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SILURIAN CEPHALOPODS OF JAMES BAY LOWLAND, WITH A REVISION OF THE FAMILY NARTHECOCERATIDAE

Rousseau H. Flower

Ottawa
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PREFACE

Cephalopods are common fossils in the Palaeozoic rocks of northern Canada. Readily collected and commonly of distinctive appearance they offer many desirable features as index fossils, but only if their morphology and stratigraphic distribution are fully understood. This report, which provides systematic descriptions and a discussion of associated stratigraphy, is based on extensive material collected by officers of the Geological Survey of Canada and the Quebec Department of Natural Resources.

The collections were submitted for identification to the author, who is one of the prominent authorities on the cephalopoda. A considerable amount of original research was involved in the identification, and it seemed desirable that Dr. Flowers' work should be available in a wider context.

Y. O. FORTIER,
Director, Geological Survey of Canada

OTTAWA, MARCH 1967

BULLETIN 164 — Silurische Kopffüsser des James Bay-Tieflands, mit einer Revision der Familie Narthecoceratidae

Von Rousseau H. Flower

Systematische Beschreibungen der Kopffüsser einschliesslich einer Anzahl neuer Arten und Erőrterung der Stratigraphie

БЮЛЛЕТЕНЬ 164 — Силурские цефалоподы низменности Джеймс Бей и пересмотр семейства Narthecoceratidae

Руссо Флауэр

Дается систематическое описание цефалопод которые включают много новых видов, а также обсуждение сопряженной стратиграфии.

SILURIAN CEPHALOPODS OF JAMES BAY LOWLAND, WITH A REVISION OF THE FAMILY NARTHECOCERATIDAE

Abstract

Cephalopod faunules were found in six horizons within the Silurian Severn River and Ekwan River Formations. Of the twenty-five species described, eighteen are new, four are new but unnamed, and three are attributed to previously described species. All belong to the general *Discosorus-Huronia* faunas, commonly but imperfectly confined to the third of four horizons recognized within the Silurian rocks of north-central North America. Problems of correlation are discussed. The beds are regarded as of early Clinton age.

New material contributes to the solution of two systematic problems: (1) *Humeoceras* is a piloceroid, morphologically very close to *Piloceras sensu stricto*; it is the only post-Canadian member of the Piloceratidae known; (2) the family Narthecoceratidae belongs to Michelinoceratida, not to Endoceratida as was previously thought, and developed from the family Troedssonellidae. The family is revised, and Ordovician forms, mainly belonging to *Narthecoceras*, are described. Here also are placed *Donacoceras, Tasmanoceras*, and the new genus *Farroceras*. *Calhounoceras* is considered a synonym of *Narthecoceras*.

Résumé

Des associations fauniques de céphalopodes ont été découvertes dans six horizons des formations de Severn River et d'Ekwan River du Silurien. L'auteur décrit vingt-cinq espèces, dont dix-huit nouvelles, quatre non identifiées et trois qui ont déjà été décrites. Toutes appartiennent à la grande famille *Discosorus-Huronia*, dont l'extension se limite, à quelques exceptions près, au troisième des quatre horizons connus des roches siluriennes du centre-nord de l'Amérique du Nord. L'auteur aborde aussi les problèmes de corrélation. Ces couches remonteraient au début de l'âge Clinton.

De nouveaux spécimens ont permis de résoudre deux problèmes de systématique: 1) *Humeoceras* est un pilocéroïde, dont la conformation morphologique est très semblable à celle de *Piloceras sensu stricto*; c'est le seul représentant postcanadien connu des Piloceratidés; 2) la famille des Narthecocératidés appartient à l'ordre Michelinoceratida, et non pas à Endoceratida, comme on l'a cru jusqu'ici; cette famille a évolué à partir de la famille des Troedssonellidés. On apporte des rectifications à la composition de la famille: les formes ordoviciennes, qui appartiennent surtout à *Narthecoceras*, sont décrites. Parmi elles, on range *Donacoceras, Tasmanoceras* et le nouveau genre *Farroceras*. Enfin, on prétend que *Calhounoceras* est synonyme de *Narthecoceras*.

INTRODUCTION

This study began with the description of cephalopods from the Silurian of the James Bay lowland that were submitted by C. J. Durden of the J. H. Remick field party of the Quebec Department of Natural Resources in 1961. Locality and horizon data were supplied by Remick. A preliminary report was published by Remick, Gillain, and Durden (1963). A report in preparation will deal with the stratigraphy more thoroughly: the Silurian will be divided into a number of new formations and more precise locality data will be supplied. The area consists of four quadrangles covered by the Quebec geological maps 1476, 1477, 1478, 1479 (Remick, *et al.*, 1963).

The stratigraphic units recognized by Norris, *et al.* (1967) in the Harricana River area, however, are adopted in the present report. The cephalopods are located within their Severn River and Ekwan River Formations in terms of a column of lithic units supplied by Durden. These lithic units are indicated by letters A-V.

EKWAN RIVER FORMATION

V dolostone
U calcilutite
T *Favosites* reef limestone
S silty calcilutite
R basal conglomerate

Q sandstone
P dolostone
O sandstone, encrinital

SEVERN RIVER FORMATION

N ostracod coquina
M silty calcilutite
L calcilutite
K lithographic limestone

MS. received September 1965.

J dolostone
I sandy dolostone
H brown shale

G silty calcilutite and dolostone
F glauconitic sandstone
E coquina
D encrinite
C sandstone
B ostracod coquina
A silty sandstone

This section lies between the Ordovocian, identified with the Bad Cache Rapids Formation (Nelson, 1963), and higher Silurian that yielded no cephalopods and is not immediately relevant to the present work. The cephalopods came from several horizons. The fauna principally is part of the *Discosorus-Huronia* assemblage which developed in the early Middle Silurian throughout a region extending from northern Michigan to Southampton Island, including the west shore of Hudson Bay (Foerste and Savage, 1927); it is well developed at Lake Timiskaming in the Thornloe limestone. Some characteristic genera extend east to Anticosti Island, but are obscured by the addition of orthoconic and breviconic types allied to faunas of eastern North America and Europe.

Material in this collection contributed to the solution of two important systematic problems: (1) New material of *Humeoceras,* formerly known only from the Thornloe limestone of Lake Timiskaming and described as an organism of uncertain affinities, shows that it is a piloceroid siphuncle, and is close in structure to true *Piloceras*. No *Piloceras* and no other Piloceratidae are known beyond the close of the Canadian, and *Humeoceras* remains as the only certain member of the order Endoceratida in the Silurian. The possibility of homeomorphy was investigated, but no supporting evidence was found.

(2) Some isolated siphuncles of the general aspect of *Donacoceras* showed two diametrically opposed types of siphonal deposits: in one, endocones developed uniform within the circumference and terminated in a central tube; in the other type, the cones extended far forward on one side, the supposed venter, and are complete dorsally only near their apical extremities, they terminate in a transverse tube between the centre and the dorsum. Deposits of *Donacoceras* had never been described in detail, and it was necessary to re-examine the type material of *D. timiskamingense* to determine which type characterizes the genus. It was found that true *Donacoceras* has the second of these two types, and that the genus *Narthecoceras* has characteristics of the first. The James Bay material also included a nondescript phragmocone which, when sectioned, revealed a siphuncle of *Narthecoceras*. The section showed a siphuncle wall characteristic of the Michelinoceratida and cameral deposits that are common in that order but are unknown in the Endoceratida. The evidence suggests most strongly that the Narthecoceratidae are not Endoceratida as was formerly supposed, but are Michelinoceratida developed from the Troedssonellidae, and are only homeomorphic with the Endoceratida.

Extension of the study beyond the limits of the James Bay Silurian material was necessary to examine other available Narthecoceratidae; it was particularly important to determine whether Silurian species of the aspect of *Narthecoceras* were possibly different enough from Ordovician species to be considered a distinct genus. The results were negative. Brevity is achieved and repetition avoided by including the study of the Narthecoceratidae in this work.

Acknowledgments

I am indebted to C. J. Durden for an opportunity to study the collection of James Bay Silurian cephalopods, and to J. H. Remick and the Quebec Department of Natural Resources for stratigraphic and locality data.

The Geological Survey of Canada through the kindness of T. E. Bolton and G. W. Sinclair loaned necessary comparative material of *Donacoceras* from Lake Timiskaming as well as all available specimens of *Narthecoceras, Farroceras,* and *Tuyloceras.*

One specimen from the Fremont limestone of Colorado, described as *Narthecoceras?* sp., was collected and submitted for study by E. A. Frederickson of the University of Oklahoma. Additional *Narthecoceras,* mainly from the Second Value Formation of New Mexico, were collected by the writer.

The problem of *Humeoceras* could not have been solved readily had it not been for material of *Piloceras invaginatum* of the Durness limestone of Scotland loaned to the writer in connection with another study. This material was loaned by the Hunterian Museum of Glasgow through the kindness of E. D. Curie and W. D. Ian Rolfe, from the Royal Scottish Museum of Edinburgh through the kindness of C. D. Waterson, by the Geological Survey of Great Britain at Edinburgh through the kindness of R. B. Wilson, from the Geological Survey and Museum (London) through the kindness of F. W. Anderson and J. D. D. Smith, and from the British Museum of Natural History through the kindness of M. K. Howarth.

STRATIGRAPHIC DISTRIBUTION

The stratigraphic distribution of the cephalopods of the Silurian of the James Bay lowland is tabulated. Cephalopods were not found in all the lithic units but were found in both formations.

EKWAN RIVER FORMATION

Unit S *Tuyloceras* sp.
Huronia horizontalis n. sp.
"*Lambeoceras*" sp. 1
Euorthoceras? sp.

Unit Q unidentifiable orthocone
"*Lambeoceras*" sp. 2

Unit O *Humeoceras durdeni* n. sp.
Ormoceras expansum n. sp.
Narthecoceras exile n. sp.
Narthecoceras subannulatum n. sp.
Donacoceras timiskamingense Foerste
Donacoceras arundineum Foerste
D. cf. *D. arundineum* Foerste
Donacoceras mutabile n. sp.
Donacoceras humei n. sp.

SEVERN RIVER FORMATION

Unit M *Kionoceras* cf. *K. loxias* (Hall)
Narthecoceras brevicameratum n. sp.
Donacoceras or *Narthecoceras* sp.

Unit G *Megadiscosorus* sp.
Humeoceras tardum n. sp.

Unit E *Discosorus transversus* n. sp.
Discosorus megistos n. sp.
Kionoceras sp.
Narthecoceras contractum n. sp.

Float believed to come from unit E as it yielded two species of that horizon:

Discosorus megistos n. sp.
Discosorus transversus n. sp.
Discosorus durdeni n. sp.
Discosorus cf. *D. ehlersi* Foerste

CORRELATIONS INDICATED BY THE CEPHALOPODS

James Bay Faunal Succession

Conclusions are necessarily tentative, as cephalopods are sparsely distributed, and it is doubtful whether one expedition, however industrious, could exhaust the cephalopod content of a section such as the one dealt with here. Further, the cephalopods alone, without the evidence of the remainder of the faunas, can hardly be expected to yield final results; indeed, from correspondence with those working on other faunal groups, largely through Durden, it is evident that some conflicts of interpretation exist that cannot now be resolved.

The cephalopods described come from a 184-foot section in which there is considerable lithic change; five formations may be recognized.

The lowest cephalopod fauna in unit E of the Severn River Formation has yielded two species of *Discosorus*; two other species are known from float believed to have been derived from this interval. The species are new except for *D.* cf. *D. ehlersi* a species of the Manistique of Michigan, also tentatively identified in the Thornloe limestone of Lake Timiskaming. *Discosorus* is known in both the Burnt Bluff and the Manistique Formations of Michigan. It is present in the Thornloe limestone of Lake Timiskaming, but is unknown in the underlying Wabi Formation; on the west side of Hudson Bay it is found in the Ekwan River limestone but not in the underlying Severn River limestone. In outlying regions, Anticosti Island has yielded a species in each of the Gun River and Jupiter Formations; the genus occurs in the lower Clinton of New York, the Dayton limestone of Ohio, and has close relatives in the Hopkinton of Iowa. Other cephalopods in this bed are not diagnostic; the *Kionoceras* is a generalized species, and the genus is wide-ranging. *Narthecoceras* is represented by other species in higher beds of the James Bay lowland sequence but outside of this region is not known in the Silurian.

Unit G has yielded only *Humeoceras tardum* and *Megadiscosorus* sp. Both genera are known elsewhere only in the Thornloe limestone of Lake Timiskaming. A reported *Megadiscosorus* of the Interlake region (Stearn, 1956) is probably an *Endodiscosorus*.

Unit M of the Severn River Formation has yielded *Kionoceras* cf. *K. loxias*, a species described from the Manistique of Michigan, with *Narthecoceras brevi-*

camerarum and *Narthecoceras* or *Donacoceras* sp., which are not diagnostic for correlation in the Silurian.

Unit O of the Ekwan River Formation contains the largest assemblage of cephalopods: there are four species of *Donacoceras*, three of which are found also in the Thornloe limestone of Lake Timiskaming, a second species of *Humeoceras*, a genus previously known only from the Thornloe limestone; *Ormoceras expansum*, which belongs to a wide-ranging genus, and shows no close affinities with any described Silurian forms; *Narthecoceras* is represented by two new species, but as already noted is unknown in the Silurian outside of the James Bay region.

Unit Q of the same formation has yielded a *"Lambeoceras"* sp. that has no known Silurian relatives outside of this region, and an unidentifiable orthocone.

Unit S in the Ekwan River Formation has yielded another *"Lambeoceras"* sp. The *Euorthoceras* is not diagnostic; possibly affinities will be found with some described Silurian species formerly assigned to *Sactoceras,* but significant comparisons are not now possible. *Huronia* appears here, but has not yet been found lower in the section. It is a genus found in the Manistique but not in the underlying Burnt Bluff of Michigan, and in the Thornloe limestone of Lake Timiskaming; it is not known in the Silurian of Hudson Bay or Southampton Island, though it occurs in the Ordovician of Hudson Bay (Manitoba) lowland and on Akpatok Island. It is found in the upper Jupiter and Chicotte Formations of Anticosti Island; it penetrates the normal southern limit of its range in the Hopkinton of Iowa (Thomas, 1915), and Sweet (1955) has described one specimen from the Silurian of Utah. *Tuyloceras* also has Thornloe congeners.

Although there is a definite local faunal succession, it fails to correspond clearly with a general faunal sequence found in other regions. Repeatedly, one encounters affinities with the fauna found in the Thornloe limestone of Lake Timiskaming, and the Ekwan River limestone of Hudson Bay, where the underlying formations—the Wabi and Severn River Formations respectively—to date have yielded no cephalopods similar to those of the James Bay succession.

It was hoped that the James Bay faunal succession would show lower beds with affinities with the cephalopod faunas of the Burnt Bluff, Wabi, Severn River Formations, perhaps the Interlake Group, and the Gun River Formation, in contrast to the higher beds of Anticosti Island with an overlying fauna of Manistique, Thornloe, Ekwan River affinities possibly continuing into the Jupiter and Chicotte of Anticosti. Clearly, there is no such division. Rather, throughout the section, one finds closest affinities of the James Bay cephalopods with the higher of these two horizons and in particular with the Thornloe.

Could this evidence have been distorted by the simple accident of the development in the Wabi limestone of Lake Timiskaming and the Severn River limestone of western Hudson Bay of environments unsuitable for the penetration of the *Discosorus-Huronia* faunas? Indeed, Hume (1925, p. 32) cited *Orthoceras* sp. as the only cephalopod of the Wabi Formation (I cannot confirm the report of a *Stokesoceras* cf. *S. romingeri* attributed to Foerste *in* Hume, by Ehlers and Kesling, 1957, p. 27). The only cephalopod of the Severn River limestone of the Hudson Bay lowland (Foerste and Savage, 1927, p. 15) is a small *Phragmoceras*, *P.*

severnense. There is a similar Ekwan River limestone species, *P. nelsonense,* and these two, as small *Phragmoceras* appearing early in the Silurian, have possible relatives in two similarly small species of the Interlake area, where Stearn (1956) described *P. nelsoni* from the Inwood dolomite and identified *P. parvum* from the Cedar Lake dolomite.

Only one general similarity emerges, namely that the Discosoridae appear early in the Burnt Bluff of Michigan and in the Gun River of Anticosti, but *Huronia* appears definitely later; the latter is exclusively Manistique in Michigan and is found in the upper Jupiter and Chicotte of Anticosti Island. This generalization is hardly a basis for any sound correlation. It is, however, evident that the entire James Bay section lies within the limits of the Burnt Bluff–Manistique of Michigan, and the Gun River through Chicotte of Anticosti Island, and by correlation of other faunal elements we may include the Interlake Group of Manitoba, the Wabi–Thornloe succession of Lake Timiskaming, and the Severn River and Ekwan River limestones of the west side of Hudson Bay. However, the cephalopods of the lower beds of the Severn River Formation do not support the postulation that a considerable part of the James Bay section is older Silurian.

Discosorus-Huronia Faunas

As noted in the introduction, the *Discosorus-Huronia* faunas are a local phenomenon of north-central North America, largely confined to a rather short time span. In geographic range, the southernmost expression of this assemblage is found in the Silurian of northern Michigan. There the faunas are incipient in the Burnt Bluff Formation and reach their fullest development in the Manistique Formation. They are found also in the Thornloe limestone of Lake Timiskaming, in the entire Middle Silurian of the James Bay lowland, in the Ekwan River limestone (but not in the Severn River limestone) on the west side of Hudson Bay, and in Silurian rocks of Southampton Island; one *Discosorus* has been identified from Prince Regent Inlet. Only three possible strays of the fauna occur in the Interlake Silurian of Manitoba. Several of the salient genera in Anticosti Island range from the Gun River through the Chicotte Formations, but they are merged there and somewhat obscured by a more varied cephalopod fauna with affinities with faunas of England, Bohemia, and eastern and east-central United States. A few other strays are discussed later.

In general, this fauna is characterized by the maximum known development of two families of the Discosorida, the Lowoceratidae and Discosoridae. Characteristic actinoceroids are *Huronia, Huroniella*, and *Megadiscosorus*. The genera *Armenoceras* and *Ormoceras* are commonly conspicuous elements in the faunas, but these genera are wide ranging and the species in these faunas are not strikingly diagnostic save that it is only here that one finds in the Silurian, large *Armenoceras* reminiscent of those of the Ordovician Red River faunas. For the most part one could not tell species of these genera, *a priori,* from those of other faunas. *Donacoceras* is characteristic of this fauna in the Silurian, and we know *Narthecoceras* only here in so far as Silurian species are concerned. More generalized Michelinoceratida of this fauna may include some Michelinoceratidae and Kionoceratidae, which again are so widespread and generalized as to be hardly diagnostic, but the development here of simple generalized Proteoceratidae is a phenomenon not found in more general Middle Silurian faunas in either North America or Europe. The faunas are made the more striking by the absence of those forms that characterize the Niagaran of the east-central region; brevicones constituting the Phragmoceratidae and Mandaloceratidae of the Discosorida, several families of the Oncoceratida, the Ascoceratida, and coiled forms of the Barrandeoceratida are all missing. Some strays from the *Discosorus-Huronia* faunas south of their main range are noted later.

General Faunal Succession

The maximum development of the *Discosorus-Huronia* cephalopod fauna is found in the third of four faunas that have been noted as occurring widely over the north-central region of North America (Foerste, 1924, 1925, 1929a; Foerste and Savage, 1927). These consist of, in ascending order, (1) *Virgiana decussata* fauna, (2) fauna with *Leperditia hisingeri fabulina*, *Pterinea occidentalis*, and *Camarotoechia winiskensis,* (3) *Discosorus-Huronia* faunas, and (4) the coral fauna of the Attawapiskat limestone which brings the first typical Niagaran breviconic cephalopods into this region.

In the following I have drawn heavily, often without precise citation, upon much excellent published information on Silurian faunas and stratigraphy, as follows: Savage and Van Tuyl (1919), information on the Hudson Bay Silurian, with a study of the cephalopods by Foerste and Savage (1927); Hume (1925), the main information for Lake Timiskaming and Twenhofel (1928) for Anticosti Island (Foerste treated the cephalopods in both these works); Baillie (1951) and later a more comprehensive revision by Stearn (1956), information on the Interlake Group; Foerste (1924) and Ehlers and Kesling (1957), the main information on the Silurian of northern Michigan. Less closely involved but significant is the work of Bolton (1953), which supplied some significant correlations. I must also acknowledge discussions carried on, intermittently, for years with the late Professor E. R. Cumings.

1) *Virgiana* Fauna

Beds variously regarded as latest Alexandrian or earliest Clinton (Niagaran) in the north-central region are dominated by a single conspicuous brachiopod, *Virgiana decussata.* Ehlers and Kesling (1957) place this as the Lime Island dolomite, and assign it as the basal formation of the Burnt Bluff Group. On whichever side of the Lower–Middle Silurian boundary this zone is placed (a matter on which opinions have differed), it is a significant zonal marker over a large region. In Wisconsin it is considered as marking the highest zone of the Alexandrian Mayville dolomite. *Virgiana* extends east into the Dyer Bay dolomite of southern Ontario, and west into the Fisher Branch dolomite, the basal Silurian of the Interlake region of Manitoba. It appears on the west side of Hudson Bay in the Port Nelson limestone. It is unknown in the James Bay lowland and in the section at

Lake Timiskaming. At Anticosti Island related forms, *Virgiana barrandei* and *V. barrandei anticostiensis* occur in the Becscie Formation and continue into the lower Gun River Formation (Twenhofel, 1928). Knowledge of the more western Silurian is very incomplete, but a species which is at least very like *V. decussata* extends into the Cordilleran region and is common in the Fusselman dolomite of New Mexico.

The apparent restriction of *Virgiana* to a relatively narrow zone is an odd phenomenon, one might expect older or younger species or both. Our published evidence, however, fails to yield indications of such forms, and we must look upon the short explosive development of this genus as useful stratigraphically, and a phenomenon rather like the similar short development of *Eoorthis* in one narrow horizon in the Upper Cambrian.

2) *Leperditia hisingeri fabulina* Fauna

This fauna is less easily delimited, as it is more varied, and one could claim that it ought to be named for a different diagnostic species. I have here employed the designation that is familiar from the work of Foerste, but it is true that there are other equally diagnostic faunal elements. Ehlers and Kesling (1957) cite and figure a number of such forms that occur in the Hendricks dolomite of the Burnt Bluff Group (the underlying Byron dolomite is barren). Certainly, significant elements of the fauna are *Camarotoechia winiskensis* and *Pterinea occidentalis*, and the list could be further enlarged. This fauna is developed in the Hendricks dolomite of northern Michigan and in the Wabi Formation of Lake Timiskaming, the fauna of which is listed by Hume (1925) and is dominated by ostracods and brachiopods. It appears again in the Severn River limestone of Hudson Bay. In the Interlake region of Manitoba (Stearn, 1956) the fauna is somewhat modified, and various of its elements are scattered through several formations. *Leperditia hisingeri* and *Pterinea occidentalis* occur with *Virgiana* in the Fisher Branch dolomite, but *L. hisingeri fabulina* and *Pterinea occidentalis* appear in the overlying Inwood Formation; both continue into the overlying Moose Lake dolomite. The *Leperditia* continues into the Atikameg dolomite, but *Camarotoechia winiskensis* makes its first appearance in the overlying East Arm dolomite and continues into the Cedar Lake dolomite. That formation yielded a *Pycnostylus* which was identified as *P. guelphensis* and was considered as a basis for correlating the Cedar Lake with the Guelph Formation of southern Ontario. Ehlers and Kesling (1957, p. 28) note that the Cedar Lake contains a preponderance of faunal elements of older aspect, and question the specific assignment of *Pycnostylus*. They correlate the complete Interlake Group with the Burnt Bluff Group of Michigan, and the Wabi Formation of Lake Timiskaming. This conclusion is reasonable, though the writer would perhaps put the Cedar Lake at least as slightly higher, though still well below the Guelph and even below the underlying Racine.

The fauna is not strictly identifiable in the Anticosti Island section, where its more characteristic elements are not developed.

3) *Discosorus-Huronia* Faunas

As previously noted, these faunas have their fullest development in the Manistique dolomite of Michigan, being most fully developed in the upper Cordell member. They are well developed in the Thornloe limestone of Lake Timiskaming, the full fauna of which has been listed by Hume (1925). The entire section of the James Bay Silurian here discussed seems to belong to this fauna. It is developed in the Ekwan River limestone of Hudson Bay, and continues onto Southampton Island. Allied cephalopods in the Anticosti Island section are scattered among the Gun River, Jupiter, and Chicotte Formations.

4) Attawapiskat Fauna

This fauna is given complete by Savage and Van Tuyl (1919) with emendation of the cephalopods by Foerste and Savage (1927). The association of corals in abundance with breviconic cephalopod types suggested "Lockport" to early writers, and a general correlation with late Niagaran was commonly accepted. This view, however, involved some misconceptions, as was the consideration of the Manistique, Thornloe, and the Louisville as Lockport, a matter now generally corrected. Ehlers and Kesling (1957) have pointed out that the Attawapiskat Formation has several species in common with the underlying Ekwan River limestone, and many faunal elements that indicate an older age than Racine. More recent work has shown that some of the cephalopod genera that appear here are found elsewhere in pre-Racine faunas in various places including the Clinton (Flower, 1948). Ehlers and Kesling (1957) consider both the Ekwan River and Attawapiskat to be no younger than the Burnt Bluff Group. The Ekwan River, however, though it has apparently some species in common with the underlying Severn River, contains a more advanced fauna, with the fullest development of the *Discosorus-Huronia* faunas in the region, and without the forms of the *L. hisingeri fabulina* fauna which we hope are diagnostic. Further, the Attawapiskat, which lies still higher, shows a greater departure from these faunas. It would seem reasonable to regard the Attawapiskat as younger than any of the faunas here discussed, unless regional change leaves an Ekwan River equivalent obscure in the Interlake region, with the Cedar Lake or at least its Chemahawin Member, in which a number of new forms are introduced, as equivalent to the Attawapiskat.

It should be noted that the breviconic cephalopods of the Attawapiskat are an odd assortment, with *Chicagooceras, Ekwanoceras, Octameroceras, Oocerina, Pentameroceras*, and three species of *Phragmoceras*. We have here also two species of *Huroniella, H. inflecta* and *H. subinflecta,* suggesting that these beds are not much above the *Discosorus-Huronia* faunas to which this genus is otherwise confined. We have two *Armenoceras* with large siphuncles, which have some parallel in the *Discosorus-Huronia* faunas, but none is known of this aspect in other Silurian faunas.

The large faunal listings of Savage and Van Tuyl (1919) seem to require some reinterpretation, but even so, there can be little doubt of a strong affinity with the Ekwan River fauna below. There is not the contrast that one would expect were the earlier interpretation correct: that this horizon represents the first incursion of a fauna which is more fully expressed in the Racine-Guelph faunas of the east-central region.

Relic Aspects of the *Discosorus-Huronia* Faunas

The *Discosorus-Huronia* faunas contain several elements that are isolated survivals, and further, to the present extent of our knowledge, isolated recurrences of stocks otherwise known from considerably older strata.

The most anomalous of these is the genus *Humeoceras,* which is not only a piloceroid and a member of the true Piloceratidae, but is so close to true *Piloceras* that the only criterion by which the genera can be distinguished is that in true *Piloceras* the compressed tube has two vertical blades of which one and usually both bifurcate, whereas in *Humeoceras* the blades are simple and undivided. The possibility of its being a homeomorph of the Piloceratidae was investigated, but no evidence was found. The Piloceratidae are not otherwise known to extend beyond the close of the Canadian. Oddly, true *Piloceras* first appears in the last half of the Demingian (Flower, 1957, p. 17), and the El Paso limestone has yielded several undescribed species (more than are known from later horizons) though the Romaine *P. acinaces* and the Durness *P. invaginatum* are probably from Cassinian faunas.

Though *Huronia* was first known from Silurian strata, largely northern Michigan, it is another of these relic types, for it makes its first appearance in the Ordovician Red River faunas, and is sparingly known from the overlying Richmond; there is a species in the Shamattawa limestone of Hudson Bay, and the same form has been found on Akpatok Island in equivalent strata. Teichert (1937, p. 24) calls attention to a listing of *Huronia vertebralis* (which is certainly not that species) in a fauna with *Maclurites* and *Receptaculites* in King William Land, an occurrence that is certainly Ordovician. Oddly, *Huronia* when it reappears in the Silurian is wanting generally in the earlier beds with *Discosorus*; in Michigan its range is exclusively in the Manistique; in the James Bay lowland, it is found only in the highest fauna; and in Anticosti Island it ranges through late Jupiter into the Chicotte.

Narthecoceras is widely developed in the Red River faunas, ranging from New Mexico and western Texas to Greenland. Nelson (1963) reported a few specimens from the overlying Richmond. Until now, these were the youngest specimens known, but surprisingly the James Bay lowland has yielded four species from three horizons. *Donacoceras* may be a similar relic, for though one species is cited from the Whitehead Formation of Gaspé, and a siphuncle with the proportions of the genus is known from the Fremont limestone of Colorado, it is not certain that either of these is true *Donacoceras,* as internal structure is unknown. The genus in the Silurian is confined to the Thornloe of Lake Timiskaming and mainly to the Ekwan River Formation of the James Bay section. Clearly, the ultimate ancestor of *Donacoceras* is *Tasmanoceras,* thus far known only from the Ordovician of Smelter's Quarry, Zeehan, Tasmania. Teichert and Glenister (1952,

1963) regard the fauna as Upper Ordovician in aspect, but the cephalopod genera cited are long ranging, and *Hecatoceras* is the only one suggesting a Late rather than Middle Ordovician age, and the evidence of this genus is certainly not final, as it is not known from any other occurrence.

A lesser known stock which seems to be a similar survival is that represented by *Euorthoceras?* sp. of the James Bay fauna. This is a survivor of the family Proteoceratidae which is widely developed in the Ordovician, though its range is not yet fully published. It certainly includes not only Chazy forms, but a large number of the Mohawkian "*Orthoceras*", including most of the smooth orthocones abundant in the Trenton faunas, and *Orthonybyoceras* (=*Treptoceras*) is the dominant orthocone in the Cincinnatian faunas of eastern North America. Allied to this stock is typical *Euorthoceras* of the Brassfield limestone, but higher Silurian faunas of east-central North America lack representatives of this family. It is not developed except for the specialized genus *Cyrtactinoceras* in the Silurian of Bohemia, nor is it known elsewhere in Europe. A number of orthocones of the general aspect of *Sactoceras,* in which members of this stock may be found, occur in Middle Silurian in both American and European faunas, but thus far all species represented by adequate material have been found to be actinoceroids, though some show a perplexing retardation of siphonal deposits so that they are confined to siphuncle segments only in the apical parts of phragmocones. In so far as is known, generalized Proteoceratidae survive beyond the Brassfield only in the *Discosorus-Huronia* faunas. *Sactoceras vadocameratum* of the Lake Timiskaming region is a member of this stock.

ANALYSIS OF CEPHALOPOD ELEMENTS

Lowoceratidae and Discosoridae

The families Lowoceratidae and Discosoridae have their metropolis in the *Discosorus-Huronia* faunas as outlined above, but show a few strays outside of the region. Granting equivalence of the Ekwan River limestone, the Thornloe limestone and the Manistique dolomite, these faunas find their fullest development in this one horizon, but we have a few forms that occur in Michigan in the underlying Burnt Bluff Group, and a few in the Interlake region which we tentatively accept as of Burnt Bluff age.

Of the Lowoceratidae, the known species include *Tuyloceras percurvatum,* Ekwan River limestone, Hudson Bay; *T.* sp., Ekwan River Formation, James Bay; *T. humei,* Thornloe limestone, Lake Timiskaming; *Lowoceras southamptonense,* Silurian limestone, Southampton Island; and *L. imbricatum,* Inwood dolomite, Interlake region, Manitoba.

The Discosoridae range largely in the Manistique–Thornloe–Ekwan River horizon, but there are a few in the underlying *Leperditia hisingeri fabulina* fauna.

Northern Michigan has yielded a large association described by Foerste (1924). There is some uncertainty as to the precise stratigraphic position of some of the specimens (those collected long ago lack precise data) but Ehlers and Kesling (1957) have confirmed the occurrence of some species in the Burnt Bluff Group. The following are known: *Discosorus ehlersi,* Burnt Bluff (?), Manistique;[1] *D. halli,* Burnt Bluff, Manistique; *D.* sp., Burnt Bluff; *Stokesoceras romingeri,* Burnt Bluff,[1] Manistique; *S. gracile,* Manistique; *S. engadinense,* Manistique; and *Endodiscosorus remotus,* Manistique (?).

At Lake Timiskaming, Discosoridae occur only in the Thornloe limestone; I have been unable to confirm the mention of Ehlers and Kesling of *Stokesoceras* cf. S. *romingeri* in the Wabi Formation, either from Foerste (1925) or from records or material in the Geological Survey of Canada collections. Examination of materials, however, suggests that there are more species of *Discosorus* in the Thornloe fauna than were cited by Foerste. The Thornloe limestone has yielded

[1] Confirmed by Ehlers and Kesling (1957).

Discosorus humei, D. spp., *D.* cf. *D. ehlersi, Stokesoceras* cf. *S. romingeri, S.* cf. *S. engadinense, S. perobliquum,* and *Endodiscosorus foerstei.*

The Discosoridae of the James Bay lowland are all from unit E of the Severn River Formation or from float attributed to this formation and include *Discosorus megistos, D. transversus, D.* cf. *D. ehlersi,* and *D. durdeni.*

On the west side of Hudson Bay Foerste and Savage (1927) reported from the Ekwan River limestone, *Discosorus parksi* and *Stokesoceras ekwanense.*

Southampton Island has yielded the following, all attributed to the Ekwan River limestone equivalent (Foerste and Savage, 1927; Teichert, 1937): *Stokesoceras ekwanense, S. perobliquum, S. cylindratum, Discosorus troedssoni, D. parksi,* and *D. regularis.*

D. regularis was originally described from the Silurian of Prince Regent Inlet, and is the most northerly of the Discosoridae so far known.

Anticosti Island has yielded *Discosorus gunensis,* Gun River Formation; *D. infelix,* Jupiter Formation; and *D.* sp., Jupiter Formation (Twenhofel, 1928).

Outlying formations have yielded apparently few species and few specimens are known. The Clinton of New York has yielded only *Discosorus conoideus;* the type occurs in limestone with *Pentamerus,* which is either Reynales or Walcott limestone; a second specimen is apparently from the Sodus shale, judging from the locality and the sections presented by Gillette (1947).

In Ohio, the Dayton limestone has yielded *D. austini* and *D. perexpansus.* No forms are known from the Silurian in Indiana, despite considerable investigation and collecting. In Iowa the Hopkinton limestone (Thomas, 1915; Foerste, 1934; Flower and Teichert, 1957) has yielded the only known species of *Kayoceras* (which is little more than a *Discosorus* whose siphuncle has become subcentral rather than ventral), *K. biconoideum,* and *K. thomasi,* with *Endodiscosorus lyonense.*

Interestingly, despite possible differences of opinion as to detailed correlation, the New York and Ohio sections indicate that the *Discosorus* faunas are not only of Clinton age, but in the early rather than the late half of the Clinton.

Oddly, there is no reason for such stratigraphic and local concentration of Lowoceratidae and Discosoridae. We know almost nothing of the Discosoridae of the Alexandrian other than *Glyptodendron* of the Brassfield (I have one undescribed form from the Medina sandstone, but it belongs to the Ruedemannoceratidae), and in the Richmond we have nothing intermediate between *Faberoceras* of Cynthiana-Cathys and Maysville age, and the appearance of the Lowoceratidae and Discosoridae in the Clinton above the *Virgiana* fauna. The stock then apparently disappears from the known fossil record, but *Alpenoceras* of the Devonian (ranging from the late Middle Devonian *Stringocephalus* faunas into the Fammenian of the Upper Devonian in Germany) is a descendant of this stock. Sweet (1959) has described the Silurian genus *Konglungenoceras* from Norway, and has suggested that it is a link between the Cyrtogomphoceratidae and *Alpenoceras.* It is a compressed shell with the siphuncle on the concave side, looking much like *Tuyloceras* except for the position of the siphuncle. This form shows a siphuncle in which the bullettes are uninflated, and the writer is inclined to regard it as a member of the Discosoridae or Lowoceratidae, rather than of the Cyrtogomphoceratidae. Whether it is endogastric or whether the siphuncle has moved to a dorsal position is still not certain. It is possible also (Flower and Teichert, 1957) that the interpretation of *Alpenoceras* as endogastric rather than as having a dorsal siphuncle may be incorrect; the septal furrow, which is a more reliable criterion than the presence of a sinus on the concave side of the shell, has not been observed in the genus. It is worth noting that there are no Discosorida yet known connecting the oldest *Alpenoceras* with any of its probable ancestors which, in North America at least, are known only from the early half, possibly the earliest quarter, of the Middle Silurian.

Actinoceratida

The Silurian development of *Huronia* is known in the Manistique but not in the Burnt Bluff of northern Michigan; there *H. bigsbyi, H. bigsbyi intermedia, H. vertebralis, H. engadinensis, H. annulata, H. minuens, H. paulodilatata, H. obliqua, H. portlocki, H. distincta, H. turbinata,* and *H. romingeri* are noted by Foerste (1924). The Thornloe limestone of Lake Timiskaming has yielded *H.* cf. *H. paulodilatata, H. obliqua,* and *H.* sp. The Ekwan River Formation of the James Bay lowland has yielded *H. horizontalis,* the only *Huronia* so far found in the Silurian there. No *Huronia* are known from the Ekwan River limestone of western Hudson Bay. Anticosti Island has yielded *H. vertebralis* and *H. chicottense* in the Chicotte Formation, and *H. obliqua* in the Jupiter. *Huronia* is reported in the Hopkinton of Iowa (Thomas, 1915), and Sweet (1956) has described one from the Silurian of Utah.

Huroniella was first regarded as a genus intermediate between *Huronia* and *Armenoceras;* if this is true, it is surprising that we have no *Huroniella* known in Ordovician beds; the writer regards *Huroniella* and *Huronia* as homeomorphs, *Huronia* descending from *Actinoceras* and related to *Kochoceras* and *Lambeoceras*. *Huroniella* may well be a derivative of *Armenoceras*. It is known only from these *Discosorus-Huronia* faunas with *Huroniella ehlersi* in the Manistique of Michigan, *H. inflecta* in the Ekwan River or Attawapiskat of Hudson Bay, *H. timiskamingense* from the Thornloe of Lake Timiskaming, *H. persiphonata* from the Jupiter of Anticosti Island and *H.* sp. from the underlying Gun River of the same region. Oddly, *H. subinflecta* (Foerste and Savage, 1927) occurs not in the Ekwan River beds but in the overlying Attawapiskat limestone of Hudson Bay lowland.

The Thornloe of Lake Timiskaming has yielded *Megadiscosorus crassisegmentatus, M. crassisegmentatus brevior,* and *M. inoptatus*. The Jupiter of Anticosti Island has yielded *M. crassisegmentatus orientalis*. The *Megadiscosorus* reported from the East Arm dolomite of the Interlake region of Manitoba requires more study; the form of the segments is more like those of *Endodiscosorus*. *M.* sp. is from unit G of the Severn River Formation of the James Bay lowland. The genus is known only in the *Discosorus-Huronia* faunas.

Summary

The James Bay lowland faunules seem all a part of the general *Discosorus-Huronia* faunas of the north-central region of North America. This fauna appears to lie in the Clinton, and more specifically in the early half. Close affinities with the presumably equivalent Manistique, Thornloe, and Ekwan River limestones are indicated; particularly strong evidence is found in the occurrence of three species of *Donacoceras* present also in the Thornloe limestone of Lake Timiskaming. Evidence of other fossil groups, suggesting equivalence of the lower part of the section with the Burnt Bluff of Michigan, the Interlake Group of Manitoba, the Wabi of Lake Timiskaming, and the Severn River limestone of Hudson Bay is not fully supported by the cephalopod evidence. On one hand, the confinement of the allied cephalopods to the Ekwan River of Hudson Bay and the Thornloe of Lake Timiskaming may be ecological; we have reviewed the known distribution of the salient stocks and have noted some allied forms in the Burnt Bluff of Michigan in the *Leperditia hisingeri fabulina* fauna, and the occurrence of a few allied types in the Interlake Group of Manitoba. It has also been noted that confinement of the Lowoceratidae, Discosoridae, and such locally confined genera as *Megadiscosorus, Huronia,* and *Huroniella* to Thornloe-Manistique equivalents in contrast to the underlying *Leperditia hisingeri fabulina* fauna is theoretically suspect. However, to reject the evidence of the cephalopods completely in favour of zone markers in the brachiopod, ostracod, or other sequences is to accept as valid zone fossils forms that are even more suspect on phyletic grounds. There is no reason to question the validity of the *Virgiana* zone, but distinguishing the faunal zones typified by the Hendricks dolomite of Michigan in contrast to the overlying Manistique faunas and their presumed equivalents, one must select subjectively certain faunal criteria and allow the rest considerable theoretical latitude in vertical distribution.

It must be noted that the correlation of much of the James Bay section with the Severn River Formation is strongly opposed by the evidence supplied by the cephalopods, unless equivalence of the Severn River to the Wabi in contrast with the Thornloe and with the Hendricks dolomite of the Burnt Bluff Group in contrast with the Manistique is to be rejected.

Thickness is certainly fallible as a criterion, but the James Bay Silurian here considered has a thickness of 184 feet more or less, which corresponds reasonably to the 180 feet reported by Hume for the Thornloe limestone alone, whereas the Wabi adds another 118 feet to the Silurian section of Lake Timiskaming.

FAUNAL SPREAD

Other faunal criteria accepted, the confinement of the cephalopod types of the *Discosorus-Huronia* faunas to the third of four faunal zones discussed above is imperfect. Both in the James Bay and in other regions, many related cephalopods are found in older beds, and the Discosoridae are found in younger beds as well. From a phyletic viewpoint the previously used zonal criteria, consisting as they do of species in disparate genera, may be even more questionable. One may claim that unrelated *species* are more valid as guides than groups such as the cephalopods in which different but congeneric species are used. The claim is reasonable but its value is hard to estimate. Cephalopod species are not infallible, as they rest commonly upon specimens that are fragmentary and often too few individuals are available. The writer believes that the identification of species (Foerste, 1924) common to the Hendricks and Cordell dolomites of northern Michigan may involve species too broadly drawn. The James Bay section has yielded two species of *Donacoceras, timiskamingense* and *arundineum* of the Thornloe limestone of Lake Timiskaming, and it may be that the tentative identification of *Kionoceras loxias* and *Discosorus ehlersi* is an excess of conservatism. Such conservatism in identification at least avoids the temptation of false correlations. Indeed, if there is any criticism of the present work it is that the species may be too narrowly drawn. We are dealing with relatively few known specimens, sometimes with single specimens, and species are recognized where reasonable differences in proportions are demonstrable. However, more material might show, to select one example, that *Humeoceras tardum* is somewhat abortive, living in an unfavourable shaly environment, and that it might grade into the more robust *H. durdeni,* known only from a higher horizon, and that both grade into *H. unguloideum* of the Thornloe of Lake Timiskaming.

From one section to another, one finds in this general region a spreading and separation of faunal elements of one horizon and their merging into elements of adjacent horizons—a spread and a mingling of forms which, from one section, one might hope to be good zonal markers. This is frustrating and confusing from the viewpoint of precise correlation; to achieve any detailed results one must make a somewhat subjective selection of some faunal elements and reject others. From such selection, conflicting opinions may readily result. It is, however, possibly indicative of a condition which is important and not always easy to recognize, namely that such faunal spread could occur only in deposits laid down in a continuous sea, without intervals of elevation and erosion. In such a sea, local ecological factors would exercise some control. In the James Bay section such control is easy to accept, for the formations show wide lithic variation. In other sections this is sometimes less obvious, but organically significant ecological factors are not necessarily inferable from inspection of the sediments. We may reasonably accept the existence of such controlling factors, even though we cannot estimate them closely from sediments or associations. As an example, we may note the complete absence of corals in the Wabi of Lake Timiskaming, though the apparently equivalent Hendricks dolomite and the Severn River both have a moderate supply.

Such a faunal spread has apparently affected all faunal elements. In the Interlake region one finds *Pterinea occidentalis* supposedly of our second zone, in association with *Virgiana decussata* of the first zone in the Fisher Branch dolomite. In the overlying Inwood dolomite, *P. occidentalis* recurs and is joined by *Leperditia hisingeri fabulina*, but it is not until the East Arm dolomite that the familiar *Camarotoechia winiskensis* is found after the *Pterinea* and *Leperditia* have disappeared. *C. winiskensis* occurs with *Stokesoceras* and *Endodiscosorus*? *remotus* possible indicators of the third fauna. The writer would suspect that this horizon may be Manistique–Ekwan River–Thornloe in equivalence, and that the faunal anomalies of the overlying Cedar Lake dolomite, with *Pycnostylus* appearing, may indicate equivalence with the Attawapiskat limestone, in which the same genus is found. We have throughout this section, however, faunal elements as noted by Ehlers and Kesling (1957), suggestive of the *Virgiana* and the *L. hisingeri fabulina* faunas, the Lime Island and the Burnt Bluff of northern Michigan.

