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MISSISSIPPIAN HORTON GROUP OF TYPE WINDSOR-HORTON DISTRICT NOVA SCOTIA

W. A. Bell

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By
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DEPARTMENT OF
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PREFACE

The type area of the Mississippian Windsor and Horton groups is the Horton-Windsor district. Results of a detailed study of the Windsor of that area made by the Geological Survey in 1913-14, were published in Memoir 155 in 1929. Descriptions of the Windsor fauna and sequence of fossil zones have assisted geologists subsequently in geological mapping and study of that group in other areas of the Atlantic provinces, including Newfoundland.

The lithology of the Horton group of the type area, which underlies the Windsor group, was rather fully described in the earlier memoir, but its flora and fauna was not treated in specific detail; correction of this deficiency, based on the same early field work, is the primary reason for this present report. Meanwhile the Horton group has taken on greater significance because the geology of many areas in the Maritimes is currently being revised, and because oil has been produced continuously since 1909 in New Brunswick from the Albert formation of the group. This economic development has been a major incentive in the exploration for petroleum within the group in Nova Scotia and Prince Edward Island.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, September 4, 1959

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MISSISSIPPIAN HORTON GROUP OF TYPE WINDSOR-HORTON DISTRICT, NOVA SCOTIA

Abstract

This report presents an outline of the stratigraphy and structure of the non-marine Horton group as it occurs in its type Horton-Windsor area, together with a description and illustration of plants and invertebrates that have been gathered from the group. In the restricted type area the group is divided into two formations: the Horton Bluff and conformably overlying Cheverie. The deposits are fluviatile and fluvio-lacustrine, the latter being largely confined to a middle member of the Horton Bluff formation. Soil zones, as indicated by siltstones bearing abundant rootlets and small stems normal to the bedding, occur at various horizons throughout the entire group, but are particularly abundant in the upper of three members into which the Horton Bluff formation is arbitrarily divided.

Nineteen plants and ten invertebrates from the Horton group are described and thirteen of the plants and eight of the invertebrates are specifically named. New species comprise two plants, *Triletes cheveriensis, Sphenopteris strigosa,* and three invertebrates, viz., *Spirorbis avonensis, Limnoprimitia ? hortonensis* and *Euestheria lirella.* The Horton flora is considered to be an early part of the nearly worldwide *Triphyllopteris-Lepidodendropsis-Rhacopteris* flora. A Tournaisian age is established by an early Visean age of the marine fauna of Windsor limestones that overlie the Horton group within the area. For comparative purposes the report includes a description of six plant species that have been gathered from the Windsor group or from its equivalent in Eastern Canada.

Résumé

Le présent rapport donne un aperçu stratigraphique et tectonique des roches, d'origine non marine, du groupe Horton, tel qu'il est représenté dans sa région type de Horton-Windsor. On y décrit aussi, à l'aide d'illustrations, des fossiles végétaux et invertébrés recueillis dans le groupe. Dans la région type étudiée, qui est de dimensions restreintes, le groupe Horton est divisé en deux formations: la Horton Bluff et la Cheverie, qui recouvre la première en concordance. Les dépôts sont tantôt fluviatiles, tantôt fluvio-lacustres; la plupart de ces derniers se trouvent dans le membre intermédiaire de la formation Horton Bluff. A en juger par les siltstones contenant beaucoup de radicules et de petites tiges perpendiculaires à la stratification, il y a des zones de sol à plusieurs horizons du groupe tout entier, mais elles abondent surtout dans le membre supérieur des trois membres arbitrairement établis pour cette formation.

On décrit 19 plantes et 10 invertébrés provenant du groupe Horton, dont 13 plantes et 8 invertébrés ont reçu des noms d'espèces. Les nouvelles espèces comprennent 2 plantes: *Triletes cheveriensis* et *Sphenopteris strigosa,* et 3 invertébrés: *Spirorbis avonensis, Limnoprimitia ? hortonensis* et *Euestheria lirella.* On estime que les fossiles végétaux du groupe remontent aux débuts de la flore *Triphyllopteris-Lepidodendropsis-Rhacopteris,* qui était répandue sur presque toute la surface du globe. Cette flore et cette faune datent sans doute du Tournaisien, d'après l'âge du Viséen inférieur qu'on attribue à la faune marine des calcaires Windsor qui recouvrent le groupe Horton dans cette région. Pour fins de comparaison, le rapport comprend une description de 6 espèces de plantes qu'on a recueillies dans le groupe Windsor ou dans son correspondant dans l'Est du pays.

Chapter I

INTRODUCTION

The type area of the Horton group, known as the Horton-Windsor district, is the same as that of the younger Windsor group, including land on both sides of the estuary of the Avon River between 44°55′ and 45°15′ north latitude and 64°05′ and 64°20′ west longitude. A detailed field study of this area, made by the writer in 1913-14, was primarily concerned with the stratigraphy and fauna of the Mississippian marine Windsor group, but the underlying non-marine Horton group also was given much attention. All streams with important outcrops of Horton strata were surveyed by telemeter traverses, and collections were made of contained plants and shells.

Immediately following field work in the area, war services and subsequent assignments precluded until the past year a satisfactory laboratory study of fossil material other than that derived from the marine Windsor group, results of which were published in 1929 in Memoir 155, Geological Survey of Canada. That memoir summarized results of previous geological work done in the area, gave a brief account of the general geology and a rather comprehensive account of lithological characters of the Horton group. The present report amplifies to some degree Memoir 155, revises where necessary estimates of thicknesses, and presents a descriptive and illustrative account of the flora and fauna of the group, excluding, however, treatment of vertebrate remains, which occur abundantly in some beds in the form of fish scales, spines and teeth.

The greater number of plants and shells described were collected from the type area, but localities of occurrence elsewhere in the Maritimes are noted, and a few species are described that are not represented in present collections from the type area.

Chapter II

STRATIGRAPHY

Strata of the Horton group in its type area occur in the generalized stratigraphic sequence there as follows:

TABLE OF FORMATIONS

Era	Period or epoch	Group	Formation	Lithology
Cenozoic	Recent Pleistocene (0-75 feet)			Gravel, sand, tidal alluvium, till, stratigraphic gravel, sand
			unconformity	
Mesozoic	Triassic		Scots Bay (15+ feet)	Calcareous sandstone and arenaceous limestone
				Basaltic flows (900+ feet)
			Annapolis (3,200± feet)	Red conglomerate, sandstone, siltstone, shale
			unconformity	
Palæozoic	Pennsylvanian	Riversdale (?)	Scotch Village (800+ feet)	Red and grey conglomerate, sandstone, siltstone, shale
			disconformity	
	Mississippian	Windsor	Undivided (1,500+ feet)	Red, minor grey, siltstone, shale, grey limestone, dolomite, anhydrite, gypsum, minor subsurface salt
			Pembroke (0-100 feet)	Limestone and limestone-conglomerate
			Macumber (0-25 feet)	Arenaceous limestone
			conformity or disconformity (?)	
		Horton	Cheverie (625+ feet)	Red and grey arkosic and feldspathic conglomerate; red, minor grey, sandstone, siltstone, shale
			Horton Bluff (3,500± feet)	Grey to brownish feldspathic conglomerate; quartzitic sandstone; siltstone, shale; rare, thin, lenticular, ferruginous limestone

Era	Period or epoch	Group	Formation	Lithology
	unconformity			
Palæozoic (*Conc.*)	Silurian		New Canaan (1,000 ± feet)	Calcareous breccia; siltstone, slate
			Kentville (1,600 ± feet)	Impure limestone; slate, siltstone
			White Rock (100-500 feet)	Grey quartzite, siltstone, slate
	disconformity			
	Ordovician	Meguma (?)	Halifax (?) (11,700 ± feet)	Grey to black slate; minor quartzite
			Goldenville (occupies very small part of surface in area)	Quartzite and contact metamorphic rocks

For a brief account of early geological work in the area, regional geological and geomorphological relations, as well as for a discussion of some events in the tectonic history of the region, the reader is referred to earlier reports of the author (1927, pp. 75-108; 1929, pp. 2-19, 75-80; 1944, pp. 1-30; 1958, pp. 65-77)[1]; reference may also be made to the most recent geological map that covers a large part of the area (Geological Survey of Canada, Map 52-18) and has brief descriptive notes.

Lithological Differentiation

Within the type area the Horton group may be divided into two formations, the Horton Bluff, which comprises the greater part of the group, and the overlying Cheverie. At no place was the basal contact of the Cheverie observed, and covered intervals may account for 50 feet or more of strata. Where outcrops of the two formations were seen to be closest to one another without any intervening fault or reliable change in strike, as on Rupert Brook, Hantsport, below the road bridge, the two formations are apparently conformable.

The Cheverie is mainly differentiated by its red siltstones and unweathered fragments of feldspar and of biotite in many of its coarser beds. Channelling phenomena are also of much more common occurrence than in the Horton Bluff formation. Occurrence of passage beds from one formation to the other cannot be proved to exist in the type area, but to the east in the vicinity of Tennycape River thin zones showing Cheverie lithology are interfingered with thick zones made up of beds indistinguishable from those commonly occurring in the Horton Bluff formation.

Horton Bluff Formation

This formation was thus named by the writer in deference to prior description, particularly by J. W. Dawson (1868, p. 252), of beds prominently displayed for 1¾ miles in the low cliffs of Avon River known as Horton Bluffs. This natural

[1] Dates in parentheses are those of references cited at the end of this report.

section, however, shows only about one fifth of Horton Bluff strata contained in the area, representing only a lower part of an upper member and an upper part of an underlying middle member of the formation. Division of the Horton into three members was made by the writer previously (1929, pp. 30-33) on the basis of lithological distinctions, but owing to transitional passage from one member to another these could not be mapped to ordinary map scales. Arbitrary boundaries, however, may be made for convenience of description and for elucidation of the sequence.

The *basal member* of Horton Bluff formation outcrops most advantageously for study in the channels and banks of Duncanson and Harding brooks which flow northward into Gaspereau River; in a tributary of Lebreau Creek, the mouth of which lies about a mile east of Martock; and in Fall Brook, south of Three Mile Plains, 1½ miles farther east. On all these brooks the lower contact of the basal member upon pre-Carboniferous rocks is exposed.

On Duncanson Brook, Horton outcrops extend from 1,675 feet in a straight line above the Melanson-Gaspereau road bridge to the Horton contact about 3,970 feet above the same bridge. The basal Horton bed above the contact is a breccia, several feet thick, composed almost wholly of slate like that on which it rests, but with the addition of a few pebbles of quartz. Overlying Horton beds are feldspathic, fine conglomerate, made up largely of angular grains of translucent quartz up to 3 mm diameter, a few pebbles of quartz and slate as much as 3 inches, and disseminated black particles of slate and light grey or white kaolinitic matter in the finer matrix. Interbedded with the conglomerate are a few beds of purplish brown siltstone and sandstone. The Horton beds strike about N70°E, dip about 25 degrees north; underlying slate strikes roughly in the same direction, but dips apparently 35 to 50 degrees south. The slate is banded, purplish to green to variegated, and the bedding planes are inclined southward more steeply than the cleavage planes, but whether the beds are overturned or not is not known. The Horton feldspathic beds are grey when fresh, but commonly weather to various shades of purplish brown or grey with rusty blotches owing to oxidation of ferrous iron oxides and in some instances of pyrite, which occur disseminated and less commonly as nodules. Exposed part of the basal member of Horton on Duncanson Brook was estimated to be about 320 feet thick.

On Harding Brook, Horton outcrops extend from 1,050 feet in straight line above road bridge at Melanson to the Horton contact 4,900 feet above the bridge. As on Duncanson Brook, the Horton bed directly above the contact with pre-Carboniferous slate is a breccia of purplish and green slate fragments. The cleavage of the slates below the contact is here nearly parallel with the bedding, which strikes about N40°E and dips 40 degrees south. From these slates which are again green, purplish or variegated, *Dictyonema websteri* was collected. If the beds are not overturned, they are overlain by a partly exposed thin bed of fine-grained, buff weathering quartzite, and this by blackish banded slates of the (Halifax ?) formation. The last-mentioned beds, however, stand nearly vertical, so that a possible fault intervenes; truncated crossbeds in the black slates seem to indicate that they are there overturned. It is possible that the light colours close to the contact resulted from weathering prior to deposition of the Horton beds.

Horton strata above the basal breccia comprise grey, much crossbedded, feldspathic, fine conglomerate, interbedded with thin zones of greenish black, micaceous, arenaceous shale. The black colour is owing to comminuted, carbonized plant debris, and one bed, about 140 feet stratigraphically above the base of the formation, carries stems of *Aneimites acadica* Dawson and of *Lepidodendropsis corrugata* (Dawson). The coarser clastic beds consist of angular fragments of translucent quartz up to one quarter of an inch, some rounded pebbles of vein quartz, quartzite, and elongated fragments of slate up to 2 inches, with muscovite, small black slate particles and white kaolinitic material forming the matrix. Exposed basal member on this brook was estimated to be about 550 feet thick.

In the Lebreau Brook tributary, east of Martock, Horton beds are first seen a little east of south from bridge over Lebreau Brook on road from Martock to Three Mile Plains. The total thickness of basal member in the tributary brook from this outcrop to an exposed contact with granite was estimated to be about 600 feet. The basal member consists largely of fine arkosic conglomerate with angular fragments of pink feldspar and translucent quartz up to one-half inch diameter. In this respect it is more like some conglomerates of the Cheverie formation, but this is attributed to nearby granite that was the source rock of the sediments. For, at the contact itself it is difficult without close examination to draw the line between arkose and underlying granite, which directly beneath the contact is friable and weathered. As before, the conglomeratic beds of the member are separated by a few thin interzones of blackish grey, micaceous, arenaceous shale that carries broken and comminuted carbonized plant debris, as well as by a few thin and relatively pure greenish grey, but rusty weathering, quartzitic sandstone. The mean strike of the beds in this brook is about N70°E and dips progressively increase from about 35 degrees near the contact with granite to 73 degrees, the dip of the topmost beds exposed. This increase in dip is interpreted by the writer to be due to closer approach to the Butler Mountain fault (*see* p. 19).

