Canada

Department of Mines

Hon. CHARLES STEWART, Minister;
CHARLES CAMSELL, Deputy Minister

Geological Survey

W. H. COLLINS, Director

Bulletin No. 42

GEOLOGICAL SERIES, No. 45 — May 8, 1926

CONTRIBUTIONS TO CANADIAN PALÆONTOLOGY

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1926

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CONTENTS

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UPPER PALÆOZOIC FAUNAS OF THE LAKE MINNEWANKA SECTION, NEAR BANFF, ALBERTA

By Hervey W. Shimer

CONTENTS

Illustrations

INTRODUCTION

Lake Minnewanka, often locally called Devils lake, is about 9 miles northeast of Banff in the Rocky mountains of western Alberta. It lies in a long, narrow valley, which, with a general east and west direction, forms a pass through the ranges from the foothills westward to Bow River valley. The lake itself occupies the western half of the valley, with a length of 11 miles and a nearly uniform width of half a mile. The valley is a continuation of that of the upper reaches of the eastward-flowing Bow river and this long, northeasterly-trending trough is crossed by the northwest-southeast valley of Cascade river and the southward-bending lower Bow. Bankhead, with its coal mines, is in the valley, 2 miles west of the western end of the lake. The higher mountain tops of the region vary from 8,000 to 9,000 feet in altitude, with mount Aylmer exceeding 10,000 feet.

The sections studied lie in the southern termination of the Palliser range where it rises from the northwestern shore of lake Minnewanka and the eastward continued valley of this lake, and also westward across Cascade river along the base of the Cascade range. The mountains consist, as do the vast majority of the eastern Rockies of Canada, of folds fractured at the summits and the resultant blocks tilted westward. The general dip is 45 degrees west.

In 1886 G. M. Dawson[1] published a "Preliminary Report on the Physical and Geological Features of that Portion of the Rocky Mountains between Latitudes 49° and 51° 30′." In that report the general physiography of the region here under discussion was outlined in the chapters on the Bow valley and on Devils lake and vicinity, and on the accompanying map the strata were treated as forming two stratigraphic groups: (1) the Kootenay, the Cretaceous, coal-bearing rocks; and (2) the Limestone series, Carboniferous, and Devonian.

[1] Geol. and Nat. Hist. Surv., Canada, Ann. Rept., 1885, pt. B, 169 pp.

These larger groups were somewhat subdivided by McConnell[1] in the diagram of a section measured across the mountains eastward from the Columbia valley to the gap of Devils Lake valley. The formations appearing in the section along the valley of lake Minnewanka are: (1) Cretaceous of the Cascade trough; (2) Banff limestone (Devono-Carboniferous); (3) Intermediate (Devonian); and (4) Castle Mountain group (Cambrian); but in the accompanying report the Banff limestone was subdivided into four members which, in descending order, are: Upper Banff shales, Upper Banff limestone, Lower Banff shales, and Lower Banff limestone.

In the geological map included in his report on the "Cascade Coal Basin", D. B. Dowling[2] gives as the geological section below the Kootenay the following:

Fernie shale	Jurassic
Upper Banff shale	Permian ?
Rocky Mountain quartzite	Carboniferous
Upper Banff limestone	
Lower Banff shale	
Lower Banff limestone	
Intermediate limestone	Devonian
Castle Mountain group	Silurian and Cambrian

E. M. Kindle[3] has presented a revision of the formational nomenclature of Banff district. His proposals are as follows:

Spray River formation (Upper Banff shale)		Triassic
Rocky Mountain quartzite		Pennsylvanian
Rundle limestone (Upper Banff limestone)		
Banff shale (Lower Banff shale)		Mississippian
Banff limestone and dolomite	Lower Banff limestone Intermediate limestone	Devonian
Sawback limestone		Cambrian

In the following account, the formational terms proposed by Kindle have been adopted, except that it is now proposed to restrict the name Banff to what was originally called the Lower Banff shale and to apply the term Minnewanka to the limestone and dolomite formerly referred to as the Lower Banff and Intermediate limestones and, as by Kindle, the Banff limestone and dolomite.

Thus the Minnewanka formation includes the old Lower Banff limestone above and the Intermediate limestone below. It is well exposed and fossiliferous in section 2, localities 38-77. The type locality is in section 4, along the north side of Devils gap—the gap connecting the eastern end of lake Minnewanka and the valley of Ghost river. This gap is the eastward continuation of Lake Minnewanka valley.

The Minnewanka formation rests disconformably upon the Ghost River formation of Walcott,[4] which is exposed $1\frac{3}{4}$ miles east of the Devils gap. Walcott describes it at its type locality 2 miles farther north as consisting of 285 feet of thin-bedded and shaly, buff-coloured magnesium limestones lying conformably between the superjacent Devonian beds (Intermediate limestone) and the Middle Cambrian limestones beneath (Cathedral formation). It contained no fossils. In section 4, localities 11-13 belong apparently to the Ghost River formation.

[1] McConnell, R. G., Ibid., Ann. Rept., 1886, pt. D, 41 pp.
[2] Dowling, D. B., Geol. Surv., Canada, Sess. Paper 26b, 1907.
[3] Pan-American Geologist, vol. 42, 1924, pp. 113-124.
[4] Smith. Misc. Coll., vol. 67, No. 8, p. 463, 1923.

The formational nomenclature used in the following report is briefly as follows:

Fernie formation		Jurassic
Spray River formation (Upper Banff shale)		Triassic
Rocky Mountain quartzite		Permian
Rundle formation (Upper Banff limestone)		Pennsylvanian and Mississippian
Banff formation (Lower Banff shale)		Mississippian
Minnewanka formation	Lower Banff limestone Intermediate limestone	Devonian
Ghost River formation		Age ?
Cathedral formation		Cambrian

DESCRIPTION OF FORMATIONS EXAMINED

The work here discussed was undertaken in the summer of 1910 for the purpose of determining with greater definiteness and detail the age of the various formations downward from the Upper Banff shale to the Intermediate limestone inclusive, to distinguish the boundaries between them, and to correlate their faunas with those of corresponding formations in other parts of America and elsewhere. To this end the formations were measured and examined in detail and a representative set of fossils was collected from each bed. The work, as it progressed, resolved itself more and more into an examination of the Rocky Mountain quartzite down to and including the Lower Banff limestone, for it was these formations which, in our section, were found to contain large and rather well-preserved faunas. No extensive collection had ever been made of these faunas which proved surprisingly abundant and comparatively well preserved, totalling 102 species.

Table of Formations

The rocks of this region are entirely sedimentary; the formations studied consist mostly of limestones and calcareous shales. The following is a table of the formations:

Triassic

Spray River formation (section 1, localities 1-8, and section 3, localities 1-2). Thickness about 1,500 feet.

Permian

Rocky Mountains quartzite (section 1, localities 9-20, 37 (downfaulted), and section 3, localities 3-4). Thickness about 600 feet (in section 1, 563 feet).

Pennsylvanian

Rundle formation (upper part) (section 1, localities 21-36, section 2a, localities 1-14, section 2, localities 1-20, section 3, localities 5-10, and section 3a, localities 1-6). Thickness about 1,500 feet (in section 2, 1,453 feet).

Mississippian

Rundle formation (lower part) (section 2, localities 21-31). Thickness about 600 feet (in section 2, 615 feet).

Banff formation (section 2, localities 32-37 and section 4, localities 1-4). Thickness about 1,200 feet (in section 2, 1,175 feet).

Devonian

Minnewanka formation (upper part) (section 2, localities 38-42, and section 4, localities 5-6). Thickness about 1,000 feet (in section 2, 1,050 feet).

Minnewanka formation (lower part) (section 2, localities 43-47, and section 4, localities 7-10). Thickness about 1,500 feet.

Age ?

Ghost River formation (section 4, localities 11-13).

Cambrian

Cathedral formation (Castle Mountain group) (section 4, localities 14-16).

DISCUSSION OF FORMATIONS

Spray River Formation (Triassic)

An alternation of heavy-bedded, light grey, calcareous sandstones and thin-bedded, dark grey, calcareous-arenaceous shales. The latter are especially conspicuous for their numerous black laminæ. The shales often weather reddish. At frequent intervals throughout the entire thickness occur many ripple-marks, mud-flows, minor crossbedding, and mud-cracks.

The contact with the Fernie shale above is apparently very abrupt, though the exact contact was not seen. The topmost hundred feet of the Spray River is a light grey, heavy-bedded, calcareous sandstone, whereas the lower Fernie is an alternation of black, very fissile shale and almost black limestone. The contact with the Rocky Mountain quartzite below is plainly seen in the Mount Aylmer region; here the two formations are apparently conformable, but the change from quartzite to arenaceous shale is rather abrupt, with a very conspicuous development of iron concretions for 5 or 6 feet at the contact.

Marine fossils occur throughout most of the formation, though locally restricted. They are often found in beds varying from 2 to 6 inches in thickness, although above and below they may be apparently entirely absent. They are very poorly preserved and the species are confined to Lingulæ and pelecypods.

Good collecting grounds for the Lingulæ occur about a fourth of a mile west of the bridge over Cascade river near lake Minnewanka. They lie about 450 feet north of the road upon the eastern side of a ridge, which is bounded east and west by swamps. The best place noticed for collecting pelecypods is in a 3-foot bed in a half cut upon the north side of the road 100 feet west of locality 10, section 1.

Rocky Mountain Quartzite (Permian)

An alternation of light grey quartzite and light grey limestone, the former predominating in the upper part, the latter in the lower where it merges imperceptibly with the Rundle limestone. The uppermost 50 feet contains considerable conglomerate, with rounded quartzite and calcareous pebbles up to 2 inches in diameter.

The formation is fossiliferous at intervals throughout its entire thickness, but mostly in its upper and lower parts. All the fossils are of marine origin. About 10 feet below the top is a very light grey chert bed 2 feet thick which is one mass of silicified fossils; the majority of these are specimens of *Euphemus carbonarius arenarius* and *Plagioglypta canna*. The same association of species here noted in this chert bed is seen in the Permian ? of the region between Pipe Spring and Toroweap valley in northwestern Arizona.[1] Besides these species the following occur abundantly and usually only in the upper beds of the Rocky Mountain quartzite: *Orbiculoidea arenaria, Productus semireticulatus, Paraphorhynchus obscurum, Bakewellia parva, Myalina wyomingensis,* and *Deltopecten occidentalis latiformis.*

[1] Shimer, H. W., "Permo-Triassic of Northwestern Arizona," G.S.A. Bull. 30, pp. 480-483.

Good collecting in the 2-foot *Euphemus* bed is found upon both sides of the road about a tenth of a mile west of the bridge over Cascade river, at locality 10, section 1. The white colour of this bed renders it very conspicuous. About half the distance from this bed to the bridge the upper 2 feet of a prominent ridge affords numerous fossils. This ridge extends both north and south of the road.

Rundle Formation (Pennsylvanian and Mississippian)

Thin-bedded, light to dark grey limestones, fine-grained beds alternating with coarse-grained, often being respectively chert-bearing and chert-free. The formation below this becomes more and more shaly until it merges with the Banff shale.

The fine to medium-grained limestones are usually fossiliferous, in many cases abundantly so. The coarse-grained beds are, as a rule, free from any identifiable fossils except crinoid joints.

The separation of the Rundle formation into a Pennsylvanian and a Mississippian division is drawn in section 2 at the base of locality 20. In this locality occurs *Spirifer rockymontanus*, and below in locality 22 there is an abundance of Mississippian species. No fossils were collected from locality 21, though our field notes speak of their presence and in such terms as to suggest that they are Mississippian, hence the division line is provisionally placed between localities 20 and 21.

Pennsylvanian Beds (Upper Two-thirds)

These beds of Lower Pennsylvanian age contain very many fossils, the most abundant of which are: *Lophophyllum profundum, Campophyllum torquium, Triplophyllum minnewankensis, Lithostrotion whitneyi, L. pennsylvanicum, Aulopora curva*, and *Syringopora pennsylvanica*, among corals; *Schellwienella lata, Productus coloradoensis, P. cora, Pustula punctata, Spirifer rockymontanus, S. cameratus, Reticularia setigera*, and *Composita ozarkana*, among brachiopods.

Excellent localities for the collection of these fossils occur upon both sides of Cascade river about a mile north of its junction with Devils creek, also upon the western slope of mount Aylmer.

Mississippian Beds (Lower One-third)

These strata of Lower Mississippian age contain numerous examples of the following species: *Syringopora surcularia, Schellwienella inequalis, Productus fernglenensis, P. gallatinensis, P. blairi, P. minnewankensis, P. burlingtonensis, Dielasma chouteauensis, Spirifer centronatus, S. striatiformis, Pseudosyrinx gigas, Spiriferella minnewankensis, Reticularia pseudolineata, Squamularia depressiplicata, Eumetria marcyi, Cliothyridina lata, Composita humilis, Myalina mississippiensis, Loxonema rockymontanum*, and *Paleocapulus equilatera*.

Fossils are abundant and easily collected upon the north side of the lake just east of the hamlet of Minnewanka. The first prominent ridge crossed in following the trail eastward contains the most prolific of these Mississippian beds noticed.

Banff Shale (Mississippian)

Predominantly a dark grey to black calcareous shale, weathering brownish. It is typically shale below, but becomes more and more calcareous above, until, with many repetitions of shale and limestone, it merges with the Minnewanka limestone.

Fossils are abundant throughout the formation, except in the lower 500 feet where none was noted. The most abundant species are: *Syringopora surcularia, Schellwienella inequalis, Spirifer centronatus, S. tenuimarginatus,* and *S. albapinensis,* the last two being abundant and apparently confined to this formation.

The best collecting ground noticed was on a partly weathered, southwestward sloping ridge about a quarter of a mile west of the gully forming the western termination of mount Standly (location B on Figure 1).

Minnewanka Limestone (Upper Part) (Devonian)

Heavy-bedded, light grey limestone. The upper 150 feet are alternately more thinly bedded and of a darker colour, being thus transitional to the Banff shale.

The formation is fossiliferous, though not conspicuously so, except in the upper part. Fossils were found at intervals throughout the entire thickness. At about the middle of the formation the rock is very conspicuous on account of its dolomitic segregations and possibly some algæ; these look more like poorly preserved forms of pencil-like, branching algæ or bryozoans. Some such segregations occur in most of the beds, and also in those of the lower part of the formation and the Castle Mountain group beneath. The most abundant fossils are: *Schuchertella girtyi, Productella pyxidata, P. coloradoensis, Schizophoria striatula, Spirifer whitneyi* and its variety *monticola, Cyrtia standlyensis,* and *Athyris angelica.*

The best collecting ground is on the western slope of mount Standly at the ravine forming its western boundary.

Minnewanka Limestone (Lower Part) (Devonian)

Alternating fine to coarse-grained limestone. The rocks when struck emit a strong odour of hydrogen sulphide.

Comparatively few fossils were noted; about 600 feet below the top they were rather abundant, though very poorly preserved. They indicate a Devonian age. A brachiopod which seems to be identical with *Spirifer whitneyi* is the most abundant fossil seen.

The best place for collecting these fossils is about one-fourth of a mile east of the base of mount Standly.

FAUNAL SUMMARY

The following table gives the distribution and abundance of all the species here discussed. C = very abundant; c = abundant; r = rare; R = very rare.

—	Permian			Lower Pennsylvanian																									Lower Mississippian													Devonian					P	Lower Pennsylvanian							L M		D
	I			I								IIa			II																																		III			IIIa				IV		
	10	14	18	22	24	27	29	31	32	33	34	3	10	14	1	2	6	8	9	10	11	12	13	14	15	16	17	18	20	22	23	24	25	26	27	28	29	30	32	33	34	35	38	40	41	42	45	3	6	7	10	1	3	4	5	2	3	5
Corals																																																										
Lophophyllum profundum (E. and H.)					C			R				r	r				R	C	R		r					c																								r		C	c					
Campophyllum torquium (Owen)																		c																																								
Hapsiphyllum calcareforme Hall ?								r		r						r		r							c					R		r	r																	c	c	c					c	
Triplophyllum dalii (E. and H.) ?														R																																												
T. minnewankensis n. sp																			?							C																								R			C					
Lithostrotion whitneyi Meek									C								C	C																																								
L. pennsylvanicum n. sp										c							C	C						C																											C			C				
L. sp											C							C																																				c				
Aulopora geometrica Girty																																						r																				
A. curva n. sp					C													C																																		c						
Syringopora surcularia Girty																														c				R						c	c																	
S. aculeata Girty																		C																							c																	
S. pennsylvanica n. sp																	C							c		?																											?			c		
Blastoids																																																										
Metablastus bipyramidalis (Hall)																															r																											
Brachiopods																																																										
Orbiculoidea arenaria n. sp		c																																																								
Leptaena analoga (Phillips)																																					R																					
Schuchertella girtyi n. sp																																											r															
Schellwienella inequalis (Hall)																														C	c	c	c	R		r	r		r			r																
S. lata n. sp																					c	C																																				
Chonetes illinoisensis Worthen																																		R																								
Productella pyxidata Hall																																											r															
P. cf. *laminatus* Kindle																																											R															
P. coloradoensis Kindle																																											r															
P. concentrica (Hall) ?																																	R																									
Productus ovatus Hall																																							R		?																	
P. fernglenensis Weller																														r	c	c	c		?		R																					
P. gallatinensis Girty																														C	r	c	C				r				r	?																
P. blairi Miller																																	c																									
P. minnewankensis n. sp																																	C																									
P. arcuatus Hall																																																									R	
P. burlingtonensis Hall																															r		r				r																					
P. semireticulatus (Martin)		c													?																																											
P. coloradoensis Girty ?		r																			c		C	r																																		
P. cora d'Orbigny				?		c	c	r				r	r	r				?			R		c																											c				c				
Pustula punctata (Martin)							r									c				R																																						
P. nebraskensis (Owen)																																																							r			
Schizophoria striatula (Schlotheim)																																											C															R
S. chouteauensis Weller																																										r																
cf. *Enteletes hemiplicata* Hall																																									R																	
Rhynchotreta sp																				R																																						
Camarotoechia sp																																											R															
C. cf. *endlichi* (Meek)																																											r															
C. elegantula Rowley																															r	?	r	r	?																						c	
Paraphorhynchus obscurum n. sp		C																				R																																				
Dielasma chouteauensis Weller																														c	C	r	c	r																								
D. arkansanum Weller		R																																																								
Spirifer whitneyi Hall																																											r				?											R
S. whitneyi monticola Haynes																																											c														?	c
S. whitneyi gallatinensis Haynes																																											r															
S. raymondi Haynes																																											r															r
S. albapinensis Hall and Whitfield																																										C															c	
S. tenuimarginatus Hall																																									r	c															r	
S. centronatus Winchell																														c	C	C	C				c	c	c	r	r															r		
S. centronatus minnewankensis n. var																																c	r																									
S. missouriensis Swallow																																																									r	
S. newberryi Hall																														R																												
S. striatiformis Meek																																	c				C																					
S. rockymontanus Marcou		R	r				r					c	c	c	r	c	c				C	C		r	r	r	r	c	r																				r				c	c				
S. boonensis Swallow emend. Girty																						c																																				
S. opimus Hall																						c																																				
S. cameratus Morton							r	r				c	c	c		r											r																															
Cyrtia standlyensis n. sp																																											C	r	c	R	?											r
Pseudosyrinx gigas Weller																														?	r	R		?			c	r			r																	
Spiriferella minnewankensis n. sp																														c	C	c			r	c																						
Ambocoelia magna n. sp																																										r																
Reticularia pseudolineata (Hall)																																	c	r	R		c	?			r																	
R. setigera (Hall)							c						c	c																																							c	R				
Squamularia depressiplicata n. sp																																C					r																					
Eumetria marcyi Shumard																															c																									?		
Hustedia circularis (Miller)																																										R																
Athyris angelica Hall																																											c															R
Cleiothyridina parvirostris (Meek and Worthen)																															r		r																									
C. lata n. sp																															c		c									R															R	
C. hirsuta (Hall)																														R																												
Composita humilis (Girty)																																C																										
C. persinuata (Meek)																															R																											
C. ozarkana Mather																					c		c																																			
C. subtilita (Hall)				c																																																						
Pelecypods																																																										
Parallelodon obsoletus (Meek)																						r																																				
Conocardium indianense Miller ?																																	R																									
Bakewellia parva Meek and Hayden		c																																																								
Myalina mississippiensis n. sp																														C	c	r	R	R	R																							
M. wyomingensis (Lea)		c																																																							
Deltopecten occidentalis latiformis n. var		C																																																							
Allorisma albertense n. sp																																R																										
Pleurophorus tropidophorus Meek																				R																																						
cf. *P. mexicanus* Girty		R																																																							
Scaphopods																																																										
Plagioglypta canna White	C																																															c										
Gastropods																																																										
Euphemus carbonarius arenarius n. var	C																																															c										
Euconospira turbiniformis Meek and Worthen		c																																																								
Straparollus quadrivolvis (Hall) ?																																																										R
S. umbilicatus Meek and Worthen ?	c																																																									
Strophostylus carleyanus (Hall) var																														R																												
S. sp																																R																										
Loxonema rockymontanum n. sp																																	c	R																								
Platyceras paralius White and Whitfield var																																	R																									
Paleocapulus equilatera (Hall)																															C	c																								c	?	
Orthonychia acutirostris Hall																															r																											
O. cyrtolites (McChesney)																															R																											
Igoceras subplicatum Meek and Worthen ?							R																																																			
I. sp														R																																												
Conularia alternistriata n. sp																																	R																									
Trilobites																																																										
Proetus peroccidens Hall and Whitfield																															R		R																									

Relationships of the Fauna

As is noted under the discussion of individual species, the Upper Devonian fauna is closely related to that of the Upper Devonian Ouray limestone as described from Colorado and New Mexico.[1] It also contains many species in common with the Three Forks formation of Montana as described by Haynes.[2]

The Mississippian fauna has a remarkably large number of species identical with those of the Kinderhook of the Mississippi valley.[3] This is especially true of the species from the Banff shale, but those from the Mississippian part of the Rundle limestone show a more decided Burlington affinity. This distinction appears to be true only in a general way, for the majority of species in the basal beds continue into the highest ones. The Mississippian beds also contain, mingled with the preceding, a few elements characteristic of the Keokuk and Warsaw formations of the east. The fauna is thus very similar to that of the Madison limestone of Wyoming and Montana as described by Girty from the Yellowstone National park.[4]

What was formerly called Pennsylvanian in this region is distinctly separated into an upper and a lower part, both lithologically and faunally. The fossils in the upper strata, the Rocky Mountain quartzite, are most noticeably different from those in the lower beds, the Rundle limestone. The majority of the species in both are also present at the similar horizons throughout much of North America. The upper, the fauna of the Rocky Mountain quartzite, is here characterized by such Permian species as *Euphemus carbonarius* var., *Plagioglypta canna*, and *Bakewellia parva*. Only two of the species found here occur also in the Lower Pennsylvanian of this region—*Productus coloradoensis* ? and *Spirifer rockymontanus*. Confined to the lower horizon are such characteristic Pennsylvanian species as *Lophophyllum profundum*, *Campophyllum torquium*, *Productus cora*, *Pustula punctata*, and *Spirifer cameratus*. With these occurs also a most noticeable Mississippian element consisting especially of three species of *Lithostrotion*, *Hapsiphyllum calcareforme*?, *Syringopora aculeata*, and *Reticularia setigera*. All these species are very abundant here; they are not represented by a few decadent individuals but were evidently thoroughly acclimated to their Pennsylvanian environment. The early Pennsylvanian aspect of these faunas is further emphasized by the presence of some species (such as *Composita ozarkana* and *Dielasma arkansanum*) described by Mather[5] in basal Pennsylvanian beds from Arkansas and Oklahoma.

GEOLOGICAL HISTORY OF THE REGION

The history of this region, so far as the rocks of our section are concerned, began with the submergence of the entire area beneath the sea during Cambrian time, as attested by the marine fossils, including an abundance of trilobites, in the sediments of the Castle Mountain group. If the Upper Ordovician and the Silurian were periods of deposition for this

[1] Girty, U.S. Geol. Surv., 20th Ann. Rept., pt. 2, 1900, p. 31.
Kindle, E. M., U.S. Geol. Surv., Bull. 391, 1909.
[2] Annals Carnegie Mus., vol. 10, 1916, p. 13.
[3] Weller, "Mississippian Brachiopoda," Illinois Geol. Surv., Mono. 1.
[4] U.S. Geol. Surv., Mono. 32, pt. 2.
[5] "The Fauna of the Morrow Group of Arkansas and Oklahoma," Bull. Sci. Lab. Denison Univ., vol. 18, 1915, pp. 59-284.

region, all the sediments then deposited must have been eroded before the ocean again invaded this region during the Devonian and deposited the Minnewanka limestones. During the long time represented by the deposition of some 2,500 feet of calcareous rocks, the waters were comparatively shallow, for crossbedding occurs at intervals throughout the entire thickness of beds.

The ocean was then drained from this area and remained away so long that when it returned not a single species of those animals so common in the Devonian sea returned with it; yet the beds still remained horizontal as when laid down, for the sediment distributed by the waters of the Lower Mississippian are conformable to the beds beneath. The land remained under water for an interval sufficiently long for 1,200 feet of black and grey calcareous muds, the Banff shale, to accumulate, and above them 600 feet of limestone, the lower part of the Rundle limestone. That the waters were never very deep is evidenced by the persistently recurring crossbedding, more usually present in the coarser-grained beds. At times the sea bottom swarmed with bivalves of various kinds; at other times the condition of the sea bottom or of the water was such that during the deposition of hundreds of feet of limestones or calcareous shales not a single well-preserved shell was included.

The ocean again retired from this region at the close of the Lower Mississippian and did not return until Lower Pennsylvanian time. The life of its shores had again almost entirely changed; a few species only of all those inhabiting the ocean when it covered this region in early Mississippian time returned with it in the Pennsylvanian. The sediments brought in by the rivers and deposited by the ocean at this time, now forming the upper part of the Rundle limestone, give evidence by frequent crossbedding that the waters were never very deep. The abundance of coral reefs similarly indicates shallow waters.

That the land again emerged before the deposition of the sands forming the Rocky Mountain quartzite is indicated by the conspicuous difference between the fauna of the quartzite and that of the Rundle limestone, a difference apparently too pronounced to be accounted for only by the sands of the ocean bottom and the nearness of land.

Again the ocean was drained from the region and did not return until the Triassic when it deposited the muds of the Spray River formation. During the deposition of this shale the region remained more or less continuously under water, as marine fossils occur through its thickness. The presence of Lingulæ apparently indicates a near-shore deposit; these Lingula beds are, moreover, mostly crossbedded and ripple-marked. Mudcracks are somewhat abundant, but were never found associated with fossils; these may indicate land conditions for a time.

DETAILED DESCRIPTION OF SECTIONS

Several sections were made, partly to clear up debated ground in the main sections and partly to include some very fossiliferous beds. The main section is section 2, supplemented above by the upper part of section 1 (localities 1 to 20 inclusive).

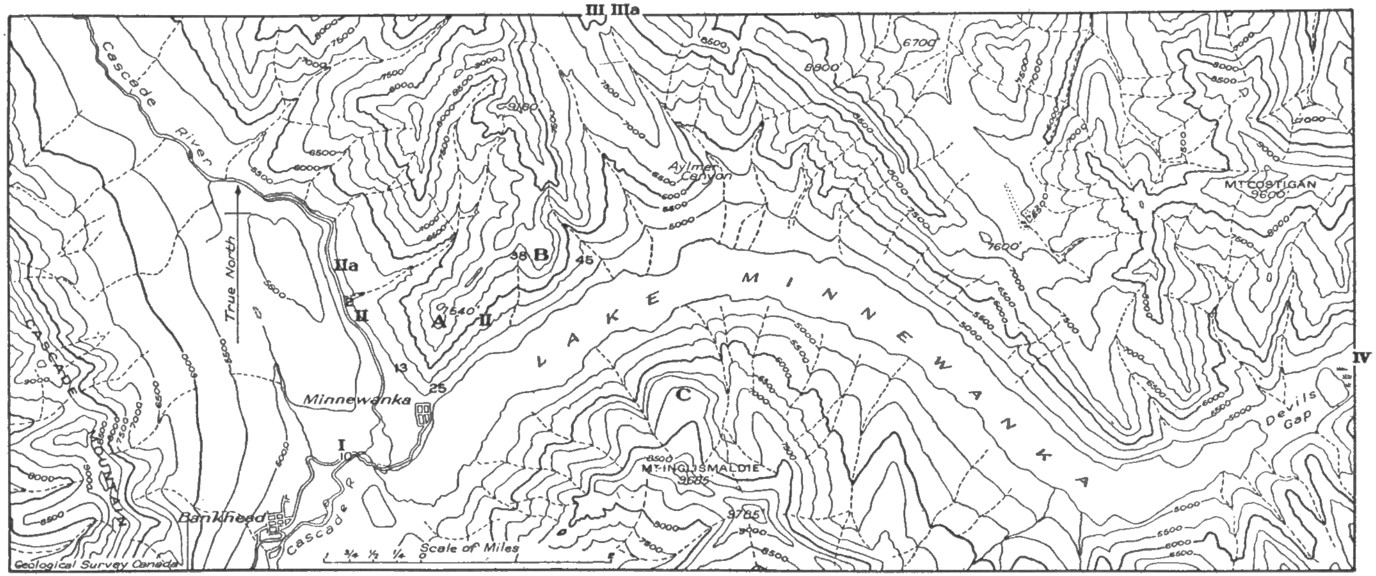

FIGURE 1. Index map showing location of measured sections (I, II, IIa, III, IIIa, and IV) and of some horizons (2, 10, 13, 25, 38, and 45). Contour interval, 500 feet. The letters A, B, and C mark localities referred to in text.

Section 1, localities 1 to 19 inclusive, was made along the road and Cascade river from northeast of Bankhead to the junction of the river with Devils creek, the outlet of lake Minnewanka. Here was an excellent section of the Spray River shale and the Rocky Mountain quartzite. The remainder of the section (in the Rundle limestone) is continued upon the western side of the river about 1½ miles north of its junction with Devils creek[1] and was measured, across the strike, eastward to Cascade river. The two parts of this section were connected by a common datum plane (the beds of locality 17) so that the measurements could be made rather exactly.

Section 2a extended south along the east bank of Cascade river from Stewart canyon to the beginning of section 2. It included some very black shale beds which were largely concealed in section 1.

Section 2 began at Cascade river just south of its junction with the most southerly gulch north of Minnewanka lake entering the river from the east. It was continued east-northeast along the northern shore of lake Minnewanka, that is, along the southwestern edge of the Palliser range, including the southern edges of mount Astley[2] (location A on Figure 1), the Castle,[3] and mount Standly.[4] This section gave excellent exposures of the Rundle limestone, the Banff shale, the upper part of the Minnewanka limestone, and much of the lower part as well.

Section 3 was made rather hurriedly up the southern slope of mount Aylmer, at the western edge of the head of Aylmer canyon. Its purpose was to secure the contact between the Spray River shale and the Rocky Mountain quartzite.

Section 3a was made somewhat farther down the slope of mount Aylmer to include some very fossiliferous beds.

Section 4 was made along the northern edge of the valley forming the eastward continuation of the Lake Minnewanka valley. The section extends from the northwestern end of West lake to the gully at the western end of Middle lake.[5] The purpose of this section was mainly to get the lower part of the Minnewanka limestone and its relation to the Castle Mountain group below.

Section 1

Along road and Cascade river from northeast of Bankhead to junction of river with lake Minnewanka, and 1½ miles north, along a line north 58 degrees east. The strike of the beds is about north 22 degrees west, dip usually about 40 degrees southwest.

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[1] This creek has been practically obliterated since these sections were made, by the damming up of the lake for waterpower and the consequent raising of its surface 9 feet above its former height.

[2] The name applied locally to the peak between Stewart canyon and the western end of lake Minnewanka. It was given in honour of Mr. C. D. Astley who lived at its southern foot for twenty years.

[3] The local name of a castle-like cliff, as seen from the lake, east of mount Astley, formed of almost horizontal strata and separated from the rocks east and west by ravines.

[4] A name here applied to the prominent projection just west of Aylmer pass, between the pass and the lake. The name is given in honour of Mr. John Standly who was the first to operate profitably on this lake a boat for the accommodation of tourists and thus assured the continuation of this accommodation.

[5] There are three lakes in this valley between lake Minnewanka and Devils gap, which are named West, Middle, and East lakes, respectively.

Fernie (Jurassic)

The lowest part of this formation is exposed along both sides of the river half a mile northeast of Bankhead. The formation here consists of an alternation of black, very fissile shale and very hard, almost black limestone. These form a succession of beds varying in thickness from half an inch to several feet.

Spray River Formation (Triassic)

(1) A light grey, very hard sandstone, with a few thin intercalated shale bands..100 feet

The dip changes from 80 degrees west in the upper beds to 40 degrees west in the lower beds. This change in dip was noted both along Cascade river and the Bankhead-Lake Minnewanka road.

(2) Heavy-bedded, light grey sandstones, alternating with more thinly bedded shales weathering reddish. Both contain black laminæ, which in the shales are very conspicuous..450 feet

(3) Dark grey, thinly laminated, calcareous shales, brownish to reddish...... 20 feet

These are fossiliferous where exposed just south of the road on a bluff by the side of the river. The fossils are very poorly preserved.

(4) Heavy-bedded, light grey sandstones, alternating with dark, thinly bedded shales, the latter weathering reddish and especially conspicuous for their numerous black laminæ..350 feet

Many of these beds, especially in the lower half, show minor crossbedding, ripple-marks, mud-cracks, and mud-flows. Strike north 53 degrees west; dip 33 degrees southwest.

Fossils were very rarely noted in these beds; only a pelecypod here and there was seen.

(5) Light grey, fine-grained sandstone, weathering shaly (Lingula bed)...... 2 feet

This layer is especially characterized by a great abundance of Lingulæ and pelecypods; the former weathering bluish, are very noticeable. This bed can best be seen on the north margin of the river and also 450 feet north of the road along the strike of the beds, upon the east side of an east and south sloping ridge, bounded on the west by a small swamp and on the east by a much larger one. The latter locality is especially good for collecting as the bed is well weathered. Ripple-marks are abundant both in and directly above and below this bed.

(6) Dark grey, thinly laminated sandstones, many weathering reddish. Many ripple-marks, mud-cracks, and mud-flows present................. about 500 feet

About 150 feet below the top a sparse bed of Lingulæ and pelecypods was noted.

(7) Dark grey sandstone and shale, weathering brownish. These are exposed in a half cut on the north side of the Bankhead-Lake Minnewanka road.......... 3 feet

The middle 3 inches especially is full of fossils.

(8) The upper 27 feet similar to the last and weathering reddish. The lower 52 feet not exposed here but the contact with the Rocky Mountain quartzite was observed in section 3.. 73 feet

Rocky Mountain Quartzite (Permian)

(Beds 18 to end were noted about 1½ miles north along the west side of Cascade river.)

(9) Quartzite. A few angular pebbles up to an inch in diameter were noticed. 10 feet

(10) Light grey quartzite, weathering white............................ 2 feet

Most of this bed was originally almost a calcareous coquina, so full of fossils is it, but all are now entirely silicified. Some quartz sand grains were mixed with the shells. The bed is well exposed for collecting along both sides of the road, a few yards in from its edge. The bed projects out into the road from the north as a very light grey ledge, a foot wide, 40 feet west of the black ridge of locality 12.

(11) Beds of quartzite alternating with dolomitic conglomerate which weathers light grey and contains many pebbles, up to 2 inches in diameter, of reddish and grey quartzite.......... 22 feet

(12) A thin-bedded limestone, with chert in nodules and bands, and a few thin bands of quartzite. It is unevenly bedded. The topmost layer is a 3-foot bed of conglomeritic quartzite, composed mostly of rounded quartzite and dolomitic limestone pebbles up to 6 inches in diameter; it is very resistant and forms a prominent ridge which is the conspicuous black ridge just east of the point where the reddish shales end on the Bankhead-Minnewanka Lake road.......... 20 feet

(13) Alternating quartzites and limestones. The upper 6½ feet is a heavy bed of quartzite, and 38 feet from the base are 19 feet of quartzites, with a few thin dolomitic bands included.......... 96 feet

(14) Solid bed of light grey quartzite.......... 2 feet

This bed forms the top of a prominent ridge as it is overlain by softer limestones. It is very full of external and internal moulds of fossils; when deposited nearly one-half of its mass must have been composed of shells. Brachiopods are largely confined to the upper foot and pelecypods to the lower foot, yet there appears to be no corresponding difference in the rock itself.

(15) Light grey, heavy-bedded quartzites..........150 feet

Thirty feet above the base is the western edge of the road where it crosses the bridge over Cascade river.

(16) Alternating thin-bedded quartzites and limestones.......... 94 feet

(17) Quartzite (this stratum is an excellent horizon marker for following across the country).......... 12 feet
(a) Thin-bedded quartzite weathering shaly.......... 7 feet
(b) A heavy bed of reddish grey quartzite.......... 5 feet

(18) A light grey limestone very full of large, light grey chert nodules arranged parallel with the bedding. This weathers back rapidly, causing the beds above and below to stand out as ridges.......... 11 feet

In the upper part of this bed are a few specimens of Zaphrentoid corals and Spirifers. These are all coarsely silicified, with consequent loss of detail.

(19) Alternation of light grey dolomites and quartzites, extending to near the base of the bluff at the north edge of the junction of Devils creek with Cascade river. The upper limestone beds are conspicuously seamed with thin white quartz bands, an eighth of an inch thick; these are especially conspicuous at right angles to the bedding plane. A few rows of grey chert nodules are present and along some bedding planes, especially the upper ones, these take the form of finely disseminated quartz particles..........97·5 feet

(a) A light grey limestone, with few chert nodules. It includes a 4-inch quartzite band 3 feet above the base. Strike north 53 degrees west; dip 33 degrees southwest..........16·5 feet
(b) Thin-bedded quartzite, with a considerable number of iron nodules so that the beds weather reddish.......... 5·5 feet
(c) Cherty grey limestone.......... 1·5 feet
(d) A heavy bed of quartzite.......... 5 feet
(e) Light grey limestone. This erodes rapidly by shaling across the bedding plane.......... 3·5 feet
(f) A light grey limestone..........30 feet
(g) Cherty quartzite, weathering reddish.......... 2·5 feet
(h) Grey limestone, with small, scattered chert nodules..........33 feet

(20) Light grey, thin-bedded quartzite, weathering brownish. Some scattered grey chert nodules and a few iron nodules are present. There is much minor crossbedding throughout the beds. The basal 2 feet are a greenish quartzite; the 1½-foot bed above this is limestone, weathering porous................46·5 feet

In the upper 16 feet were found very poorly preserved cup corals and Spirifers.

Rundle Limestone (Upper Part) (Lower Pennsylvanian)

(21) Beds concealed, except the upper 10 feet which are light grey limestones, weathering very rapidly by shaling across the bedding plane. These upper limestones, if our correlation of sections is correct, are underlain by a continuation of the soft, black, calcareous shales of section 2, localities 1 to 4, and become, accordingly, quickly covered by a soil..125 feet

(22) A light grey, calcareous shale, weathering purplish. Upon its disintegration in cold hydrochloric acid there remains a residue of purplish mud. It contains numerous small chert nodules, many of which, especially upon and near the surface of the rock, are a yellowish red jasper. The uppermost beds are of a darker colour and very shaly...12 feet
Fossils are abundant in the middle beds.

(23) Light grey limestone..53·5 feet
(a) Limestone, with very little grey chert nodules........................13·5 feet
(b) Limestone weathering brownish.................................... 3 feet
(c) Not exposed...37 feet

(24) Light grey limestone, with scattered black to grey chert nodules. Strike north 53 degrees west; dip 33 degrees southwest........................37·5 feet

The uppermost 5 feet have numerous large grey chert nodules; these 5 feet are especially characterized by a very great abundance of *Aulopora curva* and *Lophophyllum profundum.* A gastropod, somewhat resembling *Euphemus nodocarinatus*, was also noted.

Chalcedonic pseudomorphs after apatite are here very noticeable.[1] These perfect hexagons vary in diameter up to 5 mm. and in length up to 6 mm. The majority have a diameter of 4 mm. and a length of 5 mm. They stand out conspicuously upon weathered surfaces but are present in the same chemical state to the depth of at least an inch, which is the greatest rock thickness of any of our specimens. These occur in the Pennsylvanian strata of sections 1, locality 24 (C); 2, locality 11 (c); 3a, locality 1 (C).

(25) Fine-grained, light grey limestone, weathering brownish. About 6 feet above the base are many small quartz geodes.............................21 feet

(26) Mostly covered. Light grey limestone where exposed................88 feet

(27) Light grey limestone..10·5 feet
Contains many specimens of *Productus cora.*

(28) Largely concealed. Dark grey limestone where exposed..............78 feet

(29) Largely concealed..67 feet

The uppermost foot contains many specimens of *Productus cora*, also a few specimens of *Pustula punctata, Spirifer cameratus*, and *S. rockymontanus.*

(30) Dark grey, medium-grained limestone with minor crossbedding....... 11 feet
A few cup corals were noted.

(31) Limestones, alternating light and dark grey, with many large, light grey, chert nodules. Crossbedding present in the upper beds...................... 20 feet

[1] Professor C. H. Warren, of the Mass. Inst. of Tech., kindly identified the specimens for the writer.

The following fossils were noted: *Hapsiphyllum calcareforme ?*, *Productus cora*, and *Spirifer cameratus*.

(32) Rock as in 31 .... 47 feet

Eighteen feet from the top is a 3-inch band containing many specimens of *Lithostrotion whitneyi*.

(33) Rock as in 31 .... 36 feet

These beds are characterized by an abundance of *Lithostrotion pennsylvanicum* heads, especially the upper beds. The chert nodules extend through the upper 31 feet.

(34) Dark grey limestone, medium grained .... 16 feet

The basal bed rapidly erodes by shaling across the bedding plane. Just above this are many specimens of *Lithostrotion* sp.

(35) Coarse-grained, dark grey limestone .... 92 feet

A few fossils are scattered through these beds.

(36) Mostly covered. Where exposed the rock is similar to that of 35 .... 207 feet

Rocky Mountain Quartzite (Permian)

(37) Light grey quartzite, weathering reddish. Dip about 60 degrees west. 88 feet

This extends down to the present flood-plain of Cascade river. The beds are down-faulted Rocky Mountain quartzite; there is much evidence of minor faulting in the beds. The main fault probably is near the junction of localities 36 and 37.

Section 2a

Along Cascade river, beginning at the southern part of Stewart canyon. This section was noted southward along the river, to which, for much of the distance, the strike of the beds is parallel.

Rundle Limestone (Upper Part) (Lower Pennsylvanian)

(1) A solid bed of limestone. Strike north 55 degrees west; dip 57 degrees southwest .... 5 feet

(2) Grey limestone .... 97 feet

(3) Medium-grained grey limestone. This forms a conspicuous ridge. The upper 2 feet are full of chert nodules .... 15 feet

The upper part is very full of *Spirifer rockymontanus*.

(4) Light grey, medium-grained limestone, capped by 1½ feet of calcareous shale, weathering brownish, the latter closed basally by a chert band .... 6 feet

(5) Grey limestone .... 13 feet

(6) Calcareous sandstone; the minute sand grains make up slightly less than half the rock mass. Chert nodules are present .... 3 feet

(7) Very compact, fine-grained calcareous shale, dark grey above, black below 21 feet

(8) Not exposed .... 27 feet

(9) Light grey limestone .... 9 feet

(10) Dark grey limestone .... 5 feet

Contains many specimens of *Spirifer rockymontanus;* as the fossils are white, the dark colour of the enclosing rock renders them very conspicuous.

(11) Very black calcareous shale. The rock is conspicuously fissile across the bedding plane. Dip 20 degrees west .... 2 feet

(12) Light grey limestone, weathering slightly brownish. Dip about 25 degrees west .... 32 feet

(13) Light grey limestone, weathering slightly brownish. Dip about 30 degrees west. Localities 10, 11, 12, and 13, pass over a slight fold .... 35 feet

(14) Very black calcareous shale, conspicuously fissile across the bedding plane. Effervescence in cold hydrochloric acid leaves the rock mass very slightly reduced in volume but become an impalpable black mud. Dip 57 degrees west; strike north 50 degrees west .... 3 feet

From locality 14 south along Cascade river to the most southern gulch entering the river north of Minnewanka lake, there are very few exposures, but as the course of the river here is south 14 degrees east, higher and higher beds are passed over until at a point only slightly south of the rock ridge forming the angle between this gulch and Cascade river, its course gradually bends south 30 degrees east. Here occur the highest beds exposed east of Cascade river between Stewart canyon and the mouth of lake Minnewanka and here was begun section 2.

Section 2

Section 2 begins at the eastern edge of Cascade river, south of the bluff formed by the southern side of the most southerly gulch, north of the lake, entering the river from the east. The section continues east-northeast along the north shore of lake Minnewanka, that is, along the southwestern end of Palliser range, including the southern edges of mount Astley, the Castle, and mount Standly. This section corresponds to a similar projecting cliff upon the south side of the lake which is locally called Gibraltar (location C on Figure 1), but is apparently what McConnell called Tower mountain.[1]

The section, beginning in the higher beds and continuing into the lower ones, gives in succession excellent exposures of the Rundle limestone, the Banff shale, the upper part and much of the lower part of the Minnewanka formation.

Rundle Limestone (Pennsylvanian and Mississippian)

Lower Pennsylvanian

(1) A dark grey, fine-grained limestone, exposed at the edge of the river.... 20 feet

(2) Black calcareous shale. The upper bed is conspicuously seamed with white calcite veins.......... 18 feet

These beds are in places very fossiliferous. A good place to collect fossils is along the eastern bank of the river where the shales are well weathered.

(3) A medium to fine-grained, dark grey limestone, alternating with black calcareous shales.......... 38 feet

(4) A very dark shaly limestone.......... 20 feet

In places very fossiliferous, being especially rich in crinoid joints, bryozoa, brachiopods, and cup corals.

(5) Largely concealed; where exposed the rock is a fine-grained, dark grey limestone.......... 80 feet

(6) Light grey, fine to medium-grained limestone, with very many large, irregular, dark grey chert concretions developed along the bedding planes; the great hardness of these concretions causes the beds usually to form a prominent, outcropping ridge.......... 24 feet

The basal beds are especially conspicuous for their abundance of colonies of Lithostrotion and Syringopora, the latter occurring most abundantly a foot beneath the former. Brachiopods are abundant but difficult to extract except where silicified specimens stand partly weathered out upon the rock surface; the rock is so dense and jointed that fossils usually come out only in fragments. Three feet below the top is a prolific half-foot bed of Spirifers in a conspicuous chert band, and 7 feet below the top is a foot layer very conspicuous for its colonies of *Lithostrotion whitneyi*. Stylolites are present, though apparently not numerous.

[1] Geol. Surv., Canada, N.S., vol. II, p. 19 D, 1887.

(7) Where not concealed this is a dark grey limestone.................. 38 feet

(8) A dark grey limestone, very full of chert concretions; these chert nodules, especially in the lower beds, are large, 6 inches to 2 feet in diameter, and very irregular. The hardness of these causes the beds to form an outcropping ridge... 24 feet

These beds might almost be called a fossil coral reef. The rock is especially conspicuous for the abundance of Lithostrotion (three species), Aulopora, Syringopora, Lophophyllum, and Campophyllum.

(9) A dark grey, medium-grained limestone, partly concealed, with few chert nodules except in the lowermost bed where they are very abundant and are often one mass of crinoid joints.. 62 feet

Lithostrotion is conspicuous because of its absence, since in the higher beds it is so abundant; its place is taken here by cup corals.

(10) A dark grey, coarsely to finely grained limestone, friable upon weathering, partly concealed. Chert nodules apparently absent in the coarse-grained beds, a few present in the other beds...................................... 120 feet

Fossils rare except for some cup corals.

(11) This locality begins above with a fine-grained, dark grey limestone, very full of chert in bands or small but numerous nodules, both developed along the bedding plane. This upper bed is full of *Spirifer rockymontanus* and Productus. Similar limestone is continued downward with an alternation of beds rich in chert nodules and beds poor in them; fossils few..................... 40 feet

(12) A dark grey, fine-grained limestone, very full of chert in bands and in separate nodules.. 6 feet

These chert bands are persistent along the strike and cause this bed to outcrop prominently; it is frequently exposed for 15 feet along the dip. The upper foot of this chert bed is made up almost entirely of globular chert concretions, one-quarter to one-half inch in diameter. These give to the weathered surface a peculiar nodose appearance which is quite persistent along the strike. At the base of this locality is a foot thick, very prolific, brachiopod zone. The abundance of shells in this zone, coupled with their absence both immediately above and below for a distance of 2 feet in each direction is very noticeable. The lower part of this shell bed is very full of chert nodules enclosing the shells, whereas the upper part with just as many shells has no chert. The chert is, as is usual, accumulated at the base of this coarse bed.

The brachiopods are in approximately equal abundance all along the strike. The species vary considerably locally, as in modern seas. In one place, large adult and old shells of *Spirifer rockymontanus* occupied the sediment almost to the exclusion of young and small mature specimens of the same species, whereas 100 feet north these latter are quite abundant, with few of the large Spirifers. A fourth of a mile south along the strike specimens of *Schellwienella lata* strongly predominate. A quarter of a mile still farther south, the large examples of *Spirifer rockymontanus* are again prominent. The sediment is apparently similar in all places. Throughout this distance the shell bed remains a foot thick with the chert confined to its lower half.

(13) A dark grey limestone, alternately chert-bearing and chert-free........ 25 feet

The lowest bed is full of chert nodules and is locally very prolific in brachiopod shells. These fossils, as in the shell bed above, vary much locally. Where the section was made Producti predominate, whereas a quarter of a mile along the strike to the south these had entirely given place to Athyroids; a quarter of a mile still farther south Producti again became dominant.

(14) A dark grey limestone, consisting of beds alternately fine and coarse grained. The latter become friable upon weathering and increase in thickness and number downwards. This includes a foot bed of cross bedded sandstone with a dolomitic cement. A few scattered chert nodules occur................ 75 feet

Fossils are rare, though in the lower part of this succession of beds is a rather persistent bed of *Lithostrotion pennsylvanicum.*

(15) Grey limestone, partly concealed, with scattered chert concretions. The middle of this is conspicuous for its 3-foot bed of strongly crossbedded, fine-grained sandstone, cemented by a calcareous cement and with many calcareous rhombs... 55 feet

The surface upon which the crossbedded stratum rests is very irregular and hummocky, the irregularities rising to a height of from 1 to 3 inches. In the lowest part especially are many rounded pebbles of limestone, 1 to 2 inches in diameter, over which the laminæ arch conspicuously. A few fossils were found in this crossbedded material, mostly in pockets. Stylolites are present in the limestone but were not noted in the sandstone.

(16) Alternating fine and coarse-grained limestones, the former the more abundant. Partly concealed... 50 feet

Some small limestone concretions occur and in the middle beds are scattered chert nodules. Immediately below the lowest chert-bearing bed is a 2-foot bed of coarsely granular limestone very full of cup corals, lying at all angles but mostly parallel with the bedding plane.

(17) Alternating fine and coarse-grained limestone down to and including a 6-foot bryozoan bed.. 43 feet

This basal bed is very rich in Bryozoa, especially Fenestelloids, but it is almost impossible to secure identifiable specimens. They give to the edge of the bed a finely corrugated appearance. Few brachiopods were noted.

(18) A dark grey limestone, where exposed............................ 400 feet

Much of the lower half of this locality is concealed. Slightly below the middle is a succession of beds containing much chert which causes them to form a prominent ridge. About 100 feet below the top of the locality is a 4-foot bed very full of Spirifers and bryozoans, a few of which continue to the base of the locality. The majority of the beds are very coarse grained, a typical calcarenite, being composed largely or entirely of fragments of crinoid joints; no calices were found though search was made for them. These calcarenites are pockety, with many irregular cavities averaging a half inch in length and an eighth or sixteenth in depth; the rock, however, is not dolomitic as it disappears entirely with rapid effervescence in cold dilute hydrochloric acid. Stylolites are abundant in both the finer and the coarser beds.

(19) Alternating beds of fine and coarse-grained, dark grey limestone and chert concretions. These concretions occurring directly beneath the friable, granular beds of locality 18 cause the formation of a prominent ridge, both below the western limb of the anticline upon the southern face of mount Astley and directly east of the fold.. 75 feet

The following gives this locality in greater detail. The subdivision, as heretofore, is from above downward.

(a)	Fine-grained limestone with scattered chert concretions.............	21 feet
(b)	Coarse-grained. No chert..	27 feet
(c)	Fine-grained. Chert concretions rather abundant. Fossils very few...	15 feet
(d)	Coarse-grained limestone, composed mostly of crinoid joints. No chert.	7 feet
(e)	Fine-grained, with rather numerous chert nodules....................	5 feet

(20) A series of grey limestone beds, alternately coarse and fine-grained, mostly coarse and chert free.. 240 feet

In greater detail, from above downward:

(*a*) Coarse grained; no chert.. 25 feet
(*b*) Coarse grained. The base with scattered lenses of chert, varying from 1 to 10 feet in length, with a maximum thickness of 3 inches.......... 2·5 feet
(*c*) Fine grained, with some chert nodules............................ 2·5 feet
(*d*) Coarse grained, with scattered chert nodules. In this bed, as in the coarse-grained beds above noted, the chert masses are thicker in proportion to their length and not so elongate with the bed.............. 17 feet
(*e*) Medium to fine grained, with a considerable number of scattered chert concretions. In all the finer-grained beds the chert is in smaller particles or in thin elongate bands with the bed............................ 17 feet
(*f*) Coarse grained, with the exception of a few thin bands above........ 45 feet
(*g*) Very coarse grained, weathering pockety........................... 8 feet
(*h*) Coarse grained, the lowest beds very dark, almost black.............. 123 feet

Lower Mississippian

(21) A succession of dark grey, coarse to fine-grained, limestones, subdivided from above downward, thus:.. 175 feet

(*a*) Coarse to medium grained.. 85 feet
(*b*) Fine grained, weathering brown.................................. 18 feet
(*c*) Lighter grey, coarse grained..................................... 23 feet
(*d*) Fine grained, weathering brown.................................. 11 feet
(*e*) Lighter grey, coarse-grained limestone............................ 38 feet

(22) In the upper 6½ feet a very dark, fine-grained limestone, weathering brownish. This is underlain by 5 feet of a more coarse-grained rock weathering light grey, containing many fossils, and beneath this is a 2-foot bed of fine-grained limestone which shales prominently across the bedding. This locality is well exposed on the first ridge that the trail crosses as it passes northeastward from the western edge of the lake...13·5 feet

(23) Dark grey, coarse-grained limestone above, grading into a fine-grained rock below, the latter containing black chert nodules. The entire locality is fossiliferous, the coarse-grained rock being especially rich in fossils. This is exposed upon the same ridge with locality 22.............................. 20 feet

(24) An alternation of coarse- and fine-grained limestones, the latter containing black chert nodules. This locality, weathering more rapidly than the beds immediately above and below, forms a depression; it enters the lake as a gully upon the middle of the ridge noted above in localities 22 and 23.......... 25 feet

(25) Alternating beds of fine- and coarse-grained limestone, with black chert nodules. The upper part contains many well-preserved fossils. This begins at the eastern slope of the gully noted above; the eastern slope of the gully is a good place for collecting.. 20 feet

(26) Rock similar to that of the last locality. This forms a rather prominent cliff, due to the pronounced shaling across the bedding plane developed in the very dark grey lower beds. This locality begins at the highest point on the trail as it crosses the ridge noted in locality 22.................................... 50 feet

Fossils are rare throughout the beds.

(27) A dark grey, mostly fine-grained limestone, bearing black chert. The chert usually occupies shale bands and is so abundantly developed here that the shale is very unevenly bedded and often occurs merely in pockets of the chert.... 35 feet

Fossils few.

(28) Medium to fine-grained, black, chert-bearing, thin-bedded limestones 25 feet

Fossils few.

(29) A fine to coarse-grained limestone, mostly the former. Black chert is abundant, and though in separate concretions these are so numerous as to form almost continuous beds, from 1 to 3 inches thick and from a few inches to several feet apart. About half the beds fracture prominently across the bedding plane and these are well supplied with chert.. 50 feet

(30) A fine-grained limestone with black chert nodules. These rocks display many fractures across the bedding.................................. 67 feet

Fossils are very abundant in certain beds near the middle of the locality, but the prominent fracturing renders it almost impossible to remove them.

(31) Limestone in alternating beds of medium to fine grained; the latter bear black chert nodules, the former are chert-free. This locality usually stands forth as a prominent cliff due to the more rapid erosion of the uppermost 10 feet of locality 32.. 135 feet

Fossils are rare.

Banff Shale (Lower Mississippian)

(32) An alternation of dark, medium-grained limestone and thin (½-inch to 3-inch) bands of unevenly bedded, shaly limestone. The fossils cease immediately below one of these 3-inch bands. These limestones are capped by 10 feet of rock which fractures very prominently across the bedding plane and thus forms a weak zone causing the strata of locality 31 to form a cliff above and likewise aiding the softer beds of locality 33 to cause the lower rocks of locality 32 to stand out as a pronounced cliff.. 50 feet

About 30 feet of the top of the cliff section is very fossiliferous.