In Anticosti Island the situation is different, but equally anomalous. Twenhofel (1928) noted *Virgiana barrandei* and *V. barrandei anticostiensis* in the Becscie Formation, continuing also in the lower two of the four zones of the Gun River Formation. In zone 2 *Huroniella* appears; in zone 4 *Discosorus gunensis* appears; *Discosorus* continues into the Jupiter, where another *Huroniella* appears; *Huronia* ranges from the middle Jupiter into the Chicotte. None of the obvious indicators of the Hendricks–Wabi–Severn River faunas is present; they have been squeezed out, figuratively of course, and we find a mingling and even slight overlap of the *Virgiana* and the *Discosorus-Huronia* faunas, mingled with a large fauna of eastern aspect which fails to penetrate the north-central region at all.

In the interpretation of the James Bay section the absence of indicators of the *Virgiana* faunas may simply indicate that there was no deposition when *Virgiana* exercised its short-lived dominance of the north-central Silurian seas. The same appears to be true of the Lake Timiskaming region. However, the writer has been troubled by the apparent conflict of the indication of the cephalopods that the entire section is Thornloe–Manistique–Ekwan River, whereas other faunal evidence suggests Severn River–Wabi–Hendricks equivalence. Possibly the answer is that anomalies from faunal spreading affect the entire fauna. Oddly, the reports of others indicate that *Camarotoechia winiskensis* is found here only quite high in the section, in the lower Ekwan River, whereas another Wabi–Hendricks form, *L.*

hisingeri fabulina is reported here only in the highest of the units with which we are concerned.

It would appear that depending on the faunal elements selected as reliable, one might make the correlation of the whole section with the Burnt Bluff–Wabi–Severn River, all but the upper part, or might claim that the whole is of Manistique–Thornloe–Ekwan River age. Although the reality of a succession in each of these regions is beyond any possible question, it would appear that there are no faunal elements known that can be accepted as criteria of correlation with certainty when they conflict with evidence supplied by other forms; possibly this is a reflection of the fact that there was no withdrawal of the seas between these two intervals, and possibly no major break in deposition.

SYSTEMATIC DESCRIPTIONS

Taxonomy and Terminology

Confusion among readers of this work will be avoided if it is noted that the taxonomy and taxonomic and morphological terminology employed here are those of Flower (1964, a). The nautiloid volume of the "Treatise of Invertebrate Paleontology" (Teichert, *et al.*, 1964) was published after completion of the main taxonomic part of this work. The writer does not accept many points in taxonomy, taxonomic terminology or morphology that appear in that work, but it was felt that an extended discussion of these matters was out of place in the present study, except for some very specific matters. In particular, the elevation in rank of the endoceroids and actinoceroids which appears in the *Treatise* and also in some earlier Russian works is rejected.

Unless otherwise noted, the specimens described in this report are deposited in the collections of the Geological Survey of Canada and are identified by GSC numbers. The specimens collected by Durden are the property of the Quebec Department of Natural Resources, and are deposited with the Geological Survey collections as a convenience for future study.

Order DISCOSORIDA Flower

This order has been revised (Flower and Teichert, 1957). Some additional genera have been described by Sweet (1958, 1959) and Sweet and Miller (1957). It is characterized primarily as a group of dominantly cyrtoconic and breviconic nautiloids set apart by highly specialized differentiation in the connecting rings; in addition, siphonal deposits develop which may take the form of either annuli or endocones, with layered units, one primarily to each segment of the siphuncle. Deposits are fibralia (Flower, 1964a) showing characteristic fibres normal to the growing surfaces as well as fine growth lines.

Family LOWOCERATIDAE Flower, 1940

This family contains Discosorida that are intermediate between the Westonoceratidae and the Discosoridae. Shells and siphuncles are relatively slender, exogastric, and the siphuncle is ventral and relatively small and gently expanding when compared to the Discosoridae. Early segments of *Tuyloceras*, now the better known of the two genera, show segments with the subquadrate outlines of early segments of *Westonoceras*, and show inflated bullettes, which are reduced in later growth stages. Westonoceratidae with fibralia forming endocones are known, but are confined to the younger (Leipers) species of *Faberoceras*. In that family the bullettes are swollen throughout the phragmocone.

The Lowoceratidae is a subarctic family of only two genera; *Lowoceras* is known from *L. southamptonense* from the Silurian limestone of Southampton Island, and *L. imbricatum* Stearn of the Inwood dolomite of the Interlake Group of Manitoba. *Tuyloceras*, present in the James Bay Silurian, and found also in the Thornloe limestone of Lake Timiskaming is discussed below.

Genus *Tuyloceras* Foerste and Savage

Foerste and Savage, 1927, p. 81. Flower, 1940, p. 51. Flower, 1946, p. 435. Flower and Kummel, 1950, p. 61. Flower and Teichert, 1957, p. 96.

Shell strongly compressed, an exogastric cyrtoceracone, faintly fusiform, the anterior part of mature shells contracting gently, contraction beginning at or before the base of the mature living chamber. Siphuncle segments subquadrate and elongate in section in the young, become broader than long and broadly rounded, enlarging rapidly in the middle third of the phragmocone, but remaining uniform in size or slightly contracting in the anterior third. Bullettes are swollen only in the young segments. Deposits are fibralia, taking the form of endocones; retarded, generally absent in the anterior half of the phragmocone. Necks strongly recurved, but not generally recumbent.

Formerly only the type species from the Ekwan River limestone of the west side of Hudson Bay was known. A second species, evidently distinct, is described below but is not named, as it is based on too small a fragment to serve properly as the type of a new species. It is from the Ekwan River Formation of the James Bay lowland. An additional species was found in material from Lake Timiskaming, unlabelled as to horizon or precise locality, but evidently from the Silurian Thornloe limestone.

Tuyloceras sp.

Plate IV, figures 7, 8

This form is represented only by a series of seven siphuncle segments, evidently from the last part of a phragmocone of a *Tuyloceras*. One side is weathered, and the entire specimen appears to be an internal mould of segments, and offers no hope of showing significant internal structure. The siphuncle is strongly compressed, but irregularity of the surface suggests that possibly an originally compressed condition is augmented by slight crushing. The two ends of the series of segments are so nearly the same size that one could question which is anterior, but it appears that the anterior end is that showing slight shortening of the segments, a condition observed in *T. percurvatum*. The specimen, 55 mm long, has segments 30 mm high throughout; the basal segment is 8 mm long, the last is shortened to 5 mm.

Externally segments are gently convex, but expanded only 3 mm beyond their minimum diameter. Width is one third the height basally, and less than half the height and not much more than one third the height adorally. The segments slope somewhat more forward from dorsum to venter than do those of *T. percurvatum*.

Discussion. These siphuncle segments clearly represent *Tuyloceras*, and differ from *T. percurvatum* in the slight forward slope of segments on the venter, a more gentle curvature, and segments slightly higher in proportion to their length. This is unquestionably a new species, but the single fragmentary specimen is inadequate to serve as the type of a named species.

Type and occurrence. Figured specimen, GSC No. 22564, unit S, Ekwan River Formation, from about 3 miles above the mouth of the Rivière Joncas.

Tuyloceras humei n. sp.

Plate XIII, figures 1–3, 8

This species is known from a series of nine siphuncle segments, expanded in the camerae, compressed, and forming a series with a radius of curvature on the venter of 80 to 90 degrees. The eight clearest segments (the ninth is obscure) have a length of 80 mm on the venter. The basal segment expands to a height of 24 mm, 26 mm normal to the oblique slope of the segment, a width of 20 mm, and a length of 10 mm. The sixth segment has an oblique height of 35 mm, the width is incomplete from weathering of one side but is not over 22 mm. The last segments seem similar in expansion to the sixth, but are very slightly shorter. The septal markings and thus the segments themselves are inclined about 35 degrees from the horizontal, showing a marked obliquity which sets this form apart from the only other known species of the genus, *Tuyloceras percurvatum*. A section was made, but this later part of the siphuncle fails to show any deposits. Even the outline of the segments on the sectioned surface is only faintly indicated, and the original structure of the connecting ring is lost.

Discussion. This, the second known species of the genus, is distinguished by the strongly oblique siphuncle segments.

Type and occurrence. The holotype GSC No. 18750, is from the Hume collection from Lake Timiskaming. Precise locality and horizon data are wanting but the specimen is obviously from the Silurian Thornloe limestone and not from the Ordovician, though it was found in the collection with Ordovician material. The specimen bears a small round label marked "E", but no data have been found on the significance of this designation. Some *Donacoceras* bear the same designation.

Family Discosoridae Teichert, 1931

These are breviconic Discosorida (Flower and Teichert, 1957), known mainly from siphuncles consisting of broadly expanded segments, generally enlarging rapidly orad, though with a sharp adoral reduction in the rate of expansion in the anterior camerae. Fibralia take the form of endocones. Siphuncle segments show short recumbent brims, and are involved with considerable adnation of the rings with the septa.

The four genera of the Silurian are *Discosorus*, *Endodiscosorus*, *Stokesoceras*, and *Kayoceras*. *Alpenoceras* of the Middle Devonian was placed here (Flower and Teichert, 1957); it is stratigraphically isolated and differs from the other known forms in being endogastric. Sweet's (1959) *Konglungenoceras* is a strongly compressed shell like *Tuyloceras* except that the siphuncle is close to the concave side of the shell. Sweet suggests origin of *Alpenoceras* through this genus which he assigns to the Cyrtogomphoceratidae. It differs from known Cyrtogomphoceratidae in that bullettes are uninflated, and it is of Silurian age. In both respects it is typical of the Discosoridae, but is more like *Tuyloceras* in general shape.

Genus ***Discosorus*** **Hall,** 1852

Flower and Teichert, 1957, p. 100 (*see* for complete references).

Commonly only parts of siphuncles strengthened by deposits are known; deposits form endocones of fibrous structure. Segments are short, broadly rounded, with necks recumbent and rings broadly adnate; early segments form a rapidly enlarging series, and are generally slightly broader than high; commonly segments are somewhat oblique, sloping orad on the venter. Adorally the rate of expansion is reduced, more so vertically than laterally. Shells are breviconic, faintly exogastric, and living chambers contract slightly to the mature apertures.

Only *Discosorus* is known in the James Bay Silurian, but three other genera should be noted as allied almost to the point of intergradation. *Stokesoceras* is similar, but the series of siphuncle segments is more nearly straight and more gently enlarging. *Endodiscosorus* is close to *Discosorus* and is distinguished mainly by flattening of the expanded parts of the segments. *Kayoceras* is a breviconic form allied to *Discosorus*, but distinguished by a central rather than a ventral siphuncle; siphuncle segments show no obliquity in the vertical plane.

Discosorus megistos n. sp.

Plate II, figure 1; Plate III, figures 1–4, 8–10; Plate XXXII, figure 2

This is one of the larger species of *Discosorus*, and is characterized as a siphuncle showing rapid lateral expansion of the segments throughout the known extent of the material, whereas on the other hand the vertical rate of expansion is markedly reduced adorally, the outline of a series of segments being essentially straight ventrally, but markedly curved dorsally. The siphuncles expand laterally having an angle of divergence of 35 to 40 degrees. Vertically, the segments diverge at 20 to 25 degrees apically, until the siphuncle segments are 32 to 35 mm high, beyond which the vertical increase in the segments is negligible. Septal markings and segments are markedly oblique in relation to the ventral profile, though nearly transverse in relation to the apical, but not the adoral part of the dorsal profile. Obliquity of the segments varies somewhat among the specimens, but ranges from 50 to 62 degrees. There is also some variation in the point at which the dorsal profile changes direction. Sections show typical deposits, but the apical part in which the siphuncle is essentially filled is relatively short, between one fourth and one fifth the length of the fibralia as they are extended on the venter.

The holotype GSC No. 22565, is a siphuncle of seven segments, expanding from 19 and 19 mm at the base, measuring height obliquely, as the segment is oblique, to 49 and 35 mm. Segments increase in length from 4 to 10 mm on the venter. Laterally and dorsally the expanded parts of the segments are rounded, but on the venter they are flattened, suggesting that they possibly touched the interior of the phragmocone. At the adoral end the cross-section shows the venter broadly rounded, and the dorsum markedly flattened. Segments are inclined 62 degrees to the ventral profile. Lateral expansion of the siphuncle is at an angle of 42 degrees; vertical expansion is at an angle of 25 degrees apically, and is reduced at a height across the siphuncle (not oblique) of 30 mm.

One paratype (GSC No. 22567) 105 mm long, retains parts of fourteen camerae, the last two being incomplete. Lateral expansion has an angle of 40 degrees; vertical expansion is 19 mm over much of the length, but the angle is greater apically. Septa are inclined 38 degrees to the ventral profile which is here slightly convex; slight crushing of this specimen is suspected. The first three segments, weathered ventrally, occupy 13 mm in length, expanding from 6 to 11 mm in width. The fourth segment is 12 mm across, 4 mm long; the 12th segment is 10 mm long on the venter, slightly less normal to the obliquity of the segments, 30 mm high and 52 mm wide.

A second paratype (GSC No. 22566) was received sectioned vertically. It shows eight segments, the first 15 mm high, 16 mm wide, 4.5 mm long, the last incomplete, but the penultimate one 32 mm high, 45 mm wide, and 10 mm long. Segments are oblique, forming an angle of 55 degrees with the ventral profile. Beyond a height of 25 mm, the dorsal outline of the siphuncle is convex, the adoral part not expanding to over 30 mm. The rapidly expanding part is 28 mm long, probably not more than 32 mm long from the apex.

Discussion. Though these specimens show some differences in proportions and outline, they appear logically to be included in a single species. This is a relatively large *Discosorus*. Adoral segments would show scarcely any increase in height, and in this respect *Discosorus parksi* is similar, but in that species the segments are scarcely wider than high and show a negligible lateral expansion. *D. halli* is one of the few species showing somewhat similar lateral expansion, but adoral segments do not increase markedly in length. Early stages are like *D. conoideus* in profile, obliquity and expansion of segments, but the segments fail to show similar marked flattening on the ventral side. None of the Lake Timiskaming species seems particularly close in proportions, and only *D. humei* shows a similar adoral increase in length of the segments.

Types and occurrence. Holotype and two paratypes, GSC Nos. 22565–22567. Nos. 22565 and 22566 are from float; one paratype is *in situ* in unit E of the Severn River Formation, 6½ to 7 miles above the mouth of the Rivière Joncas.

Discosorus transversus n. sp.

Plate III, figures 6, 7; Plate IV, figures 1–3

This species, known from two siphuncles, is characterized by a rather rapidly expanding series of segments, without known adoral reduction in curvature or consequent convexity of outline of the series of siphuncle segments. Lateral expansion is at an angle of 45 degrees, vertical expansion at an angle of 40 degrees. The expanded parts of the segments show slight flattening on the venter, suggesting that they may have touched the shell interior, and the cross-section shows very slight ventral flattening. The section is slightly wider than high but nearly circular, and the dorsum shows no flattening. The segments of the siphuncle are at right angles to the dorsal profile and make an angle of 65 degrees with the ventral profile.

The holotype (GSC No. 22568) a silicified siphuncle, preserves parts of eight segments; the second (the first being incomplete) is 3 mm long, 12 mm wide, and 10 mm high. The seventh is 7.5 mm long, 31 mm wide, and 30 mm high at its adoral end, at region of greatest cross-section. The specimen, showing a maximum length of 51 mm, has the six complete segments 35 mm long ventrally and 31 mm long dorsally. The anterior end of the specimen shows extreme anterior thinning of the fibralia.

A paratype (GSC No. 22569) consists of parts of nine segments, which are slightly weathered. The second segment 4 mm long, is 11 by 12 mm, and the sixth is 8.5 mm long and 29 by 31 mm, being slightly depressed. The last two incomplete segments are both 9 mm long, and show the anterior thinning of the fibralia. The siphuncle segments occupy a total length of 52 mm as before, the segments are flattened on the venter, and the venter is slightly flattened in cross-section.

Discussion. These two specimens agree most closely in proportions, and in having segments normal to the dorsum, but inclined at an angle of 65 degrees with the venter; also in the rate of enlargement of the siphuncle as a whole, and in the adoral rate of increase in length of the segments. The specimen figured by Flower and Teichert (1957, pl. 27, figs. 3, 7) from Lake Timiskaming as *Discosorus* cf. *D. ehlersi* shows a rather similar rate of increase in length of the segments, and angulation of the segments, here again at right angles with the dorsum, but the rate of expansion is appreciably smaller.

Types and occurrence. Holotype, GSC No. 22568, from float in Rivière Joncas; paratype, GSC No. 22569, unit E, Severn River Formation, Rivière Malouin.

Discosorus cf. *D. ehlersi* Foerste

Plate III, figure 5

Under this name is figured a single *Discosorus* siphuncle from the James Bay lowland, a specimen which seems to agree rather closely with this species in rate of enlargement of the siphuncle segments, and in the very gradual adoral increase in length of the segments. The specimen is somewhat crushed, has apical angles of 42 and 32 degrees, contains eleven segments that increase in length from 3 to 6 mm;

in a comparable part of *D. durdeni*, the increase is from 2 to 8 mm. The specimen is shown in a view which is essentially lateral, with the venter at the right. Obliquity of the segments to the venter is slight. The dorsum shows a faintly concave profile.

Discussion. This siphuncle is somewhat inconclusive at the specific level, being apparently somewhat distorted, but is close to *D. ehlersi* in rate of expansion and gentle adoral lengthening of the segments.

Type and occurrence. Figured specimen, GSC No. 22570, float in Rivière Joncas, believed to come from unit E of the Severn River Formation.

Discosorus durdeni n. sp.

Plate IV, figures 4–6

The unique type is a siphuncle 72 mm long with segments 4 mm across at the base, and the anterior (15th) segment 42 mm wide and 32 mm high; in cross-section there is very slight ventral flattening, with the dorsum slightly rounded. Segments show slight ventral flattening of the expanded parts on the venter. The first three segments average 2 mm in length, the last three are subequal in length and 8 mm long. Laterally, the sides diverge evenly at an angle of 34 degrees. Vertically, the venter is very gently convex in profile, the dorsum concave in the apical 20 mm, and thereafter essentially straight. Apically the angle is somewhat less than the 26 mm which is maintained beyond the first 20 mm. Segments of the siphuncle are gently oblique, and beyond the basal 20 mm are nearly 90 degrees with the dorsum, and 73 degrees with the venter.

Discussion. The proportions of this siphuncle are unique. It is just slender enough to resemble some of the more rapidly expanding species that have been referred to *Stokesoceras* as *S. engadinense* (Foerste, 1924, pl. 9, fig. 1) but it is also close to *Discosorus ehlersi* (Foerste, 1925, pl. 15, fig. 4,) from Lake Timiskaming in rate of expansion and obliquity of segments. Typical *D. ehlersi* has segments that are less oblique and in which the adoral increase in length is much smaller.

Type and occurrence. Holotype, GSC No. 22571, a float specimen from Rivière Joncas attributed, by lithology, to unit E of the Severn River Formation.

Order ENDOCERATIDA Hyatt, 1900

This order is characterized by siphuncles of tubular or concave segments, thick rings, and endosiphuncles of endocones, showing rather consistent habit, with blades generally well developed. Recent revisions of the order (Flower, 1955, 1958, 1964a) outline the rather complex and variable morphology. Fragmentary remains leave much to be desired concerning the morphology of many of the known forms, and taxonomy is yet far from perfect. The order appears at the beginning of the Middle Canadian, and was formerly thought to disappear at the close of the Ordovician, but the present study shows that *Humeoceras* is a survivor of the otherwise Canadian Piloceratidae. Silurian orthoconic types with long septal necks but without demonstrable endosiphuncles have been placed here, but those now adequately known appear to belong to the Offleyoceratidae of the Michelinoceratida. The present work removes from the order the Narthecoceratidae, which prove to be Michelinoceratida with endosiphuncles amazingly homeomorphic with those of the true Endoceratida. Balashov (1955) proposed the Interjoceratina, a group with ectosiphuncles like those of the Endoceratida, but with a filling of radial lamellae instead of endocones. New material, notably the genus *Rossoceras* (Flower, 1964a), indicates that the supposed radial lamellae are interspaces between blades of unusual prominence which branch as they pass from the tube to the margin; endosiphocones of this genus are typical of the Endoceratida. Comparable parts were not known in Balashov's material.

Family PILOCERATIDAE S. A. Miller

These are Endoceratida in which both shells and siphuncles are rapidly expanding initially and are commonly endogastric. Both siphuncles and shells may become more slender adorally, and mature shells may contract slightly at the aperture. Siphuncle walls are holochoanitic; endosiphuncles show generally simple endocones, central tubes, but show considerable diversity in section of the tube and in the patterns exhibited by the blades. Many forms are yet known only from the heavy endosiphuncles, the relatively fragile conch, septa and even the siphuncle wall, being destroyed. A work nearing completion, to be published as a memoir of the New Mexico Bureau of Mines, contains a fuller account of the family.

Teichert (*in* Teichert, *et al.*, 1964) interpreted *Humeoceras* as having a vertical partition in the siphuncle as in *Allotrioceras*, and erected the family Humeoceratidae. Our new material requires rejection of this interpretation and shows that the family is not properly distinct from the Piloceratidae.

Genus *Humeoceras* Foerste

Foerste, 1925, *in* Hume, p. 65. Teichert, 1964, *in* Teichert, *et al.*, p. K184.

Humeoceras is a piloceroid, known only from isolated siphuncles, compressed, faintly endogastric, with a blunt rapidly expanding apex, a longer more slender anterior part, where profiles may be even or faintly sinuate. Endocones are normal, simple, and terminate in a central tube so compressed that it is difficult to determine its limits, as dorsal and ventral margins have simple single blades extending from them; these blades may be somewhat askew, but are not branched. As yet only siphuncles are known, and they fail to show septal markings.

Discussion. The original material of *Humeoceras unguloideum* consisted of several siphuncles, partly silicified and leached. The cavity within showed a vertical partition. New unleached material shows that such specimens had the tube and vertical blades silicified, but the remainder of the endosiphuncle was calcitic and lost by leaching. As thus interpreted, *Humeoceras* is very close in all known respects to true *Piloceras*; in *Piloceras* the only real distinction is that one and more commonly both of the vertical blades may bifurcate. *Humeoceras* shows no septal markings, but the same condition is found in Canadian Piloceratidae, including material of *Piloceras* itself, and is a preservation phase involving either exfoliation, or slight solution of the surface, or both. One might hope that the stratigraphically isolated *Humeoceras* differed in other respects; perhaps the conch, septa and siphuncle wall were not well calcified, but the material fails to show any consistent differences between this and rather abundant Canadian Piloceratidae. Our type of *H. tardum* shows longitudinal markings on part of the surface, the significance of which is not known, but similar longitudinal striation has been found in some Endoceratidae. From its stratigraphic isolation, it seems possible that *Humeoceras* is a homeomorph of the true Piloceratidae, but the examination of the material has brought out no facts which would support such a belief; instead, the blade pattern is the only feature (which I had at first been reluctant to use in distinguishing genera because of practical difficulties involved in its study, as well as because of alteration of patterns of siphuncle interiors under advanced conditions of replacement) by which *Humeoceras* and *Piloceras* can be distinguished. It would appear necessary to look upon *Humeoceras* as one of those odd survivors beyond the previously known limits of a group, rather like the Cincinnatian aglaspid described by Caster and Macke (1952).

Humeoceras durdeni n. sp.

Plate I, figures 1–13

Only endosiphuncles are known which are smooth, compressed, with dorsum and venter equally rounded in cross-section, faintly endogastric. Enlargement in the known part is gentle and uniform, and a known height of 48 mm and a width of 38 mm are attained, a larger size than is known for *H. unguloideum*. The apex is rapidly expanding in the basal 20 mm, where dorsum and venter are both convex, and in the basal 25 mm the siphuncle is 14 mm wide and 20 mm high; beyond this point the siphuncle is more slender, with the venter gently concave in profile, the dorsum gently convex, but with dorsum and venter diverging gently to the most anterior point known. The three specimens described in detail below show simple compressed endocones terminating in a compressed very flat tube, supported by a dorsal and a ventral blade. Apically the cross-section is slightly asymmetric; this may result from slight flattening of the specimens, but may be original, as a similar condition has been found in some Canadian Piloceratidae.

H. unguloideum is different in proportions, showing the venter becoming straight adorally, while the dorsum remains convex, so that the siphuncle height is slightly decreased adorally.

The holotype (GSC No. 22572) shown on Plate I, figures 8–13, is the longest available portion of an endosiphuncle, with a lateral length of 105 mm, expanding from 37 and 26 mm to 49 and 38 mm. The section is compressed, with the venter very slightly more narrowly rounded than the dorsum. The adoral end shows the anterior thin endosiphuncle, and the specimen includes all but a small anterior part of the endosiphuncle cavity. An oblique break, extending orad ventrally (Pl. I, fig. 11), shows the anterior thinning of the endosiphuncle, and the endosiphuncle cavity as essentially elliptical, allowing for its adoral enlargement. The broken transverse end of the apex shows a central compressed tube with single dorsal and ventral blades, the dorsal blade somewhat askew. A section cut close to the apex shows the structures more clearly (Pl. I, fig. 13). The section shows extensive replacement of the material of the endosiphuncle; evidently recrystallization took place after early silicification of the tube and the blades. The surface of the endosiphuncle is essentially smooth; faintly transverse undulations suggest original septal markings, but are so faint that spacing of the septa cannot be estimated.

Paratype GSC No. 22573 (Pl. I, figs. 1–5) is part of a siphuncle of an immature individual, and shows part of the apex that is rapidly enlarging and has the venter as well as the dorsum convex in profile. The specimen consists of an apical part 50 mm long attaining a cross-section of 30 and 20 mm adorally, with the right side more flattened than the left; the break shows the vertical blades straight, the tube small, central and inconspicuous. In lateral profile, the sides are straight and gently diverging. The venter is convex apically, but concave adorally; the dorsum is gently and essentially uniformly convex. An anterior 40 mm, attached to the apical part in Plate I, figure 1, shows a continuation of gentle expansion, with gentle convexity of the dorsum and concavity of the venter. This part shows the endosiphuncle broken, and some crushing is evident. The section at the anterior end (Pl. I, fig. 4) shows the vertical blades joining the cavity near the apex of the endosiphocone an oval area filled with matrix.

A second paratype (GSC No. 22574) is the anterior part of an endosiphuncle; in part, the calcareous material is broken away, showing the smooth surface of the compressed endosiphocone. An oblique view of the base shows a section through the endosiphocone with traces of the single dorsal and ventral blades. The specimen is 65 mm long and attains 45 mm and 50 mm at the anterior end.

Types and occurrence. Holotype, GSC No. 22572; paratypes, GSC Nos. 22573, 22574. All are from the basal sandstone (unit O) of the Ekwan River Formation, Rapides des Papillons, Harricana River.

Humeoceras tardum n. sp.

Plate II, figures 9–11

This is known only from the holotype, a slightly crushed endosiphuncle. The endosiphocone is extremely long and slender, so that the part apicad of it is less than one fourth the length of the specimen, which is 115 mm long. Apical expansion is rapid, the siphuncle growing from 10 mm to 30 mm high in the first 25 mm, where the venter is convex and the dorsum, faintly convex, diverges from it rapidly. Then the dorsum becomes abruptly geniculate and is thereafter gently convex, though showing a slight flattening of profile in the middle third of the specimen, beyond which curvature is slightly greater. The venter is convex at first, becomes then gently concave, gently convex over the middle part, and then concave to the adoral end. The surface is mainly rough and featureless, but at the anterior end there are fine longitudinal markings seen only on the venter, reminiscent of the surface markings of the ornament-genus *Polygrammoceras*. No evidence of septation can be seen.

Discussion. The proportions and the extremely slender endosiphocone, which occupies most of the endosiphuncle and causes the complete filling to be retarded and greatly confined apically, characterize this species. *H. durdeni* shows more gentle and uniform curvature, without the median convexity of the ventral profile. *H. durdeni* lacks the median convexity of the ventral profile, and shows the dorsum and venter approaching each other adorally, while in *H. tardum* they are still diverging at the adoral limit of the endosiphuncle, which has a height greater than that attained in *H. unguloideum*.

Type and occurrence. Holotype, GSC No. 22575, unit G of the Severn River Formation, Rivière Malouin.

Order ACTINOCERATIDA

This order (Teichert, 1933; Flower, 1957) is characterized by the large expanded siphuncles within which annuli develop, leaving a siphonal vascular system of central and radial canals, and a perispatium. One error made in the last revision (Flower, 1957) may be noted here; *Lambeoceras*, the Huroniidae and *Kochoceras* show derivation from the genus *Actinoceras*, by the short hook-like recurved brims, rather than from *Armenoceras* or the Armenoceratidae as indicated in former works. Much confusion currently remains because *Sactoceras*, properly a genus so close to *Ormoceras* that it might rightly be considered a synonym, has been used in the past for orthocones with small spherical siphuncle segments, and in it have been included some true Actinoceratida, but also some Michelinoceratida pertaining to the Proteoceratidae (Flower, 1962a). The great expansion of the Actinoceratida is found in the Ordovician; new Silurian genera are confined to *Elrodoceras*, *Megadiscosorus*, and *Huroniella*. Investigation of *Huroniella* is needed; it is known only in the Silurian, whereas *Huronia* appears in the Red River faunas of the Ordovician. It is possibly developed from *Armenoceras* and only homeomorphic with *Huronia*, but an alternate interpretation that it is a specialization derived from *Huronia* is also a possibility. Our "*Lambeoceras*" should be a new genus, but species are represented by material too fragmentary for proper description.

Family ORMOCERATIDAE Saemann, 1852

This family as revised contains actinoceroids with the radial canals simple and horizontal; siphuncles are composed of segments rarely broader than long, although in some they become more slender. The first representatives appear in the Chazyan (*Ormoceras*), and are developed from the Whiterock genus *Adamsoceras*. *Deiroceras* (*Troedssonoceras*) is characteristic of the later Ordovician, and particularly, of the late Trenton ranging into the Maysville. Only *Ormoceras* is recognized in the Silurian. It is probable that *Metarmenoceras* of the Lower Devonian belongs here rather than in the Armenoceratidae, for it has simple horizontal canals. *Ormoceras* continues into the early Middle Devonian. The later Middle and Upper Devonian has yielded no known Actinoceratida as yet, but judging from its canal system, *Rayonnoceras* of the Mississippian is a survivor of the Ormoceratidae and not of the Actinoceratidae, a family which did not survive the close of the Ordovician.

Genus *Ormoceras* Stokes, 1838

Ormoceras is an orthoconic actinoceroid with typical siphonal deposits, simple horizontal radial canals, and siphuncle segments which are spherical or nearly so; simplification of outline and development of more slender segments may develop in adoral camerae, but never over any great length of the phragmocone. The genus ranges from the Chazyan of the Ordovician into the Middle Devonian at least; the youngest species observed is from the Onondaga limestone of New York State. The genus is not stratigraphically diagnostic, and as yet faunally significant species groups have not been recognized. Much confusion has existed concerning the distinction between *Ormoceras* and *Sactoceras* which the writer considers to be synonyms. Both generic names have been used to some extent, though this applies more particularly to *Sactoceras* for (1) true actinoceroids as outlined above, (2) orthocones with small spherical siphuncle segments with no known deposits, and (3) orthocones belonging to the Proteoceratidae Flower (1962a). The concept that there are orthocones with empty spherical siphuncle segments now seems incorrect; however, fragments from adoral parts of phragmocones of both Actinoceratida and Michelinoceratida may have this appearance.

Ormoceras expansum n. sp.

Plate II, figures 5–8

There is a single phragmocone of this form, broadly depressed in section, expanding from 14 and 19 to 17 and 22 mm in the length of 34 mm. It is very slightly curved, the siphuncle located closer to the convex than to the concave side. Sutures are straight and transverse, septa shallow in curvature as seen in section, depth equal to one and a half siphuncle segments; camerae short, eight in a length equal to the adoral shell height of 17 mm. The siphuncle has *Ormoceras*-like segments, with the septal foramina unusually broad; a segment near the anterior end expands from 2 to 5 mm, and is 2.5 mm long. Calcite occupies most of one side of the siphuncle, and the camerae of the same side are calcite-filled. On the opposite side, there are no clear siphonal deposits, and the camerae show some thin episeptal deposits.

Discussion. This species is distinctive in the broad cross-section and the rather rapid rate of expansion. The large sphaeroidal siphuncle segments indicate assignment to *Ormoceras,* but the calcite in the siphuncle appears to be a complement of an incomplete internal mould, and not the usual organic deposits of the Actinoceratida.

This form is superficially like *Sactoceras vadocameratum* Foerste of the Thornloe limestone of Lake Timiskaming in expansion and spacing and curvature of septa, but that form is circular and not strongly depressed in section.

The marked ventral concentration of deposits is suggestive of a similar condition shown by Zuravleva (1957, pl. 1, fig. 1) for *Sactoceras formosum,* regarded as Upper Silurian.

Type and occurrence. Holotype, GSC No. 22576, unit O of the Ekwan River Formation, Rapides des Papillons, Harricana River.

Family HURONIIDAE Foerste and Teichert, 1930

Genus *Huronia* Stokes, 1824

This genus is known largely from isolated siphuncles, happily the most characteristic parts of the shells. Segments are long, convexly rounded and expanded in a generally short adoral part, the apical part is tubular or concave. Teichert (1934) has presented drawings of sections showing the anterior rounded part to be outlined by the connecting ring above, while the free part of the septum is incorporated in the apical tubular part. Septa here swing apicad, but where the expanded part of the segment is reached, turn centrad, and extend into the siphuncle cavity for some distance, ending in a short hook-like recumbent neck from which the ring can be traced, broadly adnate until the expanded part of the segment is reached.

Huronia is known from several species in the Red River faunas, but is more characteristic of the early Middle Silurian dolomites and limestones of the north-central region. The genus extends east to Anticosti Island and *H. vertebralis* has been recognized in the Silurian of Utah (Sweet, 1955).

Huronia horizontalis n. sp.

Plate V, figures 8–11

This *Huronia,* though known only from three segments of a siphuncle and a fragment of a fourth, is distinctive in that segments show only the faintest obliquity, to such an extent that the identity of the ventral side, where the segments slope forward, is not at once obvious. The shape of the segments is also distinctive. The three complete segments show adoral shortening, measuring 24, 22, and 21 mm long. They are faintly compressed, 1 mm smaller laterally than vertically, expanding from 32 and 33 mm to 43 and 44 mm. The posterior limit of the broadly rounded free part is rather well delimited, largely by colour, it is in this region that the functional perispatium is developed. The connecting ring is free and 9 mm long on the anterior segment, with the lower concave part where the septum is broadly adnate to the siphuncle 13 mm long.

The base of the specimen has been ground, and shows in cross-section the central canal slightly dorsad of the centre, and a relatively symmetrical pattern of radial canals.

Discussion. Many species of *Huronia* have the anterior rounded part of the siphuncle segment shorter and less inflated, the segments being more nearly cylindrical than conical. *H. annulata* Hall is comparable, but siphuncle segments are not as broad in that form in proportion to their length, and the apical contraction of the segment is less extreme. *H. obliqua* Stokes is more similar in the conical nature of the segments, their marked contraction apicad, but here the segments are markedly oblique, whereas in *H. horizontalis* they are scarcely inclined.

Type and occurrence. Holotype, GSC No. 22577, unit S of the Ekwan River Formation, Harricana River opposite Ile des Sapins.

Family ARMENOCERATIDAE Troedsson, 1926

Genus *Megadiscosorus* Foerste, 1925

Megadiscosorus sp.

Plate V, figures 12, 13

Our only specimen representing this genus consists of a calcitic siphuncle partly weathered and partly embedded in matrix, thus failing to show exact proportions. Seven segments in a length of 43 mm are rather strongly oblique and show a suggestion of gentle curvature typical of *Megadiscosorus*. A segment at the base is 6 mm long and 19 mm high measured parallel to the oblique segment; width is not evident. Near the middle of the specimen a segment that appears 19 mm high, but was possibly as much as 23 mm (one side being weathered and some of the expanded part of the segment lost) is evidently at least 30 mm wide at this point.

Discussion. With weathering of one side and the matrix concealing the width of the siphuncle segments, no very close specific comparison can be made. It is worth noting that the genus is known from the Manistique of Michigan, *M. remotus* (Foord); from several species of the Thornloe limestone of Lake Timiskaming, *M. inoptatus* and *M. crassisegmentatus;* and by *M. crassisegmentatus orientalis* from the Jupiter Formation of Anticosti Island. *M. balticus* of the Lyckholm beds of the Baltic region, is properly a *Nybyoceras.*

Type and occurrence. Figured specimen, GSC No. 22578, unit G, Severn River Formation, Rivière Malouin.

Genus *Lambeoceras* Foerste, 1917

Lambeoceras is a strongly flattened actinoceroid, with acute lateral angles, and dorsal and ventral lobes. The absence of lateral lobes distinguishes it from the older *Gonioceras,* but a more fundamental difference is found in the siphuncles; *Gonioceras* has segments like those of *Armenoceras,* but *Lambeoceras* has septa bent apicad for some appreciable distance, and then short hook-like necks, recumbent or nearly so, and is more like *Kochoceras.* True *Lambeoceras* appears in the late Trenton of Quebec, is a significant genus in the Red River faunas, and extends into the late Richmond of Cincinnati.

The species described below are like *Lambeoceras* in gross form, but have siphuncle segments like *Armenoceras*; it is clear that a new genus is needed for these forms, which represent another distinctive Silurian genus of the Actinocera-tida, and that this is an independent development of a strongly flattened shell stem-ming from true *Armenoceras.* The two specimens represented in the present material, the only ones known, are too fragmentary to serve as types of named species; it is therefore equally impossible to propose a new generic name for this group, and they are described as *Lambeoceras* only because they are similar to that genus.

"*Lambeoceras*" sp. 1

Plate V, figures 6, 7

This is a specimen exposed by weathering from the dorsal side, 38 mm long, shell width varying from 19 to 20 mm and containing parts of ten camerae, with some others indistinct at the anterior end. There are four camerae in 10 mm; seven and one half in 20 mm. The septum is deeply curved horizontally, its curvature equal to about two camerae. The siphuncle shows segments that are 2 mm long, expand from 3 to 6 mm, more similar to those of *Gonioceras* than to those of *Lambeoceras,* inasmuch as the recurved necks are not pointed strongly apicad. A cross-section shows that the siphuncle lies close to a broad flattened side of the shell; the opposite side is lost by weathering.

Type and occurrence. Figured specimen, GSC No. 22579, unit S of the Ekwan River Formation, Harricana River just south of mouth of Ruisseau des Fossiles.

"*Lambeoceras*" sp. 2

Plate V, figures 4, 5

This is a weathered portion of a phragmocone 38 mm long, rather poorly preserved. It attains a width of 28 mm near the base, the only point at which both sides are preserved, and is apparently not more than 10 mm high. Septa are close, deeply curved horizontally, flat vertically, and inclined forward slightly from venter to dorsum. A break shows the septal foramen 6 mm wide, 5 mm high, nearly in contact with the venter. The dorsum is not complete at any point, being lost by weathering. Septa are close, about four camerae in a length of 10 mm.

Type and occurence. Figured specimen, GSC No. 22580, unit Q, Ekwan River Formation, Harricana River opposite Ile des Sapins.

Discussion. These two specimens do not agree perfectly in proportions. The older form shows camerae sloping dorsad, and septa are slightly wider apart. Also this form seems to have been more expanded laterally. Both specimens show the generally flattened section and suture pattern of *Lambeoceras.* The younger specimen shows a siphuncle in which the segments are more like those of *Armen-oceras* or *Gonioceras* than *Lambeoceras.*

Order MICHELINOCERATIDA

This is the big order of generalized "*Orthoceras*" of palaeontological works of a generation ago. Recent progress has been reviewed (Flower, 1962a) but there are still serious gaps in our knowledge of the group. Generalized forms have tubular siphuncles. Apparently siphonal and cameral deposits are archaic features, being developed in the earliest known representative of the order. Forms with tubular siphuncles range from the late Canadian into the Triassic. It is now apparent that before the close of the Canadian two families were differentiated, the Michelinoceratidae with annular siphonal deposits, and the Troedssonellidae with a lining similar to endocones of the Endoceratida.

Within the Michelinoceratidae variation develops, and there is probably no general agreement yet as to suprageneric treatment of these forms. It is evident, however, that some forms show retardation and possibly complete suppression of cameral deposits, and that in others siphonal deposits are retarded. We can trace to this stock several groups in which the siphuncle segments expand. Two are of particular importance: the Proteoceratidae which begin in the Chazyan and extend into the Silurian, and the Pseudorthoceratidae which appear in the Lower Devonian and extend into the Permian. Problems yet surround a number of groups, such as the Striatoceratidae, Allumettoceratidae, and the odd genus *Stereoplasmoceras*. The Silurian of Bohemia has yielded a large number of particularly well preserved Michelinoceratidae (in which I tentatively include Hyatt's Kionoceratidae).

Interestingly, two species of *Kionoceras* are the only representatives of this great lineage in the James Bay Silurian, and orthocones with tubular siphuncles are generally scarce or wanting in the north-central Silurian *Discosorus-Huronia* faunas. We find there, however, one member of the Proteoceratidae, here tentatively referred to *Euorthoceras*.

The great surprise yielded by the James Bay Silurian cephalopods is material of *Donacoceras* and *Narthecoceras*, showing these two genera to be allied; material of *Narthecoceras* shows it to belong to the Michelinoceratida and not, as Hyatt (1900) and the writer (Flower, 1958) thought, to the Endoceratida. Clearly, the group is one showing remarkable homeomorphy with the Endoceratida, but belongs instead in the Michelinoceratida, and is a stock derived from the Troedssonellidae (Flower, 1962a).

The family is revised in the present work, and the study extended to available Ordovician materials.

Family MICHELINOCERATIDAE

Problems concerned with the recognition of the proper scope of this family have been summarized (Flower, 1962a) and need not be repeated here. Our present material contains two species of *Kionoceras*, and raises anew the question of the desirability of recognizing the Kionoceratidae as a separate family. It is evident that there is a closely knit group of species, once placed in *Kionoceras* but now placed in several genera with longitudinal markings, siphuncle segments subtubular but slightly constricted at the septal foramina, and with siphonal and cameral deposits retarded and quite confined apically for which this family name can be used. Unfortunately, however, *Kionoceras* as presently delimited is possibly a receptacle for several homeomorphic stocks with longitudinal markings, and there is no certainty that Chazyan and Mohawkian *Kionoceras* are not homeomorphs of that genus (Flower, 1952), which is most fully and typically developed in the Middle Silurian.

Genus *Kionoceras* Hyatt, 1883

Kionoceras has a shell with prominent longitudinal ridges, and may have finer longitudinal or transverse markings or both. The typical Silurian species range from moderate to large, up to 3 feet long, and are generally moderately expanding over most of the shell length, not tubular as in some Ordovician forms that are possibly only homeomorphs of the genus. We may eliminate on the basis of surface markings the genera *Protokionoceras*, *Polygrammoceras*, *Parakionoceras*, including typically Silurian forms which seem allied to true *Kionoceras*. *Deiroceras* is a homeomorph among the Actinoceratida, and the affinities of *Striatoceras* are yet uncertain; the latter has more expanded siphuncle segments with a lining or irregular lamellar elements. *Kionoceras* ranges into the Middle Devonian, where species are generally smaller, and show some odd modifications of siphonal deposits to be described elsewhere.

The James Bay fauna contains evidently two species of *Kionoceras*, but the second is known from too fragmentary material to permit proper description of a species. Neither contributes to further understanding of the morphology of the genus.

Kionoceras cf. *K. loxias* (Hall)

Plate V, figure 1

cf. *Orthoceras loxias* Hall, 1868, p. 380, pl. 19, fig. 7.
cf. *Kionoceras loxias* Foerste, 1924, p. 29, pl. 14, fig. 1.
cf. *Kionoceras loxias* Foerste, 1928, p. 293, pl. 62, fig. 3.

One piece from the silty beds of unit M of James Bay contains two fragmentary specimens tentatively referred to this species. The better one shows an apical 90 mm of crushed phragmocone showing neither surface nor septa, orad of which there is a somewhat crushed living chamber which, including its obliquely crushed septum at the base, is 75 mm long. The septum shows a small septal foramen, slightly eccentric. The living chamber increases in 60 mm from 30 to 34 mm in width. It is crushed, and one side is deeply weathered. The other side shows the surface, which has low narrow rounded ridges, less than 1 mm across, separated by flat interspaces ranging from 5 to 7 mm in width and showing the faintest traces of very fine transverse markings. Another impression of a living chamber on the same piece is 75 mm long, the width incomplete at both ends, but 35 mm across near the middle; this specimen shows ridges fine as before, 7 to 8 mm apart.