Fall Brook has outcrops of the basal member of the Horton, estimated to represent about 570 feet of beds. The contact is with a metamorphic rock that borders nearby granite, and granitic debris comprises most of the Horton sediment as on tributary of Lebreau Brook to the west. Beds of arkosic, fine conglomerate and of coarse, arkosic sandstone are interbedded with micaceous, blackish grey, arenaceous shale, some of which carries fragments of carbonized plants. At least two beds of light grey quartz sandstone occur in the sequence of beds on Fall Brook, a lower one resting upon a nodular bed not many feet above the basal Horton contact, and an upper one some 50 feet stratigraphically higher. The latter is finer grained than the former, has ripples 6 inches from crest to crest, and abundant plant remains in its upper part.

The basal Horton contact on Fall Brook is exposed about 1,950 feet in straight line above road bridge over Lebreau Creek, and the youngest exposed beds

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of the basal member occur downstream in the tributary brook about 900 feet southwest of the same bridge. Gypsum of the Windsor group outcrops about 2,100 feet in a northeasterly direction from the bridge, the rocks as well as the Butler Mountain fault being covered by glacial drift in the intervening area.

Gormley Brook, a headwater tributary of Gudgeon Brook, flows northwesterly from Butler Hill about 4,400 feet south of Martock. Occurrence of gypsum along Gormley Brook is indicated by numerous sink-holes, but higher up the brook, beginning at 200 feet and extending to 60 feet from granite, outcrops occur of greenish grey, arkosic, fine conglomerate and of an interbedded zone consisting of purplish brown, micaceous, fine-grained sandstone and of a pink quartzitic sandstone that strikes about N14°E and dips 71 degrees east. Fine crossbeds in this sandstone, however, indicate overturning and that the tops of the beds face west. This attitude corroborates other evidence (*see* p. 19) that a major high-angle reverse fault occurs at the foot of Butler Mountain, whereby strata of the basal member of the Horton Bluff formation have been thrust against gypsum of the Windsor group. The basal arkose of the Horton on Gormley Brook is made up of granitic debris like the basal arkose on Lebreau Brook tributary noted above.

In summation, the basal member of the Horton Bluff formation has a maximum thickness of about 600 feet and consists dominantly of crossbedded, feldspathic, fine conglomerate or grit with which are interbedded zones of blackish grey or grey, arenaceous, micaceous shale and quartzitic sandstone, carrying for most part comminuted or fragmentary carbonized plant debris, but including also recognizable stems of *Aneimites acadica* and of *Lepidodendropsis corrugata*. The beds commonly weather to rusty, brown or purplish colours owing to oxidation of pyrite and ferrous oxides of iron. Arenaceous beds with upright stems or rootlets, i.e., fossil soil beds, are rare in the basal member, but not entirely lacking.

From Gaspereau River to West Branch Avon River the basal member is overlain by strata of the middle member, but south of Windsor from Butler Mountain to Three Mile Plains, the upper contact is a fault, the basal beds rest directly upon granite, and the coarser strata owing to the occurrence in them of fresh feldspar are indistinguishable from some beds of the Cheverie formation. That they belong actually to the basal member of the Horton group, and are not overlapping Cheverie beds is deduced from the following evidence:

(1) The stratigraphically highest beds outcrop not far from Windsor gypsum deposits, and their northerly dips are much steeper than those of lower beds near the Horton contact. In a tributary of Lebreau Brook the dips increase progressively towards the gypsum from 35 degrees at contact with granite to 73 degrees nearest the Windsor. In Gormley Brook the Horton strata between the granite on which they rest and gypsum (as inferred from sink-hole topography) are highly inclined and overturned in such a way as to indicate they must have been thrust against the gypsum by a high-angle reverse fault (Butler Mountain fault).

(2) Immediately northeast of the type area the extension of the Butler Mountain fault may be traced by fault gouge on Martin and Weir (Thumb Hill) brooks.

(3) From (1) and (2) above it is inferred that the basal Horton strata do not lie directly below Windsor strata as do Cheverie strata, but were separated by several thousand feet of Horton strata that were displaced by relative upward movement along the southeast or south side of a major fault.

(4) Horton beds that consist predominantly of pure quartz occur most commonly in the upper member of the Horton Bluff formation, but that they are not restricted stratigraphically to that member is shown by occurrence of a pinkish or rose coloured quartzite consisting almost wholly of quartz in the basal Horton member in Barkhouse Brook, a tributary of West Avon River. The basal member on this brook is overlain by outcropping ostracod-bearing beds of the middle member, and the nearly pure quartz sandstone occurring in the sequence closely resembles the pinkish quartzite on Gormley Brook.

(5) The occurrence of fresh feldspar in addition to feldspathic weathered material in basal Horton deposits south of Windsor may be readily explained by nearness to a granitic source rock. Relation to nearby source rock is well exemplified by basal Horton deposits in the Gaspereau River district to the northwest, which consist of a breccia made up of fragments of slate similar to the slates upon which the Horton was deposited. At the foot of Butler Mountain the Horton rests directly upon a granitic pavement.

The *middle member* of the Horton Bluff formation differs from the basal and upper members in its lack of appreciable amounts of conglomerate and occurrence of thick argillaceous zones of blackish grey shale. As compared with the basal member the following characters are most important: (1) the sandstones are finer grained, bedding more even, and crossbeds finer; (2) occurrences within the sequence of many argillaceous zones, some with concretions and lenticular thin beds of ferruginous limestones and ironstone, and many with abundant ostracoda, fish scales, teeth and spines. Ostracoda so far as known are restricted to an upper division of variable thickness, above which the member grades imperceptibly into the upper one. Indeed, the only satisfactory basis for recognition of an upper member at all is the reappearance within it of some beds of feldspathic, fine conglomerate and grit like those in the basal member, together with lack of ostracoda and more abundant occurrence throughout of arenaceous soil zones and associated erect stems. Concretions and thin lenticular beds of limestone, however, still occur.

The middle member is best exposed for study in valleys of Harding, Deep Hollow, Anderson and Oakland brooks, all of which flow northward into Gaspereau River.

On Harding Brook about 500 feet of the basal part only of the member are exposed; no beds were seen to carry ostracoda. On Curry Brook outcrops of the middle member, separated by only a few short covered intervals, occur from near the road bridge at Wallbrook upstream to a point about 9,000 feet in a straight line from the bridge, and within this distance comprise about 200 feet of an ostracod-bearing division and about 700 feet of underlying strata within which no ostracoda were seen. For another 3,200 feet upstream too much rock is covered for reliable calculations of thickness of strata represented or for certainty that no major faults exist. Blue Beach fault zone (*see* p. 19) may have extended to this part of Curry Brook, but, if no major faults exist, an additional 1,400 feet or more of strata may be added to the lower part of the middle member in this brook, giving a total thickness of 2,100 feet or more to beds lying below those carrying ostracoda. They consist mainly of grey, commonly brownish weathering quartzitic sandstone, of blackish grey, micaceous, arenaceous shale, some of it ribboned with argillaceous layers, and of a few zones of siltstone marked by abundant traces of rootlets (soil beds). The blackish grey, arenaceous shales contain much carbonized comminuted plant debris, but some beds have good imprints of *Lepidodendropsis corrugata* and of *Aneimites acadica.* Ripples are common, a few inches from crest to crest, and sandstone casts, first thought to represent worm trails and burrows but now considered to be more likely casts of rootlets, are abundant in many beds.

The ostracod-bearing or upper part of the middle member of the Horton Bluff formation is best exposed on Deep Hollow and Anderson brooks and on Oakland and its tributary Reed Brook. On Deep Hollow Brook outcrops extend from near bridge on Wallbrook road upstream 2,500 feet in straight line from the bridge. The exposed strata belong entirely to this division, and were calculated to represent a thickness of about 400 feet. On Anderson Brook outcrops begin about 2,300 feet upstream in straight line from bridge on same Wallbrook road, and continue for 4,000 feet farther; about 1,335 feet are represented, of which about 1,150 feet belong to the ostracod-bearing division, the underlying 200 feet being arbitrarily assigned to the basal part of the member which does not carry ostracoda. On Reed Brook the top 1,100 feet of a total of 1,550 feet belong to the ostracod-bearing division, and rest upon 450 feet of non-ostracod-bearing beds. On Oakland Brook neither top nor base of the ostracod-bearing division is exposed, and total thickness represented is about 1,050 feet. These thicknesses are only roughly approximate, and are all minimum, because they are based upon calculations applicable only to those parts of the respective brooks in, or along which outcrops occur, and where the exposed beds show only minor deviations in strike and dip.

In the section exposed at Horton Bluffs on the Avon River probably not more than 250 feet of the ostracod-bearing division of the middle member is exposed north of Blue Beach, the strata farther north being assigned to the upper member.

The ostracod-bearing division of the middle member contains most of the argillaceous sediment of the Horton Bluff formation. It occurs both as zones of black, brittle shale that fractures irregularly and as zones of well laminated, softer shales. Concretions and thin lenticular beds of ferruginous limestone and of calcareous ironstone are common. One siliceous ironstone bed with cone-in-cone structure outcrops on Curry Brook about 850 feet upstream in straight line from

Wallbrook road bridge. What the writer regards as the same bed outcrops on Deep Hollow Brook about 2,275 feet above bridge where that brook crosses the Wallbrook road, and on Oakland Brook about 2,530 feet from a corresponding bridge. The basal part of the ostracod-bearing division contains zones of hard, greenish black, commonly brown weathering, arenaceous shale, with thin interbeds of grey quartzite, where ostracoda are restricted to rather rare ferruginous, calcareous bands and concretions. These beds are transitional to those described above as occurring on Harding and Curry brooks stratigraphically below the octracod-bearing beds. Many of the arenaceous shales contain casts resembling worm-like trails and burrows.

The base of *upper member* may be chosen arbitrarily, but most conveniently, at the top of uppermost beds carrying ostracoda. As stated above the member is differentiated not only by lack of ostracoda, but by certain lithological features, e.g., reappearance of a few beds of feldspathic conglomerate, more common occurrence of sandstones locally made up almost entirely of quartz, and by the abundance of siltstones that carry upright stems and rootlets. Zones of blackish arenaceous shales, ribboned and banded with argillaceous material, and with interbedded thin quartzites occur more commonly than in the lower members. In the thicker zones of argillaceous shale, limestone occurs as in the middle member as concretions and lenses. Macrospores (*Triletes glaber*) and palaeoniscid scales are abundant in some beds, but *Lepidodendropsis corruguta* and *Aneimites acadica* are much less common than in the basal member. Arenaceous beds with casts resembling worm-like burrows and trails, which probably, as previously stated, are casts of rootlets, are particularly abundant in this member as may be expected from the abundance of soil beds.

The upper member west of the Avon River is best exposed in the Horton Bluffs and on Hurd Creek and Rupert Brook. On Hurd Creek the calculated thickness is about 400 feet. The top bed exposed is separated from overlying Cheverie beds by a covered interval representing about 140 feet of strata, and the lowest exposed bed is separated from ostracod-bearing beds of the middle member by covered strata computed to be about 240 feet thick. On Rupert Brook beds of the upper member are separated from outcropping Cheverie arkosic conglomerate by not more than 50 feet of covered strata, and from underlying ostracod-bearing beds by not more than 15 feet. The minimum thickness here of the upper member is about 340 feet and the maximum about 400 feet, and it may be inferred that the latter figure is roughly the thickness of the upper member in the Hantsport area.

On Halfway River feldspathic, much crossbedded, fine conglomerate at base of the upper member lies not more than 25 feet stratigraphically above exposed ostracod-bearing strata. The locality of this nearly exposed contact is about 2.6 miles in direct line above the road bridge that crosses river near its mouth. Typical higher arenaceous beds of the middle member outcrop downstream at next pronounced southerly bend about 6,500 feet upstream from the above-mentioned bridge. They dip northwards a few degrees as compared with an eastward, and comparably low dip of the Cheverie strata. It is inferred that the rocks in the intervening interval, which is about 2,200 feet wide, lie in the axial region of a shallow syncline. Outcrops of the middle member are too scattered on this river to provide a satisfactory estimate of its thickness. Moreover, on account of an abrupt change of dip, occurring about 8,500 feet upstream in direct line from the bridge, the member is inferred to be cut by a northeasterly trending fault that may have resulted in appreciable loss of strata at the present surface. The Horton outcrops along Halfway River are mainly important in that they indicate continuation southward of a sequence within the Horton Bluff formation of three members corresponding to that shown in the Gaspereau River area.

That this sequence, although apparently foreshortened by thinning or faulting, persisted as far south as West Avon River is evident from outcrops, representing some 300 feet of ostracod-bearing strata of the middle member of the Horton Bluff formation, on Barkhouse Brook which enters West Avon River near Upper Falmouth. The beds of the middle member there likewise overlie strata of the basal member. They are inferred to be in fault-contact (*see* p. 21) with arkosic sandstones that are in turn overlain by typical grey arkosic fine conglomerate and red siltstones of the Cheverie formation. Whether the arkosic sandstones belong to the upper member of the Horton Bluff rather than to the Cheverie formation may be questioned. Their arkosic character does not preclude a correlation with the upper part of Horton Bluff, for the nearby source rock is there granite and not slate. The writer favours their assignment to the upper member of the Horton Bluff and also favours a fault-contact with the middle member, on account of an abrupt change of strike and dip from N170°E and dip 11 degrees east, to N35°E and dip 24 degrees southeast. If a fault actually exists here the upper member of the Horton Bluff and overlying Cheverie formation were both downthrown, and the former may be largely or entirely lacking from the present surface, depending upon the true correlation of the arkosic sandstone beds.

East of Avon River from Little Rainy Brook, the easterly limit of the area examined by the writer, to Split Rock, the cliffs of Minas Basin show exceptionally well beds of the upper member of the Horton Bluff formation. It is not a section, however, suitable for detailed measurements or sequence of individual beds on account of the numerous small secondary folds that have resulted from northwest-southeast compression. The axial planes of the folds dip generally about 40 degrees west of north and their eastern limbs are commonly steep or overturned to the southeast. Small thrust planes that dip northwestward also occur, but displacement along them as far west as Mutton Cove is minor. The prevailing dip of the beds is west to northwest, and making allowances for repetition of beds by folding, the sequence from Little Rainy Cove to Mutton Cove is ascending. From Little Rainy Cove to about 3,000 feet west of Cambridge Creek the beds belong to the ostracod-bearing division of the middle member. Farther west and south to an inferred fault in a drift-covered area at Johnson Cove south of Split Rock the beds, except for scattered outcrops of Triassic rocks, belong to the upper member.

