TRILOBITES, CEPHALOPODS, AND BRACHIOPODS OF THE STONY MOUNTAIN FORMATION, MANITOBA

by

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ABSTRACT

A detailed study of the trilobite, brachiopod, and cephalopod part of the Stony Mountain fauna indicates a definite Richmond and in part younger age assignment. Forty-seven species belonging to 25 genera are identified, including five new species. Basic components of the fauna include cheirurid trilobites; orthocerid and ascocerid cephalopods; and orthid, rhynchonellid, and strophomenid brachiopods. The relatively small size of the trilobites and cephalopods is noted, and geographic affinities of major components discussed. Correlations with Baffin Island, Greenland, Churchill River, God's River, Bighorn Mountains, Colorado, Anticosti Island, Iowa and its associated Richmond sections are evaluated. The Stony Mountain fauna is considered to have affinities to those of sub-Arctic, eastern and upper Mississippi Valley sections.

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LIST OF ILLUSTRATIONS

ERRATA

1. Page 3: 2nd line of 2nd paragraph change is considered to are.
2. Page 8: two places Cheiruridae should read Cheiruridae.
3. Page 27: Reverse order of Stony Mountain and Penitentiary in the table at top of the page.
4. Page 28: 5th line change they Red River to the.
5. Page 47: Paleofavisites should read Paleofavosites in two places.
6. Page 85: Opakinas should read Opakina.
   Page 88:
7. Page 88: numberous should read numerous.
8. Page 95: tendancy should read tendency.

CHAPTER I

INTRODUCTION

GENERAL STATEMENT.

The Ordovician rocks of Manitoba consist of three formations which in descending order are the Stony Mountain, Red River, and Winnipeg formations. The youngest, the Stony Mountain formation, is best known from its type locality, Stony Mountain, a low hill located about 15 miles northwest of Winnipeg. Here, the formation is divided into three members which in descending order are the Gunton, Penitentiary, and Stony Mountain Shale members. The lowest member comprises red and grey calcareous shales with thin crystalline grey limestone bands. Overlying these are the dusty yellow argillaceous dolomites of the Penitentiary member. The uppermost member consists of greyish-yellow finely crystalline and nodular dolomite, interbedded near the top with shaly and sandy dolomite. All three members of the Stony Mountain formation are fossiliferous, the lower two members being particularily so.

The fauna of the Stony Mountain formation is of unusual interest in that it is known to contain forms also present in the youngest Ordovician sediments of North America at Anticosti Island. Although this aspect of the fauna has been known for over 20 years, a comprehensive study of the fauna has not been made since that of Whiteaves' in 1895.

The purpose of this thesis is to examine, describe, identify and illustrate the cephalopod, trilobite, and brachiopod parts of the fauna of the Stony Mountain formation. In addition, correlations of the formation are examined with reference to the additional faunal knowledge thus acquired. Although minor references to other phyla are made, the portion of the paper concerning correlation has been restricted to discussion of the cephalopod, trilobite, and brachiopod relationships only.

Most of the fossils used for this study belong in the University of Manitoba Collection, and is considered to be representative of the complete fauna. Included in this collection are numerous specimens collected by W. E. Cutler in 1922 and 1923. In addition, the collections of the Manitoba Museum, the Manitoba Mines Branch and the personal collection of Mr. E. I. Leith were made available to the author. Individual specimens were also borrowed from smaller private collections.

PREVIOUS WORK.

The first comprehensive study of the Ordovician rocks of Manitoba, by Dowling (1895-1900), was the result of extensive field studies of the west shore and islands of Lake Winnipeg, and it included representative fossil collections. His report also included the results of studies made earlier by J. B. Tyrrell. Dowling subdivided the Manitoba Ordovician section and proposed a correlation with the Ordovician of Minnesota. In his correlation, as shown below, Dowling considered the Stony Mountain beds as equivalent to the Richmond and Utica Groups of Minnesota.

FORMATIONS IN MINNESOTA			FORMATIONS IN MANITOBA.		
Hudson River or Cincinnati Period.	Richmond group. Utica group.		Trenton Period.	Stony Mountain Utica ?	Limestones and shales.
Trenton Period.	Trenton group.	Maclurea beds.		Trenton.	Upper Mottled limestone.
		Fusispira and Nematopora beds.			Cat Head limestone.
		Clitambonites beds.			Lower Mottled limestone.
	Black River group.	Fucoid and Phylloporina beds.		Black River ?	Winnipeg sandstone and shales.
		Ctenodonta beds.			
		Rhinidictya bed.			
	Stones River group.	Stictoporella bed			
		Vanuxemia bed.			
		'Lower Buff.'			
	Chazy formation	St. Peter Sandstone.			

Figure 1. Correlation chart by Dowling, 1900.

Whiteaves' palaeontological contributions (1895-1897) represent the first major faunal studies of the Ordovician of Manitoba. His studies were made from the collections of Ells (1875), Bell (1879), Weston (1884), Tyrrell (1888) and Dowling (1895), and many of his conclusions were published with Dowling's reports. Whiteaves' report of 1895, listed 59 species from the Stony Mountain formation, and his report is still recognized as the most comprehensive study of that fauna. The report contains descriptions and illustrations of large parts of the fauna including a few new species and varieties. Noteworthy of Whiteaves' faunal study of the Stony Mountain formation are his sections concerning the bryozoa, ostracods and pelecypods. These parts of the fauna have received very little study since Whiteaves' original work.

The next major study of the geology of Stony Mountain was made by Okulitch in 1943. Okulitch made field and fossil studies at several localities in southern Manitoba and proposed four divisions, in ascending order, the Stony Mountain Shale, Penitentiary, Gunton, and Birse members. Palaeontological studies were confined to the coelenterates, brachiopods, gastropods and cephalopods, and a faunal list was made for each member. The study made its greatest contribution in the portion on the coelenterates, and revision of the orthid brachiopods. Okulitch listed 34 species from the formation of which four were new, and 18 of which had not previously been recognized at Stony Mountain.

In 1952 Baillie published a detailed study of the Ordovician rocks of Manitoba. Okulitch's quadrate sub-division of the Stony Mountain formation was questioned by Baillie, and the Birse member was included with the Gunton. Baillie considered the Birse to be a part of the Gunton which appeared different at some localities but was indistinguishable at many others. The three members used by Baillie have been used by the present author in this thesis.

ACKNOWLEDGEMENTS.

The author wishes to thank Mr. E. I. Leith, University of Manitoba, for helpful advice and criticism during the preparation of this paper and also for the generous loan of his private fossil collection.

The assistance of Mr. Dick Sutton of the Manitoba Museum, Dr. G. H. Charlewood of the Manitoba Mines Branch, and Miss Winona Downes, who helped make collections available for study is hereby acknowledged.

CHAPTER II

THE STONY MOUNTAIN FAUNA

GENERAL STATEMENT.

The fauna of the Stony Mountain formation is both large and varied. All the major phyla are represented except the foraminifers and sponges. Of the part of the fauna reported in this thesis, 47 species belonging to 25 genera are identified. Of the genera, 4 are trilobites, 8 are cephalopods, and 13 are brachiopods. Of the three phyla the brachiopods are by far the most numerous, cephalopods being rather uncommon, and trilobites rare. This proportion of forms appears to be similar in both the Stony Mountain Shale and the Penitentiary members. Considerable differences of relative sizes, geographic affinities, and diversity of forms are apparent within each phylum, and for that reason they are discussed separately.

TRILOBITES:

The following trilobites were identified from the Stony Mountain formation:

Calymene retrorsa Foerste

Ceraurinus icarus (Billings)

Ceraurus horridus Troedsson

C. bituberculatus Troedsson

C. tuberosus Troedsson

C. bispinosus Raymond and Barton

Ceraurus sp.

Bumastus sp.

Three main elements are recognized in the above list. The largest and most important is that of the family *Cheiruridae*. All members of this element have been recognized as part of the Arctic fauna, especially the ornate members of genus *Ceraurus*. *Ceraurinus icarus* has a greater geographic distribution and longer stratigraphic range than the others, having been reported from the Winnipeg sandstone, Red River formation, and Stony Mountain formation and its western equivalents. The genus *Ceraurus* has an Arctic distribution and a range which is usually confined to units higher than the base of Red River formation equivalents. Almost all of the *Cheiruridae* found at Stony Mountain have also been reported from Cape Calhoun, whereas only single species are reported elsewhere, such as *Ceraurinus icarus* from the Vaureal formation at Anticosti. Unfortunately, trilobite faunas have received little attention in south central United States and comparisons with that area are difficult to make. However, a close affinity between the trilobites of that area and those of the Arctic region is suggested. All representatives of *Ceraurus* are much smaller at Stony Mountain than at Cape Calhoun. A similar feature is recognized among the cephalopods, indicating that the relatively small size ~~is~~ more likely associated with ecology than evolutionary development.

A second element of the trilobite fauna is that of the genus Bumastus. Although only sparsely represented, this genus is interesting as it has no easily recognized affinities with neighboring Ordovician faunas. Similarities to Black River forms are suggested, as also are those to far northern Richmond forms. This member may represent some link in the evolutionary chain between Bumastus and Bumastoides.

The third and least well known element of the trilobites is that of Calymene retrorsa. In arctic faunas Calymene is reported from several localities, and for most of them some degree of uncertainty is attached to their identity, often due to lack of good specimens. Although the Stony Mountain specimen is by no means complete, it has the diagnostic features required to refer it to the species C. retrorsa. This species is the only direct association to the Maquoketa among the trilobites and may indicate the source of this third element.

CEPHALOPODS:

The following cephalopods were identified from the Stony Mountain formation:

Huronia cf. arctica Troedsson

Actinoceras sp.

Armenoceras sp.

Westenoceras latum Troedsson

Westenoceras (?) cf. contractum Foerste and Savage

Beloitoceras percurvatum Twenhofel

Billingsites costulatum (Whiteaves)

B. boreale (Parks)

B. cf. *newberryi* (Billings)

Lambeoceras nudum Troedsson

Cycloceras selkirkense (Whiteaves)

C. cf. *acutoliratum* Foerste and Savage

The cephalopods of the Stony Mountain fauna show greater diversity of forms, both in genera represented and in geographic affinities, than the trilobites. Rather than all species of a genus showing affinities to another fauna, it appears as if only one species of any one genus is related to species of other localities. For example, *Billingsites boreale* is known from the Hudson Bay area; *B.* cf. *newberryi* from the Anticosti area; and *B. costulatum* from earlier Ordovician beds in southern Manitoba. Similar relationships may be cited for *Cycloceras* and *Westenoceras*. Species allied to the Greenland fauna are *Huronia* cf. *arctica*, *Westenoceras latum*, and *Lambeoceras nudum*. *Cycloceras* cf. *acutoliratum*, *Westenoceras* cf. *contractum* and *Billingsites boreale* are characteristic of the Shammattawa formation of northern Manitoba. *Beloitoceras percurvatum* and *Billingsites* cf. *newberryi* are Anticosti Island forms. The remainder, *Billingsites costulatum*, *Cycloceras selkirkense* and *Actinoceras* sp., appear to be survivors of the Red River fauna of southern Manitoba.

With the exception of *Lambeoceras nudum*, *Actinoceras* sp., and *Billingsites costulatum*, the cephalopods are small forms, some only half the size of their holotypes. Their small size bears no apparent relation to geographic affinities, and is probably a reflection of ecology.

It is of special interest to note the addition of two species of *Billingsites* to the one which was present in this area during Red River time. The Red River "survivor" is a large form, whereas both *B. boreale* and *B.* cf. *newberryi* are small. This relationship is also found in the Hudson Bay area, and if ecology is the controlling factor, indicates that conditions were uniform over large areas during those times.

BRACHIOPODS:

The following brachiopods were identified from the Stony Mountain formation:

Dinorthis iphigenia (Billings)
Pionorthis sola (Billings)
P. carletona Twenhofel
P. gracilis Procter n. sp.
P. cf. *sola* (Billings)
Dalmanella storeya Okulitch
D. jugosa subplicata Foerste
Opikina pergibbosa (Foerste)
O. lata Procter n. sp.
O. manitobensis Procter n. sp.

O. parva Procter n. sp.

Opikina sp.

Opinkinella sp.

Megamyonia niteus (Billings)

M. raymondi (Bradley)

M. obesa Procter n. sp.

Strophomena planocorrugata Twenhofel

S. fluctuosa Billings

S. occidentalis Foerste

S. cf. *concordensis* Foerste

Tetraphalerella cf. *planodorsata* (Winchell & Schuchert)

Holtedahlina sp.

Lepidocyclus perlamellosus (Whitfield)

Lepidocyclus laddi Wang

Hypsiptycha anticostiensis (Billings)

Dinobolus sp.

Thaerodonta dignata Wang

The brachiopods of the Stony Mountain formation can be divided into three main groups, the orthids, the rhynchonellids, and the strophomenids. Representatives of all three groups can be found in each member of the formation, the last one being most plentiful in the Penitentiary member. The orthids are the most abundant brachiopods in the fauna, followed closely by the strophomenids. The present study has added more to the knowledge of the brachiopods than other phyla studied, several major group identities, such as *Opikina* and

Megamyonia having been recognized, and several new species created. This has, however, made difficult the recognition of faunal affinities, as similar changes are probably needed at neighboring localities, especially those of northern Canada.

The most abundant group, the orthids, are widespread in North America. Those of Stony Mountain are common from the Arctic to New Mexico, and from Anticosti to probably as far west as British Columbia. The most important genus of this group is *Pionorthis* which has been reported from most localities with Arctic faunas. In some localities specific determinations differ from those of Stony Mountain, but reference is usually made to the coarsely costate nature of the form which appears typical of Arctic fauna pionorthids.

The strophomenids of Stony Mountain are a large group comprising 15 species. The most important genera are *Opikina*, *Strophomena* and *Megamyonia*. The first has long been misidentified at Stony Mountain as *Rafinesquina* which it closely resembles. In all probability a similar misidentification exists in other sub-arctic localities, as *Opikina* has been reported by Wilson (in Miller et al, 1954, p. 154) from Baffin Island. The only other apparent affinity for this genus is in the Maquoketa formation where *O. pergibbosa* is reported. The genera *Megamyonia* and *Strophomena* are well represented, with forms showing affinities to Anticosti, Iowa and the Arctic localities.

The rhynchonellids of Stony Mountain are an important but numerically small group. Specific determinations are difficult to make within this group without knowledge of internal structures. Fortunately many excellent specimens showing interiors of both valves can be obtained from the Penitentiary member at Stony Mountain. *Lepidocyclus* and *Hypsiptycha* are identified with species characteristic of the English Head, Vaureal, Ellis Bay and Maquoketa formations. Until the Arctic rhynchonellids are studied in greater detail it is impossible to prove affinities among this group in that region. Quite probably, many of the forms presently assigned to *Rhynchotrema* should be referred to *Lepidocyclus*.

OTHER PHYLA:

In addition to the portion of the Stony Mountain fauna described in this paper the following fossils have been identified by previous authors (Whiteaves, 1895-1897; Foerste, 1929; Okulitch, 1943; Baillie, 1952; Leith, 1952).

Coelenterates:

Aulacera undulata (Billings)

Beatricea nodulosa Billings

B. cf. *undulifera* Foerste

B. undulifera intermedia Foerste

Calapoecia canadensis var. *anticostiensis* Billings

Favosites intermedius Okulitch

Holophragma anticonvexa Okulitch

Paleofavosites capax (Billings)

P. cf. *capax* (Billings)

P. prolificus (Billings)

Paleofavosites ? sp.

P. asper var.

Pragnellia arborescens Leith

Protaraea cutleri Leith

Streptelasma rusticum (Billings)

S. cf. *rusticum* (Billings)

S. trilobatum (Whiteaves)

Echinoderms:

Glyptocrinus sp.

Bryozoa:

Arthroclema angulare Ulrich

Batostoma manitobense Ulrich

"Batostomella" gracilis (Nicholson)

Bythopora delicatula Nicholson

B. striata Ulrich

Dicranopora emacerata Nicholson

D. fragilis (Billings)

Goniotrypa bilateralis Ulrich

Helopora harrisi James

Monticulipora parasitica var. *plana* Ulrich

Nematopora ? sp. undesc.

Pachydictya hexagonalis Ulrich

Petigopora scabiosa Ulrich

Proboscina auloporoides (Nicholson)

P. frondosa (Nicholson)

Ptilodictya whiteavesi Ulrich

Rhombotrypa quadrata (Rominger)

Sceptropora facula Ulrich

Stictopora sp. or *Rhinidictya* sp. (in Ulrich)

Pelecypods:

Byssonychia obesa Ulrich

Plethorcardia (n. sp.) ?

Gastropods:

Cyclora minuta Hall

Hormotoma gracilis (Hall)

H. bellicincta (Hall)

Liospira sp.

Lophospira cf. *bicincta* (Hall)

Phragmolites compressus (Conrad)

"Pleurotomaria" sp. uncertain

Sinuites bilobatus Sowerby

Sinuites sp.

Trochonemopsis umbilicatum (Hall)

Ostracods:

Aparchites minutissimus (Hall)

Beyrichia (Kloedenella ?) parallella (Ulrich)

Eurychilina manitobensis Ulrich

Leperditia subcyclindrica Ulrich

Primitia (Plethoboibina ?) lativia Ulrich

Tetradella lunatifera (Ulrich)

T. simplex Ulrich

Algae:

Buthotrephis sp. cf. *succulens* Hall

CHAPTER III

CORRELATION

INTRODUCTION.

When Dowling (1895) first described the Stony Mountain formation he considered it to be of Richmond age, a consideration which has not since been seriously challenged. Later authors, concerned with Upper Ordovician rocks, have confirmed and elaborated on the position of the formation within the Richmond and some attempted to extend its time span into the Gamachian. Considerable difficulty has been encountered in determining precise correlatives among Richmond and younger Ordovician formations and has led to some thought concerning distribution of seas during that period of time. A short review of such ideas is included here to help orient the Stony Mountain formation with the rest of North American Upper Ordovician rocks.

