheral surface of the whorls and make a

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[1] Geol. Wisconsin, 2: 380.

rather sharp and deep retral curve at the summit of the whorl, indicating the position of the apertural notch.

Dimensions. Two specimens, both of which were collected at Rochester, have a greatest width of 38 mm, and the body whorl near the aperture has a hight of 18 mm.

Observations. No species of similar habit and expression has been described from the Guelph fauna. Billings's two species, Straparollus hippolyta and S. daphne, from the dolomites at Galt are small shells with elevated spires; S. mopsus Hall[1] from the Racine limestone at Racine is smaller and has cylindric volutions; its surface markings are not known; S. niagarensis Hall & Whitfield[2] has revolving ridges on the whorls. The resemblance of the species is however extremely close to certain expressions of E. gotlandicus Lindström.[3] Lindström has maintained that individuals of a given species of Euomphalus may have their whorls contiguous throughout or be evolute in varying degree. Hence to this species, E. gotlandicus, he has referred a series presenting all phases in the unwinding of the whorl, thus embracing within the same species the conditions typical of both Euomphalus and Eccyliomphalus. With the involute expression of this species the agreement of E. fairchildi is so close as fully to justify identification were the evolute condition of the species eliminated, for this is not expressed in any of the specimens before us. We are however disposed to follow Lindström's valuation of the genus Euomphalus and have hence employed the designation in preference to Mr Ulrich's equivalent construction of the later term Eccyliomphalus and the common and freer employment of Straparollus, in which the whorls are impressed and the evolute condition less complete.

Named for H. L. Fairchild, professor of geology, University of Rochester.

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[1] N. Y. State Cab. Nat. Hist. 20th An. Rep't, p. 342, pl. 15, fig. 21, 22.

[2] Pal. Ohio. 1875. 2: 144.

[3] The Silurian Gastropoda and Pteropoda of Gotland, p. 139, pl. 13, fig. 19–31, specially fig. 20–22

CEPHALOPODA

ORTHOCERAS Breyn 1732

Orthoceras trusitum sp. nov.

Plate 10, fig. 25, 26; plate 13, fig. 1–10

Shell straight, thick, regular, slender, tapering at an angle of 10°; of moderate size, diameter of largest fragment 38 mm, transverse section circular or subelliptic. Septa closely arranged, regularly and moderately concave, their depth approximately equaling that of the camerae; about 6 mm distant at the largest diameter, 3 mm distant when the shell has a diameter of 25 mm, 2.2 mm when the latter is 15 mm and about 1 mm at the apical end. The sutures are not straight, have a broad saddle on the ventral side but on the opposite side are nearly transverse. Siphuncle very small (3 mm where the diameter of the chamber is 26 mm), tubular and ventrocentren. The living chamber shows the same degree of tapering as the septate portion of the shell. The aperture has not been observed. The surface is usually entirely smooth, but when well preserved shows a very faint and fine longitudinal striation. In the largest specimen observed these lines are 1.5 mm apart and consist of broad flat ridges with narrow furrows between.

One of these specimens was labeled by Mr Arey, Orthoceras selwyni Billings. This is probably the specimen so listed in the provisional enumeration of fossils given by the discoverer. While it is true that the specimens under consideration have the same apical angle and depth of camerae as Billings's measurements of that species indicate, the siphuncle of O. selwyni is moniliform, with discoid inflations between the septa, and lies at a short distance from the ventral margin. According to Whiteaves the original specimen of this species is a very imperfect cast and the species therefore incompletely characterized.

There is some justification for comparing these specimens to O. scammoni McChesney. The somewhat complicated synonymy of this form given by Whiteaves shows that it has passed under various names, as

O. columnare and O. angulatum Hall, and has even been described under four different names by McChesney himself. A comparison with the descriptions and figures given by these authors indicates that that shell has the same rate of tapering as O. trusitum and the same small cylindric ventrocentren siphuncle. The septa show about the same convexity but in all the figured specimens are farther apart than in O. trusitum.

The surface sculpture of O. angulatum and O. scammoni is described as consisting of angular, equidistant, longitudinal ribs about one line distant when the shell is an inch in diameter. Such ribs are not observable in any of the New York specimens.

In the collection from Rochester is a single short fragment which has a much slower rate of tapering (6°), the siphuncle is relatively large and only 1 mm distant from the ventral margin at a diameter of 8 mm, and the septa are very closely arranged, 1.5 mm apart at the same diameter. It is possible that this specimen represents the apical part of O. selwyni, though there is too little known of this specimen on the one hand and that species on the other, to assert the identity positively.

Orthoceras trusitum is represented by a large number of fragments (upward of 30) from the Rochester Guelph and is of relatively frequent occurrence in the lower Shelby dolomite. In the upper Shelby bed it is rarer.

Orthoceras rectum Worthen

Plate 12, fig. 9

Orthoceras rectum Worthen, Geology of Illinois. 1875. 6: 504, pl. 26, fig. 3

Orthoceras crebescens Hall & Whitfield, Geology of Ohio. 1875. 2: 148, pl. 9, fig. 2

Worthen's original description of this species is the following:

Shell of medium size, very gradually tapering, septa moderately concave, two of the intervals being a little less in width than the diameter of the shell. Length of specimen with 12 septa preserved, 8.87 inches, length of outer chamber about 3 inches. Surface markings and siphuncle unknown.

This shell seems to be nearly related to O. crebescens of Hall, but differs from that species in its much less tapering form, and in the proportional width of the septa.

Worthen gives "the Niagara limestone" of Joliet Ill. as horizon and locality of his species.

Before us is a fragment retaining 10 camerae from the lower Shelby bed, which differs from the associated O. crebescens in the same respect as indicated above for O. rectum. It expands so slowly that its apical angle is only about 5°, and the camerae are so deep that the diameter is but a little larger than the combined depth of three camerae. While the latter are therefore still somewhat shallower than those of the type specimen of O. rectum, the difference is so small that it is well within the limits of individual variation. The section of the Shelby species is subcircular, and the siphuncle is centren.

In the same year in which Worthen differentiated O. rectum from O. crebescens, Hall and Whitfield described and figured a specimen from the "limestones of the Niagara group" at Cedarville O., which they referred to O. crebescens, but which, in the differential characters cited above, tallies quite closely with the lower Shelby specimen. Hall and Whitfield also noted the difference in the depth of the chambers between the Ohio and the original Wisconsin specimens of O. crebescens, but did not consider it sufficient for separation. The additional difference in the rate of expansion brought out by the figure of the Ohio specimen and its description, in which it is said to taper "gradually and moderately," while the types of O. crebescens are stated to taper "rapidly," seems to have been overlooked in the comparison of the forms. The constancy of the combined appearance of these differences in the Illinois, Ohio and New York specimens and the very distinct habit resulting from them, fully warrant their recognition as of specific importance.

Orthoceras crebescens Hall

Plate 10, fig. 24, 27, 28; plate 11, fig. 2–5

Orthoceras crebescens Hall. N. Y. State Cab. Nat. Hist. 20th An. Rep't. 1867. p. 354, pl. 19, fig. 1–3

Orthoceras crebescens Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 1, p. 37

Orthoceras crebescens Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 98

Not Orthoceras crebescens Hall & Whitfield. Geol. Sur. Ohio. Paleontology. 1875. v. 2, pt 2, p. 148, pl. 9, fig. 2

Among the orthocerata of the lower Shelby dolomite is a small group of specimens which contrast with the others by their large dimensions, and specially the greater depth of the chambers. These must be the relics of the giants in the cephalopod fauna that populated the lower Guelph coral reef. They are all casts of the interior.

Diagnosis. Conch straight, thin, of large size, the living chamber of one specimen attaining a diameter of about 70 mm, gradually expanding (angle 9°), cross section circular or subcircular; surface smooth, faintly striated longitudinally; sutures transverse with a distinct (ventral?) lobe, camerae very deep, the sutures lying 9 mm apart in one specimen where the conch has a diameter of 40 mm, and in another where the diameter is 50 mm; septa evenly concave and very deep, the depth being about equal to the depth of the camerae; siphuncle centren or nearly so, large, nummuloidal in the mature stage, where it passes the septum, about one sixth the diameter of the conch; living chamber possessing the same rate of expansion as the septate portion, repeatedly slightly constricted; aperture apparently nearly straight. One cast retains faint longitudinal ridges, with flat interspaces.

Horizon. Lower Shelby dolomite. No specimens have been obtained in either the upper bed at Shelby or Rochester.

Our material agrees in all essential features with the type specimen described by Hall from the Racine limestone, Wisconsin. In vol. 2, *Geology of Wisconsin*, the species is listed as occurring in the Waukesha, Racine and Guelph beds; in the Racine beds at the greatest number of localities, so that we may conclude that it reached its acme there and survived only sparsely in the Guelph, where it has been found occasionally at Hespeler and Elora, though in greater number in the lower Shelby dolomite.

The series of orthoceracones from the lower Shelby bed contains a fragment, consisting of seven chambers, which appears to be a portion of the apical part of the conch of O. crebescens, which has hitherto not been observed. It agrees with that species and differs from the other associate orthoceratites by its slender form, very deep camerae, their depth being nearly half the width of the conch, and the very large siphuncle, which occupies nearly half the interior space of the conch. This siphuncle, however, is but very slightly expanded, and the cast of the siphuncular cavity is completely cylindric. As the siphuncle of other species is known to become nummuloidal only in late growth stages, the difference between the siphuncles of this small conch and those of the large conchs of O. crebescens is not thought to militate against a reference of the same to that species.

DAWSONOCERAS Hyatt. 1883

Dawsonoceras annulatum Sowerby, var. **americanum** Foord

Plate 10, fig. 19–21; plate 11, fig. 1

Orthoceras annulatum Sowerby var. americanum Foord, Cat. Fossil Cephal. British Museum. 1888. p. 56, 57

The wide variation in the expression of the ornament among specimens which have been referred to O. annulatum Sowerby and have likewise been described under a variety of other names, now renders exceedingly difficult the accurate determination of specimens of this type, specially when the species are represented by only fragmentary parts. It is evident from the study of the long list of annulated orthoceracones of the late Siluric, and has been specifically pointed out[1] by one of the writers in the case of certain lower Siluric shells of similar type, that the ontogenic progress of the ornament in the annulate and longitudinally striate shells is quite uniform, and it may be summarized thus: The annuli are a quite

[1] Minnesota Paleontology, v. 3, pt 2, p. 787.

primitive feature appearing in the early growth stages (cf. Kionoc. darwini) with their greatest relative strength. With continued shell growth they become broader, less distinct and in progressed shells entirely obsolete even before adult growth is attained. The longitudinal lines, however, which develop before the early annuli, remain with the obsolescence of the latter, for a time the principal feature of the exterior. Contemporaneous with both of these surface features there develops a concentric lineation, which also may become more conspicuous with the suppression of the annuli, in some species becoming a prominent cancelating feature, even entirely replacing the longitudinal ribs. Among species which have been described from the American Upper Siluric the following express various conditions of this combination of surface characters: O. undulatum Hall, O. annulatum Sowerby var. americanum Foord, O. medullare Hall, O. nodocostatum McChesney, O. cadmus Billings, O. virgatum Sowerby, O. laphami McChesney. This statement does not impugn the differential specific values of certain of these forms, but, as all of them have been described from incomplete cones, it is clearly impossible with present knowledge to decide on the specific values involved. Generic characters among these late Siluric species are consequently highly obscured and uncertain, and the genera of this group proposed by the late Professor Hyatt pass into each other, as do the specific characters. Hyatt has proposed to term species which retain the annuli throughout growth with concentric undulating lines or frills, Dawsonoceras (D. annulatum Sow. = O. undulatum Hall). Shells having the longitudinal ridges conspicuous and obscure annuli in senile growth are termed Kionoceras; a condition in which the annuli of early growth become later obscured, with corresponding increase in the prominence of the longitudinal lines, are Spyroceras, while a development of spines or nodes at the intersection of annuli and longitudinal ridges constitutes the character of Thoracoceras.

We find among the material from Rochester several small specimens of sharply annulate cones which we refer to Dawsonoc. annulatum var. americanum Foord, employing that author's distinctive designation for American expressions of Sowerby's specimens. These specimens doubtless represent early growth stages; one has 15 sharply developed somewhat sinuous annuli in a length of 23 mm, another 10 in a length of 16 mm, a third 24 in a length of 45 mm. The annuli are separated by rather deeply concave depressions not always of equal width. Fine sharp longitudinal striae, often clearly in two series, cross the surface, and these are cancelated by much finer and obscure concentric lines. Nothing that would indicate the modification of those characters in later growth has been observed. Several large specimens, exceeding an inch in diameter and possessing strong, rounded annulations, were obtained from the lower Shelby bed. None were found in the upper horizon.

Dr Whiteaves has reported the presence of this species in the Guelph at Hespeler and Elora, where it seems to be rare and the surface characters are not specially noted. It is also cited in the *Geology of Wisconsin* among the Racine and Guelph fossils. Professor Hall[1] knew it only from the lower beds at Waukesha and near Wauwatosa, Wisconsin. Its occurrence at Yellow Springs and Cedarville O., is recorded by Hall and Whitfield in *Paleontology of Ohio*, 2: 148. It is therefore evident that this species rises from the lower Niagaran shales, where it is most common, into and through the higher Niagaran beds in New York as well as in the west.

Orthoceras bartonense is a shell from the Barton beds or highest member of the Niagaran series at Hamilton Ont., which has been described by J. W. Spencer[2] as distinct from D. annulatum in having the annular crests marked "by swelling waves (giving a nodular appearance on the margin)." This is the same variation which McChesney described as O. nodocostatum[3] but which Hall seems to have correctly estimated[4] as identical with O. annulatum.

[1] N. Y. State Cab. Nat. Hist. 20th An. Rep't, p. 351.

[2] Mus. Univ. Missouri. Bul. 1884. 1:60, pl. 7, fig. 7.

[3] Descr. Paleozoic Fossils. 1860. p. 94.

[4] N. Y. State Cab. Nat. Hist. 20th An. Rep't. expl. pl. 20.

KIONOCERAS Hyatt. 1883

Kionoceras darwini Billings (sp.)

Plate 10, fig. 22; plate 11, fig. 6; plate 12, fig. 1-8

Orthoceras darwini Billings, Paleozoic Fossils. 1862. 1 : 161 (not figured)

Cyrtoceras myrice Hall & Whitfield, Geol. Sur. Ohio. 1875. v. 2, pt 2, Paleontology p. 149, pl. 8, fig. 9

Orthoceras darwini Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 1, p. 38, pl. 6, fig. 2, 2a

Cyrtoceras myrice Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 1, p. 39, pl. 6, fig. 3, 3a

Orthoceras darwini Foord, Cat. Fossil Cephal. British Museum. 1888. pt 1, p. 76, fig. 8

Orthoceras darwini Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 100

Among the Rochester specimens of this species is one which is excellently preserved and shows the surface features probably better than any which have been recorded. There are sharp, angular, longitudinal ridges, between each pair of which normally lies a smaller ridge. These ridges of the first and second order are separated by equal furrows. Concentric lineation does not appear on this specimen but is shown on the later growth of a larger individual. Toward the apical end of the shell are quite well marked transverse annulations. These, as in many other species of this generic type, are completely obscured in later growth. The gentle cyrtoceran flexure of the cone is clearly indicated in the best of the specimens. The sipho is subcentral and the section is nearly circular, with the concave side slightly flattened.

No examples of this pretty and characteristic species have been obtained in the upper Shelby bed, but the lower dolomite has furnished a number of well preserved specimens, two of which are remarkable for their dimensions, which indicate a size considerably larger than hitherto recorded. One of these is preserved as a mold of the exterior and attains a length of 158 mm, with both ends imperfect. This retains the same slight curvature exhibited by the smaller specimens. Another is a cast of the interior of the living chamber and of 10 septa, which shows but very slight curvature and traces of the longitudinal surface ornament. This specimen shows a marked gerontic character in the uniformly closer arrangement of the last septa and therefore furnishes an indication of the mature size reached by this species. Its living chamber has a diameter of 48 mm and a length of 51 mm. The aperture is partly preserved and appears to have been slightly curved. The chambers show the same depth (about 5 mm) as in Billings's type specimen of Orth. darwini, the conchs of both having a like width. The sutures have a broad, low saddle on the concave side. While two of the smaller specimens bear only uniform longitudinal ridges, the larger conch is provided with low annulations throughout its entire length. In the best preserved young specimens from the Rochester Guelph these annulations appear only in the earlier stages, and it thus appears that the large individual preserved this infantile character into the ephebic stage. The three factors of the surface ornamentation follow evidently in the same order as observed by Clarke in annulated and lineated Trenton forms and above referred to, viz longitudinal ribs, annulations, transverse striae, but with this difference, that the annulations here never attain any strong development and soon disappear, while the longitudinal ribs appear to persist throughout life and become in the ephebic stage complicated with the concentric lineation, which, however, does not attain such prominence as in the mature stage of Dawsonoceras annulatum or in the Trenton forms mentioned.

Dr Whiteaves gave the first illustration of the original of K. darwini and points out its identity with Hall & Whitfield's Cyrtoceras myrice described at a later date from the dolomites at Yellow Springs O. Billings's original was from the Guelph at Hespeler, and other specimens originally identified by Dr Whiteaves with Cyrtoc. myrice are from Durham. This species is, hence, to be considered a typical Guelph form. Its connection with the longitudinally ribbed or cancelated, slender orthoceratites, so common in the Racine beds whence it probably descended, is very close, specially with Orthoceras angulatum (Wahlenberg) Hall,[1] which is

[1] N. Y. State Cab. 20th An. Rep't. 1867. p. 353.

described as possessing the same number of longitudinal ribs within the same space, the same cancelation in some parts, but has somewhat deeper camerae, tapers slightly faster and is perfectly straight. This species is said by Hall to be identical with the numerous species of longitudinally ribbed Racine forms erected by McChesney, and also with Hall's O. virgatum (?) and O. cancellatum from the Rochester shale of New York. Whiteaves identifies the latter species with Orthoceras cadmus Billings, which has been described from the Niagaran at Grimsby Ont.

Kionoceras medullare Hall (sp.)

Plate 10, fig. 23

Orthoceras medullare Hall, Geol. Sur. Wisconsin. Report of Progress. 1859.

Orthoceras medullare Hall, N. Y. State Cab. Nat. Hist. 20th An. Rep't. 1867. p. 353, pl. 20, fig. 1, 2

Orthoceras medullare (?) Meek & Worthen, Geol. Sur. Illinois. 1875. 6: 504, pl. 26, fig. 1

Orthoceras medullare Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 1, p. 37

This species is represented in our collections by a single mold of the exterior from the lower Shelby dolomite. The ornamentation of this fragment, which belonged to a conch having a diameter of about 30 mm, consists of sharp, longitudinal striae, alternately stronger and finer; these are crossed by transverse lines, arranged slightly closer than, and equal in prominence to, the finer, longitudinal striae. Seven of these longitudinal lines may be counted in 10 mm. The character of this ornamentation, the relative distance and strength of the striae, is that ascribed to O. medullare, and we, therefore, provisionally identify the Shelby species with that.

Hall described Orth. medullare from "limestone of the Niagara group at Waukesha and Wauwatosa, Wisconsin." In the lists of fossils of Wisconsin, given in *Geology of Wisconsin*, v. 2, Kion. medullare is cited only from the Waukesha and Racine beds, but not from the Guelph. Meek and Worthen doubtfully refer to the species a specimen from the Niagara at Joliet Ill. Whiteaves reports the species in the Guelph at Elora Can.

Cyrtoceras arcticameratum Hall

Plate 15, fig. 1, 2; plate 16, fig. 1–7

Cyrtoceras arcticameratum Hall, Paleontology of New York. 1852. 2:349, pl. 84, fig. 7a-d

Cyrtoceras arcticameratum Billings, in Logan's Geology of Canada. 1863. p. 340

Cyrtoceras arcticameratum Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 103

This species was very briefly characterized by Hall in the following words: "Elongated, slender, gradually tapering and gently incurved; septa numerous; slightly convex; section transversely oval, siphuncle dorsal." The original specimens from Galt were not very good. Billings cites Galt and Hespeler as localities, but Whiteaves states that he has seen no specimens of the species. It has also been recognized in the Guelph at Cedar burg Wis.[1]

In the Rochester material there are several examples, one of excellent quality, which present characters agreeing with Hall's diagnosis and figures, and these are specially marked by their long, slender and gently arcuate cones, in which the outer ventral curve is about 87° and the inner 69°. The section is nearly circular in early growth but later becomes broadly oval.

The living chamber is long, somewhat swollen in the middle, broadly contracting to the aperture, which has straight lateral margins. Septa from 2 to 3 mm apart, slightly concave and nearly transverse, broadly flexed forward ventrally. Siphuncle small and ventral.

Surface smooth, only fine concentric lines being visible. These become squamous toward the aperture and all recurve ventrally at the hyponomic sinus.

Dimensions. The most complete of these examples has a length measured on the outer curve of 95 mm. This covers most of the living chamber, which is 29 mm long. Width of living chamber dorsoventrally 21 mm, of aperture 16 mm, of lower end of specimen 9 mm.

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[1] Geol. Wisconsin, 2:380.

Cyrtoceras orodes Billings

Plate 15, fig. 3-11

Cyrtoceras orodes Billings, Paleozoic Fossils. 1865. 1 : 162 (not figured)

Cyrtoceras orodes Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 103, pl. 14, fig. 7-9

Several specimens of this species presenting a very slightly curved and rapidly tapering shell with nearly circular section, have been obtained from the lower Shelby horizon and at Rochester. The original, which was not figured by Billings, and two specimens of better preservation have been described and figured by Whiteaves.

The New York specimens are of moderate size, tapering rapidly (one increasing from 11 to 19 mm in 39 mm; another from 12 to 28 mm in 60 mm), very gently curved, of nearly circular section, becoming somewhat flattened dorsoventrally in late growth. Billings describes the dorsoventral diameter as being slightly the greater, which is true of earlier growth, while the outline of the section of the type specimens given by Whiteaves is circular. The septa are closely arranged; in the smallest specimens from 1.5 mm apart at the smaller end to 4.5 mm at the larger. The septa are but slightly concave, their depth being no more than 2 mm. The sutures run nearly straight across the shell; they show a very short, blunt lobe over the siphuncle on the ventral surface, and a very faint, broad lobe over the dorsal surface. The siphuncle is situated close to the ventral side and is not expanded between the septa.

The surface appears to have been smooth, the inner shell larger and, as shown in one specimen, bearing some fine, longitudinal furrows.

The species has not been collected in the upper Guelph of Oak Orchard creek, while in the lower bed both young and adult specimens were found, the former exhibiting well the rather rapid expansion of the conch, and the latter retaining part of the living chamber and a number of the youngest camerae. In a large example the living chamber becomes greatly contracted toward the aperture in about the same degree as a specimen referred by Whiteaves[1] with some doubt to this species. This contraction may be here a gerontic character, as it has been claimed by Pompeckj and Hyatt that numerous cephalopods constrict their apertures in gerontic stages.

Cyrtoceras cf. **brevicorne** Hall

Plate 13, fig. 11, 12

See Cyrtoceras brevicorne Hall, N. Y. State Cab. Nat. Hist. 20th An. Rep't. 1867. p. 356, pl. 18, fig. 8, 9

A small, rapidly expanding cyrtoceracone from the Rochester collection, though quite incomplete, seems to agree with Cyrtoceras brevicorne Hall in the rapid expansion of the shell. In a length of 16 mm it expands from 5 to 12 mm in diameter. The section is oval, broadly rounded on the ventral and more acutely on the dorsal side. The inner curvature is slight. Septa shallow, curving strongly downward on the venter. The siphuncle is small and situated close to the ventral margin. The chamber of habitation is not preserved in the specimen. The surface is smooth or covered with fine concentric growth lines, which show a broad and deep posterior curve on the venter.

The original specimens of this species were from the dolomite at Racine Wis. The form has not yet been observed in either the Canadian Guelph or the Niagara beds of New York, but is reported from several outcrops of the Racine beds in Wisconsin.[2]

In the lower Guelph bed at Shelby has been found a short conch, which in its extremely rapid expansion and curvature agrees with Hall's figured specimen of Cyrtoceras brevicorne, but fails to show the difference in convexity of the dorsal and ventral sides. Its section is, on the contrary, perfectly circular.

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[1] *Loc. cit.* pl. 14, fig. 9.

[2] Geol. of Wisconsin, 2 : 376

Cyrtoceras bovinum sp. nov.

Plate 16, fig. 8, 9; plate 18, fig. 5, 6

Large, robust, rapidly tapering, gently and regularly curved cones. In the most complete the arc of outer curvature is 165 mm long and its chord 135 mm, the inner curve 115 mm long, its chord 98 mm. Section transversely oval, more rounded in the apical parts, but very broad and flattened and even slightly depressed medially on the venter.

Septa closely arranged, from 2.5 to 4.5 mm apart; gently concave; suture transverse with a low median backward turn or lobe on the venter. Siphuncle subventran, moderately large, slightly contracted at the septa. Living chamber long, not constricted as far as the specimens indicate.

Surface covered with only fine, concentric growth lines, which combine to form low bands or festoons. All the internal casts of this species bear a highly characteristic roughened surface, caused by the excoriation of the inner shell layers indicating a thick shell. All surface lines make a broad backward curve on the venter but are apparently transverse on the dorsum. The shell is traversed longitudinally by very faint, fine and unequal, somewhat undulating lines and grooves. These, however, are shown only on two fragments which seem to have somewhat less curvature than the others.

This species is represented by six or seven specimens from the Guelph at Rochester, which show that it is by much the largest cephalopod in the fauna at that locality. As a species it seems distinct from any that have been described, in size, cross section and breadth of venter as well as in surface characters.

CYRTORHIZOCERAS Hyatt. 1900

Cyrtorhizoceras curvicameratum sp. nov.

Plate 17, fig. 1–10

Diagnosis. Conch a cyrtoceracone of moderate size, gently arcuate, curvature of apical part not known; expanding slowly, adult living chamber having a length of 35 mm, widening from a basal diameter of 37 mm to an apertural diameter of 45 mm. Camerae very shallow, the sutures being only 3.5 mm apart, where the major diameter of the conch is 43 mm; deeply concave, the deepest place dorsad of the center, bent forward strongly in the ventral and slightly in the dorsal region. Depth of septum of living chamber 8 mm; sutures transverse, with a higher, but narrow, rather sharp ventral, and lower, broader dorsal saddle, straight on the sides; transverse section oval, compressed laterally, the venter narrower than the dorsum, major and minor diameters in one narrow specimen 39 and 30 mm, in another broader, 44 and 36 respectively; siphuncle small, 4.5 mm wide at the perforation of the septum, where the latter has a major diameter of 44 mm, apparently empty, expanding to its double diameter in the camerae, situated propioventran; living chamber short, retaining the curvature and expansion of the septate portion, aperture not constricted, its lateral margins low, convex, the dorsal margin provided with a broad and lower sinus and the ventral margin with a narrower and somewhat deeper hyponomic sinus situated on the arched external side (exogastric shell); surface not known, the internal casts being smooth and the molds of the external surface obscured by coating of crystals. A coarse ornamentation was evidently absent.

Locality. Lower Shelby dolomite.

Observations. From Cyrtoceras cancellatum Hall, the only form of the New York Niagaran showing some superficial similarity, Cyrt. curvicameratum is readily distinguished by being laterally compressed and not dorsoventrally as the latter. In the rich cephalopod fauna which has become known from the western Niagaran, there are Cyrt. fosteri Hall and Cyrt. dardanus Hall, both clearly related to this species. Cyrtoceras fosteri Hall, described[1] from the "Niagara limestone" near Chicago, possesses a similar transverse section, curvature of sutures and like depth of chambers, but differs in having the venter relatively narrower and the ventral saddle of the sutures higher. Cyrtoceras dardanus Hall, occurring in the Racine beds at Waukesha and Wauwatosa Wis., a form with similar curvature and expansion, is

[1] *Report of Progress* of Geological Survey of Wisconsin for 1860, p. 41.

described[1] as having the dorsal and ventral sides equally rounded, and it also possesses deeper camerae.

This species, C. curvicameratum, is considered a typical representative of the genus Cyrtorhizoceras Hyatt[2] on account of its uncontracted living chamber, open aperture and the character of its dorsal and hyponomic sinuses, its laterally compressed form, the well developed ventral and dorsal saddles of the sutures and the small siphuncle. The genus is described as beginning in the Lower Siluric, where the generic type, Cyrtorhizoceras minnesotense Clarke (sp.), a small form of the western Trenton, occurs, and as extending into the Upper Siluric. It appears that this genus, a very primitive group of cyrtoceracones, is still well represented in the Niagaran, for several of the western species of Cyrtoceras evidently pertain to it.

GYROCERAS de Koninck. 1844

Gyroceras farcimen sp. nov.

Plate 18, fig. 1-4

Diagnosis. Conch robust, strongly curved, very slowly expanding, number of volutions unknown; transverse section circular, the dorsal and ventral sides not appreciably different in curvature, no impressed zone observable; camerae moderately deep, septa 8 mm distant, where the diameter of the shell is 28 mm; sutures transverse, nearly straight, a small saddle at the outer side of the arch; siphuncle submarginal, at the outer side its character not known; living chamber very long, extending for one half a volution or more, continuing with the curvature of the septate portion; aperture not known; surface smooth.

Locality. Lower Shelby dolomite.

Observations. There are only three cephalopods with gyroceran volutions known from the Niagaran; G. farcimen may be readily distinguished from G. abruptus Hall, of the Indiana Niagaran, by its very gradual expansion and the position of its siphuncle, from G. americanum

[1] *Report of Progress* of Geological Survey of Wisconsin for 1860. p. 43.

[2] Zittel-Eastman. Textbook of Paleontology. 1900. p. 529.

Billings, by the fact that the latter is annulated and from G. bannisteri Winchell & Marcy,[1] from the western Niagaran, for the same reason.

POTERIOCERAS McCoy. 1844

Poterioceras sauridens sp. nov.

Plate 14, fig. 1–19

The most common and one of the most characteristic cephalopods of the lower bed at Shelby is a small breviconic cyrtoceracone, different in important characters from all other forms reported from the Guelph or so called Niagaran horizons. A single specimen somewhat crushed dorsoventrally was also obtained at Rochester.

Diagnosis. Shell small, fusiform, somewhat abruptly tapering and relatively but little curved; in a specimen with a length of 48 mm the outer arc has a hight of 19 mm; the inner of 4 mm, measured from a chord connecting the extremities. The shell is slightly asymmetric, and seen from the ventral side, the apex is turned a little to the right. It is somewhat compressed dorsoventrally, in its mature parts the dorsoventral diameter being one tenth shorter than the lateral; the dorsum is almost flat or but slightly rounded, while the ventral side is well rounded, its section in most specimens being part of a circle. The ventrolateral slopes are evenly rounded, while the dorsolateral are quite abrupt. In the apertural part the section is entirely circular, the flattening of the dorsal side not appearing till about the neanic stage of the shell. The living chamber is remarkably short; its length rarely attains that of the diameter of the last septum; this chamber is widest at about one third of its length, whence it contracts on the ventral and lateral sides, toward the aperture to such a degree that the dorsoventral diameter of the aperture becomes slightly the smaller. The outline of the aperture is simple, with a shallow hyponomic sinus and a broad, low dorsal saddle. The shell around the aperture is thickened, so that on the very frequent casts of the living chamber, there appears a ringlike depression just within the margin.

[1] According to Hall, N. Y. State Mus. 20th An. Rep't, supplementary note, p. 393, this is a Trochoceras.

Septa transverse, closely arranged, those of the ephebic stage being about 3 mm apart on the ventral, 2 mm on the dorsal side; shallow, with a low saddle on the venter. Siphuncle ventral near the margin (propioventran Hyatt), tubular in the nepionic part, becoming slightly nummuloidal in the following stages. Surface with fine concentric lines which are recurved on the venter, where they are crossed by obscure longitudinal ridges.

The species can not have attained a large size, for, among all the specimens, none has been found to have a diameter of the living chamber above 30 mm, this being the measurement of the largest specimen observed which possesses distinct gerontic characters in the shallow later camerae. Numerous specimens of average size with but two thirds of this measurement, show the same gerontic features, and should therefore be regarded as representing the normal size. An entire specimen whose living chamber has a diameter of 18 mm, measures 54 mm along the ventral side.

Horizon and locality. Rare in the Guelph horizon at Rochester, but very common in the lower Shelby dolomite; one doubtful specimen has been taken from the upper Shelby horizon.

Observations. The large representation of this species has allowed a full elucidation of its characters; and it is also possible to attempt a generic reference more exact than to Cyrtoceras in its broad and common application. The genus Cyrtoceras, as restricted by Hyatt, while including similar exogastric, breviconic cyrtoceracones, with flat dorsum and elevate venter, is defined as having the aperture contracted to a T-shaped opening, and a large, nummuloidal siphuncle. Thus restricted, the generic term is only applicable to Devonic forms, on which it was originally based, but we have not been able to apply the term in this meaning because of lack of evidence. Hence our use of the name in the foregoing is to be regarded in a broad sense as covering species not at present referable with greater exactitude. The genus Oncoceras, which is suggested by the short, abruptly terminated septal part and the contracted aperture, is restricted to laterally compressed forms of the Lower Siluric, with distinctly nummuloidal siphuncle. It is however clear that this genus is a primitive representative of the genus Poterioceras, as defined by Hyatt, primitive in so far as its aperture is not yet laterally contracted and still possesses a wide open, roundly triangular outline; also primitive in its less developed fusiform shape, which, it appears, does not attain its most typical expression till Carbonic time. This genus, in its restricted sense, was placed by Hyatt (*Genera of the Fossil Cephalopoda*),[1] under the term Acleistoceras, but subsequently was regarded by him as a synonym of Poterioceras; Acleistoceras *nobis* includes brevicone fusiform bodies with partially contracted living chamber. The aperture has a large ventral sinus and a dorsal saddle, and is only slightly smaller in diameter than the living chamber, while the outline is usually subtriangular. The siphuncle remains ventral, and the form in section is an oval with the dorsum broader than the venter.

It appears from the frequent coincidence of shallow ultimate camerae indicating gerontic conditions, with marked contraction of the aperture, that the latter feature alone may indicate gerontic condition rather than specific character. This fact would, in some measure, conform to the statement made by Hyatt, that Oncoceras is a phylogerontic group, one of the phylogerontic characters being the transverse contraction of the living chamber during gerontic age. On the other hand, it was pointed out by Clarke that the expansion of the shell during later growth and a sudden contraction at the close of the swelling near the aperture is a character appearing in the early genera Oncoceras, Clinoceras, Poterioceras and Cyrtoceras (in the old sense), and that in the Devonic species of the orthoceran genus Bactrites this expression of the shell characterizes the growth stage directly succeeding the formation of the protoconch. It is in line with the latter observation that, as Foord remarks, the inflation of Poterioceras is much less conspicuous in the adult than in the young. This author probably refers only to late species of Carbonic age. It would seem to us that we have here a gerontic character indicating early decline of a series of cephalopods taking place remarkably soon after the inception of the cephalopod stock. In considering the small size and slight development

[1] Boston Soc. Nat. Hist. Proc. 22: 277.

attained by the species of these genera, they appear to us as a group of dwarfed forms comparable in their entirety to the small specimens with constricted apertures among later (mesozoic) cephalopods considered as dwarfs by Pompeckj.

One specimen, consisting of a badly crushed living chamber which may belong to this species, was found in one of the geodes of the upper Guelph at Shelby, and another was obtained at Rochester. The latter is probably also somewhat crushed, for its section is very traverse, the dorsoventral diameter of the body chamber being one third less than the transverse diameter. This specimen measures 50 mm on the ventral curve and has an apertural transverse diameter of 20 mm and an apical diameter of 8 mm.

It is a noteworthy fact that, with the exception of one or two specimens, all have retained only the living chamber and a few camerae, the apical parts being gone. It is therefore quite probable that this organism was in the habit of discarding from time to time some of its oldest camerae.

There are no forms in the Guelph or Niagara similar enough to invite comparison with this species or to necessitate distinctive characterization, but Cyrtoceras clitus Billings[1] should be cited here as possessing similar size, like curvature and contraction of the aperture, though still differing in the amount of expansion, this being much more rapid in the apical part of Pot. sauridens.

J. W. Spencer has described and figured[2] the cast of a living chamber as Cyrtoceras reversum. This cast resembles so closely that of the same part of P. sauridens that it doubtless belongs to that species. The author has succeeded however in making a very remarkable fossil out of this fragment, viewing it in a wrong direction and then calling it "reversum." He states: "Its form is rapidly tapering with a considerable curvature, until it ends in a rounded point." This rounded point is, however, the aperture, and the tapering is that of the living chamber toward the aperture. From this misconception arose the other, that "the convex

[1] Cat. Silurian Fossils of the Island of Anticosti. 1866. p. 85.

[2] Mus. Univ. Missouri. Bul. 1884. p. 60, pl. 7, fig. 8.

side of the septae is directed toward the body-chamber," a structure which would indeed be quite unique among the Cephalopoda. Cyrtoceras reversum is described as occurring in "the lower beds of the Niagara limestones at lighthouse station on the G. T. R." It may, therefore, occur at a similar horizon as the lower Shelby form.

Poterioceras sp.

Plate 13, fig. 13-16

A single living chamber, found in the lower Shelby dolomite, differs so materially from those of the associated P. sauridens that we are constrained to note it separately. The living chamber is quite evenly rounded and plump, the flattening of the dorsal side but slightly developed. The section of the living chamber and also of the aperture is nearly circular. The ventral and lateral surfaces are regularly and evenly contracted from the middle of the chamber toward the aperture. The siphuncle is marginal (subventral) and highly nummuloidal. The camerae are not preserved, but, judging from the siphuncle, they were shallow and the septa but slightly convex. The cast shows traces of transverse striae, presumably growth lines.

PROTOPHRAGMOCERAS Hyatt. 1900

Protophragmoceras patronus sp. nov.

Plate 19, fig. 1, 2

A very robust, moderately tapering, strongly and regularly curved shell. The arc of the outer curvature is 190 mm long and its chord is 165 mm; the inner curve is about 140 mm long and its chord measures 90 mm. Section in the earlier part of the septate portion broadly elliptic, the major axis being the dorsoventral; the living chamber and mature part of the cone have an oval or roundly triangular section, the outer (ventral) side being very broadly rounded, the inner side narrowly so and the lateral parts nearly flat, sloping to the dorsal ridge.

Camerae very deep, last septa being 21 mm apart on the ventral side and about 8 mm on the dorsal side; sutures transverse with a broad, low saddle extending the full width of the venter. Depth of septum almost half the depth of the camera; siphuncle not retained; living chamber relatively very large, widening at the same rate as the septate portion; aperture not contracted, but open and simple. Surface unornamented, save by closely and regularly disposed, faint growth lines, the course of which indicates the presence of a shallow hyponomic sinus on the convex side of the cone.

Locality. Lower Shelby dolomite, Oak Orchard creek.

Observations. This large species has no equal in size among the curved cephalopods of the Guelph of Canada or the Interior; it compares well in this regard with the large forms to which Barrande applied the terms C. tyrannus and C. rex. Cyrtoceras hercules Winch. & Marcy (= Cyrt. (Phragmoceras) amplicorne Hall) is a large form from the Waukesha and Racine beds of Wisconsin, which possesses a stronger curvature and broader venter. Cyrtoceras bovinum, a smaller, similarly curved species from the Guelph at Rochester, expands more rapidly and has shallower camerae. Phragmoceras nestor Hall, reported as from the Niagaran at Wauwatosa Wis., is readily distinguished from Protoph. patronus by the constriction of its aperture, its shorter living chamber and shallower camerae; from Phragmoceras byronensis Worthen,[1] described from the Niagaran of Port Byron Ill., and which very much resembles the Shelby species in the degree of its curvature and rate of expansion, it differs in the same particulars.

The form of the shell, the degree of curvature and expansion, suggest relationship to Phragmoceras, as was also indicated in Hall's description of C. amplicorne by addition of that generic name in parenthesis. Its open aperture and slightly developed dorsoventral expansion indicate that it represents one of the primitive types of the Phragmoceratidae, for which Hyatt has created the genera Cordoceras and Protophragmoceras. On account of the general similarity of our form with the type of the latter genus, Protoph. murchisoni Barr., which makes itself obvious in the curvation, expansion, situation of hyponomic sinus and ventral position of sutural saddle, we refer the species thereto.

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[1] Geol. Sur. Illinois, 6: 506.

PHRAGMOCERAS Sowerby

Phragmoceras parvum Hall & Whitfield

Plate 21, fig. 1–8

Phragmoceras parvum Hall & Whitfield, Paleontology of Ohio. 1875. 2: 151, pl. 8, fig. 10

Phragmoceras parvum Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 1, p. 41, pl. 7, fig. 2

Phragmoceras parvum Arey, Rochester Acad. Sci. Proc. 1892. 2: 107

Phragmoceras parvum Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 105

Of the several species of Phragmoceras which have been described by various authors from American Upper Siluric faunas one, P. parvum, is notable for its small size and the projection of the dorsal horn of the aperture. This species has been described only from internal casts of the chamber of habitation. The original is from the dolomites at Cedarville, Greene co. O., and others identified therewith are from the Guelph at Hespeler. There are before us several fine small examples of Phragmoceras from Rochester which retain in exceptional perfection the exterior surface, the form of the apertural and septate portions, features which for the most part have not been made known of P. parvum.

These shells in their entire condition are unguiform, sloping from a stout chamber of habitation by a gentle curve to an acute apex, the septate portion making about one half the length of the shell. The section of the living chamber is broadly oval, but on the earlier parts the cone is more flattened on the sides. The ventral margin is very broad, the dorsal narrowly rounded and subangular. In expanding upward, the shell becomes rather abruptly swollen at the base of the body chamber, thence, at first gradually, then abruptly, contracting to the aperture, where two lateral flanges of the shell almost meet in a median line, leaving a slitlike opening between. The surface of this almost plane and vertically deflected area slopes upward to the ventrolateral angle, where it is somewhat produced in the form of a rather blunt tube. At the dorsolateral angle the tube is narrower and greatly produced. This latter feature is one of the distinguishing characters of the species.

The septa are slightly but regularly concave, the camerae quite shallow. The siphuncle is ventral and almost marginal on the earlier septa; its position on later septa has not been observed. The surface, not heretofore noted, is ornamented by quite regular, low, broad, concentric ridges separated by narrow interspaces. These make a broad backward curve on the venter, bend upward at the sides, and on the dorsum make a sharply angular, posterior curvature. At the aperture they are not parallel to or concentric with the margins.

Dimensions. A specimen nearly entire to the apex has a length of 50 mm, the greatest diameter (living chamber, not including apertural extensions) being 28 mm.

Locality. Upper Guelph horizon, Rochester.

TROCHOCERAS Barrande. 1847
(SPHYRADOCERAS Hyatt)

Trochoceras desplainense McChesney

Plate 20, fig. 3-9

Trochoceras desplainensis McChesney, New Paleozoic Fossils. 1859. p. 68, pl. 6, fig. 1

Trochoceras desplainense Hall, N. Y. State Cab. 20th An. Rep't. 1867. p. 359, pl. 16, fig. 8, 9, 10

Trochoceras desplainense Whiteaves, Paleozoic Fossils. 1884. v. 3, pt 1, p. 36, pl. 5, fig. 5

Trochoceras desplainense Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 105

The specimens which we identify with this species are of better quality than those which have heretofore been figured and studied, one of them retaining almost in its entirety the living chamber and aperture, another of somewhat smaller size preserving the umbilical aspect of the entire final whorl to the aperture, while still other specimens illustrate the grosser and finer characters of the early surface.

This completeness of the material at hand gives basis for the amplification of the characters of the species which have heretofore been drawn solely from the immature conditions of the shell.

Shell dextral, forming a low torticone of about two and one half volutions, not quite one half of the last volution being occupied by the living chamber. The volutions expand and coil downward very gradually, so that the apex of the shell and the upper side of the outer chamber lie in almost the same horizontal plane. The section is described by McChesney as being subelliptic with the dorsoventral diameter greater than the lateral, while Hall states that the volutions in these immature examples are "essentially circular." The Rochester specimens are subcircular in the section of the early part of the last whorl but become laterally flattened in later growth, so that in the final stages the cross section is ovate. The ventral side is subacutely and the dorsal obtusely rounded, but the latter is not flattened nor does it bear any trace of an impressed zone. In gerontic specimens the sides become flattened to parallel planes, a fact mentioned by Hall as characteristic of the genus. The siphuncle, which is described and figured by Hall as being central, is centren in the nepionic whorl, becomes however, in the mature stage, as shown by several of the Oak Orchard creek specimens, ventrocentren. The ventral position of the siphuncle is given by Hyatt as a family character of his Plectoceratidae, to which this genus appertains. The siphuncle is small, apparently tubular. The camerae are of slight depth and the septa closely arranged (the final ones 3 mm apart), the suture has a prominent saddle on the venter and a broader and lower one on the dorsum. The lateral lobes are shallow and broad, deepest near the dorsolateral curve.

The surface sculpture consists, in the earlier stages, of angular, oblique ridges, with slightly concave to flat interspaces. These bend strongly forward on the dorsal and backward on the ventral side, thus intersecting the suture lines at a considerable angle. They become faint as growth advances and on the last half or two thirds of the final whorl are obsolescent, in old shells disappearing before septation ceases. Concentric with these ridges and covering both ridges and the intervening sulci, are finer lines which are crossed and cancelated on the early shell by revolving lines of the same size. With the obsolescence of the ridges, the concentric lines retained to the aperture become more and more conspicuous and defined. The revolving lines may also be seen under favorable conditions in later growth.

The living chamber continues in the curve of the volutions, though, in a gerontic stage, it continues in a nearly direct line. The aperture is large, provided with a shallow dorsal and probably a deep ventral sinus.

Localities. Not infrequent in the lower Shelby dolomite and at Rochester; rare in the upper Shelby bed.

This form was first described by McChesney from the "Niagara division" of Joliet and on the Kankakee river, Ill. Professor Hall obtained his specimens from Racine Wis. and Whiteaves reports two specimens from the Guelph at Hespeler. The shell is definitely dextral and is thereby distinguished from the otherwise closely allied form termed Troch. aeneas Hall[1] from the dolomites at Lyons Ia.

The generic term Trochoceras was employed by Barrande in 1847 and independently introduced by Hall in 1852. The former's conception of the generic value is expressed in the species T. optatum Barr. (Etage E), which is very closely allied to T. desplainense, but is a sinistral shell. Hall's type is T. gebhardi Hall of the Coralline limestone, a shell with high spire, smooth whorls and of quite distinct aspect from the group under consideration; it has been made by Hyatt the type of his genus Mitroceras. Hyatt has taken Barrande's Troch. optatum as the type of his genus Sphyradoceras, and we have therefore employed Trochoceras here in the restricted sense ascribed to Sphyradoceras by its author.

Hyatt considers Sphyradoceras as an offshoot of Spyroceras, a genus with, in early growth, longitudinally ridged, and, in later, annulated longicones; and mentions the presence of longitudinal ridges among the generic characters of Sphyradoceras. Our material does not show this last

[1] N. Y. State Cab. of Nat. Hist. 20th An. Rep't, revised ed. pl. 25, fig. 16.

named feature, but it appears that the fine longitudinal lines mentioned above would point to the presence of longitudinal ridges in the neanic stage, as they do in Spyroceras, in which Clarke[1] has shown from Spyroceras bilineatum, that coarser longitudinal ridges, with advancing growth and by interplantation, become changed into more numerous uniform, fine, longitudinal striae. The presence of such fine, longitudinal striae in Troch. desplainense allows us, hence, to infer the presence of longitudinal ridges on the earliest parts of the conch.

Trochoceras costatum Hall

Plate 20, fig. 1, 2

Trochoceras costatum Hall, Geol. Sur. Wisconsin. Rep't Prog. for 1860–1861

Trochoceras costatum Hall, N. Y. State Cab. Nat. Hist. 20th An. Rep't. 1868. p. 360

Trochoceras costatum Hall, N. Y. State Cab. Nat. Hist. 20th An. Rep't. revised ed. 1870. p. 402, pl. 25, fig. 15

With the specimens of Trochoceras desplainense from the lower dolomite at Shelby, are several which are not only sinistral, but also differ from the former in their loose coiling and closer arrangement of costae, sufficiently to warrant their reference to T. costatum, another species reported from the Racine limestone.

Conch a low torticone, slightly asymmetric, but sufficiently to show that it is sinistral, very closely coiled, with wide open umbilicus, expanding moderately; whorl beginning with circular section, becoming within the first volution depressed convex and assuming an oval section; position of siphuncle not determined; surface ornamented by strong annulations, which cross the sides obliquely backward, in the earlier part of the whorl, being slightly curved, with the convexity directed forward, and becoming slightly sigmoidal on the later portion. On the venter they are curved backward. The costae number nine within the first 10 mm of the whorl, and the interspaces increase regularly till there are at the end of the whorl five costae within 10 mm.

[1] Geol. Minnesota, v. 3, pt 2, p. 786.

Observations. In describing this species, Professor Hall stated that it differed from T. desplainense in its more numerous and more sharply elevated annulations, which do not increase beyond the point opposite the apparent apex of the shell. As "a conspicuously distinguishing feature," is cited the sinistral direction of the volutions. A comparison of the specimens here described with our material of T. desplainense leaves no doubt as to the greater prominence and closer arrangement of the costae in that species, characters which give a distinctly different habit to the shell. In regard to the sinistral enrolment, Hall deemed it necessary to add an explanatory note, stating that, as in T. desplainense the inner volutions are sometimes a little depressed below the outer, it might perhaps be suspected that T. costatum is an exaggerated condition of the former species, with the inner volutions still more depressed. This, however, is claimed not to be the case, as T. costatum is clearly sinistral. It is added that Barrande described several sinistral forms of Trochoceras and found that "the enrolment is sometimes dextral and sometimes sinistral according to the species, but the dextral forms greatly predominate." In two forms, however, viz T. asperum and T. sandbergeri, Barrande concedes that "we find both modes, varying in individuals." Barrande's descriptions and fine figures of these two species, show that they are but very slightly asymmetric. They belong therefore near the beginning of the morphologic series, which according to Barrande, extends from perfectly symmetric to the highly asymmetric torticones; and it may be inferred that the tendency to become asymmetrically enrolled to the right side had not yet become established in these Bohemian forms. The two sinistral species described by Hall, viz T. costatum and T. aeneas, when compared with the decidedly dextral T. desplainense, are conspicuously less asymmetric, and therefore appear to represent an earlier and less fixed stage. We are disposed to believe that the species of Trochoceras can not be naturally divided into a sinistral and a dextral series, but that, as by far the prevailing number of species and those the most progressed, are dextral and the sinistral are but slightly asymmetric, the general tendency is toward a dextral enrolment, and the sinistral forms represent only early variations. It should be noted also that the late Devonic species are all dextral.

As Professor Hyatt has made no mention of this difference in enrolment, it may be inferred that he did not regard it of special significance. He did, however, at one time[1] separate from Trochoceras in its restricted sense the genera Peismoceras and Systrophoceras, basing these divisions principally on the characters of the aperture, position of siphuncle and section of whorl. From a note in Whiteaves's description of T. desplainense, it seems that Hyatt would have referred that species and evidently also T. costatum to his Peismoceras. In Zittel-Eastman's *Textbook of Paleontology*, however, he has covered these names again under Sphyradoceras, which is here considered a synonym of Trochoceras Barrande, *sensu stricto*.

Trochoceras costatum was described as from the Niagaran limestone at Racine and near Milwaukee Wis. In v. 2, *Geology of Wisconsin* it is only cited by Chamberlin among the species of the Racine limestone, but not among the Guelph forms.

ANNELIDA

CORNULITES Schlotheim

Cornulites arcuatus Conrad

Plate 4, fig. 1–5

Cornulites arcuatus Conrad, Acad. Nat. Sci. Jour. 1842. 8: 276, pl. 17, fig. 8

Three well preserved specimens from the dolomites at Rochester and a greater number from both horizons near Shelby are referable to this species which was described as follows:

Curved, rapidly attenuate; the base of each ring contracted, the upper edge angular.

It is not altogether certain that Cornulites flexuosus Hall (= C. clintoni Hall) from the Clinton, is sufficiently different to permit

[1] Phylogeny of an Acquired Characteristic, p. 500 and 502.

the separation from this species though Professor Hall failed to identify Conrad's species. Another specimen preserved as an internal cast has the body longer and more slowly tapering than the rest, while the rings project more at their lower ends; this may represent a form approaching C. flexuosus.

Most of these specimens are internal casts in part retaining the wall of the tube.

No specimens of Cornulites are reported from the Guelph formation; Conrad's originals came from the Niagaran dolomite in the neighborhood of Albion, Orleans co.

OSTRACODA

LEPERDITIA Rouault. 1851

Leperditia balthica Hisinger, var. guelphica Jones

Plate 21, fig. 9-11

Leperditia balthica Hisinger, var. guelphica Jones, Contrib. Canadian Paleontology. 1891. pt 3, p. 80, pl. 13, fig. 12a, 12b, 13a-c

Leperditia balthica Hisinger, var. guelphica Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 106

Of quite common occurrence in the dolomites at Rochester are specimens of a large Leperditia agreeing in dimensions with the form which Professor T. R. Jones has described under the name given above. These are valves measuring, in the adult stage, from 10-12 mm in length, 5-6 mm in hight, with long straight hinge, both angles of which are salient and beyond which the curving margins of the valves extend for a slight distance. The surface is smooth and quite convex, most so in front of the middle; the anterior slope abrupt, posterior gradual, the eye lobe well defined. These features serve to distinguish it from L. phaseolus Hisinger, var. guelphica Jones (Guelph of Ontario), which is more oblique in outline, with angles not projecting and convexity more regular.

It seems quite possible that on close comparison L. balthica guelphica may be found identical with L. fonticola Hall[1] from

[1] N. Y. State Cab. Nat. Hist. 20th An. Rep't. 1867. p. 335.

Niagaran dolomites at Fond du Lac Wis., and it is evidently closely related to L. scalaris Jones of the upper or Manlius waterlimes at Buffalo and elsewhere in Western New York.

Leperditia sp.?

Another large species of this genus is present in the Rochester fauna, but the examples observed are insufficient for its determination. It has narrower and more elliptic valves, rounded extremities and a curving hinge line. It may eventually prove to be the L. phaseolus Hisinger, var. guelphica Jones.

A small Leperditia has been also noticed in the Lower Shelby dolomite.

TRILOBITA

CALYMMENE Brongniart. 1822

Calymmene niagarensis Hall

Plate 21, fig. 12

Calymene niagarensis Hall, Geology of New York; Rep't on Fourth Dist. 1843. p. 182, fig. 3 (p. 101)

Calymene blumenbachii var. niagarensis Hall, Paleontology of New York. 1852. 2:307, pl. 67, fig. 11, 12

Calymene blumenbachii Whiteaves, Paleozoic Fossils. 1895. v. 3, pt 2, p. 107

The material of the Arey collection contains a few separated parts of this species, all of the usual small size prevalent in the Rochester shales of New York, the outcrops at Waldron and quite generally diffused in upper Siluric strata. In the upper layers at Shelby all the specimens observed attain much larger size than these.

Dr Whiteaves reports the species as occurring in the Guelph at Galt. It is also reported by Whitfield from Cedarville O., but does not seem to occur in the Guelph of Wisconsin.

DALMANITES Emmrich. 1845

Dalmanites sp.

A fragment consisting of some thoracic somites and part of the pygidium insufficient however to determine the species was found at Rochester. The surface of both parts is more coarsely granulose than in D. limulurus Green, and a row of coarse tubercles upon the segments indicates relationship to D. verrucosus Hall. The segmentation of the pygidium however is unlike either and the specimen may represent an unknown form.

PROETUS Steininger. 1830

Proetus sp.

Plate 21, fig. 13–16

At Rochester was obtained a single internal impression of a cranidium of Proetus with tapering glabella, quite narrow and convex but not protuberant in front, eyes small and closely appressed to the glabella, anterior border thickened and separated from the glabella by a narrow sulcus. This form may prove to be the species referred to by Hall as Asaphus stokesi Murchison[1] but that is believed to have the anterior end of the glabella more remote from the border as it is described as having "the space between it [border] and the cheeks and glabella depressed in a broad, shallow groove." Proetus corycaeus Conrad is of a somewhat different type of glabellar structure.

The material from Shelby has afforded besides a glabella several small pygidia of a Proetus with highly elevated strongly annulate axis and deeply sloping pleurae with three or four obscure duplicating ribs. These are also features ascribed to P. stokesi Hall.

The relatively frequent occurrence of the specimens of this genus in the eastern Guelph is interesting in view of the fact that no species of Proetus has been elsewhere reported from this fauna.

[1] Pal. N. Y. 1852. 2:316.

SYNOPTIC LIST OF GUELPH FOSSILS OF NEW YORK

c = common, cc = abundant, r = rare, rr = very rare

		LOWER SHELBY DOLOMITE	UPPER SHELBY DOLOMITE	ROCHESTER DOLOMITE	OTHER LOCALITIES
1	Zaphrentis *cf.* racinensis *Whitf.*	-	rr	c	Racine beds of Wisconsin, Guelph of Canada
2	Enterolasma *cf.* caliculus *Hall* (sp.)	-	-	c	Rochester shale, Lockport limestone, Racine limestone
3	Diplophyllum caespitosum *Hall*	-	-	c	Anticosti group, Lockport limestone of New York and Canada, Niagara and Guelph of Wisconsin
4	Heliophyllum *sp. ind.*	-	-	rr	
5	Favosites niagarensis *Hall*	-	cc	cc	Lockport limestone of New York and Niagaran and Guelph of Wisconsin
6	F. hisingeri *E. & H.*	-	c	c	Niagaran and Guelph of Ontario and West
7	F. gothlandicus *Lam.*	-	-	rr	Anticosti group, Niagaran and Guelph of Canada, Niagaran of New York, Michigan and Wisconsin
8	F. forbesi *E. & H.*	cc	c	c	Guelph of Canada?
9	Cladopora multipora *Hall*	cc	cc	-	Lockport limestone of New York
10	Halysites catenularius *Linné*	-	c	cc	Niagaran and Guelph of Canada and West
11	H. agglomeratus *Hall*	-	r	r	Lockport limestone of New York, Coral beds of Wisconsin, Guelph of Ontario (Nich.)
12	Syringopora infundibulum *Whitf.*	-	c	-	Racine beds of Wisconsin, Guelph of Ontario
13	Stromatopora galtensis *Dawson*	cc?	c	c	Guelph of Ontario
14	Clathrodictyum ostiolatum *Nich.*	-	cc	cc	Guelph of Ontario
15	Crania	-	-	rr	
16	Monomerella noveboracum *sp. nov.*	cc	-	-	Mon. prisca its closest ally occurs in the Guelph of Canada, Ohio and Illinois

		LOWER SHELBY DOLOMITE	UPPER SHELBY DOLOMITE	ROCHESTER DOLOMITE	OTHER LOCALITIES
17	Dalmanella *cf.* elegantula *Dal.* (sp.)	-	r	rr	Niagaran of New York and Guelph of Ontario and Wisconsin
18	D. *cf.* hybrida *Sow.* (sp.)	-	-	rr	Niagaran of New York and West, Racine of Wisconsin
19	Leptaena rhomboidalis *Wilckens* (sp.)	rr	-	-	Rare in Guelph of Wisconsin
20	Camarotoechia? neglecta *Hall* (sp.)	-	c	c	Niagaran, Guelph of Wisconsin
21	C.? indianensis *Hall*	r	c	c	Niagaran of Indiana and Kentucky
22	Spirifer crispus (*His.*) *Hall* var.	-	c	c	Niagaran and Guelph of Canada
23	Whitfieldella nitida *Hall*	-	cc	cc	Niagaran of New York, Racine of Wisconsin
24	Rhynchotreta cuneata americana *Hall*	-	rr	-	Niagaran of New York and West
25	Mytilarca eduliformis *sp. nov.*	-	-	r	
26	M. acutirostrum *Hall*	r	-	-	Racine and Guelph of Wisconsin
27	Pterinea subplana *Hall*	-	rr	rr	Rochester shale
28	P. undata *Hall* (sp.)	-	rr	-	Rochester shale
29	Conocardium *sp.*	-	-	r	Conoc. sp. in Guelph of Ontario
30	*Cf.* Modiolopsis subalata *Hall*	-	rr	-	Clinton and Rochester shale
31	Bellerophon shelbiensis *sp. nov.*	c	-	-	Niagaran and Canadian Guelph
32	Trematonotus alpheus *Hall*	cc	rr	rr	Racine of Wisconsin, Chicago limestone, Guelph of Canada
33	Diaphorostoma niagarense *Hall* (sp.)	-	rr	rr	Rochester shale, Guelph of Wisconsin
34	Poleumita scamnata *sp. nov.*	-	c	cc	Canadian Guelph
35	P. sulcata *Hall*	-	r	r	Guelph of Newark, Wayne co. N. Y., Canadian Guelph
36	P. crenulata *Whiteaves* (sp.)	c	-	c	Canadian Guelph
37	Trochonema *cf.* fatuum *Hall*	-	rr	-	Guelph of Wisconsin
38	Eotomaria durhamensis *Whiteaves* (sp.)	-	-	rr	Canadian Guelph
39	E. areyi *sp. nov.*	-	-	rr	
40	E. kayseri *sp. nov.*	-	-	rr	
41	E. galtensis *Billings* (sp.)	rr	rr	-	Canadian Guelph

		LOWER SHELBY DOLOMITE	UPPER SHELBY DOLOMITE	ROCHESTER DOLOMITE	OTHER LOCALITIES
42	Lophospira bispiralis *Hall* (sp.)	c	-	r	Rare in Guelph of Ontario
43	Hormotoma whiteavesi *sp. nov.*	-	r	cc	
44	Coelidium macrospira *Hall* (sp.)	c	rr	c	Guelph of Ontario and Wisconsin
45	C. *cf.* vitellia *Bill.* (sp.)	-	-	rr	Guelph of Ontario
46	Macrochilina *sp. ind.*	-	-	rr	
47	Euomphalus fairchildi *sp. nov.*	-	-	rr	
48	Orthoceras trusitum *sp. nov.*	c	rr	c	
49	O. crebescens *Hall*	c	-	-	Waukesha, Racine and Guelph beds of Wisconsin
50	O. rectum *Worthen*	rr	-	-	"Niagara limestone" of Joliet Ill.
51	Dawsonoceras annulatum *var.* americanum	c	-	r	Niagaran of New York, Guelph of Ontario
52	Kionoceras darwini *Bill.* (sp.)	c	-	c	Racine and Guelph of Wisconsin, Guelph of Ontario, limestone of Yellow Springs O.
53	K. *cf.* medullare *Hall* (sp.)	rr	-	-	Waukesha and Racine beds of Wisconsin, Niagaran of Joliet Ill. Canadian Guelph
54	Cyrtoceras arcticameratum *Hall*	-	-	r	Guelph of Canada and Wisconsin
55	C. orodes *Bill.*	r	-	r	Guelph of Canada
56	C. *cf.* brevicorne *Hall*	rr?	-	rr	Racine beds of Wisconsin
57	C. bovinum *sp. nov.*	-	-	c	
58	Cyrtorhizoceras curvicameratum *sp. nov.*	c	-	-	
59	Trochoceras desplainense *McChesney*	c	rr	r	Niagaran of Joliet and Kankakee river, Illinois, Racine of Wisconsin, Guelph of Canada
60	T. costatum *Hall*	c	-	-	Racine of Wisconsin
61	Gyroceras farcimen *sp. nov.*	r	-	-	
62	Poterioceras sauridens *sp. nov.*	cc	-	rr	
63	Poterioceras *sp.*	rr	-	-	
64	Protophragmoceras patronus *sp. nov.*	rr	-	-	
65	Phragmoceras parvum *Hall & Whitfield*	-	-	r	Guelph of Ohio and Canada

		LOWER SHELBY DOLOMITE	UPPER SHELBY DOLOMITE	ROCHESTER DOLOMITE	OTHER LOCALITIES
66	Cornulites arcuatus *Conrad*	c	c	c	Lockport limestone
67	Leperditia balthica *var.* guelphica *Jones*	-	-	c	Canadian Guelph
68	Leperditia *sp.*	rr	-	r	
69	Calymmene niagarensis *Hall*	-	r	r	Niagaran of New York, Guelph of Ontario and Ohio
70	Dalmanites *sp.*	-	-	rr	
71	Proetus *sp.*	-	r	rr	

Summary

Total species recorded from the Guelph fauna of New York		71
From Shelby		52
From Rochester		52
Common to	upper and lower Shelby horizons	10
"	upper Shelby and Rochester	25
"	lower Shelby and Rochester	14
"	Shelby and Canadian Guelph	26
"	upper Shelby and Canadian Guelph	15
"	lower Shelby and Canadian Guelph	13
"	Rochester and Canadian Guelph	27
"	New York and Canadian Guelph	31
"	Shelby and Niagaran faunas of New York	17
"	Rochester and Niagaran faunas of New York	16
"	New York Guelph and Niagaran faunas	19
"	Shelby Racine, and Waukesha limestones	12
"	Rochester, Racine and Waukesha limestones	8
"	New York and Wisconsin Guelph	13
Species at	Shelby not recorded from Rochester	19
"	Rochester not recorded from Shelby	18

In considering the relative prevalence of the various classes of organisms in these manifestations of the Guelph fauna in New York we observe that the several classes have the following distribution :

	CORALS	BRACHIO-PODS	LAMELLI-BRANCHS	GASTRO-PODS	CEPHALO-PODS	CRUS-TACEANS
Lower Shelby - -	2+	3	1	4	15	0
Upper Shelby - -	9	6	2	6	2	3
Rochester - - -	12	7	3	15	10	5

In the lower Shelby horizon the cephalopods prevail, notably in species and profusely in individuals; furthermore of the three brachiopods one is Monomorella noveboracum which extraordinarily abounds and is nowhere else seen; of the four gastropods Trematonotus alpheus is amazingly prolific and Poleumita crenulata is very common. As to the corals we have every reason for believing that, originally abundant, their skeletons have been largely destroyed by diagenesis.

In the upper Shelby-Rochester horizon, there has been less destruction of the corals, and the gastropods and cephalopods are prevailing species though not rising to such individual development as in the earlier appearance.

Comparing this condition with the relative development of these classes in the typical Guelph fauna of Ontario as given by Dr Whiteaves we find a corresponding prevalence of gastropods and cephalopods; the lamellibranchs are few in species (nine in a total fauna of 133 species) but one of these is the ponderous Megalomus canadensis which is extraordinarily abundant at definite horizons. The brachiopod species rise to 24 but it is a noteworthy fact that throughout this fuller representation of the Guelph fauna there is a larger percentage of normal or slightly modified Niagaran forms than is present in the New York Guelph. No crinoids or bryozoans are present in either case.

CONDITIONS OF LIFE AND SEDIMENTATION

DURING THE PREVALENCE OF THE GUELPH FAUNA

In surveying the composition of this fauna one is impressed with the fact that irrespective of class divisions, the species on the whole are either large and heavy shelled or diminutive and thin shelled. We may cite in illustration of this the condition among the brachiopods. The Trimerellidae including the genera Trimerella, Monomerella and Rhinobolus are notable, not alone for their abundance but as well for their great size and weight. Similarly heavy and abundant in Ontario is Pentamerus occidentalis, but for the rest of the brachiopod species all are not merely small and thin shelled but diminutive, specially those which have been continued forward from earlier existence in the Niagaran fauna. Among the lamellibranchs the Canadian fauna contains, as just noted, the heavy Megalomus in surpassing abundance and another thick shelled species, Goniophora crassa, but the other species in Canada and all in New York are small and insignificant. The gastropods are chiefly long, heavy, turreted shells, but a few are of small size. If a diverse habit of growth is indicated by these differences we find that among the cephalopods more uniform effects are expressed as though uniform conditions encompassed and qualified this entire group. The well known habit of life of these creatures would preclude the likelihood of their being subjected to such widely distinct conditions as those which have affected the rest. Of the trilobites all the large species of the Niagaran fauna are absent.

Professor T. C. Chamberlin, in studying the character of the upper Siluric dolomites of Wisconsin, recognized the fact that the lenticular accumulations of the Racine limestone were ancient coral reefs and we shall find on comparison of the phenomena presented by the dolomites in New York with these Racine reefs, with the Jurassic reefs which have been elaborately investigated in France and with conditions of life and sedimentation prevailing on existing reefs, conclusive reasons for construing those dolomites as reef formations.

We may note, first, that the dolomite which carries the chert nodules of the upper horizon (upper Shelby and Rochester) is highly magnesian.[1]

It shows no stratification, is usually dark and so bituminous that it gives off a strong petroleum odor when fresh or struck with the hammer. It is for the most part granular, though compact and contains numerous white silicious concretions in which the fossils are preserved. Outside of these nodules fossils are rarely found except remains of Stromatopora, Halysites and other corals.

It is claimed by Walther and other writers and may be regarded a matter of general acceptance that noncrystalline dolomites carrying so high a percentage of magnesia as these are distinctly coraligenous.[2] Coral rocks of later geologic age may show higher percentages of magnesia than this as the amount apparently increases the longer the process of diagenesis continues; in other calcareous deposits the content of magnesia is always small and this is in correspondence with the fact that shell limestones now forming are low in magnesian content. The skeleton of living corals actually contains but relatively little magnesian salts (Madrepora muricata 2.4% and Isis 6.3%) but it is known that during diagenesis or the sum of the little known processes by which a sediment is changed into rock,[3] the coral

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[1] One of the white chert nodules from the Nellis quarry, Rochester gave the following:

SiO_2	74.973%	Mg	4.366%
Ca	5.613%	CO_2 & H_2O	9.112%
Fe & Al	.68%	(Analysis by P. N. Coupland)	

The dark dolomite from the same locality gave: MgO 20.95% or $MgCO_3$ 44±%. The lighter dolomite from the lower Shelby bed at Shelby gave: MgO 16.43% or $MgCO_3$ 36±%. (Analyses by G. I. Finlay)

[2] Walther. Einleitung in die Geologie als historische Wissenschaft. 1894. p. 663 *et seq.*

[3] Doelter and Hoernes have supposed [*Jahrb. k. k. geol.-Reichsanst.* Vienna. 1875. p. 331] that the magnesian salts of the sea water, specially Mg Cl, act on the calcareous secretions of the organisms as soon as formed. Walther [*op. cit.* p. 708] thinks the product due in large measure to bacterial action, just as bacteria have been shown to produce deposits of calcium carbonate by forming ammonium carbonate which in turn acts on the calcium sulfate of the sea water.

rock segregates and concentrates the magnesia of the sea water more than any other sedimentary material. We may note that the admixture of bituminous matter in these Guelph dolomites is further indication of their coral reef origin, or is at least in harmony with recent observations on living coral reefs where petroleum has been found in process of formation as a result of the transformation of the organic matter of the reef. The cavernous character of the dolomites may, according to the views of Walther and others, be regarded not as the result of subsequent corrosion but as the remnants of original cavities in the growing reef which have not been closed up with coral sand.

The chert concretions which are characteristic of the upper Guelph horizon at Rochester and Shelby are doubtless a byproduct of the diagenesis which altered the coral limerock to a dolomite. These nodules contain fossils with their exterior ornament finely retained, that is replaced in amorphous silica, while in the dolomite the shell substance has been removed and never replaced. The source of the silica here, as in the like segregations associated with limestone, is probably to be found in spicules of sponges, organisms which contribute importantly to the comminution of shells and coral skeletons, specially the boring forms like Cliona.[1] It is known that sponges, both silicious and calcareous occur abundantly on the western edge of the Florida bank.[2]

The suggestion, derived from its lithologic characters as to the reef origin of the rocks, is fully borne out by the character of the fauna. The dolomite everywhere contains fragments or traces of corals specially of Stromatopora, Favosites, Syringopores and Cladopora. Here, however, as in other cases of fossil coral reefs, the coral masses have been largely destroyed or altered beyond recognition.

We have noted the existence of extremes of size in the Guelph organisms, the ponderous heavy shelled species, and the diminutive forms. One reading the account given by Klunzinger[3] of the life inhabiting the reefs

[1] Hancock. Ann. and Mag. Nat. Hist. ser. 2. 3: 231.

[2] Agassiz, A. Three Cruises of the Blake. 1888. 1: 149.

[3] Bilder aus Oberägypten. 1878. p. 334.

of the Red sea learns that in the numerous cavities and in the small ponds between the masses of seaweed there is displayed an overwhelming variety of small gastropods, echinoderms, lamellibranchs and crustaceans. The gastropods are evidently the prevailing class, the lamellibranchs fewer and the cephalopods almost wholly absent. On the outer edge of the reef where the surf beats with wild force and the corals best flourish there are the thick shelled mollusks which without hiding defy the surf; species of Conus, Ricinula, Fasciolaria, Turbinella and Trochus. The ponderous Monomerellas, Rhinoboli, Trimerellas, Pentamerus, Megalomus, Goniophora crassa and the numerous large gastropods were obviously adapted to similar life conditions on the Guelph reefs, and the contrasting abundant small gastropods, brachiopods and lamellibranchs found congenial conditions in the cavities between the branches of the coral stocks and in the ponds among the alga patches on the reef.

More than one consideration suggests that increasing salinity assisted the development of the thick shelled mollusks. We must look upon the Guelph as a distinct phase in the development of the vast Niagaran coral sea into the desiccating, inclosed sea of the Salina stage, when the salinity of the water finally destroyed all life. The subsequent discussion of the Guelph will show that the Guelph sea was the outcome of a shrinking of the Niagaran sea; it is a derivative of the Niagaran fauna, specially of that element which distinguishes the Racine dolomite of Wisconsin, but it has greatly diminished and its residuum shows a definite adaptation to peculiar conditions. It is therefore legitimate to conclude that the inclosure and desiccation of the continental Niagaran sea had already begun to manifest its influence. Investigations of recent marine faunas sufficiently support this view. Von Baer has shown[1] that in the deep eastern channel of the Caspian sea the magnesian carbonate is much increased and the calcium salts are decreased over their relative proportions elsewhere; under this altered composition of the sea water the shells grow thick and heavier,

[1] Neues Jahrb. für Mineral. 1856. p. 591.

while in the less saline waters of the shallow region they are thin and small.

The dolomite series from the top of the Rochester shale into the Salina bed shows an irregularly increasing magnesian content and increasing salinity. The occurrence of immense banks containing millions of the extraordinarily ponderous Megalomus suggests that increasing salinity may be an essential cause of its great size, for oysters are known to similarly increase in size and thickness of shell in the deeper and more saline parts of the sea. The corals, however, are considerably more sensitive to lack of salt than to increase in salinity. They avoid the neighborhood of river mouths but flourish luxuriantly in the Red sea, which receiving little fresh water drainage, and having but restricted communication with the open sea, is known to possess considerably higher salinity than the ocean without. Altogether the Red sea with its greater salinity, extensive coral reefs and abundant life seems an excellent portrayal of the conditions of the Guelph sea. A complete inclosure of that body of water would repeat the conditions that led to the formation of the Salina beds, with the exception that the Salina sea still at times received much terrigenous detritus.

Various writers have shown that once the optimum of salinity is passed concentration of the brine produces disastrous effects on organisms. Dall has shown that in the salt lagoons or salt pans of the Bahamas[1] the effect of this concentration is shown in the diminished size and thin shells of the mollusks and among the gastropods in a tendency to irregularity of coil and effacement of sculpture. Such extreme conditions may be conceived to have led to the depauperation and actual extinction of the fauna of the Salina stage. In this connection we may note one gastropod of the Guelph, Loxoplocus solutus Whiteaves, which is unique among upper Siluric gastropods in being a completely uncoiled Murchisonia, and which may have received the impulse to its peculiar aberration from the gradually increasing salinity of the water.

[1] Mus. Comp. Zool. Bul. 1894. v. 25, no. 9, p. 113.

We may compare the conditions of the Guelph sea and the character of its fauna with those of fossil coral reefs which have been clearly recognized in the sediments of other formations. Perhaps the best instances are to be found in the Jurassic reefs of France and the Racine reefs of Wisconsin.

In France the investigations of Oppel, Niosch, and more specially of the Abbé Bourgeat,[1] whose results are reproduced in condensed form in Felix Bernard's *Principles of Paleontology*,[2] have shown that reefs were formed at various epochs of the upper Jurassic, and that for every separate coral facies there is always a corresponding muddy or lagoon facies and pelagic facies of the same age, but very different in the character of the fossils. The reef of Valfin is cited in illustration of these conditions. The mass of the reef is described as a limestone of corallic origin; here and there in the irregular mazes is found the special fauna of the reefs which is here very abundant, and particularly rich in forms showing a thick test "which is in accordance with the fact that, the corals growing in regions beaten by waves, the forms, inhabiting them, must necessarily be provided with a strong power of resistance, while small sized species having a thinner covering are only found in well sheltered places." The fauna is described as follows: "There are of the gastropods numerous Nerineas, Cerithiums, Naticas, Turbos, Pleurotomarias; of the Acephala, Diceras (13 species), Lima, Pecten, Trigonia, Corbis; regular Echini of the family of Cidaridae." We note that the Pleurotomarias, which appear in the Guelph reef with 14 species, are still prominent upon the Jurassic reefs, the long, turreted, heavy Paleozoic Murchisonias, Loxonemas, Subulites correspond in their habit to the Nerineas and Cerithiums so prominent upon the Jurassic reefs; and the Poleumitas, so abundant in our Guelph are the Turbos of the later reefs. The Acephala however had not yet attained prominence among the earlier reefs.

On the east side of the Valfin reefs the coraligenous facies changes, passing by intercalation into marls more and more mixed with clay. This

[1] Recherches sur les formations coralligènes du Jura méridional. 1887.

[2] See translation in N. Y. State Geol. 14th An. Rept. 1895. p. 200.

is the lagoon region between the barrier reef and the shore "which was not far to the east." Its fauna is greatly different from that of the reef, the heavy Nerineas and Diceras and the corals having entirely disappeared.

On the other side of the reef the corals disappear suddenly and the pelagic facies extends far toward the north into the open sea. It is characterized by Ammonites, Belemnites, brachiopods and Echini.

The great numeric preponderance of the cephalopods in the lower Shelby dolomite would, by comparison with the equal preponderance of this class in the pelagic facies of the reef, suggest that this may represent the pelagic facies or pelagic side of an early Guelph reef.

An excellent description of the facies of the ancient coraliferous sea of Racine age in Wisconsin has been given by T. C. Chamberlin.[1] We quote part of his interesting summation:

It appears, then, that in the southern counties there are three well marked classes of limestones, with intermediate gradations, one class, consisting of very irregular often brecciated or conglomeritic dolomite, forming masses that usually appear as mounds, or ridges of rock, of obscure stratification, a second class, formed of pure, soft, granular dolomites, a part of them calcareous sandrock, and a third class, consisting of compact, fine grained, regular, even beds. We have demonstrated that the three forms change into each other when traced horizontally. They were therefore formed simultaneously. The view that best explains these facts is, (1) that the mounds and ridges were ancient reefs, and (2) that the granular sand rock was formed from calcareous sands, derived by wave-action from the reef, and (3) that the compact strata originated from the deposit of the finer calcareous mud that settled in deeper and more quiet waters, the whole process being analogous to, if not identical with, the coral formation of the present seas.

But before pursuing this analogy farther, it will be well to consider the evidences of life found in these rocks. While some of the reefs, or at least that portion of them that happens to be exposed to examination, present only a few fragments of fossils, others are prolific in organic remains, and some of them are remarkable for the richness and variety of their fauna. The reef near Wauwatosa (Schoonmaker's quarry), is a striking instance of this. There have been collected from it, chiefly by Dr Day, probably not less than 200 species. Of these there have been identified 28 corals, 8 bryo-

[1] Geol. Wisconsin. 1877. 2:368–71.

zoans, 4 crinoids, 19 brachiopods, 11 gastropods, 9 lamellibranchs, 24 cephalopods, and 16 trilobites. And an exhaustive examination of the collections would doubtless much increase the number.

Of the granular varieties of rock, that which is nearest allied to the reef rock is peculiarly notable for an abundance of crinoids. The locality near Racine is preeminent in this respect. Upwards of 30 species have been identified from this one locality. These are associated, as will be seen by consulting the table, with a large number of corals, brachiopods, gastropods, cephalopods, trilobites and a lesser number of other forms.

The fauna of the compact strata is distinguished for the conspicuous presence of the straight and curved cephalopods with comparatively few associates. The cephalopods are abundant, as already noted, in the reefs and crinoid beds, but are overshadowed by the number and variety of other forms, while in the compact rock they greatly predominate.

It appears then, (1) that upon the reefs there swarmed a vast variety of life; (2) that upon certain banks or shoal areas there was also great abundance and variety, among which the crinoid family attained unusual prominence; (3) that over areas of submarine sand flats there either was little life present, or, from the porous nature of the rock, it has been illy preserved, and (4) that over the deeper areas, that deposited fine calcareous mud, the gigantic cephalopods held sway. The counterpart of all this is to be found among the coral reefs of today.

These conditions in Wisconsin continued from Racine into the Guelph time, as Chamberlin says of the Guelph (p. 377):

In its lithological character, in does not differ essentially from the Racine limestone, being in general a rough, thick bedded, irregular dolomite, usually quite free from impurities, and of buff, gray, or blue color. The distinction between the two subdivisions is a paleontological rather than a physical one. In the latter respect there is less difference between these than either of the other members of the group. There was evidently no marked change in the physical history of the region, but the same conditions continued from the beginning of the deposit of the Racine limestone to the close of the formation of the Guelph beds. In the interval, however, the life underwent a change by the introduction of the species that characterize the Guelph horizon. This introduction was gradual, so that many localities show a mingling of the two faunas.

In New York the Guelph period was still a time of coral reefs, and the distribution of the peculiar fauna, characteristic of this reef in Ontario and Ohio, shows that probably the entire shallow Guelph basin was more or less studded with coral reefs.

DISTRIBUTION OF THE GUELPH

In the identification of the Guelph fauna in North America difficulties arise from two sources, firstly from the evident failure to discern between the Niagara and Guelph rock in some regions, again from the lack of reliable fossil lists of the upper Siluric. On account of the changing correlations of the upper Siluric beds in some of the states with advancing knowledge such an inquiry has to assume the character of a history of investigations upon the Guelph in these states. We, therefore, present here such a history which will furnish the data for a summary statement of the distribution of the Guelph in North America.

After Professor Hall had recorded the existence of "Onondaga salt group" fossils in Wayne county, N. Y. and in Ontario, he discovered during his geologic investigations of Iowa[1] a limestone at the Rapids of Le Claire, Iowa of which he says:

"In descending the Mississippi river the Niagara limestone is succeeded by a gray or whitish gray limestone. The whole mass is semicrystalline, very porous, and vescicular from the solution and removal of fossils." He thought that it might exceed 600 feet in thickness and adds:

So far as we are able to ascertain this important formation has not heretofore been recognized in western geology, or, if recognized, has been confounded with the Niagara limestone. From this, however, it is quite distinct, both in its lithological character and its fossil remains.

The fossils are all in the form of casts, and among them is a small Spirifer, a Spirigera, a Pentamerus undistinguishable from P. occidentalis, several gastropods and some chambered shells. In this reconnaissance no very complete collections were made, but as far as they enable us to form an opinion, the fossils of the limestones of the Le Claire rapids are very similar to those of the limestone of Galt in Upper Canada. The similarity of position is worthy of notice.

Should the identity of the limestone of these two distinct localities be proved, it will afford sufficient ground for separating these beds from the Onondaga salt group, and for establishing a distinct group. It seems quite probable that the limestones of this period have their eastern extremity in central New York, where, from their small development, as well as from

[1] Geol. Sur. Iowa. 1858. 1:73-80.

similarity of lithological character there seemed no sufficient ground for separating them from the nonfossiliferous bed of the Onondaga salt group. Since, however, in Canada these beds attain considerable importance, and (admitting the conclusions above given) acquire a still greater thickness and more distinctive character on the Mississippi river, it seems necessary to elevate these to the same rank as the other groups of the series.

Hall here first clearly recognizes the Galt beds as a separate group and this position was strongly reiterated in *Paleontology of New York*, 1859, 3:30.

This correlation of the Le Claire limestone was soon after attacked by A. H. Worthen[1] who claimed that the limestone was without any true lines of bedding, that Hall greatly overestimated its thickness[2] and that the beds and fossils at Le Claire were to be correlated with those of Bridgeport near Chicago and Port Byron Ill., "all of which are claimed to represent but the Niagara limestone." It would appear, however from Worthen's statements that the fossils upon which he bases his views, specially Pentamerus oblongus, occur only in the lower part of the bed at Bridgeport and Port Byron, while Hall already cited a distinct Guelph form in Pentamerus occidentalis from the Le Claire limestone. Hall and Clarke have cited several species of Trimerella and Monomerella from Port Byron and other localities of this dolomite and there can be no doubt that the Guelph is represented therein.

This rock is described by Worthen[3] as follows:

At Bridgeport, near Chicago, the rock presents the same general characters as at Port Byron and Le Claire, and is extensively used for the manufacture of lime. West and northwest of Chicago and just outside the city limits, it is highly charged with petroleum. . . This bituminous portion of the limestone is from 35 to 40 feet thick, and at the artesian well was found to be underlaid by about 80 feet of regularly bedded limestone, which no doubt includes the Athens marble and the Joliet limestone.

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[1] Am. Jour. Science. 1862. 33:46–47; Geol. Sur. Illinois. 1866. 1:30.

[2] The latter point was conceded by Hall in the N. Y. State Cab. Nat. Hist. 20th An. Rep't. 1867. p. 307.

[3] Geol. Sur. Illinois. 1866. 1:132.

From these statements of Hall and Worthen it would appear that the uppermost 35 to 40 feet of these beds alone may represent the Guelph.

A few years later Hall explored the geology of the central and eastern portions of Wisconsin, and the adjacent parts of Illinois. His results are published in the *Report of the Geological Survey of Wisconsin*, 1862, v. 1. In this important work he separated [p. 67] the Racine limestone from the Niagara limestone proper, as the upper member of the Niagara group. Of the fauna of this limestone is said:

Few of the species are identical with those in the Niagara group farther to the east, or in the State of New York, though the Caryocrinus, in its condition of casts, is not distinguishable from the C. ornatus of New York, Kentucky and Tennessee.

The species already identified with known species of the Niagara group in New York in addition to the Caryocrinus, are Spirifer niagarensis, S. radiatus and Strophomena rugosa, while we have a Spirifer allied to S. sulcatus and an Illaenus closely allied to or identical with L. (Bumastus) barriensis.

In regard to its correlation it is stated: "It may be considered identical with the Le Claire limestone of Iowa, holding precisely the same geological position, and containing some similar if not identical fossils, and both limestones must be regarded as a part of the Niagara group."

From this statement it is clear that, on account of the recognition of New York Niagaran fossils in this Racine bed, Hall considered the Le Claire limestone, which he here correlates with the Racine, neither as belonging to the Onondaga salt group nor to a later stage than Niagaran, but as a member of the Niagaran group.