Several siltstone soil zones with erect stems were noted by the writer towards the top of the middle member, but in the overlying upper member these become numerous and highly characteristic. Commonly they stand out prominently to the eye on account of their 'hackly' weathering and peculiar yellowish green coloration. Commonly too, they are marked by what was first thought by the writer to be mudcracks, but later proved to have been brought about by weathering along positions of dichotomously divided rootlets. The abundant erect stems occurring in the rootlet-bearing soil zones rarely exceed a foot in diameter, and 4 to 8 inches is most common. Generally, too, they are not more than a foot or so high. A few are marked by an external thin layer of coal, but most are arenaceous casts with no coal or surface markings. Stems were seen in some instances to have traces of rootlets directly attached to them, and organisms resembling *Stigmaria* were extremely rare among the drifted plant remains. If the small stems belong to *Lepidodendropsis,* as seems probable, rather than to a pteridosperm, that genus seemingly lacked stigmarioid rhizomes. In one bed fifty-eight erect stems were noted in a plot of 216 square feet and in another nineteen stems in 45 square feet. The siliceous soil zones are interbedded with zones of black argillaceous shale and with zones of similar black shale ribboned with grey quartzite laminae, or containing thin quartzite interbeds. A few soil zones have large limestone concretions. Macrospores and palaeoniscid scales are common in some of the beds, but recognizable stems of *Lepidodendropsis* or of plant remains other than the upright stems and traces of rootlets are rather rare. Where remnants of overlying Triassic red conglomerate overlie Horton shales the latter for some distance below the contact are commonly stained purplish red.

Cheverie Formation

The best sequence of beds in the Cheverie formation is exposed on the east side of Avon River from the headland northeast of Cheverie Point to a point on the shore opposite Summerville. At the northern headland the contact of the Cheverie with basal limestone of the Windsor is exposed, and the relations are seemingly disconformable. The sequence descends to Cheverie Point to the axial region of a low asymmetrical anticline. The mean dip of the beds in the northern limb of the anticline is about 9 degrees, and their calculated thickness is about 625 feet. The lowest beds in the axial region of the anticline at Cheverie Point are about 60 feet thick and consist mainly of greenish grey, feldspathic conglomerate with some interbedded purplish and green siltstone, carrying limestone nodules (kunkur), and greenish grey arenaceous shale. Overlying the conglomeratic zone to the north is about 180 feet of purplish grey to red siltstone, red and grey sandstone, greenish grey, 'hackly' weathering siltstone (soil beds), and a few thin beds of dark grey laminated argillaceous shale with estherioid shells, and in some instances with *Triletes cheveriensis.* The remaining overlying beds to the Windsor contact are mainly red to purplish siltstones, a number of which are soil beds with abundant rootlets, in one of which thirty-three upright stems were noted in a plot of 450 square feet, the largest stems being about 7 inches in diameter. A greenish grey, micaceous, laminated siltstone, lying below the Windsor contact, carries abundant but poorly preserved remains of sphenopterids.

Beds in the southeastern limb of the Cheverie Point anticline have dips up to 70 degrees. From 800 to 1,000 feet south of the anticlinal axis there are several parallel high-angle reverse faults heading northwesterly, but the total resultant stratigraphic displacement of Cheverie beds is unknown. No reliable correlation could be made of beds lying between this fault zone and Summerville where they are in fault contact with gypsum of the Windsor group. Most of them strike nearly parallel with the shoreline and have dips of only 5 to 7 degrees eastward. The beds nearest the fault zone are red siltstones much like those beneath the Windsor beds in the northern limb of the anticline, and some of them carry likewise kunkur-lime nodules and traces of rootlets. The remaining beds proceeding south are mainly purplish red, greenish and variegated, arkosic fine conglomerate interzoned with red and grey sandstone, red and purplish siltstone, some with limestone nodules and traces of rootlets, and rippled red and green arenaceous shale. The conglomerate beds commonly channel into siltstones below them. Some of the rootlet-bearing siltstones are marked by pseudo-mudcracks, but in one instance at least a siltstone, channelled into by arkose, was seen to have true mudcracks up to 2 inches wide, which had been filled with arkosic material like that in the bed above. Some grey arkose has abundant drift plant material in places, and where this occurs weathers commonly a buff-yellow; more rarely these patches are stained with malachite.

Abundant fragments of fresh feldspar that occur in these conglomerates south of Cheverie Point suggest that all Cheverie beds there are older than those north of the Point. In lithology and marked channelling features they resemble closely basal Cheverie conglomerates of the Hantsport area on opposite side of the Avon River. But, if these conglomerates are actually older than those at and north of Cheverie Point, the postulation of an additional fault along which movement on the northwest side was relatively downward and not upward, would seem to be necessary, and for the existence of such no present evidence can be given. Alternatively, it is possible that the arkosic conglomerate is approximately of the same age as the feldspathic conglomerate farther north, and that the freshness of the feldspars is due to original deposition closer to a river channel on the alluvial plain.

Summary of Sequence

The general sequence of the beds of the Horton group in the type area in descending order is as follows:

UPPER HORTON

Cheverie formation: maroon and brownish red siltstones interbedded with minor dark greenish grey micaceous, arenaceous siltstones and shales, argillaceous dark shales with 'estherioid' shells and *Triletes cheveriensis,* and basal, grey to reddish or purplish, feldspathic and arkosic fine conglomerate, interbedded with minor brownish red siltstone and with micaceous, arenaceous, dark greenish grey shale. Both red and grey siltstones commonly contain imprints of rootlets that grew in situ, representing soil beds, and more rarely contain abundant casts of small upright stems, generally 4 to 8 inches diameter. Carbonized plant debris occurs in many of the dark grey arenaceous beds, generally too fragmentary or too poorly preserved to be identifiable, but macrospores and fragments of sphenopterids not yet seen in the underlying Horton Bluff formation occur in addition to estherioid shells. Fish scales are relatively rare. Thickness, 625+ feet.

LOWER HORTON

Horton Bluff formation:

(C) Upper arenaceous member: feldspathic medium- to coarse-grained, grey, commonly buff or brownish weathering sandstone, and minor feldspathic, fine conglomerate, generally thinly bedded, and rarely made up almost wholly of quartz grains, interbedded with greenish grey to blackish grey, arenaceous, micaceous shale and thin quartzite, commonly showing alternating laminae of fine and coarse material, and containing carbonized plant debris, including macrospores and some identifiable plants, especially *Lepidodendropsis corrugata* and *Aneimites acadica.* Also, thin zones of blackish grey areno-argillaceous shale, some with concretions and thin interbedded lenses and layers of limestone and ironstone. Ripples and medium-sized crossbeds common; vertical and prostrate casts similar to worm-like burrows and trails, believed to represent casts of rootlets, are very common; palaeoniscid scales, spines and teeth common; interbedded siltstone zones with abundant traces of rootlets and of casts of upright stems very common. Some of the more thickly bedded sandstones have been quarried for building stone, and one for glass-sand. Thickness, 400± feet.

(B) Middle argillaceous member:

(b2) Blackish grey argillaceous and areno-argillaceous shale, of which many beds are ostracod-bearing, containing in basal part zones of hard, greenish to black, commonly brown weathering, arenaceous shale with thin interbeds of grey quartzite or thicker beds of brownish weathering, grey quartzite, ribboned with finer arenaceous and silty laminae. Concretions, lenses and very thin beds of limestone, commonly ferruginous, occur in the more argillaceous beds together with palaeoniscid scales, teeth and spines, and *Spirorbis,* in addition to ostracoda. Trails and burrows, believed to represent rootlets, occur in some arenaceous beds. Thickness, 1,150+ feet.

(b1) Grey, commonly brownish weathering, quartzitic sandstone, interbedded with blackish grey, micaceous arenaceous shale, some of it ribboned with argillaceous layers, and with a few thin zones of siltstone marked by abundant traces of rootlets. Much carbonized, comminuted plant debris, and *Lepidodendropsis corrugata* and *Aneimites acadica* common. Many beds rippled and some with casts of pseudo worm-like trails and burrows. Thickness, 700 to 2,100 (?) feet.

(A) Basal feldspathic conglomerate and sandstone member: feldspathic, rarely arkosic conglomerate, and greenish grey feldspathic sandstone, some with large crossbeds, others irregularly thinly bedded and rippled, interbedded with greenish grey, micaceous, arenaceous shale and rarely with thin siltstone zones with rootlets; rare sandstone beds made up almost wholly of quartz. *Lepidodendropsis corrugata* and *Aneimites acadica* fairly common. Thickness 600± feet.

Total thickness, 3,500 to 5,000 feet.

Geologic Age

The writer outlined early views on the age of the Horton group as follows:

The older geologists, Brown, Jackson, Alger and Gesner, regarded the gypsum or Windsor series as equivalent in age to the New Red Sandstone, i.e. the Triassic. The Horton as a consequence, as well as from its plant remains, was thought to be a development of the Coal Measures. In 1842 Logan visited the sections and considered the Horton a phase of the gypsiferous series, assigning both to the Triassic. However, he submitted some of the Windsor fossils to de Verneuil and Count Keyserling, who regarded them as identical with species from the Permian deposits of Russia, the Zechstein of Germany or the Magnesian Limestone of England. Murchison in his anniversary address to the Geological Society of London in 1843 also contributed to this view. However, Lyell's visit to the localities in 1843 initiated a new correlation. Fortified by both stratigraphical and palæontological evidence he announced the age of the gypsum formation as well as that of the Horton beds, to be Lower Carboniferous and therefore distinctly earlier than the overlying Productive Coal Measures. Of the Horton he writes: "Both in the Windsor district and on the Shubenacadie I found an intimate association between strata containing mountain limestone fossils, masses of gypsum, and coal grits, with *Sigillaria* and *Lepidodendron,* but no seams of pure coal in this part of the series." His general conclusions were abundantly verified by the work of Dawson. The latter, was, indeed, the first to give clear expression to the division of these beds into two distinct formations, naming what he considered the lower, the Horton series or Lower Coal Measures, as differentiated from the overlying Windsor series. More recently field geologists, especially Fletcher and Ells on structural and stratigraphic grounds, assigned much of Dawson's Carboniferous, including the Horton, to the Devonian. This reference gave rise to a discussion, not yet settled, which involves not only this series but the Riversdale and Union formations of Nova Scotia as well, and also the fern beds of Saint John, New Brunswick. An interesting synopsis of the controversy was published by Fletcher in 1900.

In later years the plants of these beds were submitted to Kidston of Scotland and to David White of the U.S. Geological Survey; these two palæobotanists gave independent confirmation to the age of the Horton, Kidston considering it was undoubtedly Lower Carboniferous, while White stated that "the Horton plant terrane should, on purely paleobotanical grounds, lie below the typical Carboniferous Limestone (Windsor series); but I believe it should go hardly as low as the Ursa stage (uppermost Devonian) or below the boundary generally accepted for the Lower Carboniferous (Mississippian)."

> In comparison with the Mississippian beds of Pennsylvania and Virginia, Mr. White would place the Horton as nearly synchronous with the Pocono (Kinderhook). He also regarded it as the near equivalent of the Albert shales of New Brunswick and of the Calciferous Sandstone series of Scotland. A. Smith Woodward has likewise pronounced on the Carboniferous age of the Horton fish remains, and finally L. M. Lambe, who described the fauna of the Albert shales, has correlated these two as quite, or nearly synchronous, and equivalent to the Calciferous Sandstone series as developed in Mid- and West Lothian and elsewhere in Scotland (Bell, W. A., 1913, pp. 143-144).

David White (1913, pp. 144-146) wrote more specifically on the Horton flora, as follows:

> The Horton Flora, like its probable contemporaries at the base of the Carboniferous in the Arctic regions of Alaska, Bear Island, and Spitzbergen, and in Siberia, as well as in the Appalachian trough, is remarkable at once for its paucity in genera and species and for the great profusion of two or three very variable dominant plants. The fern-like plants, which probably are Cycadofilic, vary specifically between the different regions of the Northern Hemisphere, but they everywhere show their common relation to a new and distinctly Carboniferous stock, so that in spite of varying generic names their consanguinity is unmistakable. Thus the *Aneimites* (*"Cyclopteris"* and *"Adiantites"*) *acadicus,* so characteristic of the Horton, is congeneric with and specifically close to the *A. bellidula* and other forms of the genus in the more northern regions, as well as probably with the Genus *Triphyllopteris* of the Virginian region of the Appalachian trough. Some of the widely variant forms of the Horton plants are difficult to distinguish from the *Triphyllopteris virginiana* in the Pocono of the last-named region, though the species in their ensemble are distinct. Descendents of this stock are found in *Eremopteris* and possibly in *Rhacopteris.*
>
> The stems described by Dawson as *Lepidodendron corrugatum,* the other monopolist of the Horton flora, present an almost bewildering cortical variation, which is well illustrated in the report on the "Plants of the Lower Carboniferous and Millstone Grit Formations of Canada". This singular and well marked Lepidodendroid type belongs to the older composite, stock of the Devonian known as *Archæosigillaria,* in which the alignment of the leaf bases in vertical and transverse rows sometimes, when the growth was slow, produced vertical ribs resembling *Rhytidolepis* group of *Sigillariae,* while in other cases, especially when the growth was more rapid and the leaf scars were longitudinally more remote, it caused a verticillate aspect of the scars. The *Archæosigillaria* type of scar, first noted in *Archæosigillaria* (*"Lepidodendron"*) *gaspiana* and *A. primaeva,* the latter from the Portage group in New York survive in *Eskdalia* and in *Bothrodendron. Archæosigillaria corrugata* is perhaps indistinguishable in any of its phases from the equally omnipresent and likewise monopolistic lycopod described by Meek from the Pocono formation of the eastern United States as *Lepidodendron scrobiniforme.* The latter is similarly varied in its cortical features. The Horton tree has its close correspondents in several contemporaneous Arctic species, such as *Lepidodendron glincanum.*
>
> The dominant Cycadofilic and Lepidodendroid types of the basal Carboniferous flora of North America were evidently in a state of great plasticity and variation, under the new environmental conditions (coal formation) on this continent at the beginning of the Carboniferous period.
>
> The Horton corresponds to the Pocono ("Vespertine") which certainly is in part, at least, contemporaneous in the central Appalachian trough, to the Cape Dyer beds in the Cape Lisburne region of northwestern Alaska, to the coal-bearing basal Lower Carboniferous of Spitzbergen, Bear Island, and Greenland, and probably to the lower portion of the Calciferous Sandstone series of Scotland.