(33) The upper 50 feet is a rather heavy-bedded, coarse to medium-grained, dark grey limestone. The rock is almost entirely composed of fragments of crinoids and brachiopod shells, and is underlain by a 2-foot bed quite prolific in Syringopora and Spirifer. This upper part is underlain by about 30 feet of more thinly bedded, medium-grained limestone which, except for the lowest feet, fractures conspicuously across the bedding into small angular pieces........... 80 feet

Few fossils present.

(34) A coarse to fine-grained limestone, subdivided from above downward as follows:.. 300 feet

(a) Fine-grained, thin-bedded, and fracturing prominently across the bedding 7 feet

(b) Very fossiliferous shaly limestone, full of small calcareous concretions. This forms a persistent cave zone.................................. 3 feet

(c) Fine-grained, thin-bedded, dark grey limestone, slightly fossiliferous... 23 feet

(d) Dark grey, medium to coarse grained, with few fossils............... 105 feet

(e) Fine-grained and thin-bedded. Chert rare except in the basal few feet where it is finely disseminated and where likewise occur almost all the fossils noted. Fossils are here rather abundant.................................. 162 feet

(35) Fine-grained, very dark grey to black shaly limestone. It is very thin bedded (1 to 6 inches thick) and is full of small black chert concretions. The uppermost 70 feet forms a strong cliff, weathering brown. All the beds are fossiliferous, some highly so. A comparatively long exposed ridge of the lower beds gives good opportunity for collecting fossils.................................. 215 feet

(36) An alternation of thin (3 inches to 1 foot) beds of black, very fine-grained limestone (calcilutite) and a black, very fine-grained shale, with a little calcareous cement. The latter fractures conspicuously across the bedding. The limestones weather a light grey, the shales brown. In the middle of this locality is a conspicuous cliff.. 330 feet

No fossils were noted.

(37) A black shaly limestone. This fractures very strongly across the bedding; in this respect it is similar to the shale beds of locality 36, but with an apparently higher content of iron it weathers to a more pronounced brown. This forms the conspicuous brown band almost immediately above the 1,000-foot cliff of the Minnewanka limestone, so noticeable when viewed from a distance. The upper part has a few more resistant calcareous beds, but they are entirely absent from the lower half. There is a conspicuous 6-inch bed weathering a deeper yellow 40 feet below the top.. 200 feet

No fossils were noted.

Minnewanka Limestone (Upper Part) (Devonian)

(38) Mostly a dark grey, medium to fine-grained limestone. These beds, alternating in hardness, form the conspicuous cliff and slope at the base of the Banff shale and immediately above the very pronounced cliff forming the beds of the Minnewanka limestone below.. 300 feet

(a) A dark grey, almost black, fine-grained, calcareous shale. It weathers back more slowly than the beds beneath it and forms the brownish, somewhat cliff-like lower limit to the shale of locality 37, but as it contains some fossils it is here included with locality 38. It is very full of iron concretions, some of which may represent replacements of fossils, but none was surely identified as such.......................... 30 feet

(b) Dark grey, vertically shaling limestone, with a few fossils............ 20 feet

(c) Grey limestone, medium to fine grained, prolific in fossils............ 50 feet

(d) Alternating medium to fine-grained, dark grey limestone. In the upper 20 feet containing black chert no fossils were seen; the lower 30 feet of chert-free beds contain a few fossils. These beds form a conspicuous cliff or a series of smaller cliffs, according to the rapidity of erosion, due to the more rapid erosion of the black basal beds and the strata of locality 38 e. These two series of beds, 38 d and 38 e, form the conspicuous cliff and slope immediately above the prominent 1,000-foot cliff of the Minnewanka limestone...................................... 100 feet

(e) Mostly fine-grained limestone with some beds almost black. This in the section takes the observer to the western edge of the gully. Fossils rare 100 feet

(39) A dense, fine-grained, light grey, heavy-bedded, dolomitic limestone. This rock being so much more resistant than those immediately above causes the gully in this section to migrate down the dip and hence expose the higher beds of locality 39 in a long slope; notwithstanding this, comparatively few fossils were noted. This locality continues downward to the very conspicuous "algal" bed.. 140 feet

(40) A dense, heavy-bedded, fine-grained, light grey dolomite. The majority of the beds have an abundance of branching, pencil-like, algal markings. Other fossils exceedingly rare... 450 feet

(41) Rather thin-bedded, brownish-weathering dolomites. These strata weather back more readily than those of the preceding locality............... 60 feet

Fossils rather abundant, especially in a 5-foot bed near the middle of the locality. A few beds contain some algal forms; these beds are as a rule otherwise free from fossils.

(42) Beds similar to those of the preceding locality. Near the base of this locality is a cave zone formed by a medium-grained rock that shales across the bedding plane. This takes to the base of mount Standly.................... 100 feet

The beds are slightly fossiliferous throughout. No algal markings were noted.

Minnewanka Limestone (Lower Part) (Devonian)

(43) From the foot of the cliff forming locality 42 to locality 44 occurred no outcrop in this section. If these beds are normal, with dip similar to that of the preceding and succeeding beds, their thickness is about 450 feet. There are rather strong indications of minor faulting. This locality goes from the foot of mount Standly east to a gully where begins locality 44............................ 450 feet

(44) Mostly a coarse-grained dolomite................................ 250 feet

Subdivided as follows:

(a) A coarse-grained rock yielding a strong odour of hydrogen sulphide when struck with a hammer...................................... 10 feet

(b) Rock similar to above in coarseness of grain and odour but containing many branching, algal forms...................................... 3 feet

(c) A coarse-grained rock, weathering with a peculiar pitted appearance... 57 feet

(d) Rock similar to the last but with many geodal cavities lined, or at times filled, with calcite crystals. These cavities are usually from a half inch to 2 inches in diameter and perfectly round........................ 35 feet

(e) A fine-grained, thin-bedded rock full of geodal cavities similar to those of the last locality but more elongate than in the coarser-grained rock. It also contains many calcite veins and at the base algal markings parallel to the bedding.. 20 feet

(45) A fine-grained, thin-bedded dolomite, weathering brownish and fracturing across the bedding plane. It originally contained many fossils, but solution and much minor slickensiding have made all organic remains unidentifiable, except some impressions. The rock contains small geodal cavities and becomes pitted upon weathering........ 25 feet

(46) Alternating coarse to medium-grained and medium-bedded dolomite. The upper 150 feet contains geodal cavities and becomes pitted upon weathering. 450 feet

(47) A coarse-grained dolomite with many geodal cavities........ 80 feet

Fossils rare.

Section 3

This section was rather hurriedly made along the western slope of mount Aylmer at the western edge of the head of Aylmer canyon.

Spray River Shale (Triassic)

The lower beds of this formation are well exposed just at the left of the trail up the mountain as it passes up the first steep slope upon leaving the usual summit camping place. The transition from the shale to the Rocky Mountain quartzite is here plainly seen, with the two formations apparently conformable.

(1) Thin-bedded, dark grey shales, weathering brownish red........ 220 feet
(2) Black to grey flags........ 15 feet
(a) Black shaly flags........ 12 feet
(b) Light grey shaly flags with a few iron concretions........ 3 feet

Rocky Mountain Quartzite (Permian)

(3) Quartzites........ 14 feet
(a) Dark grey quartzite very full of iron concretions. It is unevenly bedded, with an uneven surface........ 2 feet
(b) Dark grey quartzite; no concretions noted. The upper part has a very uneven surface........ 10 feet
(c) Farther up the slope along the strike of the junction of the shale with the quartzite were noted several large angular boulders of a white quartz containing *Euphemus carbonarius arenarius* and *Plagioglypta canna.* These boulders, although not in place, were probably not much more than 10 feet below 3 a........ 2 feet
(4) Quartzites and dolomitic limestones.
(a) Quartzites and dolomitic limestones not measured........ ? feet
(b) Thin-bedded quartzite........ 10 feet
(c) Mostly heavy-bedded sandstones, weathering brownish. The basal bed is a dark friable shale........ 38 feet

Rundle Limestone (Upper Part) (Lower Pennsylvanian)

(5) Limestones and shales........ 75 feet
(a) Grey limestone above; the lower half a friable greenish shale........ 25 feet
(b) Greenish shales similar to 5 a........ 12 feet
(c) Light grey dolomitic limestone........ 38 feet
(6) Light grey to dark grey dolomite........ 37 feet
(a) Light grey cherty dolomite........ 12 feet
(b) Dark grey dolomite, including thin, very irregular black shale bands. The lowest 2 feet weather purplish, with an included greenish shale band of 3 or 4 inches width........ 25 feet

Fossils are abundant in the purplish beds.

(7) Black limestones and calcareous shales........ 74 feet
(a) Very dark grey limestone........ 24 feet
(b) Compact, dark grey to black calcareous shale, at times chert-bearing... 50 feet

In both uppermost and basal beds are many specimens of *Productus cora;* the cross-sections of the white shells are conspicuous in the black rock.

(8) Dark grey, dolomitic limestone.. 91 feet
(a) Dark grey, weathering brownish.. 26 feet
(b) Dark grey, the lower part very dark. The upper part contains prominent calcite veins.. 65 feet

(9) Light grey, dolomitic limestone with many black chert nodules. The lowest bed is conspicuous for its great number of small white quartz geodes. Many blocks of this limestone lie loose upon the western slope of mount Aylmer. 28 feet

(10) Light grey, dolomitic limestone.. 42 feet
(a) Rock light grey, fine grained above, coarse grained below............ 12 feet
(b) Rock light grey, containing, except in the upper 3 feet, an abundance of chert nodules.. 30 feet

The uppermost 3-foot bed contains very many specimens of *Hapsiphyllum calcareforme* and apparently no other species. Below this there is an abundance of *Lithostrotion pennsylvanicum.* These coral heads are abundant upon the western slope of mount Aylmer, 50 to 100 feet from the summit. The trail passes up this slope.

This locality is correlated with section 1, locality 24, and section 2, locality 6.

Section 3a

A brief section, somewhat farther down the slope of mount Aylmer than section 3, was made in order to include some very fossiliferous beds.

Rundle Limestone (Upper Part) (Lower Pennsylvanian)

(1) Limestone weathering brownish.. 50 feet
(2) Grey, rather shaly limestone, weathering reddish brown.............. 20 feet
No fossils noted.
(3) Dark grey limestone, in alternately solid and shaly beds.............. 60 feet
Here occurs an abundance of *Triplophyllum minnewankensis.*
(4) Dark grey limestone, a cherty, medium-grained variety alternating with a chert-free, coarse-grained variety.. 20 feet

The chert is parallel with the bedding plane and occurs both in bands 1 to 3 inches thick with parallel banding, and as irregular concretions varying from a fraction of an inch to several feet in length. The large concretions are usually in contact by one or more of their offshoots with neighbouring concretions; this gives to the weathered surface a very uneven appearance, as the limestone enclosed by these chert masses weathers much more rapidly than the chert.

The chert-bearing beds are conspicuous for their numerous heads of *Lithostrotion pennsylvanicum;* these are especially abundant in the basal bed. The chert-free, coarsely-granular beds contain very few fossils.

(5) Grey dolomite.. 120 feet
(a) Medium grained, with few chert nodules.. 20 feet
Fossils few.
(b) Medium grained, with much chert.. 20 feet
(c) Coarse grained. No chert.. 30 feet
A few fossils noted.
(d) Medium grained.. 20 feet
No fossils seen.
(e) Fine grained, with much chert in both thin bands and nodules, alternating with chert-free, fine-grained beds. The latter are conspicuous for their fracturing across the bedding plane.. 30 feet
No fossils noted.

(6) Dark grey, medium-grained dolomite, alternating with a lighter grey, fine-grained dolomite, all fracturing across the bedding plane. A few chert nodules present. Crossbedding is common. The basal foot is a light grey quartzite which maintains a rather uniform thickness along the strike and is bounded above and below by a fine-grained dolomite.. 40 feet

Section 4

Along the northern edge of Devils gap, the narrow, steep-sided valley which forms the eastward continuation of the Lake Minnewanka valley into the valley of Ghost river. The section extends from the northwestern end of West lake eastward to the gully at the western end of Middle lake.

Banff Shales (Lower Mississippian)

(1) Rather thin-bedded, coarse to fine-grained dolomitic limestones........ 180 feet
Fossils rare.
(2) Heavy-bedded, coarse to fine-grained dolomitic limestone............. 160 feet
Fossils abundant in places.
(3) Upper part heavy-bedded, coarse-grained dolomitic limestone, with a few thin (2 to 6 inches thick) shaly limestone partings. These shaly beds become more numerous and thicker towards the base. The lowest 20 feet contains many chert nodules.. 50 feet
These beds are very rich in fossils, especially the more shaly beds.
(4) Black, finely-laminated, fissile, calcareous shales, quickly weathering brown; partly covered. Correlated with section 2, localities 36 and 37........ 300 feet

Minnewanka Limestone (Upper Part) (Devonian)

(5) Alternation of shaly limestone with brownish weathering, crossbedded shales.. 170 feet
The upper 10 feet, a shaly limestone, are fossiliferous.
(6) Coarse to medium-grained, dark grey limestone. The upper part contains many algal forms... 600 feet
Much of the Minnewanka limestone is lost in this section by a fault.

Minnewanka Limestone (Lower Part) (Devonian)

(7) Mostly a coarse-grained dolomite, weathering pitted and emitting when struck a strong odour of hydrogen sulphide................................ 750 feet
(8) Rock mostly similar to that of the last locality, with many included calcareous geodes averaging about 2 inches in diameter. Some of the strata are crossbedded. A few of the upper beds are black, fine-grained, fissile shales..... 200 feet
(9) Coarse-grained dolomite, with many calcareous geodes and algal forms. When struck the rock yields a strong hydrogen sulphide odour................ 250 feet
(10) Similar to locality 9, with the basal 2 feet crossbedded............... 40 feet

Ghost River Formation (Age ?)

(11) Similar to the last, but fine grained, with minor crossbedding and weathering yellowish.. 90 feet
(12) Similar to locality 13, alternating with a fine-grained dolomite with light grey chert concretions.. 80 feet
(13) Where not concealed, a fine-grained dolomite and yellow grey sandstone, with minor crossbedding, weathering a bright yellow.................. 100 feet

Castle Mountain Group (Middle Cambrian)

(14) Dense, rather thin-bedded, fine-grained dolomite, in many cases seamed in all directions with numerous calcite veins. There are many algal or pencil-like formations, probably dolomitic segregations, parallel with the bedding plane. Considerable minor crossbedding present............................ 270 feet
(15) Greenish, shaly limestone.. 2 feet
The upper 6 inches are almost entirely composed of trilobite tests.
(16) Rock similar to that of locality 14, but heavy bedded. The uppermost 2 feet a black fissile shale.. 300 feet

This takes to the western side of the gully at the western end of the middle lake in the gap.

DESCRIPTIONS OF SPECIES

The bibliographies here given of the species are in most cases much abbreviated. It has been the aim to include only the more easily accessible works and those with illustrations of the species.

Phylum, COELENTERATA

Class, ANTHOZOA

Genus, **Lophophyllum** Edwards and Haime

Lophophyllum profundum (Edwards and Haime)

1858. *Cyathaxonia profunda* Milne-Edwards and Haime, Mon. des Polyp. Foss., p. 323; *Lophophyllum proliferum* Meek, 1872, U.S. Geol. Surv., Neb., p. 149, Pl. 5, figs. 4a-b; Meek and Worthen, 1873, Geol. Surv., Illinois, vol. 5, p. 560, Pl. 24, fig. 1; White, 1884, 13th Rept. Geol. Surv., Indiana, p. 118, Pl. 23, figs. 6-7; *L. profundum* Worthen, 1890, Geol. Surv., Illinois, vol. 8, p. 79, Pl. 10, figs. 14-14a; *L. proliferum* Keyes, 1894, Missouri Geol. Surv., vol. 4, p. 115, Pl. 13, figs. 8 a-b; *L. profundum* Beede, 1900, Univ. Geol. Surv., Kansas, vol. 6, p. 17, Pl. 2, figs. 7-7b; Raymond, 1910, Ann. Carnegie Mus., vol. 7, p. 157, Pl. 25, fig. 2, Pl. 27, fig. 4; Mather, 1915, Bull. Sci. Lab. Denison Univ., vol. 18, p. 91, Pl. 1, figs. 11-13.

Remarks. Our specimens appear to be typical examples of this prolific species.

Locality and Horizon. Pennsylvanian from Pennsylvania to Utah. In the Minnewanka region in the Pennsylvanian of sections 1-24 (C), 31 (R); 2a-3 (r); 10 (r); 2-6 (R), 8 (C), 9 (R), 11 (R), 16 (c); 3a-1 (C), 3 (c); 3-7 (r).

Genus, **Campophyllum** Edwards and Haime

Campophyllum torquium (Owen)

1852. *Cyathophyllum torquium* Owen, Geol. Rept., Wisconsin, Iowa, and Minnesota, tab. 4, fig. 2; *Campophyllum torquium* Meek, 1872, U.S. Geol. Surv., Nebraska, p. 145, Pl. 1, figs. 1a-d; White, 1884, 13th Rept. Geol. Surv., Indiana, p. 119, Pl. 23, figs. 10-13; Keyes, 1894, Missouri Geol. Surv., vol. 4, p. 107, Pl. 12, figs. 7 a-c, Pl. 13, fig. 7; Beede, 1900, Univ. Geol. Surv., Kansas, vol. 6, p. 19, Pl. 4, fig. 1, Pl. 5, figs. 1-4; Mather, 1915, Bull. Sci. Lab. Denison Univ., vol. 18, p. 93, Pl. 1, figs. 14, 14a.

Remarks. Our specimens agree quite fully with this species as developed in the Mississippi valley.

Locality and Horizon. Pennsylvanian from Indiana to Colorado. In the Minnewanka region in the Pennsylvanian of section 2-8 (c).

Genus, **Hapsiphyllum** Simpson

Hapsiphyllum calcareforme (Hall) ?

1882. *Zaphrentis calcareformis* Hall, 12th Rept. State Geol. of Indiana, p. 293, Pl. 21, figs. 10, 11; Worthen, 1890, Geol. Surv., Ill., vol. 8, p. 74, Pl. 10, figs. 2, 2a; *Hapsiphyllum calcareforme* Simpson, 1900, Bull. 39, N.Y. State Mus., p. 203; Brown, 1909, Annals N.Y. Acad. Sci., vol. 19, p. 84, figs. 12-14.

Remarks. The specimens of Hapsiphyllum in our collection are poorly preserved, but the comparatively slow increase in diameter of corallum and the elongate inner wall are more characteristic of *H. calcareforme* than of any other species of the genus. The number of secondary septa is, however, exceedingly variable, from two or three to a number equalling that of the primary septa. Different species may here be represented, or the varying specimens may merely represent stages in the growth of a single species. The former supposition seems at present the more probable since variations in number and length of secondary septa, in extension of fossula to or beyond the centre of the calyx, etc., occur upon individuals of almost the same size.

Locality and Horizon. Mississippian (Warsaw and St. Louis) of Kentucky, Indiana, etc. In the Minnewanka region in the Pennsylvanian of sections 1-31 (r), 33 (r); 2-2 (r), 8 (r), 15 (r); 3-7 (c), 10 (c); 3a-1 (c); Mississippian of sections 2-22 (R), 24 (r), 25 (r); 4-3 ? (C).

Genus, **Triplophyllum** Simpson

Triplophyllum dalii (Edwards and Haime) ?

1851. *Zaphrentis dalii* Milne-Edwards and Haime, 1851, Mon. des Polyp. Foss., p. 329; *Z. spinulifera* Hall, 1858, Geol. Iowa, vol. 1, pt. 2, p. 650, Pl. 22, figs. 1a, b; *Z. dalii* Worthen, 1890, Geol. Surv., Ill., vol. 8, p. 71, Pl. 10, figs. 12, 12a; Keyes, 1894, Mo. Geol. Surv., vol. 4, p. 113, Pl. 15, fig. 12.

Remarks. A single fragment in our collections appears to belong to this species. It has a diameter of 35 mm. and a preserved tapering length of 20 mm. It has 60 septa, no secondary ones, a straight-sided fossula reaching the centre of the calyx, and two pseudo-fossulæ. Whether the fossula is upon the convex or concave side cannot be seen.

Locality and Horizon. Lower and Middle Mississippian (Burlington to St. Louis) of the Mississippi valley. In the Minnewanka region in the Pennsylvanian of section 2a-14 (R).

Triplophyllum minnewankensis n. sp.

Plate V, figures 1, 2

Description. Corallum cone-shaped, regularly and considerably curved to slightly curved, exhibiting irregular contractions at intervals. Fossula well marked, narrow, reaching the centre; it is situated upon the side of greatest convexity. Alar fossulæ present, though poorly developed. Primary septa somewhat sinuous, 60 to 80 in number; they mostly reach the centre. With these primary septa there alternate at the margin of the calyx an equal number of secondary septa which are short—usually about 4 mm. long. Height of calyx 40 to 60 mm.; diameter 20 to 35 mm. Some incomplete specimens, which apparently taper more gradually, may have attained a length of 10 cm. Dissepiments moderately numerous.

Remarks. This species is similar to *T. dalii* Edwards and Haime from the Mississippian of the Mississippi valley. Their description, however, and the figures later given by Worthen[1] of a specimen from the same

[1] Geol. Surv., Ill., vol. 8, 1890, Pl. 10.

locality indicate that *T. dalii* has the fossula upon the side of least curvature, possesses no secondary septa, has fewer primary septa, and usually bears short thecal spines. *T. centralis* (Edwards and Haime) from the Chester of Illinois,[1] has fewer septa, a fossula enlarging inwards and situated upon the side of least curvature. *T. ? multilamella* (Hall), from the Mississippian of Utah, is a larger form with a much more rapid increase in diameter.

Specimens from section 2-16 are apparently in a younger stage of development than those from the other and higher localities, for, though they have 60 to 80 primary septa, they do not take on the short secondary septa until a diameter of 25 mm. has been attained; those from the higher localities, however, have these secondary septa completely developed at a diameter of 15 mm., and faint incipient ones were noted at a diameter of only 7 mm. From section 2-14 one specimen shows a few secondaries at a diameter of 23 mm., another at 15 mm. Since these corals of 2-16 reach a maximum diameter of only 35 mm., the majority lack the secondary septa and in none was a septa length greater than 3 mm. noted. The specimen from section 2a-14, identified provisionally as *T. dalii*, may possibly be a greatly retarded *T. minnewankensis*.

Locality and Horizon. In the Minnewanka region in the Pennsylvanian of sections 2-9 (?), 16 (C); 3-7 (R); 3a-3 (C).

Genus, **Lithostrotion** Lhwyd

Lithostrotion whitneyi Meek

1877. *Lithostrotion whitneyi* Meek, U.S. Geol. Expl. 49th Par., vol. 4, p. 58, Pl. 6, figs. 1-1c; White, 1877, U.S. Geol. Surv. W. 100th Mer., vol. 4, 103, Pl. 6, figs. 1a-c.

Remarks. This species was originally described from the Mississippian limestone of the Wasatch range, Utah. Later White[2] noted it from Fossil hill, White Pine county, Nevada; from this locality he also listed *Hemipronites crenistria, Spirifer cameratus,* and *Seminula argentea.* Meek, in addition, cited from the same locality[3] *Productus semireticulatus, P. prattenianus,* and *P. longispinus. L. whitneyi* is thus associated in Nevada with a Pennsylvanian fauna. The corallites from Nevada differ from Meek's type description and figures only in their somewhat greater diameter (8 mm. to 14 mm.) and in the presence of three to five rows of vesicles in the outer zone; this latter character is associated with the larger size, for in the Albertan form it is the large individuals which have more than two or three rows of vesicles. Meek's type has usually from one to three rows of vesicles. The Minnewanka specimens are thus somewhat transitional between these two types, though distinctly nearer Meek's than White's form. *L. mamillare sublaevis* Meek is also a multivesiculate form of the *L. whitneyi* type, but with a very broad columella. It was found in the limestones of the Sierra Nevada mountains at Bass' ranch in Shasta county, California, associated with such Pennsylvanian species as *Fusulina cylindrica, Productus semireticulatus,* and *Reticularia perplexa.*

[1] Loc. cit., p. 72.
[2] Loc. cit.
[3] Loc. cit.

This increase in the number of vesicles, with a corresponding decrease in their size, is a normal accompaniment of old age in corals, either of the individual or of the species. There is apparently a decrease in the ability of the animal to withdraw much of its lime-secreting basal tissue at one time. We would thus naturally expect to find the species becoming multivesiculate in the higher beds. Such slight differences would hardly be worth considering were it not that they help us to distinguish between the representatives of a single species in two separate periods.

Locality and Horizon. Mississippian and Pennsylvanian of western North America. In the Minnewanka region in the Pennsylvanian of sections 1-32 (C); 2-6 (C), 8 (C).

Lithostrotion pennsylvanicum n. sp.

Plate V, figures 3, 4, 5

Description. Corallum compound, massive, rapidly expanding horizontally. One almost complete specimen has a diameter of 230 mm. and a height of 40 mm. Another specimen has a diameter of 150 mm. (incomplete) and a height of 80 mm. (apparently almost complete). As seen from the above, the corallites diverge rather rapidly.

Corallites crowded, producing polygonal individuals; varying greatly in diameter in the same colony, depending upon the age of the corallite. In one head 10 inches in diameter, individuals were noted varying in diameter from 2 mm. to 16 mm.; the average diameter of a mature corallite is, however, from 10 mm. to 12 mm.

Calyx very shallow, except in the central half which is suddenly, usually vertically, depressed into a cup from 5 to 6 mm. wide and 4 or 5 mm. deep. Columella rather small, seldom laterally compressed, rising rather suddenly nearly or quite as high as the sides of the cup. Seldom, and then only in the smaller corallites, does the columella rise from the broader projecting top of the inverted, funnel-shaped tabulæ.

Principal septa 20 to 25 in number and extending to the columella; alternating with these is a shorter series, making a total of 40 to 50 septa. Tabulæ numerous, bending downward conspicuously at almost a right angle around the columella, then arching outward and downward more gently to meet the upward bending dissepiments in an acute angle. The dissepiments at first bend upward vertically, then gradually arch outwards. They meet the walls of the corallite, in a mature individual, usually at an angle of 70 degrees to 100 degrees, at times 140 degrees, seldom as low as 50 degrees; in young individuals up to a diameter of 5 mm. the angle is usually 50 degrees. Thus in the growth of the corallite the dissepiments at first meet the walls at a sharp, upward pointing angle; with increase of width, however, the tabulæ arch more and more outward and downward. Dissepiments numerous in outer zone, absent within; the junction of these two zones is a weak spot and weathered specimens frequently show this inner part (8 mm. wide in both a 12 mm. and an 18 mm. corallite) alone remaining.

Remarks. This form is rather closely related to the typical *L. mammilare* of the St. Louis of the Mississippi Valley region. There are apparently, however, some rather constant differences. The corallum of the latter appears to be shorter and broader. The corallites usually have a greater diameter and a deeper cup (about 7 mm. deep), and the columella does not extend so nearly to the surface. The dissepiments meet the walls more acutely, usually in both mature and immature specimens at an upward pointing angle of about 50 degrees. The dissepiment-free centre has a width similar to the Minnewanka form and like it, upon weathering, often stands free from the rest of the corallite. Upon examining the very large collection in the Museum of Comparative Zoology (through the courtesy of Professor Raymond) these criteria were found to usually hold, though some silicified specimens, labelled "Subcarboniferous of Bloomington, Indiana," had cups shallow, with the tip of the columella reaching as high as the sides of the cup, and many tabulæ meeting the walls at an angle of 90 degrees; these may represent merely accelerated individuals. In old corallites of *L. mamillare*, the outer part of the calyx tends to flatten out into the typical condition seen in the mature specimens of the *L. pennsylvanicum*, whereas the immature corallites of the latter are in this respect like the adults of the former. Typically in *L. pennsylvanicum* the middle half only of the calyx is conspicuously depressed, the outer part being almost flat. Another conspicuous difference between the two species is the presence in the bottom of the calyx of *L. mamillare* of a broad convexity from the centre of which rises the short columella; this convexity (the source of the name mamillare) is half the width of the corallite and rises prominently in the bottom of the calyx. It is practically absent in *L. pennsylvanicum* except in some of the younger corallites.

L. pennsylvanicum appears to resemble most closely *L. microstylum* White[1] reported from the Chouteau limestone of Sedalia, Missouri, that is, in so far as can be judged from the very brief description and from the figure. There is, however, doubt as to the locality of the very poorly preserved type specimen, the only specimen known. White founded this species upon the "flatness or shallowness of the calyxes, the smallness of the central pit, and of the columella." It resembles *L. pennsylvanicum* in the flatness of its calyxes, the practical absence of the inverted, funnel-shaped tabulæ from the calyx, and in the small prominent columella. It has, however, a much narrower central pit, which in a corallite of 15 mm. diameter has a breadth of 3 mm., whereas a corallite of similar size in *L. pennsylvanicum* has a breadth of 9 mm. This conspicuous difference, together with its many unknown characters and its given horizon as Lower Mississippian, led to the rejection of *L. microstylum* for the Albertan form. A specimen at Harvard University, collected by Dr. W. P. Haynes from south of Virginia City, Montana, belongs to this species.

Locality and Horizon. In the Pennsylvanian ? of southern Montana. In the Minnewanka region in the Pennsylvanian of sections 1-33 (c); 2-6 (C); 8 (C), 14 (C); 3-10 (C); 3a-4 (C).

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[1] U.S. Geol. and Geog. Surv., 12th Ann. Rept., Pl. 40, fig. 7a, p. 159.

Lithostrotion sp.

Description. Corallum compound, massive. Corallites crowded, polygonal in cross-section, of very uniform diameter, about 4 mm. Calyx comparatively deep, its bottom occupied by a broad convexity (half the width of the corallite) rising to the central, low, compressed columella. Septa apparently 20 to 25 in number, extending half-way or more toward the centre; there are some indications of short, alternating, secondary septa

Remarks. This form is too poorly preserved to admit of a good description. In our field notes we called it *L. mamillare parvum* as it looks much like a very small *L. mamillare.* All our specimens are completely and grossly silicified. When broken from the rock they are almost structureless, but when weathered out they present the characters noted above.

Locality and Horizon. In the Minnewanka region in the Pennsylvanian of sections 1-34 (C); 2-8 (C); 3a-4 (c).

Genus, **Aulopora** Goldfuss

Aulopora geometrica Girty

1899. *Aulopora geometrica* Girty, U.S. Geol. Surv., Mono. 33, pt. 2, p. 508, Pl. 67, fig. 6a.

Remarks. Our few specimens exhibit all the characters noted in this species.

Locality and Horizon. In the Lower Mississippian of the Yellowstone National park. In the Minnewanka region in the Lower Mississippian of section 2-30 (r).

Aulopora curva n. sp.

Plate V, figures 6, 7, 8

Description. Corallum spreading over mud of sea bottom, probably attached only by earliest corallites, forming a broad colony several feet in diameter.

Corallites budding from the side or base of the parent at an angle usually of 40 degrees. Seldom do two corallites grow from a single individual. The young, budding off at about the middle of the parent corallite, expand gradually to a diameter of about 3 mm. and to a height of from 3 mm. to 6 mm. above the plane of budding. Usual length of corallite 10 mm. to 15 mm., curved gently upward throughout its entire length (whence the specific name). The young is partly separated from the parent by a thickening of the walls, but remains united by a persistent pore.

Locality and Horizon. In the Minnewanka region in the Pennsylvanian of sections 1-24 (C); 2-8 (C); 3a-1 (c).

Genus, **Syringopora** Goldfuss

Remarks. The forms placed here under this genus do not show a uniform series of funnels, as can be seen in comparing transverse and longitudinal sections of the same specimen. A transverse section shows that the majority of the funnel edges have a concentric arrangement; at times some meet the thecal walls or each other. In longitudinal section these funnel edges appear like a series of cysts upon each side of a central canal. The constant presence of this central canal and the dominantly concentric arrangement of the funnel edges show that the vesicular material was deposited around a more or less central opening, in the form of interrupted truncate cones.

In Syringopora, especially in those representatives with a small diameter, the crystalline aggregates of calcite or silica, with which the tubes are usually filled, make the determination of the internal characters most confusing. These crystals, growing more or less at right angles to the thecal or funnel walls, give lines running in the same direction as nodes or spines, i.e. from the walls towards the centre of the corallite. The two principal distinctions between these inorganic and organic formations are: (1) The crystal lines usually extend both without and within the funnel walls whereas true nodes or spines extend only inwards from the walls. (2) The colour of the walls is usually darker than that of the apparently purer crystalline aggregates. Even, however, with these points in mind, it is usually necessary to examine several corallites within a corallum in order to be reasonably certain of the internal characters.

Syringopora surcularia Girty

1899. *Syringopora surcularia* Girty, U.S. Geol. Surv., Mon. 32, pt. 2, p. 510, Pl. 67, figs. 4a, b; Girty, 1903, U.S. Geol. Surv., Prof. Paper 16, p. 273.

Remarks. The Minnewanka specimens appear to be identical with Girty's species from the Madison limestone.

Locality and Horizon. Lower Mississippian of Colorado, Wyoming, and Montana. In the Minnewanka region in the Mississippian of sections 2-22 (c), 26 (R), 33 (c), 34 (c).

Syringopora aculeata Girty

1899. *Syringopora aculeata* Girty, U.S. Geol. Surv., Mon. 32, pt. 2, p. 509, Pl. 67, figs. 5a, b; Girty, 1903, U.S. Geol. Surv., Prof. Paper 16, p. 273.

Remarks. The form we have identified with Girty's species resembles it in size, comparative thickness of thecal and funnel walls, number and elongation of funnels, and in the presence of thecal and funnel spines. It apparently differs only in its greater variability. Within an individual colony, both down in the Mississippian and up in the Pennsylvanian strata, occur corallites in which the thickness of the funnel walls varies from one-sixth of that of the thecal walls to equality with it.

Locality and Horizon. In the Lower Mississippian of Colorado and the Yellowstone National park. In the Minnewanka region in the Lower Mississippian of section 2-34 (c); in the Pennsylvanian of section 2-8 (C).

Syringopora pennsylvanica n. sp.

Plate VI, figures 1, 2, 3, 4

Description. Corallum large, the corallites from 1 to 5 mm. apart. Corallites 2 to 3 mm. in diameter. Walls very thick. Funnels usually numerous, their walls thin, about one-third or one-sixth as thick as the thecal walls, and without spines or nodes. Septa absent, the inner walls of the theca forming a smooth line.

Remarks. The absence of septa and nodes, the thin walls of the funnels, and the thick thecal walls distinguish this abundant form from *S. surcularia*. *S. multattenuata* McChesney, from the Pennsylvanian of the Mississippi valley and west, is at times so closely crowded as to have polygonal corallites, with the funnels most irregularly and angularly arranged.

Locality and Horizon. In the Minnewanka region in the Pennsylvanian of sections 2-6 (C), 14 (c), 16 (?); 3a-3 (?); in the Mississippian of 4-2 (c).

Phylum, ECHINODERMATA

Class, BLASTOIDEA Say

Genus, **Metablastus** Etheridge and Carpenter

Metablastus bipyramidalis (Hall)

1858. *Pentremites bipyramidalis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 607, Pl. 15, fig. 2; *Metablastus bipyramidalis* Keyes, 1894, Mo. Geol. Surv., vol. 4, p. 137, Pl. 18, fig. 13.

Remarks. Our specimens differ from this Mississippi Valley species apparently only in their more elongate basal plates. In the latter species these plates are about one-fifth the length of the entire calyx, in ours they are about one-third, but as the tip of our calyx has been destroyed the entire form would doubtless approach somewhat nearer Hall's type.

Locality and Horizon. In the Middle Mississippian of Missouri. In the Minnewanka region in the Lower Mississippian of section 2-23 (r).

Phylum, MOLLUSCOIDEA

Class, BRYOZOA

Although Bryozoa do not form a prominent element in the various formations here discussed, they are present and collections of them were made. An unfortunate accident, however, completely removed all evidence of localities, and because of this they are not discussed.

Class, BRACHIOPODA

Genus, **Orbiculoidea** d'Orbigny

Orbiculoidea arenaria n. sp.

Plate VI, figures 5, 6

Description. Shell rather large for the genus, subcircular in outline. The dimensions of a pedicle and a brachial valve, respectively, are: greater diameter 21 mm. and 17 mm., lesser diameter 18 mm. and 15 mm. Height of brachial valve 3·5 mm.

Pedicle valve nearly flat. Pedicle opening situated in the line of the longer axis of the shell, and extending from the centre of the valve half-way to the posterior margin; externally this has the form of a groove, the anterior part of which is much depressed below the general surface of the valve; posteriorly it becomes very shallow; internally it forms an elongate ridge highest and widest anteriorly. The internal surface is marked by about three faint growth lines in the space of 1 mm.; externally, besides the growth lines, which here were apparently elevated into ridges, there are very faint and numerous radiating lines.

Brachial valve moderately convex, subconical, its apex situated excentrically about two-fifths the total length of the valve from the posterior margin. From the apex the surface is most convex anteriorly; laterally and posteriorly it descends to the margins with greater abruptness. Surface markings unknown.

Remarks. This Minnewanka form is preserved in a fine-grained quartzite and lacks some desired details. There are three pedicle valves and three more poorly preserved brachial valves; of the former two are views of the interior and one of the exterior. These specimens show a certain similarity to *O. missouriensis* Shumard from the Pennsylvanian of the Mississippi valley, but this species is smaller, with apex of brachial valve nearer the margin and with greater convexity; the concentric ridges are also more numerous. *O. utahensis* (Meek) has a much higher brachial valve.

Specific name given because of its occurrence in a quartzite.

Locality and Horizon. In the Minnewanka region in the Permian of section 1-14 (c).

Genus, **Leptaena** Dalman

Leptaena analoga (Phillips)

The following are some references to this Mississippian form of *Leptaena rhomboidalis* (Wilckens).

1836. *Producta analoga* Phillips, Geol. Yorkshire, vol. 2, p. 215, Pl. 7, fig. 10; *Strophomena rhomboidalis* var. *analoga* Davidson, 1859, Brit. Foss. Brach., vol. 2, p. 119, Pl. 28, figs. 1-2; *S. rhomboidalis* White, 1874, Prelim. Rept., Inv. Foss., p. 17; White, 1877, U.S. Geog. Surv. W. 100th Mer., vol. 4, p. 85, Pl. 5, fig. 5; Hall and Whitfield, 1877, U.S. Geol. Expl. 40th Par., vol. 4, p. 253, Pl. 4, fig. 4; Herrick, 1888, Bull. Sci. Lab. Denison Univ., vol. 4, Pl. 9, fig. 6; Herrick, 1889, Am. Geol., vol. 3, Pl. 4, fig. 6; *Leptaena rhomboidalis* Hall and Clarke, 1892, Int. to Study of Brach., pt. 1, Pl. 13, fig. 9; Hall and Clarke, 1892, Pal. N.Y., vol. 8, pt. 1, Pl. 8, figs. 30-31, Pl. 20, fig. 24; *Plectambonites rhomboidalis* Keyes, 1894, Mo. Geol. Surv., vol. 5, p. 70, Pl. 39, fig. 6; *Strophomena rhomboidalis* Herrick, 1895, Geol. Surv., Ohio, vol. 7, Pl. 20, fig. 6; *Leptaena rhomboidalis* Girty, 1899, Mon. U.S. Geol. Surv., vol. 32, p. 525; Girty, 1904, Prof. Paper, U.S. Geol. Surv., No. 21, p. 48, Pl. 10, fig. 3; Weller, 1909, Bull. Geol. Soc., Am., vol. 20, p. 292, Pl. 12, figs. 2-3; *L. analoga* Weller, 1914, Geol. Surv., Mon. 1, p. 49, Pl. 2, figs. 1-10.

Remarks. Our single, partly exfoliated specimen belongs evidently to Phillip's species as discussed recently by Weller.[1] The important external characters are the strength and direction of the concentric corrugations and the number of the radiating costæ. These characters appear to be sufficient to separate the species from the earlier occurrences of *Leptaena rhomboidalis,* with which it is usually classified. The following comparison shows not only this difference, but likewise the apparent distinctness of the types of *Leptaena rhomboidalis* from the different periods. The specimens measured were from the Trenton of Anticosti island, the Niagara of Lockport, New York, the Onondaga of Waterville, New York, and our specimen from the Kinderhook of Minnewanka region. Several specimens were examined from each locality, except the last, and an average one taken for measurement, but the number of striæ, character of corrugations, etc., were the same for all examples seen. The measurements are given in millimetres. The height of the corrugations given is the maximum, that of the one next the geniculation.

——	Trenton	Niagara	Onondaga	Kinderhook
Length	12	18	21	23
Breadth at hinge-line	20	24	30	34
Breadth midway of length	18	22	24	28
Concentric corrugations	low (0·2)	higher	high (1)	high (1)
Top of concentric corrugations	rounded	narrowly rounded	ridge-like	ridge-like to rounded
Radial striæ in 5 mm	23	10–12	10–12	18

The Trenton and Niagaran forms have the lateral margins of the shell more nearly parallel than is the case with those from the higher beds. This is seen also in the development of those from the higher horizons; the young shell, as indicated likewise in the direction of the corrugations, has sub-parallel sides. Gradually the hinge-line is extended, at first with a sharp marginal concavity (typical of adult Devonian forms), later with a more gradual deflexion (typical of the adult Mississippian form). The concentric corrugations are very low, with rounded tops in the Trenton individuals, but become higher, with more narrowly rounded or ridge-like tops in shells from higher and higher beds. The number of radial costæ appears in our specimens (18 occupy the space of 5 mm.) to be an important distinction; this changes from a large number in the Trenton form to few in Silurian and Devonian specimens, back to many again in the Mississippian.

Locality and Horizon. In the Lower Mississippian of North America. In the Minnewanka region in the Lower Mississippian of section 2-29 (R).

Genus, **Schuchertella** Girty

Remarks. This genus, otherwise quite similar, both internally and externally, to *Streptorhynchus* King, differs in its lower and wider cardinal area and in its undistorted umbo. *Schellwienella* Thomas is otherwise similar internally, but has a flat or, usually, concave pedicle valve and a convex brachial valve.

[1] Loc. cit.

Schuchertella girtyi n. sp.

Plate I, figures 1a-c

1900. *Orthothetes chemungensis* var. Girty, U.S. Geol. Surv., 20th Ann. Rept., pt. 2, p. 40, Pl. 3, figs. 4-6; *Schuchertella chemungensis* Kindle, 1909, U.S. Geol. Surv., Bull. 391, p. 16, Pl. 3, figs. 2-4a.

Description. Shell small, biconvex, wider than long, with hinge-line apparently shorter than the greatest width of the shell. Delthyrium slightly higher than wide. The dimensions of a somewhat imperfect shell are: length of pedicle valve 19 mm., of brachial valve 16 mm.; greatest breadth (apparently near the mid-length of the shell) 24 mm.±; thickness 9·5 mm.; length of hinge-line 19 mm.±; length and basal breadth of delthyrium 5·5 mm. and 4·5 mm. A smaller pedicle valve was 13 mm. long and 17 mm. wide.

Pedicle valve arched from beak to front, distinctly so in the umbonal region, very slightly so or almost flat beyond. Transversely the valve is most convex in the umbonal region, from the highest point of which the valve descends in almost straight lines to the cardinal margin. Anteriorly the valve is slightly flattened medially. Cardinal area high, transversely and vertically striate, straight below, arched above, the lower part inclined posteriorly so as to form an angle of about 110 degrees with the plane of the junction of the two valves. Beak twisted, projecting slightly over the cardinal area. Delthyrium covered by a convex, transversely ridged, and striated deltidium. Internally, both dental lamellæ and median septum absent.

Brachial valve very gently and subequally convex both longitudinally and transversely. Cardinal area very narrow.

Surface of both valves marked by fine, rather sharply elevated radial costæ, about 12 to 16 of which occupy the space of 5 mm.; interspaces wider than the costæ. These costæ may be nearly equal in height and breadth, may alternate in size, or each third or fifth costa may be considerably stronger than the intermediate ones. Fine concentric growth lines are faintly visible between the striæ.

Remarks. Our form is apparently identical with the one described by Girty from the Ouray of Colorado under the name of *Orthothetes chemungensis* var.[1] Girty finds this variety variable in convexity of pedicle and brachial valves, the height of the cardinal area, and the length of the hinge-line, which may be either shorter or considerably longer than the width of the shell below. In our specimens the hinge-line is apparently always shorter. The surface striæ Girty finds as variable as in our specimens. *S. chemungensis* Conrad is a much larger shell, with stronger costæ. Generically, this species is referred to *Schuchertella* Girty, for, though the beak is twisted, this torsion does not extend to the broader umbonal region as in *Streptorhynchus* King. The genotype of *Schuchertella*, *S. lens*, has the beak distorted about as much as has this species. In *Streptorhynchus*, likewise, the cardinal area is usually high and narrow.

Locality and Horizon. In the Upper Devonian (Ouray) of Colorado. In the Minnewanka region in the Upper Devonian of section 2-38 (r).

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[1] Loc. cit.

Genus, **Schellwienella** Thomas

Remarks. *Streptorhynchus* King has similar internal characters, but the shell is biconvex and the umbo of the pedicle valve is distorted, due to the attachment of the shell by its apex. *Schuchertella* Girty, as shown by its genotype *S. lens* (White), with similar internal characters and biconvexity, is unattached and undistorted. *Orthothetes* Fischer de Waldheim and *Derbya* Waagen include both sub-plane to bi-convex shells with dental lamellæ and a median septum in the pedicle valve, but the former has a small pyramidal spondylium, formed between the joined dental lamellæ and deltidium, which is lacking in the latter.

Schellwienella inequalis (Hall)

1858. *Orthis inequalis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 490, Pl. 2, figs. 6a-c; *Streptorhynchus equivalvis* Hall and Whitfield, 1877, U.S. Geol. Expl. 40th Par., vol. 4, p. 252, Pl. 4, figs. 1, 2; *Orthotetes inaequalis* Hall and Clarke, 1892, Pal. N.Y., vol. 8, pt. 1, Pl. 9A, figs. 20-23; Girty, 1899, U.S. Geol. Surv., Mon. 32, p. 522, Pl. 68, fig. 3a; *Schellwienella inequalis* Weller, 1914, Geol. Surv., Illinois, Mon. 1, pt. 61, Pl. 3, figs. 14-16.

Remarks. This is the most abundant Orthoid shell in the Minnewanka region. It is larger than the typical Mississippi Valley form, whose average length and breadth, as given by Weller, are 23 mm. and 31 mm. The brachial valves accompanying the rather uniform pedicle valves are of two kinds—those with a somewhat prominent umbo similar to those from the type locality in Iowa, and those with a flattened umbonal region. Girty also notes[1] these two types in the Yellowstone National park. Better preserved material, with the valves in contact, might enable these two forms to be distinguished, but with the material at hand they appear to intergrade. The only way in which the pedicle valves differ from the Iowan form is in the delthyrium having height and width nearly equal instead of being wider than high, and in the more posterior origin of the concavity. In the lower beds, sections 2-29 to 2-35 inclusive, the pedicle valve is similar to those from the type locality in that the concavity originates much nearer the anterior margin, the rest of the valve being flat. *Schellwienella inflata* (White and Whitfield), similarly from the Lower Mississippian, has a very ventricose brachial valve, with the delthyrium of the pedicle valve much higher than wide.

Locality and Horizon. In the Lower Mississippian of Mississippi valley and the Rocky mountains. In the Minnewanka region in the Mississippian of section 2-22 (C), 23 (c), 24 (c), 25 (c), 26 (R), 28 (r), 29 (r), 32 (r), 35 (r).

Schellwienella lata n. sp.

Plate VI, figures 7, 8

Description. Shell concavo-convex, of medium size, slightly wider than long, with greatest width about mid-length; the hinge-line a little shorter than the greatest width; cardinal extremities angular. The dimensions of a pedicle valve of medium size are: length 13 mm., greatest width 17 mm., length of hinge-line 16 mm., height of cardinal area 2·5 mm. The dimensions of a large brachial valve are: length 14 mm., greatest width 21 mm., length of hinge-line 18 mm., convexity 4 mm.

[1] Loc. cit.

Pedicle valve slightly concave from umbo forward; in some smaller specimens the umbonal region is flat, the slight concavity beginning anterior to this; the lateral margins, especially towards the cardinal margin, are gently convex. Beak very small, extended only slightly beyond the cardinal margin. Cardinal area rather narrow, flat, almost at right angles to the plane of the valve, inclined slightly posteriorly, its lateral margins angular; delthyrium forming almost an equilateral triangle. Internally the muscle scars are poorly defined; the teeth are supported by short dental plates—merely thickened ridges bordering each margin of the delthyrium.

Brachial valve of moderate convexity, with greatest convexity posterior to the middle, the surface curving very gently and regularly in all directions except towards the cardinal margin where it is more abruptly bent downward; the cardinal extremities are slightly flattened. Extending from the beak forward is a slight median flattening. Beak inconspicuous. Internally the muscle markings are poorly defined; the cardinal process is furrowed longitudinally with two grooves, giving to it a somewhat trilobed appearance; the dental sockets are very near the beak and well developed.

Surface of each valve marked by abruptly elevated radiating striæ; at the anterior part of a mature shell about six occupy the space of 1 mm. The striæ are often alternating in size; this is more frequently true of the brachial valve than of the pedicle. There are also numerous minute concentric growth lines.

Remarks. This species is known only from separate valves; in no case were we able to find it with valves in articulation; but the abundance of the two valves, with the practical exclusion of all forms of a similar type, makes it certain that they belong to the same species. The form most nearly similar to this species with which we could compare it is *S. inequalis* (Hall) from the Kinderhook of Pennsylvania to Utah. The latter is, however, somewhat larger and narrower, with less numerous radiating striæ (Weller gives 2 to 4 in the space of 1 mm.), the pedicle valve is convex or flat in the umbonal region and usually for two-thirds its length, and the brachial valve has often a faint median sinus.

Locality and Horizon. In the Minnewanka region in the Pennsylvanian of section 2-11 (c), 12 (C).

Genus, **Chonetes** Fischer de Waldheim

Chonetes illinoisensis Worthen

1858. *Chonetes logani* Hall, Geol. Surv., Iowa, vol. 1, pt. 2, p. 598, Pl. 12, figs. 1 a-e, 2 (not *C. logani* N. and P. 1855); *Chonetes illinoisensis* Worthen, 1860, Acad. Sci. St. Louis, Trans., vol. 1, p. 571; Winchell, 1863, Acad. Nat. Sci. Phil., Proc., p. 5; Winchell, 1865, Acad. Nat. Sci. Phil., Proc., p. 116; Meek and Worthen, 1868, Geol. Surv., Ill., Rept., vol. 3, p. 505, Pl. 15, figs. 8a, b; Winchell, 1870, Am. Phil. Soc., Proc., vol. 11, p. 251; *C. loganensis* Hall and Whitfield, 1877, U.S. Geol. Expl. 40th Par., Rept., vol. 4, p. 253, Pl. 4, fig. 9; *C. illinoisensis* Herrick, 1888, Sci. Lab. Denison Univ., Bull., vol. 3, p. 35, Pl. 3, fig. 21; Herrick, 1890, Geol. Soc. Am., Bull., vol. 2, p. 48, Pl. 1, fig. 16; Keyes, 1895, Missouri Geol. Surv., vol.

5, p. 53 (date of imprint, 1894); Weller, 1899, Acad. Sci., St. Louis, Trans., vol. 9, p. 15, Pl. 4, fig. 10; *C. loganensis* Girty, 1899, U.S. Geol. Surv., Mon. 32, pt. 2, p. 525, Pl. 68, figs. 5a-5c; *C. illinoisensis* Weller, 1900, Acad. Sci., St. Louis, Trans., vol. 10, p. 67, Pl. 1, fig. 14; *C.* sp. cf. *C. illinoisensis* Weller, 1901, Acad. Sci., St. Louis, Trans., vol. 11, p. 151; *C. illinoisensis* Girty, 1903, U.S. Geol. Surv., Prof. Paper 16, p. 279; Weller, 1914, Ill. Geol. Surv., Mon. 1, p. 81, Pl. 8, figs. 63-70.

Remarks. Our single specimen is apparently a good example of this species.

Locality and Horizon. Lower Mississippian of the Mississippi valley and west. In the Minnewanka region in the Lower Mississippian of section 2-26 (R).

Genus, **Productella** Hall

Productella pyxidata Hall

1858. *Productus pyxidatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 498, Pl. 3, figs. 8a-e; *P. shumardianus* Hall, 1858, Geol. Iowa, vol. 1, pt. 2, p. 499, Pl. 3, fig. 9 (not Pl. 7, fig. 2); *Productella pyxidata* Hall, 1883, Rept. N.Y. State Geol. for 1882, Pl. (17) 48, fig. 34; Hall and Clarke, 1892, Intr. To Study Brach., pt. 1, Pl. 21, figs. 20, 23; Hall and Clarke, 1892, Pal. N.Y., vol. 8, pt. 1, Pl. 17, fig. 34, Pl. 17A, fig. 14; Keyes, 1894, Mo. Geol. Surv., vol. 5, p. 52, Pl. 38, figs. 4a-d; Rowley, 1908, Mo. Bureau Geol. and Mines, vol. 8, 2nd ser., p. 77, Pl. 17, figs. 5, 30-36; Weller, 1914, Ill. Geol. Surv., Mon. 1, p. 100, Pl. 19, figs. 1-21.

Remarks. Our specimens differ from *P. blairi* in the less prominent umbonal region and narrow median sinus of the pedicle valve, and in the less pronounced radial ornamentation. They resemble *Productella depressa* Kindle of the Ouray Devonian of Colorado in the moderate convexity of the pedicle valve, and in the small and inconspicuous beak and umbo, but differ in the much smaller size, narrower and weaker sinus, less defined ears, and shorter hinge-line. *Productella concentrica* (Hall) is much more strongly concavo-convex. The Minnewanka form apparently has more regular concentric wrinkles than the Missouri form.

Locality and Horizon. Lower Mississippian of Missouri. In the Minnewanka region in the Upper Devonian of section 2-38 (r).

Productella cf. *laminatus* Kindle

1909. *Productella laminatus* Kindle, U.S. Geol. Surv., Bull. 391, p. 18, Pl. 4, figs. 13-14.

Remarks. A single, small, slightly imperfect pedicle valve is identified provisionally with this species. The concentric bands are strongly marked; there are seven preserved. Much of the surface is partly exfoliated, but where preserved shows numerous fine spines.

Locality and Horizon. In the Upper Devonian of Colorado. In the Minnewanka region in the Upper Devonian of section 2-38 (R).

Productella coloradoensis Kindle

1909. *Productella coloradoensis* Kindle, U.S. Geol. Surv., Bull. 391, p. 17, Pl. 4, figs. 2–8.

Locality and Horizon. In the Upper Devonian of Colorado. In the Minnewanka region in the Upper Devonian of section 2-38 (r).

Productella concentrica (Hall) ?

1857. *Productus concentricus* Hall, 10th Rept. N.Y. State Cab. Nat. Hist., p. 180; *P. shumardianus* Hall, 1858, Geol. Surv., Iowa, vol. 1, pt. 2, p. 499, Pl. 7, fig. 12 (not Pl. 3, fig. 9); *P. concentricus* Hall, 1858, Geol. Surv., Iowa, vol. 1, pt. 2, p. 517, Pl. 7, fig. 3; *Productella shumardiana* Hall and Clarke, 1892, Pal. N.Y., vol. 8, pt. 1, Pl. 17, fig. 7; *P. cooperensis* Girty, 1899, U.S. Geol. Surv., Mon. 32, p. 528, Pl. 68, figs. 8a-c, 9a-b; *P. concentrica* Weller, 1914, Geol. Surv., Illinois, Mon. 1, p. 98, Pl. 19, figs. 22-34.

Remarks. The single imperfect pedicle valve identified provisionally with this variable species differs mainly in its apparent lack of elongate nodes upon the anterior and lateral parts, which frequently unite to form low, broad costæ. The anterior part of our shell, however, is imperfectly preserved and, moreover, Weller shows that upon shells from the type locality these nodes are often obsolete. *Productella pyxidata* has a much less gibbous pedicle valve, with larger ears, and is, comparatively, a much broader shell.

Locality and Horizon. In the Lower Mississippian of the Mississippi valley, etc. In the Minnewanka region in the Lower Mississippian of section 2-25 (R).

Genus, **Productus** Sowerby

Productus ovatus Hall

1858. *Productus ovatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 674, Pl. 24, fig. 1; *P. laevicostus* ? Hall and Whitfield, 1877, U.S. Geol. Expl. 40th Par., vol. 4, p. 266, Pl. 5, figs. 7-8; *P. pileiformis* Whitfield, 1891, Ann. N.Y. Acad. Sci., vol. 5, p. 582, Pl. 13, figs. 13-14; *P. ovatus* Hall and Clarke, 1892, Pal. N.Y., vol. 8, pt. 1, Pl. 18, fig. 19; *P. laevicostus* Keyes, 1894, Missouri Geol. Surv., vol. 5, p. 41, Pl. 38, fig. 1; *P. ovatus* Keyes, 1894, Missouri Geol. Surv., vol. 5, p. 44; *P. pileiformis* Whitfield, 1895, Geol. Surv., Ohio, vol. 7, p. 470, Pl. 9, figs. 13-14; *P. laevicosta* Girty, 1899, U.S. Geol. Surv., Mon. 32, p. 534, Pl. 69, figs. 9a-c; *P. pileiformis* Girty, 1909, U.S. Geol. Surv., Bull. 377, p. 26, Pl. 2, fig. 7; Girty, 1911, U.S. Geol. Surv., Bull. 439, p. 44, Pl. 4, figs. 1-2; *P. ovatus* Weller, 1914, Geol. Surv., Illinois, Mon. 1, p. 132, Pl. 16, figs. 1-15.