No mention was made in this report of the finding of Guelph fossils in the Racine bed, but it is stated in the *20th Annual Report of the New York State Cabinet Natural History*, 1867, p. 307:

At the same time, we have recognized from Racine and adjacent localities, including Le Claire in Iowa and a single locality in Illinois, the following species which are identical or very closely allied to those from Galt in Canada West: Pentamerus occidentalis, an Obolus-like fossil, a Favosites and a species of Amplexus which are identical in several localities, Cyclonema sulcata, Murchisonia logani, Murchisonia identical or closely allied to M. mylitta Billings, an undescribed Murchisonia identical with one from Galt, Subulites ventricosa, Pleurotomaria solarioides?, Loxonema longispira, besides other forms which are closely allied to species of the Guelph limestone.

Hall had hence clearly recognized the presence of the Niagaran and of the Guelph fauna also in the Racine beds, a conclusion which has been fully verified.

While Hall worked out the relations of these beds in the west, Billings[1] added to the Guelph fossils described by Hall in v. 2, *Paleontology of New York*, a considerable number of new forms, among them specially the large brachiopods Trimerella and Monomerella cited hitherto as Oboluslike forms, and Logan[2] described the stratigraphic relations of the formation in Canada. As to the relation of the Niagaran and Guelph Sir William remarks in this work:

In Canada, the Niagara rocks are succeeded by a series of strata, which appear to be wanting in the State of New York. . . It has already been stated that the strata seen near the mouth of the Riviere aux Sables, at Chief's Point, probably strike along the coast, by Lyell Island to Cape Hurd; and belong in part to the Niagara formation whose characteristic fossils are met with in several localities along the shore. These strata, however, have for the most part the lithologic characters of the Guelph formation, and some of their undescribed species of Murchisonia have a strong resemblance to others found in this series. The Pleurotomaria huronensis, which belongs to the Guelph rocks, occurs on Lyell island associated with Pentamerus oblongus, and other characteristic Niagara species; so that it is not impossible that some of the strata along this coast may constitute a passage between the Niagara and Guelph formation.

The Guelph formation appears to be absent from the State of New York, and in Canada it probably has the form of a great lenticular mass, the limit of which between Niagara and Guelph is uncertain, though it appears to extend beyond Ancaster. In the other direction it seems to thin out in Lake Huron, before reaching the northern Peninsula of Michigan.

Hall had noted before this[3] that "at some points on the northern shore of Lake Michigan and elsewhere in the lake region, there occurs a light

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[1] Paleozoic Fossils. 1861–65. v. 1.

[2] Geol. Canada. 1867. p. 336.

[3] Pal. N. Y. 1859. 3:30.

colored limestone lying above the Niagara strata, containing generally few fossils and among them some forms not unlike those of that in Canada West."

As to the general character of the Guelph Hall concludes:[1]

I am therefore induced to believe that this limestone at Racine, the mass at Le Claire and extending thence into Iowa, as well as the Guelph formation in Canada and the feeble representation of the same in New York, are really lenticular masses of greater or less extent, which have accumulated upon the unequal surface of the ocean bed in a shallow sea during the latter part of the Niagara period. These isolated masses of limestone have close relation with each other while their relation with the Onondaga salt group, though very intimate in the single locality in central New York, becomes less and less conspicuous in a westerly direction.

A considerable number of Galt fossils are described in this 20th Museum report among the fossils from the Racine beds of Wisconsin.

Wisconsin. The relations of the Guelph of Wisconsin have been fully treated by T. C. Chamberlin in *Geology of Wisconsin*, 1877, 2:335 *et seq.* The Niagara group is here divided as follows from top downward:

At the south		At the north	
1	Guelph beds	1	Guelph beds
2	Racine beds	2	Racine beds
		3	Upper Coral beds
3	Waukesha beds	4	Lower Coral beds
		5	Byron beds
4	Mayville beds	6	Mayville beds

In regard to the Guelph and Racine beds it is said:

The term Guelph has been applied to the uppermost beds on account of a similarity of fossils to those of the Guelph limestone of Canada, to which the Wisconsin formation is probably equivalent. The recognition of this equivalence is due to Professor Whitfield.

The Racine beds are the equivalent of what has been known as the Racine limestone, except that the upper portion is now separated as Guelph, and the reefs and associated rocks west of Milwaukee which have been referred to a lower horizon, are included in it.

The suggestion of Hall that a Guelph and a Niagaran horizon are con-

[1] N. Y. State Cab. Nat. Hist. 20th An. Rep't. 1867. p. 307.

tained in the Racine limestone, has here been verified and the separation carried out.

The fauna of the Racine limestone was described and figured by R. P. Whitfield in *Geology of Wisconsin*, 1882, v. 4. A consideration of the fossil lists there given brings out some interesting facts.

In the Lower Coral beds there occur, together with Niagaran corals, Dinobolus conradi (originally described from the Le Claire and Racine limestones), Trimerella grandis, Trochonema (Poleumita?), Murchisonia hercyna (a Canadian Guelph form called billingsana by Miller, as Billings's name is preoccupied). This limestone is 70 feet in greatest thickness.

None of these fossils occur in the Upper Coral beds (90 feet).

The Racine beds (consisting of three facies, viz coral reefs, coral sand and compact strata with cephalopods) contain, together with typical Niagaran brachiopods, the following Guelph forms:

Trimerella grandis, Whitfieldella hyale, Megalomus canadensis, Straparollus solarioides, Bucania angustata (=Trematonotus alpheus), Murchisonia macrospira, M. mylitta, Cyrtoceras brevicorne, C. arcticameratum, Trochoceras desplainense.

The Guelph bed is said not to differ essentially from the Racine, being in general a rough, thick bedded, irregular dolomite, usually quite free from impurities. The distinction between the two subdivisions is paleontologic rather than physical and the introduction of the Guelph fossils was so gradual that many localities show a mingling of the two faunas. The beds are more regular and compact than the subjacent Racine and gastropods predominate among the fossils.

The following Canadian Guelph species appear in the list of fossils:

Monomerella prisca, Whitfieldella hyale, Megalomus canadensis, Holopea guelphensis, H. harmonia, Loxonema boydi, M. hercyna, M. logani, M. longispira, M. macrospira, Cyrtoceras arcticameratum.

These lists bring out the following facts: (1) that a considerable number of characteristic Guelph fossils appear as early as the Racine beds, a few even in the Lower Coral beds, (2) that the large brachiopods (Trimerellids) appear before or with the earliest Guelph gastropods (as at Shelby), (3) that neither the Racine nor the Guelph beds of Wisconsin contain a pure Guelph fauna, but also numerous Niagaran forms.

Hall and Clarke,[1] writing at a later date than the work cited, give the following brachiopods from Wisconsin:

Rhinobolus davidsoni H. & C., Grafton, Monomerella cf. orbicularis Billings, near Grafton, M. egani H. & C., Grafton, M. greeni H. & C., Grafton, Dinobolus conradi Hall, Racine, Grafton. Schuchert cites[2] also Conchidium occidentale Hall, Williamstown, Stricklandinia multilirata Whitfield, Sheboygan.

Iowa. Dr Samuel Calvin in the *Report of the Geological Survey of Iowa*, 1896, 5:50, has divided the Niagaran into four stages from the top down: Bertram, Anamosa, Le Claire, Delaware (Hall's Niagara).

In regard to the Le Claire stage it is stated that its strata are restricted to the southwestern corner of the Niagaran area. It is generally a massive or heavy bedded, highly crystalline dolomite. It contains little chert and in its lower part there are few fossils. There are occasionally specimens of Pentamerus of the P. occidentalis type, and casts of corals. In the upper part small brachiopods abound of the genera Homoeospira, Trematospira, Nucleospira, Rhynchonella, Rhynchotreta, Atrypa, Spirifer and probably others.

The Le Claire limestone is, in some respects, unique among the geologic formations of Iowa. Locally, it varies extremely in thickness, so that its upper surface is very undulating and it is strongly cross bedded. It is suggested by Calvin that the eddies of strong currents piled up the material in lenticular heaps.

Anamosa stage. This is Hall's "Onondaga salt group", an earthy,

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[1] Pal. N. Y. 1892. v. 8, pt 1.

[2] Synopsis Am. Paleoz. Brach. 1897. p. 187.

finely and perfectly laminated dolomite, quite free from fossils, but in Cedar county the brachiopod fauna of the upper part of the Le Claire reappears in great force, up near the top of the formation. It was laid down on the uneven floor of the Le Claire formation.

Bertram stage. An irregularly bedded, nonfossiliferous dolomite without fossils.

In volume 11 of the same report, the Anamosa and Le Claire stages are grouped together under the designation *Gower limestone.*[1] The Anamosa "phase" is said to consist of soft granular limestones (dolomites?) with very few fossils, while the Le Claire facies is hard bluish gray limestone (dolomite?) with numerous fossils. "These are often gregarious, and while no complete list of species has been made out, the fauna is known to represent that of the Guelph of Canada. The Le Claire occurs in places in mounds 50 feet high and over, in which little semblance of stratification is to be seen. The rock is brecciated or conglomeritic." [p.305]

This paper accepts the theory which had already been suggested by Hall that "at the close of the Niagara huge mounds and ridges were built on the bottom of the shallow Silurian sea, in part by the accumulation *in situ* of corals, crinoids and molluscous shells, and in part by the drift of calcareous sediments under strong currents. That these reefs were near the surface is attested by their conglomeritic character."

Illinois. The reports of the Illinois Geological Survey [1–8] give no data in regard to the occurrence of the Guelph in Illinois, as Worthen declined to admit the Guelph nature of the Le Claire limestone [see above].

We have cited above, a number of typical Guelph species from Illinois localities but we learn from Prof. Stuart Weller who has been intimately concerned with the study of the Niagaran fauna that it is not now possible, with existing exposures, to say what part of the species recorded as from the "Niagara" of Illinois have actually been derived from the upper or Guelph horizon.

There are at Grafton 120 feet of a buff colored dolomite in regular

[1] Norton, W. H. Geology of Cedar County.

beds and in Cook county the upper beds are described as consisting of a light gray fossiliferous limestone weathering to a yellow or buff color, of a decidedly concretionary structure, and showing stratification very imperfectly. The rock is in many places stained with bitumen, and contains cavities filled with the substance in a semifluid condition. This rock seems to agree lithologically with the Guelph beds of Wisconsin.

Indiana. No indications of the presence of the Guelph beds in this state have been found in the Indiana geological reports. In the 21st report the following series of beds is given by Foerste: (1) Clinton; (2) Basal Niagara limestone; (3) Lower Osgood clay; (4) Osgood limestone; (5) Upper Osgood clay; (6) Laurel limestone; (7) Waldron shale. Above the Waldron shale follows the Louisville limestone, with an average thickness of 40–55 feet. In regard to this it is stated [p. 233] that immediately below the overlying Corniferous limestone there are found in it, in Clark county, Pentamerus mysius var. crassicosta, Strombodes pentagonus, Favosites favosus, Halysites catenulatus. There is herein no Guelph representation in the Louisville limestone. In the 22d annual report, Foerste [p. 214] records that fossils are rare in this limestone, and that most of them have been found just above the Waldron shale; that, further, the lowest fossils which could with certainty be identified with species from Devonic horizons have usually occurred 25 or 30 feet above the Waldron shale. It is added that the opinion, frequently expressed, that all the rocks overlying the Waldron shale are Devonic and that the top of the Waldron shale marks the top of the Siluric, it is believed will not stand investigation. The *Catalogue of the Fossils of Indiana*, furnished by Mr E. M. Kindle, contains no Guelph species.

In the geologic description of northern Indiana by I. A. Price in the 24th annual report, it is also stated that the Waldron shale does not form the top of the upper Siluric. At a number of places some 10 or 12 feet of intervening limestone is to be found between the shale and the base of the Devonic. This is called the Hartsville bed and is considered as corresponding stratigraphically to Foerste's Louisville limestone farther south. It contains no fossils.

We may conclude therefore from the observations here recorded that no strata which either lithologically or faunistically can be considered as representing the Guelph have as yet been found in this state.

Michigan. Hall has distinctly stated[1] that "at some points on the northern shore of Lake Michigan . . . there occurs a light colored limestone lying above the Niagara strata, containing generally few fossils and among them some forms not unlike those of Galt." He also noted this fact in his description of Pentamerus occidentalis.[2] The description of the rocks of the Niagara group of the upper peninsula of Michigan[3] furnishes no additional facts concerning the distribution of these rocks in that still little known region, but from the fact that the Niagara skirts the entire south shore of the Upper Peninsula and that the Salina beds appear along the water edge in some places, as in St Marys Bay, near Mackinac strait, the probable position of the Guelph outcrops may be located. It is, therefore, highly probable that the beds with Pentamerus and corals mentioned by Rominger as occurring at many places on the north shore of Lake Michigan represent actual Guelph beds. The occurrence of large Murchisonias, mentioned by the same author, supports this supposition.

Ohio. Guelph fossils are known to occur in Ohio. Hall and Clarke cite the following brachiopods:[4]

Monomerella prisca Billings, Rising Sun, Wood co.; M. newberryi H. & W., Genoa, M. ortoni H. & C., Rising Sun, Trimerella acuminata Billings, near Hillsboro, T. grandis Billings, near Sinking Spring, T. ohioensis Meek, Rising Sun, Genoa and Ottawa county.

In the second volume of *Paleontology of Ohio* Hall and Whitfield

[1] Pal. N. Y. 1859. 3:30.

[2] Pal. N. Y. 1852. 2:342.

[3] Rominger, Dr C. Geol. Sur. Michigan. Paleozoic Rocks. 1873. v. 3, pt 2. p. 31.

[4] Pal. N. Y. 1892. v. 8, pt 1.

described and figured the following Guelph forms: Trematonotus alpheus (Genoa and Springfield), Straparollus niagarensis (Cedarville), Trochonema pauper (Greenville), Cyrtoceras herzeri (Cedarville), C. myrice (Yellow Springs), Phragmoceras parvum (Cedarville).

Newberry[1] says:

In the northern part of the state the best exposures of the Niagara are at Geneva, Elmore and Washington. . . In all this region only the upper part of the Niagara is seen, the equivalent of the Guelph limestone of Canada. . . This portion of the formation is a rough, cellular, cream colored magnesian limestone sometimes mistaken for sandstone, yet being nearly a typical dolomite in composition. . . The cells and cavities which are so characteristic of this rock are usually produced through the removal, by solution, of the shells, of which it once contained great numbers; hence all its fossils are represented by casts only.

Among the fossils of the Niagara [Guelph] group which occur most abundantly in northern Ohio, may be mentioned Megalomus canadensis, Tremanotus alpheus, Pleurotomaria solarioides, Murchisonia macrospira, Trimerella ohioensis, Pentamerus occidentalis, Cypricardites? quadrilatera, Favosites niagarensis, Obolus conradi, etc.

In the southwestern portion of the state one of the best sections is found at Hillsboro and was thus determined by Edward Orton.[2]

		FEET
1	Hillsboro sandstone	30
2	Guelph, Cedarville or Pentamerus limestone	20
3	Upper or Springfield cliff	45
4	Lower or West Union cliff	45
5	Niagara shales	60
6	Dayton limestone	5

Newberry says of this: "The upper limestone of the Hillsboro section is evidently the equivalent of that exposed at Geneva, Elmore, etc., and like that, represents the Guelph division of the Niagara. It contains nearly the same fossils at Hillsboro as at Geneva . . . but Pentamerus

[1] Geol. Ohio. 1873. 1:129.

[2] Report of Progress for 1870, p. 301.

oblongus is much more abundant here than at the north." The appended list of fossils includes, besides Niagaran corals and crinoids: Trimerella ohioensis, T. grandis, Obolus conradi, Pentamerus oblongus, Murchisonia macrospira, M. laphami, Platystoma niagarense, Megalomus canadensis, Trochoceras desplainense, Orthoceras abnorme, Calymmene niagarensis.

From Dr Orton's original description of this section[1] we select the following data: The Guelph or Cedarville limestone is a massive magnesian limestone (carbonate of lime 54.25%, carbonate of magnesia 43.23%) varying in thickness from 20 to 90 feet. Even where the whole of the original deposit is present, as in sections where it is found inclosed between higher and lower formations, it has the wide limits already given. It contains bituminous matter distributed through its substance, and it is pointed out that the oil-bearing limestones of Chicago belong to the same horizon. This formation is often destitute of distinct bed lines in its structure. It is acted on quite easily by atmospheric agencies and by its unequal weathering the faces of the cliffs that it forms are rough and irregular.

It will be noticed that this rock shows notable agreement with the Guelph rocks of New York.

Pentamerus oblongus is the most common fossil of the Guelph through this region and further west and it gave the name to the formation. In New York and Canada this shell is a Clinton and Niagaran species but in Ohio it appears in full force only in the upper Niagaran limestone and Guelph. Certain layers are heavily charged with Megalomus while Trimerella is also very abundant. Large gastropods and corals show in many places. The Guelph is overlain by and interstratified with the Hillsboro sandstone and is the only known instance of distinct shore conditions recognizable during the Guelph stage.

Orton also described the section at Yellow Springs, Greene co. where

[1] Rep't of Progress, 1871, p. 278 *et seq.*

the Cedarville dolomite shows an exposure of 23 feet, with a total of 40 feet. In connection with this section it is remarked:[1]

It has received the names of various localities where it is distinctly shown, being styled the Guelph formation in Canada, the Racine beds or Milwaukee beds in Wisconsin and the Bridgeport beds in northern Illinois. In southern Ohio no local name can be selected as appropriate and free from ambiguity as the Cedarville limestone.

Finally in regard to this formation generally within the state of Ohio, Dr Orton wrote in 1893:[2]

The uppermost division of the [Niagaran] formation is the Guelph limestone which differs very noticeably in several points from the Niagara limestone proper. . . It has a maximum thickness in southern Ohio of 200 feet. . . It is either massive or very thin bedded. It is porous to an unusual extent. It is generally very light in color. It is exceedingly rich in fossils containing a large number that is thoroughly characteristic.

Unlike the previously named divisions of the Niagara, the Guelph limestone is as well developed in northern as in southern Ohio in all respects. Not more than 40 feet of it are found in its outcrops there, but the drill has shown several times this amount of Niagara limestone, without giving us, however, the data needed for referring the beds traversed to their proper subdivisions. What facts there are seem to point to the Guelph as the main element in this underground development of this formation in this portion of the state.

From the foregoing we may conclude that the area in which the Guelph fauna manifests itself extends from Wayne county, N. Y. westward to Hamilton Ont., thence northwestward to Cape Hurd and Manitoulin island, and northward almost to James bay. Here it follows the Niagaran on the inner side of the vast arc spanned by that formation over the islands of Georgian bay, the north shore of Lake Huron and north and west shores of Lake Michigan. Still farther to the northwest, evidence of this sediment is afforded by the presence of the coral Pycnostylus guelphensis and the Stromatoporoid Clathrodictyum ostiolatum, on the west shore of Lake Manitoba.[3]

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[1] Geol. Ohio. 1874. 2:674.

[2] Geol. Ohio, 7:12.

[3] Reported by Whiteaves. Paleozoic Fossils. 1893. v. 3, pt 2, p. 46.

West of Lake Michigan these deposits spread over southern Wisconsin, northern Illinois and into Iowa, where their extension in this direction is terminated by the barrier of earlier formations. In Ohio it borders the north and east shores of the Cincinnati dome.

Over all this amphitheater, bounded without by the Niagaran, we may conceive of a shallowing sea, dotted with coral banks which must in no small measure have fringed the shore. Indeed contiguity to the shore line of the Cincinnati dome is clearly indicated by the Hillsboro sandstone interbedded with the upper dolomites. It was an almost inclosed sea, its opening being probably through the narrow way toward the north and northwest, a region which still holds the clue to many of our exotic faunas.

In this connection it appears also significant that in the terminal beds of the upper Siluric of Gothland a fauna appears which contains the genera characteristic of the Guelph and often species which are hardly distinguishable. These are specially contained in the beds *f*, *g*, *h* ; *f* being characterized[1] as limestone beds composed of crinoids and corals ; *g*, large banks of Megalomus and Trimerella, and *h*, Cephalopodan and Stromatopora beds. In looking over these lists one can not fail to conceive the idea that the much richer fauna of these beds contains a vicarious fauna of the American Guelph, for we find there Monomerella, Trimerella (with three species), with the absence of the majority of the Wenlock forms ; Megalomus among the lamellibranchs ; Trematonotus and a very large number of cephalopods and gastropods, including Pleurotomaria, Murchisonia, Loxonema, Trochus, Pycnomphalus, Horiostoma, etc. ; also Stromatoporas.

The appearance of such peculiarly adapted forms as the Trimerellas and Megalomus, at corresponding horizons and in similar associations, is certainly very suggestive not only of the presence of the identical facies, but also of faunistic intercourse between the two seas.

There is a generally recognized distinction between the rich Siluric faunas of northern Europe and those of Bohemia and the Mediterranean

[1] *See* Swedish State Mus. Pal. Dep't. *ed.* List of the Fossil Faunas of Sweden, II, Upper Siluric.

region. Kayser has recently expressed[1] this distinction by terming the former the normal facies or that appertaining to the oceans at large, while the latter is to be regarded as having the value of a local facies. The former it is that is more widespread throughout the world and which we have constantly growing evidence for believing has entered the interior sea of America by way of northern Canada. Its incarceration in the American paleozoic mediterranean has doubtless superinduced a measure of provincial characteristics in some of the minor faunas but the features we find in the Guelph common to those of the Scandinavian faunas appertain to the marine life of the inclosed seas of late Siluric time.

The Coralline or Cobleskill limestone. This study of the Guelph fauna and stratigraphy has thrown important light on the proper construction of the fauna of the Coralline limestone of eastern New York. This formation was first recognized as an element in the succession by John Gebhard, and by Prof. Hall was considered an eastern continuation of the Niagaran limestone. We have elsewhere suggested that the objectionable character of its designation may be remedied by employing for it the term Cobleskill limestone, as along this creek in Schoharie county, N. Y., the section of the formation is typically expressed. We do not here propose entering on an extended discussion of this fauna and its stratigraphic relations. These matters, which we have had under consideration for some years, have recently been made the subject of careful and extended investigation by C. A. Hartnagel, of the staff of this division and we have invited him to insert here the following brief statement of his preliminary conclusions so far as they bear on the relation of this fauna to the Guelph.

The Cobleskill formation in its typical development at Schoharie and Howes Cave, Schoharie co. consists of a massive layer of dark gray, somewhat magnesian limestone averaging 6 feet in thickness. Above this limestone and clearly distinguished from it by a change in lithologic character, lie the Rondout beds, 40 feet thick and marked by basal layer of "cement rock," 6 feet thick. Above this are 45 feet of typical Manlius limestone. Underlying the Cobleskill and resting upon the Lorraine beds are 30 feet

[1] Geologische Formationskunde. ed. 2. 1902. p. 102.

of green argillaceous shales which doubtless pertain to the Salina stage. The Cobleskill or Coralline limestone fauna was early described by Hall who regarded it the eastern representative of the Niagaran group as then known in western New York. He interpreted the underlying shales as of Clinton age. Recent examination however clearly indicates that the Cobleskill limestone as shown in the section described pertains to an age later than Salina, as has been suggested by Schuchert.

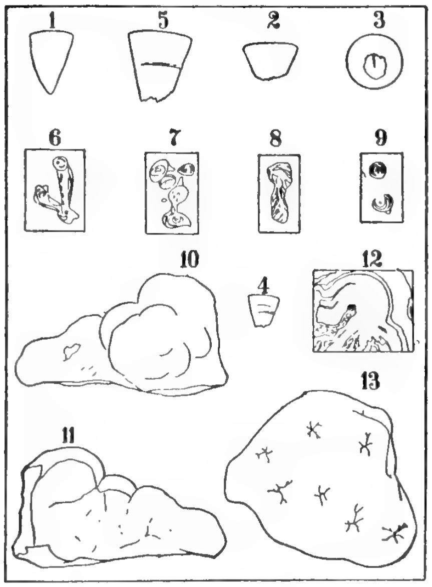
One of the marked differences between the faunas of the Niagaran of New York and the Cobleskill is the presence in the latter of quite an extensive gastropod and cephalopod fauna — one of the features which strongly affiliates it with the Guelph. And, indeed, Hall, in the original descriptions of Pleurotomaria subdepressa and Murchisonia terebralis, notes in each case a similarity to forms described from the Guelph.

An interesting feature of some of the gastropods from the Cobleskill is that in form they are sinistral. Pleurotomaria subdepressa mentioned above belongs to this class. Another species is distinguished from Poleumita crenulata Whiteaves (Guelph), only by its sinistral form. Other specimens of the genus Pleurotomaria have been found which in size and form are similar to the Guelph species, but the delicate surface markings often so well preserved in the Guelph dolomites and upon which specific determinations to a certain degree are dependent, have not yet been ascertained in the Cobleskill limestone specimens and thus specific comparisons become unsatisfactory. Kionoceras darwini Billings occurs at Schoharie, and in the western extension of the Cobleskill fauna on Frontenac island, Cayuga lake, where Orthoceras trusitum Clarke & Ruedemann and Gomphoceras septoris Hall (Guelph) are also found. In Schoharie county mature specimens of Ilionia galtensis Whiteaves occur. Associated with them are forms which in outline and dimensions approach Ilionia canadensis Whiteaves and to that species they are provisionally referred. Spirifers from the Guelph have obsolescent plications and a sinus similar to Spirifer crispus var. corallinensis Grabau.

There are other species common to these faunas but they are mostly forms occurring also in the Niagaran and indicative solely of a late Siluric stage.

EXPLANATION OF PLATES

PLATE 1



Enterolasma cf. **caliculus** Hall (sp.)

Page 24

FIG.

1 The exterior, natural size

Zaphrentis cf. **racinensis** Whitfield

Page 23

2, 3 Lateral and basal view of an internal cast of the calyx. Natural size

Heliophyllum sp. indet.

Page 28

4 Internal cast of a specimen. Natural size

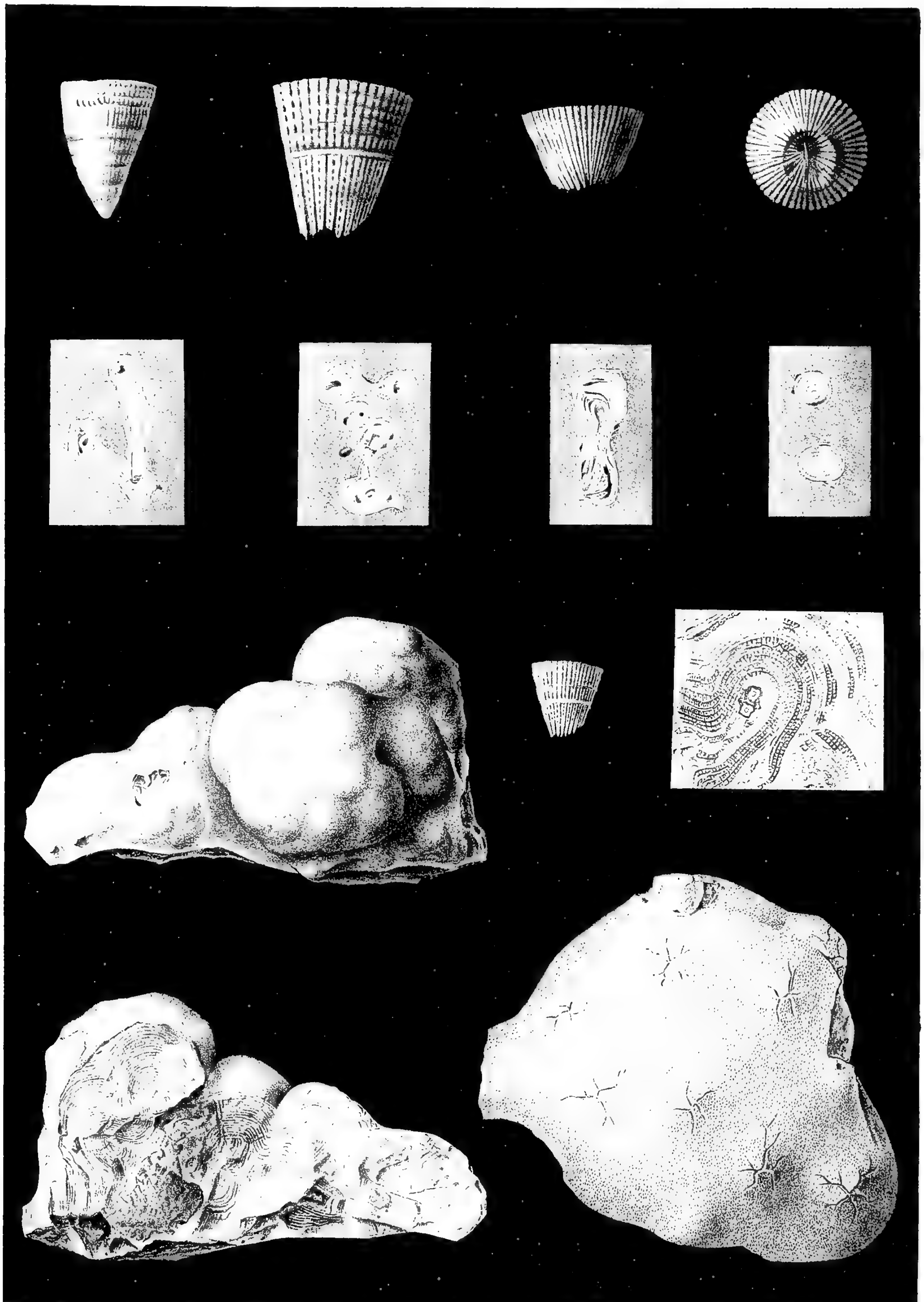
5 Same, x2 ; to show the impressions of the denticulated carinae on the septa

Syringopora infundibulum Whitfield

Page 35

6–9 Sections obtained on a polished surface, to show the spiniform septa, funnel-shaped tabulae and transverse, hollow connecting processes. x2

GUELPH FAUNA



G S Barkentin del J.B Lyon Co. State Printer Phil. Ast, lith

Clathrodictyum ostiolatum Nicholson

Page 37

FIG.

10 Surface view of specimen, showing the characteristic botryoidal surface. Natural size

11 Section, shown on broken side of same specimen, and exhibiting the calcareous laminae. Natural size

12 Thin section of a portion, x2, showing the laminae and intermediate vertical dissepiments

Stromatopora galtensis Dawson (sp.)

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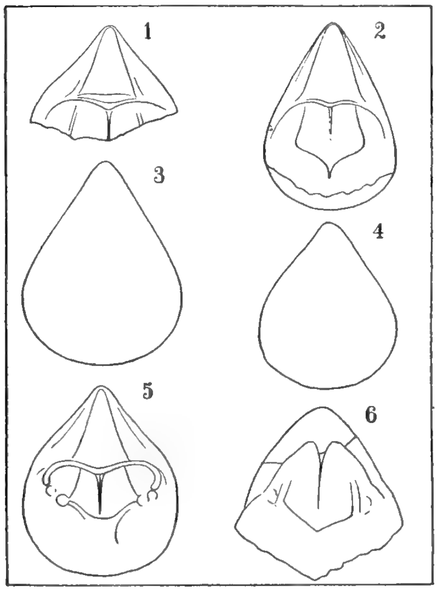
13 A fragment exhibiting the astrorhizae. x3

The originals of fig. 1–5, 10–13 are from the Guelph bed at Rochester (Arey collection); those of fig. 6–9 from the Upper Shelby bed (N. Y. State Museum).

PLATE 2



Monomerella noveboracum sp. nov.

(*See* plate 3 and plate 4, fig. 38)

Page 39

FIG.

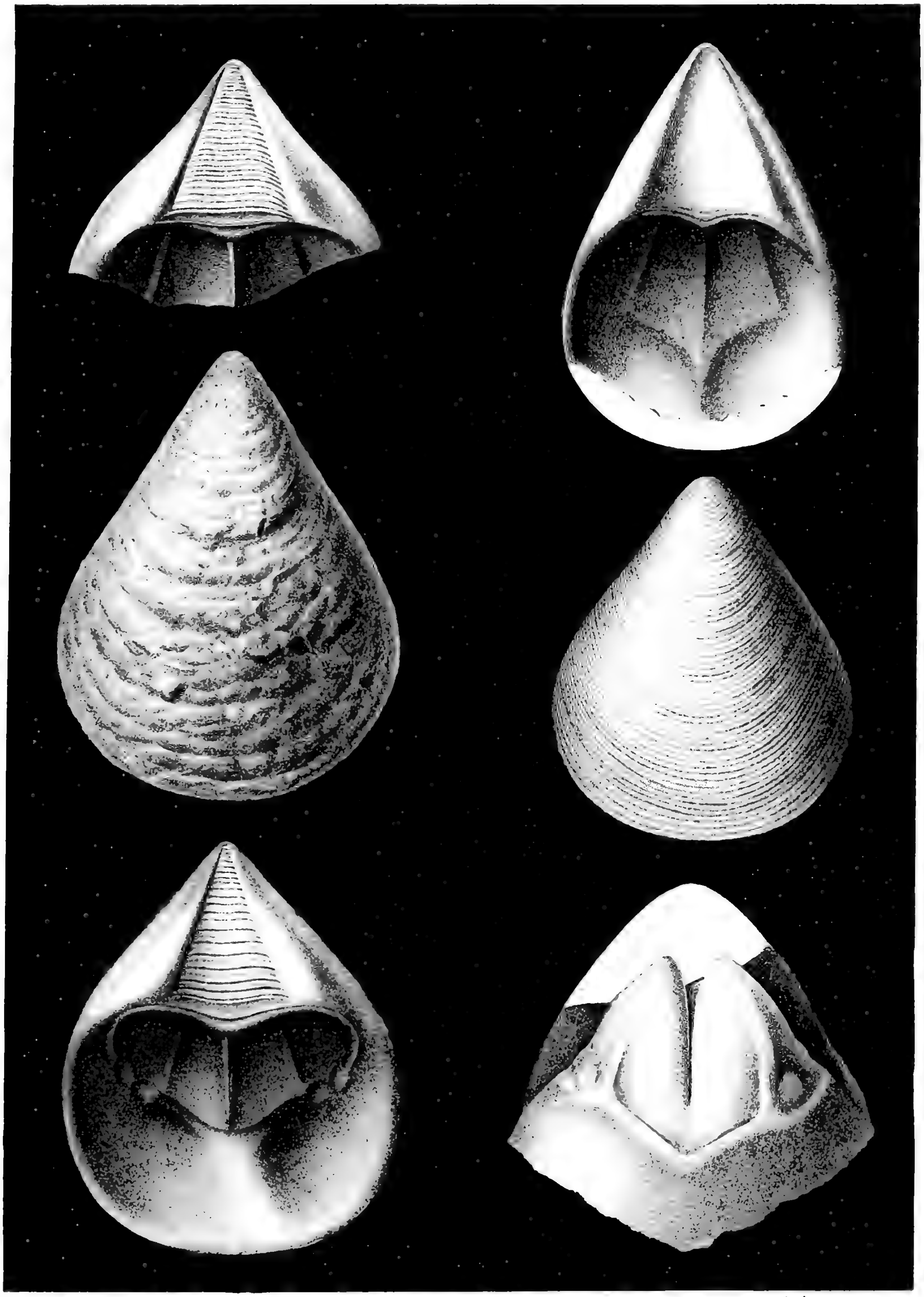
1 Cardinal area of a pedicle valve, showing the coarse striations of the pedicle groove, the lateral slopes, the character of the cardinal slope and cardinal groove, and the narrow but high cardinal buttress

2 A pedicle valve with very high and relatively narrow cardinal region and more depressed median area. From a gutta-percha squeeze of the natural impression

3 The exterior of the pedicle valve of an old individual with very irregular squamous surface. From a gutta-percha squeeze of a natural impression; slightly restored at the anterior and posterior ends

4 The exterior of a younger pedicle valve, showing the growth lines. Also from a gutta-percha impression

GUELPH FAUNA.



G. S. Barkentin. del. J. B. Lyon Co. State Printer. Phil. Ast, lith.

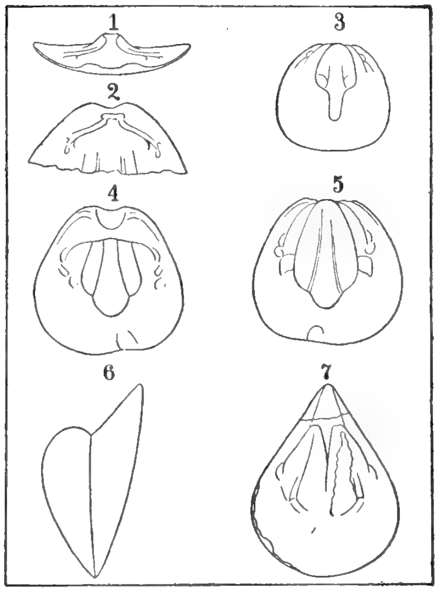
FIG.

5 The interior of a pedicle valve, with the subdivisions of the crescent sharply defined and showing the extent of the cardinal buttress and the low anterior septum. Slightly restored at the umbo. From a gutta-percha impression of the internal cast represented on plate 3, fig. 7

6 Internal cast of part of the pedicle valve of an old individual, showing very strongly marked lateral crescent and platform muscle scars, and short but broad platform vaults

All specimens are drawn in natural size and come from the Lower Shelby bed at Shelby, Orleans co. N. Y. Originals in N. Y. State Museum.

PLATE 3



Monomerella noveboracum sp. nov.

(*See* plate 2 and plate 4, fig. 38)

Page 39

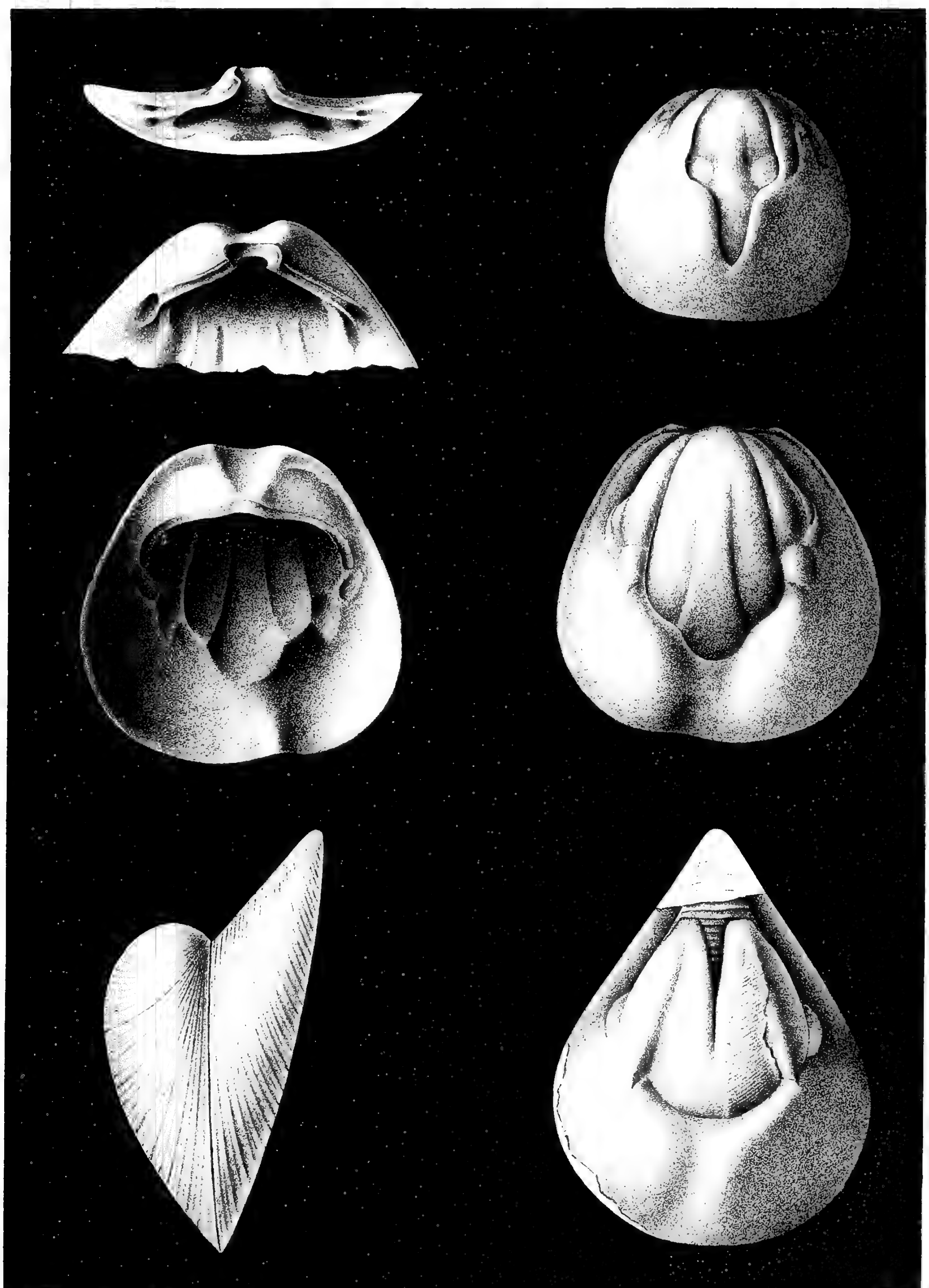
FIG.

1, 2 Two views of the cardinal region of the brachial valve, showing the hinge line and the strongly developed crescent. From a gutta-percha squeeze of a natural impression

3 An internal cast of a brachial valve, with the muscular impressions of the platform strongly defined, showing the short platform vaults

4, 5 The interior of a large brachial valve, shown as a natural cast (fig. 5) and as a gutta-percha squeeze taken from this cast (fig. 4). These show well the broad form of the valve, the muscular impressions, the form of the platform and the anterior septum.

GUELPH FAUNA.



G S Barkentin del. J B Lyon Co. State Printer. Phil. Ast. lith.

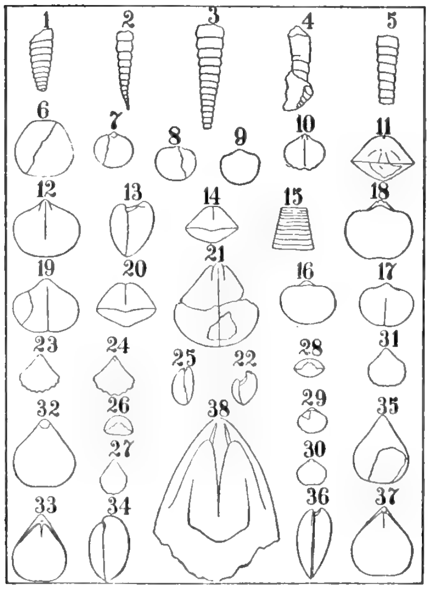
FIG.

6 Lateral view of the two valves in apposition reconstructed from the brachial and pedicle valves figured on this plate, showing the long straight cardinal region, the nearly straight profile of the pedicle valve and the more convex contour of the brachial valve

7 An internal cast of a large pedicle valve, showing the high cardinal area, the very deep platform vaults and the characteristic markings of the platform, as well as the impressions of the sides of the crescent, and the anterior septum

All specimens are drawn natural size, and are from the Lower Shelby bed at Shelby N. Y. Originals in N. Y. State Museum.

PLATE 4



Cornulites arcuatus Conrad

Page 105

FIG.

1 Internal cast of a stout, rapidly tapering specimen. Natural size. Rochester (Arey collection)

2 Internal cast of a slender, slightly arcuate specimen from a gutta-percha squeeze of a natural impression. Natural size. Lower Shelby bed (N. Y. State Museum)

3 A specimen with slightly different character of the annulations. x2. Rochester (Arey collection)

4 A specimen retaining part of the shell and natural surface. Upper Shelby bed (N. Y. State Museum)

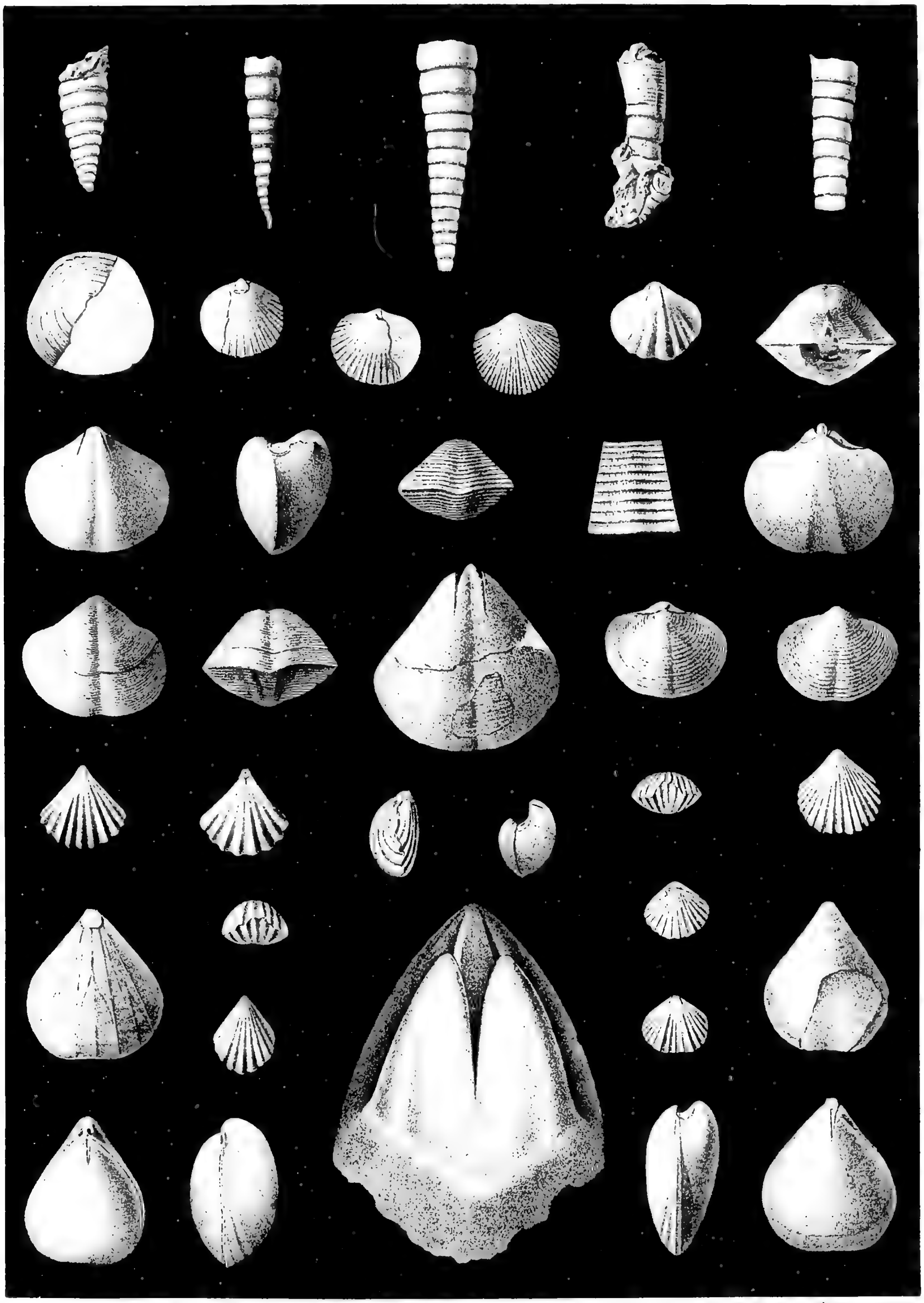
5 An internal cast of a large specimen. Natural size. Rochester

Crania sp.

Page 38

6 Single specimen observed. x2. Rochester (Arey collection)

GUELPH FAUNA



G S Barkentin del J B Lyon Co. State Printer Phil. Ast lith

Dalmanella cf. **hybrida** Sowerby (sp.)

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FIG.

7, 8 Two views of a small shell, doubtfully referred to this species. x5. Rochester (Arey collection)

Dalmanella cf. **elegantula** Dalman (sp.)

Page 41

9 Single specimen observed. x3. Rochester (Arey collection)

Spirifer crispus (Hisinger) Hall

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10 Internal cast of the ventral valve of a specimen with obscure ribs. Natural size. Upper Shelby bed (N. Y. State Museum)

11, 19, 20 Three views of a well preserved example of the prevailing expression of the species, showing the character of the surface. x2. Upper Shelby bed (N. Y. State Museum)

12, 13, 18 Three views of the internal cast of a similar form. x2. Rochester (Arey collection)

14, 16, 17 Three views of a finely preserved specimen from the same locality. x3

15 Enlargement of the surface, to show the characteristic papillose sculpture of the species. x5. Rochester (Arey collection)

Spirifer cf. **bicostatus** (Vanuxem) Hall

Page 44

21 Internal cast of a ventral valve. x2. Rochester (Arey collection)

22 Lateral view of a shell with similar characters. Natural size. Upper Shelby bed (N. Y. State Museum)

Rhynchotreta cuneata americana Hall

Page 46

23–25 Three views of a specimen, natural size. Upper Shelby bed (N. Y. State Museum)

Camarotoechia (?) **indianensis** Hall

Page 46

FIG.

26, 27 Two views of a gutta-percha squeeze from a natural impression. Natural size. Lower Shelby bed (N. Y. State Museum)

Camarotoechia (?) **neglecta** Hall

Page 45

28–30 Three views of a specimen, natural size. Rochester (Arey collection)

31 View of the ventral valve of an excellently preserved typical specimen. x2. Rochester (Arey collection)

Whitfieldella nitida Hall

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32, 36, 37 Three views of a broad and flat specimen, an internal cast, showing pallial sinuses on pedicle valve. x2

33, 34, 35 Three views of a higher and thicker specimen. x2. Rochester (Arey collection)

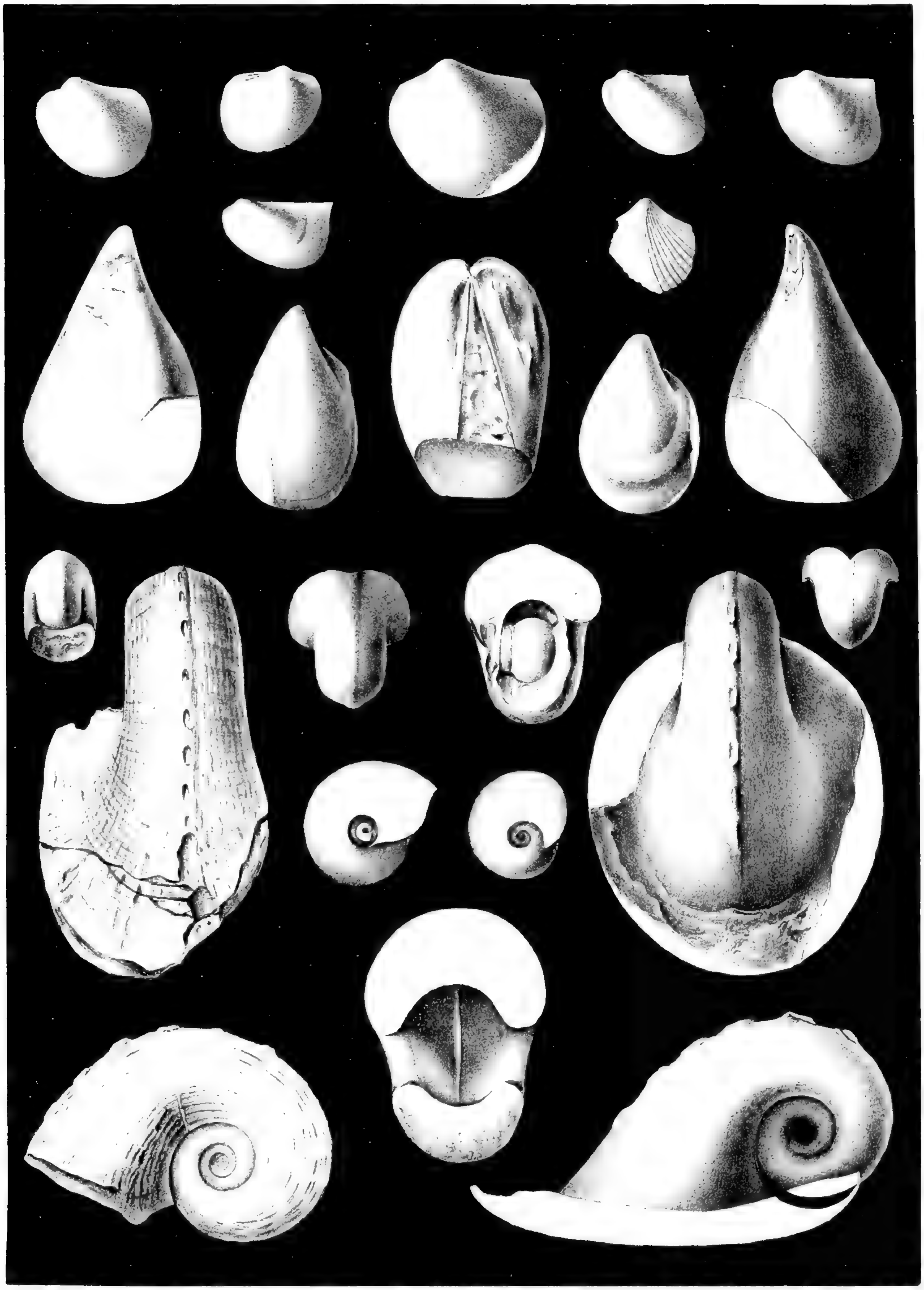
Monomorella noveboracum sp. nov.

(*See* plates 2 and 3)

Page 39

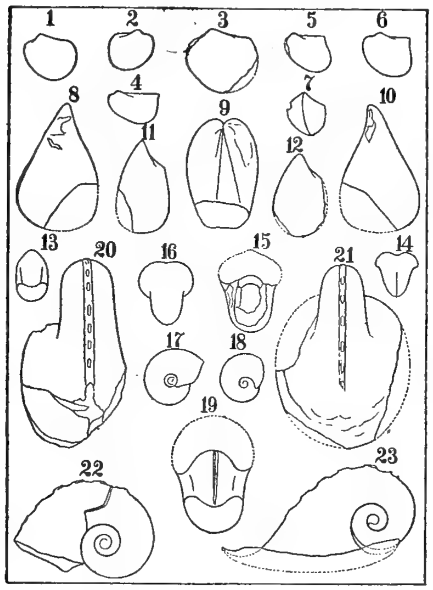
38 Internal cast of a very high pedicle valve with extremely long platform vaults. Natural size. Lower Shelby bed (N. Y. State Museum)

GUELPH FAUNA



W S Barkentin del J B Lyon Co. State Printer Phil. Ast lith

PLATE 5



Modiolopsis sp.

FIG.

1 Internal cast of left valve. x2

2 Same of a right valve, showing posterior cartilage pit. x2

3 Internal cast of a larger individual with suborbicular outline. x2

5 Internal cast of a small, more oblique specimen with long posterior wing. x2

All are from the Guelph at Rochester (Arey collection)

Pterinea subplana Hall (sp.)

Page 49

4 Internal cast of a left valve, natural size. Upper Shelby bed (N. Y. State Museum)

Pterinea undata Hall (sp.)

Page 50

6 Internal cast of a left valve. x2. Upper Shelby bed (N. Y. State Museum)

Conocardium sp.

Page 50

FIG.

7 View of a left valve. x3. Rochester (Arey collection)

Mytilarca eduliformis sp. nov.

Page 47

8–10 Three views of the type specimen. x2. Lower Shelby bed (N. Y. State Museum)

Mytilarca acutirostrum Hall (sp.)

Page 48

11 Internal cast of a high left valve. Natural size

12 Another more gibbous specimen, showing the posterior lateral teeth. Natural size

Both specimens are from the Lower Shelby bed (N. Y. State Museum).

Bellerophon shelbiensis sp. nov.

Page 51

13 Ventral view of a specimen, apertural part broken away. Natural size

14 Dorsal view of an internal cast, showing aperture and apertural emargination. Natural size

18 Lateral view of same specimen, showing cast of umbilicus. Natural size

15 Broken specimen, showing inner volution and umbilical wall. x2

16, 17 Two views of a large specimen, showing aperture and dorsal keel. Natural size

19 View of inner side of volution, showing slit band of preceding volution. Natural size

All specimens are from the Lower Shelby bed (N. Y. State Museum).

Trematonotus alpheus Hall

(*See* plate 6, fig. 1–9)

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FIG.

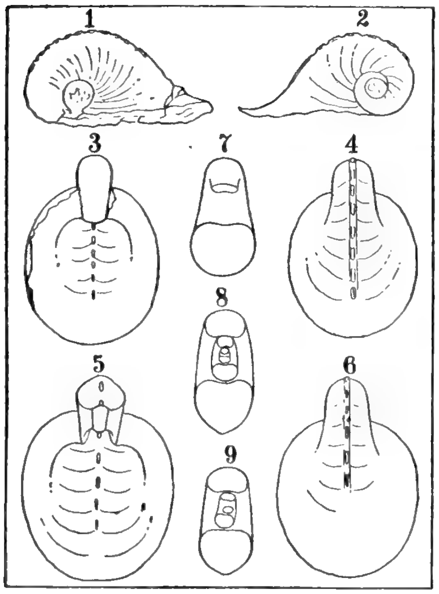
20 Dorsal view of sculpture cast, showing peristome. Natural size. Rochester (Arey collection. Same specimen as plate 6, fig. 1)

21 Dorsal view of internal cast, showing dorsal perforations and smooth internal surface. Natural size

23 Lateral view of same cast, showing umbilicus and inner volutions. Natural size. Lower Shelby bed (N. Y. State Museum)

22 Fragment of a specimen with very strongly developed revolving ridges and wide umbilicus. Natural size. Rochester (Arey collection)

PLATE 6



Trematonotus alpheus Hall

(*See* plate 5, fig. 20–23)

Page 54

FIG.

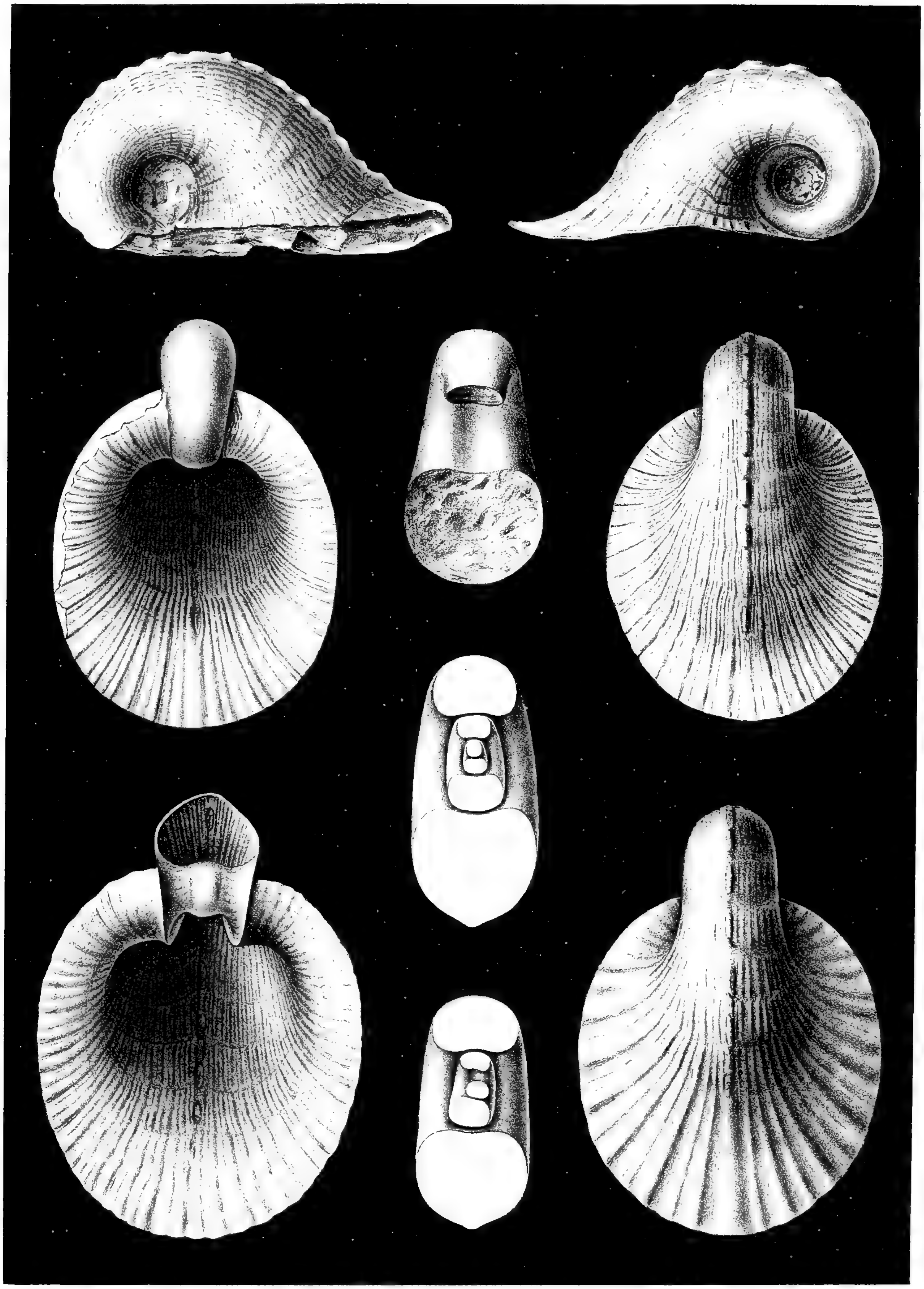
1 Lateral view of a specimen, showing the revolving ribs and the broad transverse folds

2 Lateral view of a specimen, showing distinctly the dorsal keel interrupted by the perforations, the alternation of the revolving ribs and the wide and deep umbilicus. From a gutta-percha impression of a natural mold

3 A natural cast of the exterior of the apertural part of the last volution and of the interior of the penultimate volution, showing the dorsal perforations of the last volution and the smooth internal surface of the earlier volutions

4 An exterior dorsal view of a shell, showing distinctly the interruptions of the revolving ribs by concentric growth and the widening of the ribs upon the lip. From a gutta-percha squeeze of a natural impression

GUELPH FAUNA.



G S Barkentin del J B Lyon Co. State Printer Phil. Ast, lith.

FIG.

5 A natural cast of the exterior of an older individual, showing a more nodose character of the revolving ribs upon the outer lip and the cast of one of the innermost volutions

6 The exterior of the last volution of a gerontic specimen, showing a partial suppression on the outer lip of the smaller ribs which are made much too strong in the drawing. From a gutta-percha impression of a natural mold

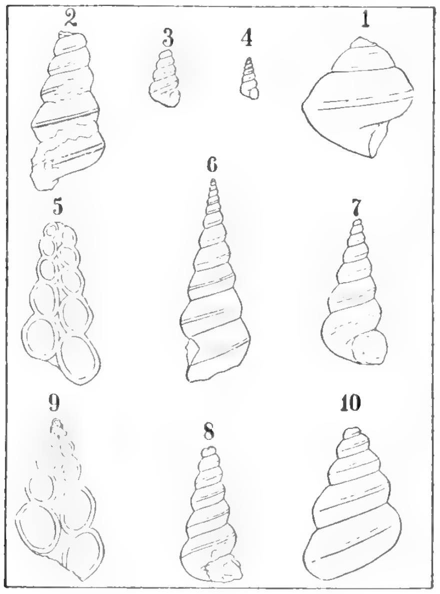
7 Ventral view of the internal cast of the last volution, showing the ventral depressed zone

8 Section of an internal cast, showing the relative width and hight of the volutions

9 Another section of an internal cast, exhibiting a somewhat asymmetric arrangement of the inner volutions

All specimens drawn natural size. With the exception of the original of fig. 1 which is from the Guelph at Rochester (Arey collection), all are from the Lower Shelby bed (N. Y. State Museum).

PLATE 7



Eotomaria kayseri sp. nov.

(*See* plate 8, fig. 1)
Page 70

FIG.

1 Lateral view of the internal cast

Coelidium macrospira Hall (sp.)

(*See* plate 10, fig. 13)
Page 65

2 Lateral view of a specimen with angular volutions, showing distinctly the surface characters

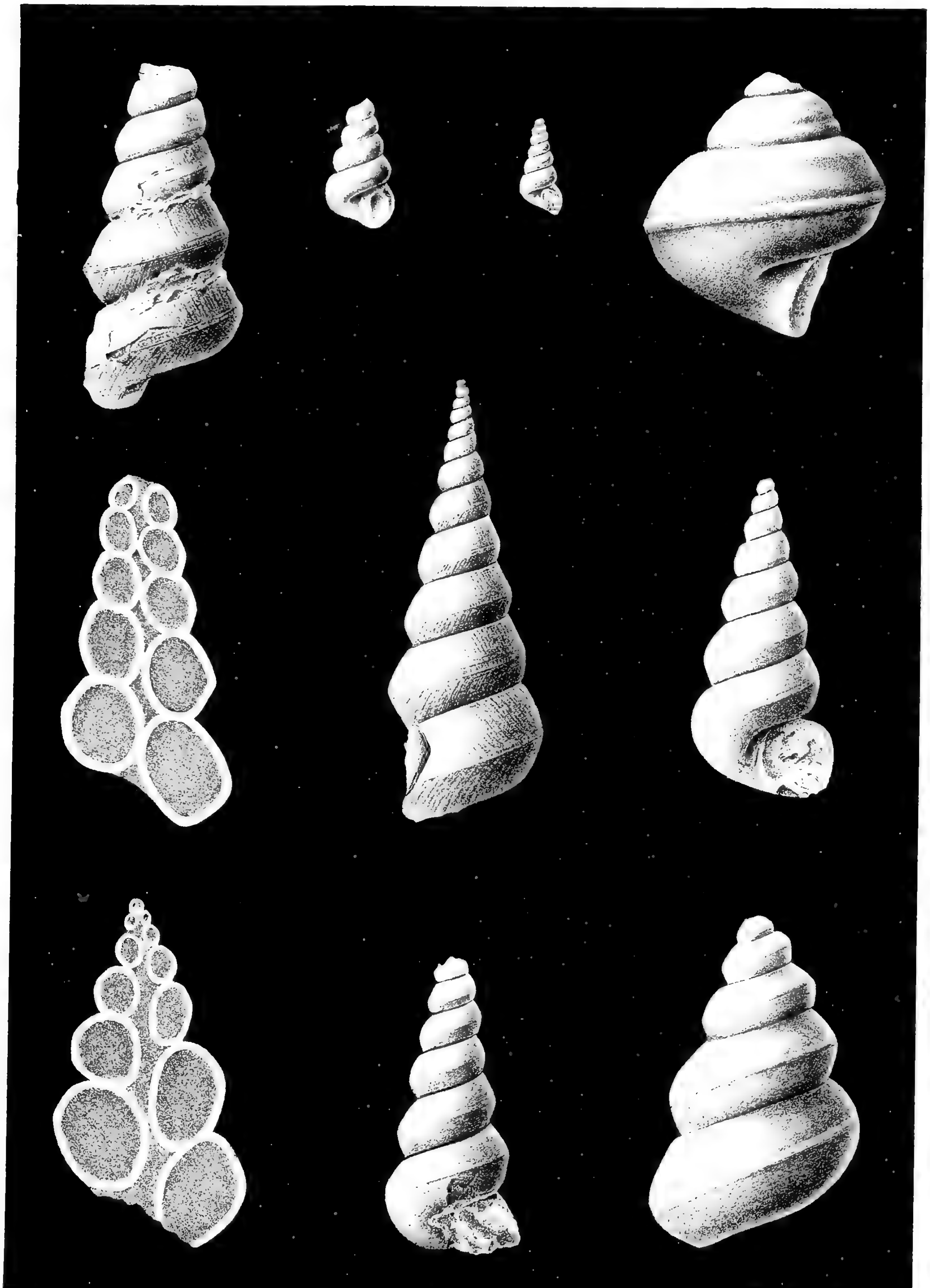
3 Young, somewhat rapidly widening specimen with rounded volutions (M. l o g a n i)

4 A still younger specimen, showing the same characters

5 A section of the specimen figure 2, showing the perforate axis of the shell

6 A nearly complete example, showing a gradual change from the round to more angulated volutions. From a gutta-percha squeeze of a natural impression

GUELPH FAUNA.



W S Barkentin. del.

J B Lyon Co. State Printer

Phil. Ast, lith

FIG.

7 An internal cast of the shell, showing the rounded character of the volutions (M. logani)

8 Another internal cast of a shell, showing the rounded volutions, which are all represented as too angular

Coelidium cf. **vitellia** Billings (sp.)

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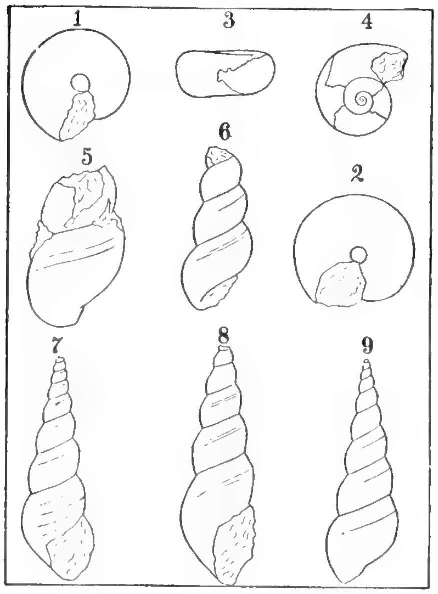
9 Section of the shell, showing the wide perforation of the axis; rather badly restored at the apex

10 Exterior view of the same specimen

All specimens are drawn natural size and are from the Guelph beds at Rochester (Arey collection).

PLATE 8



Eotomaria kayseri sp. nov.

(*See* plate 7, fig. 1)

Page 70

FIG.

1 Basal view of the specimen represented on plate 7, showing the narrow umbilicus

Eotomaria areyi sp. nov.

(*See* figures, p. 69)

Page 68

2 Basal view of the type specimen represented on p. 69, exhibiting the narrow umbilicus and the growth lines

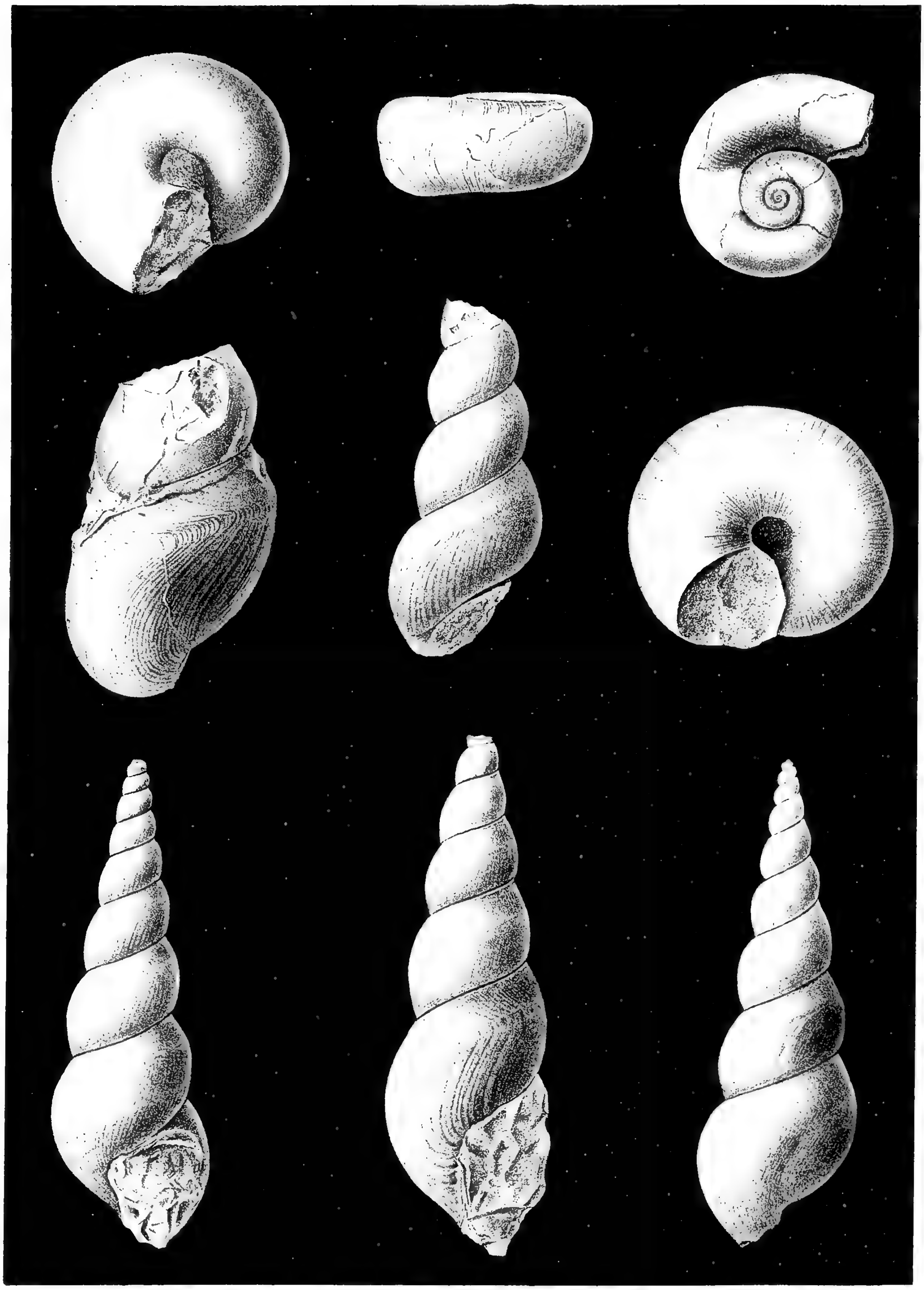
Euomphalus fairchildi sp. nov.

Page 75

3 Lateral view of the type specimen of the species, showing the forward curvature of the growth lines

4 Upper side of the same specimen

GUELPH FAUNA.



G.S. Barkentin. del. J.B. Lyon Co. State Printer. Phil. Ast, lith.

Hormotoma whiteavesi sp. nov.

Page 72

FIG.

5 Last volutions of a very large individual with strongly marked sculpture of the surface and slit band

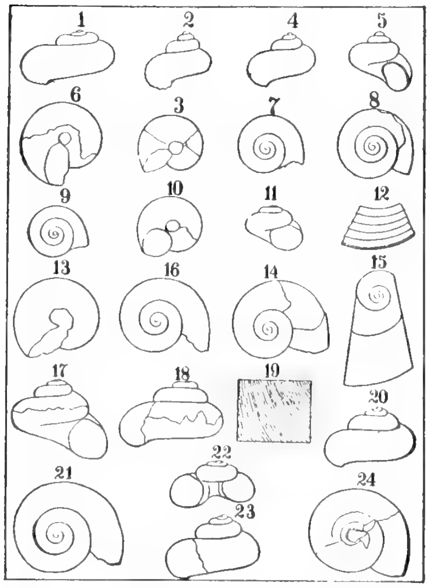
6 A younger, very slender specimen, showing the strongly recurving growth lines

7, 9 Two views of a nearly complete specimen in solid chert with very faint indications of the growth lines and slit band

8 View of a very large example, showing the long, narrow, prolonged aperture

All specimens are drawn natural size, and are from the Guelph beds at Rochester (Arey collection).

PLATE 9



Poleumita scamnata sp. nov.

Page 60

FIG.

1 Lateral view of a specimen with depressed spire

2, 3, 5 Three views of an individual with high spire

4, 7 Two views of an average specimen

6 Umbilical view, showing the size of umbilicus

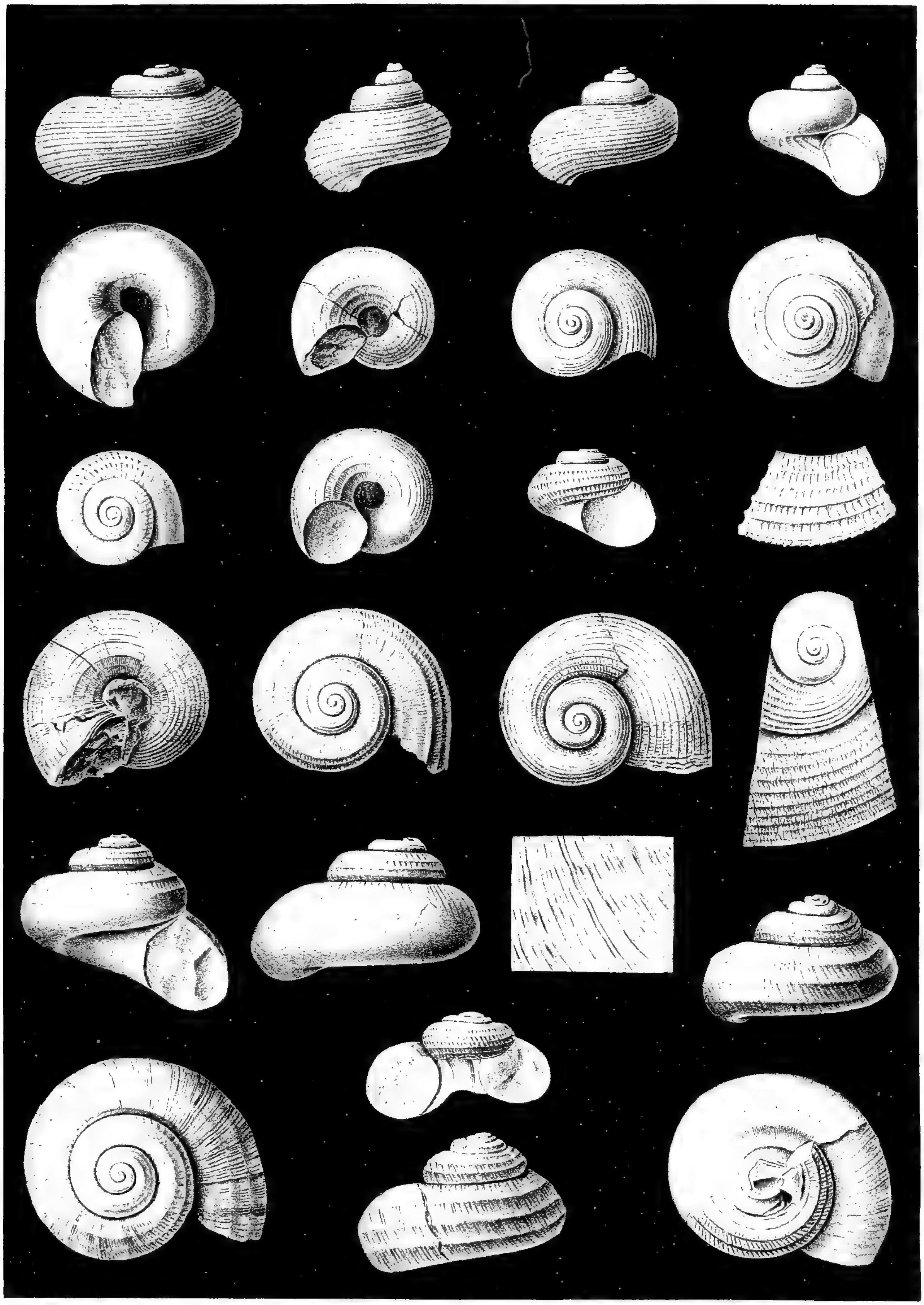
8 Apical view of a young specimen, showing distinctly the surface sculpture of the early volutions. x2

10 Umbilical view of a specimen with very distinct sculpture of the basal region

12 Enlargement of the surface. x3

13 Umbilical view of an older individual, showing the wider interval between the revolving lines near the umbilicus.

14 Apical view of an individual with very sharp revolving and indistinct transverse lines. From a gutta-percha squeeze of a natural impression (*see* fig. 12)



G. S. Barkentin. del. J. B. Lyon Co. State Printer Phil. Ast, lith

FIG.

15 Enlargement of part of a specimen with extremely coarse revolving and irregular transverse lamellose growth lines on the last volution

Poleumita crenulata Whiteaves (sp.)

Page 64

9, 11 Two views of a young specimen, exhibiting very sharp sculpture lines

16 Apical view of a typical individual. From a gutta-percha squeeze of a natural cast. Lower Shelby bed (N. Y. State Museum)

17, 18 Two views of a specimen with very sharp, distant, transverse lines, showing also the gradual suppression of the revolving ridges upon mature volutions

19 Enlargement of the sculpture on the basal side of a large individual, showing the coarse growth lines and the faint revolving ridges. x3

20 Individual retaining the revolving ridges upon the last volution

21 A very large individual, showing distinct gerontic characters upon the last volution. From a gutta-percha squeeze of a natural impression. Lower Shelby bed (N. Y. State Museum)

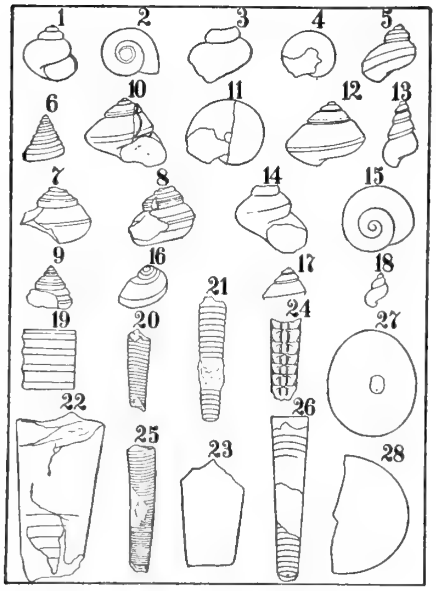
22 Natural section of the volutions

23 Lateral view of an individual with depressed spire

24 Apical view of a specimen, showing strong contrast between the ornament of the last and early volutions

All figures are natural size and all originals are from the Guelph at Rochester, where not otherwise stated.

PLATE 10



Poleumita (?) **sulcata** Hall (sp.)

Page 62

FIG.

1, 2 Two views of a typical specimen. Natural size

3, 4 Profile and umbilical views of another specimen. Natural size. Rochester (Arey collection)

Trochonema cf. **fatuum** Hall

Page 75

5 Lateral view of the only specimen observed. Natural size. Upper Shelby bed (N. Y. State Museum)

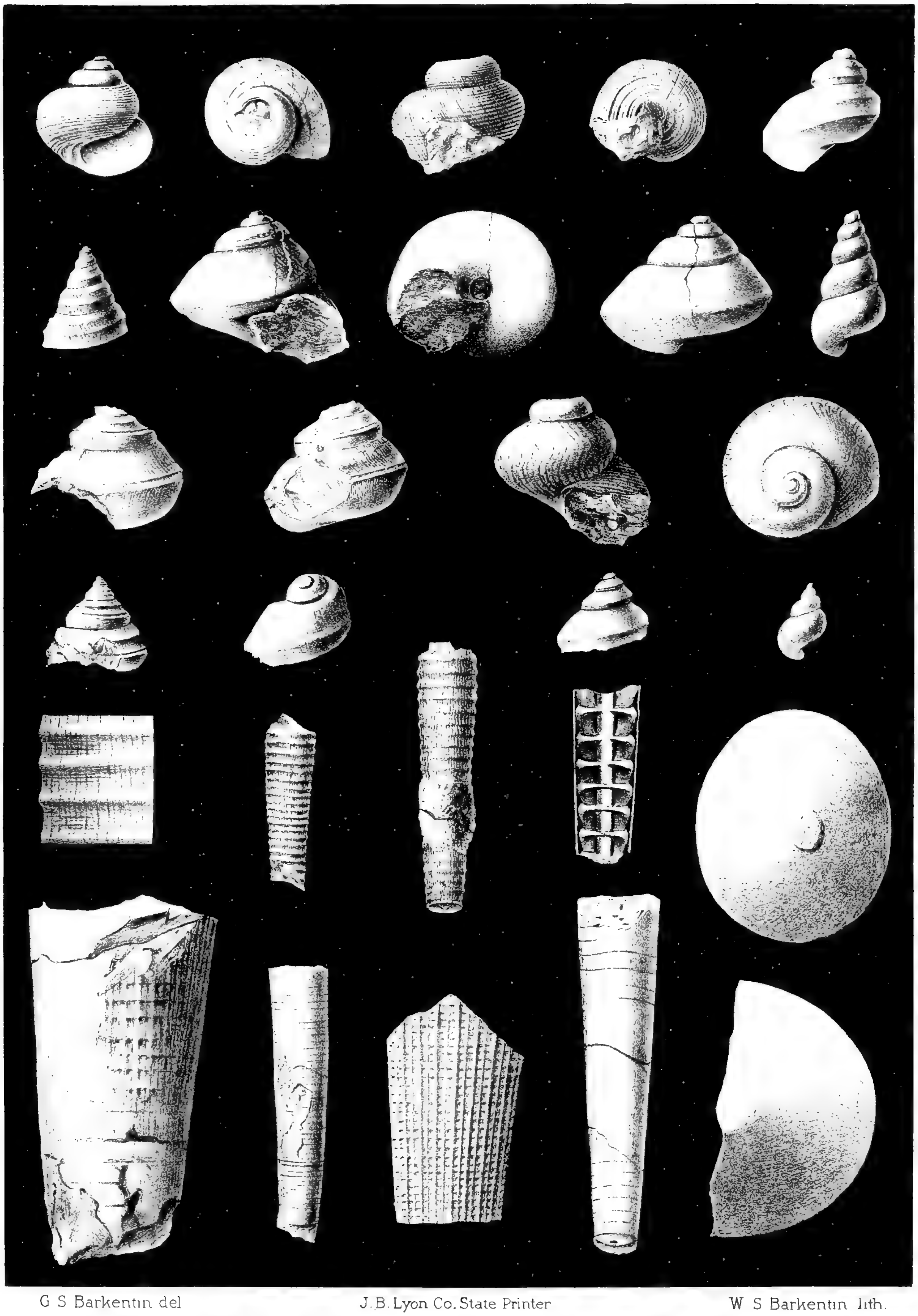
Lophospira bispiralis Hall (sp.)

Page 71

6 Apical part of a specimen, showing distinctly the carinae. From a gutta-percha impression of a natural mold. x2. Lower Shelby bed (N. Y. State Museum)

7, 8 Two older individuals which show the structure of the slit band and the gradual obsolescence of the carina on the upper side of the volution. Natural size. Rochester

GUELPH FAUNA



G S Barkentin del J. B. Lyon Co. State Printer W S Barkentin lith.

FIG.

9 Young individual with very strongly marked carinae and slit band. Natural size. Rochester

Eotomaria galtensis Billings (sp.)

Page 70

10–12 Three views of an internal cast with parts of the shell preserved. Natural size. Upper Shelby bed (N. Y. State Museum)

Coelidium macrospira Hall (sp.)

(*See* plate 7, fig. 2–8)

Page 65

13 Gutta-percha impression of an internal cast of a young individual. Lower Shelby bed (N. Y. State Museum)

Diaphorostoma niagarense Hall (sp.)

Page 59

14, 15 Two views of a very small specimen. x3. Fig. 15 is slightly restored at the apex. Rochester (Arey collection)

16 An individual from the Upper Shelby bed. From a gutta-percha impression. x2. (N. Y. State Museum)

Eotomaria durhamensis Whiteaves (sp.)

Page 68

17 Apical part of an individual. Natural size. Rochester (Arey collection)

Macrochilina sp. indet.

Page 74

18 Single individual observed. x5. Rochester (Arey collection)

Dawsonoceras annulatum americanum Foord

(*See* plate 11, fig. 1)

Page 81

19 Enlargement of surface of original of fig. 20. x5

20 A young individual, with extremely close arrangement of the annulations. Natural size. Rochester (Arey collection)

FIG.