Discussion. The well defined but low distant ridges of this specimen and the faint transverse markings are close to those of *Kionoceras loxias*. This species

Foerste (1924) at first thought came from the Racine of northern Michigan, but later (1928) he recognized that it came from the Manistique Formation.

Type and occurrence. Figured specimen, GSC No. 22581, unit M of the Severn River Formation, Rivière Malouin.

Kionoceras sp.

Plate V, figures 2, 3

The single specimen, 60 mm long, is a crushed living chamber with four attached camerae at present 19 and 28 mm across at the base. There are four camerae at the base in 12 mm, the basal two 4.0 to 4.5 mm long, the last two greatly abbreviated. The living chamber is 21 and 33 mm across at the base, 42 mm long, showing a broad internal constriction 22 to 34 mm from the base, in which the internal mould is constricted horizontally from 34 to 31 mm, then becoming 35 mm wide at the aperture. The septal foramen is obscure at the base of the specimen. The internal mould shows faint traces of longitudinal ridges, which seem closer than those of the associated *K.* cf. *K. loxias*. This is a smaller species, which attains maturity at a considerably smaller shell diameter.

Type and occurrence. Figured specimen, GSC No. 22582, from the lower coquina beds, unit E of the Severn River Formation, Rivière Joncas.

Family Proteoceratidae Flower, 1963

These are slender shells, dominantly orthoconic, with expanded siphuncle segments which show adoral simplification of outline, rather characteristic annular siphonal deposits which may fuse to form a lining of segmental units, and with the deposit growing both orad and apicad from the point of inception, and commonly thick in the apical part of each expanded segment. Our knowledge of the lineage is still imperfect. The stock is prolific in the Ordovician, continues into the Lower Silurian *Euorthoceras* as well as some inadequately known species which have formerly been assigned to the genus *Sactoceras*, and the Middle Silurian *Cyrtactinoceras*. The family declines in the later half of the Middle Silurian and is unknown in the Upper Silurian.

Genus *Euorthoceras* Foerste

Revision of this genus is contemplated in the near future. It contains smooth orthocones with gradual adoral simplification of the siphuncle segments. Examination of Foerste's type material, a suite of specimens from the Brassfield limestone of Ohio, indicates that it belongs to the Proteoceratidae, but some morphological details as well as some legalistic matters require clarification. As the only simple orthoconic genus so far recognized in the Silurian, the genus is used here as a receptacle for one species of the James Bay lowland material. Some Middle Silurian species from Lake Timiskaming may be allied; they are inadequately known morphologically and are currently assigned to *Sactoceras*, notably *S. vadocameratum*.

Euorthoceras ? sp.

Plate IV, figures 9–13

This is known from a fragment of an orthocone 30 mm long, slightly crushed, A cross-section near the base is irregular, 14 mm wide, 10 mm high, beyond which is a 52 mm interval sectioned horizontally. This portion was cut across the middle, because a horizontal section cutting the siphuncle at both ends did not reach it in the middle. In this interval the shell expands to 19 and 14 mm. Apically three and a half camerae and adorally four and a half camerae occur in a distance equal to the shell width. The siphuncle is made up of barrel-shaped segments, slightly more expanded in the anterior than in the apical ends. Necks are gently recurved and highly variable in length. Anteriorly mural deposits of the camerae are seen, which thicken rapidly when traced apically. Adorally small annuli occupy the septal foramina; they too apparently increase rapidly as they are traced apicad, but in the apical half of the phragmocone recrystallization makes it impossible to distinguish organic from inorganic calcite. The anterior part, 65 mm long as a maximum, was sectioned vertically, but inside the septa are distorted and largely wanting adorally, and the siphuncle segments are not preserved.

Discussion. This specimen, though better known than many Silurian named orthocones, remains of dubious affinities. Specific affinities are obscured by distortion and at the generic level, although it is certain that this species belongs in the Proteoceratidae, there is at present no genus to which it can be assigned with certainty. It seems closely allied to the Cincinnatian *Orthonybyoceras*, and the little known *Euorthoceras* is also comparable; it is uncertain at present whether these two genera should not be one. No closely comparable form is known, but the closest Silurian species will be found among those forms that have formerly been assigned to *Sactoceras.*

Type and occurrence. Figured specimen, GSC No. 22583, unit S of the Ekwan River Formation, Harricana River.

REVISION OF THE NARTHECOCERATIDAE

The Narthecoceratidae is here placed in the Michelinoceratida, regarded as derived from the Troedssonellidae as revised (Flower, 1962a) and as containing the genera *Narthecoceras* (= *Calhounoceras*), *Farroceras*, *Tasmanoceras*, and *Donacoceras*. The family was formerly placed in the Endoceratida (Flower, 1957) and opposing evidence was first supplied by some members of the Narthecoceratidae from the Silurian of the James Bay lowland. The study was necessarily extended to include other material, largely a fine suite of *Narthecoceras* from the Red River Formation, additional material from the Ordovician of Lake Timiskaming, with some smaller lots from other places and sections.

The history of the various concepts is largely bound up with that of *Narthecoceras* itself, for until now the genera here placed with it have not been considered as allied. Whiteaves (1891) described *Endoceras crassisiphonatum*, based upon large siphuncles from the Red River Formation of Manitoba and redescribed also *Orthoceras simpsoni* Billings (*in* Hinde, 1859) which he did not consider as immediately related. Hyatt (1895) proposed the generic name *Narthecoceras*, based upon *E. crassisiphonatum*, but supplied scarcely any definition. In 1900 we find the genus listed by Hyatt among the Endoceratidae. Troedsson (1926) reviewed the genus and added a new species, *N. inflatum*, from the Cape Calhoun series of Greenland, placing it in the endoceroids, and described a new genus and species *Calhounoceras candelabrum,* for a rather similar siphuncle, which, however, he considered an actinoceroid. Foerste (1929) reviewed both genera, redescribed and refigured *N. crassisiphonatum*, and placed *Orthoceras simpsoni* in the genus *Narthecoceras* also. He figured a Red River specimen as *Calhounoceras* cf. *C. candelabrum*. He considered the genera as possibly allied. Foerste and Teichert (1930) discussed the genera *Narthecoceras*, *Calhounoceras*, and *Donacoceras* together, noting some similarities, but were puzzled by their position. *Narthecoceras* seemed atypical of the Endoceratida in some respects, *Calhounoceras* seemed anomalous as an actinoceroid, but the two genera were seemingly distinguished by the radial horizontal fibres of *Narthecoceras* and the longitudinal fibres of *Calhounoceras*.

Teichert (1934) restudied Troedsson's types of *Calhounoceras*, reaffirmed the radial canals shown by one of the types, and reaffirmed its position as an actinoceroid. Flower, recognizing that *Narthecoceras* was distinctive among the Endoceratida by its long convex segments and fine texture of the endosiphuncle, erected for it the family Narthecoceratidae, which was regarded as of doubtful position, but as unrelated to the Endoceratidae, and as possibly springing from the Proterocameroceratina. Meanwhile Teichert and Glenister (1952) had described the genus *Tasmanoceras*, regarded as an anomalous endoceroid with short convex siphuncle segments, and an endosiphuncle with the tube well dorsad of the centre, and with the endocones steeply sloping and extended forward on the venter.

The Silurian of the James Bay lowland yielded a number of siphuncles of orthoconic shells, the segments faintly convex, some are long and slender, as in *Narthecoceras*, others short as in *Donacoceras*, but some are intermediate and show that no perfect separation can be made between these genera on the basis of proportions. The material included two types of endosiphuncles. In one, as in typical *Narthecoceras*, cones are seemingly radially symmetrical and terminate in a central tube. In others, the cones are immensely extended forward on one side, the apparent venter, rather as in *Mcqueenoceras* of the Canadian; anteriorly only half-cones, open dorsally, are apparent, and the cones are closed on the dorsum only near their apices. They terminate in a small tube generally transverse and located between the centre and the dorsum. The two types of internal patterns failed to correspond closely with the proportions of the long versus short segments. It was necessary to consult the type material of *Donacoceras* to ascertain which of these two patterns it possesses, for the endosiphuncle was not previously described in any detail. T. E. Bolton kindly examined the type material, and reported that it possesses the second of these types. Later the type material and supplementary material from Lake Timiskaming were loaned for illustration and further study.

The James Bay material of the aspect of *Narthecoceras* and *Donacoceras* showed a number of features in common, indicating that the genera are closely related. Both show very thin increments of growth, with sheaths, commonly silicified, close together. Both show, upon weathering or etching of the siphuncles, a texture in which longitudinal fibres are dominant. No structures comparable to blades are found. Their similarity of habit (Flower, 1964a) suggests a close relationship. Associated material of *Humeoceras* shows very different preservation, blades are retained though individual sheaths are commonly not clearly preserved, but aside from the tube and blades the endosiphuncle may be grossly replaced. The material suggests that *Humeoceras* is very different in material and composition from *Narthecoceras* and *Donacoceras*; one may go further and say that it suggests that these genera are not members of the Endoceratida. However, *Humeoceras* is so isolated stratigraphically from its closest relatives, notably *Piloceras* and the family Piloceratidae, that, though it shows no distinctive features, one cannot be sure that this isolated genus could not be atypical of the Endoceratida, having specializations of its own in texture and composition of the endosiphuncle.

The James Bay Silurian also yielded in *Narthecoceras brevicameratum*, a siphuncle of the aspect of *Narthecoceras* within a phragmocone. A thin section of this form showed thin episeptal and hyposeptal deposits, a siphuncle wall with a thin homogeneous ring. Both features are alien to the Endoceratida and typical of the Michelinoceratida, and suggest that the related *Narthecoceras* and *Donacoceras* belong to the latter order.

A fine suite of specimens from the Red River Formation of Manitoba yielded *Narthecoceras* and Endoceratidae both in the Dog Head and Selkirk facies of the Dog Head Member. There *Narthecoceras* is found with fine aphanitic textures apparent on broken surfaces, presenting an appearance more like that of an *Beatricea* than of an endoceroid; radial fibres are generally present, and growth lines of the endosiphuncle are close together and commonly indistinct. In contrast, the true Endoceratidae show siphuncles that are commonly grossly altered except for the blades, and are composed of coarse calcite crystals. In some instances, blades are apparently silicified early in the history of alteration, and blades and the siphuncle wall may outline cavities in which there was apparent solution of original materials followed by geoidal filling of coarse calcite. Here, in specimens subject to identical conditions of alteration, reactions were so different as to suggest again real differences in texture and composition of the siphuncles.

Fortunately, logical ancestors of the Narthecoceratidae can be found in the Michelinoceratida in the family Troedssonellidae (Flower, 1962a). This is a family of orthocones with essentially tubular siphuncles within which a lining develops and thickens apically, forming in effect very slender endocones that terminate finally in a central tube within which diaphragms may develop. Cameral deposits are well developed. This family in turn is believed to be derived from the Michelinoceratidae, similar except that the siphonal deposits take the form of small annuli at the septal foramina; our present evidence shows *Michelinoceras* to precede *Buttsoceras* stratigraphically. The Troedssonellidae are known at present only from two genera, *Buttsoceras*, which is characteristic of the closing phase of Canadian deposition in North America, and *Troedssonella*, a genus of the "upper gray of Orthoceras limestone," of essentially Whiterock age. In this family one finds the cameral deposits similar in the extensive development of materials on the free parts of the septa, the siphuncle walls are similar in composition, the siphonal deposits are made up of very thin increments of growth, and show cones so steep that they are considered rather as a lining developed in the siphuncle, and the tube which is finally developed may be crossed by diaphragms.

Changes required in the development of the Narthecoceratidae involve the following: 1. Siphuncle segments become more expanded between the septa; segments develop convex outlines, or slightly expanded interseptal regions of tubular or sinuate outline may develop between long but shallow septal constrictions. 2. Cameral deposits are reduced to vestiges, and may be suppressed completely. 3. Whereas in the Troedssonellidae the siphonal deposit is small, short, confined to an apical part of the siphuncle, in the Narthecoceratidae the endosiphuncle becomes large and massive. We do not know its relationships to the shell as a whole, for we have no complete shells, but with suppression of cameral deposits, hydrostatic balance will be maintained best by increase in the proportion in length of the siphuncle in which the endosiphuncle is developed. 4. In the Narthecoceratidae the siphuncle becomes larger in diameter, and may be as much as one third the diameter of the conch, where in the Troedssonellidae, it is typically small, more like that of other Michelinoceratida, and one fifth or less the shell diameter.

With such evident features in which the Narthecoceratidae are presaged by the Troedssonellidae, it becomes evident that the resemblance to the Endoceratida is purely homeomorphic. Review of the differences shows that those features distinguishing the Narthecoceratidae from the Endoceratida are peculiar to the family as far as the Endoceratida are concerned, and there is no transition such as would be expected were the Narthecoceratidae true Endoceratida but specialized in the several distinctive features noted above.

In this connection some revision of previous views of the writer are required. It was stated (1964a) that the endosiphuncle, as a solid structure of endocones, showing no relation of segmentation with that of the phragmocone, was confined to the Endoceratida. This statement was hardly published when the new evidence presented here came to light, showing that the Narthecoceratidae, which have essentially endosiphuncles also, are Michelinoceratida. Further, one may describe the endosiphonal lining of the Troedssonellidae as endosiphuncles also. Terminology as related to the endoceroid siphuncle may be applied here, with the reservation that no blades have been found in either of these families, endocones are typically thin, and endosiphosheaths are frequently obscure.

With the development of dominantly radial fibres in the Narthecoceratidae, particularly in the genus *Narthecoceras,* it is necessary to consider whether the combination of growth lines and such radial fibres is comparable to that of the fibralia (Flower, 1964a) of the Discosorida. Comparison shows some real differences which suggest that such resemblance as exists is homeomorphic. It is the higher Westonoceratidae (indeed in part of *Faberoceras*), the Lowoceratidae and Discosoridae, that endocones develop in that order. Here there are growth lines, and fibres normal to the growth surfaces. Two important differences are found that indicate that the resemblance between these forms and the Narthecoceratidae are only homeomorphic. Fibres of the Discosorida are invariably much finer in texture than those of the Narthecoceratidae (*see* Pl. XXXI, figs. 1–5; Pl. XXXII, figs. 1–4), they behave differently under conditions of alteration. Indeed, in thin section our best preserved Narthecoceratidae show the radial fibres as coarse and vaguely outlined (Pl. XXXII, fig. 2), in contrast to which the Discosorida show finer and sharply outlined fibres. Another difference is found in the direction of the fibres; in the Discosorida the distal parts of the fibres are essentially normal to the curving outline of the expanded siphuncle segments; in *Narthecoceras* the distal parts are purely radial, normal to the siphuncle axis, and as noted more fully below, may turn forward and assume a longitudinal course around the tube.

One related but distinct problem presented itself: Could it be that *Lowoceras* is not a member of the Discosorida as was supposed (Flower, 1946) but instead a gently curved relative of *Narthecoceras*? This was suggested by the fact that its segments are abnormally slender for the Discosorida and present some resemblance to those of the Narthecoceratidae. Useful material for the investigation was unfortunately confined to the type specimen of *Lowoceras southamptonense*. Permission was granted by the Geological Survey of Canada to make a thin section of a part of this specimen. The results are shown on Plate XXX, figure 5 and Plate XXXI, figures 3–5. It is evident that distally fibres show alignment with the margin of the siphuncle. They are fine, much finer than any of the Narthecoceratidae, and finer even than those shown here for *Discosorus* (Pl. XXXII, fig. 2). The thin section seemed perplexing, however, in that the fibres did not appear to be continuous from the siphuncle margin to the centre, but it was realized that this effect is caused by the fact that the sectioned surface used was markedly eccentric, in order to preserve the better essentially sagittal surface shown by the other half of the specimen. As a result, the planes of the fibres intersect the plane of the section. An enlargement of a part of the opposing sagittal surface is shown on Plate XXX, figure 5; there the details are less clear as the section is opaque, but the radial continuity of the fibres is evident.

Exploration of the structure in Ordovician *Narthecoceras* has yielded evidence of endosiphuncles of long slender endocones of extremely thin increments of growth, with sheaths generally inconspicuous. In addition, there are fibres that are essentially radial. However, in some species these fibres have been found to be radial distally, but they may bend forward and become nearly longitudinal around the central tube. In some species at least, the apex of the endosiphocone becomes very slender, is deeply fluted, and appears in cross-section as a polygonal cavity with angles commonly produced slightly. It is only farther apicad that this region finally is filled in by forward-projecting parts of the fibres, and such areas are commonly differentiated from the rest of the siphuncle in colour. These regions surround the tubes that have definite walls of strikingly different material; the regions are called halos in the following descriptions.

The study was extended to investigate other genera which are possible relatives of *Narthecoceras* and *Donacoceras*. It was also desirable to check further to ascertain whether any significant differences distinguish the Silurian species from typical Ordovician *Narthecoceras*. Study of the genus *Calhounoceras* contributed to both matters, though it suggests a solution not completely free from subjective matters. This genus and its only species, *C. candelabrum*, were described by Troedsson (1926) from the Cape Calhoun beds of northern Greenland. Only siphuncles are known, and the species was based upon three specimens. One is a considerable series of siphuncle segments that are convex in outline, with rather narrow septal constrictions; they are quite like the segments of *Narthecoceras crassisiphonatum* in outline, except that the segments are proportionally somewhat shorter in relation to their diameters. About two segments occupy a length of siphuncle equal to the diameter at the septal constriction. Early segments are not proportionally longer than later and larger segments, as shown by the holotype. The holotype shows weathering at the anterior end which exposes a central tube like that of *Narthecoceras*, and the tube contains diaphragms. The genus was placed in the actinoceroids on the basis of a paratype which shows apparent radial canals, a matter confirmed by Teichert (1934). However, this is a specimen of very different proportions. It has segments less rapidly enlarging adorally, with the septal constriction long and gently sinuate instead of narrow, and the diameter across the narrowest part of the segment is equal to the length of one segment instead of two segments. This specimen is believed to be an actinoceroid, but it is not conspecific with the holotype of *Calhounoceras candelabrum*. With the elimination of this specimen, *C. candelabrum* appears as a form with a siphuncle very much like that of *Narthecoceras*. Segments are somewhat shorter than those of *Narthecoceras inflatum*, but not enough so to require recognition of a distinct genus, and the only distinctive feature which might be considered as a basis for separating the genus *Calhounoceras* is the predominance of longitudinal fibres in the endosiphuncle. On this basis, the Silurian species of the James Bay lowland would be assigned to *Calhounoceras* and not to *Narthecoceras*. The difference is real, but there is some suggestion of a transition, for although some *Narthecoceras* show only radial fibres, as the young of *N. crassisiphonatum* and *N. versperale*, others such as *N. sinclairi* and *N. anomalum* show the otherwise horizontal fibres turning forward and becoming longitudinal around the tube. It is easy to see without further transition how the longitudinal fibres may become more extensive until the horizontal fibres of the distal parts are completely altered in position.

We are then faced with a question on which there will probably be no unanimity of opinion as to whether the genera *Narthecoceras* and *Calhounoceras* should be recognized as distinct entities. The writer had, before recognizing the identity of the Silurian species referred earlier to *Narthecoceras* with *Calhounoceras*, decided that the differences of horizontal and vertical fibres were hardly a desirable basis for separating two genera that showed no additional differences. With recognition of the identity of the Silurian forms with *Calhounoceras* a name is already available for these forms, but the distinction will still fail to result in any significant faunal or stratigraphic groups.[1]

It has therefore seemed best to suppress *Calhounoceras* as a synonym of *Narthecoceras*. Oddly, we are left with two specimens of uncertain position which could be referred to *Calhounoceras* only on the basis of the long sinuate broadly expanded segments shown by the paratype which has been rejected as *C. candelabrum* and has been removed as an actinoceroid. One of these specimens, the original of Foerste's (1929) *Calhounoceras* cf. *C. candelabrum*, preserves the outline of a series of siphuncle segments, slightly crushed, but without evidence of any internal deposits whatsoever. The second is a specimen of somewhat similar outline of segments, but with a deposit that has suffered from considerable alteration. This deposit, however, shows an endosiphocone anteriorly, and though some actinoceroids may simulate this appearance, this form shows no evidence of composition of the cone of fused segmental elements; there is, further, no evidence of radial canals. It has seemed best to make a new genus *Farroceras* for this species and to recognize the Red River form as a distinct species, placed in this same genus tentatively.

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[1]*Calhounoceras* is from the Cape Calhoun Formation, in which a lower Mohawkian division (the Troedsson Cliff Formation), the overlying Red River beds, and higher beds of possible Richmond age have possibly been brought together. There is, however, no indication of which part yielded the material of *Calhounoceras*.

One other genus seems allied to the Narthecoceratidae, whose affinities are strong enough that assignment of the genus to the family is made here, even though no material other than published descriptions and illustrations is available. Teichert and Glenister described from the Ordovician of Smelters Quarry, Zeehan, Tasmania, *Tasmanoceras zeehanense;* no other species of the genus is yet known. The species is known from a few specimens showing a short series of siphuncle segments, which are short, convex, and slope forward on one side, presumably the venter. A section shows that they have apparent endocones with numerous steep sheaths on the venter, the tube dorsad of the centre. Internally, sections show essentially the features of *Donacoceras*. This genus was formerly ascribed to the Endoceratida, but it is unique in that order in having short segments of convex outline. With the resemblance of outline of segments and internal pattern to *Donacoceras,* there can be little doubt as to the propriety of removing it to the Narthecoceratidae.

Family NARTHECOCERATIDAE

Orthoconic shells, known largely from siphuncles, and mainly from those parts containing siphonal deposits. The siphuncles consist either of segments gently convex between septa or with broad shallow septal constrictions separating longer areas which are broader but nearly tubular in outline. Deposits within consist of endosiphuncles like those of the Endoceratidae but so differing in habit as to indicate real original differences in composition and texture. Sheaths are poorly developed in general, exceptionally close, the increments of growth being very narrow. Siphuncles may show structure of longitudinal or of fine numerous radial fibres.

Subfamily NARTHECOCERATINAE n. subf.

Endocones in this subfamily are radially symmetrical, without dorso-ventral differentiation except occasionally in the cross-section of the tube.

Narthecoceras Hyatt—Segments generally slender, fine structure shows radial fibres, grading into forms with longitudinal fibres which appear first by turning of radial fibres forward around the tube.

Farroceras n. gen.—Like *Narthecoceras* but with more expanded segments.

Subfamily DONACOCERATINAE n. subf.

Siphonal deposits, endocones, extended far forward on the venter as half-cones, closed dorsally only apically, terminating in a tube generally transverse, and dorsad of the centre.

Tasmanoceras Teichert and Glenister—Known only from siphuncle segments less than 10 mm in diameter, segments short, four to six in a length equal to their adoral diameter, inclined forward ventrally. Known as yet only from *T. zeehanense* of the Ordovician of Tasmania. Specimens show some slight curvature which is erratic, some with venter, some with dorsum convex.

Donacoceras Foerste—Known from siphuncle segments that are larger and essentially transverse, segments may slope forward very slightly on the dorsum;

known segments range from 10 to 25 mm in diameter, segments two to three in length equal to adoral diameter. Certainly known only in the Silurian; a few similar siphuncles of the Ordovician are yet unknown internally.

Subfamily NARTHECOCERATINAE

Genus *Narthecoceras* Hyatt

Narthecoceras Hyatt 1895, p. 2; Troedsson 1926, p. 32; Foerste 1929, p. 187; Foerste and Teichert 1931, p. 209; Flower 1958, p. 437.
Calhounoceras Troedsson 1926, p. 77; Foerste 1929, p. 191; Foerste and Teichert 1931, p. 210; Teichert 1934, p. 38.

Narthecoceras is an orthoconic shell, known almost completely from endosiphuncles. The siphuncles are formed of convex segments, which vary considerably in outline and proportions. Segments may be convex between the septal constrictions, which may be narrow and poorly defined, or, where the expanded parts are sinuate, but nearly parallel and tubular, the septal constrictions may be sharply defined, and are longer ventrally than dorsally. Endosiphuncles have very long slender endocones, which may become crenulated near their tips. Where this occurs, the later filling of the tip may be materially different, generally darker, and constitutes the *halo.* In some *Narthecoceras* only horizontal fibres are known, but in the type species, such fibres may, in late growth stages, be extended forward around the tube in the region of the halo; in other species, such change in direction of the fibres may be less clearly limited and may be somewhat broader. On this basis, gradation is indicated with *Calhounoceras,* in which only longitudinal fibres are known.

As yet, apices of *Narthecoceras* are unknown, though we have endosiphuncles which, from a series of fragments, occupy a length of 3 feet from *N. sinclairi*; a comparable length is indicated for *N. crassisiphonatum.* How much farther forward the phragmocone extended, containing siphuncle segments void of deposits and therefore unknown, is a matter of conjecture. Hydrostatic relationships, granting camerae mainly filled with gas, would suggest that with the cameral deposits vestigial and possibly wanting in some species, the endosiphuncles extended farther forward in the phragmocone than in other Michelinoceratida. We have, however, no anterior empty siphuncle segments or living chambers that can be attributed with certainty to *Narthecoceras.* Judging from the Red River species, in which the siphuncle is (Whiteaves, 1891) about one third the shell diameter, *Narthecoceras* may well have rivaled if it did not exceed the associated Endoceratidae in the size of the complete shell. Unfortunately, the solid endosiphuncles made the complete shells heavy, and waves and currents capable of lifting the whole were evidently capable also of breaking the thin fragile conch and septa. Whiteaves (1891, Pl. 8, fig. 1) figured a portion of a siphuncle, evidently belonging to *N. sinclairi,* with the phragmocone intact around it. This specimen could not be located for the present study. A second specimen of *Narthecoceras brevicameratum* of the James Bay Silurian (Pl. X), supplied evidence of the thin cameral deposits and thin homogeneous rings which gave the first clue to the affinities of *Narthecoceras* with the Michelinoceratida rather than with the Endoceratida.

Fibres of the endosiphuncle are coarse in contrast to the fibralia of the Discosorida, and show some alteration; in such thin sections as are shown here, the fibres are poorly and vaguely outlined, when viewed at high magnifications (Pl. XXXI, figs. 1, 2). The halos, regions around the tube of irregularly polygonal cross-section, commonly differentiated in colour and texture, seemed at first puzzling, until it was realized that these are regions in which the tip of the cone assumes a section of this sort, as shown in the apex of the type of *N. crassisiphonatum* (Pl. XV, fig. 3) and are filled in materially later; also, that it is in these regions that the fibres, which are generally horizontal distally, turn and assume a longitudinal position.

The possibility was considered of distinguishing *Narthecoceras* as having dominantly radial fibres, and *Calhounoceras* as having dominantly longitudinal fibres. Several objections to this taxonomic procedure appeared. First, with advanced alteration, direction of fibres may not be evident; the distinction may still be valid, but of such complexity as to make its use unnecessarily laborious. It became evident that no clear stratigraphic or faunal distinctions are brought out by recognizing this distinction at the generic level. Further, with closer study, it became evident that there was some variation and gradation between the two conditions. Some forms show only radial fibres, some show radial fibres in the young, which may become longitudinal adorally. Some show, as in Plate XXXIII, figure 5, the fibres sloping forward from the edges toward the centre, then steepening and becoming longitudinal.

Unlike the Endoceratidae, the endosiphuncle of *Narthecoceras* shows a central tube with a very definite and commonly a rather thick wall, clearly distinct from the fibrous endocones in texture. It is prone to replacement by coarse calcite crystals, but where it is unaltered it is distinctive in texture and contrasts strongly with the rest of the endosiphuncle.

Within the tube there are various structures which are, in general, some variation upon a pattern of pierced diaphragms. Some part of the diaphragm, either the margin of the aperture or the region where it is attached to the wall of the tube, may develop into bracket-like processes that are extended forward. In some specimens, the forward extensions are numerous, and nearly fill the siphuncle; they extend forward for a definite distance however, and terminate in carbonaceous irregular transverse structures which in some sections resemble stylolites.

Though our specimens were imposing as to size, they were, in general, completely inadequate to show the relationship of these varied structures to the endosiphocone, which, if this were shown, would give some idea of growth relationships. It is clear that there is some variation within the species, but it is not clear how much of the apparent variation may result from simple bracket-diaphragms or even simple diaphragms, which are later augmented by forward-extending processes. The material tempts one to assume that these structures vary erratically, but it is clear that they are better developed in some species, retarded or possibly even wanting in others, as in *N. calamitiforme,* while some species are known from such fragmentary material that the role of the structures in the tube is difficult to evaluate.

N. perplexum is erected for a species that is distinctive in proportion of siphuncle segments, but is unique in that the endosiphocone shows what appear to be free sheaths of half-cones, such as are otherwise unknown in *Narthecoceras,* but are typical of *Donacoceras.* These structures are partly surrounded by matrix, but there is also calcite on their surfaces which is hard to explain on the basis of complement of an incomplete filling of matrix; it appears that, instead, these sheaths were relatively insoluble, but that material between them was dissolved early enough in the history of preservation of the specimen for matrix to fill the ensuing cavities.

It should be noted that our material of *Narthecoceras* is all incomplete. Several specimens were described by Whiteaves, including the part of siphuncle with a phragmocone around it, and one siphuncle described as having a length of "three feet all but an inch."

Narthecoceras is known from the Ordovician faunas of Red River aspect. Two species, *N. equisetum* and *N. oppletum,* are described from the Farr limestone of the Liskeard Group of Lake Timiskaming. The same region supplied a sandy cast, the only known specimen showing any preservation of the empty anterior siphuncle segments.

The Red River Formation has yielded the most abundant material. *N. crassisiphonatum* and *N. perplexum* are from the Selkirk facies of the Dog Head Member, the former is also found in the typical Dog Head facies though rare. The typical Dog Head facies is the source of *D. calamitiforme, D. sinclairi, D. planiventrum, D. lene,* and *N. anomalum.* The overlying Stony Mountain Formation has not yielded any specimens. Farther north on the west side of Hudson Bay several specimens are known from the Nelson River Formation, one species of which is here described, *N. leurosiphonatum.* The overlying Churchill River Group, equivalent to the Stony Mountain and Shamattawa limestones, has yielded some fragments, but they were insufficient for close specific analysis. *N. tyrrelli* from Sturgeon Lake, Manitoba, is from sandy dolomite; its precise position in the Ordovician faunas is not certain, but may be some of the northern dolostone mentioned by Baillie (1951), which contains some Red River elements.

The Cape Calhoun Formation of Greenland yielded *Narthecoceras inflatum* Troedsson and *N.* (*Calhounoceras*) *candelabrum* (Troedsson). As the Cape Calhoun Formation may contain elements of different ages, certainly Red River and overlying Richmond, with possibly Mohawkian beds in the lower part (Flower, 1957), and there is no indication of the part from which these specimens came, they cannot be evaluated stratigraphically. Sweet and Miller (1957) figured a fragment of a siphuncle from the Cape Phillips Formation of Little Cornwallis Island, but the specimen has the interior altered. As yet, the genus is unrecognized in Baffin Island.

As *Narthecoceras* is commonly represented by solid endosiphuncles, the absence in the Big Horn Group may be more apparent than real; such specimens are generally impossible to recover from the dolomites, and in the Lander sandstone would be represented only by impressions of the exterior, and would possibly be bypassed in collecting. The Fremont limestone of Colorado has yielded one fragment, here figured, which is either *Narthecoceras* or *Donacoceras*; it is a small series of siphuncle segments, failing to preserve internal features. The Second Value Formation of the Montoya Group contains *N. hesperale*. Specimens are not uncommon in the section at El Paso, but owing to the hardness of the massive limestone, are almost impossible to collect. *Narthecoceras* is as yet unknown in eastern Ordovician faunas.

The James Bay lowland has yielded the only known representatives of the genus in the Silurian so far known. These species and their distribution have been noted in the discussion of the James Bay cephalopod faunas.

I. Red River Species

Narthecoceras crassisiphonatum (Whiteaves)

Plate XIV, figures 1, 2; Plate XV, figures 1, 3, 4; Plate XVI, figures 1–3; Plate XVII, figures 1–5; Plate XXIII, figures 5–10; Plate XXVI, figures 10, 11

Endoceras crassisiphonatum Whiteaves, 1891, p. 79, pl. 6, figs. 1, 3, 4 (*not* fig. 2); pl. 7, fig. 1.
Narthecoceras crassisiphonatum, Hyatt, 1895, p. 2, footnote, p. 3.
Endoceras (Narthecoceras) crassisiphonatum, Whiteaves, 1897, p. 204.
Narthecoceras crassisiphonatum, Whiteaves, 1906, p. 344.
Endoceras (Narthecoceras) crassisiphonatum, Ruedemann, 1905, p. 300, fig. 1.
Narthecoceras crassisiphonatum, Foerste, 1929, p. 188, pl. 24, figs. 1, 2; pl. 25, fig. 2 (*not* fig. 1).

Several overlapping specimens indicate the siphuncle of *Narthecoceras crassisiphonatum* to expand relatively rapidly orad, from segments expanding from 15 to 20 mm across to those expanding from 40 to 46 mm; the holotype, however, although showing segments of similar outline, has the rate of expansion greatly reduced and is plainly mature. The segments are gently convex in outline and the concavities between them narrow and poorly defined. In contrast, *N. sinclairi* has the broader part of the segments flattened; the concave zones marking the septal necks are long and more clearly set off from the broader parts. Across their constricted parts segments measure a little more than the length of a segment. Obliquity of the segments is minor in the young, and slightly more marked in late growth stages. The endosiphocone is symmetrical, about equal in thickness on dorsum and venter, and the holotype shows its cross-section to be irregularly polygonal near the apex of the cone. This doubtless is responsible for the irregularly polygonal halo seen apicad of the endosiphocone in cross-sections. The tube is vertical, shows usually definite outer walls in which fibres of the endosiphuncle slope forward, though the wall is relatively thin. Within, in mature specimens, a thick wall, now of recrystallized calcite, separates an inner tube with a clearly defined wall, which is traversed at maturity by rather thin diaphragms, deeply convex apically. Matrix passes these diaphragms, suggesting that they are not complete, but that each is pierced by a rather large pore. Calcareous material may develop in the tube between the diaphragms; it shows linear striation in section, but our material failed to show its structure conclusively.

GSC No. 1866, the lectotype (Foerste, 1929, Pl. 14, figs. 1, 2; Pl. 15, figs. 3, 4) is part of a late growth stage of a siphuncle 205 mm long containing four complete segments and parts of two more. Septal markings and segments are faintly oblique, segments are convex over their expanded parts, without flattening, the first complete segments 55 mm long expands from 53 to 57 mm; the last complete one 53 mm long, expands from 54 to 57 mm and contracts to 55 mm at the adoral end. The sectioned surface passes through an endosiphocone, and shows rather faint radial lamellae and stronger growth lines. The eccentricity of the section (Pl. XV, fig. 3) results in a somewhat narrower endosiphocone, particularly at the apical end, than a central section would produce. The cone here has the irregular section of the carbonaceous halo of some other sections, which surrounds the tube.

The earliest growth stage observed is shown in Plate XXIII, figures 5–10. It is a part of an endosiphuncle 110 mm long, containing parts of five segments. The basal segment expands from 21 to 22 mm and is 22 mm long; the penultimate is 26 mm long, expanding from 24 to 27 mm and contracting to 25 mm; the last segment increases to 29 mm in diameter. Cross-sections show prominent radial fibres; in longitudinal section these fibres are normal to the tube; no growth lines are evident. The tube is elliptical, and in longitudinal section shows a wall of fibres sloping forward from the outer to the inner margin. The cavity of the tube contains a mixture of calcite, matrix, and some carbonaceous material, evidently organic. For the most part, no regular pattern can be found, but there is an irregular diaphragm at the extreme base and another, not illustrated, on the surface facing that of the middle portion of the illustrated section. Both are deeply curved, and deepest at one side of the sectioned surface.

The next fragment in terms of size and growth stages is GSC No. 18722 (Pl. XXVI, figs. 10, 11), which shows two segments, convex in outline, enlarging adorally, 59 mm long laterally, showing segments 26 mm across near the base, contracting to 24 mm, expanding to 29 mm and contracting to 26 mm. The endosiphuncle shows radial fibres that darken and slope forward to form the narrow wall of a rather large tube. The two surfaces of the section show the tube containing grey flocculent material, and within there is an irregular cavity with matrix; wide adorally in Plate XXVI, figure 11, and with a definite thin dark wall there, but narrowed apically, extending narrow and irregular to the apical end, and without a clearly defined wall. The apical end shows the cavity to be irregular, a narrow isosceles triangle in cross-section form, and at the base the longitudinal section cuts only one of the lower lateral angles. Further, it shows division of the tube into several parts by horizontal dissepiments.

A third specimen, GSC No. 18721, shown on Plate XVII, figures 1–5, is a series of five segments, 190 mm long, with the basal segment enlarging from 28 to 32 mm, contracting to 30 mm, the next expanding to 35 and contracting to 31 mm, while the adoral two segments show expansion from 35 to 41 mm, contract to 35 mm and expansion to 42 mm. Segments increase in length from 32 to

45 mm. The main part of the endosiphuncle shows fine radial fibres, which slope abruptly forward and darken to define the thin outer wall of the tube, which in cross-section is irregularly polygonal. Within the outer wall there is a rather broad lining of coarse white calcite showing no original structure, which surrounds a tube, again irregular in cross-section. It contains some matrix, and some longitudinal calcitic fibrous bands which are interrupted at two points in the section by incomplete irregular jagged-edged diaphragms.

A fourth specimen, GSC No. 1867 (Pl. XV, fig. 1; Pl. XVI, figs. 1–3), one of the original syntypes, is 310 mm long, and shows nine segments; the earliest one contracts from 30 mm maximum diameter to 29 mm, and the next expands to 32 mm and contracts to 30 mm in a length of 32 mm; the last expands from 41 to 47 mm, the adoral end is missing, but the estimated length is 55 mm. Segments are convex, widest apicad of the middle as before, and very slightly oblique. The tube is irregular, compressed, and with an irregular dark polygonal halo, most extended ventrally. The anterior two segments have been sectioned horizontally. Fibres are radial and horizontal except very close to the tube where they slope forward; a condition vestigial apically, but widening prominently in the adoral part; this slope occurs outside the evident wall of the tube. The tube shows a thick band of calcite, which in this specimen appears within irregular crenulate or undulate bands of silicified material and surrounds the central cavity within which can be seen five clear diaphragms, while two more, farther apicad, are fainter, being thinner and less carbonaceous; the apical part of the section in Plate XVI, figure 3 passes below the tube, but the tube is seen in the lower part of the facing section in figure 2; this surface, however, is too deeply etched to show possible additional diaphragms. One sheath is shown obscurely in the anterior part of these sections; it is largely within this region that the fibres slope forward about the tube.

Because of its proportions one of the syntypes, GSC No. 1870, is removed from this species and described as *Narthecoceras perplexum*. It is further anomalous in showing a semicircular sheath restricting the endosiphocone, reminiscent in its shape of the semicircular sheaths developed in *Donacoceras*.

The remaining specimens, including the lectotype and one of the original paratypes, establish the species on the basis of reasonably uniform proportions and show the above described internal structure. It is believed that one hypotype (RHF No. 418) is from an immature individual; it shows a thin-walled rather large tube; presumably this represents only the outer wall of the tube seen in GSC 18721, and that with further growth such a thickening of the tube and the development of diaphragms within it would have taken place.

Discussion. The proportions of the segments with the moderate enlargement of the siphuncle, which ceases only at maturity, characterize this species. The several fragments show a siphuncle ranging from 15 to 55 mm in diameter, and encompass a length of 2 feet 3 inches; to this must be added an apex of unknown length, and the endosiphocone of the lectotype is incomplete adorally by about 6 inches. Anterior to that, there was an unknown length of siphuncle without the endosiphuncle within it and a living chamber.

The species is known from the Red River Formation, and mainly from the Selkirk facies of the Dog Head Member, though one of our specimens is from Little Tamarack Island, well north in the lake where the typical Dog Head facies is prevalent.

Types. Lectotype, GSC No. 1866, a (two pieces); paratype, GSC No. 1867, a–c (four pieces); hypotypes here figured include GSC Nos. 18721, 18722, and a specimen in the collection of the writer.

Narthecoceras lene n. sp.

Plate XVII, figure 6; Plate XVIII, figures 1–3, 6

Only the siphuncle is known, and of that only two segments. In general aspect, the species shows the gentle convexity, the shallow poorly delimited slightly oblique constrictions of *N. crassisiphonatum,* but differs in that segments are longer in proportion to their diameter, and show here scarcely any adoral expansion; in commensurate parts of *crassisiphonatum* such expansion is still pronounced.

The holotype is a fragment 95 mm long and shows segments 40 mm long, expanding from 32 to 37 mm. Both segments show identical maximum and minimum diameters. The septal constriction is broad, shallow, its limits poorly defined, and inclined 20 to 25 degrees to the horizontal.

A vertical section shows expansion of the segments slightly greater on the dorsal than on the ventral side. A prominent sheath is undulate, conforming to the outline of the segments, thinning adorally from 7 to 4 mm in 60 mm, inner sheaths are fainter and lose their undulations. The tube shows a thick wall, partly of recrystallized calcite, rather coarse, but in part showing traces of moderately thin definite walls. The section of the holotype shows three bracket-diaphragms which are so different, one from the other, that they are figured separately. Differences are obviously to be explained in a large part by the position of the plane of the section. Plate XVIII, figure 1 shows the anterior one; there a bracket-like process extends forward from the left side of the tube, and its anterior extent is nearly but not quite matched by a vertical black partition, which begins considerably farther apicad. A second one (Pl. XVIII, fig. 2) shows at the centre left a similar bracket extending forward and sloping away from the left wall of the tube, but its anterior end is obscured in excess black material extending from the left wall. A median anterior extending process is present, but it is connected with the wall on the left with a broad transverse black band.

The third is the most remarkable, shown in Plate XVIII, figure 3. There the homologue of the bracket extending from the left wall inward and then forward, is light in colour; from its base, a band extends apicad, but at two points it swings forward, forming narrow angles, from each of which a process extends forward. The first one lies in the centre of the siphuncle, and is evidently the homologue of that seen in the preceding two sections. A third extends forward obliquely towards the right wall for a distance, and then becomes straight. A reasonable interpretation is of the development of a diaphragm extending obliquely apicad from the left to the right, as oriented in our figure, but with one marginal forward projecting process from its base, a second median forward projecting process on the left, and a third near the right. Between these processes, the diaphragm is pierced, and the appearance of the sections varies depending on whether the sections intersect the diaphragms where they are pierced, or not; also, the third of the processes seems limited in extent, normal to the plane of the section, for it is visible in only one of the three examples.

Discussion. The bracket-diaphragms alone would not have served as a secure basis for the distinction of the species, as it is felt that hazards of preservation cause their destruction in some specimens, whereas in other specimens they are not adequately known. Also, our material does not permit a full understanding of the growth relationships of these structures. The species has segments gently convex, with shallow poorly defined oblique septal constrictions. It resembles *N. crassisiphonatum* in general aspect, but segments are proportionately longer, and at commensurate growth stages, segments of *crassisiphonatum* are enlarging appreciably orad.

Type and occurrence. Holotype, GSC No. 18744, Dog Head Member, Red River Formation, Little Tamarack Island, Lake Winnipeg, Manitoba. Collector G. W. Sinclair, 1957.

Narthecoceras sinclairi n. sp.

Plate XVI, figures 4–8; Plate XVIII, figure 4; Plate XX, figures 1–8; Plate XXI, figures 8, 9; Plate XXII, figures 1–3, 7, 8; Plate XXIII, figures 1–4, 11; Plate XXIV, figures 1, 2; Plate XXVII, figures 1–5; Plate XXVIII, figures 1–6; Plate XXXI, figures 1, 2; Plate XXXII, figures 3, 4; Plate XXXIII, figures 3–5.

Orthoceras simpsoni, Whiteaves, 1891, p. 79 (pars), pl. 7, fig. 3; pl. 8, fig. 1.
Narthecoceras simpsoni, Foerste, 1929, p. 189, pl. 25, fig. 5.

This species is characterized by slender very gently enlarging siphuncle segments. A long early portion shows segments that increase in maximum diameter from 18 to 26 mm in 435 mm; a late growth stage shows six segments expanding in maximum diameter from 36 to 39 mm in 240 mm. Expansion seems somewhat more rapid below a diameter of 20 mm, but the one specimen showing this effect is somewhat abraded, certainly from 20 mm on the enlargement is most gentle, and our combined specimens indicate a siphuncle in excess of 40 cm long.

Segments show a constricted zone, shallow, faintly concave, inclined forward ventrally and longer ventrally than dorsally. At its apical end there is a fine line suggestive of termination of the septal neck, a narrow slightly convex region, marking the anterior end of the expanded zone, apicad of which the expanded zone is faintly concave in the adoral part, expanding gently apicad, and convex over the apical third of its length, its termination and passage to the next apical constricted zone is markedly convex. Proportions of segments vary with growth. Our earliest growth stage shows segments somewhat abraded, but clearly a segment 35 mm long is approximately expanded from 20 to 22 mm. A segment of 40 mm expands from 25 to 28 mm, one of 45 mm expands from 27 to 30 mm, and one of 47 mm expands from 33 to 36 mm. Adorally, the constricted zone becomes both proportionately and actually shortened, though only gently.