Remarks. A single imperfect pedicle valve is identified with this species. It has a length of 40 mm. from the umbonal region to the front margin and a width of 30 mm. The umbonal region is strongly incurved, whereas the front of the valve is gently convex. There is no median sinus but this region is gently convex transversely, whereas beyond this the surface rounds suddenly and then descends abruptly to the lateral margins. The entire surface is covered with fine, rounded, flexuous costæ, from eight to ten of which occur in a distance of 5 mm. towards the front of the valve. No spines were noted. This species is distinguished from *P. cora* of the Pennsylvanian in being more narrowly rounded transversely; the change from the gently convex median part to the lateral slopes is more sudden and the lateral slopes are more abrupt.

A brachial valve resembles this species in the character of the costæ, in the strong concentric wrinkles upon the ears which become less strong over the median part of the valve, and in the sharp delimitation of the ears. It differs in its very slight concavity, about 2 mm. in a length of 25 mm.; the usual valve of this species is highly concave.

Locality and Horizon. Throughout the Mississippian of the Mississippi valley. In the Minnewanka region in the Lower Mississippian of section 2-32 (R), 34 (?).

Productus fernglenensis Weller

1909. *Productus fernglenensis* Weller, Bull. Geol. Soc. Am., vol. 20, p. 299, Pl. 12, figs. 14-17; Weller, 1914, Ill. Geol. Surv., Mon. 1, p. 106, Pl. 9, figs. 11-17.

Locality and Horizon. In the Lower Mississippian (Kinderhook) of Missouri. In the Minnewanka region in the Lower Mississippian of section 2-22 (r), 23 (c), 24 (c), 25 (c), 27 (?), 29 (R).

Productus gallatinensis Girty

1899. *Productus gallatinensis* Girty, U.S. Geol. Surv., Mon. 32, p. 533, Pl. 68, figs. 7 a-c, 11 a-d.

Remarks. The Minnewanka form agrees fully with a suite of this species from the Madison limestone of West Gallatin canyon, Montana. We are not so persuaded, however, that it is identical with the form described under the same name from the Pennsylvanian of Colorado. This latter form, if we may judge from the figures, has a more distinct median sinus in the pedicle valve and stronger concentric wrinkles, especially over the top of the umbonal region. Such slight differences could, however, be of specific importance only upon stratigraphic grounds. The form from the basal Pennsylvanian (Morrow group) of Arkansas and Oklahoma, described by Mather,[1] is apparently more closely related to the Pennsylvanian form than it is to that from the Madison. As Girty and Mather have suggested, this Pennsylvanian form may prove to be *P. boonensis* Swallow. *Productus arcuatus* Hall from the Kinderhook of the Mississippi valley has weaker, less numerous, and less regular striæ.

Locality and Horizon. Lower Mississippian of Yellowstone National park and Montana. In the Minnewanka region in the Lower Mississippian of section 2-22 (C), 23 (r), 24 (c), 25 (C), 29 (r), 34 (r), 35 (?).

[1] Bull. Sci. Lab., Denison Univ., vol. 18, p. 163, 1915.

Productus blairi Miller

1892. *Productus blairi* Miller, 17th Rept. Geol. Surv., Indiana, p. 689, Pl. 13, fig. 16 (not fig. 17); Weller, 1914, Geol. Surv., Illinois, Mon. 1, p. 110, Pl. 14, figs. 14-21.

Remarks. Our form agrees well with Miller's species. The principal difference lies in the somewhat narrower umbonal region of the majority of the Minnewanka shells; in some it is every bit as broad. Our specimens show well the development of the surface markings of *Productella* into those of *Productus*. The beak here is in this respect a typical *Productella* with its concentric growth lines and spines with circular bases; these bases gradually become more and more elongate until upon the body of a mature shell they would be described as interrupted costæ.

Locality and Horizon. Lower Mississippian of Missouri. In the Minnewanka region in the Lower Mississippian of section 2-25 (c).

Productus minnewankensis n. sp.

Plate I, figures 6a, b, c; 7

Description. Shell small. Hinge-line shorter than the greatest width of the shell. The dimensions of a pedicle valve of normal size are: length from hinge-line to front margin 10 mm.; length from umbonal region to front 12·5 mm.; length from beak over umbo to front 20 mm.; length of hinge-line 6 mm.; greatest width 9·5 mm.; convexity 7 mm.

Pedicle valve gibbous, with prominent umbonal region. Longitudinally the posterior curvature is more pronounced and shorter than the anterior. Transversely the median part is narrowly rounded, whereas laterally the surface descends very abruptly, almost vertically, to the margins. Umbonal region narrow, pointed. Median sinus absent.

Brachial valve with a gently concave visceral part beyond which the concavity of the valve becomes almost a right angle laterally and anteriorly, becoming more flattened toward the cardinal border.

The entire surface of both valves, except the posterior umbonal region, is covered by low, rounded, rarely bifurcating, radiating costæ, about eight to ten of which occupy the space of 5 mm. Comparatively large spines are usually quite numerous upon the umbonal part and lateral slopes of the shell. Usually a few spines are scattered over the remainder of the shell, but most frequently all the median part in front of the umbonal region is devoid of spines. The entire surface is likewise covered with fine concentric growth lines.

The young shell is of the *Productella spinulicosta* Hall and *P. concentrica* Hall type (Middle Devonian and Lower Mississippian), with strongly elevated umbonal region, concentric wrinkles and striæ, and separated spine bases. These spine bases near the beak are rounded, but farther forward become more and more elongate until their ends merge in the production of costæ. Spine bases continue to occur at intervals upon these costæ, but become rarer and rarer, except upon the lateral slopes, as the anterior margin is approached.

Remarks. This form is most closely allied to *Productus sampsoni* Weller from the Kinderhook of Missouri. It is, however, proportionately narrower, with a greater convexity and shorter hinge-line, with a more abrupt curvature from the median line of the pedicle valve to its lateral margins, and with much more numerous spines (Weller's species has usually only two or three spines upon each side of the beak, whereas the radiating costæ apparently continue to the beak).

In surface markings the young shell is a *Productella,* but it rapidly attains definite costæ which, in the absence of a knowledge of internal characters, place this shell in the genus *Productus.*

Locality and Horizon. The nearest ally occurs in the Lower Mississippian of Missouri. In the Minnewanka region in the Lower Mississippian of section 2-25 (C).

Productus arcuatus Hall

1858. *Productus arcuatus* Hall, Geol. Iowa, pt. 2, p. 518, Pl. 7, figs. 4a-b; *Productella arcuata* Hall and Clarke, 1892, Pal. N.Y., vol. 8, pt. 1, Pl. 17, figs. 31, 32; *Productus arcuatus* Weller, 1914, Geol. Surv., Illinois, Mon. 1, p. 107, Pl. 13, figs. 1-8, ? 9-12.

Remarks. Our form agrees with description and figures of this species given by Weller. The only doubtful feature is the hinge-line, which is destroyed, but there is some evidence that the surface of the ears was "more nearly vertical than horizontal" as in *P. arcuatus.*

Locality and Horizon. In the Mississippian of the Mississippi valley. In the Minnewanka region in the Mississippian of section 4-3 (R).

Productus burlingtonensis Hall

1858. *Productus flemingi* var. *burlingtonensis* Hall, Geol. Iowa, vol. 1, pt. 2, p. 598, Pl. 12, figs. 3a-g; Hall and Whitfield, 1887, King's U.S. Geol. Expl. 40th Par., 4, p. 265, Pl. 5, figs. 9-12; Hall, 1883, Rept. N.Y. State Geol. for 1882, Pl. (18) 49, figs. 6-8; Hall and Clarke, 1892, Pal. N.Y. vol. 8, pt. 1, Pl. 18, figs. 6-8; *P. burlingtonensis* Keyes, 1894, Mo. Geol. Surv., vol. 5, p. 41; Weller, 1914, Ill. Geol. Surv., Mon. 1, p. 104, Pl. 9, figs. 1-10.

Remarks. It is at times difficult to distinguish this species from *P. fernglenensis;* the latter species, however, has typically a more strongly incurved pedicle valve and the median sinus and fold are absent, represented by a mere flattening along the median line of the shell. *P. inflatus* McChesney has more conspicuous ears of the pedicle valve and a narrower and deeper median sinus.

Locality and Horizon. Lower Mississippian (Burlington) of the Mississippi valley. In the Minnewanka region in the Lower Mississippian of section 2-23 (r), 25 (r), 29 (r).

Productus semireticulatus (Martin)

1809. *Anomites semireticulatus* Martin, Petrifacta Derbiensia, p. 7, Pl. 32, figs. 1, 2, Pl. 33, fig. 4; *Productus semireticulatus* Meek, 1872, Final Rept. U.S. Geol. Surv., Nebraska, p. 166, Pl. 5, figs. 7a, b; White, 1875, Wheeler's Expl. Surv. W. 100th Mer., vol. 4, p. 111, Pl. 8, fig. 1; Meek, 1877, King's U.S. Geol. Expl. 40th Par., vol. 4, p. 69, Pl. 7, fig. 5; White, 1884, 13th Rept. State Geol. Indiana, p. 125, Pl. 24, figs. 1-3; Hall and Clarke, 1892, Pal. N.Y., vol. 8, pt. 1, Pl. 17A, figs. 16-18, Pl. 18, figs. 11-13, Pl. 19, figs. 19-23; Keyes, 1895, Geol. Surv., Missouri, p. 50, Pl. 36, fig. 4.

Above are cited a few references to the Pennsylvanian occurrence of this species. The species is less widely cited from the Mississippian.

Remarks. The very poorly preserved specimens identified with this species are large, moderately convex pedicle valves, wider than long, with a broad, rather weakly developed median sinus from which the surface rounds abruptly and then gently descends to the lateral margins. A transverse section thus does not at all give a quadrate outline. Hinge-line almost as long as the width of the shell in front. Surface covered with coarse radiating costæ, from three to four occupying the space of 5 mm. Strong concentric wrinkles cover the umbonal region. Two brachial valves with a shallow median fold and with surface characters similar to those of the above pedicle valves probably belong to this species.

Locality and Horizon. Throughout the Pennsylvanian of North America, rarer in the Permian. In the Minnewanka region in the Permian of section 1-14 (c); in the Pennsylvanian of section 2-1 (?).

Productus coloradoensis Girty ?

1903. *Productus inflatus* Girty (non McChesney), U.S. Geol. Surv., Prof. Paper 16, p. 359, Pl. 3, figs. 1-3; Girty (non McChesney), 1904, U.S. Geol. Surv., Prof. Paper 21, p. 52, Pl. 11, figs. 5, 6; *Productus inflatus* var. *coloradoensis* Girty, 1910, N.Y. Acad. Sci., Annals, vol. 20; Girty, ? 1911, U.S. Geol. Surv., Bull. 439, p. 42, Pl. 4, fig. 3; Girty, ? 1915, U.S. Geol. Surv., Bull. 593, p. 47, Pl. 3, figs. 7-8 a.

Remarks. The Minnewanka form is quite similar to the one figured and described by Girty under this name. The specimens are poorly preserved; otherwise a more exact determination could be made. Our form is apparently somewhat nearer *P. coloradoensis* than to *P. hermosanus* Girty from the Pennsylvanian of Colorado. The latter very closely related species is proportionately somewhat broader with somewhat coarser costæ. The row of spines at the base of the ears, also shown upon the figures of this type, allies this shell with *P. costatus* and distinguishes it from the Mississippian *P. fernglenensis* and *P. burlingtonensis.*

Locality and Horizon. In the Pennsylvanian of Arkansas, Colorado, and Arizona. In the Minnewanka region in the Permian of section 1-14 (r); in the Pennsylvanian of section 2-11 (c), 13 (C), 14 (r).

Productus cora d'Orbigny

1842. *Productus cora* d'Orbigny, Voy. dans l'Amér. mérid., t. III, pt. 4, p. 55, Pl. 5, figs. 8-10; *Productus prattenianus* Meek, 1872, U.S. Geol. Surv., Nebraska, p. 163, Pl. 2, figs. 5a-c, Pl. 5, fig. 13, Pl. 8, figs. 10a, b; *Productus cora* White, 1884, 13th Rept. Geol. Surv., Indiana, p. 126, Pl. 26, figs. 1-3; Keyes, 1894, Missouri Geol. Surv., vol. 5, p. 47, Pl. 37, figs. 2a-c; Beede, 1900, Univ. Geol. Surv., Kansas, vol. 6, p. 75, Pl. 11, figs. 1-1 f; Girty, 1903, U.S. Geol. Surv., Prof. Paper 16, p. 364, Pl. 4, figs. 1-4 b.

Remarks. Our form agrees closely with the Pennsylvanian shell usually identified with this South American species. The presence of a few large spines upon the body of the shell is a variable feature.

Locality and Horizon. Widely distributed throughout North America in the Pennsylvanian. In the Minnewanka region in the Pennsylvanian of section 1-22 (?), 27 (c), 29 (c), 31 (r); 2 a-3 (r), 10 (r), 14 (r); 2-8 (?), 11 (R), 13 (c); 3-7 (c); 3 a-4 (c).

Genus, **Pustula** Thomas

Pustula punctata (Martin)

1809. *Anomites punctatus* Martin, Petrefacta Derbiensia, p. 8, Pl. 37, fig. 6; *Productus punctatus* Morton, 1836, Am. Jour. Sci., 1st series, vol. 29, p. 153, Pl. 26, fig. 38; Meek, 1872, U.S. Geol. Surv., Nebraska, p. 169, Pl. 2, fig. 6, Pl. 4, fig. 5; Meek and Worthen, 1873, Geol. Surv., Illinois, vol. 5, p. 569, Pl. 25, fig. 13; White, 1877, U.S. Geog. Surv. west of 100th Mer., vol. 4, p. 114, Pl. 7, figs. 2 a-c; White, 1882, 11th Rept. Geol. Surv., Indiana, p. 373, Pl. 42, figs. 1-3; White, 1884, 13th Rept. Geol. Surv., Indiana, p. 124, Pl. 27, figs. 1-3; Hall and Clarke, 1892, Pal. N.Y., vol. 8, pt. 1, Pl. 17A, fig. 21, Pl. 19, figs. 14-16; Keyes, 1894, Missouri Geol. Surv., vol. 5, p. 51, Pl. 37, figs. 1 a-c; Beede, 1900, Univ. Geol. Surv., Kansas, vol. 6, p. 87, Pl. 10, figs. 3-3 e, Pl. 11, fig. 3.

Remarks. The Minnewanka form is quite similar to the typical Coal Measures shell of the Mississippi valley. *P. alternatus* Norwood and Pratten of the Osage group has broader concentric bands, broader umbonal region, and relatively longer hinge-line. *P. biseriatus* Hall from the St. Louis group has no sinus on the pedicle valve and very few (five or six) concentric folds.

Locality and Horizon. Pennsylvanian throughout North America. In the Minnewanka region in the Pennsylvanian of sections 1-29 (r); 2-2 (c), 10 (R).

Pustula nebrascensis (Owen)

1852. *Productus nebrascensis* Owen, Geol. Rep. Wis., Iowa, Minn., p. 594, tab. 5, fig. 3; Meek, 1872, U.S. Geol. Surv., Nebraska, p. 165, Pl. 2, fig. 2, Pl. 4, fig. 6, Pl. 5, figs. 11 a-c; Meek and Worthen, 1873, Geol. Surv., Illinois, vol. 5, p. 569, Pl. 25, fig. 8; White, 1877, U.S. Geog. Surv. W. 100th Mer., vol. 4, p. 116, Pl. 8, figs. 3 a-d; White, 1884, 13th Rept. Geol. Surv., Indiana, p. 122, Pl. 24, figs. 7-9; *P. nebrascensis* ? Heilprin, 1886, 2d Geol. Surv., Pennsylvania, Ann. Rept., 1885, p. 453, fig. 4 c; p. 440, figs. 4-4 b; *P. nebrascensis* Hall and Clarke, 1892, Pal. N.Y., vol. 8, pt. 1, Pl. 19, figs. 5-7; Keyes, 1894, Missouri Geol. Surv., vol. 5, p. 48, Pl. 37, figs. 3 a-c; Beede, 1900, Univ. Geol. Surv., Kansas, vol. 6, p. 84, Pl. 9, figs. 7-7 f; Girty, 1903, Prof. Paper 16, U.S. Geol. Surv., p. 370, Pl. 5, figs. 1-2 a; Girty, 1904, U.S. Geol. Surv., Prof. Paper 21, p. 53, Pl. 11, figs. 7-9; Girty, 1909, U.S. Geol. Surv., Bull. 389, p. 62, Pl. 7, figs. 5, 6; *Pustula nebraskensis* Mather, 1915, Bull. Sci. Lab. Denison Univ., vol. 18, p. 169, Pl. 9, figs. 6, 7.

Remarks. The Minnewanka shell differs from the typical Mississippi Valley Pennsylvanian form in the greater obscurity both of the concentric wrinkles in the umbonal region and of the concentric bands of spine bases. There is, moreover, no evidence of the set of large erect spines which occur with the small appressed ones noted above. In these respects it agrees with the form noted by Girty[1] from the Manzano group of New Mexico.

Locality and Horizon. In the Pennsylvanian throughout North America. In the Minnewanka region in the Pennsylvanian of section 3 a-5 (r).

Genus, **Schizophoria** King

Schizophoria striatula (Schlotheim)

1813. *Anomia terebratulites striatulus* Schlotheim, Min. Tauschenbuch, 8, Pl. 1, fig. 6; *Orthis striatulus* Davidson, 1865, Brit. Devonian Brach., Pal. Soc., p. 87, Pl. 17, figs. 4-7; *Orthis impressa* Hall, 1867, Pal. N.Y., 4, p. 60, Pl. 8, figs. 11-19; Ibid, Whitfield, 1882, Geol. Wisconsin, p. 326, Pl. 25, figs. 13-15; Ibid, Walcott, 1884, U.S. Geol. Surv., Mon. 8, p. 115, Pl. 13, fig. 13; Ibid (genus *Schizophoria*) Hall and Clarke, 1892, Pal. N.Y., 8 ,pt. 1, pp. 212, 216, Pl. 6, fig. 31, Pl. 6A, figs. 26, 27; *Orthis iowaensis* Hall, 1858, Geol. Surv., Iowa, pt. 2, p. 488, Pl. 2, fig. 4; Ibid, White, 1881, 10th Ann. Rept. State Geol. Indiana, p. 133, Pl. 5, figs. 10-12; Ibid (genus *Schizophoria*) Hall and Clarke, 1892, Pal. N.Y., 8, pt. 1, pp. 212, 226, Pl. 6A, fig. 29; Ibid, Keyes, 1895, Geol. Surv., Missouri, 5, p. 62, Pl. 38, fig. 6.

Remarks. The Minnewanka form differs only slightly from the eastern type. Compared with a specimen of similar size from Rockford, Iowa, to which it is otherwise externally exactly similar, the Alberta form has a more convex umbonal region in the brachial valve, and a more pronounced sinus in the pedicle valve; both of these are, however, variable characters even in the specimens from Iowa. In the former character our form approaches the variety *australis*, but differs from this variety especially in the higher cardinal area of its pedicle valve. Kindle founded this variety from New Mexico upon these two characters—the notably lower area in the pedicle valve and the extremely gibbous character of the umbonal region of the brachial valve. Our large specimens, which approach this variety most nearly, have the brachial valve less convex and the cardinal area of pedicle valve considerably higher. Our largest specimen is 25 mm. long by 30 mm. wide with a broad shallow sinus at the front.

Locality and Horizon. Middle and Upper Devonian throughout North America. In the Minnewanka region in the Upper Devonian of sections 2-38 (C); 4-5 (R).

[1] U.S. Geol. Surv., Bull. 389, p. 62.

Schizophoria chouteauensis Weller

1914. *Schizophoria chouteauensis* Weller, State Geol. Surv., Ill., Mon. 1, p. 163, Pl. 23, figs. 6-19.

Remarks. The Minnewanka specimens observed are, judging from surface features, apparently identical with the form named by Weller *S. chouteauensis*. In size our specimens agree more fully with White and Whitfield's *S. subelliptica*, but in this species the beaks of both valves project posteriorly more strongly, there is a broad median sinus in the pedicle valve, and near the frontal margin the surface of the shell has four or five radiating striæ in 1 mm. Even in size, however, the difference between the Minnewanka specimens and Weller's species is slight; two specimens of *S. chouteauensis* noted give for greatest width 14 mm. and 23 mm., respectively.

Locality and Horizon. Lower Mississippian (Chouteau) of Missouri. In the Minnewanka region in the Lower Mississippian of section 2-35 (r).

Genus, **Enteletes** Fischer de Waldheim

cf. *Enteletes hemiplicata* Hall

Remarks. A single crushed specimen, further imperfect in having lost the umbonal region, shows the four prominent subangular plications upon each valve characteristic of this species. At the cardinal margin there occurs similarly a faint plication, and the entire shell is covered by fine but conspicuous radial striæ. The plications strongly zigzag at the margin. Owing to the crushed state of the shell it is impossible to say how convex it was originally; it was, however, apparently not quite as globular as the common Indiana form. Our specimen, moreover, has the two middle plications of the pedicle valve much more widely separated and lacks the single low median plication of the brachial valve.

Locality and Horizon. Pennsylvanian of Mississippi valley and the Rocky mountains. In the Minnewanka region in the Lower Mississippian of section 2-34 (R).

Genus, **Rhynchotreta** Hall

Rhynchotreta sp.

Remarks. A single shell, imperfect anteriorly, belongs apparently to this genus. The narrow umbo of the brachial valve meets the pedicle valve at nearly a right angle. The brachial valve bears a deep, angular median sinus and eight, low, rounded plications.

Locality and Horizon. In the Minnewanka region in the Lower Pennsylvanian of section 2-10 (R).

Genus, **Camarotoechia** Hall and Clarke

Camarotoechia sp.

Remarks. A single, somewhat imperfect shell looks much like *C. endlichi* Meek except that it has a rounded instead of an acutely angular margin of the pedicle valve. The median sinus of the pedicle valve is broad and flat. The entire surface of each valve is covered with about 45 low rounded plications with narrow interspaces. The sinus has six plications at bottom and five upon each inner slope.

Locality and Horizon. In the Minnewanka region in the Upper Devonian of section 2-38 (R).

Camarotoechia cf. *endlichi* (Meek)

1875. *Rhynchonella endlichi* Meek, U.S. Geol. and Geog. Surv. Terr., Bull. 1 (2nd ser.), p. 46; White, 1883, U.S. Geol. and Geog. Surv. Terr., 12th Ann. Rept., p. 133, Pl. 33, fig. 4, Pl. 36, fig. 2; *Camarotoechia endlichi* Girty, 1900, U.S. Geol. Surv., 20th Ann. Rept., pt. 2, p. 56, Pl. 6, figs. 1-4, Pl. 7, fig. 1; Kindle, 1909, U.S. Geol. Surv., Bull. 391, p. 21, Pl. 6, figs. 10-11 a, Pl. 7, figs. 1-2.

Remarks. These specimens probably fall within the limits of this very variable species as figured rather fully by Girty. They differ from Meek's description in having a rounded instead of a flat-bottomed sinus and in having fewer radial plications. In Girty's discussion of specimens from the type region, he says that the species is exceedingly variable in the character of its plications, and Kindle figures a specimen from New Mexico which shows no lateral plications and six or seven weak ones upon fold and sinus.

Locality and Horizon. Upper Devonian of Colorado and New Mexico. In the Minnewanka region in the Upper Devonian of section 2-38 (r).

Camarotoechia elegantula Rowley

1900. *Camarotoechia elegantula* Rowley, Am. Geol., vol. 25, p. 264, Pl. 5, figs. 44-47; Weller, 1914, State Geol. Surv., Ill., Mon. 1, p. 177, Pl. 24, figs. 1-8.

Remarks. The Minnewanka form agrees quite closely with this Missouri species as described and figured by Rowley and Weller. The Alberta shell is slightly less thick and has a somewhat narrower sinus. *C. tuta* (Miller) is a smaller shell with length and breadth subequal or somewhat longer than wide.

Locality and Horizon. Mississippian of Missouri. In the Minnewanka region in the Mississippian of sections 2, 23 (r), 24 (?), 25 (r), 26 (r), 27 (?); 4-3 (c).

Genus, **Paraphorhynchus** Weller

Paraphorhynchus obscurum n. sp.

Plate VII, figures 1, 2, 3

Description. Shell of medium size, longer than wide. The lateral margins of the umbonal region extend from the beak in almost straight lines for a third and a half the length of the shell. The dimensions of two pedicle valves slightly above the average size are: length 32 mm., 30 mm.; greatest width (a little anterior to mid-length) 25 mm., 25 mm. A brachial valve gives similarly 27 mm., 22 mm. Another specimen, likewise an internal mould, has a probable length and breadth of 28 mm. and 23 mm., and a thickness (immediately posterior to mid-length of shell) of 15 mm.

Pedicle valve rather strongly arched from beak to front, omitting the variable lingual extension; greatest convexity in posterior region. At mid-length of valve or slightly posterior to it arises a broad, rather shallow, rounded median sinus, which increases in width rapidly so as to occupy the entire width of the valve anteriorly; at the front of the valve it bends downward quite rapidly, forming at times an angle of 120 degrees to the plane of the valve, and producing a more or less lingual extension. Laterally from the median sinus the surface of the valve is almost flat.

Umbonal region of moderate prominence. Internally the prominent, triangular muscle area is bounded posteriorly by diverging ridges and divided medially by a short, broad septum. Teeth of moderate size, supported in youth by short dental lamellæ, which later disappear. Delthyrium apparently open.

Brachial valve arched from beak to front, rather strongly in umbonal region, much less from the middle of the valve forward; transversely it is rather uniformly convex. Greatest depth of valve about the same as that of the pedicle, but anterior to the middle instead of posterior. Internally, the hinge-plate lodges medially a small cavity, the spondylium, and laterally the dental sockets; this plate is supported by the median septum which extends almost half the length of the valve, becoming narrower and lower as it advances. The outer edges of the hinge-plate are apparently crenulated.

The entire surface of both valves is marked by fine and a few coarser concentric growth lines and by very fine radial striæ; about five of the latter occupy the space of 1 mm. There are also from three to five low, broadly rounded, radiating plications in the median sinus and upon the fold, but none upon the lateral slopes of the valves. Though the typical form has inconspicuous, obscure median plications, other specimens with all the other characters of this, both external and internal, have no plications; we are, accordingly, inclined to include these latter specimens within the species.

Remarks. The radial striæ place this Liorhynchus shell within Weller's genus Paraphorhynchus. *P. transversum* Weller from the Kinderhook of Iowa and Illinois, though similar internally, except for the presence of the long, supporting dental lamellæ, is wider than long, with plications upon the lateral slopes. *P. elongatum* Weller from the Kinderhook of Missouri differs internally and has, moreover, plications covering the entire shell. The absence of all plications upon the lateral slopes and their faint development or at times their entire absence upon the median part of the shell, together with the presence of dental lamellæ in the young shell only, argue a much later period of development and hence, very probably, a later period of earth history for their existence. Some individuals retain the dental lamellæ longer than others.

Locality and Horizon. In the Minnewanka region in the Permian of section 1-14 (C); in the Pennsylvanian of section 2-12 (R).

Genus, **Dielasma** King

Dielasma chouteauensis Weller

1914. *Dielasma chouteauensis* Weller, Geol. Surv., Ill., Mon. 1, p. 257, Pl. 32, figs. 1-17.

Remarks. Our form is apparently similar to those described by Weller from Missouri. The faint radiating costæ which are doubtfully said to be present were not noticed upon any of ours. This species may be recognized by its depressed convex shell; the greatest thickness is somewhat more than half its greatest width. In *D. formosum* the maximum width and thickness are almost equal. Internally the muscle-bearing platform bears a single cavity beneath it, whereas in *D. formosum* there are two, separated by a longitudinal median ridge.

Locality and Horizon. Mississippian (Chouteau) of Missouri. In the Minnewanka region in the Lower Mississippian of section 2-22 (c), 23 (C), 24 (r), 25 (c), 26 (r).

Dielasma arkansanum Weller

1914. *Dielasma arkansanum* Weller, Ill. Geol. Surv., Mon. 1, p. 269, Pl. 31, figs. 35-44; Mather, 1915, Bull. Sci. Lab., Denison Univ., 18, p. 180, Pl. 11, figs. 12-12b.

Remarks. The somewhat crushed state of our single specimen makes the determination of place of greatest width difficult; it is surely not posterior to mid-length of shell and most probably some distance anterior to it. In length, breadth, and thickness, and in other proportions it is similar to *D. arkansanum.* It lacks the spatulate outline of *D. subspatulatum* Weller. The absence of a distinct median sinus removes it from *D. bovidens* of the Pennsylvanian.

Locality and Horizon. Lower Pennsylvanian of Arkansas. In the Minnewanka region in the Permian of section 1-14 (R).

Genus, **Spirifer** Sowerby

Spirifer whitneyi Hall

1858. *Spirifer whitneyi* Hall, Geol. Surv., Iowa, 1, pt. 2, p. 502, Pl. 4, fig. 2; Hall, 1867, Pal. New York, 4, pp. 243, 417; *Spirifera whitneyi* Hall, 1883, Second Ann. Rept. N.Y. State Geologist, Pl. 55, figs. 18, 19; Whiteaves, 1891, Contrib. to Can. Pal. 1, p. 222; *Spirifer whitneyi* Hall and Clarke, 1893, Pal. N.Y. 8, pt. 2, pp. 24, 57, Pl. 30, figs. 18, 19; Kindle, 1909 ?, U.S. Geol. Surv., Bull. 391, p. 24, Pl. 8, figs. 2-5a; Haynes, 1916, Annals Carnegie Mus., vol. 10, p. 33, Pl. 5, fig. 5, Pl. 6, figs. 8-11.

Remarks. The Minnewanka form agrees very closely with those from Iowa; it differs principally in its more alate outline and its fewer plications. This difference is, however, very slight. The majority at least of the specimens from Colorado and New Mexico, as described and figured by Kindle, under this name, are larger, more gibbous, subquadrate, the sides being almost vertical or with rounded cardinal extremities; these very probably belong to the variety *monticola.* *S. whitneyi animosensis* Girty is very similar in size and plications, but has a very high, flat, cardinal area, at times the beak incurved very slightly. Upon comparison with Haynes' material from the Three Forks formation of Montana our specimens were noticeably in perfect agreement.

Locality and Horizon. Upper Devonian of Iowa, and the Rockies. In the Minnewanka region in the Upper Devonian of sections 2-38 (r), 45 (?); 4-5 (R).

Spirifer whitneyi monticola Haynes

1916. *Spirifer whitneyi monticola* Haynes, Annals Carnegie Mus., vol. 10, p. 36, Pl. 6, figs. 1-7; cf. *Spirifer whitneyi* Kindle, 1909, U.S. Geol. Surv., Bull. 391, p. 24, Pl. 8, figs. 2-5a.

Remarks. This variety is characterized by its robust form and short hinge-line. Upon comparison with Haynes' material from Montana there is no doubt of the Minnewanka form belonging to this variety. The form described by Kindle[1] from New Mexico and illustrated by his figures 2, 3, and 5 appears to belong to this variety, but as we have not seen his specimens it is not placed definitely in the synonymy.

Locality and Horizon. Upper Devonian of New Mexico, Colorado, and Montana. In the Minnewanka region in the Upper Devonian of sections 2-38 (lowest 55 feet) (c); 4-3 (?)-5 (c).

Spirifer whitneyi cf. *gallatinensis* Haynes

1916. *Spirifer whitneyi gallatinensis* Haynes, Annals Carnegie Mus., vol. 10, p. 35, Pl. 5, figs. 3-4.

Remarks. This variety is characterized by the low, usually flat, cardinal area which is of equal width throughout its entire extent. The Minnewanka form apparently agrees with Haynes' type, except that the former has a proportionately greater breadth; Haynes gives for length of an average specimen 19 mm., width 29 mm., height of cardinal area 4 mm., width of delthyrium 4 mm. One Minnewanka specimen was noted with this proportion; the other extreme was noted in a mucronate individual having a length of 11 mm. ±, length of hinge-line of 66 mm., and height of cardinal area of 1 mm. This height was very slightly less at the cardinal extremity than at the beak.

Locality and Horizon. Upper Devonian of Montana. In the Minnewanka region in the Upper Devonian of section 2-38 (r).

Spirifer raymondi Haynes

1916. *Spirifer raymondi* Haynes, Annals Carnegie Mus., vol. 10, p. 31, Pl. 5, figs. 1, 2, Pl. 6, figs. 12, 13.

Remarks. Our specimens agree fully with Haynes co-types with which they were compared. Radial surface striæ were observed upon some of his specimens. This species differs from *S. pinonensis* Meek[2] in that the latter form has length and breadth subequal (instead of 1 to 2), cardinal extremities rounded, 11 to 14 plications upon each side of median fold and sinus (instead of 8 to 12).

Locality and Horizon. Upper Devonian of Montana. In the Minnewanka region in the Upper Devonian of sections 2-38 (r); 4-5 (r).

Spirifer albapinensis Hall and Whitfield

Plate II, figures 12-14

1877. *Spirifera albapinensis* Hall and Whitfield, U.S. Geol. Expl. 40th Par., vol. 4, p. 255, Pl. 4, figs. 7, 8; *Spirifer centronatus albapinensis*, 1899, U.S. Geol. Surv., Mon., vol. 32, pt. 2, p. 548, Pl. 70, fig. 3 c.

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[1] Loc. cit.

[2] King's U.S. Geol. Expl. 40th Par., 4, 1877, p. 45, Pl. 1, figs. 9-9b; p. 42, Pl. 3, figs. 4-4b.

Remarks. This species was founded upon several pedicle valves, the brachial being unknown. Of the two specimens figured by Hall and Whitfield one has the median sinus smooth, the other shows three faint plications beginning near the middle of the shell, a median one and two lateral ones, the latter appear to represent branches of the bounding strong plications; in the Minnewanka specimens the lateral plications usually enter the sinus before the median one as they apparently do in the figures cited. Not only in the character cited but in all essential particulars does the Minnewanka form agree with this species. Our section likewise shows it to be a good species, and not a variety or a temporary stage in development, for though *S. centronatus* passes through this stage in its youth, as Girty showed in his Yellowstone National Park report,[1] this very recapitulation indicates an ancestral state when this youthfiul condition was the adult form. The time of the adulthood of *S. albapinensis* seems partly to be represented by the deposition of the 200 feet of limestone forming section 2-35. That this does not represent its entire range is shown first by its sudden appearance at the base of 2-35, indicating migration into this region, since no species exists in the lower beds which could have evolved into it, and second, a few individuals exist in 2-35, accelerated into almost the typical *centronatus* form. The typical *centronatus* does not appear in abundance until after the deposition of 380 additional feet of limestone.

Spirifer biplicatus Hall from the Kinderhook of Mississippi valley is smaller, with mucronate extensions to the hinge-line and with the broad plications bounding the medial sinus always simple. *S. albapinensis* resembles more closely *S. biplicoides* Weller from the Kinderhook of the same region, since this species has the large plications bounding the median sinus dividing unequally, the smaller branch entering the sinus, but this species also is smaller and has mucronate extensions to the hinge-line. *S. centronatus semifurcatus* Girty from the lower part of the Madison of Yellowstone National park differs only slightly from this species, if it is not identical with it; as the proportion of length to breadth is similar the only difference appears to be, judging from the brief description, the figures of a brachial valve, that the plications are somewhat stronger in Girty's variety. This character is variable in the Minnewanka specimens; a few complete individuals show the typical, *semi-furcatus* brachial valve with its prominent median fold divided by a furrow and the typical pedicle valve of *albapinensis*.

Locality and Horizon. Lower Mississippian of Utah, Nevada, and Wyoming. In the Minnewanka region in the Lower Mississippian of sections 2-35 (C), 4-3 (c).

Spirifer tenuimarginatus Hall

1858. *Spirifer tenuimarginatus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 641, Pl. 20, figs. 1 a-c; *Spirifera tenuimarginata* Hall, 1863, Rept. N.Y. State Geol. for 1882, Pl. (32) 57, figs. 4-6; *Spirifer tenuimarginatus* Hall and Clarke, 1895, Pal. N.Y., vol. 8, pt. 2, Pl. 32, figs. 4, 6; Weller, 1914, State Geol. Surv., Ill., Mon. 1, p. 355, Pl. 48, figs. 1-5.

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[1] Loc. cit.

Remarks. The type specimen from the Keokuk of Illinois has, according to Weller, a length of 19·5 mm. and a breadth of 21·8 mm. The Minnewanka form is somewhat smaller and narrower; it also has numerous, minute radiating striæ which are not mentioned in either Hall's original description or in Weller's re-description of a sulphur cast of the type specimen. Such minute surface markings are, however, easily destroyed and the difference in size and proportion are only slight.

Locality and Horizon. In the Lower Mississippian of Illinois. In the Minnewanka region in the Lower Mississippian of sections 2-34 (r), 35 (c); 4-3 (r).

Spirifer centronatus Winchell

Plate II, figures 1-14

1865. *Spirifera centronata* Winchell, Acad. Nat. Sci. Phil., Proc., p. 118; *Spirifer centronatus* White, 1875, U.S. Geol. Surv., W. 100th Mer., Rept., vol. 4, p. 86, Pl. 5, figs. 8 a-c; *Spirifera centronata* Hall and Whitfield, 1877, U.S. Geol. Expl. 40th Par., Rept., vol. 4, p. 254, Pl. 4, figs. 5, 6; *Spirifer centronatus* Girty, 1899, U.S. Geol. Surv., Mon. 32, pt. 2, p. 547, Pl. 70, figs. 3 a-d.

Remarks. The Minnewanka specimens agree fully with this species as developed in Montana and also apparently with those described and figured by Girty from Yellowstone National park, by White from Nevada, and by Hall and Whitfield from Utah.

S. increbescens from the Chester of Mississippi valley has plications on fold and in sinus less distinct, of more indefinite outline, the lateral plications broader, those bounding the medial sinus not so prominent as in *centronatus.* In *S. keokuk* from the Keokuk of the same region the shell is proportionately longer.

Spirifer centronatus is a direct descendant of *S. albapinensis;* the only differences between them lies in the usually smaller size of the latter, in the character of the sinus and fold, and in the plications immediately bounding these. *Spirifer albapinensis* has the sinus smooth, or with a median plication and two weak lateral ones, whereas the plications bounding the sinus are much broader than any others upon the shell; the fold similarly is composed of usually only two plications of equal size. This form occurs abundantly in limestone beds 200 feet thick to the exclusion of *S. centronatus*, and the latter first makes its appearance in abundance after the deposition of some 380 additional feet of limestone; it then continues as the most abundant spirifer and to the entire exclusion of *S. albapinensis* during the deposition of 470 more feet of limestone. In these beds, especially the lower ones, the small, young shell is still a typical *albapinensis*, only in later growth, represented in the mature shell from the anterior part of the umbo forward, do these bounding plications become less strong, and the plications in sinus and on fold increase in number and strength, producing the typical *centronatus* form. This retention of the *albapinensis* stage for a shorter and shorter time is illustrated in the following table and in Plate II.

Acceleration in the Recapitulation of the Albapinensis Stage in Spirifer Centronatus, from Successively Later and Later Beds

—	Section number	Average distance from beak in millimetres for insertion of the first plication	
		Lateral	Median
S. centronatus..................................	23	4	3
	25	5	4
	29	8	7
	32	8	7
	34	9±	7±
S. albapinensis..................................	35	Normally neither lateral nor median plication present; at times one or both appear at the anterior margin of a mature individual.	

There was here apparently a gradual change of the main mass of the *albapinensis* line into the *centronatus* form. A few retarded specimens of the former continue to occur even after the latter has become long established as the dominant group, like paleolithic humanity in the midst of our modern civilization. These disappear before *centronatus* reaches its maximum development and, apparently, without descendants.

S. centronatus minnewankensis may possibly be due to the de Vries mutation factor, as no transitional forms were noted.

Locality and Horizon. Lower Mississippian of Ohio, Colorado, Utah, Nevada, Wyoming, and Montana. In the Minnewanka region in the Lower Mississippian of sections 2-22 (c), 23 to 25 (C), 29 (c), 30 (c), 32 (c), 33 (r), 34 (r); 4-2 (r).

Spirifer centronatus minnewankensis n. var.

Plate I, figure 8a, b

Description. An alate but non-mucronate variety of S. *centronatus.* Hinge-line forming the greatest width of shell. Length of type (a pedicle valve) 18 mm., width along hinge-line 40 mm., convexity 7 mm., with 18 plications upon each side of median sinus, and 3 in the sinus. An entire shell from the same locality measures similarly 20 mm. by 45 mm. by 9 mm., the thickness of the combined valves being 15 mm.; there are apparently 18 plications upon each side of the sinus with 3 in the sinus, except at the very anterior edge where there are 5; median fold with 4 plications.

Pedicle valve most strongly arched at umbo, incurvature as in *S. centronatus*, but lateral slopes to cardinal angles much less abrupt, forming an almost straight line. Area comparatively narrow, arched. Plications low, 16 to 20 upon each side of sinus. Median sinus shallow, rather narrow, with 3 to 6 plications less conspicuous than those upon the lateral slopes.

Brachial valve much less arched than the pedicle, lateral slopes and plications similar. Median fold low, rather narrow, with 4 to 6 plications, less prominent than those upon the lateral slopes.

The finer surface markings consist of concentric growth lamellæ and fine radial lines.

Remarks. This variety is merely a *centronatus* greatly extended laterally, but lacking the submucronate cardinal extremities of the latter; activity of growth in this direction tended to lessen the depth of the sinus and resulted in less abrupt lateral slopes. In all other respects—character of plications, their method of branching in sinus and on fold, curvature, areas, etc.—it is a typical *centronatus*. This varietal offshoot occurred during the acme of the development of *Spirifer centronatus*.

Locality and Horizon. In the Minnewanka region in the Lower Mississippian of section 2-24 (c), 25 (r).

Spirifer missouriensis Swallow

1860. *Spirifer missouriensis* Swallow, Trans. St. Louis, Acad. Sci., vol. 1, p. 643; Weller, 1914, Ill. State Geol. Surv., Mon. I, p. 319, Pl. 39, figs. 11-23.

This species seems to be slightly represented among the Minnewanka specimens. A small brachial valve is 8 mm. long, 11 mm. wide along the hinge-line, and about 2 mm. in convexity. The narrow, low, median fold has four plications; these entering as a single one at the beak increase by bifurcation; the two middle ones occupy the crest of the fold, and upon each side of this fold the lateral surface of the valve is occupied at the frontal margin by 13 plications; these latter are somewhat fasciculate; from the fold outward these groups consist of 3, 3, 3, 2, 1, 1, plications; the furrows between the groups of fascicles are deeper than between the members of a fascicle, but each fascicle, because of the middle plication being only slightly, if at all, elevated above the others, lacks the individuality, the distinctness, of *S. cameratus*. The entire surface is covered with radiating striæ. Our specimens appear to agree fully with those figured and described by Weller.

Locality and Horizon. Lower Mississippian of Missouri. In the Minnewanka region in the Lower Mississippian of section 4-3 (r).

Spirifer newberryi Hall

1883. *Spirifera newberryi* Hall, Rept. N.Y. State Geol. for 1882, Pl. (31), 56, figs. 9, 10; *Spirifer newberryi* Hall, 1894, 13th Ann. Rept. N.Y. State Geol., p. 649; Hall and Clarke, 1895, Pal. N.Y., vol. 8, pt. 2, p. 362, Pl. 31, figs. 9, 10; Hall, 1897, 14th Rept. N.Y. State Geol., p. 357, Pl. 7, figs. 25, 26.

Remarks. The single specimen found agrees fully with the figure and very brief description given of this species by Hall. The figure is that of a brachial valve slightly larger than ours; the fine radiating striæ figured are duplicated upon our specimen.

Locality and Horizon. Mississippian of Ohio. In the Minnewanka region in the Mississippian of section 2-22 (R).

Spirifer striatiformis Meek

1875. *Spirifer (Trigonotreta) striatiformis* Meek, Pal. Ohio, vol. 2, p. 289, Pl. 14, figs. 8 a-e; *S. striatiformis* Herrick, 1888, Bull. Sci. Lab. Denison Univ., vol. 3, p. 44, Pl. 1, fig. 6, Pl. 3, figs. 23-26, Pl. 6, figs. 6, 7, Pl. 12, fig. 20; Herrick, 1888, Bull. Sci. Lab. Denison Univ., vol. 4, Pl. 2, fig. 9; Herrick, 1895, Geol. Surv., Ohio, vol. 7, Pl. 15, fig. 9; Weller, 1914, State Geol. Surv., Ill., Mon. 1, p. 364, Pl. 48, figs. 17-21.

Remarks. The Minnewanka form agrees apparently fully with Meek's type description and figures, and with the recent description of specimens from the same locality by Weller; the form, surface markings, and muscle impressions within the pedicle valve agree fully. From *S. striatus* it differs especially in lacking the characteristically transverse shell, the produced cardinal extremities.

Locality and Horizon. Lower Mississippian of Ohio and Missouri. In the Minnewanka region in the Lower Mississippian of section 2-25 (c), 29 (C).

Spirifer rockymontanus Marcou

Plate VII, figures 4a, b; 5; 6; 7a, b, c; 8; 9; 10

1858. *Spirifer rockymontana* Marcou, Geol. N.A., p. 50, Pl. 7, figs. 4-4e; *S. rockymontanus* White, 1877, U.S. Geog. Surv., W. 100th Mer., Rept., vol. 4, p. 134, Pl. 11, figs. 9 a-d; Girty, 1903, U.S. Geol. Surv., Prof. Paper 16, p. 383, Pl. 6, figs. 4-7 c; Mather, 1915, Bull. Sci. Lab. Denison Univ., vol. 18, p. 181, Pl. 12, figs. 1-6.

Description. Shell of medium size, variable in relation of length to breadth. Hinge-line less than, equal to, or greater than, the width of the shell below. Dimensions and other characters of various individuals are given below; the measurements are in millimetres:

——	a	b	c	d	e	f	g	h	i	j	k
Length from beak to anterior margin	15	14	21	28±	17	18±	14	30	9	22±	8
Length of hinge-line	24	21	32±	36±	29	20	22	45±	20	38±	14
Greatest width of shell	24	21	32±	36±	29	22	22	36	20	38±	16
Thickness of pedicle valve	6	....	....	11	7	5	....	10+	....	11±	....
Thickness of brachial valve	....	4	7	....	....	....	4	....	6	....	4
Number of plications in sinus or fold at anterior margin	3	4	6	3	3	3	4	5	4	3	2
Number of plications upon either side of fold or sinus at anterior margin	10	10	10	9	10	10	8	9	9	10	9
Number of plications bifurcating upon either side of fold or sinus	1	2	1	1	1?	1	1	2	1	1	1
Hinge-line less (−), equal to (=), or greater than (+), the width of shell below	=	=	=	=	=	−	+	+	=	+	−

Pedicle valve strongly and regularly convex from beak forward; the lateral slopes from umbo to cardinal extremities vary from slightly convex to somewhat concave, usually they are sigmoid, convex at umbo, becoming slightly concave towards the cardinal angles. Cardinal area comparatively high, slightly concave, vertically and longitudinally striated, extending to the cardinal angles; delthyrium slightly higher than wide. Median sinus moderately well developed; beginning at the beak as a simple furrow bounded by two plications much stronger than any others upon the valve it has implanted within it a single median plication, which remains simple; about the same time the bounding plications bifurcate unequally sending the weaker branch into the sinus. The adult shell has usually these three simple plications, but at times the bounding plications again divide unequally and send the smaller branch into the sinus giving to it five plications, which at the anterior edge of the valve are usually almost as strong and subangular as those upon the rest of the shell. Lateral plications 8 to 12, usually abruptly elevated, at times gently rounded; when no bifurcation occurs the strength of the plications decreases from those bounding the median sinus to the lateral extremities; usually the plication bounding the sinus bifurcates in the umbonal region, and often the one next it also, these four plications are then usually distinctly narrower than the next two or three out over the lateral slopes; these successive bifurcations of the plications bounding the median sinus, sending one to two branches into the sinus and one upon the lateral slope, result in their lessening prominence until they become equal in width, and often in height, to the median plication of the sinus; the other plications upon the lateral slopes are simple.

Brachial valve less convex than the pedicle; beak small, closely incurved. Median fold well defined from the beak where it originates as a single plication; this quickly bifurcates and these two plications continue strong and equal to the front of the valve, forming a level top to the sharply elevated fold; these usually bifurcate unequally but once, sending the smaller branch down the slope, resulting in four plications; at times two more are added, making six. Plications of lateral slopes similar in number, angularity, and bifurcation to those of the pedicle valve, though bifurcation is usually more forcibly expressed here than upon the opposite valve. Shells with the lateral plications bifurcating are much more numerous than those with simple plications.

The finer surface markings consist of concentric growth lines which are usually fine, but at times, especially towards the front of the shell, become lamellose. The entire surface is also covered by fine radiating lines which often become radiating rows of pustules; these radiating lines are usually equal in strength to the concentric, frequently they are the more conspicuous.

Remarks. This species, *S. boonensis*, and *S. opimus* are discussed below under "General Discussion of *Spirifer rockymontanus*."

It is at times rather difficult to distinguish this species from *S. centronatus*. The typical *rockymontanus* has, however, fewer, broader, and more angular plications than the typical *centronatus*. Comparing specimens of equal size, and taking the measurement 15 mm. from the beak, a specimen of *rockymontanus* from section 2-12 has 11 lateral plications in 15 mm. upon the convex part of the shell, whereas a *centronatus* from 2-23 had 18 plications in the same distance, and one from 2-25 had 20 plications. The latter species likewise lacks the bifurcating lateral plications and radiating pustules present upon so many of the former.

There is also usually some sign of bifurcation in the plications of the lateral slopes, especially adjacent to the median fold and sinus. Mather's specimens of *S. rockymontanus*[1] are more accelerated in bifurcation of plications than ours; for whereas their average size is the same as the majority of ours they have usually 8 plications upon the fold, 7 to 9 in the sinus, and frequently 2 to 4 bifurcating upon the lateral slopes, even when at times the 1 or 2 plications adjacent to the fold or sinus are simple; sometimes also, unlike ours, the plications within the sinus bifurcate.

Locality and Horizon. Common in the Pennsylvanian throughout the Appalachian, Mississippi Valley, Rocky Mountain, and Great Basin regions. In the Minnewanka region in the Permian of sections 1-14 (R), 18 (r); in the Pennsylvanian of sections 1-29 (r); 2 a-3 (c), 10 (c), 14 (c); 2-1 (r), 2 (c), 6 (c), 11 (C), 12 (C), 14 (r), 15 (r), 16 (r), 17 (r), 18 (c), 20 (r); 3-6 (r); 3 a-3 (c), 4 (c).

Spirifer rockymontanus, Forms A-E

In the Minnewanka region occurs a great range in the variations of this species, and all of them intergrading. These occur in a bed one foot thick in section 2-12; so that they are, with two exceptions, undoubtedly merely variations of one species and not distinct species. As may be seen under "General Discussion of *Spirifer rockymontanus*," page 57, it was thought best to separate the two variations represented by *S. opimus* and *S. boonensis* as species, since they apparently bred true in some other area, whereas the more distinctly defined among the other variations will be noted here under the terms Form A, Form B, etc. Owing to the density of the limestone the majority of specimens fail to show the finer surface markings, lack the cardinal angles, or exist merely as internal moulds. This is especially true of the larger individuals. We thus have made no effort at the different localities to distinguish between the various forms of *rockymontanus*.

Form A

Shell transverse, with hinge-line equalling the greatest width below, the lateral margins meeting the hinge-line at a right angle. Plications rounded to subangular, one or two adjacent to fold and sinus bifurcating. Represented by a to e inclusive in the table under *S. rockymontanus*, page 54. This is the most abundant form in the Minnewanka region.

Form B

Shell with length and breadth subequal; cardinal angles rounded. Plications rounded to angular, one or two adjacent to the fold and sinus bifurcating. This is the form figured under *S. rockymontanus* from Colorado by Girty, and from Pennsylvania by Raymond. In proportion of length to breadth it is similar to *S. opimus*, but this form has lateral plications simple and those of sinus and fold rather obscure. It is represented by f in the table, page 54.

[1] Loc cit.

Form C

Shell transverse, hinge-line extended forming the greatest width of the shell. From the front of the shell the lateral margins extend either straight or more usually with a gentle convexity to the cardinal extremities. Plications rather angular, 1 or 2 adjacent to fold and sinus bifurcating. This form is in outline, size, and angularity of plications, apparently identical with *S. boonensis*, but it has bifurcating plications, which the latter has not. The proportion of length to breadth of each is about 5 to 8 or 9. Represented by g and h in the table, page 54.

Form D

Shell transverse, width much greater than length, often about 2 to 1; cardinal extremities extended (i and j in the table, page 54) or rounded (k in table). Plications usually subangular, the pair adjacent to the median sinus and fold bifurcating.

Form E

Shell transverse, width greater than length, in the proportion of about 7 to 5. Cardinal extremities rounded. Plications rounded, those upon the lateral slopes simple. This appears to be identical with White's figures 9 a-c[1], agreeing with it in all observable respects.

No form with cardinal extremities mucronate was noted.

General Discussion of Spirifer rockymontanus

From a study of Marcou's illustrations it is evident that his figures 4-4 b and 4 c-e refer to different forms, the former a rather large shell with a hinge-line apparently equalling the greatest width of the shell below and with bifurcating ribs, the latter smaller with the hinge-line distinctly shorter than the shell below, and with simple ribs. It is to the latter type that his description conforms the more closely, as may be seen from his original description fully given below.[2] "Shell transverse, gibbous, subsemicircular, length and breadth nearly equal, *cardinal angles rounded.* Beak large, elevated, incurved; *hinge-line shorter than the width of the shell,* straight. Sinus of the dorsal valve shallow, extending from the beak to the margin, covered with ribs, *like* the other parts of the two valves. *The ribs are simple, sharp,* and very distinct. Area small and triangular. The lines of growth are indistinct on the two valves." The italics are ours. The plications of the smaller shell are the more angular; those of sinus and fold of both forms are practically as strong as the lateral ones. The figure of the smaller specimen has an area extending the length of the hinge-line; the larger one probably had a similar extent, but gives evidence here of imperfect preservation and the area is depicted as being triangular and short; it was probably similar to the other. It is, consequently, for the latter form (4 c-e) that his name should be retained if it is found expedient to separate them. This is similarly the opinion of

[1] Loc. cit.
[2] Loc. cit.

Girty,[1] but Mather[2] would restrict it to the form represented by figures 4-4 b, because these are the first figures cited upon the plate. Common usage has inclined to the former opinion but has also included individuals under *rockymontanus*, which show two or three plications upon a valve adjacent to the median fold and sinus, bifurcating once from the beak forward, and also forms with a slightly extended hinge-line. Thus White[3] figures two specimens, the one, 9 a-c, has the plications somewhat rounded and non-bifurcating, whereas 9 d has more angular plications, two or three of which, adjacent to the fold, bifurcate; the former has the hinge-line equalling the greatest width of the shell below, the latter slightly less than the shell below, and with more angular plications.

The form Girty[4] figures from Colorado has the hinge distinctly shorter than the shell below, and with a few lateral plications bifurcating. Two other forms that enter into this discussion are *S. opimus* Hall, usually considered a synonym of *S. rockymontanus*, and *S. boonensis* Swallow as interpreted by Girty[5]. The former, as shown by Hall's figures, has length and breadth equal, with hinge-line equal to the width below, 23 mm., sides of shell almost vertical, lateral plications simple, angular, those upon fold and sinus weaker than the rest. *S. boonensis* has hinge-line distinctly longer than width of shell below; a large shell measures 40 mm., antero-lateral angles oblique, lateral plications simple, those of fold and sinus somewhat weaker than the others. Mather[6] has revived *S. opimus* for some specimens found in association with *S. rockymontanus;* his figures approximate Hall's strength of plications, but have a more oblique antero-lateral angle, approaching in this respect *boonensis.* Some of our specimens approach in outline and size very closely the small rounded form figured by Marcou in 4 c-e as *rockymontanus*, but these pass by imperceptible gradations into the almost vertical sided type figured by Hall[7], as *opimus*, thence into the more transverse form shown by White in figure 9 d[8], or Marcou's *rockymontanus* figures 4 a-c, from this into the type shown in White's figures 9 a-c, thence into Girty's *boonensis*?, figure 3[9] and from this into Girty's form *boonensis* as shown in figures 1 and 2. The fold and sinus vary in strength and in their plications from rounded to angular; the lateral plications also vary in angularity, similarly in the number bifurcating, from none to 3 or 4. There is thus an apparent gradation in all essential features between the various forms noted above. These variations were noted upon specimens taken from the prolific brachiopod bed one foot thick of section 2-12. White[10] evidently found in Utah and New Mexico similar variations, for he says "The numerous specimens of this species in the collections present most perplexing variations, and I have repeatedly been almost persuaded to arrange some of them under a separate specific name, but the presence of intermediate forms has prevented such a decision. . . . . Many of the examples under examination agree in all essential particulars with *S. opimus* Hall, which thus becomes a synonym of *S. rockymontanus.*"

[1] Loc. cit., 1903.
[2] Loc. cit., 1915.
[3] Loc. cit., 1877.
[4] Loc. cit., 1903.
[5] Loc. cit., p. 381.
[6] Loc. cit., p. 185.
[7] Geol. Iowa, vol. 1, pt. 2, p. 711, Pl. 28, figs. 1a, b.
[8] Loc. cit., 1875.
[9] Loc. cit., 1903.
[10] Loc. cit., p. 135.

