Canada
Department of Mines

Hon. CHARLES STEWART, Minister
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Geological Survey

W. H. COLLINS, Director

Bulletin No. 44

GEOLOGICAL SERIES, No. 46 November 25, 1926

CONTRIBUTIONS TO CANADIAN PALÆONTOLOGY

OTTAWA
F. A. ACLAND
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BULLETIN NO. 44

AN UPPER ORDOVICIAN FAUNA FROM THE ROCKY MOUNTAINS, BRITISH COLUMBIA

By Alice E. Wilson

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INTRODUCTION

GENERAL STATEMENT

The present study is based upon collections of the Geological Survey of Canada made by J. R. Marshall, E. M. Kindle, J. F. Walker, and L. D. Burling.

In 1922 Mr. Marshall collected Upper Ordovician fossils from the Kananaskis-Palliser map-area, Alberta, between Spray and Palliser rivers. One lot was from the lower western slope of mount Sir Douglas and mount Munro and the western slope of a knoll between, at an elevation of about 7,800 feet; and another lot was from the second creek north from Palliser pass, entering Spray river from the east. In 1923 collections were brought from localities in the immediate neighbourhood of Palliser pass. Mr. Kindle, in 1923, collected fossils from the same general horizon in Windermere district, B.C., at Sinclair springs, the lower end of Stoddart Creek gorge around the west base of the mountain for about 2 miles north, and from Fairmont Springs. There have been available for study small collections of Ordovician and Silurian fossils from Harrogate farther north. J. F. Walker in 1924 collected from the Upper Ordovician in several localities in the Stanford range, at Fairmont Springs, and near Columbia lake. L. D. Burling when a member of the Geological Survey, Canada, made a small collection in 1915 from Upper Ordovician beds, which he later designated as "Beaverfoot" beds, from the Beaverfoot range, northeast of McMurdo, near Golden, B.C.

Among these collections of the Rocky Mountain Upper Ordovician there is a large proportion of forms quite distinct from those of the Upper Ordovician of central and eastern America, including new species and genera which are described in the following pages.

HISTORY OF NOMENCLATURE

In 1886 McConnell[1] used the term "Halysites beds" to designate the dolomites and quartzites above the "Graptolite beds" and assigned them to the Silurian. Burling[2] introduced the term "Beaverfoot" to apply to that part of the beds which bears a Richmond fauna. Walcott[3] applied the name "Beaverfoot" to the "coral beds" and referred them to the "Silurian?". Later, Walcott[4] used "Brisco" for the strictly Silurian beds and adopted Burling's interpretation of the Richmond beds, comparing the fauna with that of Stony Mountain of Manitoba and the Bighorn of Wyoming.

UPPER LIMITS OF THE BEAVERFOOT

In this paper those beds are considered as Beaverfoot in which the Richmond fauna predominates, although it is evidently necessary to extend downward the limits of the range of some forms heretofore considered Silurian. Such forms as *Streptelasma, Dinorthis, Columnaria, Halysites* without the tubuli, and the forms of *Rhynchotrema* present, point definitely to an Ordovician age. In several localities, however, *Syringopora*, a *Favosites* generally regarded as Silurian, and a doubtful form of *Diphyphyllum* appear. It is clear that beds with an assemblage of characteristic Richmond genera are followed by transitional beds in which the Richmond fauna predominates, but is associated with later forms. In other words, in the Richmond seas later forms have appeared and continued side by side with the typical Ordovician fauna. In time, the forms characteristically Richmond have failed to adapt themselves to some change, have gradually died out, and the strictly Silurian forms have survived. The transition from the Richmond to the Silurian thus appears to have been gradual, indicating that deposition has been continuous and undisturbed in the areas under consideration. Besides the *Syringopora, Favosites*, and the doubtful *Diphyphyllum* mentioned above, there is the form *Halysites delicatulus* which first appears in the Beaverfoot beds and continues upward. Its presence at Canal Flats, without other associated fossils, does not signify anything stratigraphically. On the other hand, the assemblage of fossils in Harrogate area, which includes another form of *Halysites*, does arouse doubt as to the position of the horizon holding them, but the fauna is here treated as being Richmond, because though it contains more fossils of Silurian aspect than any other Richmond horizon, there are present some of those fossils which are more abundant in definitely Beaverfoot beds.

In most of the localities it has not been possible to procure a complete section of the Beaverfoot, but one continuous section was measured,[5] locality 7 on the index map (Figure 1). In this section at 268 feet above the base of the Beaverfoot the younger forms are first associated with typical Richmond forms. It is hoped that later investigations may produce sections elsewhere in which this line can be more definitely placed.

[1] Geol. Surv., Canada, Ann. Rept., vol. II, pt. D, pp. 15-21 (1887).
[2] Geol. Mag., vol. 59, No. 700, p. 453 (1922).
[3] Misc. Coll. Smith. Inst., vol. 67, No. 8, p. 463 (1923).
[4] Misc. Coll. Smith. Inst., vol. 75, No. 1, p. 13 (1924).
[5] For further details of this section, *see* Memoir 148.

Correlation of the Fauna

Any correlation of the Beaverfoot fauna has to be made mainly by means of the corals and brachiopods. The Rocky Mountain collections do not include the ostracod and bryozoan fauna of Stony mountain, Manitoba, and Bighorn mountains, Wyoming. Although the Beaverfoot

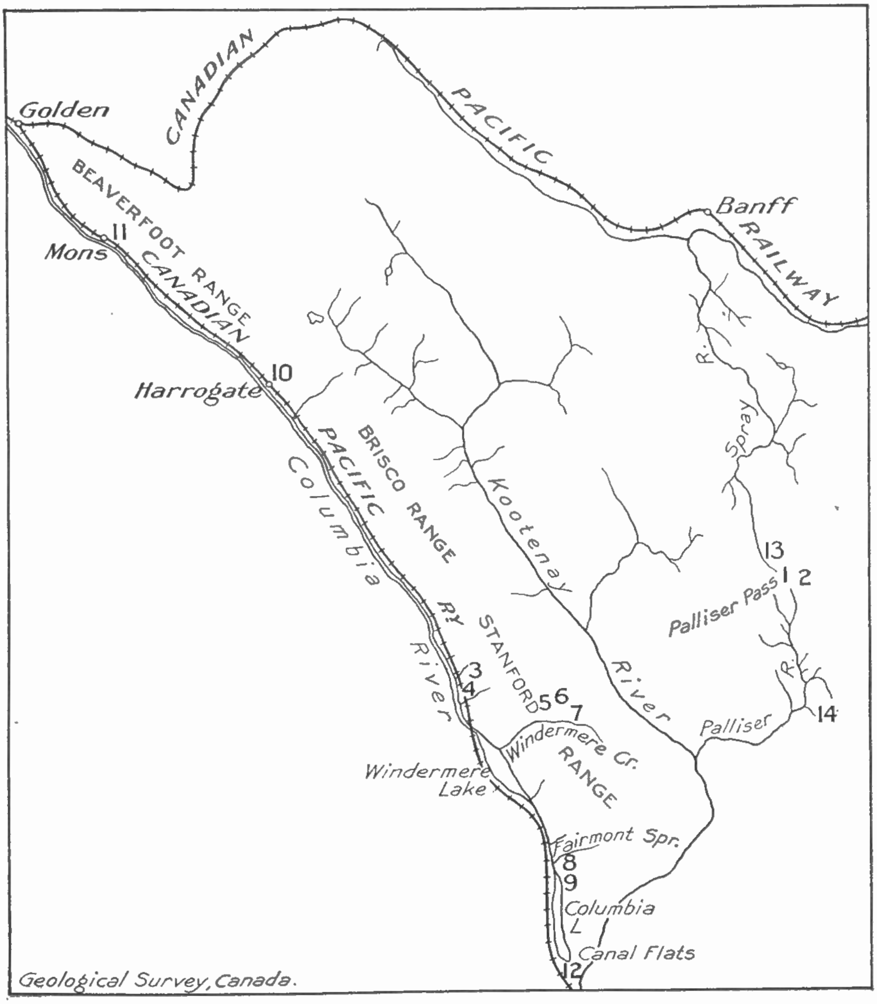

Figure 1. Index map showing localities in southeastern British Columbia and western Alberta from which Upper Ordovician fossils have been collected.

is more closely allied to these two than to the Richmond of central and eastern America, an examination of the internal structure of the brachiopods has shown that in almost every case there is a very definite specific difference. These differences in *Dinorthis*, *Rhynchotrema*, etc., are discussed in detail under the descriptions of the fossils. Of the corals *Paleofavosites* *asper* is common to all, but by eating out the *Streptelasmas* with acid and by sectioning them when possible it is seen that they are specifically different. It is also evident that the genus *Halysites* is not capable of such a broad interpretation in correlation as has been attached to it. Although a good many specimens have been sectioned not one has shown the proportions of the Manitoba species *Halysites gracilis*. So that, although in a broad sense the fauna is allied to that of Manitoba and Wyoming the differences are greater than they have been generally considered.

LIST OF FAUNULES

The accompanying index map (Figure 1) shows the relative positions of the localities in southeastern British Columbia from which Ordovician fossils have been obtained. The numbers (1-14) appearing on the figure are used in the following lists in which the high numbers are the locality catalogue numbers of the Geological Survey, Canada.

(1) East[1] of the trail over Palliser pass

7628 "East of the trail 1,150 feet"

Streptelasma prolongatum n. sp.
Rhynchotrema increbescens var. *occidens* n. var.
Rhynchotrema kananaskia n. sp.
Plectorthis? sinuata n. sp.
Orthis marshalli n. sp.
Dinorthis columbia n. sp.
Petroria rugosa n. sp. nov. gen.
Cornulites parvus n. sp.
Hormotoma sp.
Protokionoceras? gracile n. sp.

7561 "East of the trail one-half mile"

Streptelasma prolongatum n. sp.
Streptelasma distinctum n. sp.
Halysites robustus n. sp.
Columnaria alveolata var. *stellaris* n. var.
Lingula sp.
Rhynchotrema kananaskia n. sp.
Orthis marshalli n. sp.
Dinorthis columbia n. sp.
Dinorthis rockymontana n. sp.
Vaginoceras? eccentricum n. sp.

7563 "East of the trail three-quarters of a mile"

Streptelasma cf. *fragile* n. sp.
Streptelasma prolongatum n. sp.
Streptelasma distinctum n. sp.
Halysites robustus n. sp.
Rhynchotrema increbescens var. *occidens* n. var.
Rhynchotrema kananaskia n. sp.
Plectorthis? sinuata n. sp.
Orthis marshalli n. sp.
Dinorthis columbia n. sp.
Dinorthis rockymontana n. sp.
Lophospira occidentalis Wilson
Actinoceras complanum n. sp.

[1] Collected by J. R. Marshall.

(2) Between[1] Spray and Palliser rivers, from the western slope of a knoll between mount Sir Douglas and mount Munro, at an elevation of about 7,800 feet.

7969 Lot 1
7970 Lot 2, approximately the same locality
Streptelasma prolongatum n. sp.
Streptelasma distinctum n. sp.
Streptelasma sp.
Halysites robustus n. sp.
Halysites delicatulus n. sp.
cf. *Paleofavosites asper* (d'Orbigny)
Calapoecia anticostiensis Billings
Columnaria alveolata var. *stellaris* n. var.
Columnaria stokesi (M.-Ed. and H.)
Diphyphyllum? primum n. sp.
Bryozoa sp. undtd.
Rhynchotrema increbescens var. *occidens* n. var.
Rhynchotrema kananaskia n. sp.
Orthis marshalli n. sp.
Dinorthis columbia n. sp.
Hebertella sp.
Palliseria robusta Wilson
Hormotoma sp.
Orthoceras sp.

(3) In the Sinclair gorge[1] 5½ miles east of the valley road near the old construction station in the wide part of the valley loose limestone blocks full of *Plectambonites saxeus* (Sardeson) encumber the north slope near the bottom of the gorge. These talus blocks are derived from a bed of grey, dolomitic, heavy-bedded limestone about 600 feet thick, which contains:

7802 Crinoid stems
Bryozoa
Plectambonites cf. *saxeus* (Sardeson)

"These limestones overlie thin-bedded, shaly limestone with trilobite fragments, which is considered to represent the Mons."

7795 "About 500 feet of cherty dolomitic limestone follows the beds with *Plectambonites*, the uppermost beds of which furnish *Halysites pulchellus* n. sp. and a Syringoporoid coral.

(4) The Stoddard Creek section[2] is exposed north from the lower end of Stoddart Creek gorge around the west base of the mountain to the big ravine about 2 miles.

It includes more than 3,000 feet of the Mons formation at the base, consisting of thin-bedded, argillaceous, grey limestone and calcareous shale, with trilobite fragments.

Following these beds are several hundred feet of the heavy-bedded dolomitic limestones of the Beaverfoot formation. A fault contact of these beds with the Mons leaves their exact thickness uncertain in this section.

---

[1] Collected by J. R. Marshall.
[2] Collections made by E. M. Kindle, M. F. Bancroft, and J. F. Walker.

7801 The following fauna was collected from this section:
A Stromatoporoid species undtd.
Streptelasma fragile n. sp.
Streptelasma prolongatum n. sp.
Streptelasma distinctum n. sp.
Halysites robustus n. sp.
Calapoecia anticostiensis Billings
Paleofavosites asper (d'Orbigny)
Favosites cf. *favosus* (Goldfuss)
cf. *Columnaria stokesi* (M.-Ed. and H.)
Diphyphyllum? sp.
Plasmadictyon irregulare n. sp. nov. gen.
Rhynchotrema windermeris n. sp.
Rhynchotrema increbescens var. *occidens* n. var.
Rhynchotrema pisina n. sp.
Dinorthis columbia n. sp.
Dinorthis sp.
Hormotoma sp.

(5) Northeast of Windermere creek in the Stanford range.

7847 *Actinoceras* siphuncle

(6) A locality east of the above.

7852 *Rhynchotrema increbescens* var. *occidens* n. var.
cf. *Plectambonites* sp.

(7) A section[1] in the Stanford range south and east of the above, near the head of Windermere creek.

7935 "Above the base of the Beaverfoot 50 feet"
Halysites robustus n. sp.
Streptelasma patellum n. sp.
Rhynchotrema kananaskia n. sp.
Plectambonites cf. *saxeus* (Sardeson)
Protokionoceras? gracile n. sp.

7934 "Above the base of the Beaverfoot 95 feet"

There are two collections from this locality, only 2 feet apart, but having a different fauna and a different matrix.

A. *Dinorthis* cf. *columbia* n. sp.
Rhynchotrema kananaskia n. sp.
Byssonychia radiata var. *walkeri* n. var.

B. A stromatoporoid undtd.
Cyrtodonta? sp.
Spyroceras sp.
Actinoceras? siphuncle
Trilobite fragments

7933 "Above the base of the Beaverfoot 163 feet"
Streptelasma prolongatum n. sp.
Halysites delicatulus n. sp.
Coral undtd.
Crinoid stems
Rhynchotrema increbescens var. *occidens* n. var.

[1] Collections made by J. F. Walker, field No. J.

7954 "Above the base of the Beaverfoot 230 feet"
Rhynchotrema increbescens var. *occidens* n. var.

7932 "Above the base of the Beaverfoot 268 feet"
Halysites robustus n. sp.
Diphyphyllum? primum n. sp.
Favosites cf. *favosus* (Goldfuss)
Streptelasma prolongatum n. sp.
Rhynchotrema kananaskia n. sp.
Rhynchotrema cf. *increbescens* var. *occidens* n. var.
Brachiopod undtd.
Actinoceras sp.

The fossil assemblage of this bed suggests a transition zone. There are present fossils, some of which are associated elsewhere with an undoubted Richmond fauna and others which are more characteristic of a Silurian age.

(8) Fairmont Springs. Two localities representing the same beds furnished the following species:

7851
7793 *Streptelasma prolongatum* n. sp.
Streptelasma distinctum n. sp.
Halysites robustus n. sp.
Rhynchotrema increbescens var. *occidens* n. var.
Rhynchotrema pisina n. sp.
Dinorthis columbia n. sp.

(9) Near Columbia lake

7841 *Halysites delicatulus* n. sp.
Rhynchotrema sp.
Brachiopod undtd.

(10) Harrogate from two exposures of the beds

		Feet
7806	Dark grey to blackish dolomitic beds........................	500
	Streptelasma cf. *prolongatum* n. sp.	
	Paleofavosites asper (d'Orbigny)	
	Crinoid disks	
	Brachiopod undtd.	
7816	Grey, heavy-bedded dolomite.............................	450
	Halysites cylindricus n. sp.	
	Favosites cf. *hisingeri* M.-Ed. and H.	
	Paleofavosites asper (d'Orbigny)	
	Columnaria cf. *calicina* Nicholson	
	Diphyphyllum? halysitoides n. sp.	
	Syringopora columbiana n. sp.	
	Rhynchotrema increbescens var. *occidens* n. var.	

These beds appear to belong to a transitional zone. *Rhynchotrema increbescens* var. *occidens* and *Paleofavosites asper* are characteristic of beds of undoubted Richmond age, but the assemblage of corals in this lot suggests a Silurian facies.

(11) A section[1] overlooking Columbia valley at Mons, 15 miles southeast of Golden, B.C.

		Feet
	"Lighter-weathering, grey-blue limestone..................	20
5062	10 feet below top. Locality 15·109"	

cf. *Halysites robustus* n. sp.
Streptelasma prolongatum n. sp.
Streptelasma distinctum n. sp.
Streptelasma sp.
Paleofavosites cf. *asper* (d'Orbigny)
Halysites sp. (very minute)

5063 "200 feet below top. Locality 15·110"

Beatricea nodulosa Billings
Streptelasma cf. *prolongatum* n. sp.
Streptelasma sp.
Halysites delicatulus n. sp.
Calapoecia anticostiensis Billings
Syringopora burlingi n. sp.
Diphypyhllum? halysitoides n. sp.

	"Little more thin-bedded, but same as above.............	22
	Little more massive and with many chert nodules, rounded, banana-shaped, etc.	
5064	Near base. Locality 15·111"............................	22

Halysites cf. *delicatulus* n. sp.
Paleofavosites asper (d'Orbigny)
Rhynchotrema windermeris n. sp.
Rhynchotrema pisina n. sp.
Rhynchotrema kananaskia n. sp.
Dinorthis sp.
Hebertella
Cornulites sp.

(12) 7797 Canal Flats

Halysites delicatulus n. sp.

(13) The second creek entering Spray river from the east, north of Palliser pass.

7971 *Plectorthis? sinuata* n. sp.
Orthis marshalli n. sp.

(14) 7562 Shatch mountain, southeast of Palliser river

Streptelasma prolongatum n. sp.
Calapoecia anticostiensis Billings
Coral undtd.

[1] Burling, L. D.: Geol. Mag., vol. V, No. 700, p. 453 (1922).

Distribution of Species and Faunule Relations

Genera and species	Beaver-foot range				Windermere area						Stanford range								Kananaskis-Palliser area					
	Near Mons					Sinclair Gorge					Section of locality 7 on the map								East of trail					
											Above the base													
											50 ft.	95 ft.	95 ft.	163 ft.	230 ft.	268 ft.								
	5062	5063	5064	Harrogate	Stoddart 7801	7802	7795	Fairmont Springs	Columbia lake	Canal Flats	7935	7934A	7934 B	7933	7954	7932	7847. Loc. 5	7852. Loc. 6	7628	7561	7563	7969 and 7970	7971	Shatch mountain
Stromatoporoidea																								
Beatricea nodulosa Billings		x																						
Stromatoporoid (2 species)					x								x											
Anthozoa																								
Streptelasma fragile n. sp.					x																?			
Streptelasma prolongatum n. sp.	x	?		?	x			x						x		x			x	x	x	x		x
Streptelasma distinctum n. sp.	x				x			x												x	x	x		
Streptelasma patellum n. sp.											x													
Streptelasma sp. undtd.	x	x																				x		
Halysites robustus n. sp.	x				x			x			x					x				x	x	x		
cf. *Halysites robustus* n. sp.	x				x																			
Halysites delicatulus n. sp.		x	?						x	x				x								x		
Halysites pulchellus n. sp.							x																	
Halysites cylindricus n. sp.				x																				
Halysites sp. (very minute)	x																							
Calapoecia anticostiensis Billings		x			x																	x		x
Paleofavosites asper (d'Orbigny)			x	x	x																			
cf. *Paleofavosites asper* (d'Orbigny)	x			x																		x		
Favosites cf. *favosus* (Goldfuss)					x											x								
Favosites cf. *hisingeri* M.-Ed. and H.				x																				
Columnaria alveolata var. *stellaris* n. var																				x		x		
Columnaria cf. *calicina* Nicholson				x																				
Columnaria cf. *stokesi* (M.-Ed. and H.)					x																	x		
Syringopora columbiana n. sp.				x	x																			
Syringopora burlingi n. sp.		x																						
Syringoporoid coral							x																	
Diphyphyllum? halysitoides n. sp.		x		x																				
Diphyphyllum? primum n. sp.																x						x		
Plasmadictyon irregulare n. sp.					x																			
Crinoid stems				x										x										
Bryozoa																								
Species undtd.																						x		
Brachiopoda																								
Lingula (2 species)																				x				
Rhynchotrema windermeris n. sp.			x		x																			
Rhynchotrema increbescens occidens n. var				x	x			x						x	x	x		x	x		x	x		
Rhynchotrema pisina n. sp.			x		x			x																
Rhynchotrema kananaskia n. sp.			x								x	x				x			x	x	x	x		
Plectorthis? sinuata n. sp.																			x		x		x	
Orthis marshalli n. sp.																			x	x	x	x	x	
Dinorthis columbia n. sp.					x			x				x							x	x	x	x		
Dinorthis rockymontana n. sp.																				x	x			
Dinorthis sp.					x																			
Dinorthis sp.			x																					
Hebertella sp.																						x		
Hebertella sp.			x																					
Petroria rugosa n. sp. nov. gen.																			x					
Plectambonites cf. *saxeus* (Sardeson)						x					x													
cf. *Plectambonites*																		x						
Pelecypoda																								
Byssonychia radiata walkeri n. var												x												
Cyrtodonta? sp.													x											
Vermes																								
Cornulites parvis n. sp.																			x					
Gastropoda																								
Hormotoma sp.					x																			
Hormotoma sp.																			x			x		
Palliseria robusta Wilson																						x		
Lophospira occidentalis Wilson																					x			
Cephalopoda																								
Vaginoceras? eccentricum n. sp.																				x				
Antinoceras complanum n. sp.																					x			
Actinoceras sp.																x	x							
Actinoceras? siphuncle													x											
Protokionoceras? gracile n. sp.											x								x					
Orthoceras sp.																						x		
Spyroceras intermedium n. sp.													x											
Trilobita																								
Trilobite fragments													x											

DESCRIPTION OF SPECIES

ANTHOZOA

Genus, **Streptelasma** Hall

Streptoplasma Hall, Pal. N.Y., vol. I (1847) (Changed to *Streptelasma*); *Streptelasma* Milne-Edwards and Haime. Mon. d. Polyp. Foss. d. Terr. Pal. (Arch. du Mus. d'Hist. Nat., 5), p. 398 (1851); Dybowski, Archiv. f. Natur. Liv.-Ehst. und Kurl., 5, p. 381 (1874); Nicholson, Rept. Pal. Ont., pt. 2, p. 26 (1875); Rominger, Geol. Surv., Mich., vol. III, pt. 2, p. 140 (1876); Nicholson and Etheridge, Mon. Sil. Foss. Girvan Dist., p. 67 (1878); Lambe, L. M.: Geol. Surv., Canada, Con. Can. Pal., vol. IV, pt. 2, p. 107 (1901).

Owing to the imperfection of some of the specimens examined the genus *Streptelasma* has been distinguished by several more or less contradictory characteristics. The original description by Hall differentiates it by the central twisting of the primary septa. Later, Milne-Edwards and Haime add to the description the incompleteness of the development of the tabulæ, but characterize the lack of epitheca as of generic value. Dybowski rightly assigns the lack of an epitheca to poor preservation and adds to the generic characteristics the pseudo-columella formed by the central twisting of the primary septa, frequently resulting in a boss in the bottom of the calyx, giving as the two differentiating generic distinctions the tabulæ arranged in more or less regular horizontal planes occupying the whole visceral chamber, and the absence, near the margin of the cup, of the vesicular tissue which characterizes certain of the Cyathophyllides. Nicholson stresses as characteristics the poor development of the tabulæ and the total lack of dissepiments; later he notices the presence of infrequent dissepiments. Rominger first notes the presence of an inconspicuous septal fossula, a feature which in some cases makes it difficult to distinguish from *Zaphrentis*, of which he considers it a subgenus, regarding the differences as a matter of degree rather than of kind. Lambe distinguishes the two genera by the completeness of the tabulæ and the conspicuousness of the septal fossula in *Zaphrentis*.

The history of the form of the descriptions, then, lies in the fact that early writers considered it necessary to distinguish *Streptelasma* from *Cyathophyllum* and stressed the lack of the vesicular zone in the margin to the exclusion of all dissepiments. Later writers, with a wider range of species, found closer affinities with *Zaphrentis* and stressed such affinities and differences. There is also some confusion in the use of terms. Dybowski says the irregular tabulæ fill the visceral chamber, possibly including some forms of *Zaphrentis* of which his generic characteristic was the presence of the fossula. Other later authors describe the genus with a few dissepiments and interrupted irregular tabulæ. Lambe says "no true tabulæ, their place being taken by dissepiments". It is a matter of interpretation whether the irregular, frequently inclined partitions dividing the interstices between the septa are true dissepiments or incomplete, irregular, poorly-developed tabulæ.

The constant characteristic differentiating *Streptelasma* from *Zaphrentis* seems to be the vesicular cellulose central region, although *Streptelasma* in common with *Zaphrentis* has a pseudo-columella formed by the twisted ends of the primary septa, and in some cases a few marginal dissepiments. Some species possess a septal fossula, though commonly it is less conspicuous than in species of *Zaphrentis*.

Streptelasma fragile n. sp.

Plate I, figures 1, 2

Corallum small and slender, the apex as a rule slightly curved. All specimens are partly broken, the fragile cup usually being destroyed. One large, fairly well preserved specimen measures 15 mm. in length, 6 mm. in diameter. Epitheca somewhat wrinkled, faint longitudinal striæ present. Calyx circular, but sections at the base of the cup are slightly compressed, the narrower diameter being from the concave to the convex sides of the slight curvature in the corallum. Calyx three-fourths length of whole corallum, a long, gradually tapering fragile funnel, truncated, not pointed, at the bottom. Pseudo-columella not protruding. Secondary septa minute but distinct. Primary septa 15 to 20. Cardinal septum on the short diameter. Tetrameral arrangement of the septa well developed.

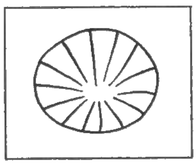

Figure 2. *Streptelasma fragile*, diagrammatic relation of septa. x 3.

S. fragile is readily distinguished from other described Ordovician forms by its size and slender proportions. The broken tips of the species resemble specimens of the Silurian *S. pygmaeum*, but a fairly complete specimen is easily recognized by the larger size, more slender form, and the proportionately deeper calyx of *S. fragile* with its truncated rather than pointed base. *S. fragile* differs from *S. conulus* Rominger in its greater size, in having faint longitudinal striæ, in the slight curving at the apex, and in the arrangement of the principal septum.

Horizon and Locality. Richmond: Beaverfoot. From the Stoddart Creek section, Windermere district, Rocky mountains, British Columbia. A somewhat broken, small *Streptelasma* probably belonging to this species is among the specimens from three-fourths mile east of the trail on the east slope of Palliser pass.

Streptelasma prolongatum n. sp.

Plate I, figures 3, 4, 5; Plate II, figure 2

Corallum simple, slightly curved, rapidly widening. In some cases attaining large proportions, several specimens approaching 40 mm. in the longest diameter. Outer surface of the epitheca thin, comparatively smooth in the younger stages of development, becoming more wrinkled with age. Longitudinal striæ on the outside corresponding to the secondary and primary striæ within. The strikingly elongated pseudo-fossula is the cause of a sharp angle upon the slightly curved side of the outer surface, the outline at the opposite end of the diameter being semicircular, the sides of the prolonged portion varying from flat to slightly convex. Cup deep, almost straight sides. The characteristic feature of the species, however, is the prolonged cardinal septum, a feature which becomes accentuated with age. In many cases the septum itself is broken, leaving a deep, pronounced fossula. Septa alternating, shorter ones almost rudimentary, only seen in the younger examples, becoming amalgamated with the thickened wall in older specimens. Primary septa 35 to 55 twisting slightly at the centre, 10 to 14 on each side of the cardinal septum directed toward the centre at different angles. Upper septa fan-shaped. Dissepiments numerous, becoming more or less contiguous in the visceral chamber, but never developed into true tabulæ and with the twisted ends of the primary septa forming a very cellulose structure which rises above the level of the cup floor in a persistent but not very pronounced pseudo-columnella. The twisted ends of the septa show the development of delicate, little, plate-like standards that flaunt themselves at various angles, making a remarkable and beautiful interior shown in the bottom of the cup of any well-preserved specimen.

S. prolongatum in outward form is quite distinct from any other described species. The closest in form is *S. trilobatum*, but its proportions are different and the Rocky Mountain species, although having in a much more pronounced degree the angular lobe due to the prolonged cardinal septum, lacks the two other side lobes with the troughs between, and it has nothing of the approximately equilateral form of the Stony Mountain species.

Horizon and Locality. Richmond: Beaverfoot. From the Stoddart Creek and Fairmont Springs sections in Windermere district; at 163 feet above the base of the Beaverfoot near the head of Windermere creek in the Stanford range; at Harrogate; and at Palliser pass, Rocky mountains, British Columbia.

Streptelasma distinctum n. sp.

Plate I, figures 6, 7

Corallum simple, enlarging rapidly, not complete in any specimen, the largest being about 1⅓ inches in length. Epitheca somewhat wrinkled, showing the vert cal striation of the septa. On the exterior surface there is a slight angle, rather rounded, along the edge of the cardinal septum, in some cases giving the cross-section a semi-rhomboid form, the subdued angles being at the ends of the alar septa, at the cardinal angle and opposite. The short diameter passes through the cardinal septum. Some specimens appear to be almost straight, but a few show a slight tendency to curve away from the cardinal angle. Cup at least two-thirds length of whole height, bottom convex when seen in section. Septa primary and secondary, the latter in some cases becoming amalgamated with one another and the primary septa, forming a complete inner wall beyond which they do not project, the primary septa thirty to forty in number extending to the centre where they are somewhat twisted.

The specimen illustrated shows the beautiful arrangement of the septa. The cardinal septum along the shorter diameter of the corallum is extended beyond the centre, shortening the length of the septa in the fan-shaped arrangement of the two counter quadrants. The septa of the cardinal quadrants are gathered up with a twist into two little knots, hollow in the centre, looking like pores in the bottom of the cup cavity. The cardinal septum casts in its lot with the right-hand group, orienting the specimen with the cardinal septum facing the observer. The septa of the two counter quadrants also run to two centres, but if they are twisted in a knot it is not preserved. The long cardinal septum appears to be weakened by its length and lack of support and is often destroyed, the space between forming a distinct pseudo-fossula.

Longitudinal sections did not prove very satisfactory. The septa can be traced to the centre, but any tabulæ or dissepiments have been destroyed by secondary deposits.

S. distinctum is easily identified when the septal arrangement is preserved. When it is not it is readily distinguished from other species by the semi-rhomboid form due to the elongated lateral diameter, and the position of the pseudo-fossula on the shorter diameter. The angle along the line of the cardinal septum suggests relationship with *S. prolongatum*, one species seems to push out its growth laterally, the other along the cardinal septum, resulting in the different outline. Otherwise they are very similar. The pseudo-columella of *S. distinctum* is more projecting and the cellulose part of it is smaller and more simple. One well-preserved specimen of *S. distinctum* shows the same tendency toward the development of the plate-like standards, though to a less degree than in *S. prolongatum*.

Horizon and Locality. Richmond: Beaverfoot. At several localities just east of Palliser pass, at the Stoddart Creek section, and at the Fairmont Springs section in Windermere district, Rocky mountains, British Columbia.

Streptelasma patellum n. sp.

Plate II, figure 1

In size and general proportion similar to *S. distinctum* with subdued angles at the ends of the alar septa, and no angle outlining the cardinal septum. As in *S. distinctum* the shortest diameter passes through the cardinal septum, but this species differs from any other in having a flat, plate-like projection which appears to be a continuation of the central part of the cardinal septum, protruding upward into the cavity of the cup and tilted slightly backward toward the opposite wall. The plate is helmet-shaped, placed with the point up, though it is possible that its outline is not complete.

Horizon and Locality. Richmond: Beaverfoot. Fifty feet above the base in a section at the head of Windermere creek, Stanford range, B.C.

Halysites robustus n. sp.

Plate I, figures 8, 9, 10

This species is a robust form growing in massive colonies. Meshes of the reticulations of corallites mostly large, many long and narrow. No tubuli present. Corallites narrowly oval, walls thickened and slightly flattened at the ends, giving the outside of the corallite an oblong outline rather than the more oval outline of the interior. Spines not well preserved, although their presence is indicated in some corallites. A longitudinal section shows strong, complete tabulæ about 1 mm. apart.

H. robustus is closely allied to *H. gracilis*, but differs from it in having less quadrangular corallites, thicker walls, and heavier tabulæ. Viewed in the cross-section *H. robustus* looks more slender on account of the narrower, more oval corallites, viewed in the longitudinal section it looks smaller but coarser and heavier because of the less numerous but thickened tabulæ and consequent smaller and more quadrangular spaces.

Horizon and Locality. Richmond: Beaverfoot. From the 'Halysites' beds and 250 feet below them, Palliser pass; from Fairmont Springs, Windermere district; at 50 feet and 268 feet above the base of the Beaverfoot in the Stanford range near the head of Windermere creek, Rocky mountains, British Columbia.

There is a *Halysites* from the Stoddart Creek section of Windermere district that seems a variation of *H. robustus*. It has the robust form, but the majority of corallites are oval rather than oblong and the longitudinal section shows more numerous tabulæ than the Palliser and Fairmont Springs form.

Halysites delicatulus n. sp.

Plate II, figures 3, 4, 5

A delicately formed *Halysites* with mesh of the reticulations much finer than in the preceding species. Corallites small, averaging about 3 in 5 mm., almost oblong, slightly narrower at the ends than in the centre, length of corallite about one and a half times the greatest width. Where crowded, the shape becomes more rectangular, and at times almost circular. A cross-section shows the two contiguous ends of the walls flattened against one another. A longitudinal section shows complete tabulæ, six to seven in the space of 3 mm., mostly straight, some bent a little at the contact with the wall.

It differs from the widely distributed *H. catenulatus* in the absence of intercorallite tubules. It can readily be distinguished from *H. robustus* and *H. gracilis* by its finer reticulations and much more delicate form. *H. gracilis* has coarser, much more rectangular corallites. In *H. robustus* the corallite tends to be oblong, but it is much heavier and a longitudinal section shows the transverse tabulæ of *H. delicatulus* to be finer and about twice as numerous.

Horizon and Locality. Richmond: Beaverfoot. This species seems to range from the Beaverfoot beds where it is found in conjunction with *Dinorthis* into beds in which it is in association with a definitely Silurian fauna. It occurs at the Beaverfoot horizon from the Palliser Pass area, from the Beaverfoot range near Golden, at 163 feet above the base of the Beaverfoot in the Stanford range near the head of Windermere creek, and at a locality near Columbia lake, which may be the upper part of the Beaverfoot or the lower part of the Silurian. Rocky mountains, British Columbia.

Halysites pulchellus n. sp.

Plate III, figures 8, 9

A massive, growing colony having reticulations with a fine mesh. Corallites small, oval, slender in outline, averaging three in 5 mm., width 1 mm., at the widest part, the whole producing a beautifully delicate chain in the cross-section. No intercorallite tubuli. Walls thicker than is usual in such a fine species. Tabulæ complete, averaging four to five in 3 mm.

It is most closely related to *H. delicatulus*, but a comparison of a cross-section shows clearly the difference between the oblong, or in many cases almost square, outline of *H. delicatulus* and the beautifully shaped oval outline of *H. pulchellus*. The tabulæ, too, are less numerous in *H. pulchellus*.

Horizon and Locality. Richmond: Beaverfoot. Sinclair gorge, about 500 feet below bridge west of Park warden's cabin.

Halysites cylindricus n. sp.

Plate II, figures 6, 7

Massive colonies of a small form of Halysites coral. Meshes very fine. Corallites cylindrical, very small, averaging 1 mm. in diameter, barely in contact, some free. No intercorallite tubuli, complete rather heavy tabulæ, about six to seven in 3 mm., a relationship which in the small corallites produces a relatively large space.

Superficially *H. cylindricus* resembles *H. micropora* on account of the smallness of the corallites, but it is easily distinguished by its cylindrical form, its lack of tubuli, and the loose contact of the corallites. The interior of *H. micropora* has not been figured, so that the tabular arrangement cannot be compared. It lacks intercorallite tubuli in common with *H. delicatulus* and *H. pulchellus*, but differs from them in the size and shape of the corallites. The tabulæ are about the same distance apart as in *H. delicatulus*, but the smaller diameter of the tube makes them shorter. A weathered specimen of *H. cylindricus* presents an aspect quite different from any other species, due to the smallness and roundness of the corallites and the frequent looseness of contact.

Horizon and Locality. Exact horizon not known. The lack of intercorallite tubuli would suggest Upper Ordovician. Harrogate, B.C.

Columnaria alveolata n. var. *stellaris*

Plate III, figures 1, 2

Massive corals, exact form not known. Corallites polygonal, small for the genus, diameter averaging about 2 mm. to 3 mm., walls contiguous but not amalgamated, as is shown by the form of weathering which leaves long columns broken apart but with walls intact, upon which the longitudinal striæ and the growth lines are visible even in very poorly preserved specimens. Septa alternating, ten to twelve primary ones reaching to the centre, giving a well-preserved corallite a starlike opening; secondary septa extending to only a little distance from the wall, in many cases hardly visible. Tabulæ about 1 mm. apart in the small section in which they are preserved.

C. alveolata var. *stellaris* differs from *C. alveolata* proper only in the smaller size of the corallites, the fewer number of the septa, and the generally more closely placed tabulæ.

Horizon and Locality. Richmond: Beaverfoot. One-half mile east of the trail, Palliser pass, and between Spray and Palliser rivers, Kananaskis area, Rocky mountains, B.C.

Favosites cf. *favosus* (Goldfuss)

Plate III, figure 7

It is with some hesitation that this coral is identified with these species. It has not previously been reported from the Ordovician, but yet the variations are not sufficient to differentiate it from a species which varies so widely in one colony. A much larger collection of material would be necessary to establish such variations as specific. The corallites are smaller than the average *F. favosus*, the longitudinal furrows are in many cases fewer than twelve; the pores in each wall are arranged in one row in many more cases than in two, and no wall, in the specimens at hand, exhibits three rows of pores. The most outstanding variation from the true *F. favosus* is the constant interspersal of small corallites between the larger ones, giving it the general aspect of the pores and mesopores of a magnified bryozoa. The small corallites seem to be similar to the large ones. This may not be a constant feature. It may only indicate that the specimens happened to come from the younger, more rapidly enlarging portion of the colony. Otherwise the specimens appear to agree with the Silurian species. Rominger, in his description of *F. favosus*, mentions transverse undulating rows of the spinulose projections forming ridges corresponding to the external transverse wrinkles of growth, a feature which is commonly very evident in the Rocky Mountain species. The general aspect of the specimens is that of an earlier, less highly developed, more primitive form of *F. favosus*.

Horizon and Locality. Richmond: Beaverfoot. From the Stoddart Creek section, Windermere area; in the Stanford range near the head of Windermere creek, at 268 feet above the base of the Beaverfoot, from an horizon in this section in which those fossils first appear which give a Silurian aspect to beds containing forms of undoubted Ordovician age. Rocky mountains, B.C.

Syringopora burlingi n. sp.