Interiors show some variation. Endosiphocones are simple, round, showing only faint undulations, clearest near the adoral ends, conforming to the segments of the siphuncle. No evidence of fluting of the endosiphocone surface has been found except at a diameter of 5 to 10 mm, where it may show the polygonal pattern of the halo; nor have any accessory structures within the cones been found. The tube is subcentral, generally compressed, small, with a rather thick wall, generally showing as recrystallized calcite, but with a fibrous inner layer of variable clarity. Odd incomplete bracket-like diaphragms may develop, which are evidently pierced, and one apical fragment shows the tube filled with longitudinal fibres, across which pass zigzag brown markings, and within are one or more larger calcite-filled tubes.

The endosiphuncle shows prominent radial fibres, which slope forward only in a narrow zone very close to the inner surface of the tube. Growth lines are of variable clarity, somewhat variable in retention of undulations. The dark polygonal halo around the tube is of somewhat variable development, but is persistent in the species.

Specimens on which this species is based are described below individually.

The holotype, GSC No. 18724 (Pl. XXVII, figs. 1–5), is a somewhat weathered portion of an endosiphuncle 200 mm long from Dog Head Member of the north side of Burton Island, Lake Winnipeg. It shows broad shallow constricted zones, widening slightly ventrally, or at least on the side on which they extend forward, the broader parts longer, faintly concave apical of the anterior ring, grading into a faintly convex apical part. The siphuncle is 46 mm wide and 43 mm high at the anterior end, where a cross-section shows the tube, or rather a section through the extreme end of the endosiphocone, irregularly polygonal, compressed, 17 mm from the venter, 6 mm high, and an estimated 10 mm from the dorsum, which is incomplete, evidently abraded or dissolved prior to burial. Adorally expanded parts of the segment increase in length from 35 to 40 mm, and the constricted zone widens from 14 mm dorsally to 16 mm ventrally.

A cross-section at the anterior end shows radial and concentric fibres, with a small polygonal tube ventrad of the centre. A section near the apical end shows strong concentric and fainter radial fibres, and the large polygonal area is filled with darker material, constituting the halo; it surrounds a small elliptical slightly compressed tube. Immediately orad of this part a vertical longitudinal section was taken. It shows fine growth lamellae in the endosiphuncle proper with fainter radial elements, the whole slightly replaced, and presenting a peculiar flocculent effect at high magnification. The radial lamellae become stronger and slope strongly forward in the region of the halo, forming what appears as a very thick wall of the endosiphotube, with the true wall of the tube a thin darker marginal band between the halo and the matrix, which there fills the tube completely. Some calcitic bodies in the apical end of the section could represent bracket-diaphragms, but they are recrystallized and their interpretation is not certain. They could also be adventitious. Borings of some unknown organic origin penetrate the endosiphotube at several points in the figured section; additional borings oblique to the plane of the section are evident.

Paratype GSC No. 18723 (Pl. XXVIII, figs. 4–6) is a portion of siphuncle 192 mm long, containing four complete segments and parts of two more. The cross-section is compressed, 42 mm wide and 45 mm high at midlength. Segments show flattened expanded regions, slightly convex and wider near their apical ends than elsewhere, constricted zones, bounded adorally by a single ridge, apically by a double ridge, and wider ventrally, the side on which the segments slope forward. Apically a segment 40 mm long expands from 30 to 34 mm; ventrally, the wide part is 28 mm long, the constricted zone 12 mm; dorsally the constricted zone narrows to 9 mm. Adorally a segment 42 mm long expands from 30 to 34 mm also; there the expanded part is 30 mm long ventrally, the constriction, 12 mm, contracts to 9 mm dorsally while the broad zone lengthens accordingly.

A section of the apical half of the specimen shows rather prominent growth lines moderately undulate, conforming to the expansion of the segments; such undulation persists rather close to the central tube which is compressed, nearly central, 15 mm from one side, 17 mm from the other, the tube shows a thin outer dark wall with fibres of the endosiphuncle sloping forward, a thick middle layer of coarse calcite, and a fine inner dark wall. The cavity is filled with matrix within which are elongate vermiform calcitic bodies; no diaphragms or other structures certainly pertaining to the species are shown. The anterior part with the endosiphocone is not preserved.

Paratype GSC No. 18753 (Pl. XXII, figs. 1–3) has a maximum length of 277 mm. One side is weathered, and the surface is rather rough and does not show the form of the segments or septal markings as clearly as some other specimens; it is notable however, for its length, all of which is endosiphuncle apicad of the endosiphocone. The four segments have maximum expansion of from 33 to 36 mm. They range erratically in length between 45 and 50 mm; one near the base expands from 32 to 34 mm. Segments are inclined about 15 degrees from the horizontal, and the constricted zones seem to widen slightly from dorsum to venter. A section of the apical part shows undulate growth lines and fine horizontal fibres. The tube shows apically some fine longitudinal fibres, but they are not evidently continuous with those of the endosiphuncle; at that point radial fibres of the endosiphuncle are not evident. Adorally, the wall of the tube is mainly of coarse calcite. The tube is filled with matrix and shows some organic fragments within. Two have the shape of slightly distorted diaphragms, but it is not certain that they are not foreign bodies. A cross-section at the base of the specimen shows the tube only faintly compressed; it is doubtful whether the cross-section was originally significantly modified from the circular; it shows a suggestion of flattening as well as weathering of one side, which is askew from the plane of symmetry but normal apparently to the plane of bedding.

Paratype GSC No. 18725 (Pl. XXIV, figs. 1, 2) is a large portion of a siphuncle 285 mm long containing six segments, with relatively long expanded regions, which are considerably flattened and set off from one another by broad shallow constricted zones generally more clearly margined anteriorly than apically. The base shows an expanded zone 35 mm across, 32 mm long; a constricted zone 33 mm across, 16 mm long followed by an expanded zone 36 mm across, 34 mm long. Adorally the segment shows a 35 mm-constricted zone 16 mm long, and a 38 mm-expanded zone 30 mm long. Segments are gently oblique, inclined about 15 degrees from the horizontal; the expanded parts are bounded apically by a single low convex ridge; adorally a similar ridge is set off by a faint constriction, so that there appear two such ridges. The specimen shows an endosiphocone at its anterior end; several breaks show this cone to be simple and devoid of free sheaths. The apical part shows only the endosiphotube; it was not sectioned, as this portion had been studied already from other specimens.

Paratype GSC No. 18754 (Pl. XVIII, fig. 4; Pl. XX, figs. 1–7; Pl. XXII, figs. 7, 8) is an exceptionally long portion of an endosiphuncle, showing none of the endosiphocone, but only the tube in the endosiphuncle. It is 434 mm long, expanding from 16 to 20 mm, subcircular, the surface is worn, but shows evidence of distant oblique rather long septal constrictions, between which the more expanded parts of the siphuncle are relatively flat. The apical part, consisting of four pieces, was sectioned, the sections being taken in different directions.

In the apical part, which has a maximum length of 55 mm, the tube is large, eccentric particularly apically, 4 mm wide where the siphuncle is 16 mm wide apically and 19 mm wide adorally. The endosiphuncle shows radial markings, coarse and now of rather flocculent white material. The tube wall is moderately thick, largely of coarse recrystallized calcite, and without sharp inner or outer margins. Within it are fine brown longitudinal dark bands, their margins also poorly defined. The tube is filled with longitudinal fibres, ranging from 0.2 to 0.5 mm in width, which are frequently interrupted by transverse zigzag bands. Among them are possibly two or three somewhat larger strands or tubes, it is difficult to say which, as the fillings may be replacements of original material or inorganic fillings of cavities. The next section shows a tube with much the same sort of filling, except that the break at the anterior end shows a stronger suggestion of three larger tubes among the fibres. The next section, cut apically and anteriorly to slightly different levels, shows in the apical end a suggestion of several tubes filled with white calcite. Only one shows in the apical part of the longitudinal section. On its left are seen apparent longitudinal fibres, but on the right the fibres are modified, and appear as slightly curved imbricating elements, projecting forward from the tube wall, and suggesting the bracket-diaphragms found in later growth stages of this and of other specimens, except that they are much more closely spaced longitudinally. The surface shown at the anterior end, which lies above that of the apical part, does not cut any of the large tubes, and shows only a rather confusing pattern of longitudinal lamellae. The last sectioned portion shows a tube, with a wall of coarse calcite on the right, but of longitudinal fibres on the left. Apically the central part of the tube is filled with white calcite, within which are traces of curved forward-projecting bracket-like processes, but near the base of the anterior third are seen what appear as two deeply curved diaphragms, the anterior one a little to one side, a more apical one with an anterior limb touching the adoral one. This one is incomplete at the extreme right; the anterior one crosses only about half of the siphuncle. Farther orad, the tube becomes dark and shows coarse calcite; the plane of the section is approaching the far wall of the tube. The tube is compressed, and is surrounded by a polygonal halo as seen in cross-section. Growth lines in the endosiphuncle are faint and variable in clarity and spacing.

Paratype GSC No. 6824 (Pl. XVI, figs. 4–8), the specimen figured by Foerste as *Narthecoceras simpsoni,* shows parts of three siphuncle segments, 38 to 40 mm long, expanding from 25 to 27 mm. It is slightly crushed, with one side poorly preserved. Sections at the ends show the usual radial fibres and a central cavity. The maximum width of the segment is about two thirds its length. Concavities are shallow, clearly margined, and broader on the side on which they slope adorally, the apparent venter.

A paratype, GSC No. 18755, shown in Pl. XXVIII, figs. 1–3, is a portion of a siphuncle circular in section expanding from 27 to 29 mm in 170 mm. It shows segments typical in outline, but with the length here nearly commensurate with that of segments of a considerably larger diameter, and representing considerably more adoral portions of siphuncles. The maximum diameter of the segment is about two thirds the length; segments have expanded portions 30 to 35 mm long, varying irregularly, with contracted zones averaging 15 mm long. In size this form connects the earlier growth stage (GSC No. 6824) shown in Plate XVI, figures 4–8, with the several specimens of larger diameter. Unfortunately our earliest observed growth stages (Pl. XX, GSC No. 18754) are from a specimen with the surface abraded or weathered and failing to show the segmentation clearly.

The apical half of this specimen was sectioned vertically. The outer part shows variable preservation of growth lines and fine horizontal fibres. The tube wall is thick and is largely composed of translucent crystals of calcite, and fails to show the forward bending of the fibres, though anteriorly the tube is less altered and shows white flocculent calcite, in which some forward bending of the fibres is evident. The tube is filled largely with white flocculent calcite. Just at the point where a fine crack crosses the section, an obscure diaphragm is seen; 12 mm farther apicad a more perfect diaphragm is seen, it is deeply curved, as deep as wide, and the wall of the diaphragm is extended considerably forward where it is in contact with the wall of the tube on the ventral side, but is not projected forward into a bracket. Some thin dark brown bands farther apicad may represent traces of diaphragms, but they are imperfect.

Paratype GSC No. 18719 (Pl. XXI, figs. 8, 9) shows five segments in a length of 180 mm. Segments are 35 to 36 mm long, with the oblique contracted zone 7 mm dorsally, 9 mm ventrally, septal ridges apicad of the zone 15 degrees or slightly less, orad of it, 15 to 18 degrees. Segments basally expand from 31 to 34 mm; adorally the exterior of the siphuncle was removed in the portion figured to expose the endosiphocone and the entire width is not shown, but the siphuncle is essentially tubular, and the anterior end is only 1 to 2 mm wider than the apical end. The minimum siphuncle diameter is about five sixths of the segment length. The endosiphocone is very long and slender; its entire length is not contained in the length of the specimen, and its apical angle is about 5 degrees. The broken endosiphuncle shows prominent radial fibres; the endosiphocone is gently undulate, conforming to the slightly expanded segments adorally, but essentially smooth apically. The endosiphuncle contains a small orthocone with low close annuli and fine longitudinal markings, which may be an early stage of a *Gorbyoceras*; this accounts for the prominent transverse markings seen at about one third the distance from the anterior end in Plate XXI, figure 9.

Paratype GSC No. 18720 (Pl. XXIII, figs. 1–4, 11) shows four siphuncle segments in 180 mm, and an anterior 75 mm which shows the anterior part of the endosiphocone, but fails for the most part to retain siphuncle outline. The segments have concave zones, 8 mm long dorsally, 10 mm long ventrally, and expanded zones, 38 mm long dorsally, 36 mm ventrally; in the expanded zone the anterior part is faintly concave, the apical part faintly convex; it is there that the greatest diameter is attained. Segments vary from 44 to 46 mm in length, and expand from 30 to 35 mm, and are nearly uniform throughout the length of the specimen. Ridges bounding the concave zone slope 12 to 15 degrees at its apical end, 15 to 18 degrees at its anterior end.

A cross-section at the base shows the anterior part of the tube, in which the wall has not yet thickened to its normal extent, slightly compressed, central, surrounded by an irregularly polygonal halo. The longitudinal section shows the apical end of the endosiphocone merging into the anterior end of the tube. Fine fibrous material makes up most of the endosiphuncle showing growth lines and radial fibres; near the centre material is darker and contains considerable recrystallized calcite, representing the central halo.

Types and occurrence. Holotype, GSC No. 18724; paratypes, GSC Nos. 18719, 18720, 18723, 18725, 18753-55, 6824, 20079, 20080. This is the common species in the typical facies of the Dog Head Member of the Red River Formation, but I have had no material of it from the Selkirk facies. Much of the material here described is from old collections of the Geological Survey of Canada, and precise locality information has been lost for some specimens, but it is known from Button Island (holotype), Mathewson Island (18719, 18720), Little Tamarack Island (18723, 18725), Snake Island (18755), and Gull Harbour (6824) of Lake Winnipeg, Manitoba.

Narthecoceras calamitiforme n. sp.

Plate XIX, figures 1–7; Plate XXI, figures 1–7

This name is given to a *Narthecoceras* that develops extremely slender siphuncles at a relatively small diameter, in which the septal markings are so transverse that dorsum and venter cannot be distinguished with certainty. Segments are long, somewhat variable in length, and the expansion, faint in the young, becomes even fainter in later growth stages, with rather broad septal concavities. Tubes are rather large, transverse, flat on the side closest to the siphuncle wall, arched or faintly angled on the other side. The tube is only slightly closer to one side than to the other. A thick rather indistinct wall of carbonaceous material outlines the tube, but no diaphragms or other structures have been found within it.

Of the two specimens, the smaller GSC No. 18716 (Pl. XXI, figs. 1–7) is 225 mm long and contains parts of nine segments. At the base a segment 25 mm long expands from 15 to 16 mm, while adorally one 27 mm long expands from 25 to 27 mm. As can be seen, there is slight irregular variation in the length of the segments, and the convexity of the segments is not uniform around the circumference of the siphuncle, but there is no certain indication of which side is ventral and which is dorsal. Septal constrictions are rather long and shallow, the expanded part of the segment attains its greatest expansion in its apical third. Cross-sections were photographed to show the slightly transverse tube, which is slightly closer to one side than to the other. The very first segment was not sectioned, but the next two broken parts were, the planes of the two sections at slight angles, but in general cutting the tube across its greatest width; they are thus lateral and not vertical. They show the tube with variable amounts of carbonaceous material in its wall, but show no diaphragms.

A later portion shown in GSC No. 18717 (Pl. XIX) is a specimen from old collections of Lake Winnipeg, but now lacks precise locality data. It is 237 mm long, and contains seven and parts of two other segments. At the base a segment is 21 mm in diameter and 33 mm long; the outlines of the expanded part are scarcely convex, the constriction marking the septal neck is long, and bounded apically by an expanded ring. Adorally a segment 28 mm long expands from 21 to 22 mm; there also the septal constriction is long and shallow, and bounded apically by an expanded ring. Segments there have their broader parts slightly more convex in outline. Sections were taken of this specimen across the slightly transverse tube, one in the adoral part and another in the apical. Neither section cuts the tube perfectly, but both show, as before, an empty tube with no diaphragms or other structures, and slightly carbonaceous walls. Growth lines in the endosiphuncle are here obscure; in the first specimen they are clearer.

Discussion. This species is possibly identical with *Orthoceras simpsoni* of Whiteaves, which was based upon a specimen (which cannot now be located) from Cat Head, presumably from the Cat Head Member. It shows a slightly later growth stage, with similar rather slender long segments, somewhat variable in length. It seems, however, better because of the slightly younger horizon of that specimen and the slight apparent differences, to give this Dog Head form a new name, one established upon known specimens. It is impossible to reconcile the specimen Foerste illustrated as *N. simpsoni* with this species; though it has long slender segments, the septal markings are strongly oblique and it belongs to *N. sinclairi.*

Types and occurrence. Holotype, GSC No. 18716, Dog Head Member, Red River Formation, Black Island, Swampy Harbour, Lake Winnipeg; paratype, GSC No. 18717, Red River Formation, Lake Winnipeg, by lithology from the Dog Head facies of the Dog Head Member.

Narthecoceras planiventrum n. sp.

Plate XXX, figures 1–4

This siphuncle, though known only from a fragment, is distinctive in that the expansion of the segments is wanting on one broad flat surface which is apparently in contact with the shell, and is thus presumably ventral. The specimen shows only parts of two segments. A segment expands from 23 and 26 mm to 24 and 27 mm, and is 56 mm long, of which 48 mm is expanded gently, while the narrow septal contracted zone is 8 mm. The endosiphuncle terminates anteriorly in a cavity, polygonal in cross-section, whose centre is 9 mm from the venter, 16 mm from the dorsum.

Discussion. The long slender segments, depressed section, flattened venter in cross-section, and smoothing of the ventral profile makes this a most distinctive species, though only a small fragment is so far known.

Type and occurrence. Holotype, GSC No. 18714, Dog Head Member, Red River Formation, from shale debris at bottom of north cliff of Gull Harbour, Hecla Island, Lake Winnipeg, Manitoba.

Narthecoceras anomalum n. sp.

Plate XXV, figures 3–7; Plate XXVI, figures 1, 2

This species is known from a part of siphuncle 150 mm long that shows five segments and part of a sixth; the segments show septal constrictions that are narrow and shallow, and are inclined 15 to 20 degrees from the horizontal. Expansion of the segments is slight, and there is no sharp apical boundary to the septal constrictions. Basally a segment 26 mm long expands from 26 to 29 mm and contracts at the next constriction to 27 mm; adorally a segment 28 mm long expands from 30 to 32 mm, and contracts to 31 mm. Our specimen shows a very faint suggestion of exogastric curvature, and segments show expansion slightly better developed dorsally than ventrally.

A section shows the endosiphuncle revealing radial fibres, but without evident growth lines. A central tube 2 mm across has on either side a narrow zone of 2 mm in which the fibres slope forward. The tube itself shows a wall of considerable prominence, and contains numerous irregularly spaced transverse black markings and diaphragms.

Discussion. The section cut in the apical part of this specimen failed to reach the tube perfectly apically, and was photographed as it was ground progressively. A concentration of carbonaceous material surrounds the tube, as in the irregular diaphragms of the small tube, but the whole specimen is preserved in relatively light calcite.

The forward development of fibres around the tube is amazing; it would be much less so, if these fibres were directed apically. True, we are without good criteria of orientation, but it would be hardly justifiable to accept the idea that the marked taper of this siphuncle indicates an adoral reduction in diameter, though future work could bring to light material requiring this interpretation. As it is, the entire specimen lies apicad of the endosiphocone, and such normal expansion as is observed in associated forms seems applicable here though this is necessarily an assumption deserving of investigation in the light of more material.

This form differs from *N. sinclairi* in the more convex segments, and approaches *N. crassisiphonatum* in aspect, but expansion is less rapid, segments are more oblique, and less expanded.

Type and occurrence. Holotype, GSC No. 18743, Dog Head Member, Red River Formation, Little Tamarack Island, Lake Winnipeg, Manitoba. Collector G. W. Sinclair, 1957.

Narthecoceras perplexum n. sp.

Plate XV, figures 2, 5–10; Plate XVIII, figure 5; Plate XXXI, figure 9

Endoceras crassisiphonatum, Whiteaves, 1891 (pars), p. 79, pl. 6, fig. 2.
Narthecoceras crassisiphonatum, Foerste, 1929 (pars), p. 189, pl. 25, fig. 1.

This species is known from two parts of siphuncles, which are evidently so gently expanding as to be nearly tubular, show gently convex expanded parts of segments like those of *N. crassisiphonatum* but longer, with much longer concave septal constrictions. The siphuncles are circular, the tube is round and central, no halo has been observed, and the endosiphocone is occupied in the holotype by sheaths of half-cones like those of *Donacoceras*, a feature not otherwise found in *Narthecoceras*.

The holotype, GSC No. 1870, formerly a syntype of *N. crassisiphonatum*, shows two exceptionally long slender segments each 55 mm long, expanding from only 45 to 46 mm in diameter. The segments slope slightly forward on one side, the apparent venter, and on that side the expanded part is markedly convex while the expansion on the other side is nearly negligible. The expanded part is 35 mm long, with the contracted zone of 20 mm.

The longitudinal section shows a very long slender endosiphocone with the usual fine fibrous endosiphuncle around it. Faint growth lines and fine radial fibres are evident. The endosiphocone shows walls that are somewhat variable but generally thick and composed of coarsely recrystallized calcite. A thick calcitic band, rather irregular, passes along the length of the endosiphocone with matrix apparently on both sides. This represents, as is shown by the cross-sections at the ends, a semicircular sheath, like that of the half-cones of *Donacoceras*; it is convex dorsally, concave ventrally. The broken anterior end (Pl. XV, fig. 2) shows the curvature of the sheath in cross-section. The longitudinal section shown in Plate XV, figure 5 includes slightly more than half of the siphuncle. The pieces from the opposite side of this cut, shown in figures 6 and 10, are eccentric and close to the margin of the endosiphocone, and present a rather perplexing aspect, the more so as the surfaces are not properly plane, but are curved.

Paratype GSC No. 18756 is a part of siphuncle that contains the tube for its entire length. It is a fragment 105 mm long that shows the greater part of two segments; a segment 60 mm long expands from 38 to 40 mm. A central tube, round in section, is only 2 mm across. A longitudinal section shows fibres horizontal distally, turning forward only in a narrow zone around the tube, but the halo is not clearly differentiated in colour or texture. The tube is filled with light calcite, and is traversed by apparently simple diaphragms nearly transverse and spaced 20 mm apart. Openings in the diaphragms are not evident, nor are bracket-like extensions of these structures.

Discussion. The proportion of the siphuncle segments of this species is distinctive with expanded parts gently convex, convexity greatest on the venter, and rather long concave constricted regions. The holotype, formerly included in *N. crassisiphonatum*, is the only *Narthecoceras* known to show what appear to be free sheaths of half-cones, like those of *Donacoceras*, in an endosiphocone that is otherwise perfectly typical of *Narthecoceras*. The thickness and irregularity of the sheath suggest that the matrix on its convex side is the result of solution which must have occurred prior to burial; the alternate explanation that the sheath was calcitic and free seems opposed by the obvious irregularities in its thickness and also by the irregular coarse calcitic material on the surface of the normal endosiphocone.

Types and occurrence. Holotype, GSC No. 1870, a, b (three pieces), Selkirk facies, Red River Valley (Lower Fort Garry or East Selkirk), Manitoba. Paratype, GSC No. 18756, Selkirk facies, Dog Head Member, Red River Formation, quarries at Garson, Manitoba. Collector G. W. Sinclair, 1955.

Narthecoceras simpsoni (Billings)

Orthoceras simpsoni Billings, *in* Hind, 1860, p. 287, pl. 1, fig. 1; Whiteaves, 1891, p. 80 (pars), pl. 8, fig. 2 (*not* pl. 8, fig. 3 or pl. 8, fig. 1).
Narthecoceras (*Endoceras*) *simpsoni*, Hyatt, 1895, p. 3.
Endoceras (*Narthecoceras*) *simpsoni*, Whiteaves, 1897, p. 205.
Narthecoceras simpsoni, Whiteaves, 1906, p. 344.
not *Narthecoceras simpsoni*, Foerste, 1929, p. 189, pl. 25, fig. 5.

Narthecoceras simpsoni was based upon a single specimen from the Cat Head Member at its type locality. The figure shows a slender siphuncle 220 mm long, 20 mm wide apically, 21 mm wide adorally, with seven complete segments that vary rather erratically in length from 24 to 34 mm, the longest segment being near the middle of the specimen. Expansion of a segment is only 1 mm more than its minimum diameter. Unlike many Narthecoceratidae, septal markings are faintly expanded, with the segments slightly concave on either side of these markings and faintly convex over their middle parts. The septal markings are transverse.

The type could not be found for the present study, nor could it be found for Foerste's (1929) study. Foerste followed Whiteaves (1891) in attributing to this form siphuncle with slender segments but with quite long shallow oblique septal markings; these forms are clearly distinct and are here given the name of *N. sinclairi*. The form here described as *N. calamitiforme* is possibly close to true *N. simpsoni*, but there are differences in proportion. The segments of that form show long shallow septal constrictions, and unless the figures of Billings and

Whiteaves are inaccurate in this respect, the species are possibly different. This possibility is further strengthened by the fact that the type of *N. simpsoni* is from the Cat Head Member whereas *N. calamitiforme* is from the Dog Head Member.

Narthecoceras tyrrelli n. sp.

Plate XXXIII, figure 1

Only a small portion of a siphuncle is known, a fragment 113 mm long that shows most of three segments. Segments are gently convex in outline, as in *N. crassisiphonatum*, with concave poorly delimited septal constrictions. The three preserved segments show no perceptible adoral increase in length or diameter and it can only be inferred which end is anterior. A segment expands from 32 to 38 mm, is 34 mm long, and the septal constriction is slightly oblique, inclined 10 to 15 degrees to the siphuncle axis. The expanded part of the segment is 25 mm long, and the greatest diameter is attained in the apical third; the constricted region is 8 mm. The specimen is dolomitized; internal structure was so poor that it was not sectioned. A break near the assumed base shows coarse preservation of fibres that appear to be longitudinal and radially arranged.

Discussion. Commensurate parts of *N. crassisiphonatum* are similar in outline of the segments, but segments are more rapidly expanding adorally and are somewhat longer in proportion to their maximum and minimum diameters. *N. inflatum* Troedsson of the Cape Calhoun Formation is also similar in general outline; in that species the segments do not enlarge perceptibly adorally but are shorter; in *N. tyrrelli* the length of the segment is nearly equal to its minimum diameter; the maximum diameter is less than one fifth of an additional segment. In *N. inflatum*, the minimum diameter is equal to one and a third segments, the maximum diameter to one and a half segments.

Type and occurrence. Holotype, GSC No. 20081, "East end near north end Sturgeon Lake, Manitoba, Tyrrell, 1894." The same collection contains also a more slender *Narthecoceras*, not clearly enough preserved to be defined specifically, but of the general aspect of *N. sinclairi* and *N. calamitiforme*, and the whole is an association of Red River aspect.

II. Species from the Ordovician of Lake Timiskaming

Narthecoceras equisetum n. sp.

Plate XXII, figures 4–6; Plate XXIX, figures 1–9

This form, known only from a long slender siphuncle, has faintly convex segments, septal internodes rather narrow apically, broader adorally, so transverse that dorsum and venter cannot be distinguished externally. The holotype, GSC 18718, is a siphuncle 355 mm long showing thirteen segments, at the base the segment is 27 mm long, increasing from 20 to 22 mm; adorally a segment is 32 to 35 mm long, increasing from 25 to 27 mm.

The tube is slightly eccentric; at one point it is triangular in section, 12 to 14 mm from one side, 9 mm from the other, 2 mm across, the flat side facing the 9 mm distance and presumably ventral.

Except for two cross-sections the entire specimen was sectioned longitudinally. The adoral 60 mm shows the tube widening to a slender faintly annular cone; 32 mm farther apicad matrix of the tube terminates and calcite begins with a sharp transverse line which may be a diaphragm. For the next 195 mm the tube lacks any significant features, but at that point there is a slender diaphragm curved, the convex side facing apically, there is calcite for another 15 mm, but the apical 45 mm of the tube is filled with matrix, evidently it entered from the broken apical end. Cross-sections show numerous fine radial fibres, typical for the genus, and the endosiphuncle shows the usual growth lines with obscure banding at intervals of varying width, but most commonly such growth lines are 4 to 5 mm apart.

Paratype GSC No. 18745 (Pl. XXII, figs. 4–6) shows a slightly weathered portion of three siphuncle segments, a section shows this part to represent part of the endosiphocone.

Discussion. The type was received in several pieces, enclosed in limestone except for one weathered longitudinal surface. Difficulties in extraction resulted in some of the numerous breaks, and removal of the matrix was unfortunately accompanied by slight reduction of the surface in places. As a result, the full expansion of the segments is not shown in several parts of the specimen; it is important to recognize that the slight flattening, shown particularly in the lower right Plate XXIX, figure 9, is not natural.

This form develops a siphuncle that is extremely slender at a diameter of about 25 mm; the Red River *N. sinclairi* is comparable, but whereas it shows somewhat similar broad shallowly concave internodes, the segments are less expanded in the nodes.

Types and occurrence. Holotype, GSC No. 18718, paratype, GSC No. 18745, Farr Formation, Liskeard Group, Farr quarry, Haileybury, Ontario.

Narthecoceras oppletum n. sp.

Plate XXVI, figure 9; Plate XXX, figures 7–11

Only the holotype is known, a portion of a siphuncle 155 mm long showing parts of five segments. There is no perceptible adoral expansion; indeed, it was not until the specimen was sectioned that orientation was established on the basis of the endosiphosheaths. The segments are 32 mm long, and expand from 20 to 24 mm, with gently convex outlines and concave poorly defined interspaces. Plate XXX, figure 7 is a dorsal view of part of the exterior; the exterior shown in figure 11 has the septal constrictions sloping forward slightly to the right, and there also the segments are slightly more rounded in outline than on the left; this side on which the segments slope slightly forward is regarded as ventral. Obliquity is extremely slight.

The specimen was in several pieces and somewhat shattered; the several parts had to be sectioned separately. The full length of the specimen is shown in Plate XXX, figure 10, but the section shown there is well off centre adorally; apically it shows the full width of the tube, which is there filled with light calcite. Growth lines of the endosiphuncle are clearly shown, and are largely undulate, conforming with the expansion of the siphuncle segments. Plate XXX, figure 9 shows an anterior longitudinal section in which the full width of the tube is shown at mid-length. There the tube, filled with matrix, shows three remarkable bracket-diaphragms that appear carbonaceous, are evidently pierced for matrix penetrates past them; they show processes extending forward. In the middle of the section, where the plane of the section is apparently central, the forward projecting processes terminate; however, at the anterior end, shown more fully in Plate XXVI, figure 9, where the section is slightly eccentric, the process continues forward to the next diaphragm, seemingly outlining a narrow tube within the main endosiphotube.

Discussion. This is a very slender siphuncle of slightly expanded segments, and in gross proportions it is similar to the associated *N. equisetum*; however, the segments are proportionately longer and their expansion is slightly greater. Interiors show wider differences, and the strongly undulate growth lines, sheaths, characterize *oppletum*. Nowhere else have exactly comparable bracket-diaphragms been seen.

Type and occurrence. Holotype, GSC No. 18715, Farr Formation, Liskeard Group, Farr quarry, Haileybury, Ontario.

Narthecoceras ? sp.

Plate XXXIII, figure 2

Sandy beds from the east side of Lake Timiskaming yielded a poor internal mould showing parts of four apparent camerae, in a length of 124 mm.

Camerae average 40 m in width, and vary from 27 to 30 m in length. Preservation is poor, and the siphuncle is not evident. Presumably, such form would have long slender siphuncle segments as in *N. equisetum*, *N. calamitiforme*, and *N. oppletum*.

Type and occurrence. Figured specimen, GSC No. 20082, from sandy beds regarded (Hume, 1925) as belonging to the Liskeard Group, on the east side of Lake Timiskaming, Quebec.

III. Species from Hudson Bay Ordovician

Narthecoceras leurosiphonatum n. sp.

Plate XXIV, figures 3, 4; Plate XXV, figures 1, 2

This species is known only from a siphuncle, a fragment 155 mm long, so tubular that externally it was not evident which end was anterior. It shows three segments and part of a fourth, 38 mm long, with segments expanding from 41 to 43 mm, and with only very faint septal constrictions inclined 10 to 15 degrees from the horizontal. Only the wide spacing of the septal markings indicated that this was probably a *Narthecoceras* rather than an endoceroid.

Sections were made of both of the two parts of the specimen. They show the assumed orientation used when the exterior was photographed to be wrong; the endosiphuncle shows radial fibres but also shows clear undulate growth lines. Apically there is a tube of 2.5 mm diameter, slightly flattened, with prominent walls, and a filling of white calcite. The adoral 80 mm, however, shows a very slender endosiphocone, containing matrix, but the anterior end is plugged by a mass of calcareous fibres, and a similar carbonaceous concentration of material is found at the base. A halo is developed in which fibres slope strongly forward from the outer to the inner markings of this zone. In the apical part, where only the tube is shown, the band with forward-projecting fibres becomes a band with an outer wall prominent through silicification, containing abundant tiny white spheres, evidently silica. It would appear possible that the development of silica here may be involved with alteration involving destruction of original fibres. A cross-section at the base of the cone shows this region sharply bounded by a siliceous band, and set sharply apart from the radial fibres composing most of the endosiphuncle. A curious feature of the apical part is evidence of a tube, its wall white, evidently now white silica for the most part, and showing longitudinal fibres. At two places, one near the base of the cone and the other near the apex of the specimen, there are intervals where the wall of the tube is carbonaceous for a length of 5 mm more or less. The interval at the base of the cone was ground further, for both sections show seemingly tangential sections through the wall. When the section penetrates within the tube, the bulk of the carbonaceous material is passed and the whole appears rather light; there is calcite within the tube at this point, and it is possibly allied to the diaphragms and other odd obstructions found sparingly in the genus, but it does not appear here as a regular organic structure. Further confusion results from the fact that the apical part of the endosiphocone shows some patches of irregular calcite which do not seem explicable as regular organic structures.

Type and occurrence. Holotype, GSC No. 18751, member 2, Portage Chute Formation, Bad Cache Rapids Group, "near second upper limestone rapids", Nelson River, Manitoba. Collector S. J. Nelson, 1951.

Narthecoceras sp.

Plate XXX, figure 6

This is an undescribed species, but the material is not adequate for proper description. The only known specimen is a fragment of an endosiphuncle apicad of the endosiphocone, 99 mm long. The siphuncle is circular in section and shows parts of two segments. Septal constrictions are broad, slightly oblique, the anterior end moderately clear, the apical margin indistinct; they are gently concave, not flattened as in *N. sinclairi*. The expanded part of the segment is gently convex, broadest in the apical third, strongly curved where it contracts towards the next apical septal constriction.

This form shows a small tube which is circular in cross-section; it is filled with white calcite and is crossed by apparently simple diaphragms spaced about 10 mm apart. The section shows horizontal fibres that slope only slightly forward where they approach the tube; that they are clearer distally than centrally is probably a matter of preservation. Curiously, the section shows a region near the tube in which the endosiphuncle has been dissolved, this appears to the right of the tube in our figure, and extends over the apical two thirds of the specimen; at one point it is irregularly enlarged. It is filled with matrix with fine fossil fragments in it.

A siphuncle segment is 41 mm long, expanding from 35 to 37 mm, the septal constriction 16 mm long, the expanded part 25 mm long. The siphuncle is slender, and shows no such adoral increase in diameter of segments as is exhibited in commensurate parts of *N. crassisiphonatum.*

The single specimen though distinctive in proportion of segments, seems hardly adequate as a basis for the naming of a new species.

Type and occurrence. Figured specimen, GSC No. 20420, upper member, Caution Creek Formation, South Knife River, Manitoba.

IV. Other Ordovician Species

Narthecoceras hesperale n. sp.

Plate XXIV, figure 5; Plate XXVI, figures 3–8

Narthecoceras in the Second Value Formation of New Mexico and western Texas is represented by sparse endosiphuncles, very slender, subcircular in section. Good exteriors have not been obtained, but it is evident that segments are very long, tubular, with such faint constrictions that segmentation is commonly not obvious. Whether segments are oblique is not known, but, if so, such obliquity is slight. The endosiphuncle shows the usual fibres and may show growth lines. The central tube is rather large, compressed, and from the material at hand, empty, though one weathered portion suggests fine curved diaphragms.

The best preserved specimen (RHF No. 419, Pl. XXVI, figs. 3–6) is weathered, now in several pieces, with a length of 17 cm in which the endosiphuncle expands from 18 to 20 mm. Only parts of the specimen are figured. The segments, scarcely convex and with only the faintest rather narrow concavity between them, appear to be 36 mm long near the anterior end. The tube is compressed, 3 mm across at the greater diameter, where the siphuncle is 20 mm across. The endosiphuncle shows radial fibres and rather prominent equally spaced sheaths, four occurring between the wall and the tube in a width of 9 mm. They show no undulations suggesting segmentation. The tube is empty and calcite-filled in the part sectioned, but a weathered fragment from the apical end presents inconclusive evidence of diaphragms.

Another specimen, RHF No. 420, consists of three parts of an endosiphuncle two of which are shown (Pl. XXVI, figs. 7, 8). It is from a portion of a siphuncle about 300 mm long, the diameter ranging from 26 to 28 mm. Again segments are essentially tubular, with only the faintest septal constrictions, and adorally are 40 mm long. The endosiphuncle shows radial fibres, without growth lines, and again there is a slightly compressed tube that is rather large, with a maximum diameter of 5 mm. One portion shows part of a slender endosiphocone.

A third specimen, RHF No. 421 (Pl. XXIV, fig. 5) shows the largest diameter observed in these siphuncles in this occurrence, it is 37 mm across, shows a tube 6 mm across and the fragment is 76 mm long. Segmentation is not apparent.

Discussion. It is reasonable to consider these several fragments as belonging to one species, one characterized by essentially tubular segments with only the shallowest and apparently narrow constrictions. Such siphuncles are comparable to *N. simpsoni* and *N. calamitiforme* but show longer segments in which the convexity of the outline is reduced, and septal constrictions are both shallow and narrow, more like *N. equisetum* and *N. oppletum*.

Endosiphuncles of this sort are sparse in the Second Value Formation, and usually occur where they cannot be obtained. RHF No. 420 is a portion of a much longer individual. Thus far the species has been observed only in the Franklin Mountains; this is possibly because it is only there that dip slopes expose large surfaces of the Second Value Formation where the rocks are essentially free from the advanced dolomitization which prevails over so many of the sections in New Mexico; also, steepness of slope or dip, or both, limit exposures of the Second Value in most sections in New Mexico to rather restricted surfaces.

Types and occurrence. Holotype, RHF No. 419, paratypes, RHF Nos. 420, 421, collection of the writer. Second Value Formation, Montoya Group, southern Franklin Mountains, Scenic Drive, near El Paso, Texas, U.S.A.

Narthecoceras or Donacoceras sp. 1

Plate XXVIII, figure 7

Of this form only a portion of seven siphuncle segments is known. They are short, averaging 4 mm in length, but the last two shortened to 3 mm, expand from 4 mm to not quite 5 mm. Septal constrictions are transverse. The specimen is in dolomite, and fails to show definite evidence of the endosiphuncle.

This fragment is quite poor, and would not be of interest were it not the only indication of the Narthecoceratidae so far found in the Red River equivalent, the Fremont limestone, in Colorado. Without the siphonal filling, assignment to either *Narthecoceras* or *Donacoceras* to the exclusion of the other is necessarily inferential; it may be noted that as yet we know no *Donacoceras* in the Ordovician, where the Donacoceratidae are represented by the little known genus *Tasmanoceras*, in which segments are shorter and markedly oblique. The siphuncle segments are abnormally small in diameter for either genus. Assignment to other Michelinoceratida is even possible, but no species are known in the Fremont limestone other than those of *Ephippiorthoceras*, to which these siphuncle fragments cannot belong on the basis of proportions.

Type and occurrence. Figured specimen, in the collections of the University of Oklahoma, came from 140 to 160 feet below the top of the Fremont Formation, from a quarry sec. 1, tp. 18S, rge. 71W, near Canyon City, Colorado, U.S.A.

V. Silurian Species

Narthecoceras contractum n. sp.

Plate VIII, figures 1–3

The type is the only specimen known, a portion of a siphuncle 83 mm long, containing not quite eight segments. From the exterior it would appear that this is a series of gently expanding siphuncle segments, but a section shows the endocones thinning towards the smaller end indicating the siphuncle segments decrease adorally in diameter. At the base a segment 12 mm long expands from 16 to 18 mm, and adorally a segment of the same length expands from 14.5 to 16.5 mm. The segments vary irregularly in length from 12 to 10 mm, and average one and a half in a length equal to the adoral diameter. Segments are circular in cross-section. The weathered cross-section at the apical end shows a section near the apical end of the endosiphocone, roughly round, but with prominent irregular crenulations in its margin. A longitudinal section shows the endosiphuncle thinning anteriorly with close growth lines and some calcareous material dissolved between the growth lines; the material is slightly thicker on one side (the right as shown in Pl. VIII, fig. 2) than the other. Segments are very nearly transverse, but seem to slope very slightly forward on the side on which the siphonal lining is the thinner. Usual criteria of the surface suggest this side to be ventral, whereas the internal features would suggest it to be dorsal.

Type and occurrence. Holotype, GSC No. 22584, unit E, Severn River Formation, from about 77.5 miles above mouth of Rivière Joncas.

Narthecoceras subannulatum n. sp.

Plate VII, figures 10–12; Plate VIII, figures 9–13; Plate XXXII, figure 1

This species is known only from isolated siphuncles, straight, gently expanding, segments only very faintly convex in outline, septal constrictions shallow and poorly outlined, transverse, so that orientation of the siphuncles is uncertain. Segments are spaced one and a fourth apically and one and a half adorally in a length equal to the adoral siphuncle diameter.

The holotype (GSC No. 22585) is a portion of a siphuncle 70 mm long expanding from 16 to 21 mm, and shows parts of five segments, the last incomplete. Segments are slightly less than one and a half in a length equal to the adoral siphuncle diameter, septal markings scarcely inclined. A cross-section shows a central tube faintly undulate in outline, the endosiphuncle showing numerous growth lamellae, also faintly undulate and very steeply inclined. A thin section failed to show any further textures and is not illustrated. The siphuncle was removed from the matrix by etching, and the process brought out on the exterior numerous fine longitudinal impressions suggestive of the structures figured in the type material of *Calhounoceras* (Troedsson, 1926).

A second specimen (GSC No. 22586), 55 mm long is somewhat crushed apically, measuring 9 and 16 mm apically and 15 and 16 mm adorally. Segments here are one and a third in a length equal to the adoral siphuncle diameter. It shows a central tube and etching has brought out longitudinal grooves on the surface.

Types and occurrence. Holotype, GSC No. 22585, paratype, GSC No. 22586, unit O, Ekwan River Formation, Rapides des Papillons, Harricana River.

Narthecoceras exile n. sp.

Plate VIII, figures 4–8

The holotype is a portion of a slender siphuncle, circular in section, 140 mm long, increasing from 19 to 20 mm in that length. Segments are faintly convex in outline, the septal constrictions shallow, their limits poorly defined. Six segments occupy the anterior 110 mm, spaced one to one and an eighth in a length equal to the adoral siphuncle diameter. A section shows the endosiphuncle with rather slender endocones, growth lines faint and closely spaced, a relatively large central tube, round in section, one fifth to one sixth the siphuncle diameter. Diaphragms cross the tube. Three are shown in the 52 mm of the siphuncle sectioned, one is shown limiting the matrix apically in the anterior end of Plate VIII, figure 4; and two more are shown in the lower part of Plate VIII, figure 5, the opposite side of the same portion of siphuncle, though they are not clearly evident in the lower part of figure 4. The cut is slightly oblique, showing the full width of the tube anteriorly in figure 4, and apically in figure 5.

Discussion. The proportions of the segments characterize this species. The known portion of the siphuncle is so gently enlarging as to be almost tubular. Associated forms have shorter segments.

Type and occurrence. Holotype, GSC No. 22587, Ekwan River Formation, Rapides des Papillons, Harricana River.

Narthecoceras cf. *N. exile* n. sp.

Plate VIII, figures 17–19; Plate XI, figures 8–10

Under this name is figured a small part of a siphuncle (showing parts of only two segments), which shows the general long segments of *N. exile* though the fragment is too small for certain determination. A longitudinal section shows a central tube, calcite-filled, but without evident diaphragms, and fine close growth lamellae differing from those of typical *N. exile* in being more numerous and more closely spaced, and also in showing faintly undulate outlines conforming to the slight expansion of the siphuncle segments. The siphuncle is elliptical, possibly depressed in section, though the specimen fails to supply accurate criteria by which dorsum and venter can be distinguished.

A second fragment with the long slender segments of *N. exile* is shown in Plate VIII, figures 17–19. In this fragment, the siphuncle is again slightly elliptical, shows the central tube, but a longitudinal section shows the endosiphuncle material extensively replaced though a suggestion of the tube is shown in figure 17. This specimen is notable as the only one showing such advanced replacement in this material.