Practically every worker has had difficulty with some of these variations. Some are good species at one locality, i.e., with no connecting forms, at others not. It looks as though in some areas, as at White's localities and the Minnewanka region, the various forms interbred fully, producing imperceptible gradations between the different types; whereas if one of these forms, as *opimus* or *boonensis*, migrated into another area, where the types with which it could interbreed were lacking, it would breed true. The result would be a true species in the latter area, provided the regions where interbreeding had occurred were not found. Should the finding of intermediate forms in some distant region invalidate a species?; it, of course, does so among living forms today. If, however, two species do not interbreed at present but did in the late Pleistocene, distant a few thousand years, they would still be considered true species. The answer to the question then depends upon the synchronism of the containing strata. If species A, from locality A, and species B, from locality B, interbred in locality C at the same time they were living at A and B they would be considered as forming a single species; if, however, they ceased to interbreed or died out at C, and other interbreeding areas, while continuing to live separately at A and B, they would then be distinct species. Exact synchronism, which this demands, is practically impossible of attainment, correlation of strata being usually based upon similarity in the succession of faunas and floras, that is, upon homotaxis rather than upon synchronism.

The forms we are discussing come from the Pennsylvanian, a period very many times longer than from the close of the Pleistocene to the present, and which in the widely separated areas under discussion, it is impossible, at least at present, to correlate more closely than in a broad way as Lower, Middle, or Upper Pennsylvanian; it is hence impossible to say within the limits of tens of thousands of years whether the interbreeding areas existed at the same time as the separate forms in other regions. With the increase in number of palæontologic facts the connecting links between more and more species are being discovered, many of which are known to have interbred at the time of their branching into different species, and we look forward to the time when practically all species, past and present, will be arranged in such a unity. Since it is thus practically impossible to apply the zoological definition of species to fossils we should denominate as true species all forms which large collections from a single locality show to be distinct, even though in some distant area in rocks of approximately the same age they are found to grade into another species. This will likewise result in more exact correlation and especially in the development of palæogeography, for in this new science facts of migrations are very desirable. In the areas where intergrading forms occur it should first be determined if the intergradations occur within a single stratum, for otherwise an evolving line found in a succession of strata will be considered as intergrading; this error we are inclined to believe has at times occurred. When an area is determined to have been an interbreeding one for certain limiting forms these forms should be described separately as form A, form B, etc., and their relationship noted; if, however, these forms have already been described as distinct species these names should be used. It is here that this definition of species would differ from the zoological one, but it seems unavoidable by reason of the uncertain synchronism of this area and that of the described species.

Spirifer opimus apparently occurs at various localities in Mississippi valley without intergradations to *S. rockymontanus* of either of Marcou's forms. Similarly *S. boonensis* is developed in Colorado apparently without transition forms to other species. These appear to be the only forms, so far recorded, of the different variations of the *rockymontanus* type to have bred true at some locality. In the Minnewanka region occur connecting forms not only between these but between these and the following—a transverse form with hinge-line equalling the greatest width below and with bifurcating plications; an extended form like *boonensis* but with bifurcating plications; an *opimus-like* form with bifurcating plications; an alate form with much extended, rounded hinge-extremities, and plications bifurcating; a transverse form with rounded hinge-extremities and simple plications. These limiting forms may be found to have bred true in some other region, but until these places are discovered, they are treated merely as variations of *S. rockymontanus.*

This brings us back to the question of the expediency of separating Marcou's type figures into two species. Aside from the two forms represented by *opimus* with the plications of fold and sinus obscure and *boonensis* with its extended hinge-line, and both with simple plications, there are apparently transitions between the other forms in all regions so far known, that is, between those with simple plications and rounded hinge-extremities and all forms with bifurcating plications. These intergrading types vary greatly also in size. Since thus neither of the two forms represented by the two specimens figured by Marcou (the smaller one with rounded cardinal extremities, plications simple, those of sinus and fold as strong as the lateral ones, the larger form with hinge-line apparently as long as the shell below, with bifurcating plications), occurs distinct in any area, without specimens transitional to the other, we must consider them as representing a single species.

The specimens Girty has figured from Colorado[1] approach rather closely the smaller form, but have bifurcating plications; this is similarly true of *S. rockymontanus* figured by Raymond from Pennsylvania[2]; Mather's specimens from Arkansas and Oklahoma have bifurcating plications, and approach Marcou's larger form, but the hinge-line varies from less to greater than the width of shell below, that is, from rounded to extended cardinal extremities.

Spirifer boonensis Swallow *emend* Girty

1860. *Spirifer boonensis* Swallow, Acad. Sci., St. Louis, Trans., vol. 1, p. 646; Girty, 1903, U.S. Geol. Surv., Prof. Paper 16, p. 381, Pl. 6, figs. 1, 2, 3; Price, 1914, W. Va. Geol. Surv., Kanawha co., Rept. p. 652, Pl. 2, figs. 1-3.

Remarks. The Minnewanka specimens are apparently identical with the form described and figured by Girty from Colorado, though our specimens average 10 to 11 lateral plications, whereas those from Colorado average 12 to 13. There seem to be perfect gradations between *S. boonensis* and *S. rockymontanus*, form C, described above. See also "General Discussion of *Spirifer rockymontanus*," page 57.

Locality and Horizon. Pennsylvanian of West Virginia ?, Missouri, Colorado. In the Minnewanka region in the Pennsylvanian of section 2-12(a).

[1] Loc. cit., 1903.
[2] Loc. cit., 1910.

Spirifer opimus Hall

1858. *Spirifer opimus* Hall, Geol. Iowa, vol. 1, pt. 2, p. 711, Pl. 28, figs. 1 a-b; *Spirifera opima* Hall, 1883, 2nd Rept. N.Y. State Geol. for 1882, Pl. (31) 56, figs. 4-7; *Spirifer opimus* Hall and Clarke, 1894, Int. to Study of Brach., pt. 2, Pl. 27, figs. 12-13; Hall and Clarke, 1895, Pal. N.Y., vol. 8, pt. 2, Pl. 31, figs. 4-7; Mather, 1915, Bull. Sci. Lab. of Denison Univ., vol. 18, p. 185, Pl. 12, figs. 7-7 c.

Remarks. There are several Minnewanka specimens representing this species. One pedicle valve, largely an internal mould, is 17 mm. long, 18 mm. wide along hinge-line, and 9 mm. thick; there are three low plications in the sinus and 8 stronger, simple ones upon each lateral slope; the sides are apparently almost vertical, being as wide at 5 mm. anterior to the cardinal extremities, as at the hinge-line. Two of these vertical-sided forms, a pedicle and a brachial valve, and typically *opimus* also in all other respects, have the plications adjacent to the median fold and sinus bifurcating; others similar to the latter have rounded cardinal extremities, whereas still others have them extended. There is likewise among these forms a complete gradation from all plications of sinus much weaker than those upon the lateral slopes of valve, through specimens with median plication strong and the two or four side ones weak, to specimens with all strong. This is similarly true of the fold. There thus appear to be complete gradations between the straight-sided, non-bifurcate form characteristic of the type figure of *opimus* to the straight and the round-sided, bifurcate *rockymontanus*. On the other hand, the typical *opimus* seems to grade into *S. boonensis* Swallow emend. Girty. See also remarks under "General Discussion of *Spirifer rockymontanus*", page 57.

Spirifer opimus Hall may represent a line descending from *S. albapinensis* with an accentuation of growth anteriorly and to a slightly less degree antero-laterally, resulting in a comparatively long, short-hinge form; the plications of fold and sinus enter as in *centronatus*, and, attaining a similar number, become as broad as the lateral plications but remain low, at times obscure.

Locality and Horizon. Pennsylvanian of the Appalachian and Mississippi valley. In the Minnewanka region in the Pennsylvanian of section 2-12 (c).

Spirifer cameratus Morton

1836. *Spirifer cameratus* Morton, Am. Jour. Sci. (1), vol. 29, p. 150, Pl. 2, fig. 3; Hall, 1858, Geol. Surv., Iowa, vol. 1, pt. 2, p. 709, Pl. 28, figs. 2 a, b; Meek, 1872, U.S. Geol. Surv., Nebraska, p. 183, Pl. 6, fig. 12, Pl. 8, fig. 15; White, 1875, U.S. Geol. Surv., W. 100th Mer., Rept., vol. 4, p. 132, Pl. 10, figs. 1 a-d; Meek, 1877, U.S. Geol. Surv., 40th Par., vol. 4, p. 91, Pl. 9, figs. 2, 2 a; White, 1884, Geol. Surv., Indiana, 13th Rept., p. 132, Pl. 35, figs. 3-5.

Remarks. Our specimens are normal in size and ornamentation. Some specimens from Colorado and Kansas are less fasciculate than ours and many are more so. Many specimens have a more extended hinge-line, some even have mucronate extensions to the hinge-extremities. *S. cameratus* was very probably evolved from *S. rockymontanus* or some closely allied form. This is indicated by its outline, convexity, number of lateral plications and their elevation in the umbonal region. It is also indicated by the inception of plications within the sinus and upon the fold and by the striated to pustulose surface. The narrow, early, umbonal area of *S. cameratus* would thus represent the accelerated adult state of *S. rockymontanus;* in these the plications of fold and sinus are similar and those of the lateral slopes are alike in number and elevation, with one or two adjacent to the sinus and fold bifurcating; it is only in the middle or anterior part of the umbonal region that trifurcation with accompanying fasciculation takes place, and it is only very high in the Pennsylvanian, where much repetition has caused acceleration, that fasciculation occurs at the umbo.

Locality and Horizon. A common form in the Pennsylvanian of Mississippi valley and the Rocky mountains. In the Minnewanka region it occurs in the Pennsylvanian of sections 1-29 (r), 31 (r); 2 a-3 (c), 10 (c), 14 (c); 2-2 (r), 17 (r).

Genus, **Cyrtia** Dalman

Cyrtia standlyensis n. sp.

Plate I, figures 2 a, b, c, d, e; 3; 4 a, b; 5

1913. *Cyrtia cyrtiniformis* Shimer, Bull. Geol. Soc. Am., vol. 24, p. 236. Transition beds from Lower Banff shale to the Lower Banff limestone; Minnewanka region, Alberta.

Description. Shell of medium size, subpyramidal with greatest convexity at the umbo. Hinge-line equalling the greatest width, cardinal extremities angular. The dimensions of a shell of average size (the type) are: length from hinge-line to frontal margin 20 mm., from beak of pedicle valve to frontal margin 23 mm., from beak of brachial valve to frontal margin 21 mm., greatest width (at hinge-line) 21 mm., this width remains constant for 9 mm. anteriorly, greatest convexity of shell 19 mm., of pedicle valve 13 mm., of brachial valve 6 mm., delthyrium 6 mm. wide at base and 10 mm. high.

Pedicle valve subpyramidal, with greatest convexity near beak from which the surface curves very abruptly anteriorly and laterally to the margin of the valve. Beak pointed, very slightly incurved, at times slightly twisted. Cardinal area broad, extending to the cardinal extremities, almost straight below, more distinctly arched in upper half, vertically striate over its entire area. Delthyrium considerably higher than wide (its base being about one-half its height), bounded by the thickened margins of the strongly developed dental plates; these plates extend about half the distance to the frontal margin. Median sinus narrow and smooth at beak, becoming broad, of moderate depth, and plicated anteriorly; these plications entering in the umbonal region bifurcate rapidly, resulting in about 20 low, rounded plications at the front of the valve. Lateral slopes of valve each with about 20 low, rounded, simple plications.

Brachial valve much less convex than the pedicle, with the greatest convexity at the umbo; cardinal extremities flattened. Median fold low, broadly rounded, increasing in breadth rapidly towards the front. Plications similar in number, character, and size to those of corresponding positions upon the opposite valve.

The finer surface markings consist of minute radiating, papillose lines, covering the entire shell.

Remarks. The average size of this species is much greater than the type of the species *C. cyrtiniformis* from the Chemung of Rockford, Iowa.[1] The latter, a specimen of average size, has a width of 11 mm.; height of cardinal area of pedicle valve, 9 mm.; length of brachial valve, 12 mm., as against 21 mm., 12 mm., and 19 mm. for a medium-sized specimen from the Lake Minnewanka section. The pedicle valve of the latter has a more incurved cardinal area; the proportions of the delthyrium are similar, as well as the number of plications, on each side of the fold and sinus—that is, about 20—for here the plications are simple; but as those on fold and sinus bifurcate the number here has increased on this enlarged shell to 20 at the anterior edge, resulting in about 60 plications to a valve as against 45 to 50 in the Iowan forms. The mature shell is slightly incurved at the front. This Minnewanka species differs thus from *C. cyrtiniformis* principally in its larger size, increased number of plications in the sinus, and especially in the more highly arched cardinal area.

In size it is similar to the form noted by Whiteaves[2] from Hay river, Mackenzie; but this has only 29 or 30 plications upon each valve and is probably a distinct species. *Cyrtia norwoodi* Meek[3] is similar to our form in curvature of cardinal area but differs in its smaller size, narrower delthyrium, narrower and shallower median sinus, and fewer plications (30 to 40 instead of 60). *Spirifer disjunctus animascensis* Girty[4] with its characteristically twisted beak is usually a much broader shell with a vertical cardinal area, but even in the subquadrate forms, with length and breadth subequal, and with an arched cardinal area, the width of the cardinal area is 2½ to 3 times its height, the delthyrium is almost as broad as high, and of plications also there are 20 to 25 upon each lateral slope and only 5 to 10 in the sinus. *Spirifer disjunctus occidentalis* Whiteaves[5] is distinctly alate with coarse plications.

This form is abundant upon the western flanks of mount Standly, whence the name.

Locality and Horizon. The forms with which this variety is most nearly related occur in the Upper Devonian of North America. In the Minnewanka region this species occurs in the Upper Devonian of sections 2-38 (C), 39 (r), 40 (r), 41 (C), 42 (R), 45 (?); 4-5 (r).

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[1] *Cyrtia cyrtiniformis* (Hall and Whitfield), Twenty-third Rept. N.Y. State Col. Nat. Hist., 1872, p. 238, Pl. 11, figs. 21-24.
[2] *Spirifera cyrtinaeformis*, Contr. to Can. Pal., I, 1891, p. 222.
[3] *Spirifer utahensis*, King's U.S. Geol. Expl. 40th Par. IV, 1877, p. 39, Pl. 3, fig. 1.
[4] 1900, U.S. Geol. Surv., 20th Ann. Rept., p. 48, Pl. 4, figs. 1-10.
[5] Contr. to Can. Pal., I, 1891, p. 222.

Genus, **Pseudosyrinx** Weller

Pseudosyrinx gigas Weller

1914. *Pseudosyrinx gigas* Weller, State Geol. Surv., Ill., Mon. 1, p. 410, Pl. 66, figs. 1-5.

Remarks. Some specimens from the Minnewanka region apparently belong to this species, though certain differences are observable. A rather poorly preserved pedicle valve from section 2-23 has a length of 35 ± mm., width along the hinge-line of 64 mm., height of cardinal area of 24 mm., width of delthyrium at base 14 mm., angle formed by the lateral margins of the cardinal area, about 100 degrees; (Weller's type specimen gives similarly 50 mm., 82 mm., 43 mm., 18 mm., and about 100 degrees); hinge-line longer than width of shell below; cardinal extremities angular. Cardinal area flat, its lateral margins rounding rather abruptly into the lateral slopes of the valve; its base makes apparently an angle of about 90 degrees with the junction of the valves; the flat delthyrial plate is sunk but little below the level of the cardinal area near the apex, but at its termination in the middle of the area it is over a millimetre below this level; pseudodeltidium not preserved; strong deltidial plates are present, diverging at the same angle as the median sinus. Surface with concentric growth lines becoming conspicuous anteriorly; there are faint indications of 6 or 8 very low, broad plications upon each lateral slope of the valve, but these disappear towards the cardinal extremities and they are similarly absent from the median sinus. Entire surface covered with minute, low, elongate papillæ, giving a striate appearance to the shell. This specimen is intermediate in size between *P. missouriensis* and *P. gigas*, but approaches more nearly to the latter in the abrupt rounding of the lateral margins of the cardinal area, the angular cardinal extremities, and the poorly-defined plications. A brachial valve 28 mm. long by 50 mm. wide has 12 to 14 low, broad plications upon each lateral slope; these plications are much stronger than those of the preceding pedicle valve and extend to the front of the shell; this is shown also in a specimen retaining both valves.

The Minnewanka specimens appear to differ from the typical *P. gigas* merely in their smaller size. These specimens differ from *Syringothyris* in the absence of the syrinx and from *Spiriferella* in their more elevated and less arched cardinal area as well as in their longer hinge-line and more angular cardinal extremities.

Locality and Horizon. Mississippian (Keokuk) of Mississippi valley. In the Minnewanka region in the Mississippian of section 2-22 (?), 23 (r), 24 (R), 26 (?), 29 (C), 30 (r), 34 (r).

Genus, **Spiriferella** Chernuishev

Spiriferella minnewankensis n. sp.

Plate III, figures 1 a, b, c, d; 2 a, b, c

Description. Shell slightly above medium size, usually wider than long, with greatest convexity posterior to the middle. Hinge-line shorter than greatest width; cardinal extremities rounded. The dimensions of a rather large shell from the higher beds are: greatest length 30 mm., greatest width (about 8 mm. anterior to the cardinal area) 33 mm.; length of hinge-line about 18 mm.; thickness 25 mm.; greatest convexity of pedicle valve (at umbo) 15 mm., of brachial valve (at middle of valve) 10 mm.; delthyrium 11 mm. wide at base and about 11 mm. high.

Pedicle valve strongly convex, with its greatest convexity in the umbonal region, the surface curving from this region very abruptly, forming almost a straight line, to the cardinal extremities; anteriorly it curves less aburptly with a greater convexity. Beak pointed and incurved. Cardinal area high, gently arched above, almost straight below, this latter part making an angle of about 90 degrees with the plane formed by the junction of the valves; delthyrium forming an equilateral triangle, the upper third of which is covered by an almost flat, slightly convex pseudodeltidium. The cardinal area on each side of the delthyrium is bisected by a straight, slightly raised line which extends obliquely out from the beak to the hinge-line; the space within these lines is the true cardinal area and is vertically striate, beyond them the false cardinal areas round gradually into the lateral slopes of the valve. Median sinus originates at the beak, becoming broad, evenly rounded, and of moderate depth anteriorly; the anterior prolongation which extends into the fold of the opposite valve is in large shells, subparallel with the cardinal area; three low plications present, a single median and two lateral ones. Lateral slopes of the valve each bearing from 8 to 10 low, rounded, simple plications; these are more or less obscure and are entirely wanting towards the cardinal extremities. Internally the dental lamellæ are prominently developed; with divergence similar to that of the sides of the sinus they extend with lessening strength in a straight line almost half-way from the beak to the frontal margin of the valve where, before disappearing, they bend towards each other so as to partly enclose the faint muscle impressions; posteriorly these plates are united by the delthyrial plate, which, confined to the upper third or half of the delthyrium, is slightly depressed below the level of the cardinal area.

Brachial valve somewhat less convex than the pedicle, its greatest convexity near the middle of the valve, the convexity extending regularly to the front and sides of the valve except at the cardinal angles which are slightly flattened. Beak incurved. Median fold rather narrow, becoming high anteriorly, rather narrowly rounded and not prolonged anterior to the parts of the valve bounding it; this gives to the front of the shell a truncate appearance, making the anterior and posterior sides of the shell subparallel. Median fold with two low plications; lateral plications similar in form and number to those of the opposite valve but somewhat stronger.

The finer surface markings consist of concentric growth lines which increase in strength anteriorly, and of rather conspicuous, fine, radiating papillæ.

Remarks. This genus differs from Syringothyris in the absence of a syrinx; from Pseudosyrinx in its lower and more arched cardinal area, and in its shorter hinge-line and more rounded cardinal extremities.

Pseudosyrinx missouriensis from the Burlington of Missouri has a much more elevated and straighter cardinal area, with its margins much more narrowly rounded, and has also more (16) plications upon each side of fold and sinus. *Spiriferella neglecta* is similar to *S. minnewankensis* in the broadly rounding margins of the cardinal area; it differs from it in being more elongate, in having a single faint broad plication in the sinus and only six lateral plications upon each side of fold and sinus, in its more elevated median fold, which is much more produced anteriorly, and in the somewhat greater angle between the cardinal area and the plane formed by the junction of the valves.

The specimens identified with this species from the lower beds, section 2-27 and 28, are much smaller than the ones in the higher beds. A shell of average size from 2-27 has a length of 15 mm. and a width of about 20 mm. Accompanying this smaller size is a reduction of the lateral plications to five; in all other respects they appear to be identical. The young shell in the higher beds has six to eight lateral plications but those nearer the cardinal angles make their first appearance considerably later than the ones bordering the median sinus and fold. If our identifications are correct the most apparent change in the evolution of this species throughout the time represented by the deposition of 130 feet of limestone has been the great increase in size—the same kind of change noted in the evolution of so many other invertebrates, but more spectacularly so in the vertebrates.

Abundant upon the northwest shores of lake Minnewanka, whence the name.

Locality and Horizon. In the Minnewanka region in the Mississippian of sections 2-22 (c), 23 (c), 24 (c), 27 (r), 28 (c).

Genus, **Ambocoelia** Hall

Ambocoelia magna n. sp.

Plate III, figures 3 a, b, c; 4 a, b

Description. Shell small, wider than long; cardinal extremities rounded. The dimensions of a pedicle valve are: length 15 mm. ±, breadth 20 mm., convexity 6 mm. Another pedicle valve of similar size has cardinal area 4 mm. high, delthyrium 4 mm. wide at base, and hinge-line about 10 mm. long.

Pedicle valve very convex with greatest convexity posterior to middle, from which the surface descends in a straight line or with a slight concavity to the cardinal extremities, and anteriorly with a slight convexity. Beak rather narrow, pointed, slightly incurved. Cardinal area moderately high, arched, its lateral margins poorly defined. Delthyrium forming an equilateral triangle. A narrow median sinus extends from the beak to the frontal margin, broadening slightly anteriorly; the bottom of the sinus is subangular, its sides undefined.

Brachial valve unknown.

The surface marked with faint concentric growth lines and a few growth ridges; the latter are especially noticeable towards the cardinal extremities.

Remarks. This species appears to be most closely allied to *A. unionensis* Weller from the Kinderhook (Rockford limestone) of Illinois, but an average specimen of that form measures 5 mm. long by 5 mm. wide; ours is thus about three times the size of that species. The Minnewanka species likewise has a proportionately longer hinge-line, a less concave slope of surface from umbo to cardinal extremities, and a somewhat less angular median sinus.

Locality and Horizon. In the Minnewanka region in the Lower Mississippian of section 2-35 (r).

Genus, **Reticularia** McCoy

Reticularia pseudolineata (Hall)

1858. *Spirifer pseudolineatus* Hall, Geol. Surv., Iowa, vol. 1, pt. 2, p. 645, Pl. 20, fig. 4; *Spirifera pseudolineata* Hall, 1883, Rept. N.Y. State Geol. for 1882, Pl. (36), 61, figs. 28-30; *Spirifer pseudolineatus*? Herrick, 1891, Bull. Geol. Soc. Am., vol. 2, p. 45, Pl. 1, fig. 18; *S. pseudolineatus* Hall and Clarke, 1894, Int. to Study of Brach., pt. 2, Pl. 25, fig. 15; *Spirifera pseudolineata* Keyes, 1894, Mo. Geol. Surv., vol. 5, p. 82; *Spirifer pseudolineatus* Hall and Clarke, 1895, Pal. N.Y. vol. 8, pt. 2, Pl. 36, figs. 28-30; *Reticularia pseudolineata* Weller, 1914, State Geol. Surv., Ill., Mon. 1, p. 429, Pl. 74, figs. 1-11, Pl. 75, fig. 20.

Remarks. The Minnewanka specimens are somewhat broader than the majority of those from the Keokuk limestone of Keokuk, Iowa, the type locality (but have about the same relative breadth as Hall's type specimen); they likewise have a relatively shorter hinge-line—about one-half the breadth of the shell, whereas in the Keokuk forms it is about two-thirds the breadth; in the western form also the brachial valve is somewhat more convex, and the dental lamellæ are narrower. These are, however, minor and normally variable differences.

Locality and Horizon. Lower Mississippian of Mississippi valley. In the Minnewanka region in the Mississippian of sections 2-25 (c), 26 (r), 27 (R), 29 (c), 30 (?), 34 (r).

Reticularia setigera (Hall)

1858. *Spirifer setigerus* Hall, Geol. Surv., Iowa, Rept., vol. 1, pt. 2, p. 705, Pl. 27, figs. 4 a, b; *Spirifera setigera* Hall and Whitfield, 1877, U.S. Geol. Expl. 40th Par., Rept., vol. 4, p. 270, Pl. 5, figs. 17, 18; *Reticularia setigera* Waagen, 1883, India Geol. Surv., Mem. Pal. Indica, ser. 13, vol. 1, p. 542; *Spirifera setigera* Hall, 1883, N.Y. State Geol. Rept. for 1882, Pl. (36) 61, figs. 26, 27; *Spirifer setigerus* Hall and Clarke, 1895, Pal. N.Y., vol. 8, pt. 2, Pl. 36, figs. 26, 27; *Spirifera setigera* Keyes, 1895, Missouri Geol. Surv., Rept., vol. 5, p. 83; *Reticularia setigera* Beede, 1906, 13th Ann. Rept., Indiana Geol. Surv., p. 1318, Pl. 21, figs. 1, 1 a; Girty, 1911, U.S. Geol. Surv., Bull. 439, p. 69, Pl. 8, figs. 6, 6 a; Weller, 1914, State Geol. Surv., Illinois, Mon. 1, p. 431, Pl. 74, figs. 12-22; Girty, 1915, U.S. Geol. Surv., Bull. 595, p. 32, Pl. 1, figs. 6, 7.

Remarks. This species differs from *R. pseudolineata* principally in its proportionately narrower form, its narrower and more strongly developed median sinus and fold, and its somewhat broader concentric bands. The majority of the Minnewanka specimens have a length of from 20 mm. to 25 mm., but two fragments from section 3 a-3 are much larger; one has a preserved length of 33 mm. and an estimated length of 45 mm. to 50 mm., its sinus is narrow, increasing very slightly in width, and the concentric bands have a uniform width of 3 mm. The Minnewanka form of this species differs from the typical Chester shell, especially in its stronger concentric bands; this is an old age character to be expected because of the persistence of the species in this region from its normal Mississippian habitat into Pennsylvanian time.

Locality and Horizon. Middle and Upper Mississippian of Mississippi valley and Utah. In the Minnewanka region in the Pennsylvanian of sections 1-29 (c); 2 a-10 (c), 14 (c); 3 a-3 (c), 4 (R).

Genus, **Squamularia** Gemmellaro

Squamularia depressiplicata n. sp.

Plate III, figures 5 a, b, c; 6; 7

Description. Shell of medium size with length and width nearly equal and cardinal extremities rounded. Dimensions of a specimen above average size are: length of pedicle valve 30 mm.; of brachial valve 26 mm.; greatest width (just posterior to middle of shell) 32 mm.; greatest thickness (just posterior to middle of shell) 19 mm.; greatest convexity of pedicle valve 12 mm.; of brachial valve 7 mm.; length of hinge-line 19 mm. Length and breadth of a pedicle valve of average size are each 24 mm.

Pedicle valve very convex, with greatest convexity in the umbonal region; umbo relatively narrow, beak pointed; there is frequently a curve of over 180 degrees from the beak to the middle of the valve. Cardinal area small, arched, poorly defined, its margins rounding imperfectly into lateral slopes of the valve. Delthyrium open, broadly triangular. Median sinus prominent at the umbo, less so anteriorly, either smooth or with a broad, inconspicuous plication upon each slope, arising by bifurcation from the large bounding plications. Lateral slopes each with 8 to 14 low, very broad, rounding anteriorly and frequently umbonally flat-topped, plications and with narrow interspaces; the 5 or 6 plications nearer the sinus are broader and stronger than the rest; these plications usually disappear entirely at the cardinal angles; the plications bounding the median sinus are stronger and broader than the rest; these are especially high at the umbo from which they decrease in height anteriorly. At times all the plications are very low and faint.

Brachial valve less convex than the pedicle; umbo rather strongly incurved at hinge-margin. Median fold defined at beak, somewhat more strongly elevated anteriorly; either smooth or with a broad inconspicuous plication low upon each flank. Lateral slopes of valve with plications similar in character and number to those of the opposite valve, but slightly stronger.

The minute surface markings consist of fine, thread-like, concentric growth lines, and at intervals of 0·5 mm. to 1 mm. appear stronger lines; these growth varices are inconspicuous and irregular, are most apparent upon the lateral slopes where they are about 0·5 mm. to 0·75 mm. wide. The later ones extend across the front of the shell, whereas the earlier varices are usually confined to the lateral slopes. Longitudinally the shell surface is finely spinose-striate.

Remarks. The short hinge-line and spinose surface place this form in Hall and Clarke's Fimbriatae and Waagen's Reticulariinae. It completely lacks the dental plates of pedicle valve and the median septum of each valve characteristic of Reticularia and thus falls within Gemmellaro's genus Squamularia.[1] The muscle markings in the pedicle valve of our form are very faintly impressed, hardly noticeable except for the radiating lines.

We have here apparently a transitional form connecting a plicate non-varicate shell with a non-plicate varicate one; a development from a plicate Mississippian spiriferoid shell to the typical Squamularia of the Pennsylvanian with its characteristic low, irregular varices and no plications.

In form this species closely resembles *Brachythyris chouteauensis* Weller from the Kinderhook of Mississippi valley[2] and was first so identified, for most of the specimens are exfoliated. In the following comparison with *B. chouteauensis* the Minnewanka species is placed in parenthesis. Length of pedicle valve 22 mm. (30 mm.), of brachial valve 20 mm. (26 mm.); greatest width 24·5 mm. (32 mm.); length of hinge-line 13·5 mm. (19 mm.); thickness of shell 17 mm. (19 mm.), of pedicle valve 10 mm. (12 mm.), of brachial valve 7 mm. (7 mm.); plications upon fold and in sinus 2-4 (0-2), upon each lateral slope 8-11 (8-14). The Minnewanka form is slightly larger, with a greater convexity of the pedicle valve, and a stronger incurvature to the beak; plications are less prominent and less elevated; those of the lateral slopes are usually flat topped, with very narrow, abruptly depressed interspaces. An especially noticeable difference is that the entire surface is spinose-striate (in *B. chouteauensis* the plications are broadly rounded and the surface lacks longitudinal striæ). *Spirifer ? peculiaris* Shumard has a much higher cardinal area of the pedicle valve, fewer plications (5-8) upon each lateral slope, and the sinus and fold smooth or with a single median plication in the sinus and a corresponding furrow in the top of the fold. (There appears to be some doubt as to the presence or absence of spines in this species.) Girty[3] places it under Reticularia with a question mark, because some exfoliated specimens from the Chouteau limestone of Missouri (the home of Shumard's type) "appear to have possessed a finely lamellose-spinose surface." Weller[4] places the Missouri Chouteau limestone form of this species under Brachythyris, which genus lacks radiating striæ.

Specific name given because of the depressed plications; these are low, frequently flat topped, at times very obscure.

Locality and Horizon. In the Minnewanka region in the Lower Mississippian of section 2-24 (C), 29 (r).

Genus, **Eumetria** Hall

Eumetria marcyi (Shumard)

1854. *Terebratula marcyi* Shumard, Marcy's Rep. U.S. Expl. Red River of Louisiana, p. 177, Pl. 1, fig. 4; *Retzia verneuiliana* Hall, 1858, Trans. Albany Inst., vol. 4, p. 9; Hall, 1858, Geol. Iowa, vol. 1, pt. 2, p. 657, Pl. 23, figs. 1 a-d; *Eumetria verneuiliana* Hall, 1883, 12th

[1] Girty, U. S. Geol. Surv., Prof. Paper 16, p. 387, 1903.
[2] State Geol. Surv., Ill., Mon. 1, 1914, p. 373, Pl. 57, figs. 4-11.
[3] U.S. Geol. Surv., Mon. 32, pt. 2, 1899, p. 557.
[4] Geol. Surv., Ill., Mon. 1, 1914, p. 381.

Rept. Geol. Surv., Indiana, p. 335, Pl. 29, figs. 28-30; *Retzia verneuiliana* Walcott, 1884, Pal. Eureka District, p. 220, Pl. 7, figs. 5-5a; *Eumetria verneuiliana* Hall and Clarke, 1895, Pal. N.Y., vol. 8, pt. 2, Pl. 51, figs. 13-26, 34, 35, Pl. 83, figs. 26-27; Girty, 1899, U.S. Geol. Surv., Mon. 32, p. 560, Pl. 68, figs. 12 a-b; *E. marcyi* Girty, 1904, U.S. Geol. Surv., Prof. Paper 21, p. 49, Pl. 10, figs. 15-17; Beede, 1906, 30th Ann. Rept. Geol. Surv., Indiana, p. 1319, Pl. 22, figs. 28-30; Girty, 1911, U.S. Geol. Surv., Bull. 439, p. 77, Pl. 8, fig. 10; *E. verneuiliana* Weller, 1914, Geol. Surv., Illinois, Mono. 1, p. 442, Pl. 76, figs. 18-24.

Remarks. It seems impossible with the material in hand to divide the *E. marcyi* group as Hall, and lately Weller, have done in the Mississippi valley. In number of plications they most closely resemble *E. costata* (Hall); in their slight convexity they approach *E. costata* and *E. vera;* in size they are similar to *E. vera.* Since the Minnewanka material is thus variable, it seems best to use for them Hall's earliest name for this type of shell, *E. marcyi.*

Locality and Horizon. Mississippian of Mississippi valley and west. In the Minnewanka region in the Lower Mississippian of sections 2-23 (c); 4-2 (?).

Genus, **Hustedia** Hall

Hustedia circularis (Miller)

1894. *Retzia ? circularis* Miller, 18th Rept. Geol. Surv., Ind., p. 316, Pl. 9, figs. 32-34; *Hustedia circularis* Weller, 1914, State Geol. Surv., Ill., Mon. 1, p. 451, Pl. 76, figs. 47-52.

Remarks. This small shell is apparently identical with the Missouri species. The measurements of the latter as given by Weller show a somewhat thicker shell, but a slight variation in thickness is to be expected in the same species. It differs from *H. mormoni* of the Pennsylvanian, its nearest ally, in its smaller size, finer and less angular plications, and proportionately broader shell.

Locality and Horizon. Lower Mississippian of Missouri. In the Minnewanka region in the Lower Mississippian of section 2-35 (R).

Genus, **Athyris** McCoy

Athyris angelica Hall

1861. *Athyris angelica* Hall, 14th Rept. N.Y. State Cab. Nat. Hist., p. 99; ibidem, 1862, 15th Rept., Pl. 3, figs. 10-13, 24; Hall, 1867, Pal. N.Y. 4, p. 292, Pl. 47, figs. 9-20; Hall and Clarke, 1893, Pal. N.Y. State, pt. 2, p. 90, Pl. 45, figs. 26-30.

Remarks. The Minnewanka specimens somewhat resemble both *Athyris angelica* Hall from the Chemung of New York and Pennsylvania and *A. angelica occidentalis* Whiteaves from the Devonian of Athabaska river. The latter differs from our form in its smaller size; the median sinus of the pedicle valve is more marked, being deeper with bounding folds higher and narrower and extending to the beak; the brachial valve has a more conspicuous and flat-topped median fold, bordered by furrows which begin at the umbo, the outer side of these furrows being limited by a secondary, more divergent pair of folds; it thus results that the brachial valve has three folds radiating from the beak and the pedicle valve has two distinct folds bounding the median sinus, whereas in our shell, as in *A. angelica*, the sinus is depressed. *A. angelica*, as defined by Hall, is made to include both broad forms like ours and narrow, more elongate ones, though the original description applied only to the latter type with length greater than width, in the proportion of seven to six, respectively; this proportionately longer shell was due to the greater length of the umbonal region of the pedicle valve. Aside from the fact that our specimens are confined to the broad form with short umbonal region, they agree closely with *A. angelica* as described by Hall[1].

Locality and Horizon. In the Upper Devonian of the Appalachian region and Nevada. In the Minnewanka region in the Upper Devonian of sections 2-38 (c); 4-5 (R).

Genus, **Cleiothyridina** Backman

Cleiothyridina parvirostris (Meek and Worthen)

1860. *Athyris parvirostris* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 451; *A. planosulcata?* Meek and Worthen, 1866, Geol. Surv., Ill., vol. 2, p. 254, Pl. 18, figs. 8 a-d; *Cleiothyridina parvirostris* Weller, 1914, Geol. Surv., Ill., Mon. 1, p. 481, Pl. 78, fig. 25, Pl. 80, figs. 61-66.

Remarks. Our form is apparently identical with the Mississippi Valley species.

Locality and Horizon. The Lower Mississippian of Mississippi valley. In the Minnewanka region in the Lower Mississippian of sections 2-23 (r), 25 (r).

Cleiothyridina lata n. sp.

Plate IV, figure 1 a, b, c

Shell of medium size, transversely subelliptical in outline, greatest width near mid-length of the shell. Dimensions of a nearly complete mature shell are: length of pedicle valve 25 mm.; of brachial valve 23 mm.; width 31 mm.; thickness of conjoined valves 15 mm.; length of hinge-line 15 mm. Valves subequally convex. Cardinal extremities rounded.

Pedicle valve most convex in umbonal region. A faint median flattening is present at the umbo; this beyond the middle of the shell develops into a broad median sinus and remains shallow to the anterior margin of the valve. Beak rather narrow, incurved, truncated by a moderately large foramen. Internally, strong dental lamellæ extend about one-third the distance to the anterior margin.

Brachial valve most convex in the umbonal region. A median elevation corresponding to the median sinus of the opposite valve is developed, its sides merging imperceptibly into the general surface of the valve, except at the anterior margin where it becomes definitely a fold.

Surface of both valves covered with numerous, narrow, concentric ridges which are covered with minute spines. Both ridges and spines are destroyed upon slight exfoliation.

[1] Pal., New York, vol. 4.

Remarks. From *Cleiothyridina incrassata* of the Burlington of Mississippi valley this species differs especially in its more transverse form. From *C. obmaxima* of the Upper Kinderhook, Burlington, and Keokuk of the same region it differs in its smaller sinus and fold, narrower spines, and in having the greatest convexity of the brachial valve in the posterior and not anterior part.

Locality and Horizon. In the Minnewanka region in the Mississippian of sections 2-23 (c), 25 (c); 35 (R); 4-3 (R).

Cleiothyridina hirsuta (Hall)

1857. *Spirifera hirsuta* Hall, Trans. Albany Inst., vol. 4, p. 8; *Athyris hirsuta* Whitfield, 1882, Bull. Am. Mus. Nat. Hist., vol. 1, p. 49, Pl. 6, figs. 18-21; Hall, 1883, 12th Ann. Rept. Geol. Surv., Indiana, p. 328, Pl. 29, figs. 18-21; Walcott, 1884, Pal. Eureka District, p. 222, Pl. 18, fig. 5; *Cliothyris roysii* Hall and Clarke, 1895, Pal. N. Y., vol. 8, pt. 2, Pl. 46, fig. 23 (not fig. 24); *C. hirsuta* Hall and Clarke, 1895, Pal. N.Y., vol. 8, pt. 2, Pl. 46, figs. 25-28; *Cleiothyris hirsuta* Beede, 1906, 30th Ann. Rept. Geol. Surv., Indiana, p. 1320, Pl. 19, figs. 1-1a, Pl. 22, figs. 18-21; *Cleiothyridina hirsuta* Weller, 1914, Geol. Surv., Illinois, Mon. 1, p. 479, Pl. 80, figs. 13-24.

Remarks. Our single, somewhat crushed specimen agrees closely with *C. hirsuta.* The rather strong concentric growth ridges argue that it is an adult shell; otherwise it somewhat resembles the young of *C. parvirostris.* This species is very similar to *C. crassicardinalis* var. *nana* Girty from the Madison limestone of Yellowstone National park.[1] Girty informs me that the brachial valves associated with the type pedicle valve (none of the specimens retain both valves in conjunction) are subequal in convexity with the pedicle valves, "the dorsal valve being somewhat, though distinctly, more inflated than the ventral." This is similarly true of the Mississippi Valley *C. hirsuta.* Girty's *C. nana* appears to differ mainly in the greater angle made at the beak of the pedicle valve by the lateral umbonal slopes. The type figure gives 135 degrees, whereas *C. hirsuta* measured from Weller's figures[2] gives nowhere greater than 115 degrees, and for specimens the size of *C. nana* the angle is about 108 degrees. In this respect our specimen agrees with *C. hirsuta,* having an angle of about 110 degrees. *C. crassicardinalis* (White) has the pedicle valve much more convex than the brachial.

Locality and Horizon. Middle Mississippian of Mississippi valley. In the Minnewanka region in the Lower Mississippian of section 2-22 (R).

Genus, **Composita** Brown

Composita humilis (Girty)

1899. *Seminula humilis* Girty, U.S.G.S., Mon. 32, pt. 2, p. 565, Pl. 71, figs. 6 a-c.

Remarks. Certainty of identity is, of course, impossible where external form alone is available for comparison, but within these limits the Minnewanka specimens fall within Girty's species.

Locality and Horizon. Mississippian of Yellowstone National park. In the Minnewanka region in the Mississippian of section 2-24 (C).

[1] U.S. Geol. Surv., Mon. 32, pt. 2, p. 569, Pl. 71, fig. 9a.
[2] Loc. cit.

Composita persinuata (Meek)

1877. *Athyris ? persinuata* Meek, King's U.S. Geol. Expl. 40th Par., 4, p. 81, Pl. 9, fig. 4.

Remarks. Aside from the somewhat doubtful surface markings this form differs from *Cleiothyridina incrassata* (Hall) from the Lower Mississippian of the Mississippi valley in its smaller size, proportionally thicker shell, more abrupt deflexion of the frontal margin, and slightly less convex pedicle valve. *Athyris monticola* White from the Mississippian of Nevada has the median sinus extending almost to the beak and the greatest width of shell more anterior. *Composita subquadrata* from the Upper Mississippian of the Mississippi valley has the pedicle valve much more convex in the umbonal region and the brachial valve more arched from beak to front. Judging from Meek's description and figures of his types of *Composita persinuata* our specimen differs in its less convex brachial valve, both longitudinally and transversely, the latter in Meek's type meeting the opposite valve nearly at right angles; in outline and relation of length, breadth, and thickness they are similar, but our specimen is slightly smaller. We are inclined to think the Minnewanka form more closely resembles Meek's species than any other with which we are acquainted.

Locality and Horizon. In the Carboniferous of Nevada, in the Minnewanka region in the Lower Mississippian of section 2-23 (R).

Composita ozarkana Mather

1915. *Composita ozarkana* Mather, Bull. Sci. Lab. Denison Univ., vol. 18, p. 198, Pl. 13, figs. 11-15 c.

Remarks. It seems desirable to separate this large, broad form from Hall's species of *Composita trinuclea;* in the Minnewanka section the typical small, narrow form was not observed. Mather founded his species *C. ozarkana* upon this difference and as the Minnewanka specimens apparently agree in all essential respects with his species they are placed within it. From *C. subquadrata* (Hall) from the Chester it differs in its somewhat smaller size, in the more flat-topped fold of the brachial valve, and in the presence of the lateral sinuses in the pedicle valve. From *C. subtilita* (Hall) from the Pennsylvanian it may be differentiated by its less elongate form, by the lower median fold of its brachial valve, the more shallow median sinus of the pedicle valve with its slighter anterior extension as well as in the presence of the lateral sinuses upon this valve.

Locality and Horizon. Basal Pennsylvanian of Arkansas and Oklahoma. In the Minnewanka region in the Pennsylvanian of section 2-11 (c), -13 (c).

Composita subtilita (Hall)

1852. *Terebratula subtilita* Hall, Stansbury's Exped. Great Salt Lake, p. 409, Pl. 2, figs. 1 a, b, 2 a, b; *T. ? subtilita* Davidson, 1857, Mon. British Carb. Brach., Pal. Soc., p. 18, Pl. 1, figs. 21, 22; *T. subtilita* Hall, 1858, Geol. Surv., Iowa, vol. 1, pt. 2, p. 714; *Spirigera subtilita* White, 1875, U.S. Geog. Geol. Surv., W. 100th Mer., Rept., vol. 4, p. 141, Pl. 10, figs. 6 a-c (whole volume published in 1877); *Athyris subtilita* Meek, 1877, U.S. Geol. Expl. 40th Par., Rept., vol. 4, p. 83, Pl. 8, figs. 6, 6a; White, 1884, Geol. Surv., Indiana, 13th Rept., p. 136, Pl. 35, figs. 6-9; *Seminula subtilita* Hall and Clarke, 1893, Pal. N.Y., vol. 8, pt. 2, p. 95, figs. 66, 67 on p. 95, and figs. 58, 59 on p. 86, Pl. 47, figs. 17-31; Girty, 1903, U.S. Geol. Surv., Prof. Paper 16, p. 403, Pl. 7, figs. 1-1 b, 2, 2 a, 3, 3 a, 4-7, 7 a, 8-10.

Remarks. Compared with specimens from the Coal Measures of Indiana our form is slightly smaller, with a narrower and more distinct median fold, separated from the rest of the shell by more distinct furrows. In Hall's type figures the median fold is broad and very indistinctly separated from the rest of the shell. This difference between the Minnewanka specimens and the typical eastern form and Hall's type figures is one of degree and not of kind. *C. madisonensis* (Girty), otherwise quite similar, has its greatest width medially and thus differs radically.

Locality and Horizon. Pennsylvanian of North America. In the Minnewanka region in the Pennsylvanian of section 1-22 (c).

Phylum, MOLLUSCA

Class, PELECYPODA

Genus, **Parallelodon** Meek

Parallelodon obsoletus (Meek)

1871. *Macrodon obsoletus* Meek, Rept. Regents Univ., West Va.; Meek, 1875, Pal. Ohio, vol. 2, p. 334, Pl. 19, fig. 9; Herrick, 1887, Sci. Lab. Denison Univ., Bull. 2, p. 31, Pl. 4, fig. 19; Beede, 1900, Univ. Geol. Surv., Kansas, Rept., vol. 6, p. 147, Pl. 20, fig. 13.

Locality and Horizon. Pennsylvanian of West Virginia and Ohio to Colorado. In the Minnewanka region in the Pennsylvanian of section 2-12 (r).

Genus, **Conocardium** Brown

Conocardium indianense Miller ?

1892. *Conocardium indianense* Miller, 17th Rept. Geol. Surv., Ind., p. 704, Pl. 20, fig. 10.

Remarks. Since this species is here represented only by one poorly preserved specimen, and since Miller's species was rather inadequately described, the present identification is not made with certainty. It is, however, probably not the Conocardium found by Girty in his Colorado fauna,[1] since that is compared with *C. catastomum*—a form with constricted and not regularly tapering posterior part—and it differs in its ornamentation from *C. nevadensis* of the Devonian of the Eureka district,[2] which it otherwise resembles in size and outline.

Locality and Horizon. In the Lower Mississippian of Indiana. In the Minnewanka region in the Mississippian of section 2-25 (R).

[1] U.S. Geol. Surv., Prof. Paper 16, p. 310.
[2] U.S. Geol. Surv., Mon. 8, p. 177.

Genus, **Bakewellia** King

Bakewellia parva Meek and Hayden

1858. *Bakewellia parva* Meek and Hayden, Trans. Albany Inst., vol. 4, p. 78; White, 1877, U.S. Geog. Surv., W. 100th Mer., vol. 4, p. 153, Pl. 11, figs. 7 a, b.

Remarks. Only left valves are in this collection and these agree in every particular with those described and figured by Meek and Hayden from New Mexico and Arizona, except that they are slightly larger. There are indications of two or three denticulations beneath the beak, but it is impossible to be sure of them on account of the coarse sandstone in which the shells are preserved, and on account of the entire disappearance of the shell substance.

Locality and Horizon. Pennsylvanian of Kansas, New Mexico, and Arizona; Permian of Kansas, Arizona, and Nevada. In the Minnewanka region in the Permian of section 1-14 (c).

Genus, **Myalina** de Koninck

Myalina mississippiensis n. sp.

Plate IV, figures 2, 3, 4, 5, 6, 7

1903. *Myalina keokuk* Girty, U.S. Geol. Surv., Prof. Paper 16, p. 309, Pl. 1, fig. 12.

Description. Small, subquadrate, oblique. Hinge straight and equalling the greatest width of the body part of the shell. Length of hinge of a mature specimen 15 mm.; oblique length of shell, from beak to postero-ventral margin, 20 mm. Anterior and cardinal margins converging at an angle of about 65 degrees. Umbonal and body part compressed, much elevated and rather sharply delimited throughout its entire length from the large, flattened, posterior wing. Beak small, compressed, curved slightly anteriorly; its anterior slope is very steep, its posterior more gentle. A very small anterior ear is present.

Surface marked by regular concentric lamellæ from beak to basal margin and by fine, concentric growth lines.

Remarks. There are few species of this genus as small as this. It is likewise distinguished by its convexity and by its regular concentric lamellæ. In most respects except size it closely resembles *M. keokuk* of Mississippi valley.[1] An average specimen of that species is stated to measure 2·2 inches by 1·25 inches. The present species likewise closely resembles *M. sanctiludovici* of the Keokuk of Illinois to Missouri,[2] but differs in its much more convex body part. *Myalina orthonota* Mather, described from the Morrow group (Mississippian-Pennsylvanian transitional) of Arkansas and Oklahoma[3] agrees closely in size, but with its shorter, more oblique hinge-line and less definite posterior wing, finds its closest affinities with the *M. perattenuata* type of shell and not with *M. keokuk.* It would seem that the specimen identified doubtfully as *M. keokuk* by Girty from the Ouray limestone of Colorado[4] may be included with the Minnewanka species. Girty records dissatisfaction in its identification since his one specimen was much smaller than is typical of *M. keokuk,* though it is somewhat larger (oblique length 32 mm.) than is our normal type.

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[1] Geol. Surv., Ill., vol. 6, Pl. 30, fig. 5.
[2] Geol. Surv., Ill., vol. 5, Pl. 22, fig. 3.
[3] Bull. Sci. Lab. Denison Univ., vol. 18, p. 221, Pl. 15, fig. 4.
[4] Loc. cit.

Locality and Horizon. Lower Mississippian of Colorado. In the Minnewanka region in the Mississippian (whence the specific name) of sections 2-22 (C), 23 (c), 24 (r), 25 (R), 26 (R), 27 (R).

Myalina wyomingensis (Lea)

1853. *Modiola wyomingensis* Lea, Acad. Nat. Sci., Phil., Jour. (2), vol. 2, p. 205, Pl. 20, fig. 1 a; Claypole, 1886, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 247; *Myalina wyomingensis* Girty, 1903, U.S. Geol. Surv., Prof. Paper 16, p. 422, Pl. 8, figs. 8-13.

Remarks. This species is distinguished by the straight umbonal ridge which meets the hinge-line at an angle of 45 degrees and by the small anterior lobe, the beaks being thus not quite terminal. In size and general outline it is quite closely similar to *M. swallovi* McChesney. In that species, however, the umbonal ridge is less defined and not so straight, and the posterior margin meets the hinge-line in a curve. The surface, moreover, is smooth or marked only by fine, concentric lines. Our specimens are somewhat smaller than those described by Girty from Colorado.

Locality and Horizon. In the Pennsylvanian of Pennsylvania and Colorado. In the Minnewanka region in the Permian of section 1-14 (c).

Genus, **Deltopecten** Etheridge

Deltopecten occidentalis latiformis n. var.

Plate VII, figures 11 a, b; 12

A bibliography of the species is given (1909) by Girty[1]; another is listed (1915) by Mather.[2]

Description. Shell flabelliform, with transverse diameter (from anterior to posterior border) slightly greater than the distance from the hinge-line to the basal border; in consequence, the angle formed at the beak between the anterior and the posterior umbonal slopes is broad, slightly exceeding a right angle. Hinge-line nearly or quite equalling the greatest length of the valves. Length, the diameter from the anterior to the posterior margin, 30 mm.; height, from hinge-line to basal margin, 23 mm.; greatest thickness of the conjoined valves 8 mm. Angle of divergence of the umbonal slopes at the beaks 100 degrees (in one specimen 90 degrees).

Left valve sloping broadly and flatly in all directions from the slightly convex umbonal region. Ears nearly equal in size, the anterior the more obtuse and defined by a deeper sinus from the body of the shell; it is marked by six or seven radiating ribs which are finely crenulated by concentric striæ. Posterior ear separated from the body of the valve by a broad and shallow depression; on this ear the concentric markings are the more conspicuous and the radiating striæ are fine and numerous—18 or 20 in number. Surface of valve marked by strong radiating costæ between which are from one to three intercalated weaker striæ; only the stronger costæ are present at the beak, whereas at the ventral margin there are, in a space of 6 mm., about ten striæ, of which four are strong.

[1] U.S. Geol. Surv., Bull. 389, p. 84.
[2] Bull. Sci. Lab. Denison Univ., vol. 18, p. 227.

Right valve nearly flat and much more faintly ribbed than the left, with finer striæ of nearly equal size. Sinus separating the anterior ear from the body of the shell much sharper and deeper than on the left valve.

Remarks. It will be noted from the description that our specimens agree closely with *D. occidentalis* as described in previously published reports, except in the greater proportion of length to height and, consequently, in the larger angle at which the umbonal slopes diverge from the beak. The following table compares the measurements of our forms with those of previously published examples of this species as given in their descriptions and figures.

Length	Height	Angle	——
mm.	mm.	degrees	
18	20	80–85	Meek and Worthen, Illinois
37	40	84	Meek, Nevada
37	42	82–86	White, Arizona
37	42	82	White, Indiana
32	35	94	White, Texas
31	38	85	Keyes, Missouri
20	22	90	Girty, Colorado
30	23	100	The Minnewanka form here discussed

It will be seen that in all, except the Minnewanka form, the height exceeds the length and that in most cases the angle at the beak is less. Though certain forms come close to ours in these two features, still it seems to be true that the Minnewanka forms emphasize the transverse diameter, whereas the others emphasize the height, and likewise that our specimens show a pronounced tendency to a much more obtuse angle at the beak. It would seem that this reversal of the proportion of length to height and this greater angle might be considered as characterizing a variety which is here called *latiformis.*

Locality and Horizon. The species occurs in the Pennsylvanian and Permian from Pennsylvania to Texas and Utah. The variety in the Minnewanka region in the Permian of section 1-14 (C).

Genus, **Allorisma** King

Allorisma albertense n. sp.

Plate IV, figure 8 a, b, c, d

Description. Shell large, with a length of 60 mm., the greatest height (at umbo) of 28 mm., and a thickness of the combined valves of 20 mm. Valves equal, moderately convex, curving regularly from hinge-line to base. Beaks depressed, anterior, less than a third of the shell's length from the anterior margin. Hinge-line apparently slightly longer than two-thirds the length of the shell. Cardinal margin of each valve inflected behind the beaks, forming together a lanceolate depression. A low, inconspicuous umbonal ridge extends from the umbo to the posterior margin; the shell between this and the cardinal margin is less convex than towards the basal margin. Teeth apparently absent.

Surface of both valves ornamented by concentric growth lines and by low, rounded, concentric ridges varying somewhat in width; medially near the base these ridges are from 1 mm. to 1·75 mm. wide. The ridges cover the entire shell, including the umbo, but are very weak upon the flattened posterior cardinal slope. There are faint indications of radial lines upon the anterior slope.

Remarks. This species is founded upon a single, partly exfoliated shell. Generically it somewhat resembles *Sanguinolites*, but the anterior adductor muscle scar shows no indication of the buttress characteristic of this genus; if the buttress were present there should be some indication of it upon the exfoliated left valve. Specifically it approaches rather closely to *A. cuyahoga* Herrick[1] from the Waverly of Ohio, but is more elongate, narrower posteriorly, less extended antero-basally, and has much weaker concentric ridges upon the postero-cardinal slope.

Locality and Horizon. In the Minnewanka region in the Mississippian of section 2-24 (R).

Genus, **Pleurophorus** King

Pleurophorus tropidophorus Meek

1875. *Pleurophorus tropidophorus* Meek, Pal. Ohio, vol. 2, p. 338, Pl. 19, figs. 10 a-b; Herrick, 1887, Bull. Sci. Lab. Denison Univ., vol. 2, p. 35, Pl. 4, fig. 15; Beede, 1900, Univ. Geol. Surv., Kansas, vol. 6, p. 162, Pl. 20, fig. 7; Mark, 1911, Bull. Sci. Lab. Denison Univ., vol. 16, p. 312, Pl. 10, fig. 11; Mather, 1915, Bull. Sci. Lab. Denison Univ., vol. 18, p. 230.