David White (1926 and 1934a) later published two papers supporting a Mississippian age for the Pocono flora with which the flora of the Horton group was coupled. In the first he commented on the marked polymorphy of species of *Triphyllopteris* and *Lepidodendron (Lepidodendropsis),* remarking that "This is particularly true with the species of the newly formed genus *Triphyllopteris* in which indubitably a number of species are present, including *T. alleghaniensis, T. lescuriana* (Meek) and *T. virginiana* Meek, though in some cases intermediate forms difficult to refer to one species or another furnish unmistakable evidence of the activity of evolution in this genus during Pocono time. Some of these variants merge into the genus *Aneimites*" (White, 1926, p. 838).

The Catskill Upper Devonian flora was stated by White to be rich in *Archaeopteris* but none was found within the Pocono, whereas, on the other hand, *Triphyllopteris* was lacking in the American Devonian.

Additional support to a Mississippian age for the Pocono, based upon fauna of interfingering marine deposits near Wytheville, Virginia, was cited by White (1934b, p. 270). Representatives of the *Triphyllopteris* flora occurred there in coal-bearing beds lying above beds carrying a *Syringothyris–Productus* Burlington fauna.

The late Mississippian flora of the Chester group, according to D. White (1926, p. 841) was quite distinct from the Pocono flora and included a *Lepidodendron* of *volkmannianum* type, a *Sphenopteris* of *hoeninghausi* type, *Cardiopteris* like *C. polymorpha* (Goeppert) and an early *Neuropteris* cf. *schlehani* type. Forms similar to some of these occur in Eastern Canada in the florule of the late Mississippian–early Namurian Canso group (Bell, 1944, p. 23) of Nova Scotia and in that of the Searston beds of western Newfoundland (Bell, 1948, pl. I).

For a comprehensive account of paleobotanical and relevant stratigraphic investigations of the Pocono formation, and for a list of its contained plant species, the reader is referred to published work of C.B. Read (1955). Read recognized a sequence of two floras within the formation, an earlier *Adiantites* flora occurring in a lower part, and a *Triphyllopteris* flora in an upper. In the Horton group of the type area *Adiantites (Aneimites) acadica* occurs throughout in close association with *Lepidodendropsis; Triphyllopteris* is rare, but makes its first known occurrence later than that of *A. acadica* and in an upper part of the group. Because *Adiantites spectabilis* Read, a characteristic member of the lower flora of the Pocono, is considered by the writer to be probably conspecific with *Aneimites acadica,* the species has apparently a wider stratigraphical range in Eastern Canada than in the central Appalachian trough.

It is evident from the above remarks that a Lower Carboniferous age for the Horton group, advocated a century ago by Charles Lyell and J. W. Dawson, has been well substantiated by later workers. Of recently described Lower Carboniferous floras that are in part correlative with the Horton flora the one occurring in an upper part of the Bystraya series of the Minusinsk Basin in U.S.S.R. is of great interest. A. R. Ananev and M. I. Graizer (1958, p. 823) stated that "The *Sublepidodendron* flora of the upper sandstone-tuff sequence of the Bystraya series, according to its level of development can be compared, in its general features, with the early Lower Carboniferous *Lepidodendropsis-Rhacopteris-Triphyllopteris* flora of Central Europe (The Geigen flora at Hof in Bavaria), of Egypt, of North America, of China, etc." *Sublepidodendron* (Nathorst) Hirmer is very close to, possibly even identical with *Lepidodendropsis*. The writer, in view of the inconstancy of occurrence of an apparent verticillate arrangement of leaf cushions in *Lepidodendropsis corrugata* (Dawson), is unable to accept any separation of these two genera (Danzé-Corsin, Mme. Paule, 1958, p. 952) that is based only upon a spiral arrangement of leaf cushions on the one hand and on an apparent verticillate arrangement on the other. Besides *Sublepidodendron* the flora of the upper part of the Bystraya series includes *Asterocalamites scrobiculatus* and *Aneimites acadica,* two species occurring in the Horton group. Ananev and Graizer regard the *Sublepidodendron* flora as Tournaisian, and a flora found in the overlying Samokhval series as early Visean. The flora occurring in lower part of the Bystraya is very small, but includes *Cyclostigma kiltorkense.* It is regarded as early Tournaisian, partly on account of associated fish remains.

Considering the small number of species known to occur in the Horton group, one would hardly be justified in stating that two distinctive floras exist, an earlier one in the Horton Bluff and a later one in the Cheverie. For, as stated above, the two most common and most characteristic species *Aneimites acadica* and *Lepidodendropsis corrugata,* range throughout the group. Yet the Cheverie does contain floral elements that have not been found in the Horton Bluff formation. In addition to *Triphyllopteris* these are *Sphenopteris (Aneimites ?) strigosa* n. sp., *Adiantites tenuifolius, Sphenopteridium macconochiei* ? and *Sphenopteridium* sp. The age of the Cheverie is fixed by stratigraphic position as late Tournaisian, for the formation is overlain by strata of the marine Windsor group that carry an early Visean (late Meramecian) fauna. Fossil plants in the Windsor group have only been found by the writer in eastern Cape Breton and western Newfoundland; they include three species of *Rhacopteris* and two of *Telangium.* The writer concludes that the Horton flora as a whole represents only a Tournaisian part of Jongmans' widespread Lower Carboniferous *Triphyllopteris-Rhacopteris-Lepidodendropsis* flora (1952, p. 299). The Horton, therefore, is seemingly somewhat older than the Geigen flora of Germany, but approximately the same age as the Pocono flora of the Appalachian area of the United States.

Chapter III

STRUCTURE

Folds

Horton strata in areas west of Avon River and south of Windsor lie unconformably upon pre-Carboniferous slate or granite, and are openly folded into anticlines and synclines, which from north to south were previously designated by the writer as follows: Wolfville anticline, Gaspereau River syncline, Five Points anticline, Halfway River syncline, Gray Mountain anticline, French Mill Brook syncline, Eldridge anticline and Avon River syncline (Bell, 1929, p. 13). Of these structures, those as far south as the Eldridge anticline, south of French Mill Brook, inclusive, belong to an anticlinorium which may be designated the Greenfield anticlinorium, and which extends northeast from the old settlement of Greenfield on Halfway River to Walton and beyond, where the structure is partly covered unconformably by Triassic rocks. The general synclinal structure, lying southeast of this anticlinorium, and which includes the Avon River syncline, may be designated the Windsor synclinorium. Its axial region includes early Pennsylvanian, as well as Windsor group strata. The southern limb of this Windsor synclinorium is cut by the Butler Mountain fault (Bell, 1929, p. 12), as a result of which only basal remnants of the Horton group now flank crystalline pre-Carboniferous rocks of the Gore anticline, which lies southeast of the Avon River syncline.

Numerous asymmetric, gently plunging, secondary folds occur in strata of the middle and upper members of the Horton Bluff formation east of Avon River in the Bay of Minas section from Rainy Cove to Split Rock. Their axial planes and gentler limbs dip generally about N40°W, whereas the southeasterly limbs are steep or overturned. Commonly the limbs, especially the northwesterly ones, are further deformed by a tertiary series of asymmetrical folds, and thin interbeds of quartzite contained within thick zones of argillaceous shale are likewise folded as a result of northwest-southeast compression. The thrust that caused these particular minor folds in the Horton group along shore of Minas Basin apparently came from the northwest; this is inferred to be owing to existence of a competent crystalline Cobequid massif to the northwest, against which Horton strata were pressed during differential compression from the southeast.

The major primary and secondary folds enumerated above trend northeasterly. The Greenfield anticlinorium, however, in the Cheverie area includes an irregular elliptical closed syncline that has an axial trend nearly north-south. Whether this structure was controlled by shearing forces, set up by southeast-northwest compression, or was the result of earlier or subsequent folding is not known.

Faults

A few major and numerous minor faults cut strata of the Horton group in the type area. Best known faults or fault zones are five in number and comprise Butler Mountain, Blue Beach, Summerville, Cheverie and Johnson Cove faults.

Butler Mountain fault or fault zone (Bell, 1929, p. 12) south of Windsor is considered to be a high-angle reverse fault, heading south to southeast, along which pre-Carboniferous granite and quartzites and slate and basal strata of the Mississippian Horton group were thrust against Mississippian strata of the Windsor group. The stratigraphic displacement probably exceeded 2,000 feet. The trend of the fault zone is undulatory, but in general is northeasterly. On a tributary of Lebreau Brook basal Horton strata have dips that increase from contact with granite northwesterly towards gypsum of the Windsor; gypsum sinks occur within 400 feet of outcrops of the Horton Bluff strata. On Gormley Brook, tributary to Gudgeon Brook, basal Horton strata lying yet closer to gypsum sinks are overturned 20 degrees to the west and dip eastward about 70 degrees. Just east of the type area evidence for existence of this fault is presented by exposures on Weir Brook and on its tributary Martin Brook (*see* Geol. Surv., Canada, Windsor Map-sheet No. 73). On Weir Brook a fault zone, several hundred feet wide, includes a clay gouge that contains fragments and masses of greyish black limestone, red and green shale and gypsum of the Windsor group and of pre-Carboniferous quartzite. A fault gouge on Martin Brook, containing angular fragments of quartzite, lies within a zone of shattered pre-Carboniferous quartzite and slate, and gypsum of the Windsor group outcrops within 200 yards to the west. In this particular section of the fault zone all Horton rocks apparently have been faulted out.

Blue Beach fault zone exposed at Blue Beach, Horton Bluffs, comprises two or more faults, which resulted in bringing upper strata of the middle member of the Horton Bluff formation on the northwest against a basal part of the Cheverie formation on the southeast. The stratigraphic displacement there did not necessarily exceed 600 feet. That at least one fault of this fault zone extended southwesterly to Hurd Creek is inferred from steep dips of Horton strata on that brook near, and above bridge of main highway. The strike of the Blue Beach fault zone is about N62°E. If it continued with this trend as far southwest as Curry Brook it should cut strata there about a mile upstream in straight line from bridge at Wallbrook. Because strata in this part of the brook are concealed for half a mile, the existence there of a Blue Beach fault was not confirmed. Farther upstream to a point about 1,400 feet downstream from the next road bridge, scattered outcrops of Horton strata indicate occurrence of several faults, but much more detailed work on stratigraphic position of strata there would be necessary before trends of these faults, stratigraphic displacements along them, and their relationship to the Blue Beach fault zone could be ascertained.

East of Avon River a fault, inferred to belong to the Blue Beach system, resulted in bringing Windsor gypsum on southeast against Cheverie beds on northwest. The fault itself is concealed, but its position on shore is considered to

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be about 4,200 feet northwest of the wharf that lies south of Summerville. This location is only a few hundred feet south of where the fault zone at Blue Beach would strike if its course continued to be N62°E. A gypsum outcrop occurs about 1,400 feet southeast of the inferred position of the fault near a private wharf. The rocks farther southeast are concealed for 750 feet, but beyond to the main wharf at Summerville are outcrops of Cheverie shale, siltstone and arkosic conglomerate. Possibly one or more faults occur in the concealed interval as well as in the area between Summerville wharf and mouth of Big Creek, 900 feet to the east, where scattered outcrops of both Cheverie strata and of gypsum occur. Such faults, if they exist, are probably minor.

At any rate, a major fault, which may be differentiated as the Summerville fault, occurs southeast of Big Creek. It runs nearly parallel with the shore, and may be traced for half a mile. Gypsum and Windsor limestone occurring southwest of it were brought into contact against black arenaceous shales of the Horton group occurring to the northeast. Whether the Horton beds belong to the Cheverie or to the upper member of the Horton Bluff formation was not determined. Because one of the Windsor limestones contains *Martinia,* indicative of upper Windsor, the stratigraphic displacement at this locality may have totalled more than 1,000 feet. It is possible, however, that this may have resulted not wholly from movement related to those along the Summerville fault, but in part from intrusion of Windsor evaporite deposits into an upper part of the Windsor, either prior or subsequent to movements along the Summerville and related faults.

A fourth major fault system includes faults in vicinity of Cheverie that brought feldspathic quartzite and green to black shales and siltstones of the Cheverie formation on the southeast against Windsor gypsum and basal limestone on the northwest. At Cheverie a wide crushed zone, made up of a breccia of Cheverie beds, fault gouge material and some gypsum boulders, may be seen about 2,000 feet northeast of the bridge crossing Cheverie Creek, and again about 1,800 feet west by south of bridge. The strike of this breccia is about N45°E, and if this line is projected southwest it would meet the shore again south of Cheverie Point at a locality where no breccia, but a zone of high-angle thrust faults (*see* p. 12) occurs in the Cheverie formation. The faults in this zone dip at high angles to northwest, indicating relative thrust from that direction, and this is complemented by an asymmetric anticline at Cheverie Point. Because relative movement along the fault at Cheverie produced the effect of apparent thrust from the opposite or southeast direction, alternative explanations may be advanced, e.g. (1) Cheverie beds locally at Cheverie were folded into a low anticline that was partly denuded by erosion prior to deposition of Windsor gypsum, and that subsequently the Windsor beds, including gypsum, were thrust relatively from the northwest over the older Cheverie; (2) resultant relative displacement along the fault or faults may have been effected by a reversal of movement in an area between Cheverie and Cheverie Point, or within a distance of 1,500 feet; (3) the Windsor beds at Cheverie of which dip there is unknown, may dip to northwest more steeply than the fault resulting in a horizontal and stratigraphic gap at this locality. Of these the last mentioned seems more probable.

Finally, a concealed major fault (Johnson Cove fault) is inferred to exist north of Johnson Cove, about one quarter of a mile north of Cheverie. Gypsum or anhydrite, outcropping northwest of the fault breccia at Cheverie, may be traced to a point on the shore about 875 feet south of a wharf near Bramber. About 1,350 feet north of this wharf an anticlinal axis, plunging gently eastward, occurs in beds of the Cheverie formation that are overlain by basal limestone of the Windsor. On the northern limb of the anticline the limestone outcrops about 3,400 feet in a direct line from the wharf, strikes about N75°E and dips about 30 degrees north. Farther north for nearly 700 feet transverse to the strike of the limestone the rocks are covered, but beyond beds belonging to the upper member of the Horton Bluff formation dip northwards much like the younger Windsor limestone. It is inferred, therefore, that a fault, trending east-northeast to east by north occurs in the covered interval, whereby Horton strata were relatively upthrown against Windsor strata, the stratigraphic displacement at this locality probably exceeding 600 feet. No data indicating the trend of this fault were gathered by the writer. As mapped by D. G. Crosby (1952, Geol. Surv., Canada, Prelim. Map 18) it strikes about N83°E. It is possible that this fault is a normal one, for easterly trending normal faults of post-Triassic age are known to occur in the Londonderry and Bass River areas north of Minas Basin (L. J. Weeks, Geol. Surv., Canada, Maps 867A, 874A). Owing to such possibility the writer prefers at present to consider the Johnson Cove fault as separate from the Cheverie reverse fault system.