Types and occurrence. Figured specimens, GSC Nos. 22588, 22589, Ekwan River Formation, Rapides des Papillons, Harricana River.

Narthecoceras brevicameratum n. sp.

Plates IX, X

Only the holotype is known, a nondescript orthoconic phragmocone, with simple transverse septa; the whole is considerably crushed. In its present condition the phragmocone expands in its greater width from 46 to 49 mm, and shows sixteen camerae in the length of 130 mm. At the base the siphuncle is irregular in cross-section, subcentral, 16 mm wide, 17 mm high, 9 mm from the better preserved side. Adorally the siphuncle is more evenly rounded though somewhat flattened, 19 mm wide, 12 mm high, 11 mm from the better preserved side. Allowing for weathering, the phragmocone here is 30 mm high, of which 25 mm is preserved. The specimen fails to show clear evidence by which dorsum or venter can be identified. Camerae vary from 8 to 10 mm in length over most of the phragmocone, but the last two are only 7 mm long, suggesting an approach there to maturity; however the whole of the phragmocone shows a siphuncle with a filling complete, and there must have been a very appreciable adoral interval which is yet unknown.

Sections were cut across the longer diameter of both parts of the specimen, revealing a siphuncle with short segments, very faintly convex in outline, the segments spaced two and a half in a length equal to the adoral siphuncle width. Though crushing has evidently distorted the fine structure, there is evidence of a central tube and fine closely spaced growth lamellae as in associated *Narthecoceras*. The horizontal section shows rather deeply curved septa, the length of curvature equal to one and three fourths siphuncle segments; there the shell width is 3.5 times the depth of curvature of the septum. Septa show only faint irregularities in curvature, and it is believed that the depth has not been altered materially by crushing. The free parts of the septa are thickened by both episeptal and hyposeptal deposits; these are clearly developed on only one side of the siphuncle; ordinary relationships of cameral deposits would suggest this side to be close to the venter, the other side close to the dorsum.

A thin section was made from one surface of the apical part; it is shown complete in Plate IX, figure 1, and a further enlargement of a part of it is shown in Plate X. Septa are thin, apparently homogeneous, the usual condition in which alteration of the original aragonitic structure is probably involved. The bending of the septa into septal necks is gentle, the necks are short and show no special features. The rings are thin and apparently homogeneous in structure. The endosiphuncle shows some considerable alteration, an apparent outer layer is nonuniform and is clearly adventitious. The whole structure shows evidence of considerable alteration and recrystallization, and original textures are plainly lost, and lamellae are only approximately retained. The thin section shows cameral deposits, best developed on one side of the siphuncle; there relatively thick episeptal and thinner hyposeptal deposits extend over the entire length of the septum, extending to the siphuncle margin.

Discussion. It appears that the crushing of this specimen was not accompanied by actual widening of the shell as is common in crushing of orthocones in shales, for both siphuncle and phragmocone show only the slightest adoral increase in width. Similar crushing has been observed affecting both phragmocones and portions of siphuncles filled with organic deposits in the Endoceratida, in which conspecific uncrushed material has shown the crushing to depress even the filled siphuncles without increasing their width or rate of expansion. This species clearly has shorter and broader siphuncle segments than those of any other *Narthecoceras* in the James Bay Silurian material; in this respect *N. contractum* has a siphuncle more similar in proportions than any other species, but obviously these two species are not identical; *N. brevicameratum* has much shorter segments in proportion to their width and shows very gentle adoral expansion. The holotype is noteworthy as the first recognizable *Narthecoceras* siphuncle enclosed in a phragmocone that can be studied by sections (Troedsson, 1926, mentions having seen such a specimen, but it has not been studied closely and could not be located for the present study).

Type and occurrence. Holotype, GSC No. 22590, unit M, Severn River Formation, Rivière Malouin.

Narthecoceras or *Donacoceras* sp. 2

Plate XI, figures 6, 7, 11–16

Associated with *Narthecoceras brevicameratum* are some portions of phragmocones that represent appreciably earlier growth stages and are of much smaller diameter. They are all crushed, but are slender orthocones with simple transverse sutures. Sections reveal apparently subcentral siphuncles of relatively large diameter, with short faintly convex segments and traces of cameral deposits on the free parts of the septa as in that form. All siphuncles are void of any organic deposits. Consequently, although assignment to *N. brevicameratum* is tempting and may well be correct, the actual evidence does not even demonstrate that these phragmocones belong to *Narthecoceras* and not to *Donacoceras*.

The most complete of these specimens is a somewhat flattened orthoconic phragmocone shown in Plate XI, figures 11–16. The apical 80 mm is embedded in matrix and is shown only in section. It retains seventeen camerae, and shows a large siphuncle of short broad segments. The anterior 87 mm shows the surface of an internal mould of one side of the phragmocone, the other side is weathered. It shows straight transverse sutures, with seventeen camerae and a short aseptate anterior part which may be the base of a living chamber. Camerae occur four to four and a half apically and five adorally in a length equal to the adoral shell width. Septa are shallow, slightly less in curvature than the length of a segment apically; the two measurements are equal adorally. Siphuncle segments show a width equal to the length of one and a half segments apically, but equal to nearly two segments in the earlier part of the anterior part; in the adoral ten camerae the siphuncle wall is not preserved. Cameral deposits appear wanting in the first twelve camerae, are developed beyond, and are as in *N. brevicameratum*, but they thin adorally in the last eight camerae and are apparently wanting in the anterior end of this interval.

A second fragment, also crushed, is shown in Plate XI, figures 6 and 7. It is 30 mm long expanding in width from 27 to 28 mm, contains six camerae with the six in a length equal to the adoral shell width, the siphuncle large, 14 mm across, shows the slightly convex segments more clearly than did the preceding specimen; here three segments occupy a length equal to the adoral width of the siphuncle. Replacement of both septa and siphuncle wall seems advanced; under high magnification the siphuncle wall is ragged in outline as though extra material had been added to the surfaces of the rings.

A third fragment 65 mm long expanding in width from 20 to 25 mm preserves parts of fifteen camerae, shows much the same proportions as the two preceding forms. At midlength it shows prominent cameral deposits, again developed along the free parts of the septa.

Discussion. These portions of phragmocones could reasonably be from the anterior ends of young individuals of *Narthecoceras brevicameratum*, with which they are associated. Some support for the generic assignment may be found in the fact that in the James Bay Silurian all *Donacoceras* have been found in higher beds, but neither the generic nor the specific assignment can be proved.

Types and occurrence. All three of the specimens, GSC Nos. 22591–22593, are from unit M of the Severn River Formation, from Rivière Malouin.

Genus ***Farroceras*** Flower, n. gen.

Type species: *Farroceras liskeardense* n. sp.

Only siphuncles are known, which are straight, composed of long expanded segments, the profile sinuate, with broad expanded regions alternating with equally broad gently rounded constricted regions. The aspect of the siphuncles is very much that of the group of *Actinoceras simplex* (Flower, 1957). Our one good specimen, however, contains internal deposits which show an endosiphocone, with no evidence of the material being composed of segmental elements, and no evidence of central and radial canals. The endosiphuncle seems, in structure, allied to that of the Narthecoceratidae, to which this genus is tentatively assigned.

Discussion. The review of *Calhounoceras* shows that the one specimen of *C. candelabrum* with the general aspect of these siphuncles, but with apparent radial canals, is not conspecific with the holotype; from the radial canals it is apparently an actinoceroid, a conclusion of Teichert's (1934) with which the writer would agree. It is the more surprising, then, to find a somewhat similar siphuncle in the Farr Formation of the Liskeard Group of similar external aspect, without the essential features of an actinoceroid but with apparently the internal features of *Narthecoceras*. Foerste (1929) had a similar siphuncle from the Red River of Manitoba which he assigned tentatively to *Calhounoceras candelabrum*;

this form differs from true *candelabrum*, and also from the misassigned actinoceroid which was included in it, in proportions of segments; it is here redescribed and, though it shows no organic filling of the siphuncle, is tentatively placed in *Farroceras*, though it must be stressed that without the organic filling of the siphuncle such assignment is necessarily inferential.

Farroceras liskeardense n. sp.

Plate XXXIV, figures 1–5

This species is represented by a portion of a siphuncle 185 mm long, showing expansion of seven segments in 145 mm. The specimen is evidently crushed, for at midlength where the maximum width is 40 mm, the height is only 18 mm. Segments are so uniform in length and width that from the exterior it is not evident which end is anterior; indeed, the assumption made in lighting the exterior proved to be wrong. Segments average 22 mm in length, expanding from 32 to 40 mm in width. Though the illustrated surface was exposed and is somewhat weathered, the segmental expansion appears to be lost there in the middle; on the opposite side, expansion is present. A section made of the two parts of the specimen shows in the anterior part a section through an endosiphocone with an apical angle of about 15 degrees. The calcareous organic material is greatly altered, and in places is darker than the matrix. Obscure longitudinal lamellae of growth can be seen, in which segmental units and any possible radial canals are definitely wanting. A section of the apical part was less satisfactory; it failed to show a clear central tube, which was possibly lost by crushing. The calcite there is light. The thicker side was ground progressively for about 4 mm in the hope of obtaining a central tube or better fine structure, but the results were unrewarding. A curious feature is the dark band in the second expansion from the apex in the right side of Plate XXXIV, figure 5; at its anterior end this band curves out to join the siphuncle wall, and there is a faint suggestion of a more obscure radial band which it joins there, suggestive of a radial canal.

Discussion. The absence of annuli on one side, the lack of apparent obliquity of the segmentation, the even sinuate lateral outline of the segments characterize this form. Though the specimen is crushed vertically, apparently such crushing has not augmented the rate of expansion of the siphuncle laterally.

Type and occurrence. Holotype, GSC No. 18742, Farr Formation, Liskeard Group, Farr quarry, Haileybury, Ontario.

Farroceras (?) *winnipegense* n. sp.

Plate XXXI, figures 6–8

Calhounoceras cf. *candelabrum*, Foerste, 1929, p. 191, pl. 25, fig. 4.

This is based on a portion of a siphuncle of four segments, crushed vertically, 96 mm long. Laterally a segment expands from 27 to 35 mm in width, and is 25 mm long; it shows short expanded regions of convex outline approximately 10 mm long, merging into concave broad interspaces 15 mm long. As the specimen now appears, an expansion 36 mm wide is only 25 mm high, the expansion is inclined 50 to 60 degrees from the horizontal. The outline of the segments is smooth, and there are no clear septal markings. The siphuncle appears to be filled with matrix, and there is no clear indication of even the anterior end of any organic lining.

Discussion. The crushing to which this specimen has been subjected may be wholly or partly responsible for the obliquity of the segments, though experience would suggest that some appreciable obliquity probably existed; the obliquity is certainly not an adequate basis for distinguishing the species, but the proportion of the segments, as seen particularly in lateral outline is; in contrast to *C. candelabrum* there are broad concave areas between the convex expansions; in contrast to *F. liskeardense* the concave zones are conspicuous and broad; in that species the lateral outlines more closely approach a regular sine curve; also the flattening of the annuli on one side is clearly original.

Type and occurrence. Holotype, GSC No. 7140, evidently from the Dog Head Member, Red River Formation, south end of Snake Island, Lake Winnipeg, Manitoba.

Subfamily DONACOCERATINAE

Genus *Donacoceras* Foerste

Foerste, 1925, Geol. Surv. Can., Mem. 145, p. 69.
Foerste and Teichert, 1930, Denison Univ. Bull., vol. 25, pp. 210-11.
Foerste, 1936, J. Paleont., vol. 10, pp. 375.

Donacoceras is known only from straight siphuncles showing segments slightly convex in outline. Though generally the segments are shorter in proportion to their width than in *Narthecoceras*, our material now shows that separation on this basis alone is impossible, for externally, one would place such *Narthecoceras* as *N. contractum* with *Donacoceras*. However, *Donacoceras* is widely different from *Narthecoceras* in that the endocones are greatly extended forward on the ventral side, so that the endosiphocone is open dorsally over most of its length, and, as in *D. leve*, the tube may be so close to the margin that the endosiphocone is completed dorsally only at its very tip. In other forms, however, the apical end of the endocone is completed dorsally over a more appreciable interval, and a cross-section will show (1) outer half-cones on the ventral side, (2) a region of cones completed on the dorsum, and (3) a tube in the centre of the cones, but always well dorsad of the centre of the siphuncle. In three species, *D. timiskamingense*, *D. arundineum*, and *D. leve*, the tube is transverse and strongly flattened in the adult. In *D. humei* the tube is surrounded by a wider interval of complete cones, and the tube is rounded and scarcely wider than high. One specimen indicates that in *D. arundineum* the tube widens and becomes more flattened as growth progresses, but in the young stages is rounded and reminiscent of that of *D. humei*. *Donacoceras* shows much the same habit (Flower, 1964a) as associated *Narthecoceras* in the Silurian of the James Bay lowland; both types of siphuncles under slight silicification will reveal upon etching fine longitudinal grooves on the siphuncle surface similar to those figured by Troedsson (1926) in the holotype of *Calhounoceras candelabrum*, and suggest that the general texture and composition of the two endosiphuncles were quite similar. However, some specimens of *Donacoceras* show instead of some half-cones only their sheaths preserved, and between them there may be matrix. With two striking examples of this sort of preservation (Pl. II, figs. 2–4 and Pl. XI, figs. 1–5) the question arises as to whether it can possibly be original, or whether it results from such early replacement as may make some of these sheaths less soluble, followed by solution of the material between, both prior to burial, and leaving spaces which matrix has penetrated. If there are originally free sheaths in some species assigned to *Donacoceras*, they have certainly not been found in *D. timiskamingense* or *D. arundineum*, and possibly these other species might be set apart in a distinct genus. The material now available is not completely adequate to solve this difficulty, but it does indicate strongly that silicification of some of the sheaths followed by solution of material between them can be invoked reasonably as the explanation. Organic reality of the condition remains however as a very real possibility.

A hypotype of *D. timiskamingense* figured on Plate VII, figures 7–9 and on Plate XIII, figures 4–7 suggests alteration approaching but not attaining this condition. A break near the anterior end of the specimen (Pl. VII, fig. 7) shows at the left the dorsal endosiphocone thinning apically to a tube. Its ventral side is bounded by one good sheath, and a second sheath is close to the first. The remainder of the ventral part of the siphuncle is here occupied by crystalline material. However, lateral and ventral views (Pl. XIII, figs. 4–6) show on the weathered anterior end numerous fine longitudinal lamellae, representing the weathered edges of a series of very thin half-cones, the median parts of which are lost in replacement.

D. humei is represented by the holotype from Lake Timiskaming (Pl. XII, figs. 12–16) in which the ventral part of the siphuncle is weathered, and exposes numerous close thin half-cones. However, a specimen from the James Bay lowland, which is otherwise similar and is thus considered conspecific, shows in section the portion composed of complete cones as solid, but on the ventral side there are sheaths of two half-cones separated by matrix (Pl. II, figs. 2–4).

Quite the oddest and most confusing specimen showing such solution is the holotype of *Donacoceras mutabile* (Pl. XI, figs. 1–5). This is seemingly a part of a siphuncle from which some outer cones were exfoliated, and it was first considered to be oriented, as it is on our plates, with the broader upper end adoral. However, it was found that if this were true, there was no tube at all, for the central of the three preserved sheaths meets the apparent dorsal wall of the siphuncle. However, it was realized that this interpretation was wrong, and that this specimen had been oriented upside down. It represented only the ventral part of the siphuncle, showing segmentation externally on the ventral side, and showing three sheaths of half-cones; it is the dorsal part that is missing and in which the complete cones should be located.

Donacoceras has so far failed to show a good indication of which side is dorsal and which is ventral. The siphuncles are straight, and often the segmentation is transverse. *D. timiskamingense* shows segments that slope forward slightly on the side bearing the tube. Is this side dorsal? Two considerations suggest a reverse of this orientation: 1. In general, fillings of siphuncles tend to concentrate the mass of heavy material on the ventral side. 2. In the Ordovician genus *Tasmanoceras* the segments slope forward on the side bearing the half-cones; applying the normal criterion that segments normally slope forward on the venter, the tube is here dorsal. *Tasmanoceras* differs from *Donacoceras* only in the strongly oblique relatively short segments, and all indications are that the two are related. It is then at least logical to assume a primitive condition for the Ordovician genus *Tasmanoceras*, and a more specialized condition for the Silurian *Donacoceras*.

The species certainly attributable to *Donacoceras* are those described below. Two others have been assigned to the genus on the basis of the proportions of the siphuncle segments; until the endosiphuncles are known it cannot be certain that they do not belong to *Narthecoceras*. These are *D. bellense* Foerste 1925 from the Jupiter Formation of Anticosti Island, and *D. gaspense* Foerste 1936 from the Whitehead Formation of Gaspé, Quebec. A third specimen presenting a similar dilemma is a small bit of siphuncle from the Fremont limestone of Colorado; it is dolomitized, fails to show the nature of the endosiphuncle, and thus cannot be assigned to either genus with certainty. A fourth similar dilemma is presented by some phragmocones from the Severn River Formation of the James Bay lowland. Siphuncles are empty in the known specimens, and one cannot prove that they pertain to *Narthecoceras* rather than to *Donacoceras*.

Donacoceras timiskamingense Foerste

Plate VI, figures 1–15; Plate VII, figures 7–9, 13–18;
Plate XIII, figures 4–7

Donacoceras timiskamingense Foerste, *in* Hume, 1925, p. 69, pl. 10, fig. 4a.

Only siphuncles of this species are known. The holotype is a fragment 130 mm long; near the anterior end it is 26 mm high, 25 mm wide, and at the base it is circular and 22 mm. There are parts of fourteen segments; that at the base is 9 mm long and expands from 21 to 22 mm; at the anterior end the last complete segment 11.2 mm long expands from 24 to 26 mm. Septal constrictions are sharp, narrow, and segments slope slightly forward from venter to dorsum. The weathered surface of the segments shows fine longitudinal striation. The anterior end shows the endosiphuncle well advanced, but in a section near the apical end of the endosiphocone is seen a transverse cavity 16 mm wide, 3 mm high, 2 mm from the dorsum, and 17 mm from the venter. Its ventral margin shows a marked groove, and there are finer smaller grooves elsewhere on its surface. The apical end shows a tube 4 mm wide, 3 mm from the venter, and 1 mm high, again showing a median groove on the ventral side.

A hypotype (GSC No. 18748) from the same general locality and horizon as the holotype is a part of a siphuncle 118 mm long. Anteriorly, only the ventral part is preserved, and for 31 mm the dorsal surface shown is that of the penultimate blade; it shows a median groove and a surface granular from inorganic material. Apicad of this is the part shown in Plate VII, figures 7–9. The break at the anterior end shows a section of the endosiphocone, which is here quite large, its ventral surface is bounded by a sheath, then a small dissolved area to the next sheath which forms the surface of a mass of altered material in which no earlier blades can be seen. The endosiphocone is shown in oblique and dorsal views, showing the fine striations on its ventral surface and the median prominent groove. There follows apically 55 mm of siphuncle, complete dorsally but the surface is rather poorly preserved. Segmentation is as in the holotype, and segments slope slightly forward on the dorsum. The specimen is figured with the anterior end in Plate XIII, figures 4–7. It is significant that the lateral and ventrolateral views show the ventral part of the siphuncle weathered so as to accentuate numerous fine lamellae of growth, with very closely spaced blades, though the broken cross-section shows the median parts of these sheaths lost through alteration. At midlength the siphuncle is 20 mm wide and 22 mm high. The apical end shows the tube, but replacement is advanced and only a few of the sheaths are faintly indicated. This specimen is of particular interest in showing the striate surface of the endosiphocone and the central disappearance of the half-cones on the ventral side by alteration.

The James Bay lowland yielded an exceptionally long portion of an endosiphuncle, 269.8 mm long. Segments are slightly convex, more rounded dorsally than ventrally. Septal constrictions are sharp and narrow, and segments slope forward very slightly from venter to dorsum. Basally 2.0 to 2.25 segments occur in a length equal to the adoral siphuncle diameter, adorally 2.5 segments occupy a similar length. The siphuncle is very slightly depressed in section, 21 mm wide and 20 mm high at the base, enlarging the next 88 mm to 24 and 21 mm, and farther orad the expansion is negligible.

At the anterior end the endosiphuncle is thin, developed only ventrally, and shows growth lines curved, the convex side ventrad, becoming more markedly crenulate as they are traced apicad. In 140 mm the endosiphuncle thickens in the median plane from 3 mm to 16 mm. It is only apicad of this region that cones become complete on the dorsal side, but the narrowing cone occupies the next 32 mm of the siphuncle. The next portion, 40 mm long, was sectioned vertically. The surfaces show the tube, less than 1 mm high, with thin dark walls, 3 mm from the dorsum at a septal constriction, 18 mm from the venter. Fine longitudinal lamellae of sheaths are evident, but on the ventral side some material has been removed by solution. The tube is crossed by faint diaphragms. It retains to the apical end and its transverse section, but at the extreme apex the ventral groove is no longer evident.

The James Bay specimens agree closely with the Lake Timiskaming specimens in proportions and show only one difference of possible significance: there is here a marked difference between the strong annuli of the dorsum and the more flattened annuli of the ventral surface. In the Lake Timiskaming specimens the difference still exists, but it is so slight that it could be overlooked were it not shown more strikingly by this other specimen. The difference does not seem adequate to warrant setting the specimens apart as distinct species.

Types and occurrence. Holotype, GSC No. 8043, Thornloe limestone, 3 miles east of Earlton, Armstrong township, Ontario. Two hypotypes are from the same general region: one is GSC No. 18748 from Hume's locality E, the other, GSC No. 18752, is from Hume's locality 88A, Lake Timiskaming region. The hypotypes from the James Bay lowland are GSC Nos. 22594, 22595, Ekwan River Formation, Rapides des Papillons, Harricana River.

Donacoceras arundineum Foerste

Plate VII, figures 1–6; Plate VIII, figures 14–16; Plate XII, figures 7–11

Donacoceras arundineum Foerste, *in* Hume, 1925, p. 69, pl. 10, fig. 4b.

This species was originally distinguished from *D. timiskamingense* by the proportions of the siphuncle segments, which are spaced one and a half to one and three fourths in a length equal to the adoral siphuncle diameter in the type. The siphuncle only is known; the type is a portion of nearly 12 segments, 130 mm long; segments are 10 to 11 mm long. At the base a segment expands from 15 to 16 mm; adorally, a segment expands from 17.5 to 18 mm. The type shows slight curvature, probably from distortion. Septal constrictions are narrow and sharp, and slope slightly forward from venter to dorsum. The base shows a weathered cross-section with a sharply outlined elliptical area, which seemed at first to be an endosiphocone but is only a silicified blade. Cleaning of the other end shows there the true endosiphocone, which fills about half of the siphuncle and is essentially transverse on the ventral side. Here the ventral part of the siphuncle is crushed and not quite complete. Farther apicad the tube is obscure but lies in a region of dorsally complete endocones that is convex on the free side and rather irregular, as the siphuncle is slightly distorted, being slightly obliquely compressed.

The James Bay Silurian has yielded two specimens that agree with the holotype in general proportions. The best is part of a siphuncle 86 mm long, slightly compressed, increasing from 19 and 22 mm to 21 and 22 mm. Annuli are nearly transverse, but slope apicad slightly on the side away from the tube, the assumed venter. Segments widen from 20 to 22 mm; the septal constrictions are sharp and narrow. There are not quite two segments in a length equal to the adoral diameter of the siphuncle; thus segments are very slightly shorter than in the type of *D. arundineum*, but such a difference may be expected, for this specimen shows larger diameters and is a more adoral part of the siphuncle.

Cross-sections were cut near the two ends of the specimen, and the intervening part was sectioned vertically. There are ventral crescentic regions at both ends occupying about a third of the siphuncle height centrally. Apically one can see there two clear sheaths, adorally only one is apparent. The remainder of the siphuncle shows radiating structures centring on a transverse tube, the ventral side of which is concave. The longitudinal section shows the tube bounded by a prominent dark wall, and a series of longitudinal sheaths. Flocculent yellow-white material marking the radial bands of the cross-section show an undulate pattern, owing to intersection of the plane of the section with the rays, but within the region in which the cones are complete dorsally fine sheaths can be seen.

Near the base of the upper of the two pieces shown in Plate VII, figure 4, there is seen a curved dark-walled rod or tube, not directly connected with the primary tube at its base in the plane of the section, though a band of flocculent white material suggests such a connection just above the plane of the section. This tube slopes strongly apicad and dorsad at its base, curves distally, becoming more nearly horizontal at its apparent end. No other tubes of this sort are apparent, though they should be, for much of the material on the sectioned surface is semi-transparent. The main tube shows a dark wall; in the basal part it shows fibrous longitudinal material reminiscent of the apical parts of tubes of *Narthecoceras sinclairi*; in the adoral part, there is at least one good diaphragm crossing the tube in the plane of the section.

With such radial structures the portion of the endosiphuncle continuous around the dorsum was certainly solid. It is questionable whether the few distant sheaths of the half-cones of the ventral side represent free sheaths with no solid material between, or whether there was originally solid material that has been lost by solution, for in some comparable specimens of *Donacoceras* spaces between such sheaths are filled with matrix.

A second specimen here illustrated in part shows part of a siphuncle 58 mm long, 28 mm across at the base, where the height is incomplete; adorally both height and width are incomplete. The specimen shows, upon etching, longitudinal fibres both on the surface of the endosiphuncle, and extending within it. Plate VIII, figure 14 shows the weathered dorsal side; anteriorly the surface passes through the tube, which is so flat that it is not clearly evident in the photograph; its lateral margins are seen only for a short distance at midlength. The ventral side is of interest in showing radial fibres obscurely, but it displays the flat close sheaths. An apical 50 mm is not figured; it is weathered and retains only the dorsal half of the siphuncle. Here the complete cones are strongly flattened, and the tube that they surround becomes small and circular apically.

Types and occurrence. Holotype, GSC No. 8044, Thornloe limestone, 3 miles east of Earlton, Armstrong township, Ontario. The two hypotypes, GSC Nos. 22596, 22597, are from the Ekwan River Formation, Rapides des Papillons, Harricana River.

Donacoceras mutabile n. sp.

Plate XI, figures 1–5

The unique holotype is an incomplete specimen that represents only the ventral side of a siphuncle with half-cones within, and one half-cone forming its dorsal surface. The cross-section at the anterior end shows two transverse partitions or sheaths, and a longitudinal section shows these sheaths essentially parallel to the one forming the dorsal surface; one extends to the tip of the specimen, the other meets the ventral wall at about midlength. The specimen is 96 mm long, and actually contracts from a width of 21 mm and a height (incomplete dorsally) of

17 mm, to a thinning anterior end of 13 mm wide and 8 mm high. Segments are faintly convex, with sharp septal constrictions; the nine complete segments shown increase in length from 9 to 11 mm at the base, there are two segments in a length equal to the adoral siphuncle width; adorally such measurement is insecure, because the specimen is less than the full width of the siphuncle; but clearly there must be about one and a half segments in a similar length.

The development of half-cones that are nearly flat but curved with the convex side dorsad instead of ventrad suggests a general pattern more in accord with that of *D. timiskamingense* than of *D. arundineum*.

Discussion. This specimen was most vexing; it was first assumed to enlarge normally but to show an adoral decrease in the length of the segments, and it was thus oriented for photography before it was sectioned. The sections show, however, that the one blade joins the wall of the siphuncle that shows septation; there is no room for a tube or for complete cones. The specimen, as thus interpreted, would be so unlike other *Donacoceras* as to require a new genus, but if one reverses the assumed orientation and regards the large end as apical, the specimen at once is evident as the ventral part of a siphuncle preserving only half-cones, and only a few of them, the preserved ones being replaced early, the material between being dissolved, while the dorsal part, with the complete cones, is wanting. On this interpretation, the rapid adoral increase in length of the segments and the development of sheaths that are slightly convex on their ventral sides distinguish this from previously described species.

Type and occurrence. Holotype, GSC No. 22598, Ekwan River Formation, Rapides des Papillons, Harricana River.

Donacoceras leve n. sp.

Plate XII, figures 1–6

This is a *Donacoceras* in which the expansion of the segments is very slight and the septal incisions are most obscure, so much so that it is difficult to determine spacing or obliquity of the segments. The endosiphuncle terminates in a flat transverse tube that is almost in contact with the dorsal (?) surface of the endosiphuncle. The cone and the tube show surfaces with longitudinal striation, with a median ridge on the ventral surface.

The holotype is a fragment 70 mm long, slightly and obliquely compressed, expanding from 16 and 20 mm to 19 and 20 mm. Segmentation is obscure, but the segments are spaced two in a length equal to the siphuncle height and slope very slightly forward on the side away from the tube, the apparent venter. The main mass of the endosiphuncle is so replaced that sheaths are not preserved. The anterior end of the specimen shows the apical part of the tube 9 mm wide, and open on the dorsal side. At the apical end the tube is 5 mm wide, 1 mm high, and 2.2 mm from the dorsum.

A paratype is a more apical fragment 52 mm long, so slender that orientation is not obvious; it expands from 16 by 16 mm to 16 by 17 mm and is slightly wider than high adorally. Again, segmentation is obscure, segments showing only the faintest convexity, but spacing of segments seems to be two in a length equal to the adoral diameter. The tube is small and marginal. The anterior end shows advanced silicification; the tube is 4 mm wide, 1 mm high, 1 mm from the surface; other markings suggest cones that are convex instead of concave on the surface facing the tube, but alteration is advanced, and the effect may be adventitious. The other end shows wear, so that the tube is exposed from the dorsal side, but growth lines of the endosiphuncle are lost.

Discussion. The nearly smooth exterior and the extreme marginal position of the tube characterize this species.

Types and occurrence. Holotype, GSC No. 18746; paratype, GSC No. 18747, Thornloe limestone, no locality given, Hume's field designation "E", Lake Timiskaming region.

Donacoceras humei n. sp.

Plate II, figures 2–4; Plate XII, figures 12–16

This is a form having a siphuncle close to that of *D. arundineum* in proportion of segments, which range from one and three fourths to two in a length equal to the adoral diameter. The type is a siphuncle 162 mm long, with fourteen complete segments, averaging 10 mm in length. Only in the basal part is the complete width of the siphuncle preserved; there segments range from 19 to 22 mm in width; septal constrictions are narrow, segments only faintly convex in outline, one segment expanding no more than 1 mm. The anterior part shows on the dorsum similar traces of segmentation, which are only slightly fainter, but here the dorsal layers of the endosiphuncle have been exfoliated and the entire width of the siphuncle is not shown. Dorsally and laterally the siphuncle is weathered and exfoliated; faint ridges representing the sheaths of the half-cones are seen, and the surfaces of the sheaths show longitudinal striations; the whole specimen in ventral view has much the aspect of a split and weathered piece of wood. A section at the anterior end shows the endosiphocone faintly convex dorsally, more convex, more elevated on the venter, slightly flattened on the sides, and faintly subtriangular. The complete cones and a few half-cones show the same general type of cross-section. A break anterior to the middle shows the complete cones convex on their ventral side, and in their centre is a small tube, scarcely wider than high.

A second specimen from the James Bay lowland is figured on Plate II, figures 2–4. This is a small portion of a siphuncle 34 mm long. The anterior end shows a cross-section of the part showing complete cones, which are slightly irregular and surround a section near the apex of an endosiphocone, faintly subtriangular. The basal end shows the part of the endosiphuncle slightly depressed in section, with sheaths less undulate. Apparent matrix is present, and it showed what seemed to be portions of the shell wall. A longitudinal section, however, shows that instead these are sheaths of the half-cones, thin, and separated by matrix. The central portion, which contains complete cones, is uniformly calcareous, and shows in section the cone tapering to a tube.

Discussion. This species shows external proportions of the siphuncle quite like those of *D. arundineum* but the interiors are quite different. In *D. arundineum* the half-cones are flat or curved with the convex side dorsad and the tube is transverse with its ventral side concave. In this form, however, the half-cones are curved in the opposite direction, the convexity directed ventrad, the whole cones are broadly convex, even subtriangular, the ventral side convex, and the tube is scarcely transverse and rounded, the half-cones are curved, the convex side directed ventrad.

Types and occurrence. Holotype, GSC No. 18749, Thornloe limestone, Lake Timiskaming region; paratype, GSC No. 22599, Ekwan River Formation, Rapides des Papillons, Harricana River.

Genus *Tasmanoceras* Teichert and Glenister

Teichert and Glenister, 1952, p. 739.
Teichert and Glenister, 1953, p. 16.

Only one species, *T. zeehanense* Teichert and Glenister from the Ordovician of Zeehan, Tasmania, is known. The several specimens are all short portions of a siphuncle not over 10 mm in diameter. Externally they show short broad segments, rounded and expanded between sharp, narrow septal constrictions. Segments are very short, and the convexity of the outline scarcely increases a segment by more than 1 mm. Four to four and a half segments occupy a length equal to the adoral diameter of the siphuncle.

A section shows endocones within the siphuncle which terminate in a tube between one side, the dorsum (if we can accept the slope of the septa forward on the ventral side), and the centre. Endocones are steeper ventrally than dorsally, and must have extended forward far beyond the dorsal limit of the endosiphocone.

The internal structure of this genus is so similar to that of *Donacoceras*, that there seems no possible objection to placing it in the Donacoceratinae of the Narthecoceratidae. Indeed, it differs from *Donacoceras* only in the extremely short segments which are strongly inclined forward on the side that is the more distant from the tube.

Teichert and Glenister referred *Tasmanoceras* to the Endoceratida, a conclusion that was accepted by all subsequent investigators of the cephalopods, including the writer. However, it and *Narthecoceras* were the only two apparent endoceroids that showed siphuncle segments markedly convex in outline between septal constrictions. With the new evidence that *Donacoceras* has essentially the internal structure of *Tasmanoceras*, removal of *Tasmanoceras* to the Donacoceratinae of the Narthecoceratidae seems obvious.

Donacoceras is known from portions of siphuncles of a considerably larger range in diameter than is *Tasmanoceras*. Siphuncles are straight, septal constrictions are generally transverse but in some specimens the segments evidently slope slightly forward on the side to which the tube is closest, but in general endosiphuncles will extend forward on the venter, and not on the dorsum, when there is any such dorso-ventral differentiation. With *Tasmanoceras* as the older of the two genera, it seems reasonable to accept the interpretation of *Donacoceras* as also having a dorsal tube and the endosiphocone extended forward on the venter.

It should be noted that although assigning *Narthecoceras* and *Tasmanoceras* to the Narthecoceratidae of the Michelinoceratida removes from the endoceroids the only forms with the segments apparently expanding and convex in outline between septal constrictions, there remain some endoceroids that present such an appearance, but where septal markings are known they show that the septa join the siphuncle at some point other than that of greatest constriction of the segment. This condition is true of "*Mcqueenoceras*" *franklinense* of the El Paso limestone, and recently new forms from the Canadian of Alaska have come to the attention of the writer which show such expansion that from their exteriors siphuncles were mistaken for conchs of the form genus "*Cycloceras*". However, where septal markings are known, they also fail to join the siphuncle at the region of greatest constriction.

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Plates I to XXXIV

PLATE I

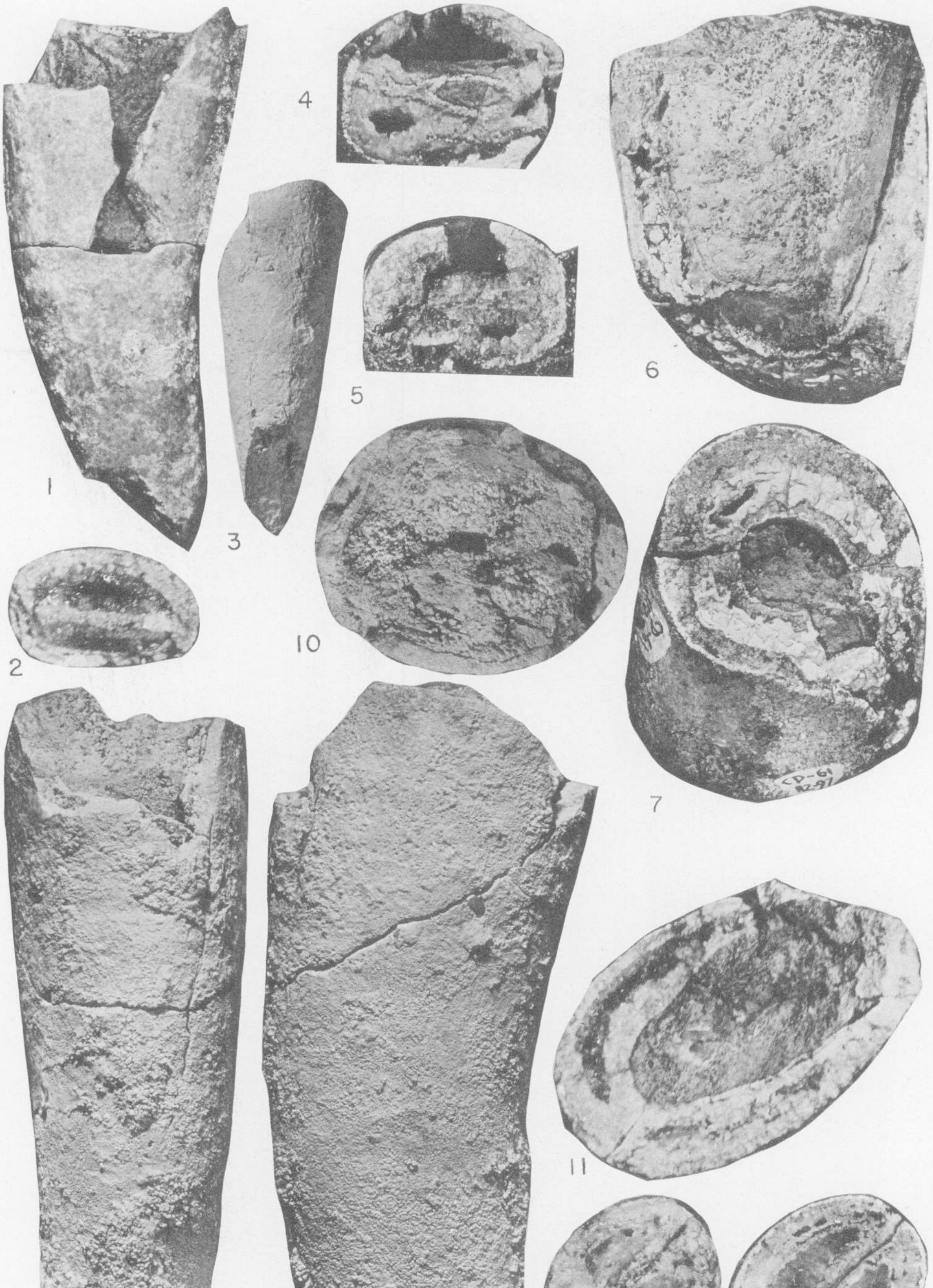
Humeoceras durdeni n. sp. (Page 28)

Figures 1–5. Paratype, GSC No. 22573. 1, lateral view, venter on right. 2, adoral view of apical part showing vertical blades and obscure central tube. 3, apical part, dorsal view. 4, adoral view, showing vertical blades and a section near the apex of the endosiphocone. 5, apical end of adoral part, showing blades and a tube obscure; this faces the section shown in fig. 2.

Figures 6, 7. Paratype, GSC No. 22574, adoral part of an endosiphuncle from a more mature individual. 6, portion with anterior part of endosiphuncle removed, showing surface of internal mould of the endosiphocone, with adoral parts of the endosiphuncle on either side. 7, oblique apical view, with portions removed in fig. 6 replaced.

Figures 8–13. Holotype, GSC No. 22572, a relatively long portion of an endosiphuncle, containing both the endosiphocone and the endosiphotube. 8, dorsal view. 9, lateral view, dorsum on left; note absence of septal markings in both. 10, adoral view, showing broken anterior end of endosiphuncle at margins. 11, section, oblique, at the break the endocones thinning adorally, at the upper right. 12, weathered section at apex. 13, section cut near apex; both oriented with the venter at the upper right, showing compressed central tube two vertical blades, the dorsal one slightly askew.

All material is from Ekwan River Formation, Rapides des Papillons, Harricana River, Quebec.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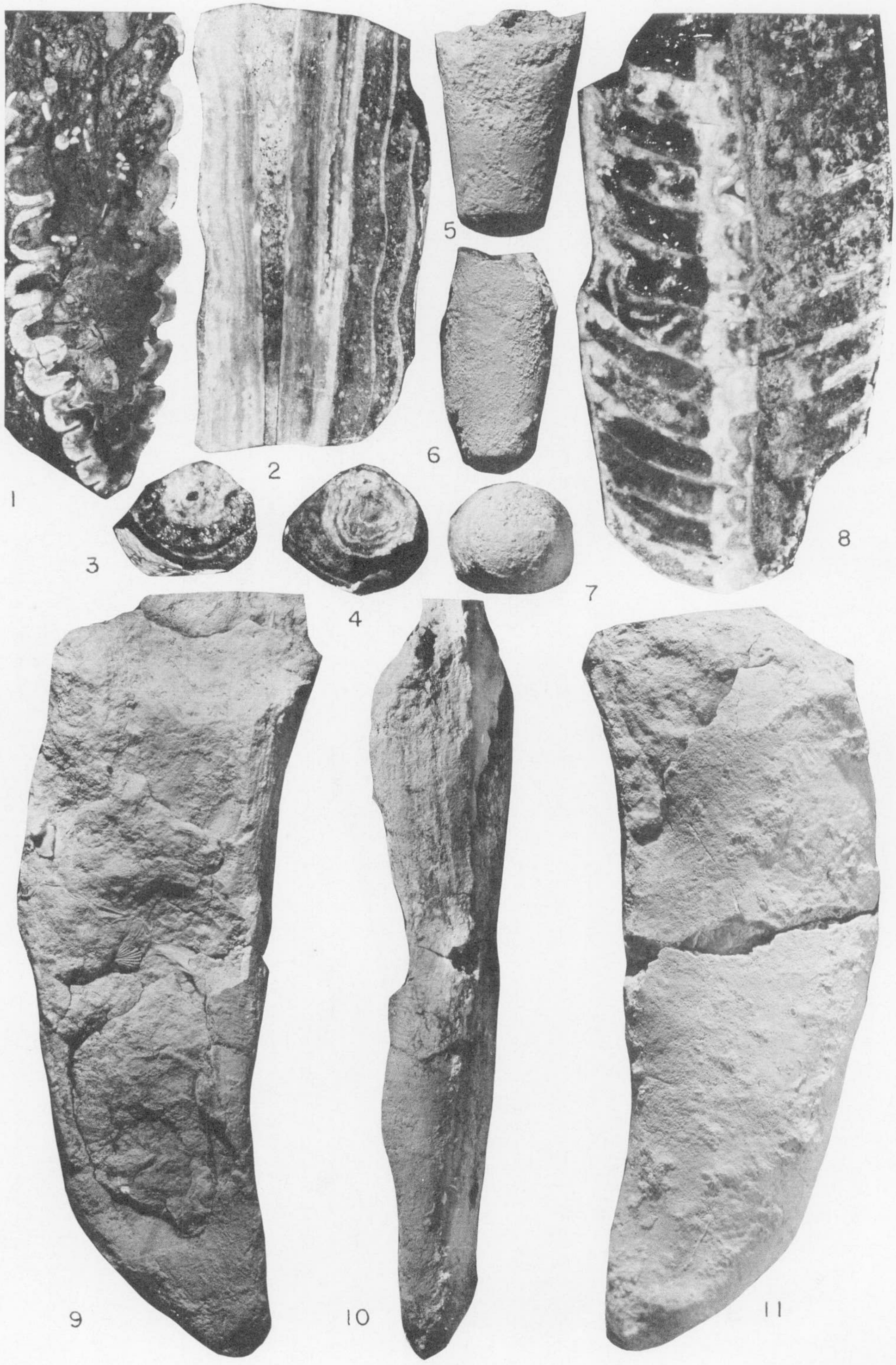
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PLATE II

Figure 1. *Discosorus megistos* n. sp. (Page 23)

Paratype, GSC No. 22566. Vertical section, venter on right, xl (*see also* Pl. III, figs. 8, 9). Float from Severn River Formation, Rivière Joncas, Quebec.

Figures 2–4. *Donacoceras humei* Foerste (Page 82)

Paratype, GSC No. 22599. 2, vertical section, x2, venter on right, showing sheaths on venter with matrix between. 3, cross-section, xl at apical end. 4, cross-section, xl at anterior end. Ekwan River Formation, Rapides des Papillons, Harricana River, Quebec.

Figures 5–8. *Ormoceras expansum* n. sp. (Page 31)

Holotype, GSC No. 22576. 5, ventral view, xl. 6, lateral view, venter on right, xl. 7, apical view. 8, vertical section, x2, venter on left, showing marked ventral concentration of siphonal deposits. Same locality as Figure 2.