Locality and Horizon. Pennsylvanian from Ohio to Arkansas. In the Minniwanka region in the Pennsylvanian of section 2-10 (R).

cf. *Pleurophorus mexicanus* Girty

1909. *Pleurophorus mexicanus* Girty, U.S. Geol. Surv., Bull. 389, p. 91, Pl. 10, fig. 1.

Remarks. Our single specimen is an imperfect left valve. It appears to approach most closely to this species but clearly cannot be identified with it. It is similar to Girty's species in its posterior outline, surface ornamentation, the low ridge paralleling the hinge-line, and in the evidence of a faint umbonal ridge; this ridge is, however, much fainter as is likewise the ridge which parallels the hinge-line, and the one or two parallel ridges between these in Girty's species are completely lacking in ours. The anterior part, including the beak, is destroyed. Length about 65 mm., breadth about 20 mm.

Locality and Horizon. In the Minnewanka region in the Permian of section 1-14 (R).

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[1] Geol. Surv., Ohio, vol. 7, Pl. 22, fig. 17.

Class, SCAPHOPODA Bronn

Genus, **Plagioglypta** Pilsbry and Sharp

Plagioglypta canna (White)

1877. *Dentalium canna* White, U.S. Geog. Surv., W. 100th Mer., vol. 4, p. 156, Pl. 12, figs. 6 a, b.

Remarks. This is doubtless identical with White's species. It agrees in size, angle of divergence, and surface markings—in every respect except curvature. White says[1] that the shell is straight or very slightly curved. None of the Minnewanka specimens show curvature. Girty, who has examined White's types, says that the type specimens are seemingly straight so that he is inclined to believe that White was mistaken in this respect.[2]

Exceedingly faint longitudinal striæ are undoubtedly present, and there may similarly be markings due to a longitudinally fibrous structure of the shell. These striæ, are, however, too weak to throw the species into the genus Dentalium.

This species and *Euphemus carbonarius arenarius* n. var. occur together in very great abundance in a white quartzite bed.

Locality and Horizon. Permian of New Mexico and Arizona, and of Guadaloupe mountains (Delaware Mountain formation), Texas. In the Minnewanka region in the Permian of sections 1-10 (C); 3-3 (c).

Class, GASTROPODA

Genus, **Euphemus** McCoy

Euphemus carbonarius arenarius var. nov.

Plate VII, figure 13

Description. Dorsum broadly rounded when mature, more narrowly rounded in immature specimens. Umbilicus closed, at least in the majority of specimens; it may be slightly open in a few forms. A thin callus is deposited upon the inner lip. Outer lip thin medially, thickened laterally. Slit band scarcely visible, sometimes slightly concave, with a faint ridge on either side upon the smooth part of the shell. (In a shell 20 mm. wide the ridges are distant from the middle of the depression 2 mm.) Surface, except for the final half of the last whorl which is smooth, ornamented in a shell of medium size with 18 low revolving costæ. Lines of growth obsolete. The transverse and longitudinal diameters of a specimen of medium size are each 26 mm.

Remarks. This variety differs from the species as described and figured by Meek,[3] principally in its greater size. A Nebraska specimen of medium size had transverse and longitudinal diameters of 14 mm., with 18 to 25 costæ. Cox's type specimen of *E. carbonarius* as figured and described by White,[4] has longitudinal and transverse diameters each of 17 mm., with 20 to 28 costæ.

[1] Loc. cit.
[2] U.S. Geol. Surv., Prof. Paper 58, p. 450.
[3] U.S. Geol. Surv., Nebraska, Final Rept., p. 224, Pl. 4, fig. 16, Pl. 11, figs. 11a-c.
[4] 13th Rept. Geol. Surv., Indiana, p. 158, Pl. 33, figs. 6-8.

The thin callus covering the inner lip clings to the quartzose matrix in our specimens so that it is rarely seen. This variety occurs in great abundance with *Plagioglypta canna* in a quartzite bed. A similar association occurs in northern Arizona (at the Wild Band Pockets and at House Rock Ranch), and likewise in a quartzite bed. In Arizona, however, the gastropod is smaller than in Alberta; a medium size specimen has transverse and longitudinal diameters of 14 mm., with 14 costæ—probably a normal *E. carbonarius.*

Since nearly all of the Belleraphontidæ at this horizon occur as internal moulds it is impossible to determine if some of the specimens may not be *Euphemus subpapillosus* (White), since this differs from *E. carbonarius* merely in its larger size and in the papillose ornamentation of the latter half of the last whorl. It is likewise impossible to say that some do not belong to *E. nodocarinatus* Hall. A few large specimens have the irregularity of coiling characteristic of *E. inspeciosus* (White), but lack the median angulation at the anterior end of the mature shell and the narrow dorsum of the immature coils.

Locality and Horizon. The species *E. carbonarius* occurs in the Pennsylvanian from Ohio to Texas, in the Permian of Arizona, New Mexico, etc. In the Minnewanka region the variety occurs in the Permian of sections 1-10 (C); 3-3 (c).

Genus, **Euconospira** Ulrich

Euconospira turbiniformis (Meek and Worthen)

1860. *Pleurotomaria turbiniformis* Meek and Worthen, Acad. Nat. Sci. Phil., Proc., p. 461; Meek and Worthen, 1866, Geol. Surv., Illinois, Rept., vol. 2, p. 359, Pl. 28, figs. 8 a-c; White, 1884, Geol. Surv., Indiana, 13th Rept., p. 160, Pl. 32, figs. 7, 8; Keyes, 1894, Geol. Surv., Missouri, vol. 5, p. 135, Pl. 48, figs. 6 a-b.

Remarks. Our specimens agree in all their preserved characters with this species. It is larger (diameter of last whorl 18 mm. to 20 mm.) than Mather's *E. arkansana.*[1]

Locality and Horizon. Pennsylvanian, etc., of the Mississippi valley and Colorado. In the Minnewanka region in the Permian of section 1-14 (c).

Genus, **Straparollus** Montfort

Straparollus quadrivolvis (Hall) ?

1856. *Euomphalus quadrivolvis* Hall, Trans. Albany Inst., vol. 4, p. 19; Hall, 1883, 12th Rept. Geol. Surv., Indiana, p. 349, Pl. 31, figs. 24, 25.

Locality and Horizon. Mississippian (St. Louis) of Indiana. In the Minnewanka region in the Mississippian of section 4-5 (R).

Straparollus umbilicatus (Meek and Worthen) ?

1860. *Euomphalus umbilicatus* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 462; *Straparollus umbilicatus* Meek and Worthen, 1866, Geol. Surv., Illinois, vol. 2, p. 362, Pl. 29, figs. 1 a-c.

[1] Bull. Sci. Lab. Denison Univ., vol. 18, p. 235, Pl. 15, fig. 25.

Remarks. This form is rather abundant. It occurs in a dense quartzite from which we did not succeed in extracting an identifiable specimen. It is large, with probably five or six regularly enlarging whorls; these have a slightly angular shoulder. Umbilicus prominent. Surface markings unknown, as all our specimens are internal moulds. These specimens may possibly be very large representatives of this species.

Locality and Horizon. In the Minnewanka region in the Permian of section 1-10 (c).

Genus, **Strophostylus** Hall

Strophostylus carleyanus (Hall) var.

1856. *Natica carleyana* Hall, Trans. Albany Inst., vol. 4, p. 31; *Naticopsis carleyana* Hall, 1883, 12th Rept. Geol. Surv., Indiana, p. 369, Pl. 31, figs. 26, 27.

Remarks. Our single specimen is rather poorly preserved but appears to fall within the limits of this species, except that it is double the size.

Locality and Horizon. Mississippian (St. Louis) of Mississippi valley. In the Minnewanka region in the Lower Mississippian of section 2-? 22 (R).

Strophostylus sp. ?

Description. Shell small, consisting of three volutions. Apex of spire depressed and minute, rising little above the final volution. Surface ornamented by fine growth lines. Height 10 mm., breadth 7 mm.

Remarks. The preservation of our single specimen is such that the columellar grooves, if present, do not show. There is some resemblance to the widespread Pennsylvanian species, *S. nanus*, but the aperture of our form is more elongate and the whorls more rounded.

Locality and Horizon. In the Minnewanka region in the Mississippian of section 2-24 (R).

Genus, **Loxonema** Phillips

Loxonema rockymontanum n. sp.

Plate IV, figures 9 a, b; 10

Description. Shell of medium size. Whorls seven or eight, slowly enlarging, convex exteriorly, somewhat flattened on the base; the smaller whorls have the outer surface also flattened, with the result that the suture is shallow. The last two or three whorls are more rounded on the outer surface and hence produce a more prominent suture. Aperture broadly ovate-cuneate antero-posteriorly; a shallow anterior canal is present. Surface of shell ornamented with numerous, low, faint, revolving lines (20 to 30 upon a whorl 4 mm. wide), and with fine, slightly S-shaped growth lines paralleling the aperture; the latter markings become rather strong upon the last whorl. Height of shell about 30 mm., height of last whorl 11 mm., length of aperture 11 mm., its greatest width 9 mm. Apical angle about 32 degrees.

Remarks. The above measurements were made by adding the last whorl of one individual to another shell as the smaller form seemed in every way to be the immature representative of the larger. Both are figured. This is an abundant form but it is quite brittle in its limestone matrix. The shell appears to be an *L. shumardanum* (Winchell)[1] of the Kinderhook of Iowa up to the last one or two whorls; the surface markings of the latter are unknown. If Winchell's species is not founded upon an immature shell our form must be distinct because of its great size, if because of no other distinction. *L. shumardanum* has a height of 14 mm., with a last whorl 6 mm. high; it has six or seven whorls and an apical angle of 34 degrees. Specific name derived from the Rocky mountains, in which it occurs.

Locality and Horizon. In the Minnewanka region in the Mississippian of sections 2-25 (c), 26 (R).

Genus, **Platyceras** Conrad

Platyceras paralius White and Whitfield var.

1862. *Platyceras paralium* White and Whitfield, Proc. Boston Soc. Nat. Hist., vol. 8, p. 302; *Capulus paralius* Keyes, 1894, Missouri Geol. Surv., vol. 5, p. 174, Pl. 53, figs. 1 a-d; Weller, 1901, Trans. Acad. Sci., St. Louis, vol. 11, p. 201, Pl. 20, figs. 13-14.

Remarks. One imperfect specimen resembles rather closely the form illustrated by Weller in figure 14[2] as a variety of *P. paralius.* It also resembles Keyes' figures 1 b-c[2] which he calls immature specimens of this species. It is also closely similar to Girty's Platyceras form E,[3] except that our form expands more rapidly and has a slightly greater incurvature. The apex is rather closely incurved and the radiating folds are indistinct though present. Shell angular on the dorsum, especially towards the apex, much less angular towards the aperture. Shell more inflated upon the right side than upon the left.

Locality and Horizon. In the Lower Mississippian of Mississippi valley. In the Minnewanka region in the Lower Mississippian of section 2-25 (R).

Genus, **Paleocapulus** Grabau and Shimer

Paleocapulus equilatera (Hall)

1860. *Platyceras equilatera* Hall, Supp. vol. 1, pt. 2, Geol. Rept., Iowa, p. 89; Meek and Worthen, 1873, Geol. Surv., Illinois, vol. 5, p. 518, Pl. 17, fig. 2; White, 1881, Dep. State and Geol., Indiana, 2d, Ann. Rept., p. 514, Pl. 7, fig. 5; *Capulus equilateralis* Keyes, 1894, Geol. Surv., Missouri, vol. 5, p. 178, Pl. 52, figs. 10 a, b.

Remarks. This is the most abundant gastropod in the Mississippi of this region. The shells described under this name from Illinois by Meek and Worthen[4] have a length and breadth of 40 mm. and 29 mm., respectively.

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[1] Trans. Acad. Sci., St. Louis, vol. 10, p. 106, Pl. 7, fig. 5.
[2] Loc. cit.
[3] U.S. Geol. Surv., Mon. 32, pt. 2, p. 576, Pl. 66, figs. 11 a-d.
[4] Loc. cit.

Our form seems to be identical in all respects with the Mississippi Valley form.

Locality and Horizon. Lower Mississippian of Mississippi valley. In the Minnewanka region in the Mississippian of sections 2-23 (C), 24 (c); 4-2 (c), 3 (?).

Genus, **Orthonychia** Hall

Orthonychia acutirostris (Hall)

1856. *Capulus acutirostris* Hall, Albany Inst., Trans., vol. 4, p. 31; Hall, 1858, Iowa Geol. Surv., Ann. Rept., vol. 1, pt. 2, p. 665, Pl. 23, figs. 14 a, b; *Platyceras uncum* Meek and Worthen, 1873, Illinois Geol. Surv., vol. 5, p. 516, Pl. 17, fig. 1; *P. acutirostris* Hall, 1883, Indiana Dept. Geol. and Nat. Hist., 12th Ann. Rept., p. 370, Pl. 31, figs. 13-15; *Orthonychia acutirostre* Keyes, 1895, Missouri Geol. Surv., vol. 5, p. 190, Pl. 54, figs. 2 a-c; (*Orthonychia acutirostre*) Cumings, 1906, Indiana Dept. Geol. and Nat. Res., 30th Ann. Rept., p. 1335, Pl. 25, figs. 13-15.

Remarks. Our two specimens appear to be identical with the species as developed in the Mississippi valley.

Locality and Horizon. Lower and Middle Mississippian (Keokuk-St. Genevieve) of Mississippi valley. In the Minnewanka region in the Mississippian of section 2-23 (r).

Orthonychia cyrtolites (McChesney)

1860. *Platyceras cyrtolites* McChesney, Desc. New Pal. Foss., p. 71; *Orthonychia cyrtolites* Keyes, 1894, Missouri Geol. Surv., vol. 5, p. 188, Pl. 53, fig. 15.

Locality and Horizon. Lower Mississippian (Burlington) of Mississippi valley. In the Minnewanka region in the Mississippian of section 2-23 (R).

Genus, **Igoceras** Hall

Igoceras subplicatum (Meek and Worthen)?

1866. *Platyceras (Orthonychia) subplicatum* Meek and Worthen, Proc. Acad. Nat. Sci., Phil., p. 265; Meek and Worthen, 1868, Geol. Surv., Illinois, vol. 3, p. 457, Pl. 14, figs. 4 a-c.

Remarks. A single specimen, slightly crushed laterally, is provisionally identified with this species. It is a small, conical shell, 6 mm. high, rapidly expanding from the excentric beak. There are three well marked folds anteriorly and indications of two other obscure ones upon each side of the shell. The anterior folds are more prominent in the specimen because of the lateral crushing. Fine growth lines encircle the shell; these become stronger toward the aperture.

Locality and Horizon. Upper Mississippian of the Mississippi valley. In the Minnewanka region in the Lower Pennsylvanian of section 1-29 (R).

Igoceras sp.

Description. Shell broadly conical, expanding very rapidly from the subcentral apex. Surface bearing about ten prominent plications. Concentric growth lines numerous, becoming somewhat lamellose anteriorly. The diameter of the aperture is 20 mm., whereas the height of the specimen is 7 mm.; this great difference between height and diameter is due to the vertical crushing the specimen has suffered, though it was probably originally somewhat broader than high.

Remarks. This somewhat resembles *I. quincyense* (McChesney) of the Burlington of the Mississippi valley, but is a much smaller shell.

Locality and Horizon. In the Minnewanka region in the Pennsylvanian of section 2 a-14 (R).

Genus, **Conularia** Miller

Conularia alternistriata n. sp.

Plate IV, figure 11 a, b

Description. Shell quadrangular, tapering very gradually. Each of the four sides is slightly convex, nearly flat. A prominent longitudinal furrow is present on each angle. Sides crossed by sharply elevated, closely arranged transverse striæ which have smooth, even tops and sides. These arch forward in an obtuse angle at the apex of which they break, their ends alternating on each side of the sharply elevated longitudinal line that traverses the middle of each side (hence the specific name). Very seldom are these transverse striæ continuous across the median longitudinal line. There are five of these striæ in a space of 2 mm. Faint longitudinal lines (about 20 across one side) further ornament the spaces between the transverse striæ, but do not cross them. The single specimen in our collection is 10 mm. long with a diameter of 4 mm. at one end and of 2½ mm. at the other. Since the specimen is broken it is impossible to judge of the adult size.

Remarks. In *C. subulata* Hall from the Middle Mississippian (St. Louis) of the Mississippi valley[1] the median longitudinal line does not interrupt the course of the transverse striæ.

Locality and Horizon. In the Minnewanka region in the Mississippian of section 2-25 (R).

Phylum, ARTHROPODA

Class, CRUSTACEA

Subclass, Trilobita

Genus, **Proetus** Steininger

Proetus peroccidens Hall and Whitfield

1877. *Proetus peroccidens* Hall and Whitfield, U.S. Geol. Expl. 40th Par., vol. 4, p. 262, Pl. 4, figs. 28-32; Girty, 1899, U.S. Geol. Surv., Mon. 32, pt. 2, p. 576, Pl. 71, figs. 14 a-b.

Remarks. Our two specimens, an imperfect cephalon and an imperfect pygidium, agree very closely with the type descriptions and figures except that our form has a more pustulose glabella, Hall and Whitfield's description noting only a few granules at the base of the glabella.

Locality and Horizon. In the Mississippian of Utah and Yellowstone National park. In the Minnewanka region in the Mississippian of section 2-23 (R), -25 (R).

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[1] 12th Rept. Geol. Surv., Indiana, p. 372, Pl. 31, fig. 3.

A TRIASSIC CORAL REEF FAUNA IN BRITISH COLUMBIA

By Hervey W. Shimer

CONTENTS

INTRODUCTION

The Upper Triassic fossils from Bridge River area, B.C., herewith described, and correlated with the Sutton formation of Vancouver island, were collected during the summer of 1920 by W. S. McCann of the Geological Survey. According to McCann[1] they occur in small lenses of black limestone in arenaceous and argillaceous shales in the upper part of a series which, in ascending order, consists of conglomerate, sandstone, and shale with, in the lower part, great thicknesses of basaltic and andesitic greenstones. The whole series as exposed has a thickness of about 2,100 feet and forms the Cadwallader series. Intrusive into the Cadwallader series are stocks of augite diorite and bodies of quartz diorite. The limestones have thus been subjected to considerable metamorphism to the detriment of the included fossils.

The limestones in which the fossils were found occur on Pearson creek, a tributary of Gun creek which joins Bridge river. This locality is 150 miles north-northeast of the type locality of the Sutton formation[2] on Cowichan lake, Vancouver island. At the type locality the Sutton consists of pure limestones (i.e. coral reefs, coquina of pelecypods, and calcarenite of fragments of these) interbedded with lavas. The Pearson Creek limestones are a rather pure lime mud in which are entire pelecypods, gastropods, brachiopods, and corals, the last rather fragmentary. The kind of limestone, the fossil remains, and the associated sands and argillaceous muds indicate a deposit much nearer shore than at the type locality.

DESCRIPTION OF FOSSILS

Isastrea whiteavesi Clapp and Shimer

Our single specimen of some 20 corallites agrees with the type.[3] It agrees very closely also with *I. profunda* Reuss[4] from the Zlambach fauna in size and shape of corallites, but differs slightly in its smaller number of septa (24 instead of 24 to 40) and in apparently having merely granules instead of spines upon the sides of the septa.

[1] McCann, W. S., "Geology and Mineral Deposits of the Bridge River Map-area, British Columbia," Geol. Surv., Canada, Mem. 130, pp. 28-29, 1922.
[2] Clapp, C. H., and Shimer, H. W., "The Sutton Jurassic of the Vancouver Group, Vancouver Island," Proc. Boston Soc. Nat. Hist., 34, pp. 425-438, 1911.
[3] Loc. cit., p. 429.
[4] Frech, F., "Die Korallenfauna der Trias," Palæontographica Bd., 37, p. 21, Taf. 5, figs. 1-3.

Calamophyllia suttonensis Clapp and Shimer

This, the most abundant coral in these beds, as well as at the type locality of the Sutton formation, resembles rather closely *Thecosmilia fenestrata* Reuss,[1] the most common species of the Zlambach fauna. This species has a diameter of 5 to 10 mm., 28-50 septa in 3 or 4 cycles with spines upon the sides of the septa. The abundant and closely related *T. clathrata* Emmr.[2] of the overlying Rhaetic has a diameter of 5 to 8 mm. (seldom 9-10), with 50-60 septa, a very thin epitheca, and weak septal spines. Our species thus resembles the latter species the more closely in size, epitheca, and septal spines, but in number of septa it is nearer *T. fenestrata.*

Calamophyllia dawsoni ? Clapp and Shimer

A few fragments of separate corallites apparently similar to *C. suttonensis* in all observable characters except size, have a diameter of 3 mm., and thus fall within *C. dawsoni.* This species approaches *Thecosmilia oppeli* Reuss of the Zlambach fauna.

Montlivaltia cf. *gosaviensis* Frech[3]

Our single specimen, little more than a cross-section, apparently agrees closely with this species, which is from the Zlambach beds and is cylindrical, has a diameter of 25 mm., 122 septa with spines, and thin epitheca.

Terebratula suttonensis Clapp and Shimer

Plate IX, figure 1

The two lateral folds of the pedicle valve are anteriorly less pronounced than on the type specimen, and the corresponding two lateral depressions of the brachial valve are less deep. These differences are probably due to the crushed condition of the type specimen.[4]

Pleuromya pearsonensis n. sp.

Plate IX, figure 2

Shell elongate, sub-elliptical, posterior end somewhat broader than the anterior and abruptly rounding. Beak in anterior third of the shell. Length about 35 mm., breadth 20 mm. Surface with four to six broad, indefinite growth ridges and numerous finer concentric growth lines.

Named from Pearson creek, western British Columbia, on which the fauna was found.

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[1] Frech, F., "Die Korallen der juvavischen Triasprovinz," Palæontographica, Bd. 37, p. 9, Taf. 1, figs. 25-27; Taf. 2, figs. 1-17.
[2] Frech, F., "Die Korallen de juvavischen Triasprovinz," Palæontographica, Bd. 37, p. 15, Taf. 4, figs. 1-11.
[3] Frech, F., "Die korallenfauna der Trias," Palæontographica, Bd. 37, p. 41, Taf. 11, fig. 7.
[4] Loc. cit., p. 432.

It differs from *P. humboldtensis* Gabb[1] of the Middle Triassic of Nevada in its somewhat larger size, more angular posterior extremity, and much less definite concentric growth ridges. In outline of valve and in posterior extremity it resembles *Anoplophora münsteri* Wissem[2] of the lower Karnic (Cassian), but has fewer growth ridges than are present in our species.

Megalodon canadensis n. sp.

Plate IX, figure 3

Shell subcircular in outline. Length from beak posteriorly 90± mm., breadth from hinge-line to base 70± mm., thickness of entire shell 50± mm. Beaks anterior, strongly incurved. Surface marked with numerous concentric growth lines, some six of which, inequally spaced, are considerably stronger than the others. Cardinal teeth probably large, situated upon a strong, broad platform extending posteriorly from the beak. The cavity formed beneath this dental platform is continued posteriorly by a very pronounced inbending of the shell at the hinge-line; whether this is due to a postero-lateral tooth our specimens do not say. This groove gives to internal moulds a very characteristic appearance.

Similar to *Megalodus subcircularis* Koken[3] from the middle Keuper (Gipskeuper) of the southern Tyrols in general shape, but our specimen is larger and the groove formed between the lateral tooth ? and the shell is much narrower, giving an internal mould of very different shape.

Myophoria sp.

Shell large, diameter 2 to 4 inches, with discrepant ornamentation.

Turcicula mccanni n. sp.

Plate IX, figure 5

Small, length of five coils (tip of shell is wanting) 22 mm.; breadth of largest coil 12± mm., of next coil 10 mm. Whorls angular, their slope less above (posteriorly) than below, the angles beset with somewhat oblique, conspicuous knobs, about 12 encircling the 10 mm. whorl. There is a slight ridge at the junction of the whorls. Faint spiral growth lines are present, and probably also oblique ones. Since both these oblique growth lines and oblique knobs are directed downward to the left, the shell may be sinistral.

Named after Dr. W. S. McCann, who discovered this Pearson Creek fauna.

Our single shell belonging to the Trocho-Turbinidae family resembles *Turcicula tuberculata* Koken from the Karnic (obere schichten des Röthelsteins).[4] The proportion of length to breadth of the whorls is about the same. It also has about 12 knobs encircling one whorl. But the shell is a

[1] Smith, J. P., "The Middle Triassic Marine Faunas of North America," U.S. Geol. Surv., Prof. Paper 83, p. 143, Pl. 16, fig. 14.
[2] Bittner, A., "Lamellibranchiaten der alpinen Trias," Abhand. der K. K. Geolog. Reichsanstalt. Wien, Bd. 18, p. 9, Taf. 1, figs. 22-25.
[3] Koken, E., "Beitrage zur Kenntnis der schichten von Heiligenkreus," Abhand. der K. K. Geolog. Reichsanstalt. Wien, Bd. 16, Taf. 5, figs. 2, 2a, b.
[4] Koken, E., "Die Gastropoden der Trias um Hallstatt," Abhand. K. K. Geolog. Reichsanstalt. Wien, Bd. 17, Heft 4, p. 57, Taf. 19, fig. 13.

dextral one, with the knobs and growth lines oblique downward to the right, and if the figures given are of natural size (length of three whorls 28 mm., breadth of largest whorl 18 mm.) our specimen is much smaller; there is also in ours a slightly greater difference between the upper and lower slopes of the whorls.

CORRELATION AND CONCLUSIONS AS TO AGE

Succession of Strata

Jurassic (lowest)	Lias	Shasta co., California
	Rhaetic	
	Noric	Pseudomonotis shales Coral reef zone
Upper Triassic	Karnic	Tropites limestones Halobia shales
	Ladinic (Upper)	

Distribution of Species

Species	Locality				
	A	B	C	D	E
Isastrea whiteavesi C. and S.	r	r	1	1	1
I. vancouverensis C. and S.	r	C	......	......	2
Calamophyllia suttonensis C. and S.	C	C	3	3	3
C. dawsoni C. and S.	?	c	......	......	4
Montlivaltia cf. *gosaviensis* Frech	R	......	......	......	x
Terebratula suttonensis C. and S.	R	R			
Pleuromya pearsonensis n. sp.	R				
Megalodon canadensis n. sp.	c				
Myophoria sp.	c				
Turcicula mccanni n. sp.	r				

Localities: A=Pearson creek; B=Vancouver island; C=Shasta co., California; D=Iliamna lake, Alaska; E=Zlambach fauna. C=very common; c=common; r=rare; R=very rare.

The numbers refer to the following closely related species in the Zlambach fauna of the Salzkammergut district: 1, *Isastrea profunda* Reuss; 2, *Coccophyllum acanthophorum* Frech; 3, *Thecosmilia fenestrata* Reuss; 4, *T. oppeli* Reuss.

Since the publication of the original discussion[1] of the age of the isolated Sutton formation there has appeared a brief discussion[2] of apparently the same fauna from coral reef beds in Shasta county, northern California, from the Blue mountains, Baker county, northeastern Oregon, and from Pilot mountain, Esmeralda county, Nevada, where, fortunately, the fauna occurs in a known succession, with well-defined, fossil-bearing beds above and below. These sections definitely place the age of this

[1] Clapp, C. H., and Shimer, H. W., "The Sutton Jurassic of the Vancouver Group, Vancouver Island," Proc. Boston Soc. Nat. Hist., 34, pp. 421-438, 1911.
[2] Smith, J. P., "The Occurrence of Coral Reefs in the Triassic of North America," Am. Jour. Sci. (4) 33, pp 92-96, 1912.

coral-reef horizon as Lower Noric of the Upper Triassic. A coral fauna found by G. C. Martin on Iliamna lake, west of Cooks inlet, Alaska, was sent to Professor Smith, who reports[1]: "this coral fauna is undoubtedly the same as that in the Lower Noric zone of Shasta county, California, and has several species in common with that fauna." The species listed include: *Isastrea* cf. *profunda*, *Thecosmilia* cf. *fenestrata*, *Phyllocoenia* cf. *decussata*, *Astrocoenia* cf. *waltheri*, *Montlivaltia* cf. *mojsvari*, etc. In the table—"Distribution of Species"—are given the very closely allied forms of these species present in the Sutton horizon. A discussion of the closeness of this relationship is included under the species descriptions above.

Later, Dr. Martin in his clarifying discussion[2] of the Triassic of Alaska has included a correlation of the Triassic of western North America. He here[3] provisionally correlates the Sutton formation of Vancouver island with these Lower Noric coral reefs, a conclusion in which the writer concurs.

A consideration of the faunas found at the type locality of the Sutton limestone and in the equivalent beds on Pearson creek leads to a similar conclusion as to age. In the latter region occur the majority of the type locality species, besides some new forms. Of these latter *Montlivaltia* cf. *gosaviensis* belongs to the classic Lower Noric coral reefs—the Zlambach beds of the Salzkammergut district of the northern Alps—and the large pelecypod, *Megalodon*, abundant here, is characteristic of the Upper Trias of the Alps, and is especially abundant in the Noric (Dachstein and Hauptdolomite) of the northern Alps. Some of the other corals also, as noted above, have near relatives in the Alpine Zlambach beds. *Isastrea whiteavesi* is near *I. profunda; I. vancouverensis* near *Coccophyllum acanthophorum; Calamophyllia suttonensis* is very close to *Thecosmilia fenestrata* and *C. dawsoni* is not far from *T. oppeli*. The distinction between *Calamophyllia* and *Thecosmilia* depends mainly upon the presence or absence of an epitheca. Yet Dr. Frech apparently shows[4] that when the thin epitheca of *Thecosmilia* is worn away, as seems to occur very readily, there frequently results the typically costate *Calamophyllia*. He hence discards the latter genus. The Sutton specimens are, however, so persistently and uniformly costate, even in the centre of reef masses, that the writer hesitates to discard this time-honoured genus, recognizing, however, the close affinity that apparently exists between costate and non-costate forms. The difference between *Isastrea* and *Coccophyllum* is also difficult to note in poorly preserved specimens. Almost the only difference is the presence of serrations upon the septal edges in the former, and their absence in the latter. *Calamophyllia suttonensis* is also nearly related to the Rhaetic *Thecosmilia clathrata;* but there is a close resemblance between the corals from the Noric, the Rhaetic, and the Lias,[5] so that well-preserved specimens are needed for the correlation of isolated beds.

[1] Op. cit., p. 95.
[2] Martin, G. C., "Triassic Rocks of Alaska," Geol. Soc. Am., Bull. 27, pp. 685-718, 1916.
[3] Op. cit., p. 709.
[4] Frech, F., "Die Korallenfauna der Trias," Palæontographica Bd. 37.
[5] Frech, F., "Ueber die Korallenfauna der Nordalpinen Trias," Jahrb. K. K. Geolog. Reichsanstalt. Bd. 39, pp. 489-496.

TERTIARY FLORAS FROM BRITISH COLUMBIA

By Edward W. Berry

Illustrations

Stratigraphic knowledge of the Tertiary of western Canada and of the states to the south has increased so greatly in recent years that a reconsideration of the numerous and scattered localities where Tertiary plants have been reported is needed. This the writer has attempted to do here for collections made by Uglow and Johnston of the Geological Survey, in 1921 and 1922[1]. Of the four principal localities from which I have studied collections three are new. These are Newhykulston and Joseph creeks in the Chu Chua area on North Thompson river, and Kitsilano, near Vancouver. The fourth, Burrard inlet, also near Vancouver, was discussed by the late Sir William Dawson[2] in 1895, who identified the following species from this outcrop, and correlated it with the deposits of Washington known as the Puget group:

Lastrea (Goniopteris) fischeri Heer
Neuropteris civica Dawson
Lygodium neuropteroides Lesquereux
Asplenites sp.
Glyptostrobus europaeus (Brongniart) Heer
Sabal campbellii (Newberry) Lesquereux
Manicaria sp.
Cyperites paucinervis Heer
Carex vancouverensis Dawson
Carex burrardiana Dawson
Populus balsaminoides Goeppert
Populus rotundifolia Newberry
Salix varians Goeppert
Salix integra Goeppert
Dryophyllum stanleyanum Dawson
Quercus dentoni Lesquereux
Platanus sp.
Juglans denticulata Heer
Aesculophyllum hastingsense Dawson
Ficus shastensis Lesquereux (?)
Ficus occidentalis Lesquereux (?)
Planera crenata Newberry

The plants contained in the Johnston collection from Burrard inlet are given in the table of distribution in this paper. There can be no question of the Eocene age of these plants, or their correlation with the Puget Group flora of Washington, although a description of the latter has never been published. There are only 17 species listed from the Puget group in Knowlton's "Catalogue of Mesozoic and Cenozoic Plants of North America" (1919), although this author states[3] that he has described in

[1] Uglow, W. L., "Geology of the North Thompson Valley Map-area, B.C.," Geol. Surv., Canada, Sum. Rept., 1921, pt. A.
Johnston, W. A., "Geology of Fraser River Delta Map-area," Geol. Surv., Canada, Mem. 135, 1923.
[2] Trans. Roy. Soc., Can., vol. 1, 1895, sec. IV, pp. 137-151.
[3] U.S. Geol. Surv., Tacoma folio, No. 54.

manuscript 365 species of plants from these beds, and that there appears to be a considerable difference in facies between the lower and upper part of the Puget, with some uncertainty as to the age of the latter.

The collection from Kitsilano was made from sections exposed along the coast near that place, on the south side of English bay, near Vancouver. They are stratigraphically about 4,000 feet above the base of the Puget and are separated from the lower beds exposed at Burrard inlet by a thick conglomerate. The collection contains the 21 species listed in the table of distribution. Like the corresponding floras from Washington, the fossil plants from Kitsilano are unlike those from the lower beds at Burrard inlet, the only species that they have in common being the doubtfully identified palm rays which I have referred to *Sabalites campbellii*. Undoubtedly some geological time is involved in this apparent change in facies and the thickness of the intervening sediments, but it would require large collections to make an estimate of the time represented.

Seven of the Kitsilano plants are common to the Joseph Creek locality; 10 are found at other localities in British Columbia; 10 are common to the Kenai flora of Alaska, and 2 others are found in beds of corresponding age to the Kenai in western Greenland. Four are found in strata as old as the Fort Union of the United States; one occurs in the Green River beds; and three in the Clarno. Not one is common to definitely recognized Oligocene or Miocene strata. The conclusion that the beds at Kitsilano are Eocene is strongly indicated, and this would seem also to be the age of the flora found in the upper part of the Puget group in Washington. Just what stage of the Eocene is perhaps not determinable at the present time. I would regard it as late Eocene, but older than the Clarno.

The table of distribution tells an approximately similar story for the floras described from Newhykulston, Joseph, and Darlington creeks, in the Chu Chua area. I regard all of these floras as considerably younger than the Fort Union-Paskapoo, and younger even than the Green River or Sauk formations of the United States, these being of approximately the same age, and belonging to the Middle Eocene.

The precise age limits of the continental lignitic deposits referred to the Kenai formation are not precisely known, but I consider that, in a general way, these scattered British Columbia floras are of the same age as those of the Puget group on the one hand, and that of the Kenai on the other. This would make them about synchronous with the Jackson flora of the Atlantic coastal plain, or, in terms of European chronology, Bartonian-Ludian.

There is no definite evidence that the Kenai, Puget, or the floras described in the following pages may not have crossed the Eocene-Oligocene boundary, and that they may not be in part Oligocene—there are no known extensive Oligocene floras near enough for comparison, that from the Oligocene of the southeastern United States being so much farther south and living under such different environmental conditions that it is not comparable. The most that can be said is that the Kenai, Puget, and the floras described in the following pages, are older than the Clarno flora of Oregon. This was originally and mistakenly considered to be Miocene, and has long been considered Eocene, although I am informed by R. W. Chaney, who is studying it under the auspices of the Carnegie Institution, that it may be slightly younger than Eocene, but unmistakably pre-Miocene.

The continental deposits which have furnished these most interesting plants are not continuous, but represent basin deposits whose lower and upper limits probably do not exactly coincide from basin to basin any better than do the similar basin deposits throughout the western United States. The fossil plants, which are so abundant at some of the localities, flourished under somewhat different environments, according as they were subject to the humid winds from the Pacific ocean, with its warm currents, as was the Puget flora; or had this oceanic, moist, and generally equable climate modified by distance from the sea and by intervening topography.

The plants described in the following pages are distinctly temperate types. Opinions differ as to the interpretation to be put on them, but I am inclined to consider them as indicating cool rather than warm temperate conditions, with abundant moisture. They are certainly in striking contrast climatically with the contemporaneous floras of the southeastern United States, and they mark about the southern limits of this essentially coniferous—hickory, oak, birch, alder, hazel—flora, that extends from the neighbourhood of the present International Boundary, northward throughout the lands of the Arctic, and constitutes the so-called Arctic "Miocene" flora, which is known to be really much older, and, in all probability, Upper Eocene.

These northern floras were probably enabled to flourish north of their existing northern limits by reason of the cumulative climatic effect of the restricted land areas of the Middle Eocene and the expanded equatorial oceans of that time, and the free water circulation from the latter northward. This was interrupted at the close of the Eocene, as the record of terrestrial plants and animals unite in proving, and was never renewed to the extent that it had had previously. This is one of the most cogent reasons for regarding all of these northern Tertiary floras as pre-Oligocene, irrespective of their particular facies.

An interesting feature of the flora described in the following pages, and of the Kenai flora as well, one that cannot be precisely evaluated at the present time, is the strong resemblance of many of its members to existing types of eastern Asia, particularly those of the mountains of central China, which last region is coming to be recognized as a sort of immense pre-Pleistocene floral retreat. The genera Ginkgo and Glyptostrobus, so common in the Canadian Eocene, survive only in that region: the so-called *Carpinus grandis* of this report is close to the existing *Carpinus seemeniana* Diels of central China; *Alnus cremastogynoides* is much like *Alnus mastogyne* Burkill of the same region; *Corylus macquarrii*, in some of its forms is very similar to the restricted Chinese genus Ostryopsis, others are much like the existing *Corylus colurna* Linnaeus, and others like *Corylus ferox* Wall., both Asiatic; the fossil genus Trochodendroides appears to represent the restricted eastern Asiatic family Trochodendraceae; and most of the remaining genera, notably Taxodium, Liriodendron, and Sassafras, represent types which survive at the present time in only southeastern Asia and southeastern North America, or in some few cases, as for example Sequoia, in the Pacific Coast region.

—	Newhykulston creek	Joseph creek	Darlington creek	Burrard inlet	Kitsilano	Similkameen valley	Quilchena	Tulameen river	Horsefly river	Mackenzie river	Porcupine creek	Blackwater river	Red Deer river	Tranquille river	Kenai of Alaska	Greenland	Spitzbergen	Iceland	Grinnell Land	Sakhalin island		Fort Union	Green river	Clarno	Puget
Equisetum boreale		x				x									x	x						x			
Woodwardia maxoni	x																					x			
Lygodium kaulfussi				x																		x	x	x	
Ginkgo adiantoides		x				x		x	x	x	x				x	x	x			x		x			
Sequoia langsdorfi		x			x	x			x	x	x	x	x		x	x	x			x		x		x	
Glyptostrobus europaeus		x			x	x			x				x		x	x						x			
Taxodium dubium		x					x		x				x		x	x	x		x	x		x			x
Taxodium occidentalis	x	x				x	x		x	x	x	x	x	x								x			
Pinus trunculus		x	x				x	x	x					x											
Pinus steenstrupiana		x					x									x									
Poacites tenue-striatus	x														x										
Phragmites alaskana	x	x			x										x										
Musophyllum complicatum	x							x															x		
Canna (?) *dawsoni*				x																					
Sabalites campbelli				x	x																				x
Myrica uglowi		x																							
Comptonia predryandroides		x				x	x																		
Juglans nigelloides				x																					
Hicoria stanleyanum		x		x																					
Hicoria dawsoni		x																							
Populus acuminatafolia		x																							
Betula angustifolia					x		x																	x	
Betula heterodonta	x				x		x							x	x									x	
Betula parvifolia		x			?																				
Carpinus grandis (?)		x	x		x	x	x	x						x	x	x									
Alnus cremastogynoides	x																								
Alnus crispoides		x																							
Alnus kefersteinii (?)	x	x													x	x	x	x		x					
Corylus macquarrii	x	x	x		x		x		x	x	x			x	x	x	x	x	x	x		x			
Quercus uglowi		x																							
Quercus banksiaefolia					x																				x
Quercus groenlandica		x			x										x	x	x								
Quercus simplex				x																				x	
Quercus coriacea					x																				x
Ficus (?) *johnstoni*				x																					
Ulmus columbiana		x					?		?																
Planera nervosa					x										x	x				x			x		
Trochodendroides arctica	x				x				?	x	?				x	x									
Magnolia nordenskiöldi (?)					x					x					x	x	x			x					
Liriodendron (?) sp.		x																							
Cocculus kanii					x											x									
Sorbus decorafolia		x																							
Leguminosites borealis		x								?						x									
Leguminosites johnstoni					x											?									
Celastrophyllum pugetensis					x																				
Acer macropterum		x				x		?	?						x										
Rhamnus kitsilaniana					x																				
Pterospermites alaskana	x														x										
Sassafras selwyni		x					x				x					x									
Cornus suborbifera (?)				x			x	x							x		x								
Diospyros dawsoni		x																							
Viburnum antiquum		x			x																	x			

Phylum, ARTHROPHYTA

Order, **Equisetales**

Equisetum boreale Heer

Equisetum boreale Heer, Fl. Foss. Arct., Bd. 1, p. 89, Pl. 1, fig. 17, Pl. 45, figs. 10, 13e, f, 1868; Idem., Bd. 2, p. 463, Pl. 43, fig. 16, 1871.

Equisetum similkamense Dawson, Geol. Surv., Canada, Rept. Prog. 1877-1878, p. 186, Pl. B; Trans. Roy. Soc., Can., vol. 8, sec. 4, p. 76, figs. 1-1d, 1890.

Equisetum globulosum Lesquereux, U.S. Nat. Mus. Proc., vol. 5, p. 444, Pl. 6, figs. 1, 2, 1882; Cret. and Tert. Flora, p. 222, Pl. 18, fig. 3, 1883; Knowlton, Harriman Rept., vol. 4, p. 149, 1904.

Various sized fragments of stems of an Equisetum are common in the collection from Joseph creek. They are identical with the species described by Heer from the Upper Eocene of west Greenland, and I believe are also represented by the *Equisetum similkamense* described by Dawson from Similkameen valley, and by the *Equisetum globulosum* described by Lesquereux from the Kenai formation of Alaska and the Fort Union formation of the United States.

Phylum, PTERIDOPHYTA

Family, POLYPODIACEAE

Woodwardia maxoni Knowlton

Plate X, figures 2, 3

Woodwardia maxoni Knowlton, Smith. Misc. Coll., vol. 53, p. 489, Pl. 63, fig. 3, Pl. 64, figs. 1, 2, 1910.

This beautiful and characteristic species is exceedingly common in the collection from Newhykulston creek, where it is represented by very many sterile and a considerable number of fertile fronds. It was described originally from the Fort Union formation of Wyoming, and other and somewhat similar species are present at various Tertiary horizons in western United States.

Lygodium kaulfussi Heer

Lygodium kaulfussi Heer, Beitr. nähern Kennt. Sächs-Thuring. Braunkohle, p. 400, Pl. 8, fig. 21, 1861; Newberry, U.S. Geol. Surv., Mon. 35, p. 1, Pl. 62, figs. 1-4, 1898; Knowlton, Idem., Mon. 32, pt. 2, p. 672, Pl. 80, figs. 1-3, 1900; Penhallow, Rept. Tert. Pl. Brit. Col., p. 62, 1908.

Lygodium neuropteroides Lesquereux, U.S. Geol. and Geogr. Surv. Terr., Ann. Rept. 1870, p. 384, 1871; Tert. Fl. p. 61, Pl. 5, figs. 4-7, Pl. 6, fig. 1, 1878; Dawson, Trans. Roy. Soc., Can., 2nd ser., vol. 1, sec. 4, p. 141, fig. 3, 1895.

Confirming the record of this species from the Puget group at Burrard inlet, there are two unmistakable specimens in the collection from that place. The species is a wide ranging one said to occur as early as the Fort Union of Yellowstone park, and common in the Green River, Lower Clarno, and Claiborne, as well as the Eocene of the Wilkison coal field of Washington (state).

Phylum, CONIFEROPHYTA

Order, **Ginkgoales**

Ginkgo adiantoides (Unger) Heer

Ginkgo adiantoides Heer, Fl. Foss. Arct. Bd. 5, abt. 3, p. 21, Pl. 2, figs. 7-10, 1878.[1]

This exceedingly interesting species is represented by several characteristic specimens in the collection from Joseph creek. Its wide distribution serves to correlate the Arctic floras of Europe, Asia, and North America. It has been recorded from the Lance and Fort Union formations of the United States, but is specially characteristic of the later and more northern Upper Eocene, where it has been recorded from Tulameen, Horsefly, and Similkameen rivers, B.C.; from the Mackenzie basin; from Porcupine creek and Great valley, Alberta; from the isle of Mull; Greenland; Alaska; and Sakhalin island. The fossil species is exceedingly close to the existing species which survives in a limited region in eastern Asia, although commonly planted as an ornamental tree and hardy throughout the North Temperate zone.

Order, **Coniferales**

Sequoia langsdorfi (Brongniart) Heer

Sequoia langsdorfi Heer, Fl. Tert. Helv., vol. 1, p. 54, Pl. 20, fig. 2, Pl. 21, fig. 4, 1855.

This is another Tertiary form which, like the contemporaneous Taxodium and Glyptostrobus, ranged pretty well over the northern hemisphere. Its superficial resemblance to Taxodium renders many records extremely uncertain, but it may readily be distinguished by its decurrent leaves which are not contracted to a distinct, if short, petiole, as in Taxodium, and it does not commonly occur in the form of deciduous twigs as does Taxodium, but as branched fragments.

It is a member of the Kenai flora of Alaska, and has been recorded from the following localities in Canada: Red Deer river and Porcupine creek, Alberta; Bear river, Mackenzie valley, Yukon; Blackwater, Similkameen, Horsefly, Finlay, and Omineca rivers, B.C. It is also common in the Upper Eocene of Greenland, Spitzbergen, Sakhalin island, etc. In the present collections it is contained in that from the Puget group at Kitsilano, where it is abundant and characteristic, and in that from Joseph creek.

[1] It is deemed unnecessary in this contribution to give the synonymies ofspecies in which these are extensive, or, in fact, any citations not demanded by the subject matter. The aim is to make the work useful so that the citations, as in the above case, may not be the oldest, but refer to works in which there are excellent figures.

Glyptostrobus europaeus (Brongniart) Heer

Glyptostrobus europaeus Heer, Fl. Tert. Helv., vol. 1, p. 51, Pls. 19, 20, 1855.

This wide-ranging and probably composite species has been recorded from a large number of Tertiary horizons well distributed throughout the northern hemisphere. These records in Canada comprise Stump lake, Similkameen and Horsefly rivers, B.C.; and Red Deer river, Alberta. The species is recorded from the Lance and Fort Union formations of northwestern United States. It is abundant in the Kenai formation of Alaska, as well as in beds of corresponding age in west Greenland. In the present collections it occurs at Joseph creek and Kitsilano.

Taxodium dubium (Sternberg) Heer

Taxodium dubium Heer, Fl. Tert. Helv., vol. 1, p. 49, Pl. 17, figs. 3, 15, 1855.

This is the familiar *Taxodium distichum miocenum* of authors. It has a Tertiary range throughout most of the northern hemisphere, and is apparently very similar to the existing bald cypress, with its distichous and deciduous twigs. It has been recorded in North America from horizons ranging from the Lance to the Mascall formations, and is a characteristic element in the Kenai and Puget floras.

I have not detected it in the Puget plants from Burrard inlet or Kitsilano, where its place is taken by the superficially similar *Sequoia langsdorfii*, but it is exceelingly abundant at Joseph creek.

Taxodium occidentale Newberry

Plate X, figure 1

Taxodium occidentale Newberry, U.S. Geol. Surv., Mon. 35, p. 23, Pl. 26, figs. 1-3, Pl. 55, fig. 5 (part), 1898.

This species has been recorded from both the Lance and Fort Union formations of United States and from the following Canadian localities: Mackenzie, Souris, Red Deer, Blackwater, Similkameen, Tranquille, and Horsefly rivers; Porcupine creek; and Quilchena. In so far as my abundant material permits of generalization, the twigs were deciduous and never forked as Newberry figures some of his specimens. The leaves were coriaceous, as shown by the transformed material preserved in the shales and the longitudinal striations of shrinkage; they are almost perfectly narrow elliptical in shape with rounded tips and slightly tapering and inequilateral bases. The midribs are central and not exceptionally stout, and the amount of free petiole is almost nil, although there is clear evidence of its decurrence on the twig axis, and of twisting by which the spiral phyllotaxis is modified to a distichous habit.

The material is in every way comparable to Taxodium and to no other genus of coniferophyte. There is considerable variation in size of parts and on some twigs the leaves vary to a narrower form which, if constant, would be indistinguishable from those of the familiar *Taxodium dubium*. In general for leaves of the same length those of *Taxodium occidentale* are twice as wide as those of *Taxodium dubium*. Newberry emphasizes the lack of decurrence of the leaves, a Sequoia character, and this is strictly true, but the petioles are distinctly so on the terete twigs. This author also expresses the opinion that this species is indistinguishable from the existing *Taxodium distichum*. This is hardly correct, for although the two are naturally similar, I find no difficulty in differentiating them.

Taxodium occidentale is not associated with *Taxodium dubium* in the occurrence at Newhykulston creek, but it is abundant and associated with the still more abundant remains of the latter at Joseph creek.

Pinus trunculus Dawson

Plate X, figures 4, 5

Pinus trunculus Dawson, Trans Roy. Soc., Can., vol. 8, sec. 4, p. 78, fig. 5, 1891; Penhallow, Rept. Tert. Pl. Brit. Col., p. 69, figs. 24-28, 1908.

This species has been previously recorded from Stump lake, Quilchena, Tulameen, Horsefly, and Tranquille rivers, B.C., from beds that have been referred to the Oligocene and Miocene. Penhallow gives a number of excellent figures of this species in which he finds that the leaves were in fascicles of five. Dawson's type apparently had the leaves in threes as is the case in the specimen figured by me. Associated with the latter are both short and broadly-winged seeds like that figured by Dawson, and elongate narrow-winged seeds like some of those figured by Penhallow. It would seem that two species—one with 5 leaves to a fascicle and another with 3 leaves to a fascicle—had been confused under this name, but in any event the present occurrences are identical with the material to which Dawson first applied the name *Pinus trunculus*.

The present material in this species comes from Joseph and Darlington creeks.

Pinus steenstrupiana Heer

Pinus steenstrupiana Heer, Fl. Foss. Arct., Bd. 1, p. 144, Pl. 24, figs. 23-26, 1868; Penhallow, Rept. Tert. Pl. Brit. Col., p. 68, figs. 20-23, 1908.

I have followed Penhallow's treatment of similar material from Quilchena, B.C., in referring the cone scales found at Joseph creek to this Arctic species, which they closely resemble, although I see no reason for supposing that they do not belong to the same botanical species as furnished the associated seeds and leaves that I have referred to *Pinus trunculus* Dawson.

Phylum, ANGIOSPERMOPHYTA

Class, **Monocotyledonae**

Poacites tenuistriatus Heer

Poacites tenuistriatus Heer, Fl. Foss. Arct., Bd. 2, abt. 2, p. 24, Pl. 1, fig. 14, 1871.

Grass or sedge-like remains of this sort are of slight value and exhibit few, if any, diagnostic features. Slender, finely longitudinally veined fragments in the collection from Newhykulston creek appear to represent this or a closely related species.

Phragmites alaskana Heer

Phragmites alaskana Heer, Fl. Foss. Arct., Bd. 2, abt. 2, p. 24, Pl. 1, fig. 12, 1869.

Phragmites sp., Newberry, U.S. Geol. Surv., Mon. 35, p. 27, Pl. 22, figs. 5, 5 a, 1898.

The type of this quandum species came from the Kenai beds of Alaska and similar remains are described from the Fort Union of Dakota. Identical forms are present in the collections from Newhykulston and Joseph creeks, and Kitsilano.

Musophyllum complicatum Lesquereux

Musophyllum complicatum Lesquereux, Tert. Fl., p. 96, Pl. 15, figs. 1-6, 1878; Penhallow, Rept. Tert. Pl. Brit. Col., p. 63, 1908.

I seriously question the reference of these forms to the genus Musophyllum, but whatever their botanical nature there can be no question that the remains in the collection from Newhykulston creek are identical with the specimens so named by Lesquereux from the Green River Eocene, in fact this author's figure 1 would answer admirably as an illustration for the British Columbia specimen. It is not the same as the striated, broad leaves found in the Puget group at Burrard inlet, but may be the same as the occurrence at Tulameen river recorded by Penhallow as representing this species.

Canna (?) dawsoni Berry n. sp.

In his account of the plants from Burrard inlet, Sir William Dawson, in discussing the palm-like remains that he referred to *Manicaria* sp., speaks of fragments of "broad striate leaves which may belong to this or allied endogenous forms".[1] Similar remains are contained in the collection from Burrard inlet. They are much broken and are of a type that has been described as Musophyllum, Geonomites, Zingiberites, Canna, etc. These leaves from Burrard inlet were entire and of large size, ovate or lanceolate in general form, with a relatively slender midrib from which there diverged, at rather acute angles, innumerable closely spaced and parallel simple lateral veins. There are about three of these to a millimetre, and no differentiation in size among any of them can be observed. They have this additional distinctive feature, perhaps due to a parasitic fungus; at intervals a group of laterals will be enlarged, forming a circular or elliptical, or transversely lanceolate "spot" in marked contrast with the balance of the leaf surface. The veins in these scattered modified areas appear at least twice the ordinary size, and the number of adjacent veins affected varies from 1 to 30. In the wider patches the length of vein affected is about 1·5 mm.; where single veins are enlarged this enlargement may extend for a distance of 6 mm.

I have ventured to give this form a name in honour of Sir William Dawson, and I have referred it tentatively to the genus Canna, as it is more like certain species of that genus than any other known to me. It is not a Musophyllum, whatever that may be botanically; neither is it

[1] Dawson, J. W., Trans. Roy. Soc., Can., 2nd ser., vol. 1, sec. 4, p. 143, 1895.

related to Heliconia or other American representatives of the family Musaceae; or does it appear to be related to Geonomites, Manicaria, or any other palm type. The only other possibility is that it may represent some type of fern, and that the enlarged spots represent some sort of sporangial apparatus, the objection to this being their great irregularity in position and size.

Sabalites campbelli (Newberry) Lesquereux

Sabal campbelli Newberry, U.S. Geol. Surv., Mon. 35, p. 27, Pl. 21, figs. 1, 2, 1898; Dawson, Trans. Roy. Soc., Can., 2nd ser., vol. 1, sec. 4, p. 142, fig. 7, 1895.

Sabalites campbelli Lesquereux, Tert. Fl., p. 113, 1878; Penhallow, Rept. Tert. Pl. Brit. Col., p. 85, 1908.

Single rays of what appears to be this species are contained in the collection from Burrard inlet and Kitsilano. More complete material was described by Dawson from the former locality and correlated with the type of the species, which came from the Puget group of Washington (state).

Class, **DICOTYLEDONAE**

Order, **Myricales**

Family, MYRICACEAE

Myrica uglowi Berry n. sp.

Plate XVIII, figure 1

Leaves of small size, elongate elliptical in general form, with a shortly pointed tip, and a broadly cuneate base. Sub-lobate through the development of four or five large dentate teeth on either margin. These lobules are unsymmetrical and directed upward, separated by narrow acute sinuses that extend for about one-third of the distance inward toward the midrib. Texture sub-coriaceous. Petiole short, stout, and curved, about 1·5 mm. in length. Midrib stout, prominent on the under side of the leaf. Secondaries relatively stout and prominent, diverging from the midrib at angles somewhat greater than 45 degrees, a craspedodrome one runs to each marginal tooth or lobule, and one or two camptodrome ones are intercalated between adjacent craspedodrome secondaries.

Length about 2·5 cm., maximum width about 1 cm.

This handsome, small species is not close to any previously described forms, either fossil or recent, but presents the unmistakable generic features of Myrica. It comes from Joseph creek, B.C.

Comptonia predryandroides Berry n.sp.

Plate X, figure 6

Myrica (Comptonia) cuspidata Dawson, Trans. Roy. Soc., Can., vol. 8, sec. 4, p. 80, fig. 9, 1890 (not Lesquereux).

Comptonia dryandroides Penhallow, Rept. Tert. Pl. Brit. Col., p. 46, 1908.

This is distinctly not the same as *Comptonia cuspidata* described by Lesquereux[1] from the Upper Eocene of Alaska, and with which it was confused by Dawson. Lesquereux's Alaska material has the lobes much wider, more rounded laterally, more ascending and cuspidate pointed. In Dawson's and my material, to which I am giving a new specific name, the lobes are triangular in outline, about as wide as long, bluntly pointed, nearly straight sided, with the intervening sinuses nearly triangular instead of very narrow and acute.