21 Young individual, showing the longitudinal lines with marked distinctness. Natural size. Rochester (Arey collection)

Kionoceras darwini Billings (sp.)

(*See* plate 11, fig. 6; plate 12, fig. 1–8)
Page 84

22 Fragment of shell, showing both the longitudinal ribs and transverse lines. Rochester (Arey collection)

Kionoceras medullare Hall (sp.)

Page 86

23 Fragment of shell, showing the ornament; from a gutta-percha impression of a natural mold. Natural size. Lower Shelby bed (N. Y. State Museum)

Orthoceras trusitum sp. nov.

(*See* plate 13, fig. 1–10)
Page 77

25 Internal cast of a slightly curved individual with very closely arranged septa. Natural size

26 Young individual, showing the smooth surface and the depth of the camerae. Natural size. Rochester (Arey collection)

Orthoceras crebescens Hall

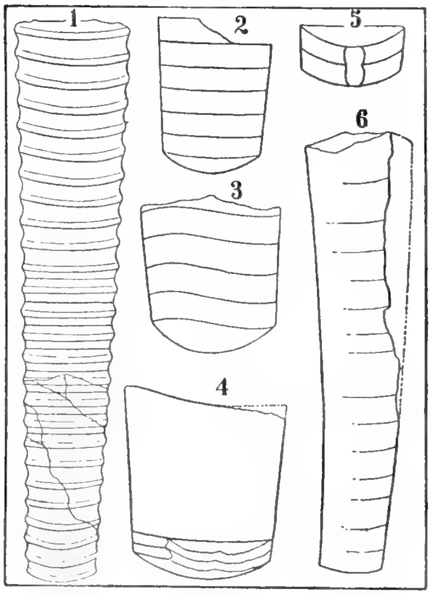
(*See* plate 11, fig. 2–5)
Page 80

24 Internal cast of camerae and siphuncle of young specimen, referred with some doubt to this species. Natural size

27 Septal view of specimen figured on plate 11, fig. 2, showing the section of conch, position and size of siphuncle. Natural size

28 Septal view of specimen figured on plate 11, fig. 3. Lower Shelby bed (N. Y. State Museum)

PLATE 11



Dawsonoceras annulatum americanum Foord

(*See* plate 10, fig. 19–21)

Page 80

FIG.

1 A large individual from the Lower Shelby bed.

Orthoceras crebescens Hall

(*See* plate 10, fig. 24, 27, 28)

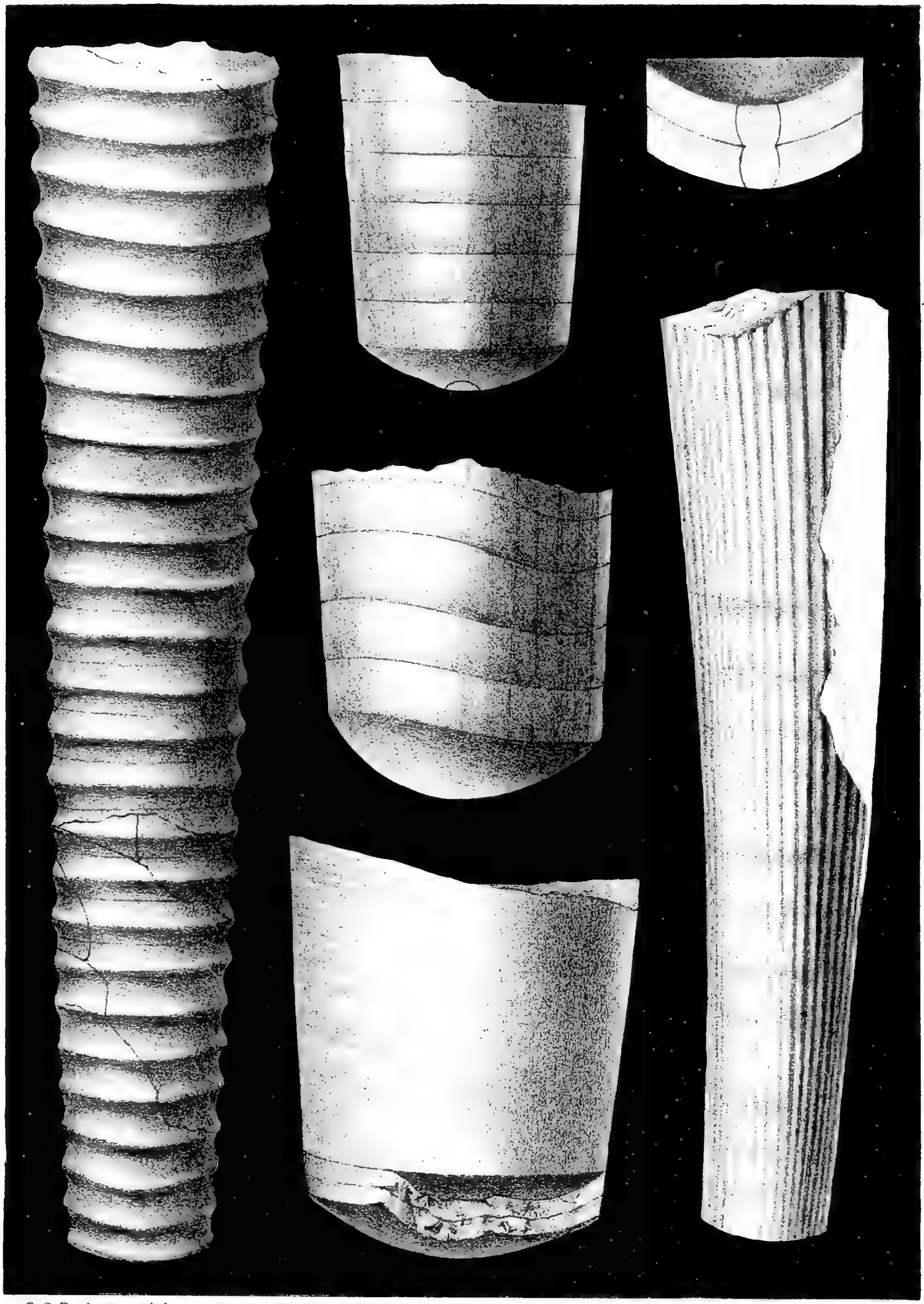
Page 80

2 Fragment of internal cast, showing septal sutures and obscure longitudinal ridges

3 Internal cast of a fragment of an old individual, showing curved septal sutures, relatively deep camerae and septa and low longitudinal ribs.

4 An internal cast of the living chamber and camerae of an old individual, showing the sinuate growth lines on living chamber and shallow gerontic chambers

GUELPH FAUNA



G S. Barkentin. del. J. B. Lyon Co. State Printer W S Barkentin lith.

FIG.

5 Section through lower part of individual represented in fig. 2, showing the curvature and depth of camerae and slightly expanded siphuncle.

Kionoceras darwini Billings (sp.)

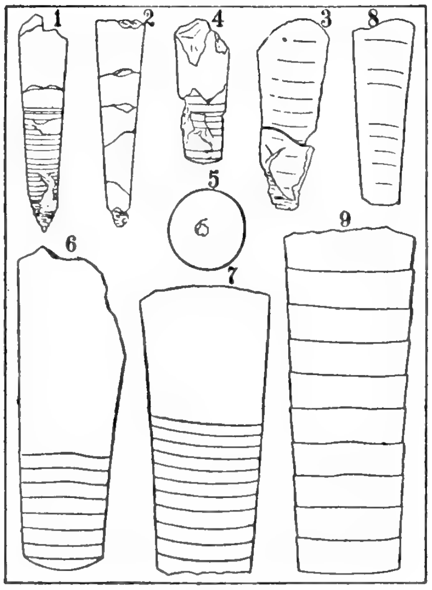
(*See* plate 10, fig. 22; plate 12, fig. 1–8)

Page 84

6 A very large individual, retaining the longitudinal ribs to mature age. From a gutta-percha squeeze of a natural impression

All figures are natural size. All originals are from the Lower Shelby bed (N. Y. State Museum).

PLATE 12



Kionoceras darwini Billings (sp.)

(*See* plate 10, fig. 22; plate 11, fig. 6)

Page 84

FIG.

1, 2 Two views of a young specimen with excellently preserved surface sculpture

3 Fragment showing obscure transverse undulations and alternating ribs

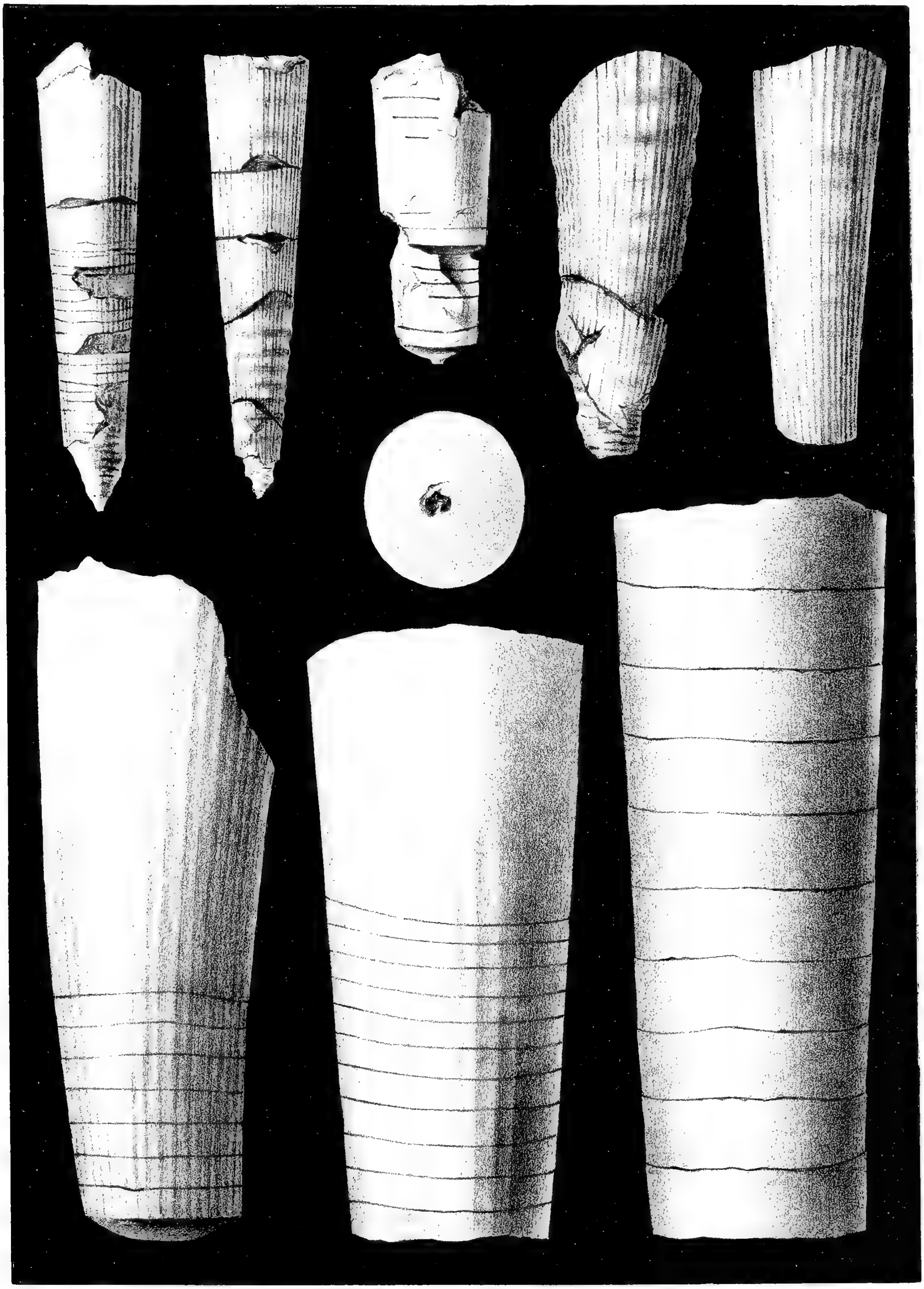
4 Specimen showing the depth of the camerae and septa

Originals of fig. 1-4 from Rochester (Arey collection).

5 Septal view of individual represented in fig. 6

6 Internal cast of older specimen, showing part of the living chamber and the increase in the depth of the chambers

7 Internal cast of specimen with gerontic approach of the septa and somewhat oblique septal sutures



G S. Barkentin del. J. B. Lyon Co. State Printer W S Barkentin lith

FIG.

8 An individual with strong subequal longitudinal ribs. From a gutta-percha impression

Originals of fig. 5–8 are from the Lower Shelby bed (N. Y. State Museum).

Orthoceras rectum Worthen

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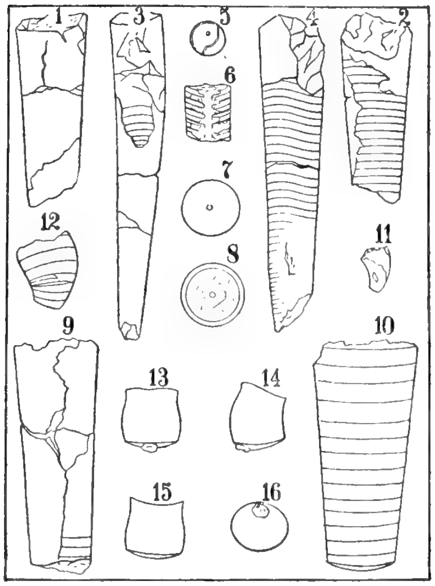
9 Internal cast of a large specimen, showing the great depth of the camerae. Lower Shelby bed (N. Y. State Museum)

PLATE 13



Orthoceras trusitum sp. nov.

(*See* plate 10, fig. 25, 26)

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FIG.

1 Fragment preserving the longitudinally lineated surface

2 Internal casts, showing the numerous, shallow camerae and straight transverse suture lines

3 Young individual, showing the slenderness of conch

4 Internal cast, showing undulating septal sutures

5 Septum with excentric siphuncle

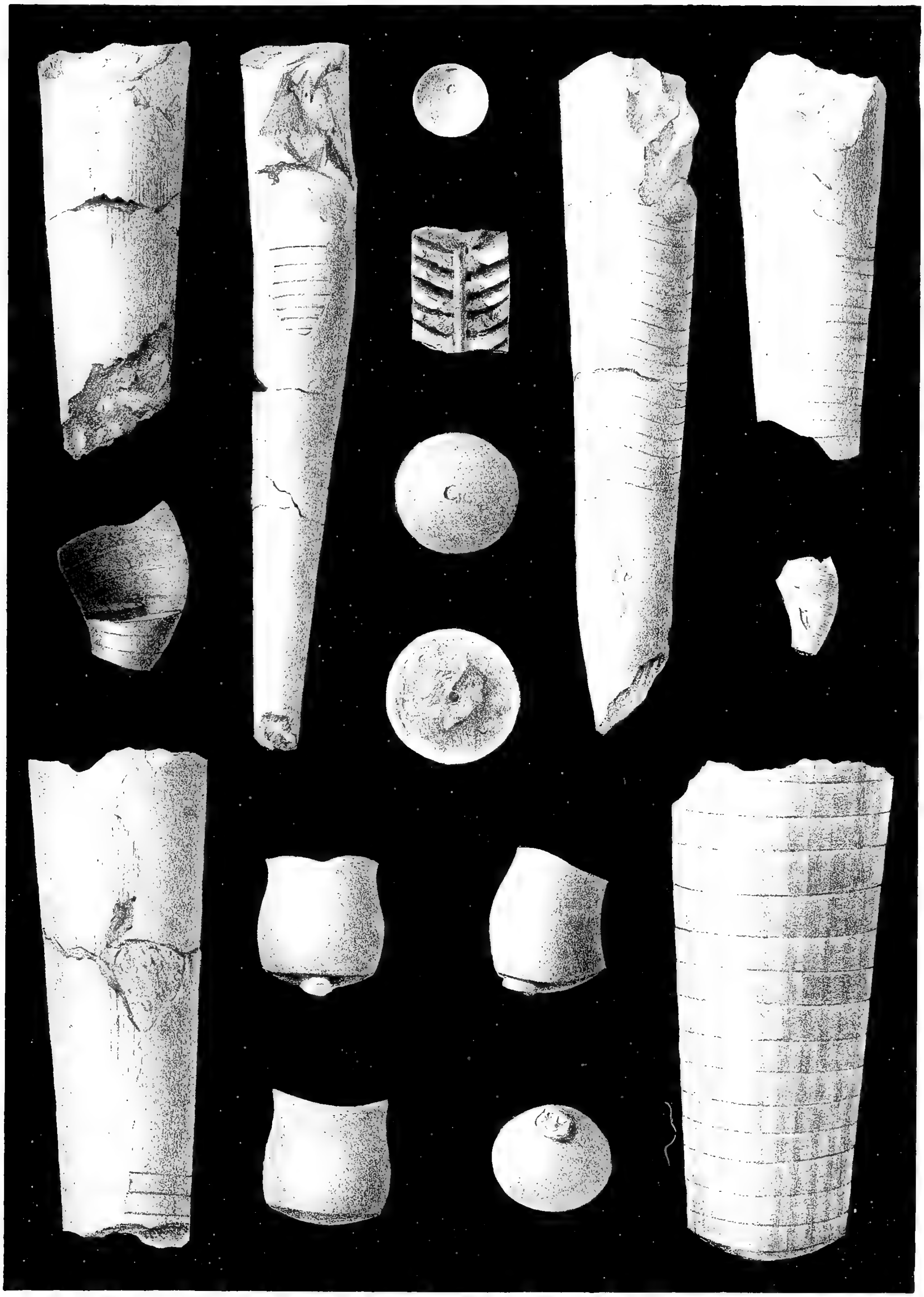
6 Broken internal cast, showing the depth of camerae and the tubular siphuncle

7 Septum, showing the circular section of conch and subcentral location and relative size of siphuncle

8 Section of specimen represented in fig. 1, showing the relatively great thickness of conch

9 Part of living chamber, showing longitudinal lineation

GUELPH FAUNA



G S Barkentin del. J.B. Lyon Co. State Printer W S Barkentin lith

FIG.

10 Internal cast of an older individual with deeper chambers and obscure longitudinal ribs

All figures are natural size. The originals of fig. 1–5, 7–9 are from Rochester (Arey collection); those of fig. 6 and 10 from the Lower Shelby bed (N. Y. State Museum).

Cyrtoceras cf. **brevicorne** Hall

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11 Fragment showing the living chamber and sinuous growth lines. Natural size. Rochester (Arey collection)

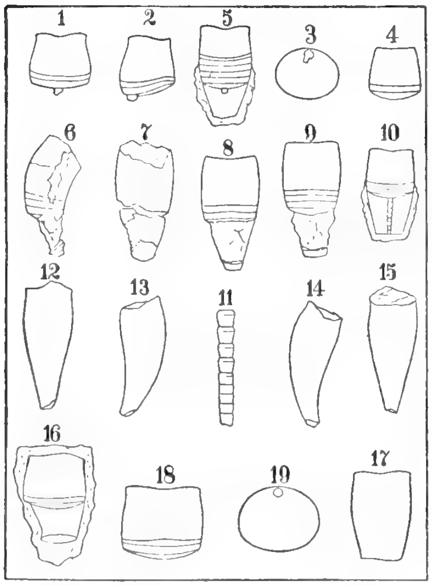
12 Mold and internal cast of a fragmentary specimen, showing the amount of curvature and the unequal depth of the camerae. Lower Shelby bed (N. Y. State Museum)

Poterioceras sp.

Page 97

13–16 Four views of the internal cast of the living chamber of the only specimen observed, showing the contraction of the chamber and the submarginal position of the nummuloidal siphuncle. Lower Shelby bed (N. Y. State Museum)

PLATE 14



Poterioceras sauridens sp. nov.

Page 93

FIG.

1–3 Three views of an internal cast of the living chamber and the two latest camerae, showing the aperture, contraction of living chamber, transversely oval section and position of siphuncle

4 Ventral view of another interna. cast, showing the depth of the septum

5 Internal cast and mold of a nearly complete individual, showing hyponomic indenture of aperture, a greater number of camerae and form of conch

Originals of fig. 1–5 are from the Lower Shelby bed (N. Y. State Museum).

GUELPH FAUNA

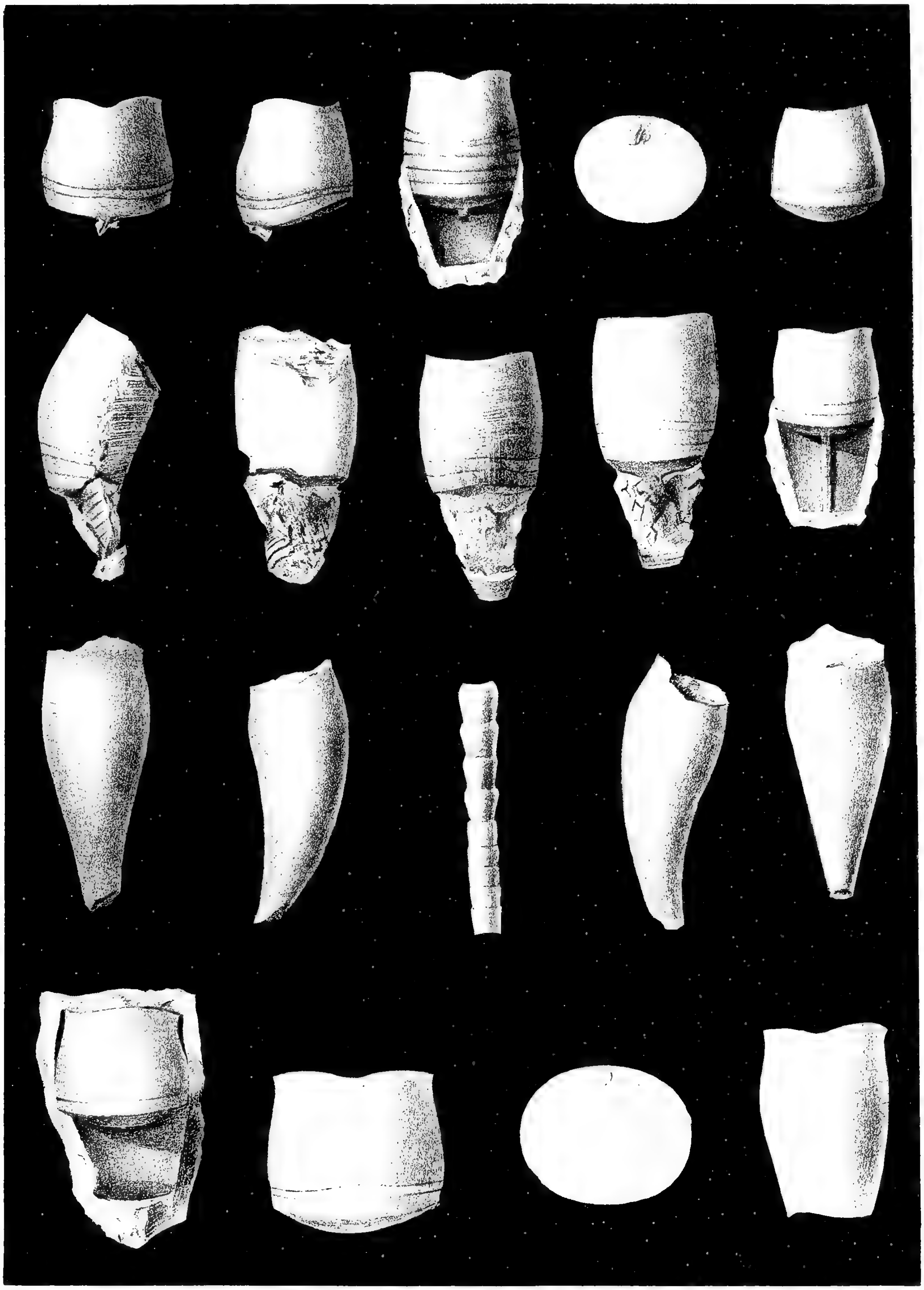


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FIG.

6–9 Four views of a partially crushed specimen which shows the surface characters of the species and the form of the living chamber. Fig. 9 is from a gutta-percha squeeze of the mold and shows the hyponomic curve of the growth lines on the ventral side. Rochester (Arey collection)

10 Interior cast and mold of a specimen, retaining the siphuncle in position

11 The siphuncle of the same specimen. x3.

12–15 Four views of the most complete specimen observed. From a sulfur cast of a natural mold in the rock

16 Mold and cast, showing the thickening of the conch near the aperture

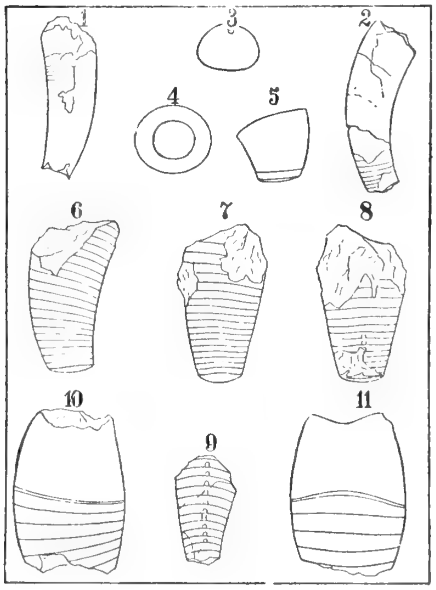
17 Specimen which shows the hyponomic sinus of the growth lines on the ventral side and the contraction of the shell near the aperture. From a gutta-percha impression of a natural mold

18 Internal cast of a large specimen, showing a broad and low living chamber and shallow septum

19 Septal view of same

All figures except 11 are natural size. Originals of fig. 10–19 are from the Lower Shelby bed (N. Y. State Museum).

PLATE 15



Cyrtoceras arcticameratum Hall

(*See* plate 16, fig. 1–7)

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FIG.

1 A specimen retaining the shell and exhibiting the character of the surface

2 A specimen with closely arranged septa

Cyrtoceras orodes Billings

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3 Septal view of a specimen, showing the marginal position of the siphuncle and the difference in curvature between the inner and outer sides

4, 5 Two views of an internal cast, referred with some doubt to this species, showing a rapidly expanding living chamber and subcircular section

6–8 Three views of an internal cast, showing the depth of the camerae and direction of the sutures

9 A specimen exhibiting the siphuncle

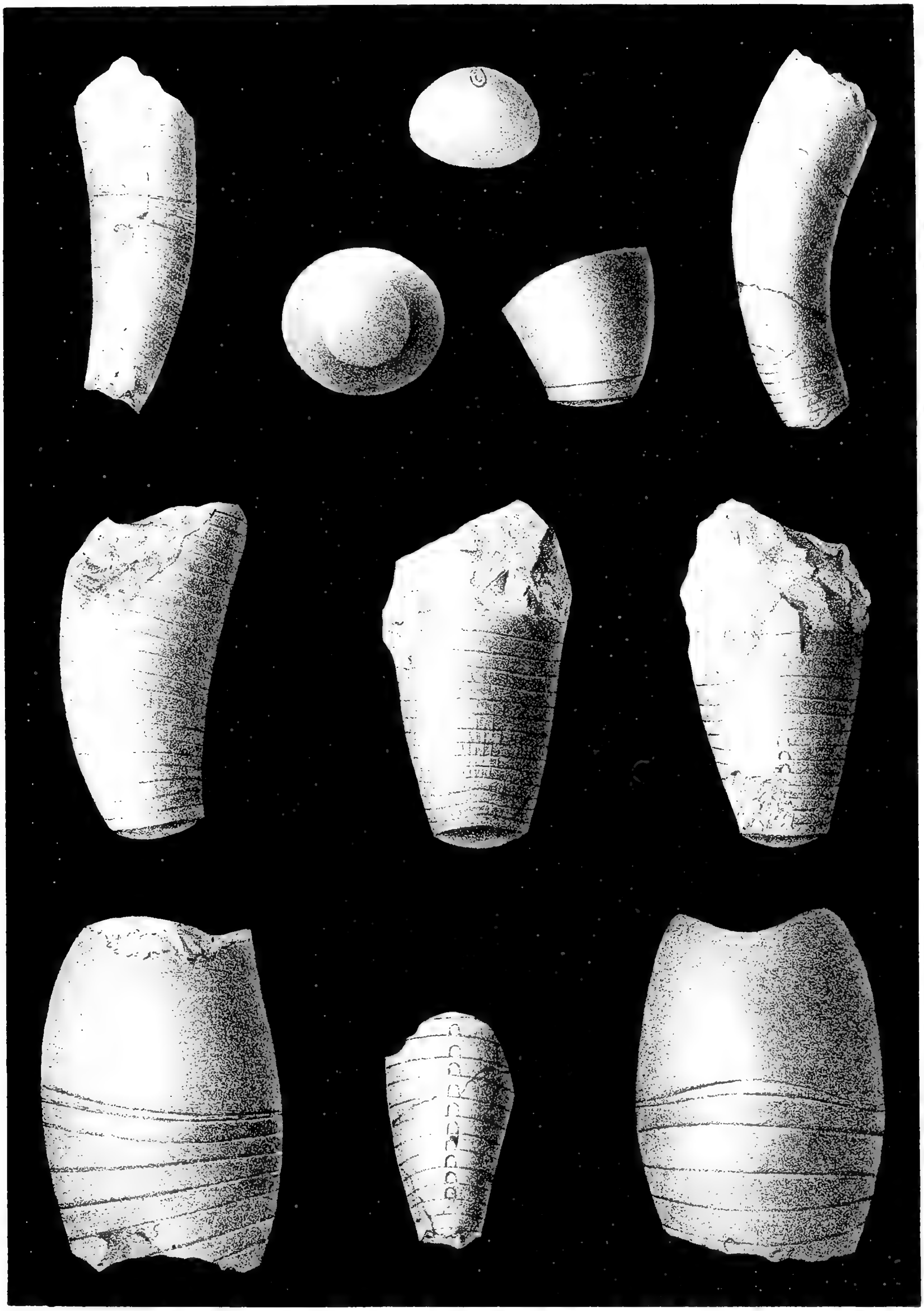

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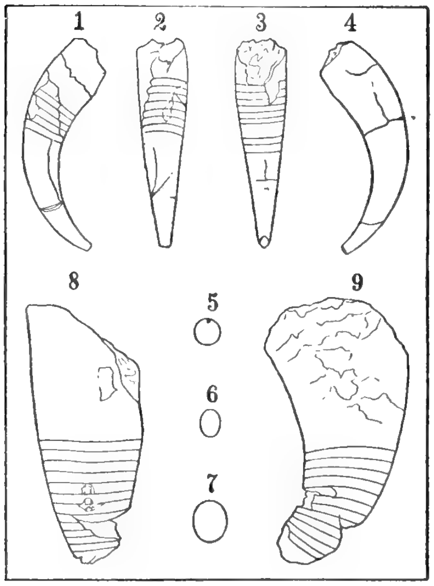
FIG.
10, 11 Internal cast of a large specimen, referred with doubt to this species, possessing a strongly contracted living chamber

All figures are natural size. The originals of fig. 1–3, 6–9 are from Rochester (Arey collection); those of fig. 4–5, 10, 11 are from the Lower Shelby bed (N. Y. State Museum).

PLATE 16



Cyrtoceras arcticameratum Hall

(*See* plate 15, fig. 1, 2)
Page 87

FIG.

1–4 Four views of the most complete specimen observed; showing the degree of curvature and rate of expansion of the conch

5 Septum of a specimen, showing the marginal position of the siphuncle and a subcircular section

6, 7 Two sections of another specimen with longer dorsoventral axis

Cyrtoceras bovinum sp. nov.

(*See* plate 18, fig. 5, 6)
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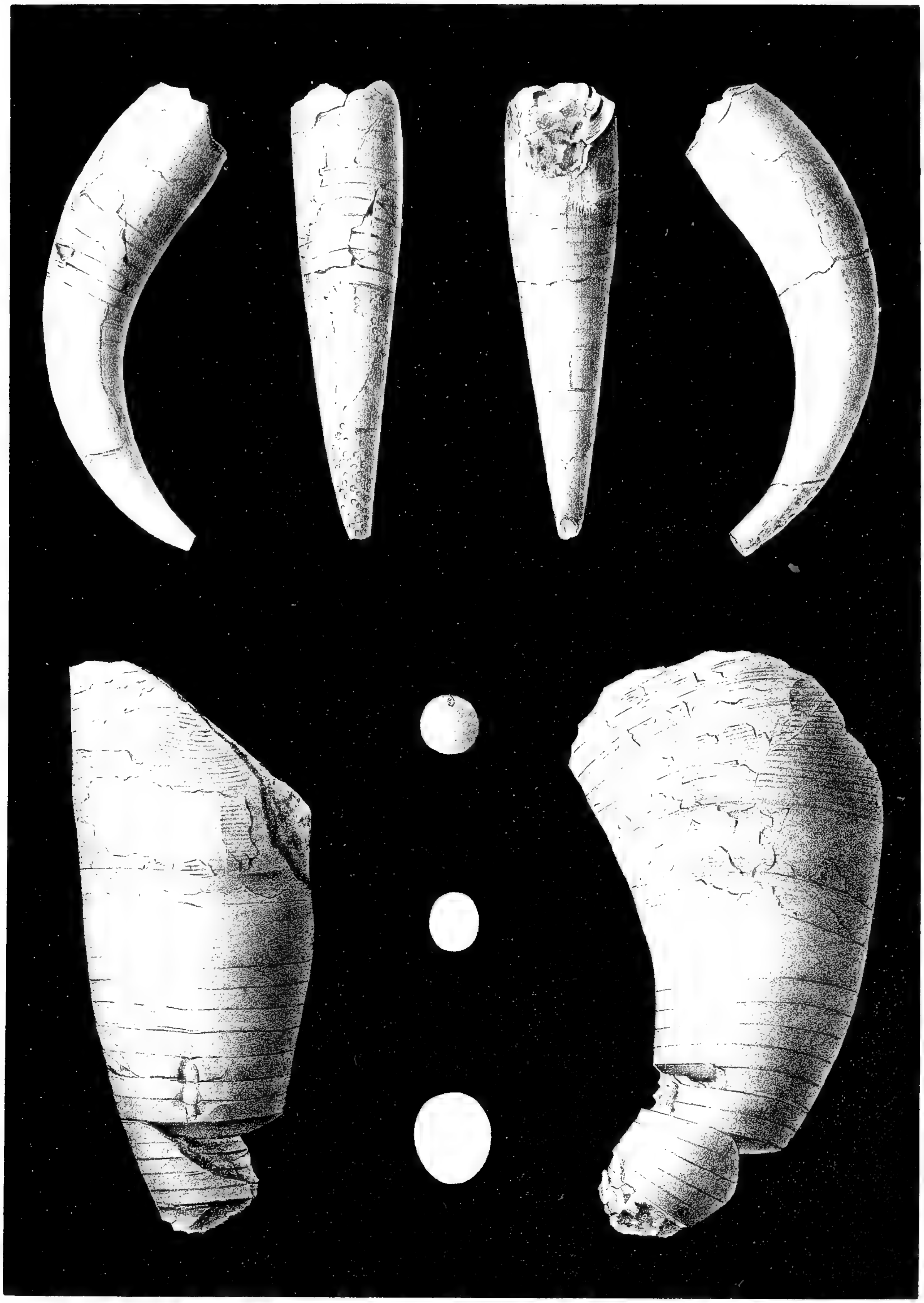
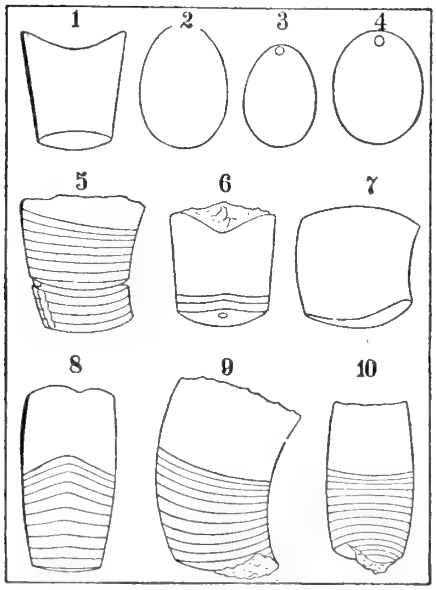
8, 9 Two views of a specimen, showing the rapid expansion of the shell, depth of camerae and surface characters

All figures are drawn natural size, and are from Rochester (Arey collection).



W S Barkentin del J. B. Lyon Co. State Printer Phil. Ast, lith

PLATE 17



Cyrtorhizoceras curvicameratum sp. nov.

Page 90

FIG.

1 Dorsal view of internal cast of living chamber (*see* fig. 7)

2 Section of aperture of same, showing the lateral compression of the living chamber

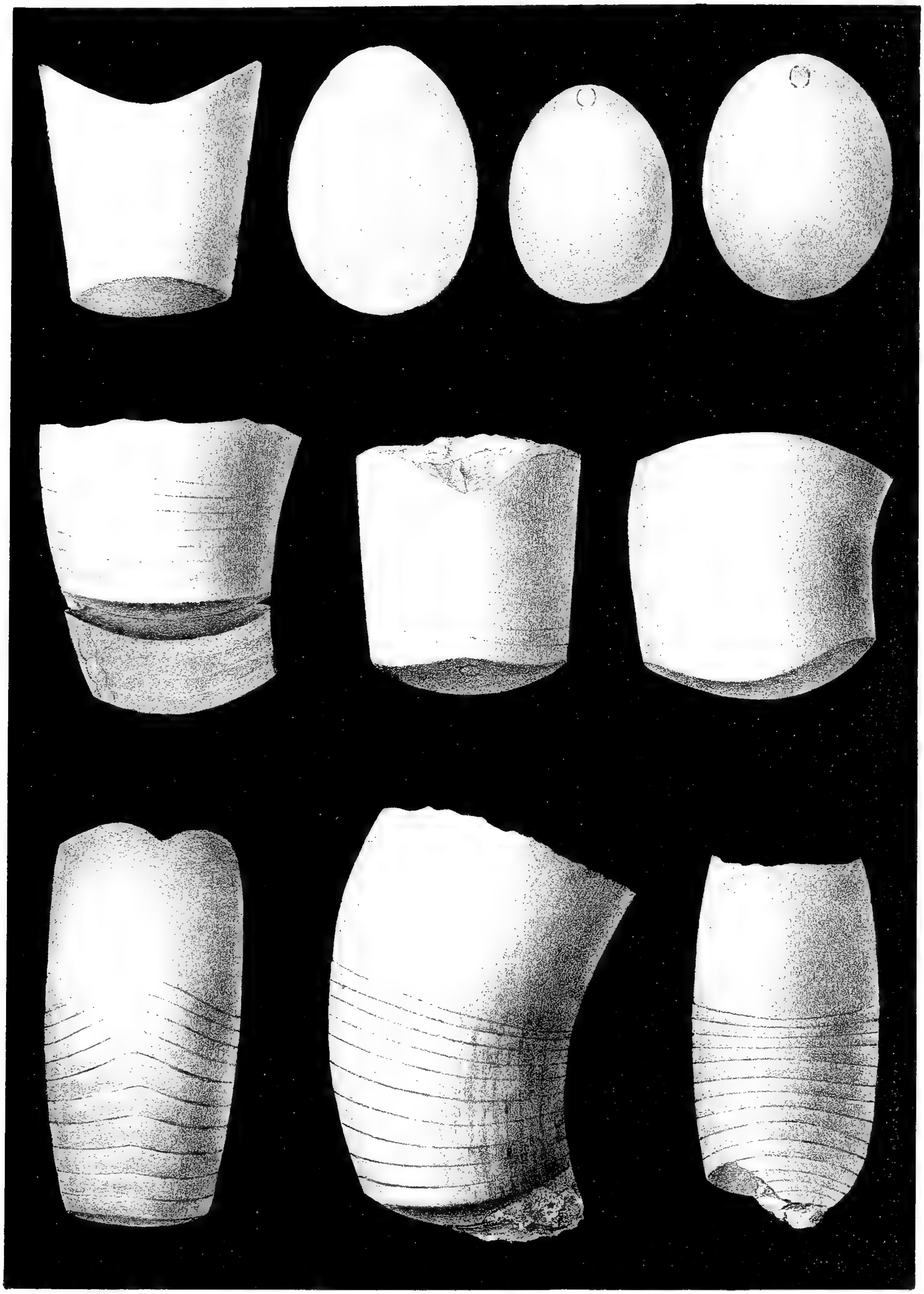
3 Septal view of same, showing marginal position of siphuncle

4 Septal view of another, somewhat rounded form (*see* fig. 6)

5 Specimen which shows the direction of septal sutures, depth of camerae, position of, and slightly expanded siphuncle

6 Internal cast, showing the living chamber and the ventral lobe of the sutures

7 Internal cast of living chamber of large individual, showing the aperture, the strong curvature of the last septum and the curvature of the chamber



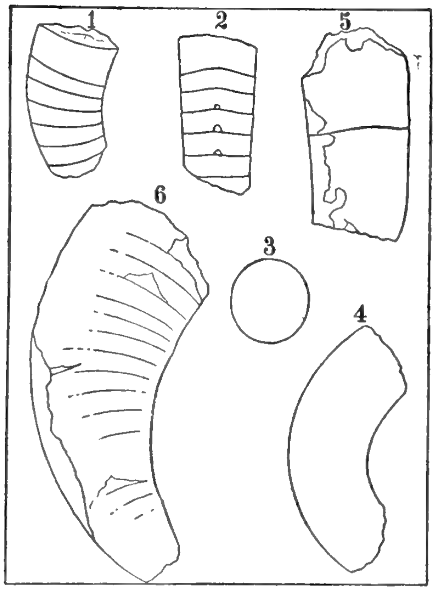
G S Barkentin del J.B. Lyon Co. State Printer W S Barkentin lith

FIG.

8–10 Three views of the most complete specimen observed; showing the depth of the camerae, the ventral lobes of the sutures and the low longitudinal surface ribs

The originals of all drawings are from the Lower Shelby bed (N. Y. State Museum).

PLATE 18



Gyroceras farcimen sp. nov.

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FIG.

1–3 Three views of an internal cast, showing the sutures, depth of camerae, position of siphuncle and circular section of conch

4 Fragment, showing the curvature of the conch and the smooth surface. From a gutta-percha impression of a natural mold

Cyrtoceras bovinum sp. nov.

(*See* plate 16, fig. 8, 9)

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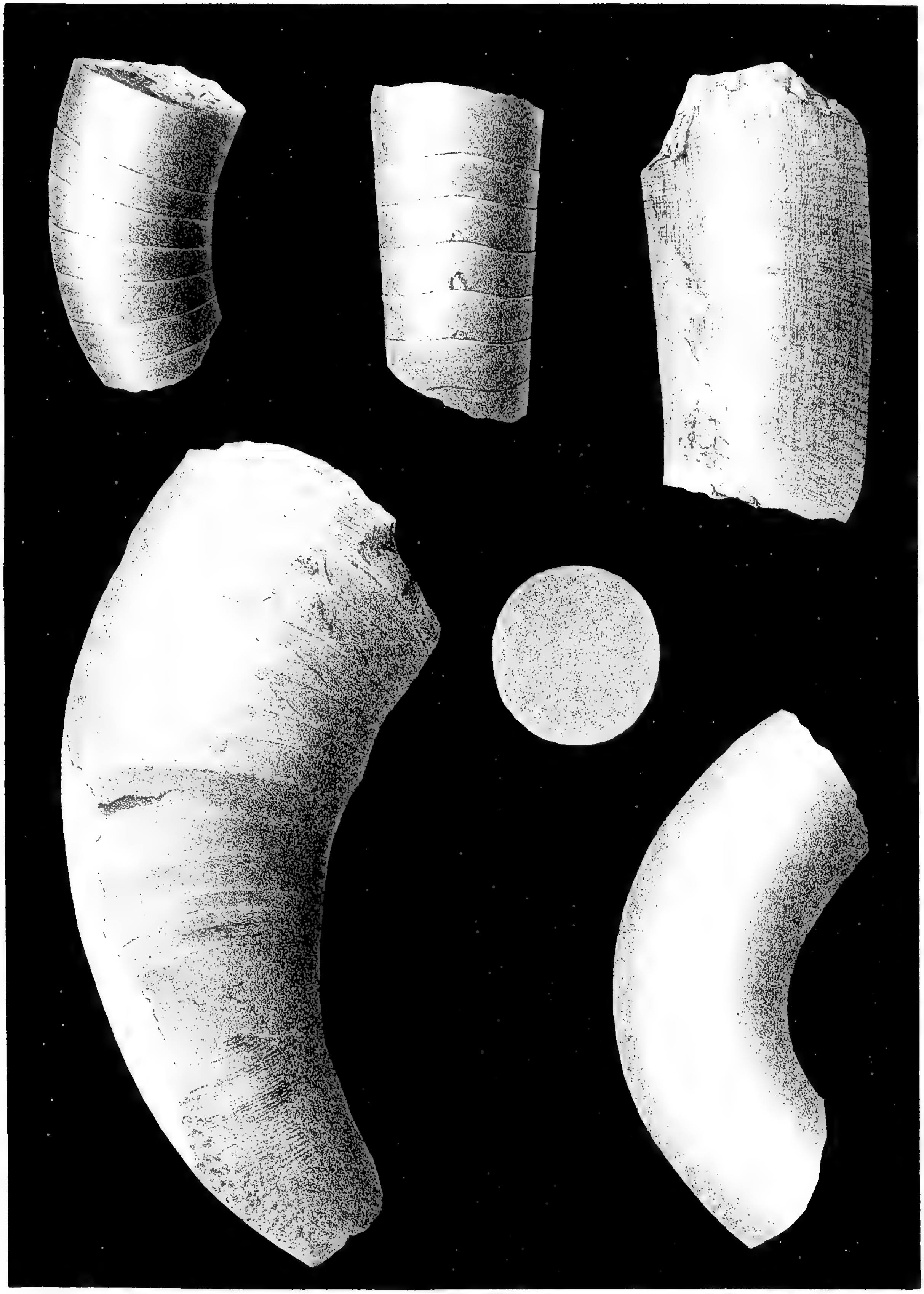
5 Specimen retaining the surface sculpture

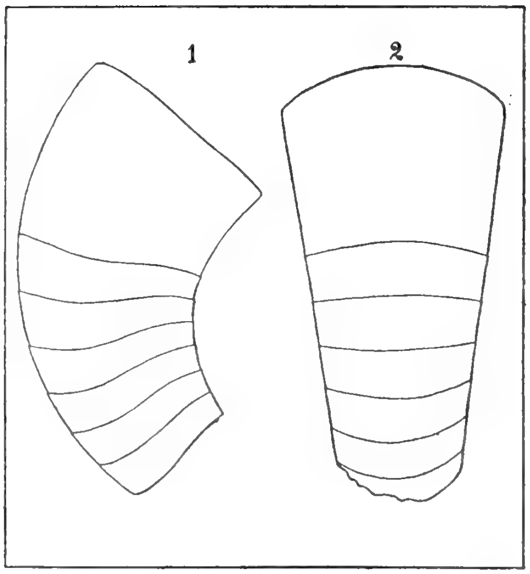
6 A large individual, showing the curvature and expansion of the conch, direction of sutures and depth of camerae

All figures are natural size. The originals of fig. 1–4 are from the Lower Shelby bed (N. Y. State Museum); those of fig. 5, 6 from Rochester (Arey collection).



W S Barkentin del. et lith. J B Lyon Co. State Printer

PLATE 19



Protophragmoceras patronus sp. nov.

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FIG.

1, 2 Two views of the only specimen observed. Natural size. Lower Shelby bed (N. Y. State Museum)

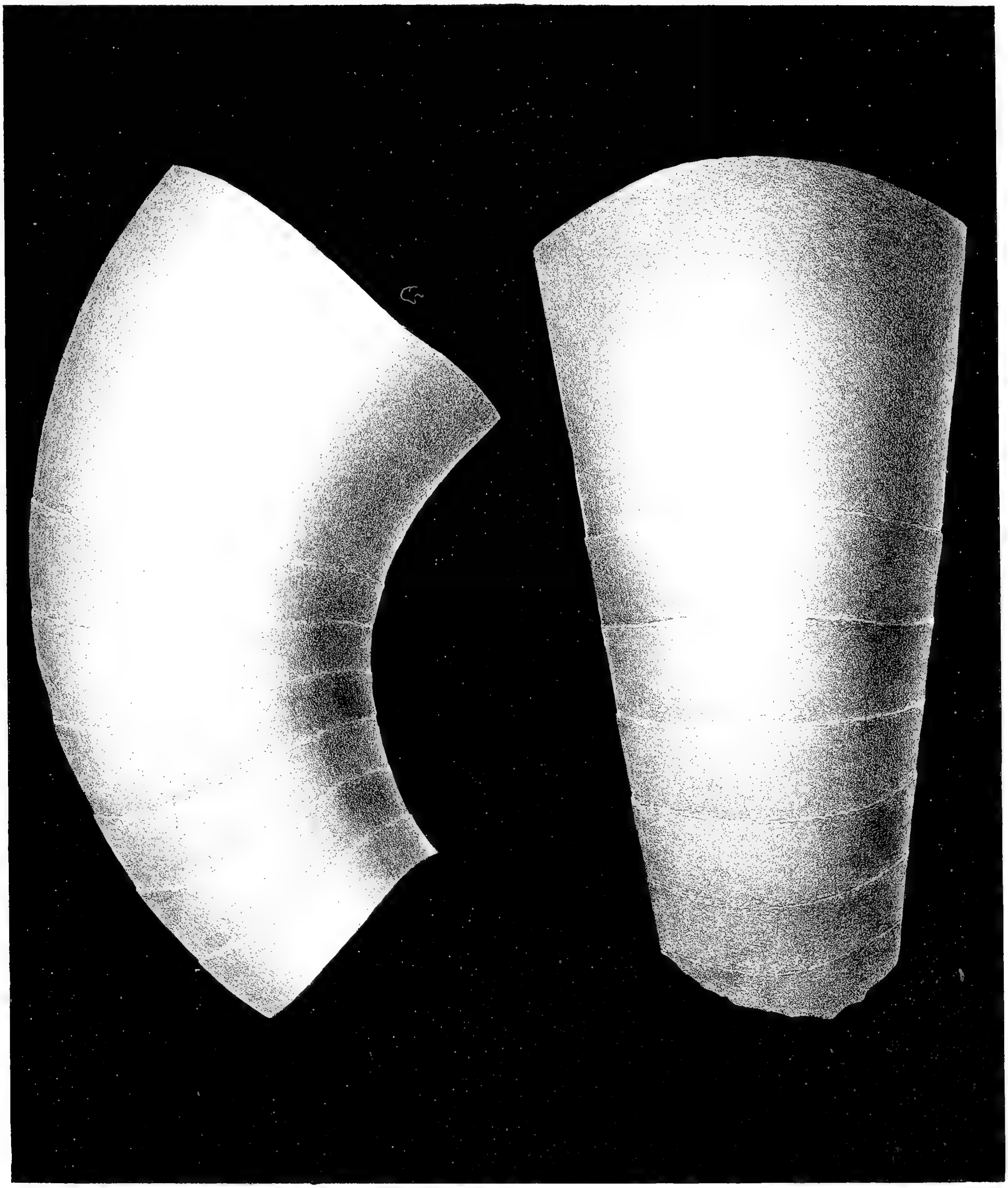
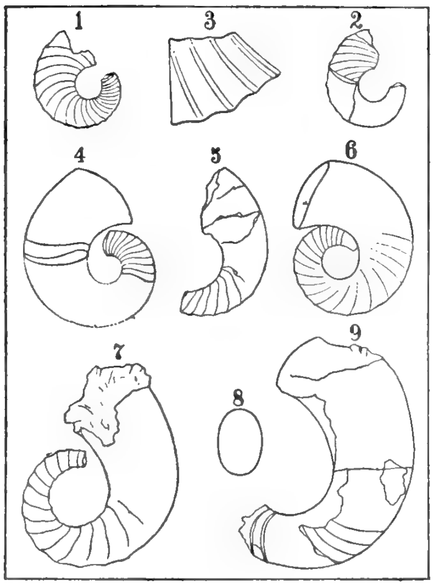


PLATE 20



Trochoceras costatum Hall

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FIG.

1 Specimen showing the rate of expansion, curvature of conch and the character of the costae. From a gutta-percha impression of a natural mold

2 An individual which shows the living chamber and the curvature and depth of the last septum. The costae on the living chamber are drawn somewhat too strong.

Trochoceras desplainense McChesney

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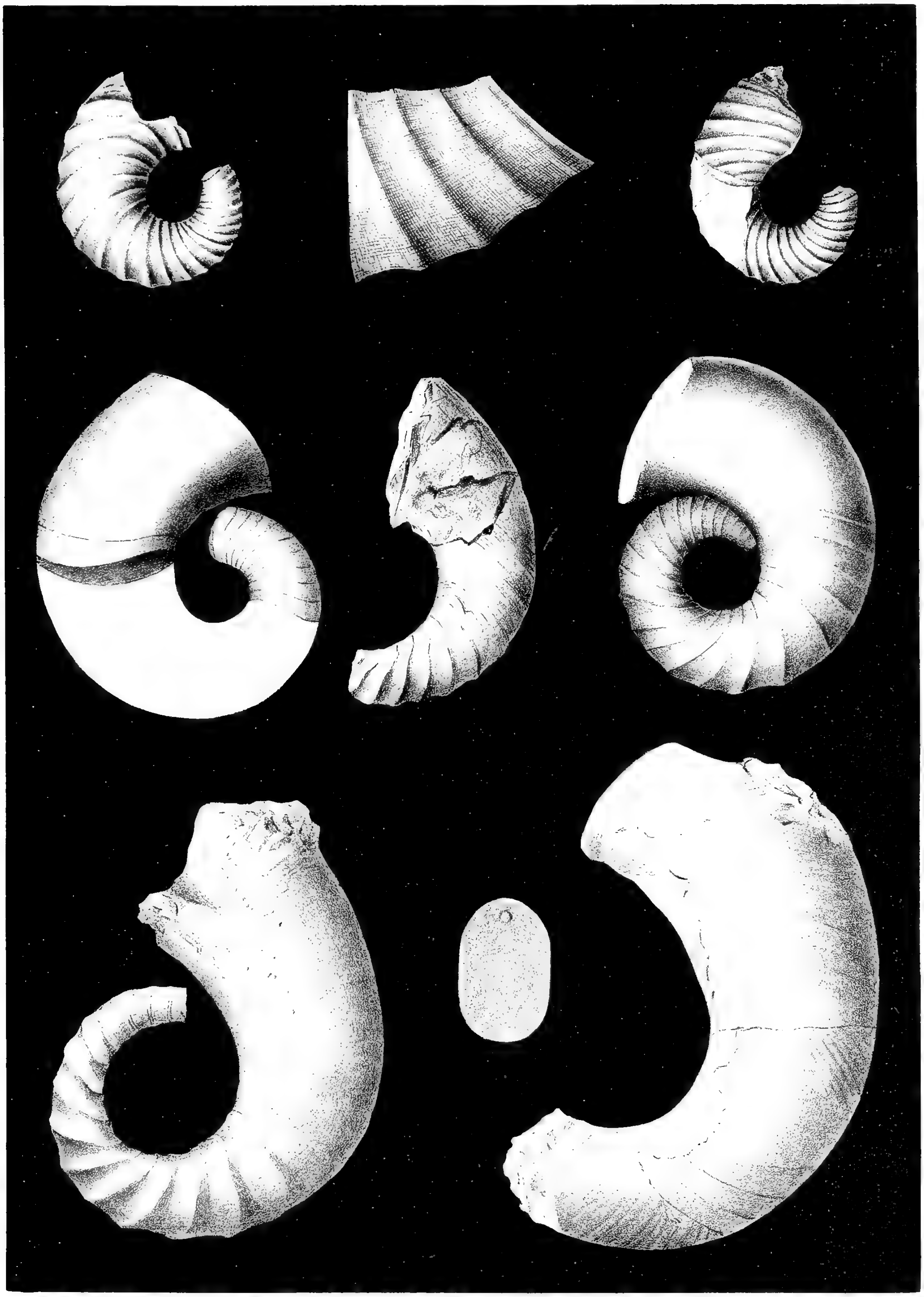
3 Enlargement of surface (x3) to show the fine transverse and longitudinal lineation. From a gutta-percha impression of a natural mold

4 Internal cast of specimen, showing the aperture, living chamber and septal sutures of an early whorl

5 Specimen with strongly developed costae and growth lines



G. S. Barkentin del. J. B. Lyon Co. State Printer Phil. Ast, et W. S. Barkentin lith

FIG.

6 A nearly complete individual, showing the gradual obsolescence of the costae on the living chamber. From a gutta-percha impression of a natural mold

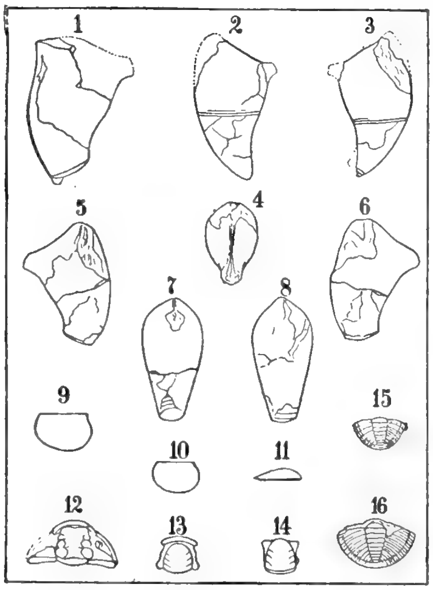
7 An older, nearly complete individual, showing the tangential direction of the gerontic portion of the conch

8 Section showing the lateral compression of the conch and the position of the siphuncle

9 Part of a mature individual, showing the size and expansion of the living chamber, and the surface sculpture on the mature shell

All figures except 3 are natural size. The originals of fig. 1, 2, 4, 6 and 8 are from the Lower Shelby bed (N. Y. State Museum); those of fig. 3, 5, 7 and 9 from Rochester (Arey collection).

PLATE 21



Phragmoceras parvum Hall & Whitfield

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FIG.

1 Lateral view of a relatively large specimen with well preserved surface sculpture

2, 3 Two views of a specimen, showing the curvature of the apical part, the last camerae, the living chamber and the different direction of the septal sutures and surface lines

4–8 Five views of a specimen, showing the long and narrow hyponomic area of the contracted aperture and the hyponomic curve of the growth lines upon the ventral side (fig. 7)

All figures are natural size. The originals are from Rochester (Arey collection).

Leperditia balthica Hisinger, var. **guelphica** Jones

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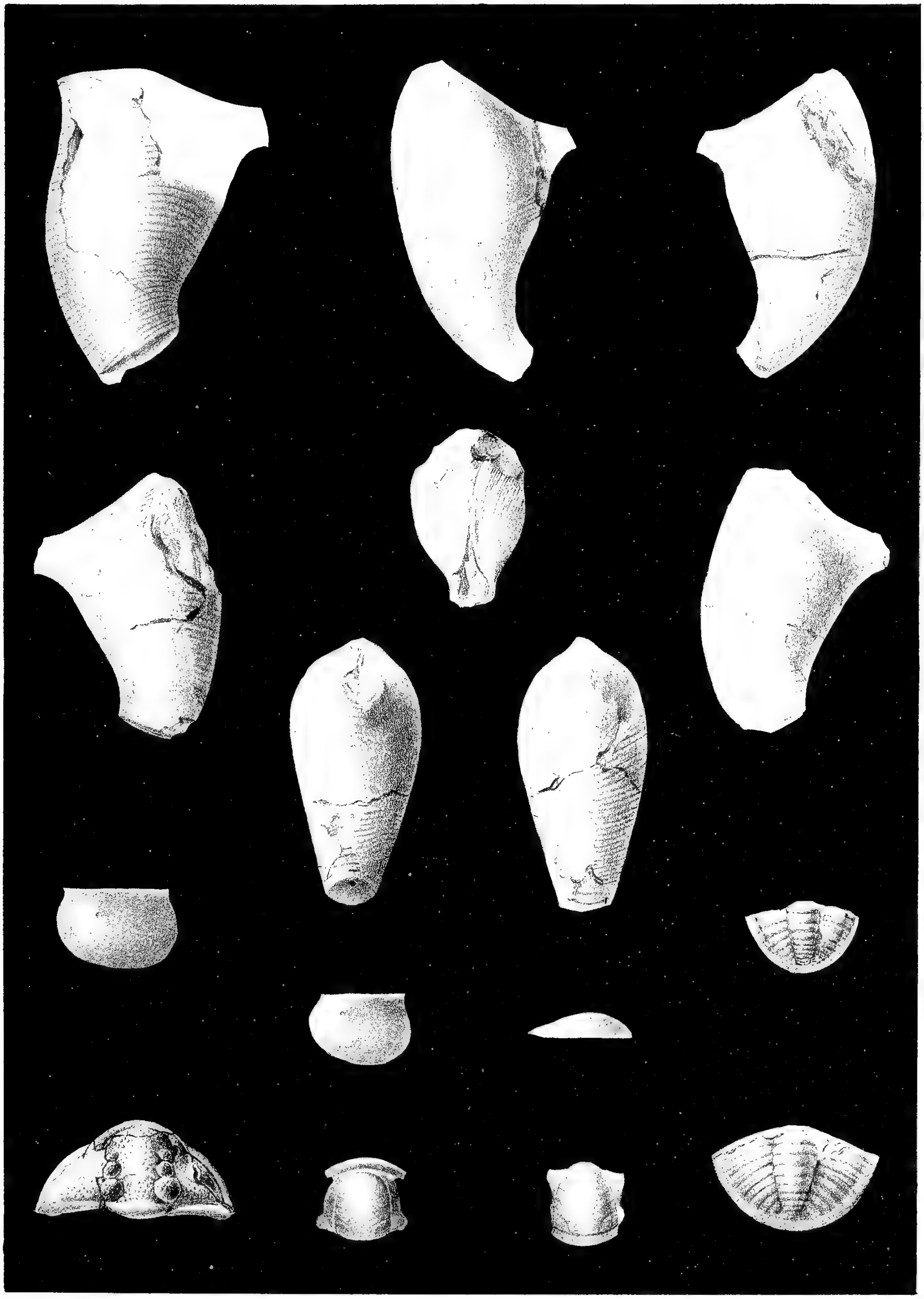
9 The largest valve observed. x2

10, 11 Two views of a valve, showing the eye tubercle distinctly. x2. Both from the Guelph at Rochester

GUELPH FAUNA



W. S. Barkentin, del. et lith. J. B. Lyon Co. State Printer

Calymmene niagarensis Hall

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FIG.

12 Cephalon from the Guelph at Rochester. x2

Proetus sp.

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13 Cranidium, from a gutta-percha squeeze of a natural impression. x2. Rochester

14 Another, smaller cranium. x3

15 Small pygidium, retaining partially the test. x2

16 Largest pygidium observed. x2

Originals of fig. 14–16 are from the Upper Shelby bed (N. Y. State Museum).

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Page numbers referring to descriptions of fossils are printed in black face type.

University of the State of New York

New York State Museum

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Memoir 6

NAPLES FAUNA IN WESTERN NEW YORK

PART 2

BY

JOHN M. CLARKE

ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

1904

University of the State of New York

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STRATIGRAPHIC MAP
OF THE
PORTAGE DIVISION
IN WESTERN NEW YORK
by
JOHN M CLARKE AND D DANA LUTHER
1903.
LEGEND
Hatch
shales & flags
Argola shale
in
western district
Grimes
sandstone
West Hill
sands
Silver Creek shale
in
western district
Dunkirk
black shales
Portage
sandstone
Wiscoy
shales
Portland shale
in
western district
Laona
(Long Beards Riffs (?))
sandstone
L A K E   E R I E
W E L L A N D
H A L D I M A N D
79°30
79°00
78°30
78°10
77°30
77°00
42°00

NAPLES FAUNA IN WESTERN NEW YORK

PART 2

BY

JOHN M. CLARKE

INTRODUCTION

This memoir is in continuation[1] of studies of the events, biologic and physical, of Portage time in the State of New York. Previous publications on this subject have been for the most part of more preliminary character; but the nature of the fauna of that provincial element of the Portage region which occupied the New York sea westward of the present meridian of Cayuga lake (Intumescens zone or Naples shales) was taken up for special consideration in the first instalment of this memoir which was devoted to the Goniatitinae. We here propose to treat specially of the lamellibranchs, gastropods and pteropods of this provincial fauna and to present therewith such considerations as have developed from a continued study of the relation of these organisms to their environment.

The sea of Portage time

The great mediterranean sea (Appalachian gulf) which spread over the southern parts of western, central and eastern New York during this opening period of late Devonic time (stratigraphically the lower Upper Devonic) was depositing tremendous quantities of sand commingled with mud, throughout its entire extent. This gulf was bounded on the north by a coast line whose exact position we can not locate, because the shoreward edges of the bottom deposits have been worn away. There are certain factors indicating that during some portion of the time its western arm was well northward to, and beyond the latitude of Lake Ontario, for the heavy beds of bituminous shales which formed at the base of the series (Genesee shales and black bands of the Naples beds) and which in the western sections attain relatively great thickness, are to be probably regarded as pointing to deposition in deep water. This interpretation would be in accord-

[1] Part 1 of this discussion of the Naples fauna was published in the 16th An. Rep't of the State Geologist. 1898. p. 29–161, pl. 1–9.

ance with the observations recently made on the constitution of the waters, the sedimentation and the bionomic conditions in a somewhat similarly inclosed marine body, the Black sea. The important results therefrom obtained by Andrussow [1] have been employed by Pompeckj [2] in the interpretation of the black deposits and depauperated fossils of the Posidonomya bronni shales (Jurassic) of the vicinity of Regensburg, Bavaria; and it is well that, for the sake of their bearing on the correct significance of the similar bituminous deposits of Portage time, an abbreviated selection from these observations be here given.

The Black sea has a superficial water layer of about 125 fathoms, of less salinity and density than the water of the depths. The yearly increment of surface water is due in great part to the ingress of fresh water. The heavier deep water is derived from a lower current coming from the Mediterranean by way of the richly saline Marmora and Aegean seas and requires about 1700 years for its renewal. In consequence of the greater salinity and density of the deep water, the Black sea shows only slight evidence of vertical currents. It is apparent only to a depth of 125 fathoms, and only to this depth therefore, is there sufficient O for the support of animal life. The deep water, fed only by the undercurrent, which, on account of the high specific gravity due to its salinity, does not mix with the surface water, has insufficient O for animal life. At a depth of about 100 fathoms the separation of H_2S is observable; 33 ccm from 100 liters of water. With greater depth the amount of H_2S rapidly grows; 570 ccm at 500 fathoms; but farther down the increase is less rapid. The separation of H_2S is regarded as due to microbes (Sulfobacteria) specially to Bacterium hydrosulfuricum ponticum, derived from animal remains of the necton and plankton; and in part also from sulfates. Hand in hand with the separation of and enrichment in H_2S is the diminution of sulfates in the sea water, the separation of carbonates and of FeS. . .

The constant, specifically lighter surface layer over the heavier, richly saline deep water, the lack of O and the separation of H_2S in the depths, thus condition in the Black sea its peculiar bionomic character, the absence of benthonic animals below the 100 fathom line. In the littoral and shallow water zone benthonic life is present; in the depths from 35–100 fathoms, the zone of the "Modiola muds," there is, with Modiola phaseolina, a large number of clams and snails. . .

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[1] La mer noire: Guide des excursions du 7 Congrès gèolog. internat. 1897. no. 29.

[2] Die Jura-Ablagerungen zw. Regensburg und Regenstauf (Separate from Geognost. Jahresheft. 1901. 14 Jahrgang, p. 43 *et seq.*)

The sediments of the Black sea are: (1) in the littoral zone and to a depth of about 20 fathoms, accumulations of sandy detritus; (2) to the 100 fathom line, gray blue sticky mud, from 35–100 fathoms, rich in Modiola phaseolina, etc.; (3) in the great depths the bottom is covered with (a) very fine, sticky, black mud with rich separation of FeS, abundant remains of planktonic diatoms and with fragments of quite young lamellibranchs (early stages of widely scattered plankton forms), (b) dark blue mud; FeS is here in less measure, but in richer quantity are separations of minutely grained $CaCO_3$ making at times thin banks; skeletons of pelagic diatoms are also abundant.

From analogy with these observations on the conditions actually existing in a secluded body of sea water, it may be necessary to conceive that the black shale deposits of the Portage with their abundant segregations of iron sulfid, sulfates of lime, barium and strontium and of limestone nodules, are likewise the result of accumulation in water of great depth and imperfect vertical circulation.

These bituminous muds of Portage time are also permeated with fragments of terrestrial drift wood, Lepidodendron, Cyclostigma, Asteropteris, Calamites, etc. But, if we may be guided by the results of recent dredgings, these are in themselves no indication of either shallow water or nearness to land. One might cite in illustration of this the results obtained by the *Blake*[1] in the Caribbean sea, where at a distance of 20 to 30 kilometers from the land and at a depth of over 1200 fathoms, great quantities of terrestrial vegetation, together with the shells of land snails, were brought up. Walther[2] remarks thereupon:

The contents of many a dredge would have put a paleontologist to confusion, for, as between the deep sea forms of crabs, annelids, fishes, echinoderms, sponges and the mango and orange leaves, bamboo stalks and land snails, it would be difficult to decide whether the deposit was a deep sea or a terrestrial one. In fossil condition this mixture would have been regarded as the deposit of a shallow estuary surrounded by forests, while it actually came from a depth of over 2000 meters.

The few animal remains that these shales contain are largely necton

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[1] Agassiz. Three Cruises of the Blake. 1888. 1:291.

[2] Walther. Einleitung in die Geologie. 1894. p. 954.

fish plates (Dinichthys, Pristacanthus) and scales (Palaeoniscus, Acanthodes) and though the calc nodules and more persistent calc sheets contain invertebrates (goniatites, Pterochaenia, Paracardium, Styliolina) we shall presently observe that the latter have been measurably effected by eastward currents from the open sea.

For the most part, however, the deposits of this Portage sea along its northern extent were in shallower water and constituted of clay muds commingled with sand, more of the former than of the latter in western New York, more sand than mud nearer the emerging and encroaching coast farther to the east. It was a period of active stream erosion on Portage land, for the sand and mud swept out to sea by river and undertow reached a notable thickness, fully 1300 feet where thickest and sandiest (Chenango county), 1200 feet on the Genesee river, where both muds and sands abound, but much less on the shore of Lake Erie.[1] It was therefore a time of extensive reduction of elevated continental areas, a time of shifting shore lines and sand bars, of encroachment of littoral deposits on the deeper water and of the foul, black muds of the depths on the sands. It is to the gray muds that the fauna specially appertains, and, though ranging through the higher sandstones of the sections, yet its development is always more sparse in such deposits. It is likewise the sands that carry for the most part abundant traces of terrestrial vegetation and that show the trails of crustaceans and annelids and the rills and ripple marks of the beaches. The eventual conditions of rapid erosion manifested during later Portage time and the rapid reduction of the Portage highlands (*Appalachia* to the south; *Laurentia* to the north) were continued in time beyond the Portage with which we are not now directly concerned. The deep water conditions represented by the black shale deposits and on which the sands encroached were continuously prevalent toward the west. In Erie county it is not easy nor is it at all important to distinguish between the black shales commonly referred to the Genesee and those which are palpably equivalent to the lower of two strongly bituminous shale bands eastward in Ontario county;

[1] See the comparative sections given on p. 212 *et seq.*

thereafter, with a brief interval of gray muds, appears a second black band of great thickness (227 feet; in Ontario county but 21 feet in thickness) separated from a bituminous band above by an interval of 257 feet of muds and sands. And again at a still higher horizon on Lake Erie is a third black band altogether absent in sections farther east. Doubtless the increase westward in the number and thickness of these bituminous deposits indicates the prevalence thither of the deeper waters of a now well inclosed sea, as indicated by their predominance in northern Ohio and in the vicinity of Kettle Point, Ontario, in both regions to the essential exclusion of the gray muds with their characteristic fauna.

The nature of the calcareous banks in these bituminous muds invites further attention. The Styliola or Genundewa limestone is a thin sheet sometimes interrupted, sometimes nodular, but virtually continuous from Lake Erie to Seneca lake. It is for the most part a mass of exuviae of the pteropod Styliolina fissurella and in many places bears little trace of intermixture of sedimentary mud. It carries with it species of the Naples fauna which now make their earliest appearance, goniatites, lamellibranchs and gastropods, and we have frequently cited this occurrence as illustrative of a *prenuncial* fauna. But notwithstanding the presence of various molluscan shells the mass is essentially a pteropod ooze. Now the existing pteropods are pelagic creatures of surface or zonal habit, rising to the top of the water or swimming below it much according to the time of day[1] and for the most part the shelled species are warm water or tropic forms; with but one or two exceptions cold water species are shell-less[2]; moreover the distribution of the dead shells on the sea bottom, says Walther,[3] corresponds to the distribution of the living animals on the sea surface.

There is no reason to doubt the pteropod nature of the needlelike shells of Styliolina fissurella, the essential component of the

[1] Thomson, W. The Atlantic. 1878. p. 125.

[2] Murray & Renard. Challenger; Deep Sea Deposits, p. 224.

[3] Walther. Einleitung, p. 507.

Styliola limestone, distinguished from the living Styliola only, so far as evidence goes, etymologically.[1]

Species of recent Styliola occur in immense abundance in the warm Atlantic currents, but the cold northern waters keep them from the coast of Britain.[2]

In these facts we find a rational ground for inferring that the pteropod ooze represented by the Styliola limestone, and the free dissemination of Styliola in the overlying Naples beds in association with Hyolithus and myriads of the minute spiral and probably pteropodous shell Protospirialis, indicates the presence of swarms of these creatures swept through the upper waters by warm currents coming in from the southwest. The pteropod deposits do not extend in mass eastward of Seneca lake nor do they approach the eastern shore line of this period. Their dissemination in this direction was doubtless prevented by the cold coastal current entering the gulf from the northwest and laving the northern and eastern shore lines.

The origin of the sediment which constitutes the bands of bituminous shale in the gulf deposits of this time is, in our judgment, to be sought less in the impregnation of the sediments by admixture of organic constituents resulting from decomposition, than in the influx of drainage from low, flat, continental and insular land masses of the southwest or from the deep but swamp filled valleys of Appalachia. This supposition assumes that the organic intermixture was largely terrestrial.

Here too we may note the gradual introduction in Portage time of a coastal change to the east which became of increasing and widespread importance as time passed on and into the subsequent, or Chemung epoch.

The apex of the Appalachian gulf during the earlier part of Portage time, must have reached to Albany, the northern shore approximately

[1] The zoologist Pelseneer has suggested that the pteropods are a race of comparatively recent development in the earth's history, an opinion for which a restricted acquaintance with the facts of paleontology would seem to be responsible.

[2] Thomson, W. The Atlantic. 1878. p. 127.

following the line of the Mohawk river and the southern shore coming in from the southwest along the inner margin of the Appalachian ridges, the two meeting in a narrow curve which gave to this inward projection of the sea but relatively slight breadth. A shoaling of the water at this end of the gulf, a differential movement raising the crust in this region, commenced when Portage time was well under way, and produced banks which must have become a more or less efficient land barrier, throwing the interior coast line well to the west, and for a while, probably for the remainder of Portage time and perhaps through all the subsequent epoch, excluded forms of marine life from these almost landlocked waters. This was the place and such the origin of the Oneonta sands, a mass of strata freely tinted with red and green. At the head of the gulf, where the waters were earliest affected by the barrier, these lie close on the very basal layers of the marine contemporaneous Portage sediments and rise ever higher in the section as they encroach southward on the gulf by the outward extension of the barriers. Having become shut off from free access to the salt water by land bars over which the sea entered only at times of stress or when the barrier was parted for a while, this apical or Albany segment of the gulf was gradually purified by heavy land drainage and became a large brackish or fresh-water lagoon in which no true marine organisms could flourish.

Lake Oneonta. The history of this Devonic lagoon may be outlined thus. Beginning almost directly after the close of Hamilton time, the marine waters were shut out of the Albany end of the Appalachian gulf in such manner as seems to indicate the establishment of estuarine conditions at the head of the gulf. With progress of Portage time this lagoon expanded in area, spreading to the west across the present Chenango valley and to the south into Pennsylvania. During the latter part of Portage time this body of water was so nearly purified of its salinity as to support in abundance a bivalve, Archanodon or Amnigenia catskillensis, very like the fresh-water Unios of the present, and doubtless of similar habit.[1]

[1] Clarke. N. Y. State Mus. Bul. 49. 1901. p. 199.

There was present also the little phyllopod, Estheria membranacea,[1] which is elsewhere known only in the old Devonic lakes of Scotland and Russia, but, on the whole, invertebrate animal remains are most unusual in these sediments. The fact that ingress of salt water into this lagoon occurred at times, probably of storm and heavy tidal flow, is shown by the presence of shells of Orthoceras standing vertical in great numbers[2] in certain strata, where they were evidently floated in by inrush from the deep waters without, dead or killed by contact with the fresh water.[3] Large quantities of terrestrial vegetation, Lepidodendron, ferns (Archaeopteris, Psaronius) were washed down into this lagoon. Apparently the low shores of the land were transgressed in some measure by the spreading lake waters, as indicated by the stumps of fern trees which have been found in place in the lower sediments. In this lagoon fish characteristic of Old Red lake conditions also flourished (Bothriolepis, Holoptychius, etc.). Indeed, the conditions of deposition so far as indicated by the organisms therein contained, were altogether similar to those prevailing in the formation of

[1] Clarke. N. Y. State Pal. Rep't 1900. 1901. p. 103.

[2] Following the arguments presented by Jaekel (Zeitschr. d. deutsch. geol. Gesellsch. 1902. 54:67–101) for the attached condition and erect growth of Orthoceras, it has been suggested by Beushausen (*loc. cit.*) that these occurrences of vertical Orthoceras in the Oneonta sands, which are the only ones recorded of these shells in such position, may be due to the accumulation of sediments about the organisms while still attached to the bottom. Aside from other considerations which would tend to show that while Orthoceras may have been sedentary in its habit it was not affixed by its apex, the physical conditions involved in the instances cited seem to require a modification of this interpretation. Granted that these bodies of littoral habit were buried in the marine sediments on the outer or seaward side of the submarine barrier, it is readily conceivable that an excessive outflow of fresh waters carrying them beyond their proper boundary would kill outright an entire settlement of these creatures, and would have washed into close proximity with them remains of Archanodon and terrestrial plants such as characterize the true Oneonta deposits. The position of these marine bodies is on the remote western boundary of the lagoon during its earlier stages, and their occurrence evinces the instability of the barrier separating the marine or outer fauna from that within.

[3] Clarke. N. Y. State Mus. Bul. 39. 1900. p. 167.

the Devonic lakes of Scotland and the Orkney islands, whose existence and geographic details have been demonstrated by Sir A. Geikie.[1] Comparison may also be made with such existing bar-locked lagoons as those which fringe the Baltic coast of East Prussia, the Frisches Haff and the Kurisches Haff. Into each of these opens a considerable drainage, the Vistula and the Niemen, and each is cut off from the marine waters by a long thin bar through which the fresh water normally finds exit at only one narrow opening. At times of storm from without these bars are shifted or broken only to be rebuilt by the natural reaction between the currents of sea and river. With the sporadic breaking down of the barriers the sea fauna is washed into the unpropitious conditions of the lagoon or the lagoon fauna carried out into the marine deposits.

We have shown from the nature of the Styliola limestone and the abundance of pteropods in the still higher strata, the probable existence of warm currents setting into the Appalachian gulf from the southwest, and of colder currents sweeping the coast line eastward to the region of the Oneonta lagoon and presenting to the incoming fresh waters the obstacle necessary to the building of a barrier.

Nonmarine stages succeeding Lake Oneonta. Probably at no time in the long history of the shallowing of the waters of the gulf was any part of it so nearly cut off from ingress of the sea waters as during this early period of Portage time. During the following epoch (Chemung time) similar conditions continued, but the area of impounded water expanded southwestward by the opening or extension of old barriers. The interleaving of its sediments with those of the marine Chemung and even post-Chemung deposits indicates a possibility of easier encroachment of one

[1] The sands of the Scottish Old Red lakes have been shown to be in no inconsiderable part wind blown, and imply arid and desert wastes about the shores of the impounded waters (See the investigations by William Mackie and J. G. Goodchild in the Transactions of the Geological Society of Edinburgh for 1897–99). To what extent similar conditions are implied in the composition of the Oneonta and Catskill sands has yet to be determined.

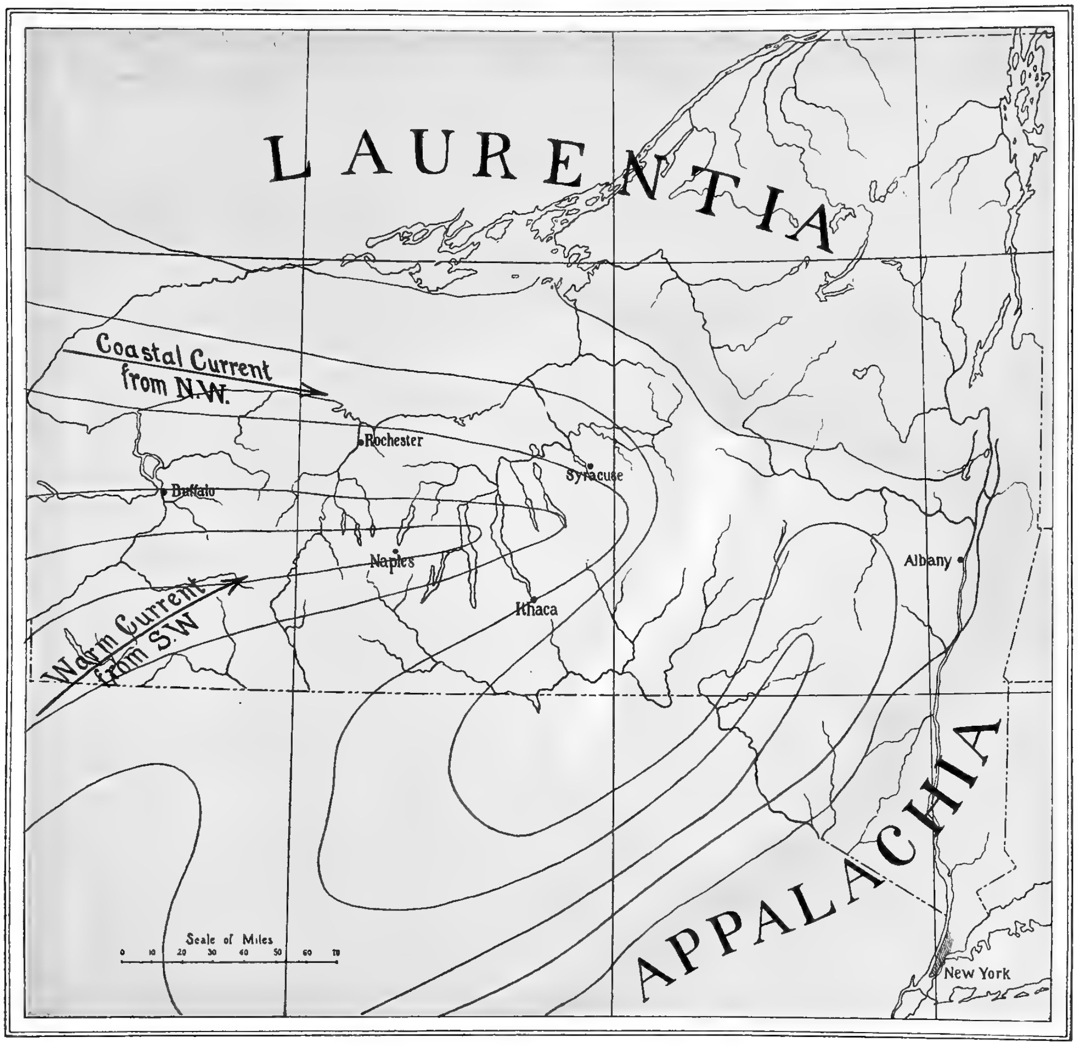
area on the other.[1] Our present evidence seems to indicate with a measure of conclusiveness that the encroachment of the enlarging Oneonta lake was continued beyond the close of the Chemung and Devonic time into the period of Lower Carbonic deposits. The recent study of the Upper Devonic and higher strata of southwestern New York (Olean and Salamanca quadrangles) indicates that a marked change in the fauna, one which involves the disappearance of the majority of Chemung species and the sudden introduction of forms of Carbonic type, manifests itself at a horizon directly beneath the red sand beds with Holoptychius, Bothriolepis, etc., which have long and correctly been looked on as a westward extension of Catskill sediments. If thus the later strata of the great Catskill formation both in eastern and southern New York and in central western Pennsylvania represent in some measure time later than Devonic, we shall find this ancient Old Red lake again in full correspondence with those of Scotland, which have been shown to be areas of localized lacustrine deposit during a period of rapid erosion extending from before the close of the Siluric till after the close of the Devonic. The varying extent of these fresh and brackish water boundaries is well expressed in the existing sediments, and we may hence with convenience designate those successive stages in time and growth as follows:

(1) The Oneonta stage, a relatively small area of deposit almost landlocked, probably restricted to Portage time; (2) the Catskill stage, the enlarged area of deposit extending from the Catskill mountains southward into Pennsylvania[2] and continuing through Chemung time; and probably

[1] Lest this should be interpreted as positive evidence of open connection between the fresh and salt waters, it is to be borne in mind that in the case of the Scotch Old Red lakes the same conditions prevail, with evidences of interlamination of marine and freshwater sediments at the feather edges of both and occasional irruptions from the heart of the sea over the lacustrine deposits.

[2] The character of Catskill beds in Pennsylvania, Maryland, West Virginia and Virginia has been the subject of careful study by Stevenson, Claypole, Prosser, White, Campbell and others, but we still lack the requisite information concerning their relation to the estuarine conditions farther north, and to the marine deposits of the heart of the gulf.

PLATE A



APPALACHIAN GULF IN EARLY PORTAGE TIME

(3) the Cattaraugus stage, in which the area of deposit extended westward from the Catskill area into the southern tier of New York counties and in northern Pennsylvania, time being early Carbonic. The deposits of this stage may be represented in the higher strata of the Catskill mountains section.

Bionic provinces of the Appalachian gulf during Portage time

The distinctions in the life provinces over the north shore of this ancient gulf are marked with wonderful clearness. No such striking illustration of distinct faunal association in an area of so slight extent is elsewhere afforded by the rocks of New York. The provincial distinctions have been referred to by the writer on several occasions; they are here briefly recounted.

1 **Oneonta province.** This is the easternmost part of the sedimentation area of Portage time, or, if not of the entire epoch, at least of most of it.[1] The area covers large parts of Delaware, Otsego and Chenango counties east of the Chenango river, and tongues of its upper deposits extend westward across the last named county. As has been explained at length above, we look on the organisms which occupied this area as of freshwater or at least estuarine habit. The sediments are sands similar, save for their notable iron oxid tints, to those of the marine provinces adjoining.

2 **Ithaca province.** A typical marine fauna of benthonic habit spread over the heart of the gulf. It was the Ithaca fauna, profuse in species and individuals. Its area of sedimentation at the opening of this time seems to have spread from the Albany head of the gulf, but the shallowing which gave birth to Lake Oneonta initiated the transgression of the lagoon area over this marine province. Westward the fauna continues in force to the meridian of Cayuga lake, in its later stages transgressing in this vicinity for a short distance the earlier sediments of the bionic province next west.

