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PALEONTOLOGY 14

CEPHALOPODA OF THE BEEKMANTOWN AND CHAZY FORMATIONS

OF THE

CHAMPLAIN BASIN

BY

RUDOLF RUEDEMANN

ALBANY

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New York State Education Department

Science Division, October 12, 1905

Hon. Andrew S. Draper
Commissioner of Education

My dear sir: I beg to transmit herewith for publication, the manuscript of a bulletin of the State Museum entitled, *The Cephalopoda of the Beekmantown and Chazy Formations of the Champlain Basin* by Dr Rudolf Ruedemann, Assistant Paleontologist.

This work constitutes an important contribution to our knowledge of the ancient faunas of New York State and I have explained its bearings somewhat fully in my preface to the paper.

Very respectfully yours

John M. Clarke

Director and State Geologist

Approved for publication October 12, 1905

A. S. Draper

Commissioner of Education

New York State Education Department

New York State Museum

John M. Clarke Director

Bulletin 90

PALEONTOLOGY 14

CEPHALOPODA OF THE BEEKMANTOWN AND CHAZY FORMATIONS OF THE CHAMPLAIN BASIN

BY
RUDOLF RUEDEMANN

PREFACE

The faunas of the older New York formations have never received adequate consideration. The invaluable determinations made by Prof. James Hall in the first volume of the *Palaeontology of New York* were based on the material collected chiefly from the central and western skirts of the Adirondacks during the progress of the geological survey of 1836–43 or brought together from still older collections belonging to private individuals or to the Albany Institute. Although this great work laid the foundation of all our knowledge of these early faunas in America yet as the years passed on its distinguished author realized its incompleteness. The Siluric region of the Lake Champlain basin was then an unopened field to the paleontologist. The profusion of its fossil remains, which far exceed in abundance those of the region from which the original collections were assembled, was not recognized and it was not till the later years of Professor Hall's long life that explorations in this basin began to reveal the inadequacy of his early work. It was one of his unrealized purposes of this later period to revise and amplify the volume referred to. Though it did not fall to him to see this important work executed yet he may be credited with having initiated the undertaking. Explorations having for their end a more exact knowledge of the stratigraphy of the region were inaugurated by him and at his instance Professors J. F. Kemp and H. P. Cushing commenced their study of the geology of Essex and

Clinton counties which have now been so fruitful in setting forth with clearness the relations and extent of the lower formations. Somewhat earlier than this Professors Brainerd and Seely of Middlebury College, Vermont, had exhumed and R. P. Whitfield had described the rich fauna of the Beekmantown formation at Fort Cassin Vt. and this work gave a new impetus to investigations of the faunas on the New York side of the Lake Champlain basin. During the period from 1890 onward, collecting was done here for the State Museum in a desultory way by Dr Carl Rominger and Jacob Van Deloo but it was not until 1899 that the acquisition of fossils was taken up seriously by the State Paleontologist. At that time Mr Gilbert van Ingen entered the field, carrying on operations in a systematic and refined manner. He was thereupon joined by Dr Ruedemann who has since continued the work alone. The result of these operations for several seasons has been the acquisition of very extensive collections upon which the present work is chiefly based. Meanwhile some writings have appeared which bear upon the composition of these faunas; we may note especially a recent paper issued in the *Report of the State Paleontologist for 1903* by Prof. George H. Hudson on Chazy fossils from Valcour island and a treatise on the trilobites of these rocks by Percy E. Raymond. The present work deals exclusively with the cephalopod fauna of the Beekmantown and Chazy formations of the Champlain valley. The study of these objects involves peculiar difficulties, their preservation is not always good, the determinations of their organic relations have been rendered somewhat complicated by recent labors on fossil cephalopods and yet being the most highly organized mollusca at this period of the earth's history and of primary importance in determining the stratigraphic values of the formations concerned, the unraveling of their ontogeny and genetic relations constitutes a definite advance in New York paleontology.

In the preparation of this work the author has received utmost consideration from coworkers in this field and makes acknowledgment especially to Prof. H. M. Seely of Middlebury College, Prof. G. H. Perkins of Burlington University and Prof. G. H. Hudson of Plattsburg, to Dr J. F. Whiteaves of Ottawa, Dr F. D. Adams of Montreal and Prof. R. P. Whitfield of New York for the opportunity to consult the collections in their charge, and to Dr F. W. Sardeson of Minneapolis and Mr R. S. Bassler of Washington for the loan of specimens.

JOHN M. CLARKE
State Paleontologist

INTRODUCTION

1 Statement of previous investigations

The status of our present knowledge of the Cephalopoda of the Champlain basin may be understood from the following data.[1] Hall has described in his volume 1 of the *Palaeontology of New York* two species of cephalopods from the Beekmantown limestone, both from small fragments, showing neither siphuncle nor living chamber, and one only the surface; and four species from the Chazy limestone, from but one of which the siphuncle is known, from another only the surface and from the remaining two only accidental sections.

On the other hand, Billings has distinguished no less than 49 cephalopods from the Beekmantown formation of Newfoundland, Quebec and Philipsburg,[1] only a small number of which have been figured, and has also added 10 species of Chazy limestone cephalopods to the five made known by Hall.

Barrande also has made us acquainted with six species from the Beekmantown formation of Canada and Newfoundland and Whitfield has carefully described and well illustrated an excellently preserved upper Beekmantown limestone fauna from Fort Cassin in Vermont, but unfortunately has, under the misapprehension that the beds were of the age of the Lowville (Birdseye) limestone, compared them rather with Trenton limestone forms than with Billings's Beekmantown limestone species. The same author has also de-

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[1] *See* bibliography at end.

[1] In regard to the fauna of the Beekmantown beds at Philipsburg, Missisquoi co., which lie at the northeastern terminus of Lake Champlain in the Province of Quebec, we had no desire to enter the domain of the paleontologist of the Canadian survey in charge of the invertebrate faunas, hoping that he, having the advantage of the use of the first collections from this locality, of Billings's types and of a thorough knowledge of the Canadian cephalopods, will himself undertake the needed revision and elaboration of the Beekmantown cephalopod fauna of this region. It is specially desirable that the considerable number of species of Orthoceras, described by Billings from that locality, without figures, should be redescribed, referred to their proper genera, and above all figured, to make them available for comparison with those of other Beekmantown faunas.

We have only cited here [p. 508] the cephalopod species recorded from Philipsburg by Billings and Barrande; and in the case of the species of nautiloid forms described by Hyatt, inserted the descriptions. Hyatt's new species of Philipsburg nautiloids have not yet been illustrated nor described in all their characters.

scribed four species from the Beekmantown beds at Beekmantown. These and the Fort Cassin fossils had been secured by Professors Seely and Perkins, the untiring collectors of the fossils of the Champlain basin.

H. Schröder [1891] has had occasion to discuss the generic relations of some of the Fort Cassin cephalopods; and Hyatt has used the large collection of Fort Cassin fossils deposited in the National Museum and his own collections to elaborate the phylogenetic relations of the greater number of the coiled forms [1894].

Hyatt has considerably increased the number of nautiliconic species of the Nautiloidea from the Lower St Lawrence region and Newfoundland, has laid open the lines of evolution of the Cephalopoda by his penetrating investigations into their phylogeny, and supplied a new system, which is here adopted.

It may be stated here that this system so far as the nautiloid cephalopods are concerned may be indeed, as we believe it is, a true expression of the natural relationship of the forms and therefore be considered as an important improvement on the former artificial arrangement by the degree of curvature of the conch; yet anyone who seriously attempts to distribute a series of cephalopods of average preservation in this system can not fail to observe that its fundamental criteria of division, as the character of the funnels or septal necks and the internal structure of the siphuncle are so difficult of observation and fail so frequently of preservation or are so obscured that a positive decision as to the relation of the specimens in hand to the larger divisions and thereafter to the families is in a great number of cases impossible. And again where these have been recognized, it becomes apparent that if the principles of Hyatt's division are to be followed out, the number of genera established, large as it is, is yet by no means sufficient; and that the generic diagnoses, often construed on theoretic grounds, frequently do not occupy contiguous sections in the uninterrupted phylogenetic series, thereby leaving wide gaps between the hitherto defined genera.

It is for these various reasons that such a considerable number of the species here described are considered as not yet conclusively determined generically. In several cases, rather than create new genera, we have placed the species with the nearest genus, leaving the task of filling the gaps in the generic series to him who will undertake the work — as difficult as it is meritorious — of continuing the investigation where Hyatt unfortunately had to leave it.

2 Sections for reference

Since the majority of the cephalopods here described have been obtained from the shore at Valcour, south of Plattsburg, we insert here for reference a brief section of the exposures in which the cephalopods both of the upper Beekmantown and lower Chazy are found to occur more profusely and better preserved than in any other locality on the west shore of the lake, known to the writer. A fuller discussion of the important Valcour section is necessarily deferred until the investigation of the Beekmantown and Chazy faunas has been completed. The major part of this material has been jointly collected by Prof. G. van Ingen and the writer during the summer of 1899; a number of valuable specimens have also been obtained by Professor van Ingen during the field season of 1901, and the specimens cited from Beekmantown, Chazy and Valcour were mostly collected by the writer during the summer of 1903.

The exposure of the Beekmantown beds on the Valcour shore begins about one half mile north of the mouth of the Little Ausable river, in front of the farmhouse of W. H. Ayers (Lake View farm) and continues with some interruptions to the Valcour dock (Port Jackson) where a fault separates it from the exposures of Lower Chazy rocks, which thence continue northward around Day's point.

The Beekmantown beds have been provisionally distinguished as 2065 A_1-A_8[1] and the Chazy beds as 2066 B_1-B_8.

Section of the Beekmantown beds at Valcour in ascending order

A_1 is a four foot bed of hard bluish gray, gritty dolomite. Strike, n. 30 e.; dip, 5° s. e.

A_2 begins 100 feet north of end of A_1. 3 feet. Bluish gray dolomite, with lenses of lighter dolomite; the latter very fossiliferous.

A_3, exposed about 300 feet north of A_2. 6 feet. This division is shaly at the base, compact, gray or black at the middle and shaly and black at the top, the whole weathering yellowish. The gray portion is a mass of fossil fragments derived from crinoids, trilobites, cephalopods, gastropods and brachiopods, and contains small rounded pebbles or concretions. The shaly portion at the top is a valuable depository of *cephalopods* (nautilicones and orthoceracones).

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[1] This A is not identical with the division A of the Beekmantown of Brainerd and Seely, nor is B, Chazy, identical with their Chazy B. On the contrary the Beekmantown beds at Valcour are undoubtedly equivalent to a part of the Fort Cassin beds and therefore probably to be placed at the top of their Group D [*see* section on p. 399] and the Chazy beds correspond to Brainerd and Seely's upper A of the Chazy.

A_4 is a mass of rocks exposed for a considerable distance along the shore and consisting of an irregular series of beds of gray brown and bluish black sandy dolomite with thin intercalations of very fossiliferous limestone. The surfaces of the strata are characteristically marked by an entangled mass of vermiform ridges suggesting fucoids, and by channels, such as are formed on sandy beaches at low tide. These channels are filled with a bluish gray limestone, contrasting with the sandy rocks and choked with fossils, specially orthoceracones, which lie in the longitudinal direction of the channels. The channels run slightly north of east. Systems of large ripple marks extend over some of the rock surfaces. Thickness not obtained.

A_5, rock exposed on north side of Sibley point, exposures beginning behind Pacno's barn, where a dolomite bed, 4½ feet thick rests upon A_4. This is followed by a cross-bedded impure limestone containing numerous cephalopods (nautilicones) and other fossils.

A_6, 6 feet of a purer, blue limestone, which is irregularly bedded and contains seams of black shale.

A_7, a heavy bed (7 feet) of blue sandy limestone, weathering yellow, exposed at top of bank, at east end of Sibley point.

A_8, separated by a concealed interval from A_7 and consists of about 25 feet of heavy bluish limestone strata, which weather gray, are barren and contain some geodes. This bed ends at the Valcour dock. Strike n. 40 w.; dip, 15° s. w.

Section of the Chazy beds at Valcour in ascending order

The Chazy beds at Valcour form a low anticline.

B_1, a hard, compact, gray limestone, exposed at water edge, on land of Ezra Day. 2 feet of its top exposed.

B_2, same rock. 6 inches.

B_3, gray, shaly impure limestone with mud seams; very fossiliferous. 1 foot 4 inches.

B_4, more crystalline limestone with darker shaly intercalations. 1 foot 10 inches. Contains numerous small bryozoan reefs and other fossils; also many cephalopods in its upper layer (just north of fence dividing lands of George and Ezra Day).

B_5, darker, impure shaly limestone. 1 foot 6 inches. Contains some large nautiloids.

B_6, a gray shaly limestone, 3 feet, containing a rich fauna (Bolboporites, Malocystites, brachiopods, trilobites).

B_7, series of heavier, dark gray beds with abundant plates of Palaeocystites.

7a-10 inches, barren; 7b-14 inches, in lower 3 inches full of trilobites; 7c-3 feet 6 inches, heavy, crystalline bed, full of Palaeocystites; $7c^1$-24 inches, barren; $7c^2$-8 inches, hard crystalline gray limestone with trilobites.

B_8, 5½ feet of dark shaly limestone, nearly bluish gray and very fossiliferous, containing orthoceracones.

Since we can do no better than base our future stratigraphic work on the larger lithologic divisions recognized by Brainerd and Seely in the Beekmantown formation at East Shoreham Vt. and in the Chazy formation at Chazy village, we refer the fossils obtained at other places than the Valcour shore provisionally to those divisions.

The Beekmantown beds have been divided by these authors [1890, p. 2] into five divisions, termed A-E.

Section at East Shoreham in ascending order

Division A. Dark iron gray magnesian limestone, usually in beds one or two feet in thickness more or less silicious, in some beds even approaching a sandstone. Fossils none. Thickness 310 feet.

Division B. Dove colored limestone, intermingled with light gray dolomite, in massive beds. Fossils: Orthoceras primigenium, Cryptozoön steeli. Thickness 295 feet.

Division C. In succession gray, thin bedded, fine grained, calciferous sandstone; magnesian limestone in thick beds, weathering drab; sandstones, sometimes pure and firm, but usually calciferous or dolomitic; magnesian limestone like no. 2, frequently containing patches of black chert. Fossils, none, except Scolithus minutus Wing. Thickness 350 feet.

Division D. In succession blue limestone, in beds one or two feet thick, breaking with a flinty fracture; the weathered surface with a rough, curdled appearance; drab and brown magnesian limestone; sandy limestone in thin beds; blue limestone in thin bands. Fossils: Ophileta complanata, Maclurea affinis, Lituites eatoni, Asaphus canalis and species of Cryptozoon, Bathyurus, Maclurea, Murchisonia, Orthoceras, Cyrtoceras. Thickness 375 feet.

Division E. Fine grained magnesian limestone in beds one or two feet in thickness, weathering drab, yellowish or brown. Fossils: Bucania tripla, Murchisonia confusa, Bathyurus extans? var., Primitia seelyi and species of Lingula, Maclurea?, Murchisonia, Orthoceras, Bathyurus, Cheirurus? and encrinal columns. Thickness 470 feet.

Brainerd and Seely as well as Cushing and the writer have observed that also on the west side of Lake Champlain these greater divisions of the Beekmantown beds at East Shoreham can be recognized, as a rule, by their lithologic characters.

The section at Chazy village [Brainerd & Seely, 1888, p. 323] is, for several reasons, to be considered as the type section for the Chazy formation. Not only did Professors Hall and Emmons name the formation after this locality, but it is here also exposed more perfectly than anywhere else in the Champlain valley, with the possible exception of Valcour island, only small portions at the top and bottom being concealed; and better opportunities for collecting the fossils, bed for bed, are offered here than elsewhere. Professors Brainerd and Seely have carefully mapped the neighborhood of Chazy village and elaborated the section. They found a total thickness of 732 feet of Chazy rocks. These were conveniently divided into a lower group (Group A), a middle one (Group B) and an upper one (Group C). Group A is largely characterized by the presence of Orthis costalis; group B by Maclurea magna, while group C is, at least in some beds, replete with shells of Rhynchonella plena. The three groups have been subdivided, on lithologic grounds, into a considerable number of minor divisions. Some of these appear to be recognizable in distant localities; as the red spot stratum of A_8 with Bolboporites americanus, which is also found on Valcour island and on the Valcour shore. The writer has made extensive collections from every stratum of this type locality. These collections, when studied, will it is hoped, afford the means of recognizing distinct fossil horizons and of establishing the sequence and life zones of the Chazy faunules. Since we shall, for the present, refer the cephalopods from the Chazy, here described, to Brainerd and Seely's subdivisions, we reprint here in full their careful section.

Measurements at Chazy in ascending order

	GROUP A	FEET
1	Iron gray, fine grained dolomitic limestone, in beds one or two feet in thickness, weathering drab with fine yellowish streaks at right angles to plane of bedding; containing Orthis costalis and crinoidal fragments...........	110
2	Tolerably fine limestone, filled with fragments of crinoids, containing Orthis and Strophomena.........................	20
3	Measures concealed	40
4	Impure limestone, filled at bottom with Orthis, thin bedded when long exposed to weather, the upper six feet abounding in crinoidal fragments	30
5	Fine grained, massive limestone containing Scalites angulatus, Raphistoma and fragments of trilobites...	25

		FEET
6	Impure limestone, abounding in Orthis	10
7	Measures concealed	25
8	Massive, gray limestone, largely made up of crinoidal remains, having red spots in a stratum about 10 feet from the top; abounding near the middle of the strata with gastropods. Bellerophon, Raphistoma, Metoptoma, Asaphus marginalis, Stenopora fibrosa, Bolboporites americanus, Retepora gracilis.	50
		310
	GROUP B	
1	Thick bedded, nodular, dark colored limestone, containing Maclurea magna	50
2	Massive, pure limestone, gray, fine grained, often oolitic, abounding in crinoidal remains and Stenopora fibrosa	20
3	Massive, bluish black, tolerably pure, nodular limestone, containing Maclurea magna and masses of black chert	45
4	Similar to no. 3, but containing in addition to Maclurea, various species of Orthoceras and large masses of Stromatocerium	90
5	Less massive limestones, quite impure and often disintegrated into nodules as though shaly	60
		265
	GROUP C	
1	Dark, iron gray, dolomite, weathering yellowish	1
2	Blue, compact, fine grained, pure, limestone, containing fine lines of calcite	6
3	Dove colored, compact, brittle, perfectly pure limestone containing small nodules of calcite	5
4	Iron gray dolomite	3½
5	Like no. 3, only containing larger nodules of calcspar	4½
6	Dark gray, fine grained compact limestone somewhat impure, having a mottled aspect when weathered, containing several undetermined species of Murchisonia, Orthoceras and usually enveloped in Strephochetus	2
7	Iron gray dolomite	1
8	Blackish, impure limestone, abounding in Rhynchonella plena	36½
9	Dark or light gray, massive coarsely granular limestone, mostly made up of crinoidal fragments which are sometimes red, containing Rhynchonella	26½
10	Same as no. 8	32
11	Measures concealed	7
12	Tough, impure dolomite	8
13	Concealed	24
		157
	Total thickness of A, B and C	732

Terminology

In employing Hyatt's system in this group it is necessary also to adopt his terminology with some alterations and additions proposed by Holm and others. The less common of these technical terms are here briefly defined.

The word *conch* is used for the entire shell; this may have a *nepionic bulb* (or *preseptal cone*) which is a conical part at the apical end, formed before septation took place and appears as an apical dilation of the siphuncle. The septate part is termed the *phragmocone.* It consists of *cameras* or *chambers* and the *siphuncle.*

The phragmocone may be an *orthoceracone,* which is "the older stage of a straight form, and is nearly or quite straight on both venter and dorsum" (*see* below); or a *cyrtoceracone,* which is a shell "curved like Crytoceras on both venter and dorsum"; or a *gyroceracone,* curved in a loose spiral-like Gyroceras; or a *nautilicone,* which is a closely coiled shell having an impressed zone. The *impressed zone* is the longitudinal impression formed in the dorsum by the contact of the whorls. A *persistent dorsal furrow* occurs in the free senile whorls of some shells, and is a remnant of the impressed zone.

The *venter, ventral* side or *abdomen* is the side on which the *hyponomic sinus* or *ventral sinus* is situated. The latter is a single median bend in the apertural margin for the "ambulatory funnel" or hyponome of the animal. It locates the ventral side (and not the siphuncle as usually assumed). Its former position can be recognized by the corresponding bend in the growth lines of the conch. To avoid using, in cases where the position of the hyponomic sinus is not known, the terms *ventral* and *dorsal* in their old conception as determined by the position of the siphuncle, we will in such cases denote the sides by the self-explanatory terms *siphonal* and *antisiphonal. Exogastric shells* are those which have the ventral sinus on the arched, external side (the great majority of the forms); *endogastric shells,* those which have it on the concave, internal side. The opposite side of the venter is the *dorsum* or *dorsal side* (mostly the inner side).

The longitudinal areas of the whorl are termed *zones* (*dorsal, ventral, lateral zones*); when they become flat they are called *faces.* The junctions of the lateral faces and the abdomen are termed *abdominal angles* and those of the lateral faces and the inner faces *umbilical shoulders.* The *lines of involution* are the outer boundaries of the impressed zone.

The conch, if not circular in section, may be either *compressed* (when the transverse diameter has been shortened) or *depressed* (when the dorsoventral diameter has been shortened).

The direction of the conch is designated as *apicad* (in apical direction), *orad* (in oral direction), *dorsad* and *ventrad.*

The apertural margin frequently possesses, besides the hyponomic sinus, lateral expansions, termed *crests* or *lappets.*

The *siphuncle* is the calcareous tube containing the fleshy siphon. It may be *tubular* or *nummuloidal* (moniliform); i. e. inflated in the interseptal spaces. The position of the siphuncle within the phragmocone can be precisely stated by the use of the terms given in the appended diagram [text fig. 1].

The *ectosiphuncle* is the external wall of the siphuncle; the *endosiphuncle* comprises all structures within the same.

The anterior or upper part of large siphuncles remains unobstructed and was doubtless occupied by an extension of the mantle cavity. This part of the siphuncle is here termed *endosiphocylinder* (Hyatt's endoconal or siphuncular chamber).

Fig. 1 Diagram to explain the terminology used in describing the position of the siphuncle. (Copy from Hyatt)

It is followed apicad by the *endosiphocone,* a conical extension of the same cavity, bounded by the *endosiphosheath* (Hyatt's endocone).

The endosiphocone is continued in forms with organic deposits in a tube to the apex; this tube is the *endosiphotube* (endosiphuncle Hyatt, prosiphon Zittel). Sometimes a wider broad flat tube, closing apicad into a double plate, extends apicad from the endosiphocone. This is the *endosiphocoleon.* The endosiphotube and endosiphocoleon may be suspended by membranes (*endosiphoblades*).

The siphuncular wall or ectosiphuncle consists originally entirely of the *septal necks* or *funnels,* which arise from the bending of each septum apicad into a funnel around the point of origin of the siphon. In most forms the septal necks are short and continued in apical direction by a more or less porous wall (the *septal segments*) to the next septal neck or beyond. The inside of this siphuncular wall is sometimes still covered by another layer of organic deposit, the *endosipholining*.

Forms in which the ectosiphuncle is composed only of septal necks are called *holochoanitic* (order Holochoanites); those in which the septal necks are short but straight, *orthochoanitic* (order Orthochoanites) and those in which the septal necks are short and bent outward or crumpled, *cyrtochoanitic* (order Cyrtochoanites).

Order NAUTILOIDEA

Suborder A HOLOCHOANITES Hyatt

Division II ENDOCERATIDA

Family ENDOCERATIDAE

Genus CAMEROCERAS (Conrad) emend. Hyatt

This genus was defined by Conrad in the following diagnosis:

Straight; siphuncle marginal; a longitudinal septum, forming a roll or involution with the margin of the siphuncle.

Hall recognized the genus stating that he found no evidence of the longitudinal septum and, seeing its generic character in the "oval form of the shell", restricted the term to Conrad's genotype Cameroceras trentonense erecting a new genus Endoceras for the many similar forms of the Trenton with a different section. The latter name has found very wide acceptance and Cameroceras treated as a synonym of Endoceras [*see* Foord, 1888, p.129]; while others, inclined to recognize the right of priority, have referred the whole group of forms with long septal necks and endosiphuncular organic deposits to Cameroceras [*see* Clarke, 1897, p. 775].

Hyatt has from the beginning [1884, p. 266] held that three genera could be differentiated in this group of obviously closely related forms, viz Vaginoceras (Hyatt), Endoceras (Hall) and Sannionites (Fischer de Waldheim). The latter term he has later on replaced by Cameroceras. The principal diagnostic characters of Vaginoceras are seen in the posterior extension of the septal necks beyond the next preceding septum and the great number of endosiphosheaths; those of Endoceras in the posterior extension of the septal necks to the next septum only, the smaller number of endosiphosheaths and the absence of an internal lining layer in the siphuncle (endosipholining); those of Cameroceras in the presence of one large thick walled sheath only in connection with the living chamber, the extension of the septal necks to the preceding septum and the presence of the endosipholining.

We adopt here these genera since we have had occasion to observe the varying lengths of the septal necks and the presence of the endosipholining in some forms and its apparent absence in others. As to the endosiphosheaths we infer from our material that they are present in all these genera in like close arrangement and frequency, but not in equal preservation, becoming in some more calcified than in others. Indeed the diagram given by Hyatt in Zittel-Eastman's textbook shows them in great number in Endoceras, while that genus had been defined as possessing but few. The statement in regard to Cameroceras is due to the formation of a thick final endosiphosheath by the senile cephalopod. Drawings, distinctly showing this thick sheath as well as the endosipholining of Cameroceras, have been given by the writer.[1]

The assertion made by Whitfield [1881, p. 25, fig. 2] in regard to the genotype, V. multitubulatum, that the endosiphosheaths are continuous with the septal necks in Vaginoceras, needs verification, for the endosiphosheaths have certainly no connection with the septal necks in the other two genera nor could any such connection be inferred from Holm's careful sections of Endoceras belemnitiforme [1895, pl. 22, fig. 9],[2] which species is referred to Vaginoceras by Hyatt. The septal necks, which in that species reach beyond the preceding septum, are represented as gradually thinning out upon the older septal necks. This condition corresponds to that found in the other genera.

The siphuncular structures of the endoceratid forms of the Trenton which are the types of these genera need further investigation before the relations of the latter can be considered as being cleared up.

Cameroceras (Proterocameroceras) brainerdi Whitfield (sp.)

Plate 1, figure 5, 6; plate 2, figure 1

Orthoceras brainerdi Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 319, pl. 27, fig. 14–16

Orthoceras explorator (Billings) Whitfield. Am. Mus. Nat. Hist. Bul. 1890. v. 3, no. 1, p. 33, pl. 2, fig. 3

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[1] An. Rep. State Paleontol. for 1903. N. Y. State Mus. Bul. 80. 1905. pl. 9, fig. 2.

[2] Copy in An. Rep't State Paleontol. for 1903. N. Y. State Mus. Bul. 80. 1905. text fig. 19.

Cameroceras (Proterocameroceras) brainerdi, Ruedemann. An. Rep't State Paleontol. for 1903; N. Y. State Mus. Bul. 80. 1905. p. 296ff

The attention of Professor van Ingen and the writer was, at the time of their collecting in the Fort Cassin beds at Valcour, at once attracted to large, very gradually tapering orthoceratites which frequently attained a length of a foot and a half or more and were piled up in mud channel fillings of the Beekmantown rock, together with Ophiletas and other gastropods. Comparison with the original description and types, and with material from Fort Cassin in the State Museum has demonstrated the identity of these shells with Orthoceras brainerdi, a species described by Whitfield from the original Fort Cassin beds. To the careful description of the septa, sutures, position and size of the siphuncle by the author of the species, we have little to add. Our material from Valcour and specimens from Fort Cassin have however allowed us to make out the endosiphonal structures and the characters of the apical end, both of which proved to be of great interest and have been made the object of a separate investigation since they invited a fuller discussion.[1]

Description. Orthoceracones of large size; specimens measured had attained a length of 1½ feet (45cm) with the greater part of the apical portion missing, and hence must have reached at least 4 feet and probably considerably more. The conch expanded very gradually, the rate of growth being about 1:30 (15 mm in 450 mm). Diameters of 60 mm in the septate portion have been observed. The section is elliptic, the ratio of the major and minor diameters as 7:9.

Surface smooth and only provided with growth lines.

The living chamber was apparently of moderate size and lacking apertural contractions. In a specimen having a diameter of more than 50 mm at the base of the living chamber it has a length of 135 mm or not quite three times the width of its base. Its surface was marked with faint transverse lines (growth lines).

Cameras shallow, their depth about one fifth the width; septa closely arranged, 3 to 4 mm distant from each other (7 in the space of one inch or of 25 mm in the mature parts of the conch) each running up along the outer shell to the base of the succeeding septum; sutures undulating, showing a narrow, often acute siphuncular

[1] State Paleontol. An. Rep't for 1903. N. Y. State Mus. Bul. 80. 1905. p. 296ff.

or ventral saddle (sometimes absent when the siphuncle is separated a little more from the outer wall, as on plate 2, figure 1), which is flanked on both sides by broad lobes, passing into still broader saddles, which are separated by a low lobe approximately opposite the siphuncle.

Siphuncle tubular, of roundish oval section similar to that of the conch, but as a rule flatter on the side next to the conch; very large, approximately one third the diameter of the conch; in contact with the latter and lying on the flatter side of its ellipse. The surface is characteristically marked by strong transverse ribs which on the outer or ventral side curve abruptly upward on account of the direction of the septa, its apical part projecting beyond the chambered shell for a distance of about 75 mm; gradually expanding from the blunt apical end, which here has a diameter of about 3 mm to 11.5 mm at the beginning of the phragmocone, where it contracts to 10 mm and then gradually expands again. The anterior third, roughly stated, of the siphuncle is empty (endosiphocylinder), the remainder filled with calcite, containing the endosiphosheaths, which like the endosiphocone possess an apical angle of not quite 20°. The endosiphocone has a subtriangular section, one side of which corresponds to the flatter side of the siphuncle. A conchiolinous flattened tube (endosiphocoleon) proceeds apicad from the interior of the endosiphocone. It attains a width of 10 mm behind the endosiphocone, but gradually tapers to the width of the enclosed endosiphotube, becoming apicad more and more indistinct by a loss of conchiolinous matter and replacement by organic calcite. The endosiphotube is a fine subcentral tube with conchiolinous walls, circular section and a diameter not surpassing one half mm. It continues to the apical end, diminishing slightly in diameter. The endosiphocoleon and endosiphotube are suspended by three membranes (endosiphoblades) arranged like an inverted T. In some specimens a longitudinal, strongly impressed (muscular?) line passes along the outer wall directly above the siphuncle.

Position and locality. Very common in the Fort Cassin beds at Valcour, along the shore of Lake Champlain (2065 A_3 and A_4 of our section) and also at Fort Cassin Vt, from where it was originally described. As a rule only the solid calcified apical portions of the siphuncles are observed.

Observations. Whitfield has assigned smaller orthoceracones from Fort Cassin to Orthoceras explorator Billings, a species from the "Quebec group" of Newfoundland. The greater rate of growth of the conch, closer arrangement of the septa, smaller size and different position of the siphuncle in the Newfoundland form forbid, however, this identification; while on the other hand these smaller fragments correspond in their rate of growth, relative size and position of the siphuncle and the undulating character of the sutures sufficiently well with C. brainerdi to permit their reference to that species. It is true the depth of the chambers is in the large type of C. brainerdi and the fragments in question nearly the same, but since also other forms show sometimes hardly any increase in chamber depth with advancing age, it is not necessarily to be inferred that the later growth stages of the fragments must have possessed deeper chambers.

Cameroceras tenuiseptum Hall (sp.)

Plate 3, figure 1, 2; plate 4, figure 1; plate 5, figure 5, 6; plate 6, figure 2

Orthoceras tenuiseptum Hall. Pal. N. Y. 1847. 1:35. pl. 7, fig. 6

Orthoceras tenuiseptum Raymond. Am. Pal. Bul. 1902. v. 1, no. 14, p. 19

The original description of this species is:

Cylindrical, gradually tapering, straight; surface smooth; section cylindrical; septa very thin, gently arched, approximate about 1/25 the diameter; siphuncle small?

Only fragments of this shell have been found in this limestone, and therefore all its characters can not be ascertained. It corresponds in many respects with O. primigenium of Vanuxem [pl. 3, fig. 11]; but the specimens of that fossil attain only a small size, while this one is very large. Another difference will be observed in the concavity of the septa, which are less arched in the specimen under consideration.

Position and locality. Chazy, Clinton co., in the dark limestone, associated with Maclurea magna. The specimens appear on the surface of the strata, and are all more or less weathered.

The description and the figure of the type which is deposited in the New York State Museum [no. 4026 of type catalogue] show that this species has been based upon the oblique section of a fragment, which fails to show either siphuncle, living chamber or rate of growth. Nevertheless, we feel that we do not go amiss when we refer one of the most common larger cephalopods of the Chazy formation of New York to Hall's species, partly because there is little danger of error, for no other equally large and equally closely septate cephalopods occur in our Chazy formation and partly because Hall's statement expressly implies that the form is very common in the middle Chazy beds, which is the case with the material here referred to C. tenuiseptum. From more complete material we derive the following description:

Description. Large, slender orthoceracone, with closely arranged septa and very large, ventren siphuncle. The conch attains at least a size of ½ m as indicated by our largest specimen. Its rate of growth is 13 mm in 100 mm; the largest section has a diameter of 105 mm. The section of the conch is circular, with a slight flattening on the ventral side, where the siphuncle is in contact with the outer wall.

The cameras are extremely shallow, 7 cameras being found in the space of 20 mm. The septa are exceedingly thin, very concave, their depth attaining thrice that of the cameras. The sutures are slightly undulating; they are provided with a narrow, low, ventral saddle and wider low lateral lobes. The living chamber is large; its full extent and the aperture have not been observed.

The siphuncle is large, its diameter more than one third that of the phragmocone in younger and fully one half of the same in older specimens; circular in section, at least in the earlier stages; ventren in position, though not in absolute contact with the outer side, for the sutures of the septa form a high, sharp saddle upon the ventral side of the siphuncle and a correspondingly deep lobe on the opposite side [*see* pl. 5 fig. 6]; the septal necks reach apicad to the preceding septum but no farther. A large (ephebic) portion of the siphuncle remains continuously open, that of the earlier stages is solidly filled with organic deposits, which exhibit distinct endosiphosheaths and an endosiphotube. A nepionic bulb [pl. 5, fig. 5] which had become entirely or mostly incorporated into the phragmocone and hence is not visible from the outside is present. It attains a greatest width of 13 mm and the siphuncle shrinks directly anteriorly again to a diameter of 9 mm.

The surface is marked with fine engirdling lines.

Position and locality. This species is common in the dove-colored Chazy limestone near Little Monty bay near Chazy village and has also been obtained from dove-colored limestone (C_1) of Valcour island and of Isle La Motte and from the Strephochetus bed (C_6) at Chazy village; in the latter place in poorly preserved specimens of somewhat doubtful reference. Raymond cites it from the beds with Maclurea magna at Crown Point and Hall's type came from the dark Maclurea magna limestone of Chazy.

Observations. This common and characteristic cephalopod of the Chazy formation of New York is so similar in its form, dimensions, position and character of siphuncle, suture etc. to C. brainerdi from the Upper Beekmantown beds of the same region, that a direct genetic connection between the two species suggests itself very strongly; and there is no doubt that if a continuous series of forms from the Beekmantown to the Upper Chazy types could be obtained, interesting facts in regard to the developmental tendencies of this race of cephalopods could be ascertained. If the primitive characters resting in the presence, relative size and development of the nepionic bulb are taken in consideration as indicators of development, the Chazy form had not progressed materially beyond the Beekmantown species, the principal progress consisting in the partial incorporation of the nepionic bulb into the phragmocone. The group of large Trenton forms, comprised under the specific name Endoceras proteiforme, which also has the aspect of being a member of the same stock, has proceeded, as far as present evidence goes, to a complete incorporation of the apical portion of the siphuncle within the phragmocone, or in other words to the formation of cameras in the nepionic stage.

Billings [1865, p. 173] has described as Orthoceras velox, a large cephalopod with nearly identical characters — notably in the small depth of the chambers, the rate of growth and size — from the Chazy formation of the Mingan islands, the islands of Montreal and Bizard. The most important difference between the two similar species I find to consist in the different relative width of the siphuncles which in C. tenuiseptum is about one half of the width of the phragmocone in mature specimens, in O. velox only one third. Besides, in O. velox the conch is slightly curved, probably a difference of little import.

Numerous specimens of C. tenuiseptum, specially those occurring near Little Monty bay, appear to be much more closely septate than they actually are. This misleading impression is due to the fact that the incrustation proceeding from both the upper and lower walls of the cameras, produces a sharp division line in the middle of the same, which has the appearance of a further septum. The extension of the septal necks to the preceding septum only and the observation of the endosipholining in the apical conch warrants the reference of the form to the genus Cameroceras, as emended by Hyatt.

Camcroceras curvatum sp. nov.

Plate 2, figure 6, 7

Description. Medium sized cyrtoceracones with extremely closely arranged septa and large, marginal siphuncle. The size attained by the mature conch is unknown; the fragment which is the type of the species has a length of 62 mm but its rate of growth which is 8 mm in 62 mm (17 mm at smaller diameter and 25 mm at larger diameter) indicates a missing apical portion of 120 mm, and the living chamber is also missing. The type specimen can be said to have had a length of approximately 200 mm. The curvature is slight (the hight of the arc of the fragment is 3 mm) and a little stronger in the apical than in the anterior part of the conch. The section of the conch is circular.

The cameras are exceedingly shallow; there being counted 9 of them in the space of 20 mm in the type specimen. The sutures have been observed only in part and a narrow high saddle on the inner side of the conch has been noticed. The septa are very thin, advancing considerably on the convex side of the phragmocone and their depth is thrice that of the cameras. The shell is thin and not only the siphuncle but also the chambers appear to have become partly filled with organic deposit.

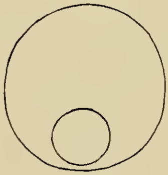

Fig. 2 Cameroceras curvatum sp. nov. Transverse secti n. x $\frac{9}{10}$

The siphuncle, which is tubular and exactly two fifths the width of the phragmocone, is in contact with the wall at the inner side of the curve [*see* text fig. 2]. The endosiphocone is very long and slender (30 mm) and the endosiphosheaths are correspondingly long conical in shape. The endosiphotube is well developed. The septal necks end upon the geniculations of the preceding septa.[1]

Position and locality. In the dove-colored Chazy limestone (C_1) of Isle La Motte (loc. 215, Professor Perkin's coll.; type in the collection of Burlington University). Its presence in the same horizon at Valcour and Chazy in New York can hardly be doubted, but the fragility of the shell renders it one of rare observation.

Observations. This peculiar form shows, if we disregard the curvature, an extreme development of some of the characters of

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[1] The structure of the siphuncular wall, described under E. oppletum, is also here observable; notably the presence of a slight interspace between each septum and the termination of the septal neck of the following septum.

C. tenuiseptum, specially in the frequent septation and the thinness of the septa. On the other hand its siphuncle does not attain the large relative width of that of the latter species. Also from (O.) velox Billings, to which it bears considerable similarity in its curvature, closeness of septa and marginal position of the relatively large siphuncle, it can be distinguished by the still closer arrangement of the septa and the smaller size of the siphuncle.

It appears that in this form as in C. tenuiseptum the frequency of the septa is correlated to their extreme thinness; and that the organic deposits of the cameras served in part the purpose of counteracting a lack of strength in the septa.

Genus VAGINOCERAS Hyatt

The genus Vaginoceras Hyatt, with V. multitubulatum Hall (sp.) as type was originally defined by Hyatt [1884, p. 266] as follows:

> The funnels extend posteriorly beyond the next septum to that from which they originated. The sheaths are very numerous, and continuous, according to Whitfield, with the funnels. Endosiphon unknown.

The diagrammatic section of Endoceras by the same author in Zittel-Eastman's textbook as well as the reference of Endoceras belemnitiforme of Holm to Vaginoceras, indicates that Hyatt did no longer support Whitfield's view as to the direct connection of the septal necks and endosiphosheaths. This point can, however, be cleared fully only by an investigation of the genotype, V. multitubulatum, a form of which it is difficult to obtain specimens suitable for this work. We have here referred a single form to Vaginoceras and this reference requires explanation.

The enlarged section of the ectosiphuncle of this form, reproduced in plate 4, figure 3, shows that each septal neck extends to the second preceding septum where it rests on the septal neck, the place being marked by a white spot that contrasts with the black carbonaceous substance of the ectosiphuncle. There appears to have remained just above the end of the septal neck, a vacant ring which later on has been filled with infiltrated white calcite.

A like vacant ring has been indicated by Hyatt in a diagrammatic section through the siphuncle of Endoceras proteiforme, given in Zittel-Eastman's textbook. The presence of this vacant space and the observation of a collarlike extension of the lumen of the camera between the septal necks (appearing in plate 4, figure 3, as tonguelike processes and noted more fully under V. oppletum) in one species of Vaginoceras suggests that we might have here a condition like that represented by Hyatt in the above mentioned diagram, where each septal neck extends only to the next preceding one and supplementary pieces are intercalated between the adjoining septal necks. Hyatt has not mentioned this structure in the text, as far as I am aware and I have here [*see* text fig. 3] reproduced an enlargement of a portion of the drawing in question to bring out more distinctly this peculiar structure.

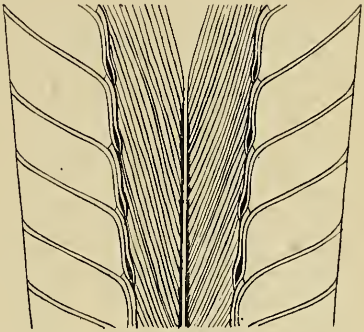

Fig. 3 Endoceras proteiforme Hall. (Copy from Hyatt)

Since the species here referred to Vaginoceras shows in some parts of the section distinctly the continuation of the septal necks though in others it might easily lead to a reconstruction of the siphuncular wall like that given in the diagram of Endoceras proteiforme, I have preferred to adopt the former view as the simpler one and as the one more liable to be correct.

Vaginoceras oppletum sp. nov.

Plate 4, figure 2, 3; plate 5, figure 1-4; plate 6, figure 1; plate 9, figure 1-3

Description. Large orthoceracone which must have attained a size of 1 m and more. Imperfect specimens 45 cm long and with a diameter of 10 cm, which at the rate of growth of this species would correspond to a length of 120 cm, have been observed. The rate of growth is very slow (one conch was found to expand 10 mm in the distance of 117 mm, or 1 in 12; another 6 in 57 mm) and decreases slightly with advancing age. The section of the conch is subcircular or but slightly elliptic (major and minor diameters 58 and 51 mm; respectively 55 and 50 in another, but from the elliptic sections of the siphuncles in these specimens it is probable that the conchs are slightly compressed). The living chamber attained a large size but its proportions are not fully determined owing to the imperfection of the specimens. The aperture is unknown.

The cameras are shallow, slightly and regularly increasing in depth to the living chamber, there being counted four in the space of 20 mm in the mature phragmocone and five in the same space in the apical portion of the shell. The sutures appear undulating; they are provided with a ventral saddle, whose hight is in some measure proportional to the nearness of the siphuncle to the wall of the phragmocone; this saddle is flanked by broad, low lobes, which are followed by broad and higher lateral saddles, which on the dorsal side inclose a short low lobe. The septa are moderately convex, about one and a half times as deep as the cameras.

The siphuncle is circular in section, large (two fifths the width of the conch); subventran in position, but not in contact with the outer shell and distant from the latter by one fourth of its diameter (5 mm when its width is 20 mm). In the apical region it forms a nepionic bulb [pl. 5, fig. 1] having a length of about 35 mm from the apex to the widest point and a maximum width of 10.5 mm, protruding beyond the chambered shell in its posterior part. A large portion of the siphuncle is filled with long conical endosiphosheaths which leave open a fine endosiphotube [*see* pl. 4, fig. 2]. In the cameras of the older parts of most larger specimens organic deposits are found which frequently reach the outer walls and completely fill the cameras [*see* pl. 6, fig. 1; pl. 9, fig. 1–3]. The surface is smooth.

Position and localities. This species is very common in the dove-colored limestone of Isle LaMotte (C_1) and Valcour island and in the like beds exposed near Little Monty bay south of Chazy village. It has also been observed in the lower Chazy of the Valcour shore (123 B_4).

Observations. The most striking character of this species is the organic deposit in the chambers. Its character and appearance on the septa and siphuncle vary greatly in the same individual, the variation depending upon the distance from the living chamber. The organic deposit is heaviest in the apical region of older individuals and diminishes in apertural direction. It appears to have been formed, as a rule, slightly in advance of the filling of the siphuncle by the endosiphosheaths and is hence absent in the greater (anterior) part of the phragmocone. It also is frequently more developed on the antisiphuncular side than on the opposite one and appears to have been heavier and more developed in the specimens of one locality than in those of another. It is most strikingly developed in the specimens from the east side of Valcour island and but weakly in those from Isle La Motte and Little Monty bay and not at all in the specimens from the Lower Chazy of the Valcour main shore, referred to this species.

The deposit has an irregular mammillary surface [*see* pl. 6, fig. 1; pl. 9, fig. 2, 3]; the larger nodular parts are again composed of smaller, more or less indistinct segments of spherules. Sections demonstrate that it consists of successive layers. These, however, do not lie concentrically around the siphuncle, as one would expect, or fill the chambers by growing progressively from all sides toward the interior but are arranged symmetrically to a diagonal plane, extending in the section [*see* pl. 9, fig. 1, and text fig. 4] from the lower inner corner of the camera to its upper outer corner. Where the cameras had not yet been filled entirely and the mud was able to enter them at the time of the entombment of the shell, the upper inner corners have become filled with it or rarely with anorganic deposits, and the outer lower corners, which also remained empty, with secondary anorganic deposits. Previous to the gerontic stage the cameras became filled with organic deposit to the extent of solidifying the entire shell, and all this deposit arranged itself symmetrically to the diagonal plane of the cameras.

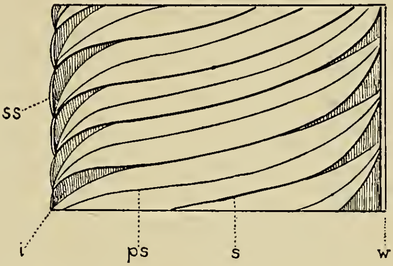

Fig. 4 Vaginoceras oppletum sp. nov. Diagram to show the relation of the anorganic deposits to the pseudosepta (*ps*): *s*=septa, *w*=outer wall of conch, *ss*=septal necks, *i*=spaces in cameras free from organic deposit

This mode of deposition can only be understood if the former presence of diagonal membranes is assumed, which served as a base for the deposits. These membranes were of the character of the "pseudosepta" observed by Dewitz, Holm and others. The pseudosepta themselves are not preserved in this species; they probably were of a similar frail character as the septa themselves which are also lost in a great number of the specimens on account of their great thinness.

Holm has on the occasion of his description of perfect pseudosepta and additional structures in the species of Ancistroceras furnished a historical sketch of the views of different authors on these membranes and also attempted to give an explanation of their origin.[1] From this review we learn that Woodward had first noted the presence of a membrane within the cameras of Orthoceras, and that the organic origin of this structure was disputed by Barrande, but reasserted and described more fully from several other

[1] Pal. Abhandl. 1886–87. 3:18ff, 25ff.

forms by Dewitz and Noetling. American paleontologists have thus far paid no attention to the intracameral structures of the cephalopods and it is to be expected that the study of our large Lower Siluric cephalopod faunas will furnish important additional data bearing on this problem.

Holm does not adopt Dewitz's view that the pseudosepta were "Hilfskammerwände" formed by the animal during a pause in its advance in the shell, but rather concurs with Woodward's older view, that they were a sort of cast-off membranes, though he does not assume with the latter author that they originated through contraction of the layer lining the inner walls of the chambers. He holds that they formed a membranous double bag which was not coalescent with the mantle and, covering its posterior part, was cast off and left behind when the animal left the old chamber, and later became calcified.[1]

In the European forms the pseudosepta are described as extending from the upper margin of the chambers to the middle of the siphuncular segment. From the structure of the organic deposits in V. oppletum we conclude that here the pseudosepta extended from the upper outer margins of the chambers to their lower inner margin or the neighborhood of the beginning of the septal necks. The structure of the siphuncular wall, which is here that of a Vaginoceras would suggest that the pseudosepta extended through or caused the collarlike interspace which enters between the septum where it bends into the septal neck and the septal neck of the next younger septum which at this point also bends slightly outward [*see* pl. 4, fig. 3].

The observation of the extremely heavy deposit of organic carbonate of lime in the chambers and siphuncles of this species naturally invites inquiry into its function. Barrande,[2] I believe, observed the first organic deposit in the chamber of orthoceratites and, pointing out that it appears to be analogous to that in the large and complicated siphuncles of Endoceras, Huronia and Actinoceras, suggested that it was secreted by the animal to give strength and weight to the shell.

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[1] The peculiar "Pseudoseptalfalten" observed by Holm in the species of Ancistroceras, do not seem to exist in this species of Endoceras, nor have they been found by Holm in the two species of Orthoceras from which he records the presence of pseudosepta.

[2] Syst. Sil. du centre de la Bohême, v. 2, t. 4, p. 280.

Later on, Hall and Beecher[1] had occasion to observe the filling of chambers by organic deposit in several species of Orthoceras from the Schoharie grit. They, in following the suggestion that the shells of Orthoceras and other related genera were probably carried in a vertical position, concluded that "the volume of the septate or chambered portion being considerably in excess of the chamber of habitation, and the external shell comparatively thin, a deposit on the interior of the chambers would afford the required strength and gravity".

Two years ago Jaekel[2] advanced a number of very suggestive theses on the mode of existence of the cephalopods. One of these holds that the orthoceratites were sessile in such a fashion that their chambered shell grew upward from a bell-shaped fixed embryo chamber and throughout life retained flexible connection with this by means of conchioline secretion. In a translation of a part of Jaekel's paper by the present writer[3] the ground was taken that the orthoceratites probably allowed themselves to sink or actively buried themselves in the bottom deposits. Among other arguments in support of this view the complete filling of the chambers of the Schoharie grit species cited above was named. Certain facts ascertained in regard to V. oppletum and Endoceras? hudsoni [*see* p. 422] would seem to support our contention; i. e. that there exists a difference in the amount of deposition of organic carbonate of lime in different localities, and that the deposition is heaviest where the irregular sedimentation and the presence of large masses of coralloid forms indicate coral reef conditions but is more or less absent where the presence of more regularly bedded, argillaceous calcareous shale points to deposition in deeper and less turbulent water. This mode of occurrence and that of the Schoharie forms lead to the inference that the deposition in the siphuncle and chambers served principally as a safeguard for the fragile conchs against destruction by being thrown against the reefs and as a device to safely anchor the shell to the bottom. This view is also supported by the observation that the younger shells, which harbored the younger and more active animals have only the large siphuncles filled with endosiphosheaths which were sufficient to weigh down the shell, that older conchs however are liable to have also the

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[1] Pal. N. Y. 1879. v. 5, pt. 2, text, p. 247ff.

[2] Zeitschr. d. Deutsch. Geol. Gesell, 1902. 54:67–101.

[3] Am. Geol. 1903. 31:199.

entire phragmocone filled solidly. It must have been impossible for the latter to move to greater distances and they must have lived much as the recent octopus which prefers to sit in cavities of the rocky bottom, and thence to extend its arms in all directions in search of prey.

The complete filling of the cameras of some individuals and the absence of the deposition in others is at variance with the view that the deposit served to counteract the buoyancy of the air supposed to have been in the air chambers[1] and to give strength to the shell. Nor can we see how these heavy unwieldy shells could have been carried in a vertical position without making the animal top-heavy. On the other hand it is readily understood what advantage this solid block of lime that could be driven into the ground like a post, would have offered to the animal in turbulent water.

From the similar Cameroceras tenuiseptum Hall, this species is distinguished by the greater depth of the chambers and the smaller size of the siphuncle.

Genus ENDOCERAS (Hall) emend. Hyatt

Endoceras (?) champlainense sp. nov.

Plate 1, figure 1–4

In the Beekmantown beds D at Beekmantown I have collected several orthoceracones and siphuncles, which were at first thought to belong to O. primigenium, the only species of Orthoceras thus far described from the Beekmantown formation of New York. Subsequent study and comparison with the types of that species have shown that the present form is readily distinguishable from the long known O. primigenium by its deeper chambers and larger siphuncle.

Description. Conch of rather small size, straight, very gradually expanding, at the rate of about 1 mm in 15 mm. The apertural diameter of the largest specimen observed about 25 mm; and the corresponding length of the conch about 275 mm; the latter estimate being somewhat conjectural and based upon the rate of expansion. Cross-section elliptic (?); minor and major diameters in living chambers 14 mm and 24 mm respectively, but conch probably slightly compressed. The surface apparently smooth, and in the ephebic stage provided with transverse lines only.

[1] The writer has in the paper cited, adduced evidence for the contention that the cameras became filled with gas only after the death of the animal or when it was brought to the surface of the water.

Septa rather strongly concave (depth about one third of width), sutures apparently regularly transverse; cameras short, 7 to 9 being counted within 20 mm, where the diameter is about 20 mm.

Siphuncle large, nearly half as wide as the phragmocone; marginal, in contact with the outer shell; flatter on the outer marginal side than on the opposite; not projecting apicad beyond the chambered portion of the conch. Its apical part mostly solid, apparently by organic deposition of carbonate of lime.

Position and locality. All specimens were obtained at the so called Spelman ledge near Beekmantown station. This belongs to Brainerd and Seely's division D of the Beekmantown formation.