Additional major faults that cut strata of the Horton group in its type area are inferred by the writer to occur rather rarely where a marked change of dip that cannot be explained by folding alone occurs within a short horizontal distance. For example, on Barkhouse Brook, a tributary of West Avon River, two major faults are inferred, one about 3,500 feet in direct line above bridge at Upper Falmouth, and the other 4,300 feet above same bridge. Movements along them relatively upraised a block of Horton strata lying between them to such an extent as to result in loss from the present surface at this locality of a part, probably a large part, of the ostracod-bearing zone (*see* p. 10) of the middle member of the Horton Bluff formation. The more northwesterly of these faults is evidenced by drag-folds as well as by a change in dip from 10 to 60 degrees, the other one only by an increase of dip from 10 to 35 degrees and by change of strike of about 40 degrees. Both faults are considered to strike northeasterly, and displacements to be normal. A second example may be cited of an inferred fault along which stratigraphic displacement was seemingly much less. The locality is on Halfway River a little more than a mile in a direct line downstream from Bishopville Bridge, where the dip changes from 20 to 54 degrees within a distance of 25 feet. The fault is inferred to strike northeasterly and to be probably normal. The fault cuts ostracod-bearing beds of the middle member of the Horton Bluff formation, which outcrop both upstream and downstream from its inferred position.

Minor faults would not likely be exposed or show reliable evidence for their existence in brooks and rivers of the area, because outcrops are commonly restricted to channels and low banks of the streams. Their occurrence, therefore, is best displayed in cliff sections, e.g., on Minas Basin, and in Horton Bluffs on west side of Avon River. It was noted above that numerous secondary and tertiary asymmetric folds occur in Horton strata west of Cambridge. Their axial planes dip northwesterly, and because they are overlapped unconformably by remnants of gently dipping Triassic conglomerate, they were formed and partly eroded prior to the Triassic. A number of high-angle faults heading northwestwards cut these folded Horton strata, but it should not be assumed a priori that all of them are likewise pre-Triassic. For, about a half mile southeast of Split Rock, where several Triassic trap sills are intruded into strata of the upper member of the Horton Bluff formation, Triassic conglomerate along with Horton strata was downthrown on the southeastern side of a high-angle reverse fault, proving that this fault at least was post-Triassic. A normal fault occurring in the Minas Basin cliffs about 3,450 feet west of Cambridge Creek also displaced Triassic conglomerate. The fault strikes N40°E and dips N75°W, the Trias being downthrown on its southeastern side.

That some minor thrust faults were formed after minor normal faults is attested by an occurrence in Horton Bluffs, about 800 feet north of Blue Beach, where a normal fault dipping southward is truncated by a thrust fault that dips northward or northwestward at a much lower angle than those observed in the Minas Basin section. Altogether about twelve minor faults were noted by the writer at Horton Bluffs, mostly normal and with stratigraphic displacements less than 50 feet. A few normal faults were noted from Cambridge to Split Rock, but most are reverse faults with relative upthrow on their hanging walls.

Chapter IV

DESCRIPTION OF SPECIES

Summary List of Plants

Horton Group

Lepidodendropsis corrugata (Dawson)
Lepidodendropsis sp. A
Lepidodendropsis sp. B
Lepidophyllum (*Lepidostrobophyllum*) *fimbriatum* Jongmans, Gothan and Darrah
Lepidostrobophyllum sp.
Lepidodendron sp.
Triletes glaber (Dawson)
Triletes cheveriensis n. sp.
Asterocalamites scrobiculatus (Schlotheim)
Nematophyllum sp.
Aneimites acadica Dawson
Sphenopteris strigosa n. sp.
Adiantites tenuifolius (Goeppert)
Triphyllopteris minor Jongmans, Gothan and Darrah
Triphyllopteris virginiana (Meek)
Sphenopteridium macconochiei ? Kidston
Sphenopteridium sp.
Diplotmema patentissimum (Ettingshausen)
Carpolithus tenellus (Dawson)

Windsor and Codroy Groups

Rhacopteris petiolata (Goeppert)
Rhacopteris robusta Kidston
Rhacopteris circularis ? Walton
Telangium bretonensis n. sp.
Telangium sp.
Diplotmema ? sp.

Summary List of Non-marine Invertebrates

Spirorbis avonensis n. sp.
Limnoprimitia ? *hortonensis* n. sp.
Hollinella ? *novascotica* (Jones and Kirkby)
Carbonita cf. *subula* (Jones and Kirkby)

Summary List of Non-marine Invertebrates *(Conc.)*

Euestheria dawsoni (Jones)
Euestheria lirella n. sp.
Euestheria belli (Raymond)
Asmussia alta (Raymond)
Eoleaia leaiaformis (Raymond)
Eoleaia laevicostata (Raymond)
Leaia sp. Raymond

Systematic Descriptions

Lepidodendropsis corrugata (Dawson)

Plate I, figures 1-3, 4(?), 5, 6; Plate II, figures 1-5, 6(?);
Plate III, figures 2, 8-10; Plate IV, figures 2, 4-6

Lepidodendron corrugatum Dawson, Quart. J. Geol. Soc. London, vol. 15, p. 68, fig. 2a (1859). Acadian Geology, 2nd ed., p. 486, fig. 74 (p. 253), fig. 168 (p. 451) (1868). Geol. Surv., Canada, Rept. on Fossil Plants of the Lower Carboniferous and Millstone Grit Formations of Canada, p. 19, Pl. 2, figs. 10-22; Pl. 3, figs. 23-29; Pl. 5, figs. 33-36 (1873).

Original description. "Areoles elongate ovate, acute at both ends, with a ridge along the middle, terminating in a single elevated vascular scar at the upper end. In certain states the vascular mark appears in the middle of the areole. In young branches the areoles are contiguous and resemble those of *L. elegans*. In old stems they become separated by spaces of longitudinally wrinkled bark; in very old stems these spaces are wider than the areoles. Leaves linear, 1 inch or more in length, usually reflected, one-nerved. Cones (Lepidostrobi) terminal, short, cylindric, with numerous short, acute triangular scales. Structure of stem:— a central pith with a slender cylinder of scalariform vessels, exterior to which is a thick cylinder of cellular tissue and bast fibres, and a dense outer bark. Var. *verticillatum* has the areoles arranged in regular decussate whorls instead of spirally. This difference, which might at first sight seem to warrant even a generic distinction, is proved by specimens in my possession to be merely a variety of phyllotaxis." (Acadian Geology, 2nd ed., p. 486).

Emended description. Leaf cushions low, rhombic to fusiform, three to eight times as high as wide, spirally arranged, but aligned in vertical rows and commonly appearing verticillate. In very young stems, cushions may be lacking and leaf scars occur as subcircular or suboval elevations. In somewhat older stems the cushions are subrhombic, laterally contiguous or nearly so, acutely pointed at both ends. The cushions are most elevated in upper third of their length in the area of leaf scar, the lower field being marked by a median keel, which may or may not be prominent, and which lacks transverse furrows. The field above leaf scar generally appears smooth, and surface rapidly descends to general level of the epidermis. Leaf scar occurs as a crescentic ridge enclosing below an open deltoid area about 1.5 mm wide and as high, occupying nearly whole width of upper part of cushion, having a single punctiform vascular scar at summit of the ridge. This scar commonly lies ⅓ to ⅙ distance from the upper end of leaf cushion. In older stems the leaf cushions are separated by flat areas of lightly corrugated cortex, which are as wide as the cushions or wider, and the lower ends of cushions occur as almost vertically straight, narrow tails.

Leaves, uninerved, up to 3 cm or more long, commonly about 2 mm wide at base, leaving stems transversely or at open angles, but commonly distally ascending in a broad curve or more abruptly.

Cones (?), seemingly long, terminal (?), leafy shoots with sporophylls abruptly upturned distally. Unattached sporangia, possibly belonging to the species, about 1 cm long by 3 mm wide (Pl. I, fig. 4; Pl. II, fig. 6).

Remarks. The genus *Micheevia* Zalessky 1930 has priority over *Lepidodendropsis* Lutz 1933. In deference to the usage, however, of such eminent palæobotanists as Jongmans and Gothan, who considered Zalessky's genus inadequately described and figured, the writer here provisionally adopts Lutz' genus, which certainly was founded on more abundant and much better preserved material. Jongmans (1954, p. 218), who had the opportunity of seeing or collecting specimens of Zalessky's species, admitted freely that they were congeneric with *Lepidodendropsis,* and it is true that Zalessky did describe many of the essential characters of the genus, viz., occurrence of low rhombic to fusiform leaf cushions, each having an elevated, narrowly rounded leaf scar in the upper third of its length, which surmounts a more or less deltoid area, which is open below and marked in its upper part by a single punctiform vascular scar. Figures 2 and 3, Plate I, Zalessky, 1930, show fairly well the external subrhombic to fusiform outline of the leaf cushions. Figure 2 also shows a sub-verticillate arrangement of the leaf scars, a generic character ascribed to *Lepidodendropsis* (Lutz, 1933, p. 118). To judge from Zalessky's descriptions and illustrations *Micheevia rimnensis* and *M. pulchella* are conspecific with the genotype, *M. uralica,* the first mentioned showing more rhombic scars than *uralica,* a variation of doubtful specific importance, and the second showing a *bergeria* state of preservation. *Lepidodendropsis corrugata* differs from *M. uralica* in the occurrence of a much better marked median carina in the lower field of a cushion and in the apparent lack of any carina in the short upper field.

The Pocono specimens identified by Jongmans, Gothan and Darrah (1937, pp. 431-434) with *Lepidodendropsis hirmeri* Lutz are obviously conspecific with *Lepidodendropsis corrugata* (Dawson), and the writer agrees with Darrah (1949) that *L. vandergrachii* and *cyclostigmatoides* are only variable forms of Dawson's species. Dawson (1873, p. 19, Pl. V, fig. 33) had already compared very young shoots of *L. corrugata* with *Cyclostigma* and had given them a varietal status *cyclostigmoides*. The specific identity of *L. sigillarioides* with *L. corrugata* is somewhat more doubtful, but a few specimens of *L. corrugata* from the Horton group resemble *L. sigillarioides* so closely (*see* Pl. IV, fig. 5) that a combination of *L. sigillarioides* with *corrugata* seems reasonable. Such conclusion is supported by like association of sigillarioid and typical stems in case of *Lepidodendropsis* *theodori* (Jongmans, 1939, pp. 26-28, Pls. 6-18, figs. 1-327). For *L. theodori,* to judge from excellent figures of it provided by Jongmans, lacks any characters that would differentiate it satisfactorily from *L. corrugata.* Krausel and Weyland (1949, p. 143) unite *L. theodori* to *L. hirmeri,* which itself may well be a synonym of *L. corrugata.*

Darrah (1949, p. 1) drew attention to the great polymorphism of this species. A large part of this is owing to individual stages of growth, and the remainder to degrees of decortication before burial. The width of the leaf cushions does not increase materially with age as does the length, which results in cushions varying in outline from subrhombic to elongate-fusiform.

Occurrence. Horton Bluff formation, localities 226, 228, 234, 360, 364, 423, 424, 651, 683, 684, 688, 689, 695, 698, 813, 1170, 1173, 1226, 1472, 1479, 1480, 1483, 1489, 1564, 1654, 1674, 1676, 1679, 1680, 1681, 1750, 1752, 1963, 1969, 2161, 2167, 2206, 2209, 2210, 2212, 2215, 2224, 2227, 2230, 2232, 2502, 2503, 2510, 2511, 2512, 2513, 2514, 2519, 2520, 2521, 2524, 2526, 2527, 2530, 2531, 2534, 2535, 2536, 2537, 2538, 2539, 2540; Cheverie formation, localities 1482, 2070, 2164, 2217; Horton group (Albert formation), New Brunswick, localities 418, 426, 624, 652, 659, 675, 905, 1500, 1513, 2372, 2500; Horton group (Kennebecasis formation), New Brunswick, localities 82, 653, 677, 2543; Horton group (Memramcook formation), New Brunswick, localities 1521, 2516.

Types. Hypotypes, GSC Nos. 491, 688 to 702, inclusive.

Lepidodendropsis sp. A

Plate VI, figures 1, 3

Description. Leaf cushions, low, contiguous or separated by narrow widths of cortex, spirally arranged, with alignment in vertical and nearly horizontal rows much less noticeable than with *L. corrugata.* Unlike the condition in *L. corrugata,* the ends of the lower fields of cushions are generally a little out of alignment with acute tops of cushions lying below. The cushions are subrhombic and appear commonly obovate-fusiform owing to their rounded lateral margins, the elevation of cushions in area of the leaf scars, and the shortness of the cushions above this elevation. A vascular scar in the middle of crescentic upper elevation of leaf scar is inconspicuous and punctiform, and commonly is not visible. A simple, median carina in lower field is lacking or generally inconspicuous. Character of leaves unknown.

Remarks. The preservation of the specimens to hand hardly justifies a specific name, but typical forms differ from *L. corrugata* in the greater relative width of the cushions to their length, in lesser elevation of the cushions, and in the relatively shorter and almost inconspicuous upper ends above the leaf scars. A pseudo-verticillate arrangement is likewise inconspicuous or lacking.

Occurrence. Horton Bluff formation, locality 813.

Types. GSC Nos. 706, 707.

Lepidodendropsis sp. B

Plate VI, figure 2

Description. The single specimen to hand is a negative imprint of the outer cortex which has traces of coalized epidermal tissue in the areas of the leaf scars. The leaf cushions are flattened and low with exception of a transverse, broadly arched elevation in the middle of which is a single punctiform scar, and which surmounts a roughly deltoid area. This scar lies about two-sevenths the length of a cushion from the top. The phyllotaxy is spiral, and there is no indication on this specimen of a verticillate arrangement. The cushions, about 7 mm long by 2 mm wide and about 1 cm apart in a spiral row, are smooth, although under a hand lens they show a microscopic vertical lineation. Their areas stand in marked contrast to the coarser longitudinal striae that corrugate the intervening cortex, and this contrast is accentuated by the obliquity of these striae to the lower fields of the cushions.