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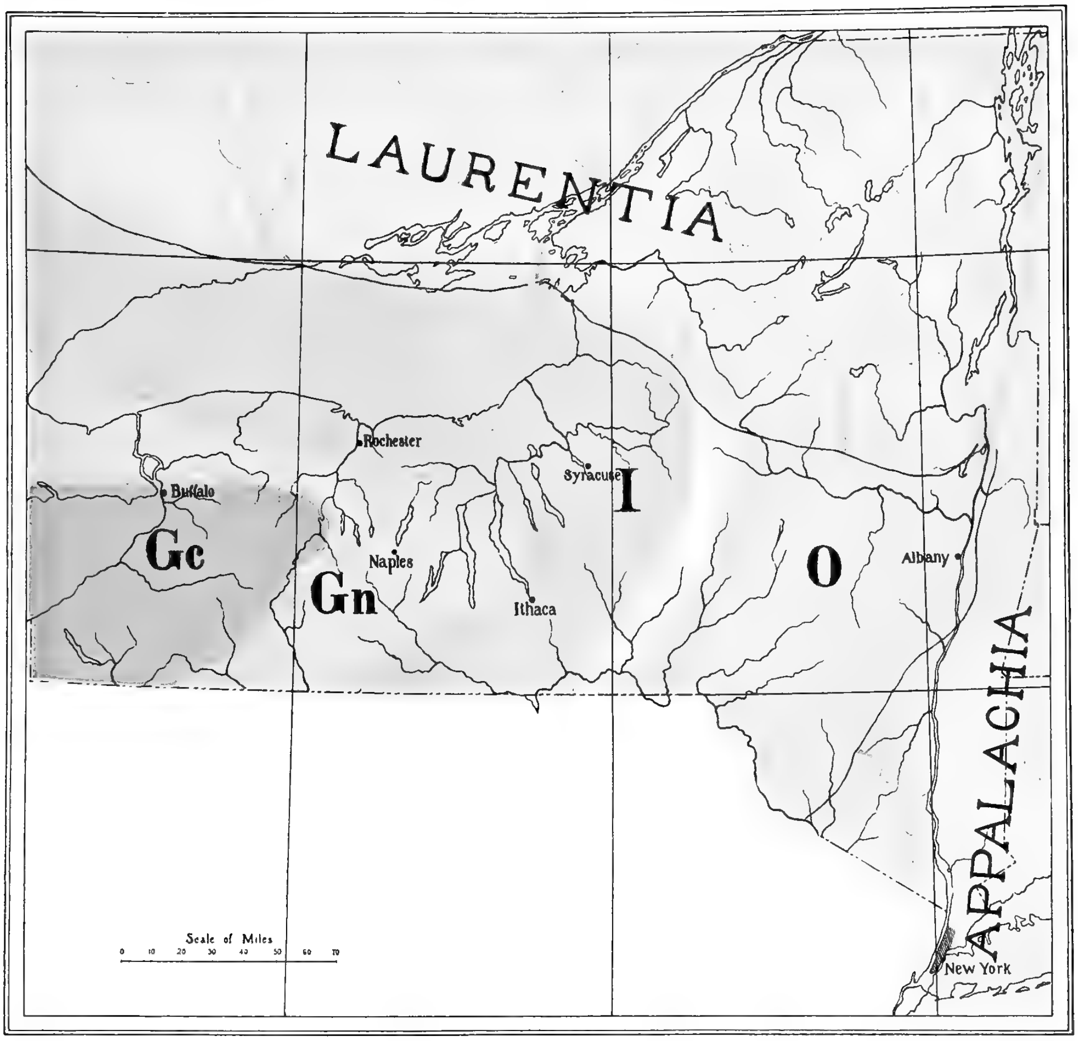
[1] According to Prosser there is evidence of slight thickness of Ithaca deposits beneath the Oneonta beds on the Hudson river side of the area.

The fauna of this province is indigenous. Prolonged study of its composition shows it to be at the outset the fauna of the Hamilton stage. It is the autochthonous fauna of this period, having been on the ground during Hamilton time. The modifications which supervened on the species as time passed, gradually changed the face of the organic association, so that eventually the species individually and the fauna as a whole became impressed with a character quite their own.

3 **Genesee province.** From the interleaved strata along the meridian of Cayuga lake, the field westward to Lake Erie is occupied by softer shales with interbedded and overlying sands, the former embodying locally two or three noteworthy bands of bituminous shales, repetitive expressions of the Genesee shale beneath. The Genesee province contained a fauna which was (as we have previously demonstrated) wholly a newcomer into the gulf from the northwest, an invasion by way of a brief submergence of the western old shore line; a world-wide traveler, it has maintained with surprising integrity its individuality on its long journey eastward from middle Germany into Russia and Siberia and down through British America (Manitoba). Its stay was brief, and with its disappearance the Appalachian sea was again shut off at the west. It is the fauna of the zone of Manticoceras intumescens, or, speaking geographically, the Naples fauna. Its earlier species penetrated as far eastward as Cayuga lake, but here the invasion ended, as the field was occupied by a resistant aggregation, the Ithaca fauna[1]; the invaders seem to have been finally driven to exile by the outburst and aggression of the Chemung fauna. Some of its associated species, specially those which seem to have ancestral relations with the antecedent Hamilton fauna, extend eastward in the interleaves of the Ithaca province, but occurrences of this kind are rare. Within the fauna of this Genesee province are two evident congeries, one an advance guard of the invasion, which extended to the eastern limit of

[1] A very few of the commoner forms of the fauna which may have been derived from the Hamilton stage beneath, occur at points still farther east, in the 200 feet of strata immediately overlying the Genesee shales.

PLATE B



BIONIC PROVINCES OF PORTAGE TIME IN NEW YORK

O Oneonta Province, I Ithaca Province, Gn Genesee Province, Naples subprovince. Gc Genesee Province. Chautauqua subprovince

the province, the other following in its train, which did not attain a point so far east. We have elsewhere defined the earliest or prenuncial appearance of the western fauna in the Genundewa or Styliola limestone of the Genesee shales, an appearance coextensive with the entire province from Yates county to Lake Erie. Even farther to the east in Seneca county where the Genundewa limestone is not present, there is a higher horizon near the top of the Genesee shales where this fauna is present.[1] Thus the species which traveled farthest have sometimes left their traces behind over the whole area, in other instances have developed fruitfully only when reaching the eastern region. On the other hand, most species of this rear guard never penetrated the easterly region. The whole fauna of the Genesee province is knit together by its biologic limitations, its evident deep water habit, the community of generic character among unlike species, its appurtenance, in eastern and western expression alike, to the fauna with Mantic. intumescens and its remarkable similarity with transatlantic manifestations of that fauna. It is with the species of this Genesee province that we are in these particulars, here alone concerned.

Consideration of the tables given at the end of the book will show our present knowledge of the geographic distribution of the members of this fauna and indicates how well founded are these differences in their dissemination. We have therefore on this basis observed the evident existence of two subprovinces of the Genesee province:

Naples subprovince; at the outset covering the entire extent of the province but subsequently closely restricted to the eastern region; during most of its existence approximately bounded on the east by the meridian of Cayuga lake, and on the west by the Genesee river.

Chautauqua subprovince; the western region; extending from the Genesee river to Lake Erie and nearly to the western state line; of later date than the opening stages of the Naples subprovince.

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[1] Clarke. N. Y. State Geol. 14th An. Rep't. 1895. p. 100.

Dissemination of the subprovincial faunas in the Appalachian gulf. In western Maryland (Allegany and Garrett counties) a meager representation of the fauna of the Naples subprovince occurs in dark and gray shales, with some allied species which have not been observed in New York. We have noted Buchiola retrostriata, B. livoniae, B. conversa, B. mariae (not in New York), Paracardium delicatulum, P. doris, Pterochaenia fragilis, Lunulicardium velatum, L. cymbula (not in New York), Bactrites aciculum, Orthoceras filosum, Tornoceras uniangulare.

The northward extent of this fauna along this southern edge of the gulf has not been carefully studied though we know the presence of Buch. retrostriata and Pteroch. fragilis in the gray shales of Perry county, Pa.

The fauna of the Chautauqua subprovince has left no trace of itself outside the region of its typical development.

Comparisons of stratigraphic sections in the Genesee province

The tables herewith given serve to indicate the stratigraphic section and its variations in three meridians of this province, one near the east (Naples section), one at about the middle (Genesee river section), and one at the west (Lake Erie section). These sections purport to represent, not a given period of homogenous sedimentation, for the sediments are not such, but the difference in duration of the Naples fauna with reference to the total sedimentation.

Naples section. We find at the top of the Genesee shale[1] a thin layer of gray flags and shale followed by

		Feet
1	Middlesex bituminous shales	30
2	Gray sandy shales and muds with thin sandstones and flags becoming thicker toward the top	243

These are the Cashaqua shales

[1] This formation is properly to be classed with the Portage beds, as its fauna, so far as distinctive, bears the first representation of the characteristic Naples congeries, but in these sections we have reckoned from the top of the Genesee shales.

		Feet
3	Rhinestreet bituminous shales	21
4	Hatch sands, flagstones and sandstones with intermingled clay shales	312

Throughout this interval of about 600 feet the Naples fauna prevails, without evidence of encroachment of the eastern or Ithaca fauna.

5	Grimes sandstone. Thin bedded, gray flags and sands containing the Ithaca fauna	50
6	Westhill sandstones; heavy bedded sands, flags and few shales	600

Fossils occur in these rocks (6) only occasionally, but they are chiefly indicative of the Ithaca or possibly the earliest stages of the Chemung fauna.[1] We find here such species as the dictyosponges, Hydnoceras tuberosum, H. variabile, Hydriodictya cylix, Ceratiodictya annulata; the brachiopods, Spirifer mucronatus var. posterus, Sp. mesastrialis, Stropheodonta cayuta, Schizophoria impressa, etc. No trace, however, appears of Spirifer disjunctus except in

7 Highpoint sandstone. Heavy bedded, more or less calcareous sandstones

Genesee river section. At the base are

		Feet
1	Middlesex black band	35
2	Cashaqua shales	130
3	Rhinestreet black band	52
4	Hatch flags and sandy shales	209
5	Representing the position of the Grimes sandstone but carrying no Ithaca fossils	25
6	Gardeau (-Westhill) flags and sandstones with few fossils	428
7	Portage sandstones	182
8	Wiscoy shales, flags and sandy or clay shales	150

[1] It is extraordinarily difficult to fix on a division plane between the Ithaca and the overlying Chemung faunas, as the one passes into the other by easy gradation, and we are still somewhat at loss in determining specific values indicial of the early stages of Chemung time.

In this section no Ithaca fossils appear, but the Naples fauna ranges throughout, that is to say that, while in the Naples section this fauna ranges through only 626 feet, in the Genesee river section it persists through about twice that amount, or 1211 feet, before the incoming of the brachiopod fauna from the east, which is here distinctly Chemung. It has been shown by D. D. Luther[1] that the original Portage sandstones in this section are equivalent to and continuous with the Highpoint sandstones in the Naples section carrying a fully developed Chemung fauna. These noteworthy differences in the distribution of the fauna in these two sections show definitely two facts, first that the Naples fauna came in from the west, second that the Ithaca-Chemung or brachiopod fauna spread westward from central New York.

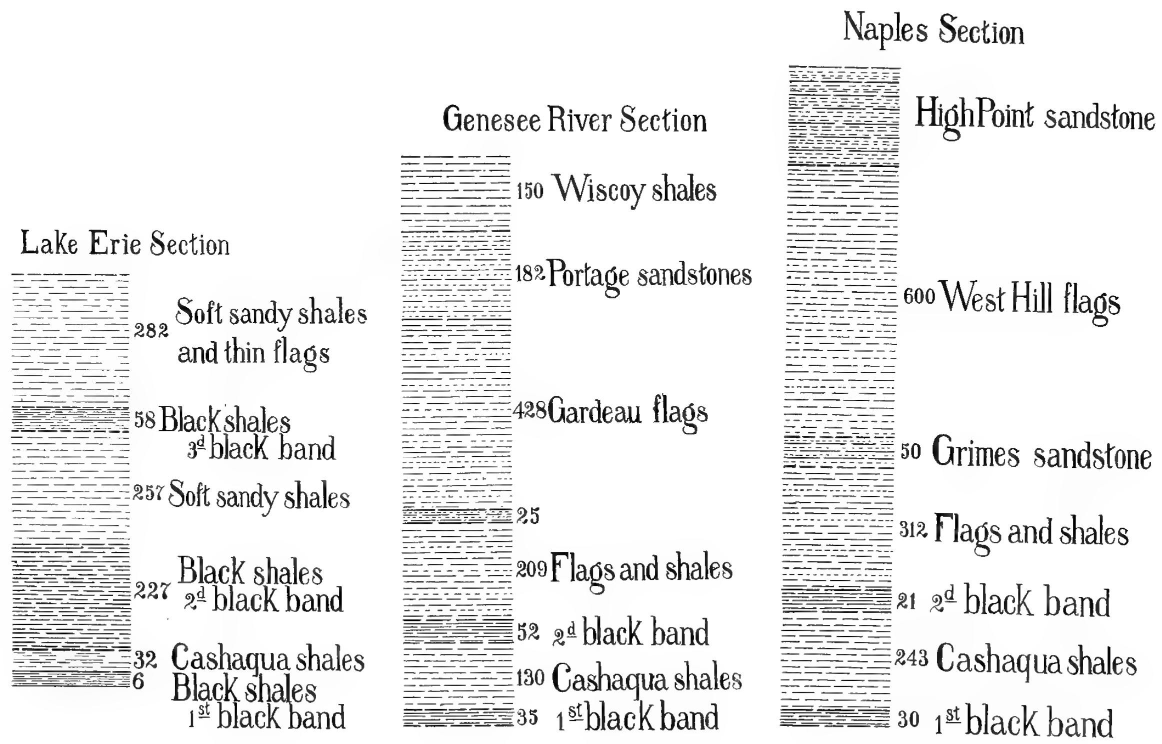
Lake Erie section (Erie and Chautauqua counties). At the bottom of the section

		Feet
1	Middlesex black band	6
2	Cashaqua shales	32
3	Rhinestreet black band	227
4	Silver Creek and Angola soft light sandy shales with few flags	257
5	Dunkirk black band	58
6	Portland light colored shales and thin flags	282

Above this total of 868 feet comes in the Chemung brachiopod fauna represented in a sandstone 22 feet in thickness, termed by James Hall the Laona sandstone, exposed at Laona, Forestville, Brocton, etc. Comparison of this section with the others shows, as we have already pointed out, the very notable increase of the black shales toward the west and the rapid decrease of sands the farther we get away from the emerging shore at the east. An examination of the fossils shows the prevalence of many species in the beds above the heaviest black band which exist neither in the Cashaqua shales at the bottom nor in the development of the shaly beds in eastern sections. These constitute the body of the fauna characterizing the Chautauqua subprovince.

[1] N. Y. State Mus. Bul. 52. 1902. p. 616.

PLATE C


Lake Erie Section
282 Soft sandy shales and thin flags
58 Black shales
3d black band
257 Soft sandy shales
227 Black shales
2d black band
32 Cashaqua shales
6 Black shales
1st black band
Genesee River Section
150 Wiscoy shales
182 Portage sandstones
428 Gardeau flags
25
209 Flags and shales
52 2d black band
130 Cashaqua shales
35 1st black band
Naples Section
HighPoint sandstone
600 West Hill flags
50 Grimes sandstone
312 Flags and shales
21 2d black band
243 Cashaqua shales
30 1st black band

Bionomic character of the fauna

Throughout the components of this fauna there is a striking homogeneity of character expressed in the fact that all classes of invertebrate organisms are thin shelled, a condition compromised solely by the presence of a few representatives from the adjoining fauna to the east. We have observed in discussing the cephalopods that beyond question the large representation of the Goniatitinae is an actual constituent of the fauna, not strangers or interlopers from some outside region. The known benthonic characters of Nautilus lead rationally to the predication of similar benthonic habits for all the coiled cephalopods of this congeries. Similarly, in other groups we have distinguishing marks of deep littoral habit, which is of itself indicated by the thinness of the shell in all.

The prevailing species of the lamellibranchs are the Lunulicardia. Even the largest of these must have been of very tenuous shell, and they were all closely attached and dependent organisms, as shown by the great development of the byssal aperture. All the other lamellibranchs are thin shelled. The gastropods, with the exception of Palaeotrochus, which we know to have existed in earlier rocks and to have continued into a still later stage, were thin shelled. There is no reliable indication throughout the fauna of shallow water habit even in the attached Lunulicardia and but few of true pelagic habit. It is quite likely that the set of the coastal current established by the temporary submergence of the northwest barrier, which allowed this fauna to enter the Appalachian gulf for a while, brought with it masses and tangles of the great algae that are found in these rocks, Dadoxylon and Nematophycus, of which we know portions of the stock having a length of fully 20 feet and a girth equal to that of a man's body; these doubtless afforded a base of attachment for the numerous thin shelled byssus-bearing lamellibranchs. The deep water conditions are also corroborated by the evidence derived from the presence of the bituminous shale beds. If the latter on the whole indicate the depths of the gulf below the line of flourishing life, and their organisms are largely those of the upper strata of the water which have dropped into the sediments below, then the soft gray mud beds which throughout the region carry the fauna in its highest development, must indicate the life of the water just above these depths. That the shales are encroached on by sand deposits, thin at first and eventually predominant, indicates only the distance from the shore line to which the coarser terrigene detritus was carried.

LAMELLIBRANCHIATA

The lamellibranchs of this fauna form a singular assemblage. Notwithstanding the abundance and high development of certain expressions of the cephalopods, particularly the Goniatite types Manticoceras, Gephyroceras, Probeloceras, Sandbergeroceras, Tornoceras and others, it is yet quite fair to say that the lamellibranch element of this fauna in both the eastern and western subprovinces is its most distinctive characteristic. Into this faunal province of Portage time strayed only an occasional representative of taxodont or aviculoid shell, while the same sea in the contemporaneous eastward or Ithaca province fairly swarmed with them. On the other hand, at no period in history have the peculiar genera Lunulicardium, Buchiola, Praecardium, Paracardium, Honeoyea, Paraptyx, Ontaria, Pterochaenia, Loxopteria, Tiaraconcha, Euthydesma, attained such development, indeed for the most part never having appeared before or since. From the list of 70 species here described one may eliminate six or eight, and of the remainder we shall find that all of these peculiar genera are knit together by one striking characteristic, viz absence of denticulated hinge. There is in all a most pronounced convergence to this structureless condition. We find that species of this character are prevalent wherever the Intumescens fauna is well developed, but at no other period of Devonic history have they thus manifested themselves. Indeed, so far as the entire Paleozoic succession of faunas is concerned, but once elsewhere does there appear to have been such an outburst of these simplified lamellibranchiate expressions; this instance is the astounding manifestation of such shells in the later Siluric stages (specially E) of Bohemia, whence Barrande has portrayed an extended variety of species, whose detailed structure has yet to be carefully studied. These representatives of Lunulicardium, Cardiola, Buchiola, Dualina, Panenka and other hingeless shells are numbered by some hundreds of specific names.

The Cardioconch condition

It was the opinion of Neumayr that such lamellibranchs as the genera above mentioned, which we have specially to consider in the Intumescens zone fauna, represent a simple and primitive type of molluscan shell structure expressed mainly and generally in the absence of cardinal apophyses. Basing his inference chiefly on the data supplied by the Bohemian Upper Siluric species, he designated these shells *Palaeoconchae* — a name expressive of an idea and not designed to take ordinal value. To Beushausen, having in mind the exuberant development of these shells in late Devonic time and only their sporadic appearance in faunas older than Upper Siluric, the name has seemed inappropriate, and he has proposed to call them preferably *Cardioconchae.* In this term, eliminating the time element in the designation, there also lurks an element of danger if it conveys the notion that ancestrally or actually these genera are necessarily related to the genus Cardium. The cardioconchs are in our judgment simply an expression of uniformity in or convergence to the obliteration of all hinge structure. We may speak of a *cardioconch condition* and of species as cardioconchs which have attained this condition, but should not employ the term otherwise than as an expression of a peculiar morphologic equivalence. The primitive aspect of the hinge in this phase or state is supplemented by other primitive features, notably the tenuity of the shell substance. Such manifestations of denticulation as are at times shown by some of the genera, e. g. Buchiola, are reversions to the condition of the provinculum and are not of the nature of permanent dentition. In the absence of permanent apophyses of articulation, this end is frequently attained by interlocking of the ends of the plications along the dorsal line. (Ontaria, Lunulicardium, etc.)[1]

[1]The minute planktonic shell described by Simroth as Planktomya henseni has on the hinge such denticulations as are shown by Buchiola and it seems probable that

The convergence of these shells is a consequence of uniform physical conditions, and it has as its result the obliteration of original differences and ancestral generic characters. Hence the determination of phylogeny herein is rendered extremely difficult. Some are doubtless Dimyarians with cardioid affinities (Ontaria, Buchiola, Praecardium), others appear to be allied to the aviculoids and Monomyarians (Posidonia, Kochia, Loxopteria and probably Lunulicardium, Honeoyea, Pterochaenia). The tenuity of the shell rarely permits any indication of muscular scars. In Lunulicardium, Honeoyea and Pterochaenia ontogeny shows that the primitive shell is simple and veneriform in outline, the great hiatus a wholly secondary development.

OTHER COMPONENTS OF THE FAUNA

The *Pteropods* are represented by myriads of individuals but only a few species. The *Gastropods* are more abundant in species, the predominant genera being Loxonema, Phragmostoma, Bellerophon, Tropidocyclus, Palaeotrochus and Pleurotomaria, all of thin shelled forms. Of the *Brachiopods* there are few, and these are seldom to be found in association with the characteristic members of the fauna. The only forms known are a Chonetes, a Crania, a small Productella, and three species of Lingula; all are rare and quite certainly survivors of the replaced Hamilton or interlopers from the adjoining Ithaca fauna. Of the *Corals* none are known save species of Aulopora found incrusting the dead shells fallen to the bottom, and a small cyathophylloid in the Wiscoy shales.

The deep littoral habit of this fauna is again indicated by its wide dissemination. We have observed that no life zone in history maintains its individuality with more persistence and integrity over the earth than this, a fact evinced by the frequency of determinations of identity between the New York and transatlantic species and expressions of close specific relationship in a still greater number of instances, and again by community in strange and peculiar genera at remote manifestations of the fauna, specially

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both are of the same nature [see Simroth. Die Acephalen der Plankton-Expedition. 1896. v. 2, F. e, pl. 1, fig. 1c]. Planktomya is a shell composed wholly of conchiolin and has been caught at the surface in the waters of the tropical Atlantic.

those of Westphalia, Franconia, Timan and New York. To a littoral fauna this permanency of composition would be incompatible with obstacles to be surmounted in the course of migration.

DESCRIPTIONS OF SPECIES

LUNULICARDIUM Münster 1840

The genus Lunulicardium was proposed by Münster in the third *heft* of his *Beiträge zur Petrefaktenkunde* (1840) for certain shells from the uppermost Devonic (Clymeniakalk) of Franconia.

No clear definition of the genus was given by the author; and hence in the progress of knowledge some difficulty has arisen in determining to what species the name is now to be applied, for the eight examples embraced under the term by its propounder have seemed to some writers to represent distinct generic types. The subject is introduced first on page 58 of the work cited, and on page 69 begins the descriptions of the species. On the former page, discussing the characters of the "Cardiaceae," the author says: "But there occur in the Franconian Clymenia and Orthoceratite limestones still other heretofore undescribed species which have at the side of the beak a sharp semilunar insection, in some, separated from the shell by an expanded process. . . These particular species I have believed it necessary to separate under the name Lunulacardium; they fall into two groups." Münster did not further specify the characteristics of the groups except in indicating as above the presence of an expansion of the shell along the hiatus. Barrande[1] in 1881, discussing the genus, noted that such of these shells as seem to possess a well developed auricle separated from the body of the valve by a groove, form a distinct association from the rest in which this character did not appear; and Zittel[2] proposed that these be placed with the Carbonic genus Chaenocardia Meek. Holzapfel[3] pointed out the difference between such shells and Chaenocardia,

[1] Systéme Silurien, 6: 101.

[2] Handbuch der Paläontologie. 1885. 2: 36.

[3] Die Cephalopoden führenden Kalke d. unt. Carbon von Erdbach-Breitscheid bei Herborn: Paläontolog. Abhandlungen. N. F. 1889. 1: 61.

and introduced for them the term Chaenocardiola. Beushausen[1] has employed the latter name and has introduced an additional generic division, Prochasma, represented by Münster's L. pyriforme.

The first of Münster's species described is L. semistriatum, one of the Chaenocardiola group. To this species we should legitimately have recourse in establishing the value of the genus. It is a matter of serious regret that no one has taken up for reconsideration the important work of Münster on these upper Devonic lamellibranchs. The description of the Lunulicardiidae of the Rhenish Devonic given by Beushausen is a most valuable account of these shells but does not specially concern itself with Münster's species. Lunulicardium semistriatum was described as follows:

Fig. 1 Lunulicardium semistriatum (after Münster)

Wider than long; opposite the large and crescentic incurvature on the anterior side is a low incision which in the lithograph is made too deep; the lower margin has a subsemicircular groove, the lower half of the surface is covered with radiating striae, the umbonal surface highly convex with a few concentric grooves; the abruptly arched and acute beak anterior to the great lunule.

It appears from this description and is furthermore evident in the descriptions of other species of the same group that Münster regarded the characteristic lateral marginal flattening of the valves as a lunule. In Holzapfel's earlier observations the author described a number of Lunulicardia from the lower Upper Devonic of Westphalia and in a later work briefly discussed Münster's species, indicating the probability of there being therein distinct groups. Here it was that he proposed to eliminate under the term Chaenocardiola, shells having a long lunule and byssal cleft cutting the valves from beak to basal margin almost midway, and having opisthogyre beaks. The species taken as the type of this genus, however, is C. haliotoidea Roemer (sp.) from the Culm.

[1] Die Lamellibranchiaten des rheinischen Devon mit Ausschluss der Aviculiden: Abhandl. d. Königl. preuss. geol. Landesanstalt. N. F. 1895. heft 17.

Beushausen construes as Lunulicardium certain suborbicular shells typified by L. ventricosum Sandberger, which he illustrates as a species having a short lunule and with the byssal opening quite or nearly closed by vertical walls; with a lineate ligamental area (common to all these shells) behind the beak, and the beaks themselves directed forward, or prosogyre. The author suggests that Münster's species L. excrescens is of this type. The reason for dissociating such a form generically from the type of the genus L. semistriatum is not clear to us, and it does not appear that this construction in any way fortifies the genus. This is rather a conception or an idea of Lunulicardium than an effort to follow closely the intentions of the author of the genus evident in the descriptions and figures of L. semistriatum as given above; for the features of this shell are in most particulars clear and quite in harmony with the great majority of forms which, so far as our experience goes, palpably belong to this group.

In all the extensive material that has been before us, some hundreds of specimens representing this genus, we have seen no instance in which the beaks are not apparently directed away from the umbolateral deflection or lunule, except in the shells we have herein designated as Pterochaenia. While Münster, Zittel, Beushausen and Holzapfel have agreed in regarding the opening of the valves as a byssal passage, Barrande and Hall were more cautious in their expressions concerning it, the former designating it alternatively as "lunule" or "pan coupé."

The great truncation and hiatus in these shells, their most conspicuous feature, may be construed as serving one of the following functions: (1) a siphonal opening, (2) a ligamental hiatus, (3) a mantle opening for the extrusion of water in swimming, (4) a passage for the byssus.

The first consideration is excluded, as Beushausen has shown from clearly defined external casts from the limestone of Martenberg the continuity of the pallial line in several species (see also our figures of L. mülleri and L. inflatum from those localities). While these specimens indicate an integripallial shell, it is worthy of note that L. mülleri displays, both in Beushausen's and our own specimens, a central juxtaposition or fusion of the adductor scars. Other specimens indicating internal characters show but the single adductor scar [*see* L. hemicardioides, pl. 2, fig. 11–16]; but we seem to have in L. mülleri a case of approximation of the muscles which may be compared to that of the genus Tridacna, in which the two adductors have approached each other and joined in the center of the shell, the byssus protruding from the anterior part of the dorsal line.

The second supposed function is improbable, as giving an external ligament of a size and power relatively immense and impracticable to the proportions of the shell.

The third suggestion is entitled to some consideration for the reason that all these Lunulicardia are thin shelled mollusks and are associated almost without exception with other equally thin shelled organisms indicating in some measure a free swimming habit. In such conditions the shell might be compared with a swimming aviculoid like Lima hians, which, though a byssus-spinning mollusk, has the power of breaking away from its byssal nest and propelling itself by the extrusion of water from between the valves. It would not be necessary to this conception of the function of the Lunulicardium hiatus that the latter should be situated on the anterior side of the animal.

Considering the probability of the flattening being anterior and hence a lunule, and of the hiatus being an opening for the byssus, we have these features of importance: When the hiatus attains considerable length, it is notable that the walls which bound it are narrow, sickle-shaped areas standing vertically to the horizontal axis of the animal. These surfaces we are proposing to term the *sicae* or *sical surfaces.* Only when the hiatus is extremely short, that is to say, less than one half the hight of the valve, do the sicae display a tendency to horizontal expansion. With such a hiatus bounded by such vertical surfaces, it seems to us a rational proposition that this structure could be brought about only by close attachment of the shell to some substantial opposing object preventing growth toward the surface of attachment. To fill so large an opening seems to us to necessitate the existence of an extensive byssus which would draw the shell close to the base of fixation. With a shorter opening, the byssus, from analogy with existing species, would be longer, and hence the flanges bounding the opening, i. e. the walls of the lunule, may find opportunity to become more horizontal in their direction. Such flattening of the valves on the byssal side is frequently indicated even where there may be no specialized opening for the extrusion of the byssus itself, e. g. the common Mytilus edulis and probably its ancient allies passing under the name of Mytilus and such other names as Mytilarca, Byssonychia, etc., where the abrupt antero-ventral slope is that which is opposed to the surface of attachment. The fact of this attachment is again indicated by the virtual absence of hinge structure in all these shells and indeed throughout the lamellibranchs of this fauna. Granting that hinge structures are provided for protection against movements of the water, dependence by attachment is thus suggested by the absence of such structures. To the prevalence of the structureless hinge in these mollusks we have already referred. It is to be noted that when, in our observation, the two valves of these shells are found spread wide open without attachment, coherence is maintained from the beak along the edge of the lunule, while in Pterochaenia the reverse is the case; in both the opening taking place along the back of the umbo, whether the direction of the beak be normal as in the latter, or reversed as in the former.[1]

As to the structure of the hinge in this species, exact barite replacements show that there is a total absence of inosculating denticles; beneath the beaks of both valves alike is a short, regular, triangular surface for the ligament; in front the hinge line runs directly into the lunular opening; behind, the valves interlock at the edges by the stronger development of the first two or three radial plications.

The larval shell or prodissoconch, which is well displayed in some of our most delicate replacements, casts very suggestive if not important light

[1] *See* Lunulicardium encrinitum, pl. 2, fig. 20, and Pterochaenia fragilis, pl. 5, fig. 1, 2.

on the morphology and to some degree phylogeny of this genus. This larval shell in the adult condition of Lunulicardium clymeniae, lies with its apex or primitive beak directed downward or toward the postlateral

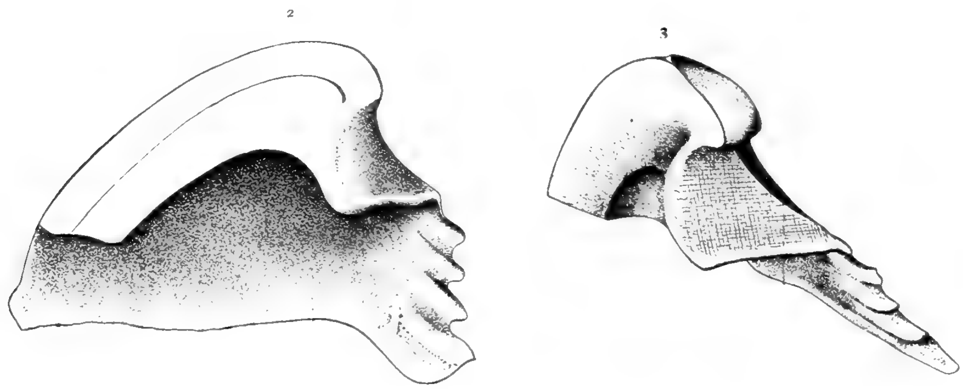

Fig. 2, 3 Umbonal parts of Lunulicardium clymeniae, showing triangular area, projecting plications and sical surface.

extremity of the adult shell, so that the original "posterior" extremity of the larval shell actually lies at and constitutes the beak of the adult. This relation is shown in the accompanying figures. The shell has in growth

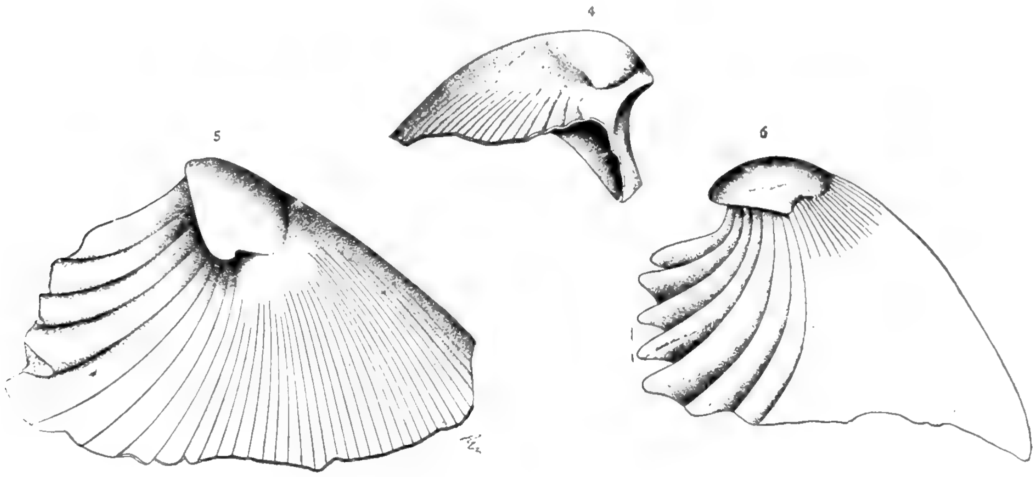

Fig. 4-6 The prodissoconch of Lunulicardium clymeniae viewed in three attitudes, to show its relation to the mature shell. The apex is directed obliquely backward and the posterior end of the larval shell is the umbonal point of the adult.

actually twisted with reference to the animal, and the axial line which we have marked *o–a* has apparently traveled through a large angle to reach the corresponding position in the adult, O–A [*see* fig. 7].

For the interpretation of this phenomenon we may be guided by the remarkable observations recently published by Noetling on the morphology of the lamellibranchs, specially that on "*Das Torsions Gesetz der Schale.*"[1]

By careful determination of the oral and anal extremities in living species, an oro-anal (O–A) axis is located which for purposes of reference is regarded as a fixed or datum line. The line of greatest growth (*Crescenz-linie*, W and *w* in figure 7) or that along which the shell increases most rapidly, is variable for different groups and makes in the series actual and hypothetic (as illustrated in Noetling's diagram), all possible angles with the oro-anal axis. As the beak is always the initial extremity of the crescence line and the latter is variable, the former also changes position with reference to the datum.

Noetling has shown the inaccuracy of the current orientation of the shell with reference to the animal and hence of the descriptive terms "hight," "length," "ventral," "dorsal," "anterior" and "posterior" as usually applied, and which circumstances still compel us to adopt. For mathematical reasons, based on the angle between the oro-anal and crescence axes, Noetling erects eight ordinal groups departing in two directions from an elementary condition, hypothetic and believed to be paleozoic, which he designates "Protoconchae."

There may of course be all possible intervals between these groups which represent only positions on the circle. From the Protoconchae departure is in one direction toward the dimyarians through the Amphigoniacea (no living representative; to be sought in the Paleozoic), the Prosogoniacea (Mesodesma, Nucula), the Orthogoniacea (Pectunculus), the Loxogoniacea (the majority of sinupalliates). In the other direction from

[1] These papers are the following: Beiträge zur Morphologie des Pelecypodenschlosses. Neues Jahrbuch für Mineral. Beilbnd 13. 1900. p. 140; Notes on the Morphology of the Pelecypoda. Paleontologia Indica, new series 1. Mem. 2. 1899; and that specially referred to here, Beiträge zur Morphologie der Pelecypoden. Neues Jahrbuch für Mineral. Beilbnd 15. 1902. p. 394. An English abstract of the last with plate has been given by Ruedemann in Am. Geol. Jan. 1903, p. 34.

the Protoconchae depart toward the monomyarians, the Staurogoniacea (unknown; to be sought in the Paleozoic), the Opisthogoniacea (Avicula), the Symptogoniacea (Pecten). It is not practicable in this place to enter into a further statement of these determinations; the reader must look to the original article or its English abstract.

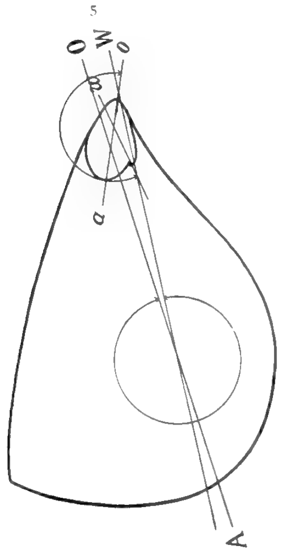

Fig. 7 Diagram giving outline of adult *Lunulicardium clymeniae* with larval shell attached: O–A, oro-anal axis in adult shell; *o–a*, the same in young shell; W, *w*, crescence line in the two. The lower arc indicates the very large critical angle for the adult stage, the upper arc, the critical angle for the young stage. The former is normal to a position between the Opisthogoniacea and Symptogoniacea, the latter in agreement with the critical angle of the Protoconchae. In comparing this with Noetling's figures it is necessary to bear in mind that here the exterior of the valve is represented while in that the interiors are given. This will account for the apparent reversal of direction in the two.

Referring again to our figures, we find that, if the adult shell of Lunulicardium be construed and oriented as a dimyarian, then the angle between O–A and W (crescence-line) is less than 90° and conforms to this angle in the extreme dimyarian line. But in such orientation we unavoidably reverse the extremities of the oro-anal axis, the anal extremity, A, appearing on the byssal side, which we know to be a condition not existing in the lamellibranchs. The inference therefore, that Lunulicardium has little to do with the dimyarians, is supported by empirical observation of a single posterior adductor or a median approximation and fusion of the two adductors. Hence, orienting the shell as monomyarian, posited between Avicula (Opisthogoniacea) and Pecten (Symptogoniacea), on the basis of its muscular and byssal structure, we find that the critical angle is exact for the position taken. We take this as excellent confirmatory evidence of the monomyarian affinity of the genus. In following the torsion of the shell backward from the adult condition to the prodissoconch we find that it passes through the angles necessary to bring it with precision to the condition of the Protoconchae, and the relations of the axes in the latter also correspond with those of the prodissoconch. I believe therefore that this larval shell is an actual representative of the Protoconchae condition, and that the stages of torsion of the Lunulicardium shell in subsequent growth are indicative of its phylogenic stages of progress toward the monomyarian stock. This conclusion is based wholly on external characters and the fact of actual observed torsion in the shell from youth to adulthood. The Protoconchae being theoretically the primitive lamellibranch condition, we may never come to know it except in this manifestation. It is well to add that the supposed position of the pallial line in this group, just within the hinge, is a feature on which the nature of our material permits no observation.

As to the systematic position of Lunulicardium it seems to us probable that its ancestry may be found in the Ambonychias and Byssonychias of the Lower Siluric; we should be disposed to hold it probable at least that the shells represent a departure from the aviculoid stock in which the anterior adductor is lost either by fusion with the posterior or by suppression. Neumayr was disposed to derive from Lunulicardium the peculiar genus Conocardium, and Beushausen has contributed a considerable body of facts supporting this proposition, describing a genus Conocardiopsis, which to him indicates a passage phase between the two genera. Having stated the reasons for our inability to conceive of Lunulicardium precisely as construed by Beushausen, we shall take occasion to remark that the genera which have been proposed as subdivisions of the old term, viz, Chaenocardiola Holzapfel and Prochasma Beushausen, seem to lack substantial grounds for recognition, except in so far as these terms express extremes of development in one direction and another. Forms referable to both of these genera in outline, character of surface, length of lunule, occur in abundance among our species, but so far as our observation extends, they are all opisthogyre and all constructed on the same plan.

We note the proposed subdivisions which have been made of this genus Lunulicardium.

Pinnopsis Hall, 1843. This name was introduced by Hall in the *Geology of New York* (report on fourth district), for the species P ornata and P. acutirostrum from the Portage (Naples) shales of western New

York. These are large and strongly plicated shells. Professor Hall subsequently abandoned this name in favor of Lunulicardium, which he recognized as congeneric with his species. There can be no question that they are in strict construction congeneric with Münster's L. semistriatum; and it may be well to remark here that, in the material which has been before us, every shade of transition in degree of plication is present from those having it strongly marked, as in the species just cited, to those in which the surface markings are the finest radial lines, and further to forms in which the surface is without any trace whatever of such lines.

Chaenocardiola Holzapfel, 1889. In these shells there is a difference from others in the great length of the truncating hiatus, the margins of which in typical expressions extend nearly the full axial hight of the shell, and cut the basal margin almost in the middle. The beaks are opisthogyre or twisted backward. Were it not for the fact that every degree of variation is presented among these shells in the position and length of the truncating margins, rendering it possible to construct series on the one hand, truncating in a very short and sharply upturned anterior margin, and, on the other, in a long straight, nearly axial, truncating margin, as in typical forms, we should find some basis for recognition of this proposed genus. Our material however does not justify us in separating the shells except in extreme cases and in a subgeneric way, from Lunulicardium.

Prochasma Beushausen, 1895. These are species of smooth or finely lineate surface and generally with short hiatus. The beaks are regarded by the author as prosogyre or turned toward the hiatus. Beushausen specified as the type species Lun. pyriforme Münster and embraced within the group elongate mytiliform shells like Lun. mülleri Holz. as well as broader and stouter species (P. bickense, P. dilatatum), which have close allies among the New York shells. We have not been able to substantiate Beushausen's observations on the direction of the beaks. Shells of this type of structure, of which many (including specimens from the Westphalian localities) have been closely studied by us, fail to convince us of the presence of prosogyre beaks, but conform in this detail to the rest of the Lunulicardia of the fauna. In Pterochaenia, hereafter discussed, the beaks are unquestionably prosogyre, and this structure is accompanied by other features distinguishing the shells from typical Lunulicardia, principally the broad and horizontally extended flanges of the lunule. In Prochasma, however, the hiatus is bounded by vertical sicae. We can therefore employ the term only with restricted value as a designation for the smooth or finely lined species of Lunulicardium, bearing in mind that in respect to this surface ornament there is every gradation to the conditions represented in Chaenocardiola and Pinnopsis.

Lunulicardium (Pinnopsis) acutirostrum Hall. 1843

Plate 1, fig. 1-6; plate 4, fig. 10

Pinnopsis acutirostra Hall, Geology of New York; report on the fourth district. 1843. p. 244, fig. 106, 7

Lunulicardium acutirostrum Hall, Preliminary Notice Lamellibranchiata. pt 2. 1870. p. 97

Lunulicardium ornatum Hall, (partim) Paleontology of New York. 1885. v. 5, pt 1, p. 437, pl. 71, fig. 30-32

Lunulicardium acutirostrum Clarke, United States Geological Survey. Bulletin 16. 1885. p. 62

In describing some of the Portage fossils, Professor Hall in 1843 designated two species of Pinnopsis, P. acutirostra and P. ornata. These were believed to differ in the acute form and more abundant plication of the former, and the much more orbicular form of the latter. When, however, these fossils were redescribed and illustrated in 1885, the species were united, the former being regarded as an accidental expression of the species due to compression or distortion. It was observed that "The typical [original] specimen of L. acutirostrum has the anterior and posterior margins abruptly infolded, giving the shell a much narrower aspect than when in its natural condition. The plications are more slender than in the prevailing forms referred to L. ornatum, and from the infolding of the margin those of the posterior end are invisible in the figure [pl. 71, fig. 30]. The specimen, figure 31, subsequently referred to the same species, has a greater proportional hight than the prevailing forms of L. ornatum, the plications are also narrower and with narrower interspaces. A comparison of these forms with larger collections, showing numerous intermediate phases, makes it impossible to draw lines of specific distinction, and it is doubtful if any fixed varietal form exists."

Notwithstanding this expression, my observation leads to the conviction that this narrow acuminate form of the shell is frequent and persistent in the abundant collections before me. That it is not a casual expression is evinced by a number of specimens which are rotund and retain their normal convexity. The coarser or less abundant plication of the surface originally given as a character of L. acutirostrum, is not always persistent, yet in the best preserved specimens the difference in this respect is noteworthy.

Diagnosis. Shells acuminate, apical angle as measured between the sical edge and the ridge of the posterior slope, 60°. Lateral margins long; the hiatus extends for nearly two thirds the length of the valve, its apparent length being often increased by compression; straight or with a gentle inward curvature. Sicae moderately broad near the apex, rapidly diminishing in width. From the very short, triangular cardinal area the posterior margin slopes downward with a very gentle curve. This margin lies almost vertically beneath the umbonal slope of the valves so that under compression it is concealed and the straight umbonal slope makes the apparent posterior margin.

Surface convex. The apex is somewhat incurved, and the convexity of the valves is greatest near the sical margin. Thence the slope to this margin is somewhat abrupt, but toward the posterior margin more gradual to near the edge, whence it becomes almost vertical. Over the pallial region the convexity is much more regular.

The surface markings consist of continuous, simple, radial plications separated by relatively narrow interspaces. These plications vary in size on different parts of the valve; they are largest where shortest, on the vertical slope to the posterior margin close to the umbones, where they strongly crenulate the margin and form an accessory to articulation. From this margin they decrease in size posteriorly, and near the hiatus there is an area which is free of striation. When normally preserved, these ribs are flat, slightly elevated at their edges, and are crossed by subequidistant, fine, elevated concentric striae which curve upward on the ribs and downward in the furrows.[1] The surface is also crossed at irregular distances by coarser concentric lines of growth. The number of radial ribs varies from 28 to 45, rarely exceeding 30.

Dimensions. A full grown and normally rotund individual measures as follows: length 43 mm, hight 50 mm; length of sical margin 30 mm.

Habitat. Genesee province; Naples subprovince. This species is generally disseminated throughout the Naples shales in Yates, Ontario, Livingston and Genesee counties. It has been found at various outcrops in Naples, on Honeoye and Conesus lakes, at Belknap's gully near Branchport, along the Cashaqua creek, and rarely on the Genesee river. It is quite rare in the sandy layers of the upper beds and is not known as yet even in the lower layers of Erie county.

Lunulicardium (Pinnopsis) ornatum Hall. 1843

Plate 1, fig. 8–14

Pinnopsis ornata Hall, Geology of New York; report on the fourth district. 1843. p. 244, fig. 106, 108

Lunulicardium ornatum Hall, Preliminary Notice Lamellibranchiata. pt 2 1870. p. 91

Lunulicardium ornatum Hall, Paleontology of New York. 1885. v. 5, pt 1. p. 437, pl. 71, fig. 25, 29

Lunulicardium ornatum Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 61

Diagnosis. Shell often of large size, outline suborbicular or obliquely subelliptic; beak projecting; apical angle 110°–115°. Posterior or sical margin straight or slightly incurved, extending to about the middle of the shell, its actual length being approximately three fifths the length of the valve.

Surface regularly convex, the line of greatest convexity being toward the anterior margin; the slope thence posteriorly is gradual, and sometimes

[1] Just the reverse of their direction as represented in Paleontology of New York, v. 5, pt 1, pl. 71, fig. 32.

the surface is slightly concave in this region. On the anterior margin the slope is abrupt and vertical for a short distance to the hiatus, but the sicae are comparatively narrow.

Surface markings consisting of radial plications crossed by fine concentric lines; of the same character as in L. acutirostrum. The number of these plications is usually 47, but may vary from 45 to 55. Those on the posterior slope are the coarsest and are separated by the widest furrows. Directly behind the beak and at the side of the triangular cardinal area the first two or three of the plications are stronger than the rest, their free edges making processes which interlock on opposite valves.

Dimensions. A full grown example of normal form is 54 mm in hight, 47 mm in length; the sical margin measuring 36 mm in length. A smaller specimen which has been subjected to no distortion is 32 mm in hight; 35 mm in length, and the sical margin 23 mm in length.

Habitat. Genesee province; Naples subprovince. This species is widely distributed and is of more frequent occurrence than its ally, P. acutirostrum. It is found in the lower shaly beds and rarely in the higher sandstones of Ontario, Livingston, Genesee, and Wyoming counties. Occasionally in the upper part of the Havana glen section, Schuyler co.; and at Himrods and Branchport, Yates co. It has not been observed in the lower shales of Erie county.

Lunulicardium (Pinnopsis) libum sp. nov.

Plate 2, fig. 10; plate 4, fig. 1, 2

This form is characterized by subacuminate valves, broadly rounded and subsemicircular on the pallial margin. Beak nearly in the axial line. Sical margin oblique, rather longer than one half the hight of the shell, incurved and slightly arched. Sicae very broad and smooth, usually vertical but extended obliquely or horizontally by compression. Surface of the shell with from 15 to 25 low, broad, flat topped plications with narrower intervals. These plications are all simple in the umbonal region, but bifurcate rapidly and irregularly over the pallial region, so that in full growth they present the appearance of great inequality specially if the multiplication is confined to certain plications and the rest simply increase in width. There are very fine concentric striae crossing the plications and occasionally low undulations in the umbonal region.

This is a species of the type of Pinnopsis, but is very unlike the eastern forms in the irregularity of its plication.

Habitat. Genesee province; Chautauqua subprovince. Terry's ravine, Forestville, and above the black shales at Fox's point, Lake Erie. It has also been found in the Wiscoy shales above the Portage sandstones on Wiscoy creek, Allegany county.

Lunulicardium (Pinnopsis) wiscoyense sp. nov.

Plate 1, fig. 7

Diagnosis. Shell small, ovate, acuminate, apical angle 40°. Sical margin arched, oblique, direct, one half the hight of the shell. Marginal curve of the pallial region semielliptic, posterior margin broadly rounded. Surface plicate, the ribs being simple, continuous, strong and rounded, separated by furrows of equal width. Thirty of these ribs may be counted at the basal margin. They are crossed by very fine concentric lines.

This shell has in some measure the aspect of a small L. acutirostrum or L. ornatum, but it may be distinguished by having rounded and more distant plications, and considerably fewer than those species at a corresponding growth stage.

Habitat. Genesee province. In the Wiscoy shales above the Portage sandstones, Wiscoy creek, upper Genesee valley, Allegany county.

Lunulicardium (Pinnopsis) accola sp. nov.

Plate 4, fig. 12, 13

Shell rather small for the plicated species, outline suborbicular, surface regularly convex, beak slightly posterior, subcentral. Sical margins extending for nearly one half the hight of the shell and quite straight. The plications are sharply defined, rounded and separated by concave intervals equal to them in size; they are simple and continuous, increasing very slowly and sparsely; they number 38 on the original specimen. These plications are crossed by fine concentric lines. Length and hight of typical specimen, 19 mm.

This species resembles in general aspect, L. ornatum, but the latter at a hight of 19 mm has from 46 to 50 plications which are flat topped, not rounded as in L. accola. The subcircular outline of L. accola is also quite characteristic. The species is based on rather meager material which represents the only evidence of the true Pinnopsis type found in the western subprovince, excepting L. wiscoyense from the upper Genesee valley.

Habitat. Genesee province; Chautauqua subprovince. Ravine at West Falls, Erie co., not far below the horizon of the Portage sandstone.

Lunulicardium (Chaenocardiola) clymeniae sp. nov.

Plate 2, fig. 1–6

Shell of medium size, subpyriform in outline with nearly vertical anterior margin, the sical margin extending for the greatest diameter of the valves. Beak moderately prominent, incurved at the apex, which is directed toward the postlateral margin [*see* description and illustration of the beak on p. 224]. Beneath the beak lies the triangular cardinal area, below which are a few coarse, angular, interlocking plications. The margin has a strongly convex curvature outward from this point to the lower margin, where it is somewhat transverse. The anterior margin is straight, passing from the beak to the base axially or just before the axis; in contrast to the thin edges elsewhere on the valve, the shell is here greatly thickened. The sicae are broad, flat and vertical, broadest on the umbonal region, tapering outward at first abruptly, thence more gently, and ending somewhat obtusely at the margin. The hiatus is elongate cordiform.

The surface slopes pretty regularly from the sical margins, there being a slight concavity sometimes apparent close to the sical margin near the lower edge of the shell.

The surface sculpture consists of exceedingly fine radial filiform lines six in the space of 1 mm over the middle of the valve. These are increased in number by very gradual intercalation, and are covered by numerous minute, concentric lines which produce a very fine cancelation of the surface.

A specimen of normal size has a length of 13 mm, a width of 17 mm.

Habitat. Genesee province; Naples subprovince. Briggs's gully, Honeoye lake; Whetstone gully near Livonia, Livingston co., associated with Cyrtoclymenia neapolitana.

Lunulicardium (Chaenocardiola) eriense sp. nov.

Plate 4, fig. 3-6

Shell of medium size, oval-acuminate in outline, with long, oblique posterior truncation. Beak slightly projecting; anterior curve subcircular or broadly elliptic. Length but slightly less than the hight of the shell. The sical margin is straight and makes an angle at the beak of 45° to the vertical axis. Its length is from five sixths to nine tenths the hight of the shell.

Surface covered with exceedingly fine radial lines, which are from 60 to 80 in number, somewhat more than half the number in L. paruncalus, and always straight, not wavy as in that species. These lines are coarser on the posterior margin near the beak and there crenulate the margin. Concentric markings are scarcely visible except as low undulations.

This species approaches in some particulars L. clymeniae and L. velatum, but is not so extremely truncate posteriorly as the former, nor are the radial striae cancelated by concentric lines.

Dimensions. Hight and length in normal examples, about 20 mm.

Habitat. Genesee province; Chautauqua subprovince. In the shales at Correll's point, Lake Erie, and Forestville.

Lunulicardium (Chaenocardiola) hemicardioides sp. nov.

Plate 2, fig. 11-16

Shell small, subovate triangular, with acute umbones; sical margin very long, nearly or perhaps quite attaining the axial length of the valves; these margins are arched and attain the greatest convexity of the shell.

Sculpture casts show moderately broad vertical sicae. Surface with radial ribs, which are flat, simple, continuous without increase, and are separated by narrow sulci. The number of these plications is from 20 to 28, and a considerable number of the anterior of these do not start from the beak but take origin along the sical margin. Only traces of concentric striae are present. The hight of a typical specimen is 8.5 mm; length 10 mm.

To this species are referred a number of specimens of quite small shells, in which there seems to be some variation in the coarseness of surface plication. One of these is specially peculiar in presenting an unusual elongation of the antelateral extremity beyond the normal basal outline of the shell. This is a limestone specimen with natural convexity and full outline. The same example shows very clearly a relatively very large anterocentral distinctly elevated (on the cast) single adductor muscle scar which covers more than one half the diameter of the valve at this place. Traces of a similar scar are to be seen on a specimen from the shale. This species differs from L. clymeniae, L. eriense and L. velatum in its more acuminate outline and coarser plications.

Habitat. Genesee province; Naples subprovince; in the Naples shales, Parrish gully, Naples; and in the Styliola limestone, Genundewa, Canandaigua lake.

Lunulicardium (Chaenocardiola) furcatum sp. nov.

Plate 4, fig. 7

Shell subtriangular in outline, beak slightly posterior, sical margin long and straight, basal margin a low broad curve rounding rather abruptly backward into a relatively narrow posterior curve. Surface quite depressed, flattened over the pallial region, covered by radial plications which show a distinct forward sweep over the surface. The plications are numerous, distinctly flat topped with flat interspaces, are obsolete in the umbonal region and seem to be devoid of concentric lines. They are highly irregular in size specially on the posterior portion of the shells, small ones rapidly intercalating among the larger and on the anterior slope the large ones are distinctly split medially by a groove, multiplication taking place by this method. This is a very peculiar feature which serves to distinguish the species.

The original specimen has a length and hight of 17 mm.

Habitat. Genesee province; Chautauqua subprovince. Forestville, Chautauqua co.

Lunulicardium velatum sp. nov.

Plate 2, fig. 7-9

Shell of moderate size, vertically subovate in outline. Sical margin short, oblique, not extending to the middle of the shell, direct or gently incurved, making an angle of about 100° with the posterior margin; posterior margin rounding and closely incurved at the beak, curvature of the pallial margin subsemielliptic.

Surface gently and evenly convex; marked by exceedingly fine radial lines which are separated by sharply incised furrows much narrower than the lines themselves. The elevated lines are filiform over the earlier portions of the shell, but become flattened toward the margins. They increase by very gradual dichotomy so that above the middle of the valves they are often of unequal size. At about the middle there are 10 of the lines in the space of 1 mm, but at the lower margin of the valve these have broadened so that six fill this space. The lines are crossed at very minute but approximately regular intervals by concentric linear striae and also by regular concentric lines of growth which multiply toward the margins.

None of the observed specimens of this species have preserved the outline of the valves in perfection, the character of the ornamentation of the shell being the feature on which main reliance is for the present placed as a means of specific distinction.

In the largest specimen the hight of the shell is 18 mm, its length approximately 23 mm; the length of the sical margin approximately 13 mm. Other fragments indicate a somewhat smaller size.

Habitat. Genesee province; Naples subprovince. Base of Hatch hill and Parrish gully, Naples.

Lunulicardium finitimum sp. nov.

Plate 2, fig. 17, 18

Shell rather small and narrow. The lateral margins are long, and approach each other at a small angle, so that the aspect of the valve is highly acute. The sical margin extends for more than one half the entire length of the shell, while the anterior edge slopes at very nearly the same angle as the posterior, with a gentle outward curvature. The apparent apical angle is about 55°. The basal margin is regularly curved, the curvature being that of the extremity of an ellipse.

Surface gently and regularly convex; abruptly deflected on the sical margin. The ornamentation consists of very minute, simple rounded or filiform radial lines, becoming broader and flat. These number over the body of the valve six to 1 mm; 70 to 90 over all. They are crossed and crenulated by exceedingly minute concentric lines. Near and at the lower margins of the valves the radial ornament is interrupted or extinguished by the moderately strong concentric striae.

The observed specimens of this rare and well characterized species are two right valves, the larger having a hight of 23 mm, and its greatest length, lying at one third the hight from the lower margin, is 14 mm.

Habitat. Genesee province; Naples subprovince. Parrish gully, Naples N. Y.

Lunulicardium sodale sp. nov.

Plate 2, fig. 22

This is a shell having the acuminate form of L. finitimum, but it shows somewhat greater curvature along the sical margin; still the apical angle, relative length of the anterior and posterior margins, curvature of the lower margin, width over the pallial region, and convexity of the valves are essentially as in the preceding species. The specific distinction is found in the character of the surface ornament, which consists of radial plications very much larger than in L. finitimum, continuous and simple, flattened on top and separated by furrows as wide as the ribs. At about the middle of the valve there are four of these in the width of 1 mm, at the margin but one in the same space. The entire surface shows 26 plications. Though these elevated lines are actually continuous throughout their extent and are not increased in number except on the very early parts of the shell, they are gracefully sinuous in their course over the valve and are interrupted at irregular intervals by concentric growth lines, in addition to which are very fine crenulating lines of ornament. The species is rare, and the single specimen observed is a left valve measuring 23 mm in hight; 15 mm in greatest length.

Habitat. Genesee province; Naples subprovince. Base of Hatch hill, Naples.

Lunulicardium encrinitum sp. nov.

Plate 2, fig. 20

Shell of medium or small size; outline orbicular or subtriangular; apex back of the middle line; sical margin slightly incurved and extending for about two thirds of the antelateral margin. Surface depressed convex, sloping pretty evenly in all directions, most abruptly to the posterior margin. Surface markings consist of 35 to 40 fine, somewhat flattened striae separated by narrow sulci, and crossed by minute concentric striae. A normal example has a hight of 11 mm, and a length of 10.5 mm.

Habitat. Genesee province; Naples subprovince. This species has been observed only in the thin calcareous Melocrinus layer which lies in the Genesee shales above the horizon of the Styliola limestone. The exposure of this bed in the Blacksmith gully, Bristol, Ontario co., has furnished several specimens.

Lunulicardium pilosum sp. nov.

Plate 2, fig. 23, 24; plate 4, fig. 8, 9

Shell of medium to large size, length and breadth equal. Beaks posterior of the axial line; lateral marginal slopes diverging at an angle of 75°. The sical margins are long, extending for a little more than half way down the shell, their actual length being four fifths the length of the valve. Their margin is distinctly though not deeply incurved, the sical walls narrow, but they are not greatly arched, and the hiatus is consequently narrow. Antelateral margin prominent, making the valves slightly aliform at the front angle; basal margin rather evenly curved, somewhat transverse beneath; the posterior margin regularly and somewhat abruptly rounded, not expanded.

Surface sloping evenly and regularly toward the commissures, rather abruptly to the posterior margin and anteriorly to a broad low depression along the hiatus. The ornamental marking consists of exceedingly fine, somewhat undulating, filiform radial lines; at the lower margin there are seven of these in the space of 1 mm and over the middle of the valve nine lines in the same space. These are interrupted by concentric lines and may be minutely crenulated by finer lines of growth. Sometimes the concentric growth completely obscures the radial markings over most of the pallial region.

Dimensions. A right valve of this species has the following dimensions: hight 18 mm, length 18 mm; length of hiatus 13 mm. A large left valve measures, hight 30 mm, length 32 mm; length of hiatus 23 mm.

Habitat. Genesee province; Naples subprovince. Parrish gully, Naples. A specimen from the lower shales on Pike's creek, Erie co., is also referred provisionally to the species.

Lunulicardium (Prochasma) bickense Holzapfel

Plate 3, fig. 3-5, 11

Lunulicardium bickense Holzapfel, Die Goniatitenkalke von Adorf; Paleontographica. 1882. 28: 256, pl. 49, fig. 9

Lunulicardium laeve Williams, U. S. Geol. Sur. Bul. 41. 1887. p. 39, pl. 13, fig. 5, 6, 8

Prochasma bickense Beushausen, Lamellibr. des rhein. Devon. 1895. p. 377, pl. 28, fig. 4, 5, 10, 12

This species, which sometimes attains moderately large size, has an obliquely ovate outline with beak behind the middle line; sical margin oblique, short, attaining about one half the hight of the valve; making an apical angle of 30° with the axial line; direct or slightly incurved and arched. Pallial surface expanded more behind than in front of the axial line. Slope quite abrupt to the anterior margin. Surface smooth with fine concentric lines, but no other ornamentation except one or two short plications directly behind the beak.

I am unable to detect in the descriptions and illustrations of this species which have been given by Holzapfel and Beushausen, any differences from shells occurring in the Naples fauna at and west of the Genesee river. The species was first quoted from Martenberg near Adorf, Bicken (Holzapfel) and other localities; Beushausen adds Oberscheld, all in the lower Upper Devonic.

It seems probable that these shells are identical with those described by Williams as above cited, though I have been unable to obtain access to the original specimens of L. laeve or to examples regarded by the author as of typical character. Our shells vary notably in size but without change in essential characters. Lunulicardium laeve was characterized as of "medium size, obliquely oval, with sharp, short beak nearly central, with byssal gap starting close under the beak on the anterior side and reaching obliquely about one half the length of the shell, lip reflected in the left valve and inflected in the right valve, the front broadly rounded and curving around regularly to near the beak on the posterior margin, upon which are two or three well defined radiating plications which may be lateral cardinal teeth. Surface nearly smooth, with concentric lines of growth and very fine radiate striae."

The species differs from L. enode in its shorter, less oblique sical margin, and from L. absegmen in the same respect as well as its smaller diameter across the pallial region.

If proper allowance be made for the compression to which these shale specimens have been subjected, it will be difficult to distinguish them from L. inflatum Holz. (Martenberg).[1]

Habitat. Genesee province; Chautauqua subprovince. Lower Portage falls of the Genesee river; Buck run near Mount Morris; Johnson's falls,

[1] *See* Holzapfel, *op. cit.* 1882. p. 33, pl. 6, fig. 11, and compare his figure with ours on pl. 3, fig. 3. *See also* Beushausen, *op. cit.* p. 377, pl. 28, fig. 6, 7.

Strykersville; Farnham creek, Lake Erie shore, three miles southwest of Angola. The originals of the L. laeve are from Varysburg and Warsaw, Wyoming co.

Lunulicardium (Prochasma) absegmen sp. nov.

Plate 3, fig. 15

Shell of medium size, subcircular over the pallial region, broadly pointed at the beak, the apical angle being about 45°. Behind the beak the margin is incurved abruptly, thence rounds outward, downward and upward in regular subcircular curvature, meeting the sical margin at the middle of the shell. Sical margin oblique, longer than one half the length of the shell, slightly arched. Surface depressed and evenly curved, smooth or with only very obscure concentric striae. No radial markings visible.

This species differs from L. bickense in its broader form, subcircular marginal outline, absence of radial lines and obsolescence of the plications beneath the beak; L. beushauseni, which it approaches in outline, has strong subumbonal, posterior plications and fine radial lines over the shell. In L. enode the sical margin is longer and more oblique.

Habitat. Genesee province; Chautauqua subprovince. Correll's point, Lake Erie.

Lunulicardium absegmen is very closely similar to L. concentricum (Martenberg) as described and figured by Holzapfel[1] and Beushausen,[2] but has a longer and more oblique sical margin.

Lunulicardium (Prochasma) enode sp. nov.

Plate 3, fig. 14

Shell small, apical angle about 60°. Anterior margin oblique, straight and arched, extending five sevenths of the length of the valve. The basal margin is oblique from the end of the hiatus and rather broadly recurved posteriorly. The surface is marked only by very fine concentric lines. This species may be distinguished from L. bickense by its much longer sical margin.

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[1] *Op. cit.* 1882. p. 33, pl. 6, fig. 10.

[2] *Op. cit.* 1895. p. 372, pl. 28, fig. 11.

Dimensions of the only specimen found: hight 13 mm, length 9 mm.

Habitat. Genesee province; Naples subprovince. From the lower Portage falls of the Genesee river gorge.

Lunulicardium (Prochasma) parunculus sp. nov.

Plate 3, fig. 17–20; plate 4, fig. 14

Cf. Prochasma dilatatum Beushausen, Lamellibr. des rhein. Devon. 1895. p. 376, pl. 28, fig. 8, 9

Shells of rather large size, obliquely ovate, beak nearly central or lying just behind the axial line. Behind the beak the margin is usually somewhat incurved, and its surface bears one or two short ribs; thence the curve is abruptly outward, and a rounded angle of nearly 90° is formed at the turn to the nearly straight postlateral margin. Over the basal margin the curve is broad, rising obliquely to the extremity of the sicae, where it makes an angle of about 60°. The sical margin is straight, arched, and is a little longer than one half the hight of the valve.

Surface usually with concentric lines and low wrinkles or festoons. Exceedingly fine, radial, filiform lines are visible on internal casts and doubtless pertain to the inner rather than the outer shell layers.

Dimensions. Hight of an average specimen 29 mm, length 23 mm; length of sical margin 19 mm.

Observations. The smaller of Beushausen's specimens of Prochasma dilatatum approach this shell very closely in all details. We should be disposed to assign the latter to that species, were it not for the difference suggested by the larger forms included under that name.

Habitat. Genesee province; Naples subprovince. Parrish gully and other outcrops of the shales, Naples N. Y.

Lunulicardium beushauseni sp. nov.

Plate 3, fig. 12, 13; plate 4, fig. 15

Shell below medium size, subcircular in general outline, beak nearly central or slightly posterior. Posterior margin incurved beneath the beak, bending outward in a nearly semicircular curve to the basal margin, which continues the same curvature but with a broader expansion over the antelateral region; anterior margin similarly curved, rounding to the sical margin, which is short (about one half the hight of the shell) and arched. The angle between it and the posterior margin is obtuse and rounded. Beneath the beak and just in front of it are three strong and short plications bending upward to the margin, comparable to the single riblet that appears in similar position in several other species of the genus. Very faint radial lines are also visible over the posterior and median parts, and concentric lines occur on the anterior slope, taking the form of regular festoons or rings.

This species is well characterized by its form, subumbonal radii, and the concentric undulations on the anterior slope. All the specimens observed are from the same locality.

Habitat. Genesee province; Chautauqua subprovince. Walnut creek, Forestville, Chautauqua co. N. Y.

Lunulicardium suppar sp. nov.

Plate 3, fig. 6-10

Shell suborbicular in outline, rotund. Beak central, directed anteriorly. Umbones full. Length and width equal. Surface highly convex, greatest elevation being attained near the center, whence the slope is rather gradual and regular toward the base, but much more abrupt both anteriorly and posteriorly and more so posteriorly than anteriorly, making a bulged and sharply deflected surface on the posterior face. The sical margin is short, oblique and transverse, making a very large angle with the anterior margin at the beak, not extending for one half the hight of the shell, and incurved or concave. The sicae are set off from the body of the shell by a sharp groove, are clearly defined, narrow, extended outward, and not downward or inward, and do not bear a smooth surface. The angle between the sicae and the anterior margin of the valve is large and prominent.

The surface of the shell is entirely covered with fine, obscure radial lines, which become broader toward the periphery. All are flattened, and a few of those on the anterior slope are larger than the rest, and are separated by broader furrows. The sicae also bear similar radial lines. Low concentric lines of growth are visible over the surface, specially near the margins.

This species is readily recognized by its unusual form and contour, and its striated sicae.

Habitat. Genesee province; Chautauqua subprovince. Johnson's falls, near Strykersville, Wyoming co., and the lower Portage falls of the Genesee river.

Lunulicardium sp. nov.

Plate 2, fig. 21

A small shell of orbicular triangular outline, has a large apical angle, long sical margin, the latter making about 45° with the vertical axis, the beak is slightly posterior, the surface quite uniformly convex with an abrupt turn downward near the periphery and a low broad sulcus just within the sical edge, which is slightly turned upward. The surface is covered with very fine concentric lines which traverse the sical groove. About the margins are evidences of radial plications, but no trace of these appears over the body of the shell.

Dimensions. The single specimen, a right valve, measures in hight 9 mm, length 10 mm, length of sical margin 9 mm. This shell is quite unlike any of the other species here described, both in form and character of surface.

Habitat. Genesee province; Naples subprovince. In the black Genesee shale just above the Genundewa limestone at Seneca point, Canandaigua lake, N. Y.

Lunulicardium sp. nov.?

Plate 2, fig. 19

A species distinct from the foregoing is represented by a single specimen whose outline is acuminate subtriangular. The umbo is subcentral, relatively long and narrow, the apical angle approximately 30°. The sical margin is long and slightly incurved, but does not reach for the full extent of the valve. The lower margin is nearly semicircular, the anterior margin incurved. The center of convexity is near the middle of the valve and toward the sical margin. The surface shows evidences over the pallial region of coarse plications; there are also a few strong concentric growth lines. A very small portion of the exterior shows an exceedingly fine, undulating ornamentation of elevated closely set lines.

The length of this single observed specimen (left valve) is 12 mm; its width 16 mm.

Habitat. Genesee province; Naples subprovince. Styliola limestone, Canandaigua lake.

Lunulicardium sp. nov.?

Plate 4, fig. 11

A single fragment of a left valve indicates a large elongate oval species with rather coarsely but obscurely plicated surface. A fragment of a much larger shell from Forestville presents similar characters. Neither of these can be identified with any species here or elsewhere described.

Habitat. Genesee province; Chautauqua subprovince, Correll's point.

Lunulicardium? (Opisthocoelus?) transversale sp. nov.

Plate 4, fig. 16

This name is applied to a small shell, undistorted but of peculiar habit in its elongate transverse outline. From its subcentral beak the anterior dorsal margin extends in nearly a transverse line for one half the length of the shell while the posterior dorsal line is more oblique. The anterior extremity curves narrowly, and the margin below it is broadly sinuated by a depression from the umbo. The basal margin is transverse, rising gradually to the narrow posterior extremity. The surface is convex in the umbonal region, sloping most gradually to the basal margin. A low ridge lies on the anterior moiety, separated from the anterior edge by a broad depression. Beneath and in front of the beak, in the place of the hiatus, is a smooth, elongate triangular and vertical lunular surface without hiatus, the edge coming down to the plane of commissure. Behind the beak the margin is incurved and erect.

The ornament consists of fine, sharp, round, simple, elevated radial lines about 60 in number, a little coarser and more widely separated on the anterior surface, and the intervals between them may vary somewhat over the shell.

Dimensions. The single left valve observed is 6 mm in length and 2.5 mm in hight.

Observations. This is a unique shell in this congeries. I have referred it with some hesitation to the genus Opisthocoelus Beushausen,[1] which was erected for species having well defined vertical areas in front and behind the triangular ligament area.[2] Shells of this genus are chiefly from the lower Upper Devonic.

Habitat. Genesee province; Naples subprovince. In the Naples shales at Ithaca N. Y.

PTEROCHAENIA gen. nov.

Among the shells which heretofore have been referred to the genus Lunulicardium is a small species with smooth exterior occurring freely in the Middle and Upper Devonic of New York and originally described by Hall as an Avicula fragilis.[3] Under this name have been covered all the expressions of the species which are known to occur in the Marcellus, Hamilton, Genesee and Portage shales. These shells have been abundantly illustrated on plate 71 of *Paleontology of New York*, v. 5, pt 1, and the figures there given (1–14) show excellently both the generic and specific characters. The relation of these shells to Lunulicardium is not remote, but there are palpable differences. The valves are, first, extremely tenuous, being apparently little more than a film of lime which may be considerably phosphatic. They bear no exterior ornamental markings save the fine concentric lines of growth; all radial lines lie on the inner surface of the valves and may be visible by translucence from without.

The beaks are distinctly prosogyre; on the anterior margins and just in front of the beak is a conspicuous byssal hiatus which may extend for one half the shell's length. This is bordered by two flanges, or narrow explanate processes, which are widest at the beak, rapidly becoming narrower toward the antelateral margin of the valves. Their surface is either convex or their outer margins are decidedly elevated and they are directed not inward nor vertically but outward in the plane of the valves.

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[1] *Op. cit.* p. 338.

[2] See figures of the type species O. concentricus Beus., *op. cit.* pl. 38, fig. 9–11.

[3] Geol. N. Y. 4th dist. 1843; subsequently referred to Aviculopecten by S. A. Miller in Cat. Am. Paleozoic Foss. 1877.

At their beginning they are not deeply separated from the beaks, but from that point downward they are divided from the body of the shell by a deep and moderately broad sulcus, in the bottom of which lies a narrow, rounded ridge. The surface of these byssal expansions is striated parallel to their outer edge by concentric lines continued from the body of the shell. The anterior projection of the beaks toward the opening suggests the characters which were ascribed by Beushausen to his genus Prochasma, which however was based on a very different order of shells. As to the structure of the hinge, no evidence can be ascertained from delicate barite replacements except the total absence of articulating processes. These valves are found not uncommonly in the shales still in normal apposition along the linear ligamental margin behind the beaks. This is well shown in several of the figures given herewith. Along this short posterior line only was attachment of the valves effected.

Species of this type are not wholly unknown in other manifestations of the Intumescens fauna. Posidonia hians Waldschmidt from Wildungen[1] is a closely related shell, and we are disposed to regard certain valves from the black limestones in the Domanik of Timan, described and figured by Holzapfel[2] as possibly of crustacean nature, as unquestionably appertaining to this genus. Of the three figures given by Holzapfel all show the sicae extended forward in the plane of the valves and two of these we have inserted here for comparison. They are described as very tenuous, fragile and depressed convex bodies. The author has not specifically designated these valves which now assume special interest from the concurrence of the genus they represent in widely separated localities. We therefore suggest the name Pterochaenia uchtensis.

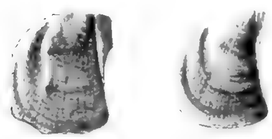

Fig. 8 Pterochaenia uchtensis Timan (after Holzapfel)

[1] Waldschmidt, Zeitschr. d. deutsch. geolog. Gesellsch. 1885. p. 924, pl. 40, fig. 4; Frech, Devon. Aviculiden. 1891. p. 72, pl. 14, fig. 13.

[2] Die Cephalopoden des Domanik im südlichen Timan. Memoires du Comité Geolog. St Petersburg. 1899. v. 12, no. 3, p. 53, pl. 9, fig. 17-19.

Pterochaenia fragilis Hall (sp.)

Plate 5, fig. 1-10

Avicula fragilis Hall, Geology of New York; report on the fourth district 1843. p. 222, fig. 94-1, 2

Lunulicardium fragile Hall, Preliminary Notice Lamellibranchiata. pt 2. 1870. p. 97

Aviculopecten fragilis S. A. Miller, Catalogue North American Paleozoic Fossils. 1877. p. 184

Lunulicardium fragile Hall, Paleontology of New York. 1885. v. 5, pt 1, p. 434, pl. 70, fig. 1-14

Lunulicardium fragile Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 62

Lunulicardium fragile H. S. Williams, U. S. Geol. Sur. Bul. 41. 1887. p. 38, pl. 3, fig. 7

This species, which has already been fully described and illustrated by Professor Hall (1885), has an unusual vertical range without wide variation. The bituminous shales of the Marcellus division and those of the Genesee division locally abound in specimens of like character. In the Hamilton group the species occurs occasionally where the sediment becomes dark, and in the shales of the Naples division it is among the less common lamellibranchs. A specimen in the State Museum collections shows its continued presence after the introduction of the Chemung fauna. Among all its appearances throughout its vertical range and its varying aspects, differences in size are not often accompanied by material or persistent differences in outline. It is undoubtedly to the fragility and tenuity of the shell that some of the apparent differences are to be ascribed. Nevertheless, we observe throughout the history of these shells that the extremes of variation in outline afford (1) the broadly spatulate or elongate form which is the normal and most usual expression of the species, and (2) a much more orbicular or subquadrate shell. The history and relations of these extremes are somewhat as follows. With the first appearance of the species in the Marcellus shales the former of these prevails, and the second, or other passage forms between the two extremes are seldom met. The normal is well maintained through this early epoch in the existence of the species. In the shales of the Genesee division, the only time at which the species becomes highly abundant, the normal extreme is common and the second extreme also not infrequent. But so common and gradual are the variations in outline between these extremes that it is hopeless to look here for a permanent distinction. We except from this statement unusually large shells with sinuous contour occurring in the Styliola limestone and occasionally in the shales, to which we have hereinafter given the name P. sinuosa. The original Avicula fragilis of Hall was described from the Genesee shales. The type specimen has never been redrawn, and the generic characters of the shell are not well shown in the original figure; but the form portrayed shows the elongate oval outline of the normal extreme. We ought, indeed, in dealing with the examples from this horizon, to restrict the original species name, fragilis, to shells with strictly this outline, and designate the opposite extreme by some species designation, but, with the presence of all intermediate phases, the attempt at distinction would here prove quite futile and confusing. In the Naples fauna, where the shells are not very common, this distinction is immediately practicable. Here the two extremes are well expressed, and, so far as our observation extends, there are none of the intermediate stages. The two extreme types of outline, both originating in the Marcellus, are here permanently fixed and at once distinguished. In the fauna of the Genesee shales the normal and restricted P. fragilis is surrounded by its variants, mobile and unstable. With the passage of time the unstable means disappear, leaving only the fixed extremes. The terms P. fragilis and P. fragilis var. orbicularis, in their application to the expressions of this type as they occur in the Naples fauna, have therefore a definite significance with relation to the species and its history. The figures of Lunulicardium fragile given by Hall [*op. cit.* pl. 71] are for the most part representations of the rounder and variant outline. Thus, figures 1, 2, 5–7, all approach the outline of var. orbicularis; only figures 9 and 11 represent the more elongate and usual form of the species. All of Hall's figures are of specimens from the Genesee shales.[1]

The surface markings of these shells vary somewhat. Normally the surface was smooth, marked only by fine, crowded growth lines. Many specimens show that in the umbonal region the concentric lines were more regular, sharper, elevated, distant, and distinctly continuous. Under ordinary preservation, however, this regular character is lost before the middle of the valve is reached. All the figures in the *Paleontology of New York*, v. 5, pt 1, pl. 71, show a concentric striation exceptionally regular, and not to be found on the specimens, with the exception of one, figure 2, taken from a group of shells in the bituminous Genesee shale near Darien N. Y., in which the fine, sharp, regular striation is maintained over the entire surface.

I have not seen specimens from other localities in which this feature is shown, but it appears to characterize all examples from the locality cited. Radial striae, as we have observed, are not a feature of the exterior. Such striae are not infrequently seen, but they appertain to the inner shell layers.

The byssal ears have not heretofore been correctly represented. In specimens from the shales their outer margins are usually broken off, leaving them narrower in appearance than they actually were. There is no evident difference in size or shape in the flanges of opposite valves ; on the contrary, all testimony confirms their equality in this respect, as well as the equivalvular character of the entire dissoconch.

Dimensions. Average specimens measure approximately as follows: one from the Marcellus shales is 6 mm in hight and 8 mm in length ; its byssal margin is 5 mm in length. Specimens from the Genesee shales present about the same size and proportions. An average example from the olive Naples shales measures, hight 5 mm, length 7 mm, length of

[1] The large smooth shell, Lunulicardium marcellense Hall, occurring in the interbedded shales of the Agoniatite limestone (Cherry Valley) suggests Pterochaenia in aspect, but the species appertains rather to the smooth Prochasma forms of Lunulicardium, lacking the critical structure of the other genus.

byssal margin 4 mm; a small shell, hight 3.5 mm, length 4.5 mm, length of byssal margin 2 mm; a large example, hight 8 mm, length 10 mm, length of byssal margin 4 mm.

Habitat. Genesee province; Naples subprovince. Widely distributed. More commonly found in the bituminous shale beds near the base of the group than in the olive shales and sands. Havana glen, Montour Falls, Schuyler co., Glenora, Rock Stream, Belknap's gully near Branchport, and south of Penn Yan, Yates co.; Parrish gully and elsewhere, Naples; at various spots in the towns of South Bristol and Bristol, Ontario co.; on the shores of Canandaigua and Conesus lakes, etc.; in the Cashaqua or lower shales at Griswold, Genesee co., Eighteen Mile and Pike's creek, Erie co. Chautauqua subprovince. Rare on Farnham creek near Angola, 250 feet above the Cashaqua shales. In the Styliola limestone at many outcrops.

In the Marcellus and Hamilton shales, and the dark shales of the Genesee common at various localities.

Pterochaenia fragilis Hall (sp.)
var. **orbicularis** var. nov.

Plate 4, fig. 17, 18; plate 5, fig. 11–16

The attenuate, narrow, erect and prosogyre beak is shown in this variety as in the specific type. The outline is suborbicular, varying to subquadrate, and the hiatus is relatively short; the byssal margin being gently incurved. Hight and length equal. Surface as in P. fragilis.

The specimens of this variety in the Naples fauna are usually of small size, measuring approximately 5 mm in hight and length. In some localities twice this size is attained.

Habitat. Genesee province; Naples subprovince. At Naples and in the vicinity; also near Ithaca (Cayuga lake inlet) and in the Ithaca fauna at Norwich, Chenango co. and in the Genesee shales on Cayuga creek, at Iron Bridge Mills. The larger form of this variety, like that occurring in the locality last mentioned, is also found in the dark shales of the Hamilton group south of Aurora N. Y.

Pterochaenia sinuosa sp. nov.

Plate 5, fig. 17-22

Shell comparatively large; beak attenuate, narrow and erect; surface strongly convex or rotund medially, with a broad and low radial sinus near the anterior margin. Outline suborbicular, varying to obliquely oval; regular on the posterior and lower edges but rendered sinuous anteriorly by the emergence of the sinus. Byssal margin short, very oblique, slightly incurved and making a large angle with the vertical axis of the shell. The byssal extensions are very broad, wing-shaped, and convex near the beaks, narrowing rapidly downward; sical grooves deep and narrow at the bottom, broad at the top. Exterior smooth, showing only concentric growth lines; radial lines appear on exfoliated surfaces.

This species is readily distinguished from P. fragilis and its variants by its large size, sinused surface, undulated outline and highly developed sicae. An average specimen has a hight of 10 mm, length of 12 mm, and the byssal margin is 6 mm in length.

Habitat. Genesee province; Naples subprovince. This shell occurs often in great numbers in the Styliola (Genundewa) limestone on Canandaigua lake, and at Middlesex, Yates co. It is also occasionally found in the Genesee shales, and Professor Hall has represented such a shell from these shales near Penn Yan N. Y.[1]

Pterochaenia perissa sp. nov.

Plate 4, fig. 19

This rare species presents the appearance of a P. fragilis nearly halved by the byssal groove and bearing an extravagant flange. The byssal groove extends over the greatest diameter of the shell, and the flange itself is very wide, its width being one third the greatest length of the shell; it tapers very slowly from the beak outward. The surface of the valve is concentrically lined; on the flanges these striae become parallel to its outer edge and are strongly marked. The ridge in the byssal groove is conspicuous.

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[1] Paleontology of New York, v. 5, pt 1, pl. 71, fig. 13.

Dimensions of the only observed example: length to byssal furrow, 3 mm, hight 5 mm, length of byssal margin 5.5 mm, width of flange 1 mm.

Habitat. Genesee province; Naples subprovince. Parrish gully, Naples.

Pterochaenia elmensis sp. nov.

Plate 4, fig. 26, 27

Shells large for this genus, elongate, marginal curve suboval over the pallial region, byssal margin very long, straight, almost attaining the full hight of the valve. Posterior margin rather abruptly expanding from the beak out. Byssal flanges narrow, separated from the body of the valve by a sharp furrow, to which the slope from the body of the valve is abrupt.

Surface smooth, only fine concentric lines being visible, with faint radial lines sometimes apparent on the inner layers.

Dimensions. Hight 11 mm, length 10 mm, length of byssal margin 10.5 mm.

Observations. This species is the largest representative of the genus observed, and, while approaching P. fragilis more closely than any other, may readily be distinguished therefrom by its very long byssal margin and narrow flanges. This margin however is shorter than in P. perissa and the flanges narrower.

Habitat. Genesee province; Chautauqua subprovince. Big Buffalo creek, East Elma, Erie co.

Pterochaenia cashaquae sp. nov.

Plate 4, fig. 20–25

This is a very small shell, never even approximating the dimensions of any other of the shells of this genus here described. It differs from P. fragilis in having a long, straight oblique byssal margin, not halving the valve as in P. perissa, but directed toward the antelateral extremity at an angle of less than 45° with the axis of the shell. The antelateral curve is much more broadly rounded than in either of the species mentioned. The byssal groove is quite broad and bears no ridge on its bottom; the byssal flanges are narrow and extroverted. The body of the shell is narrowly convex in the umbonal region, and from the posterior side of the umbo a broad depression extends to the margin. Shell thin as in other species, marked only with concentric striations.

Dimensions. An average specimen has a hight of 4 mm, a length of 3.5 mm, and length of byssus is 3 mm.