Fig. 5 Endoceras (?) champlainense sp. nov. Fragment of compressed siphuncle, the most frequently observed part of the shell. Beekmantown N. Y. Nat. size

Observations. There have been described no less than 27 species of "Orthoceras" from the Beekmantown formation of Canada and Newfoundland. Many of these are based on very imperfect specimens, or even on nothing but siphuncles and the majority are not figured; circumstances which render their recognition quite difficult. By a process of elimination we have concluded that our form approaches the following species: O. explorator, flavius, ordinatum and sayi, and differs from all the others either by not being annulated or by the depth of its chambers. O. explorator tapers faster and has a smaller siphuncle which lies midway between center and margin; O. flavius, of which the surface and rate of tapering are unknown, has clearly a smaller siphuncle; in O. ordinatum the siphuncle lies nearer to the center; and O. sayi is described as being rapidly tapering.

This form is quite representative of several peculiarities which any one who, after collecting orthoceratites in young, specially Devonic beds, engages in gathering up these earliest representatives of the straight coned cephalopods can not fail to observe. One of these is that he finds more frequently the siphuncles than the phragmocones of the earlier forms, while in passing to younger beds, gradually the entire phragmocones begin to prevail. Another is that in these older forms the siphuncles are throughout much larger in relation to the size of the conchs than in the later orthoceracones.

That in the species of Cameroceras, as in C. brainerdi, the siphuncles are met with so frequently where the phragmocone has been destroyed, is not to be wondered at as they have become filled with organic deposits of carbonate of lime; but in Endoceras champlainense, as an example, we also find the empty portions of the siphuncles more frequently than the phragmocones. This is due to the relatively stouter walls of the siphuncles of these earlier species and to the fact that in them the siphuncular necks or funnels reach still from each septum to the preceding one, thus forming a completely closed and stout tube, while in later forms these necks become reduced and only secondary, frequently but membranous annuli or siphuncular segments complete the tube. The larger size and more complete sheathing of the siphuncles of the earlier orthoceracones leave no doubt of the greater importance of the siphuncle or of its contents to the animal in Lower Siluric time, than at any later period. These siphuncular chambers were doubtless occupied by an extension of the mantle and where they have such relatively large dimensions as in Cameroceras brainerdi they contained undoubtedly also portions of the viscera. Whatever the original function of the fleshy siphuncle may have been, if it had any, it was clearly in a retrograde condition, and Zittel's suggestion [Handbuch, p. 349] that it had no physiologic function but was merely a remnant to be explained by the evolutionary history of the animal, appears to be quite acceptable.

E. (?) champlainense would, by its appearance, be readily taken for an Orthoceras and we had to compare it with several Canadian species of Orthoceras, thereby using the latter term in its old sense; but it is evident that this species like probably nearly all of the earlier species which have been referred to Orthoceras, can not belong to the genus in the restricted scope given to it by Hyatt, or even to the Orthoceratidae,[1] for the reason that the mode of preservation of the siphuncles indicates that the septal neck extended always from one septum at least to the next preceding. This, however, is the diagnostic character of Hyatt's suborder Holochoanites, while in the later Orthochoanites to which the Orthoceratidae belong, the funnels have become short and reduced and the siphuncle

[1] Hyatt's more precise and detailed delimitation of the genera of the earlier orthoceracones invites an investigation of the numerous species of Orthoceras described from the Lower Siluric in regard to their generic relations. Orthoceras primigenium for instance is, as the prevailing preservation of its solid apical cone indicates, not a true Orthoceras [*see* p. 505].

more central in position. There is hence little doubt that this species is also a member of the Endoceratidae and probably referable to Endoceras. Since we have not been able to establish whether the funnels extend only to the preceding septum or to the second next in apical direction, a conclusive reference has been impossible. Neither have we observed any "darts" or endosiphocones indicating the formation of endosiphosheaths within the wide siphuncle. Yet the solid character of the apical siphuncle would serve to indicate that such a formation may have taken place there, though it was still in an inceptive stage and did not extend very far, the greater portion of the siphuncle being still used throughout lifetime as a siphuncular chamber.

E. consuetum Sardeson, from the Shakopee formation near Pickett's Station Wis., is very closely related to this species. It possesses the same rate of growth, depth of septa and relative width of siphuncle, differing only in having the septa more closely arranged by about one fourth. The obliquity of the sutures in the type of the western form is largely or entirely caused by compression and somewhat exaggerated in the original drawing; it can not be held to constitute a specific difference.

Endoceras (?) hudsoni sp. nov.

Plate 7, figure 1

The following description is based on a single specimen which, however, well exhibits the principal diagnostic characters of this type of cephalopods.

Description. Large, very slightly curved, gradually expanding cyrtoceracone. The length of the specimen is 22 cm; its minor (not complete) width 65 mm; the major 104 mm. The curvature of the conch is very slight[1] (the hight of the inner arc 5 mm), though apparently not accidental. The rate of growth is 20 mm in 100 mm.

The living chamber has not been observed. The cameras are relatively deep, the septa being 10 mm distant in the specimen; the septa are moderately concave, their depth equal to that of three cameras. The sutures have not been observed.

The siphuncle is of excessive size, its major diameter at the upper end being 55 mm, its minor 43 mm; so that it appears to have occupied one half of the interior space of the shell. Its position is

[1] It is probable that the actual curvature would be found to be somewhat larger if measured along the siphuncular side, which in this specimen is, on account of weathering, unsuited for this measurement. The section [*see* text fig. 6] apparently elliptic, is not very well established.

marginal, at the inner side of the curvature. It is tubular and empty in the fragment at hand. The septal necks did not extend beyond the preceding septum, if we infer properly from the character of the ridges upon the siphuncle. The cameras are solidly filled with organic deposit. The apical part of the conch has not been observed. The surface appears to have been smooth and only provided with faint growth lines.

Position and locality. A single specimen has been obtained by Professor Hudson from the dove-colored limestone (C_1) of Valcour island.

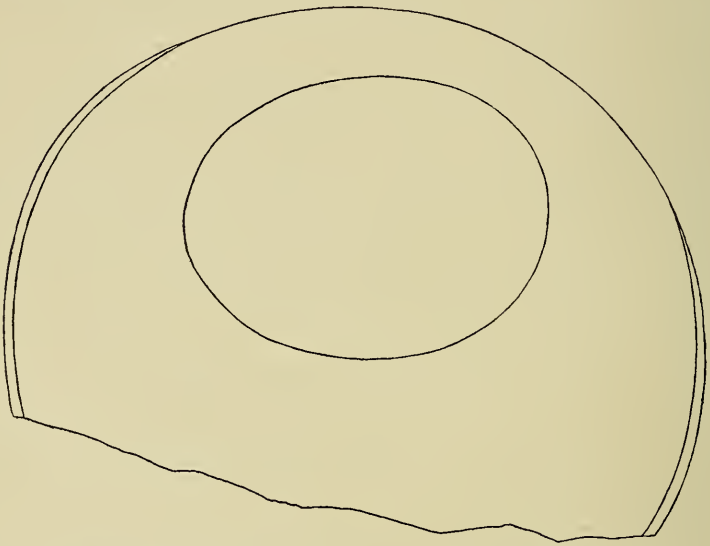


Fig. 6 Endoceras (?) hudsoni sp. nov. Transverse section. x $\frac{9}{10}$

Observations. E. ? hudsoni shows on one hand relations to E. oppletum and on the other to E. magister; to the former by the character and amount of the organic deposit in the cameras which exhibits the same peculiar disposition on both sides of the pseudoseptal plane; and to the latter in the considerable depth of the cameras and the rate of growth. It is nevertheless impossible to unite this species with either of the two similar forms, since from the former it differs by the curvature of the conch, the greater rate of growth and the greater depth of the cameras, while from E. magister it is distinguished by the considerably smaller depth of its chambers, holding in this feature a position midway between Vaginoceras oppletum and E. magister.

As far as observation of the ectosiphuncle is possible in the type specimen, it appears that the septal neck did not reach beyond the preceding septum and that an endosipholining is absent, hence the reference by exclusion of the genera Vaginoceras and Cameroceras, to Endoceras, with some doubt.

Endoceras magister sp. nov.

Plate 8, figure 1

Description. Very large orthoceracone with large ventral siphuncle and extremely deep cameras. The fragment here figured has a length of 250 mm and attains a width of 106 mm; its rate of

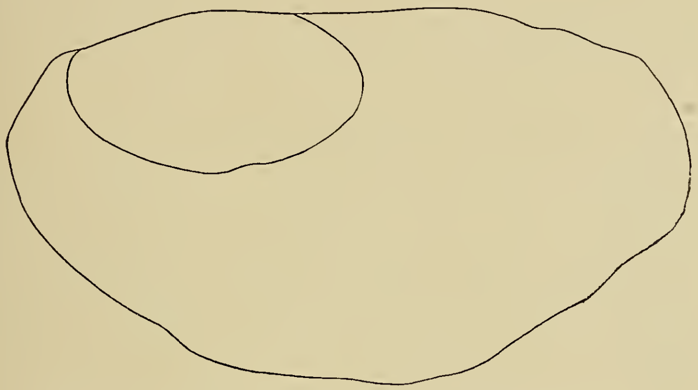


Fig. 7 Endoceras magister sp. nov. Transverse section. x $\frac{9}{10}$

growth is 20 mm in 100 mm. The cameras are very deep, the septa in the average 22 mm apart and very concave, their concavity being as large or greater than the depth of the cameras. The living chamber has not been observed. The siphuncle is large, circular (?) in section,[1] its maximal width in the specimen 47 mm; the septal necks do not extend beyond the preceding septum. The surface is smooth.

Position and locality. In the lower Chazy (B_4 of our section) at the Valcour shore of New York.

Observations. This imposing cephalopod is easily the master of the rest of the Chazy species by its dimensions and specially the depth of its chambers and the width of the siphuncle. No other form has been described from the Chazy of either New York or

[1] The section figured [text fig. 7] shows that the specimen is compressed and the original sections of conch and siphuncle not any more ascertainable.

Canada that even approaches this in the distance of the septa. The species from the Black river limestone of Henderson bay, Jefferson co. N. Y. which has been described by Hall as E. gemelliparum — under the assumption that foreign cephalopods which had entered the extremely wide siphuncle, were young ones — possesses cameras of exactly the same depth and like gigantic dimensions, but its siphuncle is so large (greatest diameter 60 mm), that the phragmocone is reduced to a narrow ring. On account of the latter fact we have refrained from identifying our form with this remarkable species from the Black river beds. If they are not identical their closest relationship can not be doubted. On account of the absence of an endosipholining and the restriction of the length of the septal necks to that of one interseptal space, we have referred this species to the genus Endoceras.

Endoceras montrealense Billings (sp.)

Plate 9, figure 8

Orthoceras montrealensis Billings. Can. Nat. & Geol. 1859. 4:363; p. 361, fig. 11c-e

Orthoceras sordidum (Billings) Whitfield. Am. Mus. Nat. Hist. Bul. 1890. 3:34, pl. 2, fig. 4

Professor Whitfield has referred an orthoceraconic form from the Fort Cassin beds, characterized by very closely set septa and marginal siphuncle to Orthoceras sordidum Billings, a species from the White limestone of the Mingan islands. He argues that O. depressum and O. montrealensis Billings are probably only variations of that species, since in examples of different sizes of his material the septa vary in their distances.

We have received some additional material of this Fort Cassin form through the kindness of Professor Perkins. This has allowed the cutting of sections and thereby cleared up the doubt as to the character of the siphuncle [*see* text fig. 8]. The latter suggested at once, by its relative size, that this supposed representative of O. sordidum should be more properly identified with O. montrealense which differs from O. sordidum less by the relative distance of the septa than by the relative size of the siphuncle. In the latter feature however as well as in the rate of growth of the conch, the specimens from Fort Cassin agree exactly with O. montrealense.[1] The further fact that the type of

[1] Billings states under O. sordidum, that it differs from O. montrealense in being a more slender species and having the siphuncle smaller. It is exactly in these characters that our material also differs from O. sordidum.

the latter species comes from the neighborhood of Montreal (village of St Eustache) and hence from the northern extension of the Champlain basin instead of the lower St Lawrence gulf, as O. sordidum does, is a further argument for the identity of the Fort Cassin material with O. montrealense.

Billings has given the following description of the form in question:

Section circular, smooth, tapering at the rate of about one line to the inch; septa very convex, 18 or 20 to the inch at a diameter of 8 lines; siphuncle cylindrical, marginal, seven sixteenths the whole diameter of the shell; surface unknown.

Whitfield has added the observation that the form has a smooth shell; and we are enabled to state that the submarginal siphuncle is tubular in form, with slight interseptal constrictions, produced by the incurving septal necks, each of which closes the space from one septum to the next preceding. The septa are very convex, their depth amounting to twice that of the chambers; the sutures possess a rather deep ventral lobe with an apparent small median saddle opposite the siphuncle [*see* pl. 9, fig. 8]. The living chamber and aperture, as well as the apex of the conch have not yet been observed.

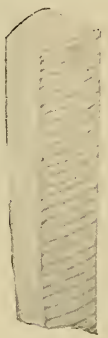


Fig. 8 Endoceras montrealense Bill. (sp) Longitudinal section. Nat. size

The marginal position and large size of the siphuncle, as well as the structure of the siphuncular wall leave no doubt that we have here before us one of the primitive forms belonging to the Endoceratidae. It is not certain whether the siphuncle contained the internal structures usually found in forms of this group, but the section given by Billings [*ibid.* fig. 11e] would suggest the presence of an endosiphocone in that specimen. The extension of the septal necks to the preceding septa only, excludes this species from the genus Vaginoceras, and the apparent absence of the endosipholining from Cameroceras; by exclusion we, hence, infer that at present it may be best referred to Endoceras.

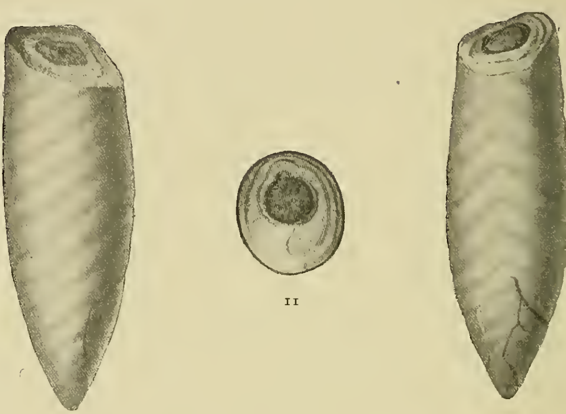
Genus SUECOCERAS Holm

Suecoceras marcoui Barrande (sp.)

Endoceras marcoui Barrande. Système Silurien du Centre de la Bohême, v. 2, t. 3, p. 748, pl. 431, fig. 11–13.

Suecoceras marcoui Holm. Geol. För. i Stockholm Förh. 1896. 18:403, 414

Barrande has described in his monumental work as Endoceras marcoui (in the explanation of the plate termed "Orthoceras" marcoui) a fragment of a cephalopod, which had been collected by Jules Marcou in the Beekmantown beds at Philipsburg and sent to him. We insert here copies of Barrande's original figures [text fig. 9-11]. These show us at once that the specimen is one of the interesting inflated apical parts of a conch, for which



9 11 10

Fig. 9, 10, 11 Suecoceras marcoui Barrande (sp.) Three views of a nepionic bulb. Fig. 9=lateral aspect; fig. 10=side which approaches the external wall; fig. 11=transverse section. Nat. size

the term preseptal cone has been used by Clarke and nepionic bulb by Hyatt and the phylogenetic meaning of which has been discussed by the present writer in another paper [1904].

While Barrande, with his characteristic keenness recognized the very imperfect specimen as belonging to the Endoceratidae and stated that "it is the only specimen in his possession which shows the initial part of the conch of an Endoceras," he erred in mistaking[1] the surface of the fragment for the external surface of the shell and in describing the rings as annulations. They are but the impressions of the septal necks and the fragment is only the inflated apical portion of the siphuncle. The central tube filled

[1] This mistake was more than natural before Holm and Clarke had recognized, from more complete material, the actual structure of these apica portions of the conchs.

with darker material, which is termed by Barrande the siphuncle of the specimen, is probably the elongate endosiphocone. The outer and older endosiphosheaths which filled the siphuncle are distinctly shown in the transverse section of the fragment figured by Barrande.

A specially interesting feature of the specimen is to be seen in the fact that the impressions of the septal necks, which show the characteristic forward angulation on the side of the siphuncle nearest to the outer wall of the conch, extend to the tip of the siphuncle, thereby indicating that the nepionic bulb had been completely incorporated into the phragmocone. This condition is found in the subgenus Suecoceras of Endoceras and Holm has therefore cited Endoceras marcoui as belonging to his subgenus. We refrain from describing the fragment, since all its characters and dimensions are fully shown by the drawings.

Genus NANNO Clarke

Nanno noveboracum sp. nov.

Plate 9, figure 6, 7

Our collection contains a single specimen which demonstrates the presence of the remarkable and much discussed genus Nanno in the Chazy beds of New York. This is the apical portion of a conch. It exhibits the characteristic preseptal cone or nepionic bulb of this genus, which while in the whole representing a rapidly expanding cone, is asymmetric in such a fashion, that viewed from the siphonal or antisiphonal sides it appears as a symmetric cone [*see* fig. 6], having a length of 19 mm and expanding from 3 mm at the rounded truncate apex to a width of 13 mm at the beginning of the first cameras; while viewed laterally, it is asymmetric, the profile of the siphonal side (marked by the contact of the siphuncle and outer wall of conch) being straight, with a geniculation at the beginning of the third camera, and the antisiphonal wall diverging from the siphonal under an angle of nearly 20° to a point 21 mm from the apex, where a sudden contraction takes place, to the middle of the phragmocone, which measures 8 mm in dorsoventral direction. The nepionic bulb is solidly filled with a gray crystalline calcite showing traces of endosiphosheaths. A small subcircular cicatrix or aperture with slightly raised margin is situated upon the middle of the apex, wherefrom radiate a few obscure impressed lines. Of the phragmocone only a short portion of six chambers is retained upon the specimen. The phragmocone is subcircular in section ; its ventral side is distinctly flattened. The cameras are moderately deep, the septa 3 mm distant and but little concave, the septal necks extending about one fourth of the interseptal space beyond the preceding septum. The siphuncle, upon emerging from the nepionic bulb, rests against the wall of the conch, is tubular, with circular section and a very slight interseptal inflation.

Position and locality. In the coral facies of the dove-colored Chazy limestone, exposed 2 miles west of Little Monty bay near Chazy village.

Observations. The relations of Nanno to Cameroceras and Vaginoceras have been fully discussed by the writer in the *Report of the State Paleontologist* for 1904 [p. 322]. It suffices therefore to state here why we have preferred to associate this form with Nanno rather than with Vaginoceras. After the publication of Clarke's observations on Nanno aulema, Holm referred several forms with like nepionic bulbs, one of which he had before described as Endoceras, to Nanno, treating the latter as a subgenus of Endoceras [1896, p. 404]. Hyatt, however, has placed Endoceras (Nanno) belemnitiforme Holm with Vaginoceras [1895, p. 9] and based the genus Nanno on the presence of the endosiphuncle only at the apical end, and on the absolute contact of siphuncle and conch on one side. Nanno noveboracum also possesses this absolute contact, the septal funnels or necks entirely disappearing upon the contact side. As to the presence of the endosiphuncle in the apical portion only we have not been able to satisfy ourselves as fully as in regard to the other critical characters, but the filling of the nepionic bulb with grayish calcite showing traces of endosiphosheaths and of the siphuncle with white calcite of somewhat coarser texture without any traces of endosiphosheaths seems to us to make the absence of the endosiphuncle the more legitimate conclusion. We will add that in Nanno noveboracum the siphonal necks or funnels clearly extend beyond the preceding septum and hence have the Vaginoceras structure, but that after inspection of Clarke's types of Nanno aulema we have no doubt that a similar condition prevails in that genotype, and that also there the septal funnels are slightly overlapping.

Nanno noveboracum differs from Nanno aulema in the plumper form of the nepionic bulb, which, while having the same length, is wider by one third just before the contraction; its apex is also blunter.

Family PILOCERATIDAE

Genus PILOCERAS Salter

Piloceras explanator Whitfield

Plates 10 and 11

Piloceras explanator Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 323, pl. 28, fig. 1–4

Piloceras explanator Foord. In Cat. Foss. Ceph. Brit. Mus. pt 1. 1888. p. 162.

Piloceras explanator Clarke. Geol. of Minn. Pal. 1897. 3:769, pl. 2.

Piloceras explanator Ruedemann. An. Rep't State Paleontol. for 1903; N. Y. State Mus. Bul. 80. 1905. p. 329, pl. 10–13.

We have found in the Fort Cassin beds at Valcour (A_3 of section) a truly gigantic Piloceras which has proved to be identical with the form which has been so carefully described and fully illustrated by Whitfield as P. explanator from the Fort Cassin beds at their type section.

In regard to the character of the conch, the cameras, living chamber and siphuncle, we refer to Whitfield's description drawn from the excellent material of the Seely collection. The internal structure of the siphuncle of this species which has not been described by Whitfield has been given in detail by the writer in the above cited report of the State Paleontologist, to which we also refer for the sake of avoiding repetition. From the large specimen which is here reproduced in outline, it follows that Whitfield was also correct in assuming that the shells attained at least 10 inches in length, for this one measured as much with the entire living chamber missing.

This species is probably closely related to P. triton Billings from the Newfoundland Beekmantown beds and we thought for a time that the two might be identical until we saw the type of Billings's species.

The dimensions of the siphuncles as well as the distances of the septa agree fully in P. triton, P. explanator and the specimens from Valcour. The elliptic shape of the section of the siphuncle of P. triton, which can be inferred from Billings's measurements furnishes also intrinsic evidence of the lateral compression of the entire conch of Billings's type such as is described of P. explanator. If we further take into account that Billings would place his divisions H and I near the boundary of the Beekmantown and Chazy formations, it will be seen that the Newfoundland and Lake Champlain forms are found in beds which are equivalent or very nearly so. Billings's type, which is in the museum of the Canadian Geological Survey at Ottawa, proved to be a rather poor fragment of a siphuncle. It shows a greater rate of growth than that of P. explanator and is not so flat in section as the latter.

Family CYRTENDOCERATIDAE

Genus CYRTENDOCERAS Remélé

Cyrtendoceras (?) priscum sp. nov.

Plate 2, figure 2–5

I obtained in the dolomite of the Beekmantown beds D at the Spelman ledge at Beekmantown half a dozen specimens of a small gyroceran cephalopod, that has the distinction of being the earliest coiled form known from this State, and of possessing very primitive characters which correspond to its early appearance.

Description. Small gyroceracones attaining a diameter of but 13 mm consisting of about two volutions which grow at a rapid rate (diameter of second volution 4 mm), possess circular sections without impressed zone and though but leaving a small interspace are apparently not coming into actual contact. Living chamber short, not more than one half volution. Aperture protracted along the dorsal line and provided with low lateral lappets. Cameras very shallow, five in the space of 5 mm in the ephebic volution; septa quite convex, their depth equal to that of the cameras; sutures apparently straight all around. Siphuncle large, fully one third the width of the conch, tubular, subdorsan in position, filled with organic deposits (?). Surface without sculpturing except that provided by faint growth lines.

Observations. Unfortunately all specimens which we were able to obtain are preserved only as molds, the conchs having been dissolved and the interspaces filled with a sandy matrix, the result of the disintegration of the sandy dolomite. While this mode of preservation gives good sculpture casts of the surface and of the aperture it has left us in some doubt about the siphuncle. The figures show that a wide empty space is left between the fillings of the chamber-spaces and the dorsal wall, which can only have been occupied by the siphuncle, since there is no trace of a smaller siphuncle perforating the septal fillings. Since in this rock all mollusk shells are dissolved, while the interspaces are always found to be filled with the dolomitic matrix, we have concluded that the siphuncle which here is dissolved out entirely must have been filled with organic carbonate of lime.

On account of the dorsal position of the siphuncle, its large size, apparent tubular segments and its supposed filling with organic carbonate of lime, we have brought this species under Cyrtendoceras which according to Hyatt is the only genus containing holochoanitic cephalopods with coiled conchs. The characters of the early volutions of this primitive and interesting species are unfortunately not sufficiently well preserved to allow satisfactory investigation.

This cephalopod bears in its general appearance considerable similarity to a gastropod that is very common in the same beds and has been identified by Whitfield with Maclurea sordida Hall. It can, however, always be distinguished from the latter by its evenly rounded volutions.

Suborder D. ORTHOCHOANITES Hyatt

Division I. ORTHOCERATIDA

Family ORTHOCERATIDAE

Genus BALTOCERAS Holm

Baltoceras (?) pusillum, sp. nov.

Plate 9, figure 4, 5

A single specimen of this form was obtained which has furnished us the data for the following description.

Description. Small orthoceracone (length of imperfect specimen 32 mm), which expands very gradually (rate 1 mm in 11 mm), section subcircular or slightly elliptic (?). Septa straight, transverse, relatively distant (6-7 in the space of 10 mm), little convex, (curvature of septa not more than one fourth the depth of the chambers). Siphuncle very wide, one half the width of the conch, beginning with a slightly curved apical portion, which is completely inclosed within the phragmocone, situated excentric (subventran?), its walls composed of very short funnels and long tubular siphuncular segments. Living chamber not known; the surface appears to have been smooth.

Position and locality. In bed A_3 (Fort Cassin beds) of Valcour section.

Observations. This little form of which we unfortunately have not been able to secure sufficient material for more complete investigation, is remarkable for two features. These are the great width of the siphuncle and its excentric position. In both of these characters the species differs from a typical Orthoceras and shows its more primitive state of development. It would by its wide siphuncle suggest its relationship to the Endoceratidae, but the longitudinal section fails to show any but rudimentary septal necks, though we must concede that we have been unable to fully satisfy ourselves upon this point. If the funnels are indeed short as in Orthoceras then this form would be one of the primitive Orthoceratidae, for which Holm has established the genus Baltoceras. The essential difference of this genus from Orthoceras is according to Hyatt the wide siphuncle. Holm states that it has the habit of an Endoceras but the siphuncular walls of an Orthoceras.

Genus ORTHOCERAS (Breyn.) emend. Hyatt

The term Orthoceras which practically had been applied to all orthoceraconic forms with the exception of those referred to Endoceras, and therefore, as a perusal of Barrande's work will show, has included a most astonishing variety of forms ranging through all possible variations in surface sculpture, rate of growth and position of siphuncle, has been greatly restricted by Hyatt, indeed so much that he stated in 1884 [p. 275] he knew only of two species in North America.

The cyrtochoanitic forms (those with short, outward curving septal necks) have been brought under the families Loxoceratidae and Rizoceratidae; the annulated and longitudinally ridged forms have been distributed among the families Cycloceratidae and Kionoceratidae, and other orthoceraconic forms with compressed oval section, impressed zone and ventren position of the siphuncle are to be referred to new genera which are not yet defined and are to be placed under the Tarphyceratidae.

Finally only the simplest patternlike forms of Orthoceras with open apertures, uncontracted living chambers and small tubular, subcentrally located siphuncle are left.

These have still been subdivided into Orthoceras (Breyn.), Geisonoceras (Hyatt) and Protobactrites (Hyatt).

In the earliest definitions of the first two genera [1884, p. 275] Orthoceras was conceived as comprising the smooth longicones and Geisonoceras the banded longicones, the transverse markings of the latter being considered as leading to the Cycloceratidae. In Zittel-Eastman's textbook emphasis is laid on the long tapering form of Orthoceras, the larger size of its siphuncle and the more rapidly spreading sides of Geisonoceras. Protobactrites is proposed for the long pencil-shaped orthoceracones.

It will be easily understood that an infinite number of transitional forms between these genera are possible, whose differences are largely those of degree of development of certain features; and indeed there exist apparently as many transitional as typical forms. Of the species here referred to the Orthoceratidae, O. lentum and O. progressum can be placed with little hesitation to Orthoceras s. str.; in regard to O. vagum some doubt is possible on account of the long, uniformly thin shape which suggests a reference to Protobactrites. Since the latter is defined as having a tubular siphuncle and our form has a slightly nummuloidal siphuncle we have preferred to leave it with Orthoceras. Geisonoceras shumardi has been referred to that genus on account of its somewhat larger rate of growth and relatively smaller size of siphuncle.

Orthoceras lentum, sp. nov.

Plate 14, figure 1–3

This species is based upon two fragments representing different growth stages of the conch. These show certain characters so greatly different from those of the other Chazy orthoceracones that we have little hesitation in seeing a new type in them.

Fig. 12 Orthoceras lentum sp. nov. Transverse section. Nat. size

Description. Slender gently curved conch. Length of type specimen only 26 mm but its small rate of growth (but ½ mm in 15 mm) indicates the attainment of considerable length in consideration of the width of the specimen (18 mm); curvature of the fragment very small, the hight of the arc not quite amounting to 1 mm. Section circular. Cameras shallow (6 in the space of 20 mm); sutures nearly straight transversal; septa thin and little concave, their depth a little more than two thirds that of the cameras.

Siphuncle centren, small, 1 mm in the smaller and 2 mm in the larger fragment (one ninth the width of the conch); the septal necks very short, ringlike; the interseptal segments slightly expanding, nearly tubular.

Deposits of carbonate of lime which do not seem to be due to secondary incrustation form a cylinder around the siphuncle and extends thence along the septa thinning out near the outer wall. The living chamber has not been observed. The surface appears to have been smooth.

Position and locality. The type specimens have been collected by Prof. G. H. Hudson in the dove-colored Chazy limestone exposed along the east shore of Valcour island.

Observations. This species is one of the few Chazy cephalopods which on account of their slender form, the character of their septal necks and siphuncular walls, can be referred to the genus Orthoceras in the restricted scope given to it by Hyatt.

As similar forms from the Chazy beds suggest themselves O. (?) vagum sp. nov. and Geisonoceras shumardi. The former has more distant septa and a wider siphuncle but may have been nearly related. G. shumardi is a straight form, has deeper cameras and a greater rate of growth.

Orthoceras progressum sp. nov.

Plate 12, figure 5, 6

The fragment of a phragmocone on which this species is based permits the elucidation of the following characters: a medium or large sized orthoceracone (fragment has a largest diameter of 34 mm) with circular section and slow rate of growth (as 1 to 8). Cameras short (6 mm deep where the conch has a diameter of 34 mm); sutures nearly straight, transversal, septa moderately concave, the depth equal to the length of the cameras.

Fig. 13 Orthoceras progressum sp. nov. Section of siphuncle. x 1.5

Siphuncle relatively wide (5.5 mm in this specimen) centren in position; the septal funnels short; but slightly bent inward. The siphuncular segments thin, perfectly straight in section [*see* text fig. 13]. No organic deposits observed. Living chamber and apical part not observed. Surface smooth.

Position and locality. In the dove-colored limestone of Valcour island [Prof. G. H. Hudson coll.].

Observations. The specimen in hand preserves in most excellent condition the extremely delicate sculpture of the "Runzelschicht" or second layer of the outer wall, which consists of a system of very fine anastomosing lines passing obliquely across the shell.

This species differs from O. lentum by its straight conch, straight siphuncular segments and greater width of siphuncle (relatively to width of conch and absolutely).

The centren position of the siphuncle, the great reduction of the siphuncular necks and the corresponding strong development of the secondary siphuncular segments indicate the progressed state of this orthoceracone when compared with the majority of the other straight shelled cephalopods of the same formation.

Orthoceras (?) vagum sp. nov.

Plate 13, figure 1–3; plate 9, figure 9

Description. Very slender gently and irregularly bending conch, attaining a length of 250+ mm and a width of more than 20 mm. Its rate of growth is but 3 mm in the space of 50 mm; its section circular. The cameras are relatively deep, there being five in the space of 20 mm where the width of the conch is 13 mm, and four in the same space where it is 18 mm. The septa are strongly convex, their depth being nearly equal to that of the cameras. The sutures pass straight transversely. Length of living chamber and character of aperture have not been observed. The siphuncle is centren, slightly nummuloidal, one fourth the width of the conch, and appears to have remained empty. The shell is thin, its surface smooth or only marked with faint transverse growth lines.

Position and localities. Two specimens of this type have come to our notice; one of these is from the dove-colored limestone of Valcour island [collected by Prof. G. H. Hudson]; the other [in the American Museum of Natural History] is from the same horizon of Isle La Motte in Lake Champlain [coll. by Prof. H. M. Seely].

Observations. The most striking character of this species is the irregular bending of the conch. This is but slightly though distinctly shown in the specimen from Isle La Motte, a photograph of which has been kindly taken for me by Dr Hovey [pl. 13, fig. 3]. In the other specimen from Valcour island, which I have been able to free entirely from the rock, the bending is very obvious and clearly not caused by fractures or folding in the rock for it takes place in different planes [*see* fig. 2], is nowhere abrupt and the septa are arranged slightly closer on the inner side of the curves than on the outer, exactly as in the regularly curved phragmocones of Cyrtoceras etc. Nor do the orthoceracones associated with this species in the same bed or (as in the Amer. Mus. specimen) even on the same slab show any trace of secondary bending with the including matrix.

Speculations as to the cause of this peculiar aberrancy naturally urge themselves upon the observer of the irregular orthoceracone. The assumption that weakening physical conditions of the environment, such as are found in the lagoon of a coral reef affecting the regularity of the volutions of gastropods might have produced this form, seems to be refuted by the character of the associated fauna which is largely one of straight gigantic cephalopods and stromatoporoid corals, suggesting that the dove-colored limestone was formed in a shallow but open sea, the floor of which was studded with small coral reefs. The excellent state of preservation of the two specimens notwithstanding the thin shell and the fact that the larger and coarser cephalopod shells in the same bed are frequently much macerated, the rarity of the form and the long tubular shape in combination with the bending of the conch would, however, indicate that this species was burying itself or actively burrowing in the mud. The central position of the siphuncle, the circular section of the conch and the absence of any impressed zone indicate that it is derived from some orthoceraconic form. As to its generic position we have remained in doubt, but consider it as being closely related, if not properly referable, to the genus Orthoceras s. str.

O. ? vagum bears aside from its bending a considerable similarity to O. shumardi Billings, a straight pencil-like form from the Chazy of the Mingan islands from which it can be distinguished by its considerably deeper cameras.

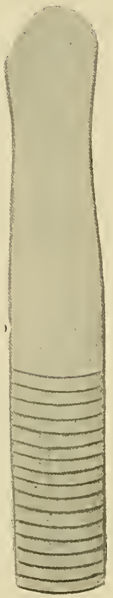


Fig. 14 Orthoceras modestum sp. nov. Natural section. Natural size

Orthoceras modestum sp. nov.

Plate 12, figure 1-3

Description. Small, slender orthoceracones with circular section which judging from our specimens may have attained a length of 130 mm and a width of 15 mm. The rate of growth is very small, about 1 mm in 30 mm. Fragments of this stage of the conch appear pencil-like, and in the ephebic stage the conch appears to have become cylindric [*see* text fig. 14 and pl. 12, fig. 2]. The cameras are moderately deep, 5 cameras occupying the space of 10 mm in the ephebic stage; the septa are very shallow, their concavity amounting to about half of the depth of the cameras. The living chamber is long (about 80 mm), hardly expanding and provided with one or several constrictions; the aperture is apparently straight transverse. The siphuncle is small, a little more than 1 mm wide, tubular, centren. The surface is marked with equal raised transverse lines which are separated by equal interspaces and are so fine that they can not be seen with the naked eye (11 in the space of 1 mm).

Position and localities. We have seen two specimens from the dove-colored limestone of Valcour island; two from that of Isle La Motte and two from the upper Chazy (C_6) of the neighborhood of Chazy village.

Observations. This is the plainest cephalopod shell which we have observed in the Chazy rocks of New York; nor are we aware of any other Chazy orthoceraconic form with which this one could be confounded since its slow rate of growth and small siphuncle serve to distinguish it from other small orthoceracones. It bears however some similarity to O. recticameratum Hall, a Lowville (Birdseye) limestone form from Watertown and the Mohawk valley. In view of the fact that also some other Chazy fossils continue into the Lowville and Black river limestones a closer comparison of the two forms became desirable. This has shown that O. recticameratum is still somewhat more rapidly expanding, has slightly deeper cameras (4 in 10 mm) and possesses somewhat angular septa from which it derives its name.

Genus GEISONOCERAS Hyatt

Geisonoceras shumardi Billings (sp.)

Plate 12, figure 4

Orthoceras shumardi Billings. Can. Nat. & Geol. 1859. 4:460

Original description. Elongate, cylindrical, section circular, tapering at the rate of a little more than half a line to the inch, septa rather strongly convex, distant nearly half the diameter; siphuncle about one fifth the whole diameter, and with its center distant from the center of the transverse section half its own diameter. Surface unknown.

In a specimen 8 inches long the diameter of the larger extremity is 10 lines and of the smaller 5 lines and it tapers therefore at the rate of ⅝ of a line to the inch. At the larger end there are 2 septa in 9 lines, and at the smaller 2 in 4 lines. The siphuncle is cylindrical and but slightly inflated between the septa; its diameter at its passage through the septum at the large end one line and a half, and between the septa about two lines.

We have no species with which this Orthoceratite can be compared except O. amplicameratum (Hall), from which it differs in having the septa proportionally a little more distant, and the siphuncle a little larger and not so excentric.

Position and localities. The type specimen came from the Chazy limestone of the Mingan islands. The specimen which we refer to this species came from a Strephochetus bed of the middle Chazy division B_2 at Chazy village.

Observations. Our specimen represents but the apical portion of this form which has been described by Billings from more mature parts. Nevertheless there can be but little doubt of its identity with Billings's species in view of the like rate of growth, characteristic great depth of the cameras, strong convexity of the septa and small siphuncle. The dimensions of our specimen are: length 34 mm; smallest width 4 mm; greatest width 7 mm; rate of growth 1 mm in 10 mm; 3 cameras in space of 10 mm; depth of septum one third that of camera; width of siphuncle one sixth that of conch. In the Chazy specimen the siphuncle is entirely tubular while Billings describes it as very slightly nummuloidal, but since it frequently begins tubular and becomes more or less nummuloidal in later growth stages, this difference can not be considered as of great importance.

Family CYCLOCERATIDAE

Genus PROTOCYCLOCERAS Hyatt

The genus Protocycloceras has been proposed by Hyatt to receive the most primitive cycloceratids. It is defined as consisting of annulated orthoceracones and cyrtoceracones without longitudinal ridges and with large siphuncles. As genotype the form described in the following pages is named which, from its occurrence in the middle Beekmantown beds of New York, can be considered as the earliest or one of the earliest annulate forms known.

The establishment of this genus and the arrangement of the succeeding genera of the Cycloceratidae presuppose the antecedence of the annuli or of the transversal portion of the surface sculpture (annuli and frills) to the longitudinal portion (ridges and lines). While, in apparent harmony with this view, sculpture casts from the Beekmantown dolomite fail to show any traces of longitudinal sculpture lines, there has been found associated with them a fragment of a shell in the neanic stage [pl. 15, fig. 6], which has no other ornamentation but strong longitudinal ridges. In view of the association of this conch with the annulated ones and the failure to observe other species of orthoceracones or of slightly curved cyrtoceracones in this bed, the reference of this little shell to the nepionic stage of the annulated form offers itself as the most plausible conclusion. The latter is supported by our finding among the material collected by Professor Rominger from the Fort Cassin beds at Fort Cassin a fragment of a young conch of this species exhibiting both annulations and sharp continuous longitudinal lines in excellent preservation [pl. 16, fig. 1].

It may be mentioned in this connection that Hall has already described and figured in the *Palaeontology of New York,* volume 1, as Orthoceras laqueatum an apical part of a conch with strong longitudinal ridges or flutings; the specimen, though found loose in the drift, undoubtedly coming from the Beekmantown formation, as we could convince ourselves on inspection of the same which is deposited in the State Museum [3909 of the type catalogue] from the character of the dolomite matrix. There are hence two longitudinally fluted conchs known from the Beekmantown formation, and both of these represent the apical parts of larger conchs. Since it has been found that in later annulated forms (as in O. bilineatum from the Trenton by Clarke, O. anellus from the same formation by Ruedemann, and O. crotalum from the Hamilton by Hall) a smooth or longitudinally striated stage precedes the annulated stage of the conch, it is proper to conclude that also the two small fluted conchs from the Beekmantown represent the early stages of forms with annulated conchs in the adult condition. We have also found last summer such young fluted conchs belonging to annulated forms in the Chazy formation. There apparently persisted from the Beekmantown into the Hamilton a whole branch of annulated orthoceracones and cyrtoceracones, all of which retained a fluted sculpture in the apical portion of their conchs. The oldest, judging from Hall's C. laqueatum, retained the longitudinal surface sculpture longer than the latest, as O. crotalum. All of these facts tend to demonstrate that the longitudinal sculpture in these forms is in a retrocessional condition and that therefore, not as Hyatt assumes the purely annulated forms precede in this family those with both transverse and longitudinal markings, but that also phylogenetically, as in the ontogeny of the forms mentioned, a group of forms with purely longitudinal sculpture preceded the annulated and frilled forms, at least of this one branch of species. The interesting ancestors with longitudinal sculpture only, would have to be sought in the lower Beekmantown beds which thus far have not furnished any fossils. In a long series of forms extending from the Champlainic to the Carboniferous the longitudinal sculpture markings persist upon the annulations into the ephebic state. For these the generic term Spyroceras has been proposed by Hyatt while in others the annulations following upon the longitudinal ridges disappear again before ephebic age is reached (Kionoceras).

The development and repression of the longitudinal ridges before that of the annulations already in early Beekmantown time, hence near the very starting point of the whole class of Cephalopoda is an interesting illustration of the principle that types are evolved more quickly and changes take place more rapidly near the point of origin of a stock of organisms than at any later period of their existence. Smooth, fluted and annulated conchs appear in the oldest cephalopodiferous beds known to us, and the faster or slower suppression of the successive stages together with the reappearance of the earliest characters in reversed order in the phylogerontic condition of the class supply all the variety of sculptural modification of the later forms without the addition of any new essential element.

In view of this much accelerated development of the annulated cephalopods we doubt that the divisions proposed by Hyatt and based on the presence or absence, continuity or discontinuity of the longitudinal ridges can be maintained. The case of the species here under discussion can be cited as a very instructive example. Orthoceras lamarcki is cited by Hyatt as a type of his genus Protocycloceras which comprises "annulated orthoceracones and cyrtoceracones without longitudinal ridges" while another presumably phylogenetically successive genus Cycloceras is proposed for "annulated orthoceracones and cyrtoceracones with discontinuous longitudinal ridges." Forms with annulations and continuous longitudinal ridges, either in early or ephebic stages are put even under a different family, the Kionoceratidae. We find now however that this type of the genus Protocycloceras not only does not fail to be without any longitudinal ridges — as the definition of Protocycloceras requires — but has them even continuous and would hence also have to be excluded from Cycloceras and from the whole family Cycloceratidae. We believe therefore that the generic distinctions of the Cycloceratidae and Kionoceratidae here involved are based too largely on theoretic considerations to be maintainable.

If Protocycloceras lamarcki is not so primitive in its surface sculpture as Hyatt supposed, it still shows its primitive nature corresponding to its very early appearance in the structure of its siphuncle; for the septal necks are not as in all later annulated forms, or orthoceratites generally, short and incomplete, but complete and extending from one septum to the plane of the preceding one, a feature only found in the earliest growth stages of the later forms, and in the ephebic stage of such primitive forms as Nanno. These funnels grow first toward the interior of the siphuncle and then again outward thus producing contractions of the siphuncular space between the septa. The siphuncular segments or an endosipholining however covers these funnels in such a way as to leave a perfectly cylindric lumen of the siphuncle [*see* text fig. 15].

Hyatt has placed his genus Protocycloceras under the suborder Orthochoanites (with the Cycloceratidae). If the above stated observation of the structure of the ectosiphuncle of P. lamarcki is correct, that form is to be referred to the Holochoanites and to be considered as an annulated endoceratid. Since we have found exactly the same condition of the siphuncle in other annulated forms from the Beekmantown described below as P. whitfieldi we have no doubt that the endoceratid condition of the ectosiphuncle still prevailed among these early annulated forms; but that the formation of endosiphosheaths had already ceased among them.

We have then before us the alternative of either referring these forms to Endoceras which according to Hyatt's definition embraces "smooth and annulated orthoceracones" and to let the genus Protocycloceras stand for orthochoanitic forms still to be discovered or since P. lamarcki has expressly been pointed out as the type of that genus to alter the definition of the latter to suit the type specimen and other obviously closely related species and thus transfer the term Protocycloceras to the annulated Endoceratidae. We would propose the latter procedure as the one least liable to create confusion.

Protocycloceras lamarcki Billings (sp.)

Plate 15, figure 1-6; plate 16, figure 1, 2

Orthoceras lamarcki Billings. Can. Nat. & Geol. 1859. 4:362, fig. f, g.

Orthoceras lamarcki Billings. Geol. of Can. Pal. Foss. 1865. 1:255, 347, fig. 336.

Protocycloceras lamarcki Hyatt. In Zittel-Eastman. Text-book of Palaeontology. 1900. 1:518.

Annulated orthoceratites appear already in rocks of the Spelman ledge at Beekmantown which belongs to Seely's D of the Beekmantown formation. Unfortunately only sculpture casts are retained in the crusts of friable sand which are left after weathering of the dolomite, while the latter in its fresh state though extremely hard and brittle shows but faint traces of these cephalopod remains. The specimens found belong all to middle sized individuals.

In the subcircular section, rate of expansion (about 1 mm in 20 mm) and slight curvature of the conch, the character of the annulations (which are concentric, prominent narrow ridges separated by concave transverse interspaces, twice the width of the ridges), their closeness of arrangement (8 in 20 mm where the width of the conch is 8 mm; 7 where it is 10 mm and 6 in the same space where it is 13 mm), they fully agree with the figure and description of O. lamarcki as furnished by Billings. A conclusive identification of these specimens whose septa and siphuncle are unknown is however impossible.

Better material of a form which is identical in external characters has been secured in the uppermost beds of Beekmantown age exposed at the Valcour shore south of Plattsburg. These beds are equivalent to the Fort Cassin beds of Vermont. The specimens obtained there [*see* pl. 15, fig. 2–5] retain the septa as well as the siphuncle and have furnished a basis for the following description of the species.

Description. Conch of but moderate size (greatest length observed 120 mm, greatest width observed 25 mm), very slightly curved (the hight of the arch formed by a fragment 58 mm long is but 2 mm), the curvature apparently somewhat increasing toward the mature part of the conch; very gradually expanding (within 50 mm from a diameter of 8 mm to one of 11 mm, or not quite 1 mm in 20 mm); cross-section subcircular. Surface in the apical part provided with sharp longitudinal lines which in more advanced stages of the conch are replaced by annulations. These increase in strength to the ephebic conch where they are prominent, narrowly rounded ridges which pass straight transversely around the shell. The width and relative distance of the annulations increase slightly toward the aperture (the latter more than the former); the average width is about 1 mm and that of the concave interspaces a little more; there being 9 in the space of 20 mm where the diameter is 8 mm and but 4 within the same space in the widest specimen observed. The surface ornamentation of the adult conchs has not been distinctly discerned but seems to have consisted, on the interspaces at least, of transverse lines.

Fig. 15 Protocycloceras lamarcki Billings (sp.) Longitudinal section. Natural size

Siphuncle with fusiform segments; large (averaging one third the width of the conch), propiocentren, more excentric in the ephebic conch than in the preceding stages, being finally distinctly dorsocentren (situated just dorsad of the center or towards the concave side of the conch). No regular deposits observed.

The cameras are shallow, the sutures regularly transverse. The septa show approximately the same closeness of arrangement as the annulations and the same relation to the width of the conch.

Position and localities. Not infrequent in the dolomite beds belonging to D of the Beekmantown formation at the Spelman ledge near Beekmantown and in A_3 of the Valcour shore section which corresponds to a part of the Fort Cassin beds. Billings records this form as occurring in the calciferous sandrock of the Mingan islands, the township of Godmanchester, counties of Leeds and Granville; in forms referred with some doubt to this species from various localities in Newfoundland, namely Cape Norman, division G; Pistolet bay on Schooner island, in division H; and at the river of Ponds in G. Divisions G and H are supposed to represent the upper part of the formation in Newfoundland. Billings states in regard to these Newfoundland specimens [p. 255] that they agree with his types of O. lamarcki in all surface characters and the rate of tapering but that the majority of the specimens possess a somewhat narrower siphuncle which is only ¼ the width of the conch; some siphuncles however also attaining the full width of the typical specimens. On the Mingan islands the species is recorded to be found in a limestone intervening between the typical Calciferous sandrock and the overlying Chazy. It seems therefore that this species may range through the entire upper Beekmantown formation.

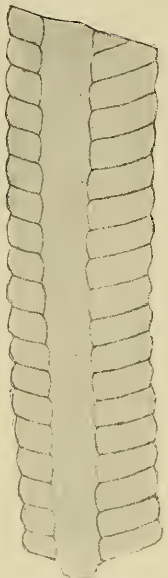
Fig. 16 Protocycloceras lamarcki Billings (sp.) Transverse section. x $\frac{9}{10}$

Protocycloceras whitfieldi sp. nov.

Plate 15, figure 7

Orthoceras bilineatum Whitfield. Am. Mus. Nat. Hist. Bul. 1890. v. 3, pl. 2, fig. 5

Professor Whitfield has referred a closely annulated cephalopod from the Fort Cassin beds to the Black river species O. bilineatum, arguing that a comparison of the Fort Cassin material with the forms from Watertown (Black river) and from the dove-colored limestone of Isle La Motte (Chazy) has not furnished any criteria by which they can be distinguished. Such a forcing of forms of the Beekmantown, Chazy and Trenton formations into one species is however only possible on the assumption of extreme variability on the part of that species; and this indeed is claimed by that eminent author. Our own observations do not warrant such conservatism but demonstrate the Fort Cassin, as well as the annulated Isle La Motte types to be different from O. bilineatum. As a matter of fact they even belong to different genera. In describing here the Fort Cassin form as new we take particular pleasure in naming it after Prof. Whitfield, who has so carefully described and figured the Fort Cassin fauna.



17a

17b

Fig. 17a Protocycloceras whitfieldi sp. nov. Longitudinal section. Natural size. Fig. 17b Enlargement of the ectosiphuncle of the same. x 3

Description. Slender orthoceracone of rather small size. The specimen figured by Prof. Whitfield has a length of 84 mm, but lacks living chamber and apical portion and indicates an original length of the individual, at least three times that of the fragment. The greatest width of the fragment is 25 mm. The rate of growth of the conch is very small, 1 mm in 12 or 13 mm. The section is circular. The outer wall possesses concentric annulations which are mostly rather oblique or undulating, in exfoliated specimens they appear as ridges with rounded edges, but on the surface they were more sharply elevated and angular. They are closely arranged, exactly corresponding in interval to the depth of the chambers, the sutures falling into the interspaces, which are of equal width with the ridges and uniformly concave. There are 5 of these annulations in the space of 20 mm, where the diameter of the conch is approximately 20 mm.

The cameras are very shallow, there being counted 5-6 in the space of 20 mm, the sutures pass obliquely or undulating around, the same as the annulations; the septa are flat, their depth mostly not reaching and never surpassing that of the cameras. The living chamber has not been observed. The siphuncle is large, one third the width of the conch, tubular and situated slightly excentrically in such a way that its inner margin coincides approximately with the axis of the conch [*see* text fig. 17].

The surface on the fragments observed is marked with fine encircling lines only and lacks longitudinal ridges.

Position and locality. In the Fort Cassin beds at Fort Cassin.

Observations. The large size of the siphuncle marks this species as one of the very primitive forms of the Cycloceratidae for whose reception Hyatt has erected the genus Protocycloceras.

From Spyroceras bilineatum this form is readily distinguished by its greater siphuncle and the absence of the longitudinal surface sculpture.

Protocycloceras (?) cf. furtivum, Billings (sp.)

Plate 16, figure 3

Orthoceras furtivum Billings. Geol. of Can. Pal. Foss. 1865. 1:348, fig. 337

There occurs at the Spelman ledge, in Beekmantown formation D, another type of annulated conchs, in which the annulations do not pass straight transverse, but obliquely around the conch. It agrees in this character and the somewhat wider intervals between the annulations (7 in 20 mm, where the conch has a width of 8 mm), with the above cited Beekmantown form, described by Billings, to which we refer it here with doubt, owing to our failure to observe either septa or siphuncle. In P. (?) furtivum, the siphuncle is described as tubular and in contact with the conch; the septa are unknown. The only specimen on which Billings based his description came from the Beekmantown beds, exposed in the rock cutting of the Brockville & Ottawa Railway in the township of Kitley.

Family KIONOCERATIDAE

Genus SPYROCERAS Hyatt

Spyroceras clintoni Miller (sp.)

Plate 14, figure 4; plate 16, figure 5–7

Orthoceras subarcuatum Hall. Pal. N. Y. 1847. v. 1:34, pl. 7, fig. 3 (lower part of drawing)

Orthoceras subarcuatum Billings. Can. Nat. & Geol. 1859. 4:461

Orthoceras clintoni Miller. Am. Pal. 1877. p. 224

Hall was the first to describe the common annulated cephalopod from the Chazy rocks here under consideration. Unfortunately his type specimen which is at present in the American Museum of Natural History is composed of fragments of two different species; for an inspection of the same after it had been taken out of its plaster packing revealed the fact that the anterior part is a fragment of a strongly annulated arcuate form while the posterior one belongs to a smooth straight form. The two fragments do not fit together properly. We have for this reason redrawn this composite original specimen [pl. 14, fig. 4].

It is evident that Hall wrote his brief description mainly from the anterior fragment while the draftsman extended the surface and septal characters of the posterior smaller fragment to the whole specimen. As a result of these different viewpoints the description and figure disagree.