Plate III, figures 3, 4

Tubes $1\frac{1}{2}$ mm. to 2 mm. in diameter, distant from one another about their own diameter, subparallel growth, rarely touching. Numerous, often verticillate, transverse tubules, stout, averaging as large as 1 mm. in diameter, closely placed, many less than 1 mm. apart. External surface covered with multitudinous wrinkled lines of growth. Diaphragms slightly concave, not funnel-shaped, four to five in 2 mm., as a rule more crowded in the region from which the transverse tubules are given off.

S. burlingi is easily distinguished from any other species in a longitudinal section by the stout, relatively closely set corallites, and thick, crowded, transverse tubules, resulting in a closely compact strong corallum. The size of the corallites is not very different from *S. retiformis* and a view of the top might suggest a comparison, but they are more closely set than in the latter species, and a longitudinal view makes the differences very evident. The corallites are smaller than *S. dalmani* and the tubules more crowded.

The species is named after Mr. L. D. Burling, who made a collection in these Ordovician beds during his time spent on field work for the Geological Survey, Canada.

Horizon and Locality. Richmond: Beaverfoot. Twenty feet up in light grey *Halysites* beds. Beaverfoot range, northeast of mount McMurdo, near Golden, B.C.

Syringopora columbiana n. sp.

Plate III, figures 5, 6

A coral forming a large colony. No specimen is complete, but judging from the erect direction of the tubes of one large specimen it grows from a small base assuming an upright rather than a spreading form. Long, slender tubes $\frac{1}{2}$ to $\frac{3}{4}$ mm. in diameter, in some cases diverging slightly, mostly subparallel, in some cases contiguous, in some cases about 1 mm. apart. Connecting tubules at intervals of from $2\frac{1}{2}$ to 3 mm. Ring growth-lines not evident, though the surface is frequently undulating.

A longitudinal section shows the interior not well preserved. It is not possible to trace the usual funnel-shaped cups, but little projections inward from the walls suggest that they are oblique rather than horizontal.

S. columbiana resembles *Cannapora junciformis* Hall (*S. fibrata* Rominger) in the fineness of its tubes, but differs from it in the smoothness of the exterior surface, and the length of the intervals between the transverse tubes is from four to five times as great, both of which characteristics tend to give it a more slender, delicate form. It differs from *S. compacta* in that the tubes are subparallel, and a slight distance apart, not in the perfect contiguity exhibited by the latter species.

Horizon and Locality. Richmond: Beaverfoot. From the Stoddart Creek section, Windermere area, and at Harrogate, B.C.

Diphyphyllum (?)

The two following species, though differing in several respects from the typical *Diphyphyllum*, are provisionally referred to it. The external characteristics and mode of growth are similar to that genus. The typical *Diphyphyllum* has an outer vesicular zone and an inner zone characterized by well-developed tabulæ. The two Rocky Mountain species appear to have a thick wall. If there is a finely vesicular area just within the outer wall the form of preservation has obliterated it, thickening the wall. Both species have long septa extending to the centre, a feature which is seen in several species of *Diphyphyllum*; the smaller does not perserve any other development in the inner side of the corallite, the larger shows the vesicular plates persisting into the interior part of the corallite, the resulting cell spaces being coarser than is usual for the outer area of *Diphyphyllum*, a condition similar to that described in *D. huronicum*. It is possible that these differences are of generic value, but if so, better material would be required to warrant separation from *Diphyphyllum*, so that pending the discovery of more and better specimens the species are here referred to that genus.

Diphyphyllum? halysitoides n. sp.

Plate II, figures 8, 9

There is no specimen sufficiently well preserved to show the marginal area of the corallite. There are, however, several characteristics which are very evident. Corallum apparently massive. A weathered longitudinal section shows that the corallites increase by lateral budding. Tubes mostly circular, though some are oval; free, or in many cases just touching one another, forming a chain of coarse reticulations suggestive of a very large species of *Halysites*. Diameter of corallites 3 mm. to 5 mm. Septa, about forty in number, primary and secondary, the former very fine, reaching nearly to the centre. One corallite which is preserved almost to the centre shows a tendency for the gathered ends of the septa to make a very slight twist. Tabulæ not preserved.

D.? halysitoides can easily be distinguished from any other species of this genus by its form of growth.

Horizon and Locality. Richmond: Beaverfoot. Twenty feet up in the light grey *Halysites* beds, Beaverfoot range, northeast of mount McMurdo, near Golden, and from Harrogate, B.C.

Diphyphyllum? primum n. sp.

Plate II, figure 10

Corallites larger than in the preceding species, circular, diameter from 3½ mm. to 6 mm. Some contiguous, mostly separate, but irregularly connected at intervals by the prolongation of the rugose growth wrinkles. Increase often by lateral germination, the new corallites enlarging rapidly, but in many cases a number will arise from the side of a tube horizontal to their direction, very similar to the stolon root form in plants.

Septa crenulated, about forty in number, clearly defined almost to the centre, apparently uniting there, though in many the central part is occupied by secondary deposits. Vesiculose plates continuing through a large proportion of the interior of the corallite. No true horizontal diaphragms. No wall nor other demarcation between the central and outer areas.

D. primum can readily be distinguished from *D.? halysitoides* by its more normal form of growth and by its larger and more circular corallites. Of the Silurian *Diphyphyllums* it resembles *D. huronicum* in the lack of true diaphragms and the large proportion of the vesiculose interstices, but the considerably smaller corallite differentiates it at once.

Horizon and Locality. Richmond: Beaverfoot. Between mount Sir Douglas and mount Munroe, Palliser pass, at 268 feet above the base of the Beaverfoot in the section near the head of Windermere creek in the Stanford range, British Columbia.

Plasmadictyon nov. gen.

The two specimens described under this genus are not well preserved, but they clearly do not belong to any previously defined genus. The corallum grows as a low, flat expansion, possibly encrusting some other shell. Surface a network of small, irregular corallites, polygonal, circular, angular, or crescent shaped, never larger than ¾ mm., many mere tubules. Pores, when present, very large. In general form of growth suggesting *Protarea*, but the corallites are not in any degree similar. A more complete generic description of this coral will have to await the finding of better material.

Plasmadictyon irregulare n. sp.

Plate I, figures 11, 12

Corallum forming thin expansions, the larger of the two incomplete specimens found measuring 1½ inches across the piece and the height of the growth ranging from 3 mm. to 5 mm. The surface is covered with small deposits due to the form of silicification. At times the top of the corallite is roofed over. In some cases the deposits are in the form of tiny, irregularly rounded nodes, or as minute separate granules; or a number run together along the top of the wall of a corallite. No epitheca evident, many of the corallites having open ends at the base. The epitheca, if present, must have been dissolved away, or if the coral were encrusting another form it must have broken from it. In one rather crushed portion of the larger corallum there is the crumpled suggestion of an epitheca. Corallites upright, very irregular in size and shape, largest tubes generally circular, from ½ mm. to ¾ mm. in diameter. Many of these larger circular tubes are surrounded by minute tubules which apparently begin in the wall and are not yet sufficiently developed to have calices of their own. Between these two forms there is every possible variation of size and shape, some crescent-shaped surrounding one-half of a circular tube, some angular, some more or less irregularly elliptical, in some cases placed as though radiating from a central larger one. Some parts show an arrangement of larger and smaller corallites that suggests the mesospores of certain bryozoans. A longitudinal section in one well-preserved part shows three, large, complete pores arranged in a vertical row in the wall of one corallite, with two partly effaced by grinding in another face of the wall. The larger tubes show cups quite half their own length, and there seems to be some form of delicate longitudinal striation within the cup. This, however, may in part be due to the nature of the silicification.

Horizon and Locality. Richmond: Beaverfoot. Stoddart Creek section, Windermere area, B.C.

BRYOZOA

There is a single bryozoan, which like *Diamesopora* is a hollow tube, but the specimen is more robust than is usual with that genus. It is too poorly preserved to admit of identification.

Horizon and Locality. Richmond: Beaverfoot. Between Spray and Palliser rivers, Palliser pass, Kananaskis area, B.C.

BRACHIOPODA

Rhynchotrema windermeris n. sp.

Plate IV, figures 1, 2, 3, 4

Shell very large for this genus, the best-preserved pedicle valve measuring 30 mm. in length, and about the same or less in width. Greatest width anterior to the middle. Beaks, particularly that of the pedicle valve, more acuminate than is usual in *Rhynchotrema*. Fold on the brachial valve inconspicuous at the beak, becoming steep-sided and prominent, corresponding sinus on the pedicle valve hardly to be distinguished at the beak, becoming deeper with maturity but with sides more sloping than those of the fold. Pedicle valve not so convex as the brachial valve. Both valves covered with strong, radiating, simple striæ, broadly rounded on top with narrow, deep troughs between, four on the fold, and four to six on each side, the corresponding number on the pedicle valve with three in the sinus. In the embryonic stage apparently there were only two striæ on the fold revealed by the eating away of the shell by acid. The bifurcation took place in the very early stages of growth, the weaker stria in each case defining the top of the steep fold, the two larger striæ in the centre. The median trough between the two original striæ is deeper than the subsidiary troughs between the two branches of each bifurcated stria. The three striæ in the sinus appear to originate separately at the beak. All are crossed by fine growth lines producing an ornamentation very similar to *R. capax*.

Internally the brachial valve is of a typical *Rhynchotrema* structure in the division of the long septum to form a support for the rather small, stout crural plates, and in having the linear cardinal process lying along the bottom of the crural cavity, but the narrow cavity itself pertains to the *Camarotoechia* type in that it does not extend to the bottom of the shell.

The crural plates are very similar to those of *R. capax*, as are also the deep dental sockets. The large deltidial plates of the pedicle valve are present, but so poorly preserved that it is impossible to distinguish the line of amalgamation. The teeth are broken, but the thin walls show no sign of dental plates.

Externally *R. windermeris* is very similar to the large Stony Mountain *Rhynchotrema* identified as a large form of *R. capax*. There was no specimen of *R. Windermeris* showing the two beaks together, so that externally there is a possibility of variation from the very much incurved beaks of the Stony Mountain species. Several attempts have been made unsuccessfully to eat out the interior of the Stony Mountain *Rhynchotrema* with acid or caustic. The writer is inclined to think, however, that this form, if not identical with *R. windermeris*, is more closely allied to it than to *R. capax*. *R. windermeris* differs from *R. capax* in its larger size, in being relatively narrower, in its somewhat less rotund proportions, and in the initial stage of the striæ on the fold. Internally, *R. windermeris* is less robust, the region around the muscle scars and below the teeth being much more fragile than the thickened heavy interior of the pedicle valve of *R. capax*. The crural cavity of the brachial valve of the western species is more open and does not reach the bottom of the shell.

Horizon and Locality. Richmond: Beaverfoot. From the Stoddart Creek section of Windermere district, and northeast of mount McMurdo, Beaverfoot range, British Columbia.

Rhynchotrema increbescens var. *occidens* n. var.

Plate IV, figures 6, 7, 8, 9, 10

Shell quite variable in size and shape, including all gradations from a narrow acuminate form to a form as large as, and very similar to, the exterior of *R.? anticostiensis*. Most of the specimens, however, are smaller than *R. increbescens*, and the form is characteristically more acuminate and less gibbous. As a rule four, though in some cases three, striæ on the fold and a corresponding number on the sinus. Interior of the pedicle valve very similar to *R. increbescens*. Interior of brachial valve showing a variation in the shape and proportions of the different parts. The crural plates of the eastern species (Plate IV, figure 5) flattened and grooved near the hinge, send into the shell cavity long, slender tongues with slightly thickened bifid ends, their direction being at right angles to the hinge-plate. The crural plates of the western variety are shorter and threadlike, continuing in the plane of the hinge-plate. The hinge-plates of *R. increbescens* are concave and at right angles to the edge of the valve. The hinge-plates of the western variety are shorter and narrower with a groove in the top. They slope down to the point from which the crural plates begin, from which point they turn abruptly downward and backward toward the beak, leaving a very short and not deep crural cavity. The cardinal process is minute, and the whole cleft and hinge-plate is placed at an angle so that the end of the septum appears to support it from below at right angles, rather than continuing in the same line as the linear cardinal process and crural cavity, as in *R. increbescens.*

Horizon and Locality. Richmond: Beaverfoot. Three-fourths mile east of Palliser pass and from the Stoddart Creek section, Windermere district, British Columbia.

Rhynchotrema pisina n. sp.

Plate IV, figures 11, 12, 13

A small, round, pea-like species of *Rhynchotrema,* a little greater in breadth than in length, some attaining the size of a small *R. increbescens* var. *occidens,* but rounder; the average specimen is considerably smaller. Beaks incurved, fold inconspicuous, hardly more than the enlarging of the four central striæ, sinus more distinct than fold. Striæ angular, fourteen to sixteen in number, the enlargement of the four central ones practically constituting the fold, the five or six on each side being much finer. The whole crossed by growth lines producing the *Rhynchotrema capax* ornamentation on a finer scale.

Brachial valve very convex, showing a slight median depression at the beak that disappears after passing over the umbonal region and usually marks the septum in the interior. The inconspicuous fold alters the anterior margin but very slightly. Only one brachial interior was produced, showing the crural plates in the same plane as the hinge-plates and tapering into two thread-like elongations produced in the same plane, not turned towards the other valve as is the case in *R. increbescens* and in a less degree in *R. increbescens* var. *occidens.* The cardinal process is not preserved, but it must have been very minute. Septum thin, plate-like, with the narrow edge towards the cavity of the shell, supporting the amalgamated hinge-plates at right angles from behind.

Pedicle valve less convex than the brachial, sinus more distinct than the fold of the brachial valve, altogether giving it a more triangular outline than that of the other valve. Beak overlapping the brachial beak, and less incurved. Interior not known.

R. pisina is readily distinguished from other species by its small round form when both valves are present, by the minuteness of the cardinal process, and the elongations of the crural plates on the plane of the hinge-plate. The detached pedicle valve tends to grade up to the size and shape of *R. increbescens occidens* and is easily confused with small specimens of that species.

Horizon and Locality. Richmond: Beaverfoot. From the chert beds of the Beaverfoot range, from the Fairmont Springs and the Stoddart Creek sections, Windermere district, British Columbia.

Rhynchotrema kananaskia n. sp.

Plate IV, figures 14, 15, 16, 17, 18

Shell of moderate size, breadth a little greater than length, average breadth 15 to 17 mm., convexity not so pronounced as in many species of this genus. In old age, however, the gibbosity of the shell greatly increases. Beak of the brachial valve incurving, enclosed by that of the pedicle valve which projects somewhat beyond it. Fold and sinus well marked, but not so deep as in *R. capax* or *R. windermeris*. Striæ simple, rather angular, four on the fold and three in the sinus in most cases, but three on the fold and two in the sinus are not infrequent with seven to nine on the sides. Zigzag growth lines produce an ornamentation similar to *R. capax*.

Brachial valve convex, but in many specimens after the greatest convexity is reached there is a flattened outline, passing from the convexity of the umbonal region to the anterior margin, best seen in a profile view. Pedicle valve less convex and more narrowly triangular than the brachial.

Several unsuccessful attempts were made to "eat out" the interior filling, but it appears to be insoluble in acid.

R. kananaskia is easily distinguished from the previously described species of Rocky Mountain *Rhynchotremas*. In its ornamentation and general form it is allied to *R. capax*, but it is smaller and although having the tendency towards a gibbous form in its gerontic stages, the average mature specimen is not so convex, the beak, particularly that of the pedicle valve, is more projecting, the striæ are finer and more numerous on the sides.

The species is larger than *R.*? *anticostiensis* and wider in proportion to its length, making a less triangular outline. The beak is less acuminate.

At 95 feet above the base of the Beaverfoot in the section at the head of Windermere creek, one specimen was found having an extra plication on the edge of the slope limiting the sinus, making five plications, three in the floor of the sinus and two on the slopes; the opposite valve is not sufficiently preserved to show whether there is a corresponding extra pair on the fold. The specimen is very gibbous and it has every appearance of being a condition of a gerontic stage of development.

Horizon and Locality. Richmond: Beaverfoot. From several localities east of Palliser pass, from the cherty beds northeast of mount McMurdo, Beaverfoot range, and from 95 feet above the base of the Beaverfoot at the head of Windermere creek, British Columbia.

Plectorthis? *sinuatis* n. sp.

Plate IV, figures 19, 20, 21

Shell small, rather flat, breadth twice the length, average length 10 mm., width 5 mm. Greatest width at hinge-line. Cardinal angles sharp. Sides narrowing down somewhat towards the anterior margin, which is subparallel to the hinge-line, producing a form almost oblong in outline. Striæ very fine, increasing by bifurcation, many of the same striæ dividing twice, primary and secondary in many cases so grouped as to result in a fascicular ornamentation, crossed by very fine concentric growth lines, more evident near the anterior margin.

Pedicle valve with a small fold sharp and narrow at the beak, becoming wider and lower as it crosses the umbonal region toward the margin. Cardinal area narrow, more elevated than that of the brachial valve. Delthyrium triangular, a little higher than wide, partly covered by a short, convex plate of the apex. Interior showing small teeth, each supported by a delicate dental lamina, the base of which continues as a slightly elevated ridge marking the limits of the small, flabellate muscle scar.

Brachial valve very slightly convex at the umbo, with a narrow but definite sinus which widens towards the margin, producing a more sinuate anterior margin than in the pedicle valve; foramen wide. The cardinal process seen from the outside is a short, wide projection filling up the foramen, the interior, however, shows it to be an elongate vertical plate along the whole length of the crural cavity. A low, very broad median ridge, which widens anteriorly in its lower part, suggests a strengthening of the shell on the interior of the sinus rather than a true septum.

The interior of the shell places it in the *Orthis* group. It is provisionally placed in the genus *Plectorthis* because of its bifurcating striæ, and its wide hinge-line with the cardinal areas of the two valves more nearly equal than in typical species of the restricted *Orthis*, but it resembles *Orthis* in the flatness of the brachial valve and in the short apical plate over the delthyrium. It differs from either, however, in the very fine striation, in the width of its hinge-line, in the incipient fold and sinus and the consequent sinuate anterior margin. The ornamentation is suggestive of *P. triplicatella*, but that species is larger and has a different outline. It is more closely allied to *P. jamesi*, from which it differs, however, in the more definite fold and sinus, and consequent more sinuate anterior margin, and in the somewhat lower cardinal areas and less prominent beaks.

Horizon and Locality. Ordovician: Beaverfoot. Three-fourths mile east of Palliser pass, British Columbia.

Orthis marshalli n. sp.

Plate V, figures 1, 2, 3, 4, 5, 6

Shell plano-convex, width slightly greater than length, average specimen length 8 mm., width 10 mm. Cardinal area of brachial valve very small, pedicle area erect, somewhat concave, height about one-third length. Delthyrium open, narrow, apex slightly rounded rather than angular, without the short apical plate frequently seen in species of *Orthis*. Striæ simple, strong, sharply defined, twenty-four on one unusually large specimen, but averaging about twenty.

Brachial valve almost flat, very slightly convex at the beak, with a slight sinus-like depression. No good interior has been preserved, but the fragments show the usual plate-like cardinal process to be rather thick and rounded. The crural plates have been destroyed except for the short, stout bases. Septum broad and strong towards the beak, tapering sharply, ending abruptly in a point, about the centre of the shell.

Pedicle valve very convex at the beak, rounding to the margin evenly without any definite fold corresponding to the slight sinus. Teeth, triangular, strong, attached to the base of the cardinal area just beyond the opening of the delthyrium and strengthened from below by supports resting on the cavity of the shell and continuing faintly for a short space along the edges of the muscle scar. Scars indistinct, but apparently rounded and not projecting beyond the middle of the shell.

In general outline *O. marshalli* somewhat resembles the Anticosti specimen *O. laurentina*, but the plications of the western species are coarser, the pedicle valve more convex, the depression in the brachial valve more defined, and none of the specimens preserved has a deltidium covering the delthyrium.

The species is named after Mr. J. R. Marshall, Geological Survey, Canada, whose collections from the Kananaskis-Palliser Pass area have been productive of much new material from these beds.

Horizon and Locality. Richmond: Beaverfoot. From several localities just east of Palliser pass.

Dinorthis columbia n. sp.

Plate V, figures 7, 8, 9, 10

Shell subquadrate, width greater than length. Hinge-line a little more than half the greatest width. Cardinal areas well developed, concave, that of the pedicle valve being more incurved and somewhat less elevated than is usual in this genus. Striæ fifty to sixty in number at the margin of a full-grown specimen, rather coarse, angular, with angular troughs between, mostly simple on the brachial valve, in some cases a few added by implantation near the margin, on the pedicle valve the additions are much more numerous and are formed both by implantation and by bifurcation. Concentric growth-lines developed on the more mature specimens forming a finely ornamented imbricating surface on the last third of the shell. In some the imbrication becomes a sharply defined line of arrested growth. Umbonal convexity of the pedicle valve in some cases almost taking the form of a fold for a short distance from the beak, flattening out with the growth of the valve. Brachial valve more convex than the pedicle valve, with a broad, shallow sinus beginning at the beak and passing over the umbonal region, after which it merges into the general, not very pronounced convexity of the valve.

Area of brachial valve not very high, slightly concave, and with a few poorly defined markings radiating from the beak. The interior of the brachial valve shows a long septum, rounded on the surface, out of the summit of which rise the cardinal process and the crural plates. Cardinal process strong, projecting obliquely and filling up the foramen and the delthyrium, angular on the external face, having a barbed projection on each side, but ending in a point. Seen from below it resembles a spear head. The support of the crural plates has its origin in the head of the septum which divides at the base of the cardinal process, one arm passing on either side and on the edge of the shell forming a callosity, the base of which is a sigmoid curve which continues on the shell about 3 mm. beyond the free end of the crural plates. Crural plates flat, exposing their long, thin edges to the opposite valve and standing out from the callosity that supports them, forming broad, triangular troughs before the abrupt deepening of the dental sockets.

Area of the pedicle valve higher and more triangular than that of the brachial valve. Interior of pedicle valve showing widespread triangular teeth, supported by a thickening of the shell at their base. Two, long, broad muscle scars extend from the beak to beyond the middle of the shell, divided by a ridge, bounded by more or less conspicuous, irregular striations. The anterior edge of the scars is truncated in outline. About a quarter of the distance from the beak the ridge flattens and a narrow groove is formed on either side showing the position of the rather narrow anterior muscle scars.

Externally the outline of *D. columbia* somewhat resembles *S. subquadrata*, though the sides and anterior margin are more rounded. It can at once be distinguished, however, by its sharper and much more simple striæ, and by the imbricating ornamentation when it is preserved. Interiorly the brachial valve differs in the spear-head shape of the cardinal process and in the form of the crural plates and their support. The muscle scar of the pedicle valve in *D. columbia* is longer than that of *D. subquadrata;* the anterior muscle scar is narrower and proportionately smaller.

None of the specimens of *D. columbia* has attained the gibbous form of some of the specimens of *D. proavita* from Stony mountain, Manitoba; some of the less robust specimens of *D. proavita*, however, are comparable in outline, but the Rocky Mountain species has finer, more sharply angular, and more numerous striæ. Internally none of the brachial valves to hand, or none of the illustrations, shows the spearhead cardinal process, but that may be due to poor preservation. The shape of the muscle scars of the pedicle valve are readily distinguished.

Horizon and Locality. Richmond: Beaverfoot. From the exposure on the west side of the mountain at Stoddart creek, and from Fairmont Springs, Windermere district, also from several localities east of Palliser pass, Rocky mountains, B.C.

Dinorthis rockymontana n. sp.

Plate V, figures 11, 12, 13, 14

Outline, excluding the hinge, almost circular, width a little greater than length. Hinge-line slightly less than half the width of the shell. Pedicle valve depressed convex, convexity being evenly distributed except for a little more prominence in the umbonal region. Brachial valve varying from about the same degree of convexity as the pedicle valve to a rather more gibbous form. Greatest convexity in the umbonal region, rounding down to almost flat on the wings. A faint, flattened area in the middle is suggestive of a sinus and makes a slight wave in the outline at the margin. Striæ fine, very numerous, flattened on tops, with flat-bottomed troughs between, troughs a little wider than striæ, the latter increasing on both valves mainly by implantation, the numerous additional striæ rapidly attaining the size of the original ones. There are two outstanding periods when the striæ are increased, one when the shell has attained a third of its growth, the other a few millimetres from the margin. Concentric growth lines very prominent on the more convex brachial valve, less so on the few pedicle valves obtained.

Cardinal area of the brachial valve very narrow and inconspicuous, almost concealed by the beak. The interior shows a rather prominent septum, out of whose summit rises a stout bifid cardinal process. At the base of the cardinal process the septum divides, each branch curving around and forming a support to the crural plates. The crural plates are flat, the narrower edge presented to the opposite valve, and on the plane of the narrow cardinal area to which they are attached for the first third of their length, the dental sockets being formed between the thickened wall of the shell and the projecting part of the crural plates.

Area of pedicle valve much more prominent than that of the brachial valve, rather high, slightly concave, especially near the beak. Delthyrium a broad triangle. Teeth strong, partly destroyed in the interior of the valve preserved. The dental lamellæ are well developed, and the callosity is prolonged around the obcordate muscle area. The three types of muscles are well marked. The long, somewhat narrow inductor muscle scars are expanded and rounded anteriorly. Flanking them behind are the shorter adjustor scars, and on an elevated ridge between them the almost linear scars of the adductor muscles.

Externally *D. rockymontana* is readily distinguished from other species by its fine striæ and conspicuous concentric growth lines. Internally it is differentiated from other species by the lobed cardinal process in the brachial valve and the form of the muscle scars in the pedicle valve, especially the raised base of the elongate adductor scars.

Horizon and Locality. Richmond: Beaverfoot. From Palliser Pass district, Rocky mountains, B.C.

Family, **Strophomenidae**

Subfamily, RAFINESQUINNAE

Petroria gen. nov.

(Petros = rock, 'opos = mountain)

Small brachiopods, semicircular in outline, pedicle valve convex, brachial valve concave, narrow but definite cardinal area on both valves. Surface in the early stages of growth covered with fine striæ, crossed by fine growth lines, becoming greatly accentuated towards maturity, giving the shell a very striking appearance. Pedicle valve having a small, round perforation, delthyrium covered by a convex deltidium. Teeth rather small. Brachial valve with a cardinal process consisting of two stout apophyses which quite fill the foramen and project beyond the plane of the cardinal area. Crural plates triangular, bearing upon their outer surface the rather shallow, triangular dental sockets. The whole cardinal region has been thickened by silicification, which also accentuates the striking ornamentation.

In size and outline *Petroria* resembles *Plectambonites*, but the ornamentation and the interior readily distinguish it. The divided cardinal process suggests a relationship with *Leptaena* or *Rafinesquina*, though the form of the process and the crural plate is quite different, and the external outline is not at all similar. Its exact affinities cannot be found until more and better interiors have been procured.

Petroria rugosa n. sp.

Plate V, figures 15, 16, 17, 18

Shell small, pedicle valve very convex, brachial valve concave, width greater than length, averaging 12 mm. or 13 mm. and 5 mm. or 6 mm. Greatest width at the hinge-line, the extremities of which are produced into rather sharp angles, the anterior margin rounded, making the outline approximately semicircular. Cardinal areas flat, almost equal in height, that of the pedicle valve slightly higher and inclined away from the brachial area at an angle of about 100 degrees, the pedicle valve being longer than the brachial by the width of the pedicle cardinal area. Some of the development of the very peculiar ornamentation may be due to the silica deposits, but in any event the ornamentation must have been unique. Except for a small portion in the very early stages, the surface is covered with concentric rows of flat, shingle-like plates, the loose ends of which turn up at the beginning of the next concentric row. The ends of the last row on the anterior margin are at right angles to their length. The shingle-like plates besides being in concentric rows are arranged in radiating rows along the lines of radiating striæ.

Pedicle valve very convex, showing a more decided development of the unique striæ, having a small, round perforation at the apex, delthyrium narrowly triangular, covered by a convex deltidial plate. Teeth small, triangular, just at the ridge of the base of the delthyrium. Interior not known.

Brachial valve concave, foramen triangular, filled by the projection of the cardinal process, extending beyond the plane of the cardinal area and trespassing on the area of the pedicle valve. Only a part of the interior has been uncovered and it is probable that each feature has been made heavier by later deposits, but the shell must originally have been stoutly built. Septum showing only the top, broad and rounded, thickening and strengthening the shell. Cardinal process two stout apophyses, apparently sessile or nearly so, that broaden and continue the end of the septum, projecting through the foramen. From the outside of the shell their thick ends resemble two plates, covering the brachial foramen, with their longer axis at right angles to the cardinal area and separated from one another by a groove. Crural plates represented by a thick, triangular projection, the outside surface of each bearing a shallow tooth socket.

The septum, cardinal process, and triangular plates are all so thickened by deposits that it is difficult to decipher the exact course of the callosity from the edge of the septum which curves over to support the crural plates.

Horizon and Locality. Richmond: Beaverfoot. Eleven hundred and fifty feet east of the trail on Palliser pass, Rocky mountains, British Columbia.

PELECYPODA

Byssonychia radiata var. *walkeri* n. var.

Plate V, figures 19, 20

Shell ventricose, medium size, outline ovate, disregarding the beak, anterior portion not alate, the tip of the beak and a part of the anterior margin not entire, umbones full, beak rather obtuse, prominent, and incurved, hinge-line short, flattened anterior ligamental area large, byssal opening not preserved, but judging from the curve of the concavity of the area it is placed high, posterior cardinal margin short, covered with thirty to forty striations, broader than the intermediate grooves, rather coarser than is usual with *B. radiata.*

This form is very similar to *B. radiata* in its general outline, in the shape and proportion of the ligamental area, and until better specimens can be procured it is considered as a variety of that species, though differing from it in having fuller beaks, in being more ventricose, especially in the umbonal region, in having a less extended posterior cardinal margin. In these features it approaches *B. obesa*, but the ligamental area occupies a larger proportion of the front of the shell than in that species. This large area is suggestive of *B. alveolata*, but the beaks are more incurved and the posterior cardinal portion is less pronounced.

The variety is named after Mr. J. F. Walker, Geological Survey, Canada, who has procured the first pelecypod from these Rocky Mountain beds.

Horizon and Locality. Richmond: Beaverfoot. At 95 feet above the base of the Beaverfoot from the head of Windermere creek, Rocky mountains, B.C.

GASTROPODA[1]

Family, **Euomphalidae** de Koninck

Genus, **Palliseria** Wilson

This genus is like *Maclurina* in its sinistral whorl, but is without an operculum so far as is known. It differs from *Maclurina* essentially in its turbinate spire and in its ornamentation, in both of which respects it more closely resembles some members of the Trochoturbinidae (*See* Plate VI, figures 1, 2; Plate VII, figures 1, 2).

[1] Descriptions abridged from original. Can. Nat., vol. XXXVIII, No. 8, p. 150.

Palliseria robusta Wilson

Plate VI, figures 1, 2; Plate VII, figures 1, 2

Can. Nat., vol. XXXVIII, No 8, p. 150, Pl. I, figs. 1, 2; Pl. II, figs. 1, 3.

Large, robust, turbinate shell. Umbilicus open and deep, five or six rapidly enlarging whorls, closely coiled, highly ornamented by carinæ and growth lines. In the early stages the whorl is narrow and deep, the margin of the umbilicus sharply defined, the other carinæ faintly indicated or not yet developed. During growth the whorl increases in thickness more rapidly than in depth. In the section of the last whorl preserved there are six outstanding angles formed by the carinæ. The preceding whorl is impressed broadly and deeply, producing two angles on the whorl, one at the umbilicus, one a sharply defined shoulder at the suture line. Exposed top of whorl evenly convex. In later life the outside of the whorl presents a broad, band-like surface, limited above by a rounded carina and below by a more sharply defined one. The fifth angle is the acute margin of the umbilicus. The umbilical margin of each whorl is free from that of the following whorl and projects into the umbilicus. The sixth carina, pointed slightly inward and downward, is entirely within the umbilicus, between the margin and the line of contact with the preceding whorl.

Growth lines, after a very slight backward inclination, pass forward with a sigmoid curve to the top of the band-like area; across the band they incline backward gently after crossing the lower carina, then again curve slightly forward; at the umbilicus margin they turn sharply back and pile upon one another, making a ridge around the umbilicus. But they again curve slightly forward until they meet the sixth carina where they again pile up; from here they incline slightly forward to the point of contact with the whorl above.

Shell substance very thick, of three layers, the inner and outer layer apparently similar and strong, the intermediate one more porous. Its place is as a rule filled by the matrix; where partly preserved it is more or less granular.

Horizon and Locality. Richmond: Beaverfoot. From Palliser pass, Rocky mountains, B.C.

Lophospira occidentalis Wilson

Plate VII, figure 3

Can. Nat., vol. XXXVIII, No. 8, p. 151, Pl. II, fig. 2.

Greatest width 17 mm., greatest length 19 mm. Five whorls, that at the apex only partly preserved. Each whorl sharply defined by a prominent carina, a little less than a third above the contact of the whorl with the succeeding one. Whorl nearly quadrate in section, the upper edge being rather shorter than the other sides and the angles more rounded. Edge of umbilicus not exposed.

The ornamentation is preserved only on one small section, but it shows the notched lip of *Lophospira* and the lines of growth sweeping back toward the band both above and below the carina. Of the Upper Ordovician species described *L. occidentalis* most nearly resembles *L. tropidophora*, but differs from it in having more and narrower whorls, a rounded rather than projecting lower part of the lip, resulting in a different cross-section of the whorl. The same differences are more pronounced between *L. occidentalis* and *L. perlamellosa* and the tendency to have a convex rather than a concave slope above and below the carina differentiates *L. occidentalis* from most other species of the genus.

Horizon and Locality. Richmond: Beaverfoot. On the slope east of Palliser pass, Rocky mountains, B.C.

VERMES

Cornulites parvus n. sp.

Plate VIII, figure 1

A small, parasitic *Cornulites* growing separately on the inside of the brachial valve of a *Dinorthis*. Slightly flexuous, largest specimen 4¼ mm. in length, the minute tip being lost under a piece of some foreign body attached to the shell. Walls very thin. Annulations, seven in number, more sharply rounded on the lower edge than on the upper, trough between not quite as wide as the annulations and almost flat bottomed. Very fine, longitudinal striæ which continue to the apex. One tiny specimen, 3 mm. in length, has the annulations worn off, so that they appear as bands around the tube, about the width of the spaces between.

Hall[1] considers that all the species of previous authors cited by him from the Upper Ordovician of Indiana and Ohio are only different forms of one species. The Rocky Mountain species, however, differs from it in the width of the space between the annulations and the continuation of the striæ from the embryonic stages.

Horizon and Locality. Richmond: Beaverfoot. Eleven hundred and fifty feet east of the trail, Palliser pass, B.C.

CEPHALOPODA

Actinoceras complanum n. sp.

Plate VIII, figures 3, 4

Shell distinctly flattened on the ventral side, otherwise oval in outline. At one point having a lateral diameter of 39 mm. and a dorso-ventral diameter of 30 mm. Tapering gradually, in a length of 32 mm., the lateral diameter diminishes from 40 mm. to 37 mm. Surface not retaining any markings. Siphuncle very large, occupying most of the interior of the shell, in contact with the ventral wall. Septa about 6 mm. apart. Septal neck curving downwards for half the depth of the chamber, meeting the connecting ring which occupies the lower half and extends 3 mm. into the camera beyond the point of juncture with the septal neck.

[1] Pal. New York, vol. VII, Sup., p. 12 (1888).

A. complanum is very closely related to *A. bigsbyi*, but differs from it in outline, in the proportionately shorter dorso-ventral diameter, and in the more compressed outline of the siphuncle. The figure of the type[1] of the latter shows that the siphuncle of *A. bigsbyi* is not in contact with the central wall.

A. complanum differs from the Manitoba form of *A. richardsoni* in the presence of the septal necks extending half the depth of the camera.

Horizon and Locality. Richmond: Beaverfoot. Three-fourths mile east of trail, Palliser pass, B.C.

Vaginoceras (?) eccentricum n. sp.

Plate VIII, figure 2

Shell incomplete, the body chamber and the apex missing. The specimen is $7\frac{1}{2}$ inches in length and has a diameter of $1\frac{1}{16}$ inches at the larger end, and $\frac{7}{16}$ inch at the smaller end, in the part preserved. Surface altered and worn, but in one part still exhibiting fine growth lines. No longitudinal striæ preserved. Chambers deep, septa distant from one another about half the width of the shell. Siphuncle tubular, about a quarter the width of the shell, very eccentric, along one edge not more than 1 mm. distant from the external wall. The septal neck extends downward the length of the camera, becoming ensheathed by the preceding neck and continuing down some distance. The poor preservation of the specimen makes it impossible to see exactly where it terminates, though in two camera a double wall can be traced to below the middle. The siphuncle does not pass through the septa at the centre, the lowest point of the concave outline, but near the circumference, so that the septal neck ensheathes the siphuncle obliquely, the highest point being on the side nearest the outside of the conch. The inside of the siphuncle is not sufficiently preserved to show its nature.

The species is referred to *Vaginoceras* doubtfully, because in the specimen at hand it cannot be definitely seen whether the second wall is the continuation of the septal funnel as in *Vaginoceras*, or an inner wall.

Horizon and Locality. Richmond: Beaverfoot. A half mile east of the trail, Palliser pass, Rocky mountains, B.C.

Protokionoceras? gracile n. sp.

Plate VIII, figures 5, 6

Shell straight, slender, and fragile, in the septate portion tapering very slightly. A fragment without any of the body chamber, measuring 22 mm. in length, has a diameter of 10 mm. at the widest part and 7 mm. at the narrower end. Body chamber expanding more rapidly, a small specimen from the head of Windermere creek preserves the lower part

[1] Univ. Michigan, Con. Mus. Geol., vol. 2, pp. 1-12, fig. 7 B.

of the body chamber, that is 15 mm. in length, 13 mm. in diameter at the top, and 10 mm. at the base, which is the top of the septal portion. Outline slightly elliptical. Exterior covered with fine, longitudinal striæ. Septa about four in 6 mm. Siphuncle eccentric, occupying about one-third the diameter of the shell, not well preserved but sufficiently so to show the nummuloid form.

This small species is provisionally referred to the genus *Protokionoceras*. When a specimen is found sufficiently well preserved to show the characters of the septal funnels it will be possible to establish the generic relations. In the meantime the longitudinal striation combined with the evident nummuloid form of the siphuncle suggest the possibility of some early form of the Silurian genus *Protokionoceras*.

Horizon and Locality. Richmond: Beaverfoot. Eleven hundred and fifty feet east of the trail at Palliser pass, and 50 feet above the base of the Beaverfoot in a section at the head of Windermere creek, Rocky mountains, B.C.

Spyroceras intermedium n. sp.

Plate VIII, figure 7

A western form of *Spyroceras* which appears to be intermediate between *Spyroceras* and *Dawsonoceras*. As defined by Hyatt *Spyroceras* includes "longitudinally striated longicones which at some stage of their growth are also annulated." *Dawsonoceras* forms have "longitudinal ridges in the larva and are annulated, but devoid of ridges in the adolescent and adults". S. *intermedium* carries both at the same time. The slightly oblique annulations are covered by an outer layer which is longitudinally striated. The specimens are not complete, but the annulations, though strongly marked where the outer cover is missing, appear on the outside underneath the longitudinal striæ as undulations so gentle that they are visible only in certain lights and even in the most developed part of the largest fragment there is no sign either of the annulations taking the place of the striæ or vice versa.

The species tapers gradually. The largest piece, 26 mm. in length, has a diameter of 10 mm. at the larger end, and $8\frac{1}{2}$ mm. at the smaller. In 19 mm. there are seven annulations, not exactly equal, the largest $2\frac{3}{4}$ mm., the smallest a little over 1 mm.; generally speaking those at the smaller end are set more closely together. The hollows between are flat bottomed. The lower ridge appears to be imbricated over the smaller end of the succeeding one. Longitudinal striæ $1\frac{3}{4}$ mm. apart where the diameter of the conch is $9\frac{1}{2}$ mm. Between each pair of striæ is a median one not so strong, but standing out in contrast with the very fine ones, three to four in number, which lie in the hollow on either side between it and the large, well-marked ones. Very faint fine cross-striations are present, but they are too poorly preserved to count. Interior filled with secondary deposits so that it is impossible to be sure of the proportions of the siphuncle.

S. intermedium differs from *S. bilineatum* in showing no indication that the annulations take the place of the striations in the more mature part of the shell. It differs from *S. balteum* in having a median stria stronger than the very fine ones in the longitudinal groove.