Observations. This shell occurs abundantly in the locality cited, but has not been observed elsewhere. It seems to take the place, in the succession here, of the common P. fragilis of more easterly localities.

Habitat. Genesee province; Naples subprovince. In the lower soft shales on Cashaqua creek.

HONEOYEA gen. nov.

This name is proposed for a group of small shells showing some affinities with Lunulicardium, but, if we have oriented them correctly, distinct in

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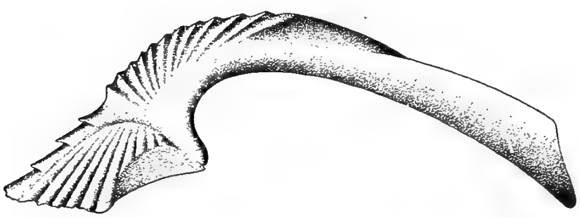

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Fig. 9 Honeoyea erinacea. Anterior view showing the arch of the valve at the byssal hiatus, the form of the posterior crescent and the triangular cardinal area.

Fig. 10 The same, showing crescent and umbonal ridge with spine bases.

important respects. In these the beak is minute, opisthogyre and inflected and the umbonal slopes to the commissure are abrupt. On the long, oblique anterior margin is an hiatus or byssal opening bounded by arched margins, on which the sicae are but very faintly developed, being thin, narrow, concave, and eflected, not vertical as in the Lunulicardia. Behind the beak is an oblique, vertical or concave crescentic wall, set off from the body of the shell by a lunate curve; the edges of this lunulelike division meet in the plane of commissure with no opening between. This feature is conspicuous, and its upper bounding ridge is thickened and crested, in the typical species (H. erinacea) becoming spinous. This depression extends for the entire length of the postlateral slope, is nearly as long as the byssal gap, and its surface is crossed by oblique plications which inosculate at their outer extremities along the commissure.

The hinge structure of this region shows analogy with that of Lunulicardium in the following respects. There is an erect triangular area wholly or nearly behind the beak; at its posterior angle is a slightly projecting process on one valve, which is probably recurved into a depression in the other. Except for this departure the lower edge of the area is horizontal. The divergent plications on the posterior crescent contribute to articulation in the same manner as do the few coarse postumbonal ribs in Lunulicardium.

The surface markings may consist solely of simple ribs (H. simplex), but in other species the plications are few in number, distant, and each medially crested with a bladelike, vertical lamella; one or two pairs of smaller but erect lamellae may occur on the slopes of the major plications. In some respects this genus resembles Mila Barrande,[1] but such similarity is confined to the general form of the shells. Mila bears no hiatus, and no clearly defined posterior crescent.

The species of this genus are not now positively known outside of the lower Upper Devonic of New York; but it seems more than probable that the shells described by Münster[2] as Cardium semialatum, C. paucicostatum and C. alternans as well as C. triangulum Goldfs.,[3] all from the upper Devonic of Elbersreuth, will prove to be Honeoyeas.

Type, Honeoyea erinacea.

Honeoyea erinacea sp. nov.

Plate 6, fig. 15-22

Shell small or of medium size, subtriangular. Beak posterior, crescent rather short, concave and sharply defined; sical margin longer, extending for two thirds the length of the shell.

Anterior slope vertical, posterior slope incurved. Surface sloping

[1] *Cf.* M. delicata, Barr. Etage E: Syst. Sil. v. 6, pl. 244, fig. 8.

[2] Beitr. 3 zur Petrefaktenkunde. 1840. p. 59, 60, pl. 13, fig. 1, 2, 5.

[3] Petref. Germaniae, pl. 142, fig. 3.

regularly to the lower margin, more abruptly toward the crescent, and vertically to the posterior hiatus. The surface markings consist of 12 to 15 primary ribs, not including the crescent ridge. These ribs are sharply angular, and each bears a vertical, bladelike lamella extending along its middle line. On each lateral slope of the primary ribs is a finer lamella, and usually two more of similar size may be seen in the furrow intervening between two ribs. Thus between the crested plications are four fine radial lamellae, the two outer of which are the coarser and the other two sometimes obscured. The primary crested ribs are continuous and simple; no example has been observed showing increase in number from the early parts of the shell outward. The rib bounding the anterior slope is shorter than the rest, not reaching to the beak; below it are a few of the finer lamellae. The ridge bounding the crescent is broad and prominent. Its summit is rounded and gives off a single series of spines, four to six in number, the upper ones being short, the lower curved somewhat irregularly outward and backward and the last, the longest, curved downward at the tip. These spines are hollow and not inclosed on the under side, with the exception of the terminal spine. They are formed by the upturning of the contracted edges of the crescent and the body of the shell at periodic cessations of growth. The surface of the crescent itself is marked with low, rounded and broad plications alternating in size. These plications are very oblique, passing from the region of the beak and the ridge backward at a low angle and crenulating the margin, where, by the interlocking of these crenulations on opposite valves, articulation is assisted.

These shells are sometimes quite small, the most perfect of our specimens not exceeding a width of 4 mm. Larger examples, however, attain a length and width of 11 mm.

Habitat. Genesee province; Naples subprovince. Parrish gully, Naples; Briggs's gully, Honeoye lake; Whetstone gully, Conesus lake; Havana glen, Schuyler co., etc.; also in the lower shales at Attica, Wyoming co., Wolf creek and the lower Portage falls of the Genesee river; rare in the Genesee shales, Canandaigua lake.

Honeoyea major sp. nov.

Plate 6, fig. 10–14

This is a species of larger size than the H. erinacea, and relatively narrower over the pallial region, the posterior margin being longer and more oblique. The general aspect and surface markings of the two are the same, but in H. major the number of primary ribs is limited to nine or ten. These differences permit the ready distinction of the species.

Honeoyea major is a more abundant shell than H. erinacea, though we have observed no specimens so well preserved as those of the latter.

Habitat. Genesee province; Naples subprovince. In the shales at Naples and vicinity, rarely in the flagstones of the middle and upper portions of the group; also in the shales at the lower Portage falls.

Honeoyea styliophila sp. nov.

Plate 6, fig. 4–9

Shell relatively large, suborbicular, beak subcentral, slightly anterior; posterior crescentic margin short, slightly incurved, nearly transverse and usually obscure, the inflected surface being quite oblique; anterior margin longer. Lower margin quite regularly rounded. Valves convex, subrotund in the umbonal region, umbones incurved.

Surface with six to eight strong primary ribs, crested medially as in H. erinacea and H. major; as in these species also there are normally four fine lamellar lines between each two ribs, but in old shells this character is obscured by the union of the radial lamellae to form a single strong plication. The crescentic ridge is low and shows no spinous processes on its surface.

Dimensions. A specimen retaining the normal proportions of the shell has the following: length 22 mm, width 24 mm, length of crescent 11 mm, length of hiatus 23 mm.

Though the feeble development of the posterior crescent gives this species a more orbicular outline than is typical in this group, yet its other surface characters indicate its affiliation herewith. It is very much the largest representative of the genus.

Habitat. Genesee province; Naples subprovince. Not uncommon in the Styliola limestone, on the shores of Canandaigua lake.

Honeoyea simplex sp. nov.

Plate 6, fig. 1-3

Shell small, subtriangular, basal margin rounded, anterior edge gently convex, posterior margin concave. Beak situated behind the median line of the shell, oblique and directed backward. Posterior crescent sharply defined, concave; its outer margin makes a broad, somewhat thickened and elevated ridge, forming the apparent posterior margin of the valve when viewed from above. The crescent wall is shorter and more oblique than the sical margin and strongly incurved. The latter is slightly ecurved and considerably arched upward, the hiatus extending nearly if not quite the full length of the antelateral margin. The sical edge is eflected and smooth, just within it is a low moderately wide groove, and above that the abrupt curve of the anterior slope of the valve.

Surface sloping rather gradually from above the center of the valve to the basal margin and to the crescent; anteriorly the slope is abrupt from the crescent ridge which forms the highest part of the valve. The ornamentation consists of simple, continuous, slightly flattened and closely set plications, about 30 in number. The surface of the crescent is smooth or finely radiate, as is likewise the surface of the sical furrow; a few plications extend on to the anterior slope above the furrow.

This species is based on a single, well preserved right valve, whose length is 5.5 mm, width 5 mm, length of lunule 3 mm, and length of hiatus 4 mm.

Habitat. Genesee province; Naples subprovince. Styliola limestone, Canadaigua lake.

Honeoyea desmata sp. nov.

Plate 6, fig. 23

In describing hereafter the genus Paraptyx we have observed its close structural affinity with Honeoyea, notwithstanding a striking difference in the general external expression of the shells. The genera are alike in the possession of a "crescent" of similar structure and surface characters; but in Paraptyx the posterior hiatus is very obscure, and the surface of the shell carries only fine, regular and closely set plications. It is with some hesitation that the species now under consideration is referred to Honeoyea. It has the suborbicular outline of Paraptyx, the transverse crescent and, if there was a posterior hiatus, it was short and narrow, our material not permitting the determination of this point. The surface ornament is however so much like that of Honeoyea that we prefer to leave the species with this genus, recognizing it as an interesting intermediary form between the two genera.

Shell of medium size, orbicular in outline, transverse on the cardinal margin. The crescentic ridge, which is prominent, makes the only interruption in the regular curvature of the margin. Beak slightly posterior. Valve a little longer than wide. Surface convex, sloping evenly with a slight depression outside of the crescentic ridge. Anterior slope short and abrupt; hiatus if present very short and narrow. Surface ornament consists of 17 primary ribs, which are rather narrow and widely separated. Though these ribs appear to be somewhat flattened, each was crested by a very fine, erect lamella, which near the lower margin on some of the ribs seems to have become double. The broad and flat interspaces bear four fine, elevated striae, two on the slopes of the primary ribs and the median two much closer together, sometimes apparently coalescing. Near the crescent the numerical regularity of the striation becomes slightly modified. The concave surface of the crescent is obliquely plicated. But a single example of this species has been observed, a left valve, slightly imperfect about the beak.

Dimensions. This specimen has a length of 15 mm, and a width of 18 mm.

Habitat. Genesee province; Naples subprovince. From the sandy layers in the upper part of the group; Tannery gully, Naples. A shell which may prove to be this species occurs in the Chautauqua subprovince in the higher beds at Varysburg, Wyoming co.

PARAPTYX gen. nov.

With this name it is proposed to designate shells showing an interesting departure from Honeoyea and yet withal closely allied to that genus and connected therewith by the species Honeoyea desmata. The type species of Paraptyx (P. ontario) is of considerable size, much larger than is attained by Honeoyea, and its surface markings are the fine, radial, simple or compound plications of the "Cardiolas" rather than

Fig. 11 Paraptyx ontario, Posterodorsal margin or crescent viewed from within

the crested ribs of Honeoyea. When oriented to correspond with that genus, we find that the beaks are opisthogyre, and that there is a sharply defined posterior "crescent" with vertical or slightly incurved face and elevated ridge; the surface of this crescent bears a few strong plications, interlocking at their ends on opposite valves. The crescent is almost transverse or on the plane of the hinge and is relatively short. Its outer extremity, unlike that of Honeoyea, is eflected. On the interior the crescent and ridge make a deep sinus, as if for the passage of some siphon, but for want of an analogy we can not venture an opinion of its function. Conceding this crescent to be posterior and the beaks directed backward, the anterior margins of the shell were very slightly if at all opened. Our material bearing on this point is not very extensive but indicates close apposition along these margins. Beneath and in front of the beak the cardinal line is smooth, without ligament area.

Paraptyx ontario sp. nov.

Plate 7, fig. 1-8

Shell of medium size, beak subcentral or slightly posterior, closely appressed against the hinge line, umbones prominent, directed posteriorly, giving the umbonal region a somewhat oblique slope. Outline elongate subovate to subcircular. Hinge line or crescent margin straight or slightly incurved behind the beak, extending to the farthest posterior margin, and making a right or acute angle with that margin; anteriorly short, and soon passing into the rounded lateral curve of the valves. Lateral and ventral curves broadly subcircular. Contour normally rotund, specially in the umbonal region, sloping regularly to the lateral and basal margins. The vertical, concave crescentic area is broad, crested at its summit, and crossed by obliquely radiating riblets which begin directly under the beak. The first of these radiate in all directions from that point posteriorly, inward and anteriorly, and strongly crenulate the margin. This is specially true of the shortest and least oblique of these radii. The more oblique radii cover the greater portion of the surface. The crest or crescent ridge is greatly elevated, its surface being modified by undulations resulting from concentric lines, which elsewhere are obscurely seen. This structure may be compared with that of the crested anterior limb in Honeoyea, where the strong varices are developed at the crossing of concentric lines not elsewhere visible on the shell. The surface bears from 120 to 150 fine, flat plications, which increase by the intercalation of smaller ones and are separated by linear grooves. These all have a strong posterior curve over the median convexity of the shell. This surficial ornament is altogether similar to that in Cardiola clarkei Beush. with which the shells also agree in all other respects save the presence of the cresent and the more oval outline. Low concentric corrugations are sometimes seen; these being in some degree due to compression in the shales. In several of the sculpture casts there are evidences of two or three short, impressed lines diverging from the beak. These would seem in such cases to represent internal umbonal ridges, but they are not always present, nor can they be seen on interiors of the most delicately replaced valves.

Habitat. Genesee province; Naples subprovince. In the Naples shales at Naples and vicinity. It is not a very common species.

ACTINOPTERIA Hall. 1883

Actinopteria sola sp. nov.

Plate 12, fig. 20

Shells small, suberect; subrhomboidal in outline, hinge line straight, extending to but not beyond the posterior extremity of the valve. Wing moderately broad, set off from the body of the valve by a rather low depression and not extending backward beyond the posterior margin of the valve. Auricle conspicuous, convex in the middle, depressed near the cardinal line and bounded below by a broad sulcus. Beak at the anterior one third of the hinge. Anterior extremity rounded abruptly, outline emarginate at the byssal groove, thence descending at first directly and then more obliquely to near the posterior extremity, to which it curves upward and beyond it inward to the base of the wing. Umbo convex, overarching the hinge; surface sloping thence gradually to the basal line and more abruptly in front and behind.

Surface bearing sharply elevated rounded radii, which are simple in the umbonal region and are about 20 in number. At the margin they have increased by intercalation to double this number and cover both auricle and wing, though simple on both these.

Dimensions. Length 5 mm; hight 4 mm.

Habitat. Genesee province; Naples subprovince. In the soft shales on Cashaqua creek.

Observations. The single left valve of this species is the only observed instance of the occurrence of this genus in the Naples shales and the diminutive shell looks much like an interloper from the contemporary Ithaca province of the central New York sea. That fauna is specially characterized by the diversity of expressions of Actinopteria, all specifically based on the type of the ancestral A. boydi of the fauna preceding this on the field (Hamilton). A. boydi, by loss of race force, breaks up at the close of Hamilton time into a number of diminutive and shortlived survivors (A. perstrialis, delta, epsilon, eta, etc.), and to this highly variant superstitial group this shell, A. sola, seems to appertain. It seems out of place, out of harmony with its usual surroundings in association with Pterochaenia cashaquae, Ontario accincta, Probeloceras lutheri, etc., and has evidently strayed far.

LEPTODESMA Hall. 1883

Leptodesma sp. cf. rogersi Hall

Specimens of this genus have been occasionally found in the darker shales of the lower part of the Naples beds, and these have somewhat the expression of L. rogersi of the Ithaca fauna. The material however is not sufficient to justify more precise determination.

Habitat. Genesee province; Naples subprovince. Parrish gully, Naples.

POSIDONIA Bronn. 1828

There is a small group of diminutive, thin shelled Devonic and even Siluric shells clearly showing aviculoid characters in the development of the byssal groove and auricle, which are still allowed to pass current under the name Posidonia. The term is, in view of its original application to a Culm species of subcircular form, undeveloped ear and wing and considerable size, probably inexact in this connection, but it is convenient for continued provisional employment till the distinctive features of the shells have been more fully analyzed. In European faunas such shells have long been noticed in Precarbonic rocks: P. glabra (Münst.) Barr., Étage E, P. hians Waldschmidt of the Middle and Lower Devonic, P. venusta Münster, Upper Devonic. Frech has redescribed and illustrated these species with a number of others[1] employing the term as a convenience and incidentally suggesting the uselessness of replacing the name Posidonia for the substitutes proposed for it on account of prior occupancy.

[1] Die devonischen Aviculiden Deutschlands. 1891. p. 68 et seq., pl. 14.

Of the three shells mentioned, it is quite clear that one (P. hians, originally described as Avicula hians[1]) has as little relation to the other species as they all have to the type, Posidonia becheri. P. hians, an upper Middle and lower Upper Devonic shell, is of the size of Pterochaenia, with the outline, thin shell, smooth concentric surface of that genus, and also has elongated byssal flanges which are relatively broad at the top, convex and gaping. The posterior cardinal end is rounded. Williams has described as Pterinopecten? atticus from the Naples shales of Wyoming county a species which suggests Posidonia hians and hence the genus Pterochaenia in many of its features, but its sculpture is of so unusual character that it seems judicious to apply to it the same noncommittal generic designation that has been used for somewhat similar fossils, for it is evident that the shell does not appertain to Pterinopecten.

Posidonia attica Williams (sp.)

Plate 12, fig. 10–15

Pterinopecten? atticus Williams, U. S. Geol. Sur. Bul. 41. 1887. p. 35, pl. 3, fig. 10, 11

Shells small, equivalve, very thin, subquadrate in outline when undistorted. Beaks minute, prosogyre, anterior, separated from the byssal flange or auricle by a groove which is sometimes well defined and sometimes obscure. Margin of flange convex on cardinal line, incurved and arched on anterior margin, fusing with the body of the shell above the basal margin, which is transverse. Posteriorly the margin is rather abruptly rounded to the cardinal line, at which the angle may be more or less sharp. Beak acute, umbo convex, long and oblique; slopes in front and behind moderately abrupt. The surface of the beaks is smooth, but, soon after secondary growth begins a series of fine ribs develops over the median portion of the valve and increases in size and number to the basal margin. These ribs do not extend over either the anterior or posterior parts of the valve, which are quite smooth, but are restricted to the median portions. They are

[1] Waldschmidt. Zeitschr. der deutsch. geolog. Gesellsch. 1885. p. 924, pl. 40, fig. 4.

for the most part simple but of very unequal size, and are separated by sharp grooves. Low concentric ridges cross the surface without modifying these radii. This style of ornament is most unusual in all aviculoid shells, and we do not find its parallel elsewhere. This species is therefore readily distinguished, however much it may have been subjected to disfigurement.

Dimensions. Average examples measure 4.4 and 6 mm in hight; 3.8 and 6 mm in length.

Habitat. Genesee province; Naples subprovince. We have found this shell only at two localities east of the Genesee river; Pogues hill, Dansville, where it occurs in some abundance, and near Union Corners, Livingston co. Chautauqua subprovince: Williams's specimens were obtained from the shales about Attica, Genesee co. It also occurs at Fox's point, Lake Erie, and Big Sister creek, Angola.

Note. While discussing shells of this character, attention may be directed to a species occurring occasionally in the bituminous Marcellus shales, which is so closely similar to Pteroch. fragilis that it is readily and has been confounded with it. This resemblance is remarkable; the shells are of about the same dimensions and shape, both have tenuous, glabrous shells, essentially the same contour and rounded postcardinal margin. The difference between them lies in the development in Pterochaenia of a deep byssal furrow, broad extended byssal flanges with a wide hiatus between them. In the Marcellus species, which, for sake of a name, we may designate as Posidonia marcellensis, the byssal flange maintains its aviculoid character as a long auricle of the dimension of the Pterochaenia flange, delimited by a very low depression from the body of the shell. It would be very difficult to find specific features, so far as they can be ascertained by comparison with the figures and descriptions given by Frech,[1] in which this shell differs from Posidonia hians Waldschmidt, unless perhaps in the latter the auricle is more sharply defined. Such shells serve to indicate the relationship of Pterochaenia to the aviculoids. Posidonia marcellensis occurs in the lower black shale beds at Marcellus, Onondaga co.

Fig. 12 Posidonia marcellensis, right valve. x 3

[1] *Op. cit.* p. 72, pl. 14, f.g. 13.

Posidonia mesacostalis Williams (sp.)

Plate 12, fig. 1-9

Ptychopteria? mesacostalis Williams, U. S. Geol. Sur. Bul. 41. 1887. p. 35, pl. 3, fig. 9 and (?) *var.* fig. 12

To bring this shell into comparison with species which have been termed Posidonia, I have employed this name in preference to Ptychopteria. Like the preceding species, it may have little in common with typical Posidonia, perhaps as little with Ptychopteria, while one could find a justification for assigning a shell with the peculiar expression of this to the genus Leptodesma. The species, however, was another of the tenuous and glabrous shells with little calcareous content in its constitution, and herein differs from the Leptodesmas so abundant in the higher Devonic.

Of 20 specimens of this shell before us, but few are right valves. The original figures were of left valves only.

Equivalve very oblique, linguate. Hinge line short and straight, cardinal angles not extended. Beak at or behind the anterior third of the hinge, anterior cardinal angle 90°, anterior margin vertical for a short distance, thence bending abruptly backward with a broad inward curve, basal margin subelliptic and almost wholly beyond the vertical dropped from the posterior angle of the hinge line. Posterior margin subparallel to the anterior, posterior cardinal angle obtuse. Beak projecting beyond the hinge line. Umbo moderately convex, the convexity extending obliquely backward. Surface marked by strong concentric festoons or undulations, which are most widely separated along the median convexity of the shell. In most of the best preserved specimens this is the chief character of the surface, but some specimens show a fine radial marking of filiform, elevated striae, which seem in part to pertain to the inner shell layer. These lines are equally distributed over the surface and are not to be compared with the median plications on P. attica. Both valves of the shell have the same form and surface characters.

Dimensions of a large individual: length of hinge 6 mm; total oblique length 11 mm, hight 9 mm.

Habitat. Genesee province; Chautauqua subprovince. In the soft shales at Varysburg (west side ravine) and common at Johnson's falls near Strykersville, Wyoming co., Correll's point, Lake Erie, and at the Hidi tannery, Gowanda.

Observations. The oblique, Leptodesmalike form of this peculiar species suggests the elongate variety of Posidonia venusta Münster which Frech has termed eifeliensis[1] from the uppermost Devonic near Büdesheim. Both are essentially smooth shells, highly oblique with short hinge and sharp cardinal angles. Frech mentions a very fine radial lineation in his shells.

Posidonia venusta Münster, var. **nitidula** sp. nov.

Plate 12, fig. 16–19

cf. Posidonomya? venusta Münster, Beitr. zur. Petrefakten-Kunde. 1840, 3:51, pl. 10, fig. 12

Shells small, equivalve. Ligament line straight, length four fifths the greatest length of the valve. Beak at anterior third of cardinal line; cardinal extremities subangular, not extended. Outline of periphery obliquely ovate, expanded behind, contracting toward the hinge angles both front and back. Surface convex; at the umbones the convexity extends obliquely backward to the posterior extremity. In front of this convexity is a low oblique depression, which gives a sinuous character to both surface and basal margin. Posterior slope from umbonal ridge broadly depressed. The ornament consists of a few broad concentric corrugations with no radial lines visible.

Dimensions. An average specimen has a hight and a length of 9 mm.

Habitat. Genesee province; Chautauqua subprovince. In the soft shales at Gowanda, Cattaraugus co. (Hidi tannery), and Correll's point, Lake Erie.

Observations. This quite well defined little shell is in general expressions so like the Posidonia venusta Münster which is distributed through the Lower, Middle and Upper Devonic of Germany that I believe

[1] *Op. cit.* p. 76, pl. 14, fig. 14.

it should be regarded a varietal form of that species, specially distinguished by its corrugated surface. One of the specimens figured on plate 12 shows in the character of its sculpture still closer approach to P. venusta. For comparison with the characters of the latter species reference is made to the figures given by Münster and Frech.[1]

KOCHIA Frech. 1891

The shells of Kochia[2] have the aspect of capulid gastropods, the left valve being strongly convex, with arched and incurved beak twisted backward, while the right valve is flat, depressed or concave, when the valves are found conjoined appearing like an operculum to the larger valve. The wings are small and suppressed; the ligament area clearly striated, elevated, short and concave; teeth are wholly wanting; and the whole expression of the shell is very unlike that of other Aviculidae, though from these shells the genus may be regarded as derived. They were early noticed in the rhenish Devonic and were referred to the Capulidae (Naticopsis) by Roemer, but their proper place was recognized by Gosselet, Kayser and others, the late C. Koch introducing for them the generic term Roemeria (a preoccupied name) and Sandberger proposing to call them Onychia, rejecting the name Roemeria because of its employment among the fossil plants. The leading species of this genus, Kochia capuliformis Koch, is widespread in the lowest horizons of the Lower Devonic (Taunus quartzite and Siegen greywack).

We have found a single well characterized species of this genus in the Portage fauna, less extreme than K. capuliformis in the elevation and incurvature of the larger valve and thus far showing no evidence of the cardinal area. In some respects these bodies suggest the cardioid species with large larval shells referred to by Barrande under the name Slava (Étage E) and which Frech and Beushausen term Tiaraconcha (T. scalariformis Beush. Martenberg, Oberscheld; T. rugosa Kayser,

[1] *Op. cit.* pl. 14, fig. 15, A, B.

[2] Frech. Die devonischen Aviculiden Deutschlands. 1891. p. 72.

Enkeberg). These toque-shaped shells are however subequivalve, and, while they are arched and mitriform and concentrically rugose like the New York species, the latter is thus far chiefly represented in our collections by specimens of the left or arched valve only. Such right valves as may be looked on as appertaining to these are depressed convex or flat.

Kochia ungula sp. nov.

Plate 13, fig. 1-7

These shells are valves with highly overarched umbo, narrow, produced and incurved beak and relatively short body with wing and ear suppressed. Shells of this character but of widely different size occur in the shales of the Chautauqua subprovince. They may be more precisely described as follows. Marginal outline subcircular or subrhomboidal. Anterior margin inflected beneath the beak, making a rounded angle of less than 90° with the basal margin; the latter transverse. Postbasal angle 90°. Posterior margin direct, postcardinal oblique and moderately long. Contour capuliform; umbo produced beyond the hinge line, strongly arched downward and beak incurved and recurved. Over the main body of the valve the umbo is delimited by abrupt lateral slopes on both sides. The posterior slope is broader and gently concave, the anterior is directed inward from edge of the umbonal slope. Surface over the umbonal region and all the early parts of the shell with broad obscure concentric wrinkles. The markings become finer about the margin where these wrinkles are obsolescent. Of 10 specimens of this species observed, the majority are of small size, and nearly all are left valves.

The specimens regarded as right valves of this species are somewhat obliquely subrhomboidal in outline with beak in front of the middle. The umbonal region is gently convex, and the surface over the pallial region, in front, behind and below is broadly depressed and gently concave about the basal margin. Length and width nearly equal. Surface covered with concentric striae, which may take on the form of low plications.

Observations. Kochia capuliformis Koch is the only other species now referred to this genus. This is an early Devonic shell, and the generic type is a belated comer in the New York sea.

Habitat. Genesee province; Chautauqua subprovince. Correll's point, Lake Erie shore near Brocton and at Smith's Mills, Chautauqua co.

LOXOPTERIA Frech. 1891

In Loxopteria, proposed as a subordinate division of the genus Kochia,[1] there is a marked difference from K. capuliformis and K. ungula in the expression of the exterior, the larger valve being less conspicuously elevated and arched and abruptly deflected on the posterior slope, with the wing on this side clearly defined and standing almost at right angles to the shell body. The smaller or right valve is depressed convex, operculum or oyster-shaped, with a broad median depression extending radially backward from the beak, leaving a low and broad radial elevation in front and where elevated, explanate expansions behind. The posterior moiety of the valve is bent upward toward the hinge line and thus forms a posterior wing of notable size. Three species of this peculiar shell are known in the German Devonic, all from high horizons in the formation. Loxopteria dispar Frech (Avicula dispar Sandberger) occurs freely in the higher Upper Devonic and the Clymenienkalk.[2] The two other species, L. laevis and L. rugosa, have been described by Frech (*op. cit.*) the former from the Clymenienkalk of Wildungen and the latter from the Upper Devonic of Beilstein. It is thus of noteworthy interest that the New York Intumescens fauna furnishes species evidently identical with some of these German shells and these too in considerable abundance in the Chautauqua subprovince. The evidence of the close relation of these shells to the Aviculidae, as inferred by Frech and the other German authors, is not altogether clear to us, except it be stated in this broad fashion: Kochia

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[1] Frech. *Op. cit.* p. 76.

[2] See Sandberger. Versteinerungen des rhein. Schichtensyst. in Nassau. 1852. pl. 29, fig. 14; Frech. *op. cit.* 1891. p. 77, pl. 6, fig. 4–4h; Drevermann. Die Fauna der Oberdevonischen Tuffbreccie von Langenaubach bei Haiger. 1901. p. 146, pl. 16, fig. 1.

(certainly an extreme development of the series of forms) has a broad subcardinal area, which Frech compares with the ligamental surface in Limoptera. There is further an aviculoid aspect apparent in the smaller valve, and also, by bringing into comparison with this bizarre shell certain Triassic genera of similar aspect, Hoernesia and Cassianella, the modified Avicula form is emphasized. It loses itself in Loxopteria by the disappearance of all trace of ligament area and wing (except on the right valve), and yet a certain resemblance to Kochia in form and the relations of the valves is evident. The extreme in this suppression of characters is attained in the forms we have referred subgenerically to Sluzka, and yet their immediate affiliation with typical expressions of Loxopteria is clear.

Loxopteria dispar Sandberger (sp.)

Plate 13, fig. 8–17

Avicula dispar Sandberger, Versteinerungen des rhein. Schichtensyst. in Nassau, p. 284, pl. 29, fig. 14

Avicula dispar Kayser, Studien aus dem Geb. d. rhein. Devon, 4; Zeitschr. der deutsch. geol. Gesellsch. 1893. p. 636

Kochia (Loxopteria) dispar Frech, Devon. Aviculiden Deutschlands; Abhandl. z. geolog. Specialkarte Preuss. u. d. Thür. St. 1891. v. 9, Heft 3, p. 77, pl. 6, fig. 4–4h.

Shell subtriangular in general outline. Valves highly unequal in form and contour. Left valve subtrihedral, umbo convex, beak incurved and anterior. Posterior outline abruptly sloping to the ventral margin. Anterior margin incurved beneath the beak, expanding somewhat to the broad anteroventral curvature. Ventral margin transverse or curving with a broad inward undulation to the posterior ridge. Slope of the surface from the posterior or umbonal ridge sharply incurved to the periphery with no trace of wing. Anterior slope broad and faintly depressed beyond the body of the shell. Surface with a few broad radial ribs or undulations of variable number and size. These are all usually sharply defined at the umbo, are three or four in number and broaden out over the body, becoming obscure or obsolete about the margin. There is much variation in the development of these ribs in different individuals; in some they are obscure except at the beak, in others clearly defined over the entire surface. The posterior rib is much broader than the rest and takes in the umbonal ridge. Besides these surface characters there are the following: very fine radial lines of subequal size cover the entire surface, and these are crossed by equally fine concentric lines. The latter make a broad upward turn along the postventral edge where passing over the umbonal ridge. On the cardinal margin there is a short subtriangular area directly beneath the beak, which is not clearly set off from a semicircular emargination (lunule?) in front. This emargination extends halfway from the beak to anterior extremity, and beyond its outer end the hinge line is straight. No ear is present. Posteriorly the subcardinal area passes into a broader concave depression, which is crossed by two oblique ridges, the surface between being depressed. No evidence is present of ligamental pit or striation, and there is no posterior wing.

No specimens of this species retain the valves in conjunction; but, from analogy with the German specimens, we feel secure in referring to it detached right valves having the following characters. Subelliptic, depressed, gently convex over the anterior portion, depressed postmedially, narrowly and often acutely elevated posteriorly. Beak one third the width of the shell from the anterior margin; umbo projecting beyond the cardinal line, but depressed. The postmedian depression or sinus is oblique, usually very broad, sometimes more sharply impressed, setting off the posterior expansion with the aspect of a wing. The latter, on account of its marginal elevation, must have bounded a wide posterior siphonal opening, which had a more extensive cover on this than on the left valve. No trace of hinge structures. Surface with obscure traces of broad radial ribs on the convex body and finer radial lines specially marked on the posterior parts. Fine concentric lines are also present.

The shell substance of the species is very thin, and none of the specimens bear indication of musculature.

Observations. This species is perhaps the commonest of the representatives of the genus, but its aviculoid characters are not altogether clear. There is a certain pterineoid aspect in the right valve due to the development of a posterior flange, but this seems to us hardly homologous with the wing of the Aviculidae, as it is a broad flaring arched surface bounding a wide open posterior aperture, extending from beak to margin. Here, however, analogy is imperfect, as it is evident that there was no corresponding surface on the left valve. This condition seems to be displayed by some of the figures given by Frech of pyrite casts of conjoined valves from Nehden.[1]

Habitat. Genesee province; Chautauqua subprovince. In the soft arenaceous shales at Forestville, Chautauqua co., and Gowanda, Cattaraugus co. In the German Devonic the species is restricted to the higher marine Upper Devonic at Oberscheld, in the Clymenia limestone of the Enkeberg and in the shales with Goniatites curvispina at Nehden.

Loxopteria laevis Frech

Plate 14, fig. 1–7

Kochia (Loxopteria) laevis Frech, Die Devonischen Aviculiden Deutschlands; Abhandl. z. geolog. Specialkarte Preuss. u. d. Thür. St. 1891. v. 9, Heft 3, p. 76, pl. 6, fig. 3–3e

Shell subtriangular, general surface depressed. Left valve with much the same outline as L. dispar, less convex in the umbonal region. Posterior margin or umbonal ridge with gentle outward curve specially in the umbonal region. Anterior margin at first incurved beneath the beak then bending outward and rounding to the base, which is transverse, with a broad sinuous upward bend toward the first lateral angle. The right valve differs from that of L. dispar in the notable depression of the beak and umbo. The larval shell itself is concave, and the umbonal area all about it is depressed and curved downward toward the hinge, and this depressed area extends obliquely backward, covering the greater portion of the valve. It is bounded in front by a low convex area with an abrupt marginal slope, incurved toward the beak, and behind it curves upward to a pretty

[1] *Op. cit.* pl. 6, fig. 4, 4a.

sharp elevated ridge running from umbo to margin, narrow on top and bending over to form a very narrow wing. Surface of both valves covered with fine concentric striae; no radial markings visible.

Habitat. Genesee province; Chautauqua subprovince. Not uncommon in the soft sandy shales at Forestville, Chautauqua co., and Gowanda, Cattaraugus co.

Observations. This shell expresses the generic characters with some variation from the genotype L. dispar, seen specially in the contour of the right valve. These differences, however, are not great. In referring these shells to the German species, I am expressing what seems to be their closest affiliation. Frech's description is very brief, but a study of his figures fails to disclose any real difference from the New York shells, unless in the contour of the smaller valve there be a distinction which is here insufficiently emphasized. If our species eventually proves dissimilar from L. laevis, the difference will doubtless be recognized in time with a new denomination, but in the meantime the present designation serves most truly to indicate its real affinities. Loxopteria laevis has been found in the German Devonic only in the Clymenienkalk of Wildungen.

Loxopteria vasta sp. nov.

Plate 13, fig. 18

Associated with L. laevis is a large right valve, the largest of all specimens observed, which differs from the valves referred to the other species of the genus here present in the following particulars. The broad expanded surface is very deeply depressed at the umbo, and the beak is bent strongly downward at the hinge. This depression widens outward, leaving in front a low, flat anterior division with a very narrow abrupt slope on the margin. Back of this broad depression the surface is elevated to a narrow ridgelike wing similar in character to that of L. laevis, but not so abruptly raised. The postlateral surface is thus broadly concave. The surface markings consist of a series of concentric wrinkles which become finer and crowded toward the margin. This valve evidently indicates a species with which we are not otherwise acquainted. It measures in length 28 mm and in hight 23 mm.

Habitat. Genesee province; Chautauqua subprovince. Forestville.

Loxopteria (Sluzka) intumescentis sp. nov.

Plate 14, fig. 8-17

Shells subcircular or irregularly subrhomboidal in outline, broader over the body, sometimes the greater diameter transverse, sometimes vertical. The prodissoconch is very prominent with the apex directed strongly forward. Its position is subcentral, but, on account of the varying outline of the shells, lies now in front and now behind the middle. A vertical line dropped from beak to base divides the shell into unequal parts, of which the larger is the anterior. Behind the beak the margin is straight for a very short distance (hinge), then bends more or less abruptly downward to a broadly rounded ventrolateral curve. The base may be transverse or curved and the anterior margin is a shorter curve than the posterior. The anterior moiety of the shell is more extended and narrower than the posterior. Surface pretty evenly convex with a narrow abrupt slope on the postcardinal margin. Surface markings irregular concentric growth lines and wrinkles.

Habitat. Genesee province; Chautauqua subprovince. From Walnut creek at Forestville and Correll's point, Lake Erie.

Observations. This description is derived from shells which seem to be all left valves. There is no wide departure in their general aspect from that of Loxopteria dispar and L. laevis, but, in the absence of the triangular form, broader posterior expansion, narrow anterior moiety and almost direct anterior margin, are found differentials which seem to justify a separation of the species in a subgeneric way from Loxopteria. The same differences are present in L. corrugata, which belongs in this association rather than with the typical representatives of that genus. We have therefore proposed to designate these two species by the subgeneric term above used.

Such shells as these are to be found among the various species referred by Barrande to his genus Sluzka. Some of these shells, e. g. S. arachne,[1] show traces on the internal cast of the hinge line which suggest that they were taxodonts. Barrande, however, regarded the hinge as devoid of teeth. It is however observable that the majority of these shells, representative of which we may cite S. amygdalina [pl. 358] from Étage G, are of very primitive aspect and subcircular outline, with concentrically striated or irregularly rugose surface, having prominent larval shells projecting at the apexes and also likewise devoid of evidence of hinge modifications. Similar characters, too, are seen in some of the species referred by Barrande to his genus Vevoda, as for example V. expectans [Barr. pl. 13], in which the large size of the prodissoconch is specially notable. Some of the more regular suborbicular shells of this kind suggest the genus Paracyclas Hall; and Neumayr has put under the latter both Vevoda and the Paracyclas and Isocardia of Barrande. It is however clearly evident that the shells we have now to consider are not species of Paracyclas, for the normal forms of that genus from the Hamilton fauna have a very distinct aspect in the character of the surface markings, the regularity of outline and absence of the general primitive expression of these later shells. To employ Barrande's term Sluzka for certain lamellibranchs in the Intumescens zone is not necessarily to admit the integrity of that genus nor to concede the reappearance in the upper Devonic of the Siluric types to which the name was first applied. The employment of the term obviates the erection of a new name; and, in the absence of definite hinge structure or, rather, with present evidence of the extreme simplicity of the hinge, we find in these Devonic shells an approximation to the structure represented by the majority of Barrande's species of the genus.

Loxopteria (Sluzka) corrugata sp. nov.

Plate 14, fig. 18-26

Shells of medium or small size, subcircular to subquadrate, general aspect of left valve suggestive of Paracyclas. Beaks nearly median,

[1] Barrande. Syst. Sil. 6, pl. 265–1, fig. 8, 9.

slightly anterior. On the left valve the prodissoconch is generally conspicuous in adult stages. Hinge line short, straight, extending backward for a little distance, then deflected downward, the posterior margin having a slight outward curve. At the posteroventral angle it is more or less abruptly deflected to the transverse basal margin, which at the anteroventral angle is bent upward in a more or less abrupt curve, which gradually recurves to the beak. The subangular umbonal ridge is well marked on the posterior moiety of the valve, reaching the margin at the posteroventral angle, and along this ridge all the folds of the surface are quite abruptly bent. The posterior slope is moderately broad and clearly defined. Surface gently and pretty regularly convex; marked by very coarse concentric corrugations, generally five to six in number, separated by narrow grooves. The right valve is very seldom seen; that referred to the species is obliquely subovate, with subanterior beaks; basal margin rising rather abruptly to the anterior extremity, while the posterior margin is broad and a regular curve. The vertical diameter of the valve across the posterior portion is nearly twice that through the umbo. From the beak obliquely backward extends a depression increasing in width downward, which divides the surface into a narrow anterior and broad posterior convexity. The latter is again depressed and flattened toward the hinge line. Surface with concentric wrinkles, which may be covered by finer concentric lines.

Habitat. Genesee province; Chautauqua subprovince. Walnut creek at Forestville and Correll's point on the Lake Erie shore near Brocton.

Observations. Loxopteria corrugata is a species closely similar to Kochia (L.) rugosa Frech, which has been described from a single left valve from the Upper Devonic at Beilstein near Oberscheld.[1] This attains a larger size than we have observed in the New York specimens, and we note that there is an apparent difference in the development of the umbonal ridge. L. rugosa is represented as having an elevated, somewhat incurved postumbonal slope, free of corrugations, but in the

[1] *Op. cit.* p. 78, pl. 6, fig. 5, 5a.

description it is stated that this part of the shell is broken. As there is a striking agreement in other points of structure, we may assume that the species are fully congeneric. These shells however, while carrying the general expression of Loxopteria, show some palpable differences from the typical members of the genus, L. dispar and L. laevis. The subtriangular aspect of the shell is lost by the development of the postumbonal slope on the left valve, carrying corrugations and showing no trace of wing, and in the right valve the broad oblique depression is anterior, while the posterior moiety of the valve is broadly convex instead of being abruptly elevated into a winglike expansion. With more data these differentials may become entitled to distinctive value.

ONTARIA gen. nov.

(**Cardiola** auct. aliq.)

Cardiola was proposed by Broderip in 1839[1] for shells typified by the species C. interrupta Sow., an Upper Siluric shell having a subcircular marginal outline, convex umbones with beaks projecting beyond the short and straight hinge line; cardinal (ligamental) areas triangular and rising to the hight of the beaks, so that they are broadest in the interval between the beaks; this area is striated horizontally. The hinge line, so far as known, is a straight edge without modification or denticulation. The strong umbones are directed forward and give a general obliquity to the convex contour of the shell. The surface is covered with strong radial ribs, which are crossed, cancelated or knotted by concentric lines grooving the surfaces of the radii without materially affecting the deep intervals. These concentric markings usually develop into or express themselves as corrugations or undulations, specially strong over the umbonal region of the valves. The shell is calcareous and relatively thick.

These shells are of striking and peculiar external habit, and we understand their variations in expression pretty thoroughly. Barrande has given nearly 200 illustrations of Bohemian specimens of C. interrupta alone and

[1] Murchison's Silurian System, 2: 617.

has supplemented these by a profusion of figures of other Siluric shells having similar character. It has been usage to refer the Upper Devonic shells of like aspect to this Siluric genus. Chenu [1] and Zittel,[2] cite C. cornucopiae Goldfs., a German Clymeniakalk species, as typical of the genus and use this for purposes of illustration.[3] Various authors have incidentally referred such Devonic shells as we have here to consider to the genus Cardiola, but no one has studied them as carefully as Beushausen, who, cautiously and with reserve, also employs this term as the present most convenient receptacle for them. This procedure can not long be justified. Granting the general similarity in aspect of these shells with Cardiola interrupta, we find structural differences in the early and later forms which seem to us reliable, and these we should supplement by the following general considerations: (1) an a priori consideration, that these late Devonic shells, connected with the Siluric Cardiolas by very few representatives, are improbably of the same generic character; (2) the evidence that the influences (whether external or internal) which have effected the paleoconch condition in so many of these lamellibranch genera, expressed in tenuity of shell, loss of special articular development and shown in all the genera which are properly distinctive of this fauna, have similarly affected this group of Cardiolas, and endowed them with an expression which entitles them to distinction; (3) the unavoidable conclusion that these shells are opisthogyre in the same sense as are Lunulicardium, Honeoyea and Paraptyx, while there is at present no ground for assuming that the typical Siluric Cardiola is of this character.

In respect to structure we observe (1) the extreme tenuity of the Devonic shells, (2) the general prevalence of an extremely fine, delicate, radial striation contradistinguished from the coarse ribbing of C. interrupta and its Siluric allies, (3) a diminution to or almost to extinction of the cardinal or ligamental area beneath the beak, (4) the presence of radial

[1] Manuel de conchyliologie.

[2] Grundzüge d. Paleontologie, etc.

[3] This species was regarded by Sowerby as synonymous with C. interrupta.

plications in front of or behind the beak or in both positions, with interlocking extremities crenulating the margin. These appear to be absent in C. interrupta. Aside from these special considerations, "Cardiola" as commonly employed has no precise value, and we shall do well to separate from the heterogeneous objects therewith included, this compact group of upper Devonic shells. Barrande figured some shells of great size under the name Pantata [= Pater; v. 6, pl. 189, 309, 329, 331], which, in respect to the character of the cardinal area and attitude of beak as well as character of surface, are in more close agreement with these shells than the latter with Cardiola.[1]

Under the description of Paraptyx we noted that the only representative of the genus, P. ontario, is so closely similar in external characters to Cardiola (Ontaria) clarkei Beushausen that specimens of the two are barely distinguishable if the cardinal line be imperfectly preserved; both species alike possess the fine, flattened, numerous and frequently split radii, and the former often assumes a subcircular outline as in the latter, though normally it is somewhat elongate vertically.[2] This resemblance is specially well shown in the specimen of Paraptyx represented on plate 7, figure 9. We have shown from the evidence derived from Honeoyea that the crescent of Paraptyx is posterior and hence the beaks opisthogyre. The suppression of this crescent with its functions would virtually change Paraptyx ontario to Ontaria clarkei. In the latter there is absolutely no trace of this structure, fine replacements showing only a narrow cardinal area, but there is no escape from present evidence that, if the beaks are posterior in Paraptyx, they are likewise posterior in Onta-

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[1] The name Pantata is probably of doubtful validity. It has not been even briefly defined, and some writers have included it under Panenka (= Puella). Frech has shown that the word is not such as could be appropriately employed for a generic designation, being a current Czechic word for *father*.

[2] This similarity of aspect in distinct organisms is paralleled by the goniatites Probeloceras lutheri and Beloceras iynx which can not be distinguished except on exposure of the sutures.

ria, even though the greater part of the ligament area lies in the opposite direction.[1]

We propose to distinguish this group of Cardiolas of the Upper Devonic by the term Ontaria (Ungulina suborbicularis Hall, type).

Ontaria suborbicularis Hall (sp.)

Plate 8, fig. 1–20

Ungulina suborbicularis and Lucina? retusa Hall, Geology of New York; rep't on fourth dist. 1843. p. 243, fig. 106, 2, and p. 246, fig. 107, 4

Cardiomorpha suborbicularis Hall, Paleontology of New York. v. 5, pt 1, plates and explanations. 1883. pl. 63, fig. 9, 10

Edmondia? tenuistriata Hall, Paleontology of New York. 1885. v. 5, pt 1, pl. 63, fig. 9, 10

Cardiomorpha suborbicularis Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 51

cf. Lucina wyomingensis and Lucina varysburgia Williams, U. S. Geol. Sur. Bul. 41. 1887. p. 44, pl. 3, fig. 13, 14

The variable aspect of this abundant and characteristic fossil has been largely though not wholly responsible for its unfortunate entanglement in literature. The original woodcut given in 1843 was a very fair and quite recognizable representation of a certain expression of the species, which may properly be regarded as typical, if not also normal; that is a subcircular shell with central beak, concentrically and sharply lined surface, and entire freedom from radial striae or plications. The brief description which accompanied it mentioned these features and the occurrence of the shell on Cashaqua creek and the shore of Lake Erie. Just such shells do occur very commonly throughout the lower beds of the formation from Lake Erie to Seneca lake. No subsequent account has been given of this original type of shell in any of the volumes of the *Paleontology of New York* except in the preliminary publication of the plates of volume 5 of that work, on

[1] Noetling's observations on the morphology of the lamellibranchs, already referred to, indicate the necessity of readjustment of current views as to the stability of the position of the beak with reference to the animal, and with change of beak the line of greatest shell growth also changes.

the Devonic lamellibranchiates, where a figure of a single imperfect specimen was ascribed to this species, then termed Cardiomorpha suborbicularis; in the final appearance of these plates accompanied by descriptive text this name was altogether abandoned, and the fossil was redescribed under the new designation Edmondia? tenuistriata, and its geologic locality cited as the "shales of the Chemung group near Elmira, N. Y."

The following remarks were also made in justification of this change: "This species has been compared with and supposed to be identical with Ungulina suborbicularis, but it is entirely distinct from that form, and from a different horizon."

The specimen is, on the contrary, an excellent representative of Ung. suborbicularis, differing from the original type, so far as one may judge from the figure, in the presence of fine, filiform, radial striae, but this, as we shall presently observe, can not be relied on as a specific character. Moreover, the specimen, a piece of dark gray sandy shale, is from the high layers carrying the survivors of the Portage fauna after the introduction of a distinct fauna from the east.

It is the existence in varying degree of this fine radial lineation of the surface that has obscured the identity of the species and seems to have given birth to the name above mentioned, Edmondia? tenuistriata, and also to the terms Lucina wyomingensis and L. varysburgia.

This radial striation may manifest itself only as a few faint lines on each cardinal slope close to the hinge line; it may extend over the entire cardinal slopes; and, finally, and most often, may cover the entire surface with extremely minute lines of equal size. Thus between a smooth shell marked with sharp concentric lines but with no trace whatever of radial striae to shells in which the entire surface is covered with fine radii, we find within this species every passage stage.

The striae along the hinge line on both sides of the beak are not stouter than those elsewhere, but they slightly crenulate the margin of the shell on the posterior side of the beak, as the others do not.

The greater number of these lineate specimens are sculpture casts and do not of themselves clearly demonstrate the external character of this radiation, but on some specimens from the limestone the shell is retained and indicate that the striation is strictly exterior and ornamental.

Description. Shell of considerable size, typically suborbicular, with central beak which is incurved and minute and oblique. The apical part of the beak is sometimes set off by a low transverse thickening which thus brings the embryonal shell into prominence.

Hinge line short and straight; cardinal area narrow, elongate, triangular, not elevated.

Surface quite evenly convex from the umbo outward; often abruptly folded downward at the periphery. The ornamentation normally consists of sharp, imbricating concentric striae which may form successive festoons or undulations far apart, covered by lines close together, or the lines may be all distant or all approximate. These more distant lines are sometimes limited to the body of the valve, while about the margins they are crowded, or again they are to be found only about the margin. Sometimes internal casts show a concentric undulation which manifests itself on the surface only in a fasciculation of the striae.

There may be no radial striae whatever on the shell, but in the majority of instances some evidence of them is to be seen. Sometimes, though seldom, there appear three or more very fine lines on each side of the beak close to the cardinal area. The lines may also cover the anterior and posterior slopes of the shell, or extend over the entire surface, cancelating the finer concentric lines and minutely crenulating the margin. All these lines are exceedingly fine, but become more prominent in the old shells near the margin.

These shells are subject to variations in some other respects. The contour of the surface is not uncommonly modified by the abrupt concentric deflection of the peripheral region, and, if this has occurred more than once in the life of the shell, a very uneven surface may result. Again, while shells which agree with the original in having a central beak are sufficiently common, the majority of specimens present a somewhat oblique condition. The degree of this obliquity varies from the normal to the situation of the beak at the posterior one third of the shell's length. It was such an oblique shell that was figured by Hall in 1843 (*op. cit.*) as Lucina ? retusa.

This obliquity is apparently not accidental or due to distortion from compression; occasional specimens show the young shell, outlined by a deep growth furrow, to be orbicular; the obliquity of the shell which commences soon thereafter is a result of natural growth.

Had we but a few specimens of this species under study, there might seem some justification for regarding these oblique shells as a persistent variety; but, among the several hundred shells before us, it is evident that the passage from the erect to the oblique form is quite as gradual as from the nonstriate to the striate shells.

Only this extensive material has served to demonstrate the protean character of this species, to which in all its various expressions we can apply but one term.

In some of its aspects the species very closely approaches the well known Cardiola concentrica von Buch, a widespread Intumescens zone organism throughout European outcrops. Guided by Beushausen's excellent figures and full description of this shell, we observe that in none of the examples of O. suborbicularis are the cardinal plications so strongly developed, nor is it often that the surface of this shell is so strongly and regularly corrugated as that. Von Buch regarded his species as bearing radial striae, but Beushausen states he could find only the barest traces of such lines, and suggests that they belong to the inner shell layers. Though we find among the Portage shells those that we regard as typical examples of C. concentrica, yet these appear not to have entered the Naples subprovince. We may safely infer that, with its wide range of variation, O. suborbicularis is, thus, a species comprehending a local expression of C. concentrica. Beushausen expresses the opinion that Hall's Edmondia? tenuistriata is C. concentrica, and, while it is unquestionably O. suborbicularis, this opinion indicates the approximation of these species.

Habitat. Genesee province; Naples subprovince. Ontaria suborbicularis is a very common shell in the lower soft shales of the Naples beds in Yates, Ontario, Livingston, Genesee and Erie counties and also occurs in the Styliola limestone on Canandaigua lake.

With Phragmostoma natator, Manticoceras intumescens and Buchiola retrostriata it rises high in the strata in the region about Elmira surviving after the introduction of the brachiopod fauna.

It is doubtful if any of the shells found in the Chautauqua subprovince can be safely referred to this species. Such forms are not frequent in any event and when well preserved seem to represent other species, e. g. O. concentrica, O. pontiaca.

Ontaria concentrica von Buch (sp.)

Plate 8, fig. 26

Orbicula concentrica v. Buch, Ueber Goniatiten. 1832. p. 50

Cardium pectunculoides d'Archiac & de Verneuil, Geol. Soc. Trans. ser. 2. v. 6, pt 2. 1842. p. 375, pl. 36, fig. 12

Cardiola concentrica Keyserling, Beob. üb eine Reise in das Petschoraland. 1846. p. 253

Cardium pectunculoides A. Roemer, Verst. des Harzgeb. Beitr. 1. 1850. p. 26, pl. 4, fig. 10

Cardiola concentrica Sandberger, Verstein. d. rhein. Schichtensyst. in Nassau. 1850–56. p. 272, pl. 29, fig. 1

Cardiola? concentrica Tschernyschew, Fauna d. mittl. u. ober. Devon am Westabhange des Urals. 1887. p. 18, pl. 6, fig. 15

Cardiola concentrica Beushausen, Lamellibr. des rhein. Devon. 1895. p. 355, pl. 37, fig. 16–20

cf. Lucina wyomingensis Williams, U. S. Geol. Sur. Bul. 41. 1887. p. 44, pl. 3, fig. 13

I refer with a little hesitation to this old species the single valve here figured, which presents an expression not attained by O. suborbicularis in the three or four strongly marked plications behind the beak and finer ones in front. These are of precisely the same character as the posterior plications in Lunulicardium and may also be compared to those of Euthydesma. Beushausen has shown that the German forms of the species do not always carry concentric undulations, but it is evident from our specimen that the sharply defined and distinct concentric lines of the body of the shell rise on low rounded surfaces, while about the periphery the lines are more closely crowded and less elevated. Though this is the only specimen observed which in our judgment can be referred to O. concentrica, it seems to us probable that the shell termed by Williams Lucina wyomingensis (*op. cit.*) is of the same nature, the figures indicating the umbonal radii. This species does not enter the Naples subprovince, and likewise, as we have before observed, the O. suborbicularis occurs rarely in the Chautauqua subprovince.

Dimensions. The specimen before us is a left valve measuring in hight and length 20 mm.

Habitat. Genesee province; Chautauqua subprovince. Correll's point, near Brocton, Chautauqua co. Lucina wyomingensis is from Varysburg, Wyoming co.

Ontaria pontiaca sp. nov.

Plate 8, fig. 21

Shell suborbicular or slightly transverse. Hinge line straight, extending two thirds the length of the shell; divided subcentrally by the beak, which projects slightly beyond it; beaks deflected very slightly anteriorly. Cardinal area narrow, erect. Valves subequilateral. Umbo gently and regularly convex, sloping with convex curve to the basal margin, but the surface is concave both in front and behind the umbo on the slope of the lateral margins. Marginal curve quite regular, the surface somewhat more expanded behind than in front. Marginal surface somewhat abruptly deflected.

Surface smooth, showing no cardinal or other radial plications and only vague, obscure suggestions of concentric lines. This general smoothness of the surface is indicated by a number of individuals and serves, with the equilateral division of the shell, as the distinguishing feature of the species.

Dimensions. An average specimen has a length of 26 mm; and hight of 20 mm.

Habitat. Genesee province; Chautauqua subprovince. Known only from the shales at Pontiac, Erie co.

Ontaria accincta sp. nov.

Plate 8, fig. 22–25

Shells small for this genus but slightly convex, with subcentral beaks. Outline circular. Cardinal line short and straight, the curve sometimes a little broader anteriorly. Surface smooth or with traces of concentric lines about the margin and an occasional circular ridge or wrinkle; no radial lines visible. The embryo shell is distinctly set off from the rest of the valve by a deep cincture, and this feature seems to be always present and may be construed as a characteristic of the species.

Dimensions. Length and hight 7–8 mm.

Habitat. Genesee province; Naples subprovince. Cashaqua creek.

Observations. A considerable number of shells from the same locality have the above features and attain about the same dimensions. The peculiar prominence of the prodissoconch seen in all these appears sporadically in adult specimens of O. suborbicularis. We believe however that it persists in all the shells of this more westerly form and, together with the other surface characters, will serve to keep it distinct therefrom.

Ontaria clarkei Beushausen (sp.)

Plate 7, fig. 10–20

Cardiola clarkei Beushausen, Abhandl. der königl. Preuss. Geolog. N. F. 1885. Heft 17, p. 347, pl. 36, fig. 10a

It is a rather singular incident that Beushausen under the above name should have described from a single valve a species which is of so frequent occurrence in the New York Intumescens fauna.

The shell is of considerable size, somewhat but not greatly oblique, with rather prominent umbo, and closely appressed, incurved beak. Cardinal area short, triangular, but inequilateral, and divided unequally by the beak. Surface quite convex, maximum convexity being attained near the middle of the shell, and the curvature thence becoming slightly concave on the anterior and posterior slopes. Outline subcircular to transversely oval.

The sculpture consists of fine radial lines, from 125 to 150 in number, which extend over the entire surface to the hinge line. These are at first round and filiform, but become flattened outward and increase by unequal division, so that on the margin these radii alternate or vary irregularly in size. The intervening grooves are very narrow. At the cardinal slopes the lines are larger on the posterior slope, and their extremities inosculate on opposite valves. Over the median portion of the shell these radial lines often show a decided backward curve parallel with the oblique line of greatest convexity from the beak to the ventral margin. In occasional instances duplication of the radial striae begins early and results in exceptionally fine lineation of the pallial region of the shell.

The surface also sometimes bears low, somewhat irregular concentric folds which seem to be largely due to compression in the shales, as rotund specimens are free from them.

We have already noted the remarkable similarity in ornamental characters between this shell and Paraptyx ontario, which conceals the distinction between the two when the cardinal parts are not retained. In O. clarkei the hinge line is very short, and the cardinal angles rounded closely about the beak, while the umbonal striae radiate to the posterior edge.

Dimensions. In average specimens the length is 20 mm, hight 18 mm. Large examples attain a length of 30 mm and hight of 25 mm, while small individuals very much below these dimensions are common.

Habitat. Genesee province; Naples subprovince. This species is common in the shales of the Naples beds in Ontario and Livingston counties, but has not been observed west of the Genesee river. Beushausen's specimen is from the lower Upper Devonic at Oberscheld.

Ontaria affiliata sp. nov.

Plate 7, fig. 21, 22

This shell is a radiate plicate species allied to O. clarkei in some respects, differing therefrom in (1) contour, this species being more convex at the umbo and over the body of the valve with steeper slopes anteriorly and posteriorly; (2) direction of plications, which pass radially with slight curve from beak to margins; (3) character of plications: these are fine, flat, even more numerous at the start than in O. clarkei, simple for one half their length, thence forward rapidly intercalating or splitting, and at the margins all are separated by linear grooves irregularly fasciculated. Faint concentric folds are evident but no concentric lines.

Habitat. Genesee province; Naples subprovince. The single valve showing the above characters is from the soft shales of Parrish gully, Naples.

Ontaria halli sp. nov.

Plate 7, fig. 23–24A; plate 8, fig. 28

These shells approach very closely Cardiola subarticulata Beushausen[1] having from 80 to 100 fine, simple, rounded striae, which become flattened over the pallial region in front and behind and are separated by linear furrows. The surface bears a series of low, broad concentric undulations and also very fine concentric cancelating striae. The shells from the Naples shales are less convex than the German species referred to, but this may be a casual difference. In outline they are somewhat transversely oval or subcircular, narrow across the umbones without the expanded subcircular extremities of associated species. The beak and umbo are prominent, and the general contour of the surface as in other species here described. The character of the surface serves to distinguish the species, being less finely striated than in O. clarkei, and no other associated form carries the combination of radial striations, strong concentric corrugations and fine concentric striae here present.

[1] *Op. cit.* p. 352, pl. 37, fig. 4.

Dimensions. An average specimen measures, hight 20 mm, length 18 mm.

Habitat. Genesee province; Naples subprovince. Occasionally in the shales at Parrish gully, Naples N. Y. Cardiola subarticulata Beush. is from Martenberg, Westphalia.

Genus **Euthydesma** Hall. 1885

Euthydesma was based on the species we are about to notice; and, after careful study of all available material of the genus from the Intumescens fauna and comparison with the accounts given by Holzapfel and Beushausen of the shell described as Mytilarca and Euthydesma beyrichi, we are disposed to conclude that at present but one specific type of this genus is known. The New York shells are of considerable, often large size, with umbones full, rotund and anterior and the surface generally characterized by broad and obliquely concentric ridges. The actual attitude of the beaks we are disposed to believe is opisthogyre, though our preparations are not of such character as finally to determine this point. Yet from analogy with Lunulicardium we find much that supports this view; the posterior cardinal ribs (two to five in number) constitute all the radial plications of the surface and are quite suggestive of the posterior plications in Lunulicardium, specially the species L. beushauseni. This similarity to L. beushauseni is somewhat emphasized by such specimens as that figured on our plate 9 [fig. 15], where the shell seems to have a scar of early injury running obliquely forward from the beak, giving the apex an apparently posterior direction and the anterior margin a subtruncate aspect. This phenomenon has been observed in more than one instance and may not prove to be wholly casual. Hall described the hinge line as "rigidly straight" and as bearing a well defined ligamental groove. Our preparations show that the cardinal or ligament area is rather short, moderately high, arched and finely striated horizontally. It is interrupted directly under the beak by a transverse or vertical ridge and corresponding depression, so that this modification of the area subserves the purposes of articulation, though these processes are not to be regarded as hinge teeth. We believe with Beushausen that the affinities of Euthydesma were doubtless with the Cardiolidae, that is with such of them as have been already here described, and the presence of the peculiar structure mentioned does not militate against this interpretation.

Euthydesma subtextile Hall

Plate 9, fig. 8–17

Astarte subtextilis Hall, Geology of New York; rep't on fourth dist. 1843. p. 245, fig. 6

Cardiomorpha subtextilis Hall, Preliminary Notice Lamellibranchiata. 1870. pt 2, p. 93

Cardiomorpha textilis and undulata, Paleontology of New York. 1883. v. 5, pt 1, plates and explanations, pl. 63, fig. 11–16

Euthydesma subtextile Hall, Paleontology of New York. 1885. v. 5, pt 1, 2, p. 385, pl. 63, fig. 11–16; 93, fig. 28, 29

cf. Mytilarca beyrichi Holzapfel, Palaeontographica. 1882. 28:257, pl. 48, fig. 8, a, b and

Euthydesma beyrichi Beushausen, Abhandl. der königl. Preuss. geolog. Landesanst. N F. 1895. Heft 17, p. 317, pl. 38, fig. 7, 8

This shell has been quite fully described and delineated in the *Paleontology of New York*, and hence its characters do not require full explication here.

The species is peculiarly localized, having been found in New York only about the shore of Lake Erie, where it appears to be very common at certain localities. In external aspect it is somewhat variable, at times being almost smooth or with fine concentric striae; usually bearing strong and low oblique ridges on the surface[1] and generally on both valves two or more strong ribs extending along the hinge line and obliquely from the beak to the posterior extremity. These are present in the original of the figure 13 cited in the accompanying footnote, but have been omitted in the drawing Good sculpture casts show fine concentric lines, distant in the

[1] In the specimens represented in figures 13 and 14 on plate 63, Pal. N. Y., *loc. cit.*, the undulations there appearing as concentric with the growth lines are actually slightly oblique.

umbonal region but crowded toward the margins, and also traces of fine radial lines are to be seen, principally on the posterior and basal slopes. These take on the form of slightly wavy lunes which undulate without cancelating the concentric striae. The figure intended to show the nature of this ornament on plate 63, *op. cit.* [fig. 15] is, as stated therein, incorrect; that given on plate 93, figure 29, approximates the actual condition.

With regard to Euthydesma beyrichi Holz., Beushausen has suggested the probability of its identity with E. subtextile but hesitated to pronounce the two forms alike, because, first, of the supposed "radial striation of the entire shell" in the latter, which is not perceptible except with extraordinarily favorable preservation; again, on account of the cancelation of the radial and concentric striae and the formation of nodes at their intersection, a condition which exists only on a minute scale; and, thirdly, because of only *two* posterior folds parallel to the hinge line. As shown by our figures, the number of these varies from one to five.

Habitat. Genesee province; Chautauqua subprovince. Barcelona, Correll's point, Forestville, Chautauqua co. and at Gowanda, Cattaraugus co. The original specimens of Mytilarca beyrichi are from the lower Upper Devonic at Martenberg, Westphalia. Beushausen further reports the species from Oberscheld and from the upper Upper Devonic of the Enkeberg.

ELASMATIUM gen. nov.

Under this name we propose to bring together series of disconnected right and left valves subtriangular or subcircular in outline, with cardinal characters obsolete and surface smooth or concentrically lined. The right valves are convex, arched in the umbonal region, with an oblique, low umbonal ridge and well defined umbonal slope. The left valves agree in marginal outline and general convexity with the right, but a vertical interior plate or ridge begins at the beak and divides the shell along the curving middle line into two subequal parts. A lesser and similar internal plate seems to lie in the place of the posterior umbonal ridge.

Surface of both valves concentrically striate.

Elasmatium gowandense sp. nov.

Plate 12, fig. 21–29

Shells of rather small size having the characters above set forth. The interior plates or ridges of the left valve are generally rendered conspicuous by the flattening of the test in the shale, breaking along the edges of the plates and leaving them standing out above the surface of the shell. This crushing, which is usual in the specimen, generally folds it along the umbonal ridge, obscuring but not concealing the smaller plate beneath.

Observations. To the relations of these shells, if the valves here described prove to belong together, we can gain little clue. The clavicle bearing left valves suggest some of the taxodont genera like Nuculites, but there is a total loss of taxodont characters. The shells are found freely in association with Kochia and Loxopteria.

Habitat. Genesee province ; Chautauqua subprovince. In the shales, at Gowanda, Cattaraugus co., and at Walnut creek, Forestville and Little Canadaway creek, Chautauqua co.

Genus BUCHIOLA Barrande. 1881

Venericardium v. Buch. 1832
Glyptocardia Hall. 1885
Cardium, Cardiola, Avicula of authors

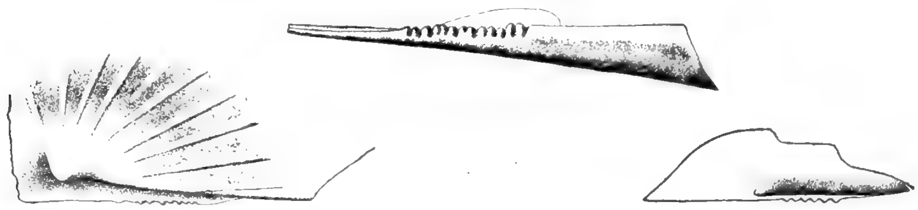

Fig. 11 Camera sketches of the hinge line in Buchiola retrostriata showing the irregular denticulations on the edge

Obscure as are the structural characters of these shells, yet the peculiarity of their ornament alone justifies their distinctive designation. This feature consists in few and broad plications crossed by fine lines caught up into festoons on the summits of the ribs. Even in this respect, however, the species pass into Paracardium, a group from which Buchiola is distinguished less in kind than in degree. The structural features of Buchiola appear to us, from the study of delicate replacements, to be these. The cardinal line is long and straight, and the beaks we regard as prosogyre; a narrow sometimes curved or concave, almost linear cardinal or ligament area is developed, on the outer edge of which we find in many cases a row of minute and often irregular denticles. This is a modification which is so frequently absent that we have repeatedly suspected it to be due to incomplete replacement, but in our present judgment such is not the nature of it. This row of denticles may extend for nearly the whole length of the cardinal line or for only a part thereof, and it is probable that those from opposite valves interlock. It is quite certain that these denticles are not termini of radial subumbonal plications, as somewhat similar appearances in Praecardium are believed to be by Neumayr and Beushausen.

Beushausen has done an estimable service in indicating the specific distinctions existing in the Devonic material of Germany which has long and everywhere passed under the name Cardiola retrostriata v. Buch. Similarly in New York all expressions of this genus have commonly passed as Avicula or Glyptocardia speciosa Hall. Though we find less diversity of specific forms in the Appalachian than in the German Devonic (18 species), yet we find it necessary to enter on some restriction of the old specific name, in order properly to apprehend the value of the genus.

Buchiola retrostriata v. Buch. (sp.)

Plate 10, fig. 1–14

Venericardium retrostriatum v. Buch, Ueber Goniatiten. 1832. p. 50

Avicula speciosa Hall, Geology of New York; rep't on fourth dist. 1843. p. 243, pt 106, fig. 1, 1a

Cardiola speciosa Hall, Paleontology of New York. 1883. v. 5, pt 1, plates and explanations, pl. 70, fig. 6–8 (not fig. 2–5, 9)

Glyptocardia speciosa Hall, Paleontology of New York. 1885. v. 5, pt 1 Lamell. 2, p. 426, pl. 70, fig. 6–8 (not fig. 2–5, 9)

Cardiola retrostriata Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 58

Cardiola (Buchiola) retrostriata Clarke, Am. Geologist. August 1891. p. 91, 96

Buchiola retrostriata Beushausen, Abhandl. der königl. Preuss. Geolog. Landesanst. N. F. 1895. Heft 17, p. 326, pl. 34, fig. 9, 10

We have already stated that the generic type of Buchiola is represented by fewer specific expressions in the Devonic of New York than in the Rhineland. It is furthermore but sparsely found among faunas which antedate the Intumescens zone, but with a few other species of this fauna it continues its existence in the eastern subprovince for a while after the introduction of the brachiopod fauna. With the arrival of the Intumescens fauna, even in its prenuncial appearance, Buch. retrostriata was common, and in the shales and sands of the Naples beds it became, probably, the most abundant fossil of these rocks.

Following the excellent example of Beushausen, we find reason to recognize certain specific differences in New York specimens of Buchiola which have heretofore been in part embraced under the specific terms cited above, by Professor Hall and the writer. Compared with Professor Beushausen's careful delineations of what must be regarded, in lieu of more precise knowledge, as typical examples of Venericardium retrostriatum v. Buch, and Cardium palmatum Goldfs., we are bound to conclude that no specific difference exists between the great majority of examples of Buchiola in the Naples beds and Buch. retrostriata. It is equally true that no material distinction can be found between these specimens and Beushausen's conception of Buch. palmata. For us these two venerable names, whose specific independence is recognized by the German savant, express the extremes of variation in sculpture of the New York species. Of both we find the equivalent in our common shell, which we designate with complete propriety, Buchiola retrostriata.

Shell small, oblique oval, this obliquity frequently being exaggerated and sometimes lessened by the angle and degree of compression in the shales. Full grown individuals are highly convex when uncompressed, the greatest elevation being near the middle of the valve ; the umbones are full and closely incurved, beaks acute, small, and directed forward. Hinge line straight, shorter than the length of the shell, making nearly a right angle with the periphery at its anterior extremity, but a much larger angle at the posterior extremity.

As specific characters in this genus rest wholly on permanent variations in the external ornament, this feature is to be depicted with care, and herein our observations are not based alone on internal and sculpture casts, but have been materially aided by barite replacements in which the contour of the detail is retained with absolute accuracy.

The number of plications in mature specimens is from 11 to 13. In young shells there may be not more than six or eight, but this number is invariably the accompaniment of diminutive size. In the umbonal regions of full grown shells these plications are distinctly convex, and their lateral slopes pass without interruption into the smooth, concave and narrow intervening furrows. Over the median part of the body of the valve the ribs become broader and flattened above, and distinct lateral ridges are gradually developed, which separate each rib from the sulcus. These ridges become more elevated toward the ventral margin, where they are raised into low carinae, while the ribs of which they form the boundaries become slightly concave because of their elevation. It is important to keep before the mind this variation with growth in view of the fact that Beushausen has laid much importance on the form of the cross section of the plications as a specific value, without taking into proper account this certainty of variation from early to later stages.

The surfaces of the ribs between the carinae are marked by quite prominent, retrally curved ridges having their longest slope toward the ventral margin. These may sometimes, if rarely, present a slight subangulation at the middle, seen best on the extremital ribs. The cross ridges are generally subequidistant, but toward the periphery become crowded and finer. Compression in the shale and complication with the matrix often have the result to obscure these cross markings or to make them appear less regular than they actually are. On the extremital slopes they are somewhat finer than elsewhere.

The grooves are regularly concave, and are smooth; faint traces of concentric lines on them are sometimes seen on the anterior slope. These grooves are always narrower than the ribs, and on the ventral margin have about two thirds of their width.

Dimensions. The length of this shell rarely exceeds 8 mm, the average of size being considerably less than this. An uncompressed valve of this length from the Styliola limestone has a convexity of 3.5 mm.

Habitat. Genesee province; Naples subprovince. Not infrequent in the Styliola limestone on Canandaigua lake. Also in a higher limestone, just beneath the sandstones, at Lodi, Seneca co. Everywhere in the argillaceous and sandy shales of the Naples beds in Seneca, Ontario, Livingston, Genesee and Wyoming counties, rarer in the lower beds of Erie county, and occasionally in the eastern extension of this fauna through Schuyler, Tompkins, and into Cortland counties. Also in the Wiscoy shales above the Portage sandstones.

Buchiola stuprosa sp. nov.

Plate 10, fig. 23, 24

Glyptocardia speciosa Hall, Paleontology of New York. 1885. v 5, pt 1, pl. 70, fig. 2–4.

In the work cited Professor Hall included with typical Glypt. speciosa from the Portage shales, specimens from the black Genesee shales, figured as above. These, which we have had redrawn in part because their characters were not accurately given, are of rather inferior preservation, but they are clearly distinct from the other species here described, in the following respects. They are quite elongate transversely, narrower in front than behind, the ribs are few, nine to 11, quite broad and flat with narrower interspaces, margins elevated on those in front of the umbo but otherwise with rounded edges, all ribs becoming more obscure and even obsolescent toward the margins. The concentric lines are faint, but fine, elevated, turned backward in a broad curve on the ribs and visible also in the sulci.

In size the shells measure 6–8 mm in length by 5–6 mm in hight.

Habitat. In the black Genesee shales of Bristol, Ontario co.

Buchiola (?) livoniae sp. nov.

Plate 11, fig. 1, 2

Shell of medium size, transversely elliptic, beak subcentral, umbo not elevated, surface depressed convex. Cardinal line long, sloping somewhat in front. Ribs rounded, slightly flattened on top, 20 to 24 in number, separated by narrower and shallow furrows; crossed by very fine, crowded elevated and slightly recurved concentric lines, scarcely visible on the grooves.

Dimensions. Length 8 mm, hight 5 mm.

This shell is the most numerously plicate of any of the species referred to the genus, and it is with some hesitation that the species is placed with Buchiola rather than with the finely ribbed group constituting Paracardium. It serves to show the easy passage of one of these divisions into the other.

Habitat. Genesee province; Naples subprovince. In the Genundewa limestone of the Livonia salt shaft, Genesee county, and on Canandaigua lake.

A specimen from the dark Portage shales at Naples, which may be somewhat distorted in outline, has similar surface characters and may represent this species. B. (?) livoniae is also known from the Naples fauna of Allegany county, Md.

Buchiola scabrosa sp. nov.

Plate 10, fig. 25–28

Shells small, highly convex, oblique, with ribs strongly elevated, rounded or without elevated edges and furrows deep, smooth and not flattened. The ornament of the ribs consists of very coarse, retrally bent subangular and elevated scales over the umbonal region and these become fine, delicate and obscure about the periphery.

The species is well characterized by its ornament and will not be confounded with others of the fauna. It is suggestive of B. halli of the Hamilton fauna, but the latter is a very much larger shell with irregular retral festoons hemmed in by the elevated edges of the ribs.

Dimensions. An average convex specimen measures, length 7 mm, hight 6 mm.

Habitat. Genesee province; Naples subprovince. In the Styliola limestone on Canandaigua lake; the calcareous concretions of the Portage shales on Honeoye lake and from the shales in Ontario and Livingston counties. Chautauqua subprovince. In the shales on Farnham creek, Erie co.

Buchiola conversa sp. nov.

Plate 10, fig. 22

Shell small, hinge line straight; surface depressed convex, beak subcentral, umbo not prominent, marginal outline subcircular. Surface with 12 or 13 ribs, which are at first flattened and at about the middle of the shell become decidedly concave with elevated edges; this concavity increases to the ventral margin. Concentric striae are extremely faint on these ribs. The intercostal furrows are not as wide as the ribs, and are but little more concave; they, however, have the concentric striae quite clearly defined toward the anterior margin. This ornament is of quite similar aspect to that of Praecardium duplicatum, described on another page, but there is no likelihood of confounding the species. Buchiola conversa is quite clearly distinguished from other species of Buchiola.

Dimensions. Length of an average example 5 mm, hight 4 mm.

Habitat. Genesee province; Chautauqua subprovince. Big Sister and Farnham creeks, Angola, Erie co., 250 feet above the Cashaqua shales; Forestville, Chautauqua co. Naples subprovince. Naples. Also in the Naples fauna of Allegany county, Md.

Buchiola angolensis sp. nov.

Plate 10, fig. 29–33

Shell of large size for this genus, suborbicular or slightly oval; beak somewhat anterior. Surface bearing as many as 17 ribs. The majority of these are rounded in contour throughout their extent, but those on the anterior slope show elevated marginal carinae and are slightly depressed on the surface. The intervening furrows are low and narrow. The ribs are crossed by very fine, elevated, retrally curved striae, which become crowded toward the periphery. The striae also cross the furrows with a downward curve and, though faint are clearly retained on well preserved sculpture casts. Concentric periodical depressions frequently mark the surface, interrupting the ribs and at times making a conspicuous feature.

The species is well characterized and readily distinguished by its size and surface characters. It is among the rarer forms of the genus.

Dimensions. Length and width of an average example 13 mm.

Habitat. Genesee province; Chautauqua subprovince. In the soft shales at Angola, Erie co., and on Farnham creek, 3 miles southwest of that place.

Buchiola lupina sp. nov.

Plate 10, fig. 34–36

Shell quite small, obliquely oval, notably narrowing anteriorly. Cardinal line straight, anterior angle large. Surface regularly convex, not greatly elevated in sculpture casts; depressed abruptly in front, more gradually behind; with 11 to 13 rounded ribs, slightly depressed above, and with narrow, shallow, intervening furrows. The concentric lines are fine, sharply elevated and closely crowded and on the ribs make a low and broad retral curve. These striae are continued over the furrows with a downward curve of about equal strength, but they are less sharply defined on these areas. In this respect the sculpture of the species is like that of B. angolensis, but there is a notable difference in the species in form, size, and number of plications.

Dimensions. Length of an average specimen 5 mm.

Habitat. Genesee province; Naples subprovince. From the soft shales at the mouth of Wolf creek near Mount Morris, in the lower Genesee valley. Chautauqua subprovince. At Pontiac, Erie co.

Buchiola halli sp. nov.

Plate 10, fig. 15, 16

In the *Paleontology of New York*, v. 5, pt 1, pl. 70, fig. 9; 80, fig. 10, Professor Hall included under the species Glyptocardia speciosa some specimens of large size, twice the usual dimensions of G. speciosa (B. retrostriata) which are distinctly different from that species in the following respects of ornamentation. The ribs, generally not more than 12, are elevated and bounded by vertical margins which the transverse ornament does not pass. In the umbonal region these ribs bear retrally curved nodes of irregular size though in regular zonal arrangement, and all quite large and conspicuous, giving the surface a scabrous aspect. Toward the margins these nodes become suppressed and the surface acquires the character usual throughout in B. retrostriata. Fine concentric and regular lines cover the coarser nodes. The grooves between the ribs are concave and smooth.

The character of this ornament suggests that of B. scabrosa, but is much less regular, the margins of the ribs are here elevated, and the shell much larger. It is even more closely allied to B. ferruginea Holzapfel[1] from the middle Devonic (Stringocephlenkalk) of Martenberg, also described and figured by Beushausen.[2] This shell is also small but it has the ribs with elevated margins and nodose, if somewhat more regular, surface not shading out toward the margin. One of the depauperated and arrested shells described by Loomis from the pyrite layer at the horizon of the Tully limestone is such a scabrous shell of Buchiola, representing an early growth stage of this species or perhaps of B. halli.[3] It is interesting to note that this coarse nodose ornament is a character of primitive growth and, as shown by adult shells both of B. halli and B. scabrosa, becomes obsolete in senile stages.

Dimensions. Average specimens measure 11 mm in length and 10 mm in hight.

Occurrence. In the Marcellus shale near Skaneateles[4] and in the Hamilton shales at Shurger's glen and Norton's landing, Cayuga lake.

Buchiola cf. **prümiensis** Steininger (sp.)

Plate 10, fig. 18, 19

See Cardium prumiense Steininger, Geognost. Beschreibung der Eifel. 1853. p. 51, pl. 3, fig. 3

Buchiola prümiensis Beushausen, Die Lamellibr. des rhein. Devon. 1895. p. 336, pl. 34, fig. 13, 14

The sandy shales of Erie county have afforded a few specimens of a shell characterized by its suborbicular form, low flattened ribs, 12 to 15 in

[1] Das obere Mitteldev. im rhein. Gebirge. 1895. p. 229, pl. 11, fig. 16.

[2] Die Lamellilbr. des rhein. Devon. 1895. p. 329, pl. 35, fig. 4–6.

[3] N. Y. State Pal. Rep't. 1903. pl. 2, fig. 7.

[4] Pal. N. Y., *loc. cit.* pl. 70, fig. 9.

number, its very narrow sulci and fine concentric lines, which together permit of its comparison with Beushausen's portraiture of Buch. prumiensis. In itself the shell is distinguished readily from its associates and it seems to approximate most nearly in its specific traits to B. retrostriata, with which it is not, to our knowledge, associated in the western region. From that species it may be distinguished by its less transversely oval form, more numerous plications, and narrower furrows. The retral lines on the ribs are low and perhaps not so numerous as in B. prumiensis; on the anterior slope of the shell these concentric lines are clearly visible on the furrows.

Over the body of the shell the ribs are depressed convex and become slightly concave about the periphery, the edges showing a decided tendency to elevation. Our specimens consist of internal and external casts of the same shells, which show very little difference in the exactness of the ornamental detail.

Habitat. Genesee province; Chautauqua subprovince. All specimens observed are from the Big Sister and Farnham creeks in the vicinity of Angola, Erie co. and the ravine at Java Village, Wyoming co. Buchiola prumiensis is from the lower Upper Devonic at Oberscheld, Budesheim, and elsewhere.

PARACARDIUM Barrande. 1881

This name has been employed only for Siluric shells (Etage E of Bohemia) except by Professor Hall, who referred to the genus the Devonic species here mentioned, P. doris of the Genesee stage (Styliola limestone). Little has been made of the genus because of its close similarity to the genera Paracardium and Buchiola, into which in external characters it seems gradually to pass. Yet the general expression of the Devonic shells here embraced under this name is distinctive, and, so far as external evidence goes, they may with safety be referred to Paracardium. They are shells of circular marginal outline, high and slightly projecting beaks and fine simple radial ribs without other ornament. With regard to hinge structure Conrath[1] has indicated that the hinge line bears denticulations which have no

[1] Sitzb. der kais. Akad. der Wissensch. 1 Abth. 1887. p. 9.

relation to the sculpture ribs, but this observation was made on Siluric shells, and we have been able to find no corresponding structure in the delicate barite replacements derived from the Naples beds. These shells are of diminutive size, and such cardinal features as they possess are very obscure.

Paracardium doris Hall

Plate 11, fig. 5 - 10

Cardiola doris Hall, Paleontology of New York. 1883. v. 5, pt 1, plates and explanations, pl. 70, fig. 10, 11

Paracardium doris Hall, Paleontology of New York. 1885. v. 5, pt 1, p. 428, pl. 70, fig. 10, 11

Shell very small, subcircular in outline when uncompressed, but usually somewhat elongate transversely or obliquely. Beaks minute, incurved and directed forward, umbones full and convex, the general contour of the shell being rotund and regular. Hinge line quite short and but slightly interrupting the regularity of the periphery. Surface covered with 20 to 25 fine rounded ribs, separated by narrower furrows. Occasionally these ribs show very faint traces of concentric lines. The shell rarely has a length and breadth exceeding 4 mm.

Habitat. Genesee province; Naples subprovince. Common in the Styliola limestone in Ontario county and in the lower, soft shales of the Naples beds in Yates, Ontario, Livingston and Genesee counties; in the Wiscoy shale, Wiscoy creek, Allegany co.; it is rare farther west and has not been seen in Erie and Chautauqua counties. The species also occurs at Folks Mill and other localities in Allegany county, Md.

Paracardium delicatulum sp. nov.

Plate 11, fig. 4

Shell of about the same size as Parac. doris, beak nearly median, outline transversely subcircular, extended slightly on the posterior margin. Surface convex, the greatest elevation being along a median line from the beak to the ventral margin. The ornamentation consists of a great number, 60 or more, of fine, filiform radiating lines.

Habitat. Genesee province; Naples subprovince. This is a rare species and has been found in New York only in the Styliola limestone on Canandaigua lake, but it occurs also in the Naples fauna of Allegany county, Md.

Genus PRAECARDIUM Barrande. 1881

The shells for which Barrande established this genus are extremely well characterized by their oblique form, truncated anterior extremity and simple, sparse ribs, generally narrow and rectangular in cross section, with broad intervening furrows. We find, however, that apart from these typical forms there are variations in all of the essential details which indicate deviation from the type toward structures common to Ontaria, Buchiola etc. Thus while the upper Devonic fauna under discussion contains an abundant localized development of the typical species, P. vetustum Hall, there are other forms which it is necessary to separate from this species, in which is presented a more or less sharp duplication of the ribs and somewhat less oblique form and yet no variant sufficient to withdraw the species from the genus. The most widely distributed of the species is the Praecardium vetustum, which has been identified by Beushausen in the lower Upper Devonic of Westphalia, but in America has not been found outside the western Portage subprovince in the vicinity of Lake Erie.