Only the anterior annulated fragment can be regarded as the type, the other fragment belonging to Loxoceras moniliforme. To increase the troubles of this species S. A. Miller in 1877 pointed out that Hall's name was preoccupied and substituted in its place the rather undesirable name Orthoceras clintoni, which however has to stand.

Hall describes the species as follows:

Cylindrical gradually tapering, slightly arcuated, marked by angular ridges which are equidistant and alternating with the septa; surface of shell smooth?; septa distant from one fourth to one fifth the diameter; siphuncle not visible.

As position and locality are given the "central dark limestone, associated with Maclurea magna at Chazy, Clinton co."

Billings records the form from the Chazy on the island of Montreal and near Cornwall, adding "the surface characters are not well known, but one of the specimens exhibits the siphuncle which is strongly moniliform, and situated halfway between the center and the outside. All the specimens that I have seen are curved".

From our own material we are able to give the following additional data:

The size attained by this species in the Champlain basin has been considerable. We have obtained at Valcour (B_5) an incomplete specimen which has a length of 57 cm and a greatest width of 75 mm. Its living chamber is 22 cm long. The aperture of this specimen is straight. The curvature is irregular and the initial fourth is as a whole curved more strongly than the later portions of the shell and often bends somewhat abruptly in one place, the preceding and following portions of the conch being less curved. In the large specimen mentioned above the arc attains a hight of not more than 10 mm. The rate of growth of the conch is small, but increasing gradually. Where the width of the conch is 15 mm, it is only 1:20; where the conch has expanded to 36 mm it is as 1:7. The surface sculpture is also variable; the apical portion bears nothing but sharp longitudinal striae as in most other annulated forms.[1]

[1] We have not observed any specimen with the transition from the non-annulated longitudinal sculpture to the annulated but the fact that near Little Monty bay where S. clintoni occurs very freely and is the only annulated

These are increased by interplantation and are, with the exception of a few intercalated smaller ones, all sharply elevated and of uniform size. There are about six of them in the space of 3 mm. They are continuous over the edges of the annulations as stated by Billings. In very well preserved specimens there are about 10 in the space of one line as noted by Billings but these are so fine that they are hardly noticeable to the naked eye while lines about 1 mm distant from each other are so prominent that they alone appear to constitute the longitudinal sculpture of the conch. It is quite apparent that the characters of the longitudinal lines are variable in different growth stages of the conch. The annulations are rounded in our specimens as they were described by Billings though they often appear acute in natural sections on account of the obliquity of the latter. In old age they become relatively low and indistinct. The interspace is always uniformly concave. The annulations and septa correspond in arrangement.

The cameras are shallow; where the conch is 15 mm wide there are counted 3½ of them in the space of 10 mm; where the conch has grown to a diameter of 55 mm the cameras are 8 mm deep. The septa are shallow, at the former place their depth is half that of the cameras, at the latter place it is equal to that of 1½ cameras.

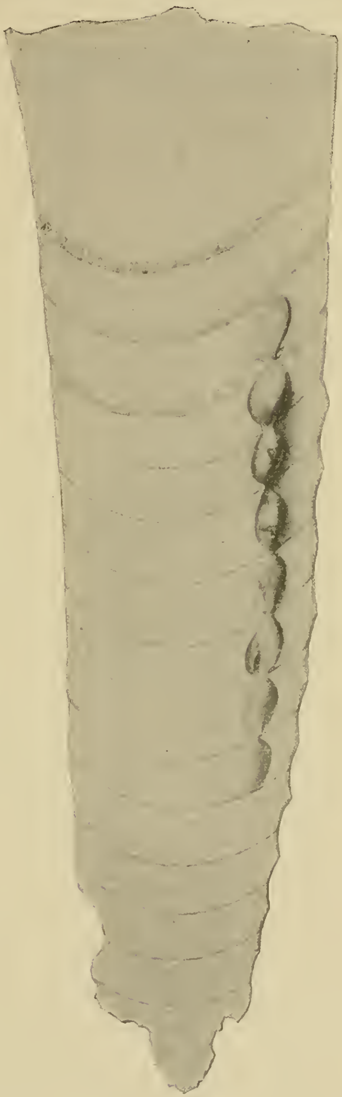


Fig. 18 Spyroceras clintoni Miller (sp.) Natural section. x ¾

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form observed, it is associated with small longitudinally striated conchs [see pl. 16, fig. 7], which in the other specific characters fully agree with this species, appears to us as fair evidence of the nonannulated character of the earliest stages of the conch.

The living chamber is large, about one third the length of the entire conch.

The siphuncle is small, about 2.5 mm wide where the conch is 15 mm; somewhat variable in its position between the center and the convex (ventral ?) side of the shell but mostly ventrocentren and notably so in the mature part of the shell; inflated to not quite double its width in an oblique direction [*see* pl. 16, fig. 5 and text fig. 18].

Position and localities. In the lower Chazy (B_5 and B_8 of Valcour section) near Chazy and on Valcour island; especially common in the dove-colored limestone of Little Monty Bay, Isle La Motte and Valcour.

Observations. Billings has compared his species with Orthoceras anellus, a Trenton form with angular sharp annulations but also angular interspaces. Two other species with similar annulations have been described by Billings himself, viz, O. balteatum and O. perannulatum, both from the Lower Siluric of Anticosti [1857, p. 318, 319]. But neither of these is figured and the descriptions given are insufficient for closer comparison.

We have long doubted whether this form should not be properly united with the species described by Billings as O. maro from the Chazy of the Mingan islands,[1] which name would then have precedence over Miller's substitute for O. subarcuatum; and indeed we know that geologists who have collected and studied the faunas of the Chazy of the Champlain basin have unhesitatingly referred all their curved annulated shells to O. maro, naturally not being aware that Hall's incorrect drawing of O. subarcuatum has just such an annulated form as a partial basis. Careful comparisons of the measurements of the depth of the cameras, distance and hight of annulations, convexity of septa and amount of curvature between my own material, Hall's type and Billings's types of O. maro have demonstrated that these measurements would not bring out sufficient differences for a specific distinction but that a difference which at present can not be neglected is found in the position and character of the siphuncle. The latter, in O. maro is situated near the center but in Spyroceras clintoni though somewhat variable, nearer to the convex margin and in mature specimens directly submarginal; in the former species I have also found it to be narrower and with but slightly inflated segments while in S. clintoni the segments are nummuloidal.

[1] Can. Nat. & Geol. 1859. 4:461.

Billings himself distinguished in the above cited publication between the two species though I am not certain that the form which he considers there as O. subarcuatum is indeed referable to that species since Hall's drawings and descriptions would give, without recourse to the original specimen, a wrong conception of the species.

Spyroceras bilineatum Hall (sp.)

Orthoceras bilineatum Hall. Pal. N. Y. 1847. 1:200

This species is cited here, because it has been repeatedly recorded as occurring in the Beekmantown and Chazy rocks. Hall figured a specimen referred to this Trenton species among the Chazy forms [*l. c.* pl. 17, fig. 4, 4a], stating that it was given to him by Dr Emmons as coming from the Calciferous sandstone of a locality six miles east of Albany (Rysedorph hill), but was recognized by him to be a Trenton form.

Billings has also cited Orthoceras bilineatum as occurring in the Chazy at Mingan (and also in the Black river limestone and Hudson river group of Canada[1]) and Whitfield[2] has described and figured a Fort Cassin form as O. bilineatum Hall. The latter is described here as a new species (Protocycloceras whitfieldi). We have not found any annulated orthoceracones in either the Beekmantown or Chazy formation which could be properly identified with the well known Trenton form S. bilineatum.

Genus Orygoceras gen. nov.

Etymology: *Oryx*, an antelope; *ceras* horn

Orthoceracones with subcircular to depressed oval section; internally annulated and externally smooth shell; empty, tubular, orthochoanitic siphuncle which is situated outside of center.

Genotype: Orygoceras cornu-oryx Whitfield (sp.)

Inability to refer Whitfield's species Orthoceras cornu-oryx from the Fort Cassin beds to any of the genera of orthoceracones enunciated by Hyatt in his elaborate system of fossil Cephalopoda, or even to any of the families which comprise the orthoceraconic forms, as the Endoceratidae, Orthoceratidae and Cycloceratidae has compelled us to propose a new genus for the reception of this most peculiar form.

The orthochoanitic character of the siphuncle will prohibit a reference to the first named family, the marginal position of the siphuncle and internal annulations dismiss the form from the Ortho-

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[1] Can. Nat. & Geol. 1859. 4:462.

[2] Am. Mus. Nat. Hist. Bul. 1890. 3:35, pl. 2, fig. 5.

ceratidae and the scope of none of the genera of the Cycloceratidae could be extended wide enough to receive the species in question. Nor are we at all sure that the family Cycloceratidae will be the proper receptacle for this genus, in view of the marginal position of the small orthochoanitic siphuncle and the character of the annulations, and consider it possible that it may be a primitive member of the Tarphyceratidae. Under the latter caption it is stated by Hyatt [Zittel-Eastman, p. 519], " Orthoceracones represented by genera at present undescribed ". This may be one of these hitherto undescribed genera.

The appearance of costae in several forms of the Tarphyceratidae, which leads to the annular costae of the Plectoceratidae may be in line with the annulations of the shell here under consideration. The placing of Orygoceras with the Cycloceratidae is for these reasons only provisional.

The peculiar restriction of the annulation to the inner side of the outer wall of the shell is more fully described under the type species. Its bearing upon the explanation of the probable origin of annulation in the cephalopod shell will be discussed in a later paper. The structure of the siphuncular wall shows this genus to belong to the Orthochoanites. The wall like that of the Orthoceratidae is composed of short straight septal necks and connecting sheaths.

Orygoceras cornu-oryx Whitfield (sp.)

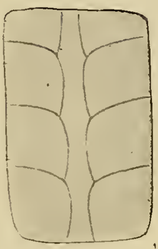
Plate 14, figure 5-8

Orthoceras cornu-oryx Whitfield. Amer. Mus. Nat. Hist. Bul. 1886. 1:320, pl. 27, fig. 1, 2, 6

Description. Short, stout orthoceracone, attaining a length of 60+mm expanding at the rate of 1 mm in 5-7 mm and attaining a greatest width of 20 mm. Section of conch depressed, elliptic (the minor and major diameters in the ratio of 6:7), but sometimes nearly circular. Outer shell thick; smooth exteriorly but provided with internal ringlike thickenings which give to the casts an annulated appearance; the apparent annuli increase in strength in apertural direction, are broad, flat and little elevated and separated by about equally broad flat depressions; their width increases from 2.5 to 3.5 mm in the specimens investigated. Living chamber large, about one third the length of the whole conch. Aperture as a rule straight, transverse. Cameras very shallow, there being 7 in the space of 10 mm in the apical phragmocone and 5 in the mature portion; sutures sightly undulating, with broad shallow lateral saddles and a similar antisiphonal lobe. Septa little convex, their depth about twice that of the cameras. Surface smooth, internal surface of outer wall marked with fine engirdling lines.

Position and localities. Frequent in the Fort Cassin beds at Fort Cassin; rare in the same beds at Valcour N. Y. (A_3 of section).

Observations. This species is one of great morphologic and phylogenetic interest in many respects. The most important of these is the presence of interior annulations (or constrictions) upon the conch which have not yet had any effect upon the outer side of the conch, the latter showing only in exceptional cases, faint transverse elevations upon the living chamber [*see* fig. 7, 8]. These internal constrictions have been mistaken by Whitfield for external annulations of the conch and the species described as strongly annulated. The form of the supposed annulations as they appear upon the inner cast of the conch is however greatly different from that of the true annulations of most orthoceratites and has led to the specific name.



19 20

Fig. 19 Orygoceras cornuoryx Whitf. (sp.) Transverse section. Natural size. Fig. 20 Same. Enlargement (x 4) of siphuncle

Note on the nautilicones of the Beekmantown and Chazy formations

Professor Whitfield has described among the Fort Cassin fossils two species of Nautilus, viz, Nautilus kelloggi and N. ? champlainensis. Since we have a considerable number of specimens from the Valcour outcrops, which clearly fall within the boundaries of these species, we have to occupy ourselves with the vicissitudes of the latter. Schröder pointed out soon after the publication of the species [1891, p. 27] that the original description and the drawings of the first named one do not agree with each other and that it is to be inferred that specimens which have not been figured were used for the description. Since the former of these drawings [*l. c.* pl. 30, fig. 1] which represents a large and perfect specimen is designated as illustrating the type specimen in the explanation of the plate, the other two have to be considered as belonging to another species. They have been made by Hyatt the types of his new species Eurystomites rotundus [1894, p. 443]. In the last cited work there is described still a third form, viz, Eurystomites virginianus as probably comprised by Whitfield's original description, but as not being figured by him. We have therefore altogether probably three species in the Fort Cassin beds which were originally described as Nautilus kelloggi, viz: Eurystomites kelloggi Whitfield (sp.), E. rotundus Hyatt and E. virginianus Hyatt. The first of these species has been redescribed by Schröder, the other two by Hyatt. They are all three referred to or can be said to constitute at present the genus Eurystomites, which according to Schröder has the following diagnostic characters (translated).

Shell completely coiled in a spiral. Aperture expanded, with a simple hyponomic sinus. Sipho centriventral to ventral.

Nautilus? champlainensis was also referred by Schröder to his genus Eurystomites, but has been brought by Hyatt [1894, p. 435] together with Lituites seelyi Whitfield, another Fort Cassin form, under Tarphyceras, while Lituites eatoni Whitfield, which was referred by Schröder to Discoceras has been made by Hyatt a member of his new genus Schroederoceras and Lituites internestriatus Whitfield, a fourth Fort Cassin species, also a Discoceras according to Schröder, is considered by Hyatt a typical Trocholites.

Later [1897, p. 182] Professor Whitfield described still another nautiliconic form from Fort Cassin, viz, N. perkinsi. This differs from Tarphyceras champlainense only in the stronger development of the oblique undulations of the surface, but agrees with it in all other important characters.

Of these genera of nautiliconic forms from New York and Vermont, Eurystomites and Tarphyceras belong to the family Tarphyceratidae. This is characterized by the compressed oval section, the venter of which is narrower than the dorsum; the smooth or nearly smooth shell and the empty and tubular siphuncle, which is situated ventrad of the center. The genera Schroederoceras and Trocholites are brought under the Trocholitidae, which are described as follows:

As a rule they have excessively broad volutions with reniform section, and an impressed zone at a very early age; the siphuncle is then ventrad of the center, but in the ephebic stage it is tubular and dorsad of center.

Since the original descriptions of Whitfield were partly emended by Schröder and greatly enlarged by Hyatt's elaborate investigation of the growth stages, based upon the large collection of the United States National Museum, we can restrict ourselves here to an enumeration — with a few supplementary remarks — of the species which have been identified in the material from the beds at Valcour.

To facilitate the understanding of the somewhat complicated generic references of these nautiliconic forms, we insert here two synoptic tables.

I Synoptic table of the nautilicones of the Fort Cassin beds of New York and Vermont

WHITFIELD'S SPECIES	SCHROEDER'S DETERMINATIONS	HYATT'S DETERMINATIONS	SPECIES NOTED BY THE AUTHOR
Nautilus kelloggi	Eurystomites kelloggi E. *sp. undet*	Eurystomites kelloggi E. rotundus E. virginianus (*pars*)	1 Eurystomites kelloggi 2 E. rotundus
			3 E. accelerans 4 E. amplectens
N. champlainensis	E. champlainensis	Tarphyceras champlainense	5 Tarphyceras champlainense
N. perkinsi	....	....	6 T. perkinsi
Lituites seelyi	....	T. seelyi	7 T. seelyi
			8 T. clarkei
L. eatoni	Discoceras eatoni	Schroederoceras eatoni	9 Schroederoceras eatoni
L. eatoni *var.* cassinensis	....	Schr. cassinense	10 Schr. cassinense
L. internestriatus	D. internestriatum	Trocholites internestriatus	11 Trocholites internestriatus
		Trocholitoceras walcotti	12 Trocholitoceras walcotti

2 Synoptic table of the nautilicones of the Chazy formation in New York and Canada

SPECIES DESCRIBED BY BILLINGS	SPECIES DESCRIBED BY HYATT	SPECIES NOTED IN NEW YORK BY THE AUTHOR
Nautilus natator..	Barrandeoceras natator..	Barrandeoceras natator
	B. minganense	
		Tarphyceras multicameratum
		Deltoceras van ingeni
N. jason..........	Plectoceras jason........	Plectoceras jason
N. tyrans		

Division II. PLECTOCERATIDA

Family TARPHYCERATIDAE

Genus BARRANDEOCERAS Hyatt

This genus has been diagnosed in the *Genera of Fossil Cephalopods* [1884, p. 299] as follows:

Gyroceran and nautilian shells with very large umbilical perforations, and compressed, slightly costated or smooth whorls, generally without an impressed zone, though this is sometimes present. The venter is narrower than the dorsum, the siphon near but above the center, septa deeply concave, and sutures with ventral saddles, lateral lobes and dorsal saddles, without annular lobes. Type, Barr. (Naut.) natator sp. Bill. Living chamber is about one half of a volution in length; it is about three fourths of a volution in length in the type species.

Later on [1894] it has been added that the lobation here described, is only found in forms having the gyroceran mode of coiling, but not in those which have the closer nautilian form. Since we are here concerned with the genotype only, which is a gyroceran form, we need not enter upon these variations of lobation.

Barrandeoceras natator Billings (sp.)

Plates 32 and 33

Nautilus natator Billings. Can. Nat. 1859. v. 4, no. 6, p. 466
Barrandeoceras natator Hyatt. Bost. Soc. Nat. Hist. Proc. 1884. 22:299
Barrandeoceras natator Hyatt. Am. Phil. Soc. Proc. 1894. 32:452

Hyatt's description of this species, which contains most of the essential characters, is this:

This species has volutions compressed oval in section, the dorsum somewhat broader than the venter; siphuncle is extracentroventran, even in the neanic stage; septa deeply concave; sutures with dorsal and ventral saddles and the lateral lobes as in other species of this genus.

The volutions are in contact, but no contact furrow was formed at any age. The contact takes place as in the young of Estonioceras perforatum [fig. 9, pl. 7] on the venter of the paranepionic volution.

The volution in the neanic stage, dorsoventral diameter 13 mm, has a much narrower venter in proportion to the dorsum than in the adult. The venter was rounded at all stages and also the dorsum. The ananeanic and nepionic stage were not present in the original specimen in the Museum at Ottawa, but in following out the same lines it is easily ascertained that the umbilical perforation must have been enormous, at least 15-17 mm in diameter. The living chamber was somewhat over one fourth of a volution in length. The whole diameter was about 108 mm. It was reported as having been found in the Chazy limestone.

A large gerontic specimen which we have collected on the east shore of Valcour island, in the dove-colored Upper Chazy limestone, furnishes the following additional data.

The conch, which on the whole seems to be well characterized by Billings in being described as "discoid planorbiform", is composed of not more than four volutions, if the umbilicus has the large size inferred by Hyatt, and it attains a diameter of 165 mm or more. The whorls are very slender and gradually expanding, the rate of growth being 1 :2.2 in one volution; the dorsoventral diameter increasing from 10 mm to 22 mm. The siphuncle is also very slender or narrow (1.4 mm in third volution). The living chamber apparently reaches one half of a volution or more, and becomes slightly evolute in the gerontic growth stage. The cameras are shallow, their depth being 4 mm at the end of the second volution and 5.5 mm at the end of the third volution; the septa are very concave, their depth equalling that of 1¼ cameras.

The surface, which is not shown in the type, is exposed on the third and fourth volutions of our specimen. The third volution shows strong ribs or costae like those of Plectoceras; they curve forward on the sides and disappear toward the end of the third volution, so that the last volution possesses fine growth lines only. From their appearance at the beginning of the third volution, there is no doubt that the second volution bore also ribs on its greater part.

From Plectoceras jason, another costated nautiloid of the Chazy rocks, this species can be readily distinguished by the more slender volutions, the gyroceran form of involution, the volutions being only in contact and the earlier cessation of costation; in sections by the different position and smaller size of the siphuncle. The early appearance and disappearance of the costation on the whorls suggest that it was here again in a retrogressive stage. Neither the type nor any other representative of the species has as yet been figured; the specimen here reproduced, while a little more imperfect in the center than the type of Billings's and Hyatt's descriptions, is more perfect otherwise; and we have no doubt, after inspection of the type specimen at Ottawa and the observation of complete equality in the relative dimensions of the two that the specific reference is correct.

Genus EURYSTOMITES Schröder emend. Hyatt

The genus Eurystomites has been established by Schröder [1891, p. 26] to comprise forms which while in most characters like Nötling's genus Estonioceras still differ in the amount and character of involution. He defines Eurystomites thus [translation]:

"Shell completely involute. Aperture enlarged, with simple ventral sinus. Siphuncle centriventral to ventral"; and includes in his genus Nautilus kelloggi Whitfield and N. champlainensis Whitfield. Hyatt has later [1894, p. 433] separated the genus Tarphyceras from Eurystomites [for differences *see* p. 464] and referred the last cited species to his new genus. N. kelloggi as emended by Schröder and here described is the genotype of Eurystomites.

Eurystomites kelloggi Whitfield (sp.) emend. Schröder

Plate 17, figure 1; plate 18, figure 1

Nautilus kelloggi Whitfield (pars). Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 328, pl. 30, fig. 1; not pl. 31, fig. 4, 5

Eurystomites kelloggi Schröder. Pal. Abh. herausg. von Dames und Kayser. 1891. B. 5, Heft 4, p. 27.

Eurystomites kelloggi Hyatt. Am. Phil. Soc. Proc. 1894. 32:442, pl. 5, fig. 4, 5

The synonymy of this species, which is the genotype of the genus Eurystomites, is extremely involved. Its original description and figures contain alien elements which have been eliminated by Schröder who emended the species, basing his description upon the first drawing given by Whitfield [*op. cit.*, pl. 30]. The other form originally comprised under Nautilus kelloggi [pl. 31, fig. 4, 5] has been described by Hyatt as E. rotundus. E. kelloggi has not been redescribed by Hyatt.

Since Schröder has shown that Whitfield based his description partly upon the specimens which are now the types of E. rotundus, we must accept Schröder's diagnosis, based on Whitfield's first figure, as the only valid one.

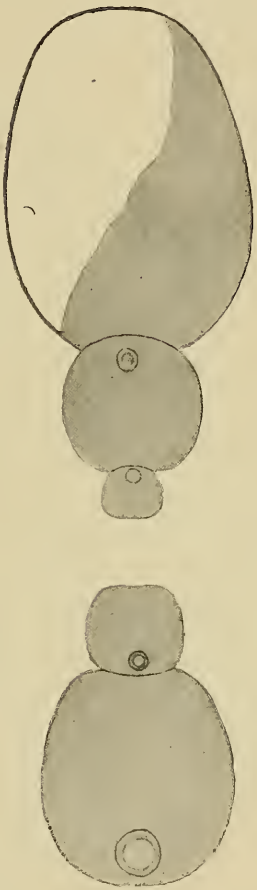


Fig. 21 Eurystomites kelloggi Whitf. (sp.) Transverse section. Natural size

Since however Schröder had not the type specimen in hand and Whitfield has figured neither longitudinal nor transverse sections of the type it is evident that that portion of Schröder's diagnosis which gives the interior characters can not be reliable. It is clearly copied from Whitfield's description, which in its turn refers again to the smaller specimen, or the present E. rotundus. It is probably on this account that Hyatt queries the correctness of Schröder's diagnosis [1894, p. 442]. Besides the internal characters, the material from Valcour furnishes other additional diagnostic characters not obtainable from the type specimen. We have for these reasons and also because Schröder's diagnosis is probably not everywhere readily accessible inserted here a full description of the species drawn from Professor Whitfield's specimen, and from our material obtained at Valcour.

Description. Conch a rather closely coiled nautilicone up to gerontic age, when the living chamber becomes free, but does not straighten and only unfolds into an arc with a larger radius, 4-5 volutions, giving the conch a diameter of 170 mm. Volutions slightly compressed, elliptic in section in the ephebic stage and subcircular in the nepionic and neanic stages [*see* text fig. 21] ; ratio of hight to width of volution where the latter has a hight of 27 mm approximately as 9:8 and where it has a hight of 40 mm as 10:8. No lateral zones differentiated; a ventral zone indicated by a slight flattening; the impressed (dorsal) zone slight but continuous upon the free gerontic volution ("persistent impressed zone"). Growth of conch quite rapid, the shell doubling in hight and width within the length of one volution; involution moderate, whorls embracing about ¼ their hight. Umbilical aperture relatively large.

Living chamber occupying three fourths of a volution. Aperture not very well known but judging from the growth lines provided

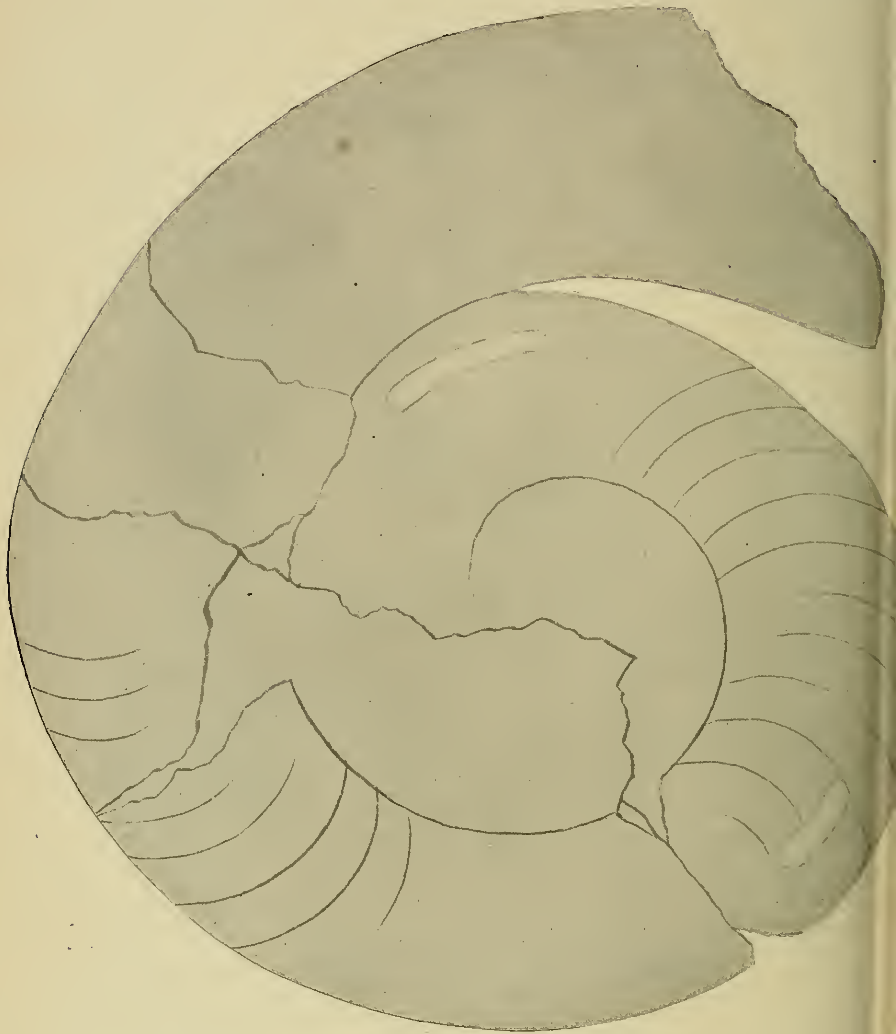


Fig. 22 Eurystomites kelloggi Whitf. (sp.) Weathered natural section from Valcour. (A_3) Natural size

with a deep hyponomic sinus [*see* pl. 18, fig. 1] and expanding, as indicated, by the periodical undulations and roughnesses of the shell. Cameras shallow, attaining an average depth in the ephebic part of the conch of 9 mm. Septa little concave, their concavity equal to about one half the depth of the cameras [*see* plate 17]; sutures straight transverse with a broad and low ventral saddle which is divided by a faint median lobe. Shallow broad lateral lobes developed in the ephebic portion.

Siphuncle tubular, large (one fifth the hight of volution), subventren in nepionic and neanic growth stages, extracentroventren in ephebic stage [*see* text fig. 22].

Shell smooth in ephebic stage, slightly costated in the neanic stage [*fide* Hyatt] and undulated in gerontic stage.

Position and localities. Fort Cassin beds at Fort Cassin Vt. and Valcour N. Y.

Observations. This large sized nautiloid can be distinguished from all other involute associates except E. rotundus and E. accelerans by its great rate of growth. E. rotundus differs from E. kelloggi according to Hyatt by its more rapid increase in the growth of the dorsoventral diameter and the retaining of the siphuncle near the venter for a longer time. Whitfield had placed this form under Nautilus rather than under Lituites as he had no evidence indicating that the last whorl becomes free and the position of the siphuncle was more suggestive of Nautilus. Hyatt however gives the outline of a specimen which shows a dorsal margin of a free gerontic whorl and we have three specimens which leave no doubt of the evolution of the last whorl.

Schröder infers from the original drawing of the type specimen that the latter retains the apertural margin and also Hyatt states [p. 442] that "the aperture as figured by Whitfield has lateral crests which are most prominent opposite the centers of the lateral zones, receding into sinuses on the umbilical zones." The retention of the aperture is however improbable in view of the short portion which is retained of the living chamber; nor does Whitfield mention the observation of the aperture. Inspection of the type specimen leaves no doubt that the aperture is not preserved, and the apparent aperture is but an accidental fracture which does not even run parallel to the growth lines. I am not aware that the aperture has been observed in any other representative of this species. From the direction of the growth lines and undulations we can infer, however, that lateral crests were present similarly as in Tarphyceras champlainense.

A small collection of cephalopods from the Shakopee formation in Minnesota, in the possession of Dr Sardeson, contains an involute form, preserved in the mold of the first 2⅓ volutions, the living chamber and the preceding chamber. The specimen was obtained at Pickett's Station [now called Dill], Wisc. It is, in its rate of growth, absolutely identical with E. kelloggi, nor does it appear to differ sufficiently in section, position of siphuncle and depth of septa to warrant specific differentiation.

Eurystomites accelerans sp. nov.

Plate 18, fig. 2, 3

We have a specimen from A_3 of the Fort Cassin beds at Valcour, which in the rate of growth of the conch, the section of the whorls and position of the siphuncle fully agrees — at least at a certain stage, represented by the last whorl of our fragment — with E. kelloggi; but differs from that species by the very marked flat ventral zone, the closer position of the septa (5 in 20 mm where the hight of the volution is 23 mm, against 4 under the same condition in E. kelloggi) and their stronger forward curvature near the line of involution. In the flat ventral zone, the closer arrangement of the septa and the dorsal direction of the sutures, this form suggests the genus Tarphyceras as represented by Tarphyceras champlainense, but the rate of growth of the whorl prohibits a reference to that species or to the genus Tarphyceras. There is little doubt that this is a new form which represents a more advanced stage in the phylogenetic development of the Eurystomites race than E. kelloggi. This is shown specially in the early appearance of the ventral zone and the greater amount of curvature of the suture which here in the neanic stage is already much greater than that in the ephebic stage of E. kelloggi. A certain amount of acceleration in the development of the characters as compared with the latter species has therefore taken place.

E. virginianus also has more numerous sutures than E. kelloggi, but these are described as straighter than those of E. kelloggi in all stages. In this particular character it is hence the direct opposite of E. accelerans. A direct comparison of the type of the latter species with those of E. virginianus, kindly forwarded by the United States National Museum, has shown that the two forms differ in their rates of growth, E. virginianus having the greater rate; in the depth of the cameras, which is greater in E. accelerans (at end of 2 volutions, 4 cameras in space of 10 mm against 5 in E. vir-

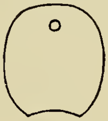


Fig. 23 Eurystomites accelerans sp. nov. Transverse section. x $\frac{8}{10}$

giniánus; at end of 2½ volutions, 2½ cameras against 3½ in E. virginianus) and the amount of involution; in E. virginianus the volutions being hardly impressed on the dorsal side.

Unfortunately our material does not permit to trace the ontogenetic development of this form which probably would present interesting facts.

E. accelerans possesses in fragments some similarity with Tarphyceras champlainense Whitfield (sp.). It can, however, in such examples still readily be distinguished by the greater rate of expansion and more convex venter.

Eurystomites amplectens sp. nov.

Plate 18, fig. 4-7

Description. Conch a closely coiled nautilicone (also in gerontic age ?) of three (or more) volutions; of moderate size, a conch of three volutions having a diameter of about 70 mm. Volutions subcircular in nepionic and neanic stages, in ephebic stage reniform with a higher and narrower ventral region [*see* pl. 18, fig. 4]. Ventral zone indicated on ephebic whorl by a slight flattening; the impressed zone appearing on first whorl and increasing steadily in depth to living chamber. Involution considerable, increasing steadily (one fourth within first whorl, one third of second whorl projecting on first, one half of third on second). Growth of conch uniform, rapid, the hight doubling (16 to 32 mm) within the last volution. Umbilical opening extremely small or absent.

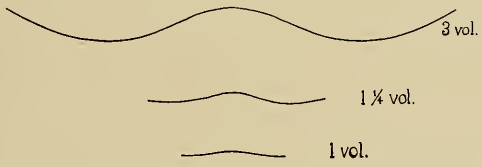


Fig. 24 Eurystomites amplectens sp. nov. Sutures x ¾

Length of living chamber and character of aperture unknown. Cameras shallow, 3½ being counted within the space of 20 mm on the ephebic whorl (counting along the middle of the lateral side). Septa possessing considerable convexity, being about as deep as the cameras; sutures straight transverse in the nepionic stage, with very low ventral saddle and shallow lateral lobe in neanic stage, broad and high ventral saddles and corresponding deep lobes in the ephebic stage, where the sutures also arch strongly forward near the line of involution (*see* diagram fig. 24). Siphuncle tubular, small, extra-centroventran. Surface unknown.

Position and locality. In A_5 of the Fort Cassin beds at Valcour.

Observations. Only a single specimen has been found which represents this interesting species. From the smaller depth of the last chamber we conclude that this specimen had already passed its ephebic stage. With none of its congeners in the Fort Cassin beds could it be confounded. It differs from the associated E. rotundus, to which it bears considerable superficial similarity, in possessing a much greater involution of the whorls and less rapid rate of growth, while from E. kelloggi it distinguishes itself by the closer arrangement of the septa (6 against 5 in the first whorl and 4 against 3 in the second), much greater involution, specially in the third whorl and more central position of the siphuncle.

In the great amount of involution of the last volution this species resembles E. undatus from the Trenton. In the strong development of the impressed zone it differs from all other congeners, except the last named later form, and the early appearance of the impressed zone (in this species already upon the first whorl) is not found in any other member of the Tarphyceratidae, but is a character of the later Trocholitidae, which this species also approaches in the reniform section of the inner portion of the ephebic whorl and the smaller siphuncle. On the other hand in the Trocholitidae the siphuncle is only in the younger stages ventrad of the center and later on passes dorsad of the center.

We have for these reasons retained this form among the Tarphyceratidae, but believe that it is well advanced on the road toward the Trocholitidae, the appearance of the impressed zone having by accelerated development been already pushed into the nepionic stage, while the siphuncle still retains its ventral position.

The strong and increasing involution of the whorls, the absence of an umbilical perforation and the early appearance of the impressed zone, resulting from the strong involution, serve all to indicate a strong tendency in this form toward a progressively closer coiling, which contrasts with the tendency to gerontic uncoiling shown by the other species of Eurystomites. The close coiling of the paranepionic stage [*see* fig. 5] is to such degree found only in Trocholites, though in Tarphyceras it may be approached, while typical Eurystomites-forms have a wide umbilical perforation.

In the depth of the septa and the strong forward curvature of the lateral sutures (sharp dorsal saddles), the sloping of the sides of the whorls and in other features, this form bears much resemblance to E. gibbosus, a species described (but not figured) by Hyatt [1894, p. 443] from the Beekmantown of Port au Choix, Newfoundland. This latter type is described however as not being very involute.

The type specimen exhibits the first chamber with the cicatrix and a faint surface sculpture, consisting of concentric and radiating lines [*see* pl. 18, fig. 6, 7].

Eurystomites rotundus Hyatt

Nautilus kelloggi Whitfield (pars). Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 328, pl. 31, fig. 4, 5

Eurystomites rotundus Hyatt. Am. Phil. Soc. Proc. 1894. 32:443, pl. 5, fig. 21–25

The probable presence of this species in the Valcour rocks (A_3) is indicated by a small fragment only, which, on account of its rotundity, large size and close position of the siphuncle to the ventral side, may be more safely referred to this species than to E. kelloggi.

E. rotundus has been separated from E. kelloggi by Hyatt on account of the presence among the figured types in the American Museum of specimens which "increase more rapidly in the growth of the ventrodorsal diameters than in kelloggi and retain the siphuncle near the venter for a longer time during the growth. This may be due, however, to the difference in the size and not a matter of age, since in large whorls it assumes a similar position to that of kelloggi."

Sections through the center and early whorls have brought out the fact, which is illustrated by Hyatt's figures, of "the large size of the umbilical perforation and the correlative rotundity of the dorsi of the meta- and paranepionic substages."

This form is apparently very rare in the Beekmantown beds of the Champlain basin and complete specimens have not yet come under observation. The types of the species come from the Fort Cassin beds at Fort Cassin Vt.

Eurystomites virginianus Hyatt

Eurystomites virginiana Hyatt. Am. Phil. Soc. Proc. 1894. 32:444

Hyatt states under the description of this species, the types of which were found near Lexington Va., that "there is a young specimen in the American Museum under the name of kelloggi, from Fort Cassin, that appears to belong to this species, having similar sutures, form of whorl and involutions."

E. virginianus is characterized as having "more cylindrical whorls and more numerous and straighter sutures at all stages than in kelloggi." We have not observed any adult specimens referable to this species in the collections from the Champlain basin.

Genus TARPHYCERAS Hyatt

This genus has been separated from Eurystomites Schröder by Hyatt [1894, p. 433]. The latter author states the relation of the two genera as follows:

This genus has heretofore been confounded with Eurystomites by Schröder, the species being found together and resembling each other in general aspect. It differs, however, from that genus in having a more discoidal form, more numerous and more slowly growing whorls, in length of living chamber, in form, aperture and other characters.

As to the differences in the length of the living chamber, it has been asserted later on [p. 442] by Hyatt that the living chamber in Eurystomites is very variable in length, shorter than in Tarphyceras in the adult E. kelloggi, and in the aged specimens very long. The length of the living chamber can, therefore, hardly be relied upon for generic distinction.

The aperture of Eurystomites has prominent lateral crests, at least in E. kelloggi, while in Tarphyceras the aperture is more as in Trocholites and has a deep broad hyponomic sinus encroaching upon the lateral zones; the latter having but low and broad crests. The amount of involution is also greater in the ephebic stage of Eurystomites than is usual in Tarphyceras, and the contact furrow is deeper.

The genus Tarphyceras can be truly considered as attaining the climax of its development in the Beekmantown formation, for there are here described from the Fort Cassin beds no less than four species (one of them new), while another one (T. farnsworthi Bill.) is cited by Hyatt from Philipsburg in the Champlain basin. Three more species occur in Newfoundland, one in Lexington Va., and one, doubtful in its generic position (T. convolvens, Angelin and Lindström) in Europe. We have added here a species from the Chazy beds (T. multicameratum), which in some characters appears already as a phylogerontic form [*see* p. 473].

Tarphyceras farnsworthi (Billings (sp.) pars) Hyatt emend.

Lituites farnsworthi Billings (pars). Pal. Foss. 1861. 1:21
Tarphyceras farnsworthi Hyatt. Am. Phil. Soc. Proc. 1893. 32:435

Hyatt, while investigating the nautiloid cephalopods, found that Billings's species Lituites farnsworthi from the Beekmantown formation at Philipsburg on Missisquoi bay of Lake Champlain, consisted really of several distinct species, one of which he referred to Tarphyceras and two others to the genus Aphetoceras (A. farnsworthi and A. attenuatum).

The first species is described by him as follows:

It has an elliptical or oval whorl in the ephebic stage, the dorsum a little broader than the venter. There is a contact furrow in the neanic and ephebic stages. The sutures have ventral saddles, with probably slight dorsal lobes in the zone of involution, and a free living chamber over one half of a volution in length. The siphuncle is subventran in the ananeanic substage, becoming propioventran in the paraneanic and ventrocentren in the metephebic substage. The diameter of the largest specimen, somewhat compressed, was 140 mm by 146 mm; the estimated longest diameter of this through the free living chamber was about 160 mm.

Tarphyceras seelyi Whitfield (sp.)

Plate 19, figure 1, 2; plate 20, figure 5; plate 21; plate 24, figure 3

Lituites seelyi Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 330, pl. 31, fig. 2; pl. 32, fig. 3
Tarphyceras seelyi Hyatt. Am. Phil. Soc. Proc. 1894. 32:435.

The mature stage of T. seelyi has been described very carefully by the author of the species. This type belongs evidently to the more common and characteristic forms of the beds at Fort Cassin; and is also well represented in the corresponding beds at Valcour. In referring to the original description we will only state that, in a general way, the species is characterized by the small rate of growth and the subcircular section of the volution, the small amount of involution and the subcentral position of the small siphuncle. The septa are closely arranged and quite concave.

The ontogeny of the species has not yet been investigated, or at least described, while that of the very similar T. champlainense has become well known by Hyatt's researches. One of our specimens retained the early volutions so well preserved that we were able to break out the first whorls successively and thus obtain the characters of the nepionic and neanic growth stages. It may be stated that they are also similar to those of T. champlainense.

The nepionic stage [*see* text fig. 25] has a very small umbilical perforation, which is curved and widening outward. The ananepionic stage is not clearly exposed, the apex of the first whorl being broken off; the metanepionic stage possesses a transversely oval section with a more prominent dorsum and flatter venter [*see* pl. 19, fig. 1]; while in T. champlainense both are about equally prominent. The siphuncle lies propioventran. In the other congener it is supposed by Hyatt to be situated centren. The early paranepionic stage is here characterized apparently by a still more abrupt curvature than in T. champlainense [*see* text fig.

Fig. 25 Tarphyceras seelyi Whitf (sp.) Section showing the umbilical perforation, and early whorls. Natural size

25]. Its section is kidney-shaped and shows a strong development of the impressed zone. Also the ventral saddle of the sutures is already well developed.

In the neanic stage the volution becomes higher than in the preceding stage, but not so rapidly and to such an extent as in T. champlainense and the siphuncle wanders more rapidly toward the center and becomes subcentren; also the abdomen is already distinctly flattened, while in T. champlainense a slight flattening does not appear until ephebic age. In the latter stage the dorsoventral diameter has become equal to the other one and the conch is subcircular in section. The sutures pass nearly straight transversely in both the nepionic and neanic stages, the lateral lobes being still undeveloped, and the ventral saddle very shallow. They begin, however, in the neanic stage to turn markedly forward near the line of involution, indicating the presence of a high dorsal saddle.

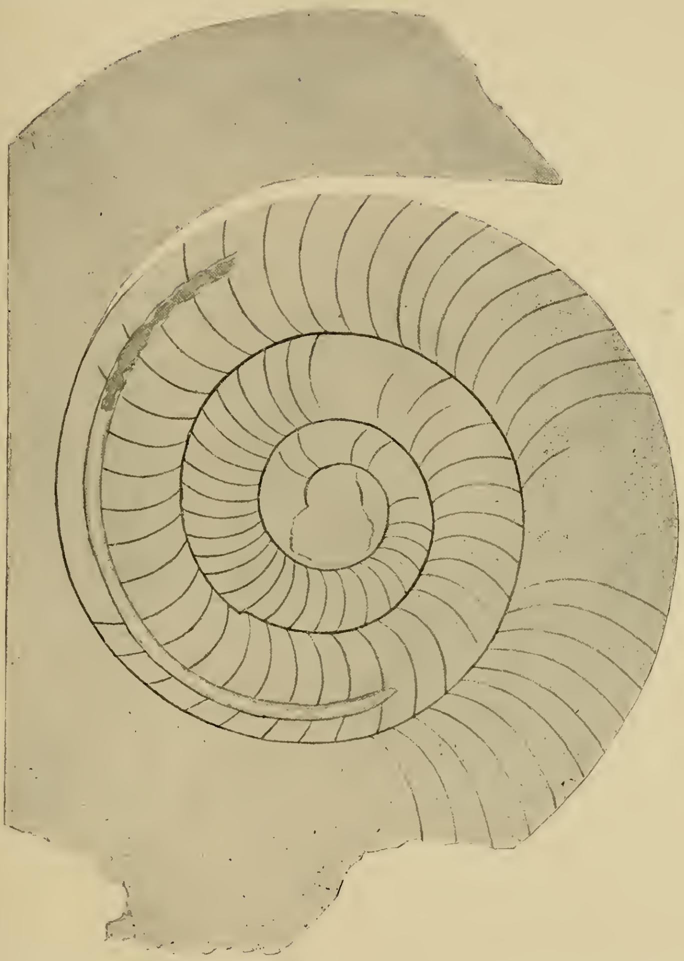


Fig. 26 Tarphyceras seelyi Whitf. (sp) Section showing the living chamber. Natural size

This forward curvature of the dorsal sutures is in our specimens developed much stronger than either Whitfield's drawings or description would indicate for the type specimen. The latter, however, showed on inspection the same feature.

The dorsal saddle remains low and broad also in the ephebic stage.

The surface has been observed in the neanic and ephebic stages. In both of them fine growth lines, very often but not regularly interrupted after each fifth or sixth line by a stronger one, were observed. They indicate a sharp hyponomic sinus, the depth of which in the neanic stage is about equal to that of a chamber. The low costae observed by Hyatt on the ananeanic stage of T. champlainense do not seem to appear upon the conch of this species.

The differences in the development of the conchs of T. champlainense and T. seelyi consist principally in the earlier appearance (and stronger development) of the ventral flattening and the earlier and more rapid turning of the siphuncle toward the center in the latter. The ephebic and gerontic volutions of the two forms differ principally in the development of later zones in T. seelyi, for though in the original description of the species it is stated that a section of the tube is nearly a circle, T. champlainense is described as different from T. seelyi in being less compressed laterally.

We give here [pl. 21, fig. 1] the outline of a very large specimen with a diameter of 175 mm which shows that even in the gerontic stage the last volution does not uncoil. The living chamber in this specimen occupies about ½ volution. The aperture had a deep hyponomic sinus but seems to have lacked any larger expansion and possessed but very low lateral crests.

Position and localities. At Valcour this species has been found in the beds A_3 and A_5 of the section. Its original locality is at Fort Cassin Vt.

Tarphyceras champlainense Whitfield (sp.)

Nautilus ? champlainensis Whitfield. Am. Mus. Nat. Hist. Bul. 1886. 1:329, pl. 31, fig. 1, 3

Eurystomites champlainensis Schröder. Pal. Abhandl. 1891. Bd. 5, Heft 4, p. 28

Tarphyceras champlainense Hyatt. Am. Phil. Soc. Proc. 1894. 32:438, pl. 4, fig. 4–11.

The description and figures of the mature form of T. champlainense by Whitfield and the very extensive illustration and description of the ontogenetic stages of the same by Hyatt do not require any further descriptive remarks upon this species which, moreover, has not been observed in any other place but at Fort Cassin, the original locality, or seen in better specimens than those which have before been described and figured.

The differences in the development of this species and the very similar T. seelyi have been pointed out by us under the latter species. The adults differ, according to the original descriptions of this species and that of T. seelyi, "in having a smaller number of volutions in the finished shell, and in their being very slightly more expanding and less compressed laterally. But the principal distinction and the only one which can be relied upon for the separation, is the expanded aperture." In the absence of this feature, it is added by the same author, that "it is barely possible to distinguish 'the species'". As we have noted before, the development of the two forms is different. The earlier appearance and stronger development of the ventral flattening, as well as the earlier and more rapid turning of the siphuncle toward the center in T. seelyi appear to suggest that this is the more advanced form and T. champlainense the more primitive of the two. Also the stronger development of lateral zones in the ephebic whorl of T. seelyi would point to the same inference.

Tarphyceras perkinsi Whitfield (sp.)

Nautilus perkinsi Whitfield. Am. Mus. Nat. Hist. Bul. 1897. 9:182, pl. 5, fig. 1, 2

This species, which has been described a considerable time after the other cephalopods of the Fort Cassin form, is based upon two specimens. I have not observed any more representatives of the same in the collections which have come under my notice and have therefore nothing to add to the original description.

It is stated in the latter that "this species is somewhat closely related to Nautilus champlainensis from the same beds, but differs principally in the presence of the oblique undulations of the surface." Since lower undulations are also found on the mature living chamber of T. champlainense and both forms agree completely in rate of growth, amount of involution and depth of the chambers, the presence of strong ribs upon the type specimen of T. perkinsi is evidently to be looked upon as constituting merely a further development of the corresponding character of T. champlainense; and the difference is one of grade only and would not appear to be of more than varietal value. The sutures in the types of T. perkinsi are straight transverse and in that of T. champlainense arching forward upon the dorsal side; but still this difference is not absolute since in the former species the sutures in the earlier volutions also possess a stronger dorsal saddle, which soon disappears, and in the other species the dorsal saddle is likewise little developed in the last sutures. It is, hence, evident that also this apparent difference is due to a little earlier development of a feature in one of the forms.

In view of the slight differences between T. perkinsi and T. champlainense, which consist only in the somewhat stronger and earlier development of features present in both, a specific separation of the two would seem unwarranted, were it not for the fact that these differences apparently happen to lie along lines of phylogenetic development to a new group, or express a tendency to a development of a new group and thereby gain greater phylogenetic importance and invite recognition.

The tendency to greater prominence of the costae and the tachygenetic pushing back of the time of their appearance on the whorls distinctly points to the Plectoceratidae. The prevalence of the strong ribs in T. perkinsi might even suggest the assignment of this variety to the genus Plectoceras. Since, however, the Plectoceratidae are diagnosed by Hyatt as forms in which the annular costae appear in the neanic stage and here they are not observed earlier than in the ephebic stage, this form still falls within the confines of Tarphyceras.

Tarphyceras clarkei sp. nov.

Plate 22

Description. Conch a loosely coiled nautilicone which in the gerontic age becomes uncoiled, the evolute portion separating but little (about its own hight at the aperture) from the rest of the conch. 4-5 volutions are found in the adult form giving the conch a diameter of 170 mm or more. Volutions in early stages subcircular, in ephebic and gerontic stages compressed elliptical with somewhat narrower abdomen [*see* text fig. 28–31], ratio of hight to width at end of third volution approximately as 6:5, in second whorl as 8:7. Ventral zone indicated by lower convexity in later whorls, impressed zone by a slight flattening, which persists on greater portion of free whorl (or throughout ?). Rate of growth of conch slow (that of hight about one third within one whorl). Umbilical perforation not observed.

Living chamber occupying one half of one volution in type specimen, but probably longer, free in gerontic age. Aperture not known, by indications from growth lines much advanced in dorsal region, and uniformly receding in ventral direction. Cameras shallow, attaining an average depth of 4.5 mm in the ephebic stage. Septa quite concave, their concavity equal to the depth of the cameras; sutures pass nearly straight transversely, with hardly any trace of a ventral

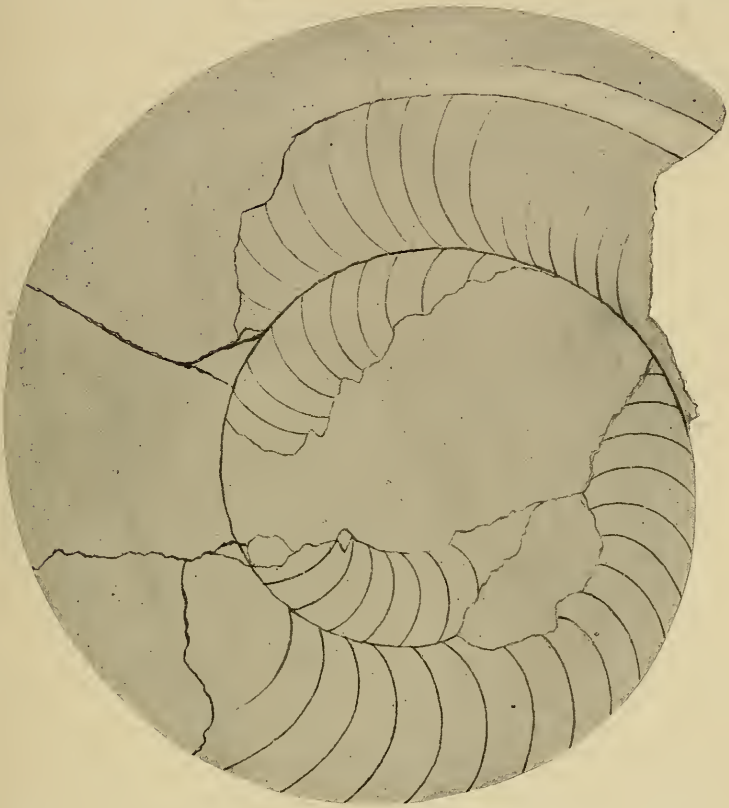


Fig. 27 Tarphyceras clarkei sp. nov. Section of type (pl. 22). Natural size

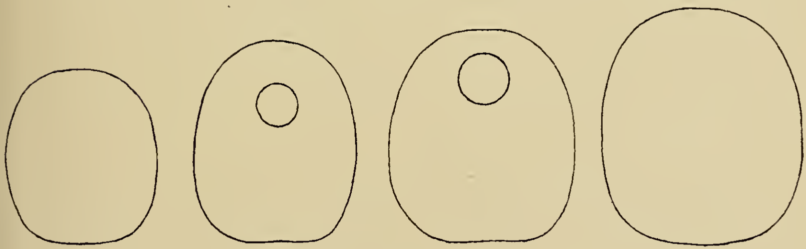


Fig. 28 Fig. 29 Fig 30 Fig. 31

Fig. 28–31 Tarphyceras clarkei sp. nov. Transverse sections x $\frac{8}{10}$
Fig. 28 Section through 2d volution; fig. 29, section at end of 3d vol.; fig. 30, section at beginning of living chamber; fig. 31, section through middle of living chamber

saddle in the ephebic and gerontic stages, or even a slight recession of the suture in the early ephebic stage upon the abdomen.