This new species is, on the other hand, extremely close to *Comptonia dryandroides* Unger[2], a rather widespread and not uncommon type of the Eurasian Oligocene and Miocene. The British Columbia form may be identical with this later European species, but I have for the present considered it to stand in an ancestral relationship to the latter. The present material comes from Joseph creek.

Order, **Juglandales**

Family, JUGLANDACEAE

Hicoria dawsoni Berry n. sp.

Plate XVI, figure 3

Leaflets of relatively small size, obovate and inequilateral in general outline, with a shortly pointed apex, and cuneate base, short petiolulate or sessile. Margins finely dentate, except near the base, where they are entire. Length about 9 cm., maximum width, above the middle, about 4 cm. The lamina, about one-third wider on one side than on the other. Midrib stout, prominent. Secondaries about 12 opposite to alternate, regularly spaced, sub-parallel, camptodrome pairs.

This is a well-marked species, which I have named in honour of Sir William Dawson. The only previously known fossil species which it resembles is *Hicoria antiquorum* (Newberry) Knowlton, a larger and earlier Eocene form, which has been recorded from the supposed Paskapoo formation.

The present material comes from Joseph creek.

Hicoria stanleyanum (Dawson) Berry

Dryophyllum stanleyanum Dawson, Trans. Roy. Soc., Can., 2nd ser., vol. 1, sec. 4, p. 147, fig. 13, 1895.

This form was found to be common but poorly preserved in the collections from the Puget group described by Dawson from Vancouver. The features were much obscured and its author suggested doubt as to the advisability of his reference to the genus Dryophyllum. Somewhat better material of this species is present in the collection from Joseph creek, and this shows that it is a Hicoria and not a Dryophyllum. The base is often less cuneate than Dawson's figures would indicate, the secondaries are ultimately camptodrome, and the margin in many cases has distinctly dentate teeth, especially in the apical region.

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[1] Lesquereux, L., U.S. Nat. Mus. Proc., vol. 5, p. 445, Pl. 6, figs. 10-12, 1883.
[2] Unger, F., Foss. Fl. v. Sotzka, p. 31, Pl. 6, fig. 1, 1850.

Juglans nigelloides Berry n. sp.

Plate XI, figures 5, 6

Leaflets ovate-lanceolate in outline, markedly inequilateral, particularly at the base, which is rounded on one side and rather straightly ascending on the other. Tip somewhat narrowed and acuminate. Margins with fairly large, not very prominent, rounded-dentate teeth. Texture sub-coriaceous. Length about 11 cm. Maximum width, in the lower part of the leaf, about 3 cm. Petiolule short and stout. Midrib stout and prominent. Secondaries stout, and prominent on the under side of the leaflet; numerous, sub-equally spaced, and sub-parallel; they diverge from the midrib at angles of about 60 degrees in the broader half of the lamina and at a somewhat less angle in the narrower half; they pursue rather straight courses and curve near the margins to become camptodrome; short curved tertiary branches run to the marginal teeth. The balance of the tertiaries are well marked, but not prominent; they have the appearance of being percurrent, which they are in part, but frequently there is an astomosis in the median region between the secondaries.

This is an exceedingly well-marked species, which shows unmistakably the characters of Juglans. It resembles the rather widely distributed *Juglans nigella* Heer, which resemblance has suggested its specific name, but always showing consistent differences, which in my judgment mark it as a distinct species. *Juglans nigella* was described by Heer from the Upper Eocene of Alaska[1], and subsequently recorded from Greenland and eastern Asia, as well as various localities in North America. The present species from the Puget group at Burrard inlet differs from Heer's type in being somewhat smaller, with less ascending and straighter secondaries, and obtusely dentate instead of serrate margins. It differs in much the same way from Lesquereux's identification from the Fort Union formation, which may not be that species.[2] Knowlton's identification[3] from the Raton formation appears to be correct, and the British Columbia species differs from it in the same features that it does from Heer's type, the Raton form having still more pronounced serrate teeth. Newberry also recorded *Juglans nigella* from Alaska[4] but his form is not even a Juglans, but a Quercus, and is quite different from the type. Both Dawson[5] and Penhallow[6] have recorded *Juglans nigella* from the Tertiary of British Columbia, but whether these last represent that species or this new species described above it is impossible to say.

Order, **Salicales**

Family, SALICACEAE

Populus acuminatafolia Berry n. sp.

Plate XVII, figures 1-3

Leaves ovate or rhombic-lanceolate, widest below the middle, acuminate tipped, slightly rounded cuneate or concave at the base. Margins entire basally, elsewhere with numerous small upwardly directed inequil-

[1] Heer, O., Fl. Foss. Arct., Bd. 2, abt. 2, p. 38, Pl. 9, figs. 2-4, 1869.
[2] Lesquereux, L., Cret. and Tert. Fl., p. 235, Pl. 46A, fig. 11, 1883.
[3] Knowlton, F. H., U.S. Geol. Surv., Prof. Paper 101, p. 292, Pl. 55, fig. 2, Pl. 63, fig. 2, 1918.
[4] Newberry, J. S., Idem., Mon. 35, p. 33, Pl. 51, figs. 2, 4, 1898.
[5] Dawson, J. W., Geol. Surv., Can., Rept. 1875-1876, p. 57.
[6] Penhallow, D. P., Rept. Tert. Pl. Brit. Col., p. 60, 1908.

ateral dentate teeth. Length ranging from 8 cm. to 12 cm., maximum width from 3·25 cm. to 5 cm. Petiole long and stout, expanded proximad, 2 cm. to 3 cm. in length. Midrib stout, prominent on the under side of the leaf. Secondaries about 9 subparallel, camptodrome pairs; sending small curved branches to the marginal teeth. Tertiaries thin, largely percurrent.

This is an exceedingly well-marked species of cottonwood, with perhaps a slightly shorter petiole than the existing forms. It resembles somewhat the existing *Populus balsamifera* Linn., but is narrower and more elongate. It is exceedingly like the existing *Populus acuminata* Rydberg, which resemblance has suggested its specific name. The former is a stream bank type, now found in the Rocky Mountain foothills from Alberta to southern Colorado. The fossil species comes from Joseph creek.

Order, **Fagales**

Family, BETULACEAE

Betula heterodonta Newberry

Plate XVI, figure 5

Betula heterodonta Newberry, U.S. Nat. Mus. Proc., vol. 5, p. 508, 1882; U.S. Geol. Surv., Mon. 35, p. 64, Pl. 44, figs. 1-4, Pl. 45, figs. 1, 6, 1898; Knowlton, Idem., Bull. 204, p. 40, 1902; Penhallow, Rept. Tert. Pl. Brit. Col., p. 39, 1908.

Betula grandifolia Heer (not Ettingshausen), Fl. Foss. Arct., Bd. 2, abt. 2, p. 29, Pl. 5, fig. 8, 1869.

This species was described by Newberry from the Upper Clarno beds of Oregon, and it has been reported from Tranquille river and Quilchena, B.C. To it should be referred the form from the Kenai formation of Alaska which Heer identified as *Betula grandifolia* Ettingshausen,[1] a distinct and later species. Penhallow remarks, of the British Columbia occurrences cited above, that as the type came from the Miocene of Oregon it tends to prove the Miocene age of the former deposits. This is an error as the Bridge Creek beds of Oregon are definitely known to be of pre-Miocene age. This species occurs in the collection from Newhykulston creek and in the collection from Kitsilano.

Betula parvifolia Berry n. sp.

Plate XV, figures 1-3

Orbicular to elliptical, nearly equilateral leaves of variable size and form, mostly small, about equally rounded at the apex and base. Margins, except near the base, beset with small, even, dentate teeth. Length ranging from 2·25 cm. to 3·75 cm. Maximum width, midway between the apex and the base, ranging from 1·5 cm. to 2·6 cm. Petiole stout, curved, 4 mm. to 8 mm. in length. Midrib stout. Secondaries 7 or 8 pairs, stout, craspedodrome, giving off a curved craspedodrome tertiary from the outside near their tips. Internal tertiaries percurrent.

[1] Ettingshausen, C. v., Foss. Fl. v. Bilin, p. 125, Pl. 14, figs. 23, 25, 1867.

This is a distinct type, whose variations are well shown in the accompanying figures. It is not especially close to any previously described forms, and comes from Joseph creek, where it is not uncommon. It is possible that *Betula* sp. from Kitsilano represents an abnormal leaf of this species.

Betula angustifolia Newberry

Plate XVI, figure 4

Betula angustifolia Newberry, U.S. Nat. Mus., Proc., vol. 5, p. 508, 1882; U.S. Geol. Surv., Mon. 35, p. 63, Pl. 46, fig. 5, Pl. 47, fig. 5, 1898; Knowlton, Idem., Bull. 204, p. 41, 1902; Penhallow, Rept. Tert. Pl. Brit. Col., p. 39, 1908.

This species was described from the Upper Clarno beds of Bridge creek, Oregon, and was recorded by Penhallow from Quilchena, B.C. It is contained in the collection from Kitsilano.

Carpinus grandis Unger (?)

Plate XV, figures 4, 5; Plate XIX, figure 4

Carpinus grandis Heer, Fl. Foss. Arct. Bd. 2, abt. 2, p. 29, Pl. 2, fig. 12, 1869; Lesquereux, Tert. Fl., p. 143, Pl. 19, fig. 9, Pl. 64, figs. 8-10, 1878; Newberry, U.S. Geol. Surv., Mon. 35, p. 59, Pl. 54, fig. 3, Pl. 55, fig. 6, 1898; Penhallow, Rept. Tert. Pl. Brit. Col., p. 41, 1908.

It seems hopeless to attempt to reduce to a rational interpretation the large number of forms from numerous localities and horizons that have been referred to this Old World Miocene type. There are large numbers of leaves in the collection from Joseph creek, and they are also present from Darlington creek and Kitsilano. Similar forms have been previously recorded from Quilchena, Stump lake, Similkameen, Tulameen, and Tranquille rivers, B.C.; from the Eocene of Birch bay, Washington (state); and from the Kenai formation of Alaska; as well as from beds of similar age in Greenland and elsewhere.

Attention should be called to the resemblance of these forms to the existing *Carpinus seemeniana* Diels of central China.

Alnus cremastogynoides Berry n. sp.

Plate XVI, figure 1

Rather elongated leaves of medium size, widest medianly, rounded upward to an obtuse tip and downward to the narrowly cuneate base. Margins entire in the lower two-fifths, above which they are beset with prominent aquiline-serrate teeth. Texture sub-coriaceous. Midrib stout, prominent on the lower surface of the leaf. Secondaries numerous, subparallel and camptodrome.

This species, clearly new, is of special interest since it is almost identical with the existing *Alnus cremastogyne* Burkill, a species with a restricted range in the mountains of central China (province of Sze-ch'uan), in fact it is much more like this species than it is like any existing American species of Alnus, although it is something like some of the leaves of *Alnus rhombifolia* Nuttall of western United States. It comes from Newhykulston creek.

Alnus crispoides Berry n. sp.

Leaves of variable size, elliptical in outline, widest near the middle and rounded at both ends, sometimes narrowed somewhat either distad or proximad. Margins with rather uniform, close-set, dentate teeth. Length ranging from 4·5 cm. to 9 cm. Maximum width ranging from 3 cm. to 5 cm. Petiole stout, curved, enlarged proximad, about 1·25 cm. in length. Midrib stout. Secondaries stout, about 7 subparallel, camptodrome pairs. Tertiaries comprising several curved craspedodrome branches from the outer distal sides of the larger secondaries and internal ones which are thin and percurrent or anastomosing midway between the secondaries.

This well-marked species is represented by a large number of, for the most part, broken specimens from Joseph creek. It is very close to the existing North American var. *crispa* (Ait.) Winkler of *Alnus alnobetula*. Associated with the fossil at Joseph creek are several Alnus cones, which may belong to the same species.

Alnus kefersteinii (Göppert) Unger (?)

Plate XV, figure 6

Alnus kefersteinii Heer, Fl. Foss. Arct., Bd. 2, abt. 2, p. 29, Pl. 3, figs. 7, 8, 1869.

What is commonly considered to be identical with this European Miocene species has been recorded from many localities in Alaska, Greenland, Iceland, Spitzbergen, and Sakhalin island. The specimen figured from Newhykulston creek has a more elongated tip than usual for this species, but more typical shapes occur in the collection from Joseph creek. Whatever their botanical affinity they represent the same form which in the northern Eocene has been referred to this species. Because they are doubtfully related to the European type I have queried the identification, as I feel sure that these Eocene forms will eventually be recognized as representing a distinct species.

Corylus macquarrii (Forbes) Heer

Plate XVII, figure 6; Plate XVIII, figures 2-4; Plate XIX, figure 5

Corylus macquarrii Heer, Fl. Foss. Arct., Bd. 1, p. 104, Pl. 8, figs. 9-12, Pl. 9, fig. 1, Pl. 17, fig. 5 d, Pl. 19, fig. 7 c, 1868.

The specific differentiation of the leaves of Corylus is a perennial problem for which I can suggest only a partial solution. *Corylus macquarri* was first described by Forbes from the Eocene of the isle of Mull as a species of Alnites. It has since been recorded from the Eocene of Alaska, Greenland, Spitzbergen, Iceland, Grinnell Land, Sakhalin island, and various localities in Canada, the United States, Europe, and eastern Asia. Meanwhile eight additional fossil species from one or the other of these same beds have been described. Definitely referred to this species are forms from the Paskapoo of Alberta, from Porcupine creek, Horsefly and Mackenzie rivers; from many localities in Alaska; from the Upper Clarno beds of Oregon and from various Fort Union localities in the United States. Many occurrences from the Fort Union, Paskapoo, and from Quilchena, Tranquille river, B.C. have been referred to either *Corylus americana* or *Corylus rostrata.*

That these last do not represent the existing American species should be obvious; that they are distinct from *Corylus macquarri* is very doubtful. Very little violence would be done to the facts if all of these Eocene forms were referred to a single species. The leaves of Corylus are notoriously variable and whenever or wherever the fossil leaves are abundant they can be considered to represent a single variable botanical species, or if the opposite view is advocated, from three to six contemporaneous botanical species. It does not seem possible to draw any specific lines among these variations, as many students have previously recognized.

I have adopted the course of considering all of them dealt with in this study as the variants of the single species *Corylus macquarri.* Under this treatment Plate XVII, figure 6, and Plate XVIII, figure 2, represent immature leaves; Plate XVIII, figure 3, is a typical large leaf; Plate XIX, figure 5, is a typical *Corylus rostrata;* and Plate XVIII, figure 4 is more like the Arctic leaves which Heer referred to *Corylus insignis.*

The modern species of Corylus number 8 or 9, and they are widely distributed in Eurasia and North America, ranging from about 31 to 35 north latitude in North America, and about 5 degrees farther north in southeastern Sweden. Some of the fossil leaves show a significent resemblance to the related existing monotypic genus Ostryopsis Decaisne of Mongolia and China. The larger leaves like Plate XVIII, figure 3, from Joseph creek are very close to the existing *Corylus colurna* Linn. of southeastern Europe and central Asia. The leaf from Kitsilano shown in Plate XVIII, figure 4, is closer to the existing *Corylus ferox* Wall. of the Himalayan region than it is to any other existing species.

The collections studied by me contain this species from Newhykulston, Joseph, and Darlington creeks, and Kitsilano.

Family, FAGACEAE

Quercus groenlandica Heer

Quercus groenlandica Heer, Fl. Foss. Arct., Bd. 1, p. 108, Pl. 8, fig. 8, Pl. 10, figs. 3, 4, Pl. 11, fig. 4, Pl. 47, fig. 1, 1868; Newberry, U.S. Geol. Surv., Mon. 35, p. 75, Pl. 51, fig. 3, Pl. 54, figs. 1, 2, 1898.

This well-known species is found in the Kenai beds of Alaska and at corresponding horizons in western Greenland and Spitzbergen. It is represented by typical specimens from Joseph creek, and from Kitsilano.

Quercus coriacea Newberry

Quercus coriacea Newberry, U.S. Geol. Surv., Mon. 35, p. 73, Pl. 19, figs. 1-3, Pl. 20, fig. 5, 1898.

This common species of the Puget group in the state of Washington is found at Kitsilano.

Quercus simplex Newberry

Plate XI, figures 1-4

Quercus simplex Newberry, U.S. Geol. Surv., Mon. 35, p. 78, Pl. 43, fig. 6, 1898.

The coriaceous lanceolate leaves of this species in all sizes are exceedingly common at Burrard inlet. They include, I believe, the materials from this locality which Sir William Dawson recorded as *Salix varians* Goeppert[1] and *Salix integra* Goeppert[2]. All belong, in my judgment, to a single species and the venation is not that of Salix, but Quercus. The species is abundant in the Upper Clarno beds of Oregon, and it has also been recorded from Eugene, Oregon. Knowlton records it[3] from the Raton formation of Colorado and New Mexico, but I regard this last determination as doubtful.

Quercus banksiaefolia Newberry

Plate XVI, figure 6

Quercus banksiaefolia Newberry, U.S. Geol. Surv., Mon. 35, p. 69, Pl. 18, figs. 2-5, 1898.

This species was described by Newberry from the Puget group at several localities in the state of Washington. Entirely characteristic specimens come from Kitsilano.

Quercus uglowi Berry n. sp.

Plate XV, figure 8

Leaves of small size and sub-coriaceous texture, elliptical in general outline, with a shortly pointed tip and cuneate base. Margins entire basally for a greater or less distance, above which they are beset with somewhat irregularly sized and spaced, small serrate tenth. Length about 3·5 cm. Maximum width, in the median part of the leaf, about 1·5 cm. Petiole stout and curved, enlarged poximad, about 7 mm. long. Midrib stout, and prominent on the under side of the leaf. Secondaries about 5 or 6 pairs, diverging alternately from the midrib at angles of about 45 degrees, rather straight and craspedodrome except for one or two basal camptodrome pairs.

This is a well-marked new species, not particularly close to any previously described forms. It shows some resemblance to the minimum-sized leaves of the Pacific Coast species *Quercus chrysolepis* and *Quercus densifolia*. It is named for the collector. Among previously described fossil forms it is somewhat similar to the minimum-sized leaves of *Quercus consimilis* Newberry[4] from the Bridge Creek Eocene of Oregon, and it is also something like what Lesquereux[5] identified as *Rhus acuminata* from the Green River Eocene.

It comes from Joseph creek.

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[1] Dawson, J. W., Trans. Roy. Soc., Can., 2nd ser., vol. 1, sec. 4, p. 147, fig. 11, 1895.
[2] Idem., fig. 12.
[3] Knowlton, F. H., U.S. Geol. Surv., Prof. Paper 101, p. 298, Pl. 70, fig. 3, 1918.
[4] Newberry, J. S., U.S. Geol. Surv., Mon. 35, Pl. 43, fig. 4, 1898.
[5] Lesquereux, L., Cret. and Tert. Fl., p. 194, Pl. 42, figs. 14-17, 1883.

Order, **Urticales** (?)

Family, MORACEAE (?)

Ficus (?) *johnstoni* Berry n. sp.

Plate XI, figure 7

Leaves of large size, orbicular in general outline, with entire and evenly rounded margins. Midrib stout and prominent. Secondaries stout and prominent; 3 sub-opposite, camptodrome pairs, the lower approaching a degree of development that almost deserves the term of lateral primaries; these and the pair next above give off, on the outside, numerous camptodrome tertiaries; the internal tertiaries, sometimes anastomosing or divided by a curved sub-secondary from the midrib, are prevailingly percurrent. The general features of venation are well shown in the accompanying figure, and although this type of leaf is commonly referred to the genus Ficus, it has none of the diagnostic features which would render such an identification conclusive. I have, therefore, queried the generic reference, but have been influenced in retaining it in this genus because of its striking resemblance to the late Upper Cretaceous species *Ficus speciossima* Ward,[1] which is a somewhat larger, more elongate, more distinctly palmately veined leaf with thinner secondaries, straighter tertiaries, and a somewhat auriculate and deeply cordate base.

The new species, which is named for the collector, comes from the Puget group at Burrard inlet.

Family, ULMACEAE

Ulmus columbianus Berry n. sp.

Plate XV, figure 7

Leaves broadly ovate in form; markedly inequilateral, especially at the base; variable in size; short petiolate; the margin coarsely crenate, with inconspicuous denticulate teeth on the lower convex limb of the very coarse crenations. Length ranging from 6 cm. to 8 cm. Maximum width, at or below the middle, ranging from 3·5 cm. to 4·5 cm. Petiole short, stout, and curved, enlarged proximad, about 8 mm. in length. Midrib stout. Secondaries about 12, opposite to alternate, straight, craspedodrome pairs which give off distad on their outer sides 1 or 2 curved craspedodrome branches. Internal tertiaries thin, percurrent.

This species, which is not uncommon in the collection from Joseph creek, is distinct from previously described forms, and appears to afford a predominance of the features of the genus Ulmus, although it shows some resemblances to some forms that have been referred to Betula. The only previously described form that it resembles is the smaller leaves from the Upper Clarno beds of Oregon that Newberry referred to *Ulmus speciosa*,[2] but which Knowlton subsequently differentiated as *Ulmus newberryi*. Penhallow[3] recorded *Ulmus speciosa* from Horsefly river, Coal gully, and Quilchena, B.C., and it is possible that these records may represent the present species.

[1] Ward, L. F., 6th Ann. Rept. U.S. Geol. Surv., p. 552, Pl. 45, fig. 1, 1886.
[2] Newberry, J. S., U.S. Geol. Surv., Mon. 35, Pl. 45, fig. 5, 1898.
[3] Penhallow, D. P., Rept. Tert. Pl. Brit. Col., p. 94, 1908.

Planera nervosa Newberry

Plate XVII, figure 5

Planera nervosa Newberry, U.S. Nat. Mus. Proc., vol. 5, p. 508, 1883; U.S. Geol. Surv., Mon. 35, p. 82, Pl. 47, figs. 2, 3, 1898.

Ulmus plurinervia Heer (not Unger), Fl. Foss. Arct., Bd. 5, p. 39, Pl. 10, figs. 3, 4, 1878; Bd. 7, p. 93, Pl. 89, fig. 8, 1883.

The type of this species was described from the Green River Eocene of Wyoming. It is probably an Ulmus, at least I do not believe that the leaves of Ulmus and Planera can be differentiated, although the present species has the form of leaf that is commonly referred to the genus Planera. There are somewhat larger leaves in the collection from Kitsilano than the one figured. The species appears to represent a descendant from the Fort Union species *Ulmus wardi* Knowlton and Cockerell, which Ward originally named *Ulmus planeroides*. It is also identical with the leaves from western Greenland, Sakhalin island, and the Kenai formation of Alaska that Heer referred to the European Miocene *Ulmus plurinervia* of Unger.

Order, **Ranales**

Family, TROCHODENDRACEAE

Genus, **Trochodendroides** Berry

Trochodendroides arctica (Heer) Berry

Plate XIII, figures 1-4

Populus arctica Heer, Fl. Foss. Arct., Bd. 1, pp. 100, 137, Pl. 4, figs. 6a, 7, Pl. 5, Pl. 6, figs. 5, 6, Pl. 8, figs. 5, 6, Pl. 17, fig. 5, Pl. 21, figs. 14, 15a, 1868.[1]

It has long been a matter for comment that many of the fossil leaves referred to Populus are unlike the existing species of that genus, and Saporta once proposed to refer some of them to the family Menispermaceae. Leaves of the type referred to are exceedingly common in the collection from Kitsilano, and these range in size from small, elongate, cordate leaves to larger ovate, orbicular, and cordate leaves. One might differentiate several nominal species if one followed the prevailing fashion of species making, but after a careful study I am convinced that they all represent a single botanical species. A similar criticism could be made, for example, of the numerous species of so-called Populus figured by Ward from the Fort Union deposits of the United States.

After a thorough comparison with recent material, I believe that the forms under discussion should be referred to the family Trochodendraceae, and I have accordingly transferred them to the form-genus Trochodendroides. If the reader will compare the accompanying figures with the leaves of the existing genera Tetracentron or Cercidophyllum he will find that they can be exactly matched. The smaller fossil leaves are identical with the seedling leaves of Cercidophyllum, and the larger are identical with the mature leaves, and this identity does not obtain when these leaves are compared with those of the genus Populus. I believe that the majority of these common types in the Eocene of high latitudes represent the former existing type, now restricted to eastern Asia.

[1] As the forms referred to this species and supposed related species are so greatly in need of critical revision, as, in fact, are most of the Eocene species referred to Populus, no additional citations are given.

This species was recorded by Dawson[1] from Mackenzie river under the names of *Populus arctica* and *Populus hookeri*, and it has also been recorded from many localities in Alaska, Greenland, and western Canada. The leaves listed as *Grewia crenata* in my preliminary list of the fossil plants from Newhykulston creek, and the occurrences listed by Penhallow and referred to *Grewia crenata*, namely, Horsefly river and Porcupine creek, also probably represent Trochodendroides.

The family Trochodendraceae consists of 7 or 8 species of temperate central and eastern Asia segregated in the genera Tetracentron, Cercidophyllum, Euptelea, and Trochodendron. They show primitive features in the absence of vessels in the wood, a unique feature among angiosperms, and in having the growing point enclosed in the petiole of the terminal leaf. This last feature as well as the leaf form are present as early as the late Lower Cretaceous, where they were again referred to Populus or Populophyllum, and it seems probable that the existing family represents the restricted progeny of this once Holarctic type.

The present species is present in the collections studied by me from Kitsilano and Newhykulston creek.

Family, MAGNOLIACEAE

Magnolia nordenskiöldi Heer (?)

Magnolia nordenskiöldi Heer, Fl. Foss. Arct., Bd. 4, abt. 1, p. 82, Pl. 21, fig. 3, Pl. 30, fig. 1, 1877; Bd. 5, p. 46, Pl. 3, fig. 2b, 1878; Bd. 6, abt. 1, p. 13, Pl. 5, fig. 10, 1880; Bd. 7, p. 123, Pl. 82, fig. 1, Pl. 108, figs. 2, 3, 1883; Dawson, Trans. Roy. Soc., Can., vol. 1, p. 33, 1883; Lesquereux, U.S. Nat. Mus., vol. 5, p. 448, Pl. 10, figs. 7-9, 1883; Penhallow, Rept. Tert. Pl. Brit. Col., p. 62, 1908.

This species was based upon numerous fragmentary specimens of a variable leaf, which has been recorded from the Eocene of Alaska, the Mackenzie basin, Spitzbergen, Sakhalin island, and Greenland. There are two specimens in the collection from Kitsilano that appear to represent this species, but they are poorly preserved and not certainly identified.

Liriodendron (?) sp.

There are two incomplete specimens in the collection from Joseph creek showing a long, stout petiole and the basal part of two leaves, which, as far as they go, are indistinguishable from those of the genus Liriodendron. In the absence of more representative material I hesitate to do more than call attention to them.

There is a considerable gap in the most interesting geological history of this genus in North America following its great abundance during the Upper Cretaceous, and there is no reason why it should not be present in our more northern Eocene as it is found at that time in Greenland. Liriodendron is another genus, like Sassafras, once abundant throughout the Holarctic region and now restricted to southeastern North America and southeastern Asia.

[1] Dawson, J. W., Trans. Roy. Soc., Can., vol. 7, sec. 4, p. 71, Pl. 10, figs. 2-5, 1889.

Family, MENISPERMACEAE

Cocculus kanii (Heer) Saporta and Marion

Plate XVI, figure 2

Daphnogene kanii Heer, Fl. Foss. Arct., Bd. 1, p. 112, Pl. 14, Pl. 16, fig. 1, 1868.
Cocculites kanii Heer, Idem., Bd. 7, p. 124, Pl. 100, fig. 1 b, 1883.
Cocculus kanii Saporta and Marion, Fl. Heer, Gelinden, p. 63, Pl. 10, fig. 1, 1873.

This characteristic form, with its strict lanceolate shape, long, stout petiole, and numerous acrodrome primaries, is unmistakable. It was described from the Upper Eocene of western Greenland, and has also been recorded from the early Eocene of Belgium. A single specimen is contained in the collection from Kitsilano.

Order, **Rosales**

Family, ROSACEAE

Sorbus decorafolia Berry n. sp.

Plate XIX, figure 2

Leaflets ovate-lanceolate in outline, widest at or below the middle and about equally and shortly pointed at the apex, and base, which is inequilateral. Margins beset with closely spaced, small, dentate-serrate teeth. Length about 4·5 cm. Maximum width about 1·6 cm. Petiolule stout, curved, about 6 mm. in length. Midrib stout. Secondaries, about 8 pairs which diverge from the midrib at angles of about 45 degrees, are mediumly stout, sub-parallel, and camptodrome.

Except for the petiolule these leaflets are not to be distinguished from certain forms of the existing var. *decora* of *Sorbus americana* Marsh, so commonly cultivated as an ornamental tree in Canada. The genus Sorbus is widely distributed in the northern and montane parts of the Holarctic region. Its geological history is practically unknown, but Heer described a supposed species from the Upper Eocene of Greenland and Spitzbergen, and various later species are known from North America and Europe. The present fossil species comes from Joseph creek.

Family, LEGUMINOSAE

Leguminosites borealis Heer

Leguminosites borealis Heer, Fl. Foss. Arct., Bd. 7, p. 139, Pl. 84, figs. 16, 17, 1883 (not Dawson, 1889).
Callistemophyllum latum Dawson, Trans. Roy. Soc., Can., vol. 7, sec. 4, p. 72, Pl. 10, fig. 8, 1889; Penhallow, Rept. Tert. Pl. Brit. Col., p. 40, 1908.

The type of this species came from the Upper Eocene of western Greenland. It is not to be confused with the *Leguminosites borealis* of Dawson, which name was proposed six years later and based on very indefinite remains of supposed pods from Mackenzie river. The latter may be renamed *Leguminosites dawsoni* in honour of their describer. The real *Leguminosites borealis* of Heer was based on leaflets, and indistinguishable leaflets are contained in the collection from Joseph creek. These appear to be identical with the somewhat obscure leaflets from the Mackenzie that Dawson referred to Callistemophyllum (op. cit.).

Leguminosites johnstoni Berry n. sp.

Plate XII, figure 1

Leaflets ovate in outline, with acuminate tip and rounded sessile or sub-sessile base. Margins entire. Texture sub-coriaceous. Length about 4 cm. Maximum width, at or slightly below the middle, about 2·4 cm. Midrib stout, prominent, and curved. Secondaries and tertiaries thin, forming a laterally elongated camptodrome or brochiodrome mesh.

This small and not distinctively characteristic leaf, which is named for the collector, appears to have features that ally it with the Leguminosae, although it may represent some form belonging to the Ericaceae. It is not unlike a form from the Greenland Eocene described by Heer as *Myrsine consobrina*[1]. The present species comes from Kitsilano.

Order, **Sapindales**

Family, CELASTRACEAE

Celastrophyllum pugetensis Berry n. sp.

Plate XII, figure 2

Leaves of large size, elliptical in general outline, widest in the median region, and narrowing somewhat distad to the short-pointed tip. The base is rounded-truncate and decurrent on the stout petiole. The texture appears to have been somewhat coriaceous, and the margins, except near the base, are beset with large dentate teeth. The petiole is long and stout. The midrib is stout and prominent. The secondaries are stout and prominent; eight or 9 pairs diverge from the midrib at wide angles, pursue a rather straight course for half or two-thirds of the distance to the margins, and then curve rapidly upward and are camptodrome, sending off short curved branches to the marginal teeth. The internal tertiaries are prevailingly percurrent, although occasionally they anastomose midway between the adjacent secondaries.

This leaf, although partaking of some of the features of the leaves of the Juglandaceae, is more closely allied to various genera of Celastraceae. The basal width and long petiole point to its reference to the latter instead of the former family, and its venation is also more like the latter. It is not a Euonymus, and I have indicated its botanical relationship by referring it to the form-genus Celastrophyllum, the specific name being in allusion to the geological horizon.

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[1] Heer, O., Fl. Foss. Arct., Bd. 7, p. 112, Pl. 107, fig. 11, 1883.

It seems probable that it is the species that suggested Platanus which Dawson mentions[1] in his report on the plants from Burrard inlet, as the large proximal fragments in the collection from Kitsilano much resemble that genus. It resembles somewhat *Hicoria magnifica* Knowlton[2] from the Upper Eocene of Kukak bay, Alaska, but is less elongate, lacks the cuneate base, has less ascending secondaries and larger teeth. It may be a descendant of the Fort Union *Celastrus curvinervis* Ward[3].

Family, ACERACEAE

Acer macropterum Heer

Plate X, figure 7

Acer macropterum Heer, Fl. Foss. Arct., Bd. 2, abt. 2, p. 37, Pl. 9, figs. 7-9, 1869.

Acer (fruit), Dawson, Trans. Roy. Soc., Can., vol. 8, sec. 4, p. 87, fig. 20, 1891.

This species, based upon fragmentary leaves, and fruits, from the Kenai beds of Alaska, was described by Heer. To it should be referred the maple fruit described by Dawson from Stump lake, Similkameen valley. Both leaves and fruit, identical with the type material, are contained in the collection from Joseph creek.

Penhallow has recorded fruits or leaves of the maple from Horsefly and Tulameen rivers and Quesnel, B.C., under the names of *Acer dubium* Penhallow, *Acer grosse-dentatum* Heer, *Acer trilobatum productum* Heer, and *Acer* sp. Dawson, but as they are very inadequately described, and are not figured, it is impossible to state their relationship to this species, although it is very probable that some of them are identical with it, rather than with the forms to which they have been referred.

Order, **Rhamnales**

Rhamnus kitsilaniana Berry n. sp.

Plate XIX, figure 1

Leaves of relatively large size, ovate-lanceolate in outline, widest medianly, and curving almost equally distad to the acuminate tip, and proximad to the slightly decurrent base. Margins entire, evenly rounded. Texture thin. Length about 12 cm. Maximum width about 4 cm. Petiole short and stout. Midrib stout, prominent, curved. Secondaries about 5 pairs, mediumly stout, alternate, somewhat irregularly spaced; they diverge from the midrib at angles of about 45 degrees, and curve immediately upward in regular sweeping curves, subparallel with one another and with the leaf margins. Tertiaries thin, percurrent, and mostly obsolete.

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[1] Dawson, J. W., Trans. Roy. Soc., Can., 2nd ser., vol. 1, sec. 4, p. 148, 1895.
[2] Knowlton, F. H., Harriman Alaska Exped., vol. 4, p. 151, Pl. 2, fig. 1, Pl. 27, Pl. 29, fig. 1, 1904.
[3] Ward, L. F., U.S. Geol. Surv., 6th Ann. Rept., p. 555, Pl. 53, figs. 9, 10, 1886.

This characteristic species is of a type commonly referred to Rhamnus or Cornus, and is not unlike numerous North American occurrences that have been identified as representing the European Miocene species *Cornus studeri* Heer, as for example, the Fort Union forms so determined by Ward[1]. I have recently referred the Wilcox *Cornus studeri* to the genus Rhamnites, and it is probable that all of the American forms should be considered to represent Rhamnus rather than Cornus. The present species, which is narrower and more elongated, more acuminate, and with more ascending secondaries than the above-mentioned leaves, comes from Kitsilano.

Family, STERCULIACEAE (?)

Pterospermites alaskana Knowlton

Pterospermites alaskana Knowlton, Harriman Alaska Exped., vol. 4, p. 156, Pl. 26, fig. 2, Pl. 32, 1904.

Described originally from the Kenai beds of Kukak bay, Alaska, a single large and characteristic leaf is contained in the collection from Newhykulston creek.

The question of the relationship of this supposed extinct genus to the existing genus Pterospermum of the family Sterculiaceae is by no means a settled one, and without anything to add to the subject I have followed precedent in the above identification.

Order, **Thymeleales**

Family, LAURACEAE

Sassafras selwyni Dawson

Plate XIV, figures 1-4

Sassafras selwyni Dawson, Geol. Surv., Canada, Rept. of Prog. 1879-1880, p. 53A, 1881; Trans. Roy. Soc., Can., vol. 4, sec. 4, p. 28, Pl. 2, fig. 13, 1886; Penhallow, Rept. Tert. Pl. Brit. Col., p. 87, 1908; Berry, Bot. Gaz., vol. 34, p. 442, 1902.

Sassafras cretaceum Penhallow, Geol. Surv., Canada, Sum. Rept. 1904, p. 7, 1905.

Sassafras ferretianum Heer (not Massalongo), Fl. Foss. Arct. Bd. 2, p. 474, Pl. 50, figs. 1, 2, 1869; Bd. 7, p. 103, Pl. 97, fig. 5, 1883.

Although the leaves of Sassafras contained in the collection from Joseph creek do not agree precisely with Dawson's type, they show a great deal of variation in both size and form, and, in my judgment, represent the same species that Dawson described. If this is true then the specimens listed by Penhallow from Quilchena, B.C., as *Sassafras cretaceum* (?) are also to be referred to this species, since some of the material from Joseph creek is very similar to what some authors have identified as *Sassafras cretaceum.*

Sassafras selwyni has been previously recorded from Souris river, Porcupine creek, and Quilchena. In discussing this species in 1902 (op. cit.) I remarked that the rounded base and basal primaries precluded considering it a true Sassafras, but this statement no longer holds, since

[1] Ward, L. F., U.S. Geol. Surv., Bull. 37, p. 55, Pl. 26, fig. 1, 1887.

the base is now known to be slightly cuneate to typically decurrent, and the primaries vary from sub- to supra-basilar. I may add that in my material (that of Dawson is very carelessly and incorrectly drawn) the venation is typical of Sassafras, especially in the marginal hem and secondary to each sinus, and in the base of the leaf—two regions in which I have shown that the venation is most diagnostic of this genus.

This new material from Joseph creek enables me to correlate with Dawson's species, the forms from western Greenland which Heer erroneously identified with the late Tertiary *Sassafras ferretianum* Massalongo, but which are not that species, and which do agree with some of the leaves that I have referred to *Sassafras selwyni*.

The features and variations are well brought out in the accompanying illustrations. The genus has a most interesting history; common and varied in the Upper Cretaceous it becomes relatively rare in the early Tertiary, and is confined in the existing flora to a single species in southeastern North America, and a couple of restricted species in southeastern Asia. It is another instance, along with Magnolia, Liriodendron, etc., of the pairing of these two regions botanically at the present time, and furnished another British Columbia Eocene type that emphasizes this resemblance and probable filiation to the existing flora of southeastern Asia.

Order, **Umbellales**

Family, CORNACEAE

Cornus suborbifera Lesquereux (?)

Cornus suborbifera Lesquereux, Tert. Fl., p. 243, Pl. 42, fig. 2, 1878; Penhallow, Rept. Tert. Pl. Brit. Col., p. 47, 1908.

This species is recorded from the Upper Eocene of Alaska and Spitzbergen, from the Laramie of Colorado, and from Tulameen river and Quilchena, B.C. As Penhallow remarks (op. cit.) it is indistinguishable from the European *Cornus orbifera* Heer[1] and I have, therefore, queried my identification, the question mark indicating, not a doubt of its reference to Cornus, but a doubt whether it should be considered distinct from the European form, which is younger in age.

Two characteristic specimens are represented in the collection from Burrard inlet.

Order, **Ebenales**

Family, EBENACEAE

Diospyros dawsoni Berry n. sp.

Plate XIX, figure 3

Leaves of ovate form, with acuminate tip and slightly decurrent base. Margins full, rounded, and entire. Length about 9 cm. Maximum width, in the middle part of the leaf, about 5 cm. Petiole stout, curved, enlarged proximad, about 1·75 cm. long. Midrib stout, curved. Secondaries 7 alternate to opposite camptodrome pairs. Tertiaries well marked and mostly percurrent.

[1] Heer, O., Fl. Tert. Helv., vol. 3, p. 27, Pl. 105, figs. 15-17, 1859.

The present leaf is practically indistinguishable from some of the leaves of the existing North American *Diospyros virginiana*. It is also like numerous fossil North American forms from a variety of geological horizons that have been identified as *Diospyros brachysepala* Al. Braun, a late Miocene European species.[1] Few, if any, of these represent the European type, but until they can be revised with ample comparative material I have not thought it proper to include any of them in the synonymy of this new species which is based on material contained in the collection from Joseph creek, although several of these occurrences probably represent this species.

It differs from *Diospyros brachysepala* in its uniformly larger size, and more robust and less elongated form, in its fewer and less ascending secondaries.

Order, **Rubiales**

Family, CAPRIFOLIACEAE

Viburnum antiquum (Newberry) Hollick

Viburnum antiquum Hollick, in Newberry, U.S. Geol. Surv., Mon. 35, p. 128, Pl. 33, figs. 1, 2, 1898.

This is the species that Newberry originally referred to the genus Tilia[2] and which Ward described as *Viburnum tilioides*.[3] In the United States it occurs in both the Lance and Fort Union formations. In British Columbia it is contained in the collection from Joseph creek, and in the collection from Kitsilano. It shows no features of the genus Tilia, and is, in all probability, correctly considered as representing the genus Viburnum.

[1] Heer, O., Fl. Tert. Helv., vol. 3, p. 11, Pl. 102, figs. 1-14, 1859.
[2] Newberry, J. S., N.Y. Lyc. Nat. Hist., Annals, vol. 9, p. 52, 1868.
[3] Ward, L. F., U.S. Geol. Surv., Bull. 37, p. 107, Pl. 50, figs. 1-3, Pl. 51, figs. 1-8, Pl. 52, figs. 1, 2, 1887.

NEW SPECIES FROM THE COLORADOAN OF LOWER SMOKY AND LOWER PEACE RIVERS, ALBERTA

By F. H. McLearn

CONTENTS

Illustrations

INTRODUCTION

The Colorado group, on lower Smoky and lower Peace rivers, contains the Dunvegan formation and the Kaskapau (lower shale) and Bad Heart (middle sandstone) members of the Smoky River formation. Whether it includes, below, a part of the St. John formation and, above, a part of the upper shale member of the Smoky River formation, cannot be said at present.

In the following pages twelve new species and the local succession of faunas, as at present known, are described. The fossil lists are more complete than any heretofore[1] given and localities and horizons are treated in greater detail. The study is based mainly on collections made in the field seasons of 1917 and 1918.

Acknowledgment is made to Dr. T. W. Stanton for advice in the study of the fossils, to A. J. Childerhose for assistance in the collecting on Smoky river, and to Messrs. R. W. Coulthard and G. M. Ponton for a collection of fossils.

System	Group	Formation	Member	Thickness	Lithology	Faunas
Cretaceous	Colorado	Smoky River	Bad Heart	feet 5–25	Sandstone	*Scaphites ventricosus*
			Kaskapau	525–545	Shale	*I. umbonatus*
						Prionotropis
		Dunvegan		450–550	Shale, sandstone, etc.	*Corbula pyriformis*- *Unio dowlingi*

[1] Geol. Surv., Can., Sum. Rept. 1917, pt. C, p. 18 C.
Geol. Surv., Can., Sum. Rept. 1918, pt. C, pp. 3 C, 4 C.
Ottawa Nat., vol. 36, No. 3, March, 1920, p. 55, 1 plate.
See also Geol. Surv., Can., Mus. Bull. 29, pp. 9-12, Pls. 3-5.

DUNVEGAN FORMATION

On Smoky river the sandstones and shales of the Dunvegan are about 450 feet thick (estimated). They dip south and outcrop on the valley sides from Sixmile point to above the railway bridge at Smoky, where they disappear below the shales of the overlying Smoky River formation. The strata include massive, crossbedded, concretionary sandstones 10 to 90 feet thick, friable shales 8 to 40 feet thick, zones of thin-bedded sandstone and shale 10 to 120 feet thick, zones of thick-bedded sandstone and shale, etc. At the top of the formation, just south of the railway bridge at Smoky, is a 2-inch coal seam. The base of the formation on Smoky river is drawn at the bottom of a massive concretionary layer, below which are thin-bedded sandstones and shales and yet farther down fine, carbonaceous, somewhat fissile, shales, all of the underlying St. John formation.

On Peace river, from Montagneuse river to the great bend below the mouth of rivière au Brûlé, the Dunvegan is exposed in steep cliffs on the valley sides and consists of thick, massive, crossbedded sandstones with or without concretions, soft sandstones, and zones of bedded sandstone and shale. A coal seam about 6 inches thick occurs in the lower half of the formation, west of Dunvegan. A 10-inch coal seam is found in the upper part of the formation about 6 miles west of the mouth of rivière au Brûlé. The thickness is estimated at about 550 feet.

Near the base of the formation on Smoky river, in concretions in massive sandstone, occur: *Unio dowlingi* McLearn and *Rhytophorus? caurinus* McLearn. The Unio is very common in this freshwater fauna. In talus, probably from the lower part of this formation, on Smoky river, occurs *Tellina dunveganensis* McLearn. Near the middle of the formation, on Peace river, between Montagneuse river and the great bend west of Dunvegan, a thin band of fossiliferous sandstone contains *Brachydontes multilinigera* Meek and *Unio dowlingi* McLearn. The *Unio* is not common. Talus along the river banks from this or similar bands contains: *Barbatia micronema* (Meek); *Brachydontes multilinigera* Meek; *Corbicula dowlingi* McLearn; *Corbula pyriformis* Meek; *Corbula* cf. *nematophora* Meek; *Tellina dunveganensis* McLearn; *Pachymelania?* sp. These fossils indicate brackish water and, in some degree, marine conditions. In the lower part of the formation, on the north bank of Peace river 3 miles west of the mouth of rivière au Brûlé, is a thin fossiliferous sandstone containing *Brachydontes multilinigera* Meek. Above this layer, 130 feet, is another containing *Ostrea* sp. Talus from the Dunvegan formation along both banks of Peace river, west of rivière au Brûlé, contains: *Brachydontes multilinigera* Meek; *Corbula pyriformis* Meek; *Inoceramus dunveganensis* McLearn; *Modiolus silentiensis* McLearn; *Ostrea* sp.; *Tellina (Moera) peaceriverensis* McLearn; *Unio dowlingi* McLearn; *Pachymelania?* sp. These fossils indicate that at various times freshwater, brackish water, and, in some degree at least, marine conditions, prevailed.

In Canada the Dunvegan fauna is not known outside of Peace River district. Several species are found in the United States. *Corbula pyriformis* occurs in the Bear River formation[1] of Wyoming. Stanton[2]

[1] White, C. A., U.S. Geol. Surv., Bull. 128, pp. 38-39.
[2] Stanton, T. W., U.S. Geol. Surv., Bull. 106, pp. 55, 88, 91.

reports the following in the Coloradoan of the United States interior: *Barbatia micronema; Brachydontes multilinigera; Ostrea anomioides. B. micronema* is in the No. 1 bed of the Coalville section[1], in association with *Inoceramus labiatus* and below the horizon of *Prionotropis.* The age of the Dunvegan is probably early Coloradoan.

SMOKY RIVER FORMATION

Kaskapau Member

On Peace river, in the vicinity of Dunvegan, the base of the Kaskapau, or lower shale, member of the Smoky River formation, outcrops at the top of the cliffs. On Smoky river this member is exposed on the valley sides from below Puskwaskau river to about 12 miles below Racing creek. The dip is to the south. At the very base are friable dark shales, but most of the lower half of this member consists of dark, rather fissile, carbonaceous shale. In the upper part are friable dark shales with concretions and at the very top, just below the Bad Heart sandstone member, are thin-bedded sandstones and shales. The estimated combined thickness of the Kaskapau and Bad Heart members on Smoky river is 550 feet.

At the base of the formation on Smoky river is *Cyprina* sp. About 60 or 70 feet above the base, in concretions in shale, at the rapid above the railway bridge on Smoky river, are: *Inoceramus corpulentus* McLearn; *I. labiatus* Schlotheim; *Prionotropis* cf. *woolgari* Mantell; *Acanthoceras* cf. *coloradoensis* Henderson. Higher in this member, and probably at about 200 feet above the base, *Prionotropis* re-occurs; fresh talus from a cliff on the east bank of Smoky river just above the mouth of Little Smoky river contains: *Prionotropis caurinus* McLearn; *P. hyatti* Stanton; *Scaphites* sp.

A different fauna is found in the uppermost part of this member. In concretions just below the Bad Heart sandstone there occurs *Inoceramus umbonatus* Meek and Hayden. Somewhat lower and 40 or 50 feet below the base of the Bad Heart, *Inoceramus albertensis* McLearn was collected.

The lower part of this member containing *Prionotropis* is correlated with the lower part of the Colorado shale of southwestern Alberta, with the lower part of the La Biche shales on Athabaska river, with the Carlile shale of the Black hills and of Wyoming,[2] and the Turonian of Europe. The age of the uppermost part of the Kaskapau member containing *I. umbonatus*, etc., is discussed below under Bad Heart sandstone, for *I. umbonatus* is a component of the *Scaphites ventricosus* fauna which is so well represented in the Bad Heart.

Bad Heart Sandstone Member

The Bad Heart sandstone is from 5 to 25 feet thick and outcrops in the cliffs on Smoky river from below Puskwaskau river nearly to the mouth of Little Smoky river. It consists of coarse sandstone and contains numerous marine fossils. The following were collected in place: *Baculites* cf. *anceps* Lamarck; *Inoceramus pontoni* McLearn; *I. coulthardi* McLearn;

[1] Stanton, T. W., U.S. Geol. Surv., Bull. 106, pp. 38-40.

[2] For distribution of *Prionotropis* fauna in the United States interior, see Reeside, J. B., jun., U.S. Geol. Surv., Prof. Paper, 132 B, p. 26.

Pteria linguiformis E. and S.; *Pecten; Protocardium.* In addition the following were collected from fresh talus of this member: *Anatina (Anatimya); Baculites* cf. *asper* Morton; *Goniomya* cf. *americana* Meek and Hayden; *Inoceramus erectus* Meek; *Nucula; Oxytoma nebrascana* (Evans and Shumard); *Pinna dolosoniensis* McLearn; *Pecten silentiensis* McLearn; *Scaphites ventricosus* Meek and Hayden. Other species are in a lot labelled, fresh talus from the Bad Heart sandstone and concretions just below it: *Inoceramus selwyni* McLearn; *Gervillia stantoni* McLearn. The following is in talus from the Bad Heart sandstone or beds a little below: *Scaphites vermiformis* Meek and Hayden.

The combined fauna of the Bad Heart sandstone and the top of the Kaskapau shale, containing *Scaphites ventricosus* and *Inoceramus umbonatus*, is correlated with most of the upper part of the Colorado shale of southwestern Alberta, with the upper part of the Colorado shale of northern Montana, and the Niobrara of Wyoming and the United States Great Plains region.[1] Reeside correlates this fauna with the Lower Santonian and Coniacian of Europe.[2]

Above the Bad Heart sandstone is the upper shale member of the Smoky River formation containing, 100 to 150 feet above the base, *Baculites ovatus* of post-Coloradoan age.

SYSTEMATIC DESCRIPTIONS

Pinna dolosoniensis n. sp.

(*Dolosonia*, a latinized form of Bad Heart)

Plate XXIII, figure 9

Valves fairly convex, rounded, not angular along the middle. Dorsal margin somewhat concave; ventral margin shorter and nearly straight; inclined to one another at a moderately acute angle. Radial costæ (rather widely spaced, but becoming closer anteriorly) cover the dorsal part of the valve to a little ventral of the middle. Lines and wrinkles of growth well marked on ventral part; one specimen shows faint lines of growth in dorsal part of shell at about right angles to radial costæ there.

Length of holotype, 100 mm., height 42 mm., thickness 27 mm.

Pinna lakesi White[3] is the nearest species, but it is more tapering, having a more acute angle between the dorsal and ventral margins, and the strong wrinkles of growth do not cease at the ventral-most radial costa, but continue across 2 or 3 of the ventral radial costæ.

Horizon and Locality. In fresh talus of the Bad Heart sandstone from east bank of Smoky river below mouth of Puskwaskau river. In fresh talus of Bad Heart sandstone from east bank of Smoky river, about 1½ miles below Puskwaskau river. In talus from north bank of Smoky river about 14 miles below Bad Heart river; probably from the Bad Heart sandstone.

Type. Victoria Memorial Museum; holotype, Cat. No. 6102.

[1] For distribution of the *Inoceramus umbonatus-Scaphites ventricosus* fauna in the United States, *See* Reeside, J. B., jun., U.S. Geol. Surv., Prof. Paper 132 B, pp. 25-27.
[2] Reeside, J. B., jun., U.S. Geol. Surv., Prof. Paper 132 B, p. 28.
[3] U. S. G. and G. S. Terr., 1878, pt. 1, p. 17, Pl. 11, figs. 1a-b.

Inoceramus pontoni n. sp.

Plate XX, figures 1, 2

Holotype longer than high, not oblique, very convex. Beaks anterior, incurved and curved slightly forward; postumbonal slope prominent, rounded, a very slight sulcus behind it; anterior part of shell inflected and has pronounced, curved sulcus. Equivalve. Hinge-line long; anterior margin rounded; basal margin very gently rounded; posterior margin rounded. Fairly strong concentric corrugations. Length 47 mm., height 36 mm., thickness right valve 18 mm.

A very variable species. In some specimens the anterior inflected area is almost flat. Other specimens are much less convex, others more convex than the holotype. The narrow sulcus posterior to the postumbonal slope is very well marked in some specimens, whereas in others it is very faint. In some specimens there is a differentiation of the concentric corrugations into two sizes, the stronger separated by a number of smaller concentric corrugations. There is also much variation in size.

Inoceramus cordiformis Sowerby[1] is a proportionately higher shell, the sulcus on the postumbonal slope separates two rounded ridges and the anterior area is bounded in some specimens by a rounded ridge. This British species also is more compressed and wing-like in the postero-dorsal angle.

The name is given for G. M. Ponton, mining engineer.

Horizon and Locality. In Bad Heart sandstone, east bank Smoky river, below mouth of Puskwaskau river; fresh talus from same. In fresh talus of Bad Heart sandstone from east bank of Smoky river, about 1½ miles below Puskwaskau river. In talus south bank Smoky river about 2 miles below mouth of Bad Heart river, probably from Bad Heart sandstone. In a lot labelled "talus from Bad Heart sandstone and concretions in shale below," east bank Smoky river about 3 miles below Puskwaskau river; probably from the Bad Heart. Thirty-five miles above mouth of Little Smoky on Smoky river, collected by Coulthard and Ponton.

Type. Victoria Memorial Museum; holotype, Cat. No. 6103.

Inoceramus coulthardi n. sp.

Plate XXI, figures 1-4

About equivalve, higher than long, much swollen. Prominent, rounded, postumbonal slope; beaks anterior, produced, incurved and a little curved forward. Anterior part of shell strongly inflected, concave and demarcated from remainder of valve by angular ridge; in some specimens flattened in postero-dorsal angle. Strong concentric corrugations, the interspaces covered with finer concentric corrugations.

Length 22 mm., height 30 mm., thickness of a single valve 16½ mm.

Differs from *Inoceramus pontoni* n. sp. in smaller size, greater proportionate height, more produced beaks, more inflected, more sharply demarcated, and more concave anterior area, and the lack of a sulcus on the postumbonal slope.

[1] *See* Woods, Henry, "Cretaceous Lamellibranchia," Pal. Soc., 1912, p. 334, Pl. 53, fig. 8, Pl. 54, figs. 2-4.

The name is given for R. W. Coulthard, mining engineer.

Horizon and Locality. In Bad Heart sandstone from east bank Smoky river, below Puskwaskau river and in fresh talus from same. In collection of Coulthard and Ponton, from 35 miles above mouth of Little Smoky on Smoky river.

Type. Victoria Memorial Museum; holotype, Cat. No. 6104.

Inoceramus selwyni n. sp.

Plate XXI, figures 8, 9

Equivalve, higher than long. Hinge-line considerably shorter than total length of shell; posterior border rounded below, oblique and nearly straight above, and concave at postero-dorsal angle; basal margin distorted, apparently rounded; anterior margin nearly straight, inclined inward above. Very tumid, maximum thickness in ventral half. Umbones prominent; beaks produced, incurved and curved forward, situated at anterior end of hinge-line. Surface deeply inflected anterior to beaks; surface somewhat depressed in postero-dorsal angle. Surface covered with strong concentric corrugations.

Inoceramus erectus Meek[1] has a more nearly vertical anterior margin, more anterior beaks, a relatively longer hinge-line, and finer concentric undulations.

The name is given for A. R. C. Selwyn, geologist and a former director of the Geological Survey.

Length 57 mm., height 70 mm., thickness 87 mm.

Horizon and Locality. In fresh talus of Bad Heart sandstone and concretions in shale just below Bad Heart sandstone from west bank Smoky river about 2½ miles below Puskwaskau river.

Type. Victoria Memorial Museum; holotype, Cat. No. 6105.

Inoceramus dunveganensis n. sp.

Plate XX, figure 5

Two specimens, moulds of the interior of the right valve, a little flattened by pressure, preserved. Somewhat oblique, a little higher than long. Hinge-line about one-half length of shell; anterior margin nearly straight, inclined at angles of 110 degrees to 115 degrees to hinge-line; ventral margin well rounded; posterior margin nearly straight, inclined at angles of 120 degrees to 125 degrees to hinge-line. Shell evenly and moderately convex; flattened in the postero-dorsal angle, narrowly inflected along the antero-dorsal border; umbones small, near the anterior end of hinge-line, but at about one-quarter distance from anterior end of valve. Surface covered with irregular, concentric, coarse undulations, more marked anteriorly and having a fairly strong ventral curvature.