In regard to the structure of the hinge in Praecardium, Barrande represented a rather high area bearing a number of vertical riblets which terminate at the hinge line in denticles. Though these were characterized by him as "teeth," it has been suggested by both Neumayr and Conrath that they are actually representatives of the radial ribs of the surface extending about and beneath the beak and their interlocking terminations and, though homologous with teeth, are not analogous thereto. The structure represented both by Barrande and Conrath is parallel with what we have occasionally found, with other writers, in species of Buchiola, and have elsewhere discussed, but whether or not these exist in the typical Bohemian species of Praecardium, our observations are in entire accord with those of Beushausen, who remarks that in the best preserved specimens of P. vetustum from the Rhenish Devonic there is no trace whatever of these teethlike structures nor of any plications or ribs on the cardinal area. We find the area to be rather high, concave and quite smooth. This part of the shell has been seen only in the species P. vetustum.

Praecardium vetustum Hall

Plate 11, fig. 11–19

Cardium? vetustum Hall, Geology of New York; rep't on fourth dist. 1843. p. 245, tab. 107, fig. 2

Cardiola vetusta (Hall) Miller, Cat. North American Paleozoic Fossils. 1877. p. 186

Praecardium vetustum Hall, Paleontology of New York. 1885. v. 5, pt 1, p. 427, pl. 70, fig. 18–20

Praecardium vetustum Beushausen, Abhandl. der königl. Preuss. Geolog. Landesanst. N. F. 1895. Heft 17, p. 301, pl. 31, fig. 6, 7

This species was early described as derived from the Portage shales on the shore of Lake Erie, and also from Cashaqua creek and the Genesee river. It would appear that at the time of preparation of the *Paleontology of New York*, 5: 1, as above cited, representatives of the species were recognized only from the Lake Erie shore near Portland Harbor, and, so far as our personal knowledge extends, the species is strictly localized to the western region.

The characters of the shell are well defined, its highly oblique and subtriangular form, its abrupt anterior cardinal slope and coarse, broad, flat, sharply defined ribs, and equally broad and flat furrows, distinguishing it. It presents some variation in the number of its ribs, which are from 9 to 15 in adult shells. According to Hall these show a tendency to duplication near the margin, but no such tendency is observable in our material. The existence of a very fine concentric ornament is evident on all specimens.

Habitat. Genesee province; Chautauqua subprovince. Common in the soft shales at Barcelona (Portland Harbor), Correll's point, Lake Erie, and Forestville (Walnut creek, Terry's ravine), Chautauqua co.; Gowanda, Cattaraugus co. Rare at all outcrops farther east and not known outside this subprovince.

The specimens of this species described by Beushausen are from the Goniatite beds at Nehden, and a variety of the same, larger and more abundantly plicated (var. clymeniae), is from the Clymenia kalk of the Enkeberg. This author regards the Cardiola nehdensis Kayser[1] as belonging to this species.

Praecardium melletes sp. nov.

Plate 11, fig. 20

This is a small shell rendered oblique by the narrow, projecting umbone. It is similar in aspect to P. vetustum, the plications being broad, flat and simple, and the grooves of the same character, but it bears only six of these plications. Though P. vetustum varies in the number of its ribs, we have seen no typical example of it in which the number falls below nine, and, as the increase in these simple ribs ceases at a very early growth stage, P. melletes may represent an arrested condition at adult growth. The single valve observed has a length of 7.5 mm and a width of 6 mm.

Habitat. From the sandstone slabs at the top of the Portage shales, at the falls in Terry's ravine, Forestville, Chautauqua co. If this species was ever a member of the Intumescens fauna, it has loitered here after the disappearance of that fauna and is associated with a true Chemung combination, Mytilarca umbonata, Lyriopecten triradiatus, Crenipecten glaber, Athyris cora, Orthis cf. leonensis, etc.

Praecardium duplicatum Münster (sp.)

Plate 11, fig. 25

Cardiola duplicata Münster, Beiträge zur Petrefaktenkunde. 1840. Heft 3 p. 68, pl. 13, fig. 20a, b; pl. 12, fig. 21

Cardiola duplicata Kayser, Zeitschr. der deutsch. geol. Gesellsch. 1873. 25: 639, pl. 21, fig. 4a, b (?)

Praecardium duplicatum Beushausen, Abhandl. der königl. Preuss. Geolog. Landesanst. N. F. 1895. Heft 17, p. 303, pl. 31, fig. 4 a

Shell of rather large size, with incurved beaks and prominent umbones, which are strongly directed anteriorly and give the valves a marked obli-

[1] Zeitschr. der deutsch. geol. Gesellsch. 1873. 25: 638.

quity. Surface strongly convex, probably when uncompressed decidedly rotund in the umbonal region. Marginal outline subcircular, extended somewhat posteriorly. The exterior is covered with sharp, broad and flattened radial ribs, which are separated by furrows of about the same width. Even in the early stages of growth these ribs are divided in the middle by a depressed area, which becomes more conspicuous with growth, and eventually on the pallial margin attain almost the depth of the intercostal furrows. The margins of the ribs thus divided are sharply erect. From 14 to 19 of these duplicate ribs may be counted.

On the anterior cardinal slope there seems to be a slight variation in the character of these ribs, and, in passing from the ventral to the anterior margin, one of the edges of the double plication appears to be magnified at the expense of the other, with the result that the earliest plications on the cardinal slope appear as simple and alternate in size. A very fine concentric ornament crosses all plications and is most sharply developed on the intercostal furrows.

Length and width of the largest specimen 17 mm.

There is little reason to doubt the identity of this species with Praecard. duplicatum as described and figured by Beushausen. Yet the character of our specimens shows with more force than do those of that author close affiliation of the shell to Buchiola and their deviation from Praecardium in the less abrupt anterior slope, the elevated margins of the plications and the nature of the festooned concentric ornament.

Habitat. Genesee province; Chautauqua subprovince. The two specimens found are in a dark sandy shale from Johnson's falls, near Strykersville, Wyoming co.

The German specimens of the species are from the Clymeniakalk of Gottendorf and the Enkeberg, Westphalia.

Praecardium multicostatum sp. nov.

Plate 11, fig. 21–24

Shell subcircular or somewhat oblique but less so than in the other species described. Beak anterior and anterior cardinal slope abrupt. Surface regularly convex and distinctly elevated in the umbonal region. Ornament consisting of about 19 sharply defined, flattened ribs, which near the pallial margin are not so broad as the interspaces. These ribs are divided on their summit by a low median depression, which leaves the edges prominent, and of the same character as in Praecard. duplicatum, though their duplication is not so pronounced. On the posterior cardinal slope, which is depressed and flattened, the ribs retain a simple character, while the broad anterior slope is quite smooth. Traces of a minute concentric striation are seen on the surface of internal casts. An undistorted specimen has a length of 10 mm and width of 9.5 mm.

This species is readily distinguished, and, like Praecard. duplicatum, shows an affiliation to Buchiola in its ornamentation.

Beushausen mentions and figures a valve of Praecardium sp.[1] which, though larger than Praecard. multicostatum, resembles it in outline and in the number of its plications. This, like the specimens of Praecard. duplicatum, is from the Clymeniakalk of the Enkeberg.

Habitat. Genesee province; Chautauqua subprovince. In the soft shales in the gorge of Walnut creek, Forestville, Chautauqua co.

PUELLA Barrande. 1881

Plate 11, fig. 26-29

Species of this genus occur occasionally in the gray and black shales of the Portage formation and the black shales of the Genesee. The specimens in our collections serve solely to indicate the presence of distinct forms, but are not well enough preserved to justify an attempt at description. There are

1 A small orbicular species having about the dimensions and outline common to Ontaria suborbicularis, with 25 to 30 coarse plications, which has been found in the gray shales at the base of the Naples beds on Canandaigua lake.

2 A large and quite oblique species with broad, coarse ribs, 28 to 30 in number, on the anterior slope and finer ribs posteriorly, which has a hight

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[1] *Op. cit.* p. 304, pl. 31, fig. 5.

and length of about 50 mm. This is from a bituminous layer of the Genesee, at Iron Bridge Mills, Cayuga creek, Erie co.

3 An oblique ovate shell of intermediate proportions and finer ribs, 40 to 45 in number, crossed by faint concentric striae. Valves of this species have a length and hight of 30 mm. These have been found in the Genesee shales just above the Styliola limestone, Seneca point, Canandaigua lake.

CONOCARDIUM Bronn. 1835

Conocardium gowandense sp. nov.

Plate 12, fig. 35, 36

This only species of the genus Conocardium in the Intumescens fauna, is represented by but a single specimen, the right valve. This however retains the form and surface characters sufficiently to justify description.

Shell small, elongate triangular, posterior extension relatively long and quite gradually tapering. Anterior extremity abruptly concave, delimited by a broad crested plication which has an oblique direction from the beak downward. Hinge line nearly straight in front of the beak.

The body or medial portion of the valve bears three stout flattened ribs, excluding the anterior one, and in the first intervening space are one or two lesser ones with intercalated fine radial lines. Over the posterior extension of the valve the ribs are simple, stout, not flattened, and of subequal size. A very fine concentric striation of elevated lines covers both plications and grooves, and is specially developed on the grooves of the median portion of the shell. With considerable enlargement exceedingly fine radial lines may be seen on the upper surface of the flat plications.

The dimensions of the valve are: greatest length 16 mm; hight, 9 mm; length on anterior carina 10 mm.

Habitat. Genesee province; Chautauqua subprovince. From the arenaceous slabs at Gowanda, Cattaraugus co.

PALAEONEILO Hall. 1870

Palaeoneilo constricta Conrad

Plate 15, fig. 9–13

Nuculites constricta Conrad, Acad. Nat. Sci. Phila. Jour. 1842. 8: 249, pl. 15, fig. 8

Nucula bellula Hall, Geology of New York; rep't on fourth dist. 1843. p. 97, tab. 78, fig. 7

Palaeoneilo constricta Hall, Paleontology of New York. 1885. v. 5, pt 1, 2, p. 333, pl. 48, fig. 1–16; pl. 51, fig. 17

This species, common in the Hamilton fauna of western New York, was identified and figured by Professor Hall from the Portage beds of Portland Harbor (Barcelona) on the Lake Erie shore, Chautauqua co. We find the species to be quite abundant at certain localities in the soft shales of that region though rare farther east and not yet recognized as far eastward as the Genesee river. All the characters presented by the Hamilton shell are well expressed in these later representatives. The species is also common in the Ithaca fauna of central New York, but is not known in the geographic interval at this horizon between Cayuga lake and Chautauqua county. In the localities of the latter region the shell is associated with Praecardium vetustum, Lunulicardium of various species and the general fauna of the province.

Habitat. Genesee province; Chautauqua subprovince. Portland Harbor (Hall), Correll's point near Brocton, and Forestville, Chautauqua co.

Palaeoneilo petila sp. nov.

Plate 15, fig. 1–8

This little shell in some features is similar to P. constricta, having a sinuous posterior extremity and the arrangement of the ligament pits as in that species. It is however always small, transversely ovate, never so broad as in P. constricta; beak behind the anterior third of the length, anterior margin subelliptic, basal margin convex, broadly curved, often with an interruption to this curvature caused by the projection of the low umbonal ridge; narrowing behind to a subattenuate posterior extremity and emarginate by the posterior sinus. Postcardinal slope long and oblique. Surface convex on the umbones, sloping rather abruptly to the front margin; behind, the surface is sinused by a broad, low depression which brings into prominence a postmedian umbonal ridge. Specimens from the shales and the barite replacements indicate that the surface was smooth or with obscure concentric growth lines. This condition is clearly shown in most of our figures. Only one, an incomplete replacement, shows that over the posterior part of the shell the concentric lines are well defined and elevated, but not to such degree as in other species. On the interior, anterior and posterior muscular scars, with thickened inner walls, are at times very sharply defined. The cardinal area is broadly arched, the denticulations are all vertical and decrease in size beneath the beak.

Dimensions. A specimen of full size has a length of 10 mm, hight 6.5, thickness through conjoined valves 3.5 mm.

Habitat. Genesee province; Naples subprovince. Not uncommon in the soft shales of Livingston, Ontario and Yates counties. Chautauqua subprovince. A single specimen has been obtained at Pontiac, Erie co.

Palaeoneilo muricata sp. nov.

Plate 15, fig. 14, 15

Professor Hall described several specimens of Palaeoneilo from the New York Devonic which bear two instead of one posterior sulcus outside of the cardinal slope, P. bisulcata from the upper Chemung of Elmira, P. muta and P. perplana of the Hamilton and Ithaca faunas, and of these P. bisulcata and P. muta show evidence of having had the concentric lines of the surface produced and lamellate.

The little species now before us can hardly be referred to any of these shells, as it is persistently of much smaller size and of somewhat different outline. Its strikingly lamellose surface ridges were probably equaled in the species cited, specially P. muta, but these characters have not been well retained in the shale specimens with which alone we are acquainted. Palaeoneilo muricata covers small subelliptic shells, subtruncate posteriorly; beak prominent at anterior third of cardinal line, anterior extremity short, regularly rounded, subsemicircular, basal margin transverse, posterior margin doubly sinuate, postlateral angle obtuse and posterior hinge line oblique and straight. Surface evenly convex over the body of the shell, rising from the beak to about the middle of the valve, sloping broadly to the basal margin and more abruptly in front. Posteriorly two furrows begin near the beaks and widen outward, emarginating the periphery. These are separated by a sharp ridge. Between the outer of these furrows and the cardinal margin there is an abruptly sloping and distinctly sinused area which is in effect a third furrow. On the interior the muscular scars are hardly visible. The cardinal line is not regularly arched as in P. petila but on its inner curvature reaches an apex from which the anterior margin curves inward. The posterior row of denticles is long, the denticles being chevron-shaped, growing small toward the beak till over the narrowest part of the area just behind the beak they are minute. Beneath the beak they turn at an oblique angle (not so acutely as in P. fecunda as represented by Hall[1]), and pass thence into the short anterior branch, which carries only a few large denticulations. The ornament consists of simple, distant and elevated lamellar concentric lines, which are specially extended on the ridges bounding and dividing the posterior grooves.

Dimensions. Length 7 mm, hight 4 mm.

Habitat. Genesee province; Naples subprovince. In the shales about Naples and Honeoye lake and as barite replacements in the concretions at Whetstone gully, Livingston co.

Palaeoneilo brevicula sp. nov.

Plate 15, fig. 16

Shell small, subtrigonal, length and hight equal, basal margin deeply convex with well marked constriction toward the posterior extremity. Cardinal area subacutely arched, umbonal angle about 90°. Beaks nearly median, anterior slope oblique and direct, curving narrowly to the broad margin. Posterior slope somewhat longer than the anterior. Surface

[1] Pal. N. Y. v. 5, pt 1, 2, pl. 49, fig. 22.

convex, posterior sinus strongly developed toward the margin. Sculptured by fine, sharp, elevated concentric and continuous concentric lines.

Dimensions. Length and hight 4 mm.

Observations. This little shell approaches in outline some of the forms which Hall assigned to his species P. brevis from the Ithaca and Chemung beds, but it attains an even more trigonal expression than any of them and indeed in respect to form expresses the most extreme aberration observed among species of the genus.

Habitat. Genesee province; Chautauqua subprovince. This rare species has been seen only in the soft shales at forks of Cattaraugus creek, Gowanda.

Palaeoneilo linguata sp. nov.

Plate 15, fig. 17-22

To this genus are referred provisionally a series of subplane shells of characteristic outline and contour, though little has been made of their cardinal structure, all being rather indistinct sculpture casts. The shells are transversely elongate with broadly rounded anterior and tapering posterior moiety; beak at about the anterior third, the margin in front bending broadly outward in a semicircular curve, transverse on the basal margin, passing to a sublinguate posterior extension and rounding thence rather abruptly to a long, oblique and straight postcardinal slope. Contour very depressed, almost flat over the entire surface, save along the hinge; beak obscure. Surface usually quite smooth or with obscure traces of fine concentric lines. The casts show by compression a hinge area bearing the characteristic denticulations of the genus Palaeoneilo. The species is similar in its marginal outline to P. elongata of the Ithaca fauna.

Dimensions. An average specimen has a length of 18 mm, a hight of 10 mm.

Habitat. Genesee province; Chautauqua subprovince. These fossils, obscure in all details of structure, are quite abundant in the soft sandy shales at Forestville (Walnut creek and Terry's ravine), Chautauqua co.

LEPTODOMUS McCoy. 1844

Leptodomus interplicatus sp. nov.

Plate 12, fig. 32-34

Though specimens of this species are not well preserved, they have proved rather common at one horizon in the Naples subprovince and show quite distinctive sculpture features. The shells are rather below medium size for the genus, were transversely ovate in outline, widening posteriorly and thence narrowing to the extremity. Beaks anterior and arched over the hinge. Surface concentrically plicate or rugose on the anterior slopes. These plications are simple near the extremity, but over the middle slope they narrow and bifurcate or receive others of equal size in the intervals. Passing backward both sets become rather abruptly obsolete and merge by twos or threes into broad obscure wrinkles on the posterior slope. The last, again, become wholly obsolete on the extremital surface, leaving it quite smooth. The oblique median umbonal furrow on the shell is quite obscure. The species may be compared in some respects of size and surface with L. arcuatus Conrad of the Hamilton shales, but the features described render it distinct.

Dimensions. An average shell has a length of about 30 mm and a hight of 20 mm.

Habitat. Genesee province; Naples subprovince. In the higher (Hatch) shales at Naples.

Leptodomus multiplex sp. nov.

Plate 12, fig. 30

This shell differs from the foregoing and other species of the genus in a transversely elongate and narrow form, rather long, straight hinge, subtruncate posterior extremity and transverse basal margin. The beak is anterior, and a low oblique median sulcus traverses the shell from beak to base. The markings of the surface consist in narrow concentric plications of subequal size over the body of the shell, and these are divided by the sulcus, where for a short distance all become obsolete. In front, and over the anterior slope the plications incline to multiplication by bifurcation, while over the posterior slope they gradually grow obsolete, leaving the extremity smooth.

Dimensions. The single valve of this kind observed has a length of 35 mm and a hight of 17 mm.

Habitat. Genesee province; Naples subprovince. In the dark Rhinestreet shale at Naples.

MODIELLA Hall. 1884

Modiella sp.?

Plate 12, fig. 31

A single specimen of this genus has been observed, representing a small species like M. pygmaea Hall, with which it may prove to be identical. It presents the expanded posterior extremity, convex and broad postumbonal slope, oblique preumbonal depression and contracted convex anterior extremity of that species, but does not show the fine radii in the postumbonal slope.

Habitat. Genesee province; Naples subprovince. In the lower soft shales at Naples. Modiella pygmaea is common in the Hamilton shales of central and western New York.

GASTROPODA

PLEUROTOMARIA Defrance. 1824

The specific type of Pleurotomaria capillaria (Conrad) Hall, which is a characteristic gastropod of the Hamilton fauna, is expressed by shells with rather short spires and a surface ornament consisting of a few (four or five) revolving ridges of unequal size crossed by retrally curved concentric and finer ridges which form nodes at the points of intersection. This style of sculpture is expressed in the Naples fauna with some variation from that of P. capillaria and so persistently that we judge it wise to indicate these departures under distinct specific titles, rather than as mutations of the earlier species, for, while they may be, and perhaps the weight of evidence would indicate that these are genetically derived from P.

capillaria, a similar type of structure was widespread in the Devonic, and these may have come into the Naples region with the invading fauna.

Pleurotomaria capillaria Conrad **cognata** mut. (?) nov.

Plate 19, fig. 27-30

Shell of medium proportions, with rather rapidly tapering spire and step-form volutions; attenuate. Whorls five to six, usually overlapping to the slit band. The upper surface of each slopes rather directly outward for more than one half its width and then falls away almost vertically to the suture. The slit band is central, narrow, prominent with sharply defined edges and depressed surface, is continuously exposed to the apex and carries closely crowded, retrally bent concentric striae, which are here more abundant than elsewhere on the surface.

The surface of the upper division of the whorls carries in early stages two (second-third whorl) in later growth five (fourth whorl) and in full growth six revolving ridges of unequal size. Of these that nearest the slit band in early growth becomes the most prominent, though eventually one or more ridges may intervene between it and the band. This angulates the whorls, changes the slope and effects the steplike contour. Next to this in size is usually its companion of later introduction, then the other primitive ridge nearer the suture is most prominent. On the under side of the body whorl are from 10 to 15 low, flattened, revolving, raised striae of subequal size; in old shells these may become obsolescent. Crossing these revolving ridges of the upper surface are fine, sharp, elevated, concentric lines, 60 to a whorl, directed backward parallel to the aperture and making sharply elevated knots at the points of intersection. On the lower surface these lines are closely crowded together and may become in old stages fasciculate, nearly obliterating the revolving ridges.

These characters differ from those of P. capillaria in these respects:

The whorls of the latter are more regularly terraced by the revolving lines, which are fewer and of more nearly equal size; the prominent knotted line of P. cognata is in the former reduced in strength, and the concentric lines are somewhat less in number.

Dimensions. A specimen of average size has a hight of 13 mm and a diameter of body whorl of 11 mm.

Habitat. Genesee province; Naples subprovince. In the shales about Naples, particularly in a thin crinoidal layer near the base of Hatch hill; in the concretions on Honeoye lake. The species also occurs in a nodular layer at the base of the Cashaqua shales at Lodi falls, Seneca co., at Bennettsburg and Beaver Dams, Schuyler co.

Pleurotomaria itylus sp. nov.

Plate 19, fig 31, 32

Shell of medium or regularly large size, spire short, whorls four to five (?), overlapped almost but not quite to the slit band; surface gently and regularly sloping; without angulation; slit band narrow. Upper surface of whorls with numerous fine elevated concentric lines (probably more than 100 for each whorl) at quite regular intervals with smooth interspaces. These slope backward to the periphery and are crossed by several (six to eight) obscure revolving lines, at the intersection with which but low elevations are found. Below the slit band only the concentric lines are apparent. This style of ornament approaches somewhat that of P. itys Hall of the Hamilton fauna, in which the intersection of numerous revolving and concentric lines produces a tubercled exterior. In P. itylus the texture is finer, and the revolving lines almost suppressed.

Dimensions. The single specimen observed has a hight and width of 14 mm.

Habitat. Genesee province; Chautauqua subprovince. In the soft shales of Walnut creek, Forestville.

Pleurotomaria ciliata sp. nov.

Plate 20, fig. 8–14

Shell quite small, spire short, volutions five. Whorls rendered step-shaped by the prominence of the slit band, to the base of which overlap occurs except on the final whorl, which may be more loosely wound. Slit band relatively broad with sharp, angular, elevated, thin edges and slightly concave surface covered with retrally curved striae. On the upper surface of the whorls is a single revolving elevated line between the suture and the slit band. This is obscure on early whorls, becomes more prominent in later growth, but is again obscure at full growth; faint trace of a second revolving ridge may sometimes be observed. The surface is crossed by a multitude of fine, hairlike, elevated concentric lines, which are raised into small nodes at intersection with the revolving ridge, but between the latter and the slit band are greatly obscured or lost. On the lower surface of the outer whorl the fine concentric lines are closely crowded together and are crossed by four to six very obscure revolving ridges.

Dimensions. An average example has a hight of 8 mm and diameter of 7 mm.

Habitat. Genesee province; Naples subprovince. Common as replacements in the concretions of Whetstone gully, Conesus lake, and on Honeoye lake.

Pleurotomaria genundewa sp. nov.

Plate 19, fig. 33, 34; plate 20, fig. 1–7

Shell having the dimensions and outline of P. ciliata, from which it differs in the character of its ornament. These shells have a narrow slit band and bear two well defined and subequal revolving ridges on the upper surface of the whorls, both of which are knotted by intersection with the concentric elevated lines, the latter being much coarser and fewer than in P. ciliata. On the lower surface of the whorls the concentric lines are quite strong and distant, with intercalated additions near the slit band; these are crossed by five or six revolving lines, but the intersections are not sharply knotted.

Habitat. Genesee province; Naples subprovince. Very abundant in places in the Styliola limestone. On Canandaigua lake and at Middlesex, Yates co. N. Y.

BELLEROPHON Montfort. 1808 (*sensu stricto*)

Bellerophon koeneni sp. nov.

Plate 17, fig. 12-23

Bellerophon striatus (Ferussac & d'Orbigny) ? Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 23

cf. Bellerophon tuberculatus (Ferussac & d'Orbigny) d'Archiac & de Verneuil, Geol. Soc. Lond. Trans. 2. 1842. ser. v. 6, pt 2, p. 353; pt 28, fig. 9

In the publication cited the writer noted the presence in the Styliola limestone of a Bellerophon allied to the well known species of the Rhenish middle Devonic, B. striatus. Additional material acquired since that date indicates that it would prove unsafe to insist on identity in the species here concerned. There are four typical Bellerophons besides B. koeneni which we may specify, all of the same form and bearing surface characters of close similarity but of some difference in combination. These are B. striatus Fer. and d'Orb., B. tuberculatus d'Orb. of the Middle Devonic, B. alutaceus d'Orb., lower Upper Devonic, and B. maera Hall of the Chemung. These are all round and compact shells with but slight apertural expansion (in this respect typical Bellerophons), and their ornament consists either of tubercles without concentric striations or of a combination of the two features. Thus B. tuberculatus and B. maera are coarsely and regularly tubercled over all the surface, and in the latter the slit band itself is sometimes broken up into such tubercles. In B. striatus the concentric striae make themselves evident in crossing the tubercles but not quite to the extinction of the latter. In B. alutaceus the tuberculation is fine and the striae more obscure. In B. koeneni we find in adult stages the tubercles, which are quite coarse, arranged with more or less regularity in rows which converge backward to the slit band ; these tubercles are often elongated in the direction of the row, and not infrequently adjacent ones are fused. Toward the peristome the very faint concentric lines of the body of the shell become more sharply defined as scaly laminae, specially about the umbilicus. The slit band is narrow and bears a succession of thickened festoons directed backward, but which do not take on the form of tubercles as in B. m a e r a. In younger stages of this species the tuberculation is relatively finer, and the form of the shell less stout than in the adult condition; and herein is found a very close approach, if not identity of character to the species B. a l u t a c e u s F. A. Roemer from the lower Upper Devonic (Hartz). In a still earlier growth stage the tubercles are absent, and the surface bears only sharp concentric lines in strong contrast to the ultimate ornament. The aperture is not expanded, but the inner lip is so reflexed as to close the umbilicus and leave a smooth callus over the early part of the final whorl. The callus, however, is rather thin and is restricted to later growth, so that young shells expose the tubercled surface, and in adult shells broken back the young whorls usually display some evidence of tuberculation and of the slit band.

Dimensions. An adult specimen has a diameter laterally across the aperture of 24 mm and vertically of 15 mm.

Habitat. Genesee province; Naples subprovince. Not uncommon in the Styliola limestone on Canandaigua lake and at Middlesex, Yates co. A single specimen has been collected from the Naples shales at Plum creek, Himrod's, Yates co.

Bellerophon denckmanni sp. nov.

Plate 17, fig. 24-28

Shell small, spire very narrow, closely enrolled, dorsal surface of whorls sloping from the slit band. Final whorl rather rapidly expanding but not explanate at the aperture. Inner lip slightly reflexed, forming an expansion over the whorl but not always closing the umbilicus. Slit band prominent, flat, with elevated margins, specially on younger stages, not crossed by concentric lines except near the aperture. Surface with concentric and revolving elevated lines; on the early whorls only the former are well defined and these are stout, subequally distant, bending back along the slit band; the revolving lines appear near the beginning of the final volution, grow stronger with age, while the concentric lines become progressively more obscure, so that in final stages the revolving lines are most conspicuous but are crossed and cancelated by the concentric lines at increasing intervals.

Dimensions. The largest shells of this species measure 4.5 mm in length and about the same in hight (diameter of aperture).

This well characterized species bears somewhat the same type of ornament of B. leda Hall and other species of the Hamilton fauna which carry expanded aperture and do not properly appertain to Bellerophon in its restricted meaning.

Habitat. Genesee province; Naples subprovince. In the Styliola limestone, Bristol, Ontario co., and at Middlesex, Yates co.

PHRAGMOSTOMA Hall. 1861

The history of this name and the reason for employing it may be briefly stated. In the *Paleontology of New York*, 1847, 1 : 183, James Hall introduced the name Carinaropsis for a group of bellerophontids from the Trenton limestone. In subsequently discussing this and allied genera,[1] he states that the genus was founded on the external characters presented by a few specimens. "These are, the usually attenuated spire, the abruptly expanding body volution, and shallow cavity, giving the shell a patelloid aspect. To this may be added the character (perhaps not constant) of an attenuated carina upon the dorsum." It is evident that the internal characters of these shells were not known when the genus was erected. Having subsequently received from the Lower Siluric beds of Tennessee and Indiana, specimens bearing the external characters enumerated and showing besides a kind of transverse plate or septum on the inner lip, Hall suggested that, in case this latter character was not present in the typical forms of Carinaropsis, these shells be designated by the term Phragmostoma, and he proceeded to describe two species of these shells as C. (Phragmostoma) cunulae and C. (P.) cymbula. The original of Carinaropsis however did prove to bear this septum, and hence, so far as this original employment of the term Phragmostoma is concerned, it was synonymous with the former name. The next use of the term was its employment by the same author[2] for the species we are about to discuss,

[1] N. Y. State Cab. Nat. Hist. 14th An. Rep't. 1861. p. 93.

[2] N. Y. State Cab. Nat. Hist. 15th An. Rep't. 1862. p. 60.

P. natator, and here the name is used without qualification.[1] Though here employed for a fossil from the soft Portage or Cashaqua shales which had been determined by Hall in 1843[2] as Bellerophon expansus? Sow., the name now takes on a new value. The description is a very clear characterization of the species, and it is here cited as from the shales on Cashaqua creek.[3] Waagen employed the term Phragmostoma,[4] but failed to make a clear generic distinction between that division and Patellostium, then introduced as new, for seamless forms having a greatly expanded flaring aperture. The type species taken for the latter genus was F. Roemer's Bellerophon macrostoma. De Koninck employed the term Phragmostoma with P. natator as type, which, as observed, is not the original application of the term. Koken likewise has made

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[1] In the explanation to plate 6 of this work, Hall referred three of the figures (12–14) to this species which are not P. natator but P. cymbula. (See the correction of this error in Pal. N. Y. v. 5, pt 2, p. 108).

[2] Geology of New York; rep't on fourth dist. p. 244, fig. 3.

[3] It is also stated to occur in the "shales of the Hamilton group in Chenango county." This may either be a locality in the Hamilton beds or in the Ithaca beds, for the fossils of the latter were for years confused with those of the beds below. For ourselves, we have never seen the species from any locality of either formation.

The Ithaca (Central Portage) fauna does however contain a species, suggestive of Bell. patulus in general proportions and size, with broadly explanate aperture, but with a definite slit band and a very distinct, flat, unthickened transverse plate across the opening from the inner lip.

The cuts on plate 16 show the nature of this septum, its doubly crescentic inner margin and the longitudinal impressed line which divides it medially, forking proximally and probably receiving the inner whorl in the fork. The outer surface apparently bore faint revolving lines in pairs as in Bell. leda of the Hamilton fauna, but these do not always manifest themselves on sculpture casts. Bellerophon leda is devoid of septum or greatly calloused lip. We see no reason for not regarding this species as a genuine Carinaropsis, even though shells of the genus have not been observed before in faunas later than Lower Siluric. This shell is figured under the designation Carinaropsis ithagenia.

[4] Paleontologia Indica. ser. 13. 1880. pt 2, p. 131.

use of the name, though somewhat vaguely. In 1879 Hall[4] in redescribing Bell. natator abandoned the term Phragmostoma evidently in favor of the Siluric species which he originally called Carinaropsis. E. O. Ulrich in the *Paleontology of Minnesota*, 1897, v. 3, p. 854, emends Waagen's Patellostium to include what that author intended by the two terms Patellostium and Phragmostoma and suggests that a number of American species pertain thereto, among others Bell. patulus Hall (Hamilton) and B. natator. In a paper submittted for publication in 1892 but not published till 1900,[2] the writer pointed out the differences in the structure of Patellostium and Bell. patulus, both seamless shells with expanded peristomes in the former entire, in the latter broadly emarginate on the outside and transected by a granulose callus on the inner lip. The latter also has concentric but no revolving surface lines and narrowly umbilicated whorls. It was there proposed to designate species of the type of B. patulus by the term Ptomatis, of which one species from the Ereré sandstone (P. forbesi) was described.

In a recent paper[3] Drevermann has described a species as Bell. (Phragmostoma) rhenanus which bears an explanate body whorl with an emarginate outer lip, and fine revolving striae cancelated by concentric lines, but without any thickening of the inner lip or any transverse septum. It is hence not a Phragmostoma. The species is compared by the author with B. patulus Hall, with which it seems to agree in all essentials, B. patulus however bearing no revolving striae.[4] The author

[1] Pal. N. Y. v. 5, pt 2, p. 108.

[2] The Palaeozoic Fauna of Parà, Brazil: Archivos do Mus. Nac. do Rio de Janeiro, 10:75 (author's reprint, p. 41).

[3] Die Fauna der Untercoblenzschichten von Oberstadtfelt bei Daun in der Eifel. 1902. [Paleontographica, 49:76]

[4] Two illustrations of the same specimen of B. patulus given in Pal. N. Y. v. 5, pt 2, pl. 22, fig. 20; pl. 26, fig. 12, are misleading in this respect. The specimen has been laterally compressed, and as a result the surface longitudinally wrinkled. Normally the species shows no revolving lines, while the transverse lines take the form of broad uninterrupted festoons.

is in error in stating that Hall ever applied the name Phragmostoma to such shells. In the characters indicated above as peculiar to the Genus Ptomatis, Bell. rhenanus is apparently in accord, except for the presence of revolving surface lines, and it may be quite properly associated with Ptomatis patula and Pt. forbesi.

Returning then to the standing of the term Phragmostoma, we may observe that, as in its original use it has proved a synonym of Carinaropsis, it is quite legitimate to employ it for the species B. natator, the only form except those of Carinaropsis to which its author applied the term. As the first and second species ascribed to Phragmostoma belong to another genus, the third (P. natator) will serve as the type species. In this sense we revive and delimit the term.

Diagnosis. Shells with short spiral, very broadly expanded peristome, transected on the inner margin by the penultimate whorl, narrow and sharply defined slit band. Surface with revolving lines, sometimes with low lateral carinae. The callus on the inner lip is thick, flattened and angular on its inner edge, and thus has a wedge-shaped appearance, which when under compression appears septiform, but does not make a true septum or transverse plate.

Phragmostoma natator Hall

Plate 16, fig. —

Bellerophon expansus (Sow.?) Hall, Geology of New York; rep't on fourth dist. 1843. p. 244, fig. 3

Phragmostoma natator Hall, N. Y. State Cab. Nat. Hist. 15th An. Rep't 1862. p. 60 (not pl. 6, fig. 12–14)

Phragmostoma natator Hall, Illustrations of Devonian Fossils. 1876. pl. 23, fig. 12

Bellerophon natator Hall, Paleontology of New York. 1885. v. 5, pt 2, p. 108, pl. 24, fig. 1

Bellerophon natator Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 52

The original specimen of Bell. expansus Hall was a portion of the aperture and final whorl, the spiral being destroyed, in a quite characteristic style of preservation in the soft Portage shales. That subsequently figured in the *Paleontology of New York* was a similar fragment stated to be from the Hamilton shales, and, if the locality record is correct, it is probably from the Ithaca fauna of Chenango county and may be a fragment of our species, Carinaropsis ithagenia.

Diagnosis. Shell of medium size. In early growth the whorls are involute, narrow, regularly convex and umbilicate; inner lip always slightly calloused; at mature growth the last whorl is abruptly and greatly expanded, the margin of the aperture generally assuming a transversely subcordate outline, the sides approaching anteriorly and the greatest diameter of the peristome being back of the middle. The lip is reflected backward over the calloused penultimate whorl or may be transected by it. It is this reflection of the inner peristome that closes the umbilicus on the last volution. The callus in the adult condition is developed into a transversely septiform projection, entering the interior cavity. This takes the form of a plate thickened axially both on the upper and under sides and excavated or thin at the sides. The median thickening is pinched together and narrowed and projects farthest. The entire structure when the shell is compressed in the shale gives the impression of a platform similar to that in Carinaropsis, but it is of quite different character. The slit band is narrow with elevated margins; it makes a deep emargination on the outer lip and is clearly defined over the entire final volution, but is seldom visible on young shells. Surface smooth or with only fine lines and festoons concentric to the margin.

Dimensions. In an average specimen the aperture has a vertical diameter (width) of 18 mm and a horizontal diameter (hight) of 23 mm.

Habitat. Genesee province; Naples subprovince. Very common in the soft shales of the lower part of the group at and about Naples and at localities in Livingston county; also on Cashaqua creek. In the eastern region at Bennettsburg and Beaver Dams, Schuyler co. In the Styliola limestone, Canandaigua lake.

Phragmostoma incisum Clarke

Plate 16, fig. 7–17

Bellerophon incisus Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 53

Shell having about the proportions of Ph. natator with small concealed spire and broadly expanded peristome. The latter however has not the subcordate outline of P. natator with its sloping lateral margins, but is quite regularly elliptic transversely. The final and inner whorls also are depressed on top and have a shouldered appearance, while in the allied species they are more evenly convex. In early stages the shell is umbilicate, but the umbilicus is covered in the final stages of volution by the reflexion of the inner lip. In this species the septiform callus is even more highly developed than in P. natator and has the same contour, thick medially, depressed laterally, the median portion projecting conspicuously inward. The slit band is narrow, well defined on the body whorl and sometimes visible on earlier volutions. It makes but a relatively slight emargination on the outer lip.

Surface covered by fine, incised revolving lines, seven or eight on each side of the slit band on the last whorl before apertural expansion begins. These may increase in number outward and become obscure. The seam itself, except in its final stage, may carry one or more of these lines.

Habitat. Genesee province; Naples subprovince. This species is quite as abundant in localities of the soft shale about Naples and in Livingston county, in the concretions on Honeoye lake and in the Whetstone gully on Conesus lake. It is also present in the Styliola limestone on Canandaigua lake.

Phragmostoma cf. **triliratum** Hall (sp.)

Plate 16, fig. 6

See Bellerophon (Phragmostoma?) tricarinata Hall, Illustrations of Devonian Fossils. 1876. pl. 22

Bellerophon triliratus Hall, Paleontology of New York. 1885. v. 5, pt 2, p. 117, pl. 24, fig. 2, 16–19

A single specimen of rather large size shows in part the characters of this species, having the narrow, well defined slit band accompanied on either side by a distinct fold which reaches part way across the body whorl and gives a squared outline to the early part of the same whorl. This specimen however shows but very obscure traces of revolving striae, which are given as a characteristic feature of the species. Phragmostoma triliratum is cited from the Chemung fauna of Steuben county, N. Y.

Habitat. Genesee province; Naples subprovince. Hamilton gully, Honeoye lake.

Phragmostoma chautauquae sp. nov.

Plate 17, fig. 1-11

cf. Bellerophon striatus (Phil.) Hall, Geology of New York; rep't on fourth dist. 1843. p. 246, fig. 107, 7

Shell somewhat larger than other species of the genus, with narrow spire rapidly widening to medium broad body and thenceforward abruptly expanding to the aperture, which is scarcely explanate. Dorsum angular, sides sloping thence rather abruptly with a slightly concave surface. Slit band very narrow, often obliterated by slight lateral compression, which changes it to a median keel. The emargination of the anterior edge produced by the slit band is quite deep. The inner lip of the peristome is reflected over the ultimate whorl, and a projecting flattened callus is formed on this surface, not extending however as far into the inner cavity as in the species P. natator and P. incisum. Surface of the adult with only fine regular and crowded concentric growth lines.

Young conditions, however, display a quite different style of ornamentation. The early whorls are covered with fine revolving elevated striae, which are closely set and traverse the entire surface, covering to obliteration the place of the slit band. These fine lines, with later growth, become interrupted and broken up into series of more or less completely disconnected tubercles, which at times press together from adjoining rows. Eventually the arrangement of these tubercles is made more distinct by the appearance of concentric lines, and in this stage the former clearly appear as the result of cancelation of the surface. Meanwhile, with the introduction of the concentric lines, the slit band has come into prominence, the concentric lines looping backward on its surface. Gradually the traces of the revolving lines disappear, and the concentric striae become closely crowded, till they alone are apparent in final growth stages on the usually exposed surface of the shell. The species presents thus all stages in the variation of ornamentation; indicates that revolving lines are, in this stock, suggestive of immature conditions and qualifies the value of attempts at generic distinction on the basis of variation in this feature and even in the permanency of the slit band. Umbilication is maintained throughout these early stages, but is lost with the development of mature conditions and the formation of the internal callus.

Dimensions. The only specimen observed which affords a clue to the outline of the peristome measures 16 mm in width and 22 mm in hight. Usually only the body of the shell is preserved, many of the specimens indicating larger size than this.

Observations. This species is placed with the genus Phragmostoma on account of its explanate peristome and well developed callus, which is hardly septiform but approaches in development that of the typical species. The exterior markings as usually preserved show marked similarity to those of B. nactus Hall of the Chemung fauna, but the latter, so far as we can judge from the type specimens, hardly appertains to the genus Phragmostoma, the aperture apparently not being expanded, and the slit band making a very deep emargination of the anterior margin extending for fully one half of the final whorl.

The original specimen referred to Bellerophon striatus Phillips by Hall, as above cited, seems to represent the proximal portion of the final volution in this species and shows the regular concentric striations.

Habitat. Genesee province; Chautauqua subprovince. Common in the soft shales at Forestville, Smith's Mills, at Correll's point, Lake Erie, near Brocton and at Silver Creek, Chautauqua co., Cattaraugus creek at Versailles, Cattaraugus co.

TROPIDOCYCLUS De Koninck. 1883 (emend. Clarke. 1899)

In the *Archivos do Museu Nacional do Rio de Janeiro*, 1899, 10:72 (39) [1] the writer made the following comments on this genus and its allies:

In the *Proceedings of the Chicago Academy of Sciences* (1866, 1:9) the late Mr F. B. Meek introduced the name Tropidiscus for bellerophont shells having the structure of B. curvilineatus Conrad, of the Corniferous limestone; that is, lentiform, sharply keeled and deeply involute shells without expanded aperture or peripheral seam and with rather coarse concentric growth wrinkles. The name proved to have been already in use, and in a later publication of the same year [2] the author emended it to Tropidodiscus and regarded a second species, there described as Bellerophon cyrtolites Hall, from the Lower Carboniferous (Kinderhook) limestone, as belonging to the same group.

Later, De Koninck rejected Meek's term on the ground of preoccupancy and introduced, to take its place, the name Tropidocyclus,[3] also adopting B. curvilineatus as the type of the group. This act was not required by any law of nomenclature, and Mr Meek's name as emended should stand as originally characterized by him. Of the three species which De Koninck referred to his Tropidocyclus, none can be regarded as congeneric with Conrad's species. All are small, with broader and more expanding body whorl, narrow umbilici and faint, lateral, revolving furrows, producing a slightly trilobed exterior. The dorsal ridge is seamless, narrow and pronounced, and the surface marked by fine, sharp, concentric, elevated striae which follow the curvature of the peristomal margin, that is, are sinuous on the lateral slopes and make a deep retral subangular curve on the dorsum.

The desirability of separating such forms as these from the peculiar B. curvilineatus will, I believe, be admitted by students, and I therefore propose to adopt De Koninck's term, restricting it to such species as he described. Of these, T. rotula[4] is the first in order, though I think his T. gratiosus[5] better exhibits the characteristics of the group. These shells differ from the Devonian species here referred to Bucaniella, in their lateral appression, narrow dorsum, small umbilici and, conspicuously, in the character of their ornamentation.

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[1] Molluscos devonianos do estado do Parà, Brazil.

[2] Geological Survey of Illinois. Pal. 1866. 2:160.

[3] Faune du calcaire carbonifère de la Belgique. 1883. pt 4, p. 123.

[4] *Op. cit.* pl. 43, fig. 5–8.

[5] *Op cit.* pl. 42 bis. fig. 44–48.

The proper designation for the latter type of shell, if obscured by De Koninck, has been still further embarrassed by the employment of the term Oxydiscus by Koken and by Ulrich for species with a distinctly seamed back, like B. curvilineatus, though by Ulrich the name is made to cover those which are seamless.

In the American Devonic, species of this type are very rare, Trop. gilletianus Hartt and Rathbun of the Ereré sandstone (Middle Devonic), Parà, and the following, T. hyalina, being the only forms known.

Tropidocyclus hyalinus sp. nov.

Plate 18, fig. 1-4

Shell small and delicate, coiled in one plane, volutions deeply embracing so that the umbilicus is quite narrow. Whorls rapidly expanding and relatively increasing their dorsoventral diameter; laterally compressed, obcordate in section, rising rather abruptly from the umbilicus to their greatest diameter, thence broadly sloping with slight subdorsal incurvation to a narrow flattened seamless dorsum. On early whorls this section is so modified that the umbilical elevation of the whorl is less and the subdorsal depression greater. The subdorsal depressions are produced by two revolving furrows, which are much more conspicuous in early growth, giving the shell an almost trilobed appearance, but become progressively obsolete with age.

The aperture is regular, not expanded, deeply emarginate on the back, while projecting on the sides medially and recurved on the ventral surface. The peristome is not thickened.

Surface marked by a series of regular concentric, sharply elevated angular lines and ridges following the curvature of the aperture, and hence having a doubly sigmoidal curve, bending forward and becoming relatively wide apart at the sides, recurving and becoming crowded on the subdorsal depressions and on the dorsum, making a series of deep and narrow linguiform retral festoons, uninterrupted by revolving lines or other evidence of slit band.

Dimensions. This shell rarely exceeds 5 mm in diameter at full growth.

Habitat. Genesee province; Naples subprovince. A rare species observed only as barite replacements in the concretions from Honeoye lake, Livingston co. N. Y.

LOXONEMA Phillips. 1841

Loxonema noe Clarke

Plate 18, fig. 6–10

Loxonema noe Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 55, pl. 3, fig. 10

Shell of small size and delicate proportions, terete and slender. Whorls at full growth 13; slightly but regularly convex, becoming more depressed toward the aperture. The incipient shell lies in position normal to the rest of the whorls, and the surface of the first two whorls, which constitute the nepionic shell growth, is smooth. When vertical or concentric ridges begin to appear, they are sharp, almost angular and are at first nearly uprignt, but on the fourth and fifth whorls begin to show a decided obliquity. After the ninth whorl they manifest a retral curve near the suture, and the course of the ridges becomes broadly sigmoidal. These ridges number, quite uniformly, about 18 for early and late whorls alike, but on the final volutions their regularity is modified by the interspersion between them of finer ridges or the irregular growth of the larger ones, all becoming relatively less conspicuous features of the surface. Finer vertical striae covering these ridges and the intervening furrows are visible over the later whorls. The suture is short and simple, both whorl surfaces rising therefrom with equal convexity. Aperture subcircular or vertically somewhat elongate; outer lip thin, inner lip not calloused. Columella gently twisted, projacent. Base nonumbilicate.

Dimensions. A fully grown shell has a hight of 17 mm, a width at the base of 4 mm. These are the normal adult measurements.

Observations. This species is at once distinguishable from the forms common in the Hamilton fauna beneath (L. delphicola, L. hamiltoniae) by its uniformly small size, more delicate and slender form and less variable surface characters. It is however freely a descendant of such species.

Habitat. Genesee province; Naples subprovince. Very common in the soft shales and lime concretions in Ontario and Livingston counties (Naples, Shurtleff's gully, Whetstone gully, Brigg's gully, Honeoye lake); Havana, Schuyler co.; also in the Styliola limestone, Canandaigua lake and Middlesex, Yates co.

Loxonema multiplicatum sp. nov.

Plate 18, fig. 14

Shell large, suture transverse and deeply impressed, nine whorls visible on a nearly entire specimen. These are subequally convex and are covered with numerous sharp, vertical (concentric) simple ridges, from 20 in number on the early whorls to 40 to 45 on the final volution. These are nearly direct or vertical on the early whorls, but later show a broad recurvature toward the suture and corresponding ecurvature toward the base of the whorl. The ridges remain simple over all the whorls.

Dimensions. Length of an entire specimen (nine whorls) 50 mm; width at base 16 mm.

Habitat. Genesee province; Chautauqua subprovince. In the soft shales on the banks of the Genesee river at the foot of the upper Portage falls.

Loxonema danai sp. nov.

Plate 18, fig. 11–13

Shell of larger proportions than L. noe, terete, bearing at full growth 13 whorls, the surface of which is gently convex. Suture deeply impressed and less oblique than in L. noe. Surface almost smooth throughout, only traces of obsolescent vertical striae being visible over the later whorls. Aperture oblique or subcircular, lips not thickened.

Dimensions. A normal adult is 26 mm long and 7 mm wide at the base.

Habitat. Genesee province; Chautauqua subprovince. Very common in the soft shales at Walnut creek and Terry's ravine, Forestville.

MACROCHILINA Bayle. 1880

Macrochilina pygmaea sp. nov.

Plate 18, fig. 17-19

This is a minute shell, but has been found frequently, and in all instances its size and proportions are uniform. It has a subpyriform outline, very short and blunt spiral of three to four volutions, the surfaces of which slope quite obliquely, the suture being but slightly impressed. The body whorl is very large and long, being five or six times the length of the spiral. Its form is obliquely ovoid, extended below, the curve of the surface being quite regular. At the aperture more than one half the volution is overlapped. The aperture itself is narrow, elongate, regularly contracted below, and the peristome has a thin outer edge and a somewhat thickened columella beneath. Shell nonumbilicate. Surface quite smooth. Average length 2 to 3 mm.

Habitat. Genesee province; Naples subprovince. In the concretions on Honeoye lake, and in the Styliola limestone, Canandaigua lake.

Macrochilina seneca sp. nov.

Plate 18, fig. 15, 16

Shell small, oblique with relatively short spire and broad body whorl. Volutions three, overlapped for about one half their hight, depressed convex. Spire not more than one half the hight of the body whorl. The final whorl expands rapidly, becoming convex ovoid and rotund but not ventricose, and its aperture is elongate oval. Surface of all whorls covered with fine and obscure concentric growth lines, which are occasionally interrupted by deeper furrows.

Dimensions. The largest of these specimens has a hight of 4 mm, basal width of 3.5 mm.

Habitat. Genesee province; Naples subprovince. In the Styliola limestone at Seneca point, Canandaigua lake.

PALAEOTROCHUS Hall. 1879

This term was introduced by Professor Hall as an expression of conviction rather than of demonstration that the paleozoic shells bearing the aspect of the recent Trochus would eventually prove unlike these in some undetermined features. No one has yet brought forward very satisfactory evidence of such differences, though a considerable variety of names has been introduced for the ancient forms which so closely resemble Trochus and Turbo. Therefore the term Palaeotrochus still serves only to indicate a presumptive distinction. The name was applied to a shell of very different aspect from that here described, and, in the event of the establishment of a subordinate division of these genera, it would be probably found necessary to restrict Palaeotrochus (P. kearnyi Hall, Onondaga limestone) to exclude such shells as P. praecursor. In the original description of the latter I employed the generic term with the same reservation as now.

Palaeotrochus praecursor Clarke

Plate 19, fig. 17-26

Palaeotrochus praecursor Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 55, pl. 3, fig. 6–9

Shell of moderate size, turbinate or trochiform, whorls five to six, with early volutions convex, while the final whorl is often obliquely flattened and depressed beneath. The hight of the aperture is five eighths that of the shell. Apical angle about 80°. Suture impressed, whorls overlapped for more than one half their hight. Aperture subcircular or slightly elongate vertically, outer lip thin, entire, inner lip excavated without callosity, but forming a smooth subspiral surface depressed medially and thickened at the inner and outer edges. Shell nonumbilicate.

Surface covered with beadlike tubercles arrayed in spiral rows. In adult shells there are from 10 to 15 of these rows, of which that nearest the suture is most conspicuous and composed of the largest tubercles. This row is separated from the suture by an impressed or flattened area. Another strong row occurs at the periphery of the whorl. These tubercles frequently present the aspect of being elevated vertically or in the direction of the spiral. They are separated by smooth furrows in which, as they become wider, new lines of tubercles develop, specially in later growth stages. Tubercles and furrows are alike crossed by very fine oblique concentric striae, which occasionally become bunched together. On the very early, one to three whorls, these concentric lines were sharp and distant oblique ridges with no other ornament, thereon followed the introduction of uninterrupted but strongly cancelated spiral ridges which gradually break up into tubercles. In respect to ornament we may therefore note four well defined stages, (1) embryonic, in which the shell (protoconch) is smooth, (2) one to two and one half whorls, in which the ornament consists of oblique ridges directed backward to the periphery (the character of the periphery at this stage is not known, (3) two and one half to three and one half whorls, in which continuous revolving ridges strongly cancelated by the oblique ridges are introduced, and (4) the normal adult condition of ridges broken up into disconnected parts or bands of tubercles.

Dimensions. Average full grown specimens have a hight of 10 to 12 mm, a width across the base of 8 to 10 mm.

Habitat. Genesee province; Naples subprovince. Very common in the soft shales through Yates, Ontario and Livingston counties. Also on the Genesee river at the lower Portage falls and on Buck run near Mount Morris. Chautauqua subprovince: near the eastern boundary of this region the shell has been found in some abundance at Java Village, Wyoming co. as fine barite replacements, at Cattaraugus creek near Versailles, Cattaraugus co., and also on the Lake Erie shore between Irving and Dunkirk. The species has also been found to range high in the Genesee valley, reappearing after the first introduction of the Chemung fauna with Spirifer disjunctus (Scott's ravine, Fillmore, Allegany co.) and also in the brachiopod fauna (Westhill flags) above the Naples fauna in the Naples section and eastward in the Seneca lake meridian. It likewise occurs above the horizon bearing the Naples fauna, near Deer Park, Garrett co. Md.

CALLONEMA Hall. 1879

Callonema filosum sp. nov.

Plate 18, fig. 5

Shell small, with spire tapering abruptly from a broad base. Whorls four to five, convex, but the earlier ones are rounder on their exposed surfaces than the last, which presents an even, slightly rounded slope from suture to base. The shell is broadest across the base, which is depressed or flattened, making a low rounded angle about the periphery. The surface markings consist of regular, sharp, subequal and continuous oblique lines concentric with the aperture. These are elevated, rounded, separated by grooves of less width and are present on all except the earliest whorls. There is no intersecting ornament and no trace of slit band. The specific characters are quite in harmony with the species already ascribed to the genus Callonema, though these are from the fauna of the Onondaga limestone. Direct comparison may be made with the shell described by Holzapfel as Holopella dechenii[1] from Martenberg, Westphalia.

Dimensions. The single specimen observed has a hight and basal diameter of 5 mm.

Habitat. Genesee province; Chautauqua subprovince. In the soft shales at Smith's Mills, Chautauqua co.

DIAPHOROSTOMA Fischer. 1887

Diaphorostoma (Naticopsis) rotundatum sp. nov.

Plate 19, fig 11–13

Shell very rotund and highly convex, subspherical ovoid. Spire small, consisting of three whorls, and so greatly depressed as to be but very slightly raised above the upper plane of the final whorl; greatly overlapped, probably for fully two thirds their hight. Suture not impressed. Whorls very rapidly expanding both in hight and width. Aperture attaining almost the full hight of the shell. The body whorl is slightly flattened above, slopes rapidly outward and attains its greatest diameter at about one third

[1] Die Goniatitenkalke von Adorf in Waldeck, p. 25, pl. 5, fig. 3.

its distance from the suture; thence it recurves more gradually. Surface bearing only very fine concentric growth lines which may be almost obsolete on the later parts of the shell.

Dimensions. But a single example of this characteristic shell has been seen. This has a hight of 7 mm and a diameter across the body whorl of 9 mm.

This shell may in form and proportions well be compared with Natica adorfensis Holzapfel[1] which is a similarly rotund shell, though larger and with slightly more elevated spire.

Habitat. Genesee province; Chautauqua subprovince. In the soft shales on Big Sister creek, Angola, Erie co.

Diaphorostoma pugnus sp. nov.

Plate 19, fig. 15, 16

Shell of fairly large size, having the general aspect of the well known Hamilton species D. lineatum Conrad. Volutions 3, rapidly expanding, spire depressed, suture not deeply impressed. Final whorl ventricose. Outer lip thin, inner lip somewhat callused. Entire surface smooth, that is covered by closely crowded concentric striae, which show a decided retral curve at the periphery and indicate a notch on the aperture. These striae are crossed by faint revolving striae of unequal size. Diameter of the shell across the top 28 mm.

Habitat. Genesee province; Chautauqua subprovince. The type specimen, a flattened shell, is from the shales at Fox's point, Lake Erie, and was found attached to a calyx of Melocrinus. Another specimen having about the characters here described has been obtained from the Melocrinus bed above the Styliolia limestone in Blacksmith gully, Bristol, Ontario co. (Naples subprovince).

[1] *Loc. cit.* pl. 5, fig. 5.

PROTOCALYPTRAEA Clarke. 1894

This genus was introduced[1] for conical, crepiduliform shells in which the apical spire is exposed, but beyond this no trace of the suture appears on the exterior except on sculpture casts, the concealed part of the whorls being represented in the interior by a spirally revolving and expanding plate. The only representatives of this structure now known are the two species here described, P. styliophila and P. marshalli, and probably the Capulus galeroides Clarke from the corresponding horizon (Ibergerkalk) at Rübeland in the Hartz.[2]

Protocalyptraea styliophila Clarke

Plate 19, fig. 7-9

Protocalyptraea styliophila Clarke, *op. cit.* p. 334

Shell conic, erect, circular at base; apical angle about 50°. Spire exposed at the apex for one to two volutions, thenceforward on the shell the only trace of volution is a low depression running along the suture. Internal spiral plate (lower surface of whorls) flat, expanding, extending one fourth the distance across the internal cavity. Surface marked by very fine concentric lines.

Dimensions. The original specimen has a hight of 12 mm, an apertural diameter of 14 mm.

Habitat. Genesee province; Naples subprovince. Rare in the Styliola limestone; Genundewa, Canandaigua lake.

Protocalyptraea marshalli Clarke

Plate 19, fig. 1-6

Protocalyptraea marshalli Clarke, *op. cit.* p. 334

Shell conic, apical angle somewhat larger than in the preceding species. Apical whorls exposed for one and one half volutions, and in compressed

[1] American species of Autodetus and some paramorphic shells from the Devonic (Am. Geologist. 1894. 13:328).

[2] Fauna d. Ibergerkalkes. Neues Jahrb. für Mineral. Beilbnd 3. 1884. p. 343, pl. 5, fig. 12.

sculpture casts from the shales the suture shows as a fine line over the rest of the surface. Exterior marked by obscure concentric lines. A small uncompressed specimen from the limestone concretions has a hight of 5 mm, apertural diameter of 6½ mm.

An example from the shales which is compressed has a diameter of 23 mm and a hight of 10 mm.

These shells are rare; further knowledge of them may prove that they are specifically identical with P. styliophila.

Habitat. Genesee province; Naples subprovince. In the soft shales at Naples and the concretions at Whetstone gully, Honeoye lake.

PTEROPODA

PROTOSPIRIALIS gen. nov.

Protospirialis minutissima Clarke

Plate 20, fig. 15–19

Platyostoma ? minutissima Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 55.

This minute and tenuous shell has the aspect of a small Platyostoma (Diaphorostoma). Its apex is minute, its whorls expand very rapidly and are not more than three or four in number. All are convex, the spire short, the body whorl very ventricose, the aperture subcircular, outer lip thin, inner lip slightly reflected, scarcely covering the umbilicus. The surface is smooth or with the fine concentric lines usual to Platyostoma. Almost without exception the shells present the same proportions, measuring about 1.5 mm in hight and width, never exceeding this size and rarely falling below it.

These delicate and diminutive shells occur in immense numbers at certain spots in the Naples section. In the concretionary goniatite layer lying near the lower part of the shales, in Parrish gully, and at its exposures in the Naples valley near Branchport, Yates co., they are accumulated in millions, rivaled only in number by individuals of the pteropod Styliolina fissurella, with which they are associated, and in places compose the rock. They occur in like abundance in the separated concretions everywhere through the Naples subprovince. Their nature and mode of occurrence, together with their association with this pelagic fauna, lead me to suspect their pteropod nature, while their pelagic character is evident. The spiral shells of living pteropods are believed to be all sinistrally coiled (Spirialis, Valvatella, etc.), but this consideration can not be given great weight in determining the point in hand. For these reasons, I have given these fossils a generic term which indicates their probable affinities.

HYOLITHUS Eichwald. 1840

Hyolithus neapolis Clarke

Plate 20, fig. 22–30

Hyolithes neapolis Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 56, pl. 3, fig. 4, 5

This species has the elongate triangular form characterizing H. aclis Hall of the Hamilton fauna, but is well distinguished from this and other species of like proportions in the following particulars. The flat or ventral side bears only fine sculpture lines concentric with the surface and no trace of radial lines. The convex side is distinctly subdivided into three parts, two flattened marginal areas each extending one fourth the diameter of the shell and separated from the median area by narrow grooves. The median area is convex and arched. This subdivision of the surface is however but slightly apparent in uncompressed specimens. Concentric lines cross the flattened areas, but on the median division these are raised into strong wrinkles which corrugate the surface. There is no trace of radial lines.

Dimensions. Average specimens attain a length of about 25 mm and an apertural width of 8 mm.

Habitat. Genesee province; Naples subprovince. Common in the shales at Naples, also in the concretions on Honeoye lake. Chautauqua subprovince. A single small individual has been found in the shales at Forestville. The species also occurs in the Wiscoy shales on Wiscoy creek.

STYLIOLINA Karpinsky

Styliolina fissurella Hall

Tentaculites fissurella Hall, Geology of New York; rep't on fourth district. 1843. p. 182.

Styliola fissurella Hall, Paleontology of New York. 1879. v. 5, pt 2, p. 178, pl. 31A, fig. 1-30

Styliola (Styliolina) fissurella Clarke, U. S. Geol. Sur. Bul. 16. 1885. p. 14-17, 57

In the work last cited I have referred to the vast abundance of this little pteropod, which constitutes the mass of the Styliola or Genundewa limestone, and permeates the kramenzel Goniatite limestone above and all concretionary and nodular masses in the formation. It is rarer in the shale beds, but at times their surfaces are crowded with these needlelike bodies. The character of these deposits has been discussed on a preceding page, and the presence of these fossils in mass constitutes one of the striking features of the black mud facies of this fauna wherever found.

Tentaculites gracilistriatus Hall

Tentaculites gracilistriatus Hall, Paleontology of New York. 1879. v. 5, pt 2, p. 173, pl. 31, fig. 12, 13; pl. 31A, fig. 37-47

This species, characterized by low, distant annulations and fine radial lines, occurs occasionally in association with Styliolina fissurella. Karpinsky[1] regards the species as synonymous with Tent. acuarius Richter. It is undeniably identical with T. multiformis Sandb. from the Cypridina shales of Weilmünster.[2]

Habitat. Genesee province; Naples subprovince. In the Styliola limestone on Canandaigua lake and the concretions in the gray shales at Naples.

[1] Die foss. Pteropoden am Ostabhange d. Urals. Acad. St Petersbourg. Mem. Ser. 7. 1884. v. 32, no. 1, p

[2] Verstein. des Rhein. Schichtensyst. in Nassau. p. 249, pl. 21, fig. 11.

Tentaculites tenuicinctus F. A. Roemer

Plate 20, fig. 20, 21

Tentaculites tenuicinctus F. A. Roemer, Beitr. 1 zur geol. Kenntniss d. nordw. Harzgebirges. 1850. p. 28, pl. 4, fig. 19

Tentaculites tenuicinctus Sandberger, Verstein. des rhein. Schichtensyst. in Nassau. 1850–56. p. 250, pl. 21, fig. 13

Very slender and delicate, elongate, gradually tapering tubes closely and regularly annulated by concentric, narrow, elevated rings with narrower interspaces. The rings run almost to the tip of the shell, and in the later growth of the tubes there are about 20 in the length of 1 mm, the length of an average shell being 4–5 mm and the diameter at the larger end about .3 mm. No longitudinal lines are visible.

This species is smaller and much more slender than any American species known to me, T. spiculus expanding more rapidly and having more distant rounded annulations with concentric lines on the intervals. It is without distinguishing characters from the German species which was described from the Intumescens horizon at Rübeland in the Hartz mountains and occurs at various localities of this fauna.

Habitat. Genesee province; Naples subprovince. In sandy concretions at Naples.

SOME ADDITIONAL SPECIES OF THIS FAUNA

Entomis serratostriata Sandberger

Cypridina serratostriata Sandberger, Leonhardt & Bronn's Jahrb. 1842. p. 226.

Cypridina serratostriata Sandberger, Verstein. des rhein. Schichtensyst. in Nassau. 1850–56. p. 4, pl. 1, fig. 2a-i

Entomis serratostriata Jones, Ann. & Mag. Nat. Hist. Oct. 1890. p. 320, pl. 11, fig. 1, 2

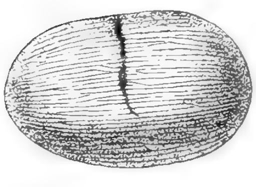


Fig. 12 Entomis serratostriata Union Corners N. Y.

Very characteristic specimens of this species, though few in number, have been found in the soft shales at Union Corners, Livingston co., associated with E. variostriata, Chiloceras sp. and Posidonia mesacostalis.

Entomis variostriata Clarke

Entomis variostriata Clarke, Neues Jahrb. für Mineral. 1884. p. 184, pl. 4, fig. 3

Entomis variostriata Jones, Ann. & Mag. Nat. Hist. Oct. 1890. p. 323, pl. 11, fig. 5–8

cf. Cypridina splendens Waldschmidt, Zeitschr. der deutsch. geolog. Gesellsch. 1885. 37: 926, pl. 40, fig. 6, 6a

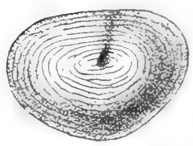


Fig. 13 Entomis variostriata Union Corners N. Y.

This species was described from Bicken, Westphalia, and the species termed at later date Cypridina splendens by Waldschmidt seems to be identical with it. Specimens indistinguishable from the Bicken examples, in size, outline and ornament occur sparsely in the soft shales at Union Corners, Livingston co. (Naples subprovince).

Chiloceras sp.

The presence of this genus is indicated by the fragment here figured which shows one half the outer course of the suture. While we have no other clue to the existence of the genus in New York waters, in the German and Polish sections Chiloceras indicates pretty constantly a horizon intermediate between the Intumescens limestone below and the Clymenia horizon above.

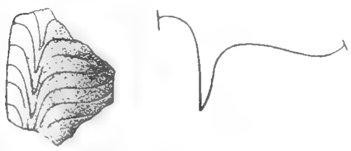
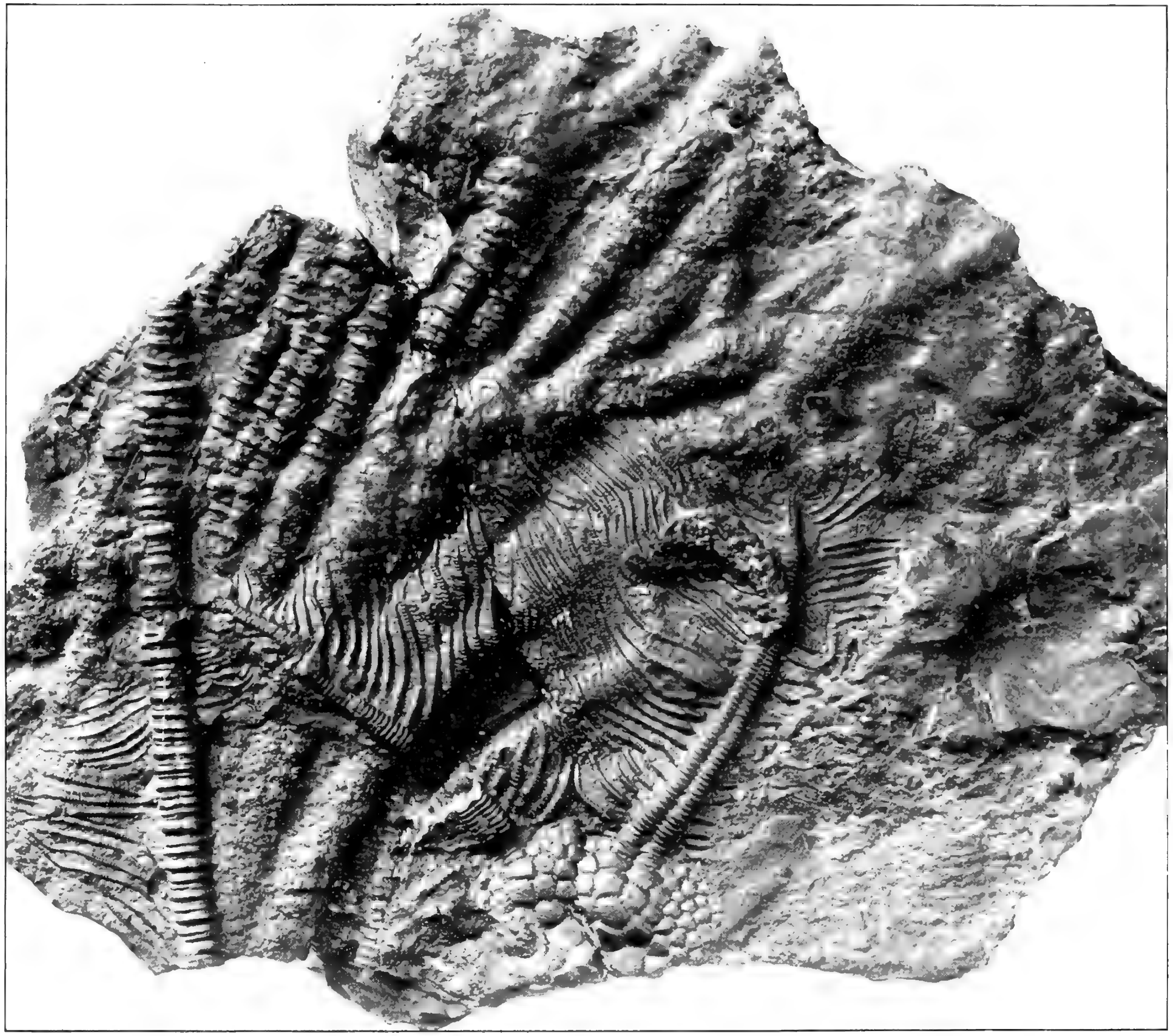


Fig. 14 Chiloceras sp. Union Corners N. Y.

PLATE D



MELOCRINUS CLARKEI (Hall) Williams

Canandaigua Lake

The specimen is from Union Corners (Naples subprovince) in association with the preceding species.

Gephyroceras cf. **domanicense** Holzapfel

See Gephyroceras domanicense Holzapfel, Mémoires du comitè geologique. 1899. v. 12, no. 3, p. 32, pl. 5, fig. 8, 9, 11, 13

This comparison is purely a suggestion of identity based on externals. Specimens which have come into our hands since the preparation of the account of the goniatites of this fauna, indicate a Gephyroceras of exterior strikingly similar to the shell cited. This is expressed in the course of the finely undulated concentric ornament, the striae being clustered into elevations which form distant, low pilae (*cf.* Holzapfel's fig. 8). The whorl is depressed lenticular with concave, peripheral grooves, broad, concave venter with elevated edges. As we know nothing yet of the suture, this comparison remains inadequate, but there is little likelihood of wide departure herein from the typical Gephyroceran suture. The New York species is somewhat more closely umbilicated than the Timan shell. [*See* p.379]

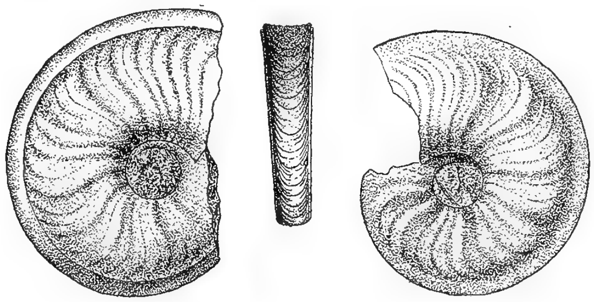


Fig. 15 Gephyroceras *cf.* domanicense Forestville N. Y.

The specimens are all from the Angola shales at Forestville (Chautauqua subprovince) associated with Loxopteria dispar, Euthydesma subtextile, Praecardium vetustum etc.

Note on **Tornoceras cinctum** Keyserling

Goniatites cinctus Keyserling, Verhandl. d. kais. russ. mineral. Gesellsch. 1844. p. 227, pl. A, fig. 2, 3

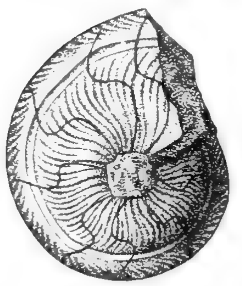


Fig. 16 Tornoceras bicostatum, somewhat enlarged. Correll's point, Lake Erie.

Goniatites cinctus Keyserling, Reise in das Petschoraland. 1846. p. 277, pl. 12, fig. 2, 3

Tornoceras cinctum Holzapfel, Das obere Mitteldev. im rhein. Gebirge. 1897. p. 90, pl. 6, fig. 12; pl. 7, fig. 4; pl. 8, fig. 8

Tornoceras cinctum Holzapfel, Mémoires du Comité geologique. 1899. p. 16, pl. 9, fig. 2–6

Hall described Torn. bicostatum in 1843 [Rep't Fourth Dist. p. 245.] This species and Torn. cinctum are apparently identical in mature characters, though their ontogeny may prove them to hold successive rather than coequal relations. The adjoining figure is given to express the aspect of Torn. bicostatum when uncompressed.

Melocrinus clarkei (Hall) Williams

Original description.[1] The shape of the calyx can not be determined on account of the crushed condition of the specimens, but the shape and number of the plates agree so well with those of M. bainbridgensis H. & W., that it is probable that the shape was the same, i. e. broadly turbinate. In size, also, the calyx agrees well with that species.

No underbasals appear.

The basals are low, wide and pentagonal.

The radials are more than double the size of the basals, in hight and width equal, or wider than high. The variation in the shape of this plate, in the several specimens on the one slab, covers the extremes met with in the two species, M. bainbridgensis and M. breviradiatus.

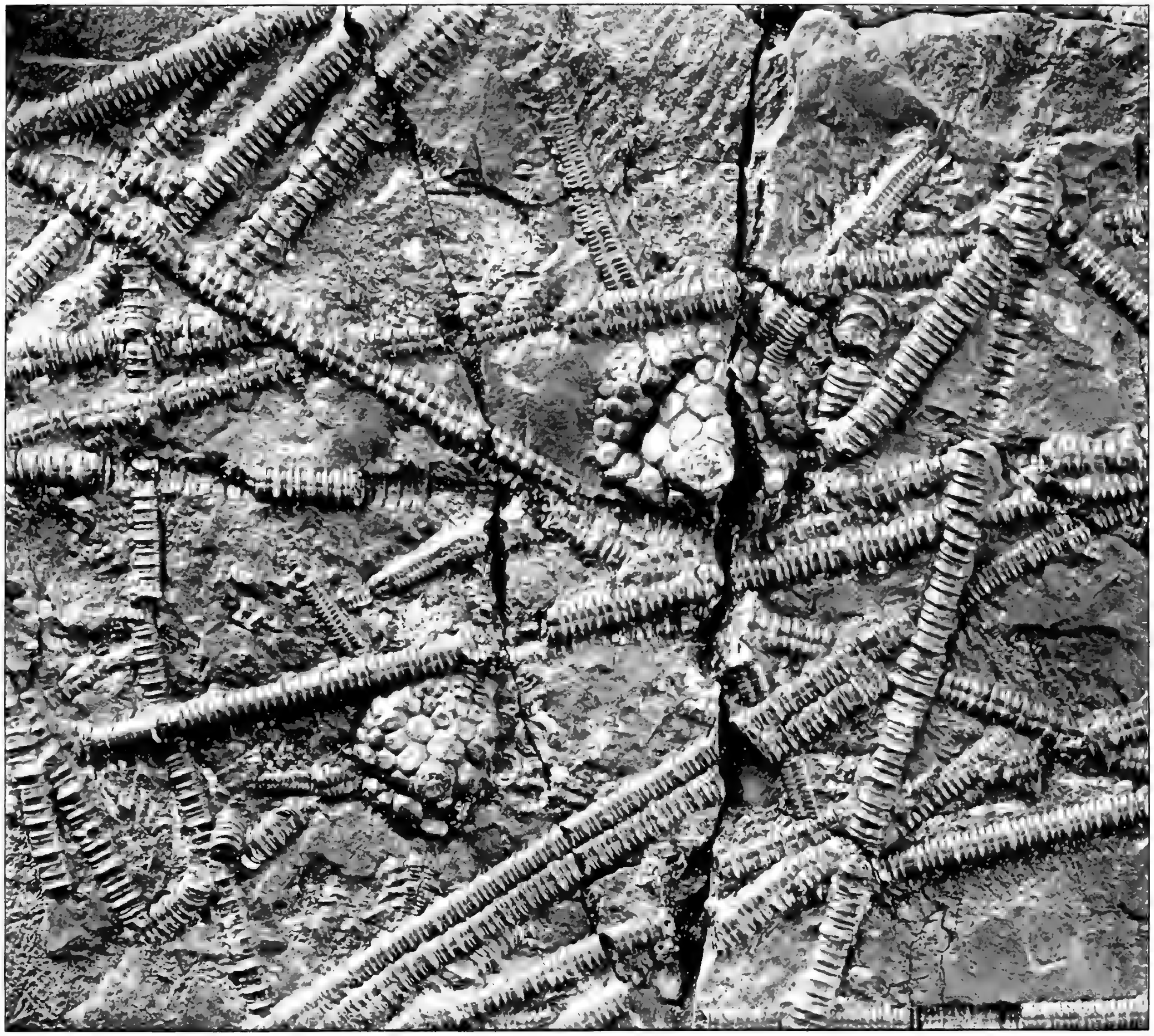
The radial is followed by two brachials of smaller size, the first hexagonal, the second pentagonal and angular above, and each is about equal in hight and width.

The second brachial supports two arm plates (still within the calyx), nearly as large as the brachials, irregularly pentagonal and meeting at their inner edges.

Of the secondary radials, three are within the calyx, the second is about half as high as wide, the third is very short. The third pair of secondary

[1] H. S. Williams. Acad. Nat. Sci. Phil. Proc. 1882. p. 31.

PLATE E



MELOCRINUS CLARKEI (Hall) Williams

Canandaigua Lake

radials together bear a strong arm, gradually tapering to a point, about three times the length of the calyx. It is broad, flattened on the back and longitudinally depressed along the center, and is composed of a double series of very short plates, meeting at the center and arranged in opposite (not alternate) order.

On the outer and ventral side the arm bears long, slender, cordlike branchlets, which appear to have fine threadlike appendages along their sides. In the central part of the arm these branchlets are as long as the arm itself. They proceed from every third arm plate, instead of every fourth, as in M. bainbridgensis, and the plates from which they appear are opposite each other, and their outer sides are lengthened slightly.

The interradials are apparently like those of M. bainbridgensis, beginning with a large plate between the upper parts of two adjacent radials, followed above by two smaller plates, and these by more, still smaller plates, the number or arrangement of which is not uniform.

The calyx plates are marked by granulations over the central portion, are rounded at the margins, which in some cases are elevated slightly above the central part of the plate, causing a depression, as in M. bainbridgensis; other plates (even on the same specimen) are convex, as in M. breviradiatus. The rows of fine ridges, connecting the calyx plates at their juncture, are very distinct in some cases, and do not appear in others. The former is a character of M. breviradiatus.

The stems are composed of alternately thin and thick plates the relative order, or proportions, of which are not constant, even varying on the same stem when preserved for long distance.

This species is closely related to Melocrinus bainbridgensis Hall & Whitfield, 1875, from the Huron shale, Bainbridge O., and to M. breviradiatus Hall (figured on a plate of "New Crinoidea, plate 1," which was published, with explanation of plates, in 1872), from the Hamilton group.

The study of the specimens (all on a single slab), from which the above diagnosis is made out, has revealed the fact that apparently all the characters distinguishing the two species just named are variable in those specimens. The arms must be excepted; none are known for M. breviradiatus, and those described for M. bainbridgensis were not found attached to any calyx.

While, therefore, we retain a distinct specific name for the specimens under consideration, we are led to believe that examination of a larger series of specimens may make it necessary to unite these three species in one.

This species is interesting for its abundance in a thin limestone layer of the Genesee, which lies close above the Genundewa limestone, and continues for considerable distances in Ontario county. On the sea bottom represented by this layer grew an immense plantation of these crinoids, and, wherever it is exposed horizontally, they are strikingly displayed. The species also occurs in the Cashaqua shales at Naples. The illustrations here given are from the original slab found about 1870 by the writer's father, Noah T. Clarke, for whom the specific name was given by Prof. James Hall. These are the first illustrations of the species.

In many respects the species is like Melocrinus of the Intumescens zone described by Fraipont, Trenkner, v. Koenen, Clarke and others.

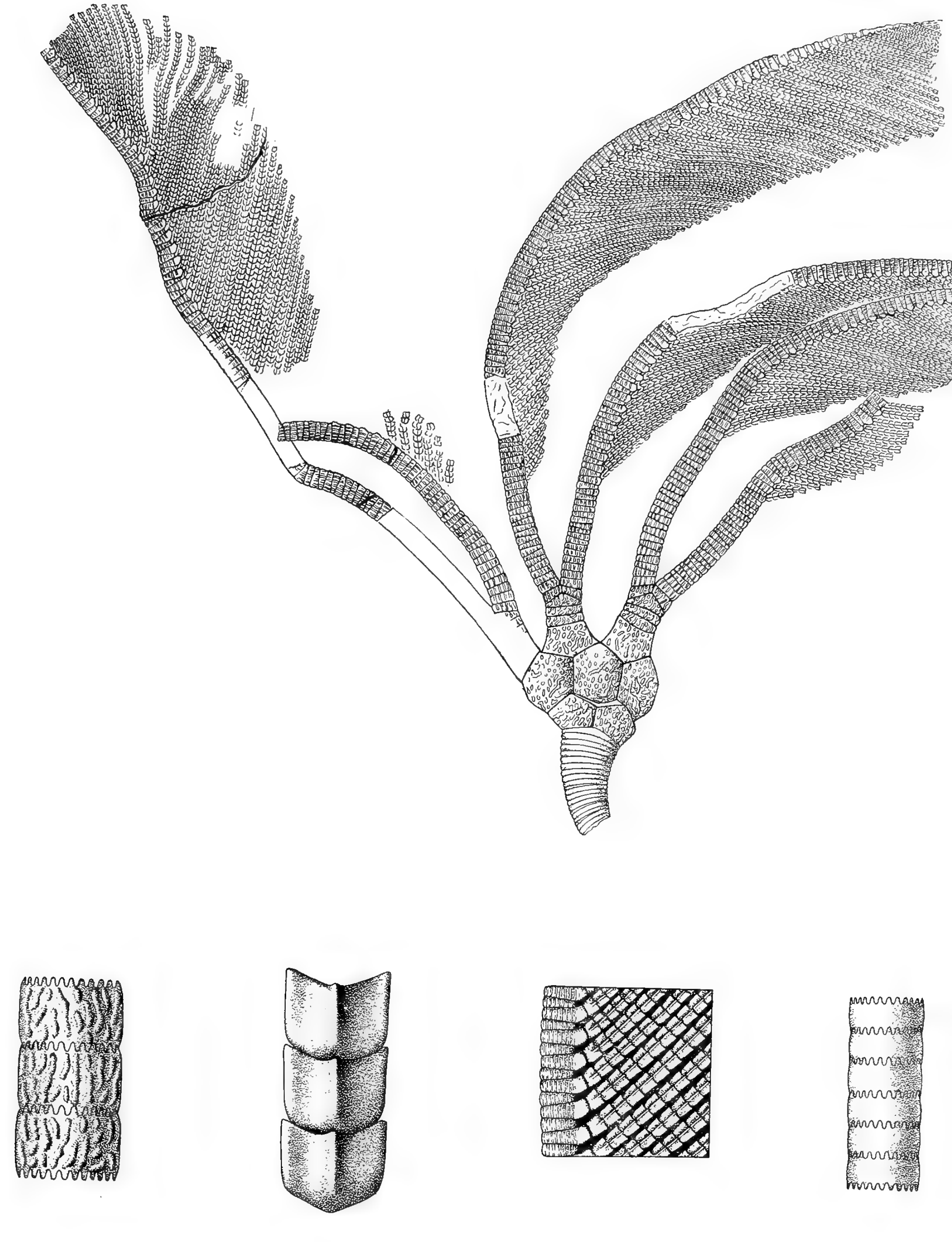
We have found in considerable quantity remains of a Melocrinus in the lower shale beds (Angola shale) at Fox's point, Lake Erie; but this appears to be distinct from Melocr. clarkei of the Naples subprovince.

Scytalocrinus ornatissimus Hall (sp.)

Cyathocrinus ornatissimus Hall, Geology of New York; rep't on fourth dist. 1843. p. 247, fig. 108

The illustration accompanying the original account of this species represented a splendid calyx with gracefully curving column and fine sweep of arms. So effective and striking was this design that it was selected as the hall-mark for some of the earlier volumes of the geologic reports, being imprinted on the cover. Some years ago I elicited from Professor Hall the statement that this drawing was a composite design from many fragments in which all the parts represented were not actually shown and that some of this material on which the figure was based had been in the possession of a collector who subsequently made over his collection to Williams College. In later years we have found many evidences of this species from the vicinity of its original locality (Lake Erie shore, town of Portland) recognized by the peculiar sculpturing of the columns, but no calyxes have been seen. At my urgent request Prof. H. F. Cleland has made a careful search of the collections under his charge at Williamstown and has found the specimen here figured, a calyx with arms and column, on the surface of a thin block made up of fragments of columns, the specimen bearing the label in

PLATE F



SCYTALOCRINUS ORNATISSIMUS Hall (sp)

The type specimen somewhat enlarged, with details of structure; at the left, segments of the column, next, the shield-shaped and keeled pinnule segments shown in smaller scale to the right; columnar segments without ornament at the right.

Professor Hall's characteristic hand, "Cyathocrinus ornatissimus." This I think we may with propriety regard the type of the species.

The specimen is remarkable specially for the structure of its pinnules which are constituted of series of flattened keeled plates. I am indebted to Mr Frank Springer for the following comments on the species: "Your figure represents an extremely interesting and remarkable crinoid. The arms are more ponderous than in any related generic form from the same or equivalent formation. The long and closely packed pinnules with their keeled elevations on the dorsal side, look very much like those of the subcarboniferous Actinocrinidae. However they spring from cuneiform brachials of uniserial arms, such as pertain generally to the earlier Inadunata, to which division this crinoid belongs. From the characters exhibited I think it may be safely assigned to the genus Scytalocrinus."