Siphuncle tubular, large, one fifth the hight of the volution, propioventran in the last whorl. Shell smooth, growth lines strong, receding on sides; living chamber with low ribs.

Position and locality. In A_3 of the Fort Cassin beds of the Valcour section.

Observations. This species is most closely related to T. extensum Hyatt, a species which occurs in the Beekmantown beds of Port au Choix, Newfoundland. Both forms have in common the rate of growth and the sections of the volutions, the position and size of the siphuncle, but T. clarkei can be readily distinguished from the Newfoundland type by the more concave septa and their less close arrangement (one half as close as in T. extensum). Also the paragerontic volution is more rapidly evolving and straightening in the other form. Still the two species are so similar by the identity of their principal characters that a close relationship seems evident. From T. seelyi, to which it also bears some similarity, it differs in the uncoiling of the last volution, greater rate of growth and wider and more ventrally situated siphuncle. Also the cameras are somewhat deeper in this species (ratio of the number of septa within a certain space in the two species as 4:3).

Tarphyceras multicameratum sp. nov.

Plate 19, fig. 3; plate 23, fig. 2

Description. Small sized nautilicone, composed of three slender but little involute volutions, the last of which becomes slightly uncoiled. Diameter of conch about 100 mm. Volutions in early stages subcircular, in ephebic and gerontic stages compressed elliptical, with subequally narrow abdomen and dorsal sides. Ratio of hight of volution to its width in the third volution as 8:7. Ventral zone little developed, impressed zone a slight flattening, appearing from the second whorl onward. Rate of growth of conch rapid, the hight increasing to double size within one volution. Umbilical perforation large. Living chamber free in gerontic age, its relative length not known. Aperture not observed.

Cameras very shallow, attaining but an average depth of 3 mm in the ephebic stage. Septa slightly concave; their depth 4 mm in the last volution; sutures nearly straight in the dorsal half of the lateral side and strongly bending forward in the ventral half; apparently without any ventral saddle in the ephebic stage. Siphuncle tubular, small (3 mm in the ephebic conch, which has a diameter of 25 mm) propioventran in position in the last whorl, a little nearer to the center in the earlier volutions, but nowhere centren. Shell smooth.

Position and localities. In the dove-colored Chazy limestones, exposed two miles west of Little Monty bay near Chazy N. Y.; on Isle La Motte and on Valcour island. In the first locality it has been observed in several specimens by the writer but only in a poorly preserved or fragmentary state of preservation. The second locality has furnished the type specimen of the species [coll. by Professor Perkins and now in the collection of Burlington University, Vt.] and from the third a specimen has been secured by Professor Hudson.

Observations. This is the first representative of the genus Tarphyceras that becomes known from rocks younger than the Beekmantown formation. It is easily distinguished from all of its Beekmantown congeners by its much shallower cameras (or more closely arranged septa), and also by its greater rate of growth. In the latter character it approaches the genus Eurystomites without however fully attaining the rapid growth of the typical representatives of that genus. It reminds also of the latter genus in its great umbilical perforation and the position of the siphuncle close to the ventral side. The latter position of the siphuncle already in the first volution, the close arrangement of the septa, the early attainment of maturity and the beginning of evolution at the third whorl give this species the aspect of a phylogerontic form, when compared with the congeners from the preceding formation.

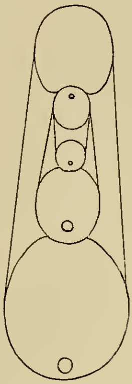


Fig. 32

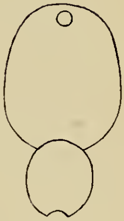


Fig. 33

Fig. 32 Tarphyceras multicameratum sp. nov. Transverse section of type. x¾
Fig. 33 Same. Section at beginning of living chamber. x$\frac{9}{10}$

Genus APHETOCERAS Hyatt

Aphetoceras farnsworthi (Billings (sp.) pars) Hyatt emend.

Lituites farnsworthi Billings (pars). Pal. Foss. 1861. 1:21, fig. 24
Aphetoceras farnsworthi Hyatt. Am. Phil. Soc. Proc. 1893. 32:448

Of this species it is stated by Hyatt:

This species probably belongs to a distinct genus, and is cited here provisionally under this name because it may be merely a highly degenerate species of Aphetoceras. It is also coiled in the neanic stage, but apparently the whorls are not in very close contact. . . . The type is that figured by Billings, and this had the living chamber free and deviating strongly from the spiral. It was 91 mm long on the dorsal surface and more than one half of a volution in length when this measurement was applied to the coil

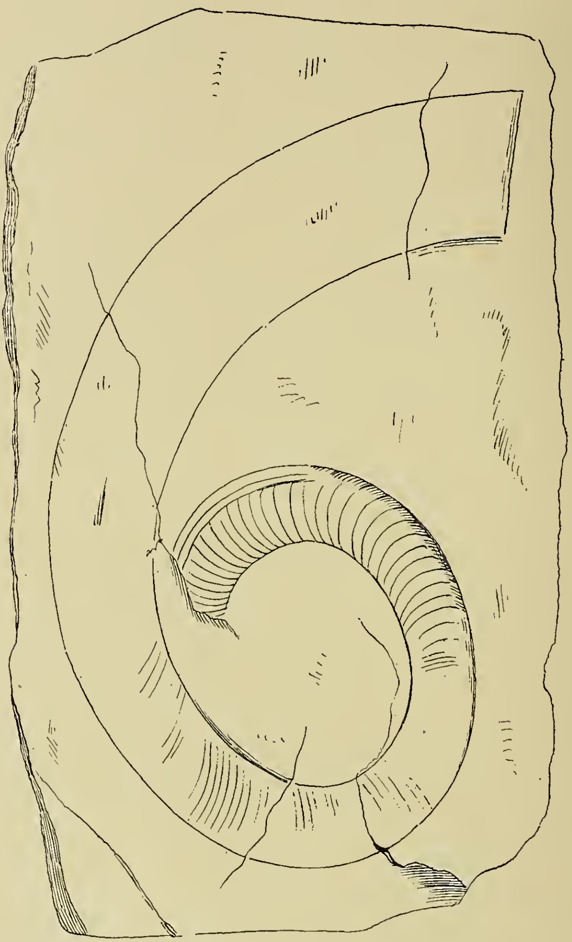


Fig. 34 *Aphetoceras farnsworthi* Bill. (sp.) Copy of original drawing. $\times\frac{9}{10}$

of the preceding whorls. The siphuncle in the ephebic stage was propioventran and the septa much closer together than is usual in this genus.

Position and locality. Beekmantown beds at Philipsburg, Missisquoi co. Can.

Aphetoceras attenuatum Hyatt

Lituites farnsworthi Billings (pars). Pal. Foss. 1861. 1:21
Aphetoceras attenuatum Hyatt. Am. Phil. Soc. Proc. 1893. 32:449

The original description of this species is:

This species is founded upon the specimen described by Billings on page 21 of his *Paleozoic Fossils* as having first two whorls in contact and making a coil an inch across. These whorls are, however, not in contact on his specimen, if my drawing of this is correct. The specimen is of nearly the same size as the type of Aphetoceras farnsworthi, but one and a quarter volutions are free, so as to leave a gap of 8 mm before the completion of the first quarter of the septate part of the eccentric volution, and at the end of the same this gap has increased to 13 mm, and in the next quarter, at the end of the living chamber, it is 25 mm. The departure of the free whorl of farnsworthi increases, as shown in Billings's drawing, in less than one half of a volution to 40 mm.

The septate part of the eccentric volution in this specimen is 58 mm long, the living chamber is 88 mm long. The former would occupy about three fourths of a volution if it followed a regular open spiral curve, and the latter would be about one half of a volution, estimated in the same way.

The septa are similar to those of farnsworthi. The fragment of the siphuncle observable in the neanic stage changes in the length of 10 mm from nearly subventran to propioventran.

Position and locality. Beekmantown formation at Philipsburg, Missisquoi co.

Family TROCHOLITIDAE

Genus SCHROEDEROCERAS Hyatt

This genus has been separated by Hyatt [1894, p. 458] from Discoceras, because the latter as defined by Schröder and Remélé has been used for the smooth forms, having a tetragonal section of the whorl and a dorsal siphuncle, as well as for the costated shells. These smooth shells have in the neanic stage decided costation with the same aspect and contour as in the adult of the genotype of Discoceras (D. antiquissimum). But as Hyatt holds: "Similar species having costations throughout life can not be included in the same genus with those that have them only in the neanic and earlier stages of growth" and he adds that "the large number and great variety of form of these smooth species, while still maintaining this difference of the later stages of growth, shows that this separation indicates a natural distinction".

The species here described, would, as far as shown by material we have had opportunity to study, seem to be entirely smooth in all stages.

Schroederoceras eatoni Whitfield (sp.)

Plate 20, figure 3, 4 ; plate 23, figure 1

Lituites eatoni Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 331, pl. 28, fig. 5-7; pl. 32, fig. 1

Discoceras eatoni Schröder. Pal. Abhandl. von Dames & Kayser. 1891. Bd. 5, Heft 4, p. 22.

Schroederoceras eatoni Hyatt. Am. Phil. Soc. Proc. 1894. 32:470, pl. 6, fig. 28-35; pl. 7, fig. 7-8

Our material of this small species from the west side of the Champlain basin is only fragmentary. Moreover, since the mature form has been fully described by Whitfield and the growth stages elaborately worked out and figured by Hyatt, it will suffice here to state that this type is present in the Valcour beds A_3 and A_5, though by no means very common there.

We figure here transverse and longitudinal sections which will serve to show the slightly depressed character of the volutions, the propiodorsan position of the rather large siphuncle and the close arrangement of the quite concave septa. From the most complete material of Fort Cassin, it has also been concluded that this species does not attain large size, that the living chamber comprises nearly three fourths of a volution and that in the gerontic stage the last portion of the living chamber becomes uncoiled. The beautifully preserved specimen reproduced here on plate 23, figure 1 exhibits these characters very perfectly and shows that the evolute gerontic whorl does not become deflected in a straight line, as the author of the species suggested, but merely describes a considerably flatter curve than the preceding volutions.

Position and localities. At Fort Cassin and in A_3 and A_5 of the Fort Cassin beds at Valcour.

Schroederoceras cassinense Whitfield (sp.)

Plate 20, figure 1, 2

Lituites eatoni var. cassinensis Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 332, pl. 32, fig. 2

Schroederoceras cassinense Hyatt. Am. Phil. Soc. Proc. 1894. 32:473. pl. 6, fig. 36-38; pl. 7, fig. 4-6

Only a few specimens in our Valcour collections represent this type which was originally described as a variety of the more common S. eatoni, but later on given full specific rank by Hyatt. The latter author states regarding the relations of this species, which he had occasion to study from both the collections in the American

Museum of Natural History and the United States National Museum:

This is a distinct species, the sutures being straighter in the ephebic stage than in true eatoni, the venter and sides are more decidedly flattened, and the relative proportions of the last whorl at the same age different. The ventrodorsal and transverse diameters are about equal, whereas in eatoni the transverse is considerably longer than the ventrodorsal in the mesal plane. The amount of involution in eatoni and the depth of the contact furrow in the ephebic stage is also greater.

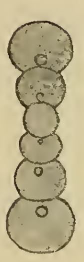


Fig. 35

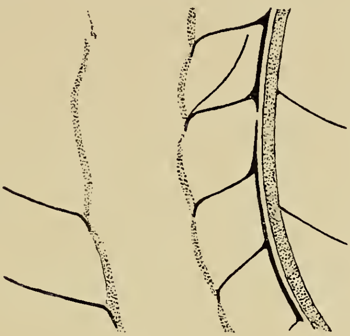


Fig. 36

Fig. 35 Schroederoceras cassinense Whitf. (sp.) Transverse section. Natural size

Fig. 36 Schroederoceras cassinense Whitf. (sp.) Enlargement (x 5.4) of portion of longitudinal section, showing the structure of the siphuncle (siphuncular segments dotted)

We have referred several specimens to this species rather than to S. eatoni on account of their straight sutures and the section of the ephebic volution, which possesses about equal transverse and dorsoventral diameters. In one specimen which we figure here the ventral and lateral faces are so strongly developed that very well marked abdominal angles on both sides of the ventral zone or abdomen are formed [*see* pl. 20, fig. 1]. A transverse section of the same specimen which is also figured here shows the characteristic low broad volution of the neanic stage and a higher whorl of the anephebic stage.

A special interest attaches to another specimen, also here figured, on account of its retaining the finer details of the siphuncular structure. The siphuncle which is propiodorsan in position exhibits very short straight septal necks [*see* text fig. 36], which are not longer than about one eighth of the depth of the cameras, the siphuncle wall being formed almost entirely by the secondary siphuncular segments.

Position and localities. At Fort Cassin Vt. and A_5 of the Fort Cassin beds at Valcour.

Genus TROCHOLITOCERAS Hyatt 1894

Hyatt's definition of the genus reads:

This genus has been framed to include forms which are essentially similar to Trocholites, but have the siphuncle ventrad of the center in the earlier substages of development.

The forms stand in development and adult characters between Litoceras and Trocholites.

Type is Trocholitoceras walcotti.

Trocholitoceras walcotti Hyatt

Trocholitoceras walcotti Hyatt. Am. Phil. Soc. Proc. 1894. 32:480, pl. 6, fig. 12–20

This form, which is cited as coming from Fort Cassin, has not been observed by us in the Fort Cassin collections. Its ontogeny and adult characters have been fully described and illustrated by Hyatt in the above cited publication.

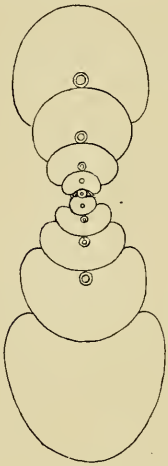


Fig. 37 Trocholitoceras walcotti Hyatt. Transverse section. x ¾ (Copy from Hyatt)

The appended transverse section [text fig. 37] shows well its characteristic features, i. e. the broad whorls of the young, which are kidney-shaped in section while they become helmet-shaped in section in the mature stage; and the close approximation of the siphuncle to the dorsum in the neanic stage.

The living chamber occupies at least the greater part of one half of a whorl and the gerontic whorl does not become evolute.

Genus TROCHOLITES Conrad emend. Schröder

The term Trocholites has had an extremely checkered career in its application to nautiliconic cephalopods. It was first defined by Conrad[1] in 1838; then in 1842[2] the first definition was revised by the same author. Both diagnoses lack in precision and the term has therefore been afterwards applied here and specially in Europe to a great number and variety of forms.

Remélé [1889, p. 246] was the first to propose a restriction of the application of the term to forms having the characters of the genotype

[1] N. Y. State Geol. An. Rep't 1838. p. 118.

[2] Acad. Nat. Sci. Phil. Jour. 8:274.

T. ammonius; while Hyatt at first [1884, p. 267] inclined to extend the diagnosis so far as to include all forms hitherto designated in Europe as "Imperfect Lituites" with dorsal or subdorsal siphuncles.

Schröder in 1891 [p. 5 ff] restricted the genus to its original limits and fully defined it; and Hyatt adopted [1894, p. 482] this definition which we insert here in translation as the correct one:

Conch symmetrically involute. Living chamber completely contiguous with preceding volutions, occupying about three fourths of a volution. Section always wider than high. Aperture expanded, with ventral sinus. Sutures simple or little lobed. Siphuncle dorsal, or subdorsal.

The ontogeny which had already been investigated by Holm and the generic relations of Trocholites are fully discussed in Hyatt's above cited publication.

Trocholites internestriatus Whitfield (sp.)

Plate 24, figure 2

Lituites internastriatus Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 332, pl. 29, fig. 5-8

Discoceras internestriatum Schröder. Pal. Abhandl. von Dames und Kayser. Bd 5, Heft 4, p. 23.

Trocholites internastriatus Hyatt. Am. Phil. Soc. Proc. 1894. 32:485, pl. 4, fig. 25

This single representative of the genus Trocholites in the Beekmantown fauna has not been observed in the beds at Valcour or anywhere else on the west shore of Lake Champlain and is thus far restricted to the outcrop at Fort Cassin. We have figured a specimen, which has been collected by Professor Perkins and which exhibits the absence of ribs on the nepionic stage and their somewhat abrupt appearance at the end of this stage better than any other specimen that we have observed. It also shows well the relatively large size of the umbilical perforation, a feature in which this species differs from its later congeners [*see* pl. 24, fig. 2, and enlargement of central part in text fig. 38].

Fig. 38 Trocholites internestriatus Whitf. (sp.) Enlargement (x 2) of first two volutions to show changes of sculpture

Whitfield saw the most distinctive features of the form in the surface undulations and striae and specially in the internal striations. The markings resemble those of Trocholites according to Hyatt with which genus it also has in common the transverse, depressed, elliptic section of the whorl throughout life and the development of the siphuncle which becomes rapidly propiodorsan.

"The sutures of the earlier stages, which are straight are trocholitean in aspect, with well marked dorsal lobes, as is also the form and ornamentation of the young whorls, which are slightly costated." In the adult stage the sutures (of the fourth whorl) are stated to have well marked lateral lobes and dorsal lobes in the contact furrow.

The tendency of the last whorl to become free, described by Whitfield, has not been observed by Hyatt, the contact furrow being well defined at the termination of the whorls of Whitfield's type.

Genus DELTOCERAS Hyatt

This genus has been erected by Hyatt for several species from the Quebec group (Beekmantown) of Newfoundland, only one of which has thus far been described. It is stated to be represented by shells similar to Aphetoceras but just one grade more complicated. The whorls are compressed in section, the dorsum wider than the venter, and the dorsoventral diameter much larger than the transverse one, in both genera, but in this one they grow more rapidly in ventrodorsal direction. The whorls are in contact, but no impressed zone has been found at any stage and the gerontic or sometimes the entire ephebic stage is free. In the neanic stage the sutures have ventral and dorsal saddles and broad lateral lobes and in the ephebic and gerontic stages, slight ventral lobes. The siphuncle is stated to be in some species very large and ventral. All or nearly all of these features will be found to be typically represented in the species from the Champlain basin here described.

Deltoceras vaningeni sp. nov.

Plates 25–28

Description. Gyroceracone of about three volutions which are in contact, without, however, developing an impressed zone; only the greater portion of the gerontic living chamber departing gradually from the coil. Rate of growth considerable, the conch increasing its diameter about 2½ times within the last volution and attaining a total diameter of 165 mm where the volutions are still contiguous. Whorls subcircular, the ventral side a little narrower than the dorsal one and becoming strongly flattened on the gerontic whorl, while the dorsal side remains round and gibbous. No impressed zone present.

Cameras shallow, about 8 mm distant in their middle portions in the ephebic stage of the conch. Septa very concave, their depth equal to that of two cameras. Sutures nearly straight transverse, with but very slight indications of lateral lobes and hardly any of the ventral saddles, while the dorsal saddles are more distinct. Living chamber incomplete in all specimens; where most

Fig. 39

Fig. 40

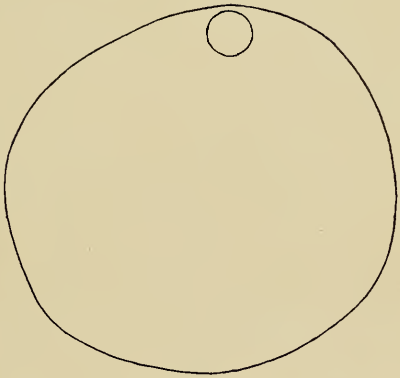


Fig. 41

Figs. 39, 40, 41 Deltoceras vaningeni sp. nov. Transverse sections at the beginning of the living chamber; fig. 39 from the type (pl. 25), x ¾; fig. 40 from the specimen reproduced on pl. 27, x ¾; fig. 41 from that reproduced on pl. 28, x $\frac{9}{10}$

perfect attaining the length of half a volution; in the gerontic stage becoming free in the best preserved specimens.

Siphuncle large (about 8 mm just before the living chamber), tubular, subventran in the last volution. Surface smooth, bearing nothing but fine growth lines.

Position and locality. One specimen each from beds B_3, B_7 and C_5 (Lower Chazy) of the Valcour section.

Observations. Owing to the rather short generic diagnosis of Deltoceras, which states but certain differences from Aphetoceras and to the lack of any illustrations of the one species representing the genus we have been unable to arrive at a conclusive reference of our species to the latter. At the same time we do not doubt that this species has more nearly attained the plane of development of Deltoceras than of any other genus. It fully agrees with the picture that is drawn of Deltoceras by Hyatt in the rapid growth of the whorls, the loose coiling, the sutures and the large size and ventral position of the siphuncle, while in the amount of the flattening of the abdomen and its relative great width upon the last whorl (gerontic stage ?) it would seem to differ from or go beyond the conception of the genus.

Billings has made known three species of Nautilus from the Chazy limestone of the Mingan islands. One of these, Nautilus tyrans, appears to have borne some similarity in its habit to our form. This is however not figured and the description being drawn from a single incomplete specimen, is insufficient to permit a definite recognition of that form; nor has Hyatt reinvestigated or even again mentioned it; but an inspection of the type specimen of N. tyrans in Ottawa has shown us that the volutions are nowhere in contact, that its rate of growth is slower and that it possesses shallower cameras. From all other nautiloids of the Chazy formation D. vaningeni is distinguished by the more rapid expansion of its conch.

We have three specimens which come from three different beds of the Chazy at Valcour. The type specimen (from bed B_3) has retained part of the adult or gerontic living chamber and shows that this became evolute.

We take great pleasure in naming this stately form after Prof. Gilbert van Ingen, of Princeton University, to whose enthusiastic collecting the State Museum owes so much of its Champlain material.

Family PLECTOCERATIDAE

Genus PLECTOCERAS Hyatt

Hyatt has erected this genus [1884, p. 268] to include the costated forms similar to Discoceras [*see* under Schroederoceras], but having the siphuncle ventrad of the center.

The original diagnosis of the genus is:

Plectoceras, nobis, includes Silurian species having costae curved posteriorly on the sides and crossing the abdomen as in Trocholites and sutures similar, but with ventral saddles. The whorls quadrate, the abdomen narrower than the dorsum and the sides convergent outwards. The siphons are ventral and holochoanoidal. The young are precisely similar in form, smoothness of the shell and striae of growth, and in sutures to the straight sutured form of Trocholites. Type: Plect. (Naut.) Jason sp. Bill.

To this first diagnosis it has later [Hyatt 1894] been added that the mode of coiling may be quite close and regular, with perhaps a slight impressed zone or flattened dorsum, or the coiling may be open, and sometimes very irregular; that the umbilical perforation is large; the impressed zone absent until the whorls come into contact and invariably absent in gerontic whorls.

The genus Plectoceras has then further been made the type of the family Plectoceratidae. A comparison of the latter with the family Tarphyceratidae will show that the essential difference lies in the presence of "annular costae from the neanic stage until late in life". Since, however, costation becomes already quite strong among the Tarphyceratidae, as in T. perkinsi — a form which on account of the prominence of the costae was separated by Whitfield from T. champlainense — it is quite apparent that a sharp separation between the forms of the two families will frequently be quite difficult or even impossible. Indeed Whiteaves has lately [1903, p. 121] suggested that the frequently cited Black river form, Nautilus undatus Hall, should be referred to Plectoceras rather than to Eurystomites as Hyatt had done. We agree with Whiteaves that the adults of N. undatus do not show any differences of generic rank from Plectoceras. Moreover, it is conceded by Hyatt himself that also in N. undatus the costae appear already in the neanic substage.

According to the phylogenetic principles followed by Hyatt in his classification we would have to see in Plectoceras a group of forms advanced beyond the Tarphyceratidae, an assumption which is in accordance with the geologic range of the genus, for while the Tarphyceratidae are prevailingly of Beekmantown age, Plectoceras does not begin until Chazy time with the species here described, ranges through the Black river stage with P. halli and is still recorded from the Niagaran. From the species known thus far it would appear that the genus is restricted to the American basin.

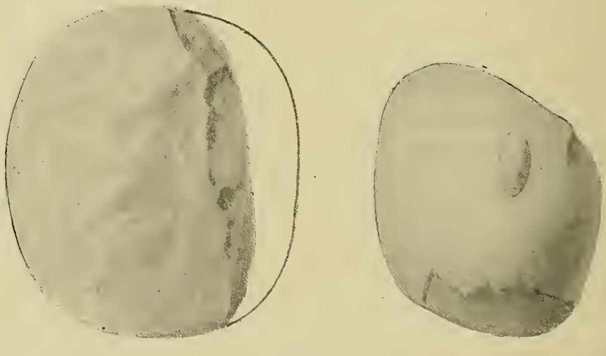
Plectoceras jason Billings (sp.)

Plates 29–31

Nautilus jason Billings. Can. Nat. and Geol. 1859. 4:464
Plectoceras jason Hyatt. Bost. Soc. Nat. Hist. Proc. 1884. 22:268
Plectoceras jason Hyatt. Am. Phil. Soc. Proc. 1894. 32:499
Plectoceras jason Whiteaves. The Ottawa Naturalist. 1903. 17:120

The Chazy bed B_4 of the Valcour section has furnished five specimens of a coarsely costate, middle sized nautiloid which we have found to be identical with a form described by Billings in 1859 from the Chazy limestone of the Mingan islands in Canada as Nautilus jason and which later on was made the type of the genus Plectoceras by Hyatt.

Description. Conch a nautilicone which as a rule is quite closely coiled; consists of three to four volutions, and attains in a specimen of not quite three volutions a diameter of 125 mm. Rate of growth moderate, the dorsoventral diameter attaining its double length within one volution. Sections of early volutions subcircular, the two diameters about equal, the abdomen slightly flattened, the dorsum slightly impressed and the sides rounded; in the ephebic stage and still more so in the gerontic stage, the section is subquadratic, the abdomen and the dorsum being broad and flat, the latter more so than the former and the sides slightly convergent outward.



Figs. 42, 43 Plectoceras jason Bill. (sp.)
Fig. 42 Transverse section through the living chamber of the specimen reproduced on pl. 29, x ¾; fig. 43 view of last septum, at base of living chamber reproduced on pl. 30, somewhat deformed by lateral pressure, natural size

Living chamber less than one half volution, in gerontic species slightly uncoiled. Aperture with very deep hyponomic sinus, the ventral margin in the ephebic stage receding behind the dorsal margin by almost the length of the dorsoventral diameter, sides of aperture with low crests. Cameras very shallow, the middle depth of the cameras being 4 mm, where the volution has a diameter of 21 mm; 7 mm where the diameter is 34 mm; sutures nearly straight in the early volutions, but developing a high ventral saddle and shallower lateral lobes upon the later whorls. Septa deep, their depth being equal to that of one chamber in the second whorl and equal to that of two chambers in the third whorl.

Siphuncle large (about one sixth of the diameter), tubular, propioventran from an early stage onward.

The surface of the first volution marked with strong growth lines; on the second volution appear rounded costae, which pass the sides very obliquely, swinging backward from the line of involution toward the abdomen. Where the dorsoventral diameter of the whorl is 35 mm, the distance of the crests of the costae is 10 mm. Both the costae and the concave interspaces bear a system of strong raised lines, running parallel to the costae.

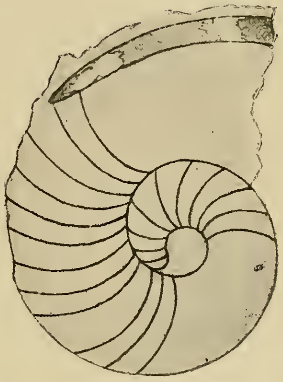


Fig. 44 Plectoceras jason Bill. (sp.) Section of first whorls, x ¾

Position and localities. Not uncommon in the lower Chazy (bed B_4) of the Valcour section. Billings's original came from the Chazy limestone of the Mingan islands. Hyatt cites it from the "Calciferous of the Mingan islands" and states that there are similar forms in the same horizon in Newfoundland. Whiteaves has lately [1903, p. 120] remarked that Hyatt was in error in placing the species in the Beekmantown formation. Raymond [1902, p. 20] cites a "Lituites undatus (?)" from the Chazy beds with Maclurea magna at Crown Point, which presumably is a representative of this species.[1]

Observations. Since neither Billings nor Hyatt has figured this species and the latter author gives but a short note about the form, identification of our material with the Mingan form had to rest primarily upon a comparison with the original description and it can not be overlooked that in such a proceeding important differences may fail to be recognized. A comparison of our drawings with authentic Canadian material in the museum at Ottawa has

[1] Mr Raymond informs me that the specimen is a small weathered fragment.

however shown the correctness of the identification. Hyatt asserts that this form is sometimes quite irregular in its mode of coiling and one of our specimens appears to indicate something of the same kind.

Hyatt made the following observation in regard to this irregularity of the mode of coiling:

In several specimens of Jason the first whorls may touch, the ephebic volution may be open and free and yet the extremity of the living chamber again come in contact.

In regard to the earliest whorl it is stated by Hyatt that the "umbilical perforation is large and the impressed zone is absent until the whorls come in contact" and that it is invariably absent in gerontic whorls. Our text figure 44 gives a section of the earliest whorls of a specimen from Valcour. This shows the large umbilicus, rapid growth of the first whorl, absence of costae on the latter and their beginning on the second.

Suborder E. CYRTOCHOANITES Hyatt

Division I. ANNULOSIPHONATA

Family LOXOCERATIDAE

Genus LOXOCERAS McCoy

This genus was originally described by Hyatt as Sactoceras [1884, p. 273] and based upon *Orthoceras richteri* Barrande as type. Later on [1900, p. 527] McCoy's term Loxoceras, which had been proposed in 1844 for Carboniferous forms but not recognized, was adopted.

The diagnostic characters of the genus are to be seen, in the orthoceraconic or cyrtoceraconic, more or less longicone form, the highly nummuloidal segments of the siphuncle in later stages and its position in the center or near the center of the phragmocone; and in the still irregular character of the endosiphuncular deposits in distinction from those of the Actinoceratidae. Thus defined the genus is said to range from the Lower Siluric into the Carboniferous. The reference of the genus to the Cyrtochoanites demands that the septal necks shall be "as a rule bent outward and crumpled, and generally short" and its being placed under the Annulosiphonata requires that the endosiphuncular deposits "when present are always gathered about or encrusting the septal necks."

The faunas here described contain only one species of which it could be asserted that it belongs here. This form (*L. moniliforme*) is clearly in all its characters a close relative of *O. richteri*, the genotype, though of smaller size, and with a little more excentric position of the siphuncle.

Loxoceras moniliforme Hall (sp.)

Plate 34, fig. 6-9

Orthoceras moniliforme Hall. Pal. N. Y. 1847. 1:35, pl. 7, fig. 5

Orthoceras subarcuatum Hall. Pal. N. Y. 1847. v. 1, pl. 7, fig. 3 (apical part of type specimen)

Description. Slender orthoceracone of circular section and moderate size, attaining a length of 100 mm or more and a width of 17 mm; the rate of growth being 3 mm in the space of 20 mm. The cameras are relatively deep, the septa being 4 mm apart where the conch has a width of 12 mm; 2.5 mm apart where it is 8 mm wide. A slight organic deposit is found in the apical cameras [*see* fig. 9]. The living chamber was large and may have occupied fully one half or more of the conch. The aperture is not known. The septa are shallow, their concavity not amounting to one half the depth of the cameras and decreasing in depth in apertural direction. The sutures appear to be straight transverse. The siphuncle is large, its greatest width being nearly one fourth that of the conch, propiocentren, nummuloidal, the interseptal segments spherical and empty as far as observed. The surface was smooth or marked with growth lines only.

Position and localities. Hall records his specimen to have been obtained from the limestones at Chazy with Maclurea magna; our specimens were collected at Chazy in B_4 (the upper part of the middle Chazy or Maclurea beds); one was also found by Prof. van Ingen at Plattsburg in the Saranac river and one has been obtained in the upper Chazy (C_6) at Chazy village.

Observations. The original drawing of this species is very poor, for the siphuncle is drawn incorrectly and the septa, which in the type are well shown, have been left out altogether. We have for this reason, with the kind permission of Prof. Whitfield, refigured the type which is in the American Museum of Natural History. It represents a natural section which in the apical region passes near the ventral margin and therefore intersects the siphuncle, and in the middle part of the fragment crosses obliquely to the dorsal margin. To this oblique fracture the subparallel margins of the upper portion of the type are due. The siphuncular segments are, as our drawing shows, considerably more inflated than in the original figure and agree well with those of the fossils referred to this species on plate 34. Since also the rate of growth and the depth of the chambers are identical, there can be no doubt of the correctness of our identification. In this case, our specimens demonstrate that the siphuncle is not central in position, as it appears from the original drawing, but submarginal [*see* pl. 34, fig. 8].

The posterior part of the type of Orthoceras subarcuatum Hall [pl. 7, fig. 3] is also a fragment belonging to this species [*see* p. 445].

Orthoceras diffidens, a species made known by Billings from the Chazy limestone of the Mingan islands is closely related to this form and may be even identical with it. Its rate of growth, the depth of the cameras, the character and position of the siphuncle are almost the same as in our specimens and only the siphuncle is relatively smaller (one third of the width in our form, one fifth in O. diffidens).

Another similar form, which has been neither figured by Billings nor described in all its details so fully as to exclude any doubts of a correct identification, is O. allumettense. Of the latter species it is stated that it closely resembles O. diffidens, both internally and externally but that it has a wider siphuncle. In the relative dimension of the latter it agrees completely with L. moniliforme, but the same is less symmetrical than in our form and the cameras are markedly deeper.

Family ACTINOCERATIDAE

Genus CYRTACTINOCERAS Hyatt

Our collection of Chazy cephalopods contains two cyrtoceraconic forms with highly nummuloidal siphuncles filled with organic deposits. The latter proved to be arranged as rosettes or obstruction rings around the septal necks. This character shows that the species belong to the division Annulosiphonata, while the highly nummuloidal form of the siphuncular segments and the extent and regularity of the filling of the siphuncle place them in the family Actinoceratidae. Also the filling of the cameras with organic deposits — which filling in Actinoceras often goes to such an extent as to solidify the entire shell in old age — is here very noticeable and in one species, the small Cyrtactinoceras champlainense, carried almost as far as in the large typical species of Actinoceras from the Lower Siluric of the Lake Huron region.

Still when compared with the typical Actinoceras with its excessively nummuloidal siphuncles as it prevails in and after the Black river and Trenton periods, our forms appear to be somewhat primitive, partly in the relatively smaller and less nummuloidal siphuncle and partly in the restriction of the organic deposits to the earlier growth stages, at least in one of the two species.

A reference to the subgenus Paractinoceras Hyatt, that is described as exhibiting a similar restriction of the rosettes in its middle stages as suggested in our material, is excluded by the long and slender form of the species of that genus.

Another genus, Cyrtactinoceras, has been erected by Hyatt in the chapter on cephalopods in Zittel-Eastman but not described and based on the citation of Cyrtoceras rebelle Barrande as genotype. That form proves to be a cyrtoceraconic species with depressed section, rather closely arranged septa, moderately nummuloidal siphuncle which shrinks somewhat in old age, is filled in the middle stages with rosettes, located near the convex side of the conch but somewhat variable in position and approaching the center again in old age. To this species the forms here brought under the Actinoceratidae approach in the somewhat stout form of the conchs, their depressed sections, and the characters of the siphuncles, nearer than to any other group, and we have, therefore, united them under the same generic term.

Cyrtactinoceras boycii Whitfield (sp.)

Plate 35, figure 1-4

Cyrtoceras boycii Whitfield. Am. Mus. Nat. Hist. Bul. 1886. 1:326, pl. 29, fig. 4

From the original description and our own material the following diagnosis can be given for this interesting form:

A rather stout, strongly convex cyrtoceracone with depressed elliptic section, the major and minor diameters of which have an approximate ratio of 6:7; expanding rather rapidly (at the rate of 1 mm in 3 mm), while its curvature decreases slightly with advancing age; the hight of an arc of 30 mm in the apical portion being 5 mm and in the mature portion but 2 mm.

The cameras are shallow, specially so in the apical portion, where 20 may be counted within the space of 20 mm, but increase somewhat fast in depth in apertural direction and in the most advanced stage observed only 9 were found in the same space. The living chamber has been observed only in one specimen, where it is expanding rapidly and has a length of 36 mm, though probably not quite complete, and a basal width of 25 mm. The aperture has not been seen.

The sutures are apparently straight transverse or nearly so; the septa very shallow, their concavity only two thirds as much as the depth of the cameras notwithstanding their slight forward arching on the convex side of the phragmocone.

The siphuncle is highly nummuloidal, centren in position, and possesses a width of 5 to 7 mm. In the early stages it is filled with rings of organic deposits, forming around the septal necks and leaving but a narrow endosiphotube open, which widens in oral direction. The septal necks are very short. The septal walls, adjoining the siphuncle are thickened by radiating deposits in correspondence to the internal deposits of the siphuncle. The surface is smooth or only possessed with such faint sculpture as the growth lines furnish.

Position and localities. The type specimen comes from the dove-colored Chazy limestone (cited in the original description as the dove-colored limestone of the Birdseye) at Isle La Motte, Lake

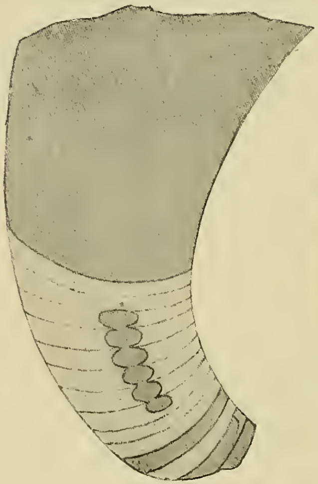


Fig. 45

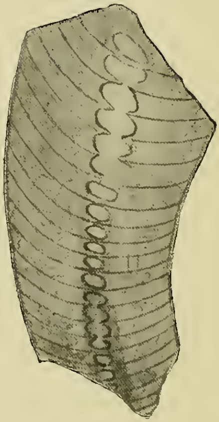


Fig. 46

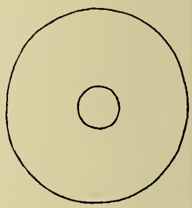


Fig. 47

Fig. 45 Cyrtactinoceras boycii Whitf. (sp.) Section of fragment, showing part of living chamber. Valcour Island. Natural size.
Fig. 46 Cyrtactinoceras boycii Whitf. (sp.) Longitudinal section of fragment showing siphuncle. x¾
Fig. 47 Cyrtactinoceras boycii Whitf. (sp.) Transverse section. x$\frac{9}{10}$

Champlain. I have found another specimen from the same horizon in the Perkins collection of Isle La Motte fossils in Burlington University; and one from the dove-colored limestone of Valcour island is figured here. I have also collected three specimens in the Strephochetus beds of B_4 and of C_6 at Chazy village.

Observations. This species is characterized as a primitive Actinoceras by the confinement of the filling of the siphuncle to the apical and middle portions. The thickening of the septa around the siphuncle observed here occurs also in Paractinoceras canadense Whiteaves. C. boycii has in the depth of the chambers, the depressed form of the conch and the nummuloidal character of the siphuncle some similarity to Cyrtoceras subturbinatum Bill. from the Lower Siluric of the Mingan islands, but differs in the subcentral position of the siphuncle and greater curvature of the conch.

Cyrtactinoceras champlainense sp. nov.

Plate 34, figure 3; plate 36, figures 1, 2

Description. Conch a small, but slightly arcuate cyrtoceracone, which expands moderately, the transverse diameter increasing within a length of 20 mm from 9 mm to 15 mm in one specimen; the rate of expansion itself increasing somewhat from the nepionic part of the conch to the ephebic. The largest specimen observed measures 44 mm with the greater portion of the living chamber and

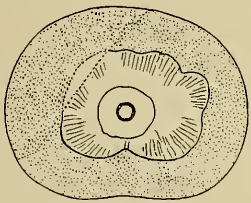


Fig. 48

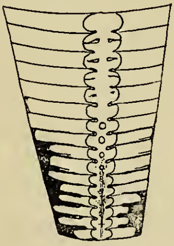


Fig. 49

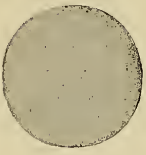


Fig. 50

Fig. 48 Cyrtactinoceras champlainense sp. nov. Transverse section showing the circumsiphuncular organic deposit, the siphuncular deposit and the endosiphotube. x2¼

Fig. 49 Cyrtactinoceras champlainense sp. nov. Longitudinal section showing the extent of the organic depositions in the cameras and siphuncle; the endosiphotube in the lower part of the siphuncle and the tubuli in the upper. x3

Fig. 50 Cyrtactinoceras champlainense sp. nov. Transverse section of the living chamber of the specimen reproduced on plate 36, figure 1, 2. Natural size

about 10 mm of the apical portion missing. The section is slightly depressed, the outer side being slightly flattened, and the dorsoventral diameter smaller by about one sixth than the transverse diameter.

Cameras very shallow, there being 9 counted in 5 mm in the apical portion and the same number in 10 mm in the ephebic portion, filled more or less by organic deposits in the form of rings or heartshaped disks concentric to the siphuncle. Septa very flat, their depth not quite equal to that of the cameras. Living chamber observed only in its posterior portion. Aperture not seen, the hyponomic sinus either extremely shallow or situated on the inner side (endogastric shell), for the growth lines are straight transverse on the outer side.

Siphuncle centren, highly nummuloidal in all parts of the phragmocone, about 2 mm in the interseptal expansion, filled by organic deposits arranged in rosettes around the septal necks and leaving open an endosiphotube and radiating tubuli. The surface is smooth.

Position and localities. This form has been found most commonly in the exposure of the dove-colored limestone near the crossing of the Chazy turnpike and Little Monty bay road, 2 miles south of Chazy. Fragmentary sections, which are referable to this species, have also been obtained by Prof. van Ingen in the Saranac river at Plattsburg.

Observations. This cyrtoceracone is readily distinguished from other forms of the Chazy and Trenton periods by its rapid expansion, the centren position and nummuloidal character of its siphuncle; from the preceding species with which it is associated and with whose young it might be confounded, it differs mainly in its smaller curvature and relatively smaller siphuncle.

Genus GONIOCERAS Hall

In the first volume of the *Palaeontology of New York* [1847, p. 54] Hall erected the genus Gonioceras for a cephalopod from the Black river beds at Watertown, which offered a very peculiar aspect. Later on the same author[1] described another species from the Trenton of Wisconsin and these are the only two species of the genus which have thus far become known. A third species, which had been announced by Whiteaves from the Trenton of Manitoba, has later been referred by Clarke to Triptoceras. The last named author, who has also recorded the presence of the two species of Gonioceras in the Trenton of Wisconsin, Minnesota and Illinois, gives the following diagnosis of the genus [1897, p. 794].

Broad, flat, straight shells, extremely compressed dorsoventrally, and with extended lateral flanges into which the septa are continued. The shells are subequally biconvex with regular concave dorsal and

[1] Report of Progress, Wis. 1861.
[2] Roy. Soc. Can. Proc. 1891. v. 9, section 4, p. 86.

ventral lobes, large moniliform siphonal beads, perforated with radiating canals.

The principal features of the structure of Gonioceras are the extreme depression of the shell and the extended lateral flanges. Hyatt, in his first publication on the classification of the cephalopods [1884] thought this genus extraordinary enough to erect a separate family for its reception, adding that its features warrant his "assuming this as probably one of the passage forms from the compressed Orthoceratites, above described, to the true Sepioidea, and possibly a more or less remote ally of Paleoteuthis dunensis Roem. of the Devonian." In regard to this view it has been stated by Foord [1888, p. 323] that the shell of Gonioceras was certainly external, while that of the sepioids is internal. Hyatt himself has later on advanced to another hypothesis on the derivation of the sepioids and placed Gonioceras [1900, p. 528] at the end of the Actinoceratidae, evidently considering it as an aberrant group, related to Actinoceras, with which genus it is connected by the structure of its siphuncle.

This genus is not only odd in its structure but equally peculiar in its distribution. It is restricted to the American basin, where it has thus far been observed to have spread in the Trenton period from New York to Wisconsin. In New York it has, however, only been found in one locality, viz, at Watertown, where the genotype occurs not infrequently in the Black river beds. In Europe it is entirely absent and it belongs therefore to the most characteristic forms of the American basin of the Lower Siluric era. In the rocks deposited in this basin it again has thus far been found to be restricted to those of Trenton age, and it has not been found in the Trenton rocks of the Appalachian basin. In view of this remarkably restricted geologic and geographic distribution of the two species of Gonioceras, the finding of a third species in the preceding Chazy beds and in an exposure lying within the Appalachian basin is of special interest, not only indicating a possible center of origin for the genus, but also in regard to the relation of the Chazy Appalachian basin to the Trenton American basin. We shall have occasion to recur to this relation in the chapter on the distribution of the Cephalopoda.

Gonioceras chaziense sp. nov.

Plate 36, figure 3, 4

On account of the great interest attaching to the appearance of this genus in the Chazy beds and in the Appalachian basin, we describe here this species, though we possess but two specimens which are retained as natural sections upon weathered rock surfaces. Another large specimen was observed by the writer in an early reconnoitering trip near Chazy village and in the same horizon as those described and figured here but could not be located again when the proper tools for collecting were at hand.

The natural section exposes the septa, which are closely arranged, there being 10 of them counted within the space of 20 mm; each septum rises within the body of the shell to about the hight of five cameras, forming broad and low saddles in the lateral flanges, and becoming slightly deflected backward towards the outer margin of the flanges. Their central portions are much thickened by secondary deposits. The outer conch, which according to Hall is also in the other species of Gonioceras excessively thin, is not preserved; the greatest width of the phragmocone, as indicated by the septa, is a little over 70 mm. The phragmocone appears to have been at least as rapidly expanding as that of G. anceps. The siphuncle is very large (its diameter 7 mm), strongly nummuloidal, filled with organic deposits which leave open but a narrow endosiphotube. From the latter radiate horizontal tubuli as in the other congeners. We have not been able to ascertain the transverse section of the conch and the surface is unknown.

Position and locality. The specimens were obtained from the middle Chazy beds (B_3) near Chazy village, N. Y.

Observations. This species is, according to the character of the saddles in the lateral flanges, more closely related to G. anceps than to G. occidentale, which seems but natural since also in time of appearance it is nearer to that form, a Black river species, than to the later G. occidentale.

Subdivision ACTINOSIPHONATA

Family OOCERATIDAE

The Beekmantown and Chazy beds have furnished a small group of five cyrtoceraconic species, three of which can be positively placed with the Actinosiphonata by the internal structure of their siphuncles, while the other two though not showing this structure belong, according to their general habit and the form and position of their siphuncles, more probably to this than to any other division.

We have placed all five with the genus Ooceras Hyatt, though only two of them, O. seelyi and O. lativentrum, are good representatives of that genus, as last defined in Zittel-Eastman's textbook. Of the others, O. (?) perkinsi shows distinctly the radiating lamellae of the siphuncle [*see* text fig. 55], characteristic of the Actinosiphonata and is most probably a primitive representative of the Ooceratidae, while the remaining two (O ? kirbyi and O. ? raei) though unknown in their internal siphuncular structures can hardly belong to any other group on account of the ventral marginal position of their nummuloidal siphuncles. Besides O. ? kirbyi possesses in its strongly compressed conch and closely set septa additional characters which are developed in the genus Ooceras and make this reference appear fairly correct. Also the faint annulations of O ? raei are repeated in several Bohemian species cited by Hyatt as typical members of the genus. Since of the last named species only one or two fragments are known and these come from the excessively hard Beekmantown dolomite of the "Kirby ledge" at Beekmantown, little hope for the collection of additional material can at present be entertained.

The most striking feature of many (or the typical ?) Ooceratidae lies in their septal necks which are hooklike in section and confined to the dorsal (or inner side) of the conch. This character is well shown in two of the specimens here described [*see* text fig. 52 and pl. 38.]

Genus OOCERAS Hyatt

Ooceras kirbyi Whitfield (sp.)

Cyrtoceras kirbyi Whitfield. Am. Mus. Nat. Hist. Bul. 1889. 2:57, pl. 10, fig. 4–7

Description. Medium sized, slender cyrtoceracone. The type of the species, a fragment, incomplete at both ends, measures 70 mm and indicates an individual of at least twice that length; its largest diameter is 34 mm. The conch is strongly compressed; its section a narrow ellipse with subacute dorsal and ventral sides; the ratio of the diameters of the section is about 4:7. The rate of growth is 1 mm in 65 mm. The curvature is moderate, an inner arc with a cord 32 mm long has a hight of 3 mm.

The length of the living chamber and the character of the aperture are unknown. The cameras are strongly curved and very shallow, there being counted 6 of them in the space of 10 mm. The sutures possess an acute and high ventral (outer) and a lower and narrower dorsal saddle. The septa are moderately concave, their depth being twice that of the cameras.

The siphuncle is small, slightly nummuloidal, marginal at the ventral side and in contact with the ventral wall. The composition of the siphuncular wall has not been seen.

The outer surface is smooth.

Position and locality. Very rare in the bed of bluish-gray crystalline Beekmantown limestone (D) below the lower Ophileta bed at Beekmantown N. Y.

Observations. The strongly compressed form of the conch, the close arrangement and the rapid rising of the septa on the ventral side and the marginal ventral position of the siphuncle leave little doubt that this form is an Ooceras or belongs to a closely related genus.

Ooceras (?) raei Whitfield (sp.)

Cyrtoceras raei Whitfield. Am. Mus. Nat. Hist. Bul. 1889. 2:58, pl. 10, fig. 8, 9

All that we know of this species which is based on a single fragment collected by Professor Seely at Beekmantown is contained in the original description, since no additional material has been obtained.

The fragment exhibits a short ventral portion only and fails to furnish sufficient data for satisfactory generic reference. All that can be said is that the form possessed a cyrtoceracone with depressed section, low annulations or undulations of the outer shell, rather shallow chambers (3½ in the space of 10 mm in the specimen), sutures with a distinct ventral saddle, and a subventran marginal siphuncle, which is nummuloidal.

The rate of growth of the conch, the characters of the living chamber and of the aperture, of the dorsal side and apical portion and those of the surface of the conch are not known and presuppose the discovery of new material for their elucidation.

Ooceras seelyi sp. nov.

Plate 38, figure 7-11

Description. Small, breviconic cyrtoceracone. Length of largest fragment 40 mm; indicating that the complete specimen possessed at least the double length. The rate of growth of the form is very great, one conch expanding from 15 to 29 mm within 32 mm;

the section slightly compressed oval with very little difference between the minor and major diameters (14 and 15 mm in one specimen); the ventral side being a little narrower than the dorsal. The largest diameter observed is about 40 mm at the base of the living chamber; the curvature is strong, an arc of 35 mm having a hight of 4 mm.

Only the base of the living chamber has been observed and the apical part of the conch is missing. The cameras are very shallow, there being 4 of them in the space of 10 mm; they are curved, strongly arching forward on the convex (ventral ?) side; the sutures nearly straight transverse with a broad lobe on the convex side; the septa flat (their depth is about 1½ that of the cameras) and bending orad on the ventral side.

Fig. 51 Ooceras seelyi sp. nov. Transverse section. Natural size

The siphuncle is large, strongly nummuloidal, expanding to twice its width (one eighth the width of the shell) in the cameras. Septal neck only present on dorsal side; the interseptal segments, which are of disklike shape, marginal in position on the convex side of the conch.

Position and localities. In the dove-colored limestone (Chazy C_1) of Isle La Motte, and of the outcrops north of the road to Little Monty bay south of Chazy village. One specimen was collected by Professor Hudson in the lower Chazy of the neighborhood of the normal school at Plattsburg N. Y., where it is associted with Rhynchonella acuticostris, Scalites angulatus, Harpes antiquatus, etc.

Observations. The most striking characters of this species, which is a typical Ooceras, are found in the structure of the siphuncle and the section of the conch. In the siphuncle the septal necks are absent on the ventral (outer) side [*see* fig. 11], but strongly developed on the dorsal side where they are bent outward and hooklike in section. This is one of the diagnostic features of the Ooceratidae.

Ooceras (?) lativentrum sp. nov.

Plate 35, figure 7-10

Description. Slender, medium sized cyrtoceracone. The largest specimen observed, which lacks aperture and apical part, measures 90 mm, and may have attained twice that size when complete. The largest aperture has a diameter of 31 mm. The rate of growth is 1 mm in 6 mm in the dorsoventral plane. The section is depressed elliptic, the ratio of the dorsoventral diameter to the transverse one as 8:9 in the earlier and later parts of the conch. The conch is strongly curved and may have approached the gyroceraconic condition; an inner arc of 50 mm has a hight of 8 mm.

The living chamber attains apparently about one third the length of the total conch. The aperture is not contracted, the margin nearly straight. The growth lines indicate that the hyponomic sinus is shallow and situated on the arched external side (exogastric shell). The cameras are shallow (6 to 8 in the space of 10 mm); the sutures straight transverse with a faint lobe on the ventral side, the septa very concave, their depth twice that of the cameras.

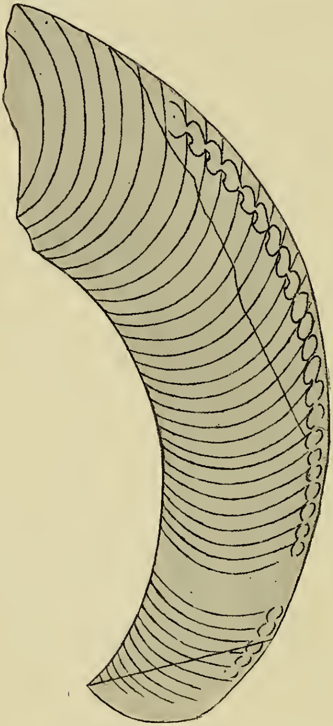


Fig. 52 Ooceras lativentrum sp. nov. Longitudinal section. Natural size.