Horizon and Locality. Richmond: Beaverfoot? Loc. B. At 95 feet above the base of the Beaverfoot near the headwaters of Windermere creek, Stanford range, B.C.

STRATIGRAPHY OF THE PORT DANIEL-GASCONS AREA OF SOUTHEASTERN QUEBEC

By Charles Schuchert and J. Doris Dart

CONTENTS

Illustrations

INTRODUCTION

The senior author's interest in Gaspe region was first aroused some twenty-five years ago, in the course of a discussion with the late Professor Henry S. Williams, then in charge of Devonian correlations for the United States Geological Survey, as to whether the lower Helderberg was Silurian or Devonian. The statement had, long before, been made in print that at Arisaig, Nova Scotia, the Silurian passed unbroken into the Helderbergian and that the whole was beneath the Old Red Sandstone equivalents. It had also been stated that about Gaspe, Quebec, there was a complete succession from the higher Silurian into the most interesting Devonian section anywhere. Schuchert, therefore, concluded that it would be well to see these places, and in 1900 the United States National Museum made it possible for him to study and collect fossils from the fine sections at Arisaig, Dalhousie, and Gaspe peninsula.

These localities had also attracted the attention of the late Dr. John M. Clarke, of Albany, who, when informed of the prospective trip, expressed a desire to accompany Schuchert, and the two were in the field from July 11 to August 8. From that time until his death Clarke returned to Gaspe almost annually, and the results of his observations in this country, which he came to love so dearly, form the subject of many geologic and palæontologic papers. Not only this, he became the historian of Gaspe and Chaleur bay, and has recorded in two most interesting books human happenings in this region since its discovery by Jacques Cartier in 1534.

The Devono-Silurian boundary dispute was adjusted some years ago, as it was shown that there is no Helderbergian at Arisaig, and no transition from Silurian into Devonian either at Dalhousie or Gaspe. The Helderbergian is now regarded by all as the base of the Devonian, a conclusion first reached in America by Dr. Clarke, in 1889.

In 1904, when Schuchert took up residence at Yale University, he found there no fossils from the Maritime Provinces of Canada. Consequently, in July and August, 1905, with Robert Gordon of Cumberland, Maryland, he revisited the Gaspe country and made extensive collections. He was again in this region with the International Geological Congress, held in Canada in 1913. Ten years later, Miss J. Doris Dart, a graduate student under his direction at Yale, was assigned the stratigraphy and faunas of the Silurian of Port Daniel area as a problem to be worked out in detail. The field work in connexion with this study was made possible by the Geological Survey, Canada, and both authors spent most of that summer in Gaspe. Finally, in 1924, the senior author devoted a month in the field to checking up the previous work. The results of these two field seasons, and of a study of the collections in the laboratory at Yale, make up the present paper.

THE GEOLOGICAL SECTION IN BRIEF

Recent deposits later than the Pleistocene, in part alluvial, but in the main brackish swamp and marine beach beds.

Latest Pleistocene (Champlainian) cut terraces and beach shingle materials found at various levels up to about 90 feet above present high tide. These terraces are best seen between Anse-à-la-Barbe and Anse-aux-Gascons, where three distinct terraces are well preserved. The same terraces are to be seen about Port Daniel and in the valleys of the Little and Middle branches of Port Daniel river.

Glacial. Everywhere there is evidence, though never in great abundance, of Pleistocene ice work. Where the native strata are recently uncovered, they are seen to be well striated. The hills, and especially the shore, have occasional boulders, up to 10 feet across, of gneisses, granite, green schist, a metamorphosed feldspathic conglomerate, and Ordovician sandstones. Almost everywhere on the lower terraces is a thin veneer of more or less rounded rubble composed of small pieces of Silurian, Ordovician, Bonaventure, and pre-Ordovician rocks, many of which are striated. Nowhere does one see any large glacial accumulations in moraines or sand outwashes, and what there is of ice work looks very recent.

Erosion during late Palæozoic, Mesozoic, and Cenozoic time. It was probably during the Pliocene that this matured surface of erosion was elevated to about its present level. Since then it has been dissected into the topography of today.

Bonaventure red conglomerates and sandstones of seemingly earliest Mississippian age. In the Percé-Gaspe area Dr. Clarke found the Upper Devonian passing unbroken into the red beds of the Bonaventure series.

Port Daniel-Gascons area, Bonaventure county, Quebec.

They are seen in widest development to the west of Port Daniel, but in many places in the area of the Silurian strata small basal remnants of the conglomerate are well exposed. They invariably overlie the Silurian in angular unconformity as a more or less coarse, red conglomerate or breccia (in places the limestone blocks are from 3 to 10 feet across), showing that the Silurian and older rocks had been folded and considerably eroded before the Bonaventure intermontane deposits were laid down over them. These deposits appear to be of mountain desert valleys, and their remnants all appear to lie in pre-Bonaventure land hollows of the Silurian strata.

Mountain making in Upper Devonian time, followed by erosion, making the marked unconformity seen in the Port Daniel-Gascons area between the Silurian and Bonaventure series. This is the well known Acadian disturbance.

Silurian or Chaleur series, made up of the following divisions, in descending order:

	Feet
Indian Point formation	194
West Point or Crotalocrinus limestones	1,445
Bouleaux formation of thin-bedded limestones, coral reefs, and breccias; and shales	800
Gascons or Taonurus muddy and shaly sandstones	1,800
La Vieille limestone or Stricklandinia beds	285
La Vieille sandstones and conglomerates	170
Clemville formation	385
Total Silurian	5,079

Disconformable contact (probable) between Silurian and Ordovician in the western part of the section, but in the eastern part of the area there is an angular unconformity between the Silurian and the pre-Ordovician strata.

Ordovician shales, sandstones, and conglomerates. Thickness unknown.

Mountain making seemingly at the close of the Cambrian, or more probably at the close of the Canadian, followed by land erosion, causing the marked angular unconformity between the later Ordovician and Silurian above, and the more or less metamorphosed and much deformed Macquereau series below.

Macquereau quartzites, slates, etc., of unknown but very great thickness, seemingly best regarded as of Canadian time.

STRUCTURE

The Silurian of Black Cape area is clearly one limb of a great anticline that after the Acadian time of mountain making during the late Devonian appears to have made a very high mountain capped by great, rocky crags of basalt, the whole of which then may have stood 1 or 2 miles high. In its simplicity of structure is again seen the open folding type of the Appalachian mountains. In Port Daniel region, however, the Silurian strata to the east of Port Daniel Centre have their folds closed and squeezed into verticality. Furthermore, in this area of closest folding occurs the most marked fault, which extends from McGinnis cove eastward to east of Anse-à-la-Barbe, where in the Gros Morbe it passes out to sea. In McGinnis cove the eastern or Pillar Point block has dropped down about

700 feet, since here the lower pink limestone of the West Point formation abuts against the older Gascons, cutting out all of the Bouleaux formation. Toward the east the fault nearly dies out, and in the Gros Morbe the drop appears to be reduced to at most 200 feet. The pressure appears to have come from the Chaleur Bay direction, either at the time of the Acadian orogeny or later during the Pennsylvanian and Permian deformations.

In Port Daniel area when these strata and all the older ones were folded in later Devonian time, the general trend of the mountains, Ells states, was from northeast to southwest. It is this trend that is found throughout the land on the western side of Port Daniel bay (at West point the strike is south 50 degrees east magnetic), but to the east of this bay the trend lines vary greatly from this. In the inner bay at the church of St. George de Port Daniel, the strike is north 40 degrees east, at point l'Enfer it is north 25 degrees east, and at the southeast of Pillar point it is north 15 degrees west. It would, therefore, appear that the trend of south 50 degrees east of West point is about the average strike of the Silurian for Gaspe peninsula, and that farther east it was locally changed by more or less horizontal thrusting, most strongly into Port Daniel bay, changing the strike all the way from north 15 degrees west to north 40 degrees east. To the east of Gascons the strike becomes again nearly normal, south 70 degrees east (magnetic). This inward thrusting of the Silurian folds is plainly shown by the distribution of the various formations as plotted on the map accompanying this paper.

The map also shows that the open Silurian folds in the area of the barrachois, and the pinched ones of the eastern side of Port Daniel bay and McGinnis cove, plunge into the depths of Port Daniel bay.

HISTORICAL GEOLOGY

The geology of the north shore of Chaleur bay is of the northwestern near-shore side of the St. Lawrence geosyncline, the southern shore being in New Brunswick. It has been shown that in the Port Daniel-Gascons area, Palæozoic time is represented by the Bonaventure formation of seemingly Mississippian time, the Silurian (Chaleur), and Ordovician (?Upper) series; and that the latter two systems transgressed over the older metamorphosed strata (Macquereau). To the northeast and seemingly more toward the central part of the St. Lawrence geosyncline, occurs a long series of Lower and Middle Devonian strata (Gaspe-Dalhousie formations) which are known to overlie the Silurian and transgress over the younger Ordovician. Marine deposition ceased with the earlier half of the Middle Devonian in the St. Lawrence geosyncline, though freshwater delta deposits continued to accumulate into Upper Devonian time.

Toward the close of the Middle Devonian, the whole of the St. Lawrence trough was involved in mountain making, the Acadian disturbance, and the prophecy of this orogeny was already heralded in Middle Silurian time when volcanoes began to pour out much basalt and some (Black Ash cape, Gaspe peninsula, and southeastern Maine). During Lower Devonian time volcanic activity was again resumed, as is attested by the very early ash and tuff beds along with later lava flows, all of which are well seen in the Helderbergian strata about Dalhousie, New Brunswick.

Although the trend lines of the St. Lawrence Ordovician are in harmony with those of the later formations of Chaleur bay, the strata older than late Ordovician are far more deformed and altered than the latter. This greater deformation is older than that known as the Taconic disturbance of late Ordovician time. This older orogeny involved the Macquereau series and, possibly, also the Quebec series, but as to the last-named series it is not so certain as the Macquereau.

The Devonian orogeny evidently folded the whole of the strata of the St. Lawrence and Acadian geosynclines, along with the New Brunswick axis, into a system of mountains, the Acadian ranges. Erosion of a very decided nature naturally went on during the rise of these mountains and apparently in the early Mississippian there was already present between Gaspe and New Brunswick a wide valley in which were laid down the Bonaventure intermontane conglomerates—flood-plain and bajada[1] deposits of a semiarid climate. Then all of the area of the St. Lawrence geosyncline remained land until near the close of the Glacial period, when parts of the St. Lawrence and Acadian geosynclines were reoccupied by the sea—the present Chaleur bay, Northumberland strait, and bay of Fundy.

Early in Mississippian time, when the Acadian mountains were still young, the somewhat thick, red, freshwater Bonaventure conglomerates and sandy shales were laid down in the Northwestern valleys of this system.

Subsequent to Bonaventure time, Gaspe peninsula was not folded, though it may have undergone several epeirogenic movements, the most marked of which took place during Pennsylvanian and Triassic times. During this long interval of continuous land there was developed a well-matured river system, which late in Pleistocene time was more or less depressed by the load of the continental glaciers. On the melting away of this ice, much of the Maritime Provinces of eastern Canada was deeply flooded by the Atlantic ocean, and even though much of the area has since risen hundreds of feet, the land still remains deeply drowned throughout the area of the gulf of St. Lawrence.

GEOLOGICAL SECTION IN DETAIL

MACQUEREAU SERIES

Along the entire north shore of Chaleur bay the only place where strata older than the higher Ordovician are known is on either side of the headland known as point Macquereau, east of Gascons. W. E. Logan[2] was first to note these old strata in 1843, and studied them with some care. In the "Geology of Canada, 1863", p. 272, Logan says, "These sandstones of cape Macquereau strongly resemble, in many parts, those of the Sillery series to which they are probably equivalent." This conclusion was changed in 1883, by W. R. Ells,[3] who wrote of them as follows:

[1] Coalescing fans bordering mountain slopes.
[2] Geol. Surv., Canada, Rept. of Prog. 1844.
[3] Geol. Surv., Canada, Rept. of Prog. 1880–81–82, pt. D.

"The rocks of cape Macquereau and vicinity, which extend across from Port Daniel river, have long been classed under the general heading of the 'Quebec Group' [=Ordovician]. They, however, apparently consist of two distinct and unconformable sets of beds, which strike almost at right angles to each other. They also differ markedly in mineral character, the newer consisting of sandstones and shales, among which black graptolitic beds occur, while the older are mostly hard metamorphic rocks, quartzites, felsites, etc., with feldspathic and talcose schists. They have on these grounds been divided into two groups, the former being assigned to the Cambro-Silurian, and the latter to the Precambrian".[1]

On the North or East branch of Port Daniel river, the Macquereau series...

........"consist principally of hard, rubbly, feldspathic and micaceous gneissic rock with quartzose micaceous, talcose, and chloritic schists. They [Macquereau series] are, as already stated, quite distinct lithologically and stratigraphically from the black slate (Cambro-Silurian) series of the river; the strike of the latter being southwest, while the older series strike northwest".[2]

West of cape Macquereau, the Macquereau series................

........" consist of hard, dark reddish, feldspathic schist, including some thin bands of talcose schist. Some of the micaceous schists hold disseminated grains of clear quartz. About the end of the cape the rocks are hard, grey quartzites with crystalline feldspathic and talco-chloritic schists. They have a strike north 60 degrees west and dip at angles of 75 degrees to 90 degrees, and they unconformably underlie the softer brown and grey sandy beds seen along the coast farther east."[2]

The present writers saw considerable of the Macquereau series to the north and east of the Silurian sandstones east of Gascons, both along the railway in its numerous cuttings, and on the shore below. It is here in its weathered aspect a very hard, dark purple and red series, of more or less schistose quartzites and sandy slates. They are wholly unlike the overlying fossiliferous Palæozoic strata, since all are considerably metamorphosed and intensely squeezed and close folded. Along the shore near the contact with the Silurian at Anse-à-la-Vieille, the strike is about south 80 degrees east.

At the eastern termination of the Silurian, the Macquereau strata immediately to the north make a high, rugged country, and here these quartzites weather into light grey. The topography is rocky and rugged and the land is abundantly strewn with the loose Macquereau rocks of Recent and Pleistocene transportation. The scenery is very unlike that of the Silurian formations, which weather into rounded, hilly land with the higher hills always of limestones, and although the soil mantle is also thin, the loose rocks are mostly small.

As no fossils were found in the Macquereau series, even though conditions looked favourable for them about Newport, we cannot date these strata. On the other hand they do not look like the Proterozoic strata of southeast Newfoundland, nor are they at all metamorphosed like Archæozoic formations. We rather agree, therefore, with Logan that they are early Palæozoic; but as yet no one can tell if they are Cambrian or earliest Ordovician. Since the Macquereau series resembles the Sillery-Quebec strata, however, the chances are best that they are of earliest Ordovician, namely Canadian.

[1] Geol. Surv., Canada, Map 165 (marginal note).
[2] Geol. Surv., Canada, Rept. of Prog. 1880–81–82, pt. D, p. 17.

ORDOVICIAN (?UPPER) SERIES

Ells, as long ago as 1883, in the report cited, held that Ordovician strata had a wide distribution in Gaspe peninsula, and that they lie unconformably upon the Macquereau series; and following the correlation of his time he accordingly referred them to the "Quebec series" of the "Cambro-Silurian". No extended search for fossils was made in this series of strata and very few were found. Ells gives no idea of their thickness, but since the area of their exposure is about 5 miles wide, it appears probable that it is considerable. They are of the shallow-water phase of the St. Lawrence trough.

Ells says that..

"On the east branch of the Port Daniel river the [Silurian] limestones are underlaid by beds of greenish-grey grits, dip south 60 degrees. . . At the distance of 1,500 paces farther up stream, ledges of dark grey and black slates occur. . . These are doubtless the bituminous and graptolitic beds mentioned by Sir W. E. Logan[1] as occurring in the middle branch (Middle river)".[2]

This is a very important statement and search was made for the original reference, which says: "Higher on the stream a series of black bituminous graptolitic shales comes to the surface, and is seen at intervals for several miles upon its banks." In the Geology of Canada, page 445, Logan says: "The position of these shales is between the calcareous series (=Silurian), and the" Macquereau series.

Inquiries were then made of the Geological Survey, Canada, to see if any of these graptolites were in their collections, but so far none has been found by Mr. Kindle. In 1924 one poor specimen of a diplograptid was found by the senior author in a drifted piece of sandstone in Middle river, showing that these strata are either of Middle or Upper Ordovician age. Ells says further:

"On the East branch of the Port Daniel river [also occur] the black slates and associated beds, though a good deal disturbed, [and they] appear to strike almost at right angles to the feldspathic gneisses which occur farther up the stream and which we have connected with the crystalline felsites of the cape".[3]

The Ordovician rocks were again seen by Ells 2 miles east of Cape Macquereau lighthouse, and east beyond Newport:

"In the vicinity of the Mahy islands, where these Cambro-Silurian rocks are first well observed, they dip south 20 degrees east 55 degrees along the shore, the dip on the islands being more easterly, or east 10 degrees south < 40 degrees. The metamorphic rocks of the cape, however, have a quite regular strike [north 60 degrees west], with dips of 75 degrees to 90 degrees".[4]

The present authors also saw something of these "Ordovician" strata, first coming upon them about Clemville. The upper 385 feet turned out to be Silurian in age, and will be described as the Clemville formation, the lowest one of the Chaleur series.

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[1] Geol. Surv., Canada, Rept. of Prog. 1844.
[2] Geol. Surv., Canada, Rept. of Prog. 1880–81–82, pt. D, pp. 14-15.
[3] Geol. Surv., Canada, Rept. of Prog. 1880–81–82, pt. D, p. 16.
[4] Geol. Surv., Canada, Rept. of Prog. 1880–81–82, pt. D, p. 15.

The northbound wagon road along the western side of the Port Daniel barrachois is also on "Ordovician" strata in its terminal half mile or more beside Middle river, and here soft, smooth, blue-green shales with some thin sandstones are exposed. These strata looked as if they should have fossils, and several attempts were made to get them, but none was found. It was less than a mile farther up the Middle branch of Port Daniel river that Logan, in 1843, found graptolites of seemingly unmistakable Ordovician age.

The most easterly area of Ordovician strata seen by the writers was along the banks of the North or East branch of Port Daniel river beyond the tidewaters of the barrachois. Here the well-exposed "Ordovician" consists largely of greenish sandstones, and more than one mile up the tributary known locally as Ruisseau du Lac à l'Appelle, crinoid columnals and poor bivalves were seen in sandstones that resemble the Upper Ordovician. In the Pleistocene wash near this place were found much decomposed, limy sandstones having an abundance of *Dalmanella rogata;* these strata, therefore, appear to be well up in the Ordovician. Since the Ordovician is well developed in Percé region, where the senior author collected Richmond fossils, the chances are good that the graptolite beds of Port Daniel river are also of Upper Ordovician.

No Ordovician is seen between the Silurian and the Macquereau east of Gascons, and according to Ells' map none appears until 3 miles northwest of Anse-à-la-Vieille, following along the contact of these two series of strata.

MIDDLE SILURIAN OR CHALEUR (NIAGARAN) SERIES

The very thick Silurian development about Gascons and Port Daniel, to Indian point, a distance in a straight line of 9 miles along the north shore of Chaleur bay, Gaspe peninsula, was first reported on by Sir William Logan in 1846. This information was later incorporated in Logan's "Geology of Canada, 1863," pages 442-445. It is now seen that Logan was fortunate in his reconnaissance trip in coming upon this well-exposed seashore section from the east, and tracing it westward into higher strata. His determined section, which is restated below, extends from Anse-à-la-Vieille (a name now forgotten along this coast) to Anse-à-la-Barbe. Farther west one learns of no new formations until cape l'Enfer is reached, but here the closed syncline, mainly of limestones, is so repeatedly faulted as to give no clear idea of the detailed succession of the strata, nor of the actual thickness, which is far greater than that of the cape. To get this information, one must go farther west and study the fine cliffs from West point westward to Indian point. Logan made out a thickness of 3,340 feet, but the work done by the writers determines the thickness to be more than 5,000 feet. This discrepancy is due to the very thick, upper limestone series, which at West point is three times thicker than at the Gros Morbe, where about 500 feet of the lower limestones are still present.

Logan says that the vertical strata of the Macquereau series extend along the coast toward Anse-à-la-Vieille, where they are overlain by the inclined strata of the Silurian limestones, which, in their turn, support the slightly deformed Bonaventure conglomerates, the three series being unconformable with each other. It is, therefore, apparent that the Macquereau series had been folded into mountain masses and worn down to sea-level before Silurian time, since apparently it is the later Ordovician deposits that first overlap the upturned strata of this ancient series. The contacts of the Ordovician and Silurian formations upon the Macquereau are, therefore, markedly unconformable.

All of the Silurian strata Logan named the Chaleur series, saying that their fossils correlated them with "the summit of the Anticosti group, about the horizon of the Niagara formation".[1] It is now known, however, that the Anticosti section has no strata younger than Clinton time, whereas the Chaleur series embraces the equivalents of all that is now referred to the Niagaran series, i.e., the Clinton, Niagara, and Lockport divisions.

Beginning to the east of Gascons, at the place once known as Anse-à-la-Vieille, and proceeding westward into higher strata to Anse-à-la-Barbe, Logan determined the following section:

		Feet
(1)	Reddish-grey, micaceo-arenaceous limestones, weathering to a dull ochre-yellow, interstratified with six bands of siliceous conglomerate....	140
(2)	Greenish calcareous shale, including a few beds of yellow-weathering limestones, with many nodules of the same..............................	200
	There is here a break in the succession, occasioned by sharp folding resulting in a small fault.	
(3)	Grey, hard limestone in beds of from 6 inches to a foot............... [Zones 1, 2, 3=our La Vieille formation]	50
(4)	Red, micaceo-arenaceous shale...	200
(5)	Grey, limestone shale, inclining to green..............................	900
(6)	Grey or greenish limestone, partly of a slaty character.................	150
(7)	Greenish calcareous shale.. [Zones 4-7=our Gascons formation. This takes the section to the mouth of Chouinard brook]	500
(8)	Light red shale with green streaks and spots...........................	500
(9)	Grey limestones, in beds of from 6 to 8 inches.......................... [To be seen in either side of Pointe aux Bouleaux. Zones 8 and 9=our Bouleaux formation]	200
(10)	Light grey, compact limestone, indistinctly bedded, and filled with corals, broken encrinites, and other fossils. Includes red, arenaceous limestone rich in white crinoid columnals............................	500
	Well exposed in the Gros Morbe [making Reddish point and beyond to Anse-à-la-Barbe. These limestones are the lower third of our West Point formation. The thickness given by Logan, however, is far less, since there is an anticline in the western part of the Gros Morbe]	

It was found readily possible on the basis of the lithology to divide the very thick Chaleur series of not less than 5,000 feet into six formations, all of which are of shallow-water seas and tidal flats of the St. Lawrence geosyncline, with faunas that are wholly different from those of the Arisaig series of the Acadian trough. Both seas had European connexions, the St. Lawrence with north Europe (Gotland) and with the interior of North America as well, and the Acadian trough with central Europe (Wales) and the southeast coast of the state of Maine.

Curiously, the lowest Silurian formation, also of the Niagaran series, is not shown along the sea front, but inland at Clemville. Its position is, therefore, nearer the northern shoreline and its character will be

[1] "Geology of Canada, 1863", p. 444.

described presently. The five higher formations of the Chaleur series continue the earliest Clinton of the Clemville formation without interruptions, probably to the close of Lockport time. On Anticosti there is now nothing younger than the Clinton and Rochester equivalents, all the younger formations having been eroded away. The proof of this erosion is seen in the presence of the Chaleur series, which lies in the same trough as that on Anticosti, and the various faunas of the Chaleur show that the Niagaran ones of interior America probably came largely from the St. Lawrence geosyncline and northwestern Europe. When the Silurian faunas of Anticosti and Quebec are fully described, it probably will be seen that many of the species now best known from the Chicago-Racine area are also common to the St. Lawrence trough. All of us have heretofore been inclined to agree with Weller that most of the interior faunas came from the Arctic realm, and whereas some of them did, most of them were in connexion with the St. Lawrence sea and so on to Europe.

Clemville Formation

The "Ordovician" strata of Little Port Daniel river, about Clemville, appear to go unbroken into the earliest Silurian strata now to be described. This probably means that the basal beds of the Silurian have not been seen, and it is certain that the boundary with the graptolitic Ordovician has not been delimited.

The fossiliferous Clemville formation is at least 385 feet thick and goes unbroken into what Ells has mapped as Ordovician. No difference was seen in the dips and strikes between them. Moreover, the lithology changes gradually from these higher, more or less calcareous rocks, to the older greenish shales that are interbedded with feldspathic sandstones and conglomerates having large pebbles of the Macquereau series. It may well be, therefore, that much more of Ells' Ordovician is also Silurian, and it may be shown that the whole of his Ordovician is early Silurian and highest Ordovician (Richmondian and Gamachian).

The Clemville formation outcrops in the banks of Little Port Daniel river at Clemville, which is about a mile north of Port Daniel Centre, or less than 2½ miles in an air-line northwest of the Catholic church of St. Georges de Port Daniel. Here, where the wagon road crosses this stream, beneath the bridge, are exposed the so-called Ordovician strata of dark greenish, thick-bedded, feldspathic and conglomeratic sandstones; the pebbles are mainly of older Ordovician slate with admixtures of the older Macquereau series. A few hundred feet upstream from the bridge, on the northern bank, occur blue-green shales with scattering thin-bedded sandstones having a strike of north 60 degrees east, dip 75 degrees northwest. These strata, of undetermined age, are also seen in a high bank one-fourth to one-half mile downstream, and all are below the fossiliferous Clemville formation to be next described.

About one-fourth mile upstream from the above-mentioned bridge across Little Port Daniel river, there is a low but fine exposure along the southern bank, and here some of the beds are rich in fossils. The following descending series was measured:

	Feet
Soft, blue-black, crumbling shale that toward the top has interbedded thin sandstones, the transition zone to the La Vieille sandstones. Dip 65 degrees south, 20 degrees east. Thickness, about	150
Toward the top occur *Hyattidina congesta*, *Coelospira hemispherica*, *Schizophoria senecta*, and *Favosites forbesi*	
Blue-green, sandy shales with a few, thin, arenaceous limestones abounding in *Tentaculites*	40
Similar shales regularly interbedded with thin sandstones	35
Blue-green, sandy shales with fossils	30
Here occur *Zaphrentis stokesi*, *Halysites catenularia microporus*, *Favosites gothlandicus*, *Heliolites*, *Stromatopora*, *Cornulites*, *Orthis flabellites*, *Dalmanella rogata*, *Rhipidomella uberis*, *Leptaena rhomboidalis*, *Rafinesquina ceres*, *Plectambonites transversalis*, *Schuchertella pecten*, *Stricklandinia* small sp., *Camarotoechia janea*, *C. fringilla*, and *Atrypa reticularis*	
Green shales becoming more calcareous and knobbly	80
Soft, green shales with light blue, dense, thin-bedded limestones, some of which abound in Monticuliporas and *Hebertella* cf. *fausta*	50
Total thickness for the Clemville	385

The edges of the highly tilted strata of the Clemville formation are again exposed about one-fourth mile downstream from the Clemville bridge over Little Port Daniel river. There the succession is hard to make out and no fossils were secured. Farther downstream the Clemville is succeeded by from 125 to 150 feet of thick- and thin-bedded sandstones with green shale partings. They dip 65 degrees south 20 degrees east. These sandstones are undoubtedly the equivalent of the La Vieille sandstone described farther on. The only fossils seen were crescentic sections of (seemingly) *Pentamerus oblongus*.

La Vieille Formation

The La Vieille formation along the shore of anse à la Vieille begins with sandstones, then passes into higher shales that become more and more calcareous, and at the top are thick-bedded and more or less reef limestones. The combined thickness of these strata is about 450 feet.

La Vieille Sandstones and Shales. Logan in "Geology of Canada" says:

> "The smoothly worn edges of the vertical strata of the [Macquereau] here support an even layer of 4 feet of hard greyish-white, strong, siliceous conglomerate."

This is the basal stratum of the La Vieille formation, and is followed by "reddish-grey, micaceo-arenaceous limestones" 140 feet thick. Our thickness is 168 feet, and in detail the ascending section is as follows:

	Feet
Macquereau folded and peneplained	
Light green, coarse, vein-quartz conglomerate with the subrounded pebbles up to 3 inches. Variable from 2 to	4
Sandy conglomerate	4
Greenish sandstones with zones of quartz conglomerate in which the pebbles are of sizes up to one-half inch. Here and there occur *Stromatopora*, *Heliolites*, and *Palaeofavosites asper*	10
Green, muddy sandstones that weather hackly. Fossils appear here in more abundance: *Syringopora compacta*, *Palaeofavosites asper*, *F. favosus*, *Heliolites*, *Orthis flabellites*, *Platystrophia biforata*, crinoid columnals, *Buthotrephis* (exceedingly common), and *Taonurus* (rare)	15
Thick-bedded sandstones with very little conglomerate, having a dip of 20 degrees to 30 degrees southwest (the regulation dip up to the highly disturbed faulted area farther west along the shore)	25
Thinner bedded, greenish, muddy sandstones, but almost without shale partings	30
Green shales with less and less of sandstones. *Palaeocyclus rotuloides*, *Syringopora compacta*, *Orthis flabellites*, *Atrypa reticularis*, etc	35
Dark green shales that become more and more knobbly and calcareous upward. Fossils rare	45
Total thickness for La Vieille sandstones	168

La Vieille Limestone. West of the sandstones just described follows a thick series of more or less muddy limestones that become more and more knobbly upward and finally pass into almost pure limestones. These strata Logan (1863) described as follows:

"(2) Greenish, calcareous shale, including a few beds of yellow-weathering limestone, with many nodules of the same, and holding many fossils, 200 feet.

"There is here a break in the succession, occasioned by a fault, which creates an interval of great confusion. The cliff shows many of the details of the disturbance. . . It appears probable that there is a downthrow to the west".[1]

The throw appears to be less than 100 feet.

The next division of Logan's section is "(3) Grey, hard limestone, 50 feet", which also belongs to the La Vieille formation. The total thickness for this formation as determined by Logan is, therefore, 390 feet, whereas our thickness is about 450 feet.

In Logan's time there was no railway in the Gaspe country, but now the difficulties of the greatly twisted strata of the La Vieille fault at the seashore may be avoided by studying the series as exposed along the railway cuts. These cuts are less than 2 miles east of the Catholic church of Gascons, and show the following section:

Knobbly and very muddy greenish limestones well seen along the railway, and along the seashore where at least 150 feet of the thickness is not affected by the fault. Along the railway, however, the whole of the Stricklandinia limestones are seen to best advantage, and here they become more calcareous and fossiliferous upward. The average dip is 25 degrees toward the southwest. The cuts along the railway have a length of about 700 feet, and as the average dip is 25 degrees, the actual thickness of the limestones is about 285 feet. These limestones are rich in fossils and more can be had in this cut from the lower 150 feet than from any other place in the Port Daniel-Gascons district. It was, in fact, from these lower strata that the type specimen of *Stricklandinia gaspiensis* was obtained. Fine corals are common here. Near the mid-depth of these limestones occur, besides the species mentioned, *Uncinulus* (same at Little Port Daniel river), *Rhynchotreta cuneata americana,* large *Actinoceras* siphuncles (*Huronia*), and *Strombodes pentagonus.*[2]

The Stricklandinia limestones are again well shown about the Catholic church of St. Georges de Port Daniel, in the adjacent railway cut, and especially well along the beach below the wagon road. The western end of the railway cut for about 135 feet has the limestones undulating and rising slowly eastward to the crest of an anticline. The eastern part of the cut, with a length of about 185 feet, has the strata standing vertical to about 15 degrees overturned. These limestones strike north 30 degrees east and make a high ridge (the east Port Daniel ridge) that continues the height of the land to the east of the barrachois, and strikes northeast for about 2 miles.

Nearly the whole of these dark blue Stricklandinia limestones are best exposed along the beach a little to the north of the railway bridge near St. George's church. The centre of the arch at the back of the beach

[1] "Geology of Canada, 1863", p. 443.
[2] "Geology of Canada, 1863", fig. 308, p. 306.

is about 200 feet to the north of the bridge and then the southeastern limb of the anticline continues southeast along the shore. Here the following ascending section was measured:

	Feet
Knobbly limestone from apex of arch to coral reef	35
Coral reef, mainly of *Eridophyllum*. Dip 30 degrees toward the southeast	16
Limestones rising in dip to vertical strata	26
Knobbly, thick-bedded limestones with corals	94
Thick-bedded limestones	22
Coral reef limestone	16
Thin-bedded limestones with corals	7
Thick-bedded limestones that are more or less coral reefs	30
Regularly bedded limestones	15
Knobbly limestones with the dip overturned 10 degrees. Strike north 40 degrees east	24
Rest of section hidden by Pleistocene material	
Total of section	285

There is another good exposure of these Stricklandinia limestones just south of Clemville, striking east and west across Little Port Daniel river. Here the strike of the northern limb of the syncline is north 60 degrees to 70 degrees east, dip 65 degrees north; they are cut through by the river, and the eastern terminus of the ridge is seen three-fourths of a mile east of the river in a bold escarpment facing the western side of the large barrachois and about one mile to the north of Port Daniel Centre. A fine section is also exposed in the gorge of Little Port Daniel river, but although it was traversed, no attempt was made to study the details of the various zones, because of the inaccessibility of the place and the lack of weathered-out fossils. At least 150 feet of the knobbly limestones are shown here above the sandstones previously described, and on the crest of the ridge at least 175 feet of them can be seen; their total thickness appears to be over 300 feet, and the upper 175 feet is less knobbly, more dense, and less fossiliferous, so far as accessible specimens are concerned, than elsewhere. Continuing downstream there are nearly continuous exposures of the higher red-weathering Gascons sandstones, but the dip soon lets down from 65 degrees north to about 25 degrees north.

A readily accessible place to collect La Vieille fossils, chiefly corals, is beneath the north-going road along the southwestern side of the Port Daniel barrachois. The exposure of the knobbly limestones is here very limited indeed, but since they lie so near the surface, the ground waters have decomposed the shales and loosened the corals and other fossils so that they wash out upon the beach of the barrachois. In addition to twenty-five species of corals, *Orthis flabellites*, *Rhipidomella uberis*, *Leptaenisca*, *Schuchertella subplana*, *Stricklandinia gaspiensis*, *Rhynchotreta cuneata americana*, *Huronia*, *Illaenus grandis?*, *Bronteus*, etc., were obtained.

It should be stated here that the Stricklandinia limestones do not weather pinkish, and since they have almost no crinoidal matter, they are easily distinguished from the quarried upper and lower pink limestones of the West Point formation, which are always replete with *Crotalocrinus* columnals. Between these two zones of pink limestones of the West Point formation there are thick zones of knobbly limestones, but since the latter are interbedded with shales and the whole series weathers red, these characters, and their higher position, will readily distinguish them from the La Vieille formation.

Gascons Formation

Logan described this long series of muddy, fine-grained sandstones under the numbers 3 to 7 of his sections in "Geology of Canada", giving them a thickness of 1,750 feet. The formation may be seen from Anse-à-la-Barbe and Gascons east to Anse-à-la-Vieille, and in scattering places back in the land. Throughout, the strata are marked by gastropod trails and especially by the worm-burrows known as cauda-galli or *Taonurus*. There are also scattering corals which are most common toward the top of the formation, or east of Chouinard brook. About Anse-à-la-Barbe the top of the Gascons formation is exposed and some fine cephalopods were collected (*Phragmoceras*, *Cyrtoceras*, *Orthoceras*, and *Gomphoceras subgracile*).

On the west side of McGinnis cove is a fine exposure of the Bouleaux formation. It passes downward into the Gascons formation, but of this little is to be seen, since all the low land here is covered by fill detritus accumulated when the sea-level stood higher than it does now. The Gascons formation underlies all the lower land of this cove, and to the southeast is in fault relation against the lower pink limestone of the West Point formation.

Another fine exposure of the Gascons formation is all along the seashore of Port Daniel Centre and outward toward West point. Here nearly everywhere it weathers red, but within, the strata are green. One descends in the strata of the syncline going northeast from West point toward little Ruisseau Castilloux, but long before reaching it the lower strata of this formation are marked by a zone 35 feet thick of thin-bedded limestones which are repeated along the beach in one minor and one prominent compound anticline. Then there is a zone with *Monograptus* that further helps to fix the structure and thickness. All the strata are closely appressed and as a rule stand nearly vertical. Other than *Taonurus* and gastropod trails, fossils are scarce.

More of the detail of these strata will now be given, descending in the synclinal series, but it should be stated that there is no break in the sedimentation at either end of the Gascons sandstones; the boundaries are arbitrarily drawn and mainly on the basis of the lithology.

	Feet
Bouleaux formation above	
Red-weathering, muddy, very fine-grained sandstone exposed in a small cove a little east of the home of John Beebe, less than one-half mile north of West Point light. Dip 50 degrees south 10 degrees west	170
Same kind of strata replete with *Taonurus* burrows from cove point to cliff ladder up to second house, and on northwestward to another little cove point. Dip varying from 60 degrees to 40 degrees toward the south. Occasional *Orthoceras* are seen	300
Same strata with *Taonurus* to a place where the beds are much twisted. Strike of strata and beach nearly alike. Average dip about 40 degrees toward the southeast	145
Area of twisted and sheared strata, due either to a small anticline or a turn in the strike. Thickness unknown but estimated at	100
Red-weathering, muddy sandstones, as before with *Taonurus*. Dip 70 degrees south 10 degrees west	380
Monograptus cf. *clintonensis* zone to waterfall	100
Muddy sandstone as before, but west of brook	175
A closed and faulted anticline consisting of thin-bedded, blue, impure, and unfossiliferous limestones, alternating with shales, on either side of a central sandstone bounded by slip faults cutting out about 16 feet of strata. Strata about vertical. Here 34 feet thick, but should be	60

	Feet
Now the strata immediately to the north are a repetition of the immediately higher beds and at about 200 feet west of the limestones there is again found the same Monograptus zone. Farther west along the beach this Monograptus zone recurs and then the thin-bedded limestones rise in a completed arch and syncline. They quickly rise again in an eastern limb of a larger arch, the western limb of which, and the Monograptus zone, are again seen farther northeast along the beach. The limestone series here has a thickness of about 30 feet, followed beneath by visible sandstones and shales 20 feet thick. Beneath this greater arch are exposed about 250 feet of older sandstones and sandy shales. The higher strata then repeat themselves in an ascending section along the beach to a short distance east of Ruisseau Castillour, where all are overlapped by the present beach sands to the eastern side of the barrachois.	
As mentioned above, older sandstones and shales are seen beneath the thin-bedded limestones with a depth of about 250 feet. In Little Port Daniel gorge the 30 feet of thin-bedded limestones are wholly exposed, dipping 60 degrees south and their distance across the strike to the La Vieille limestone is about 500 feet, giving a thickness of about 430 feet for the basal Port Daniel sandstones	430
Total thickness of Gascons formation, about	1,860

Bouleaux Formation

The Bouleaux formation embraces Logan's zones 8 and 9, which together have a thickness of 700 feet. They are seen on either side of little pointe aux Bouleaux, where the upper 200 feet consists of thin-bedded, grey limestones replete with corals. Below are 500 feet of green sandy shales and limestones that weather red and pass without break into the Gascons formation. The junction between the latter and the Bouleaux formation is to the west of Chouinard brook, where there is a zone about 40 feet thick of rippled beach sandstones in thin, slabby strata.