Remarks. In ornamentation of epidermal surface the species resembles somewhat *Bothrodendron wuekianum* (Heer) from the Baren-Insel (Heer, 1871, p. 40, pl. 7, figs. 1c, 2; pl. 9, fig. 1: *also* Nathorst, 1894, pl. XV, figs. 14, 15) in which, however, the leaf scars are subcircular and placed at summit of the cushions. The assignment of the Horton specimen to *Lepidodendropsis* is based upon the shape and size of the bolsters, and on the position and character of the leaf scars and vascular pit. It differs from *L. corrugata* in the lack of any trace of a median keel on the cushions, in the more broadly rounded and more flattened upper field and in the Bothrodendroid-like ornamentation of the cortex in the vicinity of the leaf cushions.

Occurrence. Horton group, locality 1752.

Type. GSC No. 709.

Lepidophyllum (*Lepidostrobophyllum*) *fimbriatum* Jongmans, Gothan and Darrah

Plate IV, figure 3; Plate VI, figure 5

Original description. "Auf einer Platte mit mehreren Stücken der *Lepidodendropsis hirmeri* liegt ein merkwürdiges *Lepidophyllum* (Fig. 50, 50a). Es besteht aus einem länglichen nach der Spitze zu allmählig verschmälerten, oben aber plötzlich abgestutzten Sporophyllteil und einem etwa zwei Drittel so langen Basalteil, der aber breiter ist. An der breitesten Stelle, also etwas unterhalb der Hälfte, ist der Rand deutlich kurzgefranst. Wo das Sporangium gesessen hat, und einen wie grossen Teil es eingenommen hat, ist nicht erischtlich." (Jongmans, Gothan and Darrah, 1937, p. 442).

Remarks. The largest specimen collected by the writer is 4.5 cm long by about 6 mm wide at a point a little more than half the distance from the base. A strong midrib is preserved, but the fimbriated edges of the lamina near the broad middle part of the leaf are poorly preserved. In Nova Scotia the species is associated with *Lepidodendropsis corrugata,* and this, taken in conjunction with its association with *Lepidodendropsis hirmeri* Jongmans *et al.* (=*L. corrugata*) in the Pocono beds, strongly supports an inference that the species represents sporophylls of *L. corrugata.*

Occurrence. Horton Bluff formation, localities 2534, 2540.

Types. Hypotypes, GSC Nos. 703, 710.

Lepidodendron sp.

Plate VII, figure 1

Remarks. A specimen of a lepidodendroid stem too poorly preserved for specific identification is of interest because it indicates the occurrence in lower part of the Horton group of a *Lepidodendron* with leaf cushions comparable in size to those of *Lepidodendron veltheimii* Sternberg.

Occurrence. Horton Bluff formation, locality 1963.

Type. GSC No. 708.

Lepidostrobophyllum sp.

Plate IV, figure 1

Remarks. A single specimen of an isolated *Lepidostrobophyllum* about the size and form of a large *L. lanceolatum* occurs in collections from Horton group of Moosehorn Brook, New Brunswick. It is recorded here because of its unique occurrence in association with stems of *Lepidodendropsis corrugata* (Dawson). The specimen which is not quite complete, is 4.5 cm long by 8 mm wide, the greatest width being within lower half of the length from which contraction towards apex is very gradual.

Occurrence. Horton group (Albert formation), New Brunswick, locality 624.

Type. GSC No. 718.

Triletes glaber (Dawson)

Plate III, figures 1, 3, 4; Plate V, figures 1, 2

Sporangites glabra Dawson, Acadian Geology, 2nd ed., p. 491, fig. 168F (p. 451) (1868).

Lepidodendron corrugatum Dawson, Geol. Surv., Canada, Rept. on Fossil Plants of the Lower Carboniferous and Millstone Grit Formations of Canada, p. 20, Pl. 2, figs. 22, 22a (1873).

Description. Smooth, spherical megaspores, belonging to the division *Laevigata,* commonly about 2 mm diameter, although reaching a maximum of 3 mm. Triradiate markings were not seen on non-compressed spores with thin coalized coats, which occur in great abundance in many of the arenaceous beds, but such may be found among the compressions where the markings are prominent and run half-way or somewhat more to the equatorial margin (Pl. III, figs. 1, 3, 4).

Remarks. Two types of megaspores, varying persistently in size although otherwise similar, occur associated with specimens of *Lepidodendropsis corrugata.* The larger of these, *Triletes glaber,* occurs in the lower division of the Horton group (Horton Bluff formation in the type locality) whereas the smaller, *Triletes cheveriensis,* described below, occurs characteristically in the Cheverie formation or upper division of the Horton group.

Occurrence. Horton Bluff formation, localities 360, 813, 1170, 1226, 1480, 1753, 1969, 2167, 2206, 2540.

Types. Hypotypes, GSC Nos. 711, 712, 713, 717.

Triletes cheveriensis n. sp.

Plate III, figures 5-7; Plate V, figure 3

Description. Megaspores, subtetrahedral to spherical, smooth, except for triradiate markings that are commonly preserved and that reach to, or almost to, the equatorial border.

Remarks. This type of spore is particularly abundant in beds of the upper part of the Horton group outcropping on Moosehorn Brook, west of Sussex, New Brunswick, where it is associated with stems, including leafy stems and probable cones, of *Lepidodendropsis corrugata.* It has persistently a smaller size than *Triletes glaber,* the diameters rarely reaching 1.5 mm and its commonly subtetrahedral shape and more common preservation of triradiate markings serve to distinguish it readily from *T. glaber* which it otherwise resembles. There seems little doubt that *T. cheveriensis* belongs to specimens indistinguishable from *Lepidodendropsis corrugata,* so that the relations of *T. glaber* occurring in an older part of the Horton group to *L. corrugata* are much more doubtful.

Occurrence. Cheverie formation, localities 678, 2164; Horton group (Albert formation), New Brunswick, localities 624, 659, 2500.

Types. Holotype, GSC No. 714; paratypes, Nos. 705, 715, 716.

Asterocalamites scrobiculatus (Schlotheim)

Plate VII, figures 2, 3

Asterocalamites scrobiculatus Bell, Geol. Surv., Canada, Mem. 238, p. 97, Pl. 57, fig. 2; Pl. 62, fig. 1 (1944).

Remarks. Specimen No. 782 (Pl. VII, fig. 3) about 5 cm broad, shows in part an external surface of a stem that is perfectly smooth, and in part, where this surface has been stripped off, the ribbed surface of the pith-cast. No definite nodal line was seen within the 8 cm length of the specimen, although one may occur along the transverse line where the pith-cast is revealed.

A second specimen, No. 783 (Pl. VII, fig. 2), 18 mm wide at lower end, 13 mm at upper, shows plainly five nodal lines, which are marked by small pits within the furrows between the ribs. These pits evidently mark position of vascular bundles of the leaves. The internodes in this specimen are 17 to 24 mm long and ribs 1 to 1.5 mm apart, all of which cross the nodal lines without deviation. No branch scars were observed.

A few specimens occur in the Canso group in association with *Mesocalamites*. They all show continuity of the ribs across nodal lines, which are inconspicuous and marked only by a slight transverse furrow or lines of small pits similar to those noted above.

Occurrence. Horton Bluff formation (upper part), locality 1704; Cheverie formation, localities 2217, 2533; Windsor (?) group, locality 1683; Canso group, locality 1402.

Types. Hypotypes, GSC Nos. 782, 783.

Nematophyllum sp.

Plate VI, figure 4

Remarks. W. M. Fontaine and I. C. White (1880, p. 35) created the genus *Nematophyllum* for some Permian calamitean stems that were "covered with a thick, very finely striate epidermis; internodes rather remote, swollen; leaves verticillate, numerous, very long and thread-like, of equal width throughout, finely striate, without nerves, united at base in a narrow annular band". This description is applicable to a single specimen from the Horton group, consisting of a microscopically striated stem, 3 mm wide, showing two nodes, 4.5 mm apart. The upper node was largely destroyed in collecting, the lower shows a whorl of about twelve leaves, 1 mm wide, up to 3.5 cm or more long, with surface marked by microscopic more or less irregular striae that effectively conceal the venation, with the exception of a suggestion of a single median vein in a small section of one of the leaves. The leaves are united at base by a narrow collar. Superficially the specimen recalls *Asterophyllites longifolius* forma *striata* from the Cumberland group of Nova Scotia (Bell, 1940, p. 128, pl. III, fig. 5).

Occurrence. Horton group (Kennebecasis formation), New Brunswick, locality 653.

Type. GSC No. 789.

Aneimites acadica Dawson

Plate VIII; Plate IX, figures 1-3; Plate X, figures 1-4; Plate XI, figures 1-4

Schizopteris ? Dawson, Quart. J. Geol. Soc. London, vol. 15, p. 70, fig. 4 (1859).
Poacites Dawson, ibid., p. 70, fig. 5 (1859).
Sphenopteris adiantoides Dawson (*non* Lindley and Hutton), ibid., p. 69 (1859).
Cyclopteris (*Aneimites*) *acadica* Dawson, Quart. J. Geol. Soc. London, vol. 17, p. 5 (1861).
Cyclopteris (*Aneimites*) *acadica* Dawson, op. cit., vol. 22, p. 153, Pl. 8, figs. 32, 32a-d (1866).
Cyclopteris (*Aneimites*) *acadica* Dawson, Acadian Geology, 2nd ed., p. 481, fig. 75 (p. 253) (1868); Geol. Surv., Canada, Rept. on Fossil Plants Lower Carboniferous and Millstone Grit Formations, Canada, p. 26, Pl. 7, figs. 52-63 (1873).

Original description. "Stipe large, striate, branching dichotomously several times. Pinnae with several broadly obovate pinnules grouped at the end of a slender petiolule, and with dichotomous radiating veins." (1866, p. 153).

Emended description. Main axes large, up to 4 inches or more wide, coarsely striated longitudinally, with striae generally about 1 mm apart. Subordinate axes, longitudinally striated, branched irregularly at very open angles, generally at 45 to 75 degrees, commonly with appearance of dichotomy owing to deflection in course of parent axis at junction with branch, although other branching axes may remain straight. Ultimate pinnae, short, commonly 2 to 4 cm long by about 2 cm broad, broadly elliptical to deltoid-elliptical in outline, with two to four, alternate, oblique to spreading, lateral, obtuse pinnules in addition to terminal one. Pinnules in basal position cuneate to a narrow stalk; those near apex have a broader decurrent base, and the uppermost may appear as a simple or marginally lobed segment of the terminal pinnule, being separated from last mentioned by a deep sinus. The pinnules are commonly about 15 mm long and may be simple, obovate-cuneate, but more generally are cut shallowly or more or less deeply and asymmetrically into two or three obtuse, obovate lobes. Surface of pinnules roughened by close, discontinuous, longitudinal striae which generally obscure the veins. When this rough epidermal tissue has been stripped off, the venation is seen to consist of a single, strongly ascending vein, which enters the basal stalk of pinnule and branches fanwise by numerous dichotomies, the ultimate veins being 0.3 to 0.5 mm apart.

Remarks. Dawson added to the above description the observation that fertile pinnae with recurved petiolules were borne on divisions of the main petiole near their origin. The writer collected and examined more than 400 fragments of rock containing numerous fragments of the species but was unable to find any traces of fertile organs. There is little doubt, however, that the species is a pteridosperm and that the generic designation is misleading. The dichotomous or more generally pseudo-dichotomous branching of the axes, and their strong longitudinal lineation differentiate the species from those included in *Triphyllopteris.* The writer, accordingly, does not accept Kidston's assignment of *Triphyllopteris collombiana* Schimper to *Aneimites acadica* (Kidston, 1923, p. 415), nor does he consider that there is any close relationship between American species of *Triphyllopteris* and *A. acadica. A. acadica* has a much more lax habit of pinnate division than species of *Triphyllopteris,* and in this respect is comparable to species of *Adiantites.* Axes of *A. acadica,* moreover, lack occurrence of short transverse bars in imprints of the cortex, a feature that occurs in a number of pteridosperms, including *Triphyllopteris* and *Sphenopteridium.*

Kidston was in error in considering *Cyclopteris* (*Aneimites*) *bockshii* Dawson (*non* Goeppert) as a synonym of *A. acadica,* for, as pointed out by M. Stopes, the former species came from the Pennsylvanian Lancaster formation of New Brunswick, and is synonymous with *Adiantites obtusus* (Dawson).

The pinnules of *Adiantites spectabilis* Read (1955, p. 17, Pl. 7, fig. 3; Pl. 10, fig. 6; Pl. 11, figs. 4, 5; Pl. 14, figs. 1-4), are practically indistinguishable from those of *Aneimites acadica* Dawson, and the method of branching of the rachides is similar. If the rachides of the former species are strongly striated, and the epidermis of the pinnules lineated, features of which Read makes no mention, no doubt would exist as to its specific identity with Dawson's species.

Occurrence. Horton Bluff formation, localities 226, 227, 228, 233, 423, 683, 684, 688, 689, 690, 813, 1170, 1173, 1195, 1226, 1490, 1750, 1969, 2163, 2167, 2507, 2529, 2530, 2531, 2532, 2534; Cheverie formation, localities 679, 1482, 2070, 2164; Horton group (Albert formation), New Brunswick, localities 416, 417, 624, 633, 652, 675, 814, 815, 1500, 1505, 1678, 2517; Horton group (Kennebecasis formation), New Brunswick, localities 336, 653, 677, 687; Horton group elsewhere in Nova Scotia, localities 696, 697.

Types. Hypotypes, GSC Nos. 310, 719 to 732, inclusive, 788.

Sphenopteris strigosa n. sp.

Plate XII, figures 3, 5-9

Description. The species is known only from its small and distal axes that bear sterile foliage. The branching is lateral at angles varying from moderate to a right angle. The pinnules are small, deltoid, cuneate, simple or commonly more or less deeply cut asymmetrically into two lobes, each of which may be simple or slightly emarginate; their sides are nearly straight and converge towards a foot-stalk, and the apices are flatly rounded to truncate. The axes are finely striated, and the surface of pinnules roughened by prominent, microscopic longitudinal striae like the pinnules of *Aneimites acadica.* The veins are generally concealed by this surface lineation, but where exposed branch dichotomously fanwise in their course to the apex as in *A. acadica,* and probably as in that species originate from a single entering vein at base of pinnule.