The siphuncle is small, its width one eighth the diameter of the shell; nummuloidal, propioventran in position. The septal necks are bent outward and developed on the dorsal side only; thereby giving the siphuncular segments an asymmetric section. The surface is smooth.

Position and localities. Frequent in the dove-colored limestone (Chazy C_1) of Isle La Motte and also occurring in the same horizon at Valcour island.

Observations. In the characters and position of the siphuncle, notably in the restriction of the development of the curved septal necks to the dorsal side, this species is a typical member of the Ooceratidae and specially of Ooceras, wherewith it also has in common the close septation and the rapid rising of the septa on the ventral side. A difference of as yet unknown importance appears to lie in the direction of the compression of the conch; the shell of Ooceras being compressed and that of this species depressed. This depressed section may suggest a closer relationship to the original Cyrtoceras Goldfuss, than to Ooceras.

A form which in the longitudinal section as also in its curvature, rate of growth, position and character of the siphuncle bears a remarkable similarity to this species, is Cyrtoceras laticurvatum Whiteaves [1897, p. 224] from the Galena-Trenton beds of the vicinity of Lake Winnipeg. Still the latter species is slightly more curved, has also deeper cameras and is described as compressed in transverse section.

Ooceras (?) perkinsi sp. nov.

Plate 34, figure 4, 5

Description. Slender, small cyrtoceracone with circular section; attaining in the most complete specimen observed (type specimen) a length of 75 mm — with the apical end and the living chamber missing — and a width of 20 mm; its rate of growth is 1 mm in 7.5 mm. Its curvature is slight and decreasing in apertural direction; the hight of the arc of the type specimen is 4 mm and its apex is situated at about one third of the length of the fragment. An impressed zone is absent and the living chamber has not been observed.

The cameras are relatively shallow; their depth is 3 mm at the smaller end of the specimen and 5.5 mm at the larger, indicating a rather rapid increase in depth; the sutures are straight and transverse; the septa shallow, their depth amounting to one half that of the cameras and not arching forward to any appreciable amount upon the convex side of the conch.

The siphuncle is nummuloidal, the interseptal segments more convex on the outer than on the inner side; its greatest width one fifth that of the conch and twice as large as the septal perforations. It is distant from the outer side by its own width in the apical portion of the conch, but approaches the center in anterior direction. The septal necks are short and curved outward assuring thereby the position of this form among the Cyrtochoanites. The interior of the siphuncle is filled with organic deposits, arranged in vertical, radiating lamellae; through its center passes a distinct tubular endosiphotube with conchiolinous walls [*see* text fig. 55].

The shell is thick and the surface smooth.

Position and locality. Professor Perkins, who collected the type specimen, informs me that there is some doubt in regard to the exact horizon and locality of the same. It was found in a lot of fossils from the dove-colored limestone of Isle La Motte and presumably comes from that horizon though the adhering matrix differs somewhat from that of the other specimens. We have observed fragments of what we believe to be the same species in the dove-colored limestone of Valcour island, and of the neighborhood of Chazy.

Observations. This form is in amount of curvature of the shell, rate of growth, depth of chambers and character and position of siphuncle, sufficiently similar to Hall's evasive species *O. subarcuatum* that I should have identified it with the same if the latter were not described by Hall and Billings as being sharply annulated.

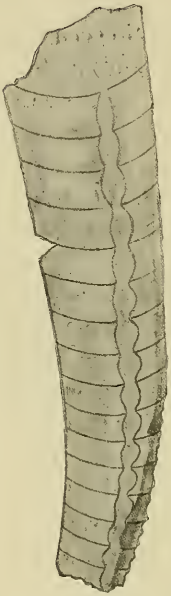


Fig. 53

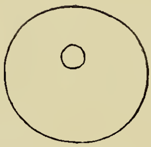


Fig. 54

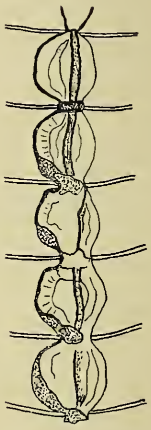


Fig. 55

Fig. 53 *Ooceras (?) perkinsi* sp. nov. Longitudinal section of the type. Natural size

Fig. 54 *Ooceras (?) perkinsi* sp. nov. Transverse section of the type. $x \frac{9}{10}$

Fig. 55 *Ooceras (?) perkinsi* sp. nov. Enlargement (x 2.7) of siphuncle to show the endosiphotube and sections of vertical lamellae

From *Loxoceras moniliforme* it can be distinguished by its curvature and the relatively smaller size of the siphuncle. *L. champlainense* has considerably shallower chambers.

Family ONCOCERATIDAE

Genus CYCLOSTOMICERAS Hyatt

This new genus is proposed in Zittel-Eastman's textbook and based upon the species described next as genotype. Its diagnosis is:

Slender, short, exogastric orthoceracones and cyrtoceracones, circular or compressed in section. Living chamber as compared with camerated part longer and larger than in most forms, less contracted and with open aperture in gerontic stage.

The genus is stated to persist from the Lower Siluric to the Devonic.

While distinctly phylogerontic, it still represents an earlier stage of the family than the genera Oncoceras and Melonoceras, since its aperture has not yet become contracted to any appreciable amount and remains open throughout life.

Hyatt describes the genus as exogastric; the excellent material of the genotype we have in hand shows that form to be endogastric. Cyclostomiceras, as represented by its genotype, would then apparently not lead to the Poterioceratidae but to the Phragmoceratidae. The exogastric forms, now referred to Cyclostomiceras, must eventually be brought under a new generic designation.

Cyclostomiceras cassinense Whitfield (sp.)

Plate 37, figure 1–3; plate 38, figure 5, 6

Gomphoceras cassinense Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 322, pl. 29, fig. 1–3

Cyclostomiceras cassinense Hyatt. Zittel's Textbook of Pal. tr. by Eastman. 1900. 1:530

The collecting zeal and liberality of Prof. G. H. Perkins have placed in my hands representatives of this species which are more perfect than its originals. Since they allow the elucidation of important additional characters and since the species has gained considerable importance by having been made the type of a new genus, we avail ourselves of the opportunity of redescribing it and furnishing drawings of the best of the specimens.

Description. Conch a middle sized subfusiform endogastric orthoceracone, which attains a size of 105 mm or more and a greatest width of about 40 mm in the middle of the living chamber of gerontic specimens. Its rate of growth is large and amounts to 33 mm within the space of 40 mm up to the widest part of the living chamber, whence it decreases at a smaller rate. The section is circular in the younger stages, but later on the dorsal side becomes more convex than the ventral.

The living chamber is relatively large, nearly half the length of the individual, with wide open aperture in the young and mature stages and slightly contracted aperture in the gerontic stage, the contraction being greater on the dorsal and lateral sides than on the ventral [pl. 37, fig. 3]. Apertural margin straight, transverse, with a shallow wide hyponomic sinus. Cameras very shallow, increasing to more than double width from the earlier stages to the ephebic stage (10 in 10 mm in nepionic stage and 4 in the same space in the ephebic stage); sutures provided with a narrow, low dorsal and a faint broad ventral saddle, in young specimens straight. Septa shallow, their concavity approximately equal to the depth of the cameras.

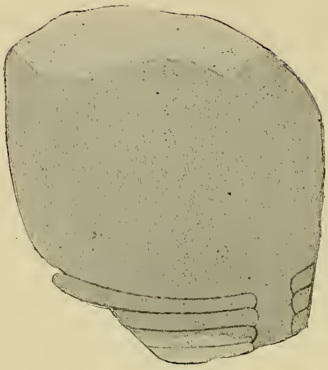


Fig. 56 Cyclostomiceras cassinense Whitf. (sp.) Longitudinal section of fragment showing the living chamber, siphuncle and depth of septa. x ¾

Siphuncle large, 5 mm wide in the septal perforations, slightly contracting between the septa, propiodorsan in position; without any organic deposits.

Position and locality. In the Fort Cassin beds at Fort Cassin.

Observations. This interesting form was referred by its author to Gomphoceras but the very slight development of the lateral contraction of the apertural margin, distinctly shown in our material, proves it to be of a more primitive character than Gomphoceras, and the Phragmoceratidae in general. Hyatt has made it a genotype and referred the new genus to the Oncoceratidae; describing it as consisting of exogastric forms. Since our specimens have the hyponomic sinus on the flat or less arched side, this form seems to have relations to or could be conceived to lead to the endogastric genus Phragmoceras.

The position of the hyponomic sinus on the flatter side indicates that the animal carried the conch very much in the position given to it in the lateral view [pl. 37, fig. 3].

Cyclostomiceras minimum Whitfield (sp.)

Plate 35, figure 5, 6

Gomphoceras minimum Whitfield. Amer. Mus. Nat. Hist. Bul. 1886, v. 1, no. 8, p. 321, pl. 27, fig. 3–5.

Observations made on specimens in the collection of Burlington University verify the statement contained in the original description, that this form had an open aperture, the margins of which were not contracted. It, therefore, can not be referred to Gomphoceras but must be assigned to a genus with more primitive characters than Gomphoceras has; and is evidently a member of Hyatt's genus Cyclostomiceras.

The hyponomic sinus is shallow and narrow, and situated opposite to the marginal, tubular, narrow siphuncle. The slight contraction of the living chamber is largely due to a thickening of the shell in apertural direction [*see* text fig. 57], evidently a gerontic feature. On casts of the living chamber one observes as in C. cassinense a deep constriction just posteriorly of the aperture, which is produced by a ringlike thickening of the apertural margin. Also two parallel vertical carinae of unequal strength may be seen passing along the siphuncular side of the cast.

Fig. 57 Cyclostomiceras minimum Whitf. (sp.) Part of longitudinal section showing thickening of shell around aperture. x 3

The species has not yet been observed outside of the beds at Fort Cassin.

Genus ONCOCERAS Hall emend. Hyatt

Oncoceras pristinum sp. nov.

Plate 34, figure 1, 2

Description. Small, very breviconic cyrtoceracone, which is but slightly curved, the arc described by the outer margin having a hight of 7 mm, when the length of the conch is 30 mm; compressed, the dorsal side rounder than the ventral; the greatest diameter — which is the dorsoventral one, at about the first half of the living chamber — is 18 mm, the transverse diameter at the same place is about 14 mm. The living chamber slightly and gradually contracting in the last half; not quite occupying one half of the conch. Aperture apparently not contracted. Cameras shallow, 9 within the space of 10 mm in the ephebic part of the conch; the septa but little concave, their depth being about equal to that of one chamber, rising toward the outer side of the conch. Siphuncle very slightly nummuloidal, 1 mm wide, marginal at the outer side of the conch, without deposits. Surface smooth.

Position and locality. Of quite frequent occurrence in C_6 (Strephochetus bed) at Chazy village, but not observed in other parts of the section at Chazy village. Also obtained by Prof. van Ingen in three specimens from the Chazy beds in the Saranac river at Plattsburg.

Observations. We are not aware of any cyrtoceracones hitherto described from the Chazy rocks of New York or Canada, with which this one could be compared, none of the others being similarly breviconic and rapidly expanding; nor do any of the Trenton species of the State invite comparison with the possible exception of the genotype of Oncoceras, O. constrictum, which, however, is readily distinguished by the much greater constriction of its living chamber. O. exiguum Billings (sp.), a Canadian Black river form, is much more slender and less curved. Not any of the species of Oncoceras from the western Trenton, made known partly by Hall and partly by Clarke, bear any similarity with O. pristinum.

This is a true Oncoceras in the short, small form of the shell, as well as in the position and character of the siphuncle. The living chamber however is distinctly contracted in apertural direction, but the aperture appears to have remained open.

While in its congeners the apical part of the phragmocone as a rule is missing and probably has been cast off by the animal, in this form the phragmocone is, with the exception of the last two cameras, filled solidly with calcite — sometimes to the degree of obscuring all structure — and in such a fashion that a solidifying of this part of the shell by organic deposition of carbonate of lime suggests itself.

The habitat of this small peculiar form seems to have been the sponge fields for it is found most frequently associated with species of the common Chazy sponges of the genus Strephochetus, which almost alone compose certain layers of the Chazy formation and which also have constantly overgrown the shells of this cephalopod. Among these sponge masses the diminutive cephalopod would seem to have found favorable conditions of shelter and preying.

FORMAE INCERTAE SEDIS

Orthoceras (?) primigenium (Vanuxem) ? Whitfield

Orthoceras primigenia Vanuxem. Geol. N. Y. 3d Dist., 1842. p. 36, fig. 4

Orthoceras primigenium Hall. Pal. N. Y. 1847. 1:13, pl. 3, fig. 11, 11a

Orthoceras primigenium Whitfield. Am. Mus. Nat. Hist. Bul. 1889. v. 11, no. 2, p. 56, pl. 10, fig. 1

Orthoceras primigenium Cleland. Am. Pal. Bul. 1900. no. 13, p. 20

Vanuxem figured a small orthoceratite among the fossils of the Calciferous group, and stated in a short note that its chambers are numerous and near to each other, that the terminal parts are solid and that it is found in considerable number in the quarry opposite Fort Plain in the Mohawk valley. Hall in his first volume of the *Palaeontology of New York* figured a group of similar apical parts of the conch and also a fragment of a more anteriorly situated portion of the phragmocone, which he refers to Vanuxem's species. From this material he extracted the following description:

Elongated, terete, gradually tapering to an obtuse point; surface smooth ?, section circular, septa thin, deeply concave, closely approximated, being distant only one twenty-fifth the diameter; siphuncle ?.

It is stated that this species is found in the higher calcareous portion of the Calciferous (Beekmantown) formation in the Mohawk valley, near Fort Plain, and that it occurs also in a brecciated mass near the same place.

Prof. Whitfield has assigned to this species a specimen, consisting of a longitudinal section, which had been obtained by Professor Seely at Beekmantown. He concedes that the septa in the same are not so closely arranged as in Hall's type, nor are they so deeply concave, but adds that it agrees with a fragment of Orthoceras which lies on the same block with Hall's type of Maclurea matutina from the Mohawk valley. His material, like that of the preceding observers, failed to show either the extent of the living chamber or the character of the siphuncle.

Prof. Cleland only states the presence of a few imperfect specimens in the Fort Hunter section.

While the specimen compared by Whitfield with Hall's original of O. primigenium differs from the latter by its deeper chambers, it agrees well in this character with the original figure given by Vanuxem. It is probable that Hall's figure [*l. c.*, fig. 11] represents a species different from that which Vanuxem had in hand. If, however, the siphuncle of Whitfield's original has indeed been small and subcentral, as is suggested by that author, then his O. primigenium is quite surely a different form, for the O. primigenium of the Mohawk occurs prevailingly and in great numbers in the form of the solid apical ends which are evidently the preseptal or nepionic bulbs and indicate a species with a wide siphuncle, such as a Cameroceras or Endoceras had.

These considerations invite a preliminary separation of the forms from Beekmantown and from the Mohawk valley as a safer procedure until more complete material of both the former and latter has been secured. The species from the Champlain valley is probably nearer related to O. deparcum Billings from the White limestone (Beekmantown) of the Mingan islands.

From the associated form here described as Endoceras ? champlainense, it differs in its more closely arranged septa, greater rate of growth and perhaps also in the position of the siphuncle.

Cycloceras ? (Spyroceras ?) rectiannulatum Hall

Orthoceras rectiannulatum Hall. Pal. N. Y. 1847. 1:34, pl. 7, fig. 2, 2a

This species, which is stated by its author to occur in the gray crystalline central portions of the limestone at Chazy, Clinton co., is based upon a single specimen. The latter though recorded in the original description as being in the Hall collection has not been located. Nor have we observed any other specimens with the characters of this species. From Spyroceras subarcuatum it would, according to the description and figure, differ in its straight conch and more distant annulations. Its surface is unknown and hence a conclusive reference to any of the genera of the Cycloceratidae or Kionoceratidae impossible.

(Cyrtoceras) beekmanense Whitfield

Cyrtoceras beekmanensis Whitfield. Am. Mus. Nat. Hist. Bul. 1889. 2:57, pl. 10, fig. 2, 3

This species is based upon a fragment too incomplete for a determination of its position in Hyatt's system of the Cephalopoda and no additional material has been secured. The original description is:

Shell of moderate size, nearly straight, the arcuation being not more than ⅛ of an inch in a length of three inches, or one twenty fourth of the length; tube laterally compressed, giving a very slightly oval section, the lateral diameter being somewhat less than the dorsoventral. Septa numerous, seven chambers occur within the space of half an inch on the side of the tube near the upper end of the septate portion, not greatly arcuated and of but shallow depth, rather strongly advanced on the inner side of the tube. Siphon unknown. Outer chamber quite long. Surface of the shell apparently smooth.

It is reported as coming from the crystalline limestone layer of the Beekmantown below the lower Ophileta bed, at Beekmantown (D).

The form can be distinguished from the few other cyrtoceraconic species of the Beekmantown by its shallow chambers with the exception of Cyrtoceras kirbyi, which, however, is more strongly arcuate and compressed.

(Cyrtoceras) confertissimum Whitfield

Plate 38, figure 1-4

Cyrtoceras confertissimum Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 327, pl. 27, figs. 7-9

A single specimen of this small form was obtained in A_6 of the Fort Cassin beds at Valcour. This we have used to ascertain the characters of the siphuncle and specially the extension and form of the septal necks, in order to establish as far as possible the relation of the species to the sub-orders distinguished by Hyatt.

The specific characters of C. confertissimum are briefly the following: conch small, attaining a length of 40 mm; curved thus that an arc 20 mm long has a hight of 2.8 mm; expanding gradually at a rate of 1:(18) in the lateral direction and of 1:11 in the dorso-ventral direction. Section depressed elliptic, the two diameters at the lower end of our specimen approximately in the ratio of 3:4, the dorsal (inner side) flatter than the ventral one.

Septa uniformly convex, depth one fourth the width. Sutures straight transverse. Cameras shallow, 1 mm deep (10 septa within the space of 10 mm). Extent of living chamber and aperture unknown.

Siphuncle very small, not more than one twelfth the minor diameter of the conch, empty, situated propioventran, consisting of short septal necks and nearly tubular (very slightly contracted) siphuncular segments.

Surface provided with bands of fine transverse lines.

Position and localities. Fort Cassin beds at Fort Cassin Vt., and Valcour N. Y. (A_6).

Observations. We have found it impossible to ascertain with the material available the exact generic position of this form. As Whitfield has rightly pointed out, this form is remarkable for its "transversal form" (depressed section). This, combined with the closely arranged septa and marginal, ventral position of the siphuncle, would indicate that the form is not so primitive as the majority of its orthoceraconic and cyrtoceraconic associates. The structure of the siphuncle would also seem to bear this out, for it is not only very small and much reduced in size, but its septal necks are also short and the greatest part of the siphuncular wall is formed by the siphuncular segments. The septal necks are, as far as we were able to observe, straight and short and would indicate the position of the form in question among the Orthochoanites. There has, however, no genus been erected for orthochoanitic cyrtoceraconic forms with such distinctly depressed section, as far as I am aware, and typically depressed cyrtoceraconic conchs appear only among the much more specialized genera of the order Cyrtochoanites. Whether our form represents a primitive member of one of the latter will have to be decided by future discoveries of the whole conch with living chamber and aperture.

The single other Beekmantown species with which this form bears some similarity has been described by Professor Dwight [1884, p. 255] as Cyrtoceras ? dactyloides from the Beekmantown at Rochdale in the Wappinger valley near the Hudson. That species has, however, a relatively much larger siphuncle.

(Cyrtoceras) acinacellum Whitfield (sp.)

Cyrtoceras acinacellum Whitfield. Am. Mus. Nat. Hist. Bul. 1886. 1:327, pl. 27, figs. 10–13

This interesting small form of which we have so far seen only the type from the Fort Cassin beds at Fort Cassin is characterized by the compressed section of the very slowly expanding curved small conch, the relatively distant septa (10 in the space of 10 mm) which are very concave and show an abrupt high ventral and a lower dorsal saddle. The siphuncle is small, tubular, with short septal necks and long straight segments and subventran in position. The outer shell is smooth or only possesses such sculpture as the growth lines provide.

From its section, the position and character of the siphuncle, we surmise that this species may represent one of the primitive cyrtoceraconic genera of the Tarphyceratidae for which generic terms have not yet been proposed.

SPECIES RECORDED FROM PHILIPSBURG, CANADA

Besides

Sueceras marcoui *Barrande* (*sp.*)
Tarphyceras farnsworthi (*Billings sp.*) *Hyatt*
Aphetoceras farnsworthi (*Billings sp.*) *Hyatt* and
Aphetoceras attenuatum *Hyatt*

there have been described by Billings from the Beekmantown beds at Philipsburg in Missisquoi county, Canada, at the north end of Lake Champlain the following species, whose generic position is uncertain.

Lituites imperator. Pal. Foss. 1:23
Nautilus pomponius. *Ibid.* p. 26
Orthoceras repens. *Ibid.* p. 312
O. catulus. *Ibid.* p. 313
O. perseus. *Ibid.* p. 313
O. missisquoi. *Ibid.* p. 314
O. cato. *Ibid.* p. 314
O. catalina. *Ibid.* p. 315
O. sayi. *Ibid.* p. 315
O. xerxes. *Ibid.* p. 316
O. tityrus. *Ibid.* p. 316
O. aristides. *Ibid.* p. 316

SYNOPTIC TAXONOMY OF THE CEPHALOPODA OF THE BEEKMANTOWN AND CHAZY STAGES OF THE CHAMPLAIN BASIN

Order NAUTILOIDEA

Suborder A. HOLOCHOANITES Hyatt

Division II. ENDOCERATIDA

Family ENDOCERATIDAE

Genus CAMEROCERAS (Conrad) emend. Hyatt

Cameroceras (Proterocameroceras) brainerdi *Whitfield* (*sp.*)
C. tenuiseptum *Hall* (*sp.*)
C. curvatum *sp. nov.*

Genus VAGINOCERAS Hyatt

Vaginoceras oppletum *sp. nov.*

Genus ENDOCERAS (Hall) Hyatt emend.

Endoceras (?) champlainense *sp. nov.*
E. (?) hudsoni *sp. nov.*
E. magister *sp. nov.*
E. montrealense *Billings* (*sp.*)

Genus SUECOCERAS Holm

Suecoceras marcoui *Barrande* (*sp.*)

Genus NANNO Clarke

Nanno noveboracum *sp. nov.*

Family PILOCERATIDAE

Genus PILOCERAS Salter

Piloceras explanator *Whitfield*

Family CYRTENDOCERATIDAE

Genus CYRTENDOCERAS Remélé

Cyrtendoceras (?) priscum *sp. nov.*

Suborder D. ORTHOCHOANITES Hyatt

Division I. ORTHOCERATIDA

Family ORTHOCERATIDAE

Genus BALTOCERAS Holm

Baltoceras (?) pusillum *sp. nov.*

Genus ORTHOCERAS (Breyn.) Hyatt emend

Orthoceras lentum *sp. nov.*
O. progressum *sp. nov.*
O. vagum *sp. nov.*
O. modestum *sp. nov.*

Genus GEISONOCERAS Hyatt

Geisonoceras shumardi *Billings* (*sp.*)

Family CYCLOCERATIDAE

Genus PROTOCYCLOCERAS Hyatt

Protocycloceras lamarcki *Billings* (*sp.*)
P. whitfieldi *sp. nov.*
P. (?) *cf.* furtivum *Billings* (*sp.*)

Genus SPYROCERAS Hyatt

Spyroceras clintoni *Miller* (*sp.*)

Genus ORYGOCERAS gen. nov.

Orygoceras cornu-oryx *Whitfield* (*sp.*)

Division II. PLECTOCERATIDA

Family TARPHYCERATIDAE

Genus BARRANDEOCERAS Hyatt

Barrandeoceras natator *Billings* (sp.)

Genus EURYSTOMITES Schröder emend. Hyatt

Eurystomites kelloggi *Whitfield* (*sp.*) emend. *Schröder*
E. accelerans *sp. nov.*
E. amplectens *sp. nov.*
E. rotundus *Hyatt*
E. virginianus *Hyatt*

Genus TARPHYCERAS Hyatt

Tarphyceras farnsworthi *Billings* (*sp.*) *emend. Hyatt*
T. seelyi *Whitfield* (*sp.*)
T. champlainense *sp. nov.*
T. perkinsi *Whitfield* (*sp.*)
T. clarkei *sp. nov.*
T. multicameratum *sp. nov.*

Genus APHETOCERAS Hyatt

Aphetoceras farnsworthi *Billings* (*sp.*) *emend. Hyatt*
A. attenuatum *Hyatt*

Genus DELTOCERAS Hyatt

Deltoceras vaningeni *sp. nov.*

Family TROCHOLITIDAE

Genus SCHROEDEROCERAS Hyatt

Schroederoceras eatoni *Whitfield* (*sp.*)
S. cassinense *Whitfield* (*sp.*)

Genus TROCHOLITOCERAS Hyatt

Trocholitoceras walcotti *Hyatt*

Genus TROCHOLITES Conrad emend. Schröder

Trocholites internestriatus *Whitfield* (*sp.*)

Family PLECTOCERATIDAE

Genus PLECTOCERAS Hyatt

Plectoceras jason *Billings* (*sp.*)

Suborder E. CYRTOCHOANITES

Division I. ANNULOSIPHONATA

Family LOXOCERATIDAE

Genus LOXOCERAS McCoy

Loxoceras moniliforme *Hall* (*sp.*)

Family ACTINOCERATIDAE

Genus CYRTACTINOCERAS

Cyrtactinoceras boycii *Whitfield* (*sp.*)
C. champlainense *sp. nov.*

Genus GONIOCERAS Hall

Gonioceras chaziense *sp. nov.*

Division II. ACTINOSIPHONATA

Family OOCERATIDAE

Genus OOCERAS Hyatt

Ooceras kirbyi *Whitfield* (*sp.*)
O. (?) raei *Whitfield* (*sp.*)
O. seelyi *sp. nov.*
O. lativentrum *sp. nov.*
O. (?) perkinsi *sp. nov.*

Family ONCOCERATIDAE

Genus CYCLOSTOMICERAS Hyatt

Cyclostomiceras cassinense *Whitfield* (*sp.*)
C. minimum *Whitfield* (*sp.*)

Genus ONCOCERAS Hall

Oncoceras pristinum *sp. nov.*

Formae incertae sedis

(Orthoceras) rectiannulatum *Hall*
(O.) repens *Billings*
(O.) catulus *Billings*
(O.) perseus *Billings*
(O.) missisquoi *Billings*
(O.) cato *Billings*
(O.) cataline *Billings*
(O.) sayi *Billings*
(O.) xerxes *Billings*
(O.) tityrus *Billings*
(O.) aristides *Billings*
(Cyrtoceras) beekmanense *Whitfield*
(C.) confertissimum *Whitfield*
(C.) acinacellum *Whitfield*
(Lituites) imperator *Billings*
(Nautilus) pomponius *Billings*

SYNOPTIC TABLE OF THE DISTRIBUTION OF THE CEPHALOPODA OF THE BEEKMANTOWN AND CHAZY STAGES OF THE CHAMPLAIN BASIN

The capital letters denote the localities as follows: B Beekmantown; C Chazy; F Fort Cassin; I Isle La Motte; P Philipsburg; V Valcour.

NAME OF SPECIES	BEEKMANTOWN STAGE	CHAZY STAGE A	CHAZY STAGE B	CHAZY STAGE C	OTHER LOCALITIES
1 Cameroceras brainerdi *Whitf.* (*sp.*)	F, V				
2 C. tenuiseptum *Hall*		V	C, V	C, V	Also Crown Point
3 C. curvatum *Rued.*				I	
4 Vaginoceras oppletum *Rued.*		V		C, V, I	
5 Endoceras (?) champlainense *Rued.*	B				
6 E. (?) hudsoni *Rued.*				V	
7 E. magister *Rued.*		V			
8 E. montrealense *Bill. sp.*	F				Beekmantown beds near Montreal
9 Suecoceras marcoui *Barrande sp.*	P				
10 Nanno noveboracum *Rued.*				C	
11 Piloceras explanator *Whitf.*	F, V				
12 Cyrtendoceras (?) priscum *Rued.*	B				
13 Baltoceras (?) pusillum *Rued.*	V				
14 Orthoceras lentum *Rued.*				V	
15 O. progressum *Rued.*				V	
16 O. vagum *Rued.*				V, I	
17 O. modestum *Rued.*				C, V, I	
18 Geisonoceras shumardi *Bill. sp.*			C		Chazy of Mingan islands
19 Protocycloceras lamarcki *Bill. sp.*	B, V				Beekmantown beds of Mingan islands, Newfoundland, etc.
20 P. whitfieldi *Rued.*	F				
21 P. (?) *cf.* furtivum *Bill. sp.*	B				Ontario, Can.
22 Spyroceras clintoni *Miller sp.*		V	C, V	C, V, I	Chazy of Mingan islands
23 Orygoceras cornu-oryx *Whitf. sp.*	F, V				
24 Barrandeoceras natator *Bill. sp.*				V	Chazy of Mingan islands
25 Eurystomites kelloggi *Whitf.* (*sp.*)	F, V				Shakopee of Wisconsin
26 E. accelerans *Rued.*	V				
27 E. amplectens *Rued.*	V				
28 E. rotundus *Hyatt*	F, V				
29 E. virginianus *Hyatt*	F (?)				Lexington Va
30 Tarphyceras farnsworthi *Bill.* (*sp.*)	P				
31 T. seelyi *Whitf. sp.*	F, V				
32 T. champlainense *Whitf.* (*sp.*)	F				
33 T. perkinsi *Whitf.* (*sp.*)	F				
34 T. clarkei *Rued.*	V				
35 T. multicameratum *Rued.*				C, V, I	
36 Aphetoceras farnsworthi (*Bill. sp.*) *Hyatt*	P				
37 A. attenuatum *Hyatt*	P				
38 Deltoceras vaningeni *Rued.*		V			
39 Schroederoceras eatoni *Whitf.* (*sp.*)	F, V				
40 S. cassinense *Whitf.* (*sp.*)	F, V				
41 Trocholitoceras walcotti *Hyatt*	F				
42 Trocholites internestriatus *Whitf.* (*sp.*)	F				
43 Plectoceras jason *Bill.* (*sp.*)		V			Chazy of Mingan islands and Newfoundland. M. Chazy of Crown Point
44 Loxoceras moniliforme *Hall* (*sp.*)			C	C	Chazy of Plattsburg
45 Cyrtactinoceras boycii *Whitf.* (*sp.*)			C	C, V, I	
46 C. champlainense *Rued.*				C	Also Saranac river at Plattsburg
47 Gonioceras chaziense *Rued.*			C		
48 Ooceras kirbyi *Whitf.* (*sp.*)	B				
49 O. (?) raei *Whitf.* (*sp.*)	B				
50 O. seelyi *Rued.*				C, I	
51 O. lativentrum *Rued.*				V, I	
52 O. (?) perkinsi *Rued.*				I (?)	
53 Cyclostomiceras cassinense *Whitf.* (*sp.*)	F				
54 C. minimum *Whitf.* (*sp.*)	F				
55 Oncoceras pristinum *Rued.*				C	Also Saranac river at Plattsburg
Incertae sedis					
56 (Orthoceras) rectiannulatum *Hall*			C (?)		Horizon unknown
57 (O.) repens *Bill*	P				
58 (O.) catulus *Bill*	P				
59 (O.) perseus *Bill*	P				

SYNOPTIC TABLE OF THE DISTRIBUTION OF THE CEPHALOPODA—(*concluded*)

NAME OF SPECIES	BEEKMANTOWN STAGE	CHAZY STAGE			OTHER LOCALITIES
		A	B	C	
60 (Orthoceras) missisquoi *Bill*	P	....	......	......	
61 (O.) cato *Bill*	P	....	......	......	
62 (O.) cataline *Bill*	P	....	......	......	
63 (O.) sayi *Bill*	P	....	......	......	
64 (O.) xerxes *Bill*	P	....	......	......	
65 (O.) tityrus *Bill*	P	....	......	......	
66 (O.) aristides *Bill*	P	....	......	......	
67 (Cyrtoceras) beekmanense *Whitf*	B	....	......	......	
68 (C.) confertissimum *Whitf*	F	....	......	......	
69 (C.) acinacellum *Whitf*	F	....	......	......	
70 (Lituites) imperator *Bill*	P	....	......	......	
71 (Nautilus) pomponius *Bill*	P	....	......	......	

SYNOPTIC TABLE OF THE DISTRIBUTION OF SOME OF THE GENERA

Heavy print means present in greater number of species. * Present, B = Beekmantown, Ch = Chazy, L = Lowville, Bl = Black river, T = Trenton, U = Utica

NAME OF GENUS	BALTIC BASIN	BOHEMIAN MEDITERRANEAN BASIN	ATLANTIC BASIN	NEWFOUNDLAND BASIN	CHAMPLAIN BASIN	MISSISSIPPIAN SEA	NOTES
Nanno	......	....	....	....	Ch	L	
Suecoceras	*	....	....	....	B	....	Philipsburg
Gonioceras	......	....	....	....	Ch	L, Bl	Also China
Piloceras	......	....	B	**B**	B, Ch	B	
Conoceras	*	*	....	....	B	....	B, Levis channel
Eurystomites	......	....	....	B	**B**	B, Bl, T	Also B of Virginia
Tarphyceras	* ?	....	....	**B**	**B**, Ch	....	Also B of Virginia
Aphetoceras	......	....	....	B	B	....	
Deltoceras	......	....	....	B	Ch	....	
Barrandeoceras	......	*	....	Ch	Ch	Bl	
Schroederoceras	*	....	....	....	B	....	
Trocholites	*	?	*(Bala)	....	B	Bl ?T, U	
Litoceras	......	....	....	B	....	....	
Trocholitoceras	......	....	....	....	B	....	
Plectoceras	......	....	....	Ch, Bl	Ch	....	Extends to Niagaran of Mississippian sea
Lituitidae	**	....	....	B	....	....	

RELATIONS OF THE CEPHALOPOD FAUNAS OF THE BEEKMANTOWN AND CHAZY FORMATIONS OF THE CHAMPLAIN BASIN TO THE FAUNAS OF OTHER REGIONS

The elucidation of the phylogenetic relations of the Cephalopoda by Hyatt and the resulting erection and precise determination of numerous genera of small compass have made this important class of fossils exquisitely adapted to furnish important data bearing on the paleogeography of the Siluric era, which could not be hoped for as long as the majority of these organisms were associated under such loose and polyphyletic groups as Orthoceras, Cyrtoceras, Gyroceras and Nautilus. We present here a few such data which can be derived from a part of the limited fauna described in this paper. On account of a lack of uniform application of Hyatt's systematic principles to the taxonomy of the paleozoic cephalopod faunas of other countries, it is as yet impossible to survey the distribution of all genera cited here. Moreover it is apparent, that some of the larger or dominating genera, as Endoceras, are of such general distribution, that only a close scrutiny of their species would promise any results. For these reasons we restrict ourselves to a discussion of the involute forms, which have been the subject of Hyatt's investigation in the *Phylogeny of an Acquired Characteristic* and to the aberrant and highly specialized genera which, by their very nature, will be bound to more limited areas of distribution and hence more readily yield clews to the former connections of the oceanic basins. It is true and must not be here overlooked that the very aberrancy and specialization of these forms may indicate that they were adopted to special peculiar conditions and to a very limited facies and the failure to find them over large areas might for this reason be simply due to a failure of exposure of the special facies to which they are bound. But this is the case, in a more general way, with all the Cephalopoda, in our paleozoic formations at least, for the scarcity of cephalopods in both the Beekmantown and Chazy formations and in the Trenton as well — in most localities and in large sections — and their profuse appearance in certain beds or localities, as at Fort Cassin (Beekmantown) and Little Monty bay (Chazy) and the Black river beds of Watertown, is sufficient evidence of their former rather restricted distribution in the paleozoic seas and of their character as facies animals. The probability of a former much wider distribution of the aberrant and specialized forms than their fossil representation would indicate, is further diminished to some extent by the fact that such forms are as a rule eagerly sought by collectors.

In discussing the paleogeographic distribution of the cephalopods of the Champlain basin we follow Frech[1] in distinguishing between a Bohemian-Mediterranean basin, Baltic basin, North-Atlantic basin and Pacific-American basin. The North-Atlantic basin is supposed to have had an important northwestern embayment, the Newfoundland embayment, which comprises the present maritime provinces of Canada, New Brunswick, Nova Scotia and Newfoundland. From the eastern portion of the Pacific-American basin, the Mississippian sea. there was separated, according to Ulrich and Schuchert[2] a long basin, extending over the area of the present Appalachian system.

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[1] Lethaea Paleozoica. 1897. 2:88.

[2] *See* An. Rep't State Paleontol. for 1901.

During the Beekmantown age, these authors assert, the Mississippian sea was connected with the Atlantic basin by means of the St Lawrence channel, which was formed by the northern part of the restricted Appalachian trough. During the Chazy age this northern part of the Appalachian trough had, in their opinion, become divided by means of the Quebec barrier into two subparallel basins, the Chazy basin to the northwest of the barrier and the Levis channel to the east. The former passed through the greater part of the present Champlain valley into the Ottawa basin, the latter formed a narrow channel between the Quebec and Green mountain barriers and extended as far as Newfoundland.

The present writer has differed somewhat from this view in correlating the greater part of the Levis graptolite shale with the Beekmantown formation. To avoid entering upon this difference of view we will here distinguish but the four grand marine divisions, recognized by Frech and besides, the Mississippian sea, the Newfoundland embayment and the Champlain basin.

The study of the relations which exist between the cephalopod faunas of the Champlain basin and the Mississippian sea is greatly embarrassed by the barrenness of the latter basin in well preserved fossils of the Beekmantown and Chazy formations. The Beekmantown age has furnished but few cephalopods in the Shakopee formation described by Sardeson and the Chazy formation is in the central Mississippi basin represented by the St Peter sandstone, in which the fossils are so poorly preserved that altogether only two cephalopods from this formation have been described by Sardeson [1896] and by Clarke [1897]. We are here, therefore, largely restricted[1] to an investigation of the relations of the Champlain basin in Beekmantown and Chazy time to the Newfoundland embayment and the Atlantic and Baltic basins, but can properly draw certain indirect inferences from the Mesochamplainic faunas of the Mississippian sea.

A perusal of the table of distribution of a number of cephalopod genera, that precedes this chapter [p. 513] leads plainly to the infer-

[1] Mr E. P. Berkey [*see* "The Paleogeography of Mid-Ordovicic Time" in Science, n. s. 1905, 21:989] has lately advanced the view that the St Peter sandstone, as well as each of the most important sandstones below, represents "an extensive retreat and readvance of the sea." If this contention that the St Peter sandstone represents largely material reworked by the sea and the wind is true, then there is little hope of ever obtaining a satisfactory suite of cephalopods from these beds, since the shell-bearing cephalopods have, as a class, generally kept well out to sea.

ences that the Champlain and Newfoundland basins have the greatest number of genera in common; further, that a considerable number of the genera characteristic of these basins is present in the subsequent formations in the Mississippian sea and that finally from the extra-American basins the Baltic basin appears to have a greater number of genera in common with the American basin than either the Atlantic or Bohemian-Mediterranean basins. On the whole these inferences are verified by an analysis of the separate genera in regard to their more or less restricted distribution and relative importance for paleogeographic investigations.

The genera which we here have in mind as being of more restricted distribution on account of the aberrant or specialized character of their component species are: Nanno, Piloceras, Gonioceras and Bathmoceras. The genus Nanno has been erected by Clarke for a species from the Black river group (Ctenodonta bed) of Minnesota. The principal diagnostic character of the genus was seen in the presence of a large preseptal cone or nepionic bulb. Holm possessing several species of lower Siluric cephalopods with like nepionic bulbs, referred them also to Clarke's genus. Hyatt, however, subsequently restricted the genus to forms, which like the species from Minnesota, develop but a few endosiphosheaths and have the siphuncle in absolute contact with the external wall. Thus determined the genus became again restricted to one species. If now the form from the Chazy of New York, which in the present paper, is, as we believe, on good ground referred to Nanno, is correctly placed, we have in the Champlain basin an earlier representative of the genus present in Trenton time in the Mississippian sea. On the other hand, the genus Suecoceras Holm, with an apical structure similar to that of Nanno, is represented, according to its author, by six species from the Lower Siluric of the Baltic basin and one from the Champlain basin.

The characters of the genus Gonioceras are so striking that it can not fail to be readily recognized wherever it is present. The first species of this genus, G. anceps, was found in the Black river formation at Watertown, near the outlet of Lake Ontario. It occurs also in the Black river beds of Canada, and has been described by Clarke from the Lowville limestone (Stones river group) of Wisconsin and Minnesota, and is also recorded [in correlation table of *Paleontology of Minnesota*] from the same formation in Tennessee. Another species, G. occidentale, has been described by Hall from Wisconsin, where it is also found in the Stones river group. Clarke records the species also from Illinois and the correlation table referred to from the same formation in Tennessee. These are all the species of Gonioceras hitherto known. The genus was hence well established in the Mississippian sea and its transgression areas in early Mohawkian time. The species here described shows that the genus existed earlier, viz, in Middle Chazy time in the Champlain basin. It is entirely missing in Europe and is hence to be considered as a typical form of the American-Pacific basin.

Crick has lately [1903] announced the occurrence of Gonioceras in a series of Lower Silurian fossils from Kiachow in North China, together with Actinoceras (Ormoceras) *aff.* tenuifilum Hall and brachiopods of the same age. This exceedingly interesting observation extends the habitat of the genus Gonioceras across the entire Pacific-American basin and furnishes further evidence of its having been characteristic of this very ancient oceanic basin.

As in the case of Nanno, which to our present knowledge is also restricted to the American basin, the distribution of Gonioceras would indicate either an immigration of these genera from the Chazy basin into the Mississippian sea at the time of the beginning of the Trenton transgression or, which is more probable, an earlier connection of the two marine expanses and an origin of these forms in a western region which as yet has furnished no fossils of early Siluric age.

Some very interesting facts are presented by the distribution of the species of the genus Piloceras. This genus is so peculiar in its characters that Hyatt erected a separate family for its reception, and that it is not liable to be overlooked wherever occurring. There have been described five species from the Beekmantown beds of the Newfoundland embayment. One species has been recorded from the corresponding beds of Scotland and one is known from the Fort Cassin beds. A small form has been described by Sardeson and another modified type by Clarke, both from the Shakopee formation of the west. The Shakopee is regarded by Winchell as probably equivalent in part to the Beekmantown formation of eastern North America. The present evidence points hence distinctly to the northwestern Atlantic as the center of distribution of this localized form, whence it reached the British embayment of the Atlantic basin in one species and on the other side entered the St. Lawrence channel and reached the Mississippian sea.

A genus which may with propriety be cited here, though we have not found it in the Champlain basin, is Conoceras Bronn (Bathmoceras Barrande). This genus, which by its split septal necks and semiconical rings, closing the siphuncle walls, holds the position of an aberrant group, has been found by Dwight to be well represented in the Beekmantown beds of the neighborhood of Poughkeepsie N. Y., in the southern portion of the "Levis channel." It is well known from the Lower Siluric rocks of the Bohemian and Baltic basins and represents a decidedly foreign element on the American continent, which can be supposed to have entered the channel by way of the Newfoundland embayment.

In regard to the remaining orthoceraconic and cyrtoceraconic cephalopods it can only be said that all of the genera here cited appear as well represented in the eastern basin (Bohemian-Mediterranean, Atlantic and Baltic basins) as here; that there are no identical species, such as we later find in the Trenton and that hence a direct connection of the Champlain basin and these eastern seas can not be assumed for the periods here under consideration. There are, however, several species cited in the above given synoptic list from the Champlain basin which are known from the Mingan islands and Newfoundland and therefore would indicate more or less of a connection between the Champlain-Canadian and Newfoundland embayments. These are Protocycloceras lamarcki from the Beekmantown beds, Geisonoceras shumardi, Spyroceras clintoni and Plectoceras jason from the Chazy beds. Their number, held against the sum total of species known from the Beekmantown beds of the Mingan islands and Newfoundland on one hand and the Champlain basin on the other, appears, however, so small that this evidence in regard to a possible connection of the two embayments is to be considered more negative than positive. We have here cited 57 species of cephalopods from the Champlain basin, out of which number these four are identical with Newfoundland and Mingan island species. On the other hand, Billings describes 31 cephalopod species from the Beekmantown and Chazy beds of Newfoundland and the Mingan islands, only six of which he cites as found either in the Canadian or Champlain basin (O. multicameratum, O. bilineatum,[1] O. sub-

[1] In studying the orthoceracones and cyrtoceracones of the Beekmantown and Chazy formations of the Champlain valley one cannot fail to be impressed with the fact of the extreme similarity of some Chazy and Beekmantown species. In the case of Cameroceras brainerdi (Fort Cassin beds) and Cameroceras tenuiseptum (Chazy) this similarity has been pointed out in the description of the latter species. It is therefore probable that certain Chazy forms were indigenous, being directly derived from Beekmantown forms which formerly occupied the same area.

arcuatum (=clintoni), O. allumettense, O. lamarcki, Piloceras canadense); two of them (O. multicameratum, O. bilineatum) again are, to my knowledge, known only from the Black river and Trenton stages of the Canadian and Champlain basins, and are hence not strictly coexistant in both basins in the Beekmantown and Chazy stages. Orthoceras subarcuatum (=Spyroceras clintoni) and Protocycloceras lamarcki are among the four common species cited by us before; there are, hence, altogether, six cephalopod species common to the Newfoundland and Canadian-Champlain basins as against 76 species named in the two mentioned lists, which are not common to the two embayments. To this must be added a number of other forms described from Canada and not known from Newfoundland and the 15 or more new nautiloid Beekmantown forms, from Canada and Newfoundland, described by Hyatt, none of which appears to go out of its province.

From these figures giving the number of identical species of cephalopods of the Champlain and Newfoundland basins but one inference could be drawn, i. e., that during the Beekmantown and Chazy periods the cephalopod faunas of the Newfoundland and the Champlain-Canadian basins did not mingle to any noteworthy degree. But we shall see later [*see* p. 525] that this inference based on comparison of beds that are not exactly equivalent, should not be given great weight.

Of the relations of the orthoceraconic and cyrtoceraconic Champlain cephalopods to those of the corresponding western horizons, we can get no more than a faint glimpse from the few forms which are at present known from the Shakopee formation. One of these, Endoceras (?) consuetum Sardeson is so closely related to one of our Beekmantown types, that we could have ventured to refer the latter tentatively to this western form. Another, as yet undescribed, extremely closely septate cyrtoceracone from the Oneota formation at Blanchardville Minn., is strikingly similar to Endoceras montrealense Billings, possessing the same chamber depth, position and relative size of siphuncle, though still differing in a somewhat greater rate of growth and greater curvature. An undescribed Cyrtocerina, which appears to be quite common in the Shakopee formation at Dresbach Minn., is plainly a close relative to the Point Levis form Cyrtocerina mercurius Billings, with which it has the curvature and chamber depth in common.

We will now turn to the relations of the nautiloid genera.

The genus Eurystomites may be said to be typically American, since of the eight species referred to it, one comes from Newfoundland, five from the Fort Cassin beds of the Champlain basin (one of the latter also occurring in the west and one at Lexington Va.), the seventh, E. undatus, is a Black river limestone form of the northeastern Mississippian sea (Watertown) and perhaps of the Champlain basin,[1] and the eighth, E. plicatus, Whiteaves, a Galena-Trenton limestone form from the Lake Winnipeg region.

As Whiteaves has lately [1903, p. 163] stated that the true Inachus undatus of Emmons has been found only in the Black river limestone at Kingston Ont. (Mississippian sea) and the forms currently referred to that species from the Province of Quebec are either Plectoceras halli (Foord) or undetermined or undescribed forms, it is probable that the Lituites undatus of White is referable to one of the latter species and Eurystomites undatus is restricted to the Mississippian sea.

The western type of E. undatus has been described by Hall as a separate variety, viz, E. undatus var. occidentalis. It is stated by Clarke, that this has a more general distribution than the eastern form and the correlation table of the Minnesota report lists it as occurring in the Stones river group (Lowville limestone).

A fact that is worthy of special notice here is the identity of the single nautiloid yet found below the Black river-Trenton beds in the west with our most common species of Eurystomites in the Fort Cassin beds of the Champlain basin, viz, E. kelloggi, [*see* p. 460]. There is, hence, no doubt that the genus Eurystomites occupied already in Beekmantown time the Mississippian or epicontinental American sea and persisted there into Trenton time.

In summing up we may say that Eurystomites finds its principal development in the Beekmantown formation of the Champlain basin and extended in that period far south in the Appalachian trough, northward into the Newfoundland embayment and also occupied the Mississippian sea; that is, it held the American epicontinental sea into Trenton time when it was carried by the Trenton encroachment to Baffin Land, whence Schuchert [1900, p. 173] records an Eurystomites (plicatus Whiteaves ?).

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[1] *See* List of Champlain Upper Ordovicic Fossils, published or circulated by Th. G. White in 1898.

The "Lituites undatus" cited by P. E. Raymond from the Chazy of Crown Point is probably a Plectoceras, of the group of P. jason, since Eurystomites undatus is in the east strictly a Black river form.

The genus Tarphyceras has a distribution, which in Pretrenton time is identical with that of Eurystomites. It is represented by three species in the Newfoundland embayment, by four in the Champlain basin (one from Philipsburg), and by one in the Appalachian trough in Virginia. It has hence the center of its development approximately in the Champlain basin and extends into the Newfoundland embayment, and the middle Appalachian trough. A later form (Discoceras convolvens ? Angelin and Lindström) from the Baltic basin is referred by Hyatt with doubt to this genus.

The genus Deltoceras is known by one species from the Beekmantown formation of Newfoundland and one from the lower Chazy of the Champlain basin.

The genus Barrandeoceras is present with two species in the Chazy formation of the Mingan islands (Newfoundland embayment), one of which extends into the Champlain basin; with three in the Bohemian basin and it persisted in Lituites convolvans Hall into the Black river formation of the Mississippian basin. Its distribution points to a previous marine connection between the Bohemian-Mediterranean sea and the Newfoundland embayment by way of the Atlantic.

A genus of the Tarphyceratidae which, though not observed in the Champlain basin of New York and Vermont, invites mention, is Aphetoceras. This is known in two species from the Beekmantown of Philipsburg and in two more from the same formation in Newfoundland.

The genus Schroederoceras is distinctly Baltic in its distribution, for it is there represented in the Lower Siluric with no less than eight species against but two in the Champlain basin.

The genus Trocholites is again quite suggestive in its distribution. Even in its restricted scope it has a very wide range and geographic distribution, when compared with the other nautiloid groups here described. Besides the two forms, originally referred by Conrad to this genus (T. ammonius and planorbiformis), Schröder recognizes 10 species in the Lower Siluric of the Baltic basin (mostly from the Echinosphaeriten-Kalk), and Hyatt refers to this genus — besides the Fort Cassin form described in this paper — a Canadian species from the Falls of Montmorency, another from the Cincinnati group (besides one previously made known by Miller and Dyer) and two more, published by Blake from the Lower Siluric of England. Trocholites ranges therefore through the whole Lower Siluric and is found in both Europe and America.

It will, however, be noted that not only the greatest number of species occur in Europe, but also that it does not appear in the American continental basin proper until Cincinnati time, though in the Champlain basin it was already present during the Beekmantown age and around the Adirondack region in Trenton time. It is not cited from the Pretrenton Newfoundland embayment.

Trocholites is phylogenetically connected with the more primitive genus Litoceras by the genus Trocholitoceras, which is represented by one species from the Fort Cassin beds (T. walcotti Hyatt) and a doubtful congener from the Baltic basin. Litoceras is restricted to the Newfoundland embayment. Present evidence would hence indicate that this race originated in the northwestern Atlantic sea, but spread with the appearance of the genus Trocholites to both the British embayment and the Baltic sea.

The genus Plectoceras finally existed in one species in Chazy time in the Newfoundland embayment and Champlain basin, persisted in Trenton time in the same region and in Niagaran time reached the Mississippian sea.

In regard to the Lituitidae, Hyatt [1894, p. 504] makes the following interesting statement:

All of these forms known to me occur in the Orthoceran and Vaginatus limestones of northern Europe and Niagara limestones and Quebec faunas in this country. They seem to be absent from more southern faunas of the same stages.

Foord doubts the appearance of true Lituites in the rocks of Great Britain, and I think he could have positively denied their appearance there since L. ibex sp. Sowerby certainly has none of the usual characteristics of any of this family.

Hyatt does not cite any representatives of the Lituitidae from the Champlain basin, nor have we observed any in either the Beekmantown or Chazy beds of that region. He describes, however, in Cyclolituites americanus, from the Gargamelle cove in Newfoundland, a lituitid from the Newfoundland basin, and in Ancistroceras (?) dyeri from the Niagaran near Chicago and Rhynchorthoceras (?) dubium from the same group in Indiana, two later representatives of that family from the American basin. In Europe the family is absent, or nearly so, from the Atlantic and Bohemian-Mediterranean basins, but remarkably well represented in the Lower Siluric of the Baltic basin by the genera Cyclolituites, Lituites, Angelinoceras, Holmiceras, Ancistroceras and Rhynchorthoceras.

Hyatt's suggestion that the Lituitidae are "absent from more southern faunas of the same stages" would seem to hint at climatic factors in the distribution of the family. Its more northern distribution is, in my opinion, the rather accidental result of its restriction to certain marine basins, notably the Baltic basin, whence it reached, in Lower Siluric time, the Newfoundland embayment along a route at present not quite apparent.