Another fine exposure of the Bouleaux formation is to be seen going from West point north along the shore of Port Daniel bay to John Beebe's home. Here it is more limestone than usual, and with many zones of coral breccias. These originally were coral plantations that have repeatedly been broken up and their stony bases scattered about by the storm waves. It was first intended to name these strata the West Point formation because of their being more fossiliferous here, but finally, because of a lack of geographic names, this place name for the next higher series was used. The latter are also well exposed at Pointe l'Enfer, but there, due to repeated faulting, about one-half of the strata are missing that are present from West point along the shore westward to Indian point. Neither, therefore, could l'Enfer be used. The descending section north of West point is as follows:

	Feet
West Point pink limestone, beneath which is a slip fault, probably cutting out some strata.	
Fine-grained, reddish-weathering sandstones. Dip 60 degrees south, 50 degrees east	4
Greenish, fine-grained, thin-bedded sandstones with scattering brachiopods: *Schuchertella pecten*, *Leptostrophia*, *Stropheodonta (Brachyprion) philomela*, *Conchidium*, *Monomorella*, etc	20
Greenish sandstones as before	26
Blue-black coral breccia	1
Greenish, thick-bedded, sandy limestone with corals becoming common upward toward the coral breccia	32
Thick-bedded, dark blue, sandy limestone with some corals	7
Same as above, with many corals, but not a coral breccia	5
Heavy-bedded, greenish, hackly, sandy limestone	15
Heavy-bedded, greenish, limy shales	90

	Feet
Hackly, greenish, sandy limestones with some corals	45
Limestone, a coral reef	10
Greenish, muddy limestone with corals toward top and bottom, weathering red	25
Limestone, a coral reef, mainly of *Stromatopora, Favosites, Eridophyllum,* and *Heliolites*	20
Greenish, hackly shale	18
Crinoidal limestone	1
Greenish, hackly limestone with some corals	25
Greenish, evenly bedded, impure limestone	12
Greenish, hackly limestones with thin beds of limestones and sandstones	88
Covered zone, probably green shales	40
Limestone, a coral reef	8
Green shale, weathering red, with corals near top	18
Limestone. Coral reef above passing into crinoidal limestone below	30
Red-weathering shales with scattering corals	40
Knobbly limestone with some corals. Dip 65 degrees south, 20 degrees west	35
Red-weathering shales along low-water beach	125
Conspicuous coral reef striking along beach	20
At one end it is 20 feet thick, at the other 55 feet, where it is made up of several thinner coral reefs.	
Greenish shales to east of spring on higher beach	35
Red-weathering shale in cove spring beneath John Beebe's home. At the top of this zone is an horizon with small brachiopods: *Orthis flabellites, Hebertella* 2 sp., *Dalmanella elegantula, Rhipidomella hybrida, Strophonella* 2 sp., *Stropheodonta, Plectambonites transversalis, Leptaena rhomboidalis, Schuchertella pecten, Chonetes, Uncinulus* cf. *stricklandi, Rhynchotreta cuneata americana, Camarotoechia* cf. *neglecta, Spirifer (Delthyris) sulcatus submersus, Atrypina disparilis, Atrypa reticularis, Trematospira, Whitfieldella nitida, Meristina, Nucleospira*	57
Same shales to crinoidal limestone	35
Crinoidal limestone	1
Total thickness for section	888

The Bouleaux formation is again well exposed along the western side of McGinnis cove to the east of the quarry in the Crotalocrinus limestones of pointe l'Enfer. The lamination and sun-cracked nature of so much of this series, along with the coral breccias, show plainly that the sea at this time and place was very shallow, and in fact that the region was at times a tidal flat. The descending succession beneath the lowest pink limestones of the West Point formation is as follows:

	Feet
Sandy shales with thin limestones	20
Limestone, a coral breccia	5
A jumbled zone in which coral breccias have been tectonically squeezed about in the shale, with corals and *Crotalocrinus* columnals. Strata vertical, strike north 40 degrees east	17
Greenish shales	40
Pink crinoidal limestones and shales with *Crotalocrinus* columnals	6
Fine-grained sandstones with thin-bedded limestones	12
Pink crinoidal limestone, with large *Crotalocrinus* stems	2
Area more or less covered by dump of the railway tunnel above. In places sandy shales are exposed	315
Thin-bedded limestones and shale with corals	14
Thick-bedded, hackly, limy sandstones	10
Laminated sandy shale	2
Coral breccia	5
Laminated sandy shale. From here downward the evidence of the strata shows plainly the shallowness of the sea, since they were virtually deposited on the tidal flats of a subsiding coast	32
Thick-bedded limestone with corals diagenetically altered. A conspicuous cliff-making zone	13
Laminated and thin-bedded sandstones and shales, sun-cracked and rain-pitted	33
Very thin-bedded, rippled limestone	3
Coral breccia	2
Laminated, sandy shale, weathering red	7

	Feet
Laminated, sandy shale, all sun-cracked to depths of 10 inches. At least one layer is rain-pitted. Strata vertical, strike north 50 degrees east, dip 85 degrees northwest	4
Laminated sandy shale with limestones	9
Coral breccia	2
Thin-bedded sandstone and laminated sandy shales	44
Laminated, limy shales, weathering red	6
Thin and thick-bedded limestones with *Stromatopora*	6
Laminated, limy-sandy shales	8
Stromatopora reef	2
Laminated limestone	3
Calcareous shales	5
Laminated shales and thin-bedded limestones	7
Thick-bedded limestones with corals	7
Laminated limestones with red shales	6
Knobbly, red limestone with small brachiopods (*Whitfieldella*)	1
Thin-bedded, red limestones	5
Laminated limestone and coral reef replete at top with branching *Favosites* and below with *Stromatopora*. Weathers brick red	6
Last laminated limestone and sandy shales	9
Breccia of *Stromatopora*	2
Red-weathering shales with thin limestones	16
Coral reef with *Cladopora* and *Halysites*, but mainly of *Stromatopora*. Dip 80 degrees north 40 degrees west	3
Red-weathering shales can be seen at low tide and as the beach material has slabs with *Taonurus*, it is evident that the Gascons formation is at hand. The rest of McGinnis cove is made up of Pleistocene and Recent debris.	
Total thickness for section	689

West Point Formation

Nowhere east of Port Daniel is there a full development of the West Point formation, and accordingly Logan (1863) made out the thickness of his division No. 10 as only 500 feet, whereas along the shore west of West point there is a thickness of not less than 1,445 feet. Logan correctly states that "about 70 feet of the tenth or upper division compose pointe aux Bouleaux. . . The Gros Morbe, between Anse-aux-Gascons and Anse-à-la-Barbe, displays the whole thickness of the two higher members" (9 and 10), and they make up most of the coast, nearly the whole way to Port Daniel.

Pointe l'Enfer is made up chiefly of West Point limestones, the quarried part being internally of light blue to white colour, but weathering pinkish; they are characterized by an abundance of *Crotalocrinus* columnals up to 1½ inches in width. *Stromatopora* and corals also abound, but it is almost impossible to get good specimens.

The Crotalocrinus series is more accessible at the wharf at pointe l'Enfer than anywhere else in the area of our studies. Here the strata stand on edge and structurally make a closed syncline that strikes about north 25 degrees east. Beginning at the structural centre of the closed syncline, in the quarried pink or uppermost Crotalocrinus limestone, and proceeding either to the east or west of the cape, parts of the whole series are easily made out, but it was not until the long sequence at West point was determined that it was learned how imperfect is the l'Enfer sequence. It was, therefore, impossible to use this easily accessible place as the type section for the formation name, and the almost inaccessible West Point cliffs had to be taken.

Almost every foot of the long, rising sequence through the descending limb of a great anticline may be seen along the sea-front from West Point lighthouse westward for $1\frac{1}{2}$ miles. As the rock succession is a long one, with several marked lithologic changes, the whole has been subdivided and each part named from the essential nature of the strata.

The following is an ascending section from West point westward:

	Feet
(1) Lower, pink, thick-bedded limestones that weather more or less reddish and are replete with *Crotalocrinus* columnals. They reach West point, on which the little lighthouse stands. Probably one-half of the limestone is made up of *Stromatopora*, and slender, branching *Cladopora* are also common. Dip about 65 degrees south. Thickness estimated at..	200
(2) Lower, intermediate, thin and thick zones of knobbly coraliferous limestones, interbedded with zones of laminated sandy limestones that usually have current ripples and are more or less sun-cracked and muddy sandstones. The whole series becomes more and more shaly and sandy upward. Measured as..	230
(3) Lower, greenish, sandy shales that weather red, interbedded with some sandstones weathering yellow. Estimated at........................	120
(4) Middle, intermediate, thin-bedded limestones reolete with *Stromatopora*, *Eridophyllum*, and other corals, separated by thin zones of shale, the whole weathering red. As these strata strike with the coast, they extend westward for three-fourths of a mile. Strike north 90 degrees east, dip 55 degrees south. Estimated thickness.....................	560
(5) Middle, pink, thick-bedded limestones. Thickness estimated at......	60
(6) Upper sandy shales, weathering red. Thickness estimated at..........	150
(7) Upper, pink, thick-bedded limestones on which the cormorants nest each year. The dip rises in the east from about 60 degrees to 15 degrees overturned at the west, and strike along the coast for one-fourth of a mile and also flatten down considerably. Estimated thickness........	125
Total thickness for West Point formation.........................	1,445

West Point limestones are again seen on the eastern side of McGinnis cove where they make Pillar point in a slightly broken or faulted anticline. To the northwest of Pillar point the highest strata of the anticline appear, a part of the lower pink limestone showing a thickness of about 80 feet. They dip 65 degrees north 15 degrees west. Then there is a covered area of about 600 feet across older beds, followed by the exposed, vertical, central part of the slightly faulted arch, all of which strata belong to the Bouleaux formation, also making Pillar point.

The Pillar Point anticline is encountered eastward all along the seashore to beyond anse Harrington, and then the arch flattens greatly toward Anse-à-la-Barbe (here the dip is low, 15 degrees northwest), but steepens again southward in the Gros Morbe and at pointe aux Bouleaux. It is an almost continuous exposure for 5 miles of the Bouleaux limestones and the lower pink formation of the West Point formation, showing in detail the lithology and fossil content of these limestones. The top of the Gascons formation is also exposed about Anse-à-la-Barbe, where good cephalopods were collected.

Indian Point Formation

The Indian Point formation is the youngest of the Port Daniel Silurian and is to be seen along the seashore east of the inconspicuous Indian point.

It is about 3 miles west of the Port Daniel railway station, over the King's road to the Episcopal church, then west to Adam Mahon's land and across it down to the seashore. On the way down is seen the upper pink limestone of the West Point formation, and beyond may be studied the following strata of the Indian Point formation:

	Feet
Top of upper pink limestone	
Covered zone	14
Crinoidal limestone	3
Covered zone	22
Thin-bedded, fossiliferous limestones beside the private road to lower farm. Dip 25 degrees south 40 degrees east. Corals, *Leptaena rhomboidalis*, *Gypidula*, *Camarotoechia* 3 sp., *Meristina*, *Atrypa reticularis*, etc	35
Muddy, fine-grained, deep green sandstones, weathering red, interstratified with local lenses of impure limestones up to 4 feet thick. It is in these limestone lenses that most of the fossils occur. *Taonurus* is again common, and in the limestones occur corals and *Crotalocrinus* columnals. It is interesting to see here how corals and bryozoans grow in single heads on the mud bottoms, but eventually are turned over by the storm waves. Estimated depth out to low tide	120
Total seen of Indian Point formation	194

BONAVENTURE SERIES

The red Bonaventure conglomerates and sandstones are not of marine origin, nor were they deposited necessarily near the seashore, but are valley accumulations of the mountains made in Devonian time. Their irregularity and coarseness of materials, the endless repetition of conglomerates, usually made of subangular to angular pebbles, largely of Silurian limestones that in places are 15 feet across, and the universal maroon to brick-red colour show that they are terrestrial deposits made under a dry climate. Everywhere in the Port Daniel-Anse-aux-Gascons area this formation is laid upon the intensely folded and deeply eroded Silurian strata, showing that before the time of Bonaventure stratal accumulation the St. Lawrence geosyncline had been folded into mountain ranges. This orogeny is now known to have taken place in later Devonian. J. M. Clarke holds that with the late Devonian orogeny the Bonaventure conglomerates began to accumulate, and that their time of origin was late Devonian and early Mississippian.[1] Nowhere in the area are there Devonian strata, though such of marine and freshwater origin are well known to the east about Percé and Gaspe, and marine to the west about Dalhousie and Campbellton, New Brunswick. They are also known to have wide, inland extension on Gaspe peninsula, and from Campbellton extend through northern Maine, but to the south in New Brunswick no Devonian formations are present. They, however, again occur in the Acadian trough of Nova Scotia.

On the western side of the area, beginning at Indian point and thence inland to the north and west for many miles, the country is topped with the Bonaventure formation. These outcrops were not studied since they are described in the report by Ells. Remnants of the Bonaventure overlying the Silurian, however, were studied wherever such outliers were seen, and the results were as follows:

At Indian point, about 2 miles to the west of West point, there is a cleanly washed contact of the Bonaventure upon the upended Silurian. The latter rocks were eroded to a level surface, the plane of which descends slowly seaward. Their dip is 40 degrees south 40 degrees east. Here the Bonaventure dips to the southwest, and is in the main a red shale that is more or less conglomeratic just above the contact. The pebbles are all small, up to 4 inches across, more or less angular, and in the main of Silurian strata.

[1] Eighteenth Rept., Director N.Y. State Mus., 1924, pp. 123-127.

A small remnant occurs along the beach to the northwest of the wharf at pointe l'Enfer. Here the younger Silurian strata stand vertical and over their jagged edges lies unconformably a basal Bonaventure conglomertate in which some of the limestone blocks are 4 feet across. This material lies in a Palæozoic hollow, and another outcrop of the same valley is seen along the northbound wagon road beginning in the King's road. It is the Bonaventure formation that has preserved this ancient topography.

One of the most interesting remnants of the Bonaventure formation is seen in Harrington cove. It has a sea face of about 400 feet across and pitches steeply down the cliff in a late Devonian valley that goes out to sea. The Bonaventure here lies unconformably upon the steeply inclined Silurian, and the very coarse basal conglomerate has numerous large blocks of the Crotalocrinus limestone, one of which measures 15 by 8 by 5 feet. The material resembles that of a talus in front of a cliff, or of a rock talus passing down a small valley.

East of Chouinard brook, to the Stricklandinia knobbly limestone, the high Silurian cliffs are overlain unconformably by the Bonaventure, here a limestone conglomerate about 50 feet thick, in which the subangular pieces are of a few inches in length. It dips to the west. The deep red colour of this conglomerate has leached down over the underlying rocks.

PLEISTOCENE MARINE TERRACE AND FILLS

Little Port Daniel river terminates in a tidal flat, faced along the seashore by a high-tide beach of pebbles and sand over which the King's road is laid. On this beach is situated a lumber mill. Along the southwestern side of the tidal flat, on the Herbert Sweetman farm, are seen two fill terraces, the lower one at about 20 feet and the higher one at about 30 feet above mean sea-level. On the eastern side of the tidal flat and just beyond the railway is a fill terrace rising to about 35 feet above sea-level.

A series of fill terraces may be seen inland along the last of the rapid-running waters of North river before it enters the barrachois. The first and widest terrace begins 3 to 4 feet above the summer level of the river and rises to about 10 feet, where there is a cliff 15 feet high. The second terrace rises about 5 feet, backed by a cliff about 30 feet high. The third terrace is about 50 feet above the river, with a cliff of some 8 feet, and the fourth, almost unrecognizable terrace stands at about 60 feet.

Along the centre of anse aux Gascons there is a Pleistocene marine blue clay with a thickness of about 10 feet, in a sea-cliff beginning at high-water level. It has an abundance of the short-shelled variety of *Mya arenaria* so characteristic of cold-water marine Pleistocene clays. No *Saxicava* was seen.

All along the coast of anse aux Gascons, marine terraces cut into Silurian strata are conspicuous. The lowest terrace is the widest one and is now being eaten into by the sea. Toward the sea, its plane is from 20 to 25 feet above sea-level, and inland it rises to about 30 to 35 feet. This terrace is best developed on either side of the east horn of the cove, and is backed by a cliff that is about 12 feet high.

The second terrace about Gascons is as a rule very narrow and rises 4 feet to the second cliff of about 10 feet elevation. On much of this terrace the railway is placed. The inshore cliffs of the first and second terraces are drawn on the map, the second terrace going west to Anse-à-la-Barbe.

East of Chouinard brook other and higher terraces are seen. The slope of the third terrace here rises 10 feet, with a cliff back of it 20 feet high. There is a fourth but much eroded terrace, the first to come out of the Pleistocene submergence. The height of the three terraces up to the base of the fourth is about 90 feet above the present sea-level.

East of Gascons along the King's road, ascending the Macquereau strata, two sets of glacial striæ are seen, one striking north 20 degrees west, the other north 30 degrees east. Both sets strike into Chaleur bay.

Along the entire shore of the Port Daniel-Gascons area may be seen somewhat large, erratic stones that have come from the interior highland to the north. Most of these are of ancient metamorphosed formations, like greenstones, schists, and arkosic conglomerates. Granites are rare, but one grey granite mass was seen with dimensions of 10 by 7 by 5 feet. There are also boulders of the Ordovician and Macquereau. Nowhere, however, does one see moraines or glacial deposits, only the scattered erratics, and sea-fill material.

IGNEOUS ROCKS

The only igneous rock seen in our area forms a dyke 15 feet across, cutting vertically the deformed Silurian strata near the northern end of anse aux Gascons beach. On either side of the dyke rock, the Silurian shales are baked red and hardened. The age of this intrusive is, therefore, later than the Devonian deformation. The composition of this dyke has been determined by Professor Adolph Knopf of Yale University to be that of an anorthosite porphyry. He describes it as follows:

"The dyke from Gascons cove proves to be a rock of uncommon type and is best designated an anorthosite porphyry. It is a grey rock containing numerous phenocrysts of glassy plagioclase in a microgranular groundmass. The plagioclase crystals constitute roughly 20 per cent of the bulk of the rock; they are of thin, tabular habit, averaging one centimetre in diameter, and are roughly in parallel alignment. Under the microscope, they are found to be a sodic labradorite ($Ab_{45}An_{55}$). The groundmass is composed largely of tabular plagioclase in seriate development, the largest individuals, however, being much smaller than any of the phenocrysts. Chlorite occurs in small amount in the triangular interspaces between the plagioclase laths and is undoubtedly derived from what little ferromagnesian mineral was originally present. Secondary calcite is more or less abundant and has resulted from alteration of the feldspar. Magnetite in small octahedrons, ilmenite in thin plates, and apatite in acicular prisms are relatively abundant accessory minerals. They appear to have separated out at a late stage of magmatic consolidation, as none of them occurs as inclusions in the large porphyritic crystals.

"On account of the marked preponderance of plagioclase in the makeup of this rock, the most appropriate name for it appears to be anorthosite porphyry."

THE SILURIAN SUCCESSION OF BLACK CAPE

About 45 miles west of the Port Daniel area occurs a most interesting Silurian sequence that is exposed continuously along the seashore for nearly 2 miles. The strata have an average dip of 60 degrees southeast, and are a part of one limb of an extensive anticline. The section begins near the base of the Silurian and appears to go without repetition or break into the higher Silurian of the Port Daniel sequence, our West Point or Crotalocrinus limestone. Finally, the Black Cape limestones are involved with marine lava flows that end in land flows of very great thickness, making the sea-shore east of Black cape for more than one-half mile. This section was first made known by Ells, and in his report of 1883 occurs the following:

About one mile east of Little Cascapedia river, the Silurian strata

. . . . "come out boldly upon the shore and form a cliff of moderate elevation for nearly 2 miles, or until they meet the intrusive traps of Black cape. At their western exposure the rocks are limestones, hard and bluish."[1]

It should be noted that Ells regarded these basalts as intrusive, but since the traps are in many places full of amygdules, and in flowing over the sea-floor picked up some of it, it is plain that they are extrusives. They will be described later.

Dr. John M. Clarke on his travels to Percé has many times seen the strata of Black cape, and in 1913 he gave a generalized statement of the Black Cape section in Guide Book No. 1, "Excursion in Eastern Quebec and the Maritime Provinces," published by the Geological Survey, Canada, for the International Geological Congress at its Toronto meeting. He says:

"The rock section [of Black cape] is of special interest for its extraordinary development of the Silurian, the shore section from the mouth of the [Little Cascapedia] river to Black cape itself displaying an unduplicated thickness of fully 7,000 feet of strata. . . They stand at high angles to the horizon, usually dipping 60 degrees to 80 degrees south-east. . . The eroded edges of the strata are overlain elsewhere in the region by the red sands and conglomerates of the Bonaventure formation, and there are several considerable fissures in the [lowest] Silurian limestones of this section which are filled in with red sand derived from the overlying beds. All these occurrences indicate land exposure of the Silurian during all of the early and middle Devonian time.

"The base of the section at the west begins with greenish, highly nodular lime shales, very compact and heavy bedded, weathering out into irregular and gnarled shapes. These alternate with more highly calcareous shales and compact limestones of red and ochreous tints. These compact limestones contain Stricklandinias of great size (*S. gaspiensis* Billings) and in great number. . . Throughout the lower beds the rest of the fauna is largely of Stromatoporoids and corals which occur in enormous quantity and great diversity."

Above the lower limestones that terminate where Mr. Howatson's farm begins, the greater part of the higher Silurian . . . .

. . . "continues sandy to near the end of the section which terminates at the volcanic mass forming Black cape, but toward the top the sands become interlaminated with thin beds of volcanic ash, with red and purplish shale, and eventually calcareous and variegated beds succeed to these, becoming in places compact limebanks entirely constituted of the debris of fossils."

"The volcanic mass which forms Black cape itself and against which these upper strata abut presents a total sea-face of 4,600 feet, and within it are two notable inclusions or separate masses of Silurian strata. The first of these is in Macrae cove, 600 feet from the beginning or base of the intrusive, and the second at Lazy cove, one-third mile farther east. . . At Macrae cove the thickness of the sediments is 150 feet and in the narrower Lazy cove they are 75 feet. . . The volcanic cliff ends one-half mile beyond Lazy cove and at its termination the red conglomerates of the Bonaventure formation lie against it at an angle of 30 degrees".[2]

The senior author of the present paper had visited Black cape in 1905 and 1913, and during the summer of 1923 both authors spent some days there studying the continuous and unrepeated sequence, which afforded a fine opportunity to check up results in the highly disturbed Port Daniel-Gascons region.

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[1] Geol. Surv., Canada, Rept. of Prog. 1880-81-82, pt. D, p. 13.
[2] Twelfth Inter. Geol. Cong., Guide Book No. 1, pp. 110-112 (1913).

At Black cape the ascending Silurian section was made out as follows:

	Feet
Fill of Little Cascapedia river when the land lay lower	
Base of the Silurian not visible. The lowest Silurian seen here is not as old as the oldest beds of the Port Daniel section	
La Vieille formation of Port Daniel section, 990 feet thick	
Thin-bedded, impure limestones with zones of shale and sandy limestones. Fossils very scarce except at about 190 feet above the visible base, where occur *Coelospira hemispherica*, *Chonetes*, and *Dalmanella rogata*	225
Thin-bedded, knobbly, impure limestones with greatest abundance of *Stricklandinia gaspiensis*. Corals occur also	35
Knobbly limestones that become more and more muddy upward. Some layers sun-cracked. The slender-tubed *Syringopora compacta* is common and is identical with one collected at Anse-à-la-Vieille east of Port Daniel. Thickness, estimated	310
Thin-bedded, shaly, impure limestones, much rippled and sun-cracked. Also some rain-pitting. Thin zones are made up of small Stromatoporas or calcareous algæ. Thickness, estimated	125
Thin-bedded and more or less nodular, impure limestones, showing 80 feet of thickness up to the crest of the anticline which strikes along the coast for an eighth of a mile	80
Marked headland composed of hard, dark blue, nodular limestones. Has a Camarotoechia zone 15 feet across	100
The knobbly limestones become more and more impure to the east of the headland, pass into calcareous shales, and finally into sandy mudstones. They abound in fine corals and the beach here is strewn with them	115
It appears that Clarke made this thickness about 1,500 feet, but the writers could not estimate it as greater than 1,000 feet. The difference may be due to the presence of the anticline and the strike of the beds along the shore	
Gascons formation of Port Daniel section, 3,400 feet thick	
Greenish, somewhat sandy shales that weather yellowish, with scattering, thin zones of impure limestones across the Howatson property to Mr. Service's dock. *Taonurus* is common, but other fossils are very scarce. Average dip 60 degrees southeast. About	1,700
Sandy greenish shales and sandstones, weathering yellowish, with zones of coral breccias and impure limestones. These beds are east of Service's dock up to two nodular limestone zones shown on Clarke's illustrated section of the Black Cape coast	1,700
Bouleaux formation of Port Daniel section, 2,670 feet thick	
Sandy shales with zones of coral breccia 3 feet thick, and beds of impure, nodular, and even-bedded limestones	200
Sandy shales with an occasional impure, thin limestone	750
Laminated, sandy shale with a coral limestone	25
Sandy, calcareous, greenish shales with several coral breccias and impure limestones, showing current action, and much sun-cracking just above the limestones	90
Sandy, calcareous shales, much sun-cracked and rippled. There is also one bed of corals, and another in a breccia of fossils	60
Sandy, laminated, and much sun-cracked and rippled, calcareous, greenish shales, with a bed of calcite concretions. About 70 feet from the top of this zone there is an *ash bed* about 1 foot thick	165
Shale with *four ash beds* (lowest 8 inches; No. 2, 3 inches; No. 3, 6 inches; and the highest one about 30 inches)	6
Greenish, sandy shales beneath Black Cape section	700
Green shales that weather red, with sun-cracks and rain-pittings, up to a headland	108
More of the same red-weathering, sandy shales up to the brook near the centre of Black Cape beach	375
Red-weathering, sandy, laminated, calcareous shales, much sun-cracked, and rain-imprinted. Lower 25 feet with impure limestones having wave-washed and broken fossils. *Crotalocrinus* columnals. Strike north 30 degrees east, dip 60 degrees southeast	190
West Point formation of Port Daniel section, 325 feet of sediments and nearly 4,000 feet of basalt flows	
Impure limestones, more or less sun-cracked, with scattering corals and one bed having an abundance of *Leperditia*	150
Two beds of slightly baked and hardened limestones or coral breccias	6
First marine basalt flow, more or less replete with amygdules, included large and small masses of white limestone, and many fragments of shale.	100
Crotalocrinus limestone (3 feet), followed by shale	20
Second marine basalt flow	10

	Feet
West Point formation—*Con.*	
Crotalocrinus limestone with a 2-foot flow of basalt	50
Third marine basalt flow and breccias with inclusions of limestone and shale	380
Interbedded limestone and shale of Macrea cove. Dip 90 degrees	100
Fourth or great and final basalt flow, about	3,500
Near the centre of this mass is Lazy cove, backed with about 75 feet of red clay, probably of the Bonaventure formation. Clarke gives the sea-face of this fourth flow as about 4,000 feet long	
Great break in section. Devonian mountain-making followed	
Bonaventure intermontane desert conglomerates and shales, with many boulders of the Silurian basalts; near the base they are of reddish Silurian limestones and corals.	

COMPARISON OF THE BLACK CAPE SECTION WITH THAT OF THE PORT DANIEL-GASCONS AREA

In contrasting the Black Cape sequence with that of the Port Daniel-Gascons area, it is at once apparent that the former area has far less limestone and is at least 2,200 feet thicker. This greater thickness occurs in the middle time of accumulation when the detritals were pouring into the seaways of both regions.

Another very interesting feature is that at Black cape the Middle Silurian seas were overwhelmed with volcanic eruptions of basalt, there being about 500 feet of these flows interbedded with marine deposits, followed by the final flows over the dry land that at Black cape still preserve not less than 3,500 feet of basalts. But long before the basalts attained the surface, volcanic vents were blowing out ash, since the latter appears in the marine deposits about 1,600 feet beneath the first basalt flow. These volcanic eruptions fall in with the time of other great ash and basalt accumulations of southeastern Maine, and it will probably be learned that volcanism of this time was even more widely spread throughout the Maritime Provinces of Canada.

In the follow ng table the Silurian formations of Port Daniel-Gascons area are approximately correlated with those of Black Cape region. In detail no exact correlations can as yet be made, nor can definite boundary lines be drawn between the unbroken formations of the two areas, and yet we know enough to make approximate correlations. These are as follows:

—	Port Daniel	Black cape
	Feet	Feet
Indian Point formation	194	Absent
West Point limestones	1,445	326
Bouleaux shales and limestones	800	2,670
Gascons formation (Taonurus zone)	?1,800	3,400
La Vieille limestones	285	765
La Vieille sandstones	170	225
Clemville formation	385	Covered
	5,079	7,386 and 4,000 of basalt

ORDOVICIAN AND SILURIAN FOSSILS FROM GREAT SLAVE LAKE

By G. S. Hume

CONTENTS

INTRODUCTION

The rocks of North arm, Great Slave lake, have been described by A. E. Cameron[1] and by the writer[2] in the Summary Reports of the Geological Survey for 1917, 1920, and 1921. In the report for 1920 the two horizons recognized by Cameron were discussed and a provisional list of fossils given from each. The age of both horizons was considered to be Silurian, but more detailed studies have shown that the Halysites on which the age of one horizon was based is in reality *Halysites gracilis* and the age is Ordovician. There is thus on the North arm at least one horizon of Silurian and one of Ordovician, the latter being now recognized for the first time. It is possible other Silurian beds occur above the Ordovician and below the Silurian, from which fossils were obtained.

ORDOVICIAN BEDS

At no place were the field relationships of the Ordovician and Silurian rocks seen, so that the position and age as here deduced are entirely based on fossil evidence. The character of the sedimentation has already been somewhat described. It varies for the different localities on the North arm. At Gypsum point at the south end of the North arm, the rocks are mostly red, arenaceous limestones and shales with gypsum. The gypsum occurs both bedded and in vein, the veins cutting across the strata and obviously being later than the sedimentation. Where the gypsum beds occur there are no fossils. To the north of Gypsum point a section has been described from Red Rock point.[3] The section shows a lower part of 35 feet of variegated coloured sandstones, but at no place was the base exposed. Observations elsewhere, however, led to the conclusion that the basal part of the formation is sandstone which rests unconformably on the Precambrian below. It is quite evident that the sandstone varies greatly in thickness as well as character from place to place, owing to the

[1]Geol. Surv., Canada, Sum. Repts. 1917, pt. C; 1921, pt. B.
[2]Geol. Surv., Canada, Sum. Rept. 1920, pt. B.
[3]Geol. Surv., Canada, Sum. Rept. 1920, pt. B.

very irregular underlying Precambrian surface. The first beds deposited on such a floor by an advancing sea would be formed in the hollows between the knobs of Precambrian rocks. Towards the north end of the North arm observations show that the Precambrian floor had a topographic relief of at least 200 to 300 feet at the time it was submerged by the Ordovician sea.

At Red Rock point above the sandstones there are 7 feet of heavy beds of massive, red, dolomitic limestones which form the capping rock of cliffs which owe their persistence to the extremely resistant character of these beds. At this point the red beds contain no gypsum and are less red in colour than the rocks at Gypsum point. Farther to the north in red dolomitic limestones of approximately the same stratigraphic level fossils were found. A list is as follows:

Receptaculites nearest *oweni*
Camarotoechia sp.
Cyrtodonta septentrionis n. sp.
Conularia esclavensis n. sp.
Endoceras sp.
Orthoceras sp.
Trochoceras sp.

Some of these fossils were in chert in red limestone and consequently in a fine state of preservation. Others were in the limestone itself and in many cases the more detailed structure is lacking.

To the north of the locality where the above fauna was collected the rocks become less and less red in colour and more dolomitic in character, changing to a yellowish or buff dolomitic limestone. A fauna somewhat similar to that found in the red beds occurs at several places, but always affords rather poorly preserved material. The fauna is as follows:

Halysites gracilis
Palaeofavosites asper
Camarotoechia sp.
Leptaena sp. (peculiar geniculate form, *See* Plate XIII, figure 3)
Strophomena sp.
Strophomena ruga n. sp.

Other brachiopods whose determination is questionable, but two of which probably belong to *Rafinesquina.*

Fragmentary lamellibranchs
Calymene sp.

Of the above, *Halysites* is the most abundant, and as a rule either the fossil itself has weathered out leaving the mould, or else the whole has been replaced by calcite. However, on detailed examination, it can be definitely stated that the cross-section of the individual corallites is quadrangular as in *H. gracilis*. The conclusion, therefore, is that this is the Ordovician rather than the Silurian *Halysites* and this conclusion seems to be borne out by the detailed study of the remainder of the fauna. The *Receptaculites* is described and figured in this report. Most of the Silurian species so far described are globular forms and such a form was found along with the expanded form figured. However, the globular form is too poor for identification and the expanded form is very close to *R. oweni*. A number of Strophomenidae with ridged surface markings have been described by Holtedahl from the Ordovician of the Kristiania region. The form here figured has the same general, peculiarly ridged surface, but is believed to be a new species of *Strophomena* and is consequently described as *S. ruga*. Of the other fossils Dr. Foerste has shown that *Endoceras* is typically Ordovician, whereas the other Cephalopods are not distinctive. In this connexion it might also be said that *Cyrtodonta* is much more common in Ordovician rocks than in strata of any other age, so that its occurrence in this assemblage is also somewhat significant.

In conclusion, therefore, it is believed that these fossils indicate an Ordovician rather than Silurian age, as has previously been supposed. The information is not sufficient to assign them to a definite position in the Ordovician, although some facts are worth consideration.

Halysites gracilis occurs in the Trenton[1] of Manitoba, the nearest Ordovician rocks known to those of Great Slave lake, and in the Richmond[2] of Anticosti. In Manitoba it is found with *R. oweni*, and in the Anticosti faunas[3] *Palaeofavosites asper*, which is also common on Great Slave lake, occurs. At the present time, therefore, the information at hand is insufficient to say whether this Great Slave Lake fauna is Trenton or Richmond in age.

Silurian Beds (*Fitzgerald Dolomite*)

The horizon correlated by Cameron[4] with the Fitzgerald dolomite contains a fauna that correlates it most closely with the Guelph of southwestern Ontario. The following fossils were found in a single outcrop southwest of Gypsum point.

Pycnostylus elegans
Pycnostylus guelphensis
Spirifer nearest *coralliensis*
Phragmoceras sp.
Poterioceras sp.
Rizoceras sp.

Such characteristic fossils as *Pycnostylus guelphensis* and *P. elegans* occur abundantly in the Guelph of southwestern Ontario and are known elsewhere only from beds which according to Williams[5] are transitional between the Lockport and the Guelph in southwestern Ontario. The Cephalopods have been described by Dr. Foerste in the accompanying report and his conclusions in regard to age agree with that indicated by the *Pycnostylus*.

[1] Geol. Surv., Canada, Ann. Rept., vol. XI, pt. F, p. 49 (1899).
[2] Contr. Can. Pal., vol. IV, pt. I, p. 69.
[3] Geol. Surv., Canada, Mus. Bull. 3, p. 6.
[4] Geol. Surv., Canada, Sum. Rept. 1917, pt. C.
[5] Williams, M. Y.: Geol. Surv., Canada, Mem. 111.

This fauna is from a single small outcrop and represents the only collection from rocks of this age on Great Slave lake. On the fossil evidence the conclusion seems justified that this locally is a link in the connexion between the Arctic and the great Interior Guelph Sea.

DESCRIPTION OF SPECIES

Receptaculites sp.

Plate XII

Only a fragment is known. It is a flattened and expanded form which bears the closest resemblance to *R. oweni* of any described species. The cells of the disk are small at the central point and diverge concentrically into larger ones toward the margin. Preserved in red, arenaceous limestone so that only the form and general characters are definitely determinable.

Locality and Horizon. North arm, Great Slave lake, North West Territories. Ordovician.

Camarotoechia sp.

Plate XIII, figures 1a-d

Medium sized, length in the best preserved specimen 20 mms. and greatest width 22 mms. Ventral valve with prominent umbo and sharp beak which projects over the dorsal valve. Median sinus extending two-thirds of the distance from the anterior margin toward the beak. Dorsal valve more convex than the ventral valve. Surface covered with plications, of which there are three in the sinus and four on the fold. On each side of the sinus seven plications can be distinguished, although they become progressively less distinct the farther they are removed from the more median ones. The plications are not very distinct over the umbonal part of the shell. Imbricated concentric lamellæ over the plications.

One specimen is peculiar in that one plication on the fold is suppressed so that only three are well developed; the fourth is evident,though in the alternate arrangement with those on the sinus at the anterior margin. Most of the specimens are preserved in dolomitic limestone and consequently only in those best preserved does the concentric lamellæ show.

Occurs in dolomitic limestone that outcrops in the vicinity of one of the former sites of Rae.

Locality and Horizon. North arm, Great Slave lake, North West Territories. Ordovician.

Strophomena sp.

Plate XIII, figures 2a, b

Shell medium sized, greatest width along the hinge-line which is extended into acute ears at the cardinal extremities. Surface marked by fine, uneven, bifurcating striæ which show two or more finer ones between the coarser ones at the anterior margin. Striations curved toward the posterior margin. Dorsal valve moderately convex, the central depression marked in the posterior portion and continued, but less distinctly, to the anterior margin. Ventral valve known only as an interior cast. Adductor muscle scars well defined and subcircular in outline and separated by a narrow groove indicating the former position of the median septum. Hinge-line shows no teeth.

Occurs in dolomite where the preservation is not very good.

Locality and Horizon. Le Gros point, North arm, Great Slave lake, North West Territories. Ordovician.

Strophomena ruga n. sp.

Plate XIII, figures 4a, b

Outline subtriangular, greatest width along the hinge-line. Dorsal valve concave posteriorly, becoming convex or flattened over the medial portion and sharply geniculate at the anterior margin. Muscle scars with a distinct outline and very slightly longer than wide. Surface marked by zigzag corrugations or wrinkles. Striations only seen on the geniculate portion of the anterior margin where they are rather coarse.

Dorsal valve only known.

Locality and Horizon. Le Gros point, North arm, Great Slave lake, North West Territories. Ordovician.

Cyrtodonta septentrionis n. sp.

Plate XIII, figures 5a, b, c

Shell small, ovate; beaks quite prominent and slightly incurved, umbones inconspicuous. Shell thin and marked by concentric lines of growth. Hinge-plate strong and quite straight. Cardinal teeth well developed, three in each valve. Posterior lateral teeth known only from a right valve where they are two in number, strong, with the outer one especially elongate and curved and situated near the extremity of the hinge-line. Pallial line simple.

Locality and Horizon. North arm, Great Slave lake, North West Territories. Ordovician.

Conularia esclavensis n. sp.

Plate XIII, figures 6a, b

Shell small, apical angle about 24 degrees. Faces concave. Ornamentation of faces of fine ridges which are uninterrupted over the marginal angles and are continuous across the faces. Ridges very slightly crenulated and on each face in the form of flattened chevrons with the apex away from the apex of the shell.

The chevrons on the faces are not symmetrical, one side being more bent toward the apex of the shell than the other side. This is probably not a characteristic of the shell, but has resulted from the application of pressure along the marginal angle between the faces.

Locality and Horizon. North arm, Great Slave lake, North West Territories. Ordovician.

CEPHALOPODA FROM THE ORDOVICIAN AND SILURIAN OF GREAT SLAVE LAKE

By A. F. Foerste

CONTENTS

Illustration

INTRODUCTION

Among the specimens collected by George S. Hume, Geological Survey, Canada, along the west shore of the North arm, Great Slave lake, are several fragments of cephalopods which are not sufficiently well preserved to serve as types of new species; nevertheless they are of sufficient interest to merit description and figuring. The character of the associated fauna is indicated in the accompanying report by Mr. Hume.

The three specimens here referred to *Endoceras*, *Orthoceras*, and *Trocholites*, Plate XIV, figures 1, 5, and 6, were found along the southern part of the northern arm of Great Slave lake. Of these three specimens, the *Endoceras* indicates an Ordovician horizon. The other two specimens referred to *Orthoceras* and *Trocholites*, occur in cherty rock from the same locality, and although neither of these two specimens, in our present knowledge of American cephalopods, can be utilized in determining the age of the containing rock, the latter also is regarded as of Ordovician age.

Plate XIV, figures 2, 3, 4, show the remaining three specimens, here referred to *Phragmoceras*, *Poterioceras*, and *Rizoceras*. They are found associated with *Pycnostylus guelphensis* and *Pycnostylus elegans*. These two corals originally were described by Whiteaves from the Guelph of southern Ontario, and both were identified by Lambe from the Silurian of the portage road at the fall on Ekwan river, west of James bay, in northern Ontario. *Pycnostylus guelphensis* is listed by Whiteaves from the Silurian also, at Davis point, lake Manitoba; it occurs too in the Racine of southeastern Wisconsin and of the adjacent part of Illinois. The specimens here referred to *Poterioceras* and *Rizoceras* are closely related to undescribed species of cephalopods occurring in the Racine. The specimen referred to *Phragmoceras* appears to belong to an erect species, little curved lengthwise, different from any species so far discovered in American strata. The general horizon for this part of the Silurian on Great Slave lake appears to be Guelph or Racine.