Figures 9–11. *Humeoceras tardum* n. sp. (Page 29)

Holotype, GSC No. 22575. 9, lateral view, venter at right, endosiphuncle surface crushed, and showing fine longitudinal striae at upper right. 10, ventral view. 11, lateral view, venter at left, showing endosiphuncle surface uncrushed. Unit G, Severn River Formation, Rivière Malouin, Quebec.

Plate III

Figures 1–3, 10. *Discosorus megistos* n. sp. (Page 23)

Holotype, GSC No. 22565. 1, ventral view. 2, lateral view, venter at left. 3, dorsal view. 10, adoral view, venter below. Float believed to be from the Severn River Formation, Rivière Joncas, Quebec.

Figure 4. *Discosorus megistos* n. sp. (Page 23)

Paratype, GSC No. 22567, ventral view. Unit E, Severn River Formation, Rivière Joncas, Quebec.

Figure 5. *Discosorus* cf. *D. ehlersi* Foerste (Page 25)

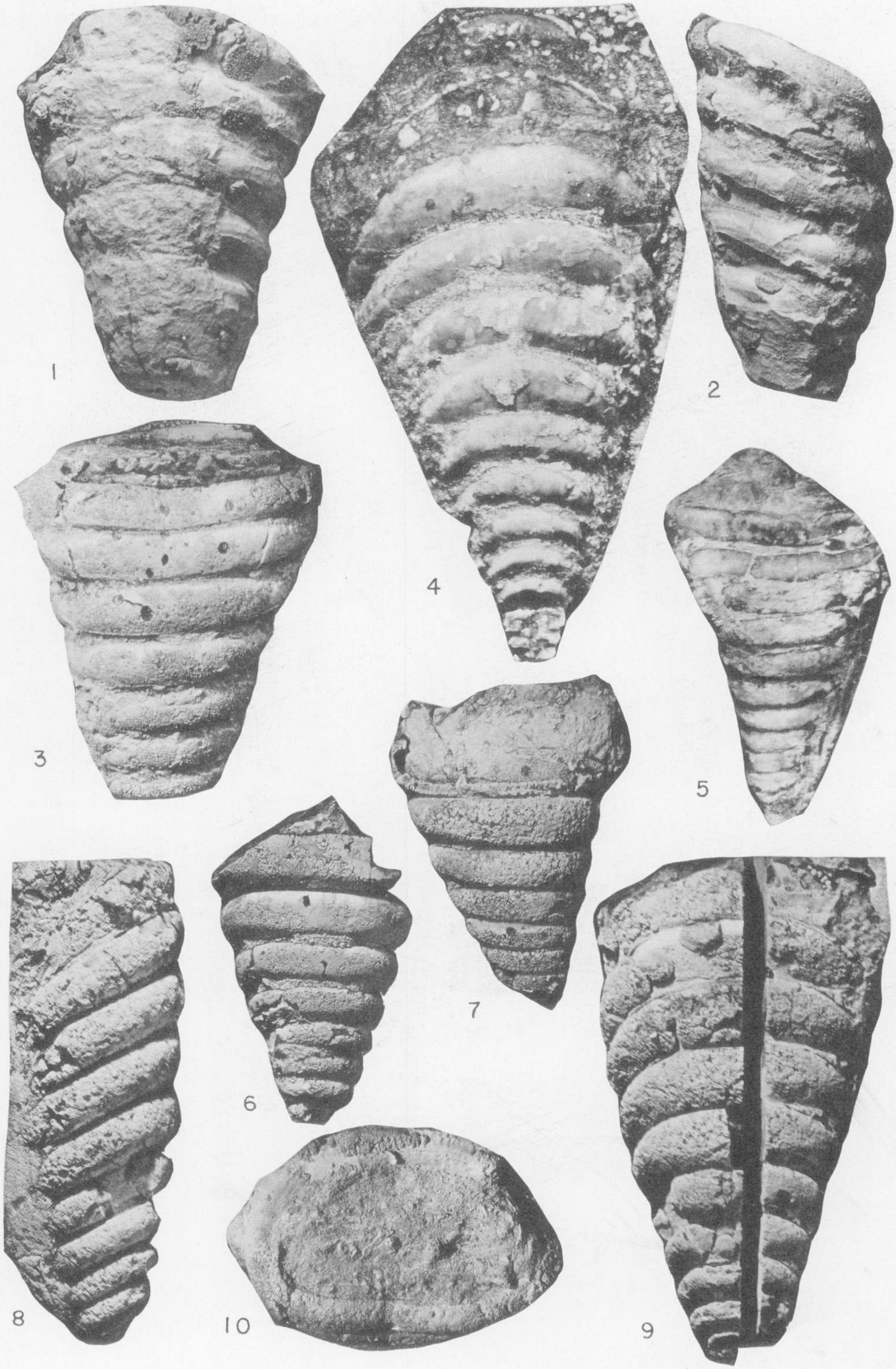
Hypotype, GSC No. 22570, lateral view. Same locality as fig. 1.

Figures 6, 7. *Discosorus transversus* n. sp. (Page 25)

Holotype, GSC No. 22568. 6, ventral view. 7, lateral view, venter on left. Same locality as fig. 1.

Figures 8, 9. *Discosorus megistos* n. sp. (Page 23)

Paratype, GSC No. 22566. 8, lateral view, venter on right. 9, ventral view (*see also* Pl. II, fig. 1; Pl. XXXII, fig. 2). Same locality as fig. 1.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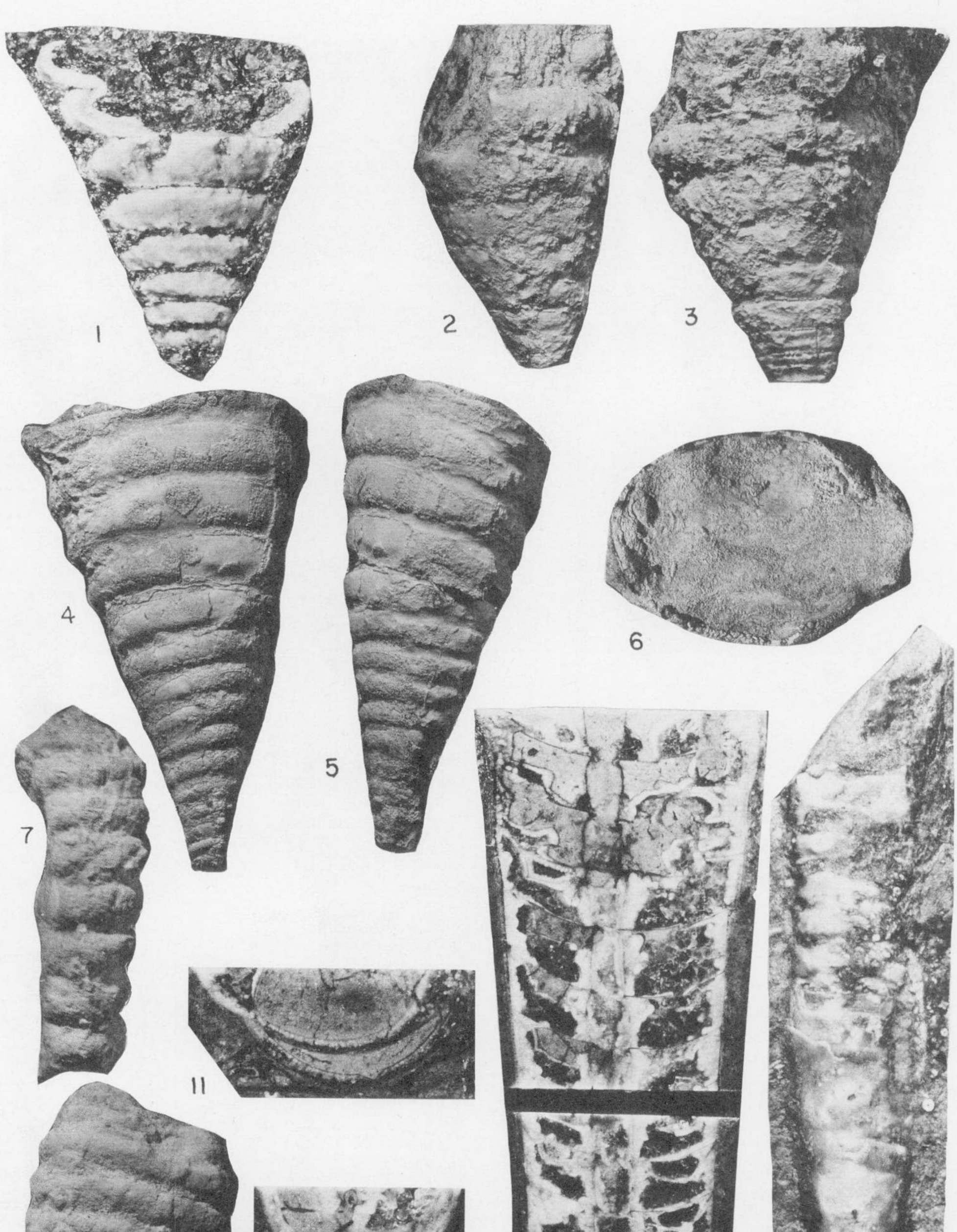
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Plate IV

Figures 1–3. *Discosorus transversus* n. sp. (Page 25)

Paratype, GSC No. 22569. 1, dorsal view, unwhitened. 2, lateral view, dorsum on left. 3, ventral view. Unit E, Severn River Formation, Rivière Malouin, Quebec.

Figures 4–6. *Discosorus durdeni* n. sp. (Page 26)

Holotype, GSC No. 22571. 6, ventral view. 7, lateral view, venter at left. 8, adoral view, venter below. Float, probably from Severn River Formation, Rivière Joncas, Quebec.

Figures 7, 8. *Tuyloceras* sp. (Page 21)

Fig. specimen, GSC No. 22564. Lateral view, a series of adoral siphuncle segments, venter on left, somewhat flattened. Unit S, Ekwan River Formation, Rivière Joncas, 3 miles above the mouth, Quebec.

Figures 9–13. *Euorthoceras ?* sp. (Page 38)

Figured specimen, GSC No. 22583. 9, partly exposed surface of the entire specimen, xl. 10, two apical parts, section horizontal, normal to the surface shown in fig. 9, x2. 11, cross-section at anterior end of fig. 10. 12, cross-section at break in middle of fig. 10. 13, cross-section at apical end of fig. 10. The adoral part of fig. 9 was sectioned vertically; most structures were lost and the section is not figured. Unit S, Ekwan River Formation, Harricana River opposite Ile des Sapins, Quebec.

Plate V

Figure 1. *Kionoceras* cf. *K. loxias* (Hall) (Page 36)

Adoral portion of a specimen (GSC No. 22581). Unit M, Severn River Formation, Rivière Malouin, Quebec. An apical part, a considerably shattered portion of a phragmocone, is not illustrated.

Figures 2, 3. *Kionoceras* sp. (Page 37)

Figured specimen, GSC No. 22582. An internal mould of a somewhat flattened living chamber, with one side deeply weathered. 2, shows the most complete surface; 3, is at right angles to 2. Unit E, Severn River Formation, Rivière Joncas, Quebec.

Figures 4, 5. *"Lambeoceras"* sp. 2. (Page 34)

A portion of a phragmocone (GSC No. 22580). 4, viewed from the exposed flattened side. 5, cross-section, taken at break near anterior end of fig. 4. Ekwan River Formation, Harricana River opposite Ile des Sapins, Quebec.

Figures 6, 7. *"Lambeoceras"* sp. 1. (Page 34)

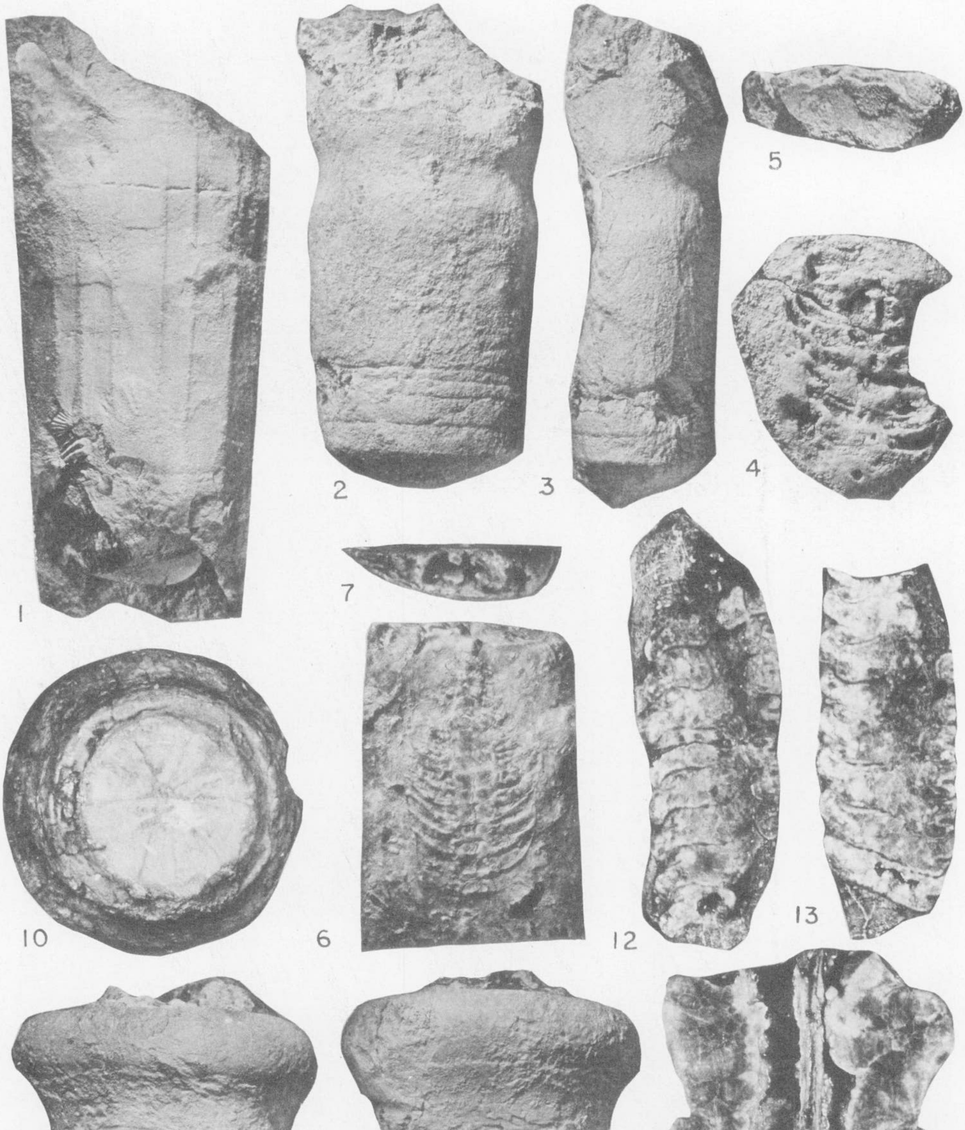
Figured specimen, GSC No. 22579. 6, exposed weathered surface of a phragmocone. 7, cross-section taken near midlength of the specimen. Ekwan River Formation, Harricana River just south of the mouth of the Ruisseau des Fossiles, Quebec.

Figures 8–11. *Huronia horizontalis* n. sp. (Page 32)

Holotype, GSC No. 22577. 8, lateral view, apparent venter at right. 9, ventral view. 10, apical view, the broken surface ground slightly to show canal system. 11, vertical section; the siphuncle is calcite-filled, with some calcite near the central canal dissolved. Ekwan River Formation, Harricana River opposite Ile des Sapins, Quebec.

Figures 12, 13. *Megadiscosorus* sp. (Page 33)

Figured specimen, GSC No. 22578. Two sides of a vertical section through a somewhat weathered portion of a siphuncle. Unit G, Severn River Formation, Rivière Malouin, Quebec.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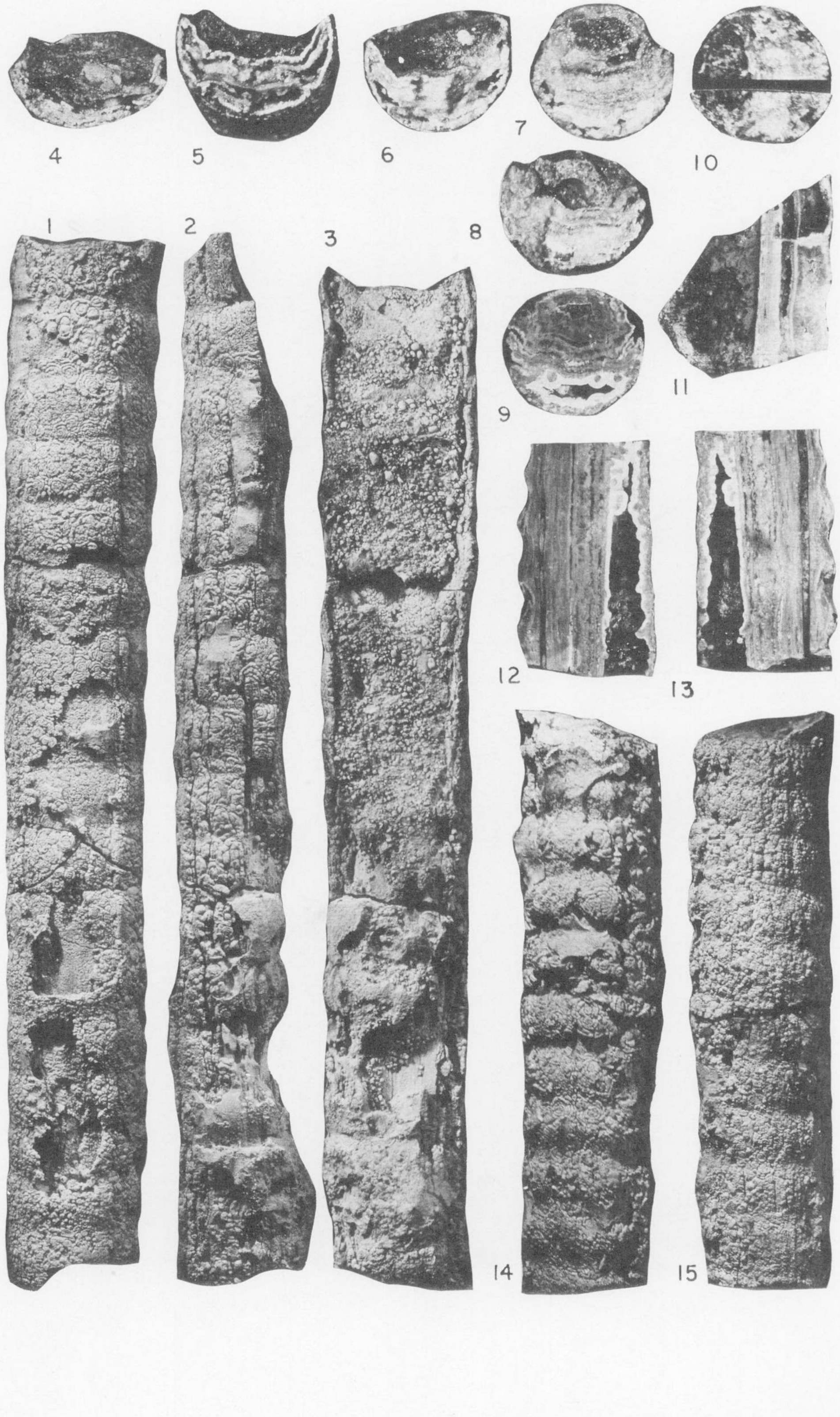
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Plate VI

Donacoceras timiskamingense Foerste (Page 77)

Figures 1–9, 12–15. Hypotype, GSC No. 22595. A long portion of a siphuncle, figured in several parts. Figs. 1–3 are three views of the adoral part. 1, ventral. 2, lateral, venter on left. 3, dorsal. 14 is ventral and 15 lateral view, venter on left, of an imperfectly fitting apical portion. Cross-sections are shown: fig. 4, at anterior end of figs. 1–3; 5, at break 5–6 segments from the anterior end; 6, opposite side of same break; 7, section farther apicad, showing closure of endocones on the dorsum. 8, section at apical end of figs. 1–3. 9, break at anterior end of figs. 14, 15. 12, 13 opposite sides of section taken through the anterior portion of figs. 14, 15, showing small tube, at left of fig. 12, at right of fig. 13, with a large cavity representing solution of part of the siphonal deposits, and of no organic significance.

Figures 10, 11. A short portion of a siphuncle (GSC No. 22594). 10, adoral view, showing section, with venter to the right. 11, vertical section, venter to the right. Both specimens are from the Ekwan River Formation, Rapides des Papillons, Harricana River, Quebec.

Plate VII

Figures 1–6. *Donacoceras arundineum* Foerste (Page 79)

Hypotype, GSC No. 22596. 1, lateral, venter on right. 2, ventral. 3, 4, opposing surfaces of a longitudinal section, the tube marking the dorsal side. 5, 6, anterior and apical cross-sections, dorsum on left. Ekwan River Formation, Rapides des Papillons, Harricana River, Quebec.

Figures 7–9. *Donacoceras timiskamingense* Foerste (Page 77)

Hypotype, GSC No. 18748. Three views of a portion of a siphuncle in which the dorsal endosiphocone is hollow, and exposed adorally and in part dorsally. 7, adoral view, dorsum on left. 8, oblique adoral and dorsal views looking into the cavity which shows longitudinal striation. 9, dorsal view. Thornloe limestone, Lake Timiskaming region.

Figures 10–12. *Narthecoceras subannulatum* n. sp. (Page 69)

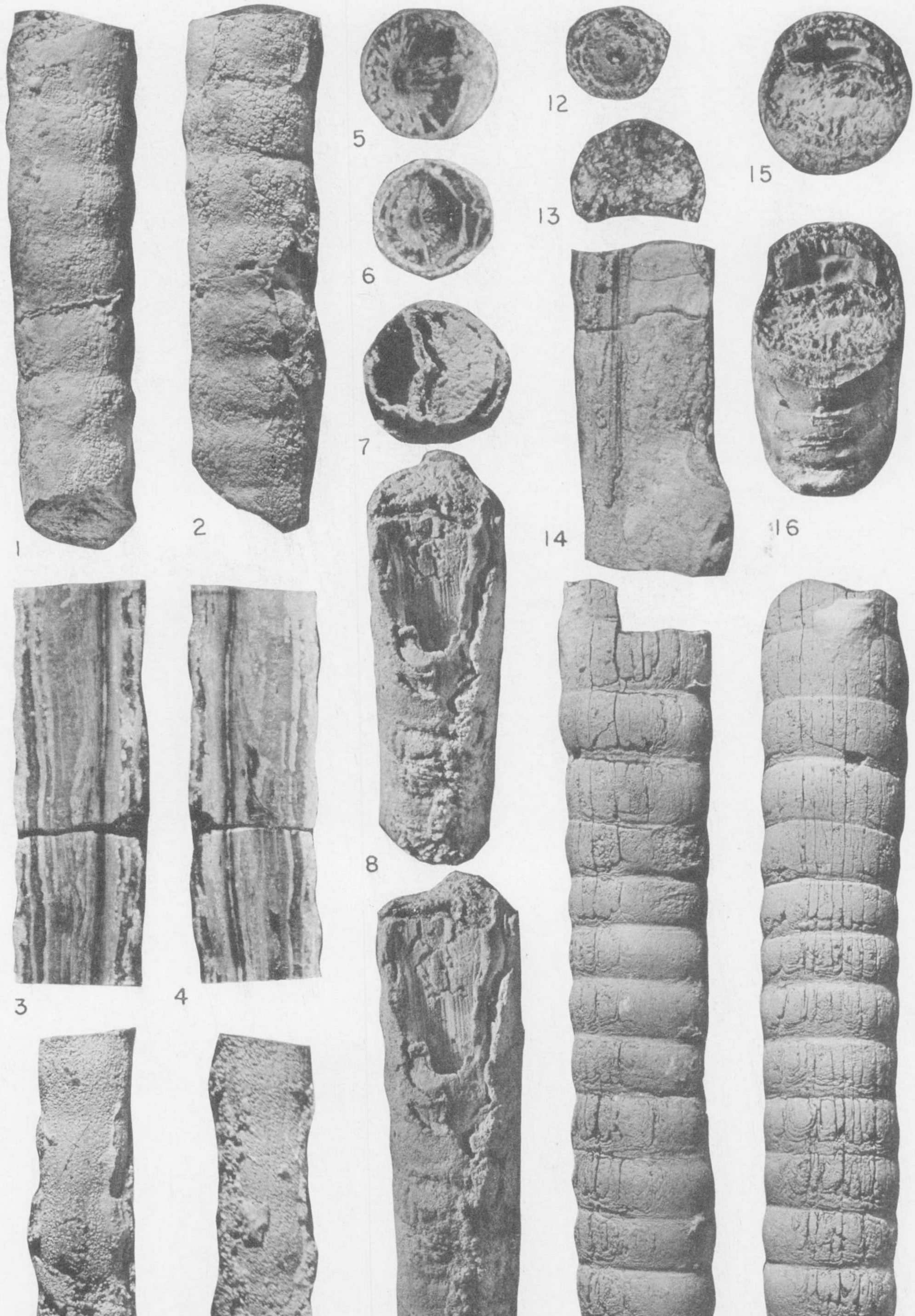
Paratype, GSC No. 22586. A small portion of a siphuncle showing faint annular expansions and longitudinal furrows from etching. 10, lateral view. 11, ventral view. 12, adoral view. Same locality as fig. 1 (*see also* Pl. XXXII, fig. 1).

Figures 13, 14. *Donacoceras timiskamingense* Foerste (Page 77)

Hypotype, GSC No. 18752. A portion of a siphuncle split longitudinally, retaining the tube, the wall of which is slightly silicified. 13, adoral view, dorsum on left. 14, longitudinal view of the broken or weathered surface. Lake Timiskaming region.

Figures 15–18. *Donacoceras timiskamingense* Foerste (Page 77)

Holotype, GSC No. 8043. 17, siphuncle, dorsum on left. 18, dorsal view. 15, adoral view, dorsum with transverse tube above. 16, oblique adoral view. Thornloe limestone, Lake Timiskaming region.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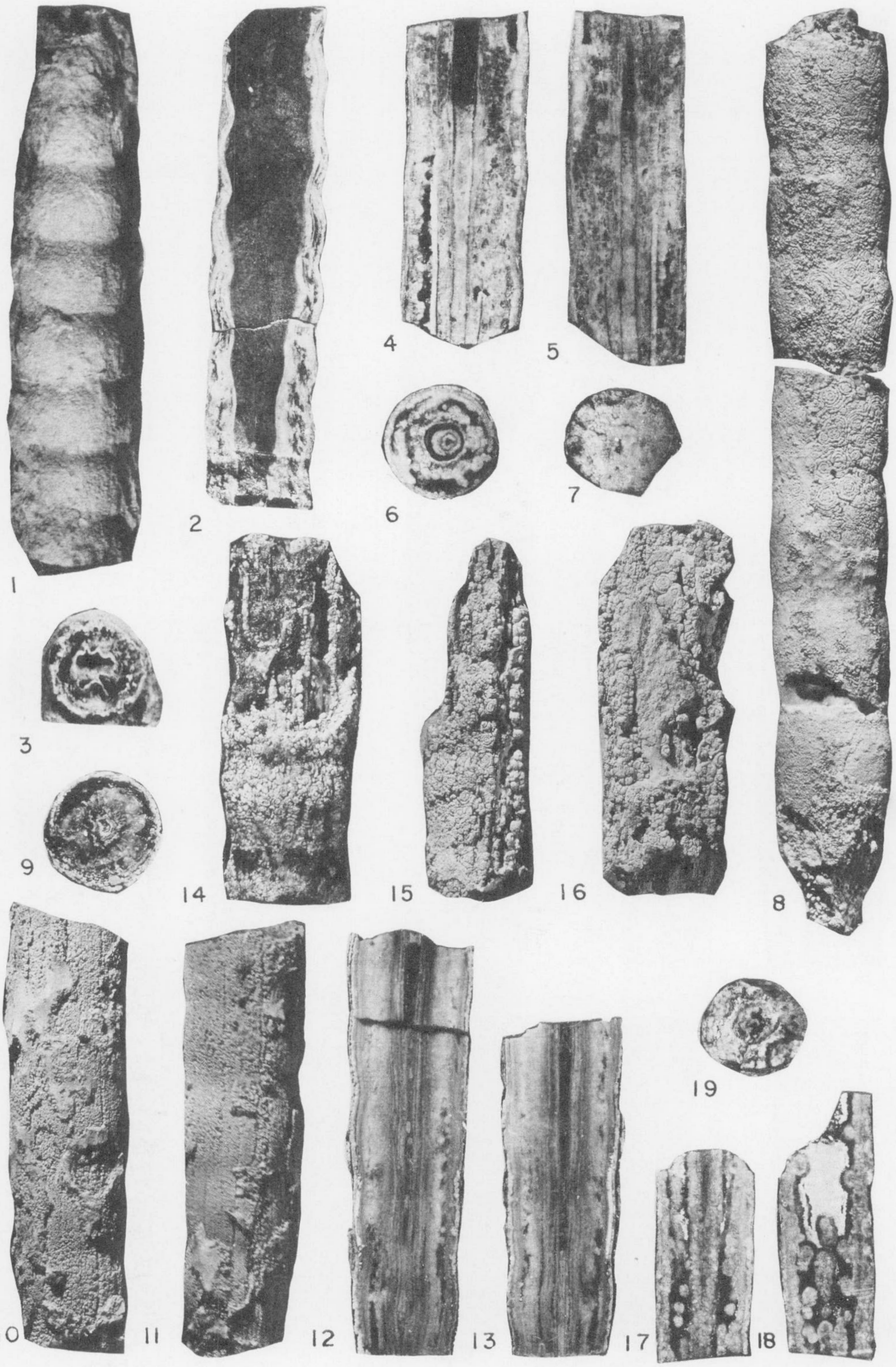
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Plate VIII

Figures 1–3. *Narthecoceras contractum* n. sp. (Page 69)

Holotype, GSC No. 22584. 1, longitudinal view, of only exposed surface. 2, longitudinal section. 3, apical end, showing cross-section of siphuncle and the irregular cavity of the endosiphocone. Unit E, Severn River Formation, Rivière Joncas, Quebec.

Figures 4–8. *Narthecoceras exile* n. sp. (Page 70)

Holotype, GSC No. 22587. 4, 5, opposite sides of a longitudinal section, the lower part of 5 shows obscure diaphragms, from anterior part. 6, section from the adoral part. 7, section near apex. 8, external view of the entire siphuncle. Unit O, Ekwan River Formation, Rapides des Papillons, Harricana River, Quebec.

Figures 9–13. *Narthecoceras subannulatum* n. sp. (Page 69)

Holotype, GSC No. 22585. 10 and 11 are two views, at right angles of the siphuncle exterior; true orientation is uncertain. 9 is an anterior view, 12 and 13 longitudinal sections; 13 opposes the greater part of the length of fig. 12. Same occurrence as fig. 4 (*see also* Pl. XXXII, fig. 1).

Figures 14–16. *Donacoceras arundineum* Foerste (Page 79)

Hypotype, GSC No. 22597. Weathered part of a siphuncle. 14, dorsal. 15, lateral view, dorsum at left. 16, a basal part is not shown. Same locality as fig. 4.

Figures 17–19. *Narthecoceras* cf. *N. exile* n. sp. (Page 70)

Hypotype, GSC No. 22588. A small portion of a siphuncle the interior extensively replaced. 17 and 18 are opposing surfaces of a longitudinal section. 19, adoral, prior to sectioning. Same locality as fig. 4.

PLATE IX

Narthecoceras brevicameratum n. sp. (Page 71)

Figure 1. Thin section, x3, from the apical part of the type (*see* Pl. X).

Figure 2. Exposed surface of phragmocone.

Figure 3. Adoral end.

Figure 4. Apical end.

Figures 5, 6. Opposing surfaces of section of the anterior part of the phragmocone. Holotype, GSC No. 22590. Unit M, Severn River Formation, Rivière Malouin, Quebec.

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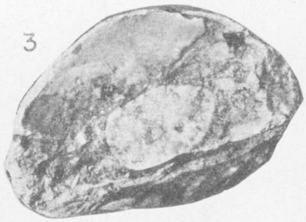

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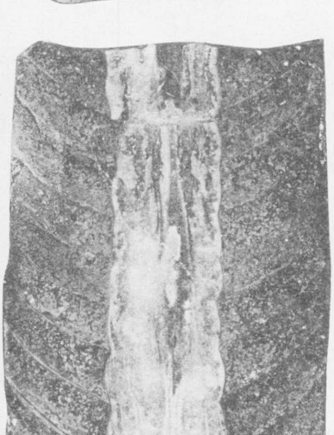

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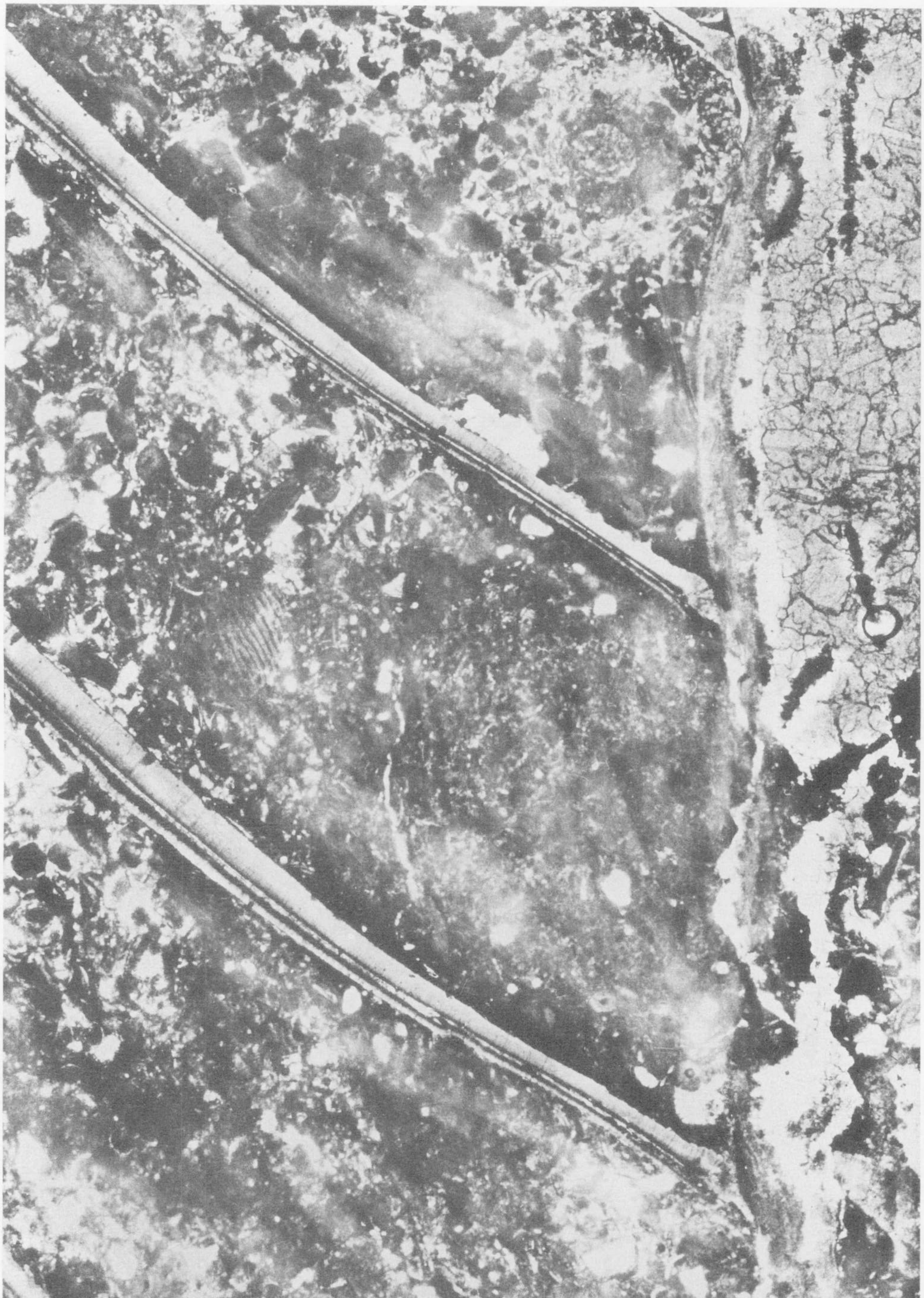


Plate X

Narthecoceras brevicameratum n. sp. (Page 71)

Figure 1. Holotype, GSC No. 22590. Enlargement of part of the thin section shown on Pl. IX, fig. 1, showing more clearly the septa, septal neck, thin homogeneous rings and episeptal and hyposeptal deposits on the free parts of the septa.

PLATE XI

Figures 1–5. *Donacoceras mutabile* n. sp. (Page 80)

Holotype, GSC No. 22598. 1, siphuncle viewed from dorsal side, showing exterior and segments. 2, lateral view, dorsum on left. 3, ventral surface, showing sheath surface. 4, longitudinal section, venter on left. 5, cross-section at anterior end, venter on left. Unit O, Ekwan River Formation, Rapides des Papillons, Harricana River, Quebec.

Figures 6, 7. *Narthecoceras* or *Donacoceras* sp. 2 (Page 72)

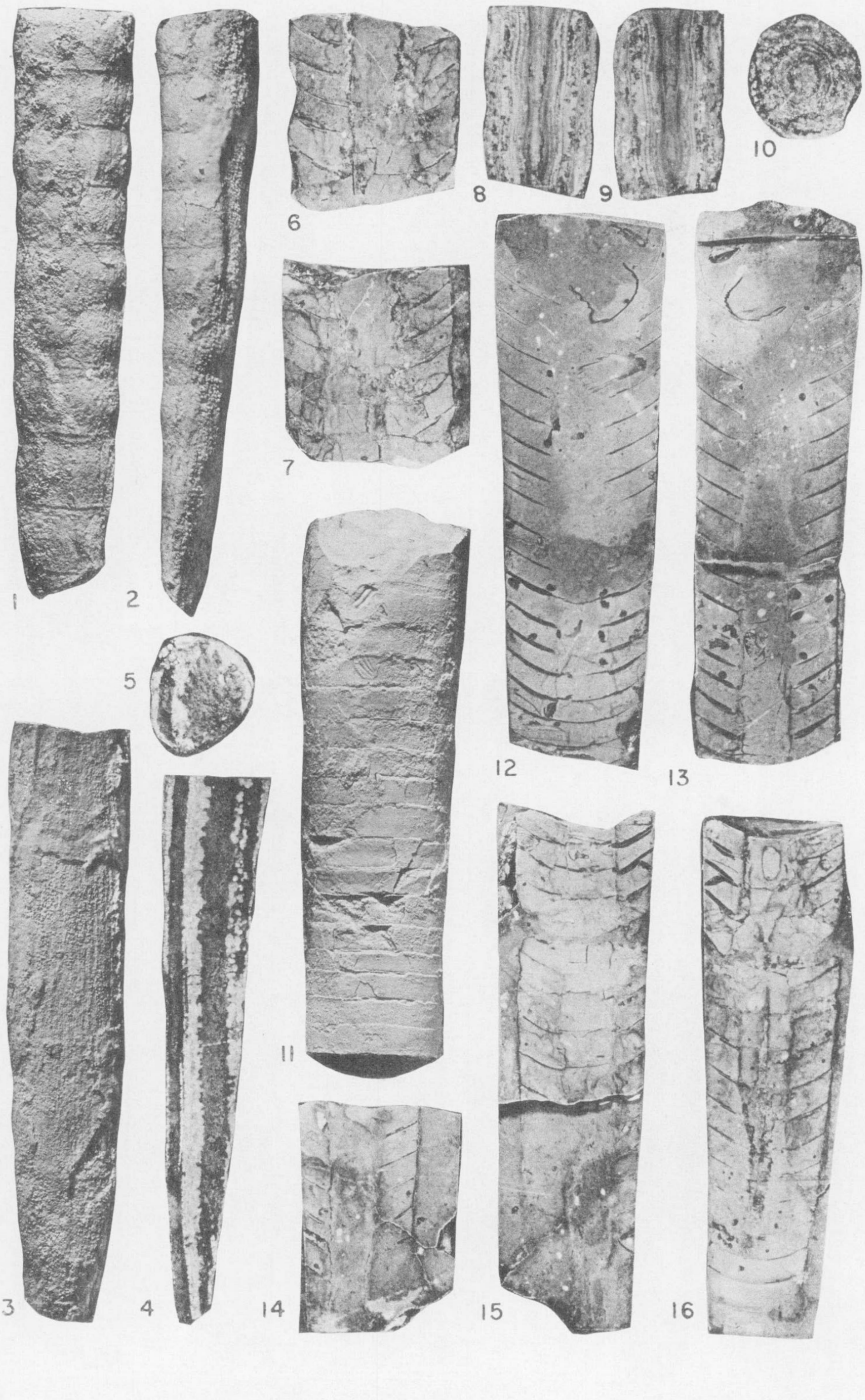
Figured specimen, GSC No. 22592. Opposite surfaces of a section through the greater width of a crushed phragmocone. Severn River Formation, Rivière Malouin, Quebec.

Figures 8–10. *Narthecoceras* cf. *N. exile* n. sp. (Page 70)

Hypotype, GSC No. 22589. 8, 9, opposite sides of a longitudinal section. 10, adoral cross-section. Same locality as fig. 1.

Figures 11–16. *Narthecoreras or Donacoceras* sp. 2 (Page 72)

Figured specimen, GSC No. 22591. The specimen is a flattened phragmocone of considerable length. The anterior part, shown in fig. 11 is sectioned, producing the surfaces shown in figs. 12 and 13. 14, the opposing surface of the lower part of fig. 15, and its counterpart, 16, are from a more apical part enclosed in matrix. Same locality as fig. 6.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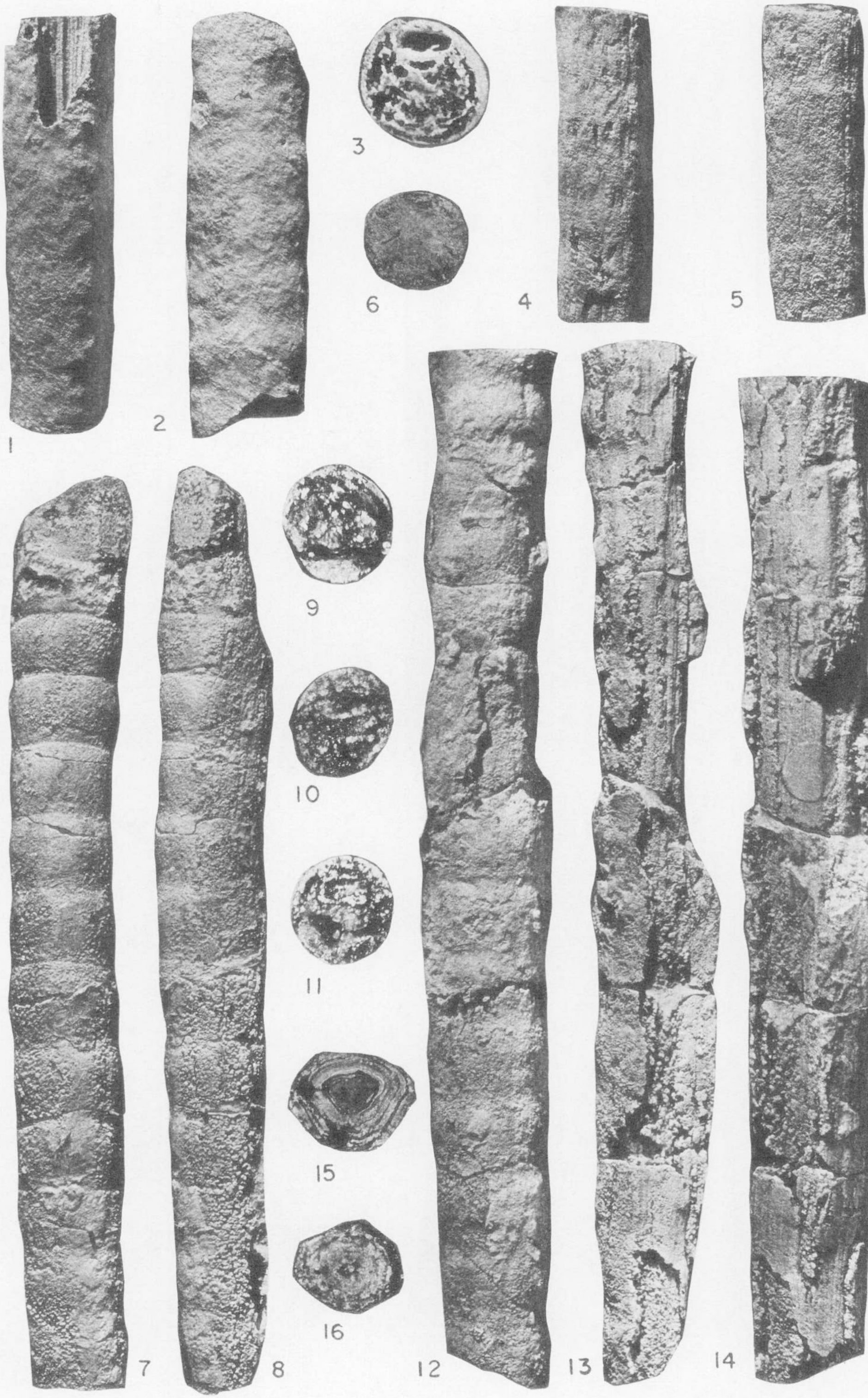
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Plate XII

Figures 1–3. *Donacoceras leve* n. sp. (Page 81)

Holotype, GSC No. 18746. 1, dorsal view, showing the endosiphocone exposed anteriorly. 2, lateral view, dorsum on left. 3, adoral view, dorsum with endosiphocone above. Thornloe limestone, Hume's locality E, Lake Timiskaming region.