The absence of the Lituitidae from the Champlain and Mississippian basins during Champlainic or Lower Siluric time is quite suggestive as indicating a lack of free communication between the Baltic and Mississippian basins in that era, such as is claimed by some geologists, apparently on good grounds, for the Upper Siluric time by way of the Arctic regions.

If we sum up the evidence furnished by this analysis of the distribution of the cephalopod genera, we find that one genus (Trocholitoceras) is restricted to the Champlain basin, one (Litoceras) to the Newfoundland embayment, two (Nanno and Gonioceras) are found only in the Champlain basin in Chazy time and persisted in the Mississippian sea (in the case of Gonioceras in the Pacific-American basin); further, that Tarphyceras, Deltoceras and Plectoceras (and probably also Aphetoceras) are restricted to the Newfoundland embayment and Champlain basin (extending in the two first named into the central Appalachian trough); that Piloceras and Eurystomites find their principal development in the Newfoundland embayment and Champlain basin, but that while the former in one species also reached the British embayment, the latter is entirely restricted in Beekmantown and Chazy times to the Newfoundland embayment, the Appalachian trough and Mississippian sea. On the other hand, the Lituitidae flourished in the Baltic basin in Lower Siluric time, reached the Newfoundland embayment with but one or a few representatives, and are not known from either the Appalachian trough or the Mississippian sea. The genera Schroederoceras and Trocholites also attained plainly their maximal development in the Baltic basin; the former found its way into the Champlain basin in Beekmantown (Fort Cassin) time with two species and the latter with one, and the genus Barrandeoceras extended from the Bohemian-Mediterranean basin to the Newfoundland embayment and Champlain basin.

We have hence from their geographic distribution in Beekmantown and Chazy times four larger groups of cephalopod genera:

1 Those which are known only in the Champlain basin and later are also found in the Pacific-American basin: Nanno, Gonioceras, Trocholitoceras.

2 Those which are restricted to the Newfoundland embayment and Champlain basins: Tarphyceras, Deltoceras and Plectoceras.

3 Those which have their principal development in the Newfoundland embayment and Champlain basin (or Appalachian trough), and are not known in Europe, but extended also to the Pacific-American basin: Eurystomites. A more complete knowledge of the cephalopod faunas of the earliest Lower Siluric of the west would probably bring some or all of the genera cited under 2 into this group.

4 Those which are better represented in Europe than in the Champlain or Newfoundland basins: the family Lituitidae, and Schroederoceras, Trocholites and Barrandeoceras.

Besides these the small genus Litoceras is thus far restricted to the Newfoundland basin and Piloceras which centers in the Newfoundland and Canadian basins has reached the Mississippian basin on one side and England on the other.

The existence of these groups of genera leads to the recognition of the following components of the cephalopod faunas of the Champlain basin in early Lower Siluric time:

1 A Pacific-American element, foreign to the European seas, and in part also to the Newfoundland embayment.

2 A Newfoundland-Champlain element which may be a part of the former group.

3 An Atlantic-Bohemian element, extending into the Newfoundland embayment.

4 A Baltic element which in very small parts has reached the Newfoundland embayment and Champlain basin.

An attempt to weigh off accurately the relative importance of these elements in the composition of the Champlain faunas would, with our insufficient knowledge of the western faunas and the omission of the orthoceraconic and cyrtoceraconic forms, be premature and wholly unwarranted by the data at hand. Still so much is suggested by the foregoing analysis that the Pacific-American element in the Champlain basin fauna may turn out to be greatly more important than the European one. This is indicated by the distribution of the genera Eurystomites, Gonioceras and Trocholitoceras, discussed before, and quite strongly supported by the presence of Eurystomites kelloggi in both the Appalachian trough (including Champlain basin) and the American epicontinental or Mississippian sea. It is further suggested by the fact that the Atlantic-Bohemian element is practically absent in the Champlain basin and apparently not so strongly represented in the Newfoundland embayment as one should expect.

As to the connection of the Champlain basin and Newfoundland embayment, in Beekmantown time, we have curiously enough two entirely different and apparently militating groups of facts. On one hand the Fort Cassin fauna of the Champlain basin of New York and Vermont has no species in common with the Newfoundland Beekmantown fauna, though a considerable number of genera are restricted to the two faunas. On the other hand, Billings has made the following positive statements [1865, p. 376]:

> No one could compare the collections from Cow Head (Newfoundland) with those of Point Levis and Philipsburg (Lake Champlain) without some feeling of astonishment, that in localities nearly a thousand miles distant from each other, there should be such a perfect identity, not only in the fossils, but also in the character of the rock.
>
> Out of the 34 species collected at Cow Head, 23 are perfectly identical with those collected at Point Levis, Bedford, Philipsburg and other typical localities of the formation.

Billings's conclusion and ours can be easily reconciled by the following consideration. The Beekmantown faunas, which Billings here has in mind and which alone were known to him, viz, those of Philipsburg and Point Levis, are entirely different from the Fort Cassin fauna and represent other subdivisions of the Beekmantown age than the Fort Cassin fauna. All evidence goes to show that the Philipsburg beds like the typical beds at Beekmantown are older than the Fort Cassin beds. In the age, or ages represented by the former beds, there existed undoubtedly an open marine channel from the Champlain basin to the Newfoundland embayment.[1]

The Fort Cassin fauna is not yet known from the St Lawrence channel and Newfoundland. Since the Newfoundland Beekmantown limestone is well developed and its faunas have been fully described by Billings and later on searched for cephalopods by Hyatt, the fact that no Fort Cassin forms have as yet been recorded from there, does in some measure indicate their absence in the Newfoundland basin, and thereby an interruption of the connection between the Newfoundland embayments and the Champlain basins, for the Fort Cassin stage at least. We may mention here that, in another place [1904, p. 503] we have concluded from the distribution of the graptolite *Goniograptus thureaui* — which is found in Australia, New York and Quebec, but has not entered the Atlantic and Baltic basins — that the Champlain basin (as part of the Appa-

[1] It is in this connection quite significant that one of the few cephalopods found at Beekmantown itself, viz, *Protocycloceras lamarcki* Billings, is also known from the Mingan islands and Newfoundland.

lachian trough) in part of the Beekmantown stage stood in closer marine connection with the Pacific basin than with the Atlantic.

In the Chazy rocks proofs of a closer connection between the Champlain basin and Newfoundland embayment become more frequent among the Champlain cephalopods and the faunas of the Champlain basin, the St Lawrence channel and the Mingan islands have in common a number of forms other than cephalopods. Of the 24 species of Chazy cephalopods here described, 4 are known from the Mingan islands.

Frech [1897, p. 93, 100] has inferred from an analysis of the trilobite genera and species of North America and Europe, that the Mississippian sea and Appalachian valley trough had no connection with the Atlantic sea, the Bohemian-Mediterranean and the Baltic basins during the earlier Lower Siluric era and that an exchange of species did not begin until the Trenton period. The inferences to be drawn from the distribution of the cephalopods here described would seem to corroborate this view.

On the other hand the Newfoundland embayment does not seem to have stood in such open and direct connection with the Atlantic sea, as Frech's chart [*op. cit.* chart II] would indicate. We have before pointed out that the common possession of the important genera Eurystomites, Tarphyceras, Deltoceras and Plectoceras by the Newfoundland and Canadian-Champlain basins and their absence in the Atlantic basin in the early Lower Siluric could only be accounted for by the assumption of a connection of the Newfoundland basin with the American basin closer than that with the Atlantic basin at some time previous to the Fort Cassin stage. It must, however, be conceded here that in the great number of genera of orthoceraconic and cyrtoceraconic forms, which have been excluded from the discussion for reasons before stated, many may be contained which are common to the Atlantic basins and Newfoundland embayment.

A like restriction as that here placed on the inference of a separation of the Newfoundland embayment and Atlantic basin would have to check a conclusion of a closer connection between the Champlain-Newfoundland sea and Baltic basin, which apparently follows easily from the greater number of common genera, listed in the synoptic table on page 513, the checking being necessary on account of the fact that the important family of the Lituitidae, which is so characteristic of the Baltic basin, failed entirely to reach the Champlain basin and is known from the Newfoundland embayment in but one species. It is different with the evidence in regard to a connection of the Champlain basin and Mississippian sea. Here the lack of knowledge of organisms from the latter is the chief obstacle to a positive conclusion, but the few cephalopods obtained from the west point all to but one inference, namely that of a closer connection of these marine expanses.

The presence of the genera Nanno and Gonioceras which in the Champlain basin are restricted to the Chazy, in the next formation, the Lowville limestone in the Mississippian sea would, combined with the fact that the Lowville limestone is not present in the Champlain basin, suggest that these genera may have existed before Lowville time in the Mississippian sea and persisted there into that period, thus indicating a connection before Lowville time. This inference receives strong support from the occurrence of Gonioceras in China, in the far western part of the Pacific-American basin, of Eurystomites kelloggi, and of two species of Piloceras in the small known fauna of the Shakopee formation.

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EXPLANATION OF PLATES

PLATE I

Endoceras (?) champlainense sp. nov.

Page 418

1 Fragment of siphuncle, showing the smooth area of contact with the external wall

2 Fragment of shell, seen from the same side, showing the rate of growth of the siphuncle

3 Specimen, showing the chambers and the position of the siphuncle. The curving of the siphuncle is accidental and the septa are slightly more convex than represented in the figure

4 Fragment retaining a partial cast of the living chamber and showing the depth of the septa

The originals are all from the Beekmantown beds at the Spelman ledge (D) at Beekmantown N. Y. and now in the New York State Museum.

Cameroceras (Proterocameroceras) brainerdi Whitf. (sp.)

Page 405

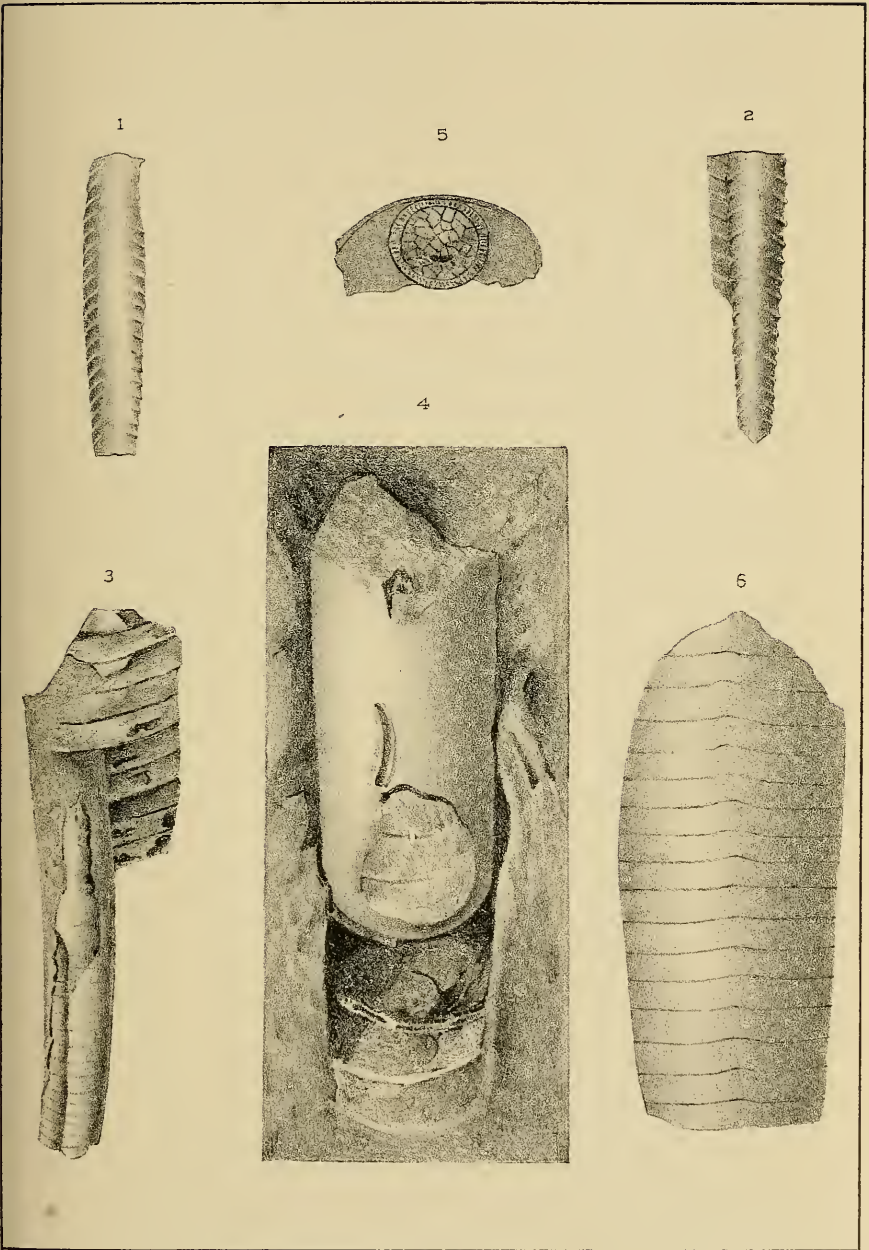
See pl. 2, fig. 1

5 Section through siphuncle showing its marginal position, thick endosipholining and endosiphocoleon

6 Fragment showing the slight saddles of the sutures opposite the siphuncle

The originals come from the Fort Cassin beds (A_3) at Valcour N. Y. and are now in the New York State Museum.

CEPHALOPODS



G. S. Barkentin. del. W. S. Barkentin. lith.

PLATE 2

Cameroceras (Proterocameroceras) brainerdi Whitf. (sp.)

Page 405

See pl. 1, fig. 5, 6

1 Fragment showing the broad lateral saddle of the suture

The original is from the Fort Cassin beds (A_3 of section on page 397) at Valcour N. Y. and now in the New York State Museum.

Cyrtendoceras (?) priscum sp. nov.

Page 430

2 Specimen showing the septa as empty spaces between the fillings of the chambers and the siphuncle on the inside of the curved conch

3 Specimen which retains an earlier volution than the preceding type. The chambers are represented as too large

4 Cast from a mold of a fragment of a volution, showing its circular section

5 Specimen retaining the chambers and siphuncle space in a later volution. The apparent evolute form of the conch is due to imperfect preservation of the inner volutions

The originals come from the Beekmantown beds D of the Spelman ledge at Beekmantown N. Y. and are in the New York State Museum.

Cameroceras curvatum sp. nov.

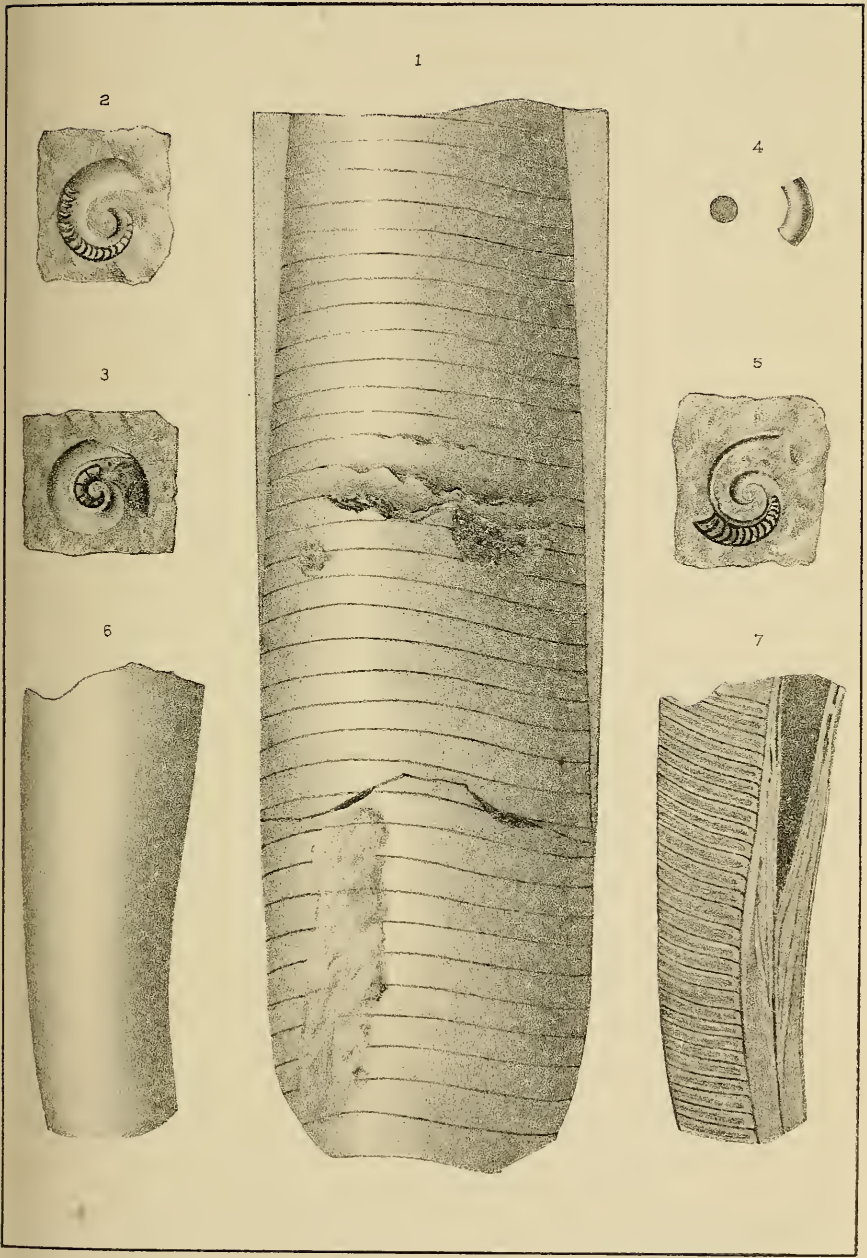
Page 411

6 Exterior of the type of the species

7 Section of the same, showing the closely arranged cameras, large siphuncle, endosipholining, endosiphocone. endosiphosheaths and endosiphotube

The type is from the dove-colored Chazy limestone of Isle La Motte and now in the museum of Burlington University.

CEPHALOPODS



G. S. Barkentin del. W. S. Barkentin, lith.

PLATE 3

Cameroceras tenuiseptum Hall (sp.)

Page 408

See pl. 4, fig. 1; pl. 5, fig. 5, 6; pl. 6, fig 2

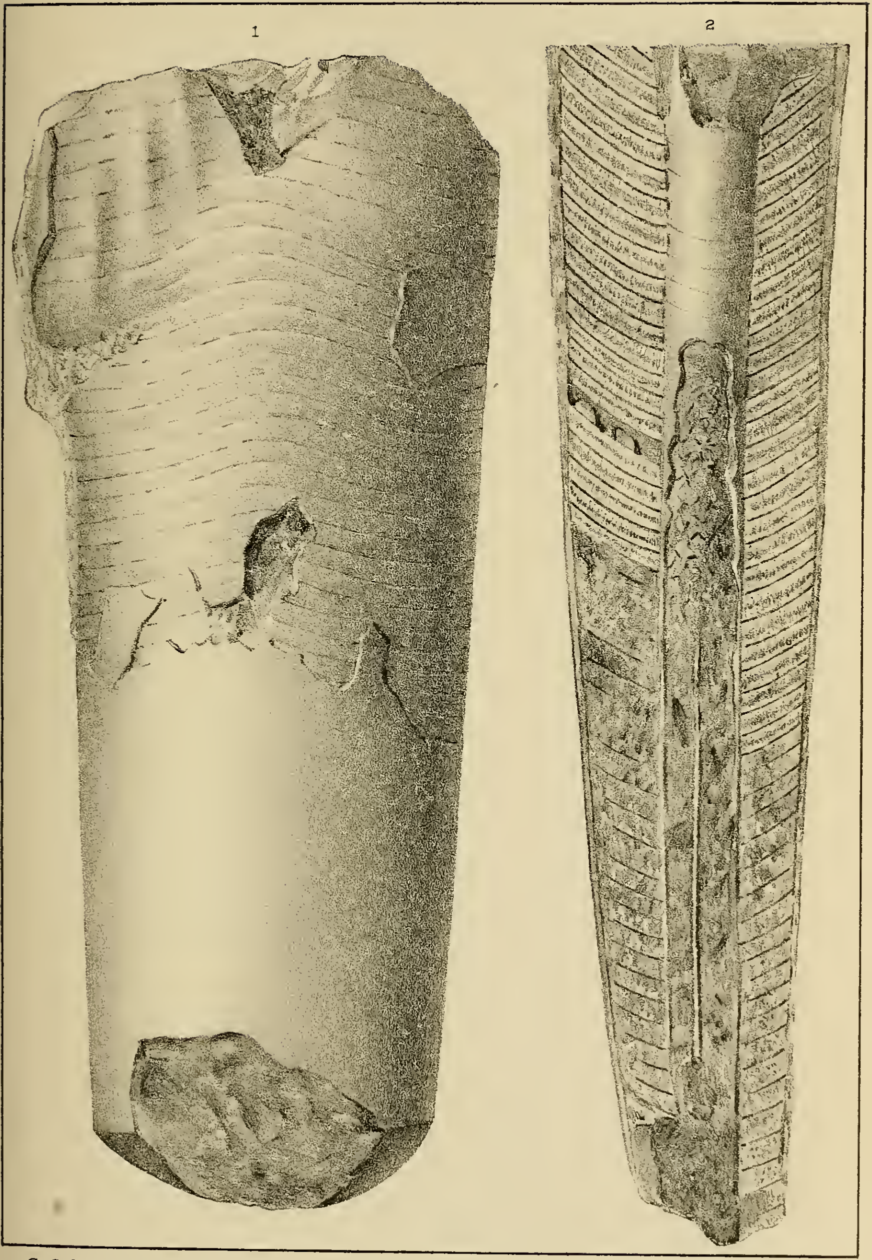
1 Fragment of large specimen, retaining the outer shell on the lower part and showing the sutures on the upper part. Section of the same represented on plate 4, figure 1

2 Natural section of a specimen, showing the cameras, the depth of the septa, the siphuncle with endosipholining and endosiphotube. The septa are drawn too straight in the lithograph

The original of figure 1 is from the dove-colored Chazy limestone of Isle La Motte, Vt. and now in the museum of Burlington University and that of figure 2 is from the dove-colored Chazy limestone near Little Monty bay, south of Chazy village, N. Y. and now in the New York State Museum.

Bull. 90 N. Y. State Museum

Plate 3



G. S. Barkentin. del.

W. S. Barkentin. lith.

PLATE 4

Cameroceras tenuiseptum Hall (sp.)

Page 408

See pl. 3, fig. 1, 2; pl. 5, fig. 5, 6; pl. 6, fig. 2

1 Section of the specimen represented in plate 3, figure 1.

Vaginoceras oppletum sp. nov.

Page 413

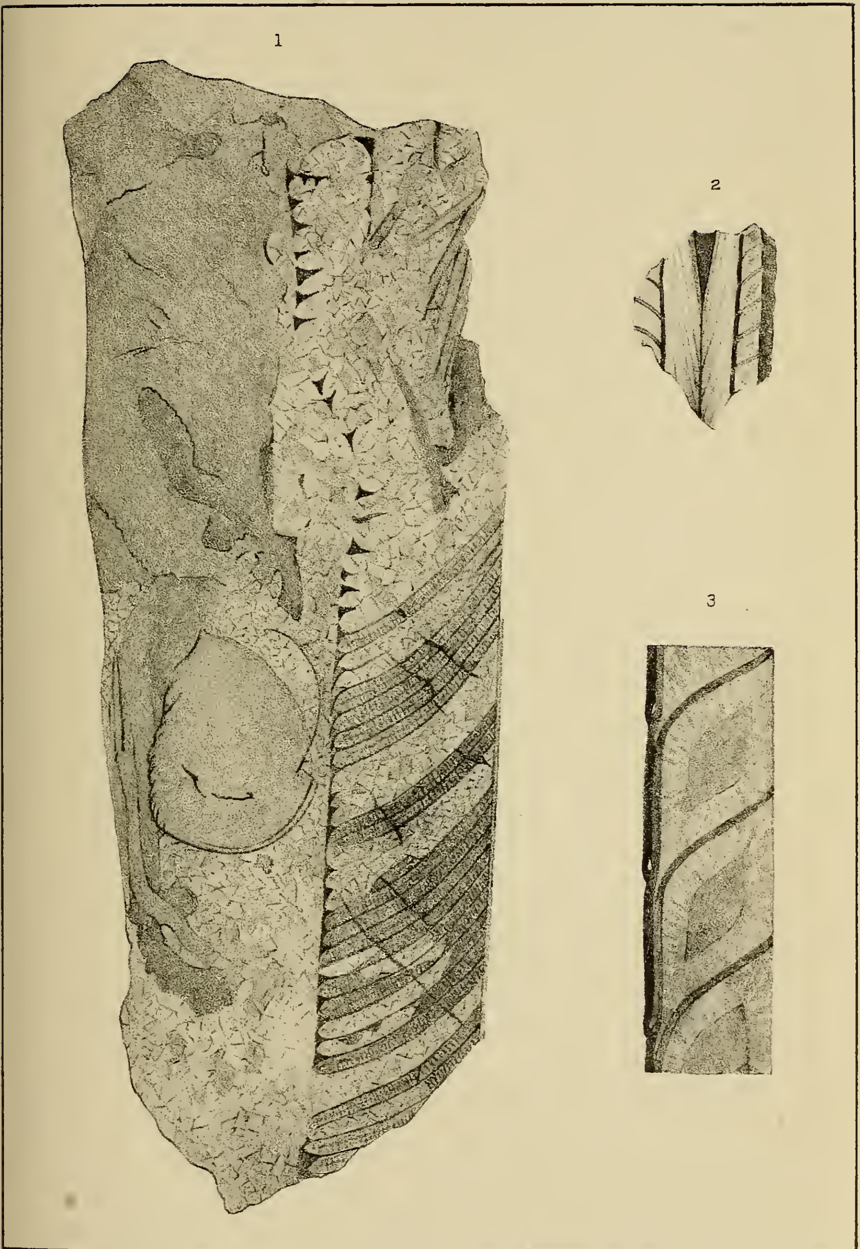
See pl. 5, fig. 1-4; pl. 6, fig. 1; pl. 9, fig. 1-3

2 Section of fragment, showing the apical end of the endosiphocone, and the endosiphosheaths

3 Enlargement of part of the siphuncular wall of the last specimen to show its structure. x 5

The original is from the dove-colored Chazy limestone near Little Monty bay, south of Chazy N. Y., and now in the New York State Museum.

Bull. 90 N.Y. State Museum. Plate 4



G.S.Barkentin.del. W.S.Barkentin.lith.

PLATE 5

Vaginoceras oppletum sp. nov.

Page 413

See pl. 4, fig. 2, 3 ; pl. 6, fig. 1 ; pl. 9, fig. 1–3

1 Apical portion of a specimen, showing a natural section of the nepionic bulb

2, 3, 4 Three views of a septum to show its lobation

The original of figure 1 is from B_4 of the lower Chazy of the Valcour section, that of figures 2, 3, 4 from the dove-colored Chazy limestone west of Little Monty bay near Chazy village. Both are now in the New York State Museum.

Cameroceras tenuiseptum Hall (sp.)

Page 408

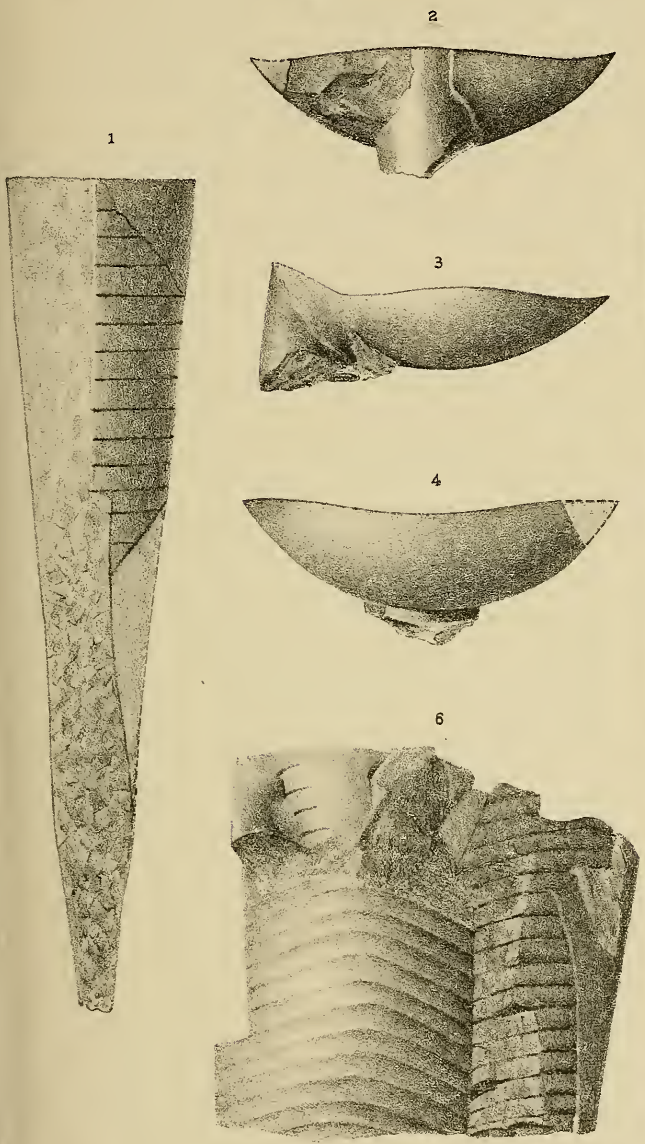
See pl. 3. fig. 1, 2 ; pl. 4, fig. 1 ; pl. 6, fig. 2

5 Section of fragment of the apical portion, showing the nepionic bulb and early endosiphosheaths

6 View of siphuncle showing saddles of the septa on the siphonal side

The originals of figures 5, 6 are from the dove-colored limestone of Isle La Motte and now in the museum of Burlington University.

Bull. 90 N. Y. State Museum Plate 5



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 6

Vaginoceras oppletum sp. nov.

Page 413

See pl. 4, fig. 2, 3; pl. 5, fig. 1-4

1 Specimen showing the external confluent surface of the deposits in the chambers

Cameroceras tenuiseptum Hall (sp.)

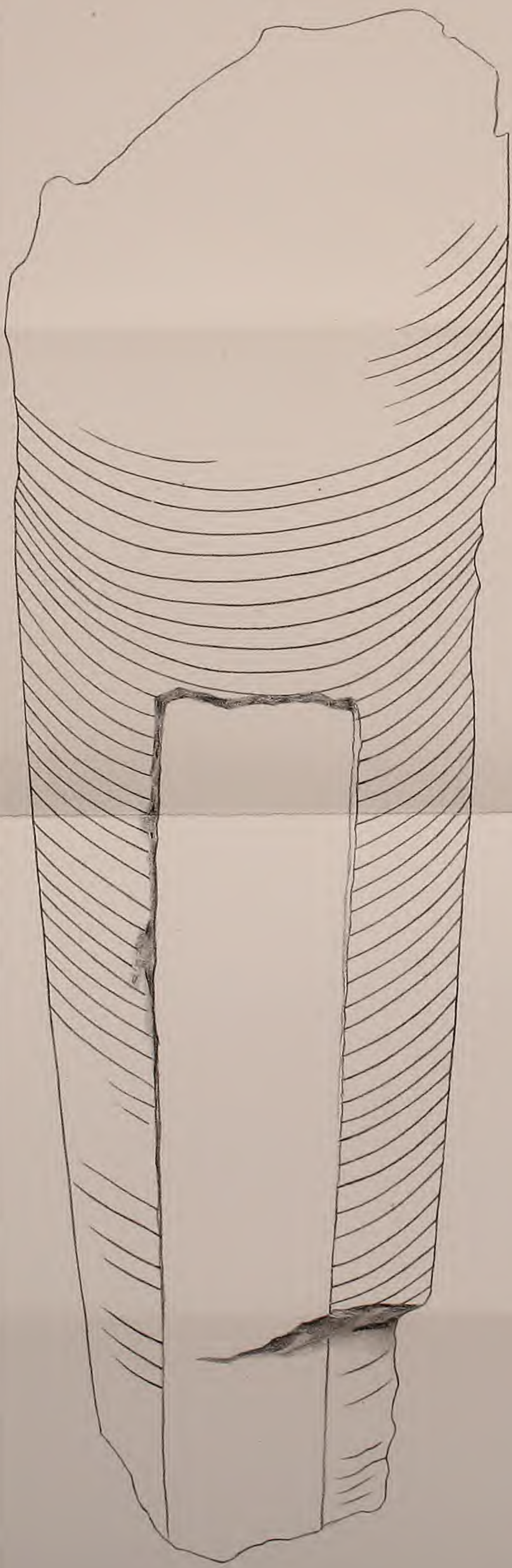
Page 408

See pl. 3, fig. 1, 2; pl. 4, fig. 1; pl. 5. fig. 5, 6

2 Natural section through the ventral side of a large specimen. Owing to a slight obliquity of the section the outlines of the specimen are more rapidly spreading than in the other figures.

The original of figure 1 is from the dove-colored Chazy limestone of the east shore of Valcour island; that of figure 2, from the same bed of the north shore of the same island. The originals are in the New York State Museum.

2



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G. S. Barkentin, del.   W. S. Barkentin, lith.

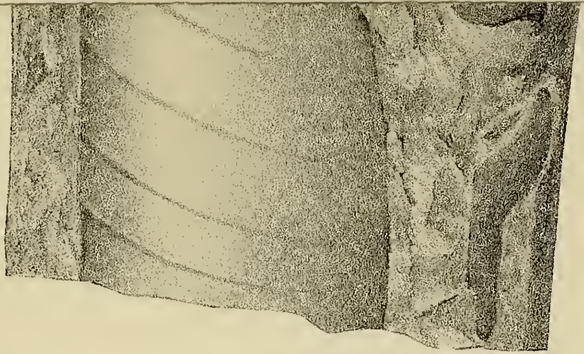
PLATE 7

Endoceras (?) hudsoni sp. nov.

Page 421

1 Natural section of type specimen showing the siphuncle in the lower end, the chambers and the organic deposits in the upper At the lower right side the mammillate surface of the deposits is shown, in the upper part of the section the extent of the organic deposition within the chambers. The middle lines in the chambers are the pseudosepta

The original is from the dove-colored Chazy limestone of the east shore of Valcour island, N. Y. and now in the New York State Museum.



G S. Barkentin. del. W.S. Barkentin, lith.

G. S. Barkentin del. W. S. Barkentin, lith.

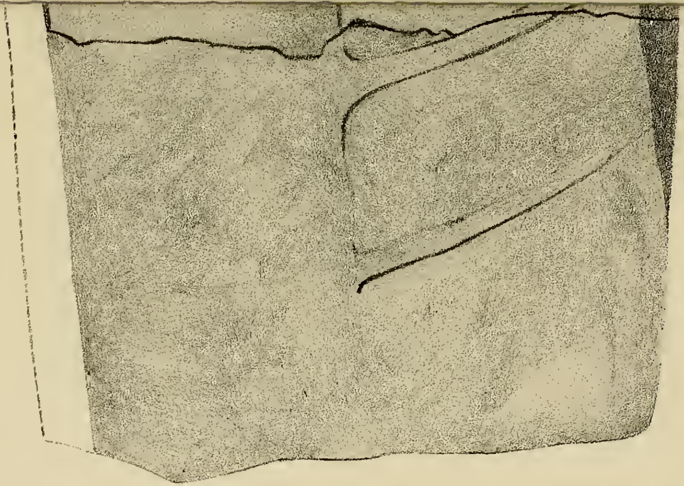
PLATE 8

Endoceras magister sp. nov.

Page 423

1 Natural section of the type specimen, showing the size and marginal position of the siphuncle and the depth of the chambers and septa

The original is from the lower Chazy beds of the Valcour shore (B_4 of the section described on page 398) and now in the New York State Museum.



G.S.Barkentin.del. W.S.Barkentin,lith.

Bull. 90. N.Y. State Museum

Plate 8

G. S. Barkentin del.

W.S. Barkentin lith.

PLATE 9

Vaginoceras oppletum sp. nov.

Page 413

See pl. 4, fig. 2, 3; pl. 6, fig. 1

1 Enlarged section (x 2) of the cameras and siphuncular wall, showing the extent and structure of the organic deposits and the pseudosepta

2, 3 Two views of a fragment of a larger specimen exhibiting well the irregularly mammillate surface of the organic deposits filling the cameras

The originals are from the dove-colored Chazy limestone (C_1) at the east shore of Valcour island and now in the New York State Museum.

Baltoceras (?) pusillum sp. nov.

Page 431

4, 5 Two views of the type, a natural section; figure 4 an enlargement (x 3) of the apical end, showing the wide siphuncle

The original is from the Fort Cassin beds (A_3 of the section on page 397) at Valcour N. Y. and now in the New York State Museum.

Nanno noveboracum sp. nov.

Page 427

6, 7 Two views of the type; the former showing the form and surface of the preseptal cone or nepionic bulb; the latter the siphuncle (seen from the outside) and early cameras, seen in section

The original is from the dove-colored Chazy limestone west of Little Monty bay near Chazy and now in the New York State Museum.

Endoceras montrealense Billings (sp.)

Page 424

8 A specimen showing the rate of growth, marginal position of siphuncle, sutures, and depth of cameras and of septa

The original is from the Fort Cassin beds at Fort Cassin, and now in the museum of Burlington University.

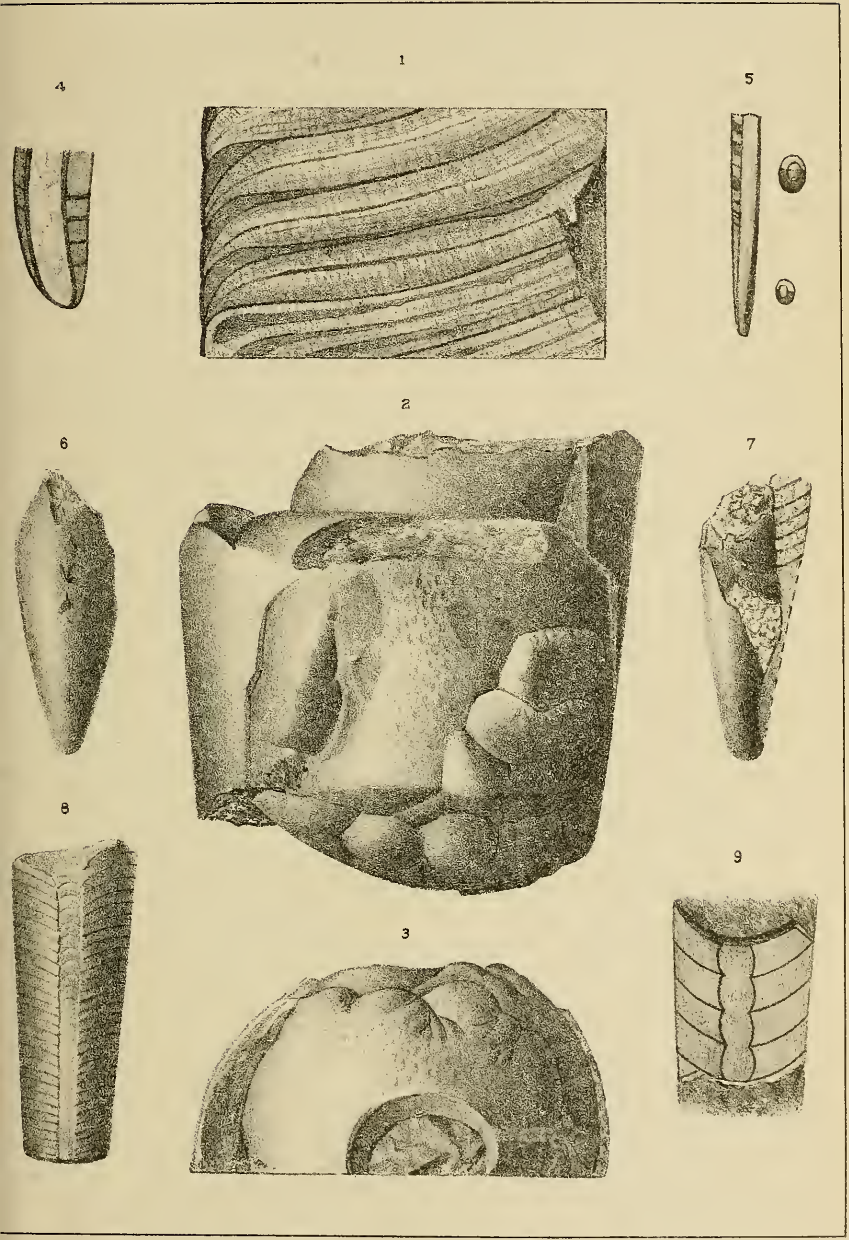
Orthoceras vagum sp. nov.

Page 435

See pl. 13, fig. 1, 2, 3

9 Section of a portion of the specimen represented on plate 13, figures 1, 2 to show the character of the siphuncle and the depth of the cameras and of the septa.

CEPHALOPODS



G. S. Barkentin, del. W. S. Barkentin lith.

PLATE 10

Piloceras explanator Whitfield

Page 429

See pl. 11

1 A large specimen retaining the apical portion, which is broken lengthwise and exhibits a section of the siphuncle; the latter being filled with calcite. Above this the break shows the exterior of the siphuncle with the septal ribs. The upper part retains the smooth exterior of the shell on the left side; and on the right side a marginal section with the septa is shown. The apparent irregularity of the septa is due to that of the break, producing the section. A natural section of this specimen is reproduced on the next plate.

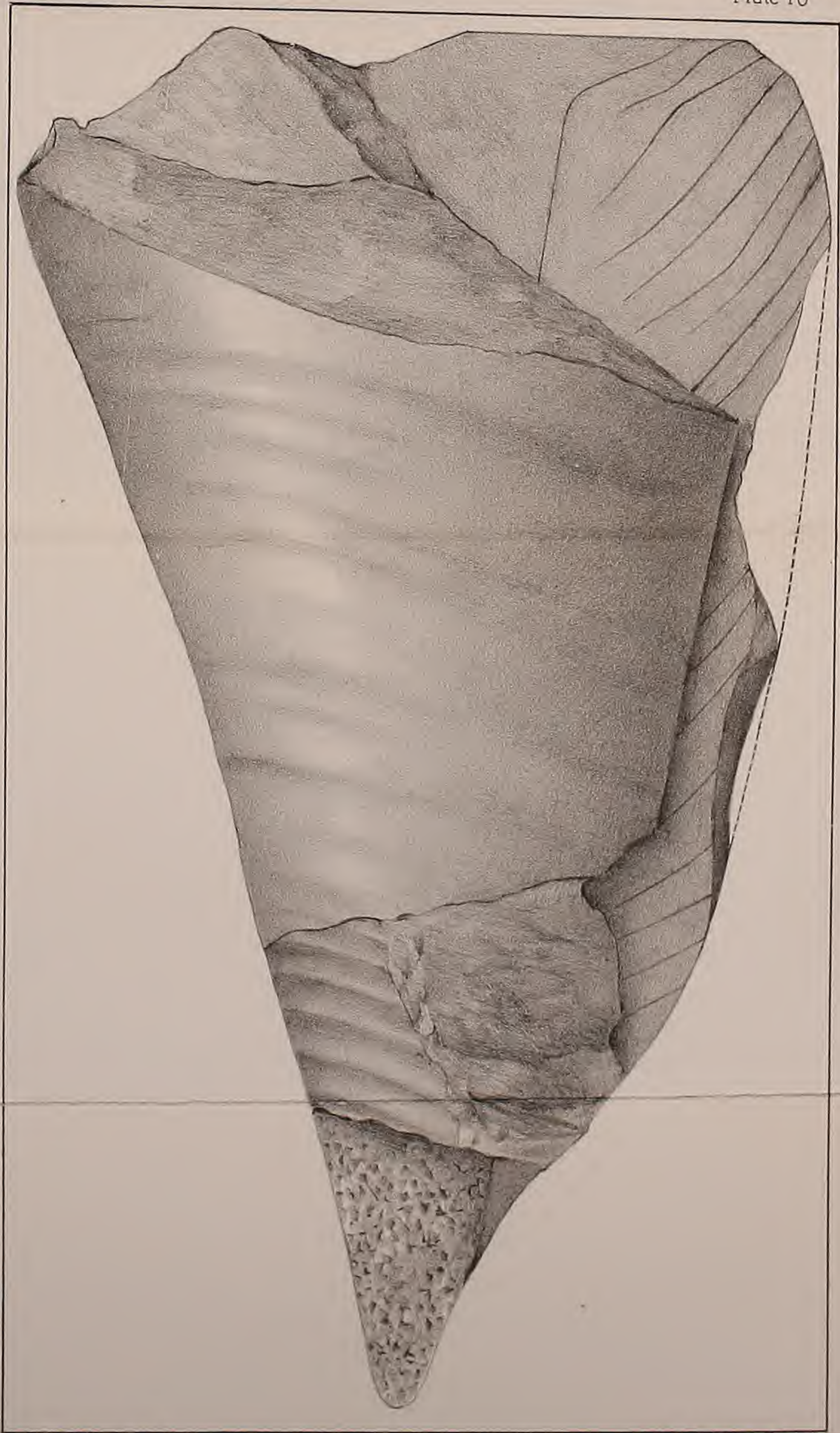
The original is from the Fort Cassin beds at Valcour N. Y., and now in the New York State Museum.

G. S. Barkentin, del.

W. S. Barkentin, lith.

Bull. 90. N. Y. State Museum

Plate 10



G. S. Barkentin. del

W. S. Barkentin. lith.

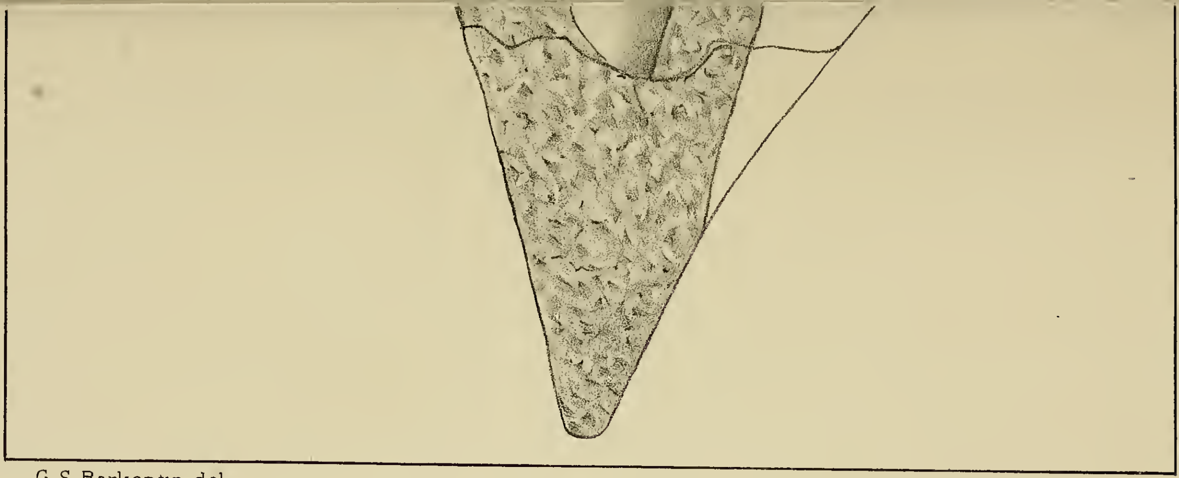
PLATE II

Piloceras explanator Whitfield

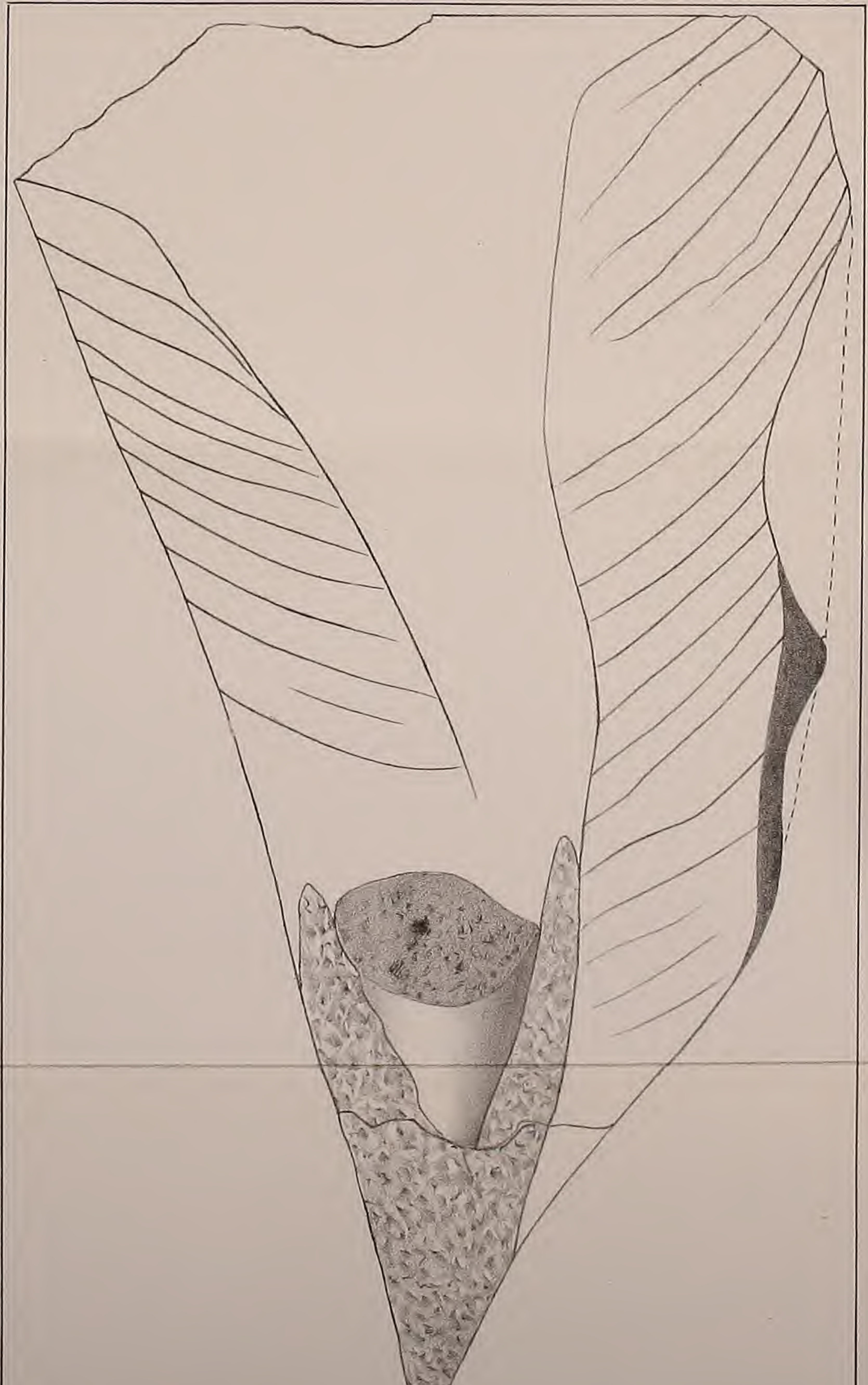
Page 429

See pl. 10

1 Natural section of the specimen reproduced on plate 10, showing the siphuncle and part of the endosiphocone



G. S. Barkentin, del. W. S. Barkentin, lith.



G S Barkentin del. W.S. Barkentin lith.

PLATE 12

Orthoceras modestum sp. nov.

Page 436

1 A natural section showing the siphuncle and the depth of the cameras

2 Specimen retaining a cast of the living chamber and one camera. Shows the size of the living chamber, its anterior contraction, the depth of the septa and of the cameras

3 A living chamber with part of the outer wall, which is not constricted

The original of figure 1 is from the upper Chazy (C_6) of the neighborhood of Chazy; those of figures 2 and 3 are from the dove-colored Chazy limestone (C_1) of the east shore of Valcour island. They are now in the New York State Museum.

Geisonoceras shumardi Billings (sp.)

Page 437

4 A natural section showing the siphuncle and cameras

The original is from the middle Chazy (B_2) of the neighborhood of Chazy N. Y., and now in the New York State Museum.

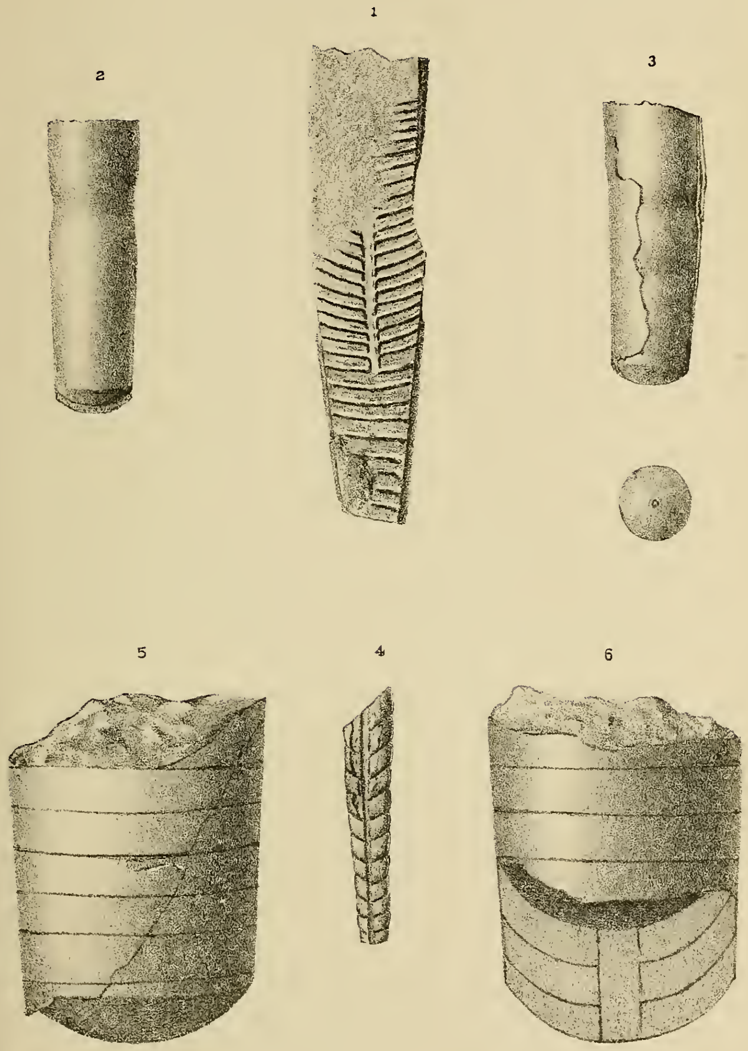
Orthoceras progressum sp. nov.