A general concensus among stratigraphers concerning Richmond rocks is that they were deposited in three different seas, separated by land barriers. The three seas have come to be known as the North Atlantic, Arctic and Gulf of Mexico seas or embayments (Savage and Van Tuyl, 1919, p. 354). This concept evolved from the rather different faunal and lithologic characters associated with each embayment. The standard Richmond section for North America was described in Ohio and Indiana, a part of the Gulf of Mexico sea. This sea is believed to have extended north over a large part of eastern United States to the St. Lawrence Lowlands. Further to the east, a second sea, that of the North Atlantic, extended along the Appalachian trough as far north as Gaspe. The fauna of this sea can not be readily correlated with that of the Gulf of Mexico embayment and indeed shows closer affinities with European faunas. The third and largest sea, the Arctic sea, extended from the Canadian Arctic across west Central United States as far south as Texas and possibly as far as northern Mexico. (Miller, 1930, p. 210). The fauna of this embayment differs considerably from those of the other two, showing only slight resemblances to the Gulf of Mexico fauna. The rocks and fauna of this largest sea include the Stony Mountain formation.

The problem of integrating the stratigraphy of the three broad areas is one which has been only partially resolved and in this paper will be ignored. It is not within the scope of this thesis to evaluate ideas concerning the different seas of Richmond time, but rather to try to place the Stony Mountain formation with its proper correlatives within the "province" in which correlations can be made. Several correlatives of the Stony Mountain formation have already been recognized. This author has attempted to evaluate their validity in terms of new information on the part of the fauna studied. In the following portion of the chapter correlations of the Stony Mountain formation with rocks of Baffin Island, Greenland, Hudson Bay, Anticosti Island, Bighorn Mountains, Colorado, New Mexico, British Columbia, Iowa and Illinois will be attempted. The palaeogeographic map, Plate 1, page 21, has been indexed to show the approximate locations of the sections discussed. In addition, the generalized location of land and seas during Upper Ordovician time are indicated. As each of the correlations are discussed, the suggested equivalents are indicated at the beginning by a small correlation chart. A composite correlation chart, Plate 2, is included with the summary and conclusions.

BAFFIN ISLAND:

Manitoba	Baffin Island
Stony Mountain fm.	
	?
Red River fm.	"Silliman's Mount" beds

Rocks of Ordovician age have been reported from a number of localities on Baffin Island, the best known of which is Silliman's Fossil Mount at the head of Frobisher Bay. The "mount" consists of approximately 300 feet of fossiliferous limestones and dolomites of probable upper Ordovician age, which are divided into an upper 50 feet of massive dolomitic limestone, a middle 75 feet of thin-bedded limestone and dolomite, and a lower 175 feet of calcareous shales. Preliminary studies of the

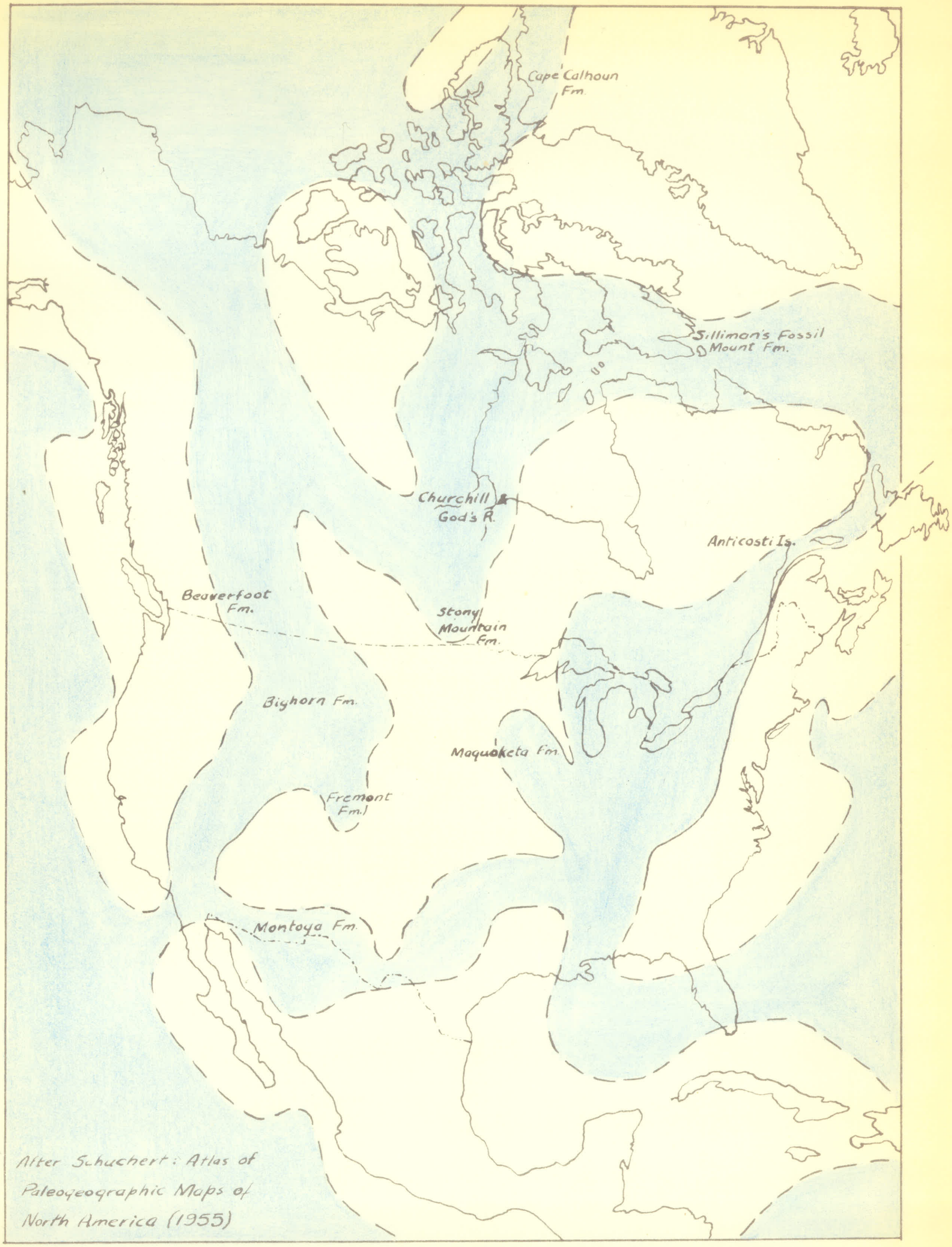

Plate 1

Palaeogeographic Map of North America - Upper Ordovician

(land areas-white, seas-blue)

fauna, by Charles Schuchert, in 1900 and 1914, indicated the presence of Trenton - Richmond equivalents with many cephalopods and brachiopod genera. Bassler in 1911, and Foerste in 1928 arrived at similar correlations after studying Schuchert's collection. The first comprehensive study of the fauna was made in 1941 by Sharat Roy who visited the area in 1927 and collected extensively. Roy reported 117 different forms from the Mount and was able to "conclude clearly that the Silliman's Fossil Mount fauna and its equivalents are a recurring Mohawkian fauna of early Richmond age." The most recent study of the fauna is that of Miller and Youngquist (1954) who visited the area and made large collections, particularily of the cephalopods. Their report on the cephalopod faunas of Baffin Island, which also includes discussion and illustrations of the brachiopods, trilobites and other phyla, indicates a close faunal relationship between the Stony Mountain formation and the beds at Silliman's Fossil Mount.

A comparison of the cephalopods from Baffin Island with those of Stony Mountain reveals that only three of the 23 genera reported by Miller and Youngquist are known at Stony Mountain. The three common genera are *Lambeoceras*, *Westenoceras*, and *Actinoceras*. Although no species are common to both areas, close similarities between Baffin Island and Manitoba forms are apparent. *Lambeoceras baffinense* Miller and Youngquist, is very close to

L. nudum Troedsson of Stony Mountain. Similarily, the Manitoba species of Westenoceras, W. (?) cf. contractum Foerste and Savage and W. latum Troedsson have close affinities to some of the 11 species of this genus at Baffin Island. The Stony Mountain specimen of Actinoceras is too incomplete to permit comparison. In contrast to the similarities of the two cephalopod faunas, noteworthy differences are apparent. No species of Huronia, or Billingsites, represented in the Stony Mountain formation by four species, are known from the arctic locality. Two species of Probillingsites are reported by Miller and Youngquist who considered the absence of Billingsites a strong indication that the Silliman's Fossil Mount strata were slightly older than the Stony Mountain formation. This consideration is well supported by a much greater similarity of the Red River cephalopods to those of Baffin Island, 16 of the 23 genera recognized at the latter locality being present at the former.

The brachiopods collected by Miller and Youngquist were identified by Preston E. Cloud, Jr., who assigned them to 15 genera. Of these, 3 genera are known in the Stony Mountain fauna, Thaerodonta, Lepidocyclus, and Strophomena. No species of the 3 genera are common to both areas, although close similarity exists between Lepidocyclus laddi, of Stony Mountain, and L. capax arcticus Roy of Baffin Island. Unlike the Stony Mountain fauna, there are no species of Pionorthis, Dalmanella, Opikina, or Megamyonia noted from

Silliman's Fossil Mount, whereas they constitute a large part of the brachiopods of the southern locality. The orthids identified by Cloud belong mainly to the genus Austinella along with Hesperorthis, Resserella, Glyptorthis and Plaesiomys. By comparison, the brachiopods of the two areas appear more different than similar, with a suggestion of distant relations. Cloud, in summarizing the evidence of the brachiopods at Silliman's Mount, stated that either a Middle or Upper Ordovician age was suggested, but that the latter was more tenable due to the presence of Austinella.

The trilobites of Silliman's Fossil Mount, which are treated in a separate paper within Miller and Youngquist's report, were studied and identified by H. B. Whittington. The large trilobite fauna was referred to 15 genera of which four show close affinity to the trilobites of Stony Mountain. Ceraurinus icarus (Billings) of Stony Mountain appears to be very close to Remipyga glabra Whittington, a new genus and species from Baffin Island. Whittington considered C. icarus to be a group of species (for which he preferred to use R. meekanus (S. A. Miller), which apparently are confined to rocks of Richmondian age. Another similarity is apparent between Ceraurus horridus Troedsson of Stony Mountain and Hapsiceraurus hispidus Whittington, a new genus and species from Silliman's Mount. Only minor differences exist between the two species and Whittington indicated that some difficutly exists in distinguishing between fragmental specimens of them. Other similarities which the trilobites of Stony Mountain and Baffin Island share can be seen in *Calymene retrorsa* Foerste and *Bumastus* sp. from the former locality and *Flexicalymene croneisi* Roy and *Bumastus* (*Bumastoides*) sp. ind. from the latter. In both cases a close relationship can be noted although important distinctions exist. In contrasting the two trilobite faunas, the Baffin Island trilobites are more numerous (generically) and more evenly distributed within each family than those of Stony Mountain. For example, the eight Stony Mountain species belong to four genera of three families, the largest of which is the Cheiruridae of which four species are reported. In contrast, the 18 Baffin Island species belong to 15 genera, of nine families, the largest of which is the Illaenidae of which four species are reported. Whittington concluded that the Baffin Island trilobite fauna is probably of Trentonian or earliest Upper Ordovician age, considering the ranges in time of the genera recognized. The present author considers the Stony Mountain trilobite fauna to be of definite Upper Ordovician age, somewhat younger than that of Baffin Island, due to the presence of *Ceraurinus* [*Remipyga ?*] *icarus* (Billings), and the absence of forms known to be restricted to Middle Ordovician beds elsewhere (as in the Silliman's Fossil Mount beds).

In summary, a comparison of the cephalopod, brachiopod and trilobite faunas of Stony Mountain and Silliman's Fossil Mount suggests an Upper Ordovician age for the faunas of both localities, the former being the younger. That the faunas are of Upper Ordovician age is best indicated by the presence of Billingsites, Austinella, and Ceraurinus [Remipyga] which are generally recognized Richmondian forms. The younger age of the Stony Mountain fauna, compared to that of Baffin Island, is best shown by the presence of Billingsites at the former locality in contrast to Probillingsites at the latter, the closer affinity of cephalopods of Silliman's Mount to those of the Red River formation than to those of Stony Mountain, and the lack of Middle Ordovician trilobite elements, present at Baffin Island but not at Stony Mountain. It is therefore suggested that the Silliman's Fossil Mount beds are of early Upper Ordovician age and that the Stony Mountain formation is of late Upper Ordovician age.

GREENLAND:

Manitoba		Greenland
Stony Mountain fm.	Gunton mem.	
	Stony Mhtn. Sp.	Cape Calhoun fm. (restricted)
	Penitentiary mem.	
Red River fm.		
		Gonioceras Bay Ls. fm.

Ordovician strata have been reported from north-west Greenland since 1921, when Koch visited Cape Calhoun and collected from the very fossiliferous limestone. The section consists of an upper 800 feet of gray and brown limestones called the Cape Calhoun formation, and a lower limestone to which the name Gonioceras Bay limestone is given. Koch's extensive collection from the Cape Calhoun beds was studied and described by Troedsson (1926, 1928) and Teichert (1939), both of whom recognized Trenton and Richmond affinities for the formation. Later work by Troelsen (1950, pp. 55-59) confirmed the previous age assignments and redefined the lower limits of Troedsson's Cape Calhoun formation. Troelson found no reason to separate the lower part of this formation from the underlying Mohawkian Gonioceras Bay beds and thereby "restricted" the Cape Calhoun formation. The latter formation where used in this thesis refers to the restricted unit.

Troedsson's work indicated several genera of most phyla to be represented, and in general aspect the fauna appears very similar to that of the Red River, Stony Mountain, and Silliman's Fossil Mount (Baffin Island) beds. A comparison of the faunal lists of the Red River and Cape Calhoun formation shows many genera, especially of cephalopods, common to both areas. *Receptaculites*, *Maclurites* and the large nautiloid cephalopods which characterize they Red River are also present at Cape Calhoun, and indicate a close, well recognized correlation. In addition, several Stony Mountain forms appear to be present in the Cape Calhoun limestones. Of the part of the Stony Mountain fauna discussed in this thesis the following forms were also reported from the Cape Calhoun formation:

Cephalopods:

Huronia cf. *arctica* Troedsson

Lambeoceras nudum Troedsson

Westenoceras latum Troedsson

Brachiopods:

Dinorthis iphigenia (Billings)

Strophomena fluctuosa Billings

Trilobites:

Ceraurinus icarus (Billings)

Ceraurus horridus Troedsson

C. bituberculatus Troedsson

C. tuberosus Troedsson

In addition, the brachiopod genera *Dalmanella*, *Lepidocyclus* (*Rhynchotrema*) and *Megamyonia* (*Leptaena* ?), are common to both formations. *Bumastus fronto* Troedsson and *Calymene* sp. ind. I of Troedsson, both Cape Calhoun trilobites, are very close to the Stony Mountain forms, *Bumastus* sp. and *Calymene retrorsa* Foerste, respectively.

The most noteworthy feature of the faunal comparison between the Stony Mountain and Cape Calhoun formations is that of the close affinity indicated with the trilobites. All four Manitoba genera, *Calymene*, *Ceraurinus*, *Ceraurus* and *Bumastus* are reported from Cape Calhoun with four species in common and two species with close affinities, as noted previously. The present author considers this evidence sufficient to correlate the lower two members of the Stony Mountain formation, the Pentitentiary and Stony Mountain Shale members, from which the trilobites were collected, with part of the Cape Calhoun formation.

CHURCHILL RIVER, MANITOBA:

<table>
<tr><th colspan="2">Stony Mountain</th><th>Churchill River</th></tr>
<tr><td rowspan="3">Stony Mountain fm.</td><td>(Birse)
Gunton mem.</td><td>Keating Creek fm.</td></tr>
<tr><td>Penitentiary mem.</td><td rowspan="2">Bell Creek fm.</td></tr>
<tr><td>Stony Mntn. Sh.</td></tr>
<tr><td colspan="2" rowspan="2">Red River fm.</td><td>Surprise Creek fm.</td></tr>
<tr><td>Portage Chute fm.</td></tr>
</table>

Preliminary studies of strata along the lower reaches of the Churchill River revealed a prolific cephalopod fauna which was assigned a Trenton age (Bell, 1880; Alcock, 1916). Later investigations by A. K. Miller showed the fauna to have affinities with the Bighorn and Red River faunas, indicating a younger age, possibly early Richmond. A recent study of the fauna by S. J. Nelson (1952) has revealed a more diversified fauna than was formerly considered. Nelson states that equivalents of both Red River and Stony Mountain formations are present in the Churchill River section and that on the basis of corals and brachiopods as well as cephalopods, the entire section is of Richmond age with the possible exception of some of the upper most beds which may be Gamachian.

Nelson has divided the Churchill River section into four formations which in descending order are the Keating Creek, Bell Creek, Surprise Creek and Portage Chute formations. It was found that the latter two formations could be closely correlated with the Red River formation and that the upper two formations appear equivalent to the Stony Mountain formation. Nelson attempted to correlate the Bell Creek formation with the Stony Mountain shale and Penitentiary members of the Stony Mountain formation, and similarily the Keating Creek formation with the Gunton and Birse members. Although an approximate correlation was achieved, Nelson felt that further detailed studies of parts of the faunas of both sections would be required before such close correlation could be secure.

A comparison of the trilobites, cephalopods and brachiopods of Stony Mountain with those of the Bell Creek and Keating Creek formations shows several genera and species common to both sections. In the following list of Stony Mountain fossils common to the two localities, G indicates the same genus, similar species, and GS indicates the same genus, same species to be present.

Stony Mountain	Churchill River	
	Keating Creek	Bell Creek
Brachiopods:		
Pionorthis carletona Twenhofel		GS
P. sola (Billings)		G

Dalmanella storeya Okulitch	GS	GS
Opikina pergibbosa (Foerste)		GS
Megamyonia nitens (Billings)	GS	GS
M. raymondi (Bradley)		GS
Strophomena fluctuosa Billings		GS
S. planocorrugata Twenhofel		GS
Lepidocyclus perlomellosus (Whitfield)		GS
Cephalopods:		
Huronia cf. *arctica* Troedsson	G	
Armenoceras sp.		G
Westenoceras (?) cf. *contractum* Foerste and Savage		GS
Billingsites boreale (Parks)		GS
B. costulatum (Whiteaves)		G
Trilobites:		
Ceraurinus icarus (Billings)	GS	
Ceraurus tuberosus Troedsson	GS	

From the preceeding list, a close correlation between the faunas of the Stony Mountain formation and the Bell Creek and Keating Creek formations is apparent. The brachiopods of the Bell Creek especially seem close to those of Manitoba which were nearly all collected from the lowest two members of the Stony Mountain beds. This comparison would appear to substantiate Nelson's attempted member-for-member correlation, although too few fossils have been collected from the upper member (Gunton) of the Stony Mountain to confirm its correlation with the

Keating Creek. In addition, all of the Stony Mountain trilobites are from the lower members whereas on the Churchill River the only two species reported are from the highest beds. The evidence of the brachiopods and trilobites thus seems contradictory and suggests some doubt as to the possibility of member-for-member correlation of the two sections at this time.