DESCRIPTION OF SPECIES

Endoceras sp.

Plate XIV, figures 1A, B

Conch enlarging at the rate of 10 or 11 mm. in a length of 100 mm., indicating an apical angle of 6 degrees. The specimen consists of part of a phragmacone 160 mm. in length and 56 mm. in width near the larger end of the specimen. Ten cameræ occur in a length equal to the diameter of the conch at the top of the series of cameræ being counted.

Passing through the entire length of the specimen is a nearly cylindrical object, interpreted as the siphuncle, although its structural details cannot be determined. At the smaller end of the specimen the diameter of this siphuncle equals 0·42 of the diameter of the conch; at the larger end this ratio is 0·43; and about the same ratio is shown at mid-length of the specimen, where a transverse break discloses the siphuncle. At the smaller end of the specimen the siphuncle is almost in contact with the ventral wall of the phragmacone, but there is no downward flexure of the sutures along the median line of this ventral side indicating the close proximity of the siphuncle. At the upper end of the specimen that part of the outline of the siphuncle which is nearest the ventral wall of the phragmacone is not preserved, but an estimate, based on the curvature of that part of the transverse outline which remains, suggests that the upper end of the siphuncle is about 5 mm. from the ventral wall. In the absence of a vertical section, it is impossible to determine how far the septal funnels invaginate into the funnels next beneath.

Locality and Horizon. From the southern part of the North arm, Great Slave lake; in the Ordovician. Collected by George S. Hume, Geological Survey, Canada.

Remarks. The specimen of *Endoceras* here described probably is a new species, characterized by its rate of expansion and by the relatively low cameræ. The latter are more numerous than in *Endoceras angusticameratum* Hall. They apparently agree in relative number with those of *Endoceras duplicatum* Hall, but the type of the latter species is much compressed. Owing to our meagre knowledge of the siphuncle, it is regarded as inadvisable to make this specimen the type of a new species.

It is customary to differentiate *Endoceras* from *Cameroceras* chiefly on the basis of the structure of the siphuncle. Ruedemann[1] states the situation as follows.

In *Vaginoceras* the septal necks extend beyond the next preceding septum, and the number of endosiphosheaths is great.

In *Endoceras* the septal necks extend posteriorly only as far as the next septum, and the number of endosiphosheaths is smaller, and there is no internal lining within the siphuncle (endosipholining).

In *Cameroceras* the septal necks extend to the preceding septum, there is an endosipholining, and there is one large, thick, walled sheath only in connexion with the living chamber.

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[1] Ruedemann, R.: New York State Mus., Bull. 90, p. 412 (1906).

A study of the types of *Cameroceras trentonense* in connexion with specimens occurring in the United States National Museum suggests that the chief difference between *Endoceras* and *Cameroceras* consists in the character of the endocones. In *Endoceras* these are strictly cones, from their origin at the walls of the siphuncle to their pointed ends which terminate near the centre of the cross-section of the siphuncle at some more or less remote point beneath. In *Cameroceras*, on the contrary, that part of the structure which is comparable with the endocones of *Endoceras* is conical only at the base. Here, for a length corresponding to that of three to six segments of the siphuncle, the endocone is conical in form, but excentric in position, the pointed end terminating near or in contact with the ventral wall of the siphuncle. Above the conical portion of the endocone its walls appear to conform for a length of four or more cameræ with the shape of the siphuncle, this part having the form of a cylindrical body more or less conspicuously annulated in a diagonal direction. The conical part at the base is filled with a calcareous deposit, its upper part thinning, until, a short distance above the top of the conical portion, this deposit has thinned to the average thickness of the walls of the siphuncle. The structure is that of *Nanno.*

The genus *Endoceras* was described by Hall,[1] and no type was designated. The species described first under this generic designation is *Endoceras subcentrale* Hall. Plate XVII, figure 4, accompanying the original description of this species, is printed upside down, and only the middle half of the type specimen is included. The type specimen exposes an endocone, as in the figure; the septal necks have a length of two cameræ, invaginating into the funnels next beneath.

In Bassler's "Bibliographic Index of American Ordovician and Silurian Fossils, 1915", *Endoceras proteiforme* Hall is stated to be the accepted type. In Zittel-Eastman's "Text-book of Palaeontology," *Endoceras proteiforme* is figured, and under *Endoceras* it is stated that "Funnels reach from septum of origination to the next apicad, but no farther."

Hall, at the time of his original description of the genus *Endoceras*, had no clear conception of the variation in the distance to which the septal necks extended downward in different species of *Endoceras*. His attention was centred on the endocones, which he regarded as the characteristic feature of *Endoceras*. Therefore, he did not differentiate between forms whose septal necks extended downward only as far as the septum next beneath and those whose septal necks extended considerably farther. Nor did he differentiate between forms having numerous endocones and forms having only few. The writer has not seen any specimens with numerous endocones, such as those figured by Hyatt in Zittel-Eastman.

Endoceras proteiforme is figured by Hall on Plates 48, 49, 50, and 53, accompanying the original description. On Plate 48, figure 4 is described first, and this is regarded as the type of the species. In this type six cameræ occur in a length equal to the diameter of the conch, at the top of the series being counted.

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[1] Pal. of New York, vol. I, p. 58 (1847).

Endoceras duplicatum Hall has about ten cameræ in a length equal to the diameter of the conch. *Endoceras magniventrum* Hall has about eight cameræ in a corresponding length. *Endoceras angusticameratum* Hall has between seven and eight cameræ in this length. All of these species are of Trenton age.

Endoceras is known also from Silurian strata, in the area west of Hudson bay. From the Silurian at Limestone rapids, Severn river, Ontario, Prof. W. A. Parks described *Endoceras hudsonicum*, with at least eleven cameræ in a length equal to the diameter of the conch at the point under investigation. The siphuncle of this Severn River species, however, is relatively larger, and the septal necks do not extend down even as far as the septum next beneath. In a second specimen of *Endoceras*, found by Professors Savage and Tuyl in the Silurian of Severn river, the septal necks extend apicad for a distance of one and a half cameræ.

Whiteaves notes the presence of *Endoceras* or *Nanno* also in the Silurian on the portage road at the falls on Ekwan river, west of James bay.

Phragmoceras sp.

Plate XIV, figures 2A, B

The specimen consists of a cast of the interior of the living chamber, attached laterally to matrix retaining an impression of one side of this living chamber and of the immediately adjacent part of the phragmacone. For purposes of study, the cast of the interior of the living chamber was broken loose from the matrix.

Living chamber 22 mm. in height at the ventral margin of the dorsal lobe of the aperture; at mid-height the dorso-ventral diameter is 21 mm., and the lateral diameter is estimated at 20 mm. As far as may be determined from the specimen at hand, the aperture consists of a relatively large, approximately circular dorsal lobe, and of a narrow, approximately linear intermediate slit, terminating at its ventral end in a short, spout-like projection. The dorsal lobe appears to be 12 mm. wide and 12 mm. long in a dorso-ventral direction, with a tendency toward a lessening of its curvature along its dorsal outline and toward an increase of curvature along its dorso-lateral outlines. The narrow, linear part of the aperture was at least 10 mm. in length. The spout-like projection at the ventral end of the aperture is not preserved, but its former presence is suggested by the curvature of the adjacent parts of the shell. Along the dorsal margin of the dorsal lobe of the aperture the shell is erect as in *Phragmoceras*, not incurved as in *Gomphoceras*. Compared with the general horizontal plane passing parallel to the suture at the base of the living chamber, both the dorsal and the ventral sides of the living chamber slope moderrately but distinctly backward. The maximum lateral diameter of the chamber is at mid-height, and above this level the sides of the chamber contract so as to give its upper part a semi-globose aspect, at least toward its ventral side. For a distance of 2 mm. above the suture at the base of the living chamber, the cast of the interior of the latter is indented by the impression of the annular attachment ring, marked by vertical corrugations, of which eleven occur in a width of 10 mm.

So little of the surface of the exterior of the phragmacone is preserved that very little definite information is added to our knowledge of the conch. However, this little suggests that the conch was curved only slightly lengthwise, in a dorso-ventral plane, and its general aspect probably was erect.

Locality and Horizon. From North arm, Great Slave lake; in the Silurian, associated with *Pycnostylus guelphensis* and *Pycnostylus elegans.* Collected by George S. Hume, Geological Survey, Canada.

Remarks. The relatively erect position and slight curvature of the conch, if verified by future discoveries of better specimens, will readily discriminate this Great Slave Lake species from all others hitherto described from American strata. For determining its relationship to other species a much better knowledge of the margin of the aperture is needed.

Poterioceras (?) sp.

Plate XIV, figures 3A, B

Living chamber depressed dorso-ventrally; at its base the lateral diameter is 18 mm., and the dorso-ventral diameter is about 15 mm.; a short distance below the top of this chamber its width has increased to 21 mm., and its dorso-ventral diameter to about 19 mm. The height of the chamber, along its ventral side, is estimated at 20 mm. The living chamber is curved lengthwise, the radius of curvature on the convex, ventral side being 30 mm., and that on the concave, dorsal side equalling about 25 mm.

The suture of the septum at the base of the living chamber is straight. The septum at this point is rather strongly concave, especially in a dorso-ventral direction. The siphuncle is situated close to the ventral wall, its centre being about 1·5 mm. from the latter. The form of the segments of the siphuncle can not be determined definitely, but it appears to have been more or less nummuloidal rather than tubular.

The margin of the aperture is not distinctly defined. Along the median line of its ventral side, toward the margin of the aperture, the cast of the interior of the living chamber is strongly curved inward, suggesting an inward projecting dentate growth, a millimetre in length. It is not known whether this growth is characteristic of the species or represents only an aberrant feature confined to a single specimen.

Locality and Horizon. From North arm, Great Slave lake; in the Silurian, associated with *Pycnostylus guelphensis* and *Pycnostylus elegans.* Collected by George S. Hume, Geological Survey, Canada.

Remarks. This Great Slave Lake species is a Poterioceroid only in the sense that it is a conch strongly depressed in a dorso-ventral direction. There is no evidence of strong contraction of the living chamber toward the aperture. It belongs to a group of species, forming a distinct undescribed genus, well represented in the Racine dolomite of southeastern Wisconsin and adjacent Illinois, and also in the Hopkinton dolomite of northwestern Illinois and adjacent Iowa.

Rizoceras (?) sp.

Plate XIV, figures 4A, B

Living chamber short and tumid, with circular cross-sections. The width of the chamber at its base is 18 mm.; 8 mm. farther up its width is 22 mm.; above this level the width diminishes until a point 15 mm. above the base is reached, beyond which the shell is not preserved.

At mid-height the chamber is crossed by a relatively strong, transverse line of growth, which curves downward along the median line of the ventral side so as to form a very shallow angle with sides diverging at 160 degrees. This angle evidently locates the position of the hyponomic sinus at some earlier stage of growth of the conch. Directly beneath this downward curvature of the transverse growth line, a single segment of the siphuncle projects from beneath the base of the living chamber, a short distance from its ventral margin. This segment is poorly preserved, but appears to have been nummuloidal. Considering the size of the living chamber, the septum at its base is rather strongly concave.

Locality and Horizon. From North arm, Great Slave lake; in the Silurian, associated with *Pycnostylus guelphensis* and *Pycnostylus elegans*. Collected by George S. Hume, Geological Survey, Canada.

Remarks. Living chambers similar to the Great Slave Lake specimen here described occur in the Racine of southeastern Wisconsin and of the adjacent parts of Illinois.

At an elevation of 13 to 16 mm. above the suture at the base of the living chamber of the Great Slave Lake specimen, along the median line of its ventral side, there appears to be a slight outward curvature of the shell. Should this be verified by future discoveries of better specimens, it would not agree with Rizoceroid structure; but, as far as can be determined from the single specimen at hand, its general structure is Rizoceroid, rather than Gomphoceroid. In a Poterioceroid shell, the living chamber should be depressed dorso-ventrally, and should be more elongate and more contracted toward the aperture.

Orthoceras sp.

Plate XIV, figures 5A, B

Conch orthoconic, depressed slightly dorso-ventrally. At the smaller end of the specimen the lateral diameter is 8 mm. and the dorso-ventral one is 7 mm.; at the larger end the lateral diameter is 10 mm. and the dorso-ventral is 9 mm. The entire length of the fragment is only 11 mm., and in this length there are seven cameræ.

The sutures of the septa curve slightly downward along the ventral and dorsal sides of the phragmacone, resulting in very shallow ventral and dorsal lobes and in very low ventral saddles. The curvature of the septa has a radius of about 10 mm. both laterally and dorso-ventrally, indicating that the dorso-ventral depression of the conch is not due to compression of the conch. The siphuncle is located along the dorso-ventral diameter, about one-sixth of the diameter of the shell in this direction from the ventral wall. It is narrowly cylindrical, and at the top of the specimen its diameter slightly exceeds half a millimetre.

Locality and Horizon. From the southern part of the North arm, Great Slave lake, in a cherty fragment of rock of Ordovician age. Collected by George S. Hume, Geological Survey, Canada.

Remarks. Distinctly depressed orthocones, with shallow ventral and dorsal lobes, are known from various horizons and localities. Until their internal structure has been studied it is not safe to assume that they are cogeneric.

In *Orthoceras ekwanense* Whiteaves, from the Silurian, Portage road, Ekwan river, west of James bay, a similar disposition of saddles and lobes is noted.

The Great Slave Lake specimen here described is distinguished by the close proximity of the siphuncle to the ventral wall of the conch; apparently this siphuncle was of small size, judging from the size of its passage through the septa.

Trocholites sp.

Plate XIV, figures 6A, B, C

Specimen consisting of three-fourths of a volution of some strongly curved conch, apparently nautiloid in structure. An open space, 4·5 mm. in diameter, partly enclosed by that part of the volution which remains, evidently was occupied originally by the apical part of the conch. To what extent this central space was filled is not known, but the cross-section of the fragment is circular, and there is no evidence of an impressed zone along the dorsal margin of the whorl. Apparently the rate of curvature of this fragment of the conch is such that later growths could not have continued without interference by the more apicad parts of the shell. If such interference actually took place the later formed whorls may have had an impressed zone as in *Trocholites*, but no evidence of such a structure is at hand. The chief reason for assigning this fragment to the Trocholitidae rather than to the Tarphyceratidae is on account of its circular cross-section, there being no evidence of lateral compression as in the latter family.

The specimen consists of three parts. At the smaller end, a cast of the interior exposes a little over three cameræ. Adjoining this is an equal length in which the phragmacone retains the surface features of the shell. The remainder consists of a cast of the exterior of the specimen, also retaining the surface ornamentation of the latter. All of the cross-sections are circular.

The septa are distinctly concave in a dorso-ventral direction, but are only slightly concave in a lateral direction. The radius of curvature in a dorso-ventral direction is estimated at 3 mm., that in a lateral direction is about 15 mm. This results in distinct dorsal and ventral saddles and lateral lobes. The siphuncle is located slightly less than one-fourth of the dorso-ventral diameter of the phragmacone from the ventral wall. It is relatively small and tubular. Where the dorso-ventral diameter of the phragmacone is 3 mm., the diameter of the siphuncle appears to be scarcely one-fifth of a millimetre. About eight cameræ occupy a length of 7 mm., at the apical end of the species.

The strongly ventrad location of the siphuncle would oppose the reference of this specimen to *Trocholites* were it not for the fact that in the Trocholitidae the siphuncle starts ventrad of the centre, but becomes dorsad of the centre in later stages of growth. Since the fragment may represent only an early stage of growth it is possible that at later stages the siphuncle may have shifted toward the dorsal side of the conch.

In a similar manner, the absence of an impressed zone is unfavourable to the reference of this specimen to the Trocholitidae, but this impressed zone may have developed later.

The surface of the conch is striated transversely with sharply defined raised lines which are farther apart on the ventral side of the conch. It is estimated that about six striæ occur in a length of 2 mm., where the diameter of the conch is 5 mm. On the ventral side of the whorl these transverse striæ curve backward so as to locate former successive positions of the hyponomic sinus. The sides of the latter diverge at 152 degrees from each other. On the dorsal side of the whorl the striæ are strictly transverse.

Locality and Horizon. From the southern part of the North arm, Great Slave lake; in the same chert fragment as that containing the depressed *Orthoceras* described in the preceding lines. Collected by George S. Hume, Geological Survey, Canada.

Remarks. The possibility of future identification of this small fragment with larger specimens rests chiefly on the curvature of the septa and the surface ornamentation of the shell. If a more mature specimen could be secured the generic position of this species probably could be determined readily. Its reference to *Trocholites*, in our present meagre knowledge of the species, is merely tentative.

A NEW SPECIES OF THESPESIUS FROM THE LANCE FORMATION OF SASKATCHEWAN

By C. M. Sternberg

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Illustrations

INTRODUCTION

During the season of 1921 the writer made a collection of dinosaurian and other vertebrate remains from the bad lands on the southern face of Wood Mountain plateau, southern Saskatchewan. The beds from which these remains were collected have been referred to the Lance formation largely on the evidence of their vertebrate fossils.[1]

The most important specimen in this collection represents an undescribed species of a hadrosaurian dinosaur. Although dinosaurian remains were reported from these beds, by Dr. G. M. Dawson, as early as 1875, this is the first specimen found in Saskatchewan of which a considerable part of the skeleton is preserved. It was discovered by the writer on a tributary of Rocky creek in section 22, township 1, range 5, west of the third principal meridian, in an argillaceous sand 55 feet below the lowermost coal seam, which is about the middle of the Lance formation as here exposed.

The writer is greatly indebted to Mr. C. W. Gilmore, Curator of Vertebrate Palæontology in the United States National Museum, Washington, D.C., for very helpful criticism of this paper.

DISCUSSION OF THESPESIUS AND OTHER RELATED GENERA (OF THE HADROSAURIDAE)

The genus and species *Trachodon mirabilis*,[2] founded on teeth and tooth fragments from the Judith River formation of Montana, was the first member of the *Hadrosauridae* to be described. Since that time the generic name *Trachodon* has been used by different writers for the reception of all

[1] Sternberg, C. M.: "Notes on the Lance Formation of Southern Saskatchewan"; Can. Field Nat., vol. XXXVIII, pp. 66–70 (April, 1924).

[2] Proc. Acad. Nat. Sci., Phila., vol. VIII, p. 72 (1856).

the species of hadrosaurian dinosaurs from the Lance formation as well as from the Judith River. This is partly due to the fact that some of the early palæontologists believed the Judith River and the Lance formations to be of the same age, and partly because of the difficulty of distinguishing genera by the teeth alone.

In 1902 J. B. Hatcher published an article[1] entitled "The Genera and Species of the Trachodontidae (Hadrosauridae, Claosauridae) Marsh", in which he says . . . .

"A careful examination of the original descriptions and figures of the types of the ten genera and twenty species (of the Hadrosauridae) enumerated above, shows that there should be a great reduction in each and that the ten genera which have been proposed should be reduced to two, *Trachodon* Leidy and *Claosaurus* Marsh, while the remaining eight genera should be treated as synonyms of *Trachodon* which should also be made to include *T.* (*Claosaurus*) *annectens* Marsh; while the smaller *Claosaurus agilis* described by Marsh from the Kansas chalk may still be considered as pertaining to a distinct genus."

That Hatcher was correct in referring *annectens* to a genus other than *Claosaurus* is evident when it is compared with Marsh's *Claosaurus agilis* and this conclusion has been generally accepted by later writers. That he was correct in assigning all the other species to *Trachodon* is not so apparent.

It is pointed out by Gilmore[2] and Lambe[3] that the type material on which the genus and species *T. annectens* are based is inadequate, and that it is not possible to identify with it better and subsequently discovered specimens. Hatcher[4], at a later date, in discussing the *Hadrosauridae*, says, "It is scarcely possible to identify the various species of this genus or the genera of the family from the teeth alone."

In more recent years Lambe, Brown, Parks, and Gilmore have described no less than nine genera and fifteen species of hadrosaurian dinosaurs from the Belly River and Edmonton formations of Alberta, based on adequate material, but in no case has a single genus been described from both of these formations, which are closer in time than the Judith River and Lance. Among the hadrosaurian caudal vertebræ, from the Belly River formation, in the collections of the Geological Survey at Ottawa, there is not one in which the anterior face of the centrum is convex; a character common to certain Lance forms. In six years collecting from the Belly River formation the writer has not seen a single specimen of hadrosaur that could be referred to any of the Lance species. These facts, coupled with the differences found in the teeth of *Trachodon mirabilis* as contrasted with those of the species found in more recent formations, seem to be ample reasons, as suggested by Gilmore[5] and Lambe[5], for restricting the use of the name *Trachodon* to a Judith River species.

The first species, and the only genus of a hadrosaurian dinosaur to be described from the Lance formation, was *Thespesius occidentalis*[6] founded by Leidy, in December, 1856, upon two caudal vertebræ and a proximal phalanx of the hind foot.

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[1] Ann. Carnegie Mus., vol. I, pp. 377-385 (1902).
[2] Sci., New Ser., vol. XLI, pp. 658-660 (1915).
[3] Ottawa Nat., vol. XXXI, pp. 135-139 (Feb., 1918).
[4] U.S. Geol. Surv., Bull. No. 257, p. 97 (1915).
[5] Loc. cit.
[6] Proc. Acad. Nat. Sci., Phil., vol. VIII, pp. 303-304.

In 1900 Lucas called attention to the identity of the types of *Thespesius occidentalis* Leidy and *Claosaurus annectens*[1] Marsh. In 1915 Gilmore published a short article[2] in which he says, in part:

"I have recently compared the types, *Thespesius occidentalis* Leidy and *Claosaurus annectens* Marsh, and can testify to the close similarity of the homologous bones. The inadequacy of the type material upon which *Thespesius* is based (two caudal vertebræ and a proximal phalanx) is fully recognized, but that these pertain to a Trachodont dinosaur there can be no doubt. It is now positively known from the geological mapping done in recent years in the locality where the type material was obtained, that the specimen came from the Lance formation on Grand river in what is now the state of South Dakota. . . While it can not be positively determined that *occidentalis* and *annectens* are identical it is equally true that they can not be shown to represent distinct species. . . I would, therefore, endorse the use of *Thespesius occidentalis* as proposed by Lucas."

A comparison of anterior caudal centra of the type of *Thespesius saskatchewanensis* n. sp., with those of the type of *Thespesius occidentalis* as figured and described by Leidy,[3] shows no generic distinction.

As pointed out by Gilmore the type material on which *Thespesius occidentalis* is based is inadequate, but as *Thespesius* is the only generic name ever established on a hadrosaurian dinosaur collected from the Lance formation, and as the present specimen shows no generic distinction from the type of the genus, it is considered advisable to refer the Saskatchewan specimen to that genus while awaiting a thorough revision of the *Hadrosauridae.*

DESCRIPTION OF SPECIES

Thespesius saskatchewanensis n. sp.

Type, Cat. No. 8509, Geological Survey, Canada, consists of skull, almost complete; sixteen dorsal vertebræ; thirty-seven caudal centra, fragmentary chevrons, left scapula and coracoid, left femur and part of the right, right tibia with astragalus and calcanium, both ischia and some fragmentary ribs. With the exception of the skull all the bones were disarticulated.

Locality and Horizon. Rocky creek, Saskatchewan; Lance formation, uppermost Cretaceous. Collected by C. M. Sternberg.

The caudal centrum, Cat. No. 8509, Geol. Surv., Canada, Plate XVII, figures 2 and 3, which has been chosen for comparison with Leidy's type of *T. occidentalis*, of those present, most nearly resembles the one figured by Leidy and judging from the stage of development of the lateral processes and chevron facets, is thought to be the sixth of the caudal series. Viewed from the front it is roughly circular in outline with a transverse diameter of 110 mm. and a vertical diameter of 105 mm. taken at the centre of the face. It is 63 mm. in length. The anterior face is slightly convex and the posterior face is concave to the extent of 13 mm. Just below the centre, on the anterior face, is a well-marked circular convexity 40 mm. in diameter. In the vertebræ immediately succeeding the sixth caudal the posterior faces are more deeply concave and the anterior faces are less convex.

[1] Sci., New Ser., vol. XII, pp. 809–810 (1900).
[2] Sci., New. Ser., vol. XLI, pp. 658-660 (1915).
[3] Trans. Am. Phil. Soc., vol. XI, Pl. 10, figs. 1-3 (1860).

The transverse processes spring from the junction of the centrum and the neural arch, and, viewed from the front, stand at almost right angles to the centrum, with a slight inclination backwards.

The lateral and inferior faces are concave and there are two well-marked foramina side by side on the inferior surface. On the inferior surfaces of the succeeding caudals, except the more distal ones, are two or three well-marked foraminæ always in a transverse line.

The sixth caudal of *T. saskatchewanensis* differs from the type of *T. occidentalis* in being proportionately broader, less concave inferiorly, and in having the inferior foramina in a transverse line.

It cannot be stated with certainty that this centrum occupies the same position in the series as the one figured by Leidy as the type of *T. occidentalis*, but in none of the caudal centra of specimen No. 8509 is the anterior face higher than wide, as it is shown to be in Leidy's type.

Though it is fully recognized that these are minor differences it is also true that one would not expect great variation, in this region, within the genus. Since Lucas has identified *T. occidentalis* and *T. (Claosaurus) annectens* as pertaining to the same species and Gilmore has shown that they can not be positively separated, it would seem unwise to refer the Saskatchewan specimen, which is clearly distinct from *T. annectens*, to *occidentalis*. The name *saskatchewanensis* is accordingly proposed for its reception.

In 1890, Marsh described the right dentary of a hadrosaur under the name *Trachodon longiceps*[1]. The specimen was collected from the Lance formation in Niobrara county, Wyoming, and is described as being 3½ feet long. The edentulous portion is 1½ feet long; the alveolar border is the same length; and there are grooves for fifty-one vertical rows of teeth. The great difference in size, proportionate length of edentulous portion to length of alveolar border, and the difference in the number of vertical rows of teeth of *T. longiceps*, when compared with *T. saskatchewanensis*, make it clear that these two cannot be referred to the same species, if indeed they belong to the same genus.

Some of the outstanding features in which *Thespesius saskatchewanensis* differs from *T. annectens* are: skull proportionately higher; quadrate longer when compared with the total length of skull; beak broader; enamel faces of dentary teeth longer; frontal contributing less to the formation of the orbit; and scapula longer and straighter.

Gilmore recently described a specimen from the Edmonton formation under the name of *Thespesius edmontoni*[2]. Though the skull of the type of *T. edmontoni* is not so well preserved as the Saskatchewan specimen and lacks such details as shape and size of teeth and number of tooth rows, it shows sufficient differences to preclude the possibility of the two specimens belonging to the same species. When compared with the skull of *T. edmontoni* the skull of *T. saskatchewanensis* shows distinct differences, of which the outstanding are: skull higher and quadrate longer when compared with the length of the skull; beak broader; frontals contributing less to the formation of the orbit; orbit less triangular in outline, and jugal more slender.

[1] Am. Jour. Sci. and Arts, vol. XXXIX, p. 422.
[2] Geol. Surv., Canada, Bull 38, pp. 13-28 (1924).

Thespesius saskatchewanensis falls within the subfamily *Hadrosaurinae* as defined by Lambe [1] e.g. . . . .

"Forms large, posterior part of skull variable, supraorbital region flat, fronto-parietal region enlarged, nasals extending far forward, anterior nares transversely confluent, nasal passage, anteriorly, not enclosed in bone, premaxillæ confined to anterior portion, lachrymal of moderate size, ischium pointed distally."

Generic Characters

Skull long, narrow posteriorly. Anterior expansion of premaxilla recurved so as to roof over a cavity of moderate size. Nasal extending in advance of anterior border of narial opening, frontal relatively long and contributing to formation of orbital rim, lateral temporal fossa high and moderately narrow. Mandible long and slender, anterior caudal vertebræ concavo-convex. Femur considerably longer than tibia.

Specific Characters

Skull high posteriorly. Premaxillæ broadly expanded anteriorly, antero-inferiorly thickened and marked with tooth-like projections. Jugal long and slender. Quadrate long. Frontal contribution to orbital rim slight. Fifty-two vertical rows of teeth in maxilla and forty-four rows in dentary. Maxillary teeth with bluntly rounded apices and median keel very high in basal portion, edges slightly raised and sparsely studded with papillæ. Dentary teeth with bluntly pointed apices and smooth borders, except for very slight papillations on the anterior ones. Enamel faces of dentary teeth slightly more than twice as long as wide, scapula long and moderately straight.

Skull. The left side of the skull is best preserved, all the bones being articulated except the predentary, which is missing. The bone is in a splendid state of preservation and the sutures can be clearly distinguished. Viewed from the side the skull is subtriangular in outline, high posteriorly, but gradually decreasing in height anteriorly. The length of the quadrate is to the total length of the skull as 1 over 2·33, whereas in *T. edmontoni* the proportion is as 1 over 2·75 and in *T. annectens* it is as 1 over 2·90.

Viewed from above the skull is broad in its posterior half, has its greatest expansion through the distal ends of the quadrates, is greatly constricted in advance of the jugals, and is broadly rounded in front.

The nasal orifice is a large, well-defined, oval-shaped cavity, as in other members of the genus. It lies mainly within the premaxilla, but is bounded superiorly and supero-laterally by the nasal, the anterior portion of which flanks the upper limb of the premaxilla.

The *orbit* is large and subcircular in outline, it is bounded above by the prefrontal, frontal, and postorbital; behind by the postorbital and ascending process of the jugal; below by the jugal and in front by the jugal, lachrymal, and prefrontal. The post-orbital has expanded so far forward as to almost exclude the frontal from the orbital rim.

The *infratemporal fossa* is proportionately longer than in other members of the genus, due to the excavation of the jugal. It is bounded above by the postorbital and squamosal; behind by the squamosal, quadrate, and jugal; below by the jugal, and in front by the jugal and postorbital.

[1] Lambe, L. M.: Geol. Surv., Canada, Mem. 120, p. 68 (1920).

The *supratemporal fossa* is the same as in *T. annectens*, except that the parietal forms a greater part of the anterior border than it does in that species.

The *premaxilla* resembles that element in *T. annectens*, though the anterior expansion is considerably greater. It is not, however, so greatly expanded as in *Edmontosaurus regalis*[1] or the Lance form figured by Cope as *Diclonius mirabilis*[2]. The antero-inferior extremity of the premaxilla is notched so as to leave five, well-marked, tooth-like projections. On the inferior surface, slightly behind these, is another series of less prominent but well-marked projections. The superior border of the anterior expansion of the premaxilla is recurved for a short distance so as to roof over a cavity of moderate size which opens backward. The floor of this cavity is smooth and the inner half is in the form of a depressed tract, separated from a sub-nasal depression by a broad buttress of bone which continues downward and outward from the upper limb of the premaxilla. The buttress gives considerable strength to the otherwise very thin bone. Penetrating the buttress and connecting the two depressions is a large, oval foramen, a cross-section of which is 20 mm. in its greatest diameter. This foramen is 50 mm. in length and is continued forward, into the anterior depressed tract, as a well-marked excavation which divides into three branches. The antero-inferior border of the foramen is pierced by an elliptical foramen 35 mm. in length, which opens into the mouth. The backward prolongation of the lower limb of the premaxilla reaches and overlaps the lachrymal, terminating opposite the midlength of that bone. The upper limb reaches beyond the midlength of the nasal aperture and is flanked by the anterior portion of the nasal for nearly one-half the length of the latter. The sub-nasal depression is the lower part of a well-defined area of which the nasal aperture is the centre. This was doubtless for the lodgment of the nasal gland.

The *nasal* and *prefrontal* resemble those elements in *T. annectens* in form, proportion, and position, except that the prefrontal does not extend downward in advance of the orbit, quite so far as shown by Marsh.[3] The inferior surface of the prefrontal is excavated so as to form a small pocket or recess at the supero-anterior border of the orbit. A similar pocket is present in the prefrontal of *T. edmontoni* and apparently also in *T. annectens*.

The *lachrymal* is a moderately sized, irregularly shaped, flattened bone, that is wedged in between the prefrontal, nasal, premaxilla, and jugal, and infero-internally meets the palatine. The posterior border is free and makes up the central one-third of the anterior border of the orbital rim. The bone is not pierced by a lachrymal canal as in *Edmontosaurus regalis* and *Gryposaurus notabilis*, though there is a slight excavation on the internal face which probably lodged the naso-lachrymal duct.

The *frontal* region is large and flat except for a slight concavity on either side of the midline in the anterior portion, the greater part of the top of the head, between the orbits, being composed of these bones. They resemble those bones in *T. annectens*, but are longer in proportion to their breadth than in any other known genus of the *Hadrosauridae*. Postero-laterally the frontal forms the antero-lateral border of the supratemporal fossa and externally, toward the front, it extends outward between the

[1] Loc. cit., figures 3 and 4.
[2] Proc. Acad. Nat. Sci., Phila., vol. XXXV (1883).
[3] Marsh, O. C.: "Dinosaurs of North America", Washington, 1896, Pl. LXXII.

postorbital and prefrontal and contributes to the formation of the orbital rim, but not to as great an extent as in the case of *T. annectens* or *T. edmontoni*. Posteriorly the frontals meet the anterior border of the coalesced parietals, to the full extent of their breadth, with a digitating suture.

The *postorbital* is a triradiate bone with a stout anterior process which unites internally with the frontal; a long, thin, posterior bar which overlaps the anterior process from the squamosal; and a descending process which meets the ascending postorbital process of the jugal. The descending process is quite large in the superior three-fifths of its length; then it suddenly diminishes and continues as a small, thin bar which is overlapped antero-internally by the long, slender, ascending process of the jugal. The postorbital resembles that bone in *Edmontosaurus regalis* in that it develops a well-defined fold or pocket subsidiary to the orbital cavity. This pocket differs from that of the above-mentioned species in being smaller, situated at a lower level, and in having different proportions. The greatest diameter is supero-inferior, being almost three times the transverse diameter. Marsh makes no mention of such a pocket in the postorbital of *T. annectens*, but his illustration suggests the presence of a similar one.

The *parietals* are thoroughly fused and resemble those of *T. annectens*, except that they have a greater expansion anteriorly and form a considerable part of the anterior border of the supratemporal fossa.

The *squamosal* resembles that element in *T. annectens*, and, as in that species, sends a process forward which with the posterior process of the postorbital forms the supratemporal arcade.

The *quadrate* is a long, vertically placed, transversely compressed bone. From its inner surface a large, thin flange is directed inward and forward for attachment with the pterygoid. When viewed from the side, in the articulated skull, it appears to be straighter than that element in *T. annectens*, this being largely due to the fact that in the upper portion the anterior face is less convex and the posterior face less concave. Just below the midlength on the antero-external surface is a prominent excavation for the reception of the quadratojugal. This is more strongly defined than in the above-mentioned species, due to the greater size of the quadratojugal. The inferior condyle might be said to be made up of two articulating surfaces, a large, strongly convex, lower surface which articulates with the surangular and a small, flattish, inner surface which faces downward, inward, and somewhat backward and articulates with the articular. This surface is at a higher level than the main condyle.

The *quadratojugal* is a thin discoid bone of considerable size. It runs to a very thin edge anteriorly where it is overlapped, to about one-half its extent, by the jugal, but is thicker on its posterior margin where it overlaps the emarginated, antero-external border of the quadrate. It separates the jugal and quadrate, except for a slight contact between these bones at the extreme postero-superior tip of the jugal.

The *jugal* is of the general hadrosaurian shape, but is long and slender. Its length is more than four times its greatest breadth, whereas in *T. annectens* the length is slightly more than three times the greatest breadth. Posteriorly it is particularly slender and unites with the jugal in its supero-posterior extremity. This slenderness of the posterior portion is due to the great excavation of its upper surface which also increases the length of the infratemporal fossa.

The postorbital process is long and slender and in its upper portion overlaps, anteriorly, the inner border of the descending postorbital process. That is, it is internal to the postorbital pocket, thus making it within the orbit and well removed from the exterior of the skull. Anteriorly the jugal sends a process forward which wedges in between the lachrymal and maxilla and comes in contact with the posterior portion of the lower limb of the premaxilla. Antero-superiorly a small, tongue-like process extends upward, and fits into a groove on the infero-external surface of the lachrymal, thus giving great strength to this union, and internal to this contact it unites with the anterior border of the palatine.

The exact shape of the *foramen magnum* can not be determined, due to its distortion by lateral crushing. It is bounded below by the basioccipital; laterally, and apparently superiorly, by the exoccipitals. Viewing the skull from behind, the foramen magnum is set deeply in the occiput with the exoccipitals extending upward and backward, thus making a large overhang much as in *Edmontosaurus*.

The *occipital condyle* is roughly U-shaped, the sides being formed by the exoccipitals and the base by the robust basioccipital. These elements are well preserved and the sutures separating them are clearly distinct.

The *basioccipital* is a thick bone and is in contact superiorly with the exoccipitals and anteriorly with the basisphenoid. It forms the base of the occipital condyle, contributing more than one-half of its articulating face. Inferiorly it is very rugose. Superiorly it is encroached upon by the exoccipitals, contributing only slightly to the floor of the brain cavity.

The *exoccipitals* bound the foramen magnum laterally and superiorly and contribute to the formation of the occipital condyle. There is no indication of the supraoccipital separating the exoccipitals at the superior border of the foramen magnum, but apparently the exoccipitals unite and form the whole of the superior border of the opening and roof over the occipital region. On the inferior surface of this roof, at the midline, is a ridge which possibly represents the co-ossified union of the exoccipitals. On the superior surface of the united exoccipitals is a thick, broad, ridge of bone which has the appearance of a separate ossification. This probably represents the supraoccipital. This is much the condition found in the hadrosaurian cranium figured by Brown, from the Edmonton formation.[1]

The suture between the exoccipital and *opisthotic* is not discernible and the one between the exoccipital and *alisphenoid* is only faintly indicated. There is no indication as to the limits of the *epiotic* or *prootic*. The suture between the alisphenoid and basisphenoid is well shown, and proves, as in *Lambeosaurus lambei* (*Stephanosaurus marginatus*)[2] that the flange above and slightly behind the basisphenoid process is a part of the basisphenoid.

The cranial foramina are well shown on the right side of the brain case. They closely resemble, both in form and position, those of the brain case of the hadrosaur from the Edmonton formation figured by Brown[3]. The only difference of note being, that the exit for the seventh nerve is not divided by a transverse bridge of bone, but the lower division passes downward, on the side of the brain case in a shallow, open channel, and the foramina are not located at the bottom of well-marked depressions.

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[1] Brown, B.: "Anchiceratops; a New Genus and Species of Horned Dinosaur from the Edmonton Cretaceous of Alta."; Am. Mus. of Nat. Hist., Ext. Bull., vol. XXXIII, p. 545 (1914).

[2] Geol. Surv., Canada, Mem. 120, p. 76.

[3] Loc. cit.

As in Brown's specimen, the ophthalmic branch of the fifth nerve runs downward in a large, open channel. Posteriorly this channel is overhung by a flange of considerable size. Below and behind the flange of the basisphenoid is a large, elliptical foramen for the lower entrance of the internal carotid artery. The foramen for the passage of the jugular vein does not pierce the external surface of the brain case as in *Edmontosaurus*, but runs from the internal surface of the brain case into the foramen lacerum posterus. The exits for the first, second, third, and fourth nerves are as in *Edmontosaurus*.

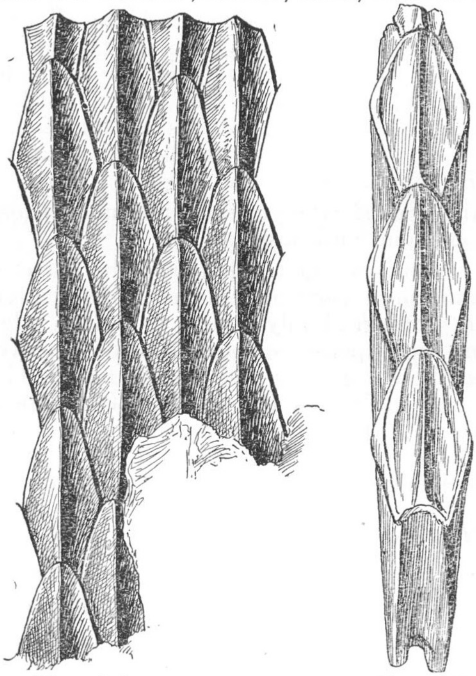

Figure 3 A. Figure 3 B.