Remarks. The species differs from *A. acadica* in its much smaller pinnules, which are also much narrower generally in proportion to the length, and have truncated or much less rounded apices. The more elongate-cuneate pinnules may resemble those of *Diplotmema patentissimum* from which, however, they differ in their striated surface layer that generally conceals the veins. The pinnules of *S. strigosa* resemble too those of *Telangium affine* (Lindley and Hutton), but again their roughened surfaces serve to distinguish them. A third species with pinnules very similar to those of *S. strigosa,* including a lineated surface, is *Sphenopteris flexibilis* Heer, as illustrated by Nathorst (1894, Pl. 3, figs. 5, 6), and our species possibly may represent that species. However, *strigosa* so far as known has no associated fertile pinnae similar to those found with *S. flexibilis,* and apparently also lacks zigzag flexures of the axes so characteristic of Heer's species.

S. strigosa may well belong to the same genus as *Aneimites acadica* but, because it is not known whether it possessed strongly striated major axes with a type of branching common to the latter species, it is advisable to assign it in a broader sense to *Sphenopteris.*

Occurrence. Horton group (Albert formation), New Brunswick, localities 652, 1677, 1678, 2517; Horton group (Kennebecasis formation), New Brunswick, localities 336, 674, 677, 1229; Cheverie formation, Nova Scotia, locality 2164; Anguille group, Newfoundland, locality 5157.

Types. Holotype, GSC No. 733; paratypes, GSC Nos. 734, 736, 738, 780.

Adiantites tenuifolius (Goeppert)

Plate XIII, figure 5; Plate XV, figure 3

Description. Frond, large, at least tripinnate. Penepenultimate rachis, up to 5 mm wide, microscopically striated. Penultimate pinnae, oblique, commonly at angle 50 to 60 degrees to parent rachis, straight, or slightly curved, up to 10 cm or more long by 4 cm broad, oblong-lanceolate with acute summits, commonly touching; rachis, canaliculate. Ultimate pinnae, up to 3 cm long by half as broad, oblong-obtuse, with commonly two pairs lateral alternate pinnules that are well spaced on either side giving open appearance; rachis up to 2 mm broad. Pinnules, obovate, the largest about 1 cm long, simple, or one or both basal pair with a narrow lobe more or less deeply cut off to near base of pinnule on posterior side; surface microscopically lineate.

Remarks. The pinnules have coalized remnants of epidermis and, owing to this and to the sandy rock matrix, the veins are not seen. Kidston (1923, p. 193) stated that they are of equal strength and radiate from the base of pinnules.

Occurrence. Cheverie formation, locality 2164.

Types. Hypotypes, GSC Nos. 769 to 771, inclusive.

Triphyllopteris minor Jongmans, Gothan and Darrah

Plate XIX, figure 9

Remarks. Parts of two penultimate pinnae, and several isolated fragments of ultimate pinnae occur on a single large piece of rock derived from the Cheverie formation on Tennycape River. One of the penultimate pinnae is 22 cm long and is not complete; its rachis is 3 mm broad and slightly curved. Thirteen closely spaced ultimate pinnae are exposed on one side only. The second penultimate pinnae, lying near the first and approximately parallel with it, belongs either to a separate frond or to a bent-over part of the same frond, because its pinnae are oriented in the reverse direction; its rachis shows short, transverse bars.

The ultimate pinnae on both of these parent pinnae are 4 to 5 cm long by 1.5 to 2 cm broad; they are oblique, crowded, alternate, with pinnules decreasing in size to the apex; rachis is relatively stout and canaliculate. Pinnules, oblique, alternate, except for basal ones which may be sub-opposite, subrhombic to ovate, contracted at base to thick, short footstalk, the largest definitely tripartite, those of intermediate size commonly with two lateral marginal lobes and a terminal one, the last mentioned being the largest.

The species as pointed out by its authors is very close to, if not a variant of, *T. collombiana* Schimper (cf. Gothan, 1927, Pl. 4), and differs mainly in the less spreading and smaller size of the tripartite pinnules. Identification of the Nova Scotia specimens with *T. minor* rather than with *T. collombiana* is made largely on this factor of size, for the figure of the type specimen of *T. minor* is too poor to permit close comparison.

Occurrence. Cheverie formation or its equivalent, locality 1656.

Type. Hypotype, GSC No. 760.

Triphyllopteris virginiana (Meek)

Plate XX, figures 2, 3

Original description. "Frond apparently attaining a large size, and probably tripinnate. Primary pinnae with a rather stout, rigid, smooth, or slightly striated rachis. Secondary pinnae long lanceolate, regularly alternating, nearly straight, rather closely arranged, and standing nearly or quite at right angles to the rachis. Pinnules more oblique, rather approximate and regularly alternating; lower or inner ones shorter and broader than the others, abruptly narrowed, or apparently sometimes subcordate at the base, and attached to the rachis by an extremely short petiole, more or less distinctly trilobate, the lobes being obtuse, and broad-ovate in form; succeeding pinnules gradually becoming five-lobed, more elongated, or obtusely sublanceolate, more oblique, and less abruptly tapering at the base; beyond these, the others are less and less strongly lobed, or merely undulated on the margins, while a few near the extremities of the pinnae are quite simple, still more oblique, and very gradually tapering to, and more or less decurrent upon the rachis. Nervation distinct, nerves slender, palmately spreading, and bifurcating several times." (Meek, F. B., 1881, appendix 8, p. xviii).

Remarks. David White (1926, p. 838) stated that species of both *Triphyllopteris* and *Lepidendron* (=*Lepidodendropsis*) of the Mississippian Pocono "were remarkable for their polymorphy—that is, for the variability of their characters" and that this "is particularly true with the species of the newly formed genus *Triphyllopteris,* in which indubitably a number of species are present, including *T. alleghaniensis, T. lescuriana* and *T. virginiana,* though in some cases intermediate forms difficult to refer to one species or another furnish unmistakable evidence of the activity of evolution in this genus during Pocono time". Regardless of this observation, Jongmans, Gothan and Darrah (1937, pp. 426-427) recently created three additional species of *Triphyllopteris* from the Pocono, viz., *T. compacta, T. adiantiformis,* and *T. minor.* Of these *T. compacta* was considered closely related to, and possibly conspecific with *Cyclopteris virginiana* Meek, and *T. adiantiformis* possibly conspecific with *T. alleghaniensis.* Unfortunately, the illustrations of *T. compacta* and *T. adiantiformis* (op. cit., Pl. 45, figs. 9-12) fail to bring out adequately differences of specific importance from *T. virginiana* and *T. alleghaniensis* respectively, and in view of White's observation the writer considers it justifiable to identify the Nova Scotian species here in question with *T. virginiana.* A variability in segmentation of pinnules in different specimens may be largely illusory, for, when positions within large fronds are taken into consideration, ultimate pinnae in a low position on a frond may be expected to be represented by pinnatifid pinnules in more apical positions. In the single good Nova Scotian specimen of the species the penepenultimate (primary?) rachis is about 7 mm wide, and the penultimate rachis 2 to 2.5 mm; the latter being about the size of the primary rachis in specimen illustrated by Meek (op. cit., Pl. 1, fig. 3a). Accordingly, Meek's specimen is interpreted by the writer to represent a more apical part of a primary pinna than specimen No. 761 from Nova Scotia, and its deeply lobed or pinnatifid pinnules are considered to correspond to tertiary or ultimate pinnae that would occupy a lower position on a frond. If this interpretation is correct, lack of final stage of foliar segmentation, and occurrence of a large number of tripartite 'pinnules' on the type specimen as compared with that from Nova Scotia is readily explicable.

The rare Nova Scotian fragments are all imprints, and the containing rock underwent strong compressive forces, factors unfavourable for preservation of certain characters that may have marked the rachides. At certain places, however, (e.g., at arrow Pl. XX, fig. 3) a rachis may be seen to possess short transverse bars in the central region; otherwise they were obscurely striated, and the finer ones have a central chord. A strong costation, comparable to that on rachides of *Aneimites acadica,* is lacking, as well as a surface lineation sufficiently prominent to obscure the veins. But a much greater difference between the two species is seen in the habit of their fronds. A regular, lateral pinnate segmentation and a *Neurocardiopteris*-like aspect of the pinnules have resulted in a compact appearance in *T. virginiana* that is in marked contrast to the lax segments of fronds and *Adiantites*-like pinnules of *A. acadica.*

Occurrence. Horton group, locality 5032.

Types. Hypotype, GSC Nos. 761, 761B.

Sphenopteridium macconochiei ? Kidston

Plate XII, figures 1, 2, 4; Plate XIII, figures 1, 2

Remarks. Numerous fragments of a bipinnate sphenopterid agreeing closely with the above species, occur in the Cheverie formation near Cheverie. They consist either of isolated ultimate pinnae or of apical fragments of penultimate pinnae. The pinnules are highly ascending, rhomboidal or subrhomboidal, contracted to a narrow base, laciniately divided marginally into bluntly rounded, narrow segments. Veins are seemingly numerous, divided and radiating from base of pinnule, but generally concealed in Cheverie specimens by immersion in the coalized pinnule substance or by close, microscopic continuous striae.

Occurrence. Cheverie formation, locality 2164; Horton group (Albert formation), New Brunswick, locality 1678.

Types. Hypotypes (?) GSC Nos. 762 to 766, inclusive.

Sphenopteridium sp.

Plate XIV, figures 1-3

Remarks. The material comprises only two fragments of penultimate pinnae, and is too poorly preserved to warrant specific differentiation or close comparison with described species. The primary (?) rachides are straight, microscopically, longitudinally striated, each about 2 mm wide. One, which has a little coalized epidermis, has a few short transverse ridges or bars. The ultimate pinnae are lanceolate, straight, alternate, up to 7 cm long by 1.5 cm wide, provided with crowded, oblique pinnules, oblong to lanceolate, the largest about 24 mm long by 8 mm broad, pinnatifid, contracted at base to very short footstalk, more or less deeply cut into two or three pairs oblique, obtuse lobes and rounded terminal lobe; pinnules near apex of parent pinna, smaller, entire, decurrent and little contracted at base. A number of veins enter base of a pinnule and divide in a radiating manner. Surface of pinnules microscopically striated, without obscuring close and prominent veins.

It is possible that the pinnatifid pinnules represent ultimate pinnae that may occur on lower positions in a frond, and that the frond was tripinnate. If so, this would seem to preclude their comparison with the short pinnae of *Sphenopteridium dissectum* (Goeppert) which according to Kidston (1923, p. 161) is bipinnate. On the other hand, if the pinnules do not represent pinnae, the Nova Scotian form may be bipinnate in habit, and a described species with which it may be best compared is *Archaeopteridium tschermaki* (Stur) Kidston.

Occurrence. Cheverie formation, locality 2164.

Types. GSC Nos. 767, 768, 845.

Diplotmema patentissimum (Ettingshausen)

Plate XIII, figures 3, 4; Plate XV, figures 1, 2; Plate XVI, figures 7, 9; Plate XVII, figure 3

Hymenophyllites ? Dawson, Geol. Surv., Canada, Rept. on Fossil Plants Lower Carboniferous and Millstone Grit Formations of Canada, p. 27, Pl. 7, figs. 64, 64a (1873).

Description. Petiole macroscopically smooth, microscopically marked by a longitudinally elongate, cell-like reticulum of striae, bifurcating at angle of about 90 degrees into two flexuous arms. Primary pinnae, alternate, broadly lanceolate. Ultimate foliar segments, linear, commonly bifid or simple on small pinnae, further divided on older pinnae, about as wide as parent rachis or little wider, obtuse or bluntly pointed at apex. A single vein enters each pinnule sending a simple branch to each segment. Surface of pinnules microscopically roughened by a linear network of lines which in some instances may obscure the veins.

Female fructifications, associated with, and perhaps belonging to the species, are oval, platyspermic, winged seeds, about 5 mm long by 3 mm wide with a wing about 0.75 mm wide that is marked with transverse lines or wrinkles, and a central area marked by microscopic cell-like network similar to reticulum marking the rachides of the pinnae.

Small bodies interpreted to be sporangia, with elliptical or oval longitudinal section are singly attached at apices of ultimate axes, and these may likewise belong to the species; they are about 0.8 mm long by 0.5 mm wide, and are marked by pronounced microscopic linear elevations that define a network of elongated cells.

Remarks. The material to hand from the Horton group is very fragmentary and comprises impressions rather poorly defined from the rock matrix. It agrees so closely, however, with that from the Calciferous Sandstone of Scotland, described and figured by Kidston (1923, p. 253, Pl. 54, figs. 5, 6; Pl. 56, figs. 4, 4a) that there is little doubt of its specific identification.

Although there is no clear evidence of actual attachment of the seeds, they occur in close juxtaposition with pinnae, and both position and ornamentation strongly suggest that they are fruits of this species.

Occurrence. Horton group (Albert formation), New Brunswick, localities 633, 675; Horton group (Kennebecasis formation), New Brunswick, locality 653; Horton Bluff formation, locality 228.

Types. Hypotypes, GSC Nos. 752 to 759, inclusive.

Carpolithus tenellus (Dawson)

Plate XVII, figures 6, 7

Cardiocarpon tenellum Dawson, Geol. Surv., Canada, Rept. on Fossil Plants of Lower Carboniferous and Millstone Grit Formations of Canada, p. 28, Pl. 6, figs. 50, a (1873).

Original description. "Elongated, oval, margin very narrow, a slight notch at the apex leading to a median furrow. Nucellus small, striated longitudinally, with traces of transverse striae." (p. 28).

Remarks. Dawson recorded that seeds with above characters were rather rare in the beds at Horton. Half a dozen specimens were collected by the writer from the Horton Bluff formation of this area, but all occur as poorly preserved imprints and it was impossible to decide whether they all belong to a single species or to what particular genus they should be assigned. They are apparently platyspermic; the sclerotesta is ovate to elliptical, averaging about 7 mm long and 3 mm wide, and has a narrow border or flange, scarcely 0.5 mm broad, as well as a median rounded keel. They might be allocated to *Rhabdocarpus* were it not that characteristic species of that genus are striated and lack keels. The Nova Scotian seeds have only a microscopic lineation in the form of close longitudinal lines that anastomose to form an elongated network of cell-like meshes. GSC specimen 786 (Pl. XVII, fig. 6) appears to have an apical sinus, but whether this was natural or produced by splitting was not determined. A specimen (GSC No. 787) from the Anguille group of western Newfoundland certainly seems to have a natural sinus at the apex, and is illustrated here for comparison (Pl. XVII, fig. 7).