In regard to the age of the Bell Creek and Keating Creek formations, the present author agrees with Nelson's Richmond or younger assignment. Nelson's conclusion was based to large extent on coral evidence plus the presence of three species of Beatricea in the Keating Creek beds. As this genus has been reported from Richmond and Gamachian beds only, notably the Vaureal and Ellis Bay formations at Anticosti Island, Nelson's age assignment appears secure. The presence of Billingsites, Ceraurinus and Huronia, all of which are considered of upper Ordovician and particularily Richmond age, also confirms the correlation. In addition, the lower part of the Churchill River section, the Surprise Creek and Portage Chute formations, contains the typical Red River elements Receptaculites and Maclurites which, as indicated in the discussion of the Baffin Island section (page 20), are probably of pre-Richmond, upper Ordovician age. Thus, the Stony Mountain equivalents of the Churchill River section appear to be of Richmond or possibly younger (Gamachian) age.

GOD'S RIVER, MANITOBA:

Stony Mountain		God's River	
Stony Mountain fm.	(Birse) Gunton mem.	Shamattawa fm.	? Upper Dolomite
	Penitentiary mem.		Lower Limestone
	Stony Mntn. Sh.		

Large fossil collections were made by Savage and Van Tuyl (1919) from the Shamattawa formation which outcrops on God's River, Manitoba. The formation is about forty feet thick and consists of an upper yellowish brown dolomitic limestone member and a lower grey limestone member. Both members were recognized as having a Richmond fauna, much like that of Stony Mountain and with some similarities to the Richmond of Anticosti Island. Later work by Foerste and Savage (1927), dealing mainly with the cephalopods, confirmed the correlation with the Stony Mountain formation. Although the fauna excluding the cephalopods bears only a tentative identification, some significance can be seen in the following list of species in common with Stony Mountain forms, in which G indicates the same genus, similar species, and GS indicates the same genus, same species.

Stony Mountain	Shamattawa River Upper Dolomite	Shamattawa River Lower Limestone
Brachiopods:		
Strophomena fluctuosa Billings		GS
Pionorthis sola (Billings)	G	G
Lepidocyclus laddi Wang	G	G
Dinobolus sp.		G
Cephalopods:		
Billingsites boreale (Parks)		GS
Westenoceras (?) cf. contractum Foerste and Savage		GS
Cycloceras cf. acutoliratum Foerste and Savage		GS
Huronia cf. arctica Troedsson	G	G
Trilobites:		
Bumastus sp.		G

In the above list, a similarity both in forms (although much limited) and in distribution of species is apparent with the "common fossils list" for the Churchill River (page 31). The lower limestone beds appear to correlate well with the Bell Creek formation and the upper dolomite with the Keating Creek formation. Consequently it appears that the Stony Mountain - Churchill River correlation can be extended to the God's River sections with a similar, tentative, member-for-member correlation.

NELSON RIVER:

Stony Mountain fm.	Shamattawa fm.
Red River fm.	Nelson River fm.

Rocks very similar to those of the Churchill and God's Rivers were described from the Nelson River by Savage and Van Tuyl in 1919. Two major units were recognized, each with an abundant fauna. The lower unit, the Nelson River formation is very similar to the Churchill River formation, both in fauna and lithology. The upper unit resembles the Shamattawa formation of God's River and was referred to that unit by Savage and Van Tuyl. Like the Shamattawa at its type locality, that of the Nelson River consists of two units. Unfortunately, the faunal lists for this section are incomplete and contain only generic identifications, of little use for exact correlation. Recent work by S. J. Nelson should be forthcoming soon, which should help to show the complete fauna of these strata. Until then, Savage and Van Tuyls' correlation to the Shamattawa of God's River, and hence to the Stony Mountain, is the best generalization available.

ANTICOSTI ISLAND, QUEBEC:

Stony Mountain	Anticosti Island
Stony Mountain fm.	Ellis Bay fm.
	Vaureal fm.
	English Head fm.
Red River fm.	(concealed)

Twenhofel, in 1928, described the very fossiliferous rocks of Anticosti Island. The Richmond section consists of a lower English Head formation and an upper Vaureal formation. These are overlain by the Ellis Bay formation which is believed to be the youngest Ordovician strata exposed in North America, to which the series name Gamachian is applied. In Twenhofel's report a definite correlation was made between the Stony Mountain formation and zones three to five of the Vaureal formation. This correlation was based on thirty-three Stony Mountain species which were common to the Anticosti section (Twenhofel, 1928, page 67). Nelson (1952, page 99) found that of the thirty-three species, only six which were all bryozoa, were confined to the Vaureal formation, and suggested that more detailed studies would be necessary to validate Twenhofel's correlation.

The present study of the trilobites, cephalopods and brachiopods of the Stony Mountain formation enables a more satisfactory comparison of the Manitoba and Anticosti sections. In the following list of forms common to both areas, fossils which are present at Anticosti with the same genus and species as at Manitoba are indicated by the letters GS, those with the same genus but similar species with the letter G.

Stony Mountain	Anticosti Island		
	English Head	Vaureal	Ellis Bay
Trilobites:			
Ceraurinus icarus (Billings)	GS	GS	GS
Calymene retrorsa Foerste	G	G	G
Cephalopods:			
Beloitoceras percurvatum Twenhofel			GS
Billingsites cf. *newberryi* (Billings)	GS		
B. costulatum (Whiteaves)	G	G	
Brachiopods:			
Pionorthis carletona Twenhofel	GS	GS	GS
P. sola (Billings)		GS	
Dalmanella storeya Okulitch	G	G	G
Megamyonia nitens (Billings)	GS	GS	GS
Strophomena fluctuosa Billings	GS	GS	GS
S. planocorrugata Twenhofel	GS	GS	
Dinobolus sp.	G	G	
Hypsiptycha anticostiensis (Billings)	GS	GS	GS
Lepidocyclus perlamellosus (Whitfield)	GS	GS	

From the foregoing list, the Stony Mountain formation would appear to be closely related to the entire Richmond and Gamachian section at Anticosti with about equal affinity for each of the English Head and Vaureal formations and somewhat less affinity with the Ellis Bay formation. It is of interest that only a small part of the Anticosti fauna is represented at Stony Mountain, the remainder showing little similarity to other sub-arctic localities, suggesting that the seas to which the Anticosti and Stony Mountain faunas were associated, were at least partially separated. It should also be noted that much of the fauna at Stony Mountain, notably the bryozoans, have not been adequately studied, and further work may change the above noted correlations.

BIGHORN MOUNTAINS, WYOMING:

Stony Mountain	Wyoming	
		?
Stony Mountain fm.	Bighorn Dolomite	Leigh member
Red River fm.		
		Lander Ss. mem.

Upper Ordovician rocks are known to underly most of Wyoming, Montana and southeastern Idaho where they are included in the Bighorn formation. At the type locality from which the formation gets its name, the Bighorn Mountains, Wyoming, this formation is over 300 feet thick and is divided into three members, a basal sandstone (Lander member), a middle massive bedded dolomite member, and an upper thin bedded dolomite (Leigh member). The age of the Bighorn formation has for a long time been somewhat of a problem. Dunbar (in Twenhofel, 1954, page 257) states:

"One of the most troublesome problems to be faced in constructing the chart [G. S. A. Correlation Chart of the Ordovician Formations of North America] has been the age of the Bighorn formation and its correlatives. Such formations are widespread in the Rocky Mountain region and form extensive outcrops in Manitoba and along the west side of Hudson Bay and farther north in the Arctic Islands, notably in Baffinland and Greenland. They are believed to record a very extensive arctic invasion of relatively short duration. They carry a large and diversified fauna that permits ready correlation from one area to another in this province, but has little in common with any of the faunas in the standard section based on the Appalachian province. Furthermore, these western and arctic faunas have a strange mixture of Mohawkian and Richmondian genera as a result of which there has been a good deal of uncertainty as to whether they were of Middle or Upper Ordovician age or whether in many areas Richmondian rested disconformably on Black River or early Trenton beds".

The Bighorn formation was originally placed in the Silurian system, on the basis of corals. (Comstock, 1873;

Eldridge, 1894). Beecher in 1896 recognized it to be older than Silurian, and after the first extensive fossil collection, made by Darton in 1906, and identified by Ulrich, an Ordovician age was established. Ulrich regarded the fauna of the middle massive member to be of Galena-Trenton age and that from the upper thin bedded member to be Richmond. Miller (1930, 1932) made the most comprehensive study of this formation and regarded all of it as having a Richmond age.

Unfortunately only the cephalopod part of the fauna has been adequately studied. Faunal lists of the three members have very few fossils of the other phyla which bear specific designation, most having merely "confer" or "affinis" notations. As a result, a list of species of brachiopods, cephalopods and trilobites probably common to both the Stony Mountain and Bighorn formations includes only Pionorthis carletona and Megamyonia nitens, the former from the Lander member, the latter from the Leigh. In addition, Tetraphalerella, Hypsiptycha, Lepidocyclus, Thaerodonta, and Billingsites have been reported from the Bighorn formation and in all probability are closely related in both localities. It is noteworthy that whereas these genera are usually associated with the Stony Mountain formation above the typical Red River fauna, in Wyoming they are found throughout the Bighorn formation, associated with typical Red River faunal forms in the lower members. Until specific determinations of the Bighorn forms have been made any explanation of this unusual association is conjectural.

From the cephalopods Miller has been able to show that the fauna of the Lander and Lower Dolomite members are probably of similar age, their differences being due largely to different ecologies. He stated (Miller, 1930, page 205) that the "combined faunas of these two members really represent a single fauna zone which is to be contrasted with the Upper Bighorn" [upper thin bedded dolomite member]. In the same paper the Lander member was correlated with the Dog Head member, and the lower massive dolomite member with the Cat Head and Selkirk members of the Red River formation. This correlation was based primarily on a comparison of cephalopods of the two areas. The upper thin bedded dolomite member was correlated with the Stony Mountain formation on the basis of stratigraphic position and overall similarity of faunas. After further study of the cephalopods of the lower massive dolomite, Miller decided that a member-for-member correlation with the Red River formation could not be made due to the appreciable range of the components of the parts of the fauna which have been studied, (Miller, 1942, page 531). This decision did not alter Miller's previous general correlation of the Upper Bighorn member as equal to the Stony Mountain formation, and the Lower Bighorn member and Lander sandstone member equal to the Red River formation, all of which he considered to be of Richmond age. In Miller and Youngquists' recent work on the fauna of Baffin Island (1954, pages 36-38) the age of the Lander and massive dolomite members of the

Bighorn was considered as more probably pre-Richmond but yet upper Ordovician. This would leave only the high member, or the Stony Mountain equivalent, as Richmond age.

This author agrees with Miller's correlation which is admittedly of a preliminary nature. Before the correlation can be considered definite however, the Bighorn invertebrates other than cephalopods must be studied more thoroughly.

CENTRAL COLORADO:

Stony Mountain	Colorado	
		?
Stony Mountain fm.	Fremont fm.	Priest Canyon mem.
Red River fm.		Massive Dolomite mem.

In Central Colorado there is a series of thick bedded dolomites known as the Fremont formation which has strong similaries to the Bighorn formation of Wyoming. The Fremont formation consists of a lower massive dolomite, with a maximum thickness of 208 feet, and an upper thin-bedded argillaceous dolomite, less than 75 feet thick. An upper Ordovician fauna was reported from the formation by Miller (1932), Foerste (1935), and Johnson (1945), each of whom considered the fauna an extension of the "arctic Ordovician fauna". Prior to a study by Sweet (1954) the fauna consisted mainly of cephalopods from what was considered a single faunal unit. Sweet was able to recognize significant faunal differences in the two lithologic units, based on both cephalopods and other forms present. The two lithologic and faunal units of the Fremont were considered by Sweet to be of member rank, and to which be assigned the names Massive Dolomite member and Priest Canyon member.

Although the faunal studies of the members of the Fremont are not yet complete, some comparisons are noteworthy. The list of fossils from the Massive Dolomite member (Sweet, 1954, p. 300-301) includes almost twice as many cephalopods as corals, brachiopods, and gastropods. Seventeen cephalopods are present, of which 11 also occur in the Bighorn formation, and eight are known from the Red River formation. The list for the Priest Canyon member, on the other hand, contains seven brachiopods and one or two each of other phyla. Of the seven brachiopods reported from this member, no species are "common" with those of Stony Mountain. It is interesting, however, to note that each of the three Stony Mountain brachiopod elements referred to earlier are also present in the Priest Canyon. Forms which show this affinity include:

Lepidocyclus capax (Conrad)

Lepidocyclus sp. (resembles *L. Rectangularis* Wang)

Plaesiomys proavita (Winchell and Schuchert)

Plaesiomys spp. [appears to be a pionorthid]

Strophomena spp.

The only species common to both the Priest Canyon and Stony Mountain is Ceraurinus icarus (Billings) which in Manitoba is also present in the Red River formation.

From a comparison of lithologies and faunas of the lower and upper members of the Fremont formation, Sweet concludes that they are the correlatives of the Red River and Stony Mountain formations respectively. The present author considers the correlation most acceptable, considering the distribution of forms within each member, but would indicate that the correlation can only be considered approximate until the fauna has been more completely studied.

NEW MEXICO AND TEXAS:

Stony Mountain fm.	Montoya fm.	Upper thin bedded dolomite
Red River fm.		Lower massive dolomite

Outcropping in southern New Mexico and the Trans-Pecos area of Texas, are a series of limestones known as the Montoya formation. The formation is about 250 feet thick and is thought by Miller (1930, page 209) to represent the southern extension of the Bighorn and Fremont dolomites. Like those dolomites, the Montoya can be divided into a lower massive, thick-bedded member, and an upper slabby, thin-bedded member. Unlike the Bighorn and Fremont, however, both members of the Montoya are limestones. A similarity of fauna can also be recognized between the Montoya and the Bighorn in that in both formations, typical Stony Mountain forms such as <u>Lepidocyclus</u> and <u>Ceraurinus</u> are found in both upper and lower parts, mixed with typical Red River elements such as <u>Receptaculites</u>, <u>Hormotoma</u> and <u>Maclurites</u>. Unfortunately an additional similarity is the incompleteness of palaeontological study.

Miller (1930, page 209) observed that the fossils of the two Montoya members "are strikingly similar to those of the corresponding zone in the Bighorn formation". From this tentative correlation it would seem that if the Upper Bighorn dolomite is equal to the Stony Mountain formation, then probably also is the Upper Montoya limestone. The present author would add the same reservation that was attached to the Fremont and Bighorn correlations, that more work is necessary before detailed relationships will be known.

<u>BRITISH COLUMBIA AND ALBERTA:</u>

Stony Mountain fm.	?
	Beaverfoot fm.
Red River fm.	?

In the Rocky Mountains of southeastern British Columbia and western Alberta there is a thick series of unfossiliferous limestones called the Beaverfoot formation. The formation was placed in the Richmond by Burling in 1922 who found Halysites gracilis and Beatricea in the limestones. Wilson in 1926 made a comprehensive collection and study of the Beaverfoot fossils, and came to the conclusion that although a close similarity can be found between the brachiopod genera and those of Stony Mountain and the Bighorn Mountains, internal structures showed definite specific differences. Similar relations were indicated among the corals, which include Calapoecia anticostiense, Favistella alveolata, Halysites, and Paleofavisites asper. Other noteworthy components of the fauna are Rhynchotrema [Lepidocyclus] kananaskia, Dinorthis [Pionorthis], Receptaculites, Hormotoma, and Beatricea nodulosa. The last mentioned form, Beatricea nodulosa has long been recognized as a component of the Stony Mountain formation, as are Calapoecia anticostiense and Paleofavisites asper. Other forms however, such as Receptaculites, Halysites and Hormotoma are characteristic of the Red River fauna. This mixture of faunas was also noted by Miller (1930, page 210) who thought both faunal zones of the Bighorn formation to be present in the Beaverfoot. Until the brachiopods and corals of the Bighorn fauna have been more thoroughly collected and studied, it would appear best to accept Miller's correlation. If the Bighorn - Stony Mountain correlation (page 39) is valid, this would then mean that the Beaverfoot formation is equal to part of both the Stony Mountain and Red River formations. As Beatricea nodulosa is confined to the Gunton member of the Stony Mountain formation, the upper limit of the Beaverfoot correlation must lie within that unit.

UPPER MISSISSIPPI VALLEY:

Stony Mountain fm.	Maquoketa fm.	Brainard mem.
		Fort Atkinson mem.
		Clermont mem.
		Elgin mem.
Red River fm.		

A series of shales and limestones known as the Maquoketa formation outcrop over a wide area in the upper Mississippi Valley, particularily in northern Iowa. In Iowa the formation is divided into four members which in ascending order are the Elgin Dolomite, Clermont Shale, Fort Atkinson Limestone, and Brainard Shale members. There has been considerable question regarding the relationship of the Maquoketa to the Arctic faunas. Ladd (1929), after extensive studies of the stratigraphy and palaeontology of the formation concluded that nearly all of the fauna of the northern outcrops was of Arctic derivation. Later authors consider the evidence non-conclusive (Foerste, 1935, page 233; Nelson, 1952, page 118), and suggest that the Arctic elements present may represent periods of temporary coalescence of the Arctic sea with what otherwise was a Gulf of Mexico sea. The present author feels the latter idea to be most acceptable due to a general lack of similarity between Stony Mountain forms and those of the Maquoketa, except in a few cases, all confined to the brachiopods.

A comparison of the cephalopods, trilobites, and brachiopods of the Stony Mountain and Maquoketa formations shows almost no affinities among the first two faunas and partial affinities with the brachiopods. This is indicated by the following list of Stony Mountain fossils also known to be present in the Maquoketa.

Brachiopods:

Megamyonia raymondi (Bradley)

Strophomena fluctuosa Billings

S. occidentalis Foerste

Tetraphalerella cf. *planodorsata* (Winchell and Schuchert)

Thaerodonta dignata Wang

Lepidocyclus laddi Wang

Opikina pergibbosa (Foerste)

Trilobites:

Calymene retrorsa Foerste

From the above list it is apparent that the two faunas are closely related. It is noteworthy however, that such a small part of the Stony Mountain fauna is related to a relatively small part of the Maquoketa fauna. Because of this general lack of similarity, and the meagre part of the fauna which shows definite relations, the present author has refrained from making a member-for-member correlation, but would prefer to acknowledge a general equivalence of the formations themselves.