Enamel face of dentary teeth. 3 A: T. *Saskatchewanensis*. Type. Taken from the twenty-first to twenty-fourth vertical series. Natural size. 3 B: T *annectens* (Marsh). After Marsh. Natural size.

The *palatine*, *pterygoid*, and *ectopterygoid* closely resemble those elements in *E. regalis*. Just below the notch which forms the posterior border of the posterior nares, the anterior border of the palatine is overlapped by the interno-inferior point of the lachrymal.

The *vomer* is not present.

The *maxilla* resembles that element in *T. annectens*. There are fifty-two vertical rows of teeth in the maxilla and the general arrangement and replacement are as in other members of the *Hadrosauridae*. The enamel face is moderately long and slender with bluntly rounded apex, thus differing from the diamond-shaped dentary teeth. The median keel is very high in the upper or basal portion, but decreases in height as it proceeds downward and practically disappears at the apex. The lateral faces are transversely concave and the edges are slightly raised and sparsely studded with papillæ. There is a faint, longitudinal striation near the tip. There were two teeth, of the same series, in the triturating face at the same time. As the replacement is from the inner, not the enamel, side, both teeth in the cutting surface have an enamel face; whereas in the dentary the replacement is from the enamel side, so that the enamel face of one tooth must be worn away before the apex of its successor comes into use.

On the superior surface of the maxilla, below the extreme anterior tip of the jugal, is a single, large foramen.

The *mandible* of *T. saskatchewanensis* contains all the elements common to the hadrosaurian jaw, all of which, except the predentary, are well preserved and articulated on the left side.

The *dentary* is long and moderately massive, being more robust than that element in *T. annectens*. The edentulous portion constitutes about three-eighths of its length and is more strongly decurved than in *T.*

annectens or *T. edmontoni*. The dental magazine, which occupies one-half the total length, contains forty-four vertical rows of teeth.

Except at the ends of the series there are three teeth in the triturating surface showing progressive stages of wear, e.g., one enamel-bearing crown, one partly worn stub, and one root. In some cases there is a tip of a third root. The teeth are largest at the midlength of the magazine and decrease in size toward either end, but the proportionate width is about the same. The enamel face of the dentary teeth is diamond shaped and proportionately intermediate between *E. regalis* and *T. annectens*, the length being slightly more than twice the width. The apex is bluntly pointed and the median keel is high, has a broad base, and runs the entire length with very slight difference in elevation from end to end (Figure 3 A). The lateral borders are thickened, thus giving raised edges and somewhat concave lateral faces. This is best shown in the lower part of the larger teeth. The lateral borders are smooth except for slight papillations on the anterior teeth.

The *surangular*, *angular*, and *prearticular* closely resemble those elements in *E. regalis* in form, proportion, and position.

The *articular* is a small bone which is wedged in between the postero-superior parts of the surangular and thin, vertically placed, prearticular. It is broadest anteriorly and from here gradually tapers to a thin edge at the posterior extremity. From the superior surface it thins rapidly, inferiorly, as it wedges in between the surangular and prearticular. The anterior half of the antero-superior surface is flat or slightly cupped, thus forming the small contribution of the articular to the mandibular cotylus. This articular surface faces outward and upward, this being due to the internal edge of the bone being at a higher level than the outer.

Comparative Measurements of Skull

—	*T. saskatchewanensis*	*T. edmontoni*[1]	*T. annectens*[1]
	Mm.	Mm.	Mm.
Total length of skull	786	938	1,100
Length of quadrate	337	340	380
Greatest breadth of premaxillæ	226	....	....
Greatest length of premaxillæ	453	....	....
Length in front of teeth	300	310	420
Length of nasal	442	....	....
Length of frontal (external surface)	150	....	....
Breadth of frontals (between orbits)	170	....	....
Greatest height of orbit (diagonal)	193	....	....
Greatest breadth of orbit (superior)	156	....	....
Length of supratemporal fossa	112	....	....
Breadth of supratemporal fossa	42	....	....
Height of infratemporal fossa	256	....	....
Breadth of infratemporal fossa (midheight)	57	....	....
Length of jugal	290	....	....
Length of maxilla	365	....	....
Length of dentition of maxilla	260	320	350
Length of dentary	545	570	820
Length of mandible, exclusive of predentary	670	....	....
Greatest height of dentary, including teeth	133	126	190
Length of dentary magazine	275	300	350
Length of edentulous portion of dentary	220	....	....

[1] Measurements taken from Gilmore, C. W.: Geol. Surv., Canada, Bull. 38 (1924).

Vertebræ. None of the cervical vertebræ are preserved.

There are sixteen dorsal vertebræ present, though the anterior one is in a poor state of preservation and the first two and the last three lack the neural spines (Plate XVII, figure 1). These are thought to represent numbers one to seven and ten to eighteen, respectively. A comparison of these vertebræ with the type of *T. edmontoni* points to the probability of there being twenty dorsals in the complete series of *T. saskatchewanensis*, as in *T. edmontoni*, rather than eighteen as given by Marsh for *T. annectens*.

The anterior dorsals are strongly opisthocoelous, but proceeding backward the posterior face becomes less concave and the anterior face less convex, until in the last three the anterior faces are nearly flat. The sides are concave antero-posteriorly and ventrally a longitudinal ridge connects the two ends. Proceeding backwards the centra increase in height and breadth, but there is very little change in the length from the second to the end of the series, as preserved, except that the posterior ones are inclined to shorten.

The neural spines are incomplete in some cases, but appear to increase in length from the front backwards. Their fore and aft breadth increases to the eleventh, from which point they gradually decrease as far back as they are preserved. They stand nearly erect. In the neural spines, of the median dorsals, the posterior edge is convex, thus making the fore and aft breadth greatest below the top of the spine. This posterior convexity reaches its maximum development in the eleventh dorsal. In these spines the anterior face is slightly concave. Measuring from the top of the lateral process the neural spine of the third dorsal is 115 mm. high and 60 mm. in fore and aft breadth, the eleventh is 133 mm. high and 88 mm. in greatest breadth, and the fifteenth is 155 mm. high and 55 mm. broad at midheight.

The transverse processes are long and heavy and are inclined strongly upward in the anterior vertebræ, but stand more nearly at right angles to the erect neural spine in the posterior ones. They are inclined backward to a greater degree than the neural spines, especially in the anterior vertebræ. The parapophysis is at the base of the neural arch in advance of the midlength, in the anterior dorsals, but proceeding backwards it works up the side of the transverse process until in the fifteenth it is midway between the base of the arch and the end of the transverse process.

The *caudal* series is represented by thirty-seven vertebræ, all but one of which lack the neural spines. Most of them were washed out of the bank, so it is impossible to positively place them in the series, but it is thought that not more than two of the anterior ones are missing. The first two of the series do not show facets for the attachment of chevrons and the third has poorly developed facets; from the fourth back the facets are well developed. Twenty-five of these are thought to represent the anterior portion of the tail; the other twelve constitute a continuous series from near the extremity.

In the anterior caudals the anterior face is slightly convex and the posterior face is concave, whereas in the posterior ones both faces are flat (*See* Plate XVII, figures 2 and 3). The centrum of the most anterior caudal is nearly twice as broad as long and the anterior and posterior faces are circular in cross-section, with a very slight flattening above and below. The centrum of the most posterior vertebra preserved is as broad as long and the anterior and posterior faces are roughly quadrate, with the breadth greater than the height. The intervening vertebræ grade from the one type to the other. Laterally and inferiorly they are concave fore and aft.

The anterior caudals bear moderately stout transverse processes, but these diminish rapidly as they proceed backward. They spring from the supero-lateral borders of the centrum and the base of the neural arch.

The *scapula* is longer, straighter, and more slender than that element in *T. annectens* or *T. edmontoni*, the greatest breadth being 160 mm. and the greatest length 850 mm.

The coracoid resembles that element in *T. annectens*, but is proportionately smaller. Part of it is broken away, so it is not possible to give details of the coracoid foramen, but it seems to have been surrounded by bone rather than an open notch.

The *ischium* is long and slender and closely resembles that element in *T. annectens*. Though the distal extremity is not preserved there is no doubt that it was bluntly pointed as in *T. annectens* and other members of the *Hadrosaurinae*. Between the face which articulates with the pubis and the rugose area, on the inferior surface, for articulation with the postpubis, there is a well-defined notch.

The *femur* is long and massive and considerably curved. The great trochanter is large and rises above the head of the bone. The lesser trochanter, on the antero-external face, is separated from the great trochanter by a narrow channel as in *T. annectens*, but is smaller than in that species and is located at a lower level. The fourth trochanter is below the midlength of the bone as in the above-mentioned species. The distal condyles are large antero-posteriorly and the articulating surface runs well up the posterior face. The condyles do not unite anteriorly to enclose a foramen, as in some forms, the only union between the two being a comparatively low and narrow ridge at their midlength. Length of femur 1,000 mm.

The *tibia* is much shorter and of lighter construction than the femur. It closely resembles that bone in *T. annectens*. Length of tibia 790 mm.

The right *astragalus* and *calcanium* are present, but show no differences when compared with other members of the genus.

Only fragments of the ribs are present and these do not appear to differ from *T. annectens*.

DINOSAUR TRACKS FROM THE EDMONTON FORMATION OF ALBERTA

By C. M. Sternberg

Illustrations

Long before dinosaurian remains were discovered in the western part of North America, which in later times has proved such a rich field for their collection, dinosaur tracks were known and described from the Connecticut valley. The first record of these tracks was by Edward Hitchcock in 1836 when he described them as *Ornithichnites* or "Stony Bird Tracks".[1] Since that time very many fossil footprints have been described, principally from the eastern part of the continent.

It has always been puzzling to students of palæontology why there have been so few skeletal remains found in the rocks where the footprints are so numerous. The tracks found in the Triassic of Connecticut valley represent not only a great many individuals, but also a great variety of genera and species. They show that this part of the world was thickly populated with a varied fauna while these deposits were being laid down. Yet very few of the skeletal remains of the animals are preserved in these rocks. On the other hand the absence of tracks in the rich dinosaur fields of the west has caused no less wonder.

In more recent years Schuler[2] and Wrather[3] have described dinosaur tracks from the Lower Cretaceous rocks of Hamilton county, Texas, and Peterson has recorded some very large dinosaur tracks in the roofs of coal mines in Utah.[4] The latter are attributed to a member of the *Deinodontidae* and they are said to be of Mesa Verde age. As far as the writer is aware no dinosaur tracks have been described from North America from rocks younger in age than the last mentioned.

The record of the most northerly dinosaur tracks in North America is of those discovered in Peace River canyon, B.C., by F. H. McLearn, Geological Survey, Canada.[5] These tracks are preserved at two horizons in the Gething member of the Bull Head Mountain formation which is correlated with the Kootenay of the south. The best tracks are those at the upper of the two horizons and are preserved in a fine, grey, ripple-marked, sandstone layer, which is considered as of freshwater origin. The impressions were plainly shown for a distance of about 100 feet and suggest a bipedal, carnivorous form of moderate size. Two faint impressions of smaller feet were shown which suggested to the observer that the animal touched the front feet on the ground while resting.

[1] Hitchcock, Edward: Am. Jour. Sci., vol. XXIX, pp. 307-340.
[2] Schuler, E. W.: "Dinosaur Tracks in the Glen Rose Limestone Near Glen Rose, Texas"; Am. Jour. Sci., vol. XLIV (Oct., 1917).
[3] Wrather, W. E.: "Dinosaur Tracks in Hamilton County, Texas"; Jour. Geol., vol. XXX, pp. 354-360 (1922).
[4] Peterson, W.: "Dinosaur Tracks in the Roofs of Coal Mines"; Nat. Hist., vol. XXIV, No. 3, pp. 388-391 (1924).
[5] Geol. Surv., Canada, Sum. Rept. 1922, pt. B, pp. 5 and 34.

It is more than forty years since the rich dinosaur fields were discovered along Red Deer river in Alberta and during that time many fine specimens have been collected, which show that in late Cretaceous time this country teemed with dinosaurs and other animals. In the Edmonton formation there is evidence that there were large, brackish-water pools and marsh-lands, and large tidal flats at the time these rocks were being laid down. Ripple-marked sandstones are common, especially in the upper part of the formation. In spite of these conditions, which one would think favourable for the preservation of dinosaur tracks, no such specimens have as yet been recorded from these rocks.

During the field season of 1925 the Geological Survey field party, under the direction of the writer, collected four dinosaur tracks from the Edmonton formation along Red Deer river, southwest of Rumsey, Alberta. They were discovered in the NE. ¼ sec. 6, tp. 33, range 21, W. 4th mer., 110 feet above river level. The tracks were made in a stiff mud and the impressions were rather shallow but clean cut. This mud was then covered with a medium-grained sand which filled the impressions made by the feet of the dinosaur. This has since become solidified, in certain areas, due to the concentration of calcareous cement. The specimens are, therefore, the negative or mould of the track and were on the under side of the solidified ledge. As only these solidified areas were of such a nature as to preserve the impressions, it was not possible to follow the path of the animal beyond these areas.

Two of the tracks were side by side and may have been made by an animal standing with its feet very close together, but more probably were made at different times. The better one of these is of the right foot and though it is not deep it is clean cut and shows good detail (Plate XVIII). The other is so faint that it is not possible to state whether it is of the right or left foot. The other two tracks are in almost a straight line and appear to have been made by an animal walking, rather than running, with the weight thrown strongly to the outside. The stride was 3 feet 1 inch, as shown by measuring from the tip of the third or central toe of one foot to the same point on the other.

Figure 4. ***Ornithomimipus angustus*, about ¼ natural size, showing relative position of tracks.**

The form, relative position, and the absence of manus impressions show clearly that the tracks are those of a bipedal, tridactyl, digitigrade animal. Phalangeal pads are moderately well shown, but there are no distinct metatarsal pads and there is no evidence of a web covering the toes. The heel is short and the toes well spread. The so-called heel is probably the union of the metatarsal pads. There is no pad for the proximal portion of phalanx one of digit II and this toe is separated from the rest of the foot. The fact that the weight of the animal was thrown strongly to the outside and that it did not sink deeply into the mud may help to explain this separation. The central toe is longest and most deeply impressed, indicating that it carried most of the weight.

The toe pads are not in all cases distinctly shown, but by careful examination the following formula can be made out: digit II, three pads; digit III, four pads; and digit IV, four pads. The toes are moderately long and slender and the distal extremities of the impressions indicate moderately broad, flat claws rather than sharp, decurved ones. The shallowness of the impression and the position of the tracks, e.g. one straight ahead of the other, indicate a lightly built, long-legged animal walking more or less upright.

Oyster shells were observed at an horizon about 20 feet below the tracks and it is probable that the mud-flat on which the animal walked was not much above sea-level. The above-mentioned oyster shells are at the same horizon as the oyster bed which is quite general farther down stream and is more than 2 feet thick at some localities.

An examination of the known fauna of the Edmonton formation reveals only one animal which would make tracks similar to those here preserved, e.g. *Ornithomimus*. A study of the hind feet of *Ornithomimus* leaves very little doubt that the tracks were made by an animal of that genus or at least a member of the family *Ornithomimidae*. The name *Ornithomimipus angustus* is proposed for these footprints and the best one (Plate XVIII, Cat. No. 8513) is considered as the type. The specific name refers to the slenderness of the tracks as compared with other *Cretaceous* dinosaur footprints.

	Mm.
Greatest length of track	280
Length from distal extremity to end of digit II	190
Length from distal extremity to end of digit IV	170
Greatest breadth from tip to tip of side toes	200
Greatest breadth of central toe pad	50
Length of stride	940

NEW JURASSIC SPECIES FROM THE HAZELTON GROUP OF BRITISH COLUMBIA

By F. H. McLearn

CONTENTS

INTRODUCTION

The fossils herein described were collected by G. Hanson in the field seasons of 1924 and 1925. They are important because they make possible a very exact dating of a part of the Hazelton group. Grateful acknowledgment is made to Mr. S. S. Buckman, F.G.S., the English authority on Jurassic ammonites, for valuable advice. Without his direction the writer would not have attempted the detailed comparisons of the ammonites with those of Europe. Mr. Buckman in particular aided in the determination of the ammonite genera, the recognition of the affinities of *Guhsania* n. gen., and in the correlation with England. The writer, however, is alone responsible for all statements in this paper.

STRATIGRAPHY AND CORRELATION

The Hazelton group of Hudson Bay and Babine mountains in Hazelton district, B.C., recently studied by G. Hanson, contains[1] an upper sedimentary division, an upper volcanic division of massive breccias, tuffs, flows, etc., a middle sedimentary division, a lower volcanic division of tuffs, etc., and sediments at the base. The middle sedimentary division was found by Hanson to be fossiliferous and collections were made at several localities. The best collection came from a locality about one mile southeast of Silver lake, on Hudson Bay mountain, where fossils occur in the talus from a cliff containing 300 to 400 feet of vertical strata of the middle sedimentary division. The fauna found at this place includes the following:

[1] Hanson, G.: Geol. Surv., Canada, Sum. Rept. 1924, pt. A, pp. 24-26. Also personal communication based on field work of 1925.

TUBICOLA
Serpula socialis Goldfuss

PELECYPODA
Ctenostreon gikshanensis n. sp.
Lima tizglensis n. sp.
Oxytoma submcconnelli n. sp.
Ostrea weegeti n. sp.
Perna weelaupensis n. sp.
Plagiostoma hazeltonense n. sp.
Trigonia guhsani n. sp.

AMMONOIDEA
Sonninia hansoni n. sp.
Sonninites silveria n. sp.
Sonninites skawahi n. sp.
Guhsania bella n. sp.
Guhsania ramata n. sp.

Other pelecypods, a few brachiopods, and rare gastropods are also present.

Among the pelecypods, the presence of a *Trigonia* of the *costatæ* section, of a *Ctenostreon* resembling *Ct. pecteniformis* (Schlotheim) and *Ct. electra* d'Orbigny, and of a *Plagiostoma* near *P. giganteum* Sowerby indicates a Jurassic age; as does also the presence of the annelid *Serpula socialis* Goldfuss. The ammonites admit of a finer correlation. A very detailed chronology of the English and continental Jurassic has been built up by S. S. Buckman,[1] based on the succession of ammonites. It embraces about forty-three ages and each age includes a variable number of hemeræ. Each age or hemera expresses an interval of time, the duration of certain species and genera. Now in this chronology the date of the *Sonninia* is the *sauzei* hemera of the Sonninian age; the date of the *Sonninites* is the *alsaticus* hemera of the Sonninian age; the new genus *Guhsania* is related and parellel in development to the *liostraca* group of the genus *Dorsetensia*, the date of which is the *Epalxites* hemera of the Stepheoceratan age. The affinities of the Silver Lake fauna, or faunas, therefore, are with those English faunas that date from the *sauzei* to the *Epalxites* hemera, or from late Sonninian to early Stepheoceratan. Faunas of the Sonninian and Stepheoceratan ages range throughout the Middle Inferior Oolite or Bajocian strata of England. Therefore, the fossiliferous beds of the middle sedimentary division of the Hazelton group, on Hudson Bay mountain, are to be correlated with the middle of the Middle Inferior Oolite or middle Bajocian or early Middle Jurassic strata of England.

English strata	English ages	English hemeræ	
Middle Inferior Oolite	Stepheoceratan	*Epalxites* *parcicarinata* *Masckeites*	Range of Silver Lake ammonites
	Sonninian	*alsaticus* *propinquans* *sauzei*	

[1] "Type Ammonites", vol. IV, pp. 5-18, 48-49; vol. V, pp. 71-78.

The Jurassic fauna[1] in the Fernie formation at Minnewanka lake, Alberta, also contains Sonninines and a pelecypod, *Oxytoma mcconnelli* Whiteaves[2], similar to the Silver Lake *Oxytoma submcconnelli* n. sp.; this is probably, in part at least, another Middle Inferior Oolite or Bajocian[3] fauna. Other faunas of similar age, i.e. Middle Inferior Oolite, but containing Stepheoceratidæ and Sphaeroceratidæ, are found in the lower part of the Yakoun formation at Skidegate inlet, at the base of the Fernie formation on Sheep creek, Alberta, and in the Fernie formation on Kananaskis river and at other localities in western Alberta. The Fernie formation of western Alberta and eastern British Columbia contains also other faunas, ranging as high as the middle Upper Jurassic[4]; one of these higher faunas, represented by an ammonite species from Kananaskis river, is similar in composition and age to the Kosmoceratidæ-bearing upper Yakoun fauna of Skidegate inlet.

SYSTEMATIC DESCRIPTIONS

Ctenostreon gikshanensis n. sp.

(*Gikshan*, an Indian tribe)

Plate XIX, figures 3, 4

A somewhat oblique, moderately convex species, having a short hinge-margin, a small anterior, and a large triangular, posterior ear. Commonly seven, rarely six or eight, narrow, somewhat flexuous, curved ribs, separated by wide, shallow interspaces. Somewhat rugose surface. No tubular spines known.

Height 105 mm.; length 100 mm.; thickness 29 mm.

This species has fewer ribs than the European species *Ctenostreon pecteniformis* (Schlotheim)[5]. It is proportionatly longer, has narrower ribs with wider interspaces, and commonly has one less rib than *Ctenostreon electra* (d'Orbigny)[6] of the French Jurassic; in *Ct. electra* the ribs near the umbo are narrow, but before midgrowth they begin to broaden and flatten and continue so to full growth.

Horizon and Locality. From talus of middle sedimentary division of the Hazelton group, exposed in a cliff about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Types: Victoria Memorial Museum; holotype, Cat. No. 7700; paratype, Cat. No. 7700a.

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[1] Whiteaves, J. F.: Geol. Surv., Canada, Contr. Can. Pal., vol. I, pt. 2, pp. 163-172.
[2] Whiteaves, J. F.: Geol. Surv., Canada, Contr. Can. Pal., vol. I, pt. 2, p. 166, Pl. 23, figs. 1 a, b. Whiteaves, J. F.: Geol. Surv., Canada, Mes. Foss., vol. I, pt. 4, p. 300.
[3] McLearn, F. H.: Geol. Surv., Canada, Sum. Rept. 1922, pt. B, p. 6.
[4] McLearn, F. H.: Geol. Surv., Canada, Sum. Rept. 1922, pt. B, p. 6.
[5] As figured and described by Morris, J., and Lycett, J.: Mollusca Great Oolite, Pal. Soc., pt. 2, p. 26, Pl. 6, fig. 9 (1853).
[6] Prodrome, I, p. 255; Annales Pal. 3, p. 197 (61), Pl. 20 (15), figs. 16, 17 (1908).

Lima tizglensis n. sp.

(*Tizle*, ancient home of Carrier Indians)

Plate XX, figure 1

A moderately convex, semiovate, not very oblique species. Abruptly inflected on the long, antero-dorsal submargin. Posterior ear of moderate size and triangular, anterior ear not preserved. Surface covered with forty to fifty irregular, flexuous, radiating costæ of low relief. Approximate measurements are as follows:

Height 75 mm.; length 60 mm.; thickness single valve 11 mm.

Lima occidentalis Hall and Whitfield[1] from the Jurassic of Flaming Gorge, Utah, has straighter and relatively wider radiating costæ, a smaller posterior ear, and a more narrowly inflected antero-dorsal submargin.

Horizon and Locality. From talus of the middle sedimentary division of the Hazelton group, exposed in a cliff about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Type: Victoria Memorial Museum; holotype, Cat. No. 7701.

Ostrea weegeti n. sp.

(*Weeget*, an Indian chief)

Plate XIX, figure 5

A small, ovate, somewhat depressed species. The beak of the right valve is very small, the beak of the left valve is not well defined in type specimen. Plications are well formed on the anterior half of both valves; they are broad and rounded, nine in number, and give rise to crenulate interlocking anterior and ventral margins. On the posterior half of the shell there are incipiently formed plications on the postero-ventral and lower posterior margins only; most of the posterior half is without plications and merely covered with growth-lines, which are strongly curved, convex ventrally. The paucity of plications on the posterior half may be due to attachment to a non-plicate shell or some flat object.[2]

Height 30 mm.; length 24 mm.; thickness 7·5 mm.

Horizon and Locality. From talus of the middle sedimentary division of the Hazelton group exposed in a cliff about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Type: Victoria Memorial Museum; holotype, Cat. No. 7702.

Oxytoma submcconnelli n. sp.

Plate XXIII, figure 1

Only the left valve of this large species is preserved. The semiovate body of the shell is oblique, a little longer than high, rather compressed, and narrowly inflected along the very gently curved (concave) postero-

[1] U.S. Geol. Explor. 40th Par., vol. IV, pt. 2, p. 292, Pl. 7, fig. 23.

[2] Woods has so interpreted some Cretaceous species. Mon. Cret. Lam. England, Pal. Soc., vol. 2, pt. 9, p. 385 (1913).

dorsal margin. Beaks small. All of posterior ear not preserved; fairly long, wide anteriorly, and separated from body of shell by a fairly deep sinus. Anterior ear small, not well preserved, but appears to be convex and separated from body of shell by a narrow sulcus.

Body of shell ornamented with about fourteen radiating, narrow, rounded (umbrella-like) ribs, separated by shallow, broadly concave interspaces in which are numerous radiating striæ. Some of these striæ are a little coarser than the others; these, however, do not increase in size much ventrally and do not become radii of higher order. The ears are covered with radiating striæ.

Length 63 mm.; height 55 mm.; thickness (of left valve) 9 mm.

This species is very close to *Oxytoma mcconnelli* Whiteaves[1] from the Fernie formation of Minnewanka lake, Alberta, in size, outline, and in general character of ornament. The Minnewanka Lake species, however, has more ribs on the body of the valve, the striæ are coarser and more uneven, and the sinus below the posterior ear is more shallow.

Horizon and Locality. From talus of the middle sedimentary division of the Hazelton group, exposed in a cliff about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Type: Victoria Memorial Museum; holotype, Cat. No. 7703.

Perna weelaupensis n. sp.

(*Weelaup*, a big stone mountain)

Plate XIX, figures 1, 2

A curved, semiovate species, produced in the antero-dorsal angle and expanded ventrally. The dorsal margin is fairly long and almost straight, the anterior margin deeply concave, the ventral margin long and rounded, and the posterior margin gently rounded, long, and inclined to the dorsal margin. The valves are flattened and are narrowly inflected along the anterior margin. The umbo is triangular and produced forward considerably in advance of the main body of the shell. The surface is not well preserved, but apparently has irregular lines of growth. Serial multivincular ligament preserved, but is not distinct.

Height 39 mm.; length 43 mm.; thickness 8 mm.

The shell from the Great Oolite of Minchinhampton, Yorkshire, England, identified by Morris and Lycett[2] as *Perna rugosa* Munst., is similar, but is larger, the umbo is not produced forward so much, the posterior margin is not so much inclined, and the outline does not widen so much ventrally.

Horizon and Locality. In talus of the middle sedimentary division of the Hazelton group, exposed in a cliff about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Type: Victoria Memorial Museum; holotype, Cat. No. 7704.

[1] Whiteaves, J. F.: Geol. Surv., Canada, Mes. Foss., vol. I, pt 4, p. 300 (1900).
Whiteaves, J. F.: Geol. Surv., Canada, Contr. Can. Pal., vol. I, pt. 2, p. 166, Pl. 23, figs. 1 to 1b (1899).
[2] Mon. Mollusca Great Oolite, pt. 2, Pal. Soc., p. 25, Pl. 3, fig. 1 (1853).

Plagiostoma hazeltonense n. sp.

Plate XXI, figure 1; Plate XXII, figures 1-5

A very large, semiovate, somewhat oblique, moderately convex species. Broadly inflected on the long, antero-dorsal submargin. Hinge-margin short. Anterior ear longer than wide; posterior ear as long, but wider and flatter.

The ears and most of the inflected antero-dorsal area have concentric growth-lines and ridges only. The remainder of the shell surface has radial ornament as well as concentric growth-lines: on the posterior part are small, narrow, wavy striations, which toward the middle of the shell become broad, irregular bands separated by narrow, wavy grooves; on the anterior part of the shell, the ornament is striate, also, rather than banded, for narrow, wavy, small striations are preserved on the border of the antero-dorsal inflected area. The ornament is weakest on the middle part of the shell.

Height 155 mm.; length 160 mm. (est.); thickness one valve 35 mm.

Plagiostoma giganteum Sowerby[1] is very similar, but is more elongate in outline and has feebler ornament.

One of the Silver Lake specimens is more elongate than the typical specimens of the species described above, and has a narrow, inflected area. This may be a variety of the species.

Horizon and Locality. From talus of the middle sedimentary division of the Hazelton group, exposed in a cliff about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Types: Victoria Memorial Museum; holotype, Cat. No. 7705; paratypes, Cat. Nos. 7705 a to d.

Trigonia guhsani n. sp.

(*Guhsan*, an Indian chief)

Plate XX, figures 2, 3

A large, moderately convex, ovate species, much longer than high. The dorsal margin is about half the length of the shell. The posterior margin is oblique and angular. The beaks are near the anterior end. Anterior part of shell covered with about twenty-one narrow costæ which turn abruptly in a postero-ventral direction adjacent to the marginal carina. The area has about ten radiating small costellæ, which are crossed by what appear to have been fairly conspicuous growth-lines. This species belongs to the *costatæ* section of the genus.

Height 66 mm.; length 100 mm.; thickness single valve 14 mm.

Trigonia americana Meek[2] from Jurassic strata near the lower canyon of Yellowstone river, Montana, is smaller, is not so elongate, and has coarser sculpture on the area. *Trigonia bachelieri* d'Orbigny[3] is smaller, has finer and more closely arranged costellæ on the area and a more pronounced median carina.

Horizon and Locality. From talus of the middle sedimentary division of the Hazelton group, exposed in cliff about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Type: Victoria Memorial Museum; holotype, Cat. No. 7706.

[1] Sowerby, J.: "Mineral Conchology"; vol. I, p. 176, Pl. 77.
Goldfuss, J.: Petrefacta Germaniae, pt. 2, p. 80, Pl. 101, figs. 1 a, b.
[2] 12th Ann. Rept., U.S.G. and G. S. Terr., pt. I, p. 148, Pl. 38, figs. 1 a, b (1883).
[3] Proderone, vol. I, p. 338.
Annales Pal., vol. 14, Fasc. 4, p. 150 (18), Pl. 18 (39), figs. 6-8.

Sonninia hansoni n. sp.

Plate XXIII, figures 2, 3

Diameter	76·5*mm.	56·0* mm.
Height of whorl	41·0%	39·5%
Thickness of whorl	25·8%	29·1%
Width, umbilicus	27·8%	30·0%

*Without keel

Except the part showing in the umbilicus, only the core is preserved. Living chamber not preserved. As the size of the keel is not known, the measurements are given without it.

A compressed serpenticone. Fairly involute, the inclusion about 50 per cent. Sublatumbilicate, gradumbilicate. Umbilical margin of inner whorls angular, of outer somewhat rounded. Whorl-section compressed obovate, becoming trigonal on outer whorl, much higher than thick. Whorls somewhat flattened on the sides. Venter narrowly rounded, becoming convexi-fastigate on outer whorl. A hollow (septate) keel of unknown size, leaving a smooth partition-band on the core, but neither ridge nor sulci. The outer whorl is presumably smooth; the core shows no ornament. The whorls in the umbilicus have numerous, straight, very fine ribs with just a suspicion of marginal swelling; the ventral projection of this ornament, however, is not known.

The suture-line is complex. The external saddle is deep and rather narrow. The first lateral lobe is longer than the external, is rather broad-stemmed, rather symmetrical, and the median lobule is longer than the two lateral ones. The first lateral saddle is deep and extremely narrow. The second lateral saddle is deep and very narrow, but not so deep as the first lateral. The inner margin of the suture-line is retracted a little and the auxiliary lobes and saddles slant.

In shape and ribbing this species resembles the European species, *A. sowerbyi carinodiscus* Quenstedt,[1] but is not so compressed and the ribbing is even finer. The greatest difference is in the suture-line: for Quenstedt's species has a much more asymmetrical first lateral lobe, a much broader first lateral saddle, and a shorter second lateral lobe. *Sonninia corrugata* Sowerby[2] is also similar, but has somewhat higher and thinner whorls, a smaller umbilicus, and a different suture-line, including a more narrow-stemmed and asymmetrical first lateral lobe and no retraction of the inner part. The first lateral lobe of *S. hansoni* is rather broad-stemmed and symmetrical for a *Sonninia*, but the surface is much worn and the true line may not be recorded. It is placed in *Sonninia* on account of its marked resemblance in form, proportions, and ribbing to undoubted species of the genus.

The species name is given for G. Hanson of the Geological Survey.

Horizon and Locality. From talus of middle sedimentary division of the Hazelton group, exposed in a cliff about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Type: Victoria Memorial Museum; holotype, Cat. No. 7707.

[1] Ammon. Schwab. Jura, Pl. 63, fig. 5 only.
[2] *See* Buckman, S. S.: Type Ammonites, vol. IV, Pl. 412 (1923).

Sonninites silveria n. sp.

(*Silveria,* the Silver Lake country)

Plate XXIV, figure 3

Diameter	100 mm.	32 mm.
Height of whorl	37·3%	37·0%
Thickness of whorl	20·4%	34·4%
Width, umbilicus	36·5%	37·2%

Owing to distortion and imperfection of the specimen, the above measurements are only approximate; the keel is included; allowance is made for compression of the outer whorl. Chiefly core, very little of test preserved. Definitely septate to within 18 mm. of anterior end of outer whorl.

Inner whorls serpenticonic. Outer whorl compressed serpenticonic or platyconic. The umbilicus shallow, latumbilicate. Whorls moderately embracing, the amount of inclusion about 25 per cent. Venter of inner whorls broad, rounded; keel marked on core by a ridge, with small furrows on either side; a very small amount of test preserved shows a moderately sized hollow (septate) keel. On outer whorl venter narrow, rounded; keel marked by a very low ridge on core with very faint furrows on either side; a little of test remaining shows a hollow keel of fairly large size, without ventral furrows, but with faint lateral furrows.

On the inner whorls are rather closely set, small ribs of fairly strong relief, almost straight on the sides, but bending forward ventrally; the total forward curvature cannot be determined, however, for there is not enough test preserved to trace the growth-lines on; each rib appears, however, to well overlap the next rib. On the anterior part of the second last whorl the ribs increase, somewhat irregularly, in size and spacing. On the last or outer whorl the ribs decrease in relief and become merely broad, low undulations; thus the ornament is approaching smoothness; these undulations are almost straight on the side and bend forward as they approach the venter, but owing to absence of the test the total forward curvature cannot be determined.

Suture line complex. The external saddle is deeper than wide and divided into two branches, the inner of which is the larger. The first lateral saddle is deep and very narrow. The first lateral lobe is longer than the external, has a rather broad stem and three branches or lobules, the centre of which is longer than the two lateral; it is almost symmetrical. It has only been possible to prepare a little of the second lateral lobe. It is about two-thirds as long as the first lateral lobe. A preparation of the suture-line on an inner whorl shows a deep, second lateral saddle and an inclined auxiliary lobe. The inner edge is not dependent, however.

This species is very similar to *Sonninites alsaticus* (Haug),[1] but is smaller and has finer, more regular, and more closely spaced ribs on the inner whorls. *Dorsetensia lennieri* Brasil[2] has much thinner whorls, fewer and more widely spaced ribs, a non-septate keel, and deeper ventral furrows.[3]

Horizon and Locality. From the talus of the middle sedimentary division of the Hazelton group, exposed in a cliff about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Type: Victoria Memorial Museum; holotype, Cat. No. 7708.

[1] *See* Buckman, S. S.: Type Ammonites, vol. VI, Pls. 528, 528A (1925).
[2] Ceph. nouv. jur., Bull. Soc. geol. Norm., 16, p. 10, Pl. 3, fig. 10 (1895).
[3] The writer has not access to Brasil's publication and is indebted to Mr. S. S. Buckman for the comparison.

Sonninites skawahi n. sp.

(*Skawah*, an Indian legendary name)

Plate XXIV, figures 1, 2

Diameter	55 mm.
Height of whorl	40%
Thickness of whorl	31·3*%
Width, umbilicus	38·2*%
*very approximate	

The specimen is entirely septate and the outer whorl or whorls are not preserved. The preservation is almost entirely in the form of core, i.e. mould of the interior. Allowance is made in the measurements for a keel 2 mm. high.

Slightly compressed serpenticone, latumbilicate, the whorls moderately embracing, somewhat compressed ovate, and flattened on the sides. The venter broad and gently rounded. The keel, which is not preserved, leaves on the core a ridge and two narrow sulci. The size of the keel is unknown. On the sides, the strong ribs are almost straight and ventrally they curve forward; but the total amount of forward curvature cannot be determined, owing to the absence of test; it must be considerable, however, each rib overlapping the next. The ribs are jugate on the inner margin.

The suture line is complex. The external saddle is deep, moderately broad, and divided by a small lobule. The lateral saddles are deep and extremely narrow. The first lateral lobe is cruciform, rather broad-stemmed, and longer than the external lobe. The second lateral lobe is long and very narrow. The auxiliary lobe is short and slanting. There is no retraction of the inner end of the suture-line, however.

Owing to absence of the outer whorl, a complete comparison of this species with *Sonninites silveria* n. sp. cannot be made, but they certainly differ in details of the suture-line, for *S. skawahi* has much narrower and more deeply cut lateral saddles and a longer and more slender median lobule in the first lateral lobe. *S. skawahi* is very close in form, proportions, and suture-line to *Sonninites alsaticus* (Haug),[1] but has higher whorls, somewhat weaker ribs, and much less ventral sulcation. Compared with *A. tessonianus falcatus* Quenstedt[2] the Canadian species has higher and thinner whorls, less umbilication (i.e., a smaller umbilicus), and probably a smaller keel. The Canadian species is an advance in development over both of these European species.

Horizon and Locality. From talus of the middle sedimentary division of the Hazelton group, exposed in a cliff about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Type: Victoria Memorial Museum; holotype, Cat. No. 7709.

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[1] *See* Buckman, S. S.: Type Ammonites, vol. VI, Pls. 528, 528A (1925).
[2] Ammon. Schwab. Jura; Pl. 63, fig. 10.

Guhsania n. gen.

(*Guhsan*, an Indian chief)

Compressed serpenticonic, evenly ribbed inner whorls passing to oxyconic coarsely ribbed outer whorl. Septicarinate. Sublatumgradumbilicate. Angular umbilical margin. Fairly developed suture-line, with wide-stemmed, tripartite, slightly asymmetric first lateral lobe. For further details see description of the genotype.

This genus is parallel in development to the "*liostraca* group" of the genus *Dorsetensia* S. Buckman[1] and like it attains the oxyconic outer whole and upright angular inner margin, but retains the ribbing through all stages of growth, a broader umbilication, and a more developed suture-line. Genotype, *Guhsania bella* n. sp.

Guhsania bella n. sp.

(*bellus*, trim)

Plate XXV, figure 1

Diameter..........Mm.	138	111·7	81·8	45·2
Height of whorl.......... Per cent.	42·1	42·5	42·7	42·7
Thickness of whorl.......... "	21·3	....	23·0	24·8
Width, umbilicus.......... "	28·6	28·4	28·8	....

The specimen is somewhat distorted and the measurements are approximate; allowance is made for the keel. Chiefly core, very little of test preserved. Entirely septate.

Compressed serpenticonic on inner whorls, becoming lenticular oxyconic on outer whorls. Moderately involute, sublatumbilicate, gradumbilicate, umbilical margin angular, umbilical area very narrow and vertical to plane of symmetry of shell. Whorl section of inner whorls compressed ovate, sides somewhat flattened. Section of outer whorl becoming sagittate, thickest near the inner side. Venter of inner whorls rounded (amblygastric), surmounted by a rather small, hollow keel, which leaves a low ridge and traces of sulci on the core. Venter of outer whorl fastigate (oxygastric), with rather small, hollow keel (septicarina) which leaves, on the core, a smooth, narrow partition band truncating the sharp venter. The oxygastric venter begins at a diameter of about 80 mm.