Figures 4–6. *Donacoceras leve* n. sp. (Page 81)

Paratype, GSC No. 18747, a portion of endosiphuncle with only the tube, which is nearly marginal. 4, dorsum, with part of tube exposed apically. 5, lateral, dorsum on left. 6, apical, showing dorsum and tube above. Thornloe limestone, Hume's locality E, Lake Timiskaming region.

Figures 7–11. *Donacoceras arundineum* Foerste (Page 79)

Holotype, GSC No. 8044. 7, dorsal view. 8, lateral view, dorsum on left. 9, adoral view, with endosiphocone a half circle, above. 10, break near adoral end, tube obscure. 11, apical end, with a sheath silicified and accentuated by weathering. Thornloe limestone, 3 miles east of Earlton, Armstrong township, Ontario.

Figures 12–16. *Donacoceras humei* n. sp. (Page 82)

Holotype, GSC No. 18749. 12, dorsal view, showing segmentation, but with the anterior part exfoliated. 13, lateral view, dorsum on left. 14, ventral view, showing a surface deeply weathered and partly exfoliated. 15, anterior, cross-section oriented with dorsum above. 16, section at anterior break, showing a nearly round faintly transverse tube. Thornloe limestone, Hume's locality 88A, Lake Timiskaming region.

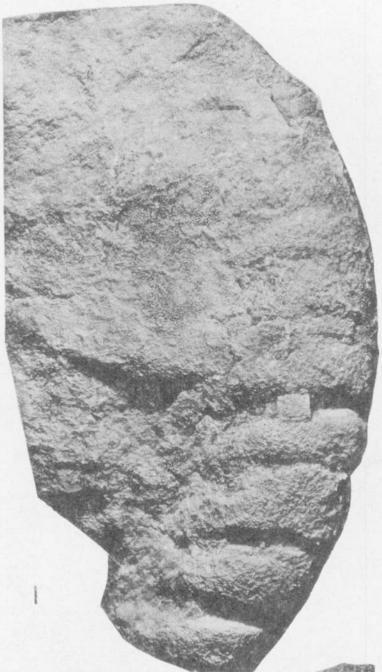
Plate XIII

Figures 1–3, 8. *Tuyloceras humei* n. sp. (Page 22)

Holotype, GSC No. 18750. 1, lateral view, venter on left. 2, ventral view. 3, lateral view, venter on right. 8, same view as fig. 1, but with siphuncle sectioned. Thornloe limestone, Hume's locality E, Lake Timiskaming region.

Figures 4–7. *Donacoceras timiskamingense* Foerste (Page 77)

Hypotype, GSC No. 18748 (*see also* Pl. VII, figs. 7–9). 4, lateral view, venter on right, showing anteriorly weathered edges of numerous ventral sheaths of the half-cones. 5, ventral view. 6, same, lighted from lower right, to bring out edges of weathered sheaths anteriorly. 7, dorsal view showing anterior part missing in fig. 9, Pl. VII. Thornloe limestone, Hume's locality E, Lake Timiskaming region.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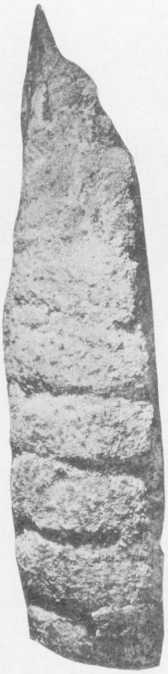
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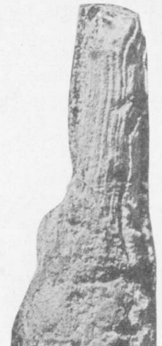
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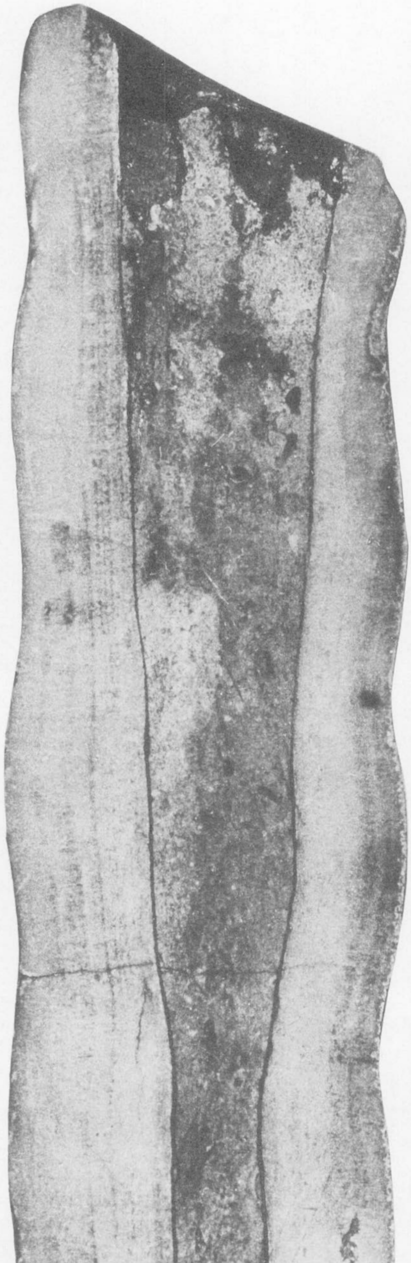

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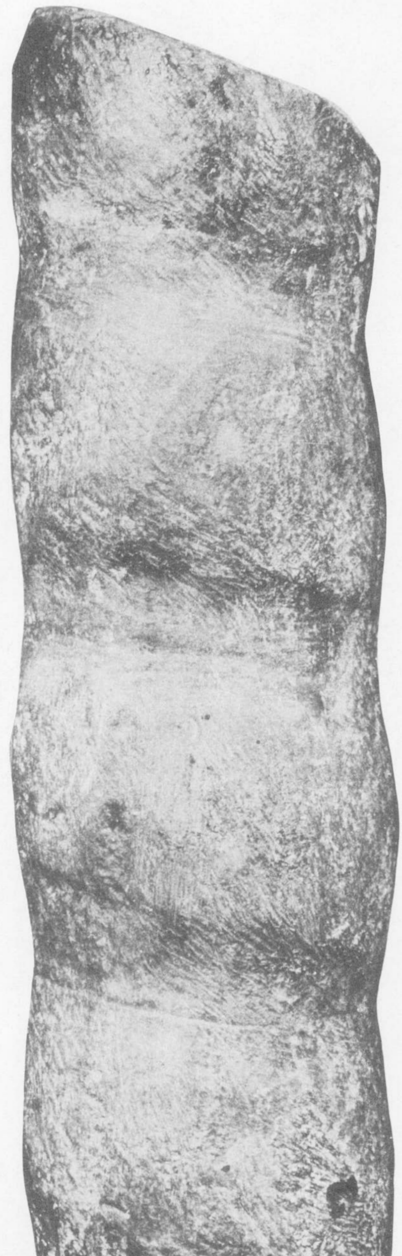

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Plate XIV

Narthecoceras crassisiphonatum (Whiteaves) (Page 49)

An anterior portion of a mature endosiphuncle.

Figure 1. Vertical section, x1.

Figure 2. Exterior.

Lectotype, GSC No. 1866, Selkirk facies, Dog Head Member, Red River Formation, East Selkirk, Manitoba (*see also* Pl. XV, figs. 1, 3, 4).

PLATE XV

Narthecoceras crassisiphonatum (Whiteaves) (Page 49)

Figure 1. Cross-section from base of anterior part of Pl. XVI, fig. 1, showing relationship of section shown in figs. 2 and 3 to the endosiphotube. GSC No. 1867, Selkirk facies, Dog Head Member, Red River Formation, Lower Fort Garry, Manitoba.

Figure 3. Base of lectotype, showing polygonal section near base of endosiphocone and position of longitudinal sections shown in Pl. XIV, fig. 1, and Pl. XV, fig. 4.

Figure 4. Longitudinal section, opposite of Pl. XIV, fig. 1, of lectotype. Reduced x½.

Narthecoceras perplexum n. sp. (Page 61)

Holotype, GSC No. 1870, Selkirk facies, Dog Head Member, Red River Formation, Lower Fort Garry or East Selkirk, Red River valley, Manitoba.

Figure 2. Anterior end of fig. 5.

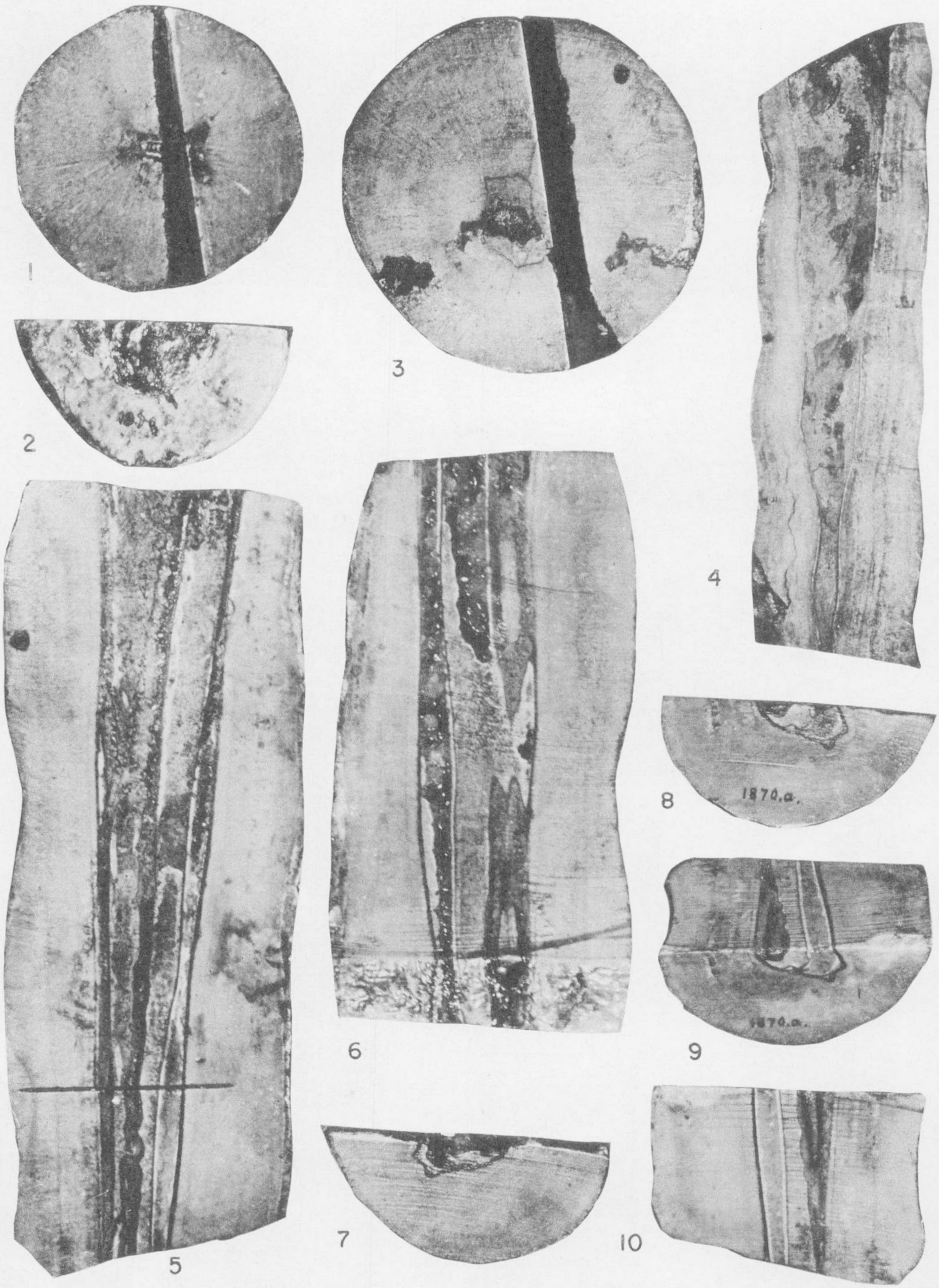
Figure 5. Longitudinal section, showing sheaths of half-cones in the endosiphocone.

Figure 6. Longitudinal eccentric section, opposing the anterior part of fig. 5.

Figure 7. Cross-section, base of fig. 6.

Figures 8, 9. Anterior end of next apical piece, and same tilted.

Figure 10. Longitudinal section, surface at top of fig. 9 (*see also* Pl. XVIII, fig. 5).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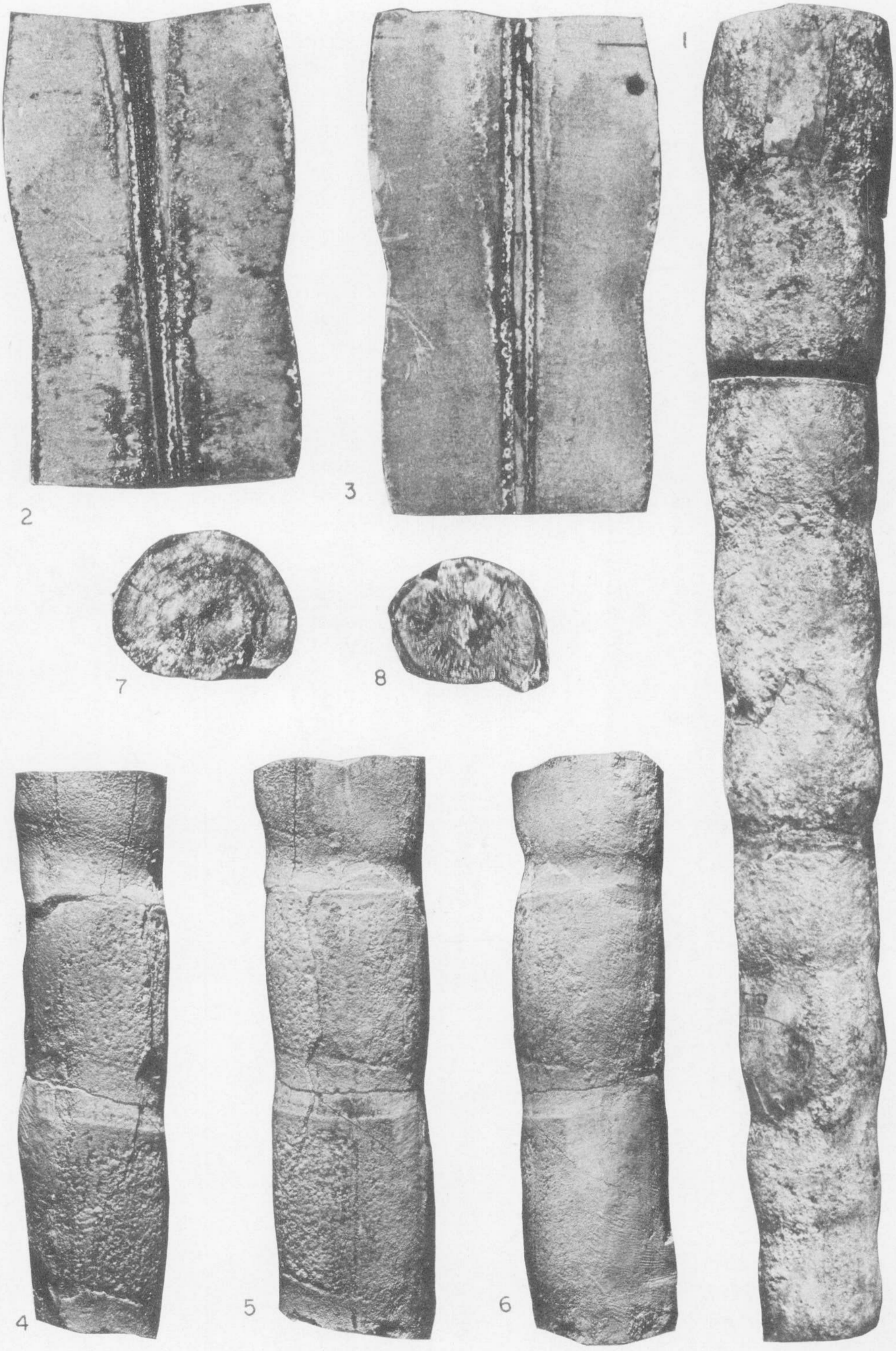

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PLATE XVI

Narthecoceras crassisiphonatum (Whiteaves) (Page 49)

Hypotype, GSC No. 1867, a portion of siphuncle. Selkirk facies, Dog Head Member, Red River Formation, Red River valley, Manitoba.

Figure 1. Entire siphuncle, reduced, x⅔.

Figures 2, 3. Opposing surfaces x1 of a vertical longitudinal section of the anterior part. Fig. 2 is nearly tangential to the tube, whereas fig. 3 cuts it more centrally, showing matrix of light calcite and two diaphragms. The section is normal to the greater diameter of the tube, and is shown in Pl. XV, fig. 1; fig. 3 is the surface on the left side of Pl. XV, fig. 1; fig. 2 is the surface of the piece on the right.

Narthecoceras sinclairi n. sp. (Page 53)

Relatively early portion of siphuncle showing external segmentation.

Figure 4. Oblique—venter at left.

Figure 5. Dorsum.

Figure 6. Lateral–dorsum at right.

Figures 7, 8. Anterior and apical ends.
The unfigured ventral side is weathered. Paratype, GSC No. 6824, Dog Head Member, Red River Formation, Gull Harbour, Lake Winnipeg, Manitoba. Original of *N. simpsoni*, Foerste, 1929.

Plate XVII

Narthecoceras crassisiphonatum (Whiteaves) (Page 49)

Hypotype, GSC No. 18721, a portion of siphuncle of intermediate size, Selkirk facies, Dog Head Member, Red River Formation, Garson quarries, Manitoba.

Figure 1. Exterior of siphuncle, lateral view, venter on right.

Figures 2, 3. Vertical longitudinal sections x1 of adoral and apical parts.

Figure 4. Enlargement of middle portion of tube of fig. 3, showing irregular carbonaceous bracket diaphragm interrupting longitudinal fibres in the tube (*see* Pl. XVIII, fig. 4, for enlargement).

Figure 5. Adoral view before sectioning.

Narthecoceras lene n. sp. (Page 52)

Figure 6. Vertical longitudinal section of holotype, GSC No. 18744, venter on left, x1. Dog Head Member, Red River Formation, Little Tamarack Island, Lake Winnipeg, Manitoba (*see also* Pl. XVIII).


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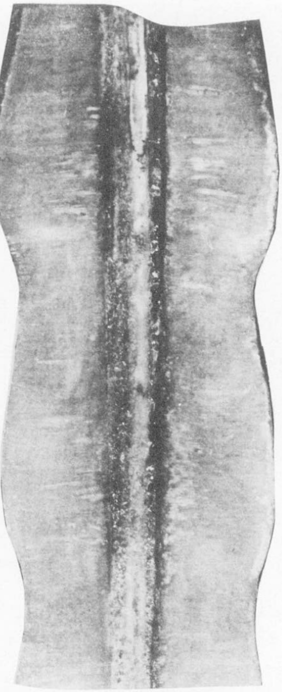
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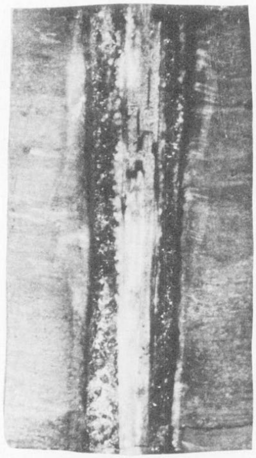
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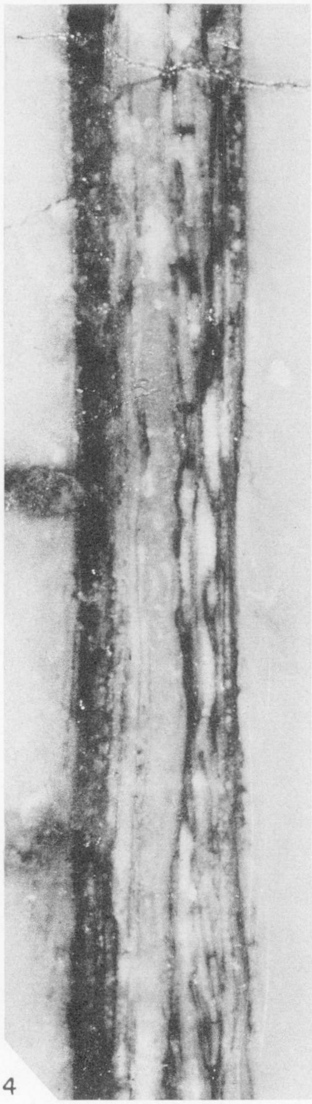

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Plate XVIII

Narthecoceras lene n. sp. (Page 52)

Holotype, GSC No. 18744, Dog Head Member, Red River Formation, Little Tamarack Island, Lake Winnipeg, Manitoba (*see also* Pl. XVII, fig. 6).

Figure 1. Enlargement of endosiphotube from anterior end of Pl. XVII, fig. 6, x3 showing bracket-diaphragm.

Figure 2. Enlargement of next apical bracket-diaphragm. From the same section, x3.

Figure 3. Enlargement of bracket-diaphragm from the apical third of the same section, showing more elaborate structure, x3.

Figure 6. Exterior of the holotype, venter at right, x1.

Narthecoceras sinclairi n. sp. (Page 53)

Figure 4. Enlargement about x20 of tube showing extreme development of forward projecting anastomosing linear elements and transverse irregular elements of bracket-diaphragms. Same section as Pl. XX, fig. 4.

Narthecoceras perplexum n. sp. (Page 61)

Figure 5. Exterior of siphuncle of holotype, GSC No. 1870, showing characteristic form and proportion of segments. Selkirk facies, Dog Head Member, Red River Formation, Lower Fort Garry or Selkirk, Red River valley, Manitoba (*see also* Pl. XV, figs. 2, 5–10, and Pl. XXXI, fig. 9).

Plate XIX

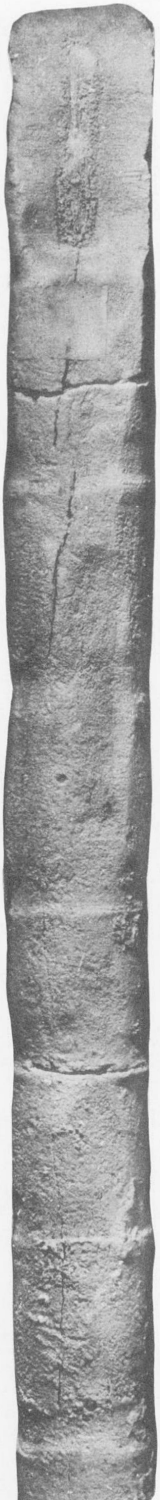
Narthecoceras calamitiforme n. sp. (Page 58)

Paratype, GSC No. 18717, apparently from the Dog Head Member of the Red River Formation, from old collections from the Ordovician of Lake Winnipeg, precise locality data lost.

Figures 1–3. Exterior of the entire siphuncle. 1, venter. 2, lateral view, venter at left. 3, dorsum. x1.

Figures 4, 5. Two opposing surfaces from longitudinal horizontal section from the anterior part, x1.

Figures 6, 7. Longitudinal horizontal section from the apical portion, x1. Fig. 7 shows the entire length of one side; the apical part cuts the tube eccentrically; the opposite side of the apical part of the opposite side, which cuts the tube centrally, is shown in fig. 6.



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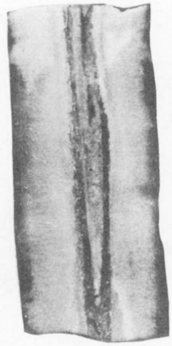

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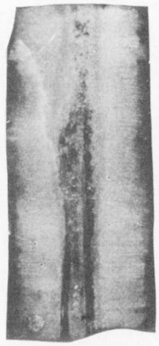

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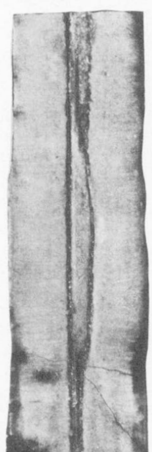

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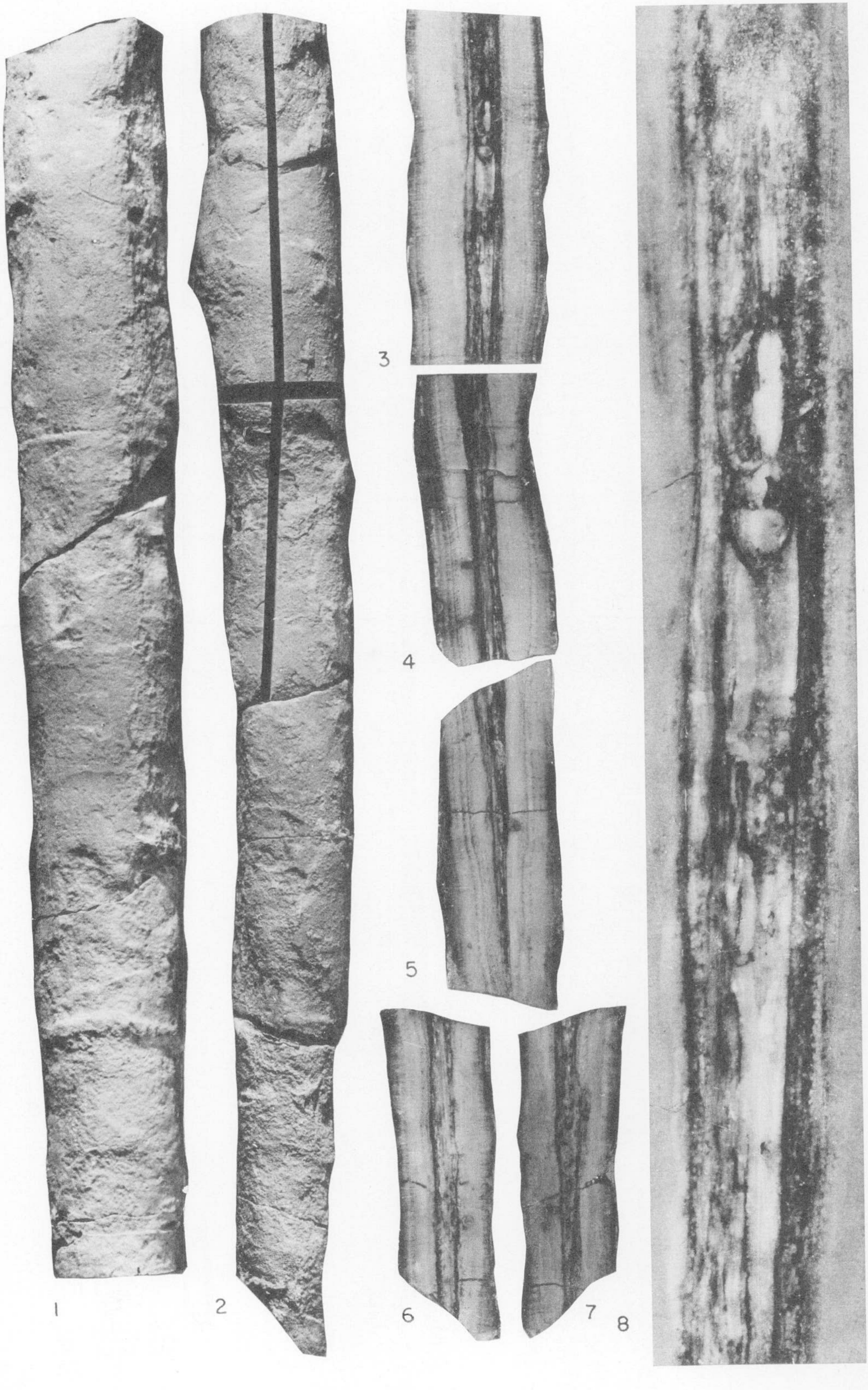

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Plate XX

Narthecoceras sinclairi n. sp. (Page 53)

Paratype, GSC No. 18754, showing the earliest portion of a siphuncle known for the species. Presumed from the Dog Head Member, Red River Formation, from old collections of the GSC, precise data lost.

Figures 1, 2. Exterior, anterior part in fig. 1; apical part in fig. 2; specimen somewhat abraded, but apparently viewed from the dorsal side.

Figures 3, 8. 3, vertical longitudinal section of the anterior piece shown in fig. 2; in fig. 8, the tube is enlarged x3, showing a clear bracket diaphragm anterior to the centre, and forward projecting elements, evidently extensions of other similar structures.

Figure 4. Vertical longitudinal section of the next apical portion.

Figure 5. Horizontal longitudinal section of the next apical portion.

Figures 6, 7. Opposing surfaces of a cut of the apical portion, longitudinal horizontal (*see also* Pl. XXII, figs. 7, 8).

Plate XXI

Narthecoceras calamitiforme n. sp. (Page 58)

Holotype, GSC No. 18716, Dog Head Member, Red River Formation, Black Island, Swampy Harbour, Lake Winnipeg, Manitoba.

Figure 1. Exterior of siphuncle x1, lateral view, venter to right.

Figure 2. Ventral view.

Figure 3. Broken anterior end.

Figure 4. Vertical section—from third to fifth segments from the anterior end.

Figure 5. Cross-section at base of fig. 4.

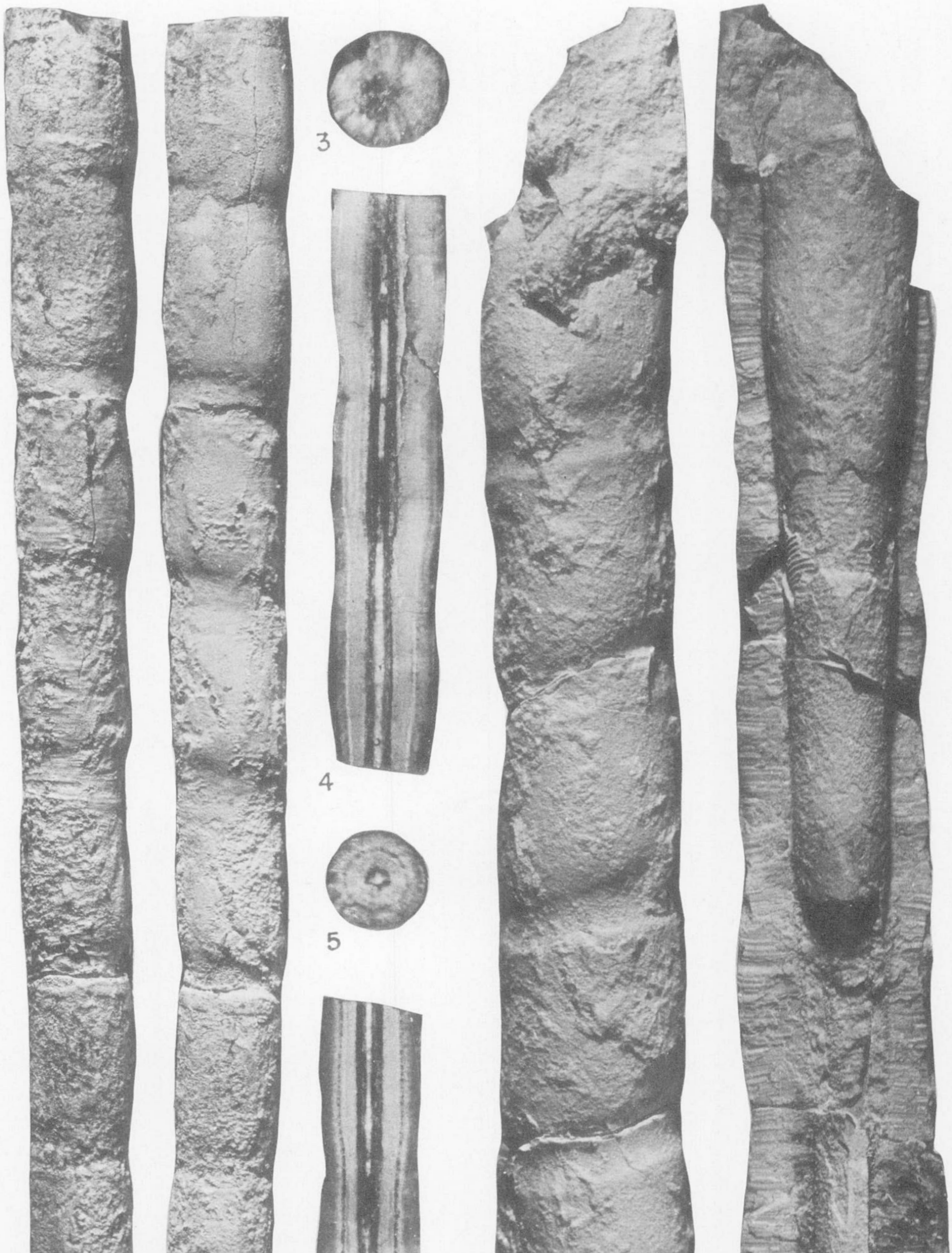
Figure 6. Next apical two segments sectioned longitudinal.

Figure 7. Cross-section at base of fig. 6.

Narthecoceras sinclairi n. sp. (Page 53)

Figure 8. Exterior of siphuncle, lateral view, venter at right.

Figure 9. Opposite side showing endosiphuncle and filling of endosiphocone.
Paratype, GSC No. 18719, Dog Head Member, Red River Formation, Mathewson Island, Lake Winnipeg, Manitoba.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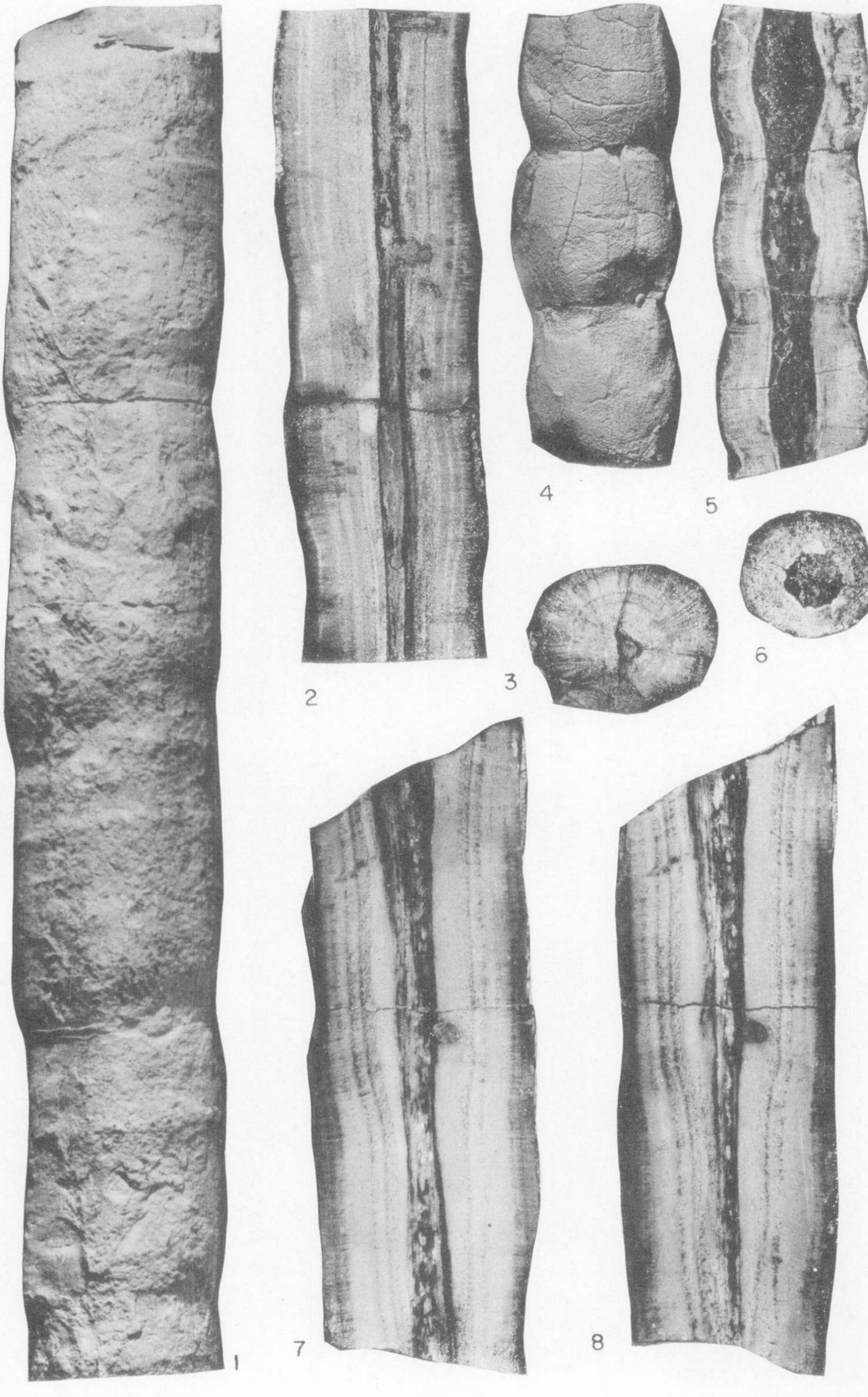
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Plate XXII

Figures 1–3. *Narthecoceras sinclairi* n. sp. (Page 53)

Paratype, GSC No. 18753. A late growth stage of an endosiphuncle; rather roughly preserved externally. 1, lateral view x1, venter on right. 2, vertical section apical part, showing matrix-filled tube with some diaphragms. 3, cross-section at base of specimen showing tube and poorly developed halo; the lower weathered side is lateral. Old collections, Lake Winnipeg region, Manitoba. Red River Formation, evidently Dog Head Member by lithology. Notation on a fragmentary label, Winnipeg, 25-7-90.

Figures 4–6. *Narthecoceras equisetium* n. sp. (Page 63)

Paratype, GSC No. 18745. 4, exterior. 5, vertical section showing part of the endosiphocone. 6, cross-section at apical end. Farr limestone, Liskeard Group, Lake Timiskaming region.

Figures 7, 8. *Narthecoceras sinclairi* n. sp. (Page 53)

Paratype, GSC No. 18754. Enlargement of specimen shown in Pl. XX, fig. 5; in fig. 8 the section is oblique apically; in fig. 7 the apical end is ground further and the section is nearly central. x1 (*see* Pl. XX for remainder of this specimen).

Plate XXIII

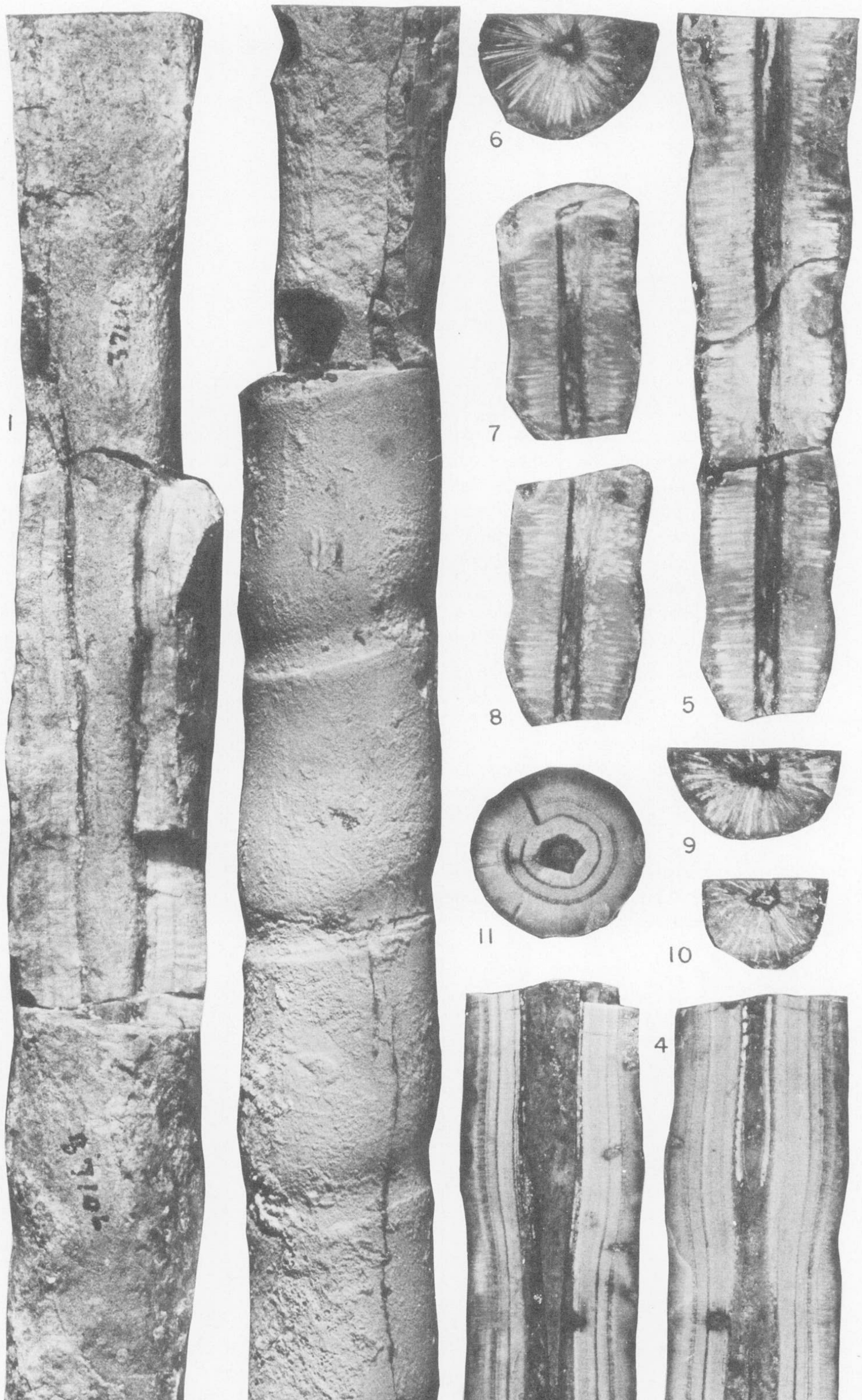
Figures 1–4, 11. *Narthecoceras sinclairi* n. sp. (Page 53)

A long anterior part of a siphuncle. Paratype, GSC No. 18720. An anterior portion of 130 mm, showing the anterior end of the endosiphocone, is not included. 1, weathered side showing much of the endosiphocone. 2, opposite side, lateral, venter at right, showing exterior of siphuncle segments. 3, 4, opposite sides of a vertical section of the apical parts showing endosiphocone narrowing, surrounded by dark material of the halo. Neither side shows the full width of the tube, which is visible in fig. 11 but not in fig. 3, which is too eccentric basally. 11, cross-section at base of figs. 3, 4, showing tube and halo. The venter is to the left. Red River Formation, Dog Head Member, Mathewson Island, Lake Winnipeg, Manitoba. Collector G. W. Sinclair, 1957.

Figures 5–10. *Narthecoceras crassisiphonatum* (Whiteaves) (Page 49)

Earliest growth stage of siphuncle so far observed, showing unusually prominent and coarse radial fibres. 5, longitudinal section, the several pieces not all ground to the same level. 6, adoral cross-section before grinding. 7, 8, opposite sides of original cut of the apical part. 9, section at adoral end, and 10, section at apical end of part shown in figs. 7, 8.

Hypotype, collection of the writer, RHF No. 418, Selkirk facies, Dog Head Member, Red River Formation, Tyndall quarries, Manitoba.