CHAPTER IV

SUMMARY AND CONCLUSIONS

From the foregoing study, the Stony Mountain fauna can be regarded as having close affinities to three, and perhaps four, other well recognized faunas. The most dominant of the three affinities is with the "Arctic fauna" and is best shown by the correlation of the Stony Mountain formation to sections at Greenland, Churchill and God's Rivers, and to lesser extent the Bighorn Mountain section. Another affinity is indicated by the correlation of the Stony Mountain fauna to that of the Upper Ordovician section at Anticosti Island which has a much different aspect, being more closely related to eastern faunas. The third affinity is with the fauna of the Maquoketa formation of the upper Mississippi Valley, with which the Stony Mountain fauna shows limited similarities, most of the Maquoketa fauna having stronger affinities to that of the Ohio section. The last affinity for the Stony Mountain fauna is perhaps to that of the Red River formation which may be considered an ancedent fauna. Geographic affinities for each of the three phyla studied are also apparent and are discussed in some detail in Chapter II.

The correlation of the Stony Mountain formation is summarized graphically on Plate 2, page 51, which is a composite correlation chart in which individual correlations

Period	Standard Section for North America	Stony Mountain, Manitoba	Greenland	Baffin Island	Churchill R.	Nelson R. & God's R.	Anticosti Is.	Bighorn Mountains, Wyo.	Central Colorado	New Mexico & Texas	British Columbia	Upper Mississippi Valley
SILURIAN		Stonewall Fm.										
UPPER ORDOVICIAN	Gamachian	Stony Mountain Fm.: (Birse)					Ellis Bay Fm.					Maquoketa Formation: Brainard mem.
UPPER ORDOVICIAN	Richmondian	Stony Mountain Fm.: Gunton mem.; Penitentiary mem.; Stony Mountain Sh. mem.	Cape Calhoun Fm. (restricted)		Keating Creek Fm.; Bell Creek Fm.	Shamattowa Fm.	Vaureal Fm.; English Head Fm.	Bighorn Dolomite: Leigh mem.	Fremont Formation: Priest Canyon mem.	Montoya Formation: Upper	Beaverfoot Fm.	Maquoketa Formation: Fort Atkinson mem.; Clermont mem.; Elgin mem.
UPPER ORDOVICIAN	Maysvillian	Red River Fm.	Cape Calhoun Fm. (restricted) (cont.)	Silliman's Fossil Mount Fm.	Surprise Creek Fm.	Nelson River Fm.	(concealed)	Bighorn Dolomite (cont.)	Fremont Formation (cont.)	Montoya Formation: Lower	Beaverfoot Fm. (cont.)	
UPPER ORDOVICIAN	Edenian	Red River Fm. (cont.)	Cape Calhoun Fm. (restricted) (cont.)	Silliman's Fossil Mount Fm. (cont.)	Portage Chute Fm.	Nelson River Fm. (cont.)	(concealed) (cont.)	Bighorn Dolomite: Lander Ss. mem.	Fremont Formation (cont.)	Montoya Formation: Lower (cont.)		
MIDDLE ORDOV.	Trentonian		Gonioceras Bay Ls.				Makasti Fm.					

Plate 2
Composite Correlation Chart

from Chapter III have been related to the standard section for North America. In placing the Stony Mountain within the Richmond the author has considered the close correlations which the formation appears to show with the Anticosti Island, and Baffin Island sections. The faunas of both have been studied carefully and more completely than those of most other areas, and part of the Anticosti fauna serves as the "standard" for the Gamachian of North America. The position of formations at other localities has been derived from consideration of equivalents of the main correlation.

Although each of the correlations has been summarized within Chapter III, several features of the composite correlation chart may bear further explanation. The basic correlation of the Stony Mountain formation to English Head, Vaureal, and part of the Ellis Bay of Anticosti Island is based on strong similarities shown among each of the three phyla studied. This equivalence is best evidenced by the brachiopod genera Pionorthis, Dalmanella, Megamyonia, Strophomena, Hypsiptycha and Lepidocyclus. Cephalopod relations are numerically small but are considered important as they comprise the genera Billingsites and Beloitoceras. The author has shown only part of the Ellis Bay formation to be equivalent to the Stony Mountain section because only a small part of the two faunas concerned appear related. The fact that very little material has been collected from the Gunton member may partially explain the apparent lack of equivalence, although the fauna of the Ellis Bay formation appears to be much larger and more diversified than that indicated by present Gunton collections. As the upper age limit of the other sections shown on the chart has been derived through correlation with the Manitoba section, they have been restricted accordingly to ages older than part of the Ellis Bay formation.

The lower age limit of the Stony Mountain formation and its equivalents is from consideration of the correlation of the "Silliman's Fossil Mount" beds with the Red River and equivalent formations. As shown by Miller and Youngquist, a study of the cephalopods, brachiopods, trilobites and ostracods from the Baffin Island strata are found to exhibit both Middle and Upper Ordovician affinities, which would most conveniently be regarded as post Trenton, pre-Richmond in age. Miller and Youngquist indicated a correlation of the Baffin Island section with the Red River formation. The present author, after a comparison of cephalopod, brachiopod and trilobite affinities of the Red River and Stony Mountain faunas with those of the Silliman's Fossil Mount fauna considers Miller and Youngquists' correlation valid, thereby fixing the lower age limit of Red River and equivalent formations at the beginning of Eden time, and also placing the base of the Stony Mountain and equivalent beds within the Richmond.

The Stony Mountain formation, as discussed in Chapter III, is considered by the author to be equivalent to the upper part of the Cape Calhoun formation of Greenland; the Keating Creek and Bell Creek formations of the Nelson River; the Shamattawa formation of the Nelson and God's rivers; the Leigh member of the Bighorn Dolomite of Wyoming; the Priest Canyon member of the Fremont formation of Colorado; the upper part of the Montoya formation of New Mexico; part of the Beaverfoot formation of British Columbia; and the Maquoketa of the upper Mississippi Valley. These equivalents have been derived from comparison mainly of the cephalopods, trilobites and brachiopods of the respective faunas as well as consideration of stratigraphic position above Red River equivalents. Details of each correlation are developed in Chapter III.

An alternative correlation which warrants consideration is that of inclusion of part or all of the Red River formation and its equivalents in the Richmond. This correlation is supported by the presence of some Stony Mountain forms in what appear to be Red River equivalents, and the general similarity of the two faunas. It is challenged however, by the abundance of "Mohawkian type" cephalopods in the Red River and equivalent units. The two conflicting ideas appear to be best compromised in considering the fauna as a recurring Mohawkian fauna of Richmond age. Such a correlation has been popular in the past with several authors, notably Miller and Foerste, and is difficult to evaluate due to a general inability to relate the fauna to that of typical Eden - Maysville age. If it were possible to show either an affinity or lack of same between such faunas, the lower age limit of the Red River and equivalent formations could be established.

Attention is drawn at this point to the inclusion of the Stonewall formation in the composite correlation chart. The Stonewall formation, which immediately overlies the Stony Mountain formation in the vicinity of Stony Mountain, has been generally considered of Silurian age. During the completion of this thesis, evidence was presented by Colin W. Stearn (1956) which that author considered would remove the Stonewall beds from the Silurian and place them with the Richmond. Stearn found that "of the 28 fossils identified from the Stonewall formation, 14 were species that also occur in Richmond age formations [including the Cape Calhoun, Shamattawa, Stony Mountain and Churchill River beds], seven were indigenous species of typically Richmond age genera, and two were indigenous species of no value in correlation." Of the remaining fossils only three had recognized Silurian significance. The present author would question Stearn's proposed changes mainly on the lack of adequate collecting from the Stonewall formation. Many of Stearn's species are based on fragmentary material for which specific identification is difficult. In addition, the fauna, although containing "Richmond" forms, does not have the same diversity and general aspect of other Richmond, or Gamachian faunas. Finally, the present author would prefer to attach greater significance to the introduction of new forms, even though few in number, than to "hold-overs" from an earlier age. For these reasons, the Stonewall formation has been included on the correlation chart, but with question marks to signify some degree of uncertainty.

CHAPTER V

SYSTEMATIC PALAEONTOLOGY

Phylum Arthropoda

Class Crustacea

Subclass Trilobita

Order Proparia

Family Calymenidae Milne - Edwards

Genus *Calymene* Brongniart

Calymene retrorsa Foerste

Plate 3, figure 1

Calymene meeki retrorsa Foerste, Bull. Sci. Lab. Denison Univ., Vol. 16, p. 85, pl. 3, fig. 19 (1919).
Calymene retrorsa Foerste, Geol. Surv., of Canada Mem. 138, p. 247, pl. 44, fig. 2, pl. 45, fig. 15 (1924).

This species is represented in the collection by one incomplete cephalon showing the glabella, occipital ring, and palpebral lobes.

The specimen shows the same essential features as *Calymene retrorsa* Foerste but also shows a close resemblence to *C. callicephalla* Green, the two species having very similar glabellae. The specimen has a less triangular glabella with a more blunt anterior margin than the latter and for that reason has been referred to *C. retrorsa*. This species is distinguished from *C. senaria* Meek [*C. meeki* Foerste], by the wider glabella, curved occipital ring, and rounded anterior margin of the latter.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Family Cheiruridae

Genus Ceraurus Green

Ceraurus bituberculatus Troedsson

Plate 3, figure 4

Ceraurus bituberculatus Troedsson, Ordov. Faunas of Greenland, Pt. 2, p. 69, pl. 17, figs. 11, 12, (1928).

This species is represented by one incomplete cephalon including the glabella, occipital ring, and part of the fixed cheeks.

The specimen agrees well with that illustrated by Troedsson except that the two prominent tubercles are better defined and well rounded on the Stony Mountain species. The spine on the neck ring of Troedsson's type specimen is present but appears to be only a large rounded tubercle. The small tubercles on the glabella are ten in number as against Troedsson's four, but retain the symmetrical arrangement. The fixed cheeks are finely punctate and less finely tuberculate.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Ceraurus bispinosus Raymond and Barton

Plate 3, figure 9

Ceraurus bispinosus Raymond and Barton, Bull. Mus. Comp. Zool., Vol. 54, p. 536, pl. 1, fig. 3, 4, (1913).

One incomplete cephalon with glabella, fixed cheek, and occipital ring shows definite similarities to the species. Although the specimen is about 2/3 smaller in size it shows the same general shape and ornamentation as C. bispinosus. Relative size of the lobes of the glabella are of the correct proportions, and the divergence of the furrows is the same. One complete fixed cheek is present and shows close similarity with C. tuberosus Troedsson. The only dissimilarities between this specimen and the C. bispinosus illustrated by Troedsson are the less pronounced spines or tubercles and the possibility of a broken spine or tubercle on the occipital ring of the Stony Mountain formation. There are at least eight small tubercles on the glabella, in a more or less symmetrical arrangement by pairs, but the pronounced second pair of Raymond and Barton's specie appear no more pronounced than the others. The front lobe appears to be rather indistinctly divided into two low but large tubercles, somewhat as in C. bituberculatus Troedsson, but much less pronounced.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Ceraurus horridus Troedsson

Plate 3, figure 8

Ceraurus horridus Troedsson, Ordov. Faunas of Greenland, Pt. 2, p. 65, pl. 17, figs. 1-9, (1928).

This species is represented by one internal mold of an incomplete and slightly distorted cephalon. The specimen shows the same general shape and dimensions as those illustrated by Troedsson, but appears to be slightly more spinose or tuberculate on the glabella. The eye stalks are prominent. There appears to be either a strongly developed tubercle rising from the posterior margin of the glabella, or the occipital ring must have been strongly arched.

Penitentiary member, Stony Mountain, Manitoba.

Ceraurus tuberosus Troedsson

Plate 3, figure 10

Ceraurus tuberosus Troedsson, Ordov. Faunas of Greenland, Pt. 2, p. 71, pl. 17, fig. 13, pl. 18, figs. 1-9, (1928).

One incomplete pygidium, one plural spine, and one incomplete thorax with pygidium and part of the fixed cheek are believed representative of this species in the collection.

The pygidia are well preserved with coarsely granulated curved spines and appear to be identical to those of the specimens illustrated by Troedsson. The incomplete thorax also agrees well with Troedsson's specimens.

The specimens show some similarity with *C. pleurexanthemus*, but the eye lobes are slightly larger and the eyes of the latter species are farther forward on the cephalon than those of the Stony Mountain specimen.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Ceraurus sp.

Plate 3, figures 2, 3

Three hypostomae are included in the group. They all are of slightly different size, but have similar proportions of width to length. The best preserved hypostoma has a length of nine mm. and width of 11 mm., comparing favorably with those of several Trenton cheirurid trilobites illustrated by Whittington (1941, pp. 492-522).

Stony Mountain Shale member, Stony Mountain Manitoba.

Genus *Ceraurinus* Barton

Ceraurinus icarus (Billings)

Plate 3, figures 5,6,7

Cheirurus icarus Billings, Can. Naturalist and Geologist, Vol. 5, p. 67, fig. 11, (1860).
Ceraurus icarus Meek, Rept. of Geol. Survey of Ohio, Paleo., 1, p. 162, pl. 14, fig. 11 a-c, (1873).
Ceraurinus icarus Barton, Bull. Mus. Comp. Zool., Vol. 54, p. 551, pl. 18, fig. 7, (1913).
Ceraurinus icarus (Billings), Troedsson, Ordov. Faunas of Greenland, Pt. 2, p. 73, pl. 18, figs. 10-15, pl. 19, figs. 1-3, (1928).

This species is represented by one excellent enrolled specimen, which lacks only the genal spines, and six incomplete specimens, most of which show part of the thorax and the pygidium.

The specimens are identical to those described and illustrated by Meek, Barton, and Troedsson.

Little difference is apparent between specimens of this species from the Stony Mountain formation and those of the Red River formation, although the glabella and fixed cheek of the latter group appear to have greater relief.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Order Opisthoparia

Genus Bumastus Murchison

Bumastus sp.

Plate 3, figures 11-13

Two incomplete specimens from the Stony Mountain collection are included in this group. The larger and more complete specimen, the one illustrated, includes most of the cephalon and about four thoraxial segments. Although some fracturing has occurred, there appears to be very little distortion.

The specimens are here referred to the genus Bumastus for their approximate similarity to species of that genus and in particular to such forms as B. fronto Troedsson (1928, pl. 14, figs. 9, 10), and B. rowleyi Bradley (1930, pl. 28, figs. 15, 16). Although a fair degree of similarity is apparent among these species, some noteworthy differences can also be seen. In the Stony Mountain specimens the first two thoraxial segments are shorter than the others which is not true of other species of this genus. In addition, the posterior margin of the cephalon shows unusual curvature which does not seem due to crushing. Also the lateral furrows are not typical, being almost completely absent and very short. The first two differences noted appear to be of generic rank, possibly indicating the presence of a new genus closely related to *Bumastus*. This author feels that this is a strong possibility but that two incomplete specimens are insufficient to warrant the establishment of a new genus, especially with no knowledge of the pygidium.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Phylum Mollusca

Class Cephalopoda

Order Nautiloidea

Suborder Cyrtochoanites

Family Actinoceratidae

Genus Huronia Stokes

Huronia cf. *arctica* Troedsson

This species is possibly represented in the collection by one siphuncle consisting of 3½ annulations. The shape of the siphuncle corresponds very well with *H. arctica* although its diameters are smaller, being 22 mm. at the widest part and 17 mm. at the constricted part. Like *H. arctica*, the annulations are strongly concave, below the widest part, in vertical section. There is a slight similarity to *H. septata*, but the proportions and concavity show a much closer relation with *H. arctica*. The incomplete nature of the specimen, the size, and the inability to determine the obliquity of the annulations makes closer identification impossible.

Penitentiary member, Stony Mountain, Manitoba.

Genus *Actinoceras* Bronn

Actinoceras sp.

Plate 5, figure 9

Several incomplete specimens of siphuncular deposits are included in this group. The specimens are not conspecific but probably congeneric as the only differences are of size. The specimens have a strong resemblence to one illustrated by Foerste (1929), as *A.* cf. *bigsbyi* from the Red River formation.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Genus *Armenoceras* Foerste

Armenoceras sp.

The collection contains several siphuncles of this species. The range considerably in size, are often compressed dorso-ventrally, and are probably not conspecific. Some of the specimens resemble *A. saxosum* very closely, but without more complete specimens, definite identification is impossible.

Penitentiary, Stony Mountain Shale and Gunton members, Stony Mountain, Manitoba.

Family Oncoceratidae

Genus *Westenoceras* Foerste

Westenoceras (?) cf. *contractum* Foerste and Savage

This species is represented by one incomplete internal mold with 3 camerae and part of the living chamber. Another somewhat similar living chamber is present, which may be conspecific.

The specimen with the three camerae agrees well with *W. contractum* except in size, being about 3/4 the size of Foerste and Savage's specimen. Although the specimen has been compressed laterally during preservation, the strongly concave septa and the apicad curvature of the sutures laterally are quite evident. Gentle dorsal and ventral saddles are also preominent. The siphuncle, visable on the base of the specimens, is sub-ventral in position and about 2 or 3 mm. in diameter.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Westenoceras latum Troedsson

Plate 5, figure 11

Westenoceras latum Troedsson, Upper Ordov. Faunas of North. Greenland, Pt. 1, p. 90, pl. 54, figs. 2, 3, (1926).

This species is represented by one complete internal mold. Although smaller than Troedsson's specimen, it compares well in all other respects. The constriction of the aperture is prominent and the gentle lobes in the lateral view. The uppermost of the 9 camerae present is much smaller than those below it, indicating probable maturity. The specimen is worn on one side showing the deeply concave nature of the septa.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Genus Beloitoceras Foerste

Beloitoceras percurvatum Twenhofel

Plate 5, figures 8, 10

Beloitoceras percurvatum Twenhofel, Geol. Survey of Canada of Canada, Mem. 154, p. 305, pl. 49, figs. 4, 5, (1928).