DEVELOPMENT OF THE INTUMESCENS FAUNA OUTSIDE OF NEW YORK

A very notable feature of the Upper Devonic deposits of the continent of Europe is the clearness of its subdivision by facies. This is specially appertinent to the ammonitoid[1] faunas, and it is indeed essentially on these that this subdivision has been elaborated. This facial division, so far as based on the ammonoids, is quite generally regarded as sequential in time rather than an expression of geographic variants, unlike the variations in facies represented by the Naples, Ithaca and Oneonta faunas of Portage time in New York. Encroachments are recognized of indicial ammonoids into contemporaneous areas of brachiopod and coral growth, as in the case of Manticoceras intumescens in the Iberg reef limestone at various sections. Throughout the succession positive time values attach to leading species, though such species are not restricted to their climacteric horizon. We shall presently advert to the considerable disturbance in the New York province of the chronologic values of such of those Eurasian species or their allies as are represented here. Spirifer disjunctus in the continental sections ranges from the upper Middle Devonic into the Culm[2]; it is found as a member of the Cuboides zone, a straggler into the true ammonoid facies of the Intumescens zone, but still its climacteric is in the brachiopod facies of this and the succeeding stages. Herein the acme of the species both in Eurasia and America is quantivalent, though in the latter it does not precede the Intumescens zone, while recent investigations[3] indicate that it may ascend, as in Europe, into strata which may properly be construed as Carbonic. To bring this facies development of the Eurasian Upper Devonic before the eye, we present the following tabulation, compiled from various authors, with the help afforded by

[1] The German writers frequently apply the term *pelagic* to this association, but probably this term is, as we have before observed, not fully justified.

[2] The Culm is now regarded by Holzapfel and others as a deeper water facies of the Coal Measures rather than a subsidiary member of the Carbonic. The presence of Spirifer disjunctus in strata subsequent to the introduction of the Carbonic fauna is noted by Drevermann.

[3] *See* N. Y. State Pal. Rep't 1901.

Kayser's most useful compendium of stratigraphy[1] and Frech's amplifications of Roemer's *Lethaea Palaeozoica*.[2]

In these tables horizons of the intumescens fauna are in roman

SOUTH DEVON	BRITTANY	CABRIERES
Cypridina shales, red and green. Entomis serratostriata, Ent. sandbergeri, Ent. gyrata, Posidonia venusta	Rostellec dark shales with Entomis serratostriata, Tentaculites tenuistriatus, Posidonia venusta, Chiloceras verneuili	Cypridina shales
		Clymenia limestone
		Chiloceras horizon
Adorf limestone with Manticoceras intumescens		Horizon of Mantic. intumescens
Massive limestones with Hypothyris cuboides, Pugnax pugnus, etc.		

BELGIUM	AACHEN	EIFEL
Condroz psammites with Spirifer disjunctus, Phacops granulatus, land plants (Palaeopteris, Sphenopteris, Lepidodendron); dictyosponges: D. morini, Hydnoceras barroisi, H. jeumontense, Rhabdosispongia conarozi-ana; fishes (Holoptychius, etc.)	*Micaceous sandstones and green shales with Spir. disjunctus, Pugnax pugnus, Cyrtia murchisoniana*	
Famenne schists with Sp. disjunctus, Pugnax pugnus, P. acuminatus, Entomis serratostriata	Beds with Chiloceras verneuili	Greenish shales with Entomis serratostriata

[1] Geologische Formationskunde. ed. 2. 1902.

[2] Besides the authorities cited, works of the following writers have been consulted in the construction of this tabulation, Barrois, Gosselet, Holzapfel, Beushausen, Denckmann, Koch, Tschernyschew, Waldschmidt, Toll, De Koninck, Gürich, Whidborne.

BELGIUM	AACHEN	EIFEL
Matagne schists; dark shales with limestone banks. Buchiola retrostriata, Bactrites, Mantic. intumescens, Tornoc. simplex	Black fissile shale with Buch. retrostriata	Kellwasser limestone: black bituminous shales and limestones with Buch. angulifera, small goniatites, Ceratiocaris (Echinocaris ?), fish remains Büdesheim goniatite dark shales and limestones with small pyritized goniatites (Mantic. intumescens var., Torn. simplex, auris, Bactrites gracilis, etc.)
Frasne limestones and shales. Hypothyris cuboides, Pugnax pugnus, Sp. disjunctus, gastropods, lamellibranchs, corals, trilobites	*Dark clay shales and concretionary limestones. Sp. disjunctus, Hypothyris cuboides,* etc. *Tornoc. simplex, Phillipsastraea, etc.*	*Dolomitic schists with Hypoth. cuboides, Sp. disjunctus, Mantic. intumescens, Torn. simplex*

SAUERLAND, DILL BASIN AND WESTPHALIA

Cypridina shales (red, green, gray); Entomis serratostriata, Posidonia venusta, Phacops anophthalmus

Pöns sandstone with rill marks and mud cracks (plant remains)

Clymenia limestone; gray and reddish kramenzel. Clymenia striata, undulata, speciosa, subarmata (forms with complicated suture); C. annulata, flexuosa, angustiseptata (with simple suture); Chiloceras planilobus, curvispina, subpartitum, Sporadoceras muensteri, Loxopteria dispar, L. laevis, Posidonia venusta, Buch. retrostriata, palmata, Euthydesma beyrichi, Praecardium vetustum var. clymeniae, Tiaraconcha rugosa

Nehden shales with Chiloceras verneuili, curvispina, subpartitum, planilobus, Tornoc. circumflexum Praecardium vetustum, Loxopteria dispar

SAUERLAND, DILL BASIN AND WESTPHALIA	
Adorf limestone; gray, red, platten and concretionary limestone. Mantic. intumescens, primordiale, carinatum, Beloc. multilobatum, kayseri, Tornoc. simplex, paucistriatum, Gephyr. calculiforme, aequabile, forcipifer, Bactrites subflexuosus, Orthoceras vittatum, Loxonema piliger, tenuicostatum, arcuatum, Macrochilina dunkeri, Pleurotomaria angulata, globosa, tenuilineata, Buchiola retrostriata, palmata, Praecardium duplicatum, Euthydesma beyrichi, Loxopteria rugosa, Lunulicardium bickense, inflatum, concentricum, muelleri, adorfense, Cardiola articulata, subradiata, concentrica, Tentaculites tenuicinctus	
Kellwasser limestone (see Eifel). (?) Horizon of Prolecanites	
Iberg limestone with Hypothyris cuboides, Pugnax pugnus, Spir. disjunctus, etc. gastropods, lamellibranchs, trilobites, etc.	In the *Wildungen* section the lowest beds are dark shales with Liorhynchus, small goniatites (Tornoceras simplex Manticoceras)

UPPER HARTZ	EASTERN ALPS	POLAND
Cypridina shales with Entomis serratostriata, Posidonia venusta, Loxopteria dispar.		
Clymenia limestone. Clymenia levigata, undulata, striata, Tornoceras, Chiloceras, Brancoc. sulcatum, Sporad. bronni, Posidonia venusta, Loxopteria rugosa, dispar, Praecardium, Cardiola ar-	Clymenia limestone with Cly. laevigata, striata, undulata, etc., Posidonia venusta	Psiarnia beds with Clymenia levigata, annulata, undulata, Posidonia venusta, Brancoceras sulcatum

UPPER HARTZ		EASTERN ALPS	POLAND
ticulata, Euthydesma, Buchiola angulifera, prumiensis, palmata, retrostriata, Entomis serratostriata			
Adorf limestone. Entomis serratostriata, Tornoc. simplex, Mantic. intumescens, Gephyroc. calculiforme, Beloc. multilobatum, kayseri, Tentaculites tenuicinctus, Loxopteria rugosa, Posidonia cf. hians, Cardiola inflata, concentrica, bickensis, Euthydesma, Buchiola angulifera, prümiensis, palmata, retrostriata, Lunulicardium koeneni			Lagow limestone with Chiloceras sacculus, Sporadoceras bronni, Branc. lentiforme, Bactrites, Praecardium vetustum, Tornoceras simplex (Elsewhere, Kadzielnia, Kirchhofsberg, brachiopod and coral facies) Goniatite limestone with Manticoceras intumescens, Gephyroceras calculiforme, Torn. auris, simplex, Tentaculites tenuicinctus, Buchiola retrostriata, shales with Entomis serratostriata
Kellwasser limestone with Buch. angulifera, Tentac. tenuicinctus			
Dark shale with Tornoc. simplex, Manticoceras, Gephyroceras, Bactrites, Tentac. tenuicinctus, Styliolina, Pleurotomaria turbinea, Buchiola prumiensis, Lunulicardium	*Iberg limestone. Reef limestone with Mantic. intumescens, Hypothyris cuboides, gastropods! brachiopods! corals!*	*Iberg limestone. Reef facies with Hypothyris cuboides, Pugnax pugnus, corals!*	*Coral reef limestone with Hypothyris cuboides*

URALS		
WEST SLOPE	EAST SLOPE	SOUTHERN EXTENSION
	Cypridinia shales with Entomis serratostriata	
Clymenia limestone. Clymenia, annulata, flexuosa, krasnopolskii, Tornoc. simplex, Chiloc. verneuili, Pugnax acuminata, Schizophoria striatula	Clymenia limestone	Shales with Clymenia undulata, angustiseptata, levigata, dunkeri, speciosa, Sporadoceras muensteri
Iberg limestone with coral reef facies, Tentac. tenuicinctus, Mantic. intumescens, ammon, Tornoc. simplex, Bactrites carinatus, subflexuosus, Buchiola retrostriata, Pleurotomaria koltubanica, Cardiola concentrica		Limestone with Tornoc. simplex, Bactrites carinatus, Hypothyris cuboides, Spirifer etc.
Brachiopod limestone with Hypothyris cuboides	*Brachiopod limestone with Hypo. cuboides*	

TIMAN (PETSCHORALAND)	ALTAI
Sandstone with Spirifer disjunctus	
Domanik shales; black bituminous shales with interbedded limestones. Tornoc. simplex, cinctum, Mantic. intumescens, ammon, retrorsum, backlundi, Gephyroc. bisulcatum, tschernyschewi, regale, domanicense, uralicum, auritum, uchtense, keyserlingi, lebedeffi, syrjanicum, Timanites acutus, stuckenbergi, Prolecanites timanicus, Bactrites subflexuosus, Gomphoceras, Phragmoceras, Orthoceras	Gerichowsk limestone
Clay shale with Spirifer anossofi, Rhyn. meyendorffi, etc. Corals	

We have already had occasion to note the indications of the Intumescens fauna in the regions of western North America. These are:

BRITISH COLUMBIA HAY RIVER	IOWA CERRO GORDO CO.
Manticoceras intumescens with Hypothyris cuboides, Schizophoria striatula, Pugnax pugnus, Spir. disjunctus (Horizons not differentiated)	Lime Creek shales with Manticoceras intumescens, Pugnax pugnus, Spir. disjunctus, Stroph. arcuata and other species common to the fauna of Highpoint, Naples, which is stratigraphically equivalent to the Portage sandstones

RANGE OF SPECIES IN THE CHAUTAUQUA AND NAPLES SUBPROVINCES

To bring into comparison the fauna of the Genesee province with the most carefully studied sections in the Rhineland, Westphalia, the Hartz and Timan, we give in the following tables the variation in the composition of the subfaunas in their typical or best developed manifestation, the two subprovinces of New York.

VERTICAL RANGE OF SPECIES IN THE LAKE ERIE SECTION (CHAUTAUQUA SUBPROVINCE)

At top Laona sandstone with Spirifer disjunctus and the brachiopod fauna of the Chemung; equivalent to Long Beards riffs sandstone, Genesee valley.

Portland shales and flags

Stratigraphic equivalent of Wiscoy shales and Portage sandstone in Genesee section, of Highpoint sandstone and Prattsburg sandstones (in part) of the Naples section. The last named units carry only a Chemung fauna.

Cephalopods	*Pteropods*	*Gastropods*
Tornoceras bicostatum	Styliolina fissurella	Phragmostoma chautauquae
Manticoceras rhynchostoma		Palaeotrochus praecursor

Lamellibranchs

Lunulicardium accola	L. intumescentis
L. eriense	L. corrugata
L. furcatum	Ontaria concentrica
L. absegmen	Euthydesma subtextile
Posidonia mesacostalis	Elasmatium gowandense
P. venusta nitidula	Praecardium vetustum
Kochia ungula	Conocardium gowanense
Loxopteria dispar	Palaeoneilo constricta
L. laevis	P. brevicula
L. vasta	

Dunkirk black shales

Not represented in eastern sections

Silver creek shales underlain by Angola shales

Representing the Gardeau (Westhill) and Hatch flags of the Genesee and Naples valleys

Cephalopods

Tornoceras bicostatum
Manticoceras rhynchostoma
M. sororium
Orthoceras thyestes
O. pacator
Gomphoceras ajax
Bactrites

Pteropods

Hyolithus neapolis

Gastropods

Pleurotomaria itylus
Phragmostoma chautauquae
Loxonema danai
Palaeotrochus praecursor
Callonema filosum
Diaphorostoma rotundatum
D. pugnus

Lamellibranchs

Lunulicardium libum
L. eriense
L. bickense
L. beushauseni
Pterochaenia fragilis
Posidonia attica
Loxopteria laevis
L. intumescentis
L. corrugata
Ontaria pontiaca
Euthydesma subtextile
Buchiola scabrosa
B. conversa
B. angolensis
B. *cf.* prümiensis
Praecardium vetustum
P. duplicatum
P. multicostatum
Palaeoneilo constricta
P. linguata

Rhinestreet black shale

No fossils recorded

Cashaqua shales

Cephalopods

Probeloceras lutheri
Gephyroceras holzapfeli
G. *cf.* domanicense

Lamellibranchs

Lunulicardium pilosum
Pterochaenia fragilis
P. elmensis
Buchiola retrostriata
B. lupina
Palaeoneilo petila

Middlesex black shales

Conodonts

Prioniodus spicatus
P. erraticus
Polygnathus dubius

Upper Genesee shale
Genundewa (Styliola) limestone

VERTICAL RANGE OF SPECIES IN THE NAPLES SECTION

At top, Highpoint sandstones, Westhill flags and Grimes sandstone bearing a brachiopod fauna.

Hatch sands, flags and shales

Fishes

Dinicthys newberryi
Pristacanthus vetustus
Spathiocaris emersoni

Plants

Lepidodendron

Cephalopods

Manticoceras pattersoni
M. oxy
Probeloceras lutheri

Pteropods

Styliolina fissurella

Lamellibranchs

Lunulicardium ornatum
Honeoyea majora
H. desmata

Posidonia attica
Leptodomus interplicatus

Rhinestreet black shales

Fishes

Palaeoniscus devonicus
Acanthodes pristis

Lamellibranchs

Lunulicardium velatum
Pterochaenia fragilis
Leptodomus multiplex

Conodonts

Polygnathus dubius
Prioniodus spicatus
P. erraticus

Spathiocaris emersoni

Cashaqua shale

Crustacea

Eleutherocaris whitfieldi
Stylonurus? wrightianus

Spathiocaris emersoni
Dipterocaris

Cephalopods

Manticoceras pattersoni
M. apprimatum
M. tardum
M. accelerans
M. vagans
Probeloceras lutheri
P.? naplesense
Beloceras iynx
Tornoceras uniangulare
T. uniangulare *var.* obesum
Cyrtoclymenia neapolitana
Bactrites gracilior
B. aciculum
Orthoceras pacator
O. ontario
O. filosum

Pteropods

Hyolithus neapolis
Tentaculites gracilistriatus
T. tenuicinctus
Styliolina fissurella
Protospirialis minutissima

Gastropods

Loxonema noe
Macrochilina pygmaea
Palaeotrochus praecursor
Diaphorostoma rotundatum
Pleurotomaria cognata
P. ciliata
Protocalyptraea marshalli

Lamellibranchs

Lunulicardium acutirostrum
L. ornatum
L. clymeniae
L. hemicardioides
L. velatum
L. finitimum
L. sodale

Gastropods

Phragmostoma natator
P. incisum
P. *cf.* triliratum
Tropidocyclus hyalinus
Bellerophon koeneni

Lamellibranchs

Lunulicardium pilosum
L. parunculus
Pterochaenia fragilis
P. fragilis *var.* orbicularis
P. perissa
Honeoyea erinacea
H. major
H. simplex
Paraptyx ontario
Ontaria suborbicularis
O. clarkei
O. affiliata
O. halli
Buchiola retrostriata
B. scabrosa
B. conversa
Paracardium doris
Palaeoneilo petila
P. muricata

Middlesex black shale

Cephalopoda

Sandbergeroceras syngonum

Lamellibranchs

Pterochaenia fragilis

Spathiocaris emersoni

Brachiopods

Lingula ligea

Upper Genesee shales

Intumescens fauna absent

Genundewa (Styliola) limestone

Fishes

Dinicthys newberryi

Spathiocaris emersoni

Pteropods

Styliolina fissurella
Protospiralis minutissima
Tentaculites gracilistriatus

Cephalopods

Manticoceras pattersoni *var.* styliophilum
M. contractum
M. fasciculatum
M. nodifer
Gephyroceras genundewa
Tornoceras uniangulare *var.* compressum

Gastropods

Loxonema noe
Pleurotomaria genundewa
Protocalyptraea styliophila
Phragmostoma natator
P. incisum
Bellerophon koeneni
B. denckmanni
Macrochilina seneca
Diaphorostoma pugnus

Lamellibranchs

Lunulicardium hemicardioides
L. encrinitum
Honeoyea styliophila
Pterochaenia fragilis
P. fragilis *var.* sinuosa
Buchiola ? livoniae
B. scabrosa
Paracardium doris
P. delicatulum

Crinoids

Melocrinus clarkii
Taxocrinus

Corals

Aulopora annectens

In the following tabulation the geographic distribution in the two subprovinces is portrayed.

GEOGRAPHIC DISTRIBUTION OF THE FAUNA OF THE GENESEE PROVINCE

c = common; cc = abundant; r = rare; rr = very rare. Species marked with a dagger have been found only in the black shale beds.

	NAPLES SUBPROVINCE			CHAUTAUQUA SUBPROVINCE
	Styliola or prenuncial fauna	Cashaqua shales, west		
Dinicthys newberryi *Clarke*	r	-	r	
Palaeoniscus devonicus *Clarke*†	-	-	r	
Acanthodes pristis *Clarke*†	-	-	r	
Pristacanthus vetustus *Clarke*	-	-	r	
Polygnathus dubius *Hinde*†	-	-	c	r
Prioniodus spicatus *Hinde*†	-	-	c	r
P. erraticus *Hinde*†	-	-	c	r
Stylonurus ? wrightianus *Dawson* (sp.)	-	-	r	
Echinocaris ? beecheri *Clarke*	-	r		
E.? longicauda *Hall* (sp.)	r			
Eleutherocaris whitfieldi *Clarke*	-	-	r	
Entomis serratostriata *Sand.*	-	-	r	
E. variostriata *Clarke*	-	-	r	
Spathiocaris emersoni *Clarke*	r	c	c	
Cardiocaris	c			
Dipterocaris	-	-	r	
Manticoceras pattersoni *Hall* (sp.)	-	-	cc	
M. pattersoni *var.* styliophilum *Clarke*	c			

	NAPLES SUBPROVINCE			CHAUTAUQUA SUBPROVINCE
	Styliola or prenucial fauna	Cashaqua shales, west		
Manticoceras apprimatum *Clarke*	-	-	- - r	
M. tardum *Clarke*	-	-	- r	
M. simulator *Hall* (sp.)	-	-	r (Ithaca)	
M. rhynchostoma *Clarke*	-	-	- -	- cc
M. contractum *Clarke*	r			
M. fasciculatum *Clarke*	c			
M. nodifer *Clarke*	r			
M. sororium *Clarke*	-	-	- -	- - c
M. accelerans *Clarke*	-	-	- r	
M. oxy *Clarke*	-	-	- - c	
M. vagans *Clarke*	-	-	- r	
Gephyroceras perlatum *Hall* (sp.)	-	-	r (Ithaca)	
G. holzapfeli *Clarke*	-	r		
G. cataphractum *Clarke*	-	-	- -	- r
G. *cf.* domanicense *Holzapfel*	-	-	-	- - r
G. (Probeloceras ?) genundewa *Clarke*	c			
Probeloceras lutheri *Clarke*	-	c	- - cc	
P.? naplesense *Clarke*	-	-	- r	
Beloceras iynx *Clarke*	-	-	- - c	
Sandbergeroceras syngonum *Clarke*†	-	-	- r	
Tornoceras uniangulare *Conrad* (sp.)	-	-	- - cc	
T. uniangulare *var.* obesum *Clarke*	-	-	- r	
T. uniangulare *var.* compressum *Clarke*	r			
T. peracutum *Hall* (sp.)	-	-	r (Ithaca)	
T. bicostatum *Hall* (sp.)	-	-	- - rr - -	- cc
T. rhysum *Clarke*	-	-	- -	- - r
Cyrtoclymenia neapolitana *Clarke*	-	-	- - c	
Bactrites gracilior *Clarke*	-	-	- c	
B. aciculum *Hall* (sp.)	-	c	- - c	
Bactrites *cf.* subflexuosus *Keys.*	-	-	-	- c
Orthoceras pacator *Hall*	-	c	- cc	
O. ontario *Clarke*	-	-	- - r	
O. filosum *Clarke*	-	-	- r -	- - r
O. thyestes *Hall*	-	-	- - c	
O. atreus *Hall*	r	-	- r - - r	
Gomphoceras ajax *Hall*	-	-	- - r -	- - r
G. manes *Hall*	-	-	- r	
Hyolithus neapolis *Clarke*	-	-	- - cc - -	- r
Styliolina fissurella *Hall*	cc	cc	- cc -	- - c
Protospiralis minutissima *Clarke*	-	r	- - cc	
Tentaculites gracilistriatus *Hall*	c	-	c	

	NAPLES SUBPROVINCE				CHAUTAUQUA SUBPROVINCE
	Styliola or prenuncial fauna	Cashaqua shales, west			
Tentaculites tenuicinctus *Roemer*	-	-	c		
Pleurotomaria cognata *Clarke*	-	-	c		
P. itylus *Clarke*	-	-			r
P. ciliata *Clarke*	-	-	c		
P. genundewa *Clarke*	cc				
Bellerophon koeneni *Clarke*	c	-	r		
B. denckmanni *Clarke*	c				
Phragmostoma natator *Hall*	r	c	cc		
P. incisus *Clarke*	r	-	c		
P. chautauquae *Clarke*	-	-			cc
P. *cf.* triliratus *Hall*	-	-	r		
Tropidocyclus hyalinus *Clarke*	-	-	r		
Loxonema noe *Clarke*	r	c	cc		
L. danai *Clarke*	-	-			c
L. multiplicatum *Clarke*	-	-			r
Macrochilina pygmaea *Clarke*	r	-	r		
M. seneca *Clarke*	r				
Palaeotrochus praecursor *Clarke*	-	c	cc		c
Callomena filosum *Clarke*	-	-			r
Diaphorostoma rotundatum *Clarke*	-	-			r
D. pugnus *Clarke*	r	-			r
Protocalyptraea styliophila *Clarke*	r				
P. marshalli *Clarke*	-	-	r		
Lunulicardium acutirostrum *Hall*	-	-	x		
L. ornatum *Hall*	-	-	x		
L. libum *Clarke*	-	-			r
L. wiscoyense *Clarke*	-	-		r	
L. accola *Clarke*	-	-			r
L. clymeniae *Clarke*	-	-	c		
L. eriense *Clarke*	-	-			c
L. hemicardioides *Clarke*	r	-	r		
L. furcatum *Clarke*	-	-			r
L. velatum *Clarke*	-	-	r		
L. finitimum *Clarke*	-	-	r		
L. sodale *Clarke*	-	-	r		
L. encrinitum *Clarke*	r				
L. pilosum *Clarke*	-	r	c		
L. bickense *Holzapfel*	-	-		c	c
L. absegmen *Clarke*	-	-			r
L. enode *Clarke*	-	-		r	
L. parunculus *Clarke*	-	-	c		

	NAPLES SUBPROVINCE				CHAUTAUQUA SUBPROVINCE
	Styliola or pre-nuncial fauna	Cashaqua shales, west			
Lunulicardium beushauseni *Clarke*	-	-	- - -		- c
L. suppar *Clarke*	-	-	- -	r	- - r
L. *sp. nov.*	r				
L. *sp. nov.*	-	-	- - -		- r
L. (Opisthocoelus ?) transversale *Clarke*	-	-	- - r		
Pterochaenia fragilis *Hall*	cc	c	- c - -		- - r
var. orbicularis *Clarke*	-	-	- - c		
P. sinuosa *Clarke*	cc				
P. perissa *Clarke*	-	-	- r		
P. elmensis *Clarke*	-	c			
P. cashaquae *Clarke*	-	-	- - -	c	
Honeoyea erinacea *Clarke*	-	-	- - c - -	c	
H. major *Clarke*	-	-	- c -	r	
H. styliophila *Clarke*	c				
H. simplex *Clarke*	r				
H. desmata *Clarke*	-	-	- - r - -	r	
Paraptyx ontario *Clarke*	-	-	- c		
Actinopteria sola *Clarke*	-	-	- - r		
Leptodesma *cf.* rogersi *Hall*	-	-	- r		
Posidonia attica *Williams* (sp.)	-	-	- - r -	c	- r
P. mesacostalis *Williams* (sp.)	-	-	-		- - c
P. venusta *var.* nitidula *Clarke*	-	-	- -		- r
Kochia ungula *Clarke*	-	-	-		- - r
Loxopteria dispar *Sandberger*	-	-	- -		- c
L. laevis *Frech*	-	-	-		- - c
L. vasta *Clarke*	-	-	- -		- r
L. intumescentis *Clarke*	-	-	-		- - c
L. corrugata *Clarke*	-	-	- -		- c
Ontaria suborbicularis *Hall* (sp.)	r		- - cc		
O. concentrica *v. Buch* (sp.)	-	-	-		- - r
O. pontiaca *Clarke*	-	-	- -		- r
O. accincta *Clarke*	-	-	-	c	
O. clarkei *Beushausen* (sp.)	-	-	- - c		
O. affiliata *Clarke*	-	-	- r		
O. halli *Clarke*	-	-	- - r		
Euthydesma subtextile *Hall*	-	-	- -		- - cc
Elasmatium gowandense *Clarke*	-	-	-		- c
Buchiola retrostriata *v. Buch* (sp.)	r	c	- - cc		
B.? livoniae *Clarke*	r	-	- r		
B. scabrosa *Clarke*	c	-	- - c -		- - r
B. conversa *Clarke*	-	-	- r - -		- r

	NAPLES SUBPROVINCE			CHAUTAUQUA SUBPROVINCE
	Styliola or pre-nuncial fauna	Cashaqua shales, west		
Buchiola angolensis *Clarke*				r
B. lupina *Clarke*				r
B. *cf.* prümiensis *Stein.* (sp.)				r
Paracardium doris *Hall*	cc		c	r
P. delicatulum *Clarke*	r			
Praecardium vetustum *Hall*				cc
P. duplicatum *Münster* (sp.)				r
P. multicostatum *Clarke*				r
Conocardium gowandense *Clarke*				r
Palaeoneilo constricta *Conrad* (sp.)				c
P. petila *Clarke*			c	r
P. muricata *Clarke*			c	
P. brevicula *Clarke*				r
P. linguata *Clarke*				cc
Leptodomus interplicatus *Clarke*			c	
L. multiplex *Clarke*			r	
Productella speciosa *Hall*			r	
Chonetes scitulus *Hall*			r	
Crania centralis *Hall*				r
Lingula ligea *Hall*†		r	c	c
L. triquetra *Clarke*			r	
L. spatulata *Hall*	cc			
Lingulipora williamsana *Girty*	r			
Aulopora annectens *Clarke*	cc		cc	c
Melocrinus clarkei (*Hall*) *Williams*	cc		c	
Taxocrinus *sp.*	r			
Scytalocrinus? ornatissimus *Hall*				r
Cordaeoxylon clarkei *Dawson*	cc		c	r
Cladoxylon mirabile *Unger*	r			
Cyclostigma affine *Dawson*	r			
Lepidodendron gaspianum *Dawson*	r		c	
L. primaevum *Rogers*	r		r	
Asteropteris noveboracensis *Dawson*			r	

DISTINCTIVE FEATURES OF THE SUBPROVINCIAL FAUNAS

The last of the tables given brings out with force the fact that, while there is but a small proportion of species common to the extreme east and west sections of the Genesee province in New York, there is a striking preponderance of species whose genera are common to both regions. This commonalty of genera however is a no more impressive feature of these subprovinces than it is of the development of the Intumescens fauna throughout the world.

We have previously noted that these subprovinces are regarded not as contemporaneous divisions throughout, but as sequential in this degree: that the fauna of the Naples or eastern subprovince covered the westward area at the opening of Portage time and is represented in moderate degree in the contracted deposits of Cashaqua shales of that area. So far as its eastward and westward representatives are concerned, there is no important variation, but the fauna attained its profusion of development toward the east. The distinctive fauna of the Chautauqua subprovince comes in with the Angola gray shales, while in the east at this time the Naples fauna continued and at a still later date, during the perdurance of the Chautauqua fauna at the west, was replaced by the invading brachiopod fauna. Hence the Chautauqua is sequential to the Naples fauna in western sections and contemporaneous with the late stages of that fauna in the Genesee valley and eastward.

The discrepancies in these faunas east and west, we have in a measure already noticed in our previous discussion of the cephalopods. Here we observe the prevalence of the Manticoceras intumescens type in both, but under very distinct expressions, the M. pattersoni of the east being a more highly progressed species than the common M. rhynchostoma of the west. The smaller expressions of this genus which are frequent in the east have a highly local significance and are absent in the Chautauqua region. With Gephyroceras much the same is the condition. We recognize no form of this genus in the Chautauqua subprovince except the G. cf. domanicense Holz., but in the Genundewa limestone of the east and in the Cashaqua shales of both east and west there are species of this genus. The specially interesting Probeloceras lutheri, Beloceras iynx and Sandbergeroceras syngonum are not known nor are the genera recognized in the Chautauqua subprovince. Bactrites is common to both faunas but not in species. We recognize in the west, in accordance with the many other European affiliations of that fauna, B. cf. subflexuosus, in the east B. aciculum and B. gracilior.

The mode of occurrence of Clymenia is noteworthy. It is known in the Naples subprovince only, and, though it occurs as far west as Java, it does not pertain to the Chautauqua fauna. Nor does it occur at a specific or high horizon in the rocks, but, on the contrary, the fauna is long continued in typical expression after its disappearance. Herein is a noteworthy convergence from the differentiation of facies exhibited by the European sections. Most marked among the faunal differences are the presence and often profusion of Euthydesma, Kochia, Loxopteria in several species, Praecardium and Elasmatium in the Chautauqua subprovince and their exclusion from more eastern sections, and by contrast the abundance of the coarsely plicated forms of Lunulicardium (Pinnopsis) in the east and their absence in the west. Throughout the lamellibranchs it is noticeable that species common to both subprovinces if abounding in one are unusual in the other. It will be observed that, so far as we understand the succession of fossils in the Chautauqua region, there is no sequential appearance of the leading fossils such as Mantic. rhynchostoma, Euthydesma, Kochia, Loxopteria and Praecardium, on the contrary they appear now to be pretty uniformly distributed through the Silver Creek, Angola and Portland gray soft shales and, with the other members of the assemblage, to correspond to the sedimentation. This uniformity of distribution is equally manifested in the leading species of the Naples subprovince. Minuter assemblages recurring at brief intervals through the strata of course vary somewhat in their combination, but the significance of such variations is here as in other cases in the sequence of faunas, of very minor importance save as they may serve to indicate the first or the final appearance of given species in a certain section. It would be difficult indeed to indicate any governing principle in such assemblages or to draw therefrom conclusions of breadth or weight in the interpretation of faunation.

CORRELATION OF THE FAUNA OF THE GENESEE PROVINCE WITH THE INTUMESCENS FAUNA OF EUROPE

To enter into detail with regard to specific similarities between the New York and other manifestations of this fauna would be to redescribe a large measure of the entire assemblage. We have noted several species which, ignoring fugitive variations, are here determined as identical in both the Eurasian and American regions; many others reveal indications of closest alliance which are provisionally designated with distinctive terms. Herein are evinced a most remarkable uniformity and persistence of specific characters over a tremendous area of the ocean, which make this zone one notable in geologic history for the vigor with which its life forms have perpetuated and disseminated their distinctive traits; and, accompanying this uniformity of bionic expression, is a singular correspondence in the rather unusual quality of sedimentation.

We find the following species of European faunas present in the New York basin.

Entomis serratostriata Sandberger. The index species of the Cypridina shales everywhere; occasionally at lower horizons (Upper Hartz). Rare in the Cashaqua shales of Livingston county.

Entomis variostriata Clarke. In the Goniatite limestone at Bicken and the Cashaqua shales of Livingston county.

Manticoceras intumescens Beyrich. M. pattersoni and M. rhynchostoma, the principal expressions of this type in the eastern and western subprovinces respectively, differ no more from each other than the varying expressions of M. intumescens. To apprehend the real value of these differences in the European forms, much study is still required, for in them doubtless is to be found the key to the origin and point of dissemination of the species. We have employed other specific terms as indicatory of significant distinctions. M. ammon (Timan) is a parallel expression of M. pattersoni.

M. simulator and the extremely progressed M. oxy appertain to the same category in New York, and likewise M. orbiculus, M. buchi, M. carinatus etc. in Europe.

Gephyroceras *cf.* **domanicense** Holzapfel. This species has been found in the Angola shale of Chautauqua county. Typical forms of G. domanicense from the Domanik are assigned to no distinctive horizon apart from the rest of the fauna.

Tornoceras bicostatum Hall. This species, highly characteristic of the Angola and Portland shales of the Chautauqua subprovince, is identical with Torn. cinctum Keyserling.

Bactrites *cf.* **subflexuosus** Keyserling. Of the Domanik shales; is a species of the Angola shale of the Genesee province.

Lunulicardium bickense Holzapfel. In the Adorf limestone and the Angola shale.

Buchiola retrostriata v. Buch. Very common in the lower horizons in both continents.

B. prümiensis Steininger. At Büdesheim and Oberscheld; probably in the Angola shale.

Loxopteria dispar Sandberger. This occurs at a high horizon (Clymenia limestone, Nehden schists) in the Rhine sections. In the Chautauqua subprovince its horizon is likewise high (Portland shale).

Lox. laevis Frech. From the Clymenia limestone at Wildungen, from the Angola and Portland shales of Chautauqua county.

Praecardium vetustum Hall. From high horizons (Nehden shales, Clymenia limestone) in Westphalia and in the Angola and Portland shales of western New York.

P. duplicatum Münster. In the Clymenia limestone of Franconia and the Angola shales of New York.

Euthydesma subtextile Hall. In the Clymenia and Adorf limestones and in the Angola and Portland shales.

Ontaria concentrica v. Buch. In the Adorf limestone and the Portland shale.

O. clarkii Beushausen. In the shales at Oberscheld and at Naples.

Posidonia venusta Münster. This species occurs in the Cypridina shales of Westphalia and the Hartz, in the Clymenia limestone of Poland and the var. nitidula in the Portland shales.

Tentaculites tenuicinctus Sandberger. In the lower horizons "Goniatite limestone" of Poland, Adorf limestone and the Cashaqua shales of Naples.

Cordaeoxylon clarkei Dawson. Very common in the Genundewa limestone and occasionally in the Cashaqua shales of Ontario county. Dawson in late papers regarded this as probably identical with Aporoxylon primigenium Unger from the Cypridina shale of Thuringia.

Cyclostigma affine Unger. In the Cypridina shale of Thuringia and the Genundewa limestone.

Cladyoxylon mirabile Unger. In the Cypridina shale of Thuringia and the Genundewa limestone.

Kalymma grandis Unger. In the Cypridina shale of Thuringia and the Black shale of Moreland Ky.

Spathiocaris emersoni Clarke. Common in Timan and in the gray and black shales of New York and Indiana.

Cardiocaris. In the black shales at Büdesheim and in New York.

Dipterocaris. In the black shales and limestone of Büdesheim, Timan and New York.

The correspondence of these identical species with reference to sequential position is noteworthy. Restated in tabular form they are thus:

	HIGHER HORIZONS		LOWER HORIZONS	
	EUROPE	NEW YORK	EUROPE	NEW YORK
	Cypridina shales Clymenia limestone Nehden schists	Angola and Portland shale	Matagne schists Adorf limestone Domanik shale	Cashaqua shale
Entomis serratostriata	x	-	-	x
E. variostriata	-	-	x	x
Gephyroceras *cf.* domanicense	-	x	x	
Tornoceras cinctum	-	x	x	
Bactrites *cf.* subflexuosus	-	x	x	
Lunulicardium bickense	-	x	x	
Buchiola retrostriata	-	-	x	x
B. prümiensis	-	x	x	
Loxopteria dispar	x	x		
Lox. laevis	x	x		
Praecardium vetustum	x	x		
P. duplicatum	x	x		
Euthydesma subtextile	x	x		
Ontaria concentrica	x	x		
O. clarkei	-	-	x	x
Posidonia venusta	x	x		
Tentaculites tenuicinctus	-	-	x	x
Spathiocaris emersoni	-	x	x	x
Cardiocaris	-	-	x	x
Dipterocaris	-	-	x	x
Cordaeoxylon clarkei	x	-	-	x
Cyclostigma affine	x		-	x
Cladoxylon mirabile	x	-	-	x
Kalymma grandis	x	-	-	x

Relationships in the species of the faunas, apart from these identities, are constantly displayed and have been elsewhere referred to in more detail. These are briefly restated. (In this list species of the lower horizons are indicated by italics.)

	REPRESENTATIVE	AFFINE
Gephyroceras ? (Probeloceras ?) genundewa Clarke		*G. forcipifer* Sandberger
Beloceras iynx Clarke		*B. kayseri* Holzapfel, Martenberg
Sandbergoceras syngonum Clarke		*Gon. tuberculoso-costatus* Sandberger
Tornoceras uniangulare Conrad	Torn. simplex *v. Buch*	*T. circumflexum* Sandberger

T. uniangulare-obesum Clarke		*T. circumflexum-incrassatum* Gürich
T. uniangulare-compressum Clarke		*T. circumflexum-applanatum* Gürich
Bactrites gracilior Clarke		*B. gracilis* Sandberger
Cyrtoclymenia neapolitana Clarke		C. spinosa *Münster*
Gomphoceras atreus Hall		*G. uchtense* Holzapfel, Timan
Orthoceras filosum Clarke		*Orthoceras* sp. nov. Holzapfel, Martenberg
O. pacator Hall	O. *sp.* Timan	
O. ontario Clarke	O. *sp.* Timan	
Lunulicardium clymeniae nov.		*L. paradoxa* Holzapfel, Martenberg
L. accola nov.		*L. denckmanni* Beushausen, Wildungen
L. parunculus nov.	*L. dilatatum* Beushausen, Martenberg, Wildungen	
L. absegmen nov.		*P. inflatum* Holzapfel, Martenberg
Pterochaenia fragilis Hall		*Avicula hians*, Waldschmidt, Wildungen *Pteroch. uchtensis* Clarke, Timan

Honeoyea. Though species of this genus have not been specially reported by recent German writers, it is noteworthy that some of the shells described by Münster in 1840 from Elbersreuth very intimately suggest these New York forms. Of these attention may be specially directed to his Cardium semialatum, C. paucicostatum and C. alternans.

Loxopteria corrugata *nov.*	L. rugosa *Frech*, Oberscheld	
Praecardium multicostatum *nov.*		P. *sp.* Beushausen, Enkeberg
Ontaria suborbicularis Hall		*Cardiola concentrica* v. Buch
O. pontiaca *nov.*		C. concentrica
O. halli nov.	Avicula problematica *Münster*, Presseck	*C. subarticulata* Beushausen, Martenberg
		C. articulata Münster, Timan
Conocardium gowandense *nov.*		*C. ibergense* Beushausen, Grund, Rübeland
Macrochilina pygmaea nov.		*M. dunkeri* Holzapfel, Martenberg
Loxonema noe Clarke	Melania arcuata *Münster*, Schübelhammer	*Lox. arcuata* Holzapfel, Martenberg
Palaeotrochus praecursor Clarke		*Pleurotomaria zitteli* Holzapfel, Martenberg
Pleurotomaria ciliata nov.		*P. angulata* Phillips P. *globosa* Holzapfel, Martenberg

Diaphorostoma pugnus nov.	Naticopsis domanicensis, *Keys.* Timan
Callonema pilosa *nov.*	*Holopea decheni Holzapfel,* Martenberg
Bellerophon Koeneni nov.	*B. tuberculatus* d'Orb. Timan

These lists suffice to demonstrate two important facts with regard to the affiliation of the faunas:

1 The species of the lower faunas in the European and New York expression are in many instances closely allied, but are seldom identical.

2 Specific identities prevail in the upper faunas of both regions.

RELATION OF THE FAUNA TO THE BLACK SHALES

The three bands of bituminous shales (four including the upper Genesee slate) which are intercalated amongst the beds to which the Intumescens fauna in New York is normal, are not to be regarded as in any sense the proper carriers of the fauna itself. The organic contents of these beds are few — some Lingulas and Orbiculoideas, Pterochaenia fragilis, Probeloceras lutheri, Bactrites, fish plates and plant remains, other organisms seldom appearing save with some concurrent change in the sediment with increase of lime or clay content, and doubtless for the most part those cited with other occasional remains have dropped down into the black muds from the higher zone of more prolific life.

These bands of black shale are eastward outrunners from a more continuous and extensive deposit of the same character farther westward. One arm of this black shale deposit extends westward of New York north of the Cincinnati dome through northern Ohio (Ohio shale) and into Ontario about Kettle Point, Lake Huron, Bosanquet and the region southward; westward into northern and thence western and southern Indiana (New Albany shale), Illinois and western Kentucky. Another reaches southward, east of the Cincinnati dome, through eastern Kentucky and eastern Tennessee into Alabama. Through this mass traces of lime bands and nodules, or lime-bearing shales, have been seldom noted, and the fossils which occur in the black shales have been quite generally regarded as indicating the age of the Genesee of New York.[1]

In the area north of the Cincinnati dome[2] Newberry found, in a thin gray layer near the upper part of the Ohio shale, fossils which he regarded as indicative of the Portage fauna of New York. These are cited as "Clymenia? complanata, Chonetes speciosa, Orthoceras aciculum and Leiorhyncus quadricostatus." For these names we may read Probeloceras lutheri, Cardiola speciosa (= Buchiola retrostriata), Bactrites aciculum, L. quadricostatum, a congeries which is indeed indicative of the Intumescens fauna; Whitfield has described from the nodules occurring in the Huron shale a number of remarkable Crustacea, Palaeopalemon newberryi, Echinocaris multinodosa, E. pustulosa and E. sublaevis. Remains of Echinocaris and other Phyllocarids occur with rarity in the Intumescens zone of New York, while Lingula ligea Hall, which Whitfield also found in the Huron shale, is everywhere present in the black shale bands of the Portage and occasionally in the gray shale. We may note in passing that, though the remains of decapods have not been observed at this stage elsewhere in America, yet Richter long ago described from the Cypridina shales of the Thuringian Forest a species of this character which he termed Gitocrangon granulatus.[3] The Ohio geologists agree that the black shale is there underlain by beds carrying the Hamilton fauna. In Indiana, according to recent observation by E. M. Kindle, the New Albany black shale rests on the Devonic limestones which carry a profuse Middle Devonic brachiopod fauna. Mr Kindle has shown that in these sections the black shale is interbedded with gray sandy shale,

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[1] Dr Girty has brought together the various views which have been expressed on the correlation of the black shale in eastern Kentucky and has described a number of species from the beds at Vanceburg with the New York formations and other localities. (Fauna found in the Devonian Black Shale of Eastern Kentucky. Am. Jour. Sci. 1898. 6 :384)

[2] Geol. of Ohio. 1873. 1 :154.

[3] Richter. Beitrag zur Paläontologie des Thüringer Waldes. 1848. p. 43.

and, while the whole mass attains a thickness of only about 100 feet, there are many alternations of black with the gray shale. At Lexington and other localities of the black shale the fossils are those usual in similar deposits eastward, Styliolina fissurella, Orbiculoidea lodensis, Lingula spatulata, Schizobolus concentricus etc.; but at Delphi Kindle has found, pyritized in blue shale, Goniatites wabashensis and G. delphiensis Kindle, both species of Gephyroceras or small individuals of Probeloceras or Manticoceras in a gephyroceran stage. Spathiocaris occurs in these shales, as it does throughout the black and gray bands of the Genesee and Portage in New York. No element of the fauna obtained from these Indiana beds, however, argues very strongly for equivalence with New York faunas later than Genesee.

The development of this shale at Irvine Ky. is stated by Williams to continue upward beyond the Devono-Carbonic boundary,[1] while the beds at Big Stone Gap he finds to be underlain by limestone carrying Onondaga corals. Girty calls attention further to Shaler's opinion that the formation in Kentucky and Tennessee represents the entire series of formations from the top of the Oriskany to the Chemung. The earliest incursion of these black muds on the New York area is represented by the Marcellus shales when the sediments were distributed northward and eastward from the deep waters lying off the southern coast of the Appalachian gulf, while the faunas of the limestones embedded in these black Marcellus shales were derived from the west.

The small group of species described by Dr Girty is from the base of the black shale and shows some characters which are common to both Marcellus and Genesee shales in New York;[2] but one Lingula, Lingulipora

[1] Am. Jour. Sci. 1897. 3:398.

[2] The fauna reported consists of the following:

(1) Lingulipora williamsana, (2) Liorhynchus quadricostatum, (3) Prioniodus armatus, (4) Sporangites huronensis?, (5) Orbiculoidea, (6) Meristella *cf.* haskinsi, (7) Plethospira socialis. Of these 2, 3, 4 are known alike in both Marcellus and Genesee; 7 is very similar indeed to P. rugulata,

williamsana Girty, the author also reports from the Styliola limestone of Ontario county and from the Genesee shale on Seneca lake, N. Y.

In this shale at Moreland, central Kentucky, occurs the plant Kalymma grandis Unger[1] originally described from the Cypridina shales of Thuringia.[2] Though this species has not been found in New York, yet the Styliola limestone here and occasionally the beds above have produced other Thuringian Cypridina shale plants, Cladoxylon mirabile Unger and Cordaeoxylon clarkei Daws. The latter of these, Dawson, in the final discussion of the species, regarded as very closely allied to, if not identical with, Araucarites ungeri Goeppert (=Aporoxylon primigenium Unger).

Let us note again the fact that, throughout the wide extent of this shale in the regions considered, it does not at any time attain the thickness which we may ascribe to it in New York, where bathymetric conditions seem to have been more favorable for its accumulation.[3]

The exposures of black shale along the Sydenham river at Alvinston and at Kettle Point (Lake Huron), Ontario, have been recently examined by Mr Luther and show only a slight thickness (15-20 feet, but incomplete at the top), and the bands rest directly on the Hamilton limestones. The organic contents are largely plant remains with Sporangites huronensis, a few fish plates and an impunctate Lingula, evidently L. ligea, which is common in the Portage black bands of New York. The beds may for stratigraphic reasons safely be regarded as exemplifying a continuation northwestward from New York of the Genesee and Portage black mud conditions.

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which occurs in both. So it would seem that the fauna and the beds containing it might be properly construed as representing the Devonic black shale beds of New York rather than any one of their component parts.

[1] Dawson, W. & Penhallow, D. P. Canadian Record of Science. Jan. 1891. 4:242.

[2] Unger.

[3] A maximum thickness for the black bands in New York, (1) Marcellus, (2) Genesee, (3) Middlesex, (4) Rhinestreet, (5) Dunkirk (2-5 to be included in the Portage), would be about 700 feet.

In the regions of British Columbia now included within the districts of Athabasca and Mackenzie, a wide expanse of black shale is known from the Clearwater or Little Athabasca river (lat. 57° n., long. 110° w.) northward along the Elk, Peace and Great Slave rivers to Great Slave lake (61° n.). Meek, in giving an account of the fossils collected in this region by Kennicott[1], and Isbister[2], who had previously traversed the region with Sir John Richardson, notes that at the mouth of the Clearwater the shales are 150 feet thick, lie on a concretionary limestone and are overlain by sandstones. Isbister regarded these bituminous shales, on the basis of some identifications of fossils by H. Woodward, as equivalent to the Marcellus of New York; but Meek has shown the lower limestones to bear a middle Devonic fauna with Hamilton characters, and the overlying sands are regarded as equivalent of the Chemung. This judgment, at least so far as the character of the lower limestones is concerned, is substantiated by Whiteaves, who has based his study of the fossils on new material largely collected by R. G. McConnell.[3] Near Fort Resolution on Great Slave lake these bituminous shales carry Styliolina fissurella, Chonetes setiger, "Avicula laevis" (= Pterochaenia fragilis), a "Lucina-like bivalve" (probably some form of Ontaria, perhaps O. suborbicularis) and Lingula cf. spatulata. Herein is the same indication of alliance to the black shales fauna of New York, whether Genesee or Portage, an indication of the contiguity of the true Intumescens fauna being shown in the presence of the "Lucina-like bivalve" and also in the occurrence reported by Whiteaves (to which we have previously adverted)[4] of a goniatite, undoubtedly Manticoceras intumescens, on the Hay river, which enters Slave lake west of Fort Resolution, in association with species characterizing the brachiopod facies or cuboides zone fauna (Hypothyris cuboides, Pugnax pugnus, etc.).[5] Still farther

[1] Chicago Acad. of Sci. Trans. 1869. 1:61.

[2] Quar. Jour. Geol. Soc. 1855. 11: 497.

[3] Contrib. to Canadian Paleontology. 1891. v. 1, pt 2.

[4] See part 1 of this work, N. Y. State Geol. An. Rep't. 1896. p. 138.

[5] Whiteaves. *Op. cit.*

west on the Liard river the bituminous underlying limestones have been observed. In this barely explored region and the vast territory northward and west to the seaboard much more definite evidence of the migration path of the Intumescens fauna is doubtless buried.[1]

Similarly throughout the immense and geologically unexplored region of northern Asia we still lack all but intimations of the presence of this fauna.

In the Timan or Petschoraland of northeastern Russia, lying on the Frozen sea, the fauna again blooms out in its fulness and purity, that is as an ammonoid or deep littoral congeries in calcareous banks and nodules interbedded with bituminous shales.

Of such special interest is this occurrence for comparison with the New York fauna that we give a brief analysis of its characteristics so far as now known. The general character of this fauna was portrayed in the celebrated work of Keyserling, *Wissenschaftliche Beobachtungen auf einer Reise in das Petschoraland im Jahre 1843;* 1846. We have given the section on page 355, but this is not as Keyserling determined it, the upper sands with Spirifer disjunctus being located by him as beneath the goniatite horizon of the Domanik shale.

Holzapfel's important treatise on the cephalopods of these Domanik shales of southern Timan,[2] and the writer's memoir on the Goniatites of the Naples fauna appeared almost simultaneously; hence neither writer

[1] It may be observed here, as a counterpoise to intimations of incompleteness of evidence bearing on these points, that, with the close of the well ordered and carefully executed geological survey of New York in 1843, but a handful of species had been acquired from the Portage formations of the State, too few indeed even to indicate the relationship with European faunas, and the formation as a whole was characterized in the final reports as one essentially barren of organic remains. Time and labor have shown the imperfection of this judgment (see list of species on page 360). From the vaster Canadian territory, so much less systematically explored in the first instance, we may rightfully look for proportionally greater results.

[2] Die Cephalopoden des Domanik in südlichen Timan: Mémoires du Comité geologique. 1899. v. 12, no. 3, p. 1–56, pl. 1–10

had the full benefit of the other's observations. The wonderful homogeneity in the development of the fauna in these two restricted regions, separated by 129 degrees of longitude,[1] is manifested not alone in the composition of generic and specific characters of the organisms, but equally in the nature of the sediments. The latter are largely black shales with intercalated limestone banks. Of the nature of these sediments Holzapfel says:

> The name *Domanik* is applied to a dark, mostly brown, somewhat calcareous and strongly bituminous shale with numerous calc concretions, which are arranged in successive layers. These concretions are the situs of immense numbers of fossils and are often completely filled with them while the shale itself contains but few. Once in a while one finds in the latter a compressed cephalopod, while, on the other hand, the shields described as Spathiocaris are quite abundant. Besides the cephalopods the limestones contain numberless Tentaculites and also Entomis and Buchiola retrostriata. Gastropods are rare; species of Cardiola are present, and also a peculiar brachiopod which is related to Camarophoria.

There is nowhere else so complete a parallel in all the factors involved in the homogenic manifestation of the fauna; and, as with these conditions it attains the fullest development of its peculiarities, we may give brief attention to a comparative analysis of the similarities and divergences in these two manifestations.

Manticoceras. On inspection of the young stages as well as the adult forms of M. intumescens, it is evident that this shell approaches M. pattersoni most closely without attaining in respect to whorl section the progressed adult condition of the latter. As little does it show in early stages the plump, broad whorls of the delayed M. rhynchostoma. It is interesting to observe that the Domanik form of M. intumescens retains the peculiarities of whorl section of the type of this species from the limestone at Oberscheld. We have shown that M. pattersoni and M. rhynchostoma, in adult and gerontic condition, both pass the stage represented by these broad backed shells, the former however very much earlier than the latter. Without difference in umbilication or other external

[1] The location of southern Timan is approximately 67° n., 51° e.; of western New York (centrally) 43° n., 78° w.

feature than that specified, these three terms, intumescens, pattersoni and rhynchostoma, express distinct paraphases of the specific type. [See table of paraphases of Manticoceras expressed in terms of M. pattersoni, pt 1 of this work, p. 83.]

Manticoceras ammon Keyserling is confessedly a very close ally of M. intumescens. Study of the figures and description given by Holzapfel impresses me with the striking agreement in essential differentials with the typical M. pattersoni, an agreement seen not alone in the evolution of the contour, but also in the progressive development of the sculpture from early stages onward. I think we may fairly conclude that in both the New York and the Timan faunas the two types are present, and that these two stand for each fauna, in essentially the same relations to each other.

In Manticoceras backlundi we have a broad backed shell with lateral pilae highly developed, an expression for which we find no precise equivalent in the Naples fauna.

It is remarked by Holzapfel that this genus is not as abundantly developed in individuals in the Domanik as in the Naples fauna, and it is a natural consequence that the variety of expression is less. But in the Naples fauna the minor expressions of the genus are relatively of less common occurrence.

Gephyroceras. We have noted in part 1 that this name, so far as dependent on its type species, is actually synonymous with Manticoceras, but have employed it for flat, discoid, widely umbilicated shells having a suture differing from that of Manticoceras in degree rather than kind, the lobes and saddles being equivalent in adulthood to an immature condition in Manticoceras. The name as it now stands is not grounded on any specified type and hence is of itself of unsubstantial value, but it has been employed by both Holzapfel and the writer with application to essentially the same group of forms.

In the Naples fauna the shells that could be referred to Gephyroceras are relatively few, but they share with Probeloceras lutheri and

Beloceras iynx the thin, disk-shaped, wide umbilicate shell, and in respect to suture there is an easy gradation from the simple outline of Gephyroceras into that of Probeloceras and Beloceras. Taking this series as a whole, it constitutes in New York the most abundant element of the goniatite fauna, and it is proper to bring it in its entirety into comparison with that group in the Domanik called Gephyroceras, which is by much the most prolific there in expression and individuals. Holzapfel describes 10 species of this genus, and in the Naples beds the series now includes eight members. Many of the Domanik species attain striking dimensions and the larger of them (G. rex, G. tschernyschewi) suggest to us the remains of equal size which occur in soft shales in southern Erie county (Pike's creek), but the sutures of which have not yet been ascertained, though they are probably progressed beyond the Gephyroceras stage and in harmony with the prevailing habit in the fauna, namely Probeloceras.

So far as externals are concerned the Naples fauna, in Gephyroceras holzapfeli, Probeloceras lutheri, P. naplesense and Beloceras iynx, will essentially duplicate some of the Domanik species; and we have noted that the Angola shales of Chautauqua county carry a species indistinguishable from G. domanicense in respect to exterior. Its suture is not known; and, while we have ventured to designate it as Gephyr. cf. domanicense, it is with the conviction that, in spite of its external agreement with that species, this suture will prove to be progressed beyond the gephyroceran stage. This agreement in exterior differentials amongst so important elements in the two faunas is perhaps the most remarkable of the characteristics common to both. It shows that the integrity of the entire group has suffered no external change throughout its travels, while there has been definite progress internally toward more complicated septation. Still further interpreted, it means that the Domanik is the point of geographic departure of this fauna westward, its species conserving traits which are in part unchanged and in part progressed during the geographic progress of the congeries.

Turning to the genus Timanites, these shells are closely umbilicated, and the suture is essentially equivalent in degree of lobation to Beloceras iynx, but, instead of the lobes and saddles all being narrow and angled, the lobes in Timanites acutus (type) are acute, the saddles broadly rounded; in T. stuckenbergi both lobes and saddles are rounded. Shells of this strange type seem to indicate a progression from Gephyroceras both external and internal. Close enrolment in this group is one of the indexes of progress, multisection of the suture another; the latter being the manifestation of such progress which, as just noted, has alone affected the migrants of Gephyroceras.

Prolecanites. As with the Naples fauna, the genus is represented by only a single and rare species. Prolec. timanicus has a less divided suture than Sandbergeroceras or Prolec. chemungensis, that is the former has an embryonal aspect with reference to the latter, but both are further exemplifications of the presence of inceptive forms of this genus in the Intumescens stage.

Tornoceras. The Domanik carries two species of this genus, T. simplex v. Buch, which is in effect T. uniangularis of the Naples fauna, and T. cinctum Keyserling, which is identical with T. bicostatum Hall. The last named in the writer's illustrations presents the edges of the broad hyponomic ridge apparently nearer to the back of the whorl but specimens are not infrequent which show all the characters afforded by T. cinctum.

Bactrites. Holzapfel redescribes B. subflexuosus Keyserling, which attains large size and bears an apparently smooth exterior and elliptic cross section, and also an undetermined species with characteristic oblique surface lines. We have already noted the presence in the Angola shales of a species very similar to the former, specified as B. cf. subflexuosus.

As for the other cephalopods of the Domanik, we find excellent equivalents in the New York fauna. Gomphoceras uchtense, cf. G. atreus, Phragmoceras [or Gomphoceras] timanicum, cf. a smaller species not described in the Chautauquan subprovince, Orthoceras sp., a smooth longicone like O. pacator, Orthoceras sp., a subannulate shell like O. ontario or identical with a form from the western subprovince.

Spathiocaris occurs in great abundance in the bituminous shales and lime banks of the Domanik, just as it does, and in like form, in the black shales and sandy shales and flags of the Portage beds. It is noteworthy that all the forms figured by Holzapfel take on the outline of S. emersoni, which is the prevailing form in the Portage, though in New York we find the Cardiocaris outline as well as the doubly cleft shields, Dipterocaris (occurring also at Büdesheim), and Holzapfel puts forward a strong argument in favor of the view that these bodies have no organic connection with the goniatites.

This cephalopod fauna is accompanied by lamellibranchs and gastropods, to which less attention has been thus far specially given. Keyserling described Cardiola [Ontaria] tenuistriata Münst., C. [O.] concentrica v. Buch, C. [O.] articulata Münst., C. [Buchiola] retrostriata, Bellerophon tuberculatus d'Orb. (cf. B. koeneni), Naticopsis domanicensis Keys. (cf. Diaphorostoma pugnus) and Sigaretus uchtae Keys.

SUMMARY

1 The fauna of the *Naples beds*, as the term has been heretofore employed and as used in the title of this work, is a congeries integrated by its organic characters and its bionomic relations from appearance to vanishment and unitive in its essentiality. With contemporaneous faunas of the Appalachian gulf it has, in its purity, no organic relation direct or sequential, but at the boundaries of the province may become implicated with the latter by the incident of geographic contiguity.

2 This Naples fauna as a whole is geographically characterized with greater accuracy as that of the *Genesee province*. In its integrity it represents the Eurasian Upper Devonic faunas above the horizon of Hypothyris cuboides (Tully limestone of New York) and below the brachiopod fauna with culminating Spirifer disjunctus. In the New York sections, however, it is followed by and is in part contempo-

raneous with a tremendous development of the brachiopod fauna, which is equivalent in sequence and in composition to that of the Condroz and Famenne sands of Belgium etc.

3 The geographic subdivision of this integral into (1) the Naples and (2) Chautauqua subprovinces determinates: (*a*) the early arrival of the lower fauna in the Genesee province, its primary occupancy of the entire area, its eventual profuse development at the eastern end of the province till the incoming of the brachiopod fauna from the east; (*b*) the subsequent arrival of the organic assemblage which more fully exemplifies the later stages of the Eurasian fauna, stratigraphically sequential to the feeble western development of its predecessor, profuse in its own development in its proper province but unable to penetrate the province of its antecursor, consubstantial and contemporaneous with it during all its own stages but during the later stages only of the antecedent fauna.

4 The fauna in its entirety shows a subversion of the facial differentials distinguishing its European phases, and species there recognized as successional indexes are here disvalued (Clymenia, Entomis serratostriata, Chiloceras). On the other hand, entire convergence of faunal differentials is not effected, and certain indexes retain their value in both lower and higher components of the fauna.

5 In terms of paleontology the fauna as a whole is the Intumescens fauna, for it is permeated throughout, in the development of both of its geographic elements, with goniatites of the type of Manticoceras intumescens and their normal accompaniments.

6 The uniformity of expression of the fauna as a whole throughout its world-wide manifestation is its most noteworthy character and is without parallel.

7 By the letting down of the old Mississippian land barrier, which guided the Middle Devonic (Hamilton) fauna from the far south into the Appalachian gulf, the Intumescens fauna entered this region from the northwest, and the proximal part of the path of its migration lies buried beneath Lake Erie.

8 Analysis of progressive development in septal structure of the goniatites indicates that species in Timan, New York and Germany having external differentials closely approximate, are simplest in septal expression in Timan, more progressed in New York and attain extreme specialization in this respect in Germany. Interpreting this as an indication of progressive modification during migration we find herein additional evidence of dispersion from Timan eastward to New York and from New York eastward to Europe.

EXPLANATION OF PLATES

With much regret the author feels impelled to state that, owing to the demise of Mr Philip Ast who for upward of 30 years lithographed with superior skill the plates for the paleontologic reports, it became necessary to resort temporarily to less satisfactory methods for the reproduction of the plates here presented. While this proceeding was deemed judicious in order to avoid too long delay in publication, the finer details of structure shown on the excellent original drawings have suffered seriously in this process and so wide a departure from the standard quality of the work is deplored.

PLATE 1

Genus LUNULICARDIUM Münster

Page 219

Lunulicardium (Pinnopsis) acutirostrum Hall

[*See* pl. 4]

Page 229

1 A left valve with strong growth marks and well defined surface characters. x2
Naples subprovince — Naples

2 A left valve; figure copied from *Paleontology of New York*, v.5, pt 1, pl. 71, fig. 31, where it is stated that the specimen is from the Chemung beds at Elmira. This statement is not to be accepted without question.

3 A right valve with fine and numerous ribs
Naples subprovince — Naples

4, 5 Lateral and rear views of a large left valve
Naples subprovince — Naples

6 A small left valve
Naples subprovince — Naples

Lunulicardium (Pinnopsis) wiscoyense sp. nov.

Page 233

7 A small right valve. x3
Genesee valley — Wiscoy creek

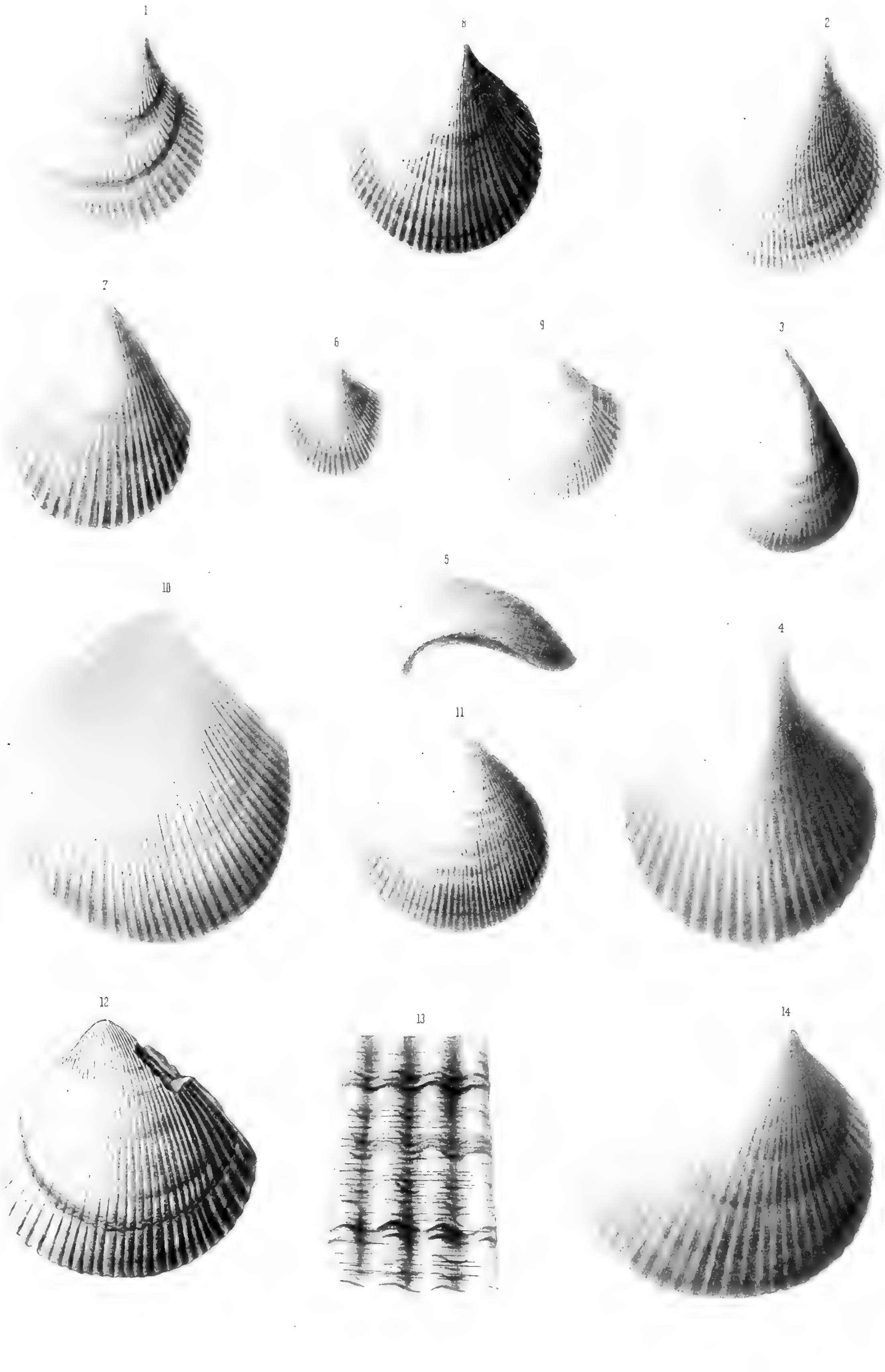
Lunulicardium (Pinnopsis) ornatum Hall

Page 231

8 A mature left valve
Naples subprovince — Naples

9 A smaller right valve showing the coarse plications behind the beak
Naples subprovince — Naples

10 A large left valve, the flatness of the plications being somewhat intensified by maceration
Naples subprovince — Naples



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11	A less oblique left valve	
	Naples subprovince	Naples
12, 13	A right valve with enlargement of surface	
	Naples subprovince	Belknap's gully, near Branchport
14	A rather transverse specimen of the left valve	
	Naples subprovince	Naples

PLATE 2

Genus LUNULICARDIUM Münster

Page 219

Lunulicardium (Chaenocardiola) clymeniae sp. nov.

Page 234

1-5 Views of a right valve, showing rear view with normal convexity and coarse plications behind the beak, lateral view with very fine surface striation, interior of valve and structure of the hinge which has been modified by a fine seam traversing and slightly distorting the ligament area, enlargement of the surface, and side view of the vertical sical wall. All are enlarged x3 except figure 4 which is x5

Naples subprovince — Whetstone gully near Livonia

6 Another right valve. x2

Naples subprovince — Briggs gully, Honeoye lake

Lunulicardium velatum sp. nov.

Page 237

7 A right valve somewhat restored. x1.5

Naples subprovince — Base of Hatch hill, Naples

8 One of two valves in conjunction. Natural size

Naples subprovince — Parrish gully, Naples

9 Enlargement of surface. x5

Naples subprovince — Base of Hatch hill, Naples

Lunulicardium (Pinnopsis) libum sp. nov.

[*See* pl. 4]

Page 232

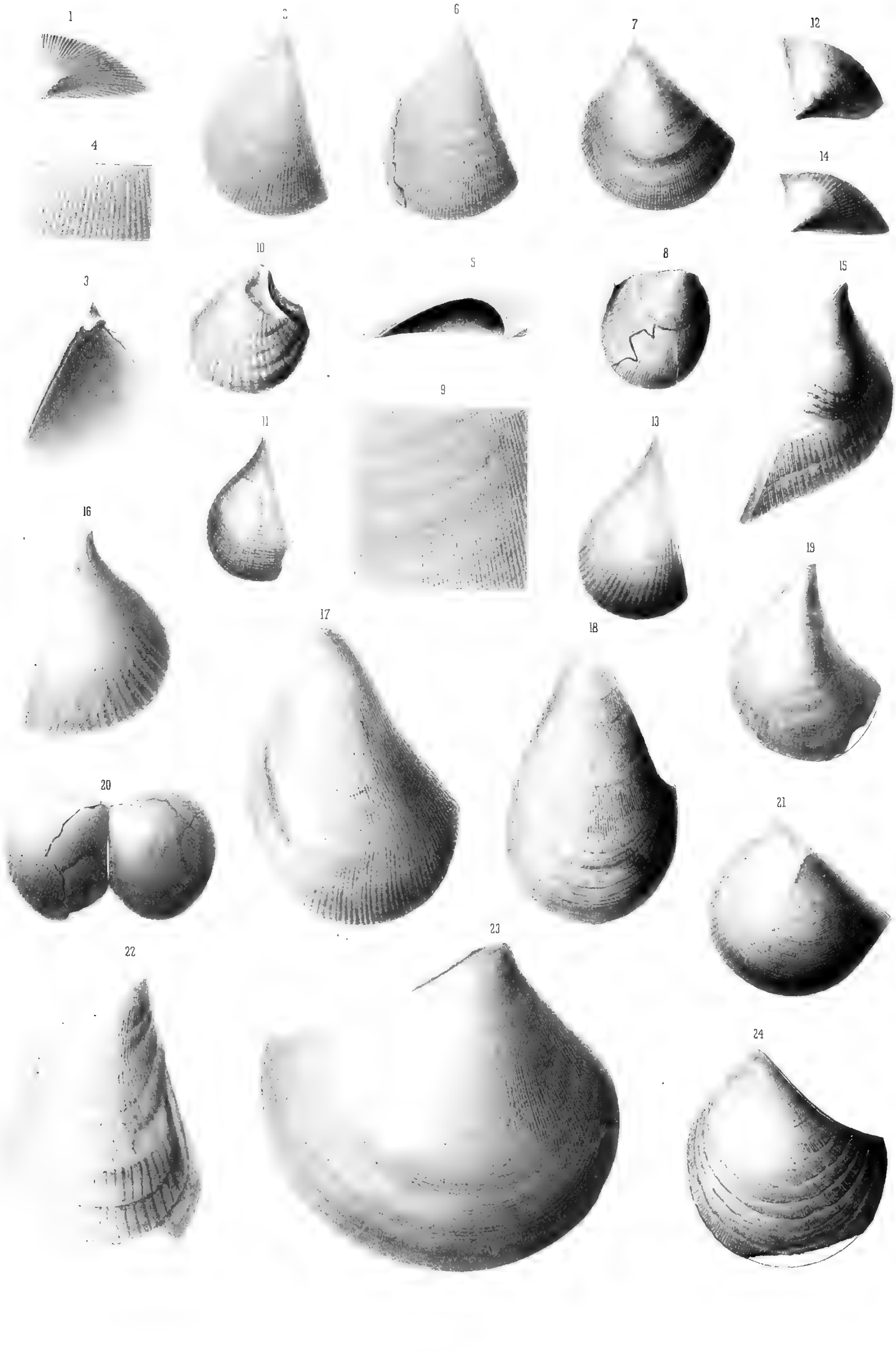
10 A right valve showing the broad ribs and short, oblique sica

Chautauqua subprovince — Fox's point, Lake Erie

Lunulicardium (Chaenocardiola) hemicardioides sp. nov.

Page 235

11 Sculpture cast of a right valve showing a scar which is probably muscular. x2



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12 The same viewed from behind showing the convexity. x2
Naples subprovince Parrish gully, Naples

13, 14 Similar views of another right valve with the surface plication better retained. x3
Naples subprovince Parrish gully, Naples

15 An apparently undistorted and complete internal cast of the left valve which is referred to this species

The specimen bears a large single muscle scar and shows the upturned broad sica. x3
Naples subprovince
Genundewa limestone, Canandaigua lake

16 Another internal cast with indistinct plications. x3
Naples subprovince
Genundewa limestone, Canandaigua lake

Lunulicardium finitimum sp. nov.

Page 238

17, 18 Two right valves showing the elongate form and exceedingly fine surface striation. 17, x3; 18, x2
Naples subprovince Parrish gully, Naples

Lunulicardium sp. nov.?

Page 245

19 Internal cast of a right valve with curved sical margin and few coarse plications
Naples subprovince
Genundewa limestone, Canandaigua lake

Lunulicardium encrinitum sp. nov.

Page 239

20 The valves juxtaposed showing orbicular outline and fine surface characters. x2
Naples subprovince Blacksmith gully, Bristol

Lunulicardium sp. nov.

Page 245

21 A right valve of orbicular form, long, oblique and straight sical margin, fine concentric striae and marginal traces of plications

Naples subprovince Seneca point, Canandaigua lake

Lunulicardium sodale sp. nov.

Page 238

22 A left valve with elongate form and relatively coarse plications. x2

Naples subprovince Naples

Lunulicardium pilosum sp. nov.

[*See* pl. 4]
Page 239

23 A left valve enlarged to show the extremely fine radial lines. x2

Naples subprovince Naples

24 A right valve showing the curved sical margin and usual outline. x2

Naples subprovince Parrish gully, Naples

PLATE 3

Genus LUNULICARDIUM Münster

Page 219

Lunulicardium mülleri Holzapfel

Pages 221, 228

1 Internal cast of left valve showing pallial line and juxtaposed or fusing muscle scars. x2

2 Rear view of the same. x2

Intumescens zone — Martenberg, Westphalia

Lunulicardium (Prochasma) bickense Holzapfel

Page 240

3 A right valve showing the absence of radial surface characters

Chautauqua subprovince — Big Sister creek, Angola

4 A small left valve

5 A larger right valve

Chautauqua subprovince

Lower Portage falls, Genesee river

11 A larger left valve

Chautauqua subprovince — Johnson's falls, near Strykersville

Lunulicardium suppar sp. nov.

Page 244

6, 7 Right and left valves. Natural size

Chautauqua subprovince — Johnson's falls, near Strykersville

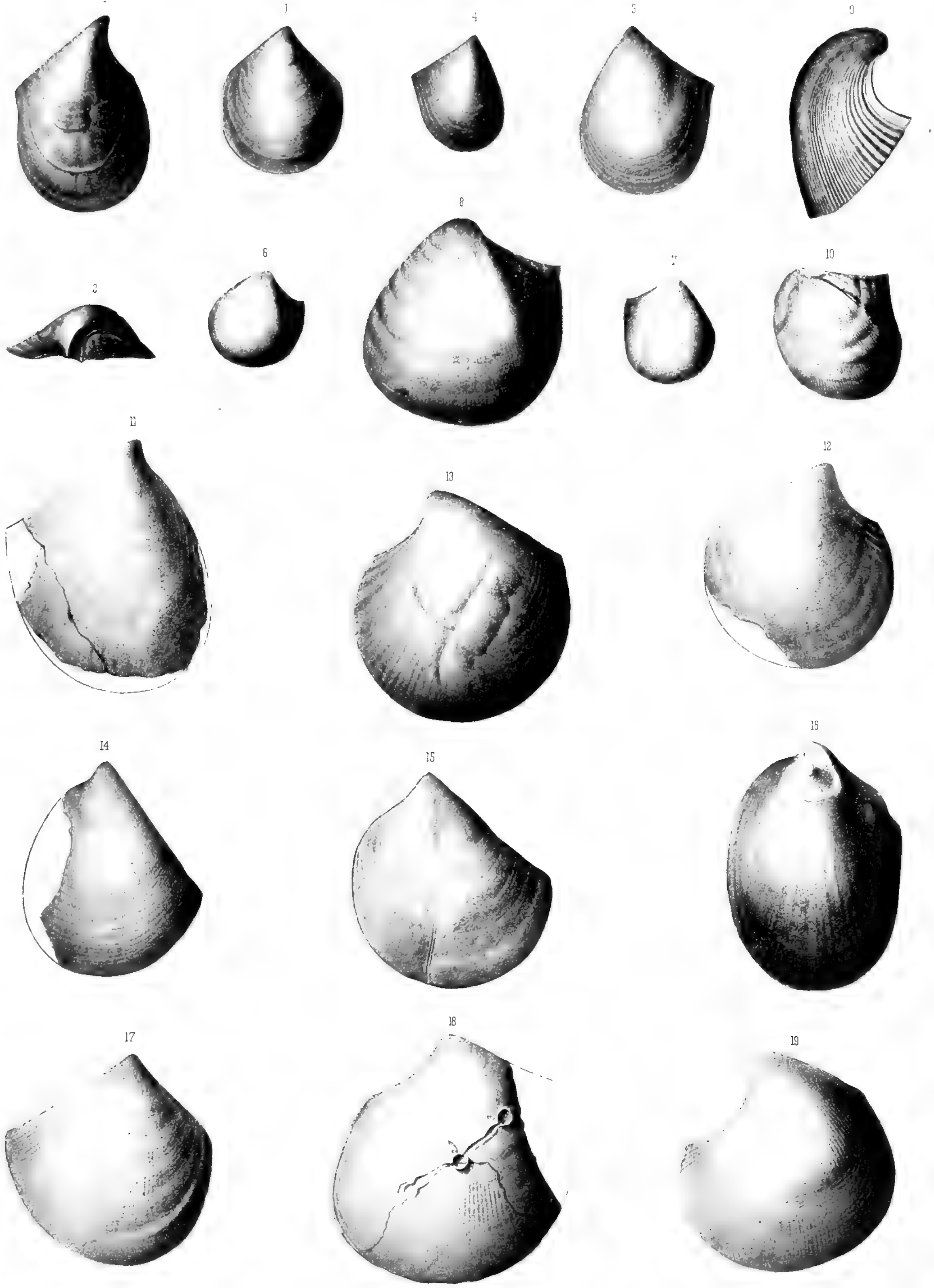
8 A right valve enlarged showing the imprint of the sica, the form, contour and surface lines of the shell. x2

9 Anterior view of the same specimen, showing the coarse flat plications near the sica. x2

Chautauqua subprovince — Johnson's falls, near Strykersville

10 A right valve flattened in shale

Genesee valley — Lower Portage falls



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Lunulicardium beushauseni sp. nov.

[*See* pl. 4]
Page 243

12 A left valve showing the orbicular outline, low, coarse posterior ribs, and generally smooth surface. x2

13 A right valve with radial plications on the posterior surface. x2

Chautauqua subprovince — Forestville

Lunulicardium (Prochasma) enode sp. nov.

Page 242

14 A right valve showing the relatively long and oblique sical margin. x3

Genesee valley — Lower Portage falls

Lunulicardium (Prochasma) absegmen sp. nov.

Page 242

15 A right valve showing the subcircular marginal outline and relatively broad posterior slope. x2

Chautauqua subprovince — Correll's point, Lake Erie

Lunulicardium cf. **inflatum** Holzapfel

16 Internal cast of right valve preserving the mantle line, an apparently posterior muscle scar and a depression at the umbo corresponding to an internal thickening of the valve.

Intumescens zone — Martenberg, Westphalia

Lunulicardium (Prochasma) parunculus sp. nov.

[*See* pl. 4]
Page 243

17 A left valve with highly arched sica and faint radial lines. x1.5

18 A right valve showing the usual form and incurved postumbonal margin. x1.5

19 A similar valve of this species. x1.5

Naples subprovince — Naples

PLATE 4

Genus LUNULICARDIUM Münster

Page 219

Lunulicardium (Pinnopsis) libum sp. nov.

[*See* pl. 2]

Page 232

1, 2 Left and right valves somewhat restored, showing the characteristic broad and unequal plications.
Chautauqua subprovince — Fox's point, Lake Erie

Lunulicardium (Chaenocardiola) eriense sp. nov.

Page 235

3 A right valve preserving the extraordinarily fine radial lines and showing the coarse plications on the posterior margin. x1.5

4 A left valve with slightly coarser radii. x1.5
Chautauqua subprovince — Forestville

5 A right valve. x1.5
Chautauqua subprovince — Correll's point, Lake Erie

6 A small right valve slightly compressed along the sical margin. x1.5
Chautauqua subprovince — Forestville

Lunulicardium (Chaenocardiola) furcatum sp. nov.

Page 236

7 A right valve showing the flat plications, split on the anterior slope. x2
Chautauqua subprovince — Forestville

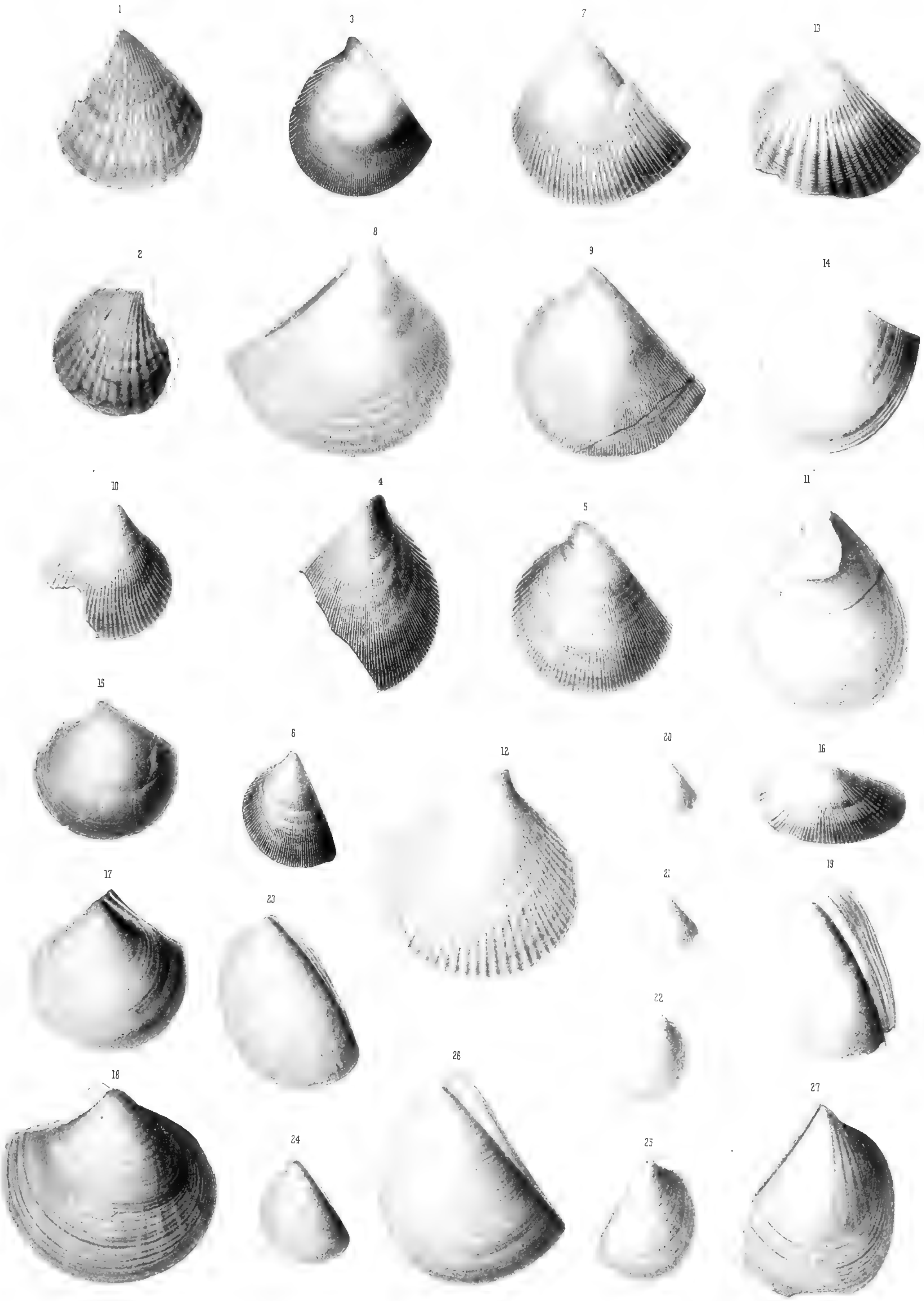
Lunulicardium pilosum sp. nov.

[*See* pl. 2]

Page 239

8 A normal left valve showing by impression the form of the sica. x2
Naples subprovince — Naples

LAMELLIBRANCHS



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9 A right valve provisionally referred to this species
Cashaqua shales Pike's creek, Erie co.

Lunulicardium (Pinnopsis) acutirostrum Hall

[*See* pl. 1]

Page 229

10 A small left valve
Naples subprovince Naples

Lunulicardium sp. nov.

Page 246

11 Part of a left valve of a rather large elongate, obscurely plicate species
Chautauqua subprovince Correll's point, Lake Erie

Lunulicardium (Pinnopsis) accola sp. nov.

Page 233

12 A normal left valve showing relatively sparse plication and subcircular outline. x2
Chautauqua subprovince West Falls, Erie co.

13 The umbonal portion of right valve showing the concentric striation
Chautauqua subprovince Forestville

Lunulicardium (Prochasma) parunculus sp. nov.

[*See* pl. 3]

Page 243

14 A right valve with arched sica and smooth surface
Naples subprovince Naples

Lunulicardium beushauseni sp. nov.

[*See* pl. 3]

Page 243

15 A right valve
Chautauqua subprovince Fox's point, Lake Erie

Lunulicardium? (Opisthocoelus ?) transversale sp. nov.

Page 246

16 A left (?) valve showing the undistorted form and the surface characters. x5
Naples subprovince — Ithaca

Genus PTEROCHAENIA gen. nov.

Page 247

Pterochaenia fragilis Hall (sp.) var. **orbicularis** var. nov.

[*See* pl. 5]
Page 252

17, 18 Right and left valves of large shells. x3
Ithaca province — Near Noblesville, Otsego co.

Pterochaenia perissa sp. nov.

Page 253

19 A right valve with the extraordinary byssal flange. x3
Naples subprovince — Parrish gully, Naples

Pterochaenia cashaquae sp. nov.

Page 254

20, 21 Right valves. x3
22 A left valve. x5
23 A right valve. x5
24 A right valve. x3
25 A left valve. x5
Genesee valley — Cashaqua creek

Pterochaenia elmensis sp. nov.

Page 254

26, 27 Right and left valves. x3
Chautauqua subprovince
Big Buffalo creek, East Elma, Erie co.

PLATE 5

Genus PTEROCHAENIA gen. nov.

[*See* pl. 4]

Page 247

Pterochaenia fragilis Hall (sp.)