The inner whorls have numerous, small ribs, nearly straight on the sides and curved forward near the venter. The outer whorl has, on the dorsal part, straight, broad, low, rounded undulations, which die out ventrally. The total amount of forward curvature of the ribs and growth-lines cannot be determined, for so little of the test is preserved; it must be considerable, however, at least on the inner whorls.

The suture-line is fairly complex, with somewhat deep saddles, and the external saddle is narrow, relatively of about the width of the lateral saddles. The first lateral lobe is a little longer than the external lobe,

[1] Mon. Infer. Ool. Ammon., Pal. Soc., p. 308 (1892).

is broad-stemmed, and has three lobules, the median of which extends a little below the lateral ones and is slightly asymmetric. The auxiliary lobes slant somewhat, but the inner edge of the suture-line is not retracted.

The inner whorls resemble the more primitive species of *Dorsetensia* S. Buckman and are like *D. edouardiana* var. δ S. Buckman,[1] but have a rounded venter and obsolescent ventral furrows like *D. edouardiana* var. γ S. Buckman.[2] The outer whorl is oxyconic as in the "*liostraca* group" of *Dorsetensia*,[3] but is ribbed, not smooth, and is not so involute. The suture-line, also, is more developed.

Horizon and Locality. From the talus of the middle sedimentary division of the Hazelton group, exposed in a cliff about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Type: Victoria Memorial Museum; holotype, Cat. No. 7710.

Guhsania ramata n. sp.

(*ramus*, a branch)

Plate XXII, figures 6, 7

Diameter	115 mm.
Height of whorl	38·8%
Thickness whorl	14·8%
Width, umbilicus	

The above measurements are approximate. Only the core of about one-quarter of one whorl and a fragment of an inner whorl are preserved. The outer whorl is partly septate and partly living chamber. This whorl is compressed, the height being about 2·6 times the thickness. The whorl section is sagittate and the venter fastigate (oxygastric). A smooth, narrow partition band on the core. A small part of preserved test shows a hollow keel about 2 mm. high. The core shows slightly curved undulations on the sides which die out ventrally. The fragment of inner whorl has a compressed ovate section, a rounded venter, and, marked on the external mould, a 1·8 mm. keel. The suture-line is deeply cut, the saddles are deep, and have slender, twig-like branches. The first lateral lobe is broad-stemmed and has a long, median lobule. The inner margin of the suture-line is strongly retracted. This species differs from *Guhsania bella* n. sp. in the more compressed whorl and the more deeply cut suture-line with its twig-like branches, its longer median lobule on the first lateral lobe, and its retracted inner margin.

The suture-line shows some resemblance to that of the Hammertoceratidæ, but owing to the marked resemblance in whorl-shape and ribbing to *Guhsania bella* n. sp., this species is for the present placed in the same genus.

Horizon and Locality. From the talus of the middle sedimentary division of the Hazelton group, exposed in a cliff, about 1 mile southeast of Silver lake, Hudson Bay mountain, B.C.

Type: Victoria Memorial Museum; holotype, Cat. No. 7711.

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[1] Mon. Infer. Ool. Ammon., Pal. Soc., Pl. 52, figs. 21, 22 (1892).
[2] Mon. Infer. Ool. Ammon., Pal. Soc., Pl. 52, figs. 18, 19 (1892).
[3] Mon. Infer. Ool. Ammon., Pal. Soc., p. 308 (1892).

Plate I[2]

Streptelasma fragile n. sp.

Figure 1. Looking into the base of a broken cup, showing the septal arrangement. X 2. (Page 11.)

Figure 2. Section of interior showing the proportion of the cup. (Page 11.)

Streptelasma prolongatum n. sp.

(*See also* Plate II, figure 2)

Figure 3. Top of an average-sized specimen, showing the septal arrangement well developed. (Page 11.)

Figure 4. Outline of a large specimen, showing the prolonged pseudo-fossula. (Page 11.)

Figure 5. Base of the cup of another specimen showing the peculiar network formed by the irregular plate-like standards on the septa at the centre. The sides of the cups are broken unevenly. (Page 11.)

Streptelasma distinctum n. sp.

Figure 6. Interior showing shortened diameter along the cardinal septum, and arrangement of the septa in the quadrants. (Page 12.)

Figure 7. Bottom of the cup showing the comparatively small part occupied by the cellulose structure. The edge of the cup is broken unevenly. (Page 12.)

Halysites robustus n. sp.

Figure 8. Top of large colony, showing some of the long, narrow reticulations. (Page 14.)

Figure 9. Cross-section showing the thickened end walls outlining the oval interior and oblong exterior of the corallites. (Page 14.)

Figure 10. Longitudinal section, showing the rather thick and relatively not very numerous tabulæ. The three corallites on the right are at an angle and are somewhat foreshortened. (Page 14.)

Plasmadictyon irregulare gen. nov.

Figure 11. View from the top showing the network of the irregular corallites. X 2. (Page 19.)

Figure 12. Corallite showing the large pores. X 4. (Page 19.)

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[1] Unless otherwise stated all figures are natural size.

PLATE I

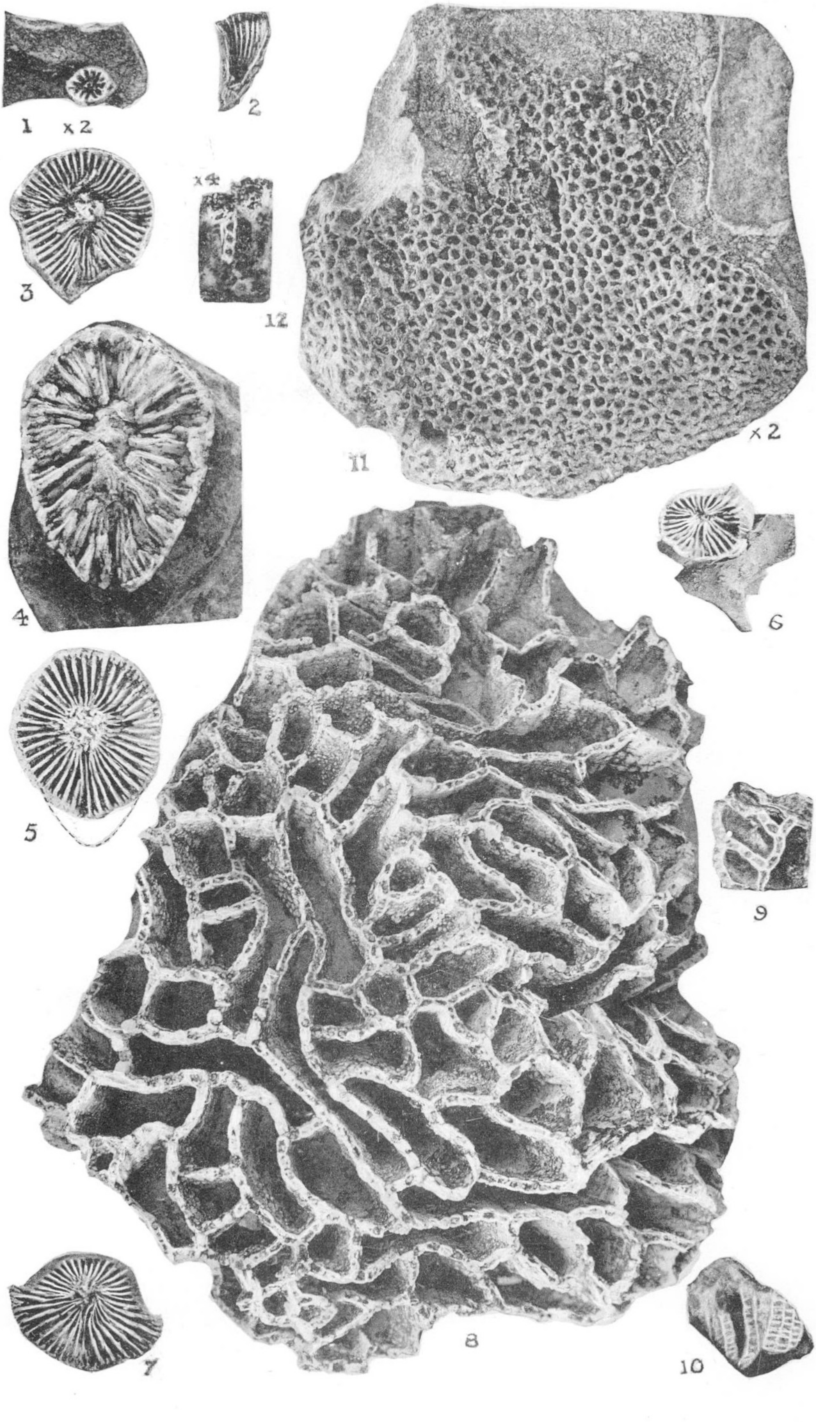


Plate II

Streptelasma patellum n. sp.

Figure 1. Broken coral showing the plate-like protrusion into the bottom of the cup. (Page 13.)

Streptelasma prolongatum n. sp.
(*See also* Plate I, figures 3, 4, 5)

Figure 2. Section showing the shape of the cup. (Page 11.)

Halysites delicatulus n. sp.

Figure 3. A piece of a colony showing the narrow, oblong outline of the corallites. (Page 14.)

Figure 4. Longitudinal section exhibiting the absence of the intercorallite tubuli and the transverse tabulæ. X 2. (Page 14.)

Figure 5. Section of the top of a more crowded portion showing the corallites squeezed into a more rectangular or rounded outline. X 2. (Page 14.)

Halysites cylindricus n. sp.

Figure 6. Cross-section showing the outline of the small, round corallites and the looseness of their contact. X 2. (Page 15.)

Figure 7. Longitudinal section showing the relatively short tabulæ. X 2. (Page 15.)

Diphyphyllum? halysitoides n. sp.

Figure 8. View of the ends of the corallites showing circular and oval tubes and the *Halysites*-like form of arrangement. (Page 18.)

Figure 9. Longitudinal view of a natural section showing the bifurcated habit of growth. (Page 18.)

Diphyphyllum? primum n. sp.

Figure 10. A small piece of a colony showing the arrangement and shape of the corallites. (Page 18.)

PLATE II

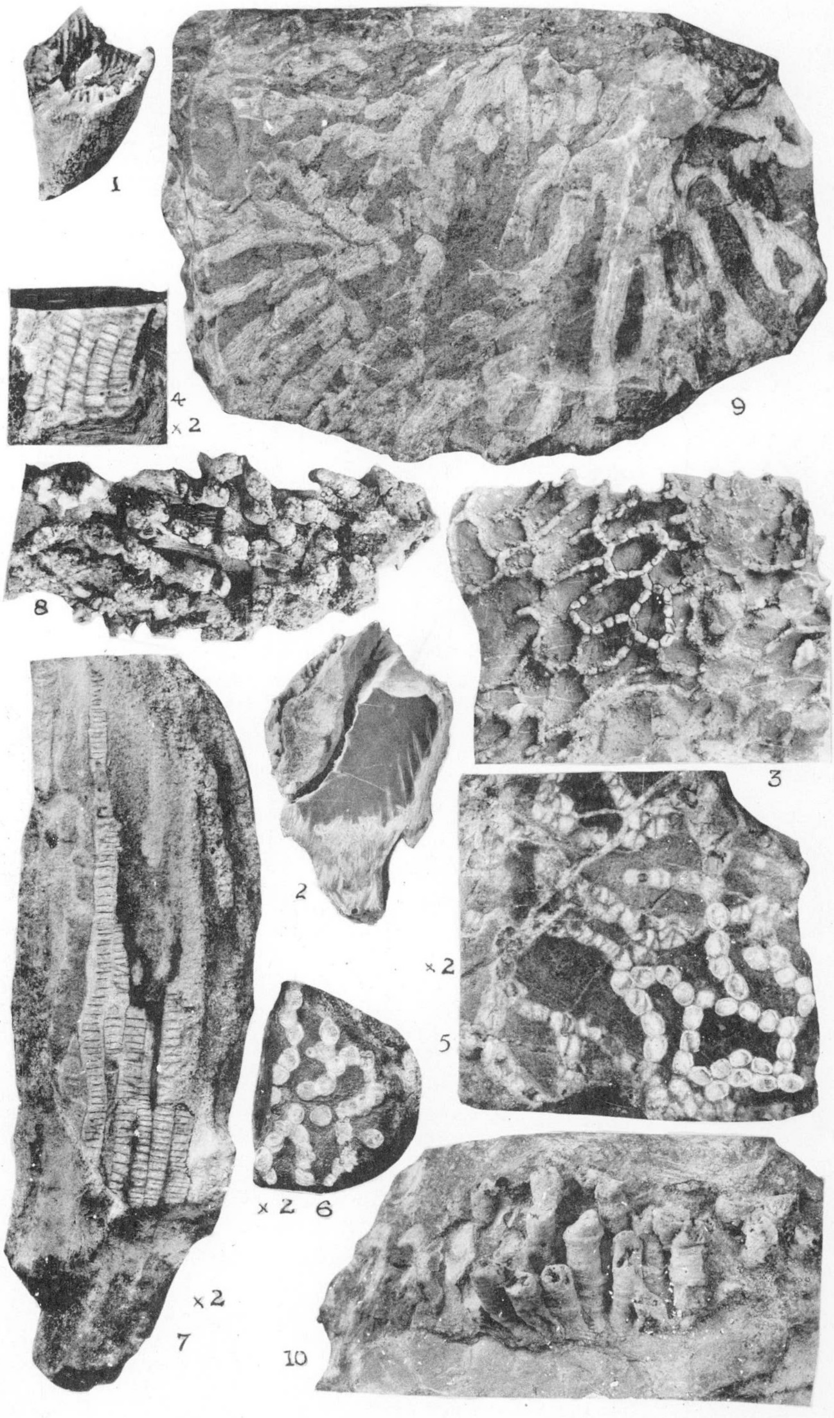


PLATE III

Columnaria alveolata var. *stellaris* n. var.

FIGURE 1. Star-like top of a corallite. (Page 16.)
FIGURE 2. Section showing the septa intercepted by tabulæ. (Page 16.)

Syringopora burlingi n. sp.

FIGURE 3. Weathered specimens showing the numerous wrinkling lines of growth and the spacing of the corallites. (Page 17.)
FIGURE 4. Longitudinal section showing the comparatively stout, closely placed tubes. (Page 17.)

Syringopora columbiana n. sp.

FIGURE 5. Large colony showing the erect form of growth and the sub-parallel tubes. (Page 17.)
FIGURE 6. Polished section exhibiting tubules. X 2. (Page 17.)

Favosites cf. *favosus* (Goldfuss)

FIGURE 7. Small piece illustrating the small corallites set around the larger ones. (Page 16.)

Halysites pulchellus n. sp.

FIGURE 8. Cross-section showing the slender, oval outline of the corallites. (Page 15.)
FIGURE 9. Longitudinal section showing the spacing of the tabulæ. (Page 15.)

PLATE III

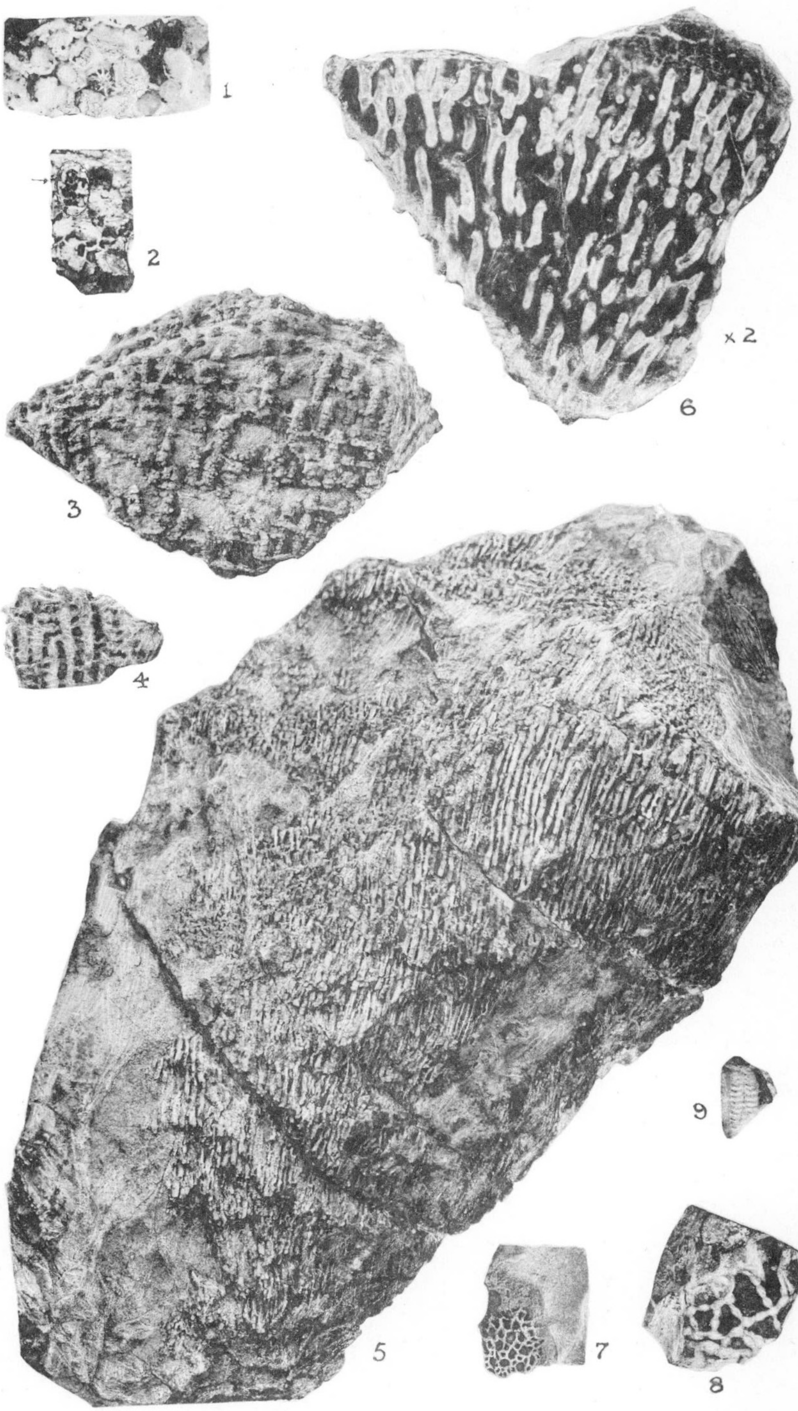


Plate IV

Rhynchotrema windermeris n. sp.

Figure 1. View of pedicle valve. (Page 20.)

Figure 2. Interior of the pedicle valve, showing the deltidial plates characteristic of the genus. (Page 20.)

Figure 3. Brachial valve, broken. The interior of the upper part is shown in figure 4. (Page 20.)

Figure 4. Interior of the brachial valve, showing the rather wide, slightly raised, crural cavity. (Page 20.)

Rhynchotrema increbescens (Hall)

Figure 5. Interior showing the grooves of the crural plates and the long, tongue-like projection with the bifid end. X 4. (Page 21.)

Rhynchotrema increbescens occidens n. var.

Figure 6. Pedicle valve. (Page 21.)

Figure 7. Profile of both valves. (Page 21.)

Figure 8. Interior of pedicle valve, showing dental plates and part of one tooth. X 4. (Page 21.)

Figure 9. Interior of brachial valve showing crural plates, short cavity, and minute cardinal process. A small piece of the pedicle valve is present and one tooth in the socket on right hand side. X 4. (Page 21.)

Figure 10. Interior of brachial valve at an angle, showing relationship of crural plates and septum. X 4. (Page 21.)

Rhynchotrema pisina n. sp.

Figure 11. Profile view showing the great convexity of the brachial valve and the relationship of the beaks. X 2. (Page 22.)

Figure 12. Brachial valve showing the small, round form and the inconspicuousness of the fold. X 2. (Page 22.)

Figure 13. Interior of the brachial valve, showing crural plates and ornamentation. X 4. (Page 22.)

Rhynchotrema kananaskia n. sp.

Figure 14. Brachial valve. (Page 23.)

Figure 15. Pedicle valve. (Page 23.)

Figure 16. Profile view showing the rather flattened outline of the brachial valve after the greatest complexity is reached. (Page 23.)

Figure 17. Hinge view, showing the relationship of the beaks. (Page 23.)

Figure 18. Part of a specimen magnified to show the ornamentation. X 4. (Page 23.)

Plectorthis sinuatis n. sp.

Figure 19. Brachial valve, showing a part of the area of the pedicle valve. (Page 23.)

Figure 20. Pedicle valve, a little crushed on the left side. (Page 23.)

Figure 21. Anterior view showing the sinuate outline of the margin. (Page 23.)

PLATE IV

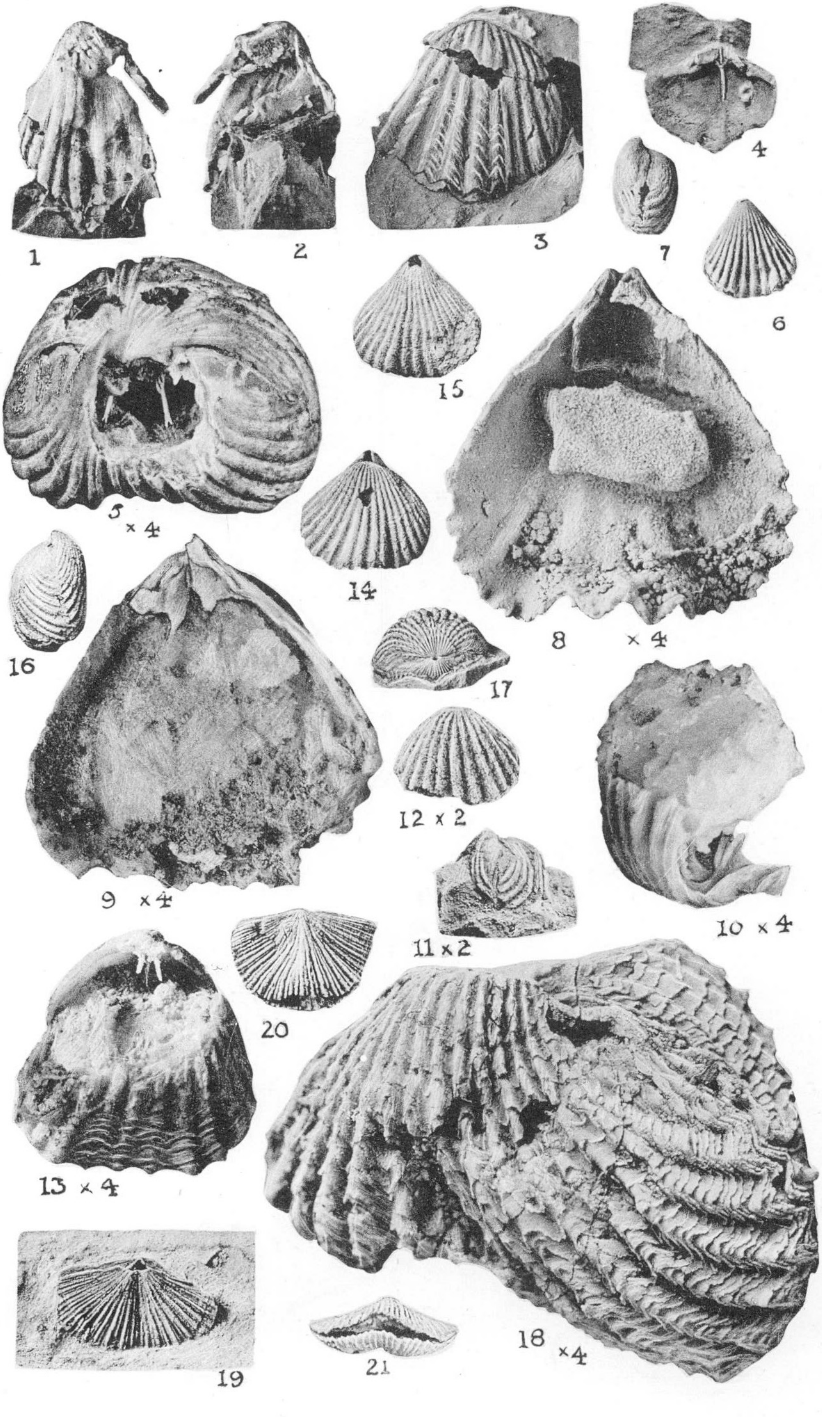


Plate V

Orthis marshalli n. sp.

Figure 1. Pedicle valve. X 2. (Page 24.)

Figure 2. Area of pedicle valve, showing teeth. X 2. (Page 24.)

Figure 3. Brachial valve. X 2. (Page 24.)

Figure 4. Interior of pedicle valve showing the muscle scars. Cardinal area and teeth broken away. X 4. (Page 24.)

Figure 5. Interior of brachial valve. X 4. (Page 24.)

Figure 6. Interior of pedicle valve taken at right angles to the dental plates showing the supports. (Page 24.)

Dinorthis columbia n. sp.

Figure 7. Beaks from the brachial valve, showing the angular external face of the cardinal process, taken at a very slight angle. (Page 25.)

Figure 8. An incomplete and rather small specimen of the brachial valve, showing the broad, shallow sinus, and the presence of one or two implanted striæ. (Page 25.)

Figure 9. Interior of pedicle valve. (Page 25.)

Figure 10. Interior of brachial valve, showing spear-head cardinal process. (Page 25.)

Dinorthis rockymontana n. sp.

Figure 11. Brachial valve, showing a part of the area of the pedicle valve. (Page 26.)

Figure 12. Profile showing the beaks. (Page 26.)

Figure 13. Interior of the brachial valve, showing the bifid cardinal process. (Page 26.)

Figure 14. Interior of the pedicle valve, showing the arrangement of the muscle scars. (Page 26.)

Petroria rugosa nov. gen. n. sp.

Figure 15. Pedicle valve. (Page 28.)

Figure 16. Brachial valve showing projection of pedicle beak. X 2. (Page 28.)

Figure 17. Hinge of brachial valve, showing the thickened end of the cardinal process filling the opening. X 4. (Page 28.)

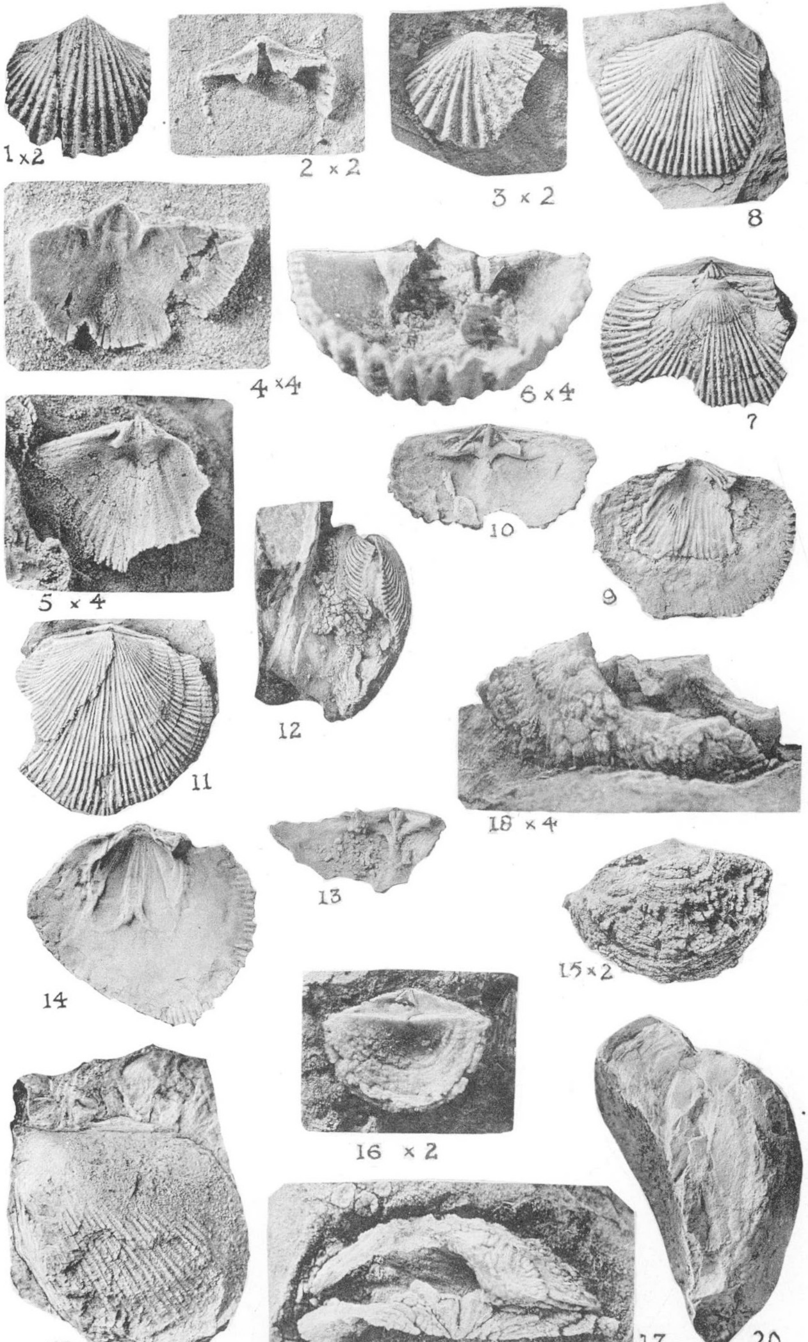
Figure 18. Interior of the brachial valve, from the anterior margin, showing the thickened cardinal process, and one triangular crural plate. X 4. (Page 28.)

Byssonychia radiata var. *walkeri* n. var.

Figure 19. Left valve, showing the general outline of the shell. The angle of the fracture at the beak erroneously suggests a curve to the right instead of the true turn to the left. (Page 29.)

Figure 20. Anterior view of the same valve, showing the ventricose nature of the shell and the large ligamental area below the broken type of the beak. (Page 29.)

PLATE V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18 x 4
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16 x 2
19
17 x 4
20

PLATE VI

Palliseria robusta Wilson

FIGURE 1. Natural section of two specimens, the lower one showing the six angles of the section, and the umbilical ridge projecting into the umbilicus. The upper specimen is not quite perpendicular. (Page 30.)

FIGURE 2. Opposite side of figure 1, showing the broad, flattened, band-like area on the last whorl, and the surface markings across it and on the under side. (Page 30.)

PLATE VI

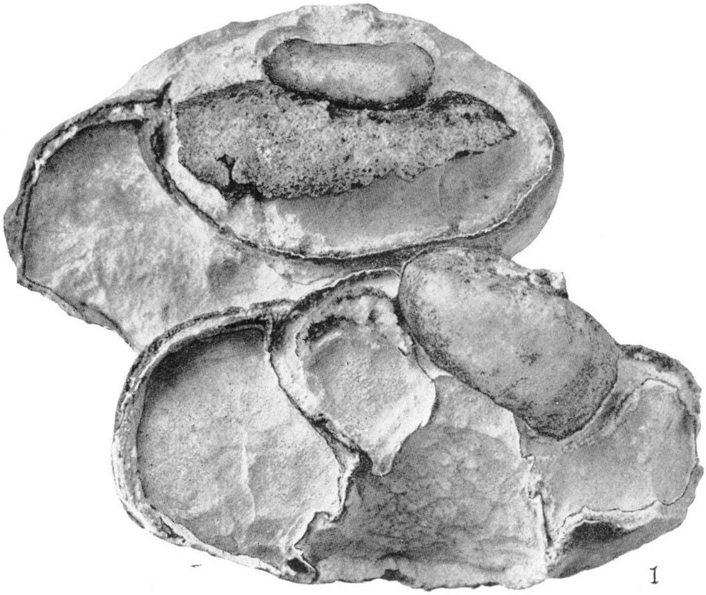

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PLATE VII

Palliseria robusta Wilson

FIGURE 1. The same specimen as figured on Plate VI, showing the growth lines on the upper surface of the upper shell. (Page 30.)

FIGURE 2. The same, from below, showing the piled-up growth lines on the umbilical ridge. (Page 30.)

Lophospira occidentalis Wilson

FIGURE 3. Showing the general shape and natural section of the last whorl, a little foreshortened. (Page 30.)

PLATE VII

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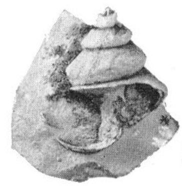

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PLATE VIII

Cornulites parvus n. sp.

FIGURE 1. Specimen seen on *Dinorthis columbia*, Plate V, figure 10. X 4. (There is another small incomplete specimen on the right of the shell.) (Page 31.)

Vaginoceras? eccentricum n. sp.

FIGURE 2. View of the only specimen obtained. (Page 32.)

Actinoceras complanum n. sp.

FIGURE 3. Fragment showing the proportions of the septal neck and ring. (Page 31.)
FIGURE 4. End view showing the position of the siphuncle. (Page 31.)

Protokionoceras? gracile n. sp.

FIGURE 5. Fragment showing its slender proportions. (Page 32.)
FIGURE 6. Exterior of Stanford Range specimen, showing the fine, longitudinal striæ. X 2. (Page 32.)

Spyroceras intermedium n. sp.

FIGURE 7. A fragment, illustrating the longitudinal striæ, the annulations, and the imbrication of one annulation upon the smaller end of the succeeding one. X 2. (Page 33.)

PLATE VIII

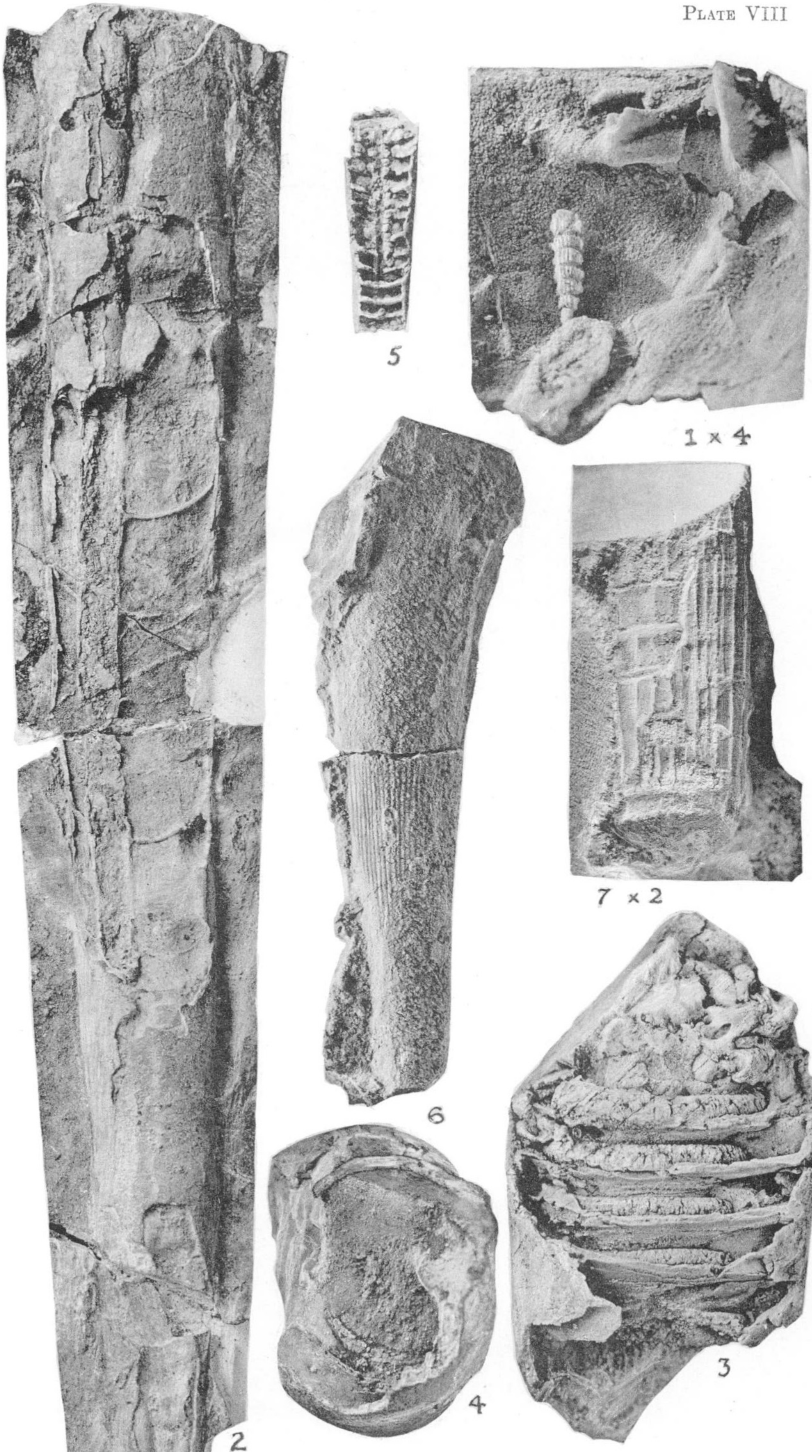


PLATE IX

Gascons cove, looking west toward Reddish point, a part of the Gros Morbe. The outer point is of the lower pink limestone of the West Point formation. Beneath the latter is the Bouleaux thin-bedded limestone; near the shore is the Gascons formation. (Photograph by Notman of Montreal.) (Page 48.)

Plate IX

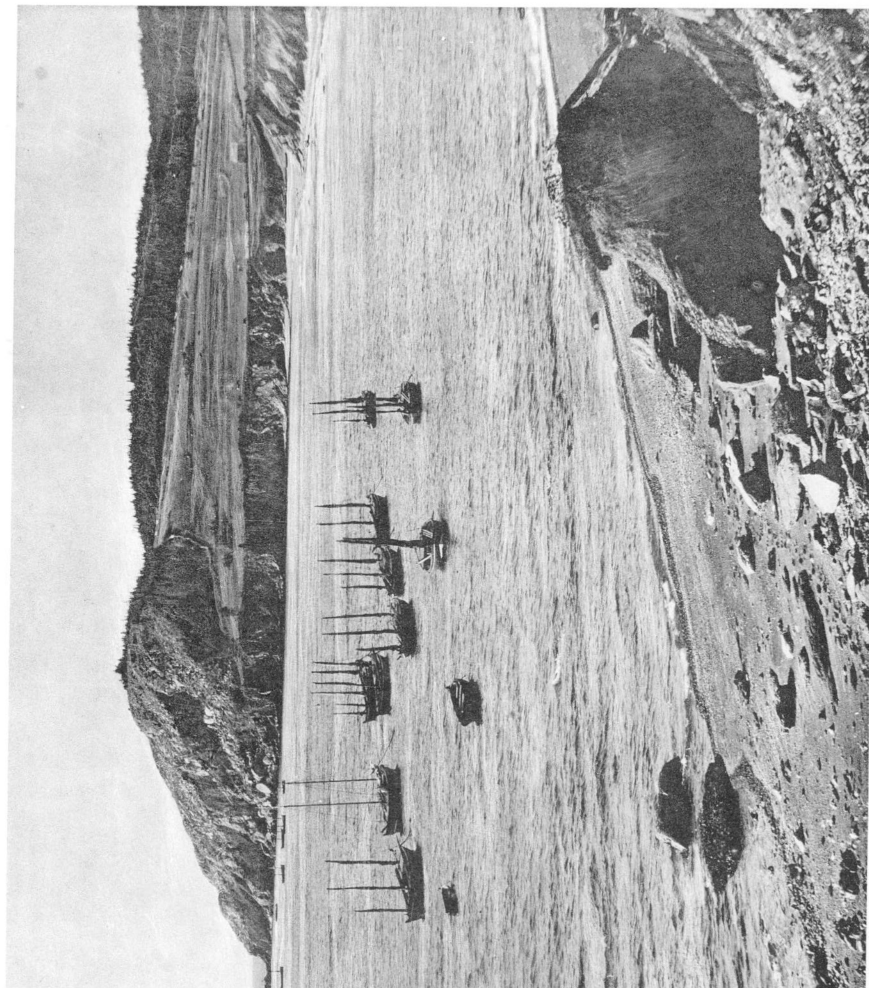


PLATE X

Gascons cove from Reddish point, looking east toward pointe aux Bouleaux (outer point is the lower pink limestone with most of the peninsula of Bouleaux strata), and in the far east is pointe Macquereau. This picture also shows the several marine-cut terraces. (Photograph by Notman of Montreal.) (Page 48.)