Length 120 mm., height 128 mm., thickness of a single valve 18 mm.

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[1] U. S. G. Expl. 40th Par., IV, pt. I, p. 145, Pl. 13, figs. 1, 1a, Pl. 14, fig. 3.

Compared with *Inoceramus crippsi* var. *reachensis* Etheridge[1] our species is much larger, is more oblique, and has more irregular concentric sculpture. Compared with the typical *Inoceramus labiatus* (Schlotheim)[2], our species is not so oblique, is not so elongated between the umbo and the postero-ventral extremity, is larger, has more irregular concentric sculpture and the ventral curvature of the concentric undulations is not so strong. A similar but much larger species occurs in the *Prionotropis* fauna on Athabaska river.

Horizon and Locality. Very rare in landslide talus from Dunvegan sandstone on the north bank of Peace river, about 6 miles west of the mouth of rivière au Brûlé.

Type. Victoria Memorial Museum; holotype, Cat. No. 6106.

Inoceramus albertensis n. sp.

Plate XX, figures 3, 4

Only left valve known. Large, moderately convex, elongate-quadrate. Anterior and basal margins gently rounded; posterior margin subtruncate; hinge-line long, but shorter than total length of shell. Beaks incurved, situated near anterior end. Surface covered with concentric undulations, stronger ventrally. Shell comparatively thin.

Length 65 mm., height 145 mm., thickness of left valve 55 mm.

Horizon and Locality. In upper part Kaskapau member of Smoky River formation about 40 to 50 feet below Bad Heart sandstone from east bank Smoky river, about 1½ miles below Puskwaskau river.

Type. Victoria Memorial Museum; holotype, Cat. No. 6107.

Inoceramus corpulentus n. sp.

(*Corpulentus*, corpulent)

Plate XXI, figures 5-7

For an *Inoceramus*, somewhat less than moderate size. About equivalve. Slightly oblique. Much higher than long. Very convex. Somewhat flattened in postero-dorsal angle. Surface deflected inwardly anterior to umbo, forming a wide, almost flattened area at right angles to plane of valves. Beaks well defined, little produced, curved inward and forward a little. Surface covered with irregular, not very well defined concentric corrugations.

Length of holotype 30 mm., height 52 mm., thickness of one valve about 24 mm.

Inoceramus lamarcki var. *apicalis* Woods[3] from the Middle Chalk of England is smaller, not quite so convex, the concentric corrugations where present are finer and more regular, the relative height is not so great, and the flattening in the postero-dorsal angle is greater. The two are very closely related, however.

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[1] *See* Woods, Henry, "Cretaceous Lamellibranchia," 2, Pal. Soc., 1911, p. 278, Pl. 48, figs. 4, 5, Pl. 49, fig. 1.
[2] Woods, Henry, "Cretaceous Lamellibranchia," 2, Pal. Soc., 1911, p. 281, Pl. 40, fig. 37.
Stanton, T. W., U.S. Geol. Surv., Bull. 106, 1893, p. 77, Pl. 10, fig. 4, Pl. 14, fig. 2.
[3] Woods, Henry, "Cretaceous Lamellibranchia," 2, Pal. Soc., 1911, p. 319, Pl. 53, figs. 4-6.

Horizon and Locality. Sixty to 70 (estimated) feet above the base of the Kaskapau member of Smoky River formation, exposed on east bank of Smoky river at rapid above railway bridge. Fresh talus from same locality.

Types. Victoria Memorial Museum; holoytpe, Cat. No. 6108; paratype, Cat. No. 6109.

Pecten silentiensis n. sp.

(*Silentia*, the Peace country)

Plate XXII, figures 1, 2; Plate XXIII, figure 8

Large; suborbicular; inequivalve, the left valve moderately inflated, the right valve fairly convex to somewhat compressed, but in all specimens the right less inflated than the left. Beak and umbo of moderate size in left valve, hardly rising above hinge-margin; beak and umbo not well defined in right valve. Hinge-margin comparatively short. Antero-dorsal margin in both nearly straight; these margins meet at angles of about from 135 to 145 degrees. Ears long, narrow; the anterior in right valve the widest and having a shallow byssal notch. Areas of both valves narrow. Surface covered with irregular lines of growth; no radial ornamentation observed.

Length of holotype 93+mm., height 98 mm., thickness 29 mm.

Pecten conradi (Whitfield)[1] from the Merchantville of New Jersey is much smaller, has radiating sculpture although faint, proportionately larger ears, smaller apical angle, and more nearly equal valves. *Pecten cliffwoodensis* Weller[2] from the Cliffwood of New Jersey is smaller, more depressed, has relatively wider ears, and a smaller apical angle. *Pecten burlingtonensis* Gabb[3] from the Merchantville, Woodbury, and Wenonah of New Jersey, has wider ears, a smaller apical angle, and fine radiating striæ. *Pecten nillsoni* Goldfuss[4] from the Cretaceous of Texas is smaller, has a slightly smaller apical angle, and somewhat wider and larger ears. *Pecten siederensis* Kniker[5] from the Buda limestone of Texas is much smaller, more equivalve, thinner, and has a smaller apical angle and more triangular ears.

Horizon and Locality. Fresh talus of Bad Heart sandstone on east bank Smoky river below mouth of Puskwaskau river. Fresh talus of Bad Heart sandstone from east bank of Smoky river about 1½ miles below Puskwaskau river. Talus on south bank Smoky river, about 2 miles below Bad Heart river; probably from the Bad Heart sandstone. Talus from north bank of Smoky river, about 4 miles below mouth of Bad Heart river; probably from the Bad Heart sandstone.

Type. Victoria Memorial Museum; holotype, Cat. No. 6110.

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[1] Geol. Surv., N.J., Pal., 4, 1907, p. 474, Pl. 50, figs. 1-4.
[2] Geol. Surv., N.J., Pal., 4, 1907, p. 469, Pl. 50, figs. 7-8.
[3] Geol. Surv., N. J., Pal., 4, 1907, p. 470, Pl. 49, figs. 5-9.
[4] Roemer, F., Kreidebildungen von Texas, Bonn, 1852, p. 67, Taf. 8, fig. 6.
[5] Bull. Univ. Texas, No. 1817, 1918, p. 15, Pl. 1, figs. 5-6.

Modiolus silentiensis n. sp.

(*Silentia*, the Peace country)

Plate XXIII, figures 3, 4

Elongate-oblique, slightly curved, contracted anteriorly, and rounded posteriorly. Hinge-line more than half length of shell; anterior margin short, rounded; antero-ventral margin long, slightly concave, inclined to hinge-margin at angle of about 48 degrees; ventral margin short, rounded; posterior margin long, rounded, almost straight above. Beaks inconspicuous, almost terminal. Post-umbonal ridge rounded, curved, widening and flattening out postero-ventrally; from this ridge the slope is steep to the antero-ventral margin. Surface covered with fine, somewhat irregular, concentric striæ.

Height 13·5 mm., length 16·0 mm.

Other specimens are more oblique in outline; in them the hinge-margin is relatively longer and the posterior margin is shorter.

Modiola meeki E. and S.[1] has the beaks not quite so anterior in position, is larger on the average, has a lesser angle between the hinge and the antero-ventral margins and has a more elongate and slender outline.

Horizon and Locality. In landslide talus of Dunvegan formation on north bank Peace river about 6 miles west of mouth of rivière au Brûlé. Slide talus of Dunvegan formation south bank Peace river, about 4 miles west of mouth of rivière au Brûlé. Landslide talus, Dunvegan formation, north bank Peace river about 3 miles west mouth of rivière au Brûlé.

Types. Victoria Memorial Museum; holotype, Cat. No. 6190; paratype, Cat. No. 6112.

Corbicula dowlingi n. sp.

Plate XXIII, figures 1, 2

Small, equivalve, suborbicular, somewhat compressed. Hinge-margin curved a little; anterior, ventral, and posterior margins well rounded. Shell moderately convex; umbones small, directed forward, situated a little in advance of the middle. Ligament external, long. Surface covered with even, well-marked concentric striæ. Preparation of hinge of right valve shows three cardinal teeth, the anterior the smallest; long, double, anterior lateral; long posterior lateral, double?

The species name is given for D. B. Dowling of the Geological Survey.

Height 21 mm., length 43·5 mm., thickness 10 mm.

Horizon and Locality. In landslide talus of Dunvegan sandstone, west bank Peace river, 5 miles below mouth of Montagneuse river.

Type. Victoria Memorial Museum; holotype, Cat. No. 6191.

Rhytophorus? caurinus n. sp.

(*Caurus*, the northwest wind)

Plate XXIII, figure 5

Stout, subfusiform. Short, conical spire about 0·25 of total length. Five whorls. Suture impressed. Whorl shouldered and tapering anteriorly. Surface covered with fine striæ and ridges of growth.

[1] U. S. G. S. Terr., 1876, p. 72, Pl. 15, figs. 3 a-c.

Length 17·8 mm., diameter 10·0 mm.

Melampus clarki White[1] is smaller, more slender, and has a less pronounced shoulder. *Rhytophorus glaber* Whiteaves[2] is larger and more fusiform.

Horizon and Locality. Very rare in talus of large concretions from near base of Dunvegan sandstone, west bank Smoky river, about 5 miles below mouth of Racing creek.

Type. Victoria Memorial Museum; holotype, Cat. No. 6192.

Prionotropis caurinus n. sp.

(*Caurus*, the northwest wind)

Plate XXIII, figures 6, 7

The specimen figured and the only known specimen, is chiefly a mould of the interior. Entirely septate, the living chamber not preserved.

Of moderate size, gently embracing, the whorl suture a little outside the inner row of peripheral tubercles. About four, fairly rapidly enlarging whorls. Umbilicus wide, stepped. Whorl section semiquadrate, a little higher than thick. Periphery keeled, fairly wide, and somewhat convex. Umbilical areas very narrow, somewhat rounded, and at right angles to plane of symmetry of shell.

Costæ straight, radiate, numbering about 14 on last whorl (more numerous on inner whorls), are progressively more distantly spaced with increase in size of whorl. Near umbilical border the costæ are raised and thickened into an incipient transverse node. Near the peripheral border there is an inner rounded node and an outer elongate narrow node nearly parallel to the keel. The keel is very small in proportion to the size of the shell and gently undulate.

Height of external lobe about twice its width; about as wide below as above; divided by a small saddle. External saddle about as high as wide and the width about twice that of the external lobe; divided by a small lobule into two nearly equal branches. First lateral lobe a little wider than external lobe, but not so deep. First lateral saddle a little higher than external saddle. Second lateral lobe very shallow.

Diameter	58·0 mm.
Height of whorl	42 %
Thickness of whorl	41·7 %
Width umbilicus	33·2 %

The nearest species in the American Coloradoan is *Prinotropis hyatti* Stanton,[3] from which it differs in the slightly greater involution of the whorls, the more rapid enlargement of the whorls, the smaller keel, the different ornamentation, including smaller tubercles, and the different suture line.

Horizon and Locality. Fresh talus of Kaskapau shale, cliff on east bank of Smoky river just above mouth of Little Smoky river; estimated from about 200 feet above base of Kaskapau shale member.

Type. Victoria Memorial Museum; holotype, Cat. No. 6193.

[1] U. S. G. S., Bull. 128, 1895, p. 42, Pl. 5, figs. 2, 3.
[2] Contr. Can. Pal., 1, pt. 1, 1885, pp. 69, 70, Pl. 10, figs. 4, 4a-c.
[3] U.S. Geol. Surv., Bull. 106, 1893, p. 176, Pl. 42, figs. 5-8.

UPPER DEVONIAN CRINOIDS FROM THE MACKENZIE RIVER VALLEY

By Frank Springer

Contents

Illustrations

INTRODUCTION

In September, 1921,[1] I gave an account of some crinoids belonging to the genus *Melocrinus*, derived from a locality on Hay river, Great Slave Lake region. They are of a type different from that prevailing in the Eifel limestone of Europe, where the genus has hitherto been chiefly known, but are closely related to species occurring in the upper Mississippi valley, in strata formerly classed as Hamilton, but which later investigations have tended to place higher. The Hay River crinoid-bearing strata have been referred by E. M. Kindle[2] to the Upper Devonian, and lie above the Simpson shale in which he finds a characteristic Portage fauna.

Mr. Kindle has recently placed in my hands for investigation some further crinoidal material, from new localities in the Mackenzie River valley to the northwest of the Hay River occurrences. One of these, found by the late E. J. Whittaker, is on Trout river, about 150 miles distant, and the other by G. S. Hume, about 175 miles farther north, on a small confluent of the Mackenzie, called Root river.

Both of these later finds are assigned by their discoverers to horizons above that of the Simpson shale, but their relation to one another has not been closely determined. Their crinoid fauna, with a single exception, belongs entirely to the genus *Melocrinus*, as in the Hay River locality, but the species from the three localities are so different, and present such striking modifications of one generic type, that they are of much interest both from a biological and a stratigraphical aspect. Whereas the *Melocrinus borealis* of Hay river is closely related to the species of Iowa, Missouri, and Wisconsin, those of the new localities are not only thoroughly distinct from that, but also from each other. And the interesting thing about them, from a geological point of view, is that in the characters by which they differ so completely from all other known American species, the three new species exhibit a tendency to an asymmetrical construction of the calyx which is not observed among the abundant species of the Eifel limestone of the Middle Devonian, but which developed in certain species belonging to the Frasnian (or lower) member of the Upper Devonian in Belgium.

Not only so, but the single specimen in the new collections which is not a *Melocrinus*, but belongs to *Hexacrinus*, another very prevalent Middle Devonian genus in the Eifel, but very rare in America, is of a type completely different from that of the Eifel, but which is also represented in the Upper Devonian rocks of Belgium.

[1] Geol. Surv., Can., Bull. 33, pp. 15-18.
[2] Geol. Surv., Can., Bull. 29, 1919, p. 4.

Therefore, these new crinoidal acquisitions reinforce in a most decisive way the correlation which Mr. Kindle has made of the extensive Upper Devonian formations of Mackenzie River district.

Before proceeding to the description of the new species, and for the better understanding of their occurrence the notes made by Mr. Whittaker and Mr. Hume, relative to the stratigraphy of the crinoidal formations are given.

Note by E. J. Whittaker

The accompanying crinoids from Trout river, Mackenzie River district, N.W.T., which were collected in 1921, occur at the top of a bed of impure greenish grey limestone. This is overlain by a heavy-bedded, pure limestone and separated from it by a parting of greenish shale about 2 inches thick. The crinoids project from the upper surface of the limestone into this shale. The upper pure limestone is characterized by an abundant, undescribed molluscan fauna with *Cryptonella* cf. *pinonensis* as a characteristic brachiopod. The lower impure limestone belongs to the *Spirifer disjunctus* horizon of the Upper Devonian. Associated with this bed is a large coral fauna including *Acervularia* and *Phillipsastraea*. This bed is the uppermost stratum of a series of pure and shaly limestones, 260 feet of which are exposed, characterized by *Spirifer disjunctus*. The crinoid bed is probably slightly higher (100 feet to 150 feet) than the horizon on Hay river in which *Melocrinus borealis* Springer was collected by the writer in 1917.

Note by G. S. Hume

The crinoids were collected from a coral reef in limestone which is described in Summary Report, 1922, as the *Leiorhynchus* zone. The fossils from this limestone are as follows:

Leiorhynchus sp., very abundant
Camarotoechia contracta, abundant at certain horizons
Schizophoria iowaensis
Spirifer disjunctus, common at certain horizons and rather long range
Athyris angelica, rather rare
Rhynchonella duplicata, rare
A few undetermined lamellibranchs

From the crinoid coral reef a fauna quite different from this was found in the same limestone. It is as follows:

Cladopora sp.
Diphyphyllum arundinaceum, abundant
Phillipsastraea verneuili, common
Phillipsastraea sp., small corallites
Aulopora sp.
Atrypa reticularis, abundant
Atrypa spinosa, abundant
Hypothyris cuboides
Leiorhynchus sp.
Spirifer sp.
Crinoids

The stratigraphic position of the limestone in which these fauna occur is above a series of shales which are the equivalents of the Simpson shales described by Mr. Kindle.[1] The fauna of the Simpson shale is correlated by Mr. Kindle with the Portage of the New York section; consequently, the crinoids occur higher stratigraphically than the equivalents of the Portage.

[1] Geol. Surv., Canada, Mus. Bull. No. 29.

DESCRIPTIONS OF THE NEW SPECIES

Genus, MELOCRINUS

Melocrinidae, with four basals, and the rays produced into two main uniserial rami, usually fused by their inner margins in Devonian species.

The most striking peculiarity of the three new species of this genus is the tendency to an unsymmetrical growth of the calyx—a character hitherto observed only in species of a single horizon and area in Europe. Usually throughout the entire order Camerata, to which this genus belongs, the calyx has a certain equal balance among the five rays of which it is composed, and is poised squarely upright upon the column, in line with its vertical axis; exceptional specimens in which this is not so are merely sporadic variations due to accidental enlargement or diminution of some plates. It is constructed with a definite radial symmetry, modified, however, in many forms by a bilateral symmetry caused by the interposition of anal plates at one side.

In the species before us, the equal poise of the calyx so typical of the Camerata crinoids has been to a greater or less extent lost—not merely in abnormal individuals, but apparently as a definite specific character. In the leading species—*M. kindlei*—the material is sufficiently abundant to test this thoroughly. There are 17 specimens, and in these the deviation of the calyx from the stem axis ranges from 5 to 15 degrees. Though most conspicuous in the larger specimens, the actual measured obliquity is fully as great in smaller ones. This disturbance of balance is accompanied by an unequal growth of the basal and radial plates on opposite sides of the calyx. In some specimens the basals in the longer side are almost twice as high as those upon the shorter side, and taking the total length of sides from the column facet to the apex of the auxillary primibrach, there is an average difference in length between opposite sides of about 4 to 5.

In the more rotund species, *M. mackenzie*, from the same locality, the obliquity is about the same, whereas in *M. whittakeri*, from the Trout River locality, the deflexion of the calyx is less in degree, but nevertheless is plainly discernible in the specimens.

It is to be observed that the specimens of *M. borealis*, from the lower Hay River beds, exhibit a similar, though less marked, tendency to asymmetry of the calyx, a fact that accords well with their Upper Devonian position, correlated with the Belgian fauna, as the relations of the two are now brought out.

If, now, comparison be made with the species described in 1883 by Fraipont[1] upon collections made by Professor Dewalque from the lower, or Frasnian, member of the Upper Devonian, near Senzielle, Belgium, it will be seen that a similar asymmetry, marked by more or less obliquity of the calyx to the stem axis, prevails quite generally among them. This is well shown by *M. konincki*, Pl. 4, figs. 6, 8; and by Pl. 1, figs. 1, 2; and Pl. 4, figs. 1, 2; figured by Fraipont as *M. hieroglyphicus* Goldfuss, but subsequently referred by von Koenen[2] to a new species, *M. dewalquei* von

[1] Annales de la Soc. géol. de la Belgique, t. X, pp. 45-68; planches 2, 3, 4, 5.
[2] Neues. Jahrb. f. Min., 1886, Bd. 1, p. 105, Pl. 2, fig. 4.

Koenen. These two elongate and pyramidal species are comparable to our *M. kindlei*, and associated with them are two species of rotund contour, *M. benedeni* and *M. mespiliformis*, both similarly asymmetric, which are of a type represented by our *M. whittakeri* and *M. mackenzie*. The oblique form of the calyx in the Belgian species is better shown in specimens from the type locality, which I owe to the generosity of M. le Professeur Dewalque, than in the figures.

Melocrinus kindlei n. sp.

Plate XXIV, figures 1-9

A large-sized species. Calyx elongate, inverted pyramidal, varying in height from 14 to 38 mm. of which the height of dorsal cup to tegmen is about as 8 to 1, and the width of calyx at the arm bases is to the total height about as 1 to 1·2; it stands oblique to the stem axis from 5 to 15 degrees. Plates of dorsal cup unequal in the same ranges, especially the basals, which may be twice as high on one side as on the opposite; the measured distance from base to apex of first auxiliary on one side may be a fourth greater than that on the opposite ray. Plates more or less convex, with a tendency to pitting at the angles, stronger in younger specimens than in the more mature. Obscure stellate ornament sometimes accompanies the pitting. The base is narrow, protuberant, cylindrical, and conspicuous by reason of its unequal projection, and the angle which it forms with the parts above it. This deflexion follows no fixed rule, although the bending seems to be most frequent toward the posterior side. Column facet large, occupying almost the full width of the base. The large basal is either in the anterior or left anterior position, more frequently the latter; and, as in other species, is distinguishable not only by its size, but by the fact that it supports a ray directly over its median line, instead of supporting it in part at either side like the other three.

Tegmen low convex, about one-eighth the height of the dorsal cup; composed of numerous smooth plates of moderate size, with a subcentral anal opening, which may have been extended into a short tube. Below the arm bases the anal area is but little differentiated. The rays at the zone of the arm bases are more or less protuberant, giving to the calyx, as seen from above or below, a pentagonal outline. A few ossicles of the doubled rami which compose the free ray are seen in several specimens.

The species may be compared with *M. konincki* Dewalque in Fraipont, which has a similar cylindrical, protuberant base, but differs greatly in its convex sides, and sharp surface ornament; and with *M. dewalquei* von Koenen, which has a similar pyramidal contour, but is smaller, has a less conspicuous base, and smoother surface.

The description is made upon the evidence of seventeen specimens, of which an average representative is about 22 mm. high by 18 mm. wide at the arm bases, and 7 mm. wide at the column facet. The original of figures 1, 2, and 3 is of disproportionate size, probably exceptional; it has all the appearance of a very mature individual, in which the obliquity of the calyx is strongly accentuated, although it is well shown in most of the specimens.

Horizon and Locality. From a coral reef in limestone above the horizon of the Simpson shale; *Leiorhynchus* zone of the Upper Devonian. Root river, about 40 miles above its confluence with the Mackenzie, North West Territories, Canada. Collector, G. S. Hume. The specific name is proposed in honour of E. M. Kindle, Chief of the Division of Palæontology, Geological Survey, Canada, whose researches have placed the correlation of the Upper Devonian formations of the Mackenzie region upon a firm basis.

Melocrinus mackenzie n. sp.

Plate XXIV, figures 10-13

A medium-sized species, ranging from 15 to 25 mm. high and 14 to 24 mm. wide; one abnormally large broken specimen is 30 mm. in height without the base. Calyx rotund, obliquely deflected from the vertical, and with opposite sides distinctly unequal in height; slightly higher than wide, and tegmen about one-fourth of the total height. Plates smooth, slightly convex, with depressed sutures, but not pitted at the angles. Base low, broad, not protuberant, and with a wide column facet; plates at opposite sides more or less unequal. Tegmen somewhat lobed, composed of numerous plates, smooth or pointed. Anal opening subcentral, apparently without a tube.

There is some intergradation between this species and the last, from the same beds, but typical specimens can be readily distinguished by the rounded contour, swelling sides of dorsal cup, and greater elevation of tegmen, as well as by the less prominence of the basal plates. There are seven specimens fairly referable to this form upon the average of characters, and several of them are so well defined that they must necessarily be separated from all the other species. In the rounded and asymmetric contour of the calyx the species may be compared with *M. benedeni* and *M. mespiliformis* of Fraipont from the Belgian Upper Devonian area.

Horizon and Locality. Same as last.

Melocrinus whittakeri n. sp.

Plate XXIV, figures 14-17

A medium-sized species, the average of three specimens being about 23 mm. high by 19 mm. wide at the arm bases, but the base not exceeding 3 mm. wide at the column facet. Calyx elongate ovoid, contracting strongly below to a very narrow base, and also between the rays into the tegmen; it is strongly asymmetrical, swelling more at one side than the other. Plates smooth or slightly rugose, flat, with a slight tendency to pitting at the angles, but without convexity or median elevation, either in dorsal cup or tegmen. Base low, saucer shape, spreading broadly from a very small column facet, which is in marked contrast with that of the two preceding species. Tegmen very low, not over one-tenth the total height of calyx, and almost flat, except for the elevation around the subcentral arial opening, which was apparently without a tube.

This species, from a different locality and probably a different horizon from the preceding, is readily distinguished from them and from all others known by its marked ovoid contour, and extremely small column facet, which indicates a considerably different type of column from that of the genus as generally found. The tendency is usually to a broad base. None of the Belgian species is at all similar to this except in asymmetry. There are three well-defined specimens in which the characters are thoroughly constant.

Horizon and Locality. From beds at least 300 feet above the Simpson shale, and thought to be somewhat higher than the *M. borealis* horizon of Hay river, Upper Devonian. Trout river, about 15 miles above its confluence with the Mackenzie, North West Territories, Canada. Collector, E. J. Whittaker. There is some reason to believe that the horizon of this species may be close to, if not identical with, the upper horizon of the Hay River crinoids, from which the fragmentary *M. canadensis* was derived. Imperfect specimens among the present material strongly suggest the form of that species. The specific name is given in recognition of the discoverer, Mr. E. J. Whittaker, whose careful observations have greatly facilitated the study of the fine material collected by him at both the Hay River and the Trout River localities.

Hexacrinus humei n. sp.

Plate XXIV, figures 18, 19

A very small species, founded upon a single specimen from which the base is partly removed by fracture. The calyx is 10 mm. high above the base, 8 to 10 mm. wide at the level of the arm bases, and 5 mm. wide at the edge of the fractured base. From analogy of related species, the base presumably was low, with a projecting rim. Plates of the cup are smooth, and not convex. Tegmen, as usual in the genus, consisting mainly of large orals and modified ambulacrals, which are all more or less acuminate. Anal opening strongly excentric, and directed laterally.

This species, one of the smallest yet described, is associated with *Melocrinus kindlei* and *M. mackenzie,* and like them bears a remarkable resemblance to the Upper Devonian forms of Belgium. Its habitus is widely different from that of the well-known species from the Eifel limestone, but in the characters by which it differs most from them it approaches *Hexacrinus verrucosus* and *H. minor* of Dewalque in Fraipont[1] from the Frasnian at Senzielle. The latter is similarly minute, but differs in the strong gibbosity of the cup plates. The former is much larger and more robust. Our species differs from both in the lateral direction of the anal opening.

Horizon and Locality. Upper Devonian, Leiorhynchus zone. Root river, North West Territories, Canada. Collector, G. S. Hume, in whose honour I have named the species, which is of especial interest, not only for the emphatic way in which it confirms the correlation of this fauna, but also for the extremely rare occurrence of the genus in America.

[1] Annales de la Soc. geol. de Belg. t. XI, 1884, pp. 108-110, Pl. 1, figs. 3, 4.

PLATE I

Schuchertella girtyi n. sp.

FIGURES 1 a, b, c. Pedicle, side, and cardinal views of the type specimen. Section 2, locality 38. (Page 34.)

Cyrtia standlyensis n. sp.

FIGURES 2 a, b, c, d, e. Cardinal, pedicle, brachial, side, and anterior views of the type specimen. Section 2, locality 38. (Page 62.)

FIGURE 3. Brachial view with the foramen of the pedicle valve projecting above it. Section 2, locality 38. (Page 62.)

FIGURES 4 a, b. Side and pedicle views of another specimen. Section 2, locality 38. (Page 62.)

FIGURE 5. Side view of a large specimen. Section 2, locality 38. (Page 62.)

Productus minnewankensis n. sp.

FIGURES 6 a, b, c. Ventral, lateral, and umbonal views of the type specimen. Section 2, locality 38. (Page 40.)

FIGURE 7. Posterior view of another pedicle valve, X 2½. Section 2, locality 38. (Page 40.)

Spirifer centronatus minnewankensis n. var.

FIGURES 8 a, b. Pedicle and umbonal views of the type specimen. Section 2, locality 25. (Page 52.)

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Plate I

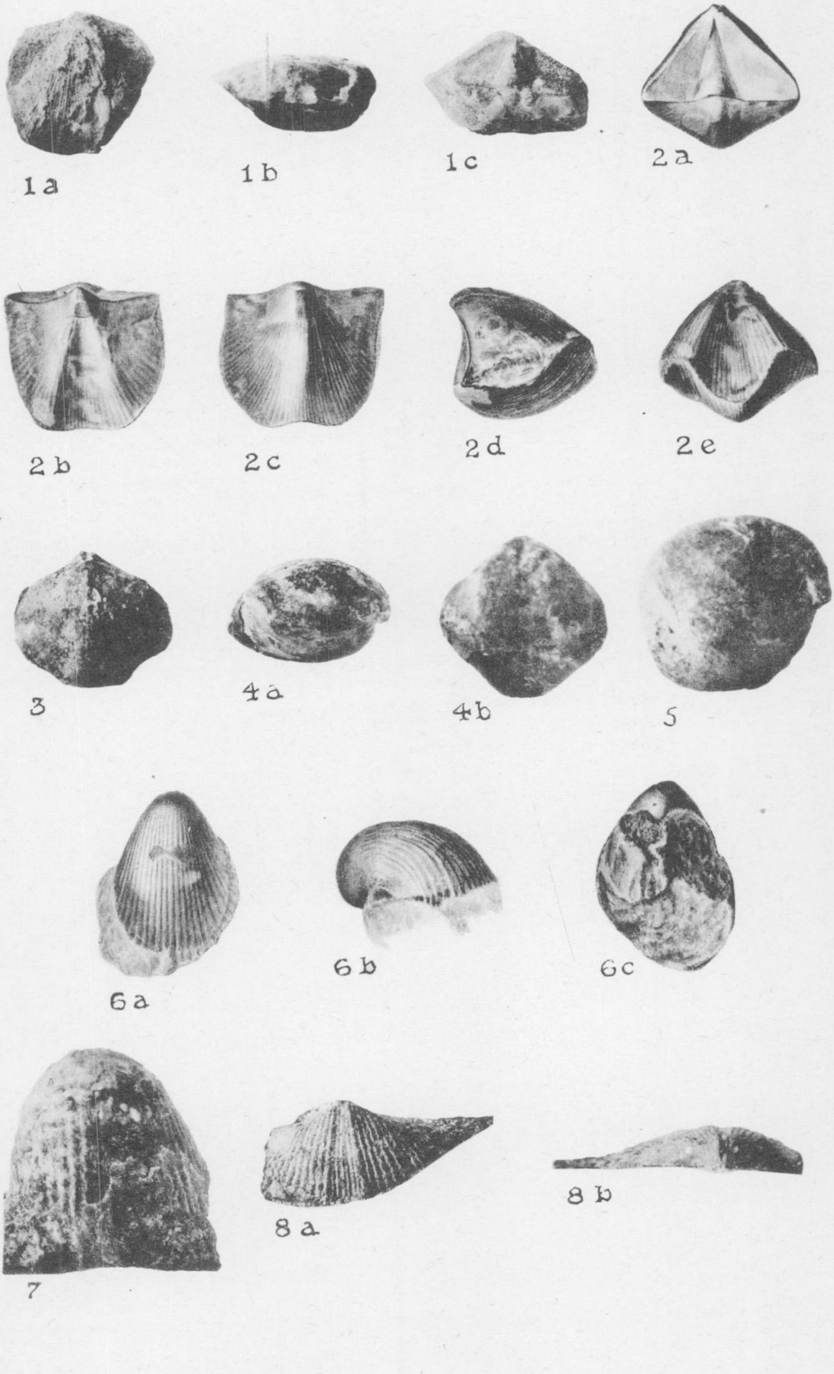


Plate II

Plate to show the evolution of *Spirifer centronatus* Winchell above, from *Spirifer albapinensis* Hall and Whitfield, below. The illustrations are arranged somewhat according to the thickness of the strata in which they occur. *S. albapinensis* occurs in locality 35, 215 feet thick, to the exclusion of *S. centronatus*. The latter species appears in locality 34 and continues in great abundance from there up through locality 22, a vertical distance of 775 feet of limestones and shales. The young in the higher beds show the broad plications bounding the median sinus characteristic of *S. albapinensis*. No specimen collected from localities 34 and 35 was sufficiently well preserved for illustration.

Figures 1, 2, 3. Pedicle views of *Spirifer centronatus*, showing change of plications from youth to maturity. Section 2, locality 23. (Page 51.)

Figures 4, 5, 6. The same. Section 2, locality 25. (Page 51.)

Figures 7, 8, 9. The same. Section 2, locality 29. The plications bounding the median sinus remain broad and strongly developed for a longer time than in the higher beds. (Page 51.)

Figures 10, 11. The same. Section 2, locality 32. (Page 51.)

Figure 12. A rather small but typical example of *Spirifer albapinensis*. Our larger specimens from this locality are too imperfect for illustration. Section 2, locality 35. (Page 49.)

Figures 13, 14. Young and mature specimens of *Spirifer albapinensis*. Section 2, locality 35. (Page 49.)

Feet	Section Number
20	23
25	24
20	25
50	26
35	27
25	28
50	29
75	30
130	31
60	32
70	33
285	34
215	35

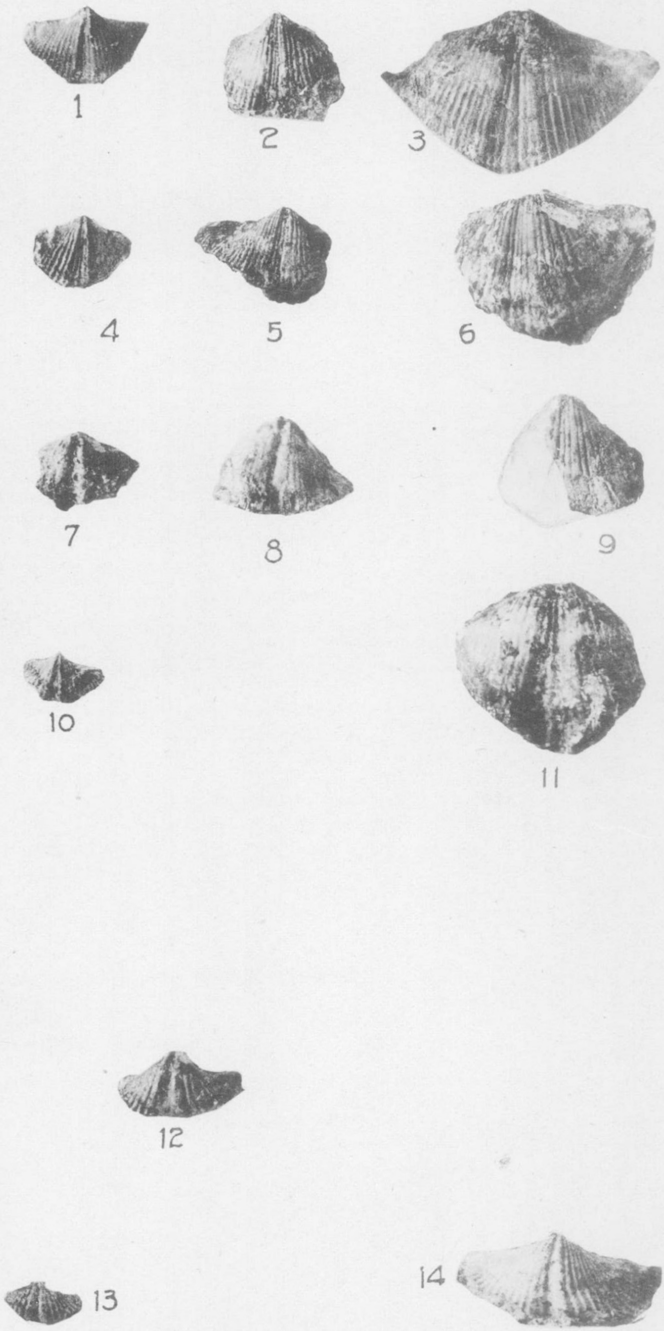


Plate III

Spiriferella minnewankensis n. sp.

Figures 1 a, b, c, d. Brachial, cardinal, pedicle, and side views of the type specimen. Section 2, locality 23. (Page 64.)

Figures 2 a, b, c. Pedicle, side, and cardinal views of another specimen. Section 2, locality 23. (Page 64.)

Ambocoelia magna n. sp.

Figures 3 a, b, c. Side, umbonal, and ventral views of a pedicle valve of the type specimen, X 2. Section 2, locality 35. (Page 66.)

Figures 4 a, b. Side and ventral views of a pedicle valve. Section 2, locality 35. (Page 66.)

Squamularia depressiplicata n. sp.

Figures 5 a, b, c. Lateral, pedicle, and postero-lateral views of the imperfect type specimen. Section 2, locality 24. (Page 68.)

Figures 6, 7. Views of an imperfect brachial valve and of a pedicle valve, showing the depressed plications. Section 2, locality 24. (Page 68.)

Plate III

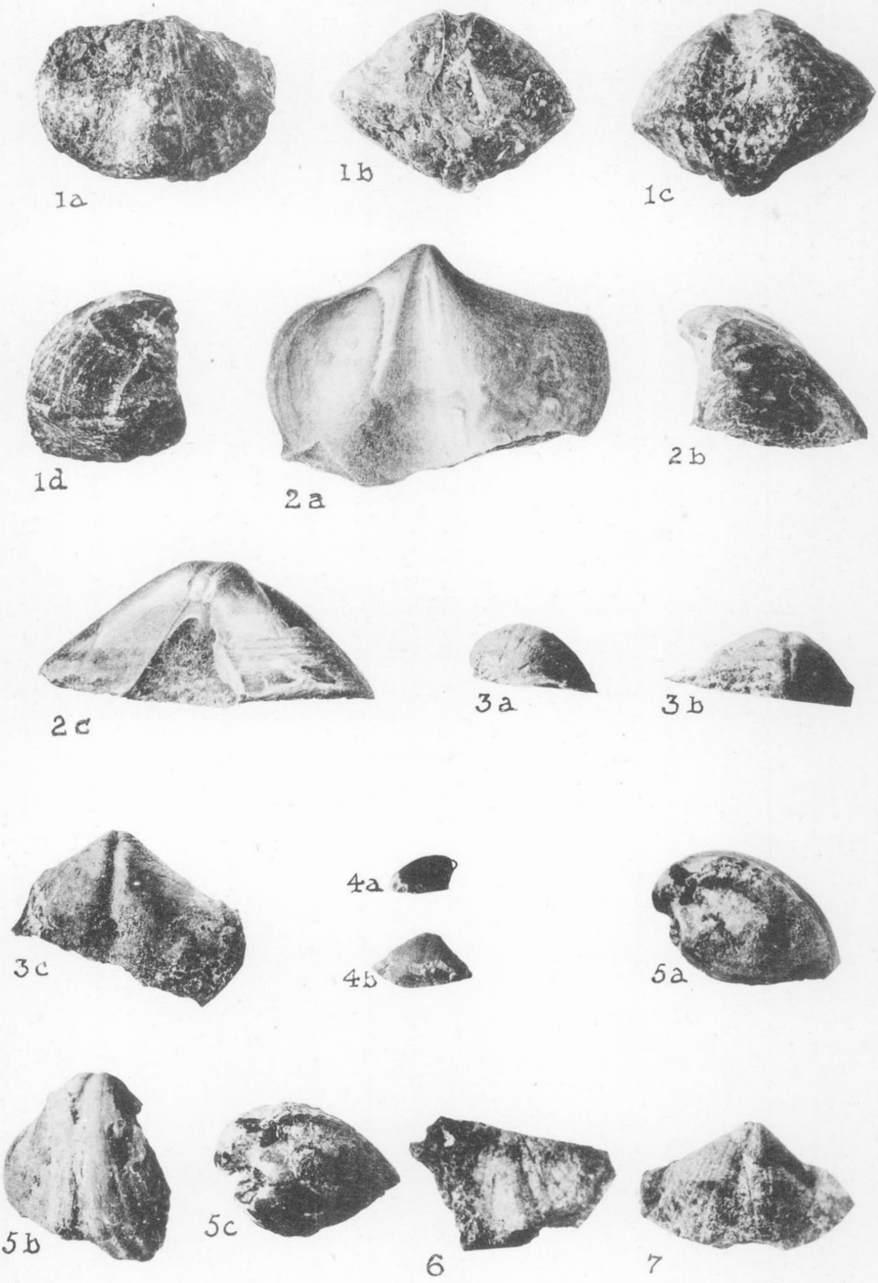


Plate IV

Cleiothyridina lata n. sp.

Figures 1 a, b, c. Anterior, brachial, and side views of the type specimen, slightly imperfect. Section 2, locality 35. (Page 71.)

Myalina mississippiensis n. sp.

Figures 2, 3, 4, 5, 6, 7. Views of separate left valves. Figure 5 is a side view showing the convexity of the valve; Figure 6 is a young shell showing the small anterior ear. Figure 4 is designated as the type. Section 2, locality 22. (Page 75.)

Allorisma albertense n. sp.

Figures 8 a, b, c, d. Drawings and photographs of the right valve and of the anterior end of the type specimen. Section 2, locality 24. (Page 77.)

Loxonema rockymontanum n. sp.

Figures 9 a, b. Two views of the type specimen, lacking the last whorl. Section 2, locality 25.

Figure 10. View of the anterior whorl of a mature specimen. Section 2, locality 25. (Page 81.)

Conularia alternistriata n. sp.

Figure 11 a, b. Two side views of the species, X 2¾. Section 2, locality 25. (Page 84.)

Plate IV

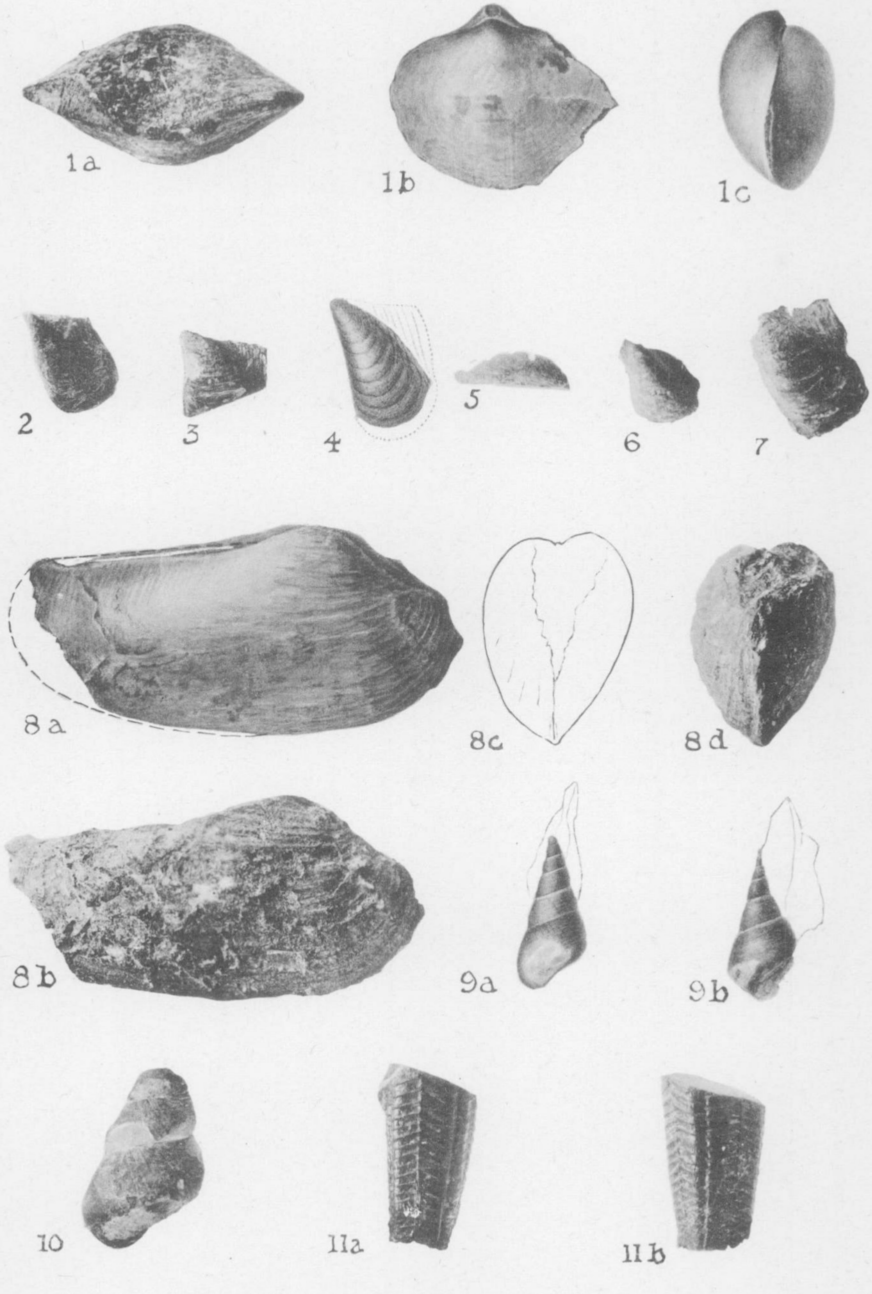


Plate V

Triplophyllum minnewankensis n. sp.

Figure 1. View of calyx of type specimen, slightly enlarged. Section 3 a, locality 3. (Page 25.)

Figure 2. Lateral view of probably the same species. Section 3 a, locality 3. (Page 25.)

Lithostrotion pennsylvanicum n. sp.

Figures 3, 4. View of calices of several individuals and a longitudinal section through others. (Page 27.)

Figure 5. Longitudinal section through corallite, X 2. This section, drawn from several specimens, shows the anter vesicular zone (dissepiments), and the central, sharp, narrow columella terminating the cone-shaped tabulæ. (Page 27.)

Aulopora curva n. sp.

Figure 6. View of a broken colony. Section 1, locality 24. (Page 29.)

Figure 7. Lateral view to show shape of corallites and method of branching. Section 1, locality 24. (Page 29.)

Figure 8. Longitudinal section to show the partial separation of the young corallite from the parent by a thickening of the walls. Section 1, locality 24. (Page 29.)

Plate V

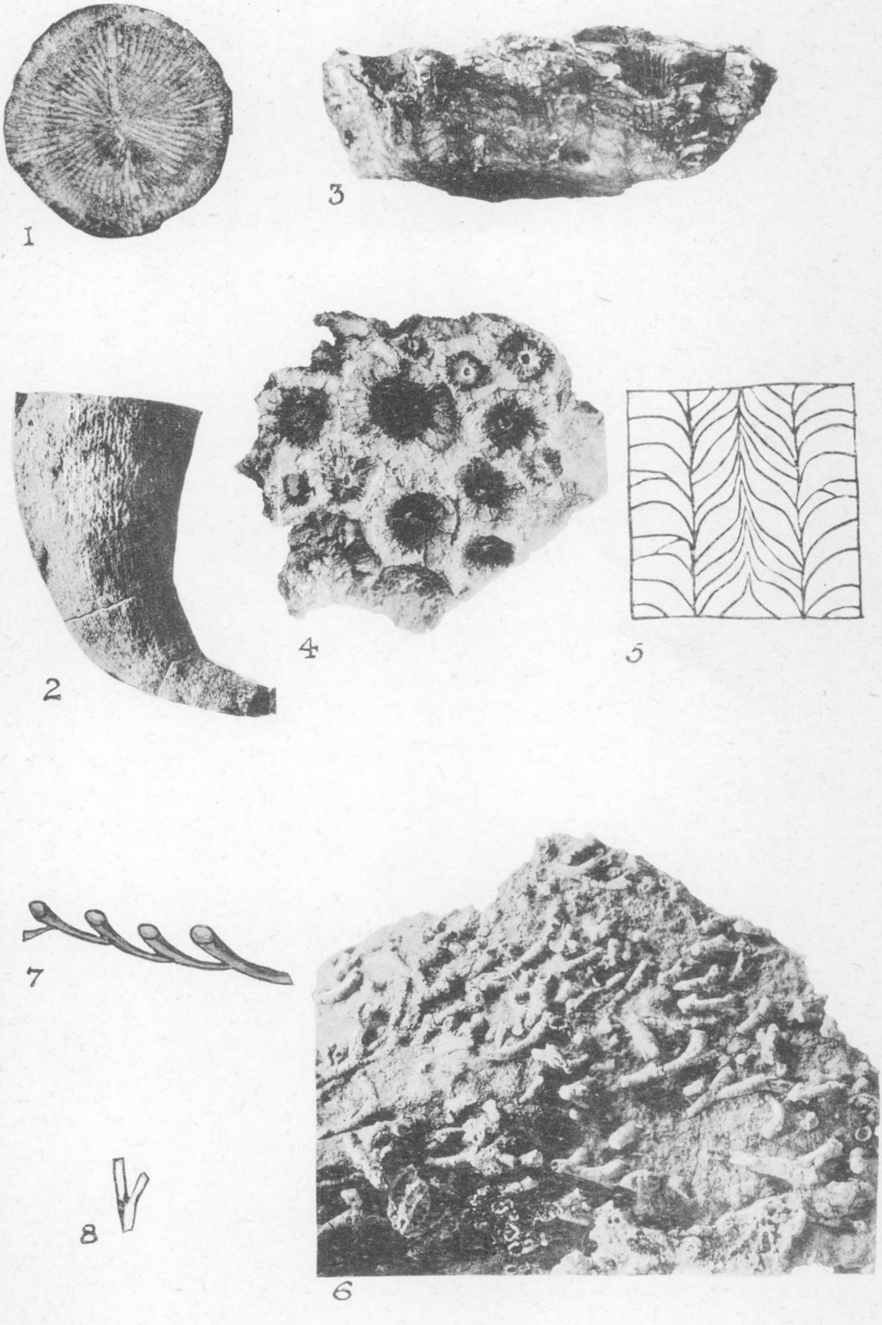


Plate VI

Syringopora pennsylvanica n. sp.

Figure 1. Top view of a colony (the type specimen), showing diameter and spacing. Section 4, locality 2. (Page 31.)

Figure 2. Lateral view of two corallites of probably the same species. Section 2, locality 6. (Page 31.)

Figures 3, 4. A longitudinal and a transverse section. Section 4, locality 2. (Page 31.)

Orbiculoidea arenaria n. sp.

Figure 5. View of inner surface of pedicle valve of type specimen. Section 1, locality 14. (Page 31.)

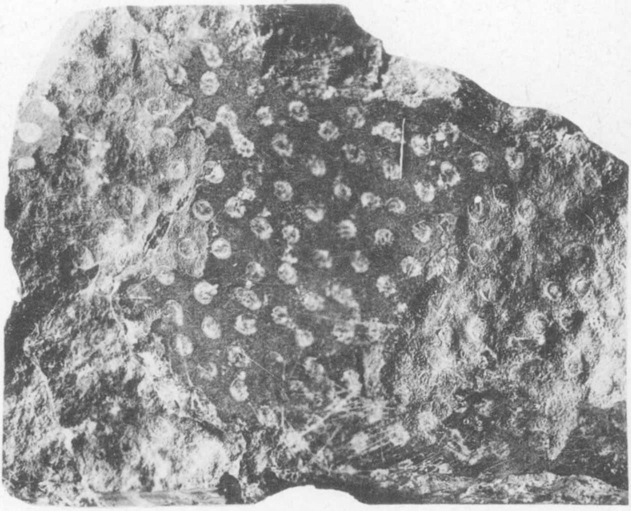
Figure 6. Side view of exterior of brachial valve. Section 1, locality 14. (Page 31.)

Schellwienella lata n. sp.

Figure 7. View of exterior of brachial valve. Type specimen. Section 2, locality 12. (Page 35.)

Figure 8. Exterior of two pedicle valves (concave) and two brachial valves. Section 2, locality 12. (Page 35.)

Plate VI



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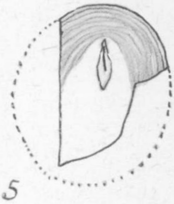

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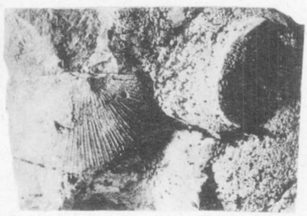

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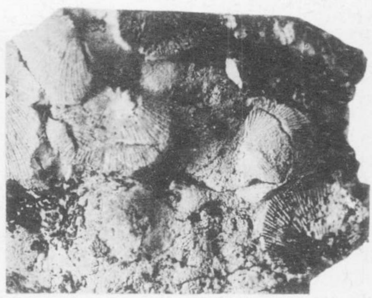

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Plate VII

Paraphorhynchus obscurum n. sp.

Figure 1. View of internal mould of pedicle valve, showing the strength of the teeth, the ridges bounding the muscle valve, and the median septum. Section 1, locality 14. (Page 46.)

Figures 2, 3. View of internal mould of brachial valve and side view of internal mould of combined valves. Section 1, locality 14. (Page 46.)

Spirifer rockymontanus Marcou

Figures 4 a, b. Lateral and ventral views of a pedicle valve of the average size. Section 2, locality 12. (Page 54.)

Figures 5, 6. Views of pedicle valves. Figure 6 is a large internal mould. Section 2, locality 12. (Page 54.)

Figures 7 a, b, c. Cardinal, ventral, and lateral views of a pedicle valve. Section 2, locality 12. (Page 54.)

Figures 8, 9, 10. Views of brachial valves. Section 2, locality 12. (Page 54.)

Deltopecten occidentalis latiformis n. var.

Figures 11 a, b. Views of the external and internal moulds of the type specimen. Section 1, locality 14. (Page 76.)

Figure 12. View of internal mould formed with both valves in place and closed. The posterior portion is imperfect. Section 1, locality 14. (Page 76.)

Euphemus carbonarius arenarius n. var.

Figure 13. View of the type specimen. The outer whorl is lacking medially. Section 1, locality 10. (Page 79.)


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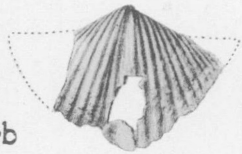
4a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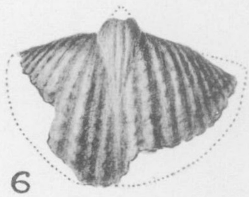
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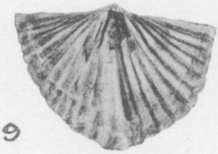
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11a


11b


12


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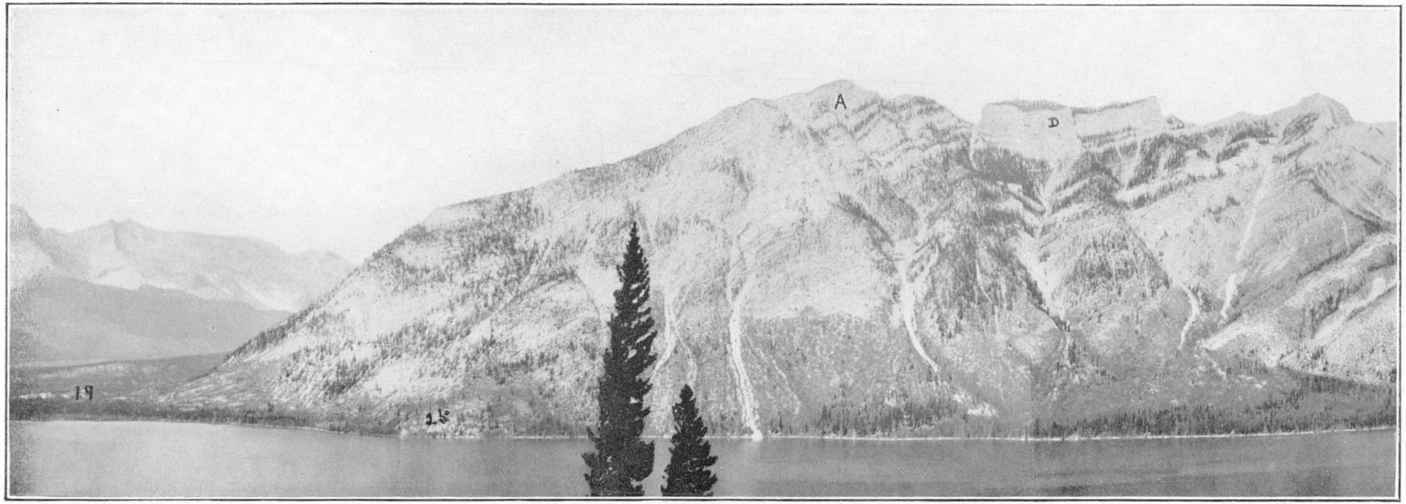

View of mountains upon the northern side of lake Minnewanka, taken from the south shore about 1½ miles east of the western end of the lake. A=mount Astley; D=the Castle; 19 and 25=the approximate locations of localities 19 and 25 of section 2. (Page 10.)

PLATE IX

Terebratula suttonensis Clapp and Shimer

FIGURE 1. Pedicle valve showing at the front the three longitudinal folds with their included two sinuses; also the low, broad growth ridges upon the middle of the valve. X 1. (Page 86.)

Pleuromya pearsonensis n. sp.

FIGURE 2. View of the type specimen. Right valve somewhat crushed; hinge-area broken away. X 1. (Page 86.)

Megalodon canadensis n. sp.

FIGURE 3. View of type specimen. Right valve showing stronger and finer growth lines, cast of cavity beneath the posterior portion of the dental platform, and to the left of this the upward bending of the hinge-area of the valve, a portion of the shell here still remaining in place. X $\frac{3}{4}$. (Page 87.)

FIGURE 4. Reconstruction of a valve; cross-section from posterior part of hinge-line to base; showing groove beneath dental platform. X 1. (Page 87.)

Turcicula mccanni n. sp.

FIGURE 5. View of type specimen. The knobs at the outer angle of the whorls are more conspicuous than appears in the photograph. Tip of shell wanting. X $1\frac{1}{6}$. (Page 87.)