This species is represented by one specimen with 11 camerae and most of the living chamber. The specimen, an internal mold, has probably been compressed laterally which has accented the apicad curvature of the sutures in the lateral view. Otherwise the specimen resembles that illustrated by Twenhofel except for its reduced size, the maximum dorso-ventral diameter measured three camerae below the living chamber being about 24 mm.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Suborder Mixochoanites Hyatt

Family Ascoceratidae Barrande

Genus Billingsites Hyatt

Billingsites costulatum (Whiteaves)

Plate 4, figures 5, 6, 7

Ascoceras costulatum, Whiteaves, Pal. Foss., Geol. Survey of Canada, 3, Pt. 3, p. 215, pl. 22, fig. 1, (1897).
Billingsites costulatum (Whiteaves), Foerste, Bull. Denison Univ., Sci. Labs., Vol. 24, p. 157, pl. 13, fig. 1, (1929).

This species is represented by a single internal mold which is complete except for part of the aperture.

The specimen very closely resembles the one described by Foerste (1929) in his description of the Red River formation cephalopods. The dimensions of the specimens are almost identical, as are the location and curvature of the sutures, the only apparent difference being in the slightly more abrupt change in the direction of the basal parts of the sutures at the point of coalescence in the Stony Mountain specimen.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Billingsites boreale (Parks)

Plate 4, figures 2, 3

Ascoceras boreale Parks, Bur. Mines Ontario, 22nd Rept., p. 192, (1913); Trans. Royal Can. Inst., Vol. 11, p. 32, pl. 2, figs. 8, 9, (1915).
Billingsites boreale (Parks), Foerste and Savage, Bull. Denison Univ., Sci. Labs., Vol. 22, p. 30, pl. 3, figs. 2, 3, 4, (1927).

One internal mold in the collection appears to belong to this species. The specimen is probably compressed laterally and is relatively small, but otherwise resembles _B. boreale_ very well. The aperture is incomplete, having broken off a few mm. above the upper suture. The sutures have strongly developed lobes in dorsal view and correspondingly well developed saddles in the lateral view. The saddles, however, may be somewhat accentuated by lateral compression of the specimen.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Billingsites cf. newberryi (Billings)

Ascoceras newberryi Billings, Geol. Surv., Canada, Pal. Foss., Vol. 1, fig. 148a, not fig. 148b, (1862).
Billingsites newberryi (Billings), Twenhofel, Geol. Survey of Canada, Mem. 154, p. 258, pl. 40, fig. 4, (1928).

This species is represented by one almost complete internal mold. The specimen is slightly distorted and preservation of the sutures is not good. However, it appears to resemble B. newberryi quite well from what can be seen, more so than it resembles any of the other Billingsites.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Suborder Orthochoanites

Family Endoceratidae

Genus Lambeoceras Foerste

Lambeoceras nudum Troedsson

Lambeoceras nudum Troedsson, Upper Ordov. Faunas of North Greenland, Pt. 1, p. 47, pl. 17, figs. 3, 4; pl. 22, (1926).

This species is represented by one internal mold with eight camerae, three of which are nearly complete. Part of the dorsal and lateral sides have been removed by erosion. The lateral diameter at the widest part is 110 mm. and the dorso-ventral diameter is 32 mm. The septa show less obliquity than those of L. princeps, but in the lateral portions considerable slope is evident. The siphuncle is slightly smaller than that illustrated for L. nudum, being approximately 8 mm., but otherwise is the same.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Genus Cycloceras M'Coy

Cycloceras selkirkense (Whiteaves)

Plate 4, figures 1, 4

Orthoceras selkirkense Whiteaves, Trans. Royal Soc. Canada, Vol. 9, sect. 4, p. 82, pl. 8, fig. 2, (1892).
Cycloceras selkirkense (Whiteaves), Foerste, Bull. Denison Univ., Sci. Labs., Vol. 24, p. 161, pl. 37, fig. 4, (1929).

One incomplete specimen comprising 2½ camerae is the only representative of this species in the collection. This specimen agrees well with the description by Foerste, although the surface markings are missing. No knowledge of the siphuncle could be obtained other than its position, which checks with Foerste's illustration.

One other specimen, consisting of four camerae, with an average diameter of 8 mm. may also belong to this species as the youthful part of a large specimen.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Cycloceras cf. acutoliratum Foerste and Savage

Cycloceras acutoliratum Foerste and Savage, Bull. Denison Univ., Sci. Labs., Vol. 22, p. 36, pl. 5, fig. 10; pl. 6, fig. 3, (1927).

Three incomplete specimens, the largest with fourteen camerae, are included in this group. One of the specimens is flattened and may not be conspecific. The specimens all compare favorably with C. acutoliratum as described by Foerste and Savage. No record of the surface markings remains, and, considering the fragmentary record, a closer identification is considered inadvisable.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Phylum Brachiopoda

Family Dinorthidae Schuchert and Cooper

Genus *Dinorthis* Hall and Clark

Dinorthis iphigenia (Billings)

Plate 5, figures 5, 7

This species is represented in the collection by two complete specimens, one of which is slightly distorted.

The specimens agree well with Troedsson's descriptions and are almost identical with his figure 1(a-d). The mesial sinus on the Stony Mountain species illustrated (figure 7) is somewhat accentuated by erosion.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Genus *Pionorthis* Schuchert and Cooper

This is probably the commonest brachiopod in the Stony Mountain formation fauna. Formerly referred to *Dinorthis proavita* or *D. subquadrata* (Dowling 1898; Whiteaves 1880; Bassler 1915), Billings was the first to indicate that the Manitoba species were more coarsely ribbed than the holotypes. Schuchert and Cooper, in their revision of the Orthoidea, created the genus *Pionorthis* on the basis of *D. sola* (Billings) and *D. carletona* Twenhofel, both biconvex costate forms. Okulitch rightly referred the Manitoba specimens to this genus in his paper on the Stony Mountain formation. Okulitch also created a new species *P. occidentalis* to include most of the Manitoba specimens, differing from the Anticosti forms largely by the smaller number of costae of the former. The present author feels that the creation of the new species was not necessary in that a study of over a hundred specimens shows an average number of 32 costae, which is within the range of number of costae for P. sola and P. carletona. Also it was found that the number of costae varied considerably within each of the two species common at Stony Mountain.

The pionorthids are well preserved as internal molds and steinkerns in the Penitentiary member, and as complete shells in the Stony Mountain Shale member. The abundance of material has enabled the separation of the specimens into two major species, P. sola, the commonest, and P. carletona, also quite common. Within each group it was found that size, shape, number of costae, and even musculature, varied considerably, so that externally the two species could be considered almost as grading into each other. One other species was found, and another created, to accomodate specimens that could not be included within the major groups even in consideration of the variable character of the latter.

Pionorthis sola (Billings)

Plate 5, figures 1-4, 6

This species is the commonest brachiopod found in the Stony Mountain formation, and numerous excellent specimens, showing both interior and exterior, are present in the collection.

The specimens show some variation in size, shape, number of costae, and arrangement of muscle scars, but not enough to justify the creation of new varieties or species. The shell is biconvex, subquadrate in outline, and ranges in size from 14 mm. to 25 mm. in length, and from 17 mm. to 33 mm. in width. Costae number from 30 to 40 usually, a few of the larger specimens having up to 50 costae. Rather coarse imbricate growth lines are common near and at the anterior margin.

The pedicle valve is subquadrate in shape, with a gentle sulcus developed anteriorally, including about seven unbifurcated costae. Other costae increase by bifurcation. The interarea is of moderate width, strongly apsacline and curved. The hinge line is about 3/4 the width of the shell. The teeth are prominent, divergent, and with distinct oblique crural fossettes which are sometimes almost completely worn off. The muscle field is rectangular to sub-rectangular in shape and is wider than long. The diductors are large, strongly impressed, divergent and rounded anteriorly. The adductors are small, elongate, very deeply impressed and divided by a low, often indistinct medial septum. The adjustor scars are usually well developed and distinguishable from the diductors. Sometimes however, they are small and this separation is difficult to make, in which case the muscle field has a more rectangular shape.

The brachial valve is sub-quadrate to broadly oval in outline. The interarea is flat, narrow, orthocline or slightly anacline. Costae increase by implantation, usually only one generation of costae being present. The shell is strongly convex being ¼ as deep as the width, or about twice the depth of the pedicle valve. The cardinal process is broad, sub-triangular in shape, and is directed slightly anteriorly. The rugose myophore is divided longitudinally by a low sharp ridge. The notothyrial platform is poorly developed and consists of a very shallow shelf joining the bases of the brachiophores. Because of the small platform, the cardinal process appears to stem from the fairly heavy, low lying medial septum. The adductor muscle field is poorly shown, but usually is divided into four almost equal sections. The medial septum divides them longitudinally, and a low ridge divides them obliquely in an anterior direction.

Penitentiary and Stony Mountain Shale members, Stony Mountain, Manitoba.

Pionorthis carletona Twenhofel

Plate 6, figures 4-9

Although not as common as *P. sola*, this species is well represented by many excellent specimens in the collection.

As with *P. sola*, the specimens show minor variations in size, shape, and the number of costae, but generally exhibit greater uniformity. Costae number about 30 to 40 and increase by bifurcation on the pedicle valve, and by implantation on the brachial valve. There is very good agreement between the specimens and Twenhofel's description and illustrations.

The pedicle valve is subquadrate in outline, but less so than P. sola, having well rounded anterior angles. The interarea is narrow, and very strongly apsacline. The muscle field is bilobed, rounded anteriorly, and wider than it is long. The rounded shape appears due in part to the development of the adjustor muscles and greater divergence of the diductors. The adductors are expanded slightly and bilobed posteriorly, unlike those of P. sola. Also different is the incomplete enclosure of the adductors by the diductors due to the greater divergence of the latter.

The brachial valve is subquadrate to broadly oval in outline, with a short hinge line (about half the width of the valve). The brachial valve is usually slightly deeper than the pedicle valve, but not as deep as in P. sola. The cardinal process is short, thick, and subtriangular, and, rising from a well developed, gently curved nototherial platform, is not directed anteriorly as in P. sola, but rises straight, at right angles to the commissure. The greater development of the nototherial platform and the strong rounded medial septum produce umbonal cavities which are not present on P. sola.

The adductor muscle scars are much like those of *P. sola*, but the low ridge dividing them laterally is less oblique in direction, almost at right angles with the medial septum.

Although *P. carletona* and *P. sola* are easily distinguished on the basis of musculature and cardinalia, externally the two species are very similar. The best criterion for external identification is probably the near equal convexity of valves and less quadrate shape of *P. carletona*.

Penitentiary and Stony Mountain Shale members, Stony Mountain, Manitoba.

Pionorthis gracilis Procter n. sp.

Plate 6, figures 1-3

This species is rare at Stony Mountain, being represented by five good specimens in the collection. Unfortunately, both valves are present in all specimens, providing no opportunity for study of the interior of the shell. This species is created on the basis of its commissure and the thickness of the valves. Instead of growth lines being imbricate near the anterior margin as in *P. sola* and *P. carletona*, they all occur at the commissure, producing a very thick shell. On one specimen, which is 24 mm. wide, 19 mm. long, and 14 mm. thick, the growth lines produce an anterior margin up to 8 mm. thick. This anterior margin diminishes to 1 or 2 mm. at the hinge line, being about $3\frac{1}{2}$ mm. thick at the greatest width of the shell. At the thickest point on the anterior margin, the growth lines are gently convex, forming a rather abrupt obtuse angle with the pedicle valve. Toward the hinge line however, the youngest growth line is successively wider than its predecessor, producing a sharp "V" shaped commissure.

With the absence of internal structures, this species in all other aspects excepting the growth lines, resembles P. sola, to which it is undoubtedly closely related.

The holotype and paratypes of this species are in the University of Manitoba collection. Although all the specimens recognized as belonging to this species are from the Stony Mountain Shale member, it may also be represented in the Penitentiary member, where it would be difficult to distinguish if present as a steinkern or an internal mold, the common types of preservation in that member.

Pionorthis cf. sola (Billings)

Plate 6, figure 10

Included in this species is one well preserved pedicle valve which differs considerably from the other pionorthids. The valve is gently convex, subquadrate in outline and gently sulcate anteriorly. Costae number 32, some bifurcating near the anterior margin. The shell is 31 mm. wide, 25 mm. long, and about 5 mm. deep. The teeth and interarea are identical with those of *P. sola*. The muscle field, however, is elongate, being 12 mm. long and 9 mm. wide, unlike the other Stony Mountain pionorthids. The elongate nature of the muscle field is due to the non-divergence of the diductor muscles. The adductor scars are more like those of *P. sola* than *P. carletona*, as are the adjustor scars, which are easily distinguished.

The similarities of this species with *P. sola* suggest a close relationship, perhaps as a variety, however, the elongate shape of the muscle field prevents the specimen from being included with *P. sola*, and the lack of good specimens justifies the "confer" notation.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Family Dalmanellidae Schuchert

Genus *Dalmanella* Hall and Clarke

Dalmanella storeya Okulitch

Plate 6, figures 14-16

This species is very common in the Stony Mountain formation, there being numerous excellent specimens in the collection.

The specimens agree very well with the descriptions and illustrations by Okulitch, and in addition give a vague outline of the muscle field. In the pedicle valve the muscle field is longer than wide and bilobed. The diductor scars are about 5 mm. long, on a valve 14 mm. wide, and are slightly divergent. The adjustor scars are about half as large as the diductor scars and are indistinctly separable from them. The adductor scars are not well preserved on any of the specimens but do not appear to be enclosed by the diductors anteriorly. A ridge which is prominent just anterior to the adductors, divides the diductors, and rapidly diminishes toward the anterior margin. The muscle scars on the brachial valve are well preserved in part at least. The adductors are small, deeply impressed and divided by the medial septum.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Dalmanella jugosa subplicata Foerste

Plate 6, figures 11-13

This species is well represented in the collection being about as common as *D. storeya*.

The specimens show many of the variations referred to by Hussey (1926), and appear identical to his description. Internally the specimens are very similar to *D. storeya*, although the teeth are larger, and farther apart. The cardinal processes also differ slightly, being lower and usually thicker than in *D. storeya*. The medial septum of the brachial valve is sometimes prominent, but on some specimens is almost completely lacking.

Externally this species is easily distinguished, especially among the adult forms, from the much thicker and more biconvex D. storeya. Among the juvenile forms, the difference is more difficult to see, but young forms of D. jugosa subplicata appear to have more sharply defined folds than those of D. storeya.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Genus Opikina Salmon

Five species of this genus are believed to be present at Stony Mountain. All five are unlike the typical Opikinas in that only three septa are usually developed in the brachial valve instead of five. The other two septa are present on some specimens but are very short and almost indistinguishable. The presence of only three septa suggests an affinity of the specimens to the genus Leptaena, which however, has conspicuous concentric wrinkles on the exterior and a different cardinal process. Externally the specimens resemble the genus Rafinesquina in many ways but can be differentiated in most cases by the psuedopunctae. In Opikina the psuedopunctae are fine, of irregular shape, and not arranged radially. Those of Rafinesquina are comparitively large, round, and arranged in rows between the striae. The external similarity of Opikina to *Rafinesquina* has resulted in many species of the former being referred to the latter.

Opikina pergibbosa (Foerste)

Plate 7, figures 5-7

Rafinesquina pergibbosa (Foerste) Hussey, 1926, Contrib. Museum of Geol., Univ. of Michigan, Vol. 2, pl. 4, figs. 7-9.

This species is represented in the collection by 13 specimens, six of which show the interior of the brachial valve, and one, an internal mold, shows the interior of the pedicle valve.

The species is subquadrate in outline, with a rounded anterior margin, posterior margin gently sloping from beak to cardinal extremities which are slightly auriculate. The lateral profile is strongly concavo-convex, with geniculation about 3/4 of the length from the beak. The length is consistently 2/3 of the width, the greatest width being at the hinge line. Surface markings are typical for *Opikina* and the posterior margin is marked by a few oblique wrinkles.

The brachial valve appears identical with the one illustrated by Hussey. The brachial interarea is narrow, about 1/3 that of the pedicle, is strongly hypercline, with a moderate size arched chilidium. The cardinal process is strong, but smaller than those of the other Stony Mountain *Opikinas*.

The pedicle valve is unfortunately incomplete. The adductor tracks are elongate, separated by a low median septum, and may or may not be enclosed by the diductor scars anteriorly. The diductor scars are expanded laterally, and flanked by the adjustor scars, which are about twice the size of the adductor track. Dental plates appear low but prominent. The interarea is wide, flat, orthocline or slightly apsacline with an arched deltidium.

This species resembles O. limbrata Wang and Opikina sp. Wang, both of which however have all five septa developed on the brachial valve. The species is easily distinguished from other members of this genus at Stony Mountain by its ratio of width to length.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Opikina lata Procter n. sp.

Plate 7, figures 8-11

This species is represented by 22 specimens, nine of which show the interior of the brachial valve, and five of which show the interior of the pedicle valve.

The shells range in size from 22 mm. to 28 mm. wide, and 18 mm. to 23 mm. long, the greatest dimension being at the hinge line or slightly anterior to it. The outline is evenly rounded with gentle slopes from the beak to the cardinal extremities which are slightly auriculate. The lateral profile is strongly concavo-convex, the greatest convexity occurring just posterior to the center. The surface is covered by unequal costellae, about 5-7 finer ones occurring between each strong pair. Additional costellae arise by implantation and do not attain the same prominence as the older generation. The psuedopunctae, where visable, appear typical for Opikina. The posterior margin is marked by oblique wrinkles.

The pedicle interarea is flat, orthocline and up to two mm. wide at the beak. The delthyrium is covered by a convex deltidium. The teeth are small, blunt, and have a rugose surface. The dental lamellae are low but distinct and diverge at an angle of about 110°. The muscle field is sub-circular to oval in shape and occupies less than half of the interior surface. The muscle field is outlined by a low marginal ridge, and divided longitudinally by the median septum which is low but sharp and extends almost to the anterior margin. The diductors scars are large and expanded anteriorly. The adjustor scars, which are about ½ the size of the diductors scars, are separated from the latter by a faint ridge. Both the diductor and adjustor scars are marked by fine radial striae. The adductor track is bilobed, slightly enlarged anteriorly, and enclosed by the diductor scars.

The brachial interarea is narrow and strongly hypercline, with a convex chilidium. The cardinal process is stout, bilobed, and elevated above the thick notothyrial platform. The visceral area is strongly marked by a marginal thickening which produces a 115° geniculation about 15 mm. from the hinge line. The adductor muscle field is small, semicircular in shape with a lobate margin, and divided by the medial septum, which is strong and tapers anteriorly. The median septum, which extends to the line of geniculation, is flanked by the first pair of lateral septa which are almost as long as the median, are curved, and are most pronounced just anterior to the muscle field. The outer lateral septa are almost obsolete, rarely extending outside the muscle field and insignificant within it. The brachial processes are strong, high, sharp, and are extended directly laterally. The sockets are partially rugose.