Page 249

1 Two valves expanded and juxtaposed along the posterior margin. x3
Naples subprovince — Naples

2 A similar specimen. x2
Genesee shale — Bristol

3 A right valve with expanded byssal flange. x3
Naples subprovince — Naples

4 A left valve. x3
Genesee shale — Moscow

5 Interior of left valve. x3

6 Interior of right valve. x3
Naples subprovince — Naples

7 A right valve. x3
Marcellus shale — Chapinville

8 A right valve. x3
Naples subprovince — Naples

9, 10 Enlargements of a barite replacement showing the contour of the valve, the width of the flange and the umbonal ridge between the flange and the beak
Naples subprovince — Honeoye lake

Pterochaenia fragilis var. **orbicularis** var. nov.

[*See* pl. 4]

Page 252

11 A right valve showing the orbicular outline. x2
Genesee shale — Penn Yan

12 A right valve. x3
Naples subprovince — Naples

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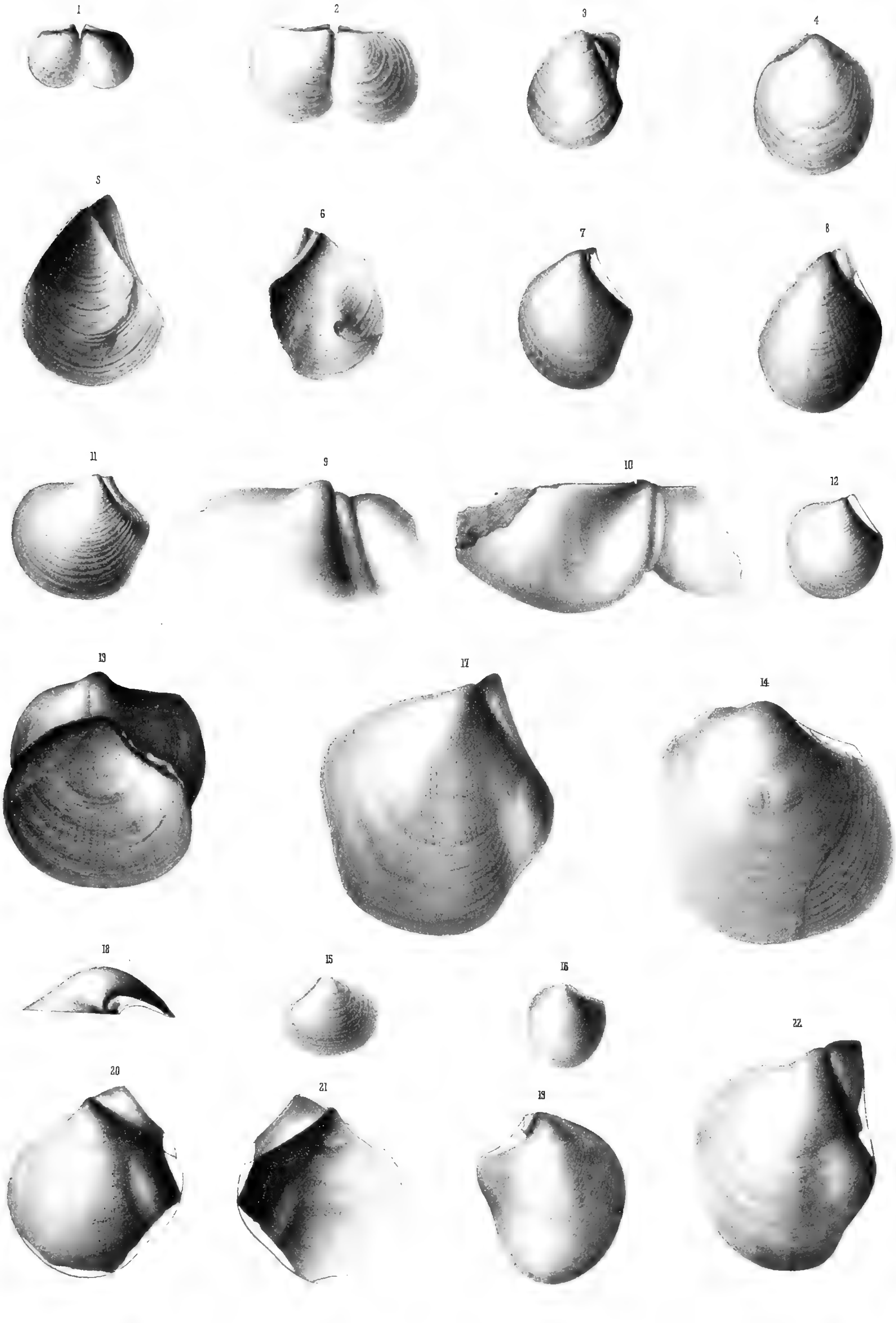

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13 Two superposed valves. x3
Naples subprovince — Ithaca

14 A large right valve. x3
Genesee shale — Aurora, Cayuga lake

15 A left valve. x2
Genesee shale

16 A right valve. x2
Genesee shale — Aurora, Cayuga lake

Pterochaenia sinuosa sp. nov.

Page 253

17 A right valve showing the contour of the surface. x3

18, 19 Two views of a left valve. x3

20, 21 Exterior and interior of a right valve with broad sica. x3

22 A more elongate right valve with very broad sica. x3
Naples subprovince
Genundewa limestone, Canandaigua lake

PLATE 6

Genus **HONEOYEA** gen. nov.

Page 255

Honeoyea simplex sp. nov.

Page 259

1-3 Three views of a left valve showing the finely and uniformly striated exterior, the sharply defined posterior crescent and slightly arched sical margins. x5

Naples subprovince

Genundewa limestone, Canandaigua lake

Honeoyea styliophila sp. nov.

Page 258

4, 5 Views of a large right (?) valve

6 Enlargement of the surface of a valve. x3

7-9 Three views of a left valve. x2

Naples subprovince

Genundewa limestone, Canandaigua lake

Honeoyea major sp. nov.

Page 258

10 An internal cast of the left valve. x4

11 The exterior of the same specimen. x4

12 A right valve. x3

13 A left valve. x3

14 A right valve. x3

Naples subprovince Naples

Honeoyea erinacea sp. nov.

Page 256

15 A left valve, a barite replacement. x3

16 Another replacement of this valve retaining the spines. x5

17 Cardinal view of a right valve. x3

18 Cardinal view of the specimen represented in figure 15. x3

19 Cardinal view of the specimen shown in figure 16. x5

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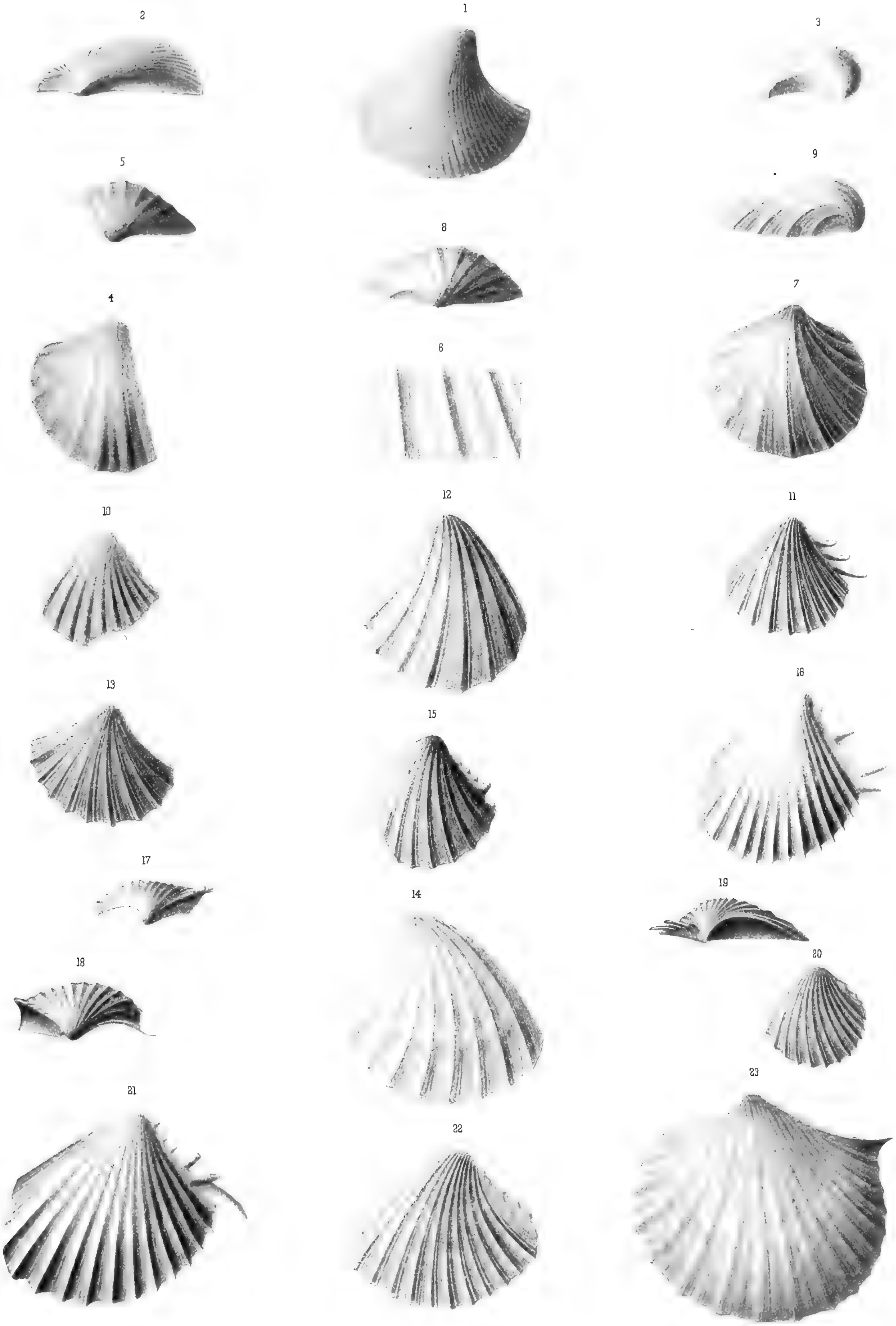

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20 A left valve. x3

21 A right valve with spines. x5

22 A right valve. x3

Naples subprovince

Naples and the region about Honeoye lake

Honeoyea desmata sp. nov.

Page 260

23 A left valve. x3

Naples subprovince Tannery gully, Naples

PLATE 7

Genus PARAPTYX gen. nov.

Page 261

Paraptyx ontario sp. nov.

Page 262

1 A left valve
2 Umbonal portion of left valve showing striated crescent. x2
3 A left valve
4 A right valve
5 Enlargement of a part of the right valve showing character of crescent. x3
6, 7 Views of a barite replacement showing the character of the crescent
8 A left valve
9 A left valve indicating the notable similarity in form and plication to the following species from which it differs in cardinal structure. x1.5
Naples subprovince Naples

Genus ONTARIA gen. nov.

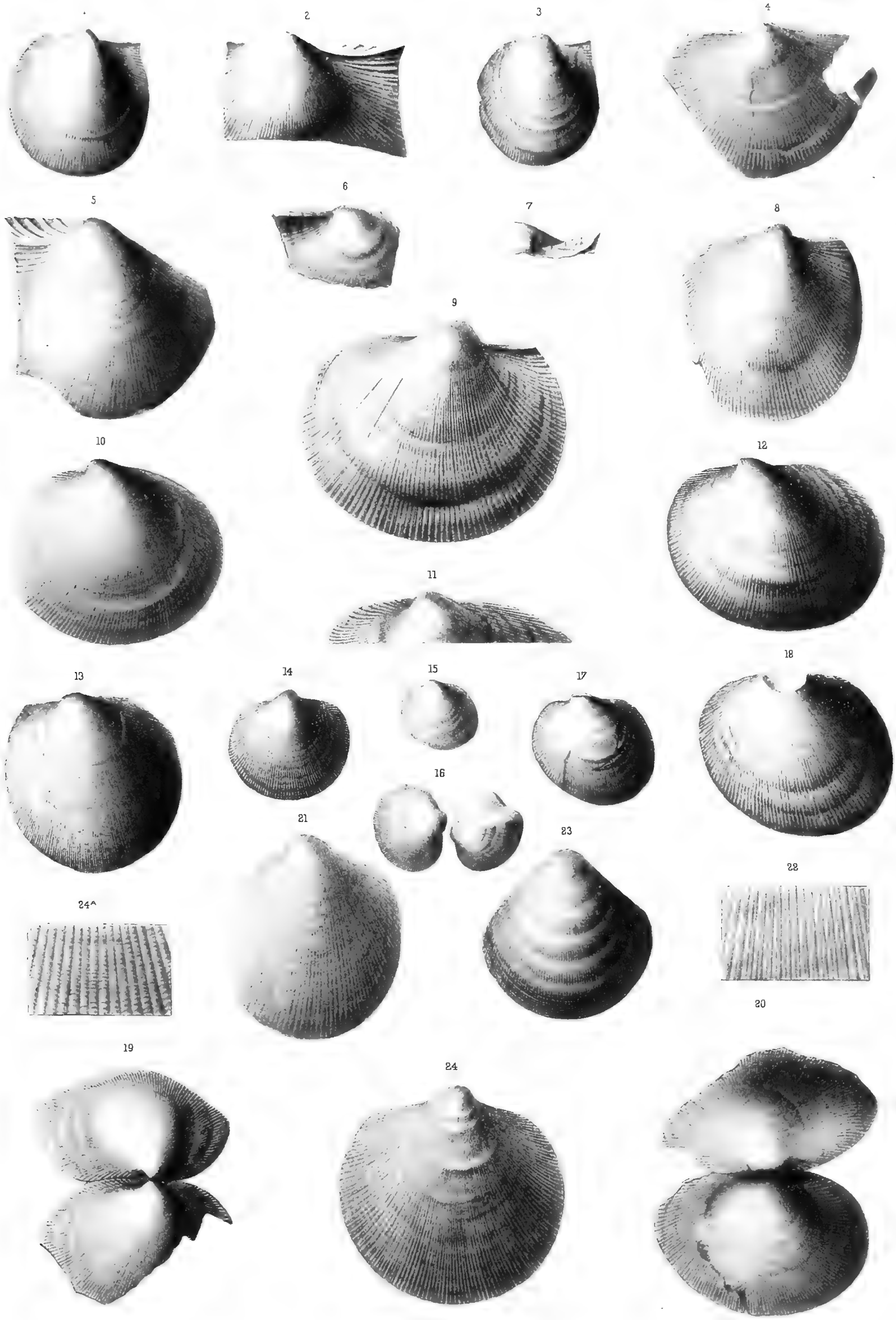
Page 279

Ontaria clarkei Beushausen (sp.)

Page 288

10 A right valve. x2
11 Cardinal portion of a right valve. x2
12, 13 Right valves. x2
14 A small left valve. x2
15 A small right valve
16 Two small right valves
17 A large right valve
18 A right valve. x2
19, 20 Cardinal views of specimens having the valves conjoined
Naples subprovince Naples and vicinity

LAMELLIBRANCHS



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Ontaria affiliata sp. nov.

Page 290

21 Right valve. x2

22 Enlargement of surface. x4

Naples subprovince — Naples

Ontaria halli sp. nov

[*See* pl. 8]

Page 290

23 A left valve

24 A left valve. x2

24A Enlargement of surface. x4

Naples subprovince — Naples

PLATE 8

Genus **ONTARIA** gen. nov.

Page 279

Ontaria suborbicularis Hall (sp.)

Page 282

1 A left valve with smooth surface

2 A right valve with concentrically lined surface

3 A left valve radially lineate outside the single strong growth line

4 A right valve with radial striations and distant growth lines

5 Profile of a valve showing an abrupt marginal deflection

6 Enlargement of surface of frontal slope on the preceding, showing cancelating striae. x3

7 A right valve with regular and sharp concentric lines

Naples subprovince — Naples

8 Interior of the umbonal region from a barite replacement. x5

9 Cardinal view showing the very narrow cardinal area. x5

10 Cardinal view of another replacement. x5

Naples subprovince — Honeoye lake

11 A right valve with radially striated surface. x1.5

Naples subprovince — Naples

12 A left valve with sharp concentric lines

Cashaqua shale — Attica

13 A left valve with sharp concentric lines about the margin

14 A left valve with concentric lines only

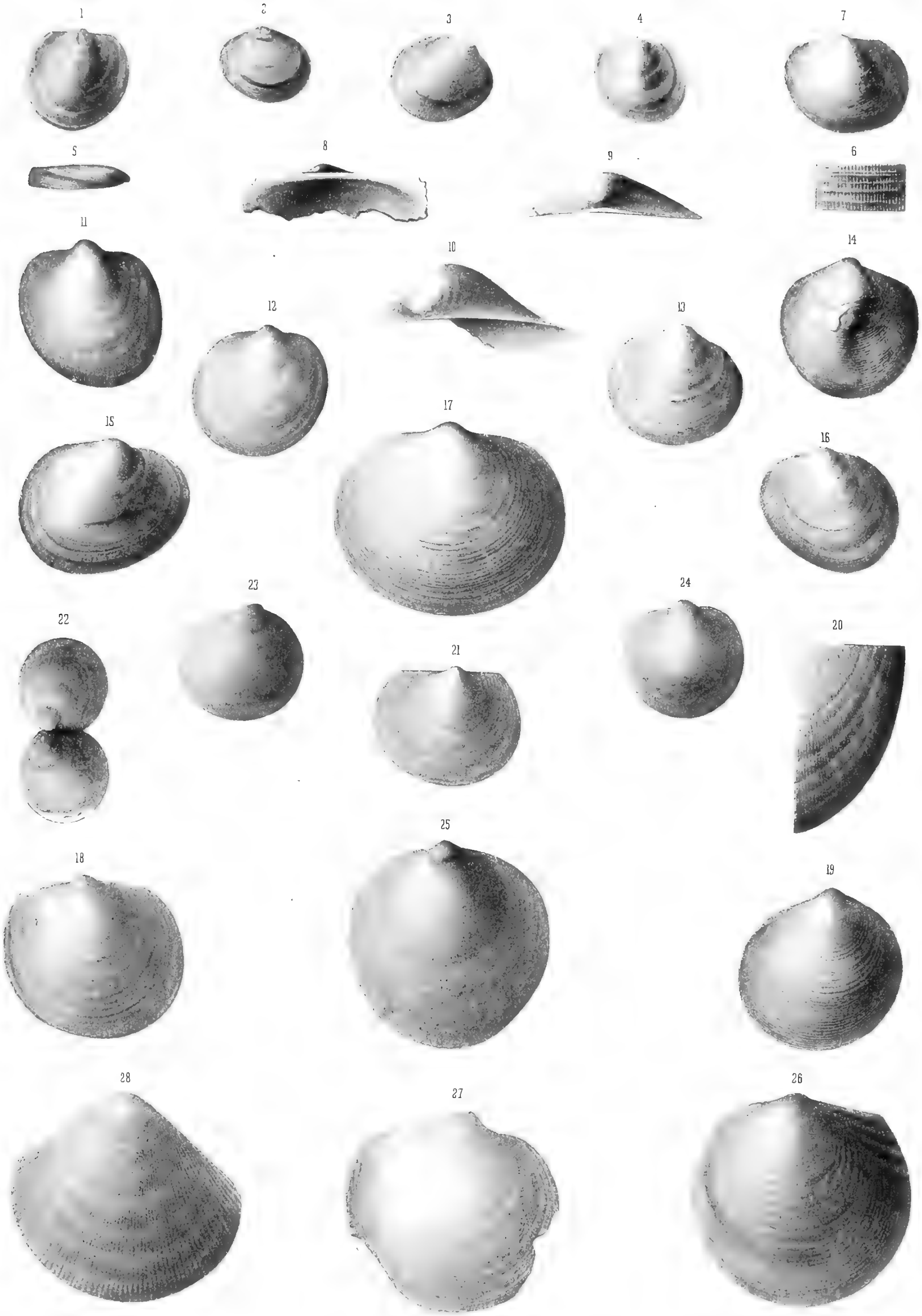
15 A left valve with both concentric and radial striae

16 A right valve with cancelating striae

17 A valve with subcentral beak and sharp regular concentric striae. x2

18 A right valve with obscure concentric markings and well marked larval shell. x2

19 A right valve, oblique in form and concentrically marked. x1.5



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20 Enlargement of surface. x3

Naples subprovince — Naples and vicinity

Among these shells several show a normal obliquity and to some such valves Hall applied the term Lucina retusa. Figures 2, 3, 11 and 16 are examples of this form.

Ontaria pontiaca sp. nov.

Page 287

21 The original specimen which is a smooth shell with relatively long hinge line

Chautauqua subprovince — Pontiac

Ontaria accincta sp. nov.

Page 288

22 Conjoined valves with smooth surface and large prodissoconchs. x3

23, 24 Left and right valves. x3

25 A larger right valve. x3

Genesee valley — Cashaqua creek

Ontaria concentrica v. Buch (sp.)

Page 286

26 A specimen referred to this species, with subcentral beak, sharply defined concentric striation and obscure radial plications behind the beak. x2

Chautauqua subprovince — Correll's point, Lake Erie

Ontaria sp.?

27 A large left valve with oblique umbo and fine concentric lineation. Natural size

Naples subprovince — Naples

Ontaria halli sp. nov.

[*See* pl. 7]
Page 290

28 A right valve showing the finely radial and corrugated exterior. x2

Naples subprovince — Naples

PLATE 9

Fig.

1, 2 These singular valves have a striking resemblance to some of the clavicle-bearing genera like Ischyrina Billings and Technophorus Miller, which are commonly regarded as lamellibranchs. On comparison of the specimens with these genera it seemed to us likely that they too were to be regarded as of similar nature. Hence their appearance here. We are, however, more inclined to regard them as bodies like Ribeiria and Ribeirella which Schubert and Waagen (the founders of the latter genus) have shown to be apodiform crustaceans [Jahrb. der k.k.geol.Reichsanst. 1903, 53:337]. The valves occur in considerable numbers crowded together in a dark shale at Livingstonville, Schoharie co. N. Y., and though the parts are sometimes in apposition, they have usually been twisted apart. Interesting is the presence of two clavicles on the interior, a small one directed forward (which is extremely obscure in the figures) and a stronger pointing backward. It is doubtless true that Technophorus is a ribeirioid crustacean and though it may not be safe to positively refer the specimens here figured to either Ribeiria or Ribeirella we may provisionally denominate them as Ribeiria? prosseri. The specimens were discovered and collected by Prof. C. S. Prosser in the horizon of the Oneonta sandstone.

Genus CARDIOMORPHA DeKoninck

Cardiomorpha obliquata sp. nov.

3 A right valve

Chautauqua subprovince — Forestville

4, 5 Side and cardinal views of a right valve

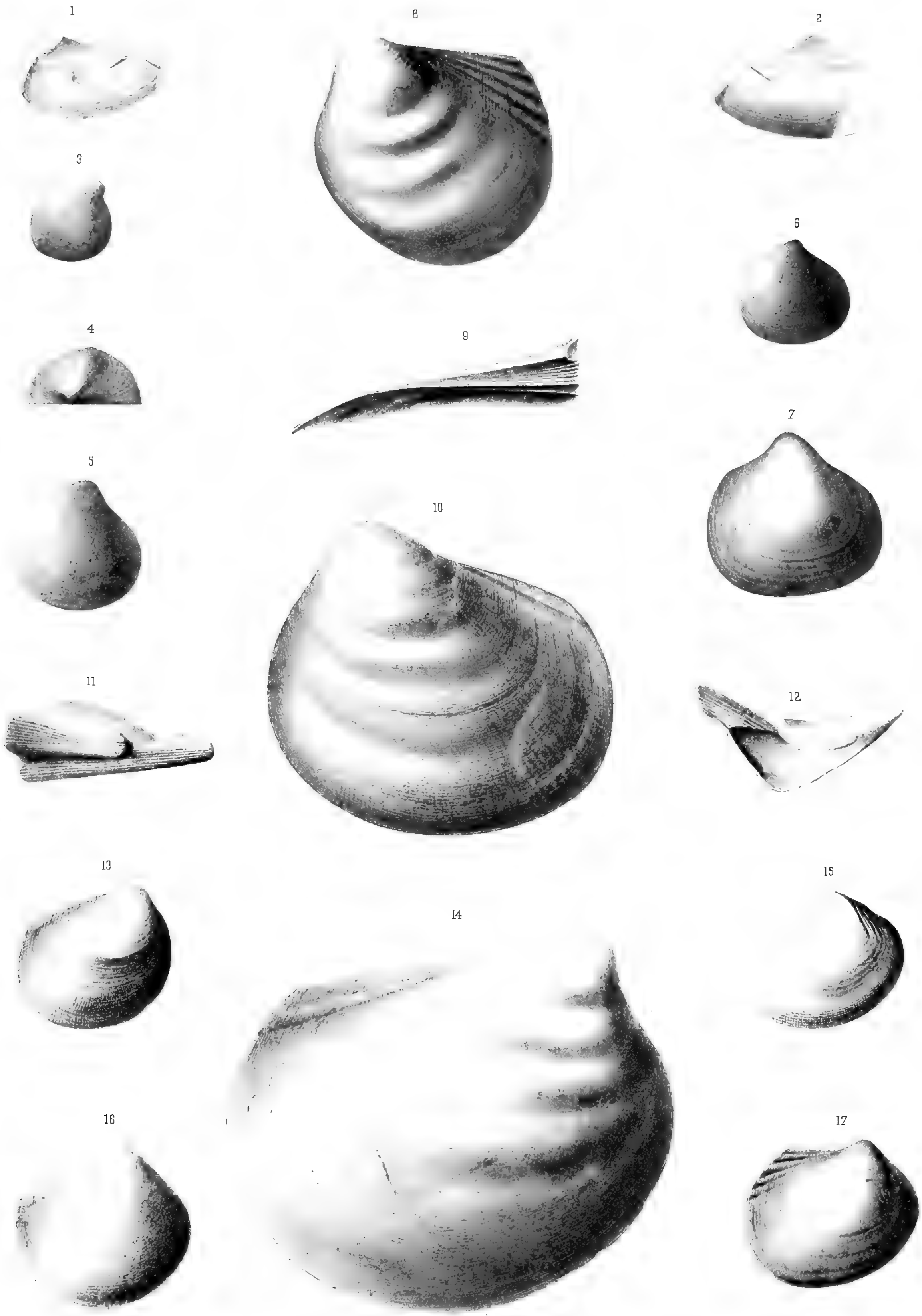
Chautauqua subprovince — Little Canadaway creek, Lake Erie

6 A right valve

Chautauqua subprovince — Forestville

7 A left (?) valve. x1.5

Chautauqua subprovince — Forestville



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Genus EUTHYDESMA Hall

Page 291

Euthydesma subtextile Hall

Page 292

8 A left valve showing oblique corrugations and postumbonal ribs

9 The posterior portion of the ligament area from a squeeze. x2

10 A left valve with fine concentric and radial striae

11 A cast of the outside of the central part of the ligament area showing the striation and the median fold on the hinge. x2

12 The same viewed from above or the cavity of the beak. x2

13 A small right valve with cancelating surface markings

14 A large right valve

Chautauqua subprovince Correll's point, Lake Erie

15 A small valve showing a cicatrix or fold running obliquely forward from the beak with growth lines concentric to it

Chautauqua subprovince Forestville

16 A small suberect shell

17 A young shell with fine umbonal ribs

Chautauqua subprovince Correll's point, Lake Erie

PLATE 10

Genus BUCHIOLA Barrande

Page 294

Buchiola retrostriata v. Buch (sp.)

Page 295

1 A left valve. x3

2 Cast of the exterior of a left valve. x3

3, 4 Other left valves. x3

Naples subprovince — Naples

5 Cardinal view from a replacement showing upturned edge of cardinal area. x5

6, 7 Umbonal views of right valves showing the thin upturned edge of the hinge line. x5

8 Interior view of the cardinal region. x5

Naples subprovince — Honeoye lake

9 Conjoined valves. x3

10 Conjoined valves of a much smaller shell. x6

11 A right valve with structure and ornamentation sharply defined. x3

12 Small valves expanded in conjunction. x6

Naples subprovince — Naples and vicinity

13 Anterior view of a replacement with the valves in normal apposition. x10

Naples subprovince — Honeoye lake

14 Enlargement of a marginal part of the ribs on which the recurved lines are very fine. x3

Genesee shale — Canandaigua lake

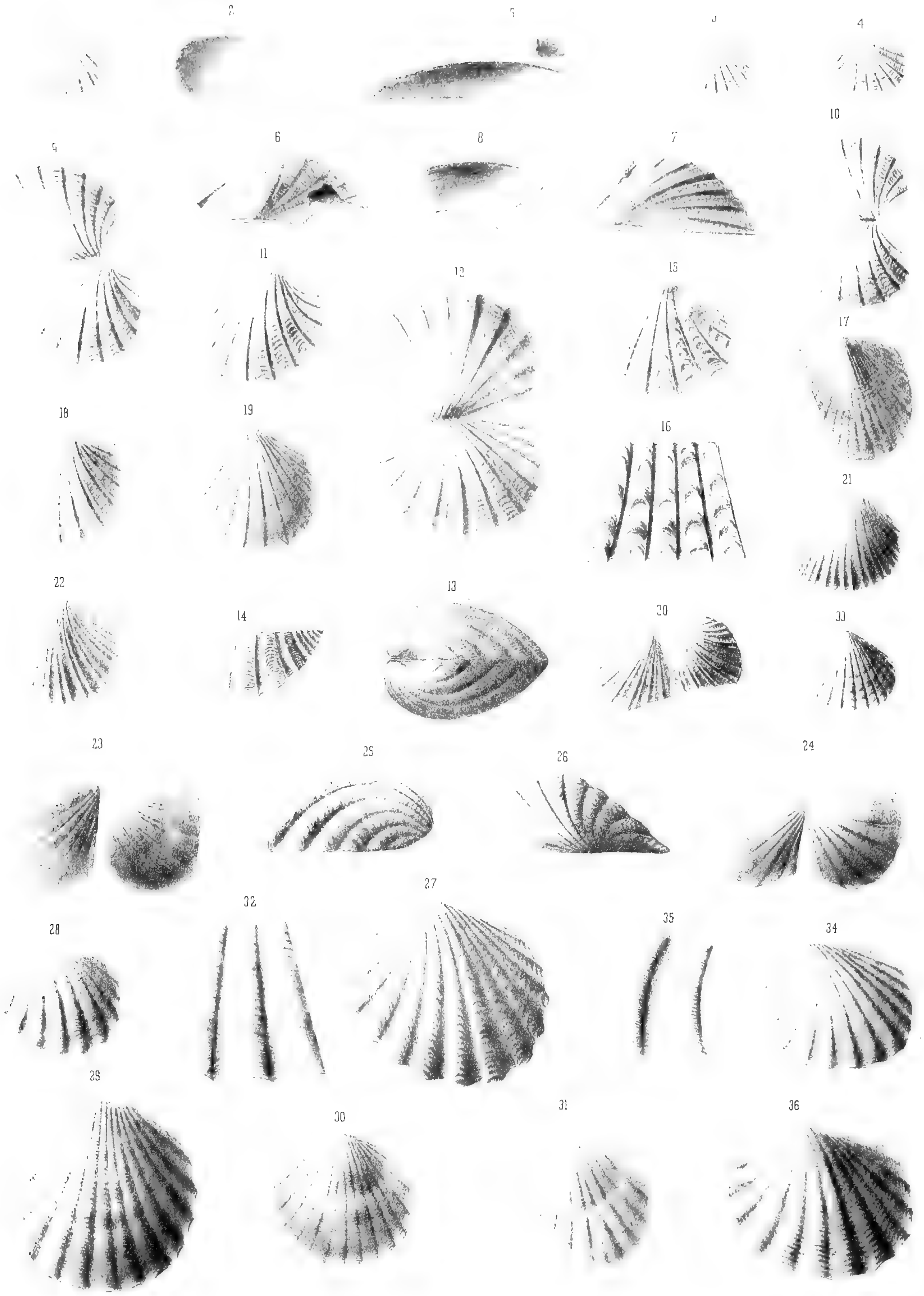
Buchiola halli sp. nov.

Page 301

15 The specimen termed Glyptocardia speciosa [Pal. N.Y. v.5, pt 1, pl.70, fig.9] redrawn. x3. This is the type of B. halli.

Marcellus shale — Skaneateles

LAMELLIBRANCHS



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16 Enlargement of the surface of another valve. x5
Hamilton shale Cayuga lake

Buchiola ? (Puella ?) sp.

17 A flattened valve with numerous ribs and fine, more or less continuous concentric striae. The relations of this shell are quite uncertain. x3
Naples subprovince Rhinestreet shales, Naples

Buchiola cf. **prumiensis** Steininger

Page 302

18, 19 Valves of the same example showing the distinctive characters. x3
Chautauqua subprovince Big Sister creek, Angola

Buchiola conversa sp. nov.

Page 300

20 Expanded valves. x4
Chautauqua subprovince Farnham creek, Lake Erie

21 A right valve. x3
Chautauqua subprovince Angola

22 A right valve showing the subcircular outline, the broad and concave ribs with elevated edges and very narrow intervening furrows. x5
Chautauqua subprovince Big Sister creek, Angola

Buchiola stuprosa sp. nov.

Page 298

23, 24 Expanded valves of two individuals bearing (in figure 23 in later growth only) the very fine concentric striation, the ribs being broadly rounded without sharply defined edges and with very narrow intervening grooves. x4. These are specimens figured among the illustrations of Glyptocardia speciosa by Hall [Pal. N.Y. v.5, pt 1, pl.70, fig.2,3].
Genesee shale Bristol

Buchiola scabrosa sp. nov.

Page 299

25–27 Three views of a left valve showing convexity, the scabrous character of the recurved growth lines on the ribs over the median portion of the shell. x5

28 Another right valve. x3

Naples subprovince — Honeoye lake

Buchiola angolensis sp. nov.

Page 300

29 A left valve showing fine concentric lines and coarser concentric furrows, also the rounded ribs and narrow grooves. x3

30 Left valve. x2

31 A left valve having one dichotomous rib. x2

32 A portion of the surface. x6

Chautauqua subprovince

Big Sister and Farnham creeks, Lake Erie

33 A small left valve with strong concentric grooves, referred with some doubt to this species. x3

Chautauqua subprovince — Forestville

Buchiola lupina sp. nov.

Page 301

34 A left valve. x6. The character of the ribs in this specimen is more like that shown on figure 36.

35 A portion of the surface of another valve. Enlarged

36 A left valve with rounded spreading ribs and fine concentric lines. x4

Cashaqua shales — Mouth of Wolf creek near Mt Morris

PLATE 11

Genus BUCHIOLA Barrande

[*See* pl. 10]

Page 294

Buchiola (?) **livoniae** sp. nov.

Page 299

1 A right valve showing the numerous ribs and very fine concentric lines. x5

Naples subprovince

Genundewa limestone, Canandaigua lake

2 A left valve. x5

Naples subprovince

Genundewa limestone, Livonia salt shaft

Buchiola cf. **eifelensis** Beushausen

3 Cardinal view of an internal cast showing serrations on the hinge. x6

Lower Upper Devonic — Büdesheim, Germany

Genus PARACARDIUM Barrande

Page 303

Paracardium delicatulum sp. nov.

Page 304

4 A right valve showing the very fine radial lines. x5

Naples subprovince

Genundewa limestone, Canandaigua lake

Paracardium doris Hall

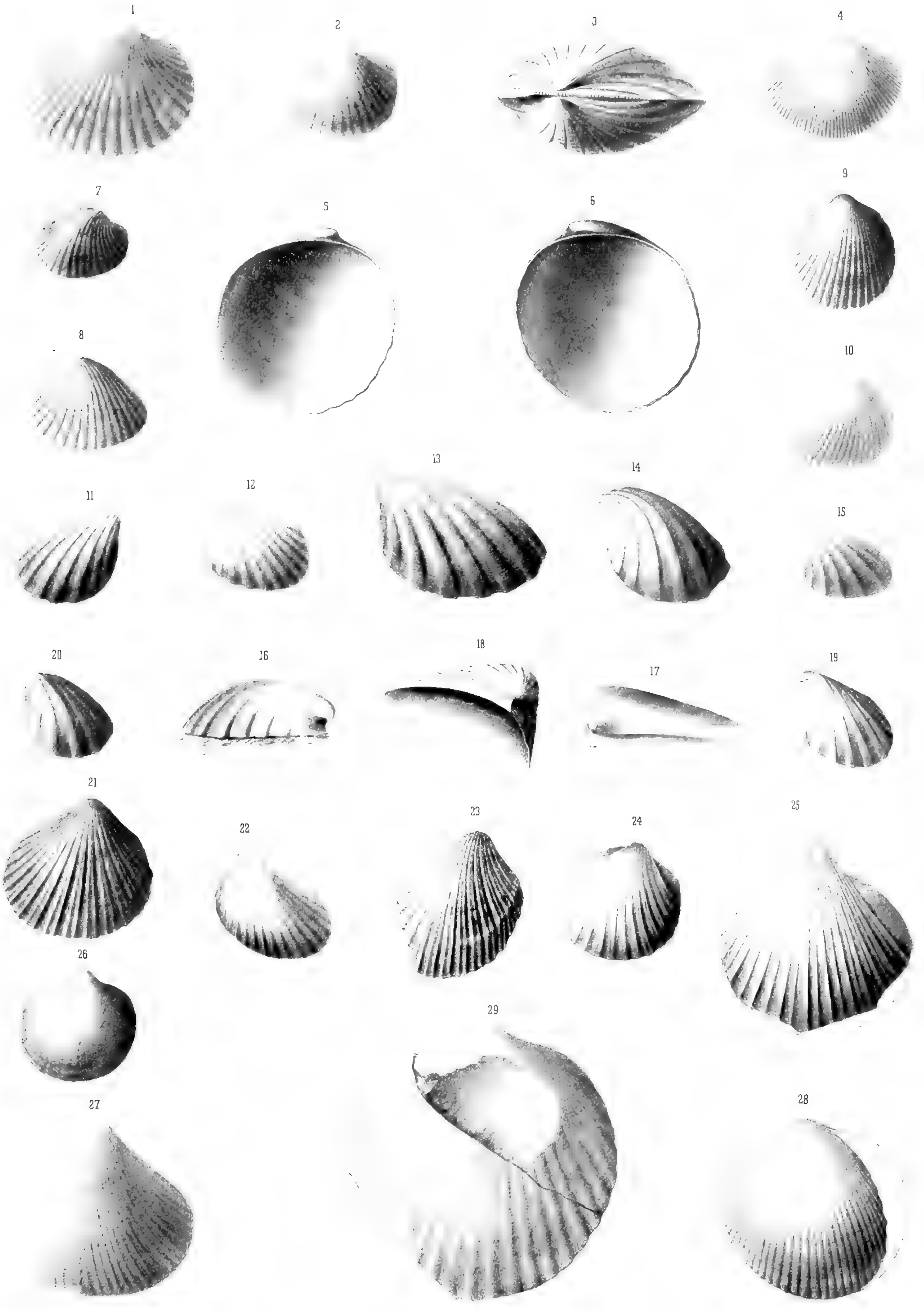
Page 304

5, 6 Interior views of replacements of both valves showing the entire absence of articular processes. x10

Naples subprovince — Honeoye lake

7 A right valve, transverse from compression. x5

8 A left valve. x3



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9 A left valve of more nearly normal outline. x5
Naples subprovince Rock Stream

10 A left valve enlarged. [Copy from Pal. N. Y. v.5, pt 1, pl.70, fig.10.]
Genesee valley Cashaqua creek

Genus PRAECARDIUM Barrande

Page 305

Praecardium vetustum Hall

Page 306

11 A right valve showing the oblique form and distant flat ribs

12 A left valve with the posterior portion flattened and hence showing more ribs
Chautauqua subprovince Correll's point, Lake Erie

13 A normal left valve with flat ribs, broad flat intervals and fine concentric striae. x1.5
Chautauqua subprovince Smith's Mills

14 Another left valve. x2
Chautauqua subprovince Forestville

15 A left valve. [Copy from Pal. N. Y. v.5, pt 1, pl.70, fig. 19]
Chautauqua subprovince Shore of Lake Erie

16, 17 Two views of an internal cast showing the smooth area beneath the beak. x2

18 Squeeze of exterior of the cardinal area showing an elongate ligament surface. x3
Chautauqua subprovince Forestville

19 A left valve. Natural size
Chautauqua subprovince Correll's point, Lake Erie

Praecardium melletes sp. nov.

Page 307

20 A left valve showing the sparse and distant ribs. x2
From the sandstone with Chemung brachiopods lying above the Portage beds, in Terry's ravine, Forestville

Praecardium multicostatum sp. nov.

Page 308

21 A right valve showing the flat and slightly concave ribs. x3

22 A left valve. x2

23 Another left valve with similar features as figure 21

24 A left valve. x2

Chautauqua subprovince — Forestville

Praecardium duplicatum Münster (sp.)

Page 307

25 A left valve bearing broad ribs, flattened and quite concave on top, and with sharply elevated edges; the intervening grooves have nearly the same width as the double ribs. x2

Chautauqua subprovince — Johnson's falls, near Strykersville

Genus PUELLA Barrande

Page 309

Puella sp.?

26 A small shell possibly representing this genus; the only one as yet found within the Portage formation

Naples subprovince — Cook's ravine, Canandaigua lake

Puella sp.

27, 28 Two valves showing the character of the exterior. x1.5

Genesee shale — Seneca point, Canandaigua lake

Puella sp.?

29 A right valve of uncertain relations

Genesee shale — Iron Bridge Mills, Cayuga creek

PLATE 12

Genus POSIDONIA Bronn

Page 264

Posidonia mesacostalis Williams (sp.)

Page 267

1 A left valve. x3
2 A right valve. x3
3-6 Left valves. x3
Chautauqua subprovince
Johnson's falls, near Strykersville, Wyoming county
7 A right valve, x3, with highly developed ear
8 External cast of right valve with the opposite valve overlying. x3
9 A left valve. x3
Chautauqua subprovince Big Sister creek, Angola

Posidonia attica Williams (sp.)

Page 265

10, 11 Right and left valves of the same individual. x3
12 A right valve. x5
Naples subprovince Pogue's hill, Dansville
13 A right valve. x5
Chautauqua subprovince Big Sister creek, Angola
14 A right valve. x3
15 Enlargement of a portion of the surface. x5
Naples subprovince Pogue's hill, Dansville

Posidonia venusta Münster var. **nitidula** var. nov.

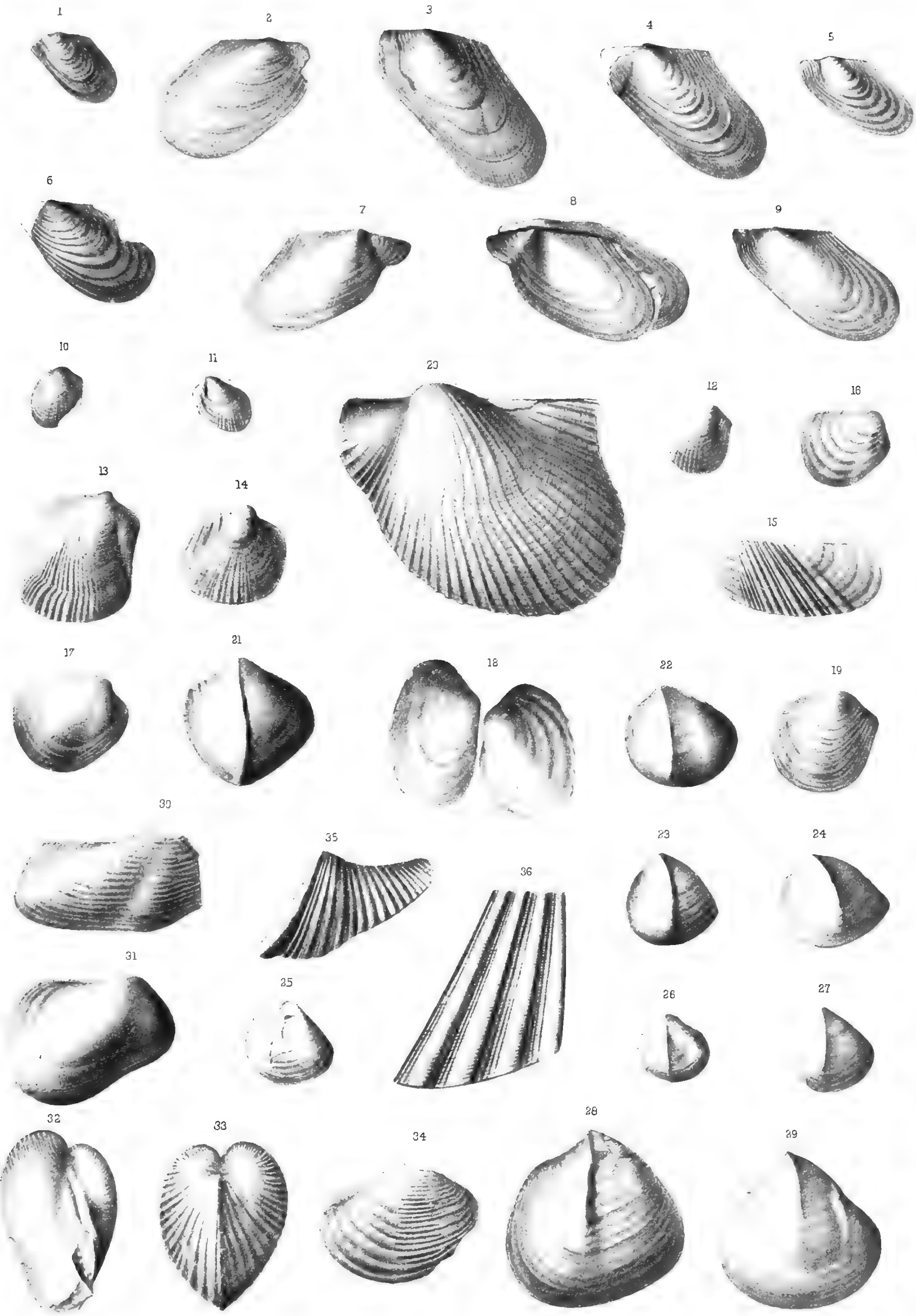
Page 268

16, 17 Right valves. x2
18 The two valves in juxtaposition. x3
19 A right valve. x3
Chautauqua subprovince
16, 17, 19 Correll's point, Lake Erie; 18, Gowanda

LAMELLIBRANCHS

Memoir 6. N.Y. State Museum

Plate 12



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Genus ACTINOPTERIA Hall

Page 263

Actinopteria sola sp. nov.

Page 263

20 A left valve. x10
Cashaqua shales — Cashaqua creek

Genus ELASMATIUM gen. nov.

Page 293

Elasmatium gowandense sp. nov.

Page 294

21–27 A series of left valves showing the bending of the shell along the principal clavicular ridge. Indications of the secondary or posterior internal ridge are shown in figures 23, 24, 27

28 A left valve. x2

29 A large left valve
Chautauqua subprovince — Gowanda and Forestville

Genus LEPTODOMUS McCoy

Page 315

Leptodomus multiplex sp. nov.

Page 315

30 A right valve showing the surface characters
Naples subprovince — Rhinestreet black shale, Naples

Genus MODIELLA Hall

Page 316

Modiella sp. ?

Page 316

31 Internal cast of a right valve. x2
Naples subprovince — Naples

Leptodomus interplicatus sp. nov.

Page 315

32–34 Three views of the shell variously compressed and showing the characteristic surface features
Naples subprovince — In the Hatch shales, Naples

Genus CONOCARDIUM Bronn

Page 310

Conocardium gowandense sp. nov.

Page 310

35 The left valve. x2

36 The median part of the surface enlarged. x5

Chautauqua subprovince Gowanda

PLATE 13

Genus KOCHIA Frech

Page 269

Kochia ungula sp. nov.

Page 270

1, 2 Two views of a left valve, showing the arched contour, incurved and recurved beak. The specimen has suffered some compression which has lessened its actual curvature

3 5 A series of small arched valves

6 A flat valve which provisionally is regarded as the right valve of this species. x1.5

7 Another of these flat valves incomplete on the right margin which gives it the expression of reversal with reference to figure 6. It is believed that both represent like valves. x1.5

8 Cardinal view of an internal cast of the arched valve from which the umbo has been removed showing the cardinal structure. x2

Chautauqua subprovince Correll's point, Lake Erie

Genus LOXOPTERIA Frech

Page 271

[*See* pl. 14]

Loxopteria dispar Sandberger (sp.)

Page 272

9 A nearly entire left valve showing contour and surface characters. x1.5

10, 11 Left valves. x1.5

12, 13 Right valves. x2

14 Surface of the left valve. x3

15–17 Incomplete right valves

Chautauqua subprovince Forestville

Loxopteria vasta sp. nov.

Page 275

18 A large right valve

Chautauqua subprovince Forestville

LAMELLIBRANCHS

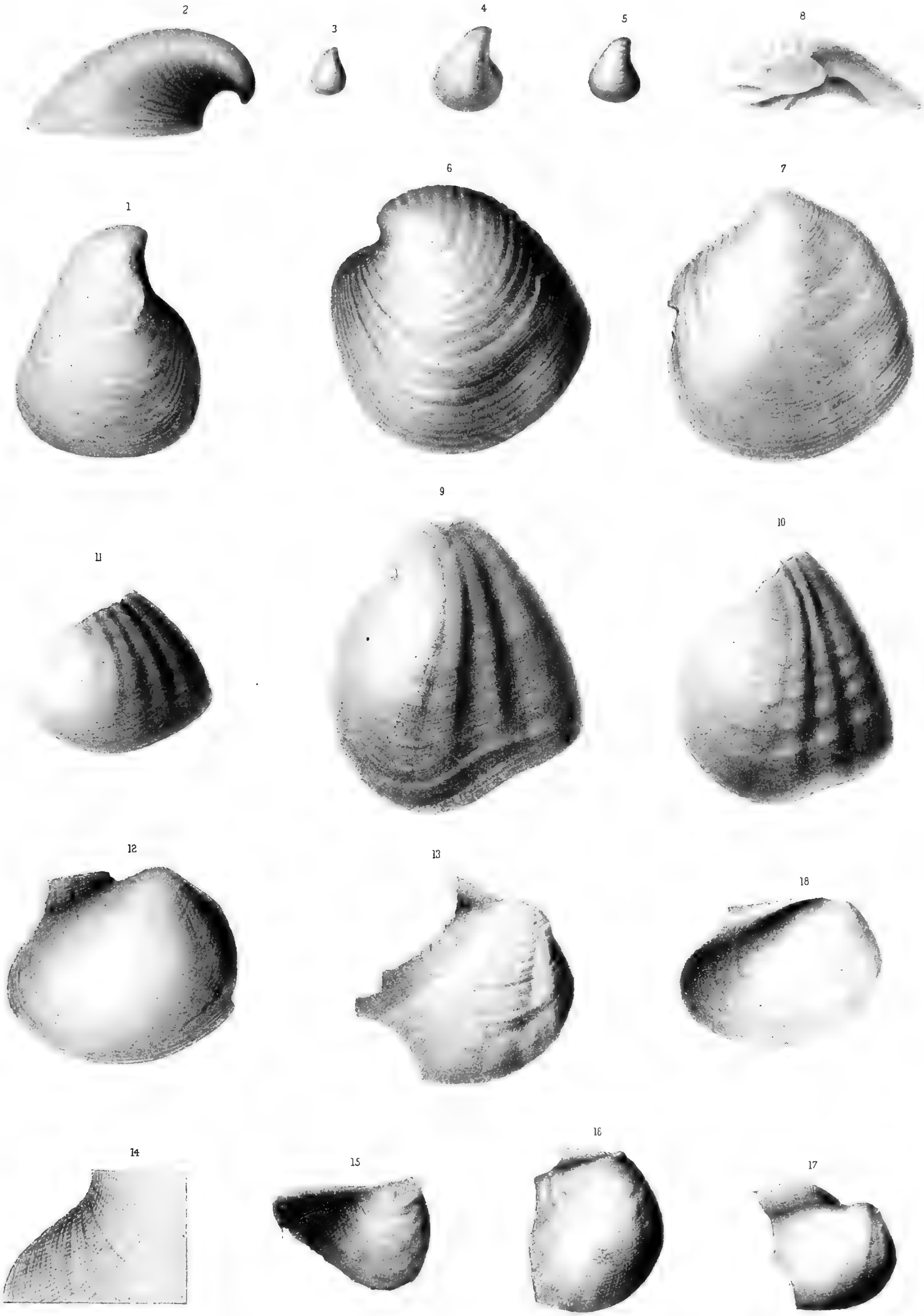

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PLATE 14

Genus LOXOPTERIA Frech

Page 271

[*See* pl. 13]

Loxopteria laevis Frech

Page 274

1–4 Right valves, showing the depressed surface and sharply elevated wing. All x2 except figure 3 which is an enlargement of the umbonal region showing the larval concavity at the beak. x5

5–7 Left valves. x1.5

Chautauqua subprovince — Forestville and Gowanda

Loxopteria (Sluzka) intumescentis sp. nov.

Page 276

8–14, 16, 17 A series of left valves showing the usual aspect and variations of these shells in different growth stages. Figure 16 is a cardinal view showing the vertical area below and behind the beak. Figure 10 shows a portion of the surface with the large larval shell. Figure 17 is an elongate shell of quite usual outline. Figure 10, x3; 11, x2; 12–14, x1.5; 16, 17, x2

Chautauqua subprovince

Walnut creek, Forestville and Correll's point, Lake Erie

Loxopteria (Sluzka) corrugata sp. nov.

Page 277

15, 18–26 A series of left valves showing the variation in the character of the corrugated surface. Figure 15, 19–21, x2; 22, x3; 23, x2; 24, x1.5; 25, 26, x2

Chautauqua subprovince

Forestville and Correll's point, Lake Erie

LAMELLIBRANCHS

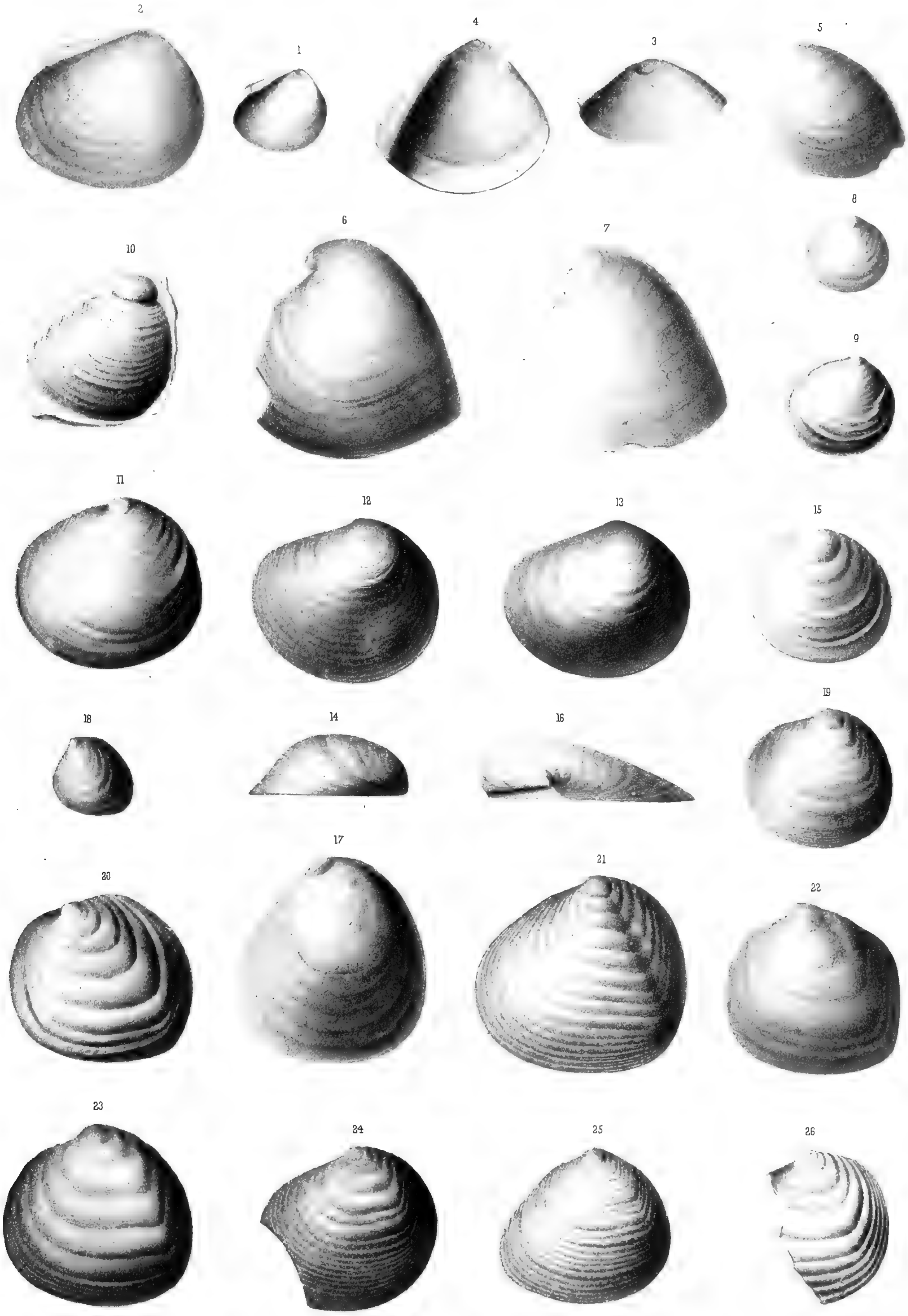


PLATE 15

Genus PALAEONEILO Hall

Page 311

Palaeoneilo petila sp. nov.

Page 311

1 Sculpture cast of a right valve. x2

2 Sculpture cast of a left valve. x2

Naples subprovince — Naples

3, 4, 5 Three views of a specimen with the valves in normal apposition; a barite replacement. x3

6 The exterior of a right valve; a replacement. x3

7 The same from within showing the straight and numerous denticulations, the relatively broad cardinal platform and the position of the muscle scars. x5

Naples subprovince — Honeoye lake

8 An internal cast showing the cardinal denticulations. x5

Chautauqua subprovince — Pontiac N.Y.

Palaeoneilo constricta Conrad (sp.)

Page 311

9 A right valve. x2

10, 11 Left and right valves. x2

Chautauqua subprovince — Correll's point, Lake Erie

12 Cast of cardinal area of left valve, showing the curvature of the denticuiations and sockets. x10

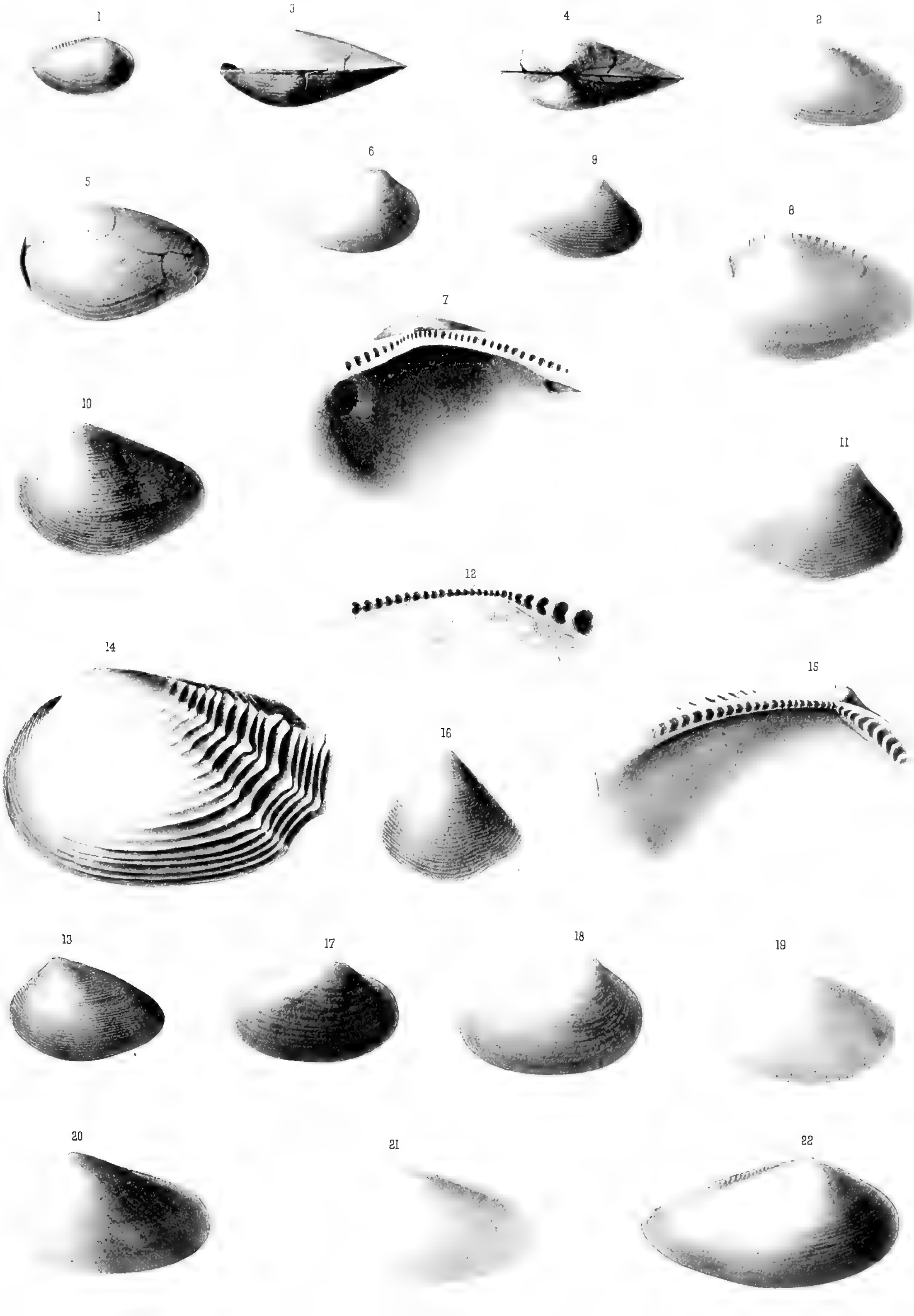
13 A left valve. x2

Chautauqua subprovince — Forestville

Palaeoneilo muricata sp. nov.

Page 312

14 Exterior of a barite replacement of the left valve showing the three umbonal ridges and furrows, strong and posteriorly lamellose growth ridges. x7



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15 Interior of the same showing the character of the cardinal denticulations. x7

Naples subprovince Honeoye lake

Palaeoneilo brevicula sp. nov.

Page 313

16 The exterior of the left valve ; the only specimen observed. x5

Chautauqua subprovince

Forks of Cattaraugus creek, Gowanda

Palaeoneilo linguata sp. nov.

Page 314

17, 18 Sculpture casts of right valves. x2

19–21 Sculpture cast of left valves. x2

22 A right valve somewhat compressed posteriorly and showing the cardinal denticulations. x2

Chautauqua subprovince Forestville

PLATE 16

Genus PHRAGMOSTOMA Hall

Page 322

Phragmostoma natator Hall

Page 325

1, 2, 4, 5 Specimens from the Cashaqua shales showing the usual form and the concentric surface markings
Naples subprovince — Naples and vicinity

3 A smaller example
Naples subprovince — Genundewa limestone, Canandaigua lake

Phragmostoma cf. **triliratum** Hall

Page 327

6 An incomplete specimen showing the divergent dorsal ridges on the lateral slopes of the shell
Naples subprovince — Hamilton gully, Honeoye lake

Phragmostoma incisum Clarke

Page 327

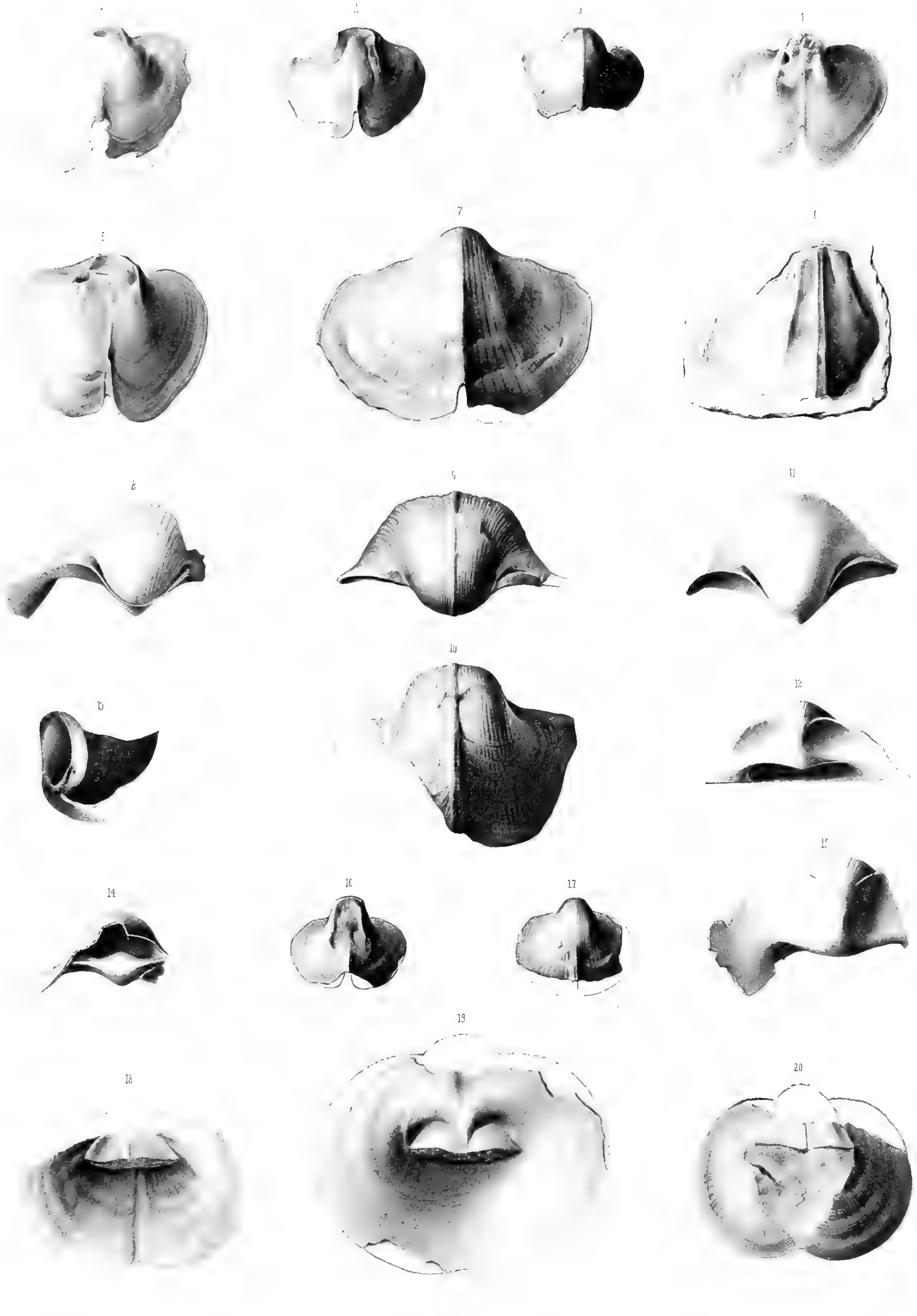
7 An entire specimen showing the marginal outline and the incised revolving lines. x1.5

8 Front view of a replacement showing the striation. x3
Naples subprovince — Whetstone gully, Honeoye lake

9, 10 Two views showing the normal contour of the shell but incomplete at the marginal outline. x3
Naples subprovince — Naples

11–15 Views of barite replacements showing the form of the flattened and excavated umbonal callus with the reflected lip. 11, 13 and 15, x3; 12 and 14, x2. Figure 15 is from the same specimen as figure 8.
Naples subprovince — Whetstone gully, Honeoye lake

16, 17 Two small specimens from the shales
Naples subprovince — Naples



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Genus CARINAROPSIS Hall

Page 323

Carinaropsis ithagenia sp. nov.

Page 323

18 An external cast showing the umbonal platform

20 Internal cast of the same, showing that the platform is medially ridged

Ithaca beds — Canasawacta creek, Norwich

19 The interior of a larger specimen

Ithaca beds — Brookins quarry near Norwich

PLATE 17

Genus PHRAGMOSTOMA Hall

[*See* pl. 16]

Page 322

Phragmostoma chautauquae sp. nov.

Page 328

1 Side view of the innermost volutions showing the revolving confluent lines. x5

2 Dorsal view of an older shell in which the seam is developed. The revolving lines have disappeared, their place being taken by fine concentric lines. x3
Chautauqua subprovince — Smith's Mills

3 Apertural view of an adult specimen, somewhat incomplete but showing the explanate stoma. x2
Chautauqua subprovince — Forestville

4 Portion of the ultimate whorl. x2

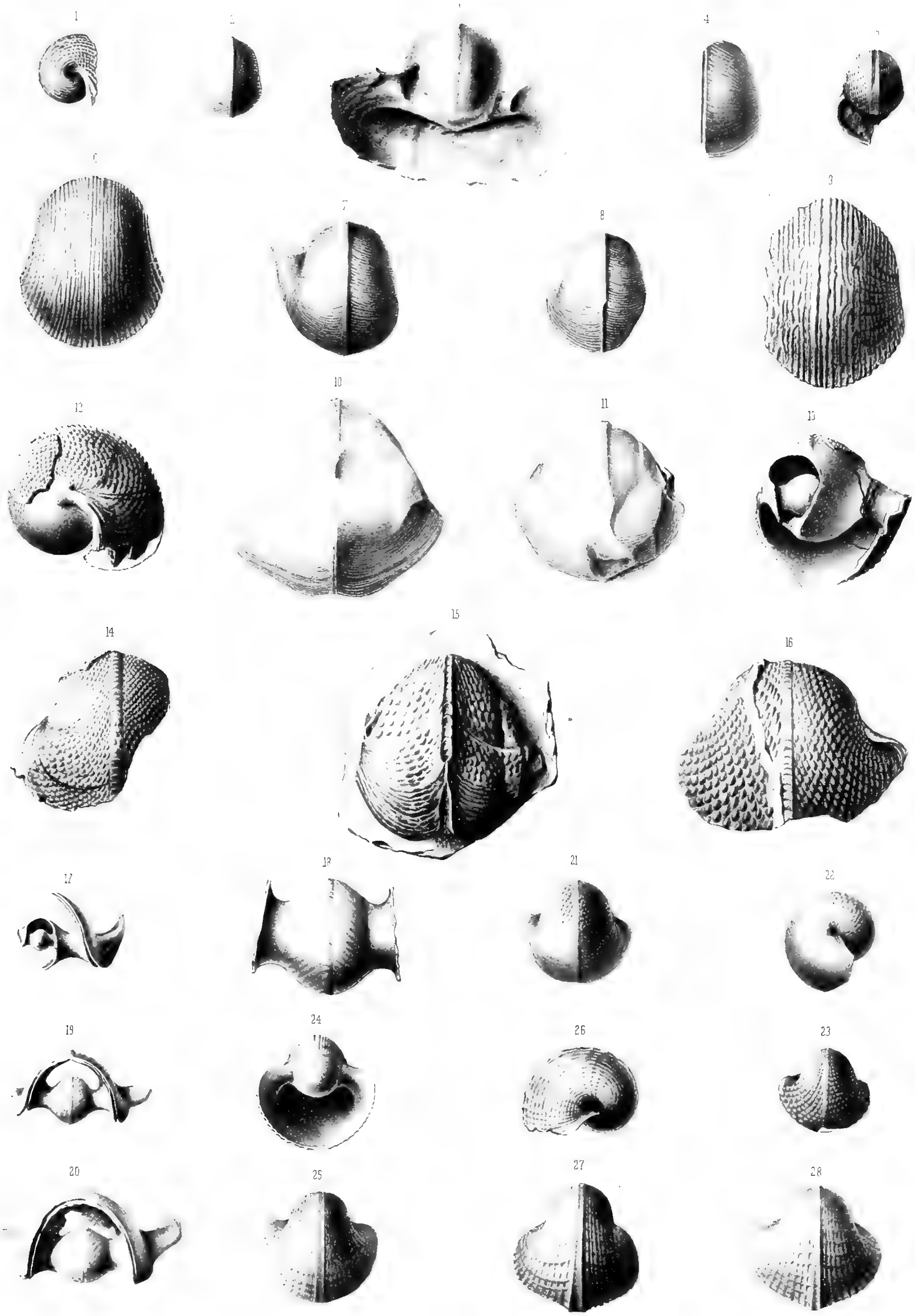
5 Part of a young shell with coexistent revolving and concentric lines. x5

6 Dorsal view of a very young shell in which the peripheral seam is only suggested and the revolving lines are seen to be confluent and interrupted. x10

7, 8 Two nearly adult shells with concentric ornaments only. The latter shows the premature closing of the peripheral seam. x3

9 An enlargement of a young shell with confluent revolving striae. x10
Chautauqua subprovince — Smith's Mills

10, 11 Two mature but compressed individuals. x2
Chautauqua subprovince — Forestville



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Genus BELLEROPHON Montfort

Page 320

Bellerophon koeneni sp. nov.

Page 320

12–14 Views of a replacement in barite, partially incomplete but showing contour and external characters. x2
Naples subprovince
Genundewa limestone, Canandaigua lake

15 Dorsal view of an old example showing the reappearance of concentric lines about the later parts of the shell. x2

16 Exterior of an adult shell, a replacement

17–20 Replacements exposing the inner whorls, the first three showing the gradual assumption of the tuberculous ornament, and all enlarged x2; except figure 18 which is x10 and shows the fine concentric lines which precede the appearance of the tubercles.

21, 22 Dorsal and side views of a small individual. x2

23 Another young shell. x2
Naples subprovince Genundewa limestone, Middlesex

Bellerophon denckmanni sp. nov.

Page 321

24–26 Views of a replaced shell. x5
Naples subprovince Genundewa limestone, Middlesex

27, 28 Dorsal views of two individuals. x5
Naples subprovince Genundewa limestone, Bristol

PLATE 18

Genus TROPIDOCYCLUS De Koninck

Page 330

Tropidocyclus hyalinus sp. nov.

Page 331

1, 2 Apertural and dorsal views of a replacement showing the trilobation of the stoma and back, due to the median ridge. x5

3 Side view of a smaller shell. x5

4 Side view of an entire shell showing the form of the aperture, the degree of umbilication and the character of the surface markings. x7

Naples subprovince Honeoye lake

Genus CALLONEMA Hall

Page 337

Callonema filosum sp. nov.

Page 337

5 The original specimen. x5

Chautauqua subprovince Smith's Mills

Genus LOXONEMA Phillips

Page 332

Loxonema noe Clarke

Page 332

6, 7 Very young shells with convex and essentially smooth whorls; enlarged about 13 diameters

8–10 Essentially entire shells, all replacements in barite. x3

Naples subprovince

Localities about Naples and Honeoye lake

Loxonema danai sp. nov.

Page 333

11 A shell overgrown with Aulopora. x2

12, 13 Two examples showing the numerous whorls and the obscure surface markings. x2

Chautauqua subprovince Forestville

GASTROPODS

Loxonema multiplicatum sp. nov.

Page 333

14 The original specimen with broad whorls and coarse surface markings
Chautauqua subprovince
Upper Portage falls, Genesee river

Genus MACROCHILINA Bayle

Page 334

Macrochilina seneca sp. nov.

Page 334

15, 16 Two specimens showing the short spire and relatively large body whorl. Each x10
Naples subprovince
Genundewa limestone, Canandaigua lake

Macrochilina pygmaea sp. nov.

Page 334

17 An entire shell replaced in barite. x20
Naples subprovince Honeoye lake

18, 19 Two larger shells. x20
Naples subprovince
Genundewa limestone, Canandaigua lake

PLATE 19

Genus PROTOCALYPTRAEA Clarke

Page 339

Protocalyptraea marshalli Clarke

Page 339

1–3 Views of the original specimen, the shell being somewhat restored to its normal outline ; a barite replacement. x3

Naples subprovince — Whetstone gully, Honeoye lake

4–6 Sculpture casts from the shales, showing the spiral suture. x2

Protocalyptraea styliophila Clarke

Page 339

7, 8 Two views of the original specimen showing the internal course of the whorls. x2

9 Surface of the same enlarged to show the concentric striae. x5

Naples subprovince

Genundewa limestone, Canandaigua lake

Genus DIAPHOROSTOMA Fischer

Page 337

Diaphorostoma lutheri sp. nov.

10 An internal cast representing a shell apparently malformed in having the periphery of the final whorl strongly indented. x1.5

14 The exterior of an associated shell showing the general aspect and elevation of the whorls. x1.5. The final whorl in this species is full and rotund but less so than in D. rotundatum and the spire is higher.

Naples subprovince — Naples

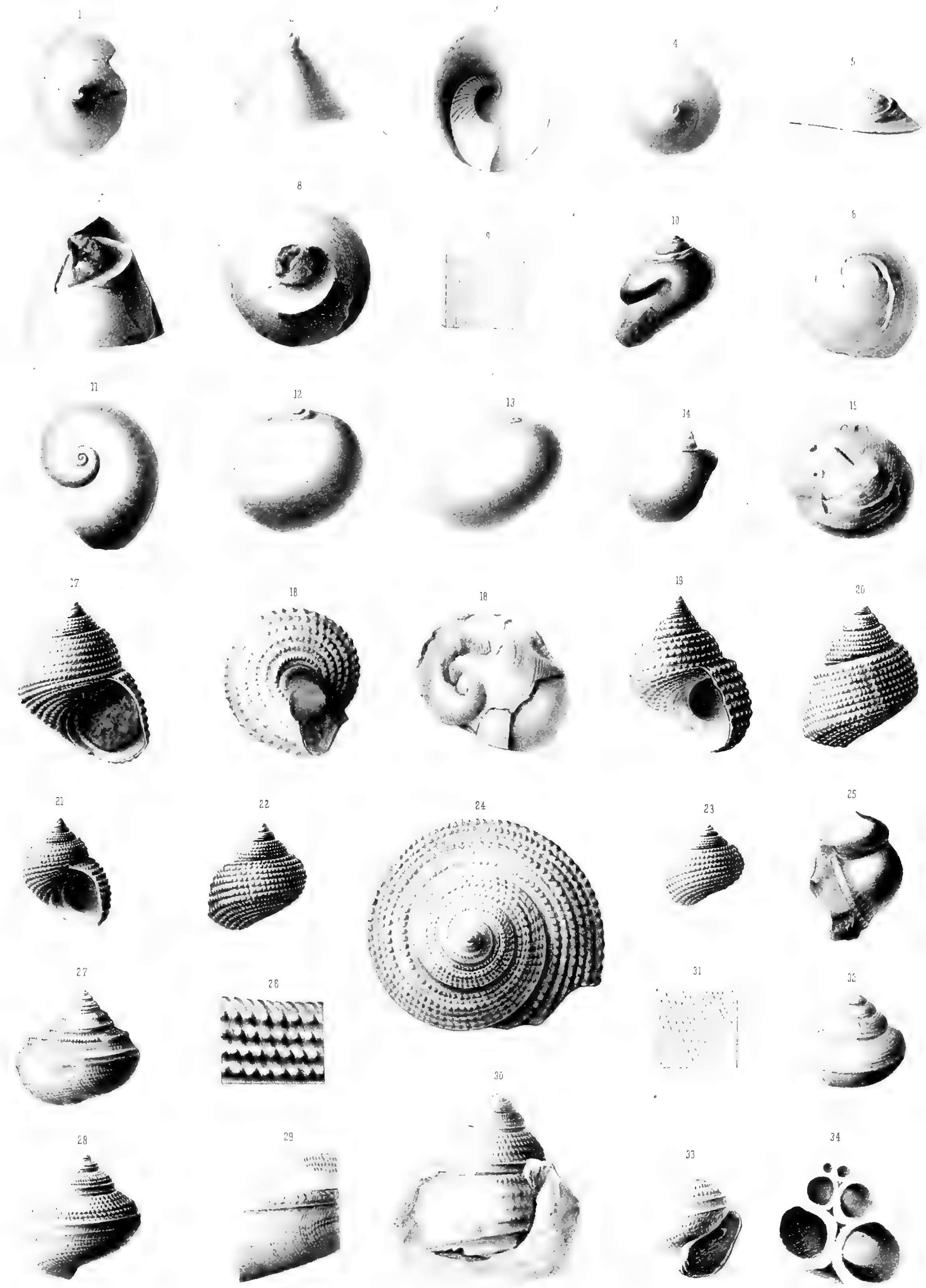
Diaphorostoma (Naticopsis) rotundatum sp. nov.

Page 337

11–13 Three views of the exterior showing the inflated body whorl and the very low spire. x3

Chautauqua subprovince — Angola

GASTROPODS



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Diaphorostoma pugnus sp. nov.

Page 338

15 A specimen from the Melocrinus plantation above the Genundewa limestone
Naples subprovince — Blacksmith ravine, Bristol

16 A specimen found attached to a Melocrinus calyx
Chautauqua subprovince — Fox's point, Lake Erie

Genus PALAEOTROCHUS Hall

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Palaeotrochus praecursor Clarke

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17–26 A series of views mostly of entire shells, preserved as replacements in barite. In figure 24 will be observed the gradual passage of the ornament from the concentric ridges of the earliest whorls into the revolving rows of tubercles which on adult whorls are crossed by fine concentric lines [fig. 26]. Figure 20 is a calcareous specimen from the shales; figure 25 an internal cast showing the internal excavation of the outer lip. All are enlarged to two diameters except figure 18, x3 and figure 24, x5.
Naples subprovince — From the shales at Naples and the concretions on Honeoye lake
Chautauqua subprovince — In the concretions at Java village

Genus PLEUROTOMARIA Defrance

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Pleurotomaria capillaria Conrad **cognata** mut. nov.

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27, 28 The exteriors of these shells. x2

29 The lower portion of the final whorl. x4
Naples subprovince — Naples

30 An incomplete specimen. x2
Naples subprovince — Lodi falls

Pleurotomaria itylus sp. nov.

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31 An enlargement of the surface

32 The exterior of the shell

Chautauqua subprovince Forestville

Pleurotomaria genundewa sp. nov.

[*See* pl. 20]

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33 Apertural view of a barite replacement. x5

34 Axial view of the interior. x5

Naples subprovince Genundewa limestone, Middlesex

PLATE 20

Genus PLEUROTOMARIA Defrance

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Pleurotomaria genundewa sp. nov.

[*See* pl. 19]

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1–7 Various views of this species showing the limits of variation in the character of the exterior. All enlarged x5 except figures 1 and 5 which are x3.

Naples subprovince Genundewa limestone, Middlesex

Pleurotomaria ciliata sp. nov.

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8–14 A series of views showing the expression and variations of the shell. x5

Naples subprovince

From the concretions in Whetstone gully, Conesus lake

Genus PROTOSPIRIALIS gen. nov.

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Protospirialis minutissima Clarke

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15–19 Various views of these tenuous and smooth shells enlarged to 5 diameters

Naples subprovince Barite replacements from the calcareous concretions of Honeoye lake

Genus TENTACULITES Schlotheim

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Tentaculites tenuicinctus A. Roemer

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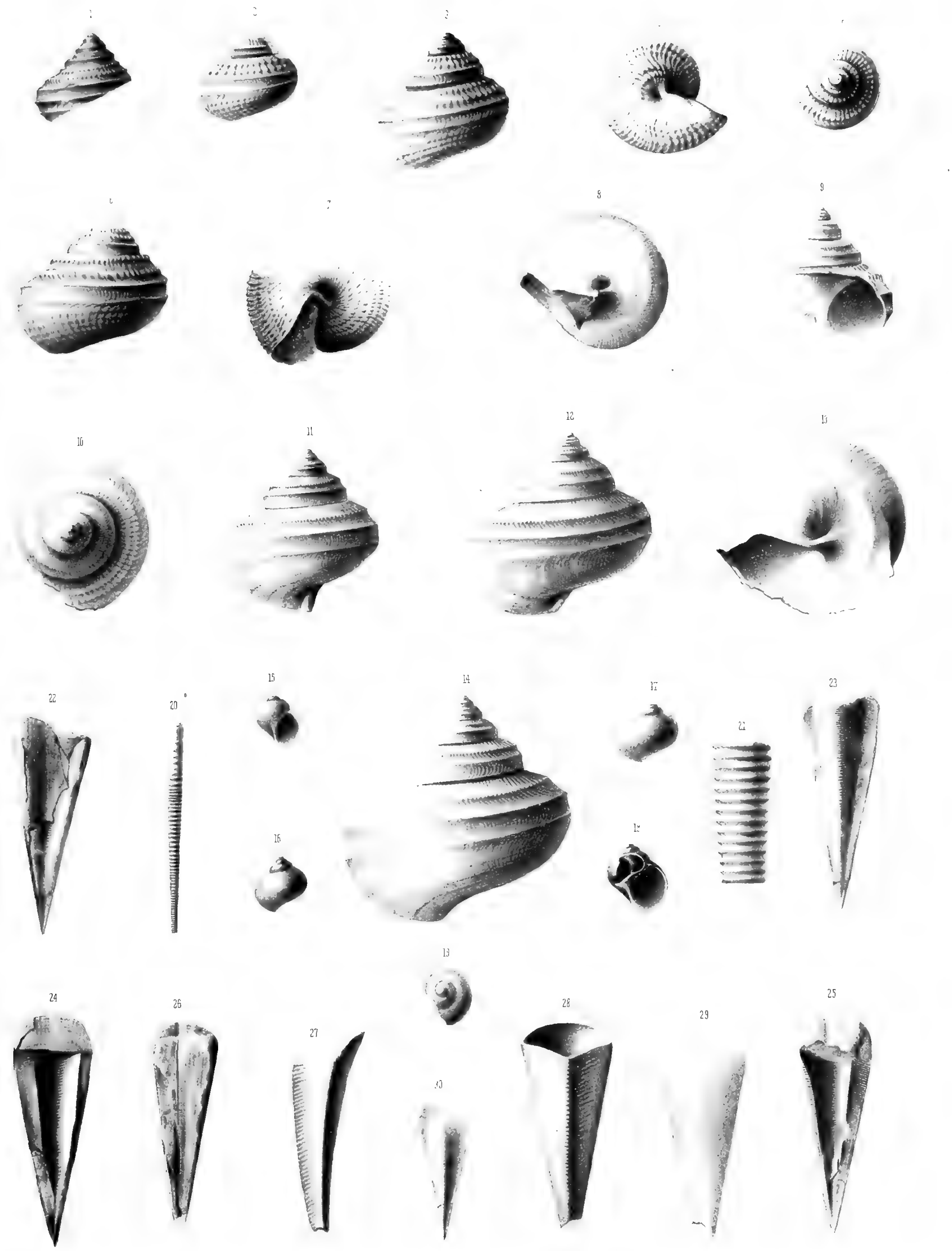
20 A specimen enlarged 10 diameters

21 A still greater enlargement to show the character of the annulations

Naples subprovince

In the arenaceous concretions at Naples



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Genus HYOLITHUS Eichwald

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Hyolithus neapolis Clarke

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22–30 A series of specimens representing both aspects of this species. Figures 27–29 are of a replacement which preserves normal contour and the form of the aperture; figure 30 is the only specimen observed from the Chautauqua subprovince, the rest are from the shales and concretions about Naples and Honeoye lake. All are enlarged 1.5 diameters except figures 27–29 which are x7.

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