Page 434

5, 6 Two views of the type; the former showing the rate of growth and the sutures; the latter, in a section, the siphuncle, the depth of the cameras and of the septa

The original is from the dove-colored upper Chazy limestone on the east shore of Valcour island, and now in the New York State Museum.

CEPHALOPODS



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 13

Orthoceras vagum sp. nov.

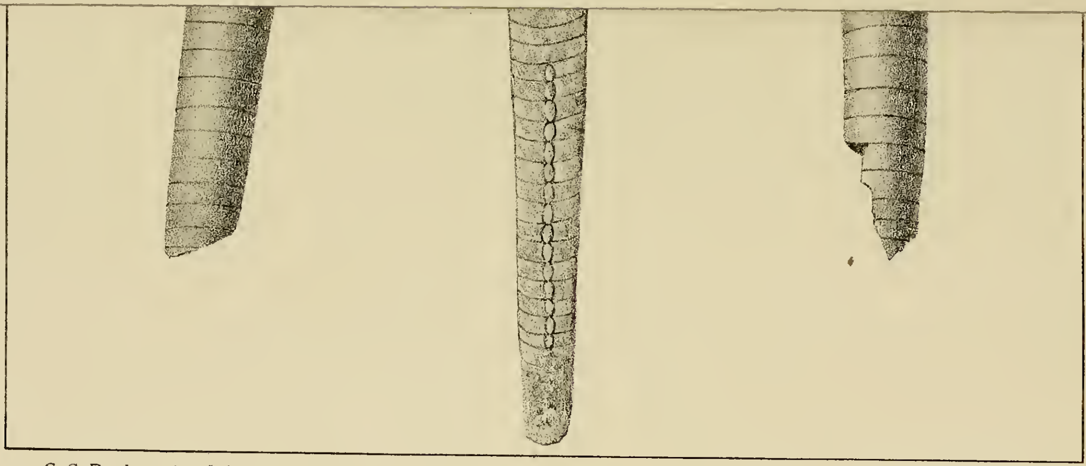
Page 435

See pl. 9, fig. 9

1, 2 Two views of the type specimen showing its irregularly curving form, rate of growth, suture and depth of chambers

3 Natural section of another specimen, showing the siphuncle and depth of septa

The original of figures 1, 2 is from the dove-colored Chazy limestone of the east shore of Valcour island and now in the New York State Museum; that of figure 3 is from the same horizon on Isle La Motte Vt., and now in the American Museum of Natural History in New York.



G S. Barkentin. del. W.S. Barkentin, lith.

G. S. Barkentin del.

W. S. Barkentin, lith.

PLATE 14

Orthoceras lentum sp. nov.

Page 433

1, 3 External view and section of the type

2 Part of the section (x 2) to show more distinctly the character of the siphuncular elements

The original is from the dove-colored Chazy limestone of Little Monty bay and now in the New York State Museum

Spyroceras clintoni Miller (sp.)

Page 445

See pl. 16, fig. 4-7

4 Redrawing of Hall's type of Orthoceras subarcuatum (=Spyroceras clintoni) figured in *Palaeontology of New York,* volume 1, plate 7, figure 3. Shows the composition of the type specimen of fragments of two different species. The original is in the American Museum of Natural History in New York.

Orygoceras cornu-oryx Whitfield (sp.)

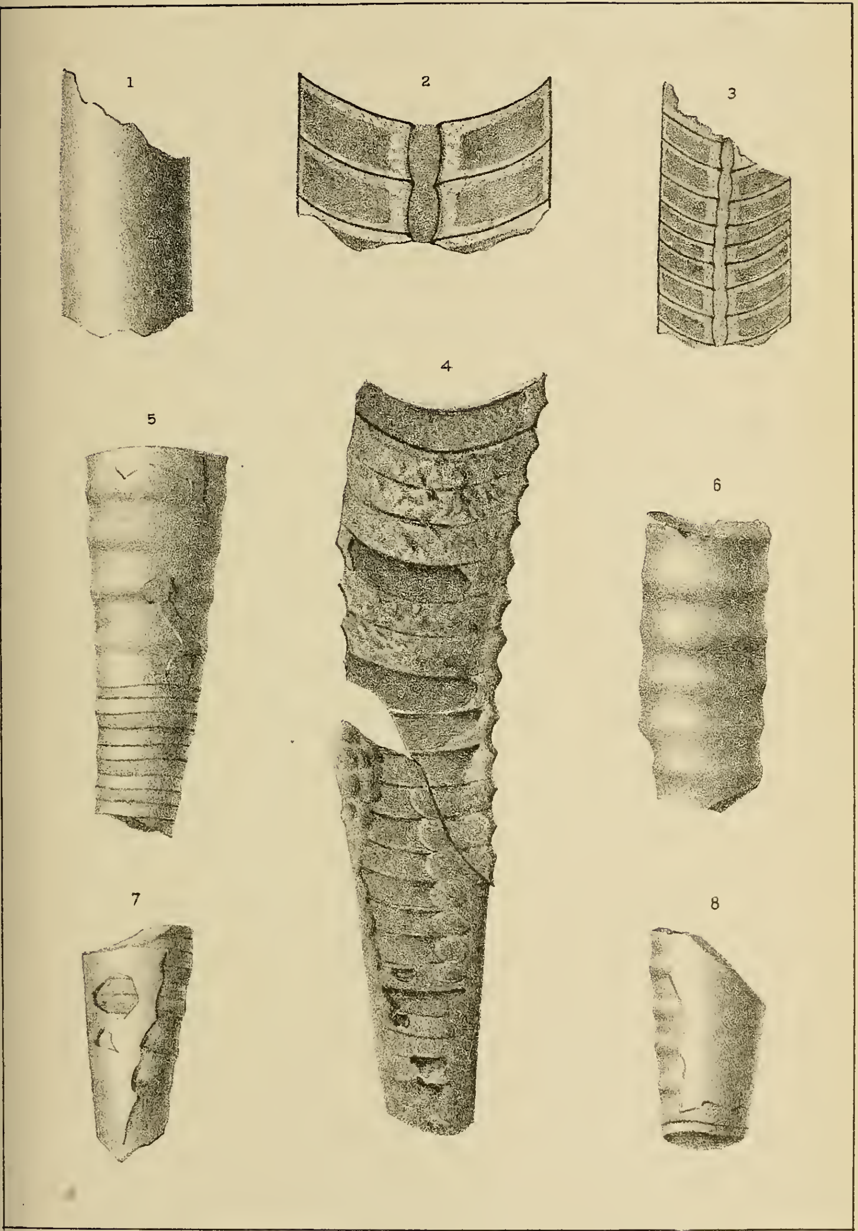
Page 450

5 Fragment showing the regular internal constrictions of the wall of the conch, its rate of growth and the depth of the cameras

6 A specimen with slightly different character of the constrictions

7, 8 Specimen showing the smooth nonannulated outside of the wall.

The originals of figures 5, 7, 8 are from the Fort Cassin beds at Fort Cassin and now in the museum of Burlington University; that of figure 6 is from the same formation (A_3) at Valcour N. Y. and now in the New York State Museum.



G. S. Barkentin, del. W. S. Barkentin lith.

PLATE 15

Protocycloceras lamarcki Billings (sp.)

Page 441

See pl. 16, fig. 1, 2

1 Fragment with narrow annulated and relatively wide interspaces. Drawn from a gutta-percha squeeze

2, 3 Two views of a specimen retaining in part the wall and showing the position and relative size of the siphuncle

4 Natural section of a specimen. The septa are slightly curved in the original.

5 Specimen showing a slight curvature of the conch and a more central position of the siphuncle in the section than the original of figure 3.

6 A longitudinally striated fragment of a conch, found associated with this species and presumably representing the apical part of the same. Drawn from a gutta-percha squeeze

The originals of figures 1 and 6 are from the Beekmantown beds of the Spelman ledge at Beekmantown; those of figures 2–5 from the Fort Cassin beds at Valcour, figures 2, 3, 4 from A_3 of the section, figure 5 from A_5. Originals are now in the New York State Museum.

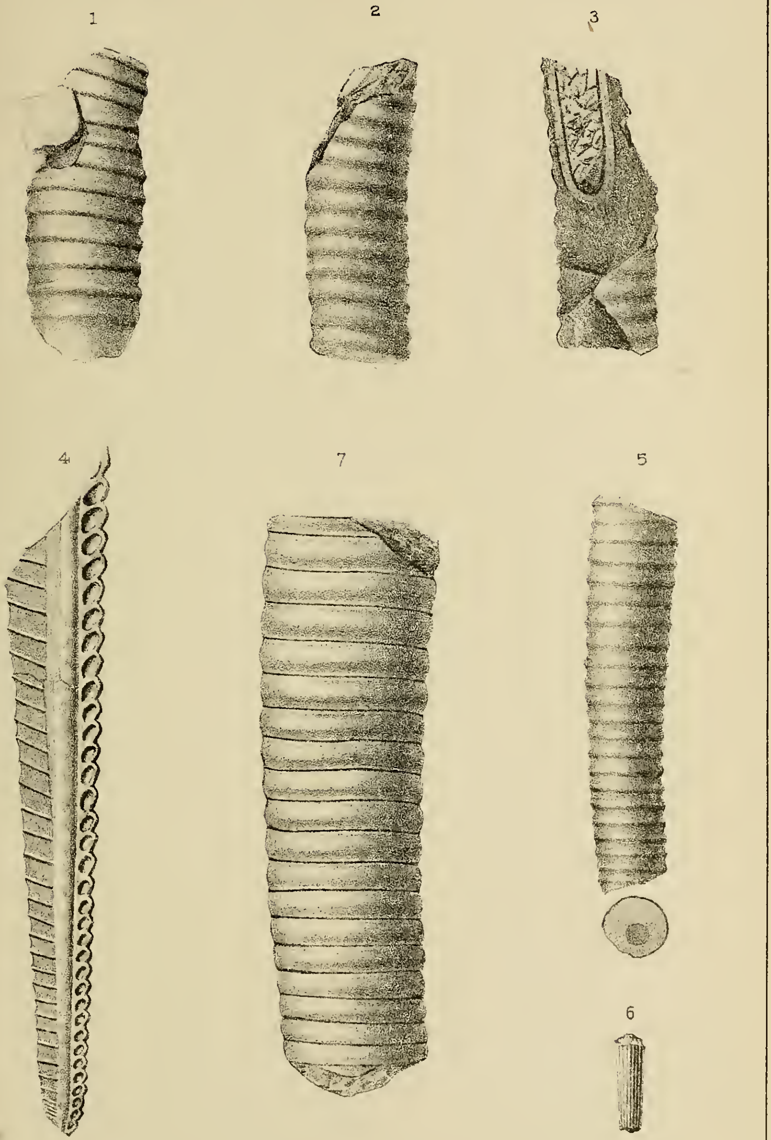
Protocycloceras whitfieldi sp. nov.

Page 443

7 The type of the species. A section of the same is reproduced in text figure 17.

The original is from the Fort Cassin beds at Fort Cassin and now in the museum of Burlington University.

CEPHALOPODS



G.S. Barkentin, del.

W.S. Barkentin, lith.

PLATE 16

Protocycloceras lamarcki Billings (sp.)

Page 441

See pl. 15, fig. 1-5

1 A specimen retaining the surface sculpture

2 Enlargement (x 3) of a portion of the sculpture of the same specimen to show the alternation of striae

The original is from the Fort Cassin beds at Fort Cassin and now in the New York State Museum.

Protocycloceras (?) cf. furtivum Billings (sp.)

Page 445

3 A fragment showing the oblique direction of the annulations. Drawn from a gutta-percha squeeze.

The original is from the Beekmantown beds at the Spelman ledge near Beekmantown N. Y. and now in the New York State Museum.

Spyroceras clintoni Miller (sp.)

Page 445

See pl. 14, fig. 4

4 Natural section of a fragment, showing the curvature of the conch and the depth of the cameras and of the septas. The siphuncle is shown in the lower part

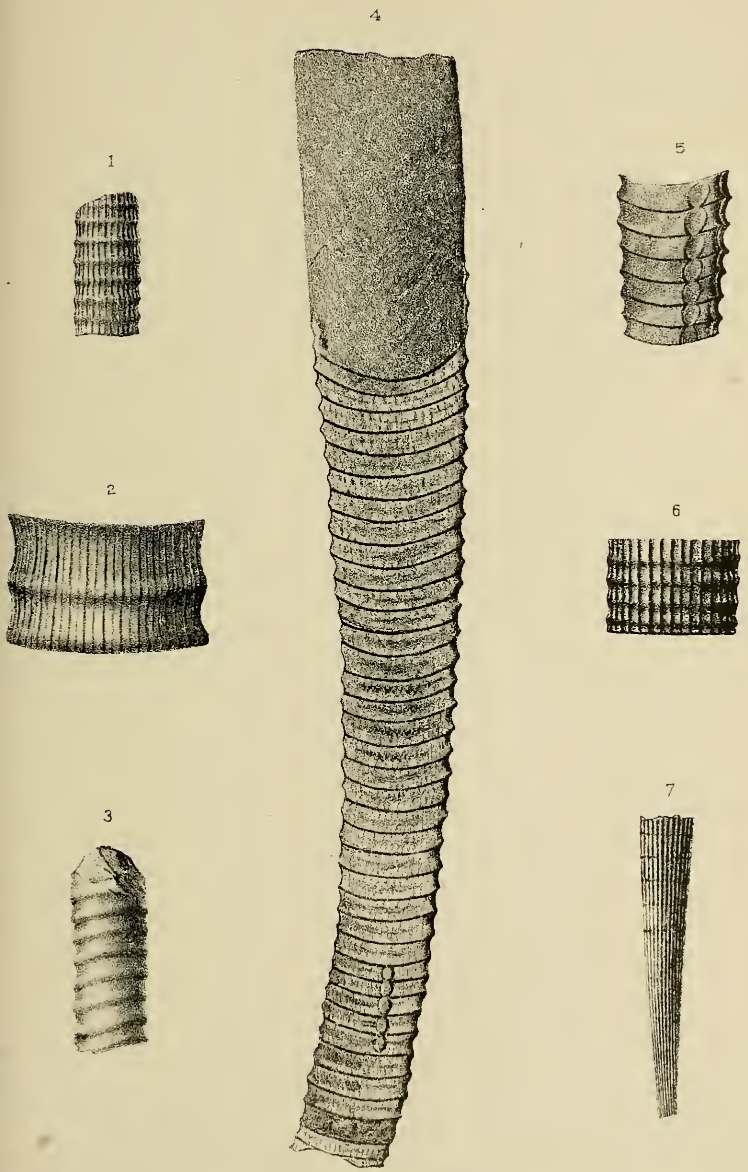
5 Natural section of a fragment showing the position of the siphuncle and the oblique direction of its inflations

6 Surface sculpture of a fragment. Faint alternating longitudinal lines are not brought out in the drawing

7 Apical part of a conch

The originals of figures 4, 6, 7 are from the dove-colored Chazy limestone near Little Monty bay; that of figure 5 is from the middle Chazy beds of the west shore of Valcour island. All are now in the New York State Museum.

CEPHALOPODS



G.S. Barkentin, del W.S. Barkentin, lith.

PLATE 17

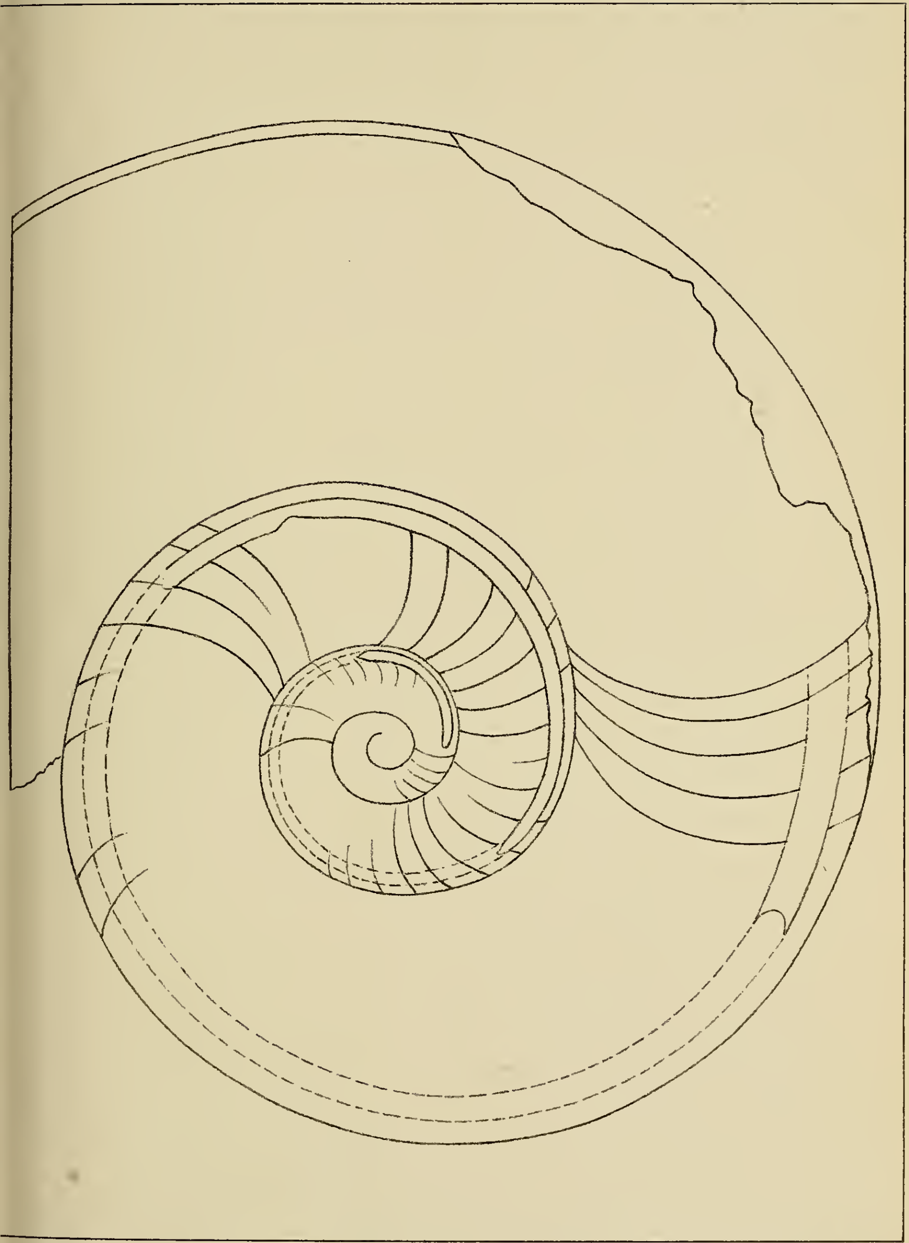
Eurystomites kelloggi Whitfield (sp.)

Page 456

See pl. 18, fig. 1

1 Section of a mature specimen

The original is from bed A_3 of the Fort Cassin beds at Valcour N. Y., and now in the New York State Museum.



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 18

Eurystomites kelloggi Whitfield (sp.)

Page 456

See pl. 17, fig. 1

1 Fragment of shell showing the coarse striae and rugae of the surface. The fragment is in a crushed condition. It comes from bed A_3 of the Fort Cassin beds (Beekmantown formation) at Valcour, and is now in the New York State Museum.

Eurystomites accelerans sp. nov.

Page 460

2 Lateral view of the type

3 View of a part of the flat ventral side of the same specimen

The original is from the Fort Cassin beds (A_3) of the Valcour section and now in the New York State Museum.

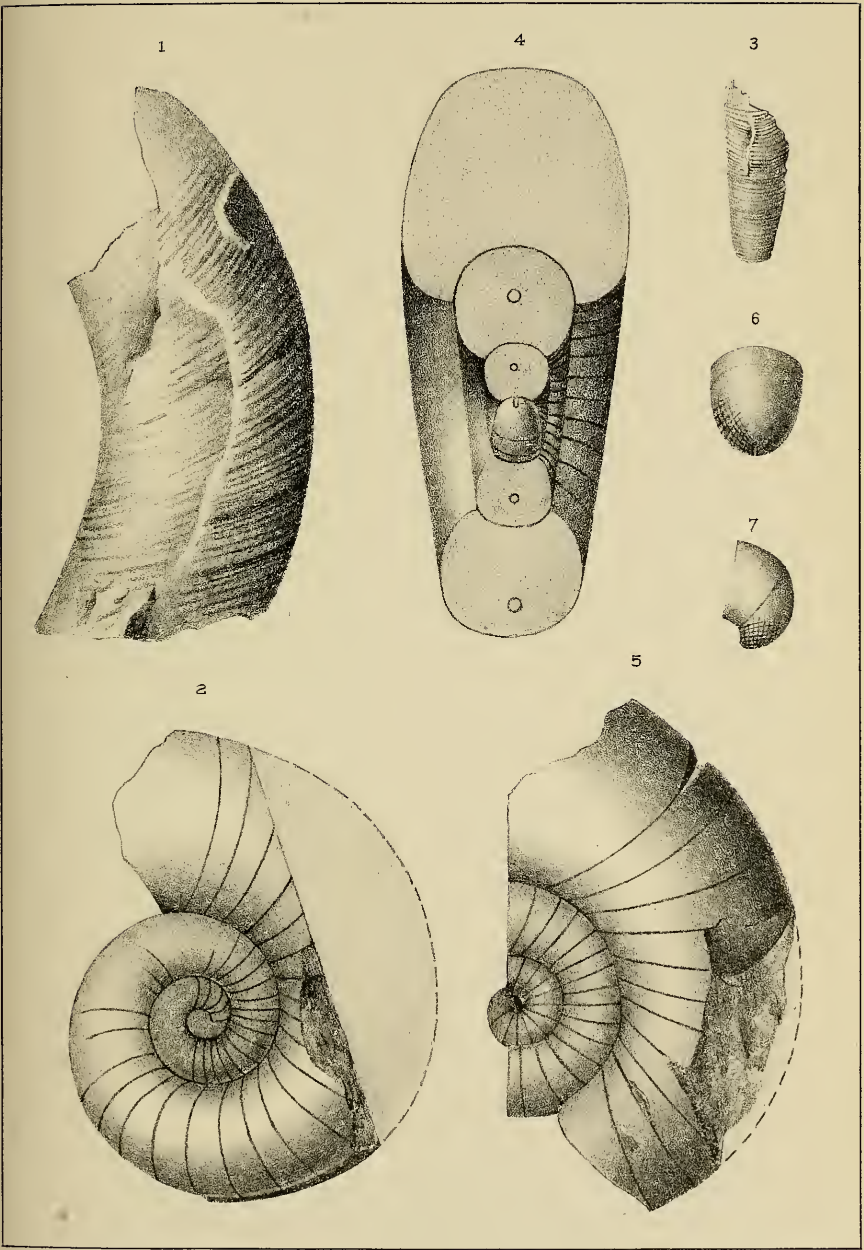
Eurystomites amplectens sp. nov.

Page 461

4, 5 Two views of the type. Figure 4 slightly restored in the lower part

6, 7 Two views of the first chamber with the cicatrix and surface sculpture

The original is from the Fort Cassin beds (A_5) of the Valcour section and now in the New York State Museum.



G.S. Barkentin, del. W.S. Barkentin, lith.

PLATE 19

Tarphyceras seelyi Whitfield (sp.)

Page 465

See pl. 20, fig. 5; pl. 21; pl. 24, fig. 3

1 Transverse section of a specimen, obtained by fracturing and showing the septa and siphonal perforations. A lateral view of this specimen is shown on plate 24, figure 3.

2 Lateral view of a living chamber. The posterior part is partly crushed

The originals are from the Fort Cassin beds (A_3) of Valcour N. Y., and now in the New York State Museum.

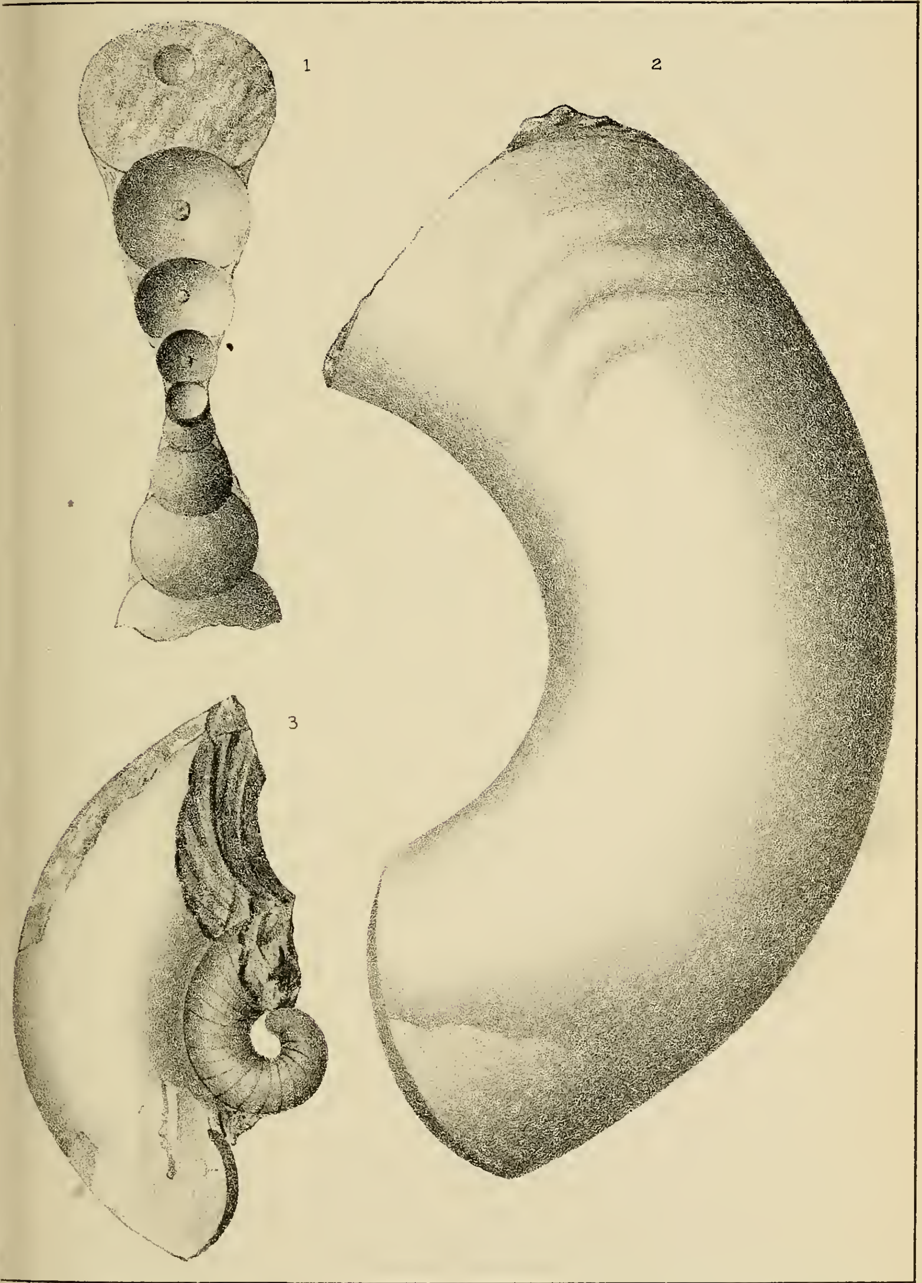
Tarphyceras multicameratum sp. nov.

Page 472

See pl. 23, fig. 2

3 The early volutions of the type specimen, the other side of which is shown on plate 23, figure 2

The original is from the dove-colored Chazy limestone of Isle La Motte and now in the museum of Burlington University.



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 20

Schroederoceras cassinense Whitfield (sp.)

Page 476

1, 2 Ventral view, showing the strong development of the ventral and lateral faces and section of the same specimen

Schroederoceras eatoni Whitfield (sp.)

Page 476

See pl. 23, fig. 1

3 Longitudinal section of a specimen

4 Transverse section of a fragment

Tarphyceras seelyi Whitfield (sp.)

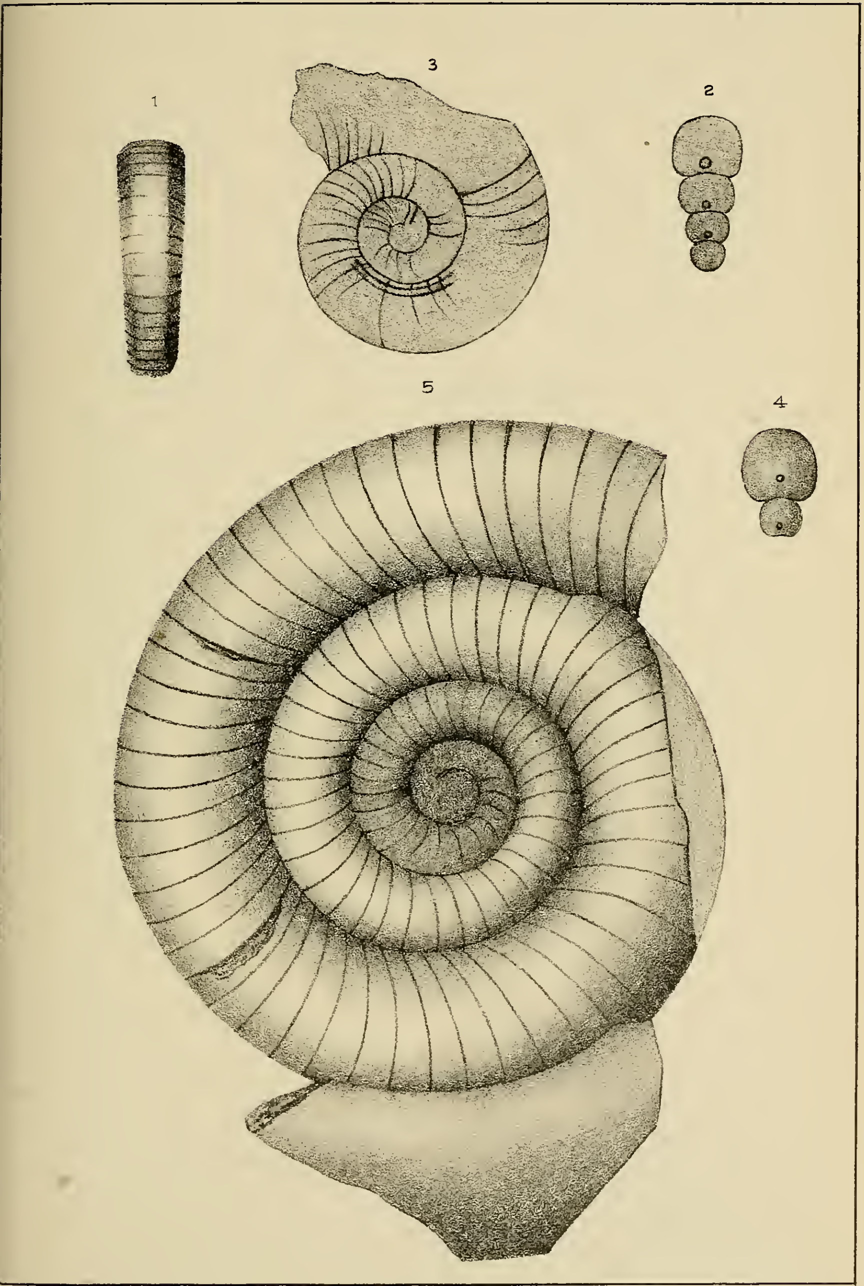
Page 465

See pl. 19, fig. 1, 2; pl. 21, fig. 1; pl. 24, fig. 3

5 Lateral view of a well preserved specimen showing the earlier volutions

All originals of this plate are from the Fort Cassin beds (A_3) of Valcour N. Y. and now in the New York State Museum.

CEPHALOPODS



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 21

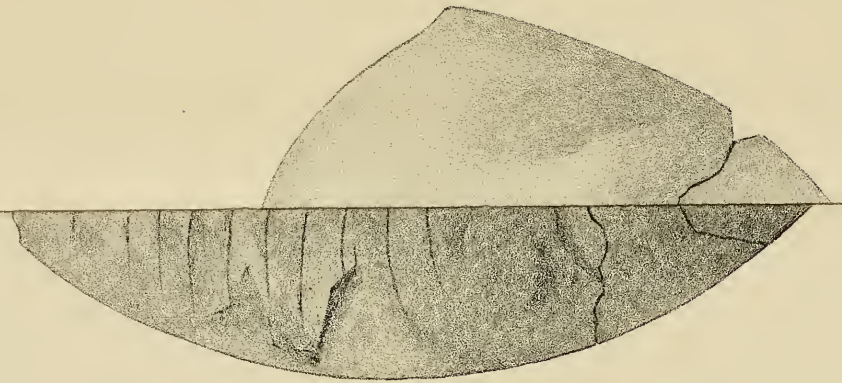
Tarphyceras seelyi Whitfield (sp.)

Page 465

See pl. 19, fig. 1, 2; pl. 20, fig. 5; pl. 24, fig. 3

1 Exterior view of a large, mature, somewhat weathered specimen, showing the absence of gerontic evolution of the whorls and the rate of growth

The original is from the Fort Cassin beds at Valcour N. Y. (A_3 of section on page 397) and now in the New York State Museum.

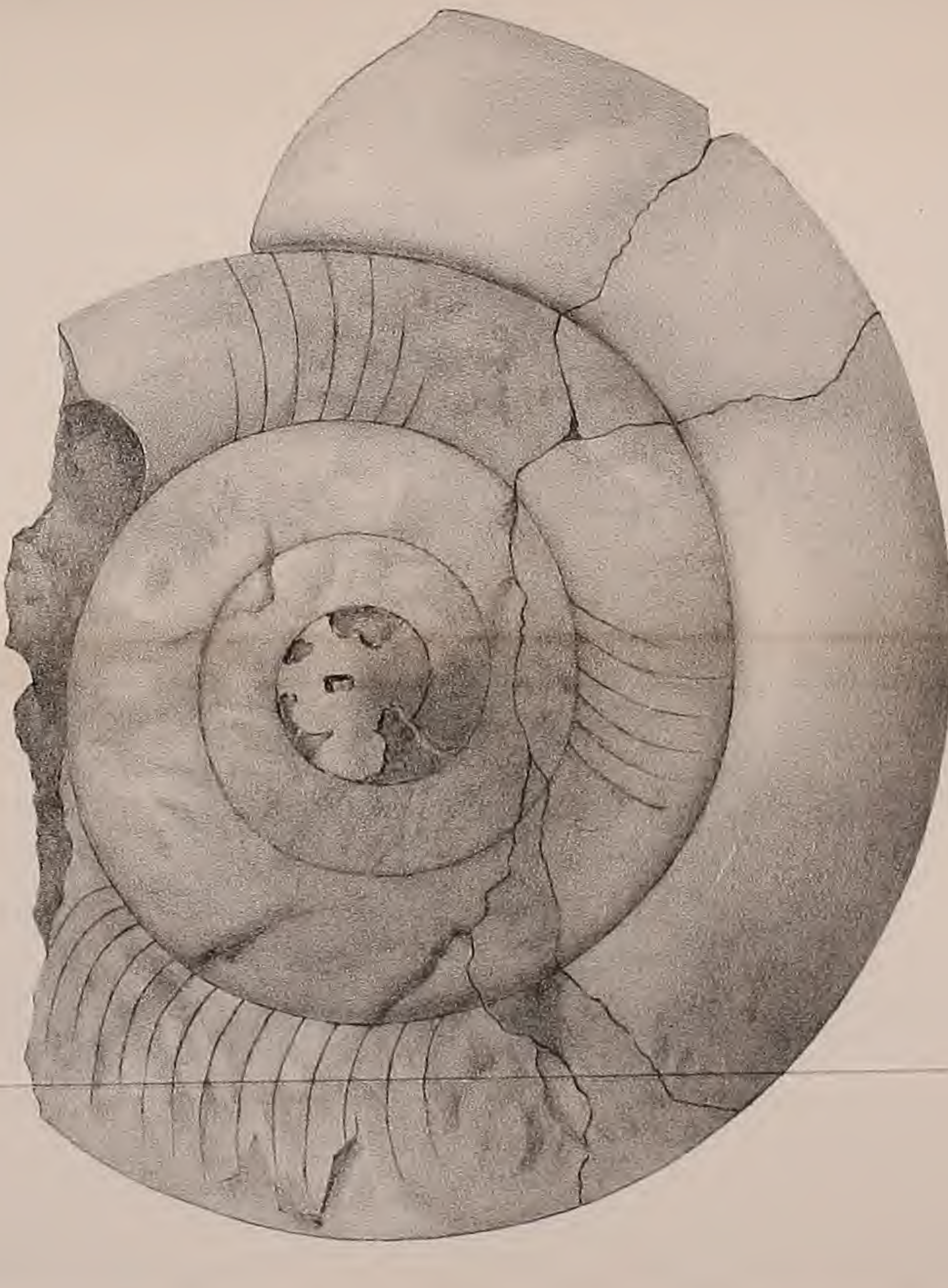


G.S. Barkentin. del.

W.S. Barkentin, lith.

Bull. 90 N.Y. State Museum

Plate 21



G. S. Barkentin del. W.S. Barkentin lith.

PLATE 22

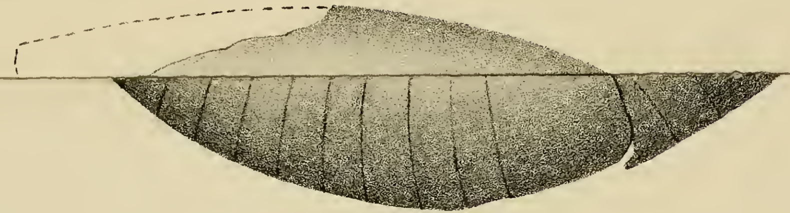
Tarphyceras clarkei sp. nov.

Page 470

1 Exterior view of the type, showing its rate of growth, smooth exterior and evolute gerontic volution

The original is from the Fort Cassin beds at Valcour N. Y. (A_3 of the section on page 397) and now in the New York State Museum.

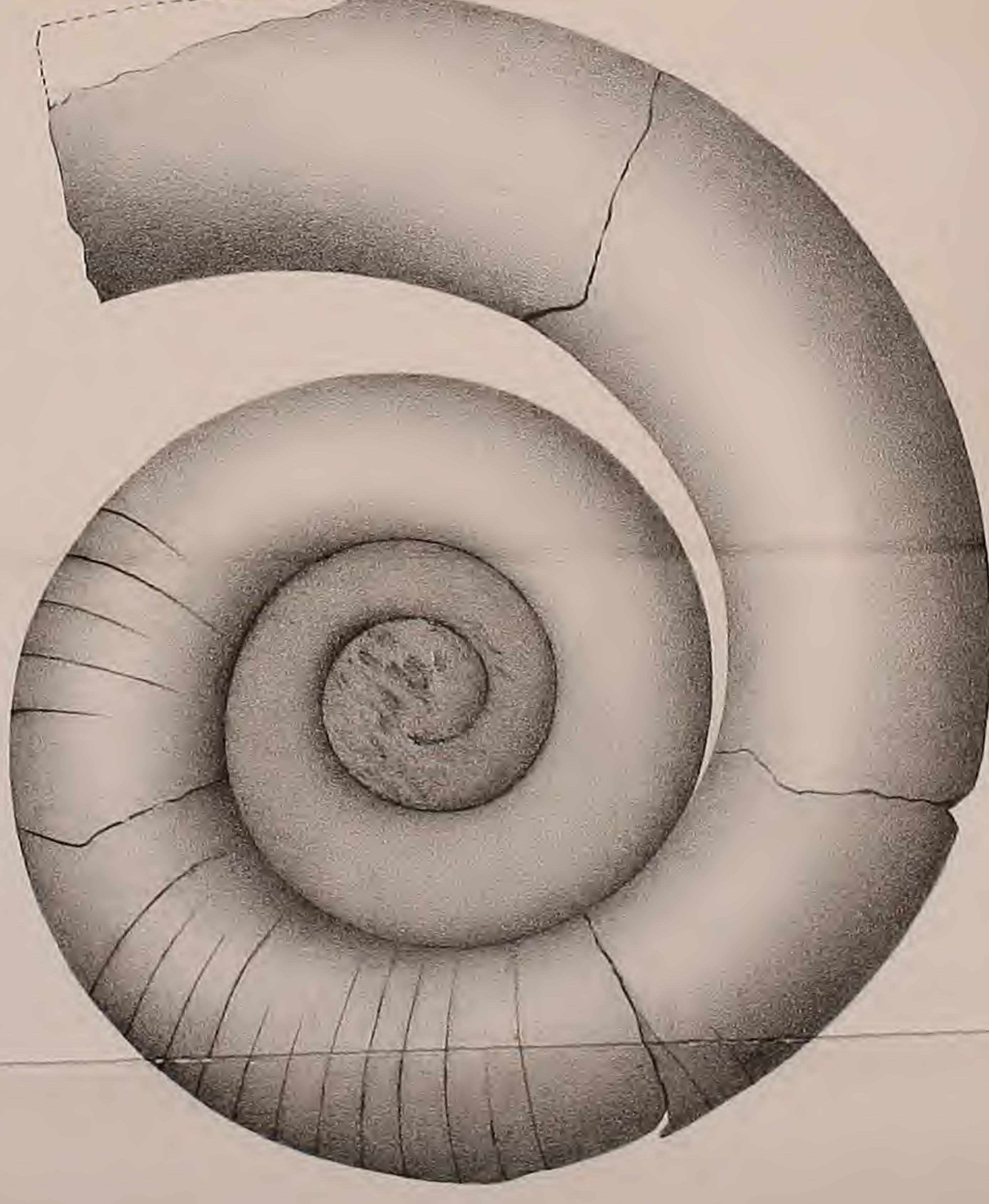
CEPHALOPODS



G S. Barkentin del. W.S. Barkentin, lith.

Bull.90. N.Y. State Museum.

Plate 22



G.S. Barkentin del.

W.S. Barkentin, lith.

PLATE 23

Schroederoceras eatoni Whitfield (sp.)

Page 476

See pl. 20, fig. 3, 4

1 Lateral view of a perfect specimen showing the entire phragmocone, the gerontic living chamber and the surface sculpture

The original is from the Fort Cassin beds at Fort Cassin and now in the museum of Burlington University.

Tarphyceras multicameratum sp. nov.

Page 472

See pl. 19, fig. 3

2 Natural section of the type, retaining part of the gerontic living chamber and part of the exterior. The inner volutions of this specimen are shown on plate 19, figure 3.

The original is from the dove-colored Chazy limestone of Isle La Motte and now in the museum of Burlington University.

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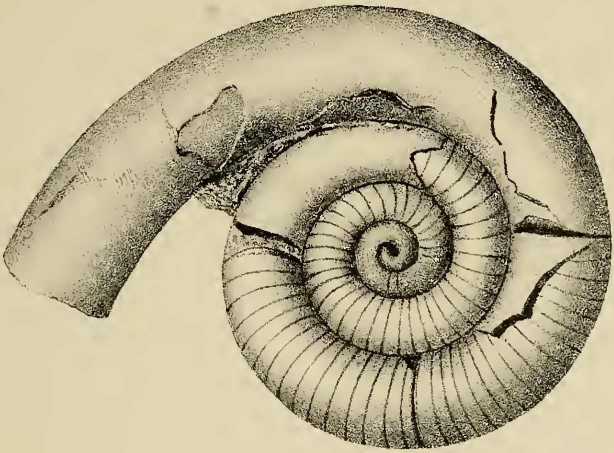

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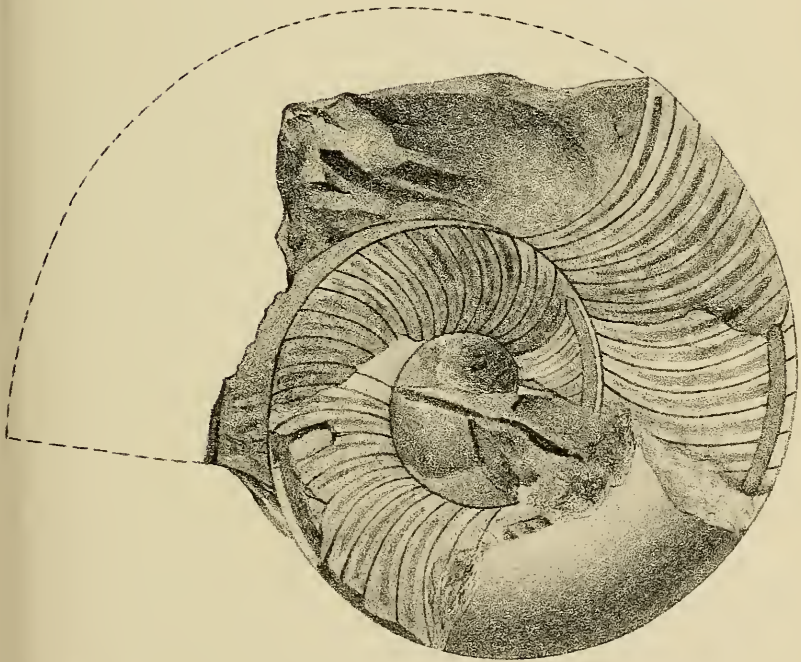


G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 24

Plectoceras jason Billings (sp.)

Page 484

See pl. 29; 30; 31

1 Ventral view of a specimen showing the recurving costae and transverse lines

The original is from the lower Chazy beds at Valcour (B_4 of section) and now in the New York State Museum.

Trocholites internestriatus Whitfield (sp.)

Page 479

2 Lateral view of a specimen which shows the surface sculpture of the first volution of the smooth shell of the earliest nepionic stage, the transverse striation of the later nepionic stage and the abrupt appearance of the ribbing with the neanic stage [*see* text fig. 38]

The original is from the Beekmantown (Fort Cassin beds) of Fort Cassin and now in the museum of Burlington University.

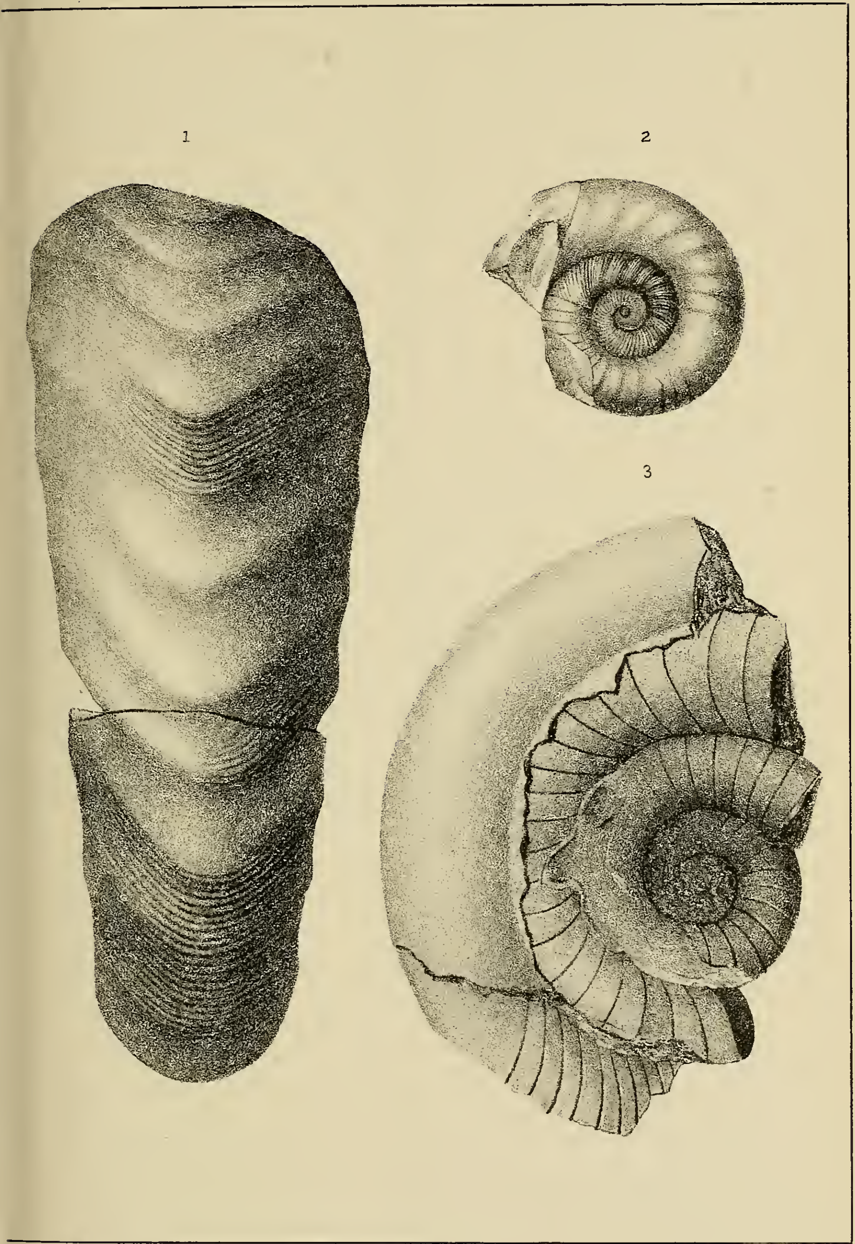
Tarphyceras seelyi Whitfield (sp.)

Page 465

See pl. 19, fig. 1; pl. 20, fig. 5; pl. 21

3 Specimen retaining part of the outer wall. A transverse section of this specimen is shown on plate 19, figure 1

The original is from the Beekmantown (Fort Cassin beds A_3) of Valcour N. Y., and now in the New York State Museum.



G. S. Barkentin, del. W.S. Barkentin. lith.

PLATE 25

Deltoceras vaningeni sp. nov.

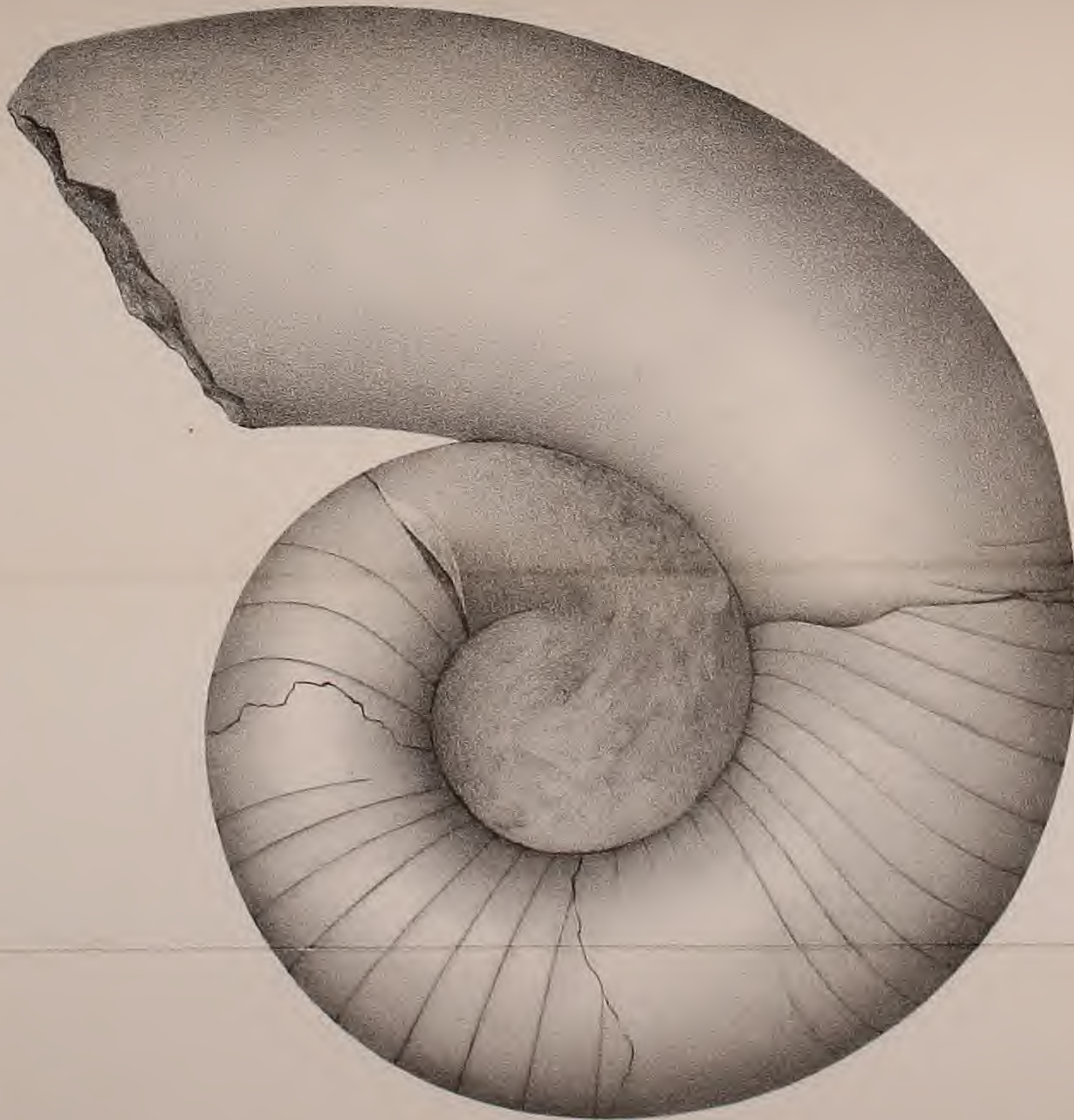
Page 480

See pl. 26, 27, 28

1 Exterior view of the type; showing the rate of growth, the depth of chambers, direction of sutures and evolution of the gerontic living chamber

The original is from the lower Chazy limestone (B_4 of the section on page 398) at the Valcour shore and now in the New York State Museum.