O. lata resembles *O. minnesotensis* (N. H. Winchell) in some respects but is easily distinguished by the smaller pedicle muscle field, obsolete outer lateral septa, and slightly different outline of the first mentioned species.

The holotype and paratypes of this species are in the University of Manitoba collection.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Opikina manitobensis Procter n. sp.

Plate 7, figures 12-15

This species is represented by 22 specimens, six of which show the interior of the brachial valve, and three of which, all internal molds, show the interior of the pedicle valve.

The shells are almost hemispherical in outline with a well rounded anterior margin. The posterior margin slopes gently from the beak to the cardinal extremities which are flattened but not auriculate. The lateral profile is strongly concavo-convex, the greatest convexity occurring at the umbo. The posterior margin is marked by 3 or 4 oblique wrinkles. The surface of the shell is covered by unequal costellae, about 4 or 5 finer ones occurring between each strong pair. The psuedopunctae, although very poorly shown, appear typical for Opikina. The specimens range in size from about 20 mm. to 30 mm. in width, 18 mm. to 26 mm. in length, and 10 mm. to 15 mm. in thickness. Most of the specimens, however, are of the larger dimensions.

The interior of the pedicle valve is not too well known as two of the specimens appear distorted and the preservation is only fair. The interarea is flat, orthocline to slightly anacline, and up to 2 mm. wide at the beak. The delthyrium is covered by a prominent convex deltidium. The teeth appear moderate in size, blunt, widely divergent and have a corrugated surface. The dental lamellae are strong and diverge at an angle of about 115°. The muscle field is not very well preserved but appears to be the same as that of O. lata but smaller. The muscle field is well outlined laterally by a low ridge, but is less well defined anteriorly.

The brachial interarea is flat, narrow, and strongly hypercline, with a convex chilidium. The cardinalia is the same as in O. lata. The visceral area is defined by a marginal thickening which produces a rounded geniculation similar to that of O. lata but not as strong or sharp. The muscle field is similar to that of O. lata but not as well defined. The septa are shown only in the center-to-posterior portion of the valve and are almost insignificant there. The median septum appears to continue to the line of geniculation but is very weak. The oter lateral septa are shown only within the muscle field. A distinguishing feature of this species is the anterior slope of the brachial processes as compared with O. lata or O. pergibbosa.

This species is easily distinguished from other Stony Mountain Opikinas by its large size, thickness, and high convexity. The interior of the brachial valve is similar to that of O. lata but differs in that the inner lateral septa are not as well developed, the brachial processes slope slightly anteriorly, and the visceral area is not as well defined.

The holotype and paratypes of this species are in the University of Manitoba collection.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Opikina parva Procter n. sp.

Plate 7, figures 1-4

This species is represented in the collection by thirteen specimens, five of which show the brachial interior, five the pedicle exterior, and three the pedicle interior.

The shells are almost hemispherical in outline, with a well rounded anterior margin. The greatest width is at the hinge line or slightly anterior to it. The lateral profile is concavo-convex with moderate uniform convexity. The surface ornamentation is identical with that of *Opikina* sp. except that the oblique wrinkles on the posterior of the brachial valve are more pronounced on *O. parva*. The dimensions of the shell are 18 mm. wide, 16 mm. long, and 4 mm. thick.

The brachial valve of *O. parva* is similar to that of *O. lata* except that the muscle field is much smaller and the median septum less pronounced on the former species. The visceral area is outlined by a low ridge and includes most of the inner surface. The muscle field is distinctly outlined, subcircular in shape and about 7 mm. wide. A low medial septum divides the muscle field but does not extend outside of it. The adductor tracks are slightly enlarged anteriorly and are enclosed by the diductor scars. The adjustor scars are about half the size of the diductor scars, from which they are not easily distinguished. Both the diductor and adjustor scars are marked by fine radial lines.

The structures of the brachial valve appear less distinct than those of the other Stony Mountain *Opikinas*. Like *O. manitobensis*, there is no abrupt geniculation at the margin of the visceral area. The muscle field is poorly defined but is essentially the same as in *O. manitobensis*. The medial septum is very weak and extends only to the center of the valve. The adjacent lateral septa are also weak, slightly curved and about as long as the medial septum. The outer lateral septa are obsolete. The cardinal process is bilobed and comparitively small. The brachial processes are strong, sharp, and extend slightly anteriorly as well as laterally.

This species is most easily distinguished from other members of this genus at Stony Mountain by its comparitively low convexity, lack of geniculation, and small pedicle muscle field. The holotype and paratypes of this species are in the University of Manitoba collection.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

<u>Opikina</u> sp.

Plate 7, figures 16-17

This species is represented by seven specimens, one of which shows the interior of the brachial valve. Unfortunately, very little of the pedicle valve is known aside from the teeth and interarea.

The shell is broadly "U" shaped in outline with straight lateral margins and a smoothly rounded anterior margin. The lateral profile is strongly concavo-convex with uniform convexity. The cardinal extremities are slightly auriculate although there is no pronounced flattening of the valve at that point. The posterior margin is marked by 3 or 4 oblique wrinkles. The surface is marked by very fine unequal costellae, about 4 finer ones between each strong pair. The growth lines, although numberous, are not as prominent as the costellae. The psuedopunctae are typical for <u>Opikina</u>. The specimens are all of the same approximate size with a length of 21 mm., width 22 mm., and thickness of 8 mm.

The interiors of both pedicle and brachial valves, from what can be seen of them, appear almost identical with those of <u>O. lata</u>. <u>Opikina</u> sp. resembles <u>O. tumida</u> Wilson in size and shape, but is readily distinguished by the unequal costellae and posterior marginal wrinkles of the former. Among the other Stony Mountain <u>Opikinas</u>, this form is easily distinguished by its ratio of width to length.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Genus *Opikinella* Wilson

Opikinella sp.

Plate 10, figure 12

This species is represented by the interiors of two brachial valves. The specimens are very similar to *Opikina* except that the medial septum bifurcates about three mm. from cardinal process. The two branches, and the first pair of lateral septa, continue to or just past the center of the valve. The outer lateral pair of septa on one specimen appear to be about half the length of the other septa, but only faintly developed. In other aspects these specimens appear identical to *Opikina*.

This species is easily distinguished from *Opikina* at Stony Mountain by its medial septum. It also differs from the *Opikinella* at Ottawa by its greater thickness and less well developed septa.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Genus *Megamyonia* Wang

Three and possibly four species of this genus are present at Stony Mountain. *Megamyonia nitens* is probably the commonest of the species and is well represented in both the Stony Mountain Shale and Penitentiary members. Included within this species are several specimens which externally are similar to *M. unicostata* in that they have more alate hinge lines than most of the others. The two species, however, are identical in so many respects that it has been impossible to separate them on any other basis, and, as nearly all the specimens can be easily assigned to *Megamyonia nitens*, they have not been separated.

Another species, *M. raymondi*, is almost as common as *Megamyonia nitens*, but from which it is easily distinguished by its ratio of width to length. Some of the specimens included in this group also show an affinity to *M. unicostata*, but are much smaller and wider than most specimens of the latter, and for that reason are included in this species. The specimens of *M. raymondi* appear thicker than those illustrated by Wang but are identical in other respects. One of the specimens of *Leptaena* cf. *unicostata* illustrated by Troedsson (1928, plate 21, fig. 8) appears to be similar to those included in *M. raymondi* at Stony Mountain.

The other specie of this genus is a new one, *M. obesa*, created on the basis of its high ratio of thickness to length and width and its rectangular pedicle muscle field.

Megamyonia nitens (Billings)

Plate 10, figures 6-9

Strophomena nitens Billings, Nat. and Geol., Vol. 5, p. 53, fig. 1, (1860).
Leptaena nitens Whiteaves, Pal. Fossils, Vol. III, Pt. 2, p. 120, (1895).
Leptaena ? *nitens* (Billings), Twenhofel, Geol. Surv. of Canada, Mem. 154, p. 186, pl. 17, fig. 19; pl. 18, fig. 13, 14, (1928).

This species is common in the Stony Mountain collection, with numerous excellent specimens showing both interiors and exteriors.

The specimens appear identical with those described and illustrated by Twenhofel (1928). Twenhofel also included some small, greatly geniculated forms in his discussion, which are excluded here. Such forms may be included in this paper with M. raymondi.

The specimens of M. nitens are mostly of the same dimensions as those of Anticosti Island, but numerous smaller ones with the same characteristics are also included. The smallest of these is about 14 mm. wide and 10 mm. long. The pedicle muscle field as shown by internal molds from the Penitentiary member, varies slightly in the divergence of the margins. This feature has been noted by Twenhofel as a means of distinguishing M. nitens from M. unicostata, which it closely resembles. However, the divergence of the muscle field margins was found to vary between two valves and it was impossible to subdivide the specimens into the two species. It is possible, therefore that some worn specimens of M. unicostata are included in this group.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Megamyonia raymondi (Bradley)

Plate 10, figures 4, 5

Leptaena raymondi Bradley, Howard College, Bull. Mus. Comp. Zool., Vol. 64, no. 6, p. 515, pl. 2, figs. 3, 4, (1921).

Megamyonia raymondi (Bradley), Wang, Geol. Soc. of America, Mem. 42, p. 33, pl. 9B, figs. 1, 2, (1949).

This species is represented by 29 specimens, some of which show the interior of both valves. The specimens appear almost identical with those described and illustrated by Wang. In general, the Manitoba forms are thicker, the average dimensions being 18 mm. wide, 10.5 mm. long, and 4.5 mm. thick. The ventral mesial costella is usually strong, but sometimes is missing completely, perhaps due to erosion. In two specimens the mesial costella appears to bifurcate a short distance from the beak.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Megamyonia obesa Procter n. sp.

Plate 10, figures 2, 3

Nine specimens are included in this group, four of which show exteriors only and five of which show the interior of the pedicle valve.

The shells are subcircular in shape, with the greatest width at the hinge line, which is straight and slightly auriculate. The lateral profile is very strongly concavo-convex and geniculate, the line of geniculation being central on the shell and gently rounded. The surfaces of all specimens are smooth but a trace of fine costellate ornamentation can be seen. Growth lines are evident near the anterior margin. Where the surface lines of the shell are worn away, the psuedopunctae are visable and appear typical for Megamyonia. Very little can be seen of the interareas but they appear identical with those of M. raymondi.

The pedicle interior is essentially the same as that of M. nitens except for the muscle field. The interior surface is finely pustulose like M. nitens but pustules are much finer and less crowded. The muscle field is small, sub-rectangular in shape, and not deeply impressed. It is divided by a medial septum which extends to the line of geniculation. The diductor scars are large, divergent, and indistinguishable from the adjustor scars. The adductor track is small, elongate, not surrounded anteriorly by the diductors, and is confined to the posterior part of the muscle field. The diductor and adjustor scars are marked by fine radial lines.

The interior of the brachial valve is unknown. This species appears externally to resemble Opikina but can be distinguished from it by the psuedopunctae.

The holotype and paratypes of the species are in the University of Manitoba collection.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Genus *Strophomena* Blainville

Strophomena planocorrugata Twenhofel

Plate 8, figures 10, 11

Strophomena planocorrugata Twenhofel, Geol. Survey of Canada, Mem. 154, p. 194, pl. 17, figs. 4-6, (1928).

This species is represented in the collection by numerous incomplete valves and fragments, two internal molds of the brachial valve, and part of the interior of a pedicle valve.

Externally the specimens appear identical with those described and illustrated by Twenhofel. Internally the resemblence is almost as good, but the longitudinal grooves and ridges of the brachial valve are longer and more clearly defined.

As at Anticosti Island, this species is easily distinguished from other *Strophomena* by the low convexity and cardinal wrinkles. The surface is covered with unequal costellae, usually one or two finer ones between each coarser pair. Growth lines are numerous but very fine and attain prominence, usually, only near the anterior margin. Specimens range in size from 16 mm. to 44 mm. in width, and from 11 mm. to 36 mm. in length. The partial pedicle interior shows a typical sub-oval muscle field, with a short, sharp, anteriorly tapering mesial septum. The individual muscle scars could not be distinguished. The teeth appear small, blunt, and widely divergent. The delthyrium is covered by a large, flatly convex deltidium.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Strophomena fluctuosa Billings

Plate 8, figures 8, 9

Strophomena fluctuosa Billings, Geol. Survey of Canada, Paleo. Foss., Vol., I, p. 123, fig. 102, (1865).
Strophomena fluctuosa Billings, Twenhofel, Geol. Survey of Canada, Mem. 154, p. 193, pl. 22, figs. 3-5 (1928).

This species is represented in the collection by ten specimens, two of which show the brachial interior, and one of which shows the pedicle interior.

The specimens agree very well with Billings' original description and illustration, and with those of Twenhofel. They are almost identical with S. occidentalis Foerste, except in size and the alate hinge line. As in the latter species, the surface is marked by fine unequal costellae which are arranged near the beak in groups of about ten fine costellae between each strong pair. Toward the anterior margin the medial costellae of each group of ten becomes prominent, and farther anteriorly, the median costellae of each smaller group repeats the process. In this manner the anterior margin is marked by alternating strong and weak costellae with occasionally three weak ones between each strong pair. The internal structures of the two species appear very similar, the only significant difference noted being a tendancy to slightly smaller cardinalia of S. fluctuosa. The two species however, are readily distinguishable by the alate hinge line and the larger size of S. fluctuosa. Some of the specimens of this species are 32 mm. wide, whereas Foerste stated the usual maximum width of S. occidentalis as 25 mm.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Strophomena occidentalis Foerste

Plate 8, figures 3-6

Strophomena fluctuosa Billings, Winchell and Schuchert, Final Rept., Minn. Geol. Surv., Vol. 3, p. 395-397, pl. 31, figs. 14-17, (1893).
Strophomena fluctuosa occidentalis Foerste, Denison Univ., Bull. Sci. Labs., Vol. 17, p. 113, pl. 9, fig. 17; pl. 10, fig. 9, (1912).
Strophomena occidentalis Foerste, Wang, Geol. Soc. of America, Mem. 42, p. 24, pl. 7A, figs. 1-8, (1949).

This species is considerably more common than S. fluctuosa in the Stony Mountain collection, and is well represented by both whole specimens from the Stony Mountain Shale, and by internal molds from the Penitentiary member, the latter being the most abundant.

As discussed under S. fluctuosa, there is little difference between S. occidentalis and the aforementioned except for size and shape. As also indicated above, the cardinalia of S. occidentalis are found to be slightly stronger than those of S. fluctuosa. Wang, under S. occidentalis, includes Iowa forms which appear identical to this species except that the pedicle interarea is not longer than the brachial one, and the small elevation between the lobes of the cardinal process is not evident.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Strophomena cf. concordensis Foerste

Plate 8, figure 7

Strophomena concordensis Foerste, Denison Univ., Bull. Sci. Labs., Vol. 17, p. 59, pl. 3, fig. 1, (1912).

This species is represented by two specimens which show the exteriors of both valves.

The specimens agree exactly with Foerste's description and illustrations as well as can be seen from the exteriors alone. The larger specimen is approximately 48 mm. wide, 31 mm. long, and has a posterior lateral angle of 70°. As in Foerste's specimens, the radial costellae are extremely fine near the umbo and become only slightly coarser at the anterior margin. With no knowledge of the internal structures, a closer identification is not considered justified.

Stony Mountain Shale member, Stony Mountain, Manitoba.

Genus Tetraphalerella Wang

Tetraphalerella cf. planodorsata Winchell and Schuchert,

Strophomena planodorsata Winchell and Schuchert, Minn. Geol. Survey, Final Rept., Vol. 3, p. 393, pl. 31, figs. 8-10, (1893).
Strophomena planodorsata Winchell and Schuchert, Foerste, Denison Univ., Bull. Sci. Labs., Vol. 17, p. 109, pl. 7, fig. 6, (1912).
Tetraphalerella planodorsata (Winchell and Schuchert), Wang, Geol. Soc. of America, Mem. 42, p. 30, pl. 9D, fig. 1, (1949).

This species is represented by five external molds of the brachial valve. The five specimens are all smaller than those described by Foerste or Wang, but otherwise appear identical as far as the brachial exteriors are concerned. The average dimensions of the specimens are 28 mm. width and 18 mm. length. With no knowledge of the pedicle valve or interior structures a closer identification is considered unwise.

Penitentiary member, Stony Mountain, Manitoba.

Genus Holtedahlina Foerste

Holtedahlina sp.

Plate 8, figures 1, 2

This species is represented in the collection by three specimens, one of which shows the interior of the pedicle valve.

The specimens are assigned to this species on the basis of their coarse, equal sized external costellae, shape, and convexity. The specimens appear almost identical to Holtedahlina sp. Wang (1949, p. 34, pl. 7F, figs. 1, 2) except that the external structures of the Manitoba specimen are less well defined. Like Holtedahlina sp. Wang, the pedicle muscle field is subrectangular in shape, with a prominent medial septum. It is considered inadvisable to attempt a closer identification with such incomplete material.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Genus Lepidocyclus Wang

Lepidocyclus perlamellosus (Whitfield)

Plate 9, figures 10-15

Rhynchonella perlamellosa Whitfield, Geol. Surv. Wisconsin, Ann. Rept., p. 73 (1877); Foerste, Geol. Surv. of Canada, Mem. 138, p. 125, pl. 11, fig. 5, (1924).
Rhynchotrema perlamellosum (Whitfield), Shimer and Shrock, Index Fossils of North America, p. 309, pl. 118, figs. 29-30, (1944).
Lepidocyclus perlamellosus (Whitfield), Wang, Geol. Soc. of America, Mem. 42, p. 14, pl. 6A, figs. 1-5, (1949).

This species is represented in the collection by several good specimens, most of which are internal molds, and show external and internal structures.

The shells are mostly medium to large in size although a few small individuals are present. Larger specimens appear to be proportionately wider than the smaller ones but otherwise are the same. The pedicle muscle field is not shown on any of the specimens. The specimens appear to be identical with those described and illustrated by Wang.

This species is similar, on the basis of internal structures, to L. laddi, from which it can be distinguished by its more equally biconvex valves and wider less numerous costae.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Lepidocyclus laddi Wang

Plate 9, figures 7-9

Rhynchotrema capax altirostratum Ladd, Iowa Geol. Surv., Ann. Rept., Vol. 34, pl. 5, fig. 15, not figs. 10-14, 16, (1929).
Lepidocyclus laddi Wang, Geol. Soc. of America, Mem. 42, p. 13, pl. 4D, figs. 1-9, (1949).