PLATE X

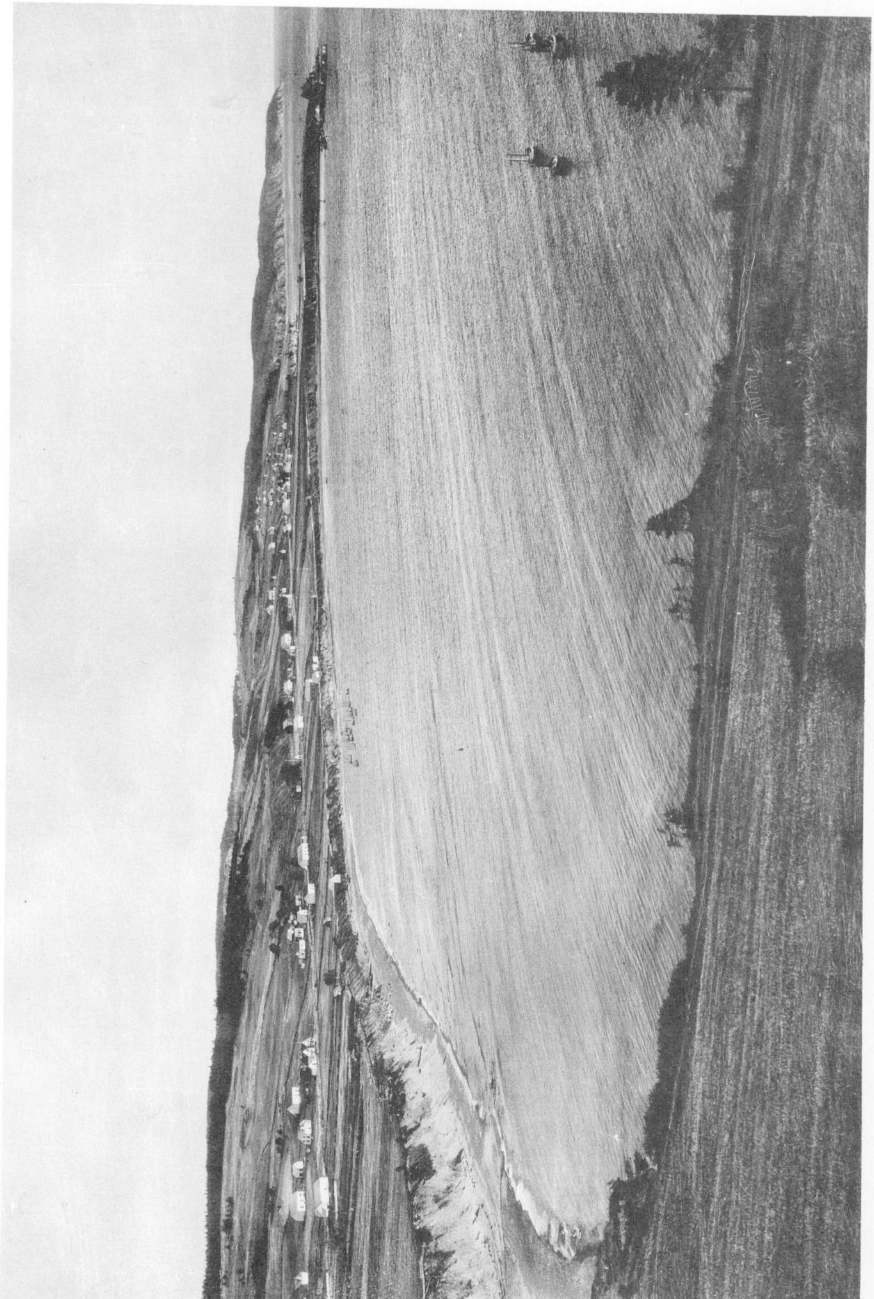


PLATE XI

Looking south from l'Enfer ridge into (east) McGinnis cove. To the left is Pillar Point ridge east to Harrington cove. West of l'Enfer ridge is Port Daniel bay, and far to the right is West point and the outer limestone ridge to Indian point. (Photograph by J. D. Dart.) (Page 49.)

PLATE XI

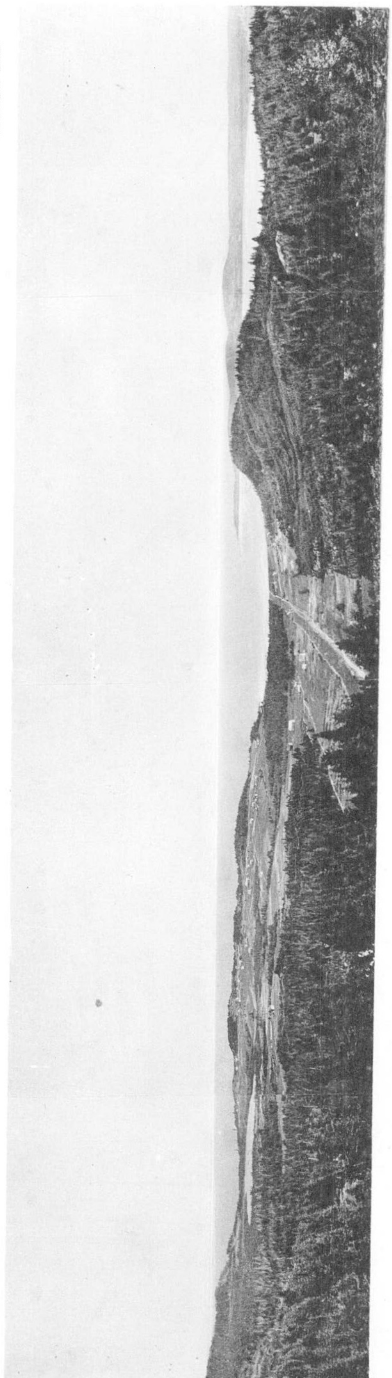


PLATE XII

Receptaculites sp.

A view of a flattened form which in shape and general appearance resembles *R. oweni* more closely than any other described species. (Page 62.)

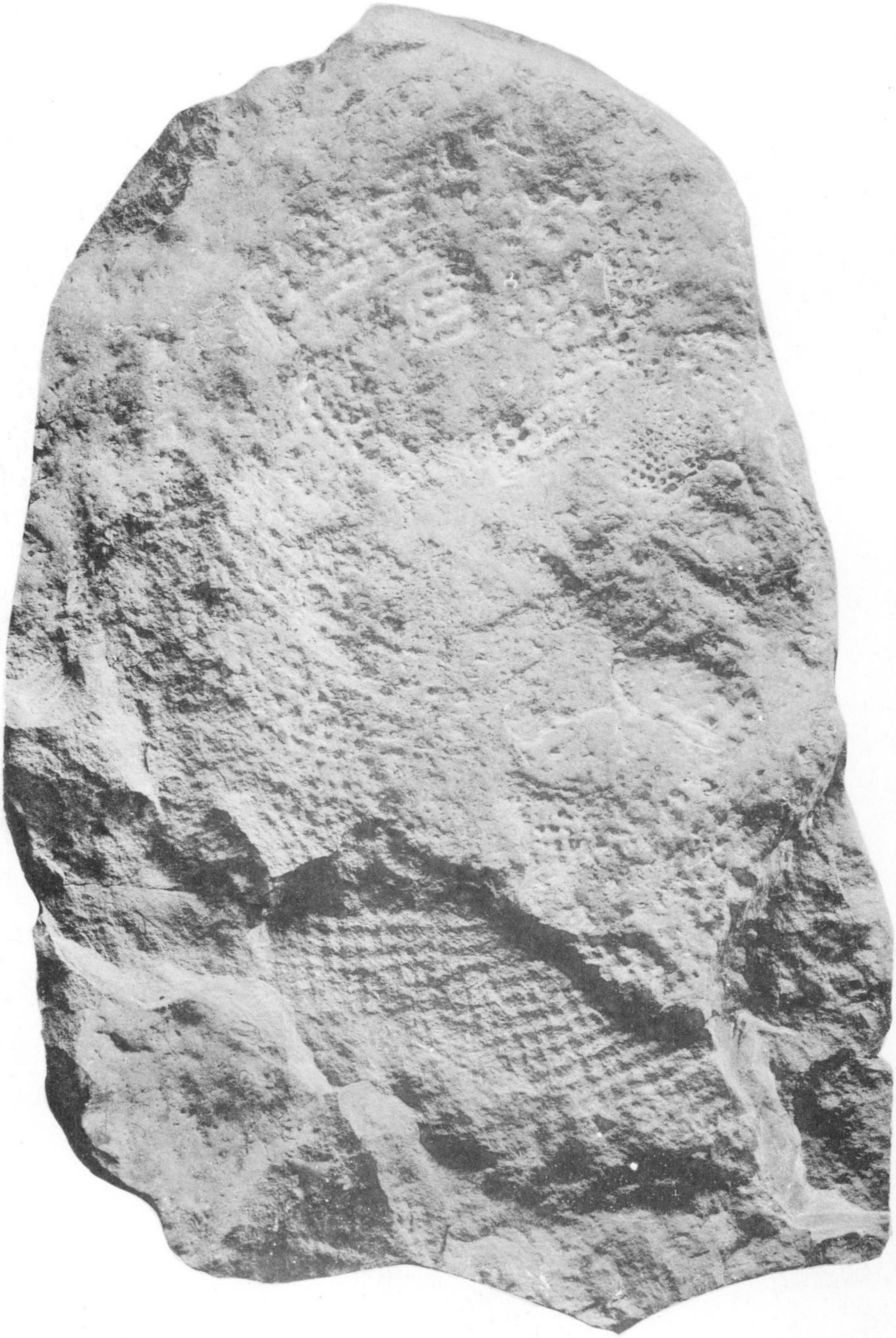


PLATE XIII

Camarotoechia sp.

FIGURES 1a, 1b. View of ventral valves of two specimens. (Page 62.)
FIGURES 1c, 1d. View of dorsal valves of two specimens. (Page 62.)

Strophomena sp.

FIGURE 2a. Dorsal valve showing the posterior depression and the character of the striæ. (Page 63.)
FIGURE 2b. Interior of the ventral valve showing the muscle scars. (Page 63.)

Leptaena sp.

FIGURE 3. Ventral valve of a very geniculate shell.

Strophomena ruga n. sp.

FIGURE 4a. Dorsal valve showing the peculiar surface markings. (Page 63.)
FIGURE 4b. Cast of a dorsal valve. (Page 63.)

Cyrtodonta septentrionis n. sp.

FIGURE 5a. Right valve showing posterior lateral teeth, a part of the shell with surface markings, and the pallial line. (Page 63.)
FIGURE 5b. Right valve of a smaller specimen. (Page 63.)
FIGURE 5c. View of the hinge-line of the smaller specimen X 2 to show the cardinal teeth. (Page 63.)

Conularia esclavensis n. sp.

FIGURE 6a. View of specimen. X 2. (Page 64.)
FIGURE 6b. View of surface markings. X 6. (Page 64.)

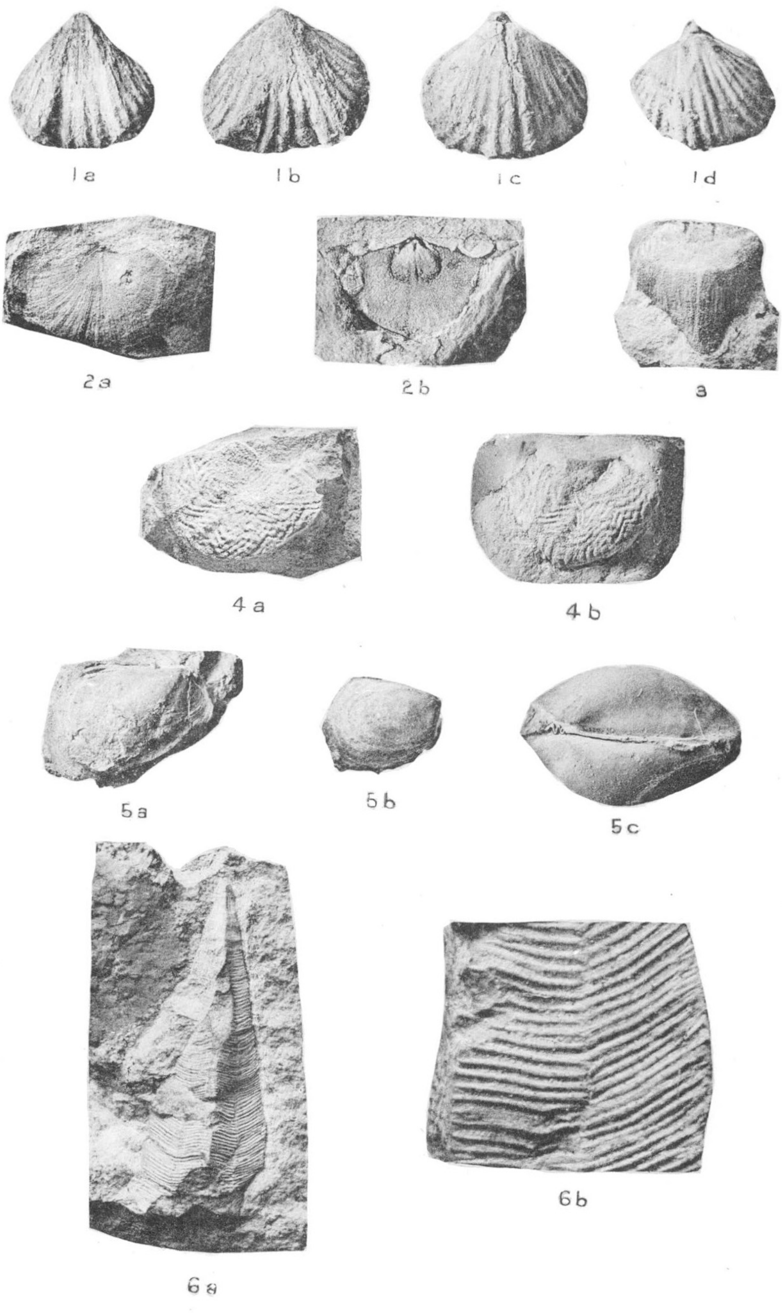


PLATE XIII

Plate XIV

Endoceras sp.

Figure 1. A, lateral view; the curvature of the preserved part of the phragmacone has been continued laterally so as to indicate the rate of expansion of the conch. B, cross-section at the smaller end of the same specimen, showing the size of the siphuncle. (Page 66.)

Phragmoceras sp.

Figure 2. A, lateral view of the living chamber, with the dorsal lobe of the aperture on the right and the ventral end of the aperture on the left. The dorsal margin of the aperture is erect, as in *Phragmoceras*, not incurved as in corresponding parts of *Gomphoceras*. B, the same specimen viewed from above, showing the general appearance of the aperture; if the living chamber had been tilted farther forward, the narrow, linear part of the aperture would have reached the ventral outline of the figure, and the constricted part of the aperture would have appeared narrower. (Page 68.)

Poterioceras (?) sp.

Figure 3. A, lateral outline of living chamber, exposing a single segment of the siphuncle at its base; a line of growth is present a short distance below the aperture. B, the same specimen, viewed from beneath, showing the dorso-ventral depression of the conch. (Page 69.)

Rizoceras (?) sp.

Figure 4. A, lateral view of living chamber, exposure a single segment of the siphuncle at its base. At mid-height there is a conspicuous line of growth. Along the upper left margin of the figure there is a projection which may not belong to the shell, and which may be above the margin of its aperture. Should it belong to the shell, the specimen could not be a Rizoceroid. B, basal view of the same specimen. (Page 70.)

Orthoceras sp.

Figure 5. A, dorsal side, showing the shallow dorsal lobes of the sutures of the septa. B, the same specimen viewed from above, showing its dorso-ventral depression, and the location and small size of the siphuncle. Both figures are magnified 2 diameters. (Page 70.)

Trochoceras (?) sp.

Figure 6. A, lateral view of the conch, exposing at its smaller end several of the air chambers; farther forward, a small part of the shell exposes the transverse surface markings; the remainder of the specimen consists of a cast of the outer surface of the shell, retaining distinct impressions of the transverse striæ, not represented in the figure. B, ventral side of that part of the specimen, near its apical end, which retains the transverse surface striæ; this figure should be inverted to indicate the location of the hyponomic sinus at former successive stages of growth of the conch. C, cross-section of the smaller end of that part of the specimen retaining its shell, locating the siphuncle. Figure 6A is magnified 3 diameters, figures 6B and C are magnified 3·5 diameters. (Page 71.)

Plate XIV

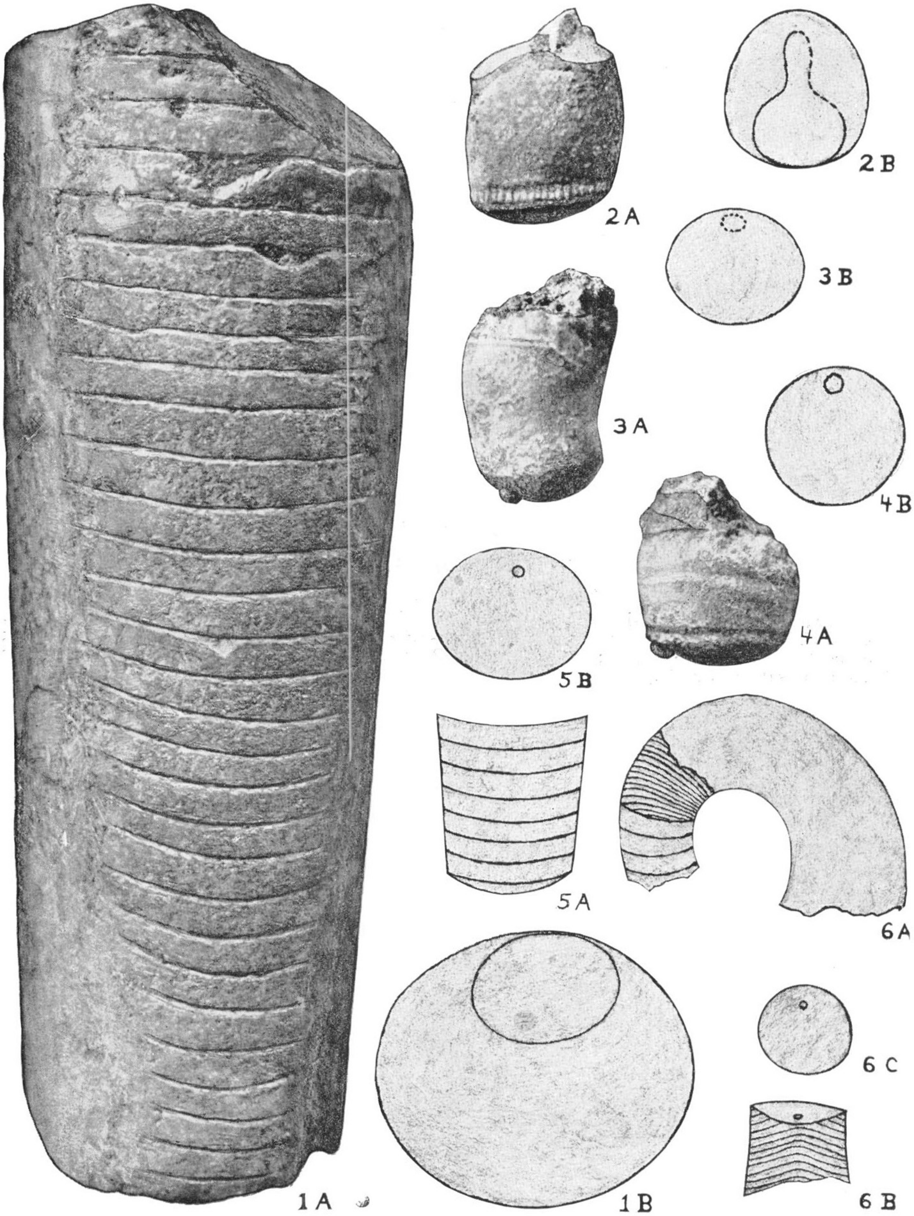


PLATE XV

Skull of *Thespesius saskatchewanensis*

Type No. 8509, Geol. Surv., Canada

Viewed from the left side. About $\frac{1}{5}$ natural size. *Dn*, dentary; *Ept*, ectopterygoid; *F*, frontal: *J*, jugal; *L*, lachrymal; *M*, maxilla; *N*, nasal; *P*, parietal; *Pal*, palatine; *Pmx*, premaxilla; *Por*, postorbital; *Prf*, prefontal; *Pt*, pterygoid; *Q*, quadrate; *Qj*, quadratojugal; *Sa*, surangular; *Sq*, squamosal. (Page 77.)

PLATE XV

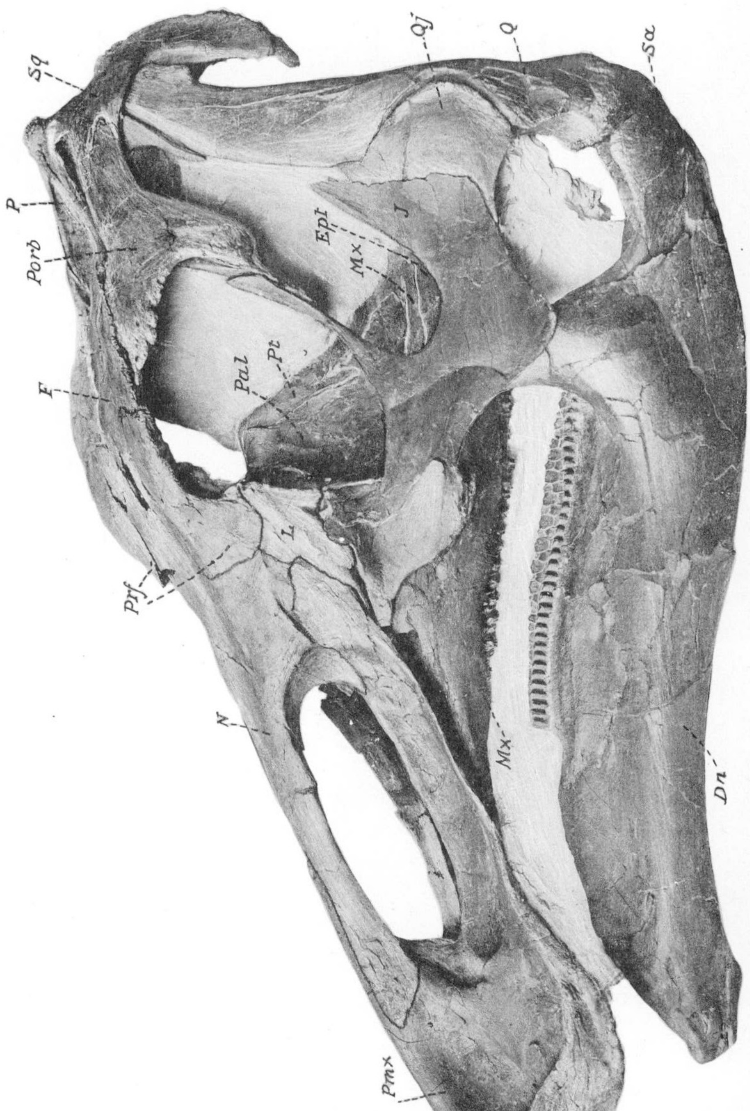


PLATE XVI

Left ramus of *Thespesius saskatchewanensis*

Type No. 8509, Geol. Surv., Canada

Internal view. *Ang*, angular; *Ar*, articular; *Dn*, dentary; *Par*, prearticular; *Sa*, surangular. ¼ natural size. (Page 75.)

PLATE XVI

PLATE XVII

Vertebræ of *Thespesius saskatchewanensis*

Type No. 8509, Geol. Surv., Canada

FIGURE 1. First to seventh and tenth to eighteenth dorsals. $\frac{1}{10}$ natural size. (Page 83.)
FIGURE 2. Sixth (?) caudal. Anterior view. $\frac{1}{3}$ natural size. (Page 83.)
FIGURE 3. Sixth (?) caudal. Inferior view. $\frac{1}{3}$ natural size. (Page 83.)

PLATE XVII

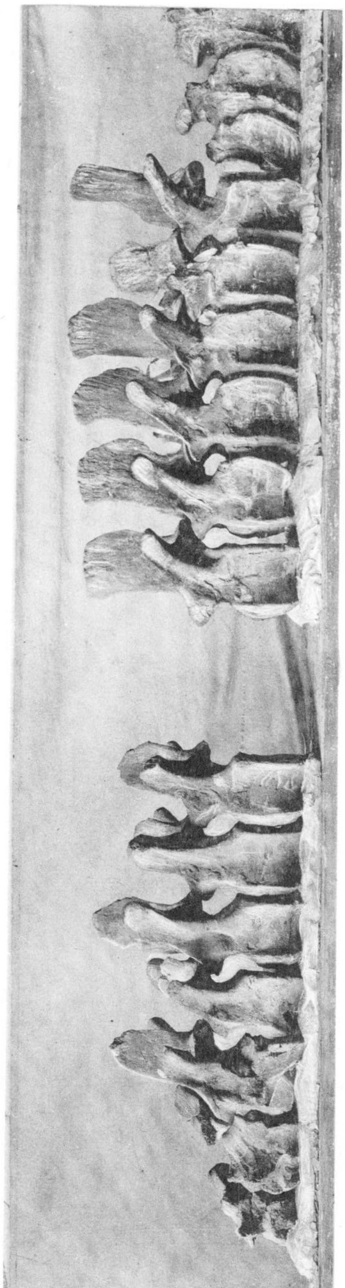


PLATE XVIII

Ornithomimipus angustus. (Cat. No. 8513), $\frac{1}{7}$ natural size. Impression of track as found on solidified sandstone. (Page 86.)

Plate XVIII

PLATE XIX

Perna weelaupensis McLearn n. sp.

FIGURE 1. Ligament of right valve of holotype. Vict. Mem. Mus., Cat. No. 7704. (Page 93.)
FIGURE 2. Right valve. Same specimen. (Page 93.)

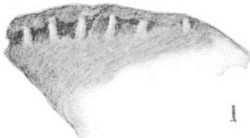
Ctenostreon gikshanensis McLearn n. sp.

FIGURE 3. Left valve of half-size specimen, showing proportions of posterior ear. Eight ribs. Paratype. Vict. Mem. Mus., Cat. No. 7700a. (Page 91.)
FIGURE 4. Right valve of holotype. Seven ribs. Vict. Mem. Mus., Cat. No. 7700. (Page 91.)

Ostrea weegeti McLearn n. sp.

FIGURE 5. Right valve of holotype. Vict. Mem. Mus., Cat. No. 7702. (Page 92.)

PLATE XIX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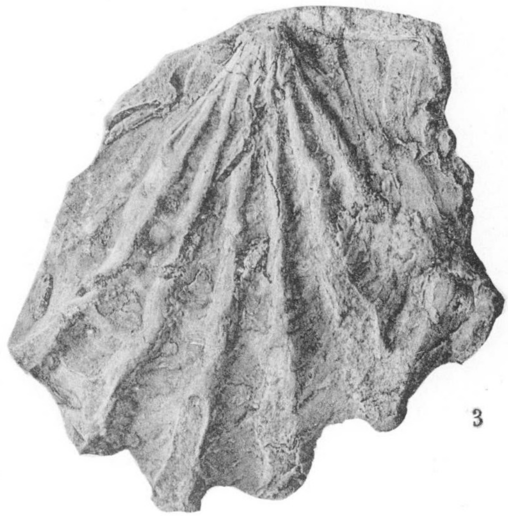
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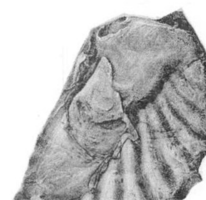
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PLATE XX

Lima tizglensis McLearn n. sp.

FIGURE 1. Both valves of holotype. Vict. Mem. Mus., Cat. No. 7701. (Page 92.)

Trigonia guhsani McLearn n. sp.

FIGURE 2. Top view of right valve of holotype. Vict. Mem. Mus., Cat. No. 7706. (Page 94.)
FIGURE 3. Right valve, same specimen. (Page 94.)

Plate XX

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PLATE XXI

Plagiostoma hazeltonense McLearn n. sp.

FIGURE 1. Left valve of holotype. Vict. Mem. Mus., Cat. No. 7705. X $\frac{9}{11}$. (Page 94.)

PLATE XXI

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PLATE XXII

Plagiostoma hazeltonense McLearn n. sp.

FIGURE 1. Radiating striæ near posterior end of right valve of a paratype. Vict. Mem. Mus., Cat. No. 7705d. (Page 94.)

FIGURE 2. Small specimen showing posterior ear of a paratype. Vict. Mem. Mus., Cat. No. 7705c. (Page 94.)

FIGURE 3. Dorsal view of a half-size specimen showing inflected area and anterior ear. Paratype Vict. Mem. Mus., Cat. No. 7705a. (Page 94.)

FIGURE 4. Ornament at posterior end of the right valve of a paratype. Vict. Mem. Mus., Cat. No. 7705b. (Page 94.)

FIGURE 5. Ornament a little posterior to middle of left valve of a paratype. Broad, flat bands separated by narrow grooves. Vict. Mem. Mus., Cat. No. 7705a. (Page 94.)

Guhsania ramata McLearn n. sp.

FIGURE 6. End view of holotype. Vict. Mem. Mus., Cat. No. 7711. (Page 99.)

FIGURE 7. Side view of same specimen. (Page 99.)

PLATE XXII

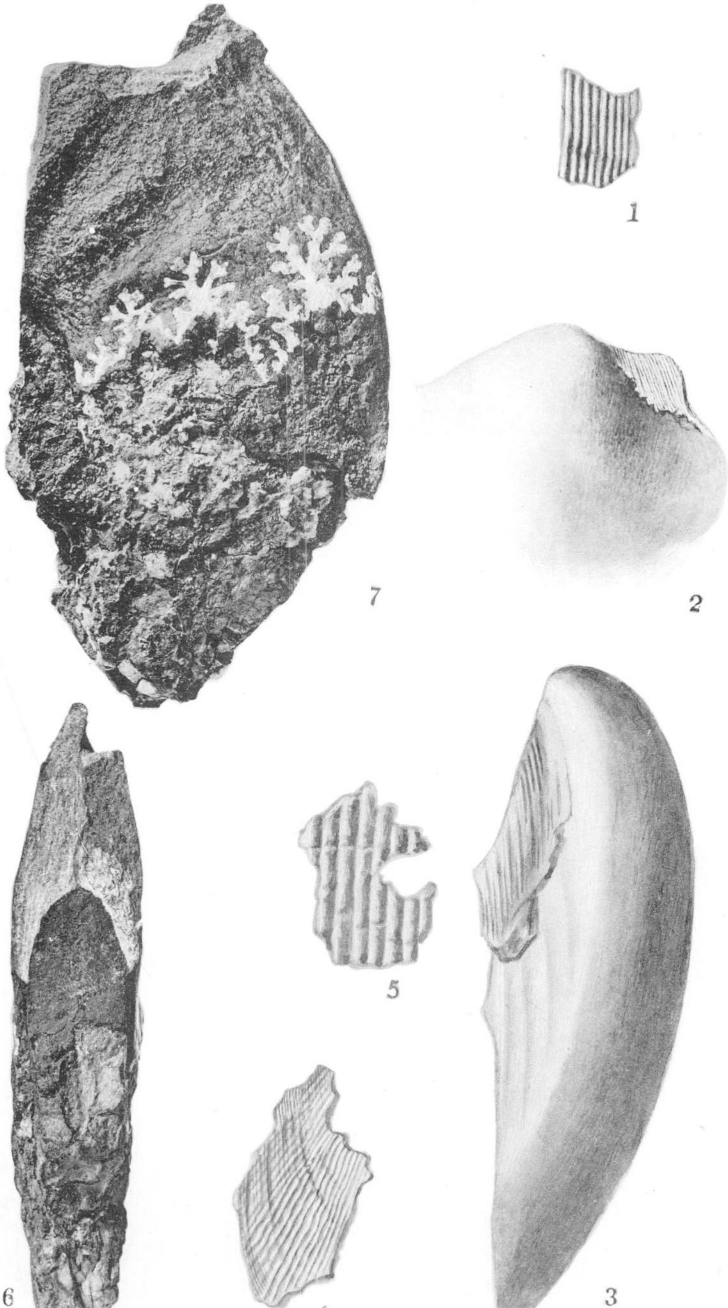


PLATE XXIII

Oxytoma submcconnelli McLearn n. sp.

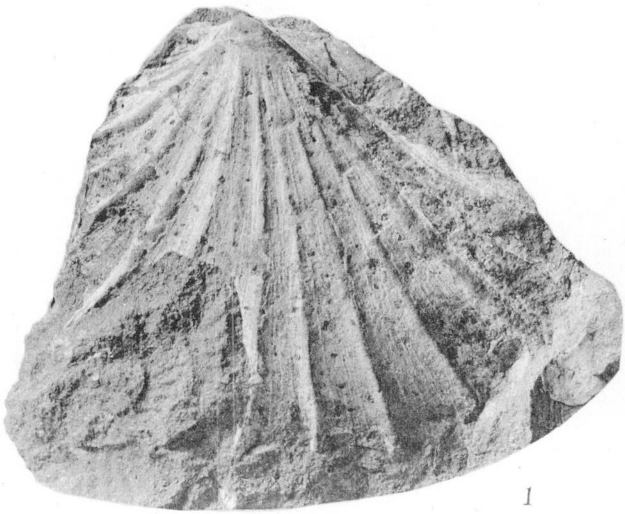
FIGURE 1. Left valve of holotype. Vict. Mem. Mus., Cat. No. 7703. (Page 92.)

Sonninia hansoni McLearn n. sp.

FIGURE 2. Side view of holotype. Details of first lateral lobe of first marked suture line imperfect. Vict. Mem. Mus., Cat. No. 7707. (Page 95.)

FIGURE 3. End view same specimen. (Page 95.)

PLATE XXIII



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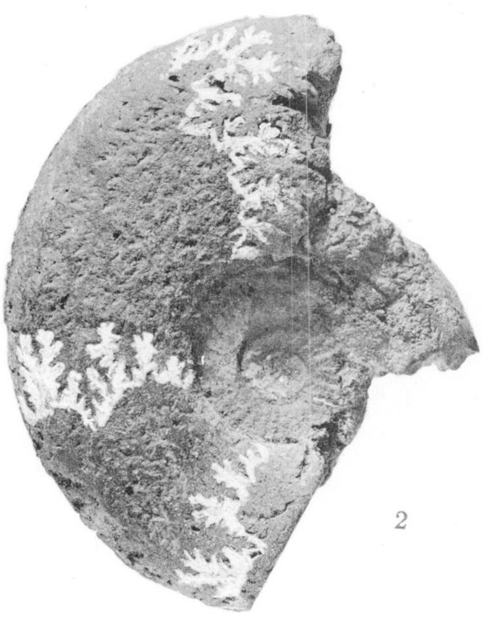

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PLATE XXIV

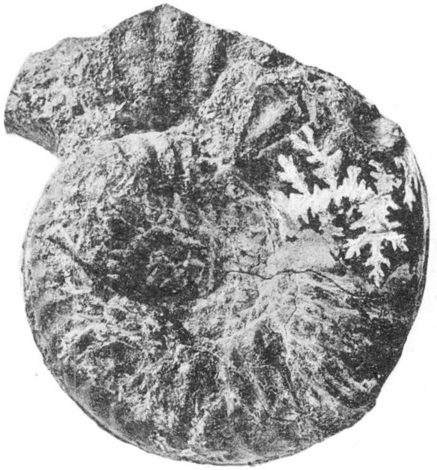
Sonninites skawahi McLearn n. sp.

FIGURE 1. Side view of holotype. Vict. Mem. Mus., Cat. No. 7709. (Page 97.)
FIGURE 2. View of periphery of same specimen. Note ventral sulcation. (Page 97.)

Sonninites silveria McLearn n. sp.

FIGURE 3. Side view of holotype. Remnant of keel at *a* removed in error. Vict. Mem. Mus., Cat. No. 7708. (Page 96.)

PLATE XXIV



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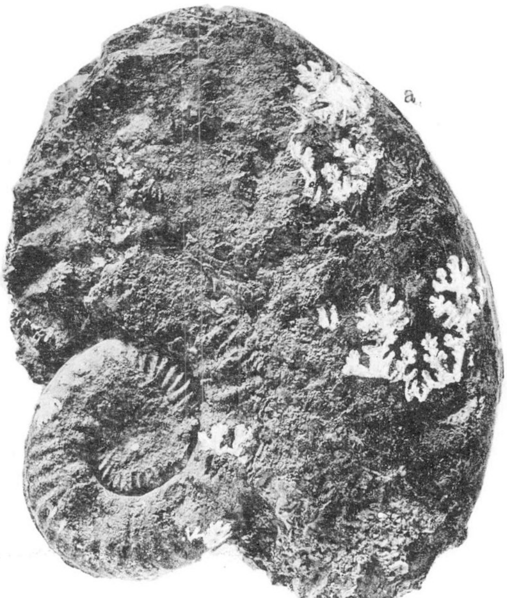

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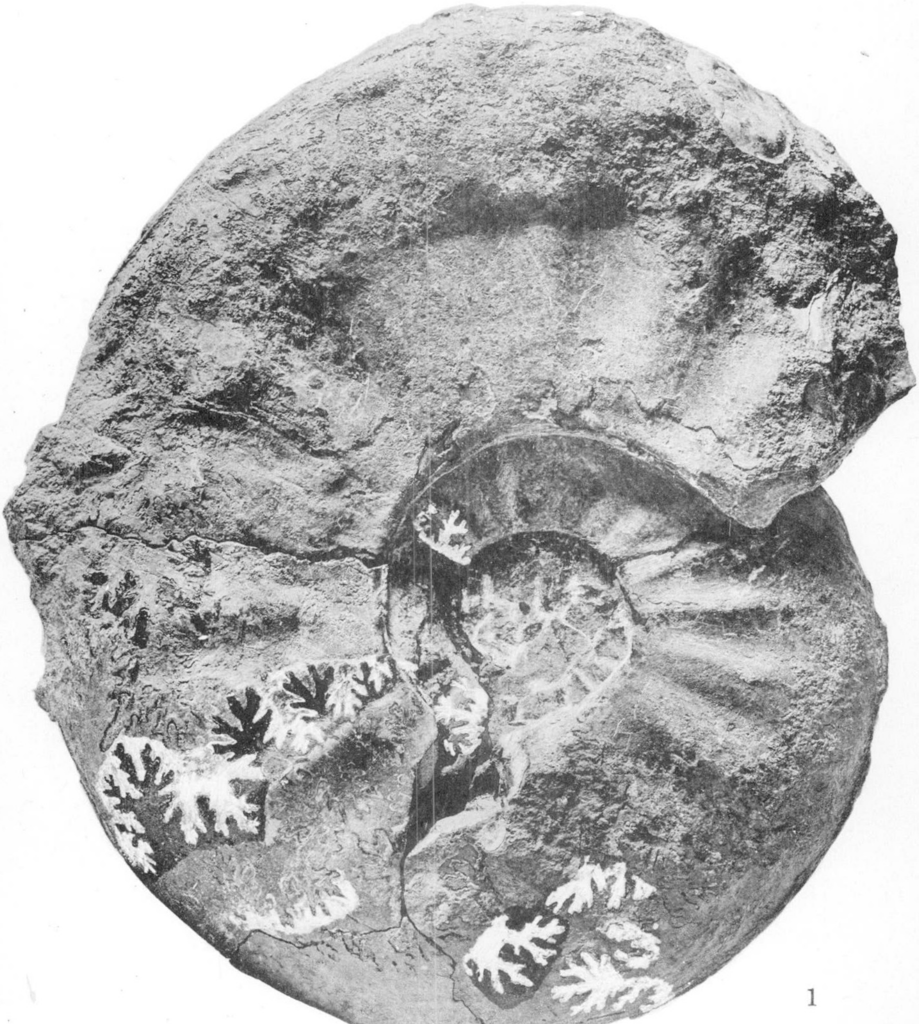
PLATE XXV

Guhsania bella McLearn n. sp.

FIGURE 1. Side view of holotype. Vict. Mem. Mus., Cat. No. 7710. (Page 98.)

PLATE XXV



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