G. S. Barkentin. del. W. S. Barkentin. lith.



G. S. Barkentin. del W. S. Barkentin. lith

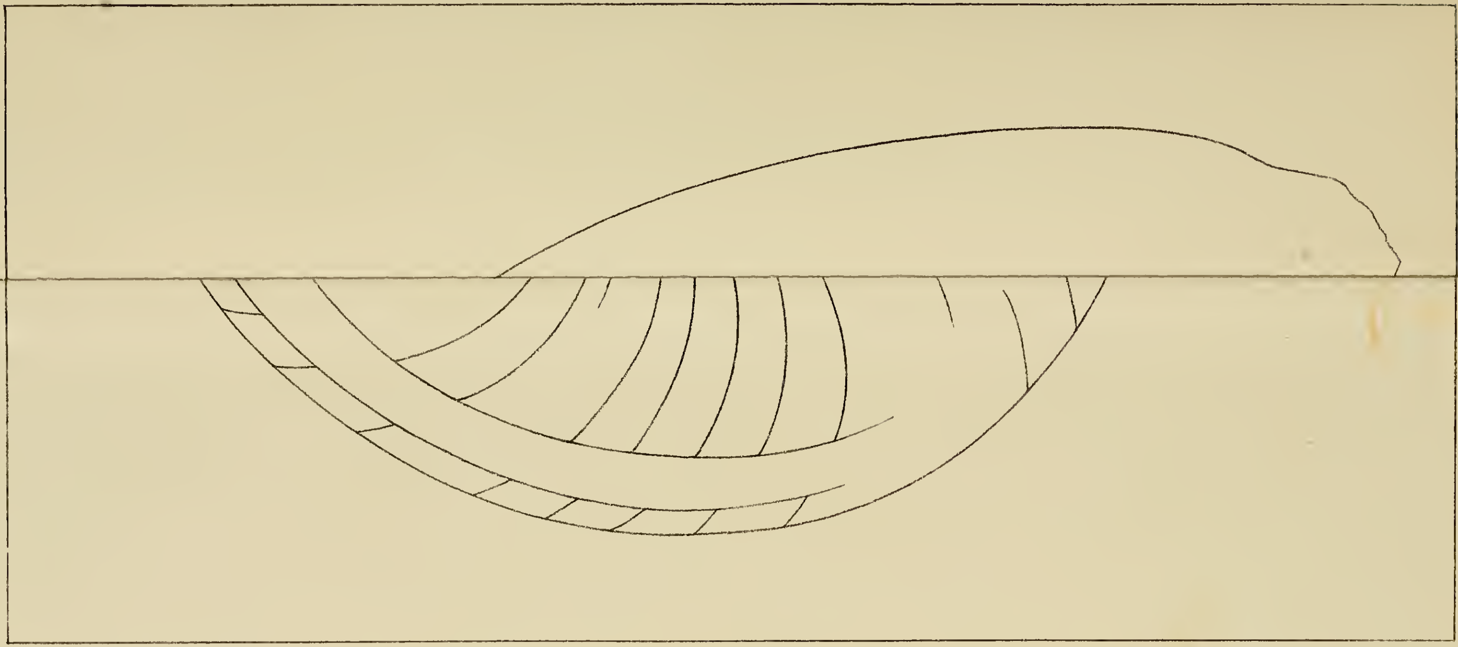
PLATE 26

Deltoceras vaningeni sp. nov.

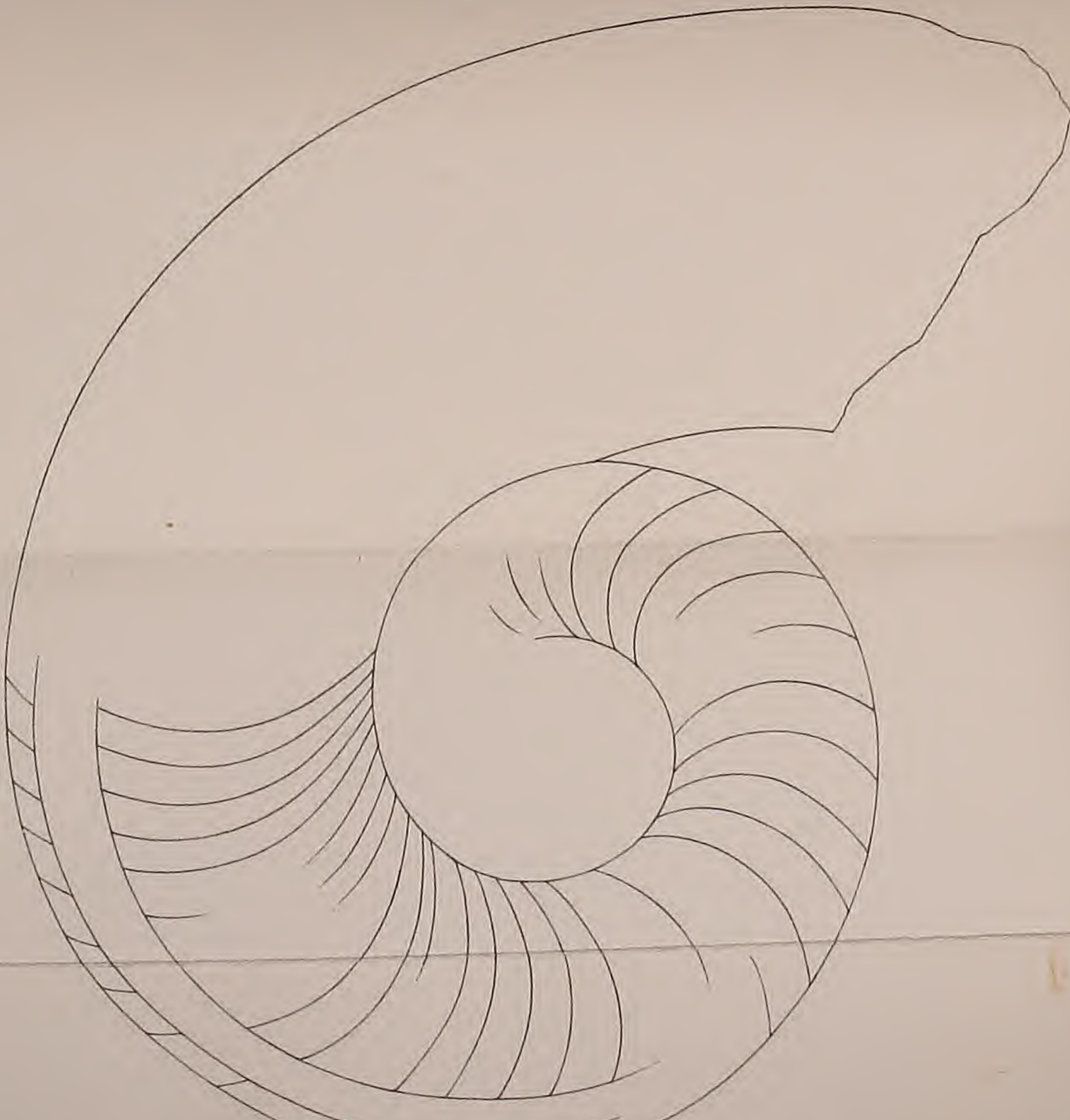
Page 480

See pl. 25, 27, 28

1 Section of the type, reproduced on plate 25, showing the depth of the chambers and septa; and the final position and size of the siphuncle



G. S. Barkentin, del. W. S. Barkentin, lith.



G. S. Barkentin del.
W. S. Barkentin, lith.

PLATE 27

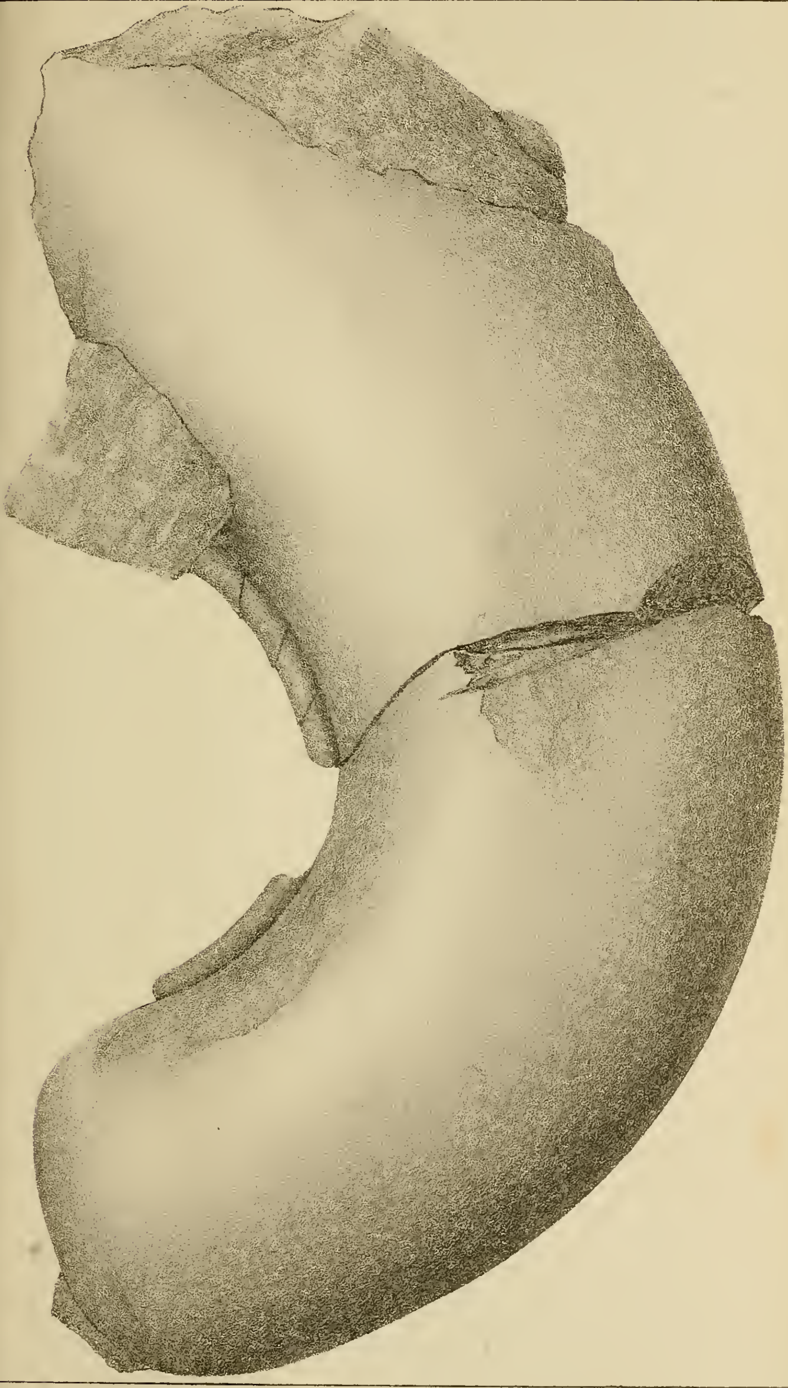
Deltoceras vaningeni sp. nov.

Page 480

See pl. 25, 26, 28

1 Living chamber with adhering siphuncle of the preceding volution showing the marginal position of the same

The original is from the lower Chazy limestone (C_1 of section on page 398) at the Valcour shore and now in the New York State Museum.



G S. Barkentin. del. W.S. Barkentin. lith.

PLATE 28

Deltoceras vaningeni sp. nov.

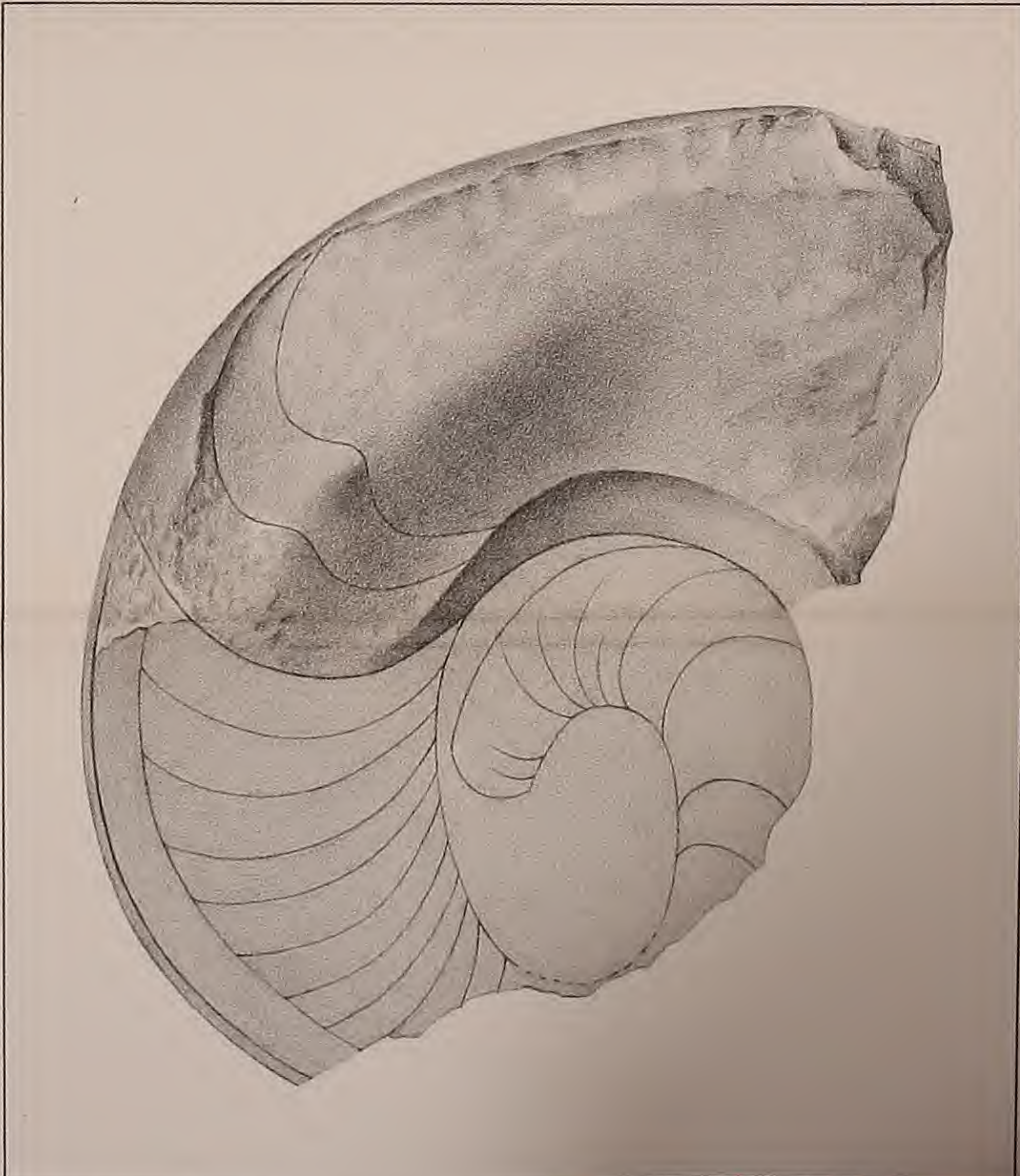
Page 480

See pl. 25, 26, 27

1 A specimen exhibiting part of an inner volution in somewhat oblique section and showing the position of the siphuncle

The original is from the lower Chazy limestone (B_7 of the section on page 398) at the Valcour shore and now in the New York State Museum.

Bull. 90 N.Y. State Museum Plate 28



G. S. Barkentin. del. W.S. Barkentin. lith.

PLATE 29

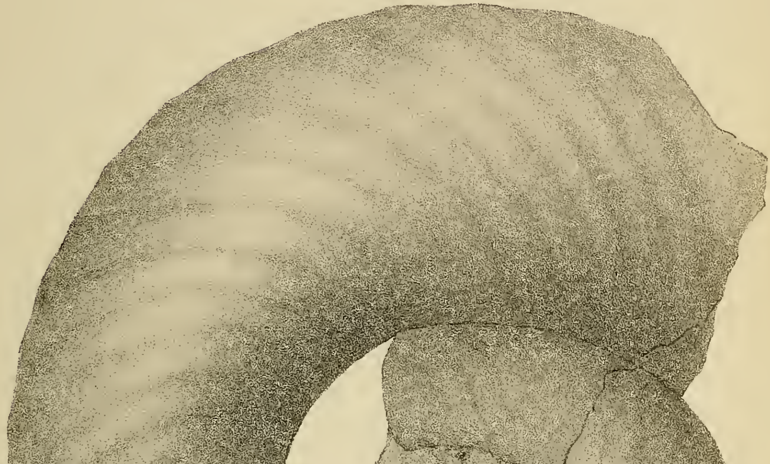
Plectoceras jason Billings (sp.)

Page 484

See pl. 30; 31

1 Exterior view of a large specimen, exhibiting the rate of growth and costae

The original is from the lower Chazy limestone (B_4 of the section on page 398) at the Valcour shore and now in the New York State Museum.



G.S Barkentin.del. W.S. Barkentin.lith.

PLATE 30

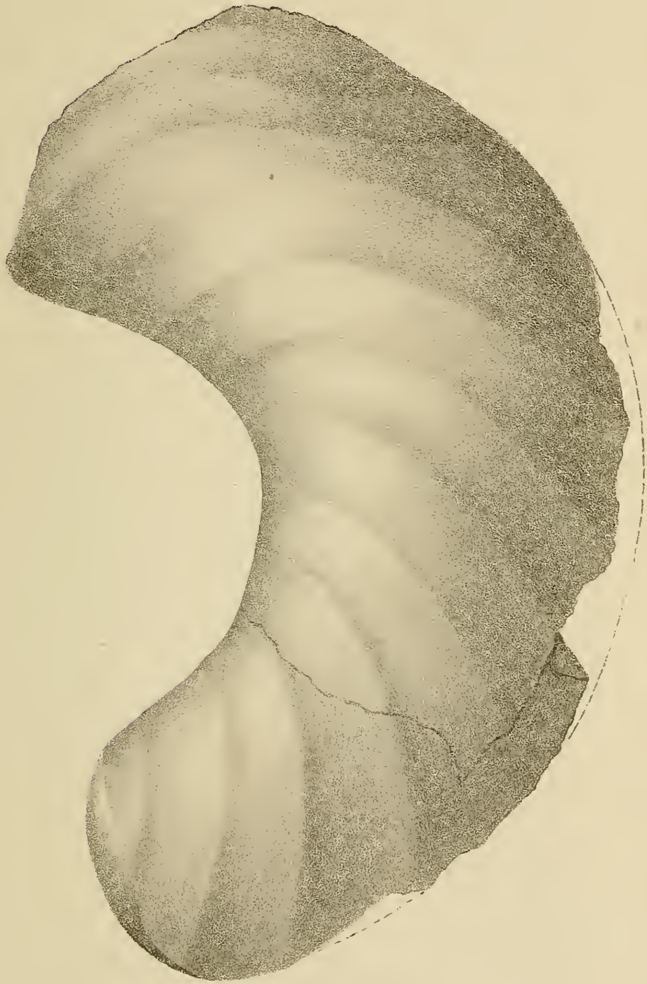
Plectoceras jason Billings (sp.)

Page 484

See pl. 29 ; 31

1 Exterior view of a gerontic living chamber with very distant costae

The original is from the lower Chazy limestone (B_4 of the section on page 398) at the Valcour shore and now in the New York State Museum.



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 31

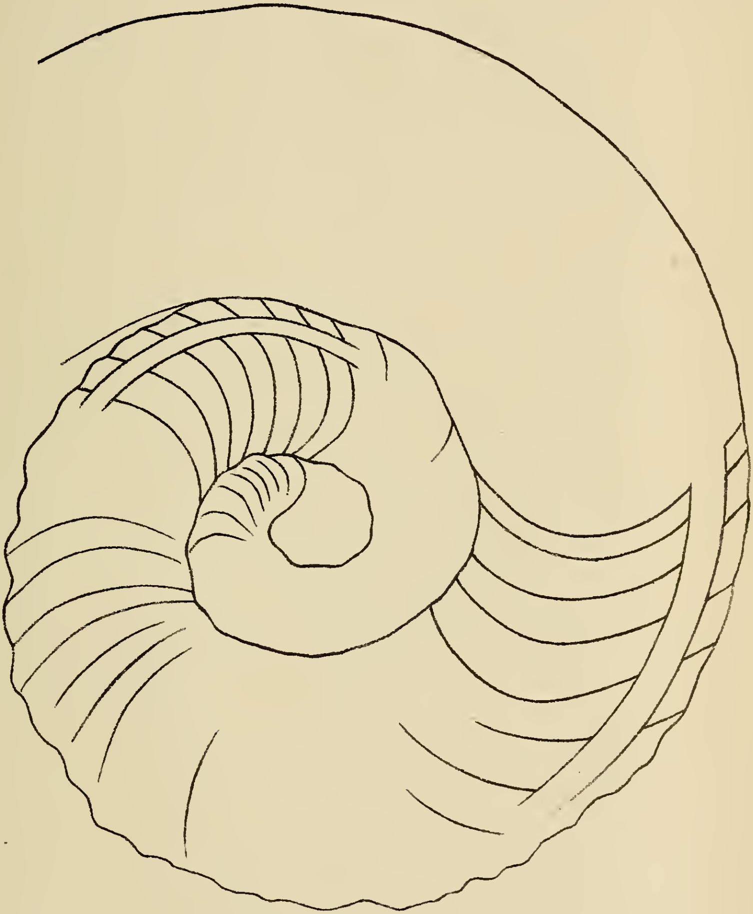
Plectoceras jason Billings (sp.)

Page 484

See pl. 29, 30

1 Section of the specimen reproduced on plate 29, showing the position of the siphuncle and the depth of the cameras and septa.

CEPHALOPODS



R. Ruedemann, del. W. S. Barkentin, lith.

PLATE 32

Barrandeoceras natator Billings (sp.)

Page 454

See pl. 33

1 Exterior view of a large specimen, showing the rate of growth, the costation of the younger stages and the evolute direction of the gerontic volution

The original is from the dove-colored Chazy limestone on the east shore of Valcour island, and now in the New York State Museum.

Bull. 90 N.Y

W.S.Bark

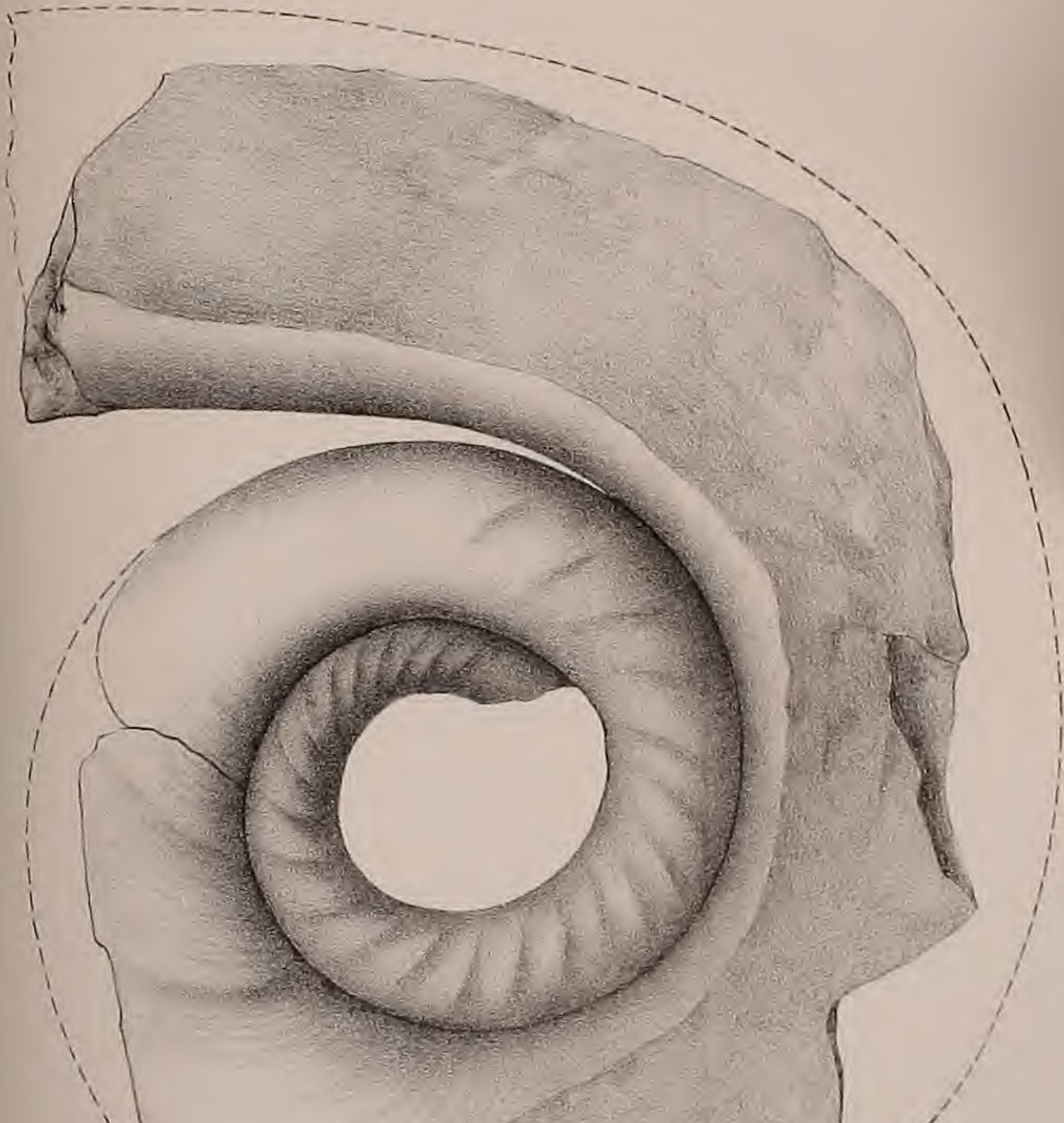


PLATE 33

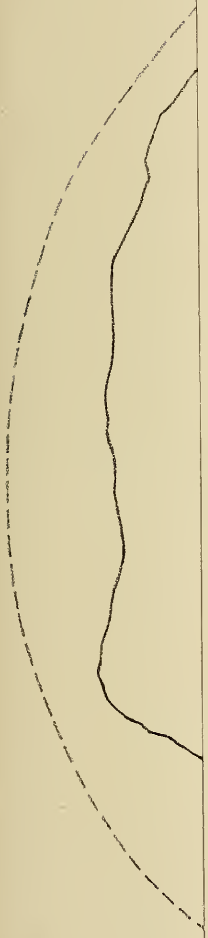
Barrandeoceras natator Billings (sp.)

Page 454

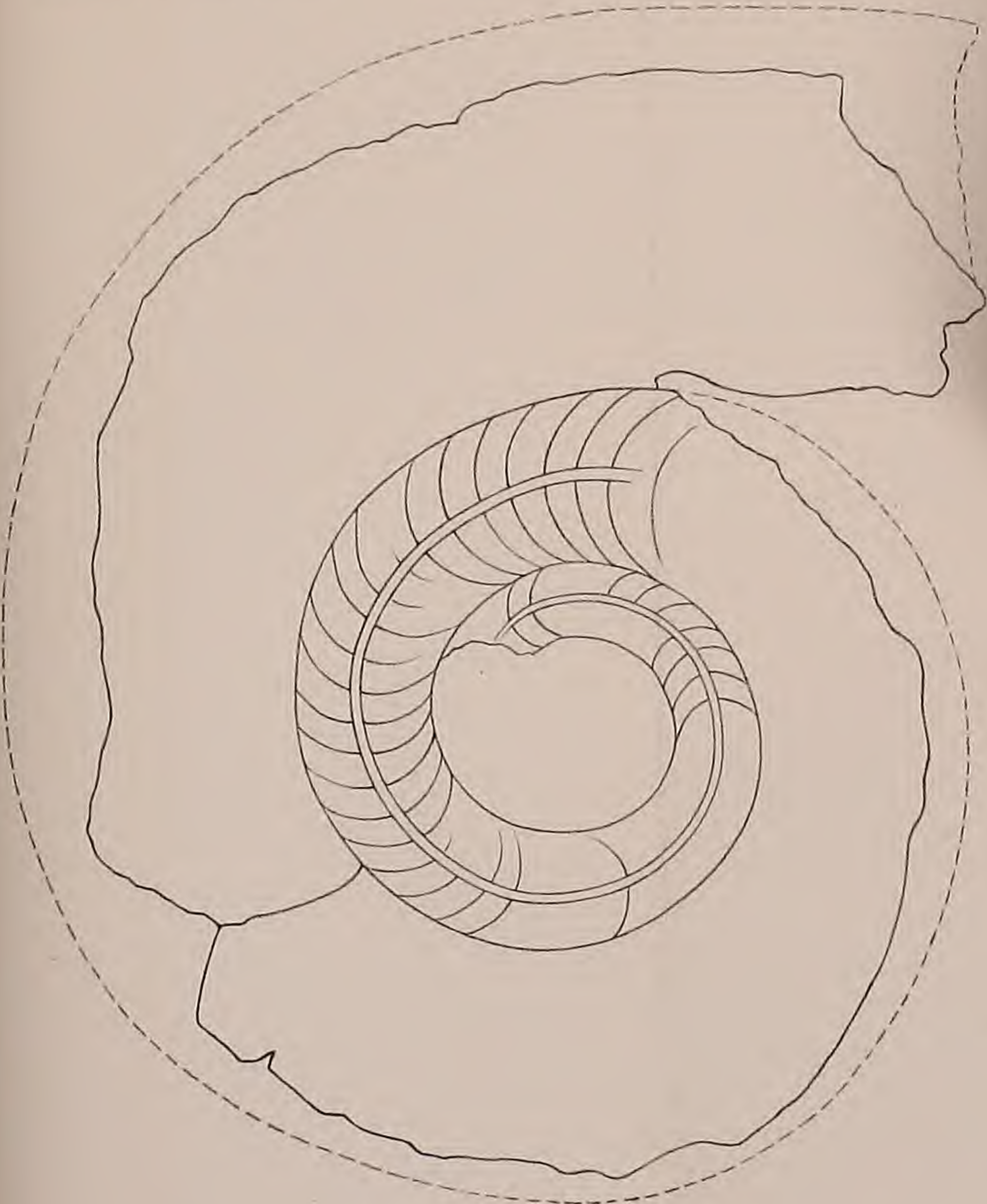
See pl. 32

1 Section of the specimen reproduced on plate 32, showing the depth of the cameras and of the septa, and the size and position of the siphuncle. Crushed septa extend in the original as far as the single septum in the middle of the last volution where the living chamber apparently began.

Bull.90 N.Y.



R.Ruedemann



R. Ruedemann, del.

W. S. Barkentin, lith.

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PLATE 34

Oncoceras pristinum sp. nov.

Page 503

1 Natural section of specimen showing cameras, siphuncle and living chamber

2 Natural, slightly oblique section of another specimen

The originals are from the upper Chazy limestone (C_6 of Brainerd and Seely's section) at Chazy village, and now in the New York State Museum

Cyrtactinoceras champlainense sp. nov.

Page 491

See pl. 36, fig. 1, 2

3 Section of a specimen, showing the shallow chambers and septa and the small nummuloidal siphuncle. The straight bounding lines of the siphuncle have been drawn in by error

The original is from the dove-colored Chazy limestone west of Little Monty bay, south of Chazy N. Y., and now in the New York State Museum.

Ooceras (?) perkinsi sp. nov.

Page 4 9

4, 5 Two views of the type (*see* section of same in text figure 53).

The original is supposed to have come from the dove-colored upper Chazy limestone (see page 401) of Isle La Motte and is now in the museum of Burlington University.

Loxoceras moniliforme Hall (sp.)

Page 487

6 Reproduction of the type of the species, illustrated in *Palaeontology of New York,* volume 1, plate 7, figure 5, where the septa are not shown and the siphuncle is wrongly figured

7 A specimen showing the exterior of the wall and the submarginal position of the siphuncle

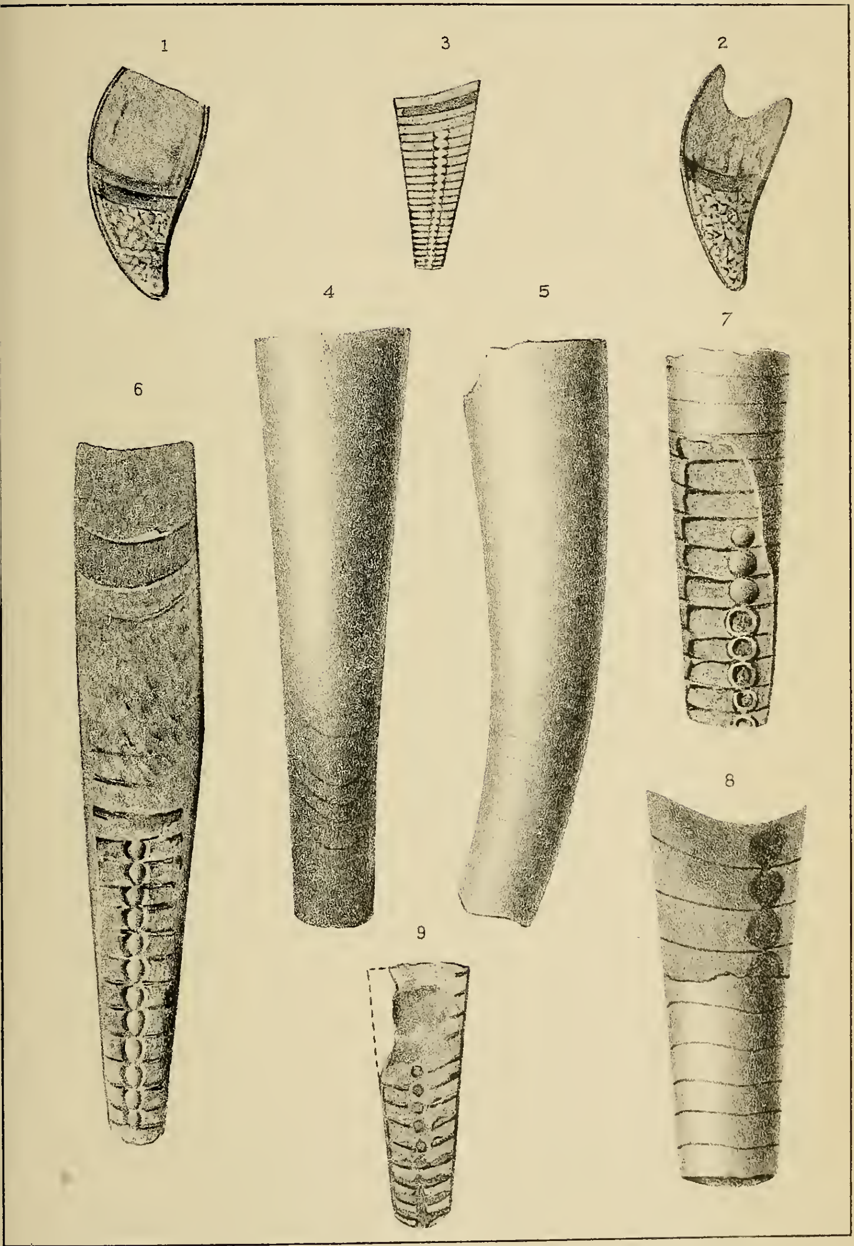
8 A specimen exhibiting the sutures and in its section the depth of the cameras and of the septa, and the siphuncle

9 Natural section of a younger portion of a conch exhibiting a somewhat closer arrangement of the septa

The type of figure 7 is from the upper Chazy (C_6) near Chazy N. Y., that of figure 8 from the middle Chazy (B_4) near Chazy N. Y. and that of figure 9 was found loose in the Saranac river and is from an unknown horizon of the Chazy formation. The originals of the last three mentioned are in the New York State Museum.

CEPHALOPODS

Bull. 90 N. Y. State Museum Plate 34



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 35

Cyrtactinoceras boycii Whitfield (sp.)

Page 489

1 External view of a specimen to show its rate of growth and curvature

2, 3 Natural weathered sections in different directions, showing the character and position of the siphuncle and the depth of cameras and septa

4 Enlargement (x 3) of a portion of the siphuncle of figure 3

The original of figure 1 is from the dove-colored upper Chazy limestone of Isle La Motte and now in the museum of Burlington University; that of figure 2 is from the upper Chazy (C_6) west of Chazy village, that of figures 3 and 4 from the middle Chazy (B_1) of the same locality. The two last mentioned originals are now in the New York State Museum.

Cyclostomiceras minimum Whitfield (sp.)

Page 502

5 Specimen showing the living chamber, hyponomic sinus, apertural contraction and the sutures

6 Another specimen showing a thickening of the shell that corresponds to the contraction of the living chamber, and the longitudinal striations of the cast

The originals are from the Fort Cassin beds at Fort Cassin and now in the Museum of Burlington University.

Ooceras lativentrum sp. nov.

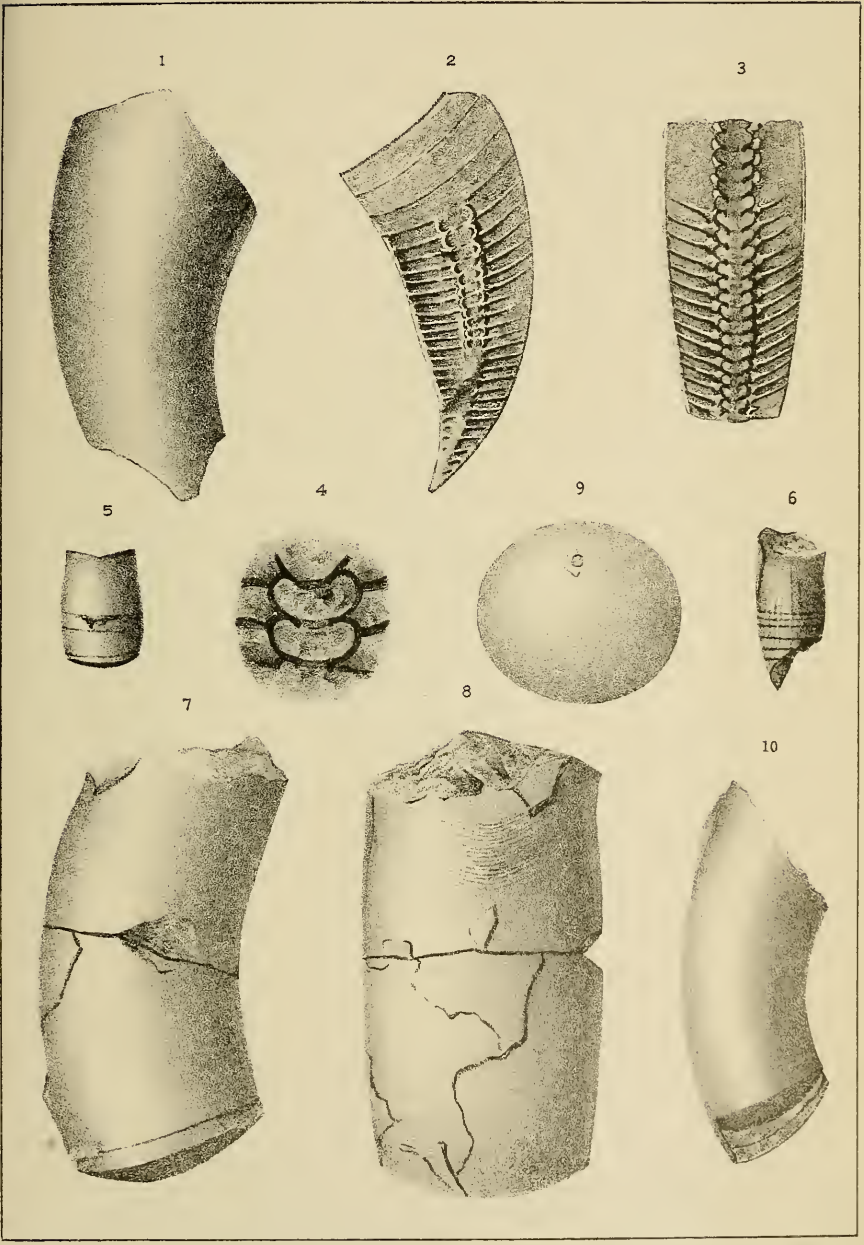
Page 497

7, 8, 9 Lateral, ventral and sectional view of the type

10 Lateral view of a fragment of a younger portion of the conch

The originals are from the dove-colored upper Chazy limestone of Isle La Motte and now in the museum of Burlington University.

CEPHALOPODS



G. S. Barkentin, del. W. S. Barkentin lith.

PLATE 36

Cyrtactinoceras champlainense sp. nov.

Page 491

See pl. 34, fig. 3

1, 2 Two views of the type, showing its rate of growth, curvature, depth of chambers and of septa and the character of the siphuncle. The living chamber is incompletely preserved.

The original is from the dove-colored upper Chazy limestone near Little Monty bay, and now in the New York State Museum.

Gonioceras chaziense sp. nov.

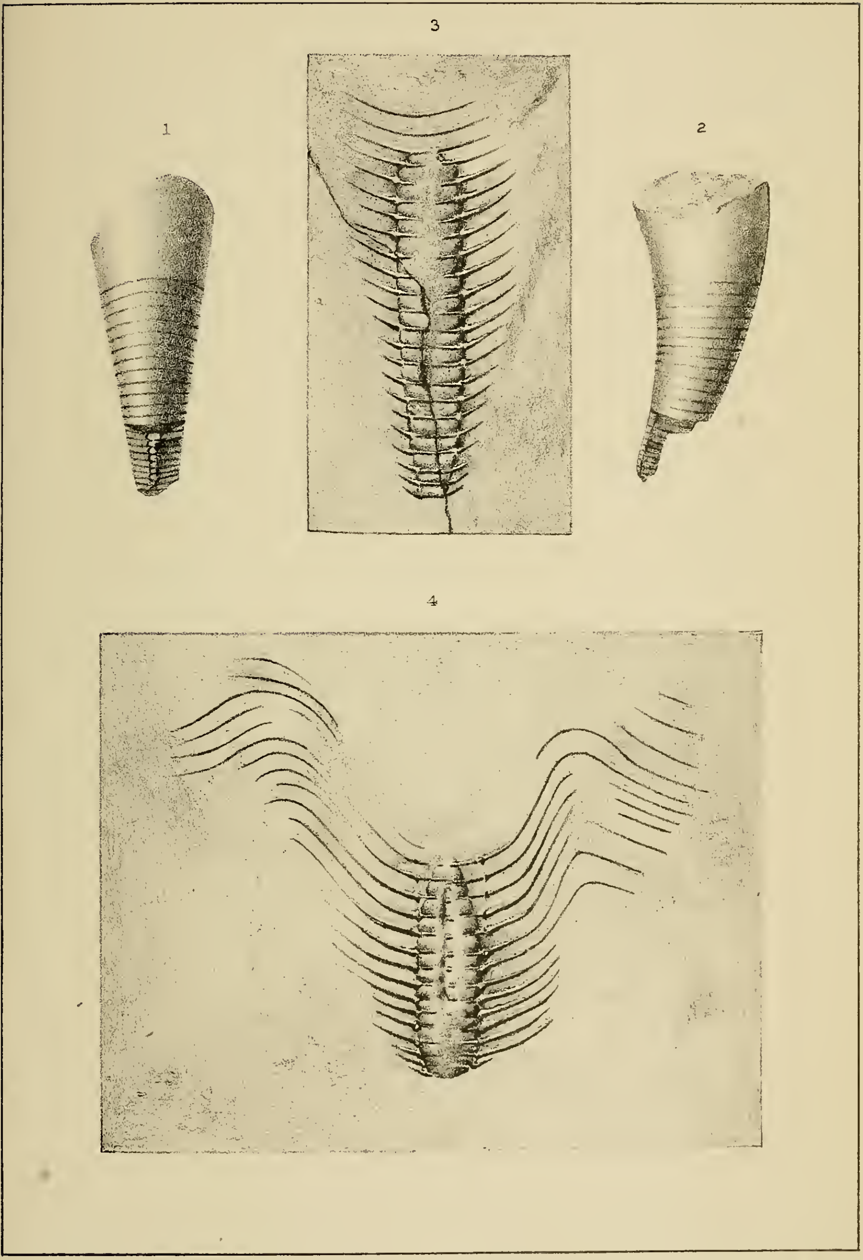
Page 494

3 Fragmentary natural section showing the character and size of the siphuncle and depth of cameras

4 The type, a natural slightly oblique section, showing the siphuncle and the extension of the conch with recurved septa

The original of figure 3 is from the middle Chazy (B_1) near Chazy N. Y., and that of figure 4 from the middle Chazy between Chazy and West Chazy; both are now in the New York State Museum.

CEPHALOPODS



G. S. Barkentin, del. W. S. Barkentin lith.

PLATE 37

Cyclostomiceras cassinense Whitfield (sp.)

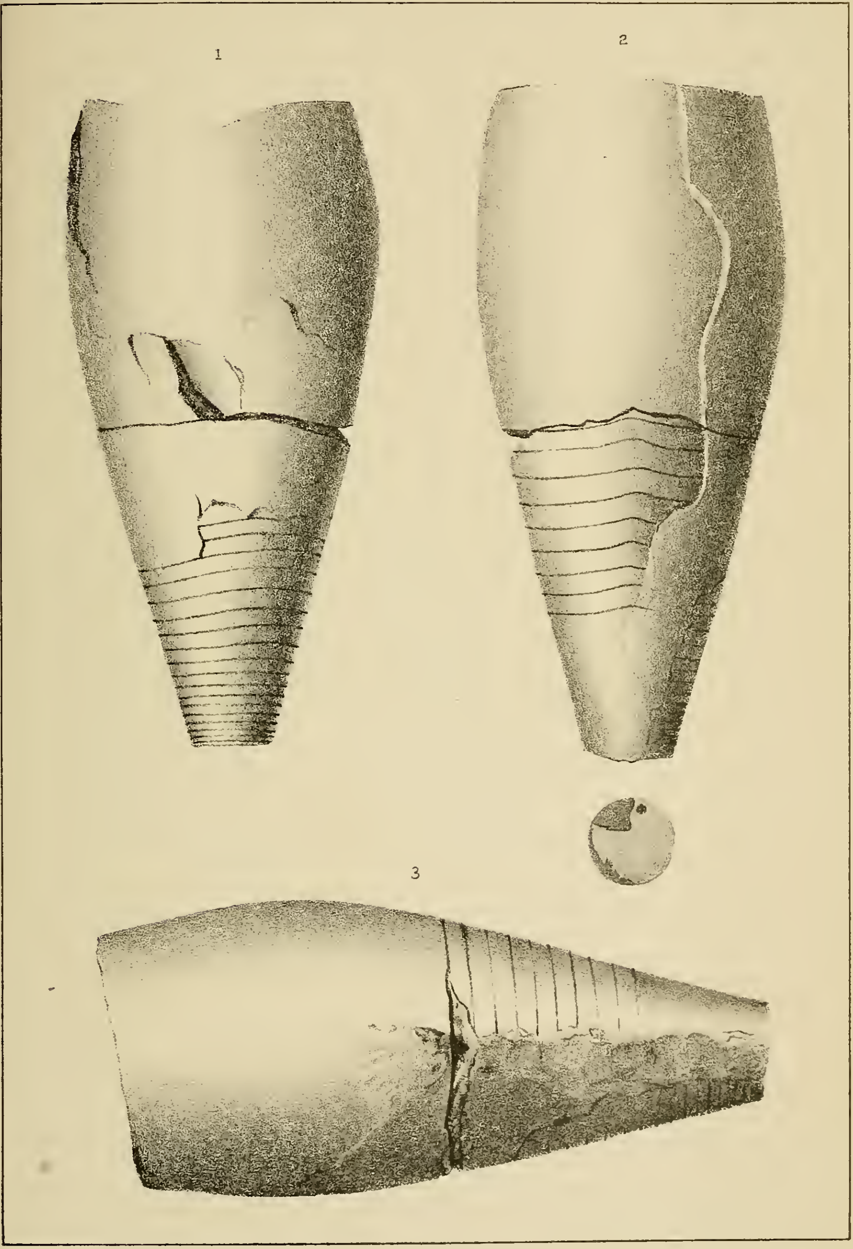
Page 501

See pl. 38, fig. 5, 6

1, 2, 3 Ventral, dorsal and lateral views of a nearly perfect specimen, showing the living chamber, hyponomic sinus, rate of growth and the sutures. In figure 3 the specimen is placed in the position which the animal probably maintained during life.

The original is from the Fort Cassin beds at Fort Cassin and now in the museum of Burlington University.

CEPHALOPODS



G.S. Barkentin, del. W.S. Barkentin, lith.

PLATE 38

(Cyrtoceras) confertissimum Whitfield

Page 506

1, 2, 3, 4 Views of a specimen from the Fort Cassin beds (A_5 of section on page 397) at Valcour N. Y.; figures 1 and 2 showing the form of the conch; figures 3 and 4 the form, character and position of the siphuncle. The original is in the New York State Museum.

Cyclostomiceras cassinense Whitfield (sp.)

Page 501

See pl. 37, fig. 1-3

5, 6 Lateral and ventral views of a young specimen retaining the living chamber and apertural margin and showing the depth of the septum. The specimen is somewhat compressed laterally, the lateral view too wide and the other correspondingly too short

The original is from the Fort Cassin beds at Fort Cassin Vt. and now in the museum of Burlington University.

Ooceras seelyi sp. nov.

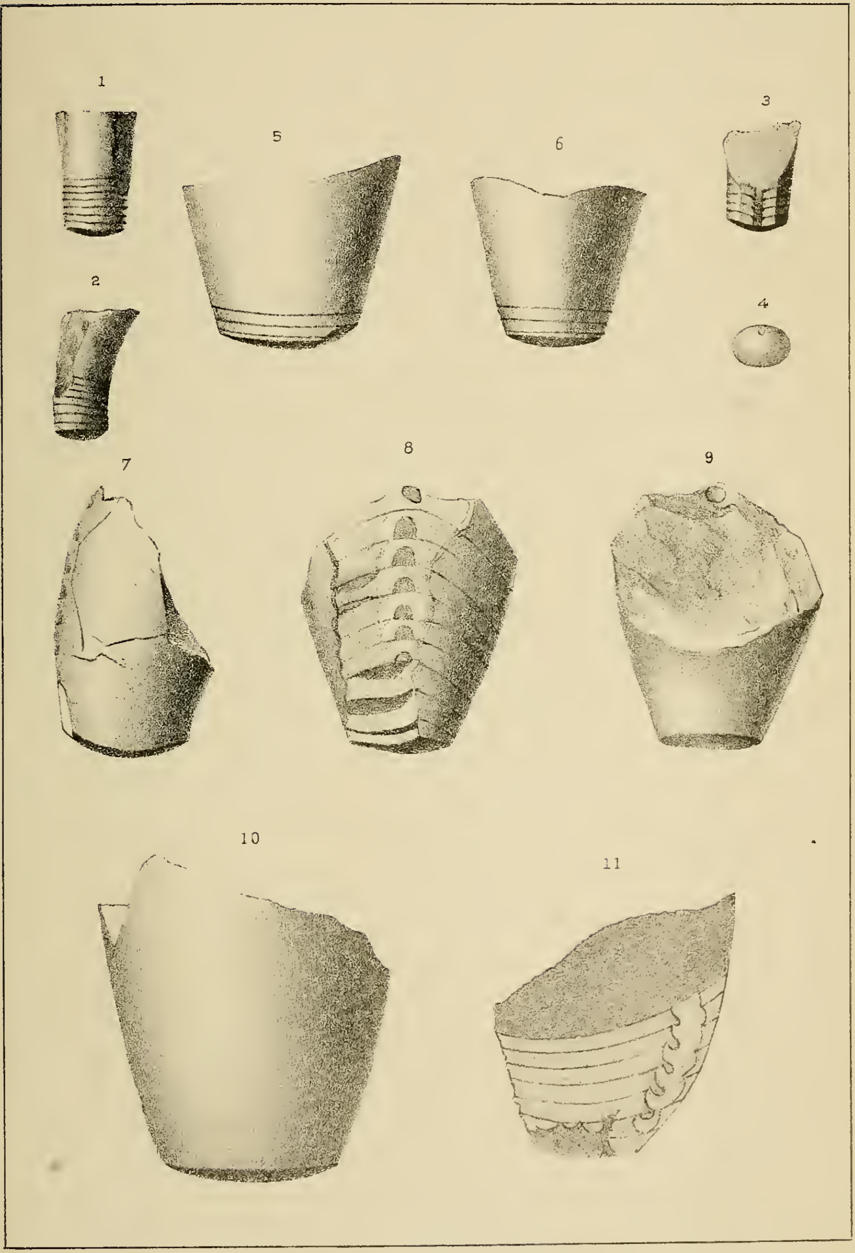
Page 496

7, 8, 9 Three views of the type; showing the curvature and rate of growth of conch, depth of chambers and position of siphuncle

10, 11 Another specimen, seen from the siphonal side and in section, the latter exhibiting the hooklike funnels or septal necks on the inner (dorsal) side of the siphuncle

The originals come from the dove-colored upper Chazy limestone of Isle La Motte and are now in the museum of Burlington University.

CEPHALOPODS



G. S. Barkentin, del. W. S. Barkentin lith.

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