This species is well represented by internal molds and steinkerns and a few actual shells.

The specimens are all of medium to large size and appear identical to those described and illustrated by Wang. These specimens were formerly grouped with *L. capax* but are considered closer to *L. laddi* because they are not as gibbose, are more closely costate, and are more oval in cross-section at the greatest width than the former. There appear to be small variations in the shape of the pedicle muscle field, which may be due in part at least to the type of preservation. In general however, the muscle field appears well developed, large, flabellate, with wide anteriorly expanded diductor scars. The adductor scars are small and oval shaped, and along with the elongate adductor track, are enclosed by the diductors.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Genus Hypsiptycha Wang

Hypsiptycha anticostiensis (Billings)

Plate 9, figures 1-6

Rhynchonella anticostiensis Billings, Geol. Surv. of Canada, Pal. Foss., Vol. I, p. 142, fig. 119a-c, (1862).
Rhynchonella ? anticostiensis Billings, Winchell and Schuchert, Pal. Minnesota, Vol. 3, pl. 1, p. 464, fig. 34, (1893).
Rhynchotrema anticostiensis (Billings), Schuchert and and Twenhofel, Bull. Geol. Soc. of America, Vol. 21, p. 696, (1910).
Rhynchotrema anticostiense (Billings), Twenhofel, Geol. Surv. of Canada, Mem. 154, p. 207, pl. 21, figs. 4-6, (1928).

Numerous excellent specimens of this species are present in the collection including many whole specimens and several steinkerns.

The specimens range in size from about 7 mm. to 14 mm. in width and appear identical with those described by Billings and Twenhofel. There is a slight variation in the number of plications on the pedicle fold in some specimens which is usually due to bifurcation of a costa or distortion.

This species has been referred to the genus Hypsiptycha due to the presence of deltidial plates, conspicuous dental plates, and a sub-cordate muscle field, which according to Wang (1949, p. 17) are characteristic features of the genus. There is a resemblence between this species and two forms from the Maquoketa formation of Iowa, H. hybrida and H. neenah. It can easily be distinguished from the former by its triangular brachial valve and equality of costae on the fold, and from the latter by a much less conspicuous fold and less gibbose outline.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Genus Dinobolus Hall

Dinobolus sp.

Plate 10, figure 1

Included in this species are seven specimens which may or may not be conspecific. The preservation of all the specimens is poor and very little of the exterior remains. The specimens range in size from about 12 mm. to about 21 mm. in width and slightly less in length.

Best preserved structures of the shells are the brachial platforms which are elongate-oval in shape with the greatest width near the anterior end. The platform has an elevated margin which is very strong at the umbo and continues to be fairly strong all around.

There is a fair resemblence between this group and D. laurentinus Twenhofel (1928, p. 168, pl. 12, figs. 4-7,) especially with regard to the brachial platform. However the details of internal structure and even shape are so obscure on the Stony Mountain specimens that further identification is impossible.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Genus *Thaerodonta* Wang

Thaerodonta dignata Wang

Plate 10, figures 10,11

Thaerodonta dignata Wang, Geol. Soc. of America, Mem. 42, p. 22, pl. 11D, figs. 1-6, (1949).

This species is represented in the Stony Mountain collection by numerous excellent specimens showing both exteriors and interiors. Specimens previously identified from Stony Mountain as *Sowerbyella sericea* are included in group on the basis of denticulation and high lateral ridges of the dorsal muscle field.

The specimens appear to agree very well with the description and illustrations of Wang. Average dimensions of the specimens are 11 mm. in width, 7 mm. in length, and about 2 mm. in thickness. The pedicle interarea is marked by about 16 fairly deep cardinal fossettes. Teeth and sockets appear badly worn, but all other internal structures are identical to those described by Wang. There is a small variation in the height of the brachial processes, much of which is probably the result of erosion.

Stony Mountain Shale and Penitentiary members, Stony Mountain, Manitoba.

Explanation of Plate 3

Trilobites, Stony Mountain, Manitoba.

All specimens are from Stony Mountain, Manitoba.

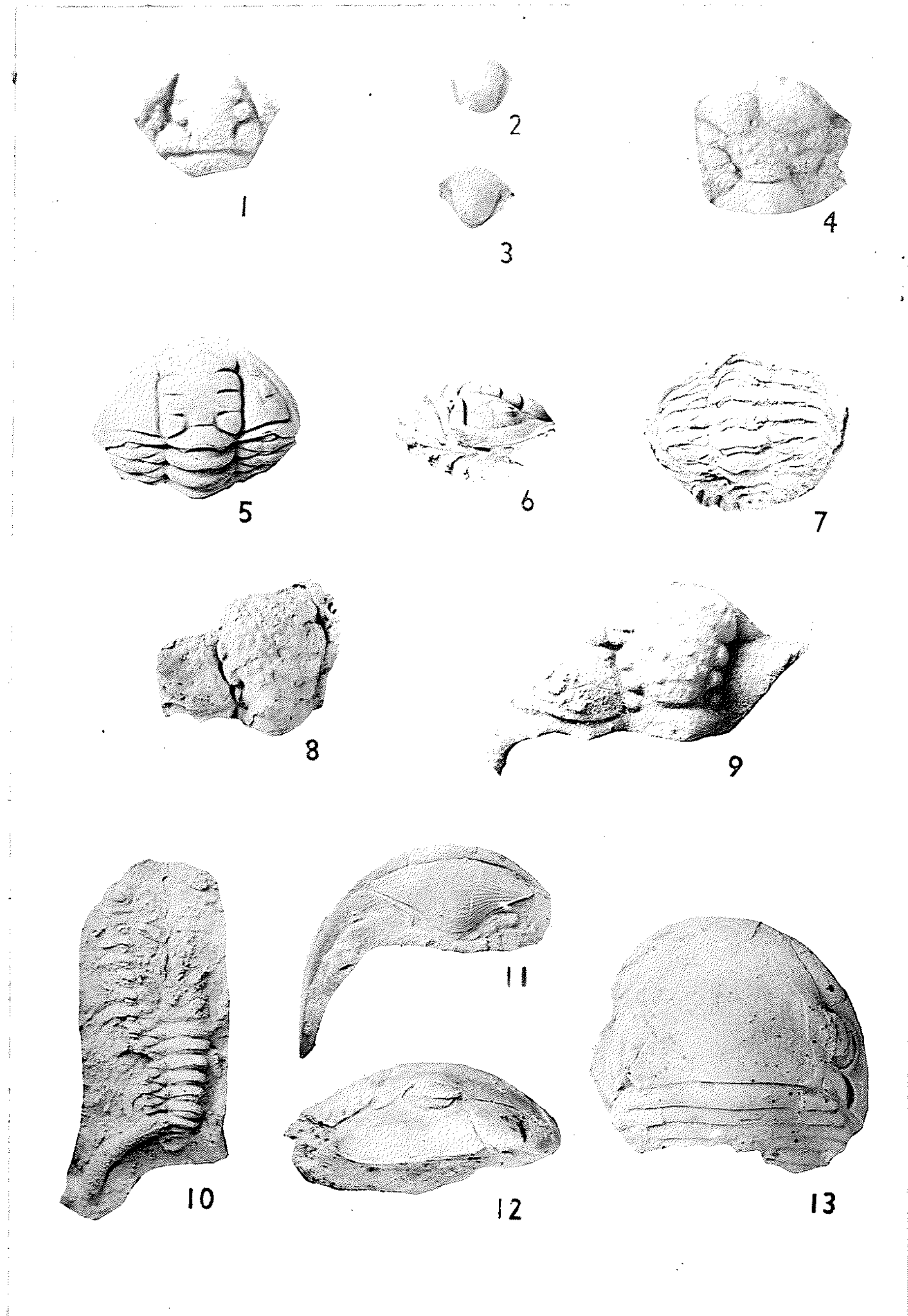

Plate 3

Trilobites, Stony Mountain, Manitoba

Explanation of Plate 4

Cephalopods, Stony Mountain, Manitoba.

Figures		Page
1,4.	<u>Cycloceras selkirkense</u> (Whiteaves) . . . . Side views of two fragmentary specimens, x 1.	69
2,3.	<u>Billingsites boreale</u> (Parks) . . . . An internal mold with sutures visable. Dorsal and lateral views, x 1.	67
5-7.	<u>Billingsites costulatum</u> (Whiteaves) . . . Internal mold of an almost complete specimen. 5, Basal view showing siphuncle. 6, Dorsal view. 7, Lateral view. All x 1.	66

All specimens are from Stony Mountain, Manitoba.

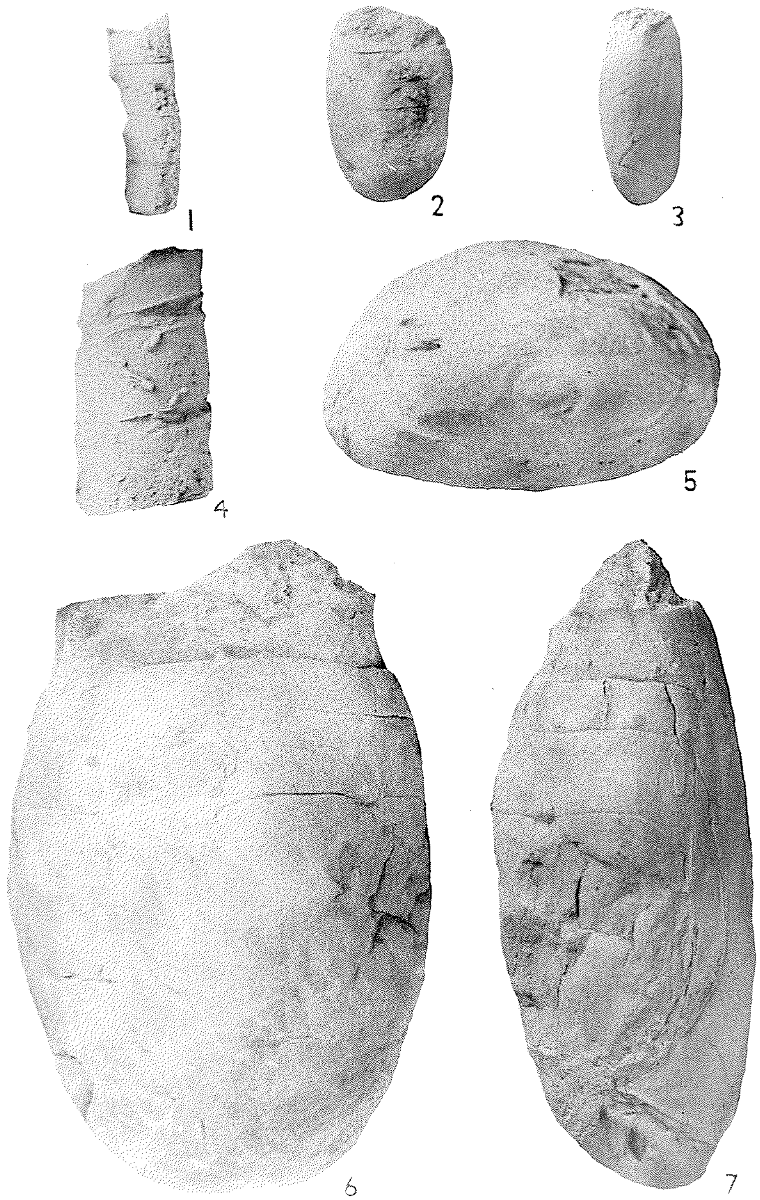

Plate 4

Cephalopods, Stony Mountain, Manitoba

Explanation of Plate 5

Brachiopods and Cephalopods, Stony Mountain, Manitoba.

Figures		Page
1-4,6.	<u>Pionorthis sola</u> (Billings) . . . . 1, Exterior of pedicle valve, x 1. 2, Side view, x 1. 3, Exterior of brachial valve, x 1. 4, Interior of brachial valve showing cardinal process, x 2. 6, Interior of pedicle valve, x 1.	71
5,7.	<u>Dinorthis iphigenia</u> (Billings) . . . . . . 5, Posterior view. 7, Exterior of brachial valve. Both x 1.	70
8,10.	<u>Beloitoceras percurvatum</u> Twenhofel . . . . An incomplete internal mold showing sutures. Dorsal and lateral views, x 1.	66
9.	<u>Actinoceras</u> sp.. . . . . Internal mold showing siphuncular deposits, x 1.	64
11.	<u>Westonoceras latum</u> Troedsson . . . . Lateral view of an almost complete internal mold showing sutures, x 1.	65

All specimens are from Stony Mountain, Manitoba.

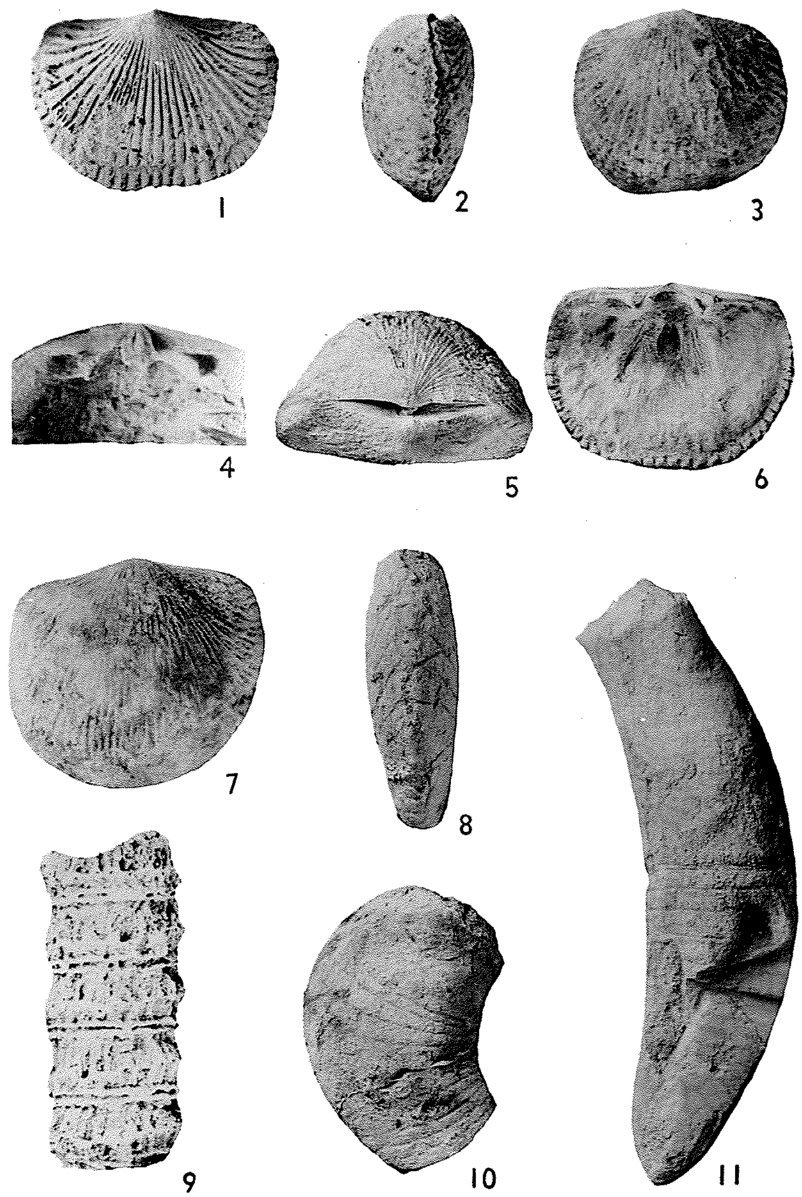

Plate 5

Brachiopods and Cephalopods, Stony Mountain, Manitoba

Explanation of Plate 6

Brachiopods, Stony Mountain, Manitoba

Figures		Page
1-3	*Pionorthis gracilis* Procter n. sp. . . . . . 1, Side view showing "V" shaped commissure. 2, Exterior of pedicle valve. 3, Anterior view. All x 1.	75
4-9.	*Pionorthis carletona* Twenhofel . . . . 4, Exterior of pedicle valve. 5, Side view. 6, Interior of brachial valve. 7, Exterior of brachial valve. 8, Interior of pedicle valve. All x 1. 9, Enlarged view of hinge line structures of brachial interior, x 2.	73
10.	*Pionorthis* cf. *sola* (Billings) . . . . Interior view of pedicle valve, x 1.	76
11-13.	*Dalmanella jugosa subplicata* Foerste . . . 11, Exterior of pedicle valve. 12, Exterior of brachial valve. 13, Interior of brachial valve. All x 2.	78
14-16.	*Dalmanella storeya* Okulitch . . . . 14, Exterior of brachial valve. 15, Interior of pedicle valve. 16, Exterior of pedicle valve. All x 2.	77

All specimens are from Stony Mountain, Manitoba.