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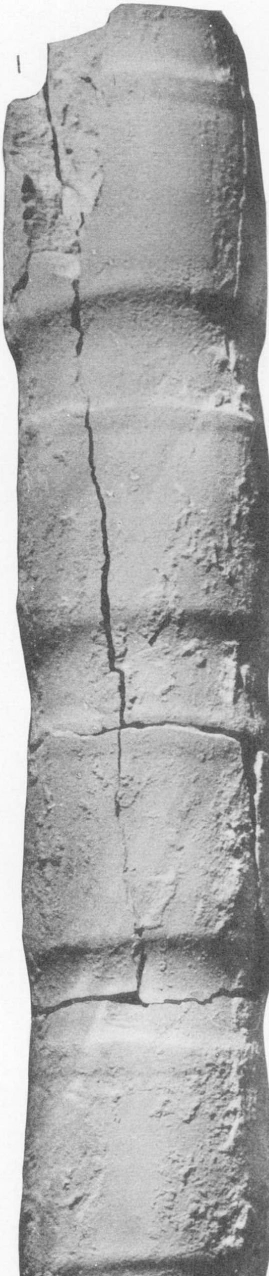

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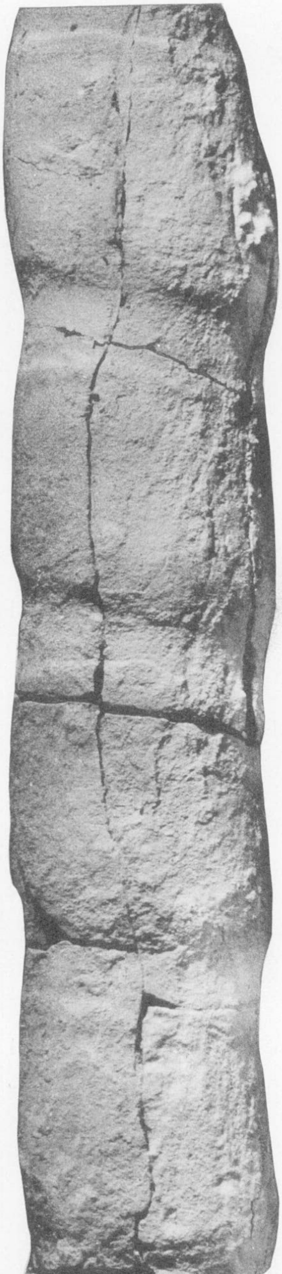

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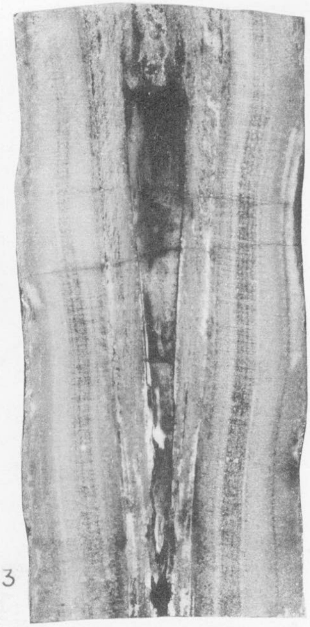

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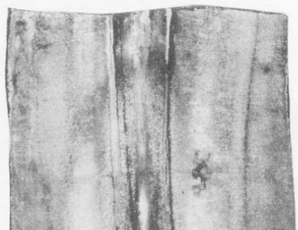

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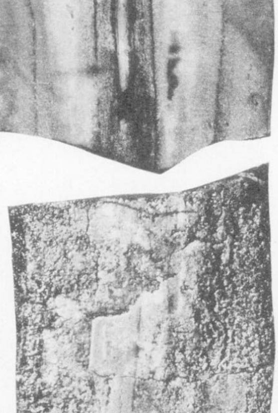


Plate XXIV

Figures 1, 2. *Narthecoceras sinclairi* n. sp. (Page 53)

Paratype, GSC No. 18725. Anterior end of latest growth stage of siphuncle observed, showing characteristic proportions of segments. 1, ventral. 2, lateral venter at left, x1. Dog Head Member, Red River Formation, Little Tamarack Island, Lake Winnipeg, Manitoba.

Figures 3, 4. *Narthecoceras leurosiphonatum* n. sp. (Page 65)

Vertical section of the holotype, GSC No. 18751, in two parts (*see also* Pl. XXV, figs. 1, 2). Member 2, Portage Chute Formation, "near second upper limestone rapids", Nelson River, Manitoba.

Figure 5. *Narthecoceras hesperale* n. sp. (Page 67)

Portion of latest growth stage of siphuncle observed, longitudinal weathered section. Second Value limestone, Montoya Group, above the Scenic Drive, El Paso, Texas, collection of the writer, RHF No. 421.

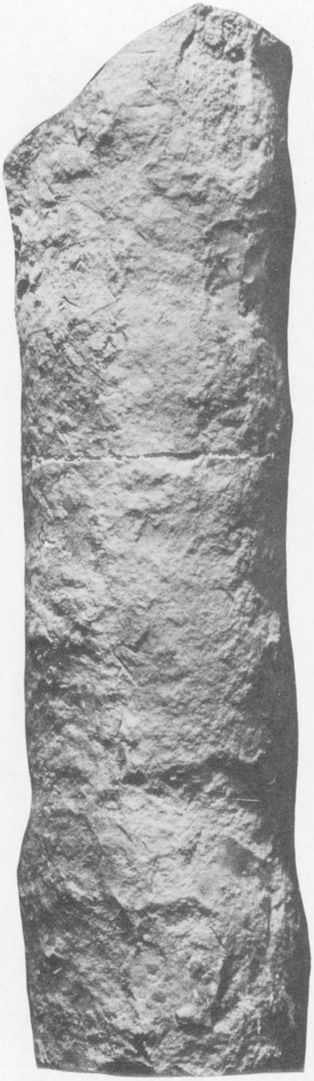
PLATE XXV

Figures 1, 2. *Narthecoceras leurosiphonatum* n. sp. (Page 65)

1, lateral view of exterior of holotype, GSC No. 18751, apical end above. 2, cross-section, natural break at apical end (*see also* Pl. XXIV, figs. 3, 4). Member 2, Portage Chute limestone, "near second upper limestone rapids", Nelson River, Manitoba.

Figures 3–7. *Narthecoceras anomalum* n. sp. (Page 60)

Holotype, GSC No. 18743. 3, ventral view of entire specimen. 4, lateral view, venter to the left. 5, cross-section near break at midlength. 6, vertical section of apical part, x1. 7, basal part of fig. 6 ground to cut the tube more centrally (*see also* Pl. XXVI, figs. 1, 2). Dog Head Member, Red River Formation, Little Tamarack Island, Lake Winnipeg, Manitoba. Collector G. W. Sinclair, 1957.



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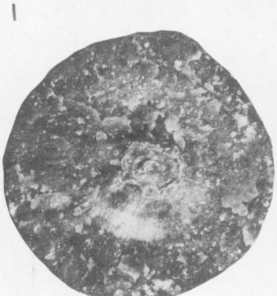

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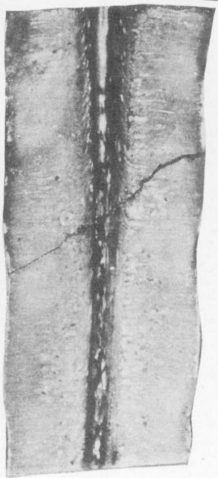

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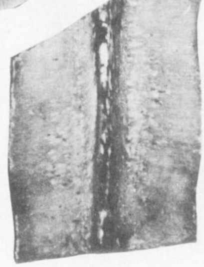

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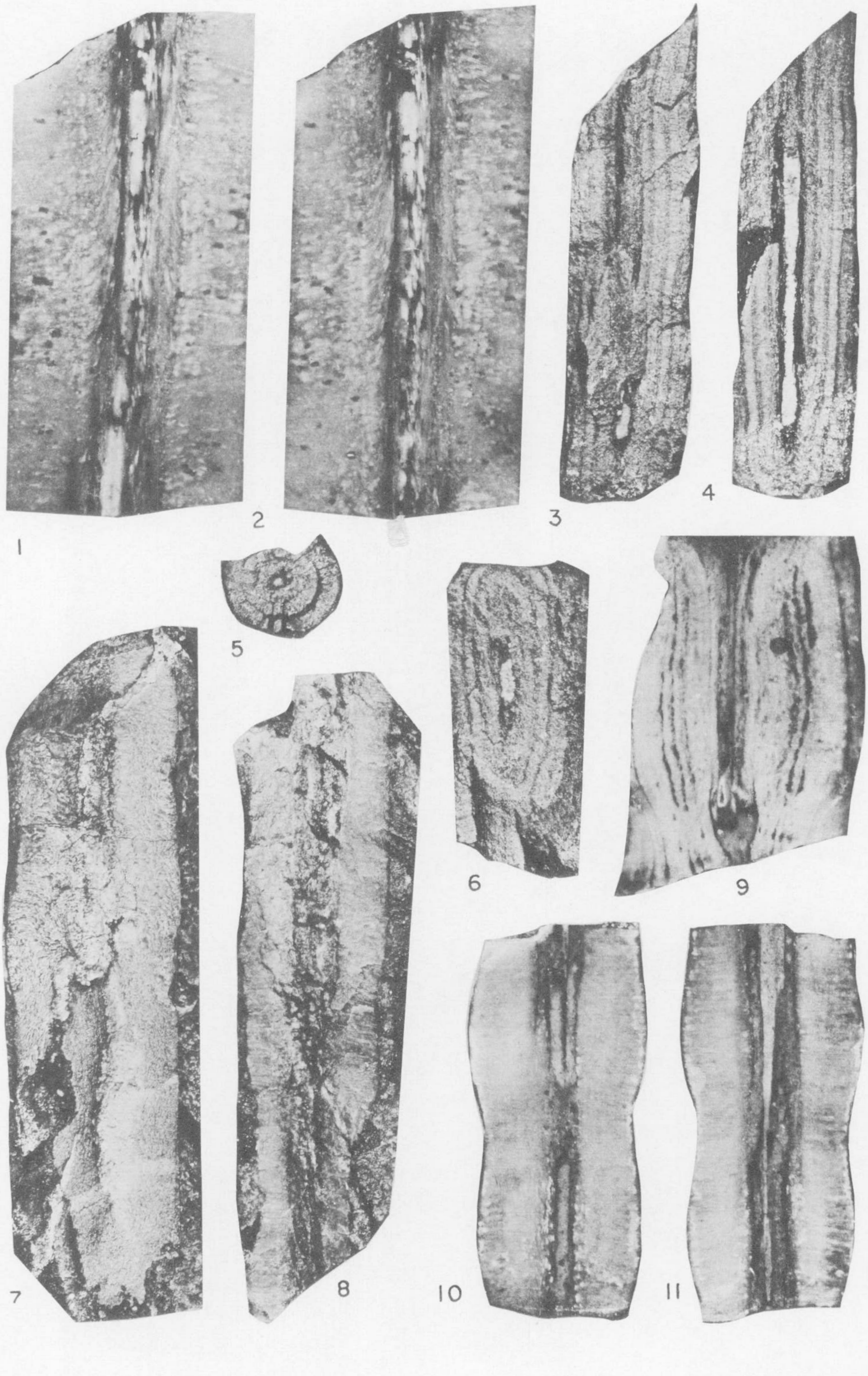
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Plate XXVI

Figures 1, 2. *Narthecoceras anomalum* n. sp. (Page 60)

Holotype, GSC No. 18743. Enlargement of centre of siphuncle to show tube, its filling, and prominent forward production of radial fibres around the tube, forming a broad but poorly limited halo. Figure 1 is ground to a greater depth than figure 2 and cuts the tube more nearly centrally. Both x2; from the apical part of Pl. XXV, figs. 6, 7. Dog Head Member, Red River Formation, Little Tamarack Island, Lake Winnipeg, Manitoba (*see also* Pl. XXV, figs. 3–7).

Figures 3–8. *Narthecoceras hesperale* n. sp. (Page 67)

3, anterior end of holotype siphuncle. 4, same ground down to the tube, filled with white calcite. 5, cross-section from another part of the same specimen. 6, obliquely broken end of another fragment. Holotype, collection of the writer, RHF No. 419. 7, 8, opposing surfaces of another fragment, representing a later growth stage; and showing the endosiphocone. Paratype, collection of the writer, RHF No. 420.

Figure 9. *Narthecoceras oppletum* n. sp. (Page 64)

Enlargement of anterior end of holotype, GSC No. 18715, showing details of forward projecting process of a bracket-diaphragm. Farr limestone, Liskeard Group, Farr quarry, Haileybury, Ontario (*see also* Pl. XXX, figs. 7–11).

Figures 10, 11. *Narthecoceras crassisiphonatum* (Whiteaves) (Page 49)

Hypotype, GSC No. 18722. Opposing surfaces of a section through a fragment of siphuncle intermediate in proportions between Pl. XXIII, figs. 6–10 and other specimens. Dog Head Member, Red River Formation, Little Tamarack Island, Lake Winnipeg, Manitoba.

Plate XXVII

Narthecoceras sinclairi n. sp. (Page 53)

A relatively late growth stage of a siphuncle, largely apicad of the endosiphocone.

Figure 1. Lateral view; slightly reduced.

Figure 2. Ventralateral view of anterior part, x1.

Figure 3. Cross-section at anterior end, showing small polygonal cavity, later to become the halo, filled with matrix.

Figure 4. Vertical section, venter on left, showing organic borings, growth lines, radial fibres and a tube, the thick wall merging with the halo, largely filled by matrix.

Figure 5. Cross-section at apical end showing the dark halo and the small compressed tube.

Holotype, GSC No. 18724. Dog Head Member, Red River Formation, Burton Island, Lake Winnipeg, Manitoba. Collector G. W. Sinclair, 1957.

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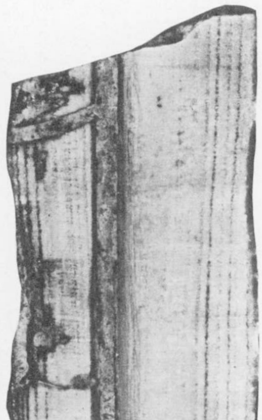

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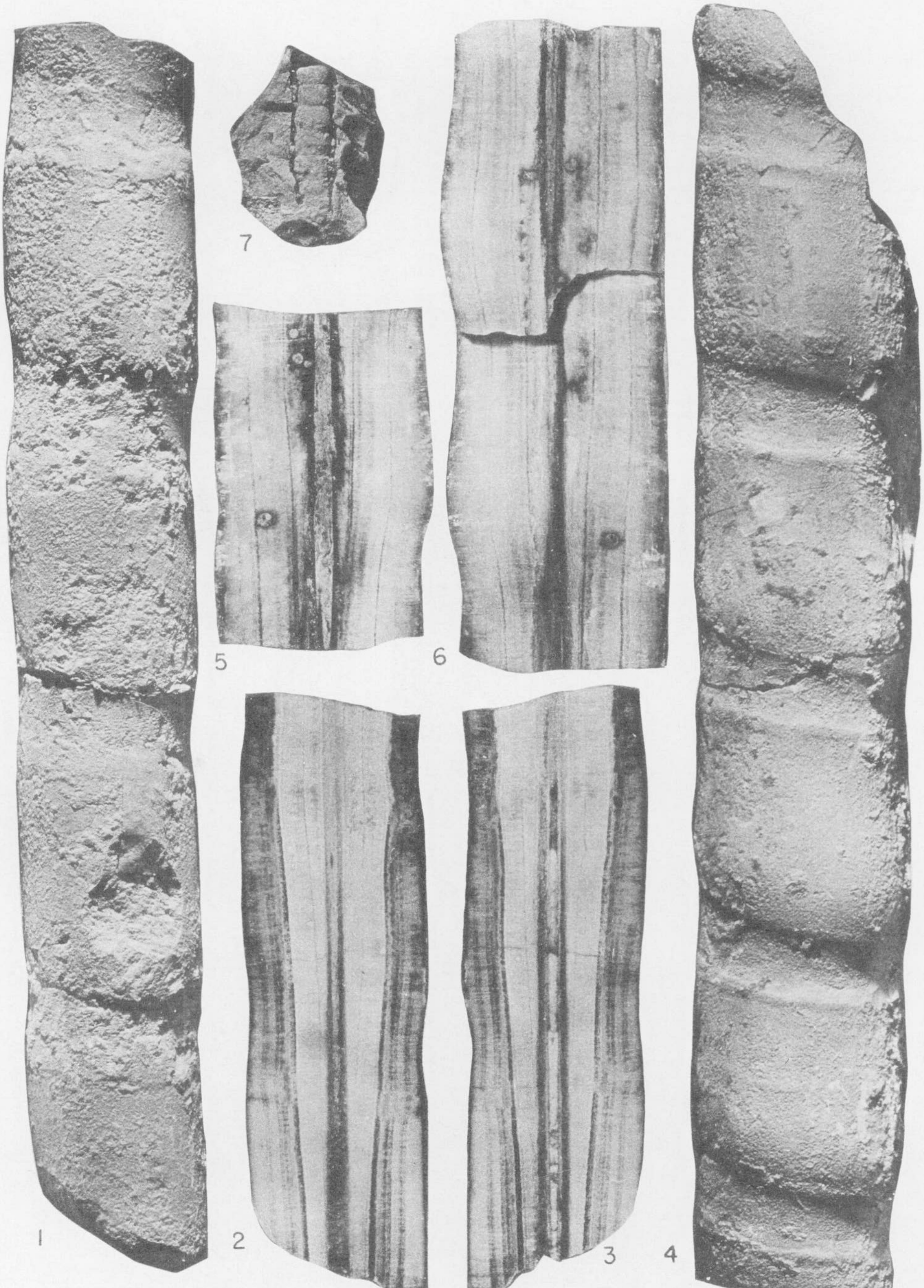

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Plate XXVIII

Figures 1–3. *Narthecoceras sinclairi* n. sp. (Page 53)

Paratype, GSC No. 18755. A portion of a siphuncle showing a relatively young growth stage with segments as long as those shown by later growth stages of greater diameter. 1, exterior, lateral view, venter at left. 2, 3, opposite sides of a longitudinal section of the apical part. Fig. 3 shows some bracket-diaphragms in the tube. Dog Head Member, Red River Formation, Snake Island, Lake Winnipeg, Manitoba.

Figures 4–6. *Narthecoceras sinclairi* n. sp. (Page 53)

A late growth stage of a paratype, GSC No. 18723, showing features of the siphuncle exterior with unusual clarity. 4, lateral view of exterior, showing widening of septal constriction on the venter, at the left of the figures. 5, 6, vertical section from the basal part. Fig. 5 opposes the lower part of fig. 6, and shows the tube filled with matrix, but with possible traces of bracket-diaphragms. Dog Head Member, Red River Formation, Little Tamarack Island, Lake Winnipeg, Manitoba.

Figure 7. *Narthecoceras* or *Donacoceras* sp. 1 (Page 68)

A series of siphuncle segments of the aspect of *Donacoceras*, but without preservation of siphonal deposits, from the Fremont limestone, near Canyon City, Colorado, U.S.A. Univ. Oklahoma specimen.

Plate XXIX

Narthecoceras equisetum n. sp. (Page 63)

Figures 1, 2. Holotype, GSC No. 18718, entire siphuncle lateral view, dorsum on left.

Figure 3. Longitudinal section of anterior part x1 showing merging of endosiphocone into the tube.

Figure 4. Cross-section.

Figure 5. Cross-section at apex.

Figures 6, 7. Longitudinal section of next apical portion. Fig. 7 shows the entire length of one section; fig. 6 opposes the anterior part of fig. 7, showing the tube which lies outside of the plane of the surface of fig. 7.

Figures 8, 9. Opposing surfaces of longitudinal section at apical end, orad of cross-section shown in fig. 5; in fig. 8 matrix has penetrated the apical end of the tube but its forward progress is stopped by a diaphragm in the anterior third.

Farr Formation, Liskeard Group, Farr quarry, Haileybury, Ontario.

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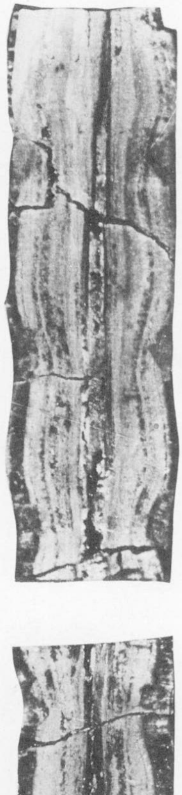

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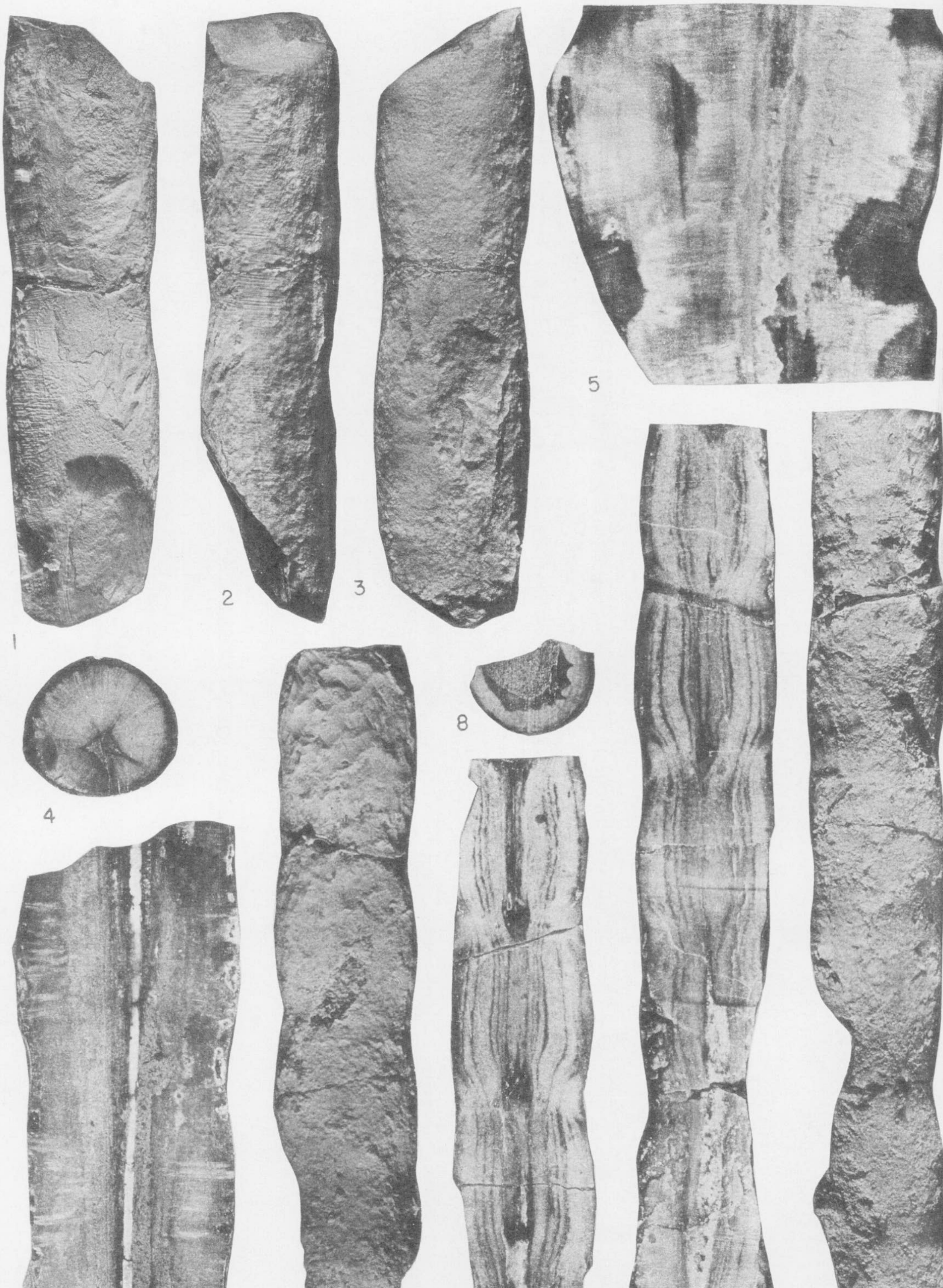
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Plate XXX

Figures 1-4. *Narthecoceras planiventrum* n. sp. (Page 60)

Holotype, GSC No. 18714, a portion of two segments of a siphuncle. 1, dorsal side. 2, lateral, dorsum on left. 3, ventral side. 4, cross-section at anterior end. Dog Head Member, Red River Formation, debris at base of north cliff, Gull Harbour, Hecla Island, Lake Winnipeg, Manitoba.

Figure 5. *Lowoceras southamptonense* Foerste and Savage (Page 43)

Enlargement of part of the holotype, GSC No. 7846, *ca.* x3.5 showing the radial fibres aligned in accordance with the siphuncle wall; also growth lines (*see also* Pl. XXXI, figs. 3-5). Silurian, south half of west side Southampton Island, District of Keewatin.

Figure 6. *Narthecoceras* sp. (Page 66)

Figured specimen, GSC No. 20420. Vertical section x1 of a form with a small circular tube and apparently simple diaphragms. Upper Member, Caution Creek Formation, South Knife River, Manitoba.

Figures 7-11. *Narthecoceras oppletum* n. sp. (Page 64)

Holotype, GSC No. 18715, a somewhat shattered siphuncle. 7, exterior of an anterior portion, showing outline on both sides before sectioning. 8, section at anterior end. 9, longitudinal section of anterior part central showing tube and bracket-diaphragms. 10, longitudinal section, eccentric adorally showing tube apically filled with calcite. 11, exterior of the entire specimen, reverse of fig. 10. Farr Formation, Liskeard Group, Farr quarry, Haileybury, Ontario.

Plate XXXI

Figures 1, 2. *Narthecoceras sinclairi* n. sp. (Page 53)

Paratype, GSC No. 18723. Portions of endosiphuncles in thin section at enlargements comparable with those of *Lowoceras* and *Discosorus*, showing the wide difference in texture and alteration of fibres. Fig. 1, x12, is from a portion of the section shown in Pl. XXXII, fig. 3, with part of the tube in the left third of the figure. Fig. 2 is from the upper left of the section shown in Pl. XXXII, fig. 4, x16. Dog Head Member, Red River Formation, Little Tamarack Island, Lake Winnipeg, Manitoba.

Figures 3–5. *Lowoceras southamptonense* Foerste and Savage (Page 43)

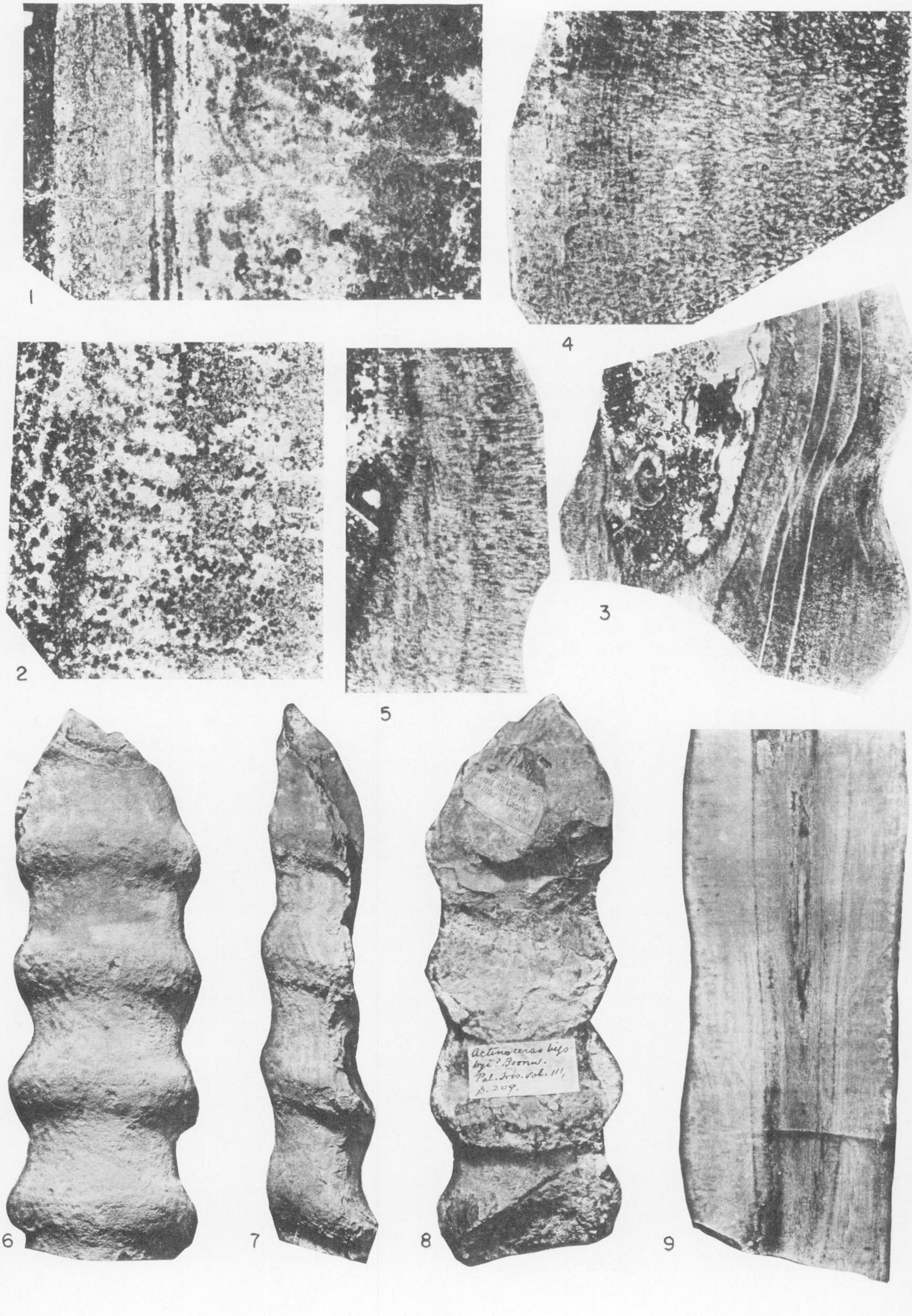
Thin section from part of holotype, GSC No. 7846. 3, section reversed, x3.5 showing growth lines and traces of fibres; the section is eccentric, and figures are oblique to its plane and are not continuous. 4, from the lower right of fig. 3, x18, 5, is from the lower left of fig. 3, x18 (*see also* Pl. XXX, fig. 5). Silurian, south half of west side Southampton Island, District of Keewatin.

Figures 6–8. *Farroceras* (?) *winnipegense* n. sp. (Page 74)

Holotype, GSC No. 7140, original of *Calhounoceras* cf. *C. candelabrum*, Foerste, 1929. Three views of the siphuncle, somewhat crushed and evidently without siphonal deposits. Dog Head Member, Red River Formation, south end of Snake Island, Lake Winnipeg, Manitoba.

Figure 9. *Narthecoceras perplexum* n. sp. (Page 61)

Paratype, GSC No. 18756, a portion of endosiphuncle with the tube developed throughout. Selkirk facies, Dog Head Member, Red River Formation, Garson quarries, Manitoba.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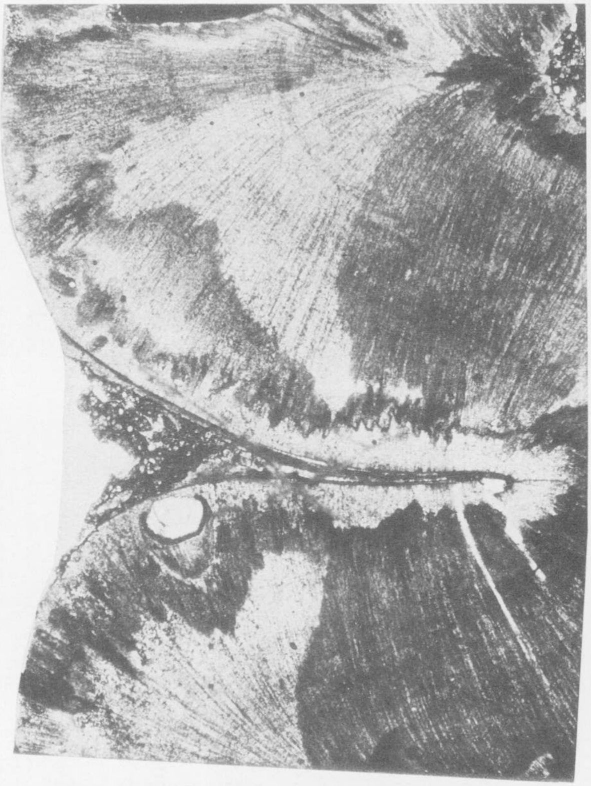

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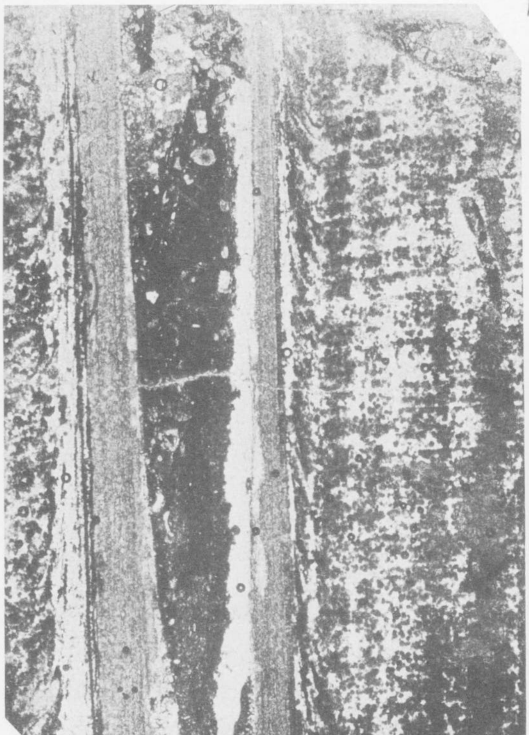

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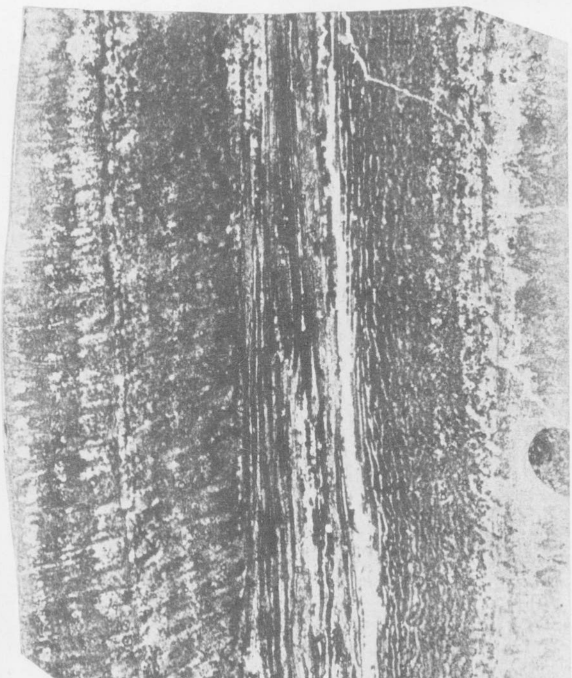

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Plate XXXII

Figure 1. *Narthecoceras subannulatum* n. sp. (Page 69)

Longitudinal thin section from the holotype, GSC No. 22585, x4; there is considerable replacement, fibres are lost, growth lines and tube remain (*see also* Pl. VIII, figs. 9–13). Unit O, Ekwan River Formation, Rapides des Papillons, Harricana River, Quebec.

Figure 2. *Discosorus megistos* n. sp. (Page 23)

Portion of thin section from a paratype, GSC No. 22566 (*see also* Pl. III, figs. 4, 8, 9), showing portions of connecting rings and fibralia which are normal to the outline of the siphuncle segments, x14. Float, believed to come from the Severn River Formation, James Bay lowland, Quebec.

Figure 3. *Narthecoceras sinclairi* n. sp. (Page 53)

Portion of thin section from paratype, GSC No. 18723, showing the tube at left of centre, with fibres, horizontal distally, turning forward and becoming longitudinal around the tube. Dog Head Member, Red River Formation, Little Tamarack Island, Lake Winnipeg, Manitoba.

Figure 4. *Narthecoceras sinclairi* n. sp. (Page 53)

Paratype, GSC No. 18754. Portion of a thin section, slightly eccentric, longitudinal, just missing the tube, showing the forward bending of the fibres near the tube, x5 (same specimen as Pl. XX). Precise locality unknown.

Plate XXXIII

Figure 1. *Narthecoceras tyrrelli* n. sp. (Page 63)

Portion of siphuncle, holotype, GSC No. 20081, lateral view, venter on right. Ordovician, east end near north end Sturgeon Lake, Manitoba.

Figure 2. *Narthecoceras* ? sp. (Page 65)

Figured specimen, GSC No. 20082. A sandy internal mould, apparently of adoral siphuncle segments of *Narthecoceras*, anterior to the endosiphocone, the only specimen observed. Liskeard Group, east side of Lake Timiskaming, Quebec.

Figures 3, 4. *Narthecoceras sinclairi* n. sp. (Page 53)

Two thin sections, x4, paratype, GSC No. 20079. Fig. 3, shows nearly uniformly horizontal fibres, becoming longitudinal only in a most narrow zone close to the tube; the tube wall and some of its interior are replaced by coarse calcite. Fig. 4, shows a slight variation in the pattern of the fibres; the tube wall is again replaced, but is filled with dark matrix. From old collections from the Red River Formation of Lake Winnipeg, Manitoba.

Figure 5. *Narthecoceras sinclairi* n. sp. (Page 53)

Opaque section, enlargement of a portion of paratype, GSC No. 18754, x3. The section is tangential to the tube, but shows fibres with unusual clarity, which extend obliquely forward from the margin to a point close to the centre where they become longitudinal (*see also* Pl. XX).

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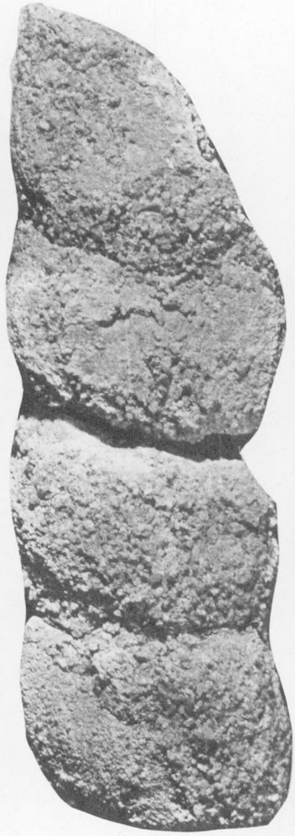

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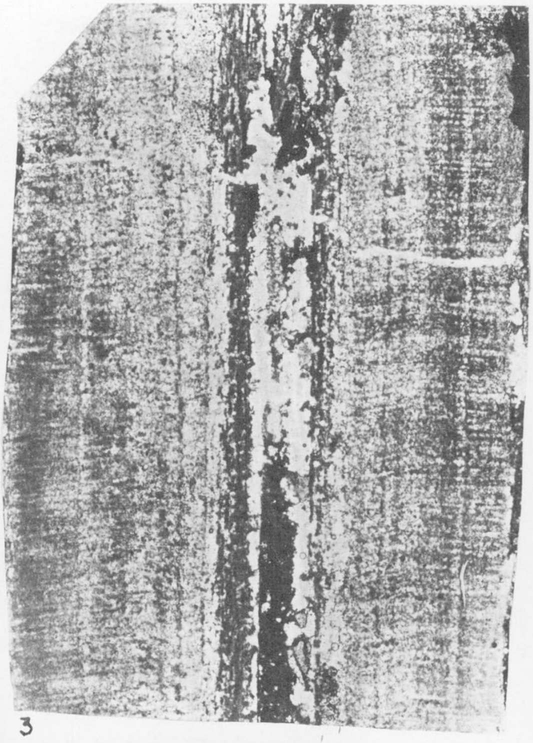

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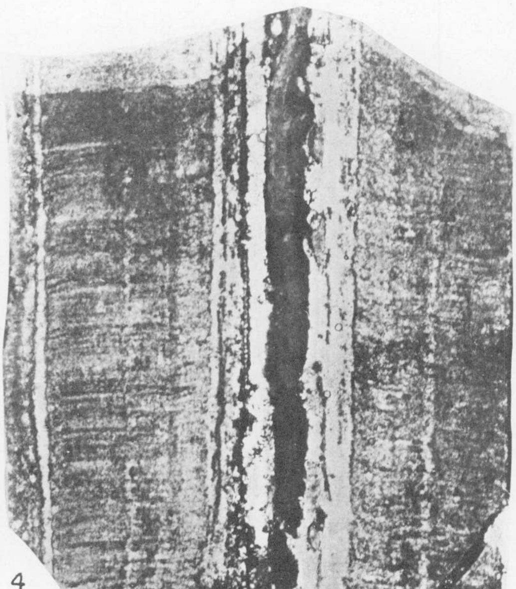

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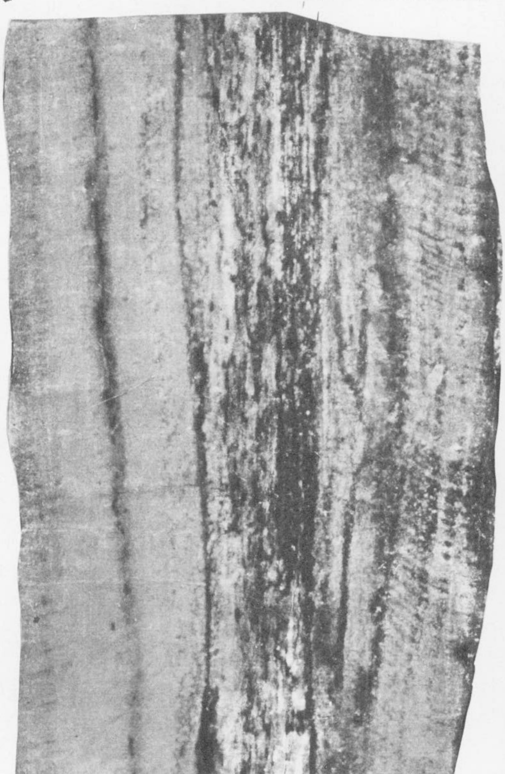

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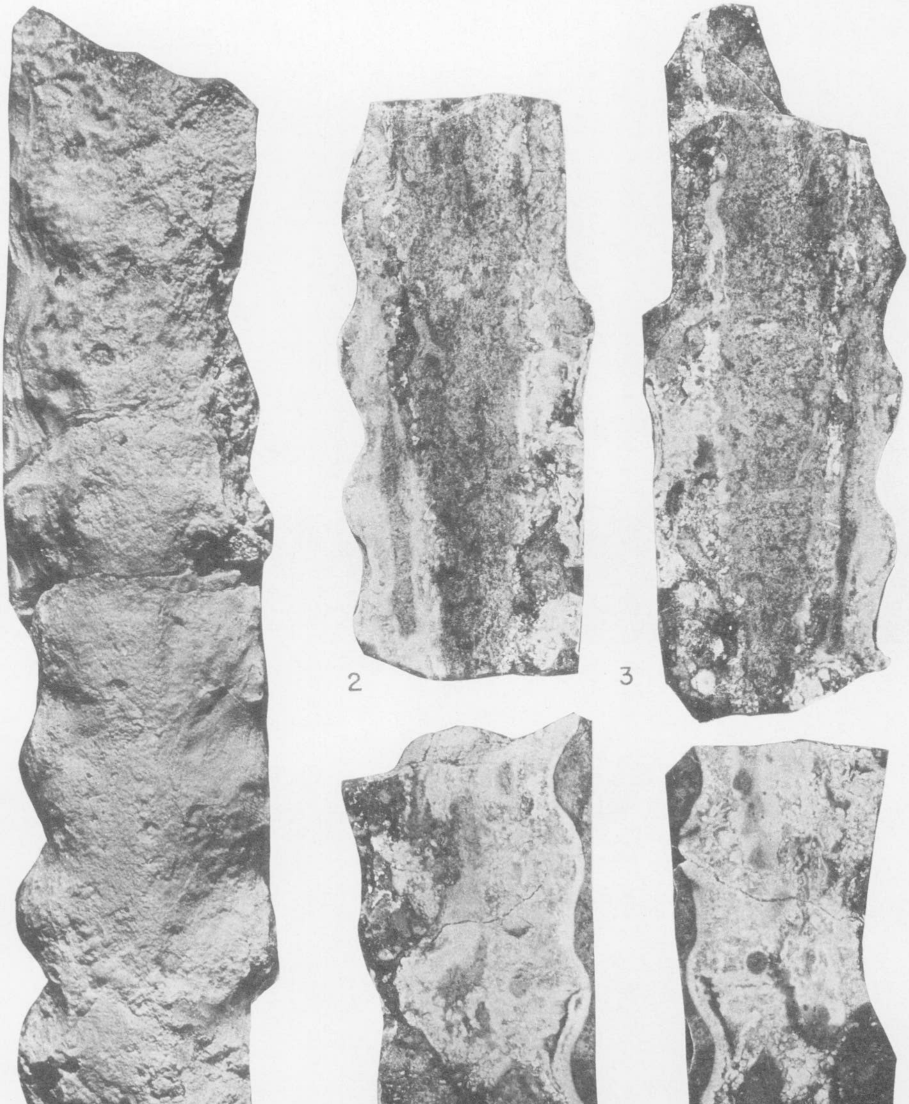
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Plate XXXIV

Farroceras liskeardense n. sp. (Page 74)

Figure 1.	Exterior of holotype, a portion of a somewhat flattened siphuncle, x1. Apical end above.
Figures 2, 3.	Opposite sides of a longitudinal section of anterior part, cut horizontal to the surface shown in fig. 1.
Figures 4, 5.	Opposite sides of horizontal longitudinal section of the apical part, showing interior considerably altered.
	Holotype, GSC No. 18742, Farr Formation, Liskeard Group, Farr quarry, Haileybury, Ontario.

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