Plate IX

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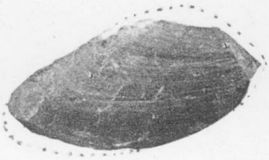

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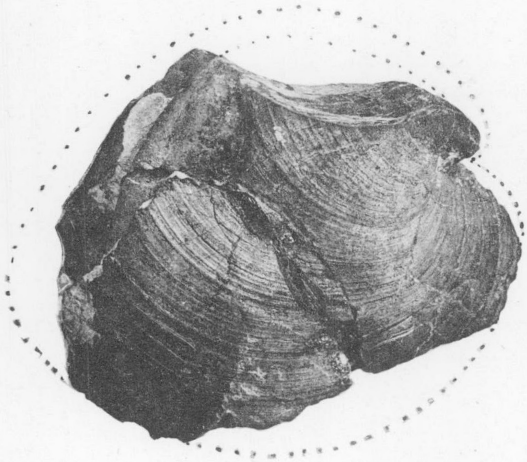

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PLATE X

Taxodium occidentale Newberry

FIGURE 1. From Newhykulston creek. (Page 97.)

Woodwardia maxoni Knowlton

FIGURES 2, 3. From Newhykulston creek. Enlarged sterile and fertile pinnules are shown in figure 3. (Page 95.)

Pinus trunculus Dawson

FIGURE 4. Seed from Joseph creek. (Page 98.)
FIGURE 5. Leaves from Darlington creek. (Page 98.)

Comptonia predryandroides Berry n. sp.

FIGURE 6. From Joseph creek. (Page 100.)

Acer macropterum Heer

FIGURE 7. From Joseph creek. (Page 113.)

Plate X

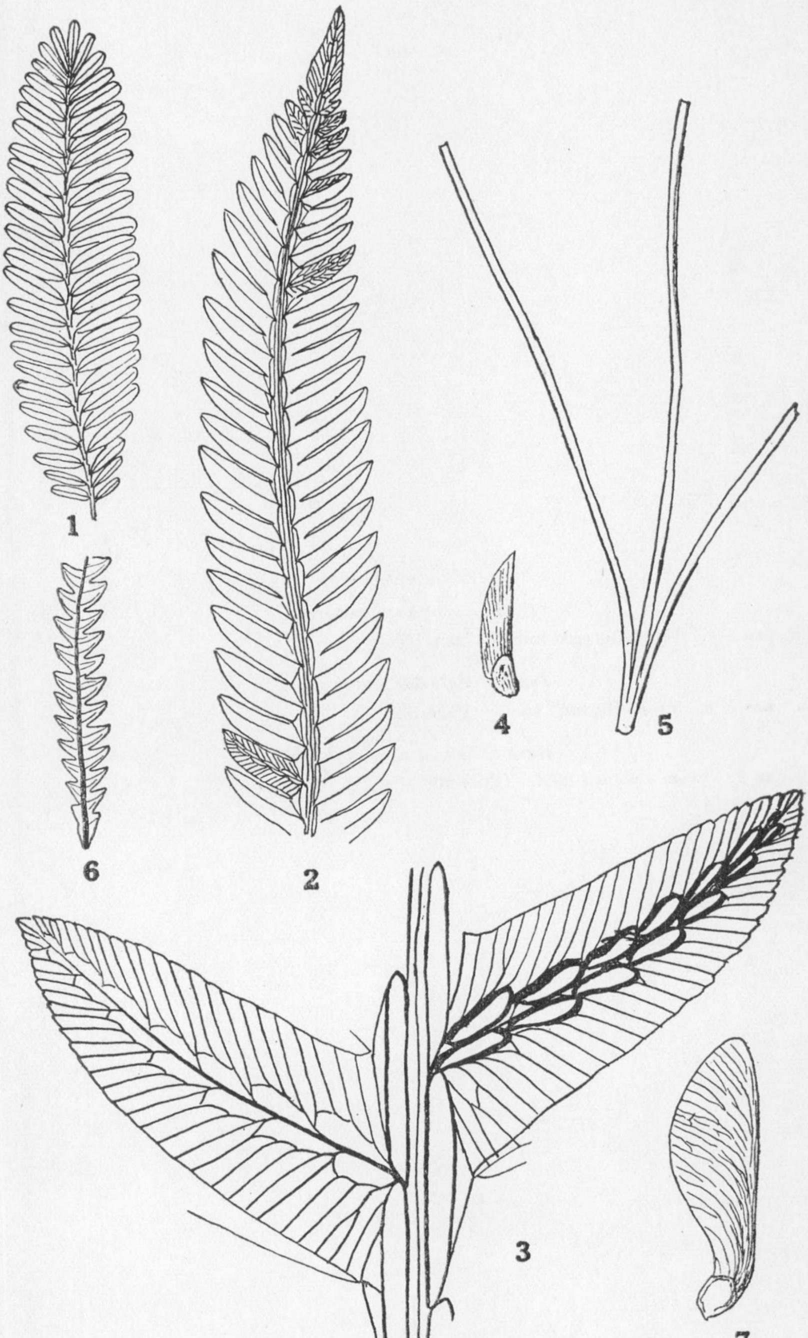

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PLATE XI

Quercus simplex Newberry

FIGURES 1–4. From Burrard inlet. (Page 107.)

Juglans nigelloides Berry n. sp.

FIGURES 5, 6. From Burrard inlet. (Page 102.)

Ficus (?) johnstoni Berry n. sp.

FIGURE 7. From Burrard inlet. (Page 108.)

Plate XI

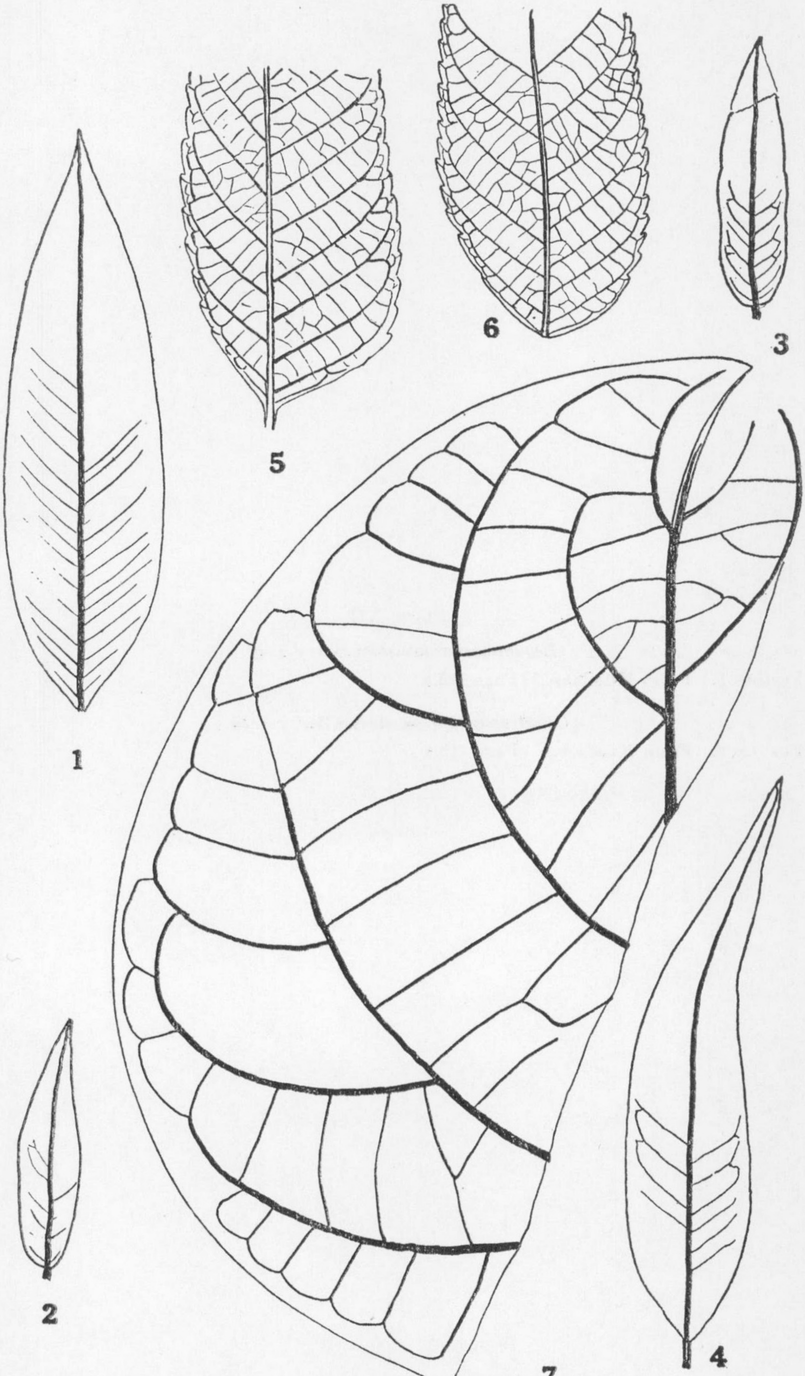

PLATE XII

Leguminosites johnstoni Berry n. sp.

FIGURE 1. From Kitsilano. (Page 112.)

Celastrophyllum pugetensis Berry n. sp.

FIGURE 2. From Kitsilano. (Page 112.)

Plate XII

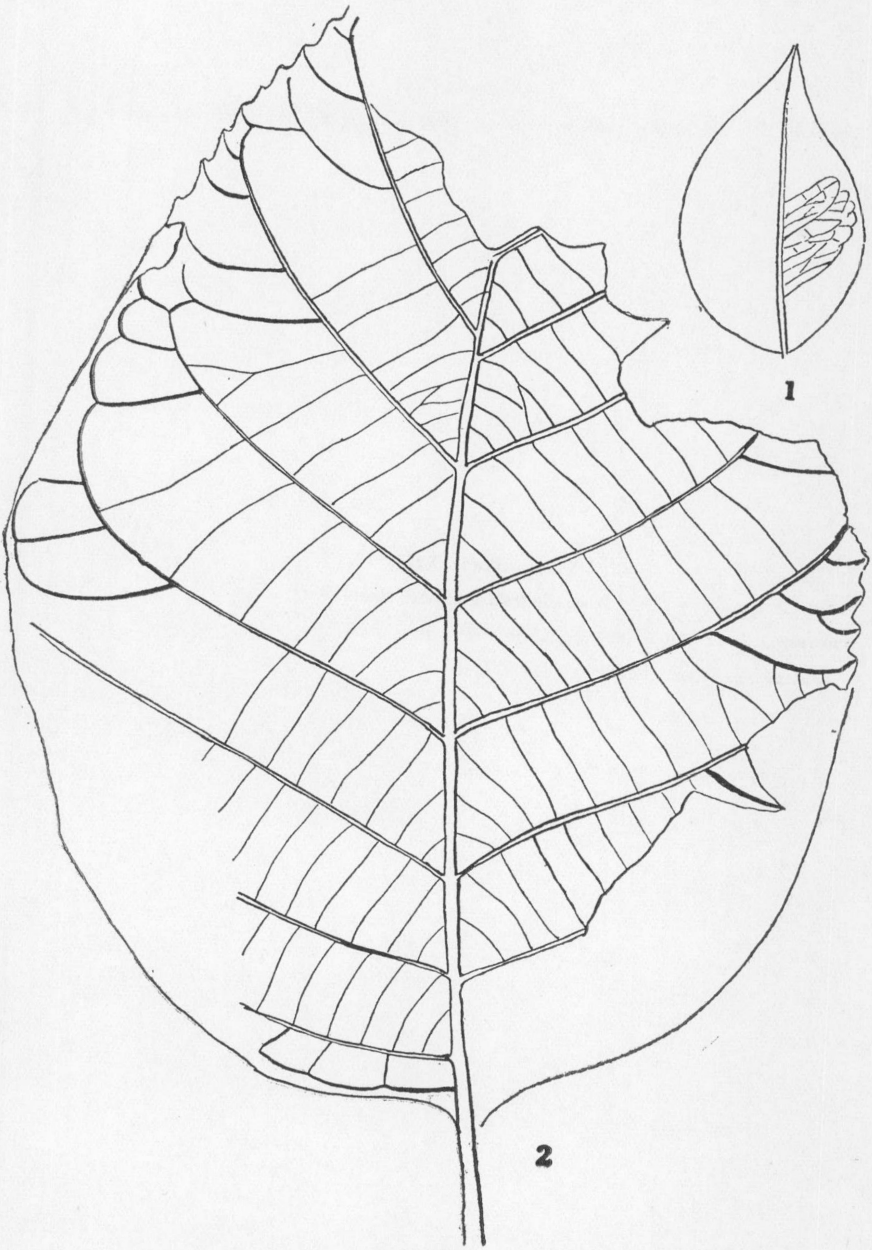

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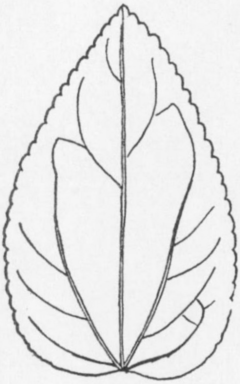
PLATE XIII

Trochodendroides arctica (Heer) Berry

FIGURES 1–4. From Kitsilano. (Page 109.)

Plate XIII



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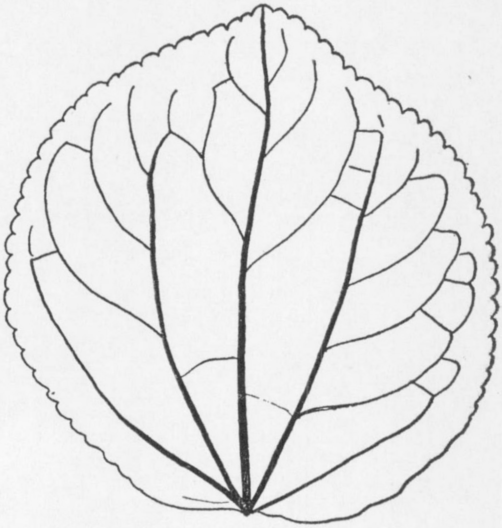

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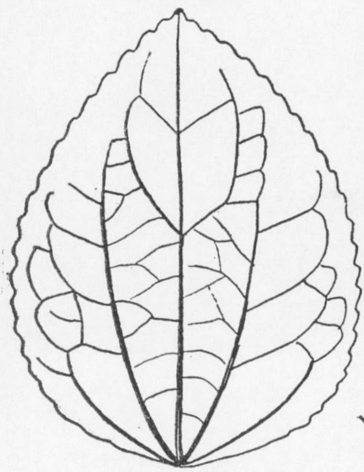

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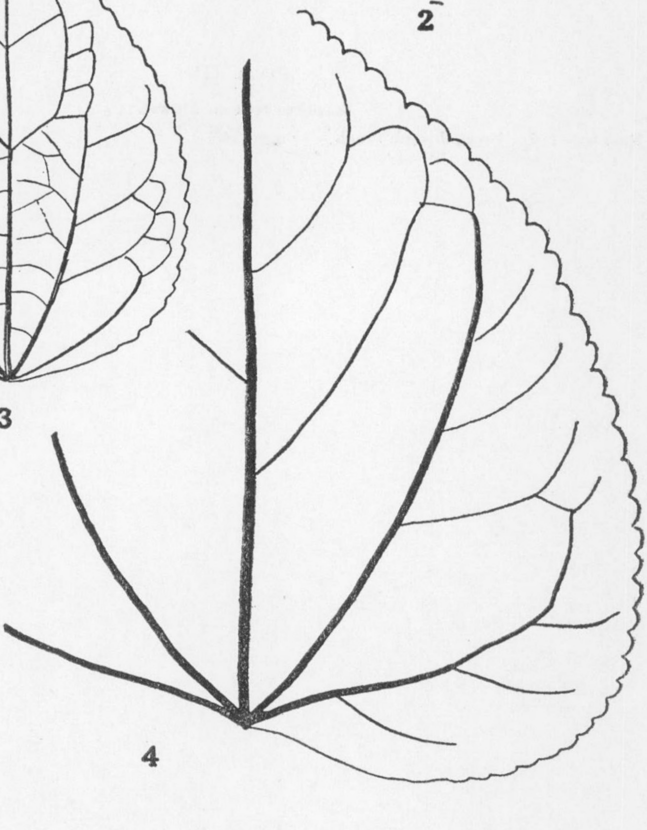

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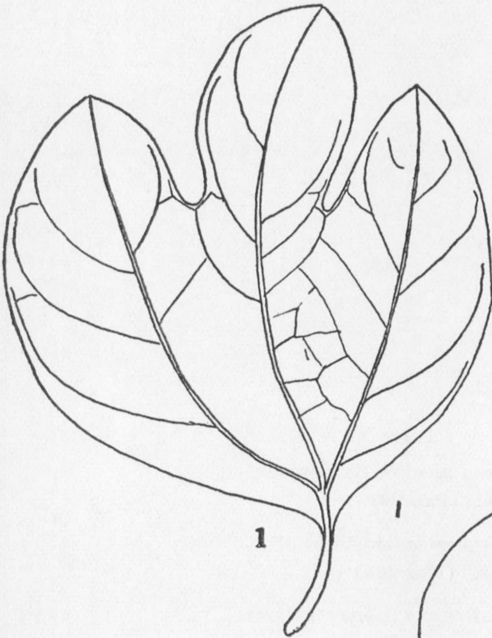
PLATE XIV

Sassafras selwyni Dawson

FIGURES 1–4. From Joseph creek. (Page 114.)

Plate XIV



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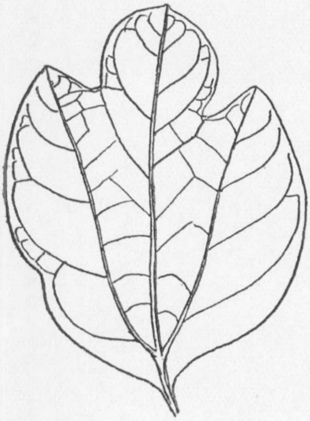

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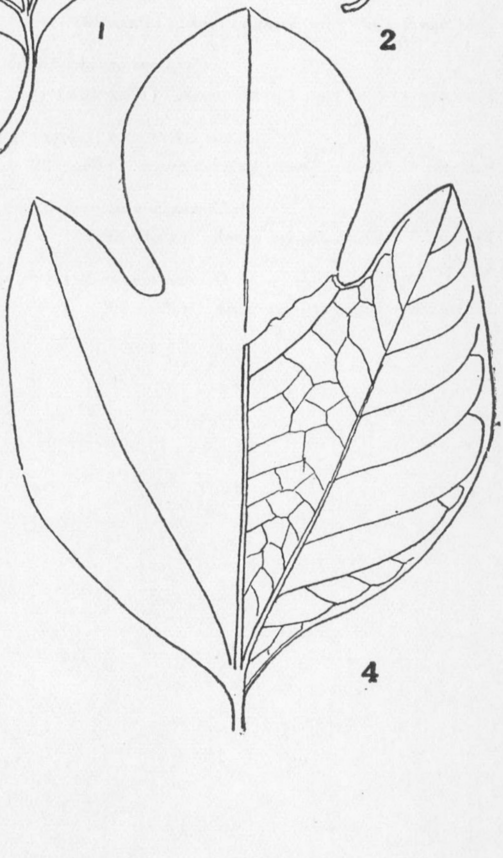

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Plate XV

Betula parvifolia Berry n. sp.

Figures 1–3. From Joseph creek. (Page 103.)

Carpinus grandis Unger (?)

Figures 4, 5. From Joseph creek. (Page 104.)

Alnus kefersteinii (Göppert) Unger (?)

Figure 6. From Newhykulston creek. (Page 105.)

Ulmus columbianus Berry n. sp.

Figure 7. From Joseph creek. (Page 108.)

Quercus uglowi Berry n. sp.

Figure 8. From Joseph creek. (Page 107.)

Plate XV

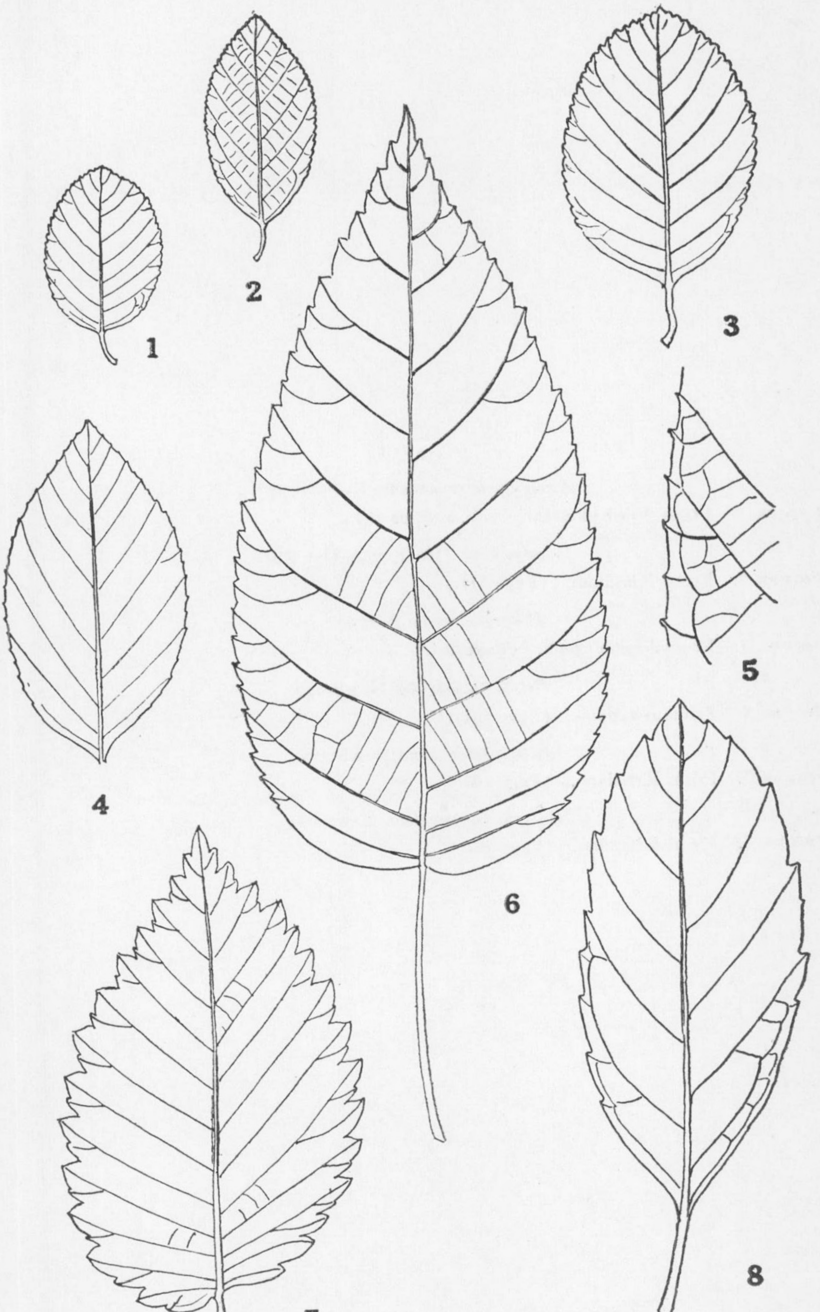


Plate XVI

Alnus cremastogynoides Berry n. sp.

Figure 1. From Newhykulston creek. (Page 104.)

Cocculus kanii (Heer) Sap. and Mar.

Figure 2. From Kitsilano. (Page 111.)

Hicoria dawsoni Berry n. sp.

Figure 3. From Joseph creek. (Page 101.)

Betula angustifolia Newberry

Figure 4. From Kitsilano. (Page 104.)

Betula heterodonta Newberry

Figure 5. From Kitsilano. (Page 103.)

Quercus banksiaefolia Newberry

Figure 6. From Kitsilano. (Page 107.)

Plate XVI

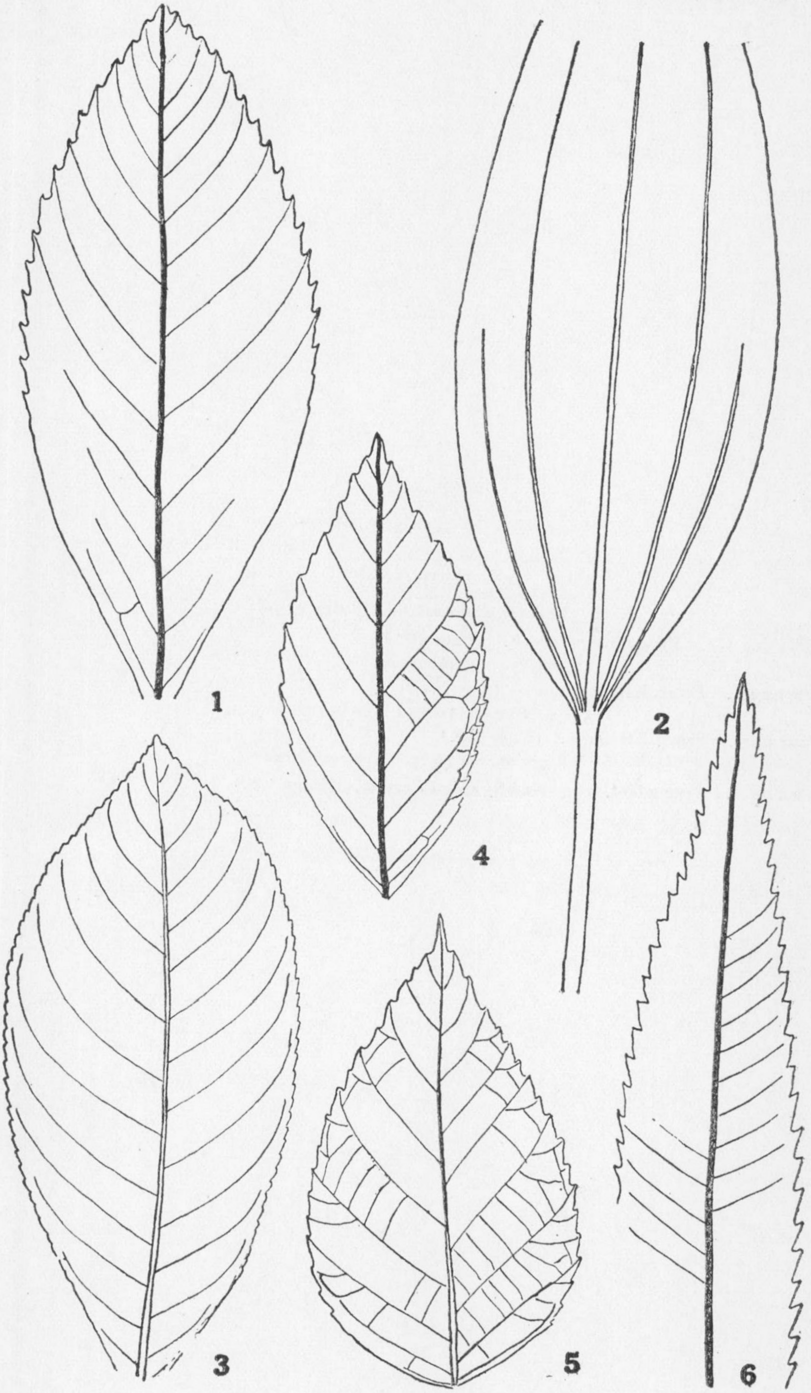


Plate XVII

Populus acuminatafolia Berry n. sp.

Figures 1–3. From Joseph creek. (Page 102.)

Betula sp.

Figure 4. From Kitsilano.

Planera nervosa Newberry

Figure 5. From Kitsilano. (Page 109.)

Corylus macquarrii (Forbes) Heer

Figure 6. Young leaf, from Newhykulston creek. (Page 105.)

Plate XVII

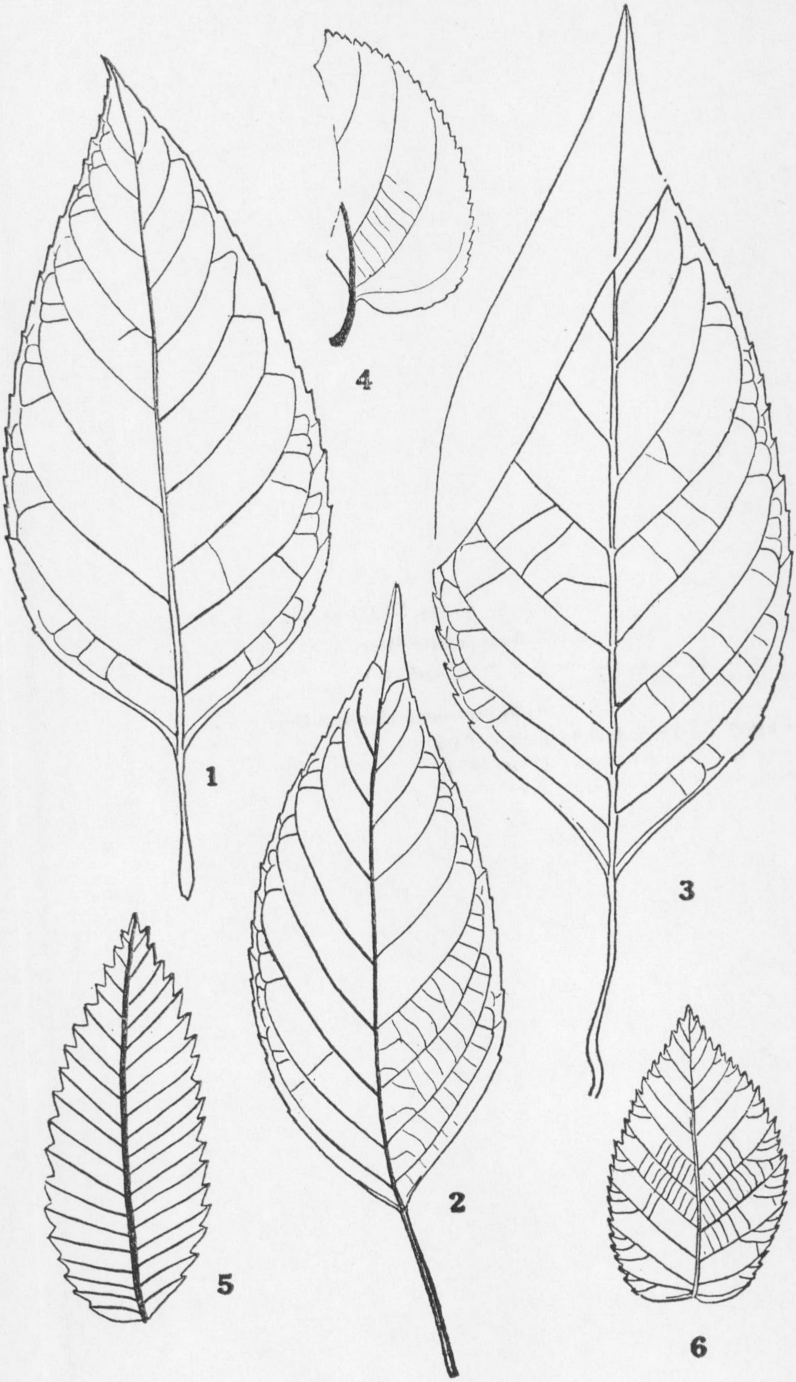


Plate XVIII

Myrica uglowi Berry n. sp.

Figure 1. From Joseph creek, X 2. (Page 100.)

Corylus macquarrii (Forbes) Heer

Figures 2, 3. From Joseph creek. (Page 105.)
Figure 4. From Kitsilano. (Page 105.)

Plate XVIII

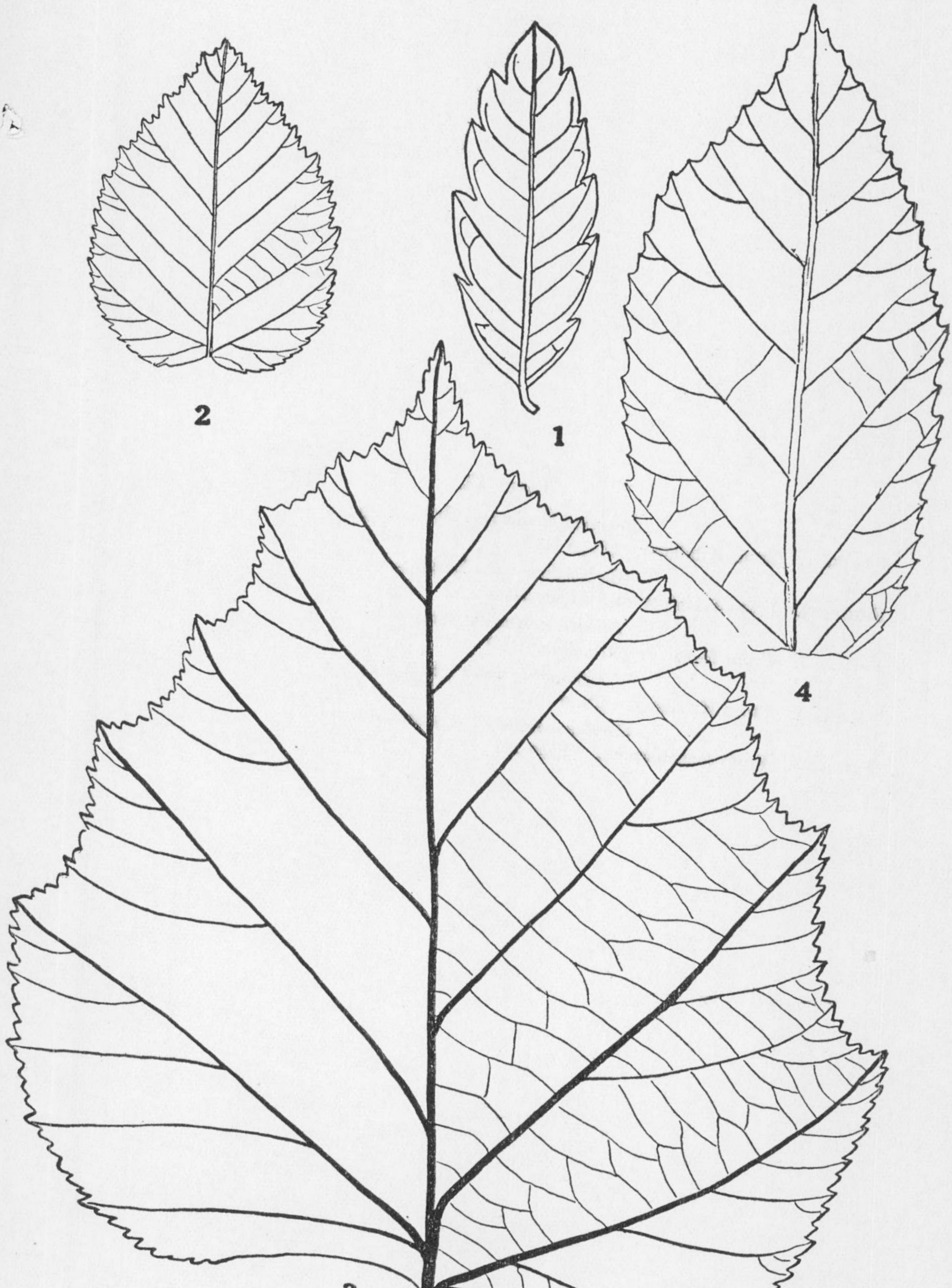


PLATE XIX

Rhamnus kitsilaniana Berry n. sp.

FIGURE 1. From Kitsilano. (Page 113.)

Sorbus decorafolia Berry n. sp.

FIGURE 2. From Joseph creek. (Page 111.)

Diospyros dawsoni Berry n. sp.

FIGURE 3. From Joseph creek. (Page 115.)

Carpinus grandis Unger (?)

FIGURE 4. From Kitsilano. (Page 104.)

Corylus macquarrii (Forbes) Heer

FIGURE 5. From Joseph creek. (Page 105.)

Plate XIX

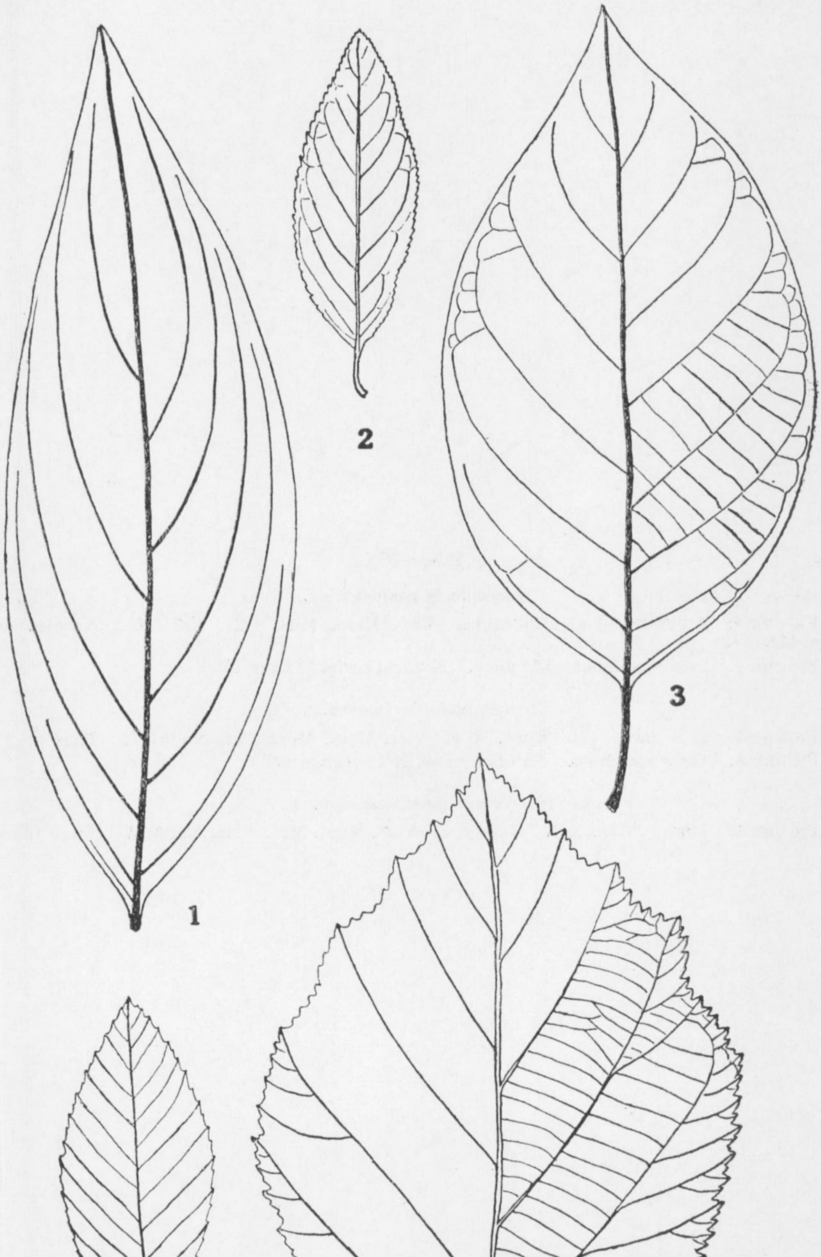


PLATE XX

Inoceramus pontoni n. sp.

FIGURE 1. Anterior view of holotype. Vict. Mem. Mus., Cat. No. 6103. Natural scale. (Page 121.)

FIGURE 2. Same specimen, side view. Natural scale. (Page 121.)

Inoceramus albertensis n. sp.

FIGURE 3. Left valve. Holotype, X ½. Vict. Mem. Mus., Cat. No. 6107. (Page 123.)

FIGURE 4. Same specimen. Anterior view, X ½. (Page 123.)

Inoceramus dunveganensis n. sp.

FIGURE 5. Right valve, X ½. Holotype. Vict. Mem. Mus., Cat. No. 6106. (Page 122.)

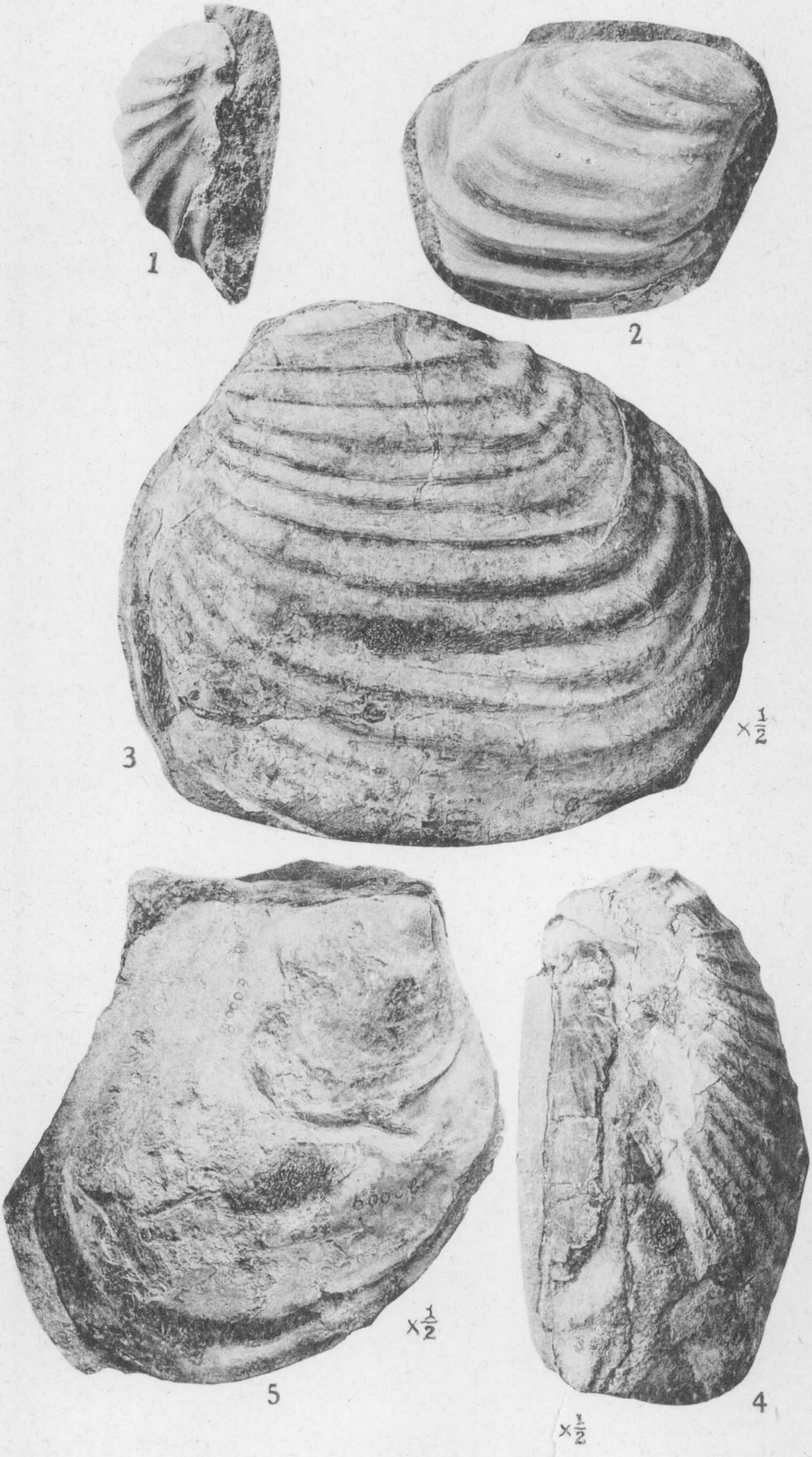

1
2
3
×1/2
5
×1/2
4
×1/2

Plate XXI

Inoceramus coulthardi n. sp.

Figure 1. Anterior view of left valve. Holotype. Vic. Mem. Mus., Cat. No. 6104. Natural scale. (Page 121.)

Figure 2. Same specimen. Dorsal view. Natural scale. (Page 121.)

Figure 3. Same specimen. Side view. Natural scale. (Page 121.)

Figure 4. Same specimen. Enlarged drawing, X 3, to show ligamentary pits. (Page 121.)

Inoceramus corpulentus n. sp.

Figure 5. Side view of left valve. Holotype. Vict. Mem. Mus., Cat. No. 6108. Natural scale. (Page 123.)

Figure 6. Anterior view of right valve. Paratype. Vict. Mem. Mus., Cat. No. 6109. Natural scale. (Page 123.)

Figure 7. Same specimen as in figure 5. Anterior view. Natural scale. (Page 123.)

Inoceramus selwyni n. sp.

Figure 8. Dorsal view of both valves. Holotype. Vict. Mem. Mus., Cat. No. 6105. Natural scale. (Page 122.)

Figure 9. Same specimen. Side view of left valve. Natural scale. (Page 122.)

Plate XXI

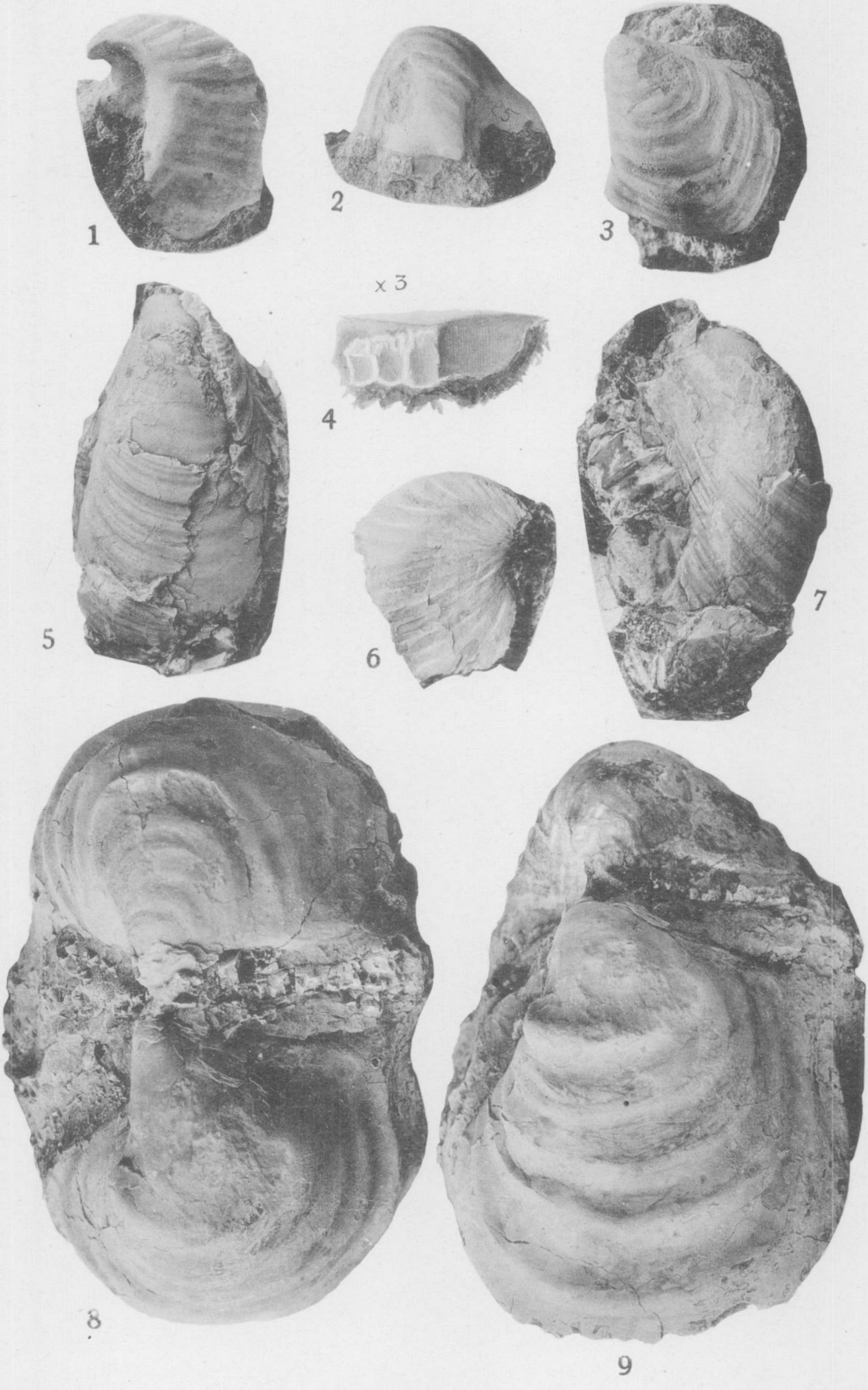


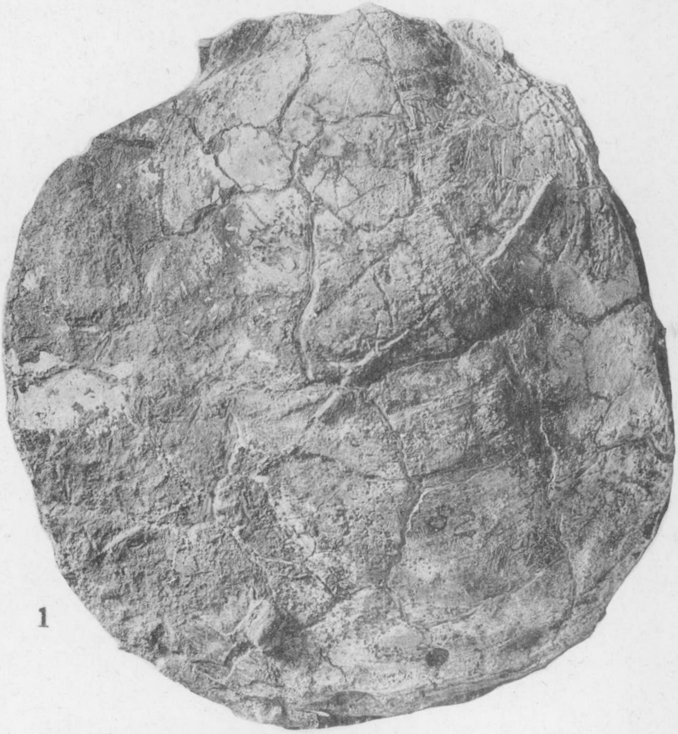
PLATE XXII

Pecten silentiensis n. sp.

FIGURE 1. Left valve of holotype. Vict. Mem. Mus., Cat. No. 6110. Natural scale. (Page 124.)

FIGURE 2. Same specimen. Right valve. Natural scale. (Page 124.)

Plate XXII



1

2

Plate XXIII

Corbicula dowlingi n. sp.

Figure 1. Right valve of holotype. Vict. Mem. Mus., Cat. No. 6191. Natural scale. (Page 125.)

Figure 2. Same specimen. Dorsal view. Note external ligament. Natural scale. (Page 125.)

Modiolus silentiensis n. sp.

Figure 3. Right valve. Paratype. Vict. Mem. Mus., Cat. No. 6112. Natural scale. (Page 125.)

Figure 4. Right valve. Holotype. Vict., Mem. Mus., Cat. No. 6190. Natural scale. (Page 125.)

Rhytophorus? caurinus n. sp.

Figure 5. Drawing, X 2. Holotype. Vict. Mem. Mus., Cat. No. 6192. Natural scale. (Page 125.)

Prionotropis caurinus n. sp.

Figure 6. Side view. Holotype. Vict. Mem. Mus., Cat. No. 6193. Natural scale. (Page 126.)

Figure 7. Same specimen. Ventral view. Note keel. Natural scale. (Page 126.)

Pecten silentiensis n. sp.

Figure 8. Posterior view of holotype. See Plate XXII, figures 1, 2. Natural scale. (Page 124.)

Pinna dolosoniensis n. sp.

Figure 9. Side view. Holotype. Vict. Mem. Mus., Cat. No. 6102. Natural scale. (Page 120.)

Plate XXIII

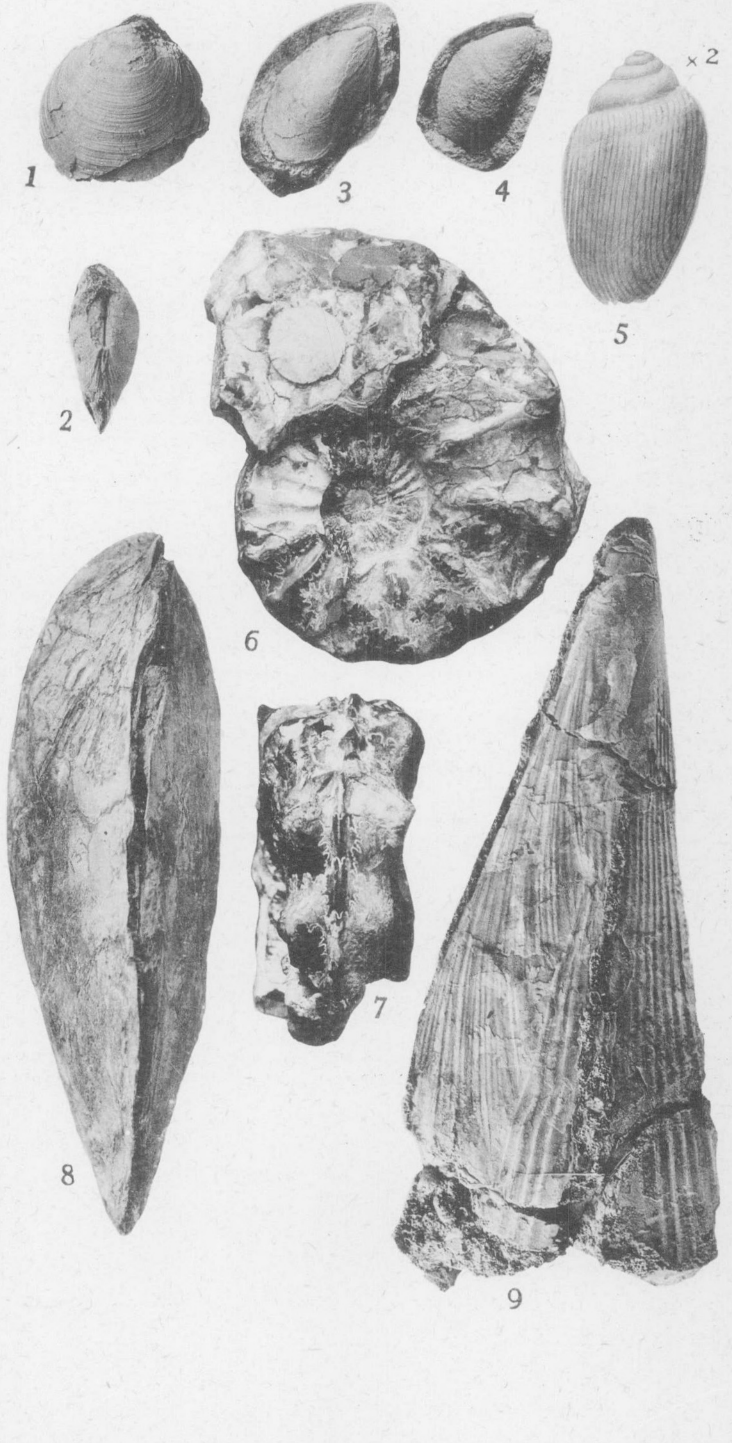


Plate XXIV

Melocrinus kindlei n. sp.

Figures 1, 2, 3. Three views of a maximum specimen, showing the extreme asymmetric proportion of the calyx, and its obliquity to the axis of the column: 1, from right posterior radius, showing anal opening; 2, from posterior interradius; 3, from the left anterior radius, showing large basal in that position; also the beginning of the doubled ray. (Page 130.)

Figures 4, 5, 6, 7. Four average specimens exhibiting different degrees of obliquity: 4, 5, left anterior and posterior interradial views, calyx strongly pitted at the angles, basals and radials at anterior side much higher than at posterior; 6, left anterior radial view, with large basal in that position, and beginnings of the two rami of which the ray is composed; 7, posterior interradial view. (Page 130.)

Figure 8. Basal view of another specimen, showing the division into four plates. (Page 130.)

Figure 9. Tegmen of another specimen, showing strongly rimmed anal opening. (Page 130.)

Root River locality.

Melocrinus mackenzie n. sp.

Figure 10. Left anterior radial view of a rotund specimen, showing short basals, rounded contour, and high tegmen, as contrasted with the last species. (Page 131.)

Figure 11. Left anterior interradial view of another specimen showing extreme obliquity of calyx. (Page 131.)

Figure 12. Tegmen of same specimen, showing small anal opening, probably without a tube. (Page 131.)

Figure 13. Basal view of another specimen, right anterior interradius uppermost. (Page 131.)

Root River locality.

Melocrinus whittakeri n. sp.

Figures 14, 15, 16, 17. Different views of the type specimen: 14, posterior interradial view of calyx; 15, right anterior radial view, showing asymmetry; 16, basal view, right posterior interradius up, and large basal in the most frequent left anterior position; note the extremely small size of the column facet as compared with that of the others; 17, the tegmen, with opening for small subcentral anal tube. (Page 131.)

Trout River locality.

Hexacrinus humei n. sp.

Figure 18. Posterior view of the type and only specimen, with fractured base restored in outline; anal opening strongly excentric and directed laterally. Enlarged X 2. (Page 132.)

Figure 19. Tegmen of same, chiefly occupied by oral plates. X 2. (Page 132.)

Root River locality.

All figures natural size unless otherwise stated.

The photographs for the figures on this plate were made by Dr. Charles E. Resser, of the U.S. National Museum, and carefully redrawn by Miss Francesca Wieser, with the kind permission of Dr. T. W. Stanton, of the U.S. Geological Survey; to all of whom the author extends his thanks.

Plate XXIV