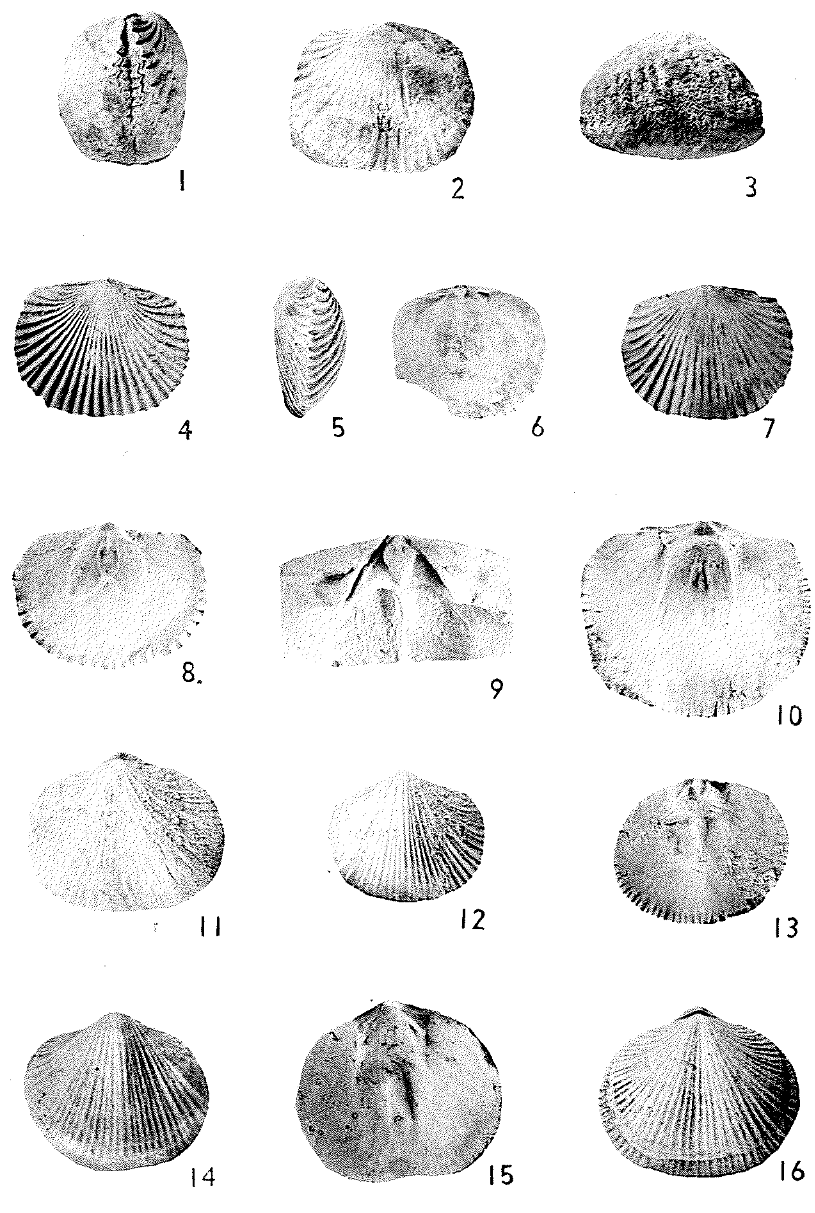

Plate 6

Brachiopods, Stony Mountain, Manitoba

Explanation of Plate 7

Brachiopods, Stony Mountain, Manitoba.

Figures		Page
1-4.	*Opikina parva* Procter n. sp. . . . . 1, Exterior of pedicle valve. 2, Interior of brachial valve. 3, Internal mold of pedicle valve. 4, Interior of pedicle valve. All x 1.	86
5-7.	*Opikina pergibbosa* (Foerste). . . . . 5, Interior of brachial valve. 6, Exterior of pedicle valve. 7, Exterior of brachial valve. All x 1.	80
8-11.	*Opikina lata* Procter n. sp. . . . . 8, Interior of brachial valve. 9, Exterior of brachial valve. 10, Exterior of pedicle valve. 11, Internal mold of pedicle valve. All x 1.	81
12-15.	*Opikina manitobensis* Procter n. sp. . . . 12, Interior of brachial valve. 13, Exterior of brachial valve. 14, Exterior of pedicle valve. 15, Side view. All x 1.	84
16.	*Opikina* sp. . . . . Side view and exterior of pedicle valve, x 1.	88

All specimens are from Stony Mountain, Manitoba.

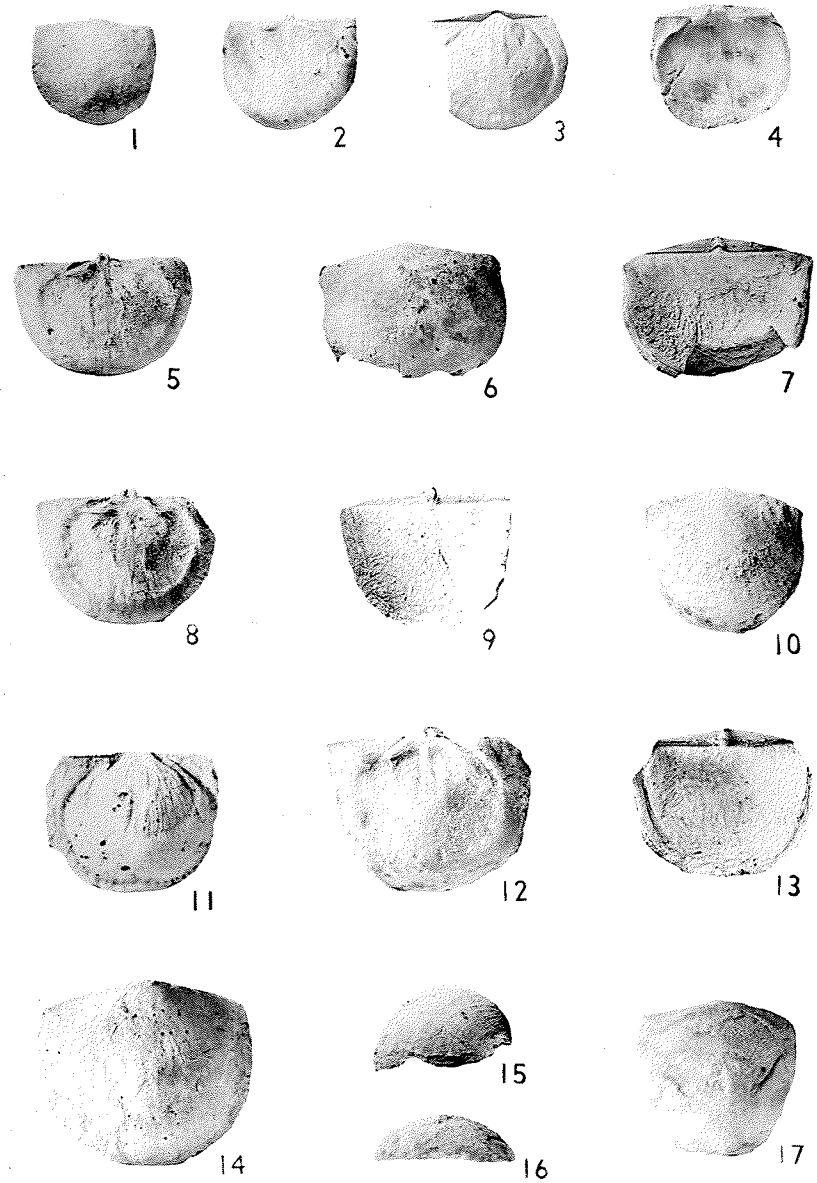

Plate 7

Brachiopods, Stony Mountain, Manitoba

Explanation of Plate 8

Brachiopods, Stony Mountain, Manitoba.

Figures		Page
1,2.	*Holtedahlina* sp. . . . . Internal mold of pedicle valve and exterior of pedicle valve, both x 1.	98
3-6.	*Strophomena occidentalis* Foerste . . . . . . 3, Internal mold of pedicle valve. 4, Internal mold of brachial valve. 5, Interior of brachial valve. 6, Interior of pedicle valve. All x 1.	96
7.	*Strophomena* cf. *concordensis* Foerste . . . Exterior of pedicle valve, x 1.	97
8,9.	*Strophomena fluctuosa* Billings . . . . 8, Interior of brachial valve. 9, Exterior of pedicle valve. Both x 1.	95
10,11.	*Strophomena planocorrugata* Twenhofel . . . 10, Interior of brachial valve. 11, Exterior of pedicle valve. Both x 1.	94

All specimens are from Stony Mountain, Manitoba.

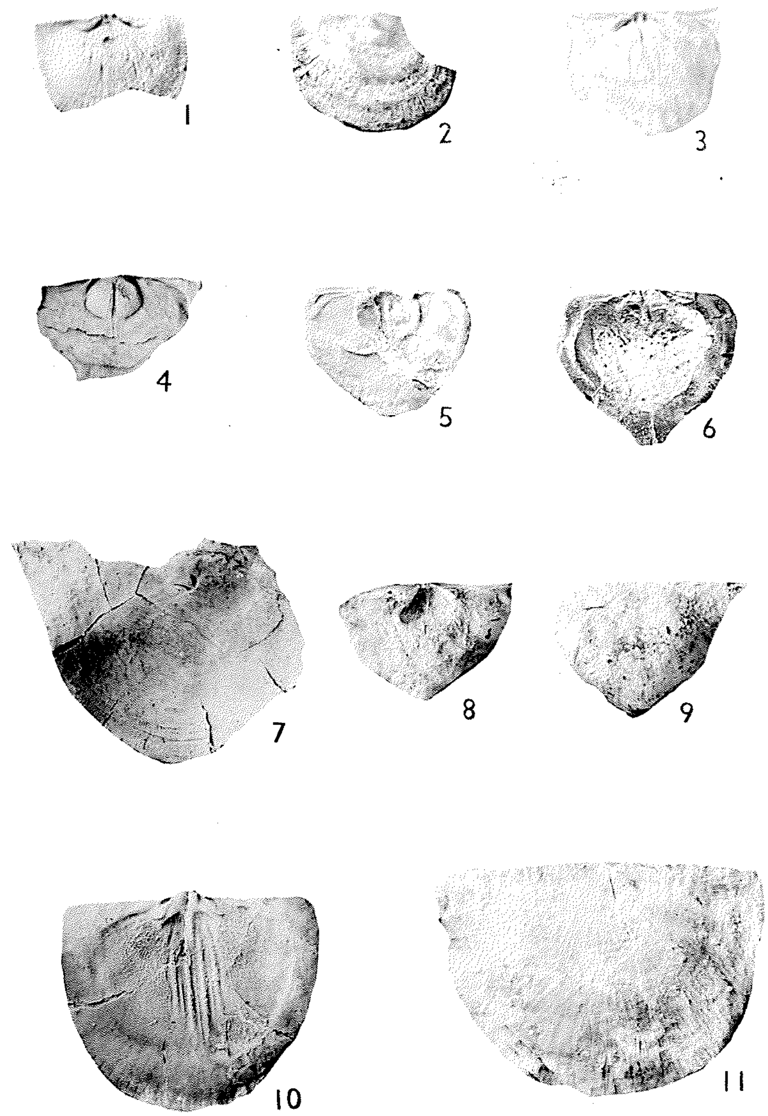

Plate 8

Brachiopods, Stony Mountain, Manitoba

Explanation of Plate 9

Brachiopods, Stony Mountain, Manitoba

Figures		Page
1-6.	<u>Hypsiptycha</u> <u>anticostiensis</u> (Billings) . . 1, Exterior of pedicle valve. 2, Side view. 3, Exterior of brachial valve. 4, Interior of brachial valve. 5, Posterior view of an internal mold. 6, Interior of pedicle valve. All x 1.	101
7-9.	<u>Lepidocyclus</u> <u>laddi</u> Wang. . . . . 7, Posterior view of an internal mold. 8, Internal mold of pedicle valve. 9, Side view. All x 1.	100
10-15.	<u>Lepidocyclus</u> <u>perlamellosus</u> (Whitfield) . . 10, Anterior view. 11, Posterior view. 12, Internal mold of brachial valve. 13, Exterior of brachial valve. 14, Side view. 15, Exterior of pedicle valve. All x 1.	99

All specimens are from Stony Mountain, Manitoba.

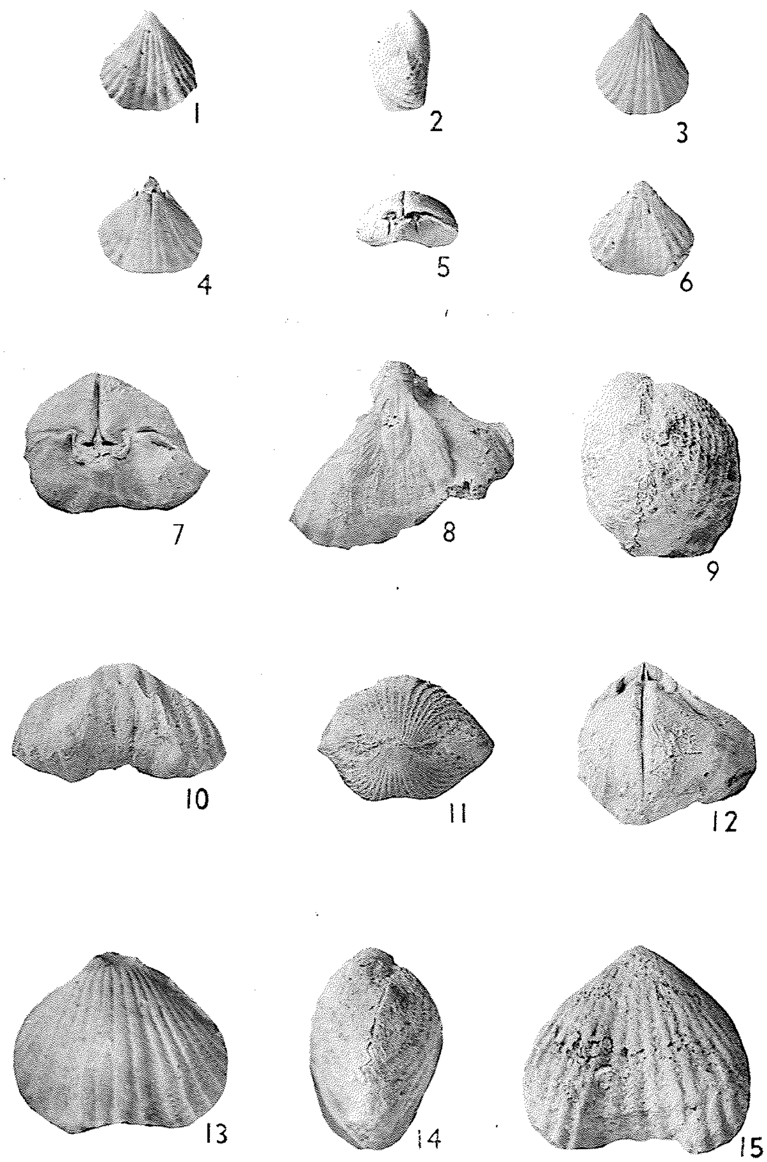

Plate 9

Brachiopods, Stony Mountain, Manitoba

Explanation of Plate 10

Brachiopods, Stony Mountain, Manitoba.

Figures		Page
1.	*Dinobolus* sp. . . . . Internal mold of brachial valve, x 1.	102
2,3.	*Megamyonia obesa* Procter n. sp. . . . . . . 2, Exterior of pedicle valve. 3, Internal mold of pedicle valve. Both x 1.	92
4,5.	*Megamyonia raymondi* (Bradley) . . . . . . Exteriors of pedicle and brachial valves, both x 1.	92
6-9.	*Megamyonia nitens* (Billings) . . . . 6, Internal mold of brachial valve. 7, Exterior of brachial valve. 8, Exterior of pedicle valve. 9, Internal mold of pedicle valve. All x 1.	90
10,11.	*Thaerodonta dignata* Wang . . . . Internal mold of brachial and pedicle valves, both x 1.	103
12.	*Opikinella* sp. . . . . Interior of brachial valve, x 1.	89

All specimens are from Stony Mountain, Manitoba.

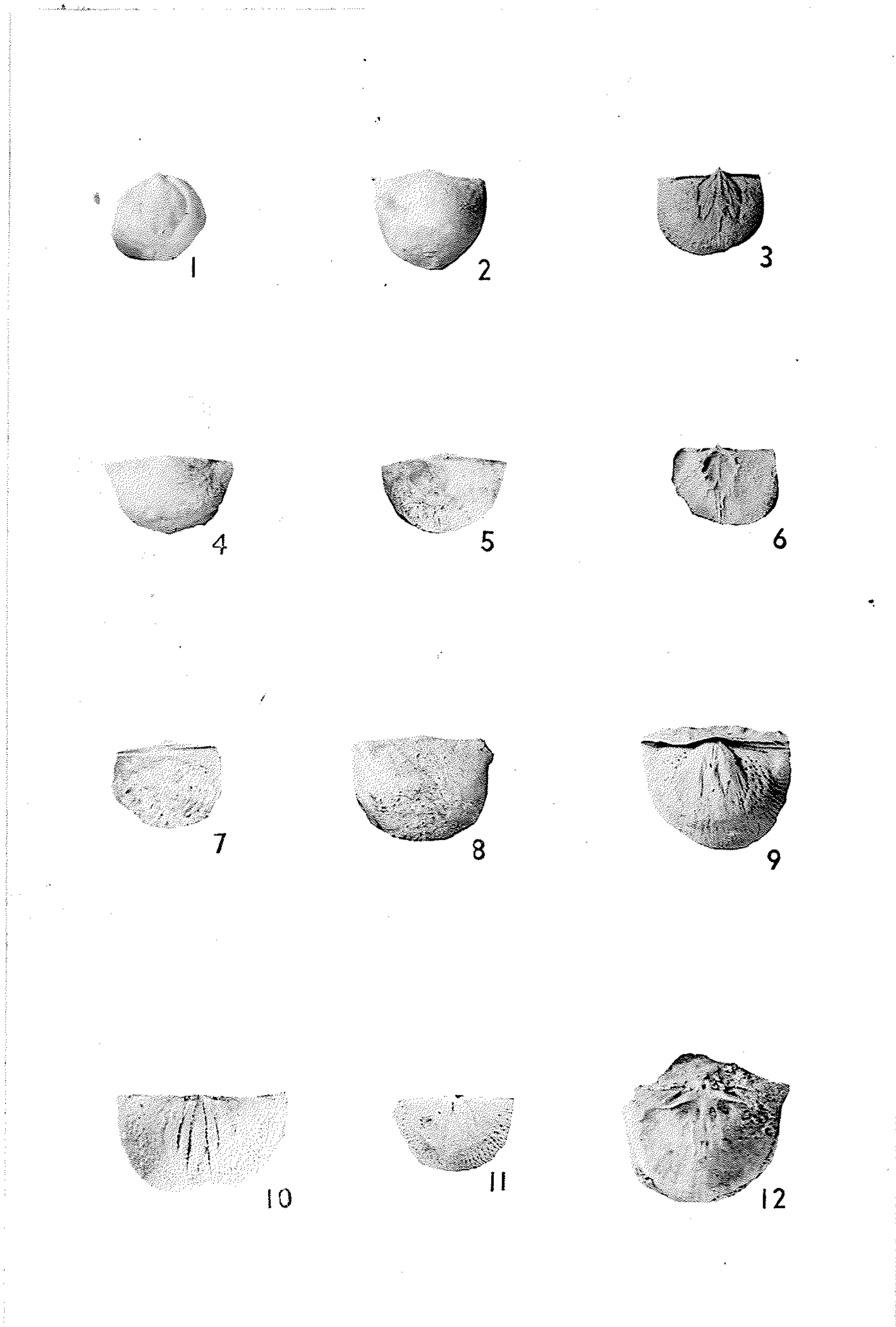

Plate 10

Brachiopods, Stony Mountain, Manitoba

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