A few seeds that resemble those from the Horton Bluff formation occur rarely in collections from the Albert and Kennebecasis formations of New Brunswick, but all are too poorly preserved to add to our knowledge of the species.

Occurrence. Horton Bluff formation, localities 226, 683; Horton group (Kennebecasis formation), New Brunswick, localities 653, 677, 2543; Horton group (Albert formation), New Brunswick, locality 1678; Anguille group, Newfoundland, locality 3579.

Types. Hypotypes, GSC Nos. 786, 787.

79026-1—4½

Rhacopteris petiolata (Goeppert)

Plate XVIII, figure 6

Remarks. Kidston (1923, p. 211) described the species as follows:

> Frond pinnate, linear, rachis moderately stout, straight, faintly striated longitudinally. Pinnules alternate, semi-flabelliform, placed almost at right angles or oblique to rachis, and divided into 2-4 more or less distinct fasciculate bundles of segments. Each group through dichotomy consists ultimately of from 3-4 more narrow-linear, blunt-pointed divisions, into each of which a single vein enters.

The material to hand consists of a very small fragment of a pinna, but the pinnules agree with the above description very closely. The pinnules are alternately attached to rachis at angles of about 45 degrees, and are unilaterally divided into oblique segments more or less grouped into three bundles, each of which is divided again into two or three linear bluntly pointed segments.

Occurrence. Codroy group, Newfoundland, locality 3654.

Type. Hypotype, GSC No. 779.

Rhacopteris robusta Kidston

Plate XVII, figures 5, 8; Plate XVIII, figures 2, 3

Original description. "Frond linear, rachis straight, slender. Pinnules, attaining a length of 3.5 cm., subalternate or opposite, spreading, semiflabelliform, segments unilateral, arranged in 3-5 groups, according to size and position of pinnules on rachis; groups further dichotomously divided one or two times to form the ultimate, narrow, blunt or bluntly-pointed segments of the pinnules. A single vein seems to enter each ultimate segment or tooth." (Kidston, 1923, p. 216).

Remarks. The original description is presented above, because the material from the Windsor group consists only of isolated pinnules or tips of small ultimate pinnae. Although the ultimate divisions in the pinnules seem to have generally more than one vein, this appearance is considered to be possibly deceptive, for the apices are rarely well marked from the rock matrix, and ultimate segmentation in the form of crenae might readily escape notice. There is commonly a perceptible major division of the pinnules into three groups, separated by deep sinuses, and one or more of these segments commonly dichotomise again, the resulting sinuses cutting less deeply into the leaf. Ultimate segmentation in some instances at least take the form of marginal crenae.

The pinnule substance was thin but firm, the surface perfectly smooth, and the veins equal and semi-immersed.

Occurrence. Windsor group, localities 1659, 1662.

Types. Hypotypes, GSC Nos. 748 to 751, inclusive.

Rhacopteris circularis ? Walton

Original description. "Frond pinnate, linear-lanceolate, rachis fairly stout, with fine longitudinal striations and with a short expanded region at the base.

Pinnules distant near the base of the frond, but overlapping farther up, alternate or opposite, set obliquely to the rachis, but not overlapping it. Margin of pinnules entire, more rarely crenulate or lobed. Pinnules circular to semiflabelliform, contracted at the base to form a short footstalk. The veins radiate from the footstalk and dichotomise two or three times in the lamina before attaining the margin. There is a tendency to asymmetry in the higher pinnules on the frond. Venation circinnate." (Walton, 1926, p. 208).

Remarks. A single fragment of a pinnae represents an apical part of a frond, and is an imprint poorly differentiated from the rock matrix. It agrees with the types (Walton, 1926, Pl. 16, figs. 5-8; Pl. 17, figs. 13, 14) in the form of the pinnules, in a greater asymmetry of the upper ones as compared with the lower, in the oblique attachment and strong radial venation, in what appears to be a slightly crenate margin in one of the pinnules, and finally in an apparent overlap of the top lateral pinnule upon the terminal one.

Occurrence. Codroy group, Newfoundland, locality 3657.

Type. Hypotype, GSC No. 777.

Telangium bretonensis n. sp.

Plate XV, figures 4, 5; Plate XVI, figures 1-5, 8;
Plate XVII, figures 1, 4 (?)

Description. Sterile and fertile pinnae very dissimilar, the latter being reduced to branching filiform axes with fertile organs at their ends. All axes are longitudinally striated, and in one specimen short, irregular, transverse bars or elevations occur in addition. Pinnules, rhomboid to deltoid cuneate, shortly stalked, alternate, oblique to parent rachis, consisting generally of one to three more or less deeply and asymmetrically cut, simple, or sparingly and marginally lobed, obtuse segments, and a terminal segment of similar character, the apices being rounded. Pinnule substance, coriaceous, and surface of pinnules marked by microscopic, prominent, longitudinal striae as well as by strong veins, which dichotomise and radiate from base of pinnule and which seemingly originate from a single entering vein.

Axes of fertile pinnae, filiform, longitudinally striated, branching laterally and rarely dichotomously. Synangia, closely associated with these axes, comprise at least twelve sporangia and perhaps as many as fifteen, sessile on a disc-like plate, 4 mm or so long, about the marginal area of which most of the sporangia are attached and inclined towards the centre. Individual sporangia, about 1 to 1.5 mm long by 0.5 mm wide at base, tapering to pointed distal ends, free for most of their length at least, thick walled, with surface coarsely lineated, so as to produce an elongate reticulum; seemingly unilocular. Associated also with filiform axes are organs considered to be capsules of seeds. They consist of a basal laminae about 9 mm long with six or more distal, linear, narrow, free segments, 5 to 7 mm long.

Remarks. The material is too fragmentary for knowledge of the frond as a whole. An axis of one specimen shows inconspicuous, short, transverse elevations or bars in addition to striae as in *T. affine*. Although no synangia were noted unequivocally attached to the termini of the pinnae that consist only of branching axis, the close association with the latter suggests strongly original organic connection. The number of sporangia in a synangium is intermediate between that of *T. affine* and *T. bifidum*. Rare isolated, small, bean-shaped bodies, with smooth coalized coats, the larger 4 mm long by 2.3 mm thick (Pl. XVII, fig. 4) occur in association with fragments of the species, but whether they represent its seeds must be considered doubtful.

Occurrence. Windsor group, localities 1661, 1684, 5155; Codroy group, Newfoundland, locality 5156.

Types. Holotype, GSC No. 739; paratypes, GSC Nos. 740 to 746, inclusive, 778, and No. 747 a possible seed of species.

Telangium sp.

Plate XVII, figure 2

Remarks. Specimen No. 781 shows a cup-shaped fruiting body, about 8 mm long by 5 mm wide, consisting of at least five linear, apically pointed, free segments, which are united at base by an expanded terminal part of a short, thin rachis that branches off obliquely from a parent rachis that is about 1 mm wide. The segments, which are carbonized and microscopically lineate, are interpreted to be microsporangia. They are much larger than those of *T. affine* and *T. bifidum,* but otherwise resemble them in habit and structure. Imprint of a second branch with a similar terminal synangium is also shown on this specimen.

Occurrence. Codroy group, Newfoundland, locality 5160.

Type. GSC No. 781.

Diplotmema ? sp.

Plate XVI, figure 6; Plate XVII, figures 9, 10; Plate XVIII, figures 1, 4, 5

Remarks. The material consists only of fragments, but because branching of a frond is not known, an assignment to *Diplotmema* rather than to *Rhodea* is questionable. The disposition of the fragments suggests a spreading lax habit. The various rachides are strongly striated longitudinally, and, if cortex had transverse bars of sclerenchymatous tissue, they are not preserved. Some primary (?) pinnae, e.g., in specimen No. 773 (Pl. XVII, figs. 9, 10) give off secondary pinnae almost at right angles. Some pinnules or ultimate pinnatifid pinnae consist of five major segments, each of which may divide by one or two dichotomies, the ultimate divisions being linear and bluntly rounded. Veins are not commonly seen, owing either to immersion in pinnule substance or to a microscopic surface striation. Where seen more than one enters an ultimate division.

The species as evidenced by the largest pinnules is more robust than *Diplotmema dissectum* (Brongniart). It is more robust too than *Rhodea smithi* Kidston (1923, p. 226, Pl. 56, figs. 1, 2; Pl. 57, figs. 2, 2a, 3), and its ultimate segments differ from those of the latter species in their bluntly rounded ends. The smallest pinnules are distinguishable with some difficulty from *Diplotmema patentissimum*.

Occurrence. Codroy group, Newfoundland, locality 3652.

Types. GSC Nos. 772 to 776, inclusive.

Spirorbis avonensis n. sp.

Plate XIX, figures 10-12; Plate XX, figure 1

Description. Tubular shells coiled closely in a sinistral spiral almost in a single plane for about two revolutions, in older individuals passing outward without departing widely from the original plane of enrollment in an extended slightly curving tube for a distance that commonly exceeds the diameter (3 to 4 mm) of the first two revolutions. The final diameter of a tube, apparently near the aperture, is 1.5 to 2 mm. The umbilicus is broad. Surface of tubes marked by close, raised, transverse growth lines and in addition in final stages by irregular prominent transverse ridges.

Remarks. Most of the specimens are isolated and lack perceptible objects of attachment. One rock fragment, however, shows a number of individuals appressed to fragments of plant tissue to which they were apparently attached during development of one and a half to two revolutions of the shell. In possessing a final free, lightly curved portion after two revolutions the species resembles *Spirorbis caperatus* McCoy, which the writer reported from the younger and marine Windsor group (Bell, 1929, p. 98, Pl. VI, figs. 1, 2) which, however, is dextrally enrolled.

Occurrence. Horton Bluff formation, localities 2209, 35326, 35328, 35337.

Types. Holotype, GSC No. 14414; paratypes, Nos. 14410 to 14413, inclusive.

Limnoprimitia ? *hortonensis* n. sp.

Plate XIX, figures 1-8

Leperditia okeni Jones *in* Dawson, Acadian Geology, p. 256, fig. 78b (1868).
Leperditia okeni Jones and Kirkby, Geol. Mag., dec. 3, vol. 1, p. 356, Pl. 12, fig. 3 (1884); Can. Rec. Sci., vol. 7, p. 318, figs. 1, 1b (1897).
Leperditia okeni var. *scotoburdigalensis* Jones and Kirkby, op. cit., p. 357, Pl. 12, figs. 1, 1b, 1c, 2: Can. Rec. Sci., vol. 7, p. 318 (1897).
Kirkbyina sp. Bell, Geol. Surv., Canada, Mem. 155, p. 39 (1929).

Description. Valves, almost equal, but left slightly larger, in outline semi-oval to sub-oblong to sub-quadrate, up to 3 mm long by 2 mm high. Dorsal border, straight, shorter than total length of valve; anterior and posterior angles moderately obtuse, the posterior generally less so than anterior; anterior, ventral and posterior borders gently and rather evenly rounded. Inside the free edge of carapace is a false elevated border and a narrow marginal channel exterior to it to the raised contact edge; the false border of left valve rises slightly higher than that of the right, but there is no apparent overlap at free contact of the valves. The central dorsal area of a valve is marked by an undefined, or obsolete, linear, shallow primitian sulcus, commonly visible only on certain internal moulds; it is bordered anteriorly at or near its base by an inconspicuous tubercle that may represent an adductor scar. The cardinal corners of the valves are flattened. The carapace is slightly wider posteriorly and slightly higher anteriorly.

Remarks. The genera *Euprimitia* and *Aparchites* both have channelled borders rather similar to the species here in question. Some species of *Jonesina,* e.g. the Coal Measures form *Beyrichia arcuata* Bean as described by Jones and Kirkby (1886, p. 438, Pl. 12, figs. 12-14) are stated to have "rimmed valves" but whether this means possession of an entire false border as in *Limnoprimitia* ? *hortonensis* is uncertain. E. Kummerow (1949, p. 48) made *Cypris arcuata* (=*Beyrichia arcuata* Jones and Kirkby 1886 and *Jonesina arcuata* Ulrich and Bassler 1908) the type of a new genus, *Limnoprimitia,* and with this rather than with *Jonesina* the Nova Scotian form is doubtfully assigned.

The writer, following the orientation of valves recommended by R. V. Kesling (1951, pp. 94-104) considers that Jones and Kirkby's figures of the Horton species are oriented in reverse. Although these authors recorded no traces of a dorsal sulcus, they stated that the species described by them was the most widespread and abundant in Horton strata (i.e., in Horton area), and consequently there is no doubt they were dealing with the form here under discussion.

Occurrence. Horton Bluff formation, localities 1170, 1682, 2203, 2209, 5195, 5196 (?), 35325, 35328, 35329, 35332, 35333, 35334, 35337, 35338, 35339, 35357.

Types. Holotype, GSC No. 14391; paratypes, GSC Nos. 14392 to 14395, inclusive.

Hollinella ? *novascotica* (Jones and Kirkby)

Plate XXI, figures 1, 5, 6, 7

Beyrichia sp. Jones *in* Dawson, Acadian Geology, 2nd ed., p. 256, fig. 78C (1868).
Beyrichia nova-scotica Jones and Kirkby, Geol. Mag., n. ser., dec. 3, vol. 1, p. 358, Pl. 12, figs. 5, 6 (1884).
Beyrichia nova-scotica Dawson, Can. Rec. Sci., vol. 7, p. 319, text fig. 2 (1897).
Beyrichia (? *Hollinella*) *novascotica* Bassler and Kellett, Geol. Soc. Amer., Spec. Papers, No. I, p. 202 (1934).

Original description. "In Figure 6, which represents a left valve, the dorsal line is seen to be straight and the anterior extremity projects only a little way beyond the dorsal line or margin, and then curves rapidly backwards and passes into the evenly convex ventral margin; the posterior extremity is boldly rounded. The valve is divided into four bosses, lobes, or elongated protuberant areas, by deep sulcations or depressions. The two uppermost swellings, which are submedial in position, are the most round and boss-like; behind and below the more posterior boss is an elongate, curved swelling, and another, similar, but smaller, lies in advance, parallel to the margin of the antero-ventral curve. A narrow depressed area follows the course of the free margins, and separates them from the main and convex portion of the valve. Surface apparently smooth. Length varying from 1/23 to 1/17 inch."

Emended description. Shell obliquely semi-oval; dorsal border, straight, almost reaching anterior end; cardinal angles obtuse, but anterior one much less so than posterior and almost a right angle. Free margins, flatly curved anteriorly and posteriorly, but narrowly rounded in ventro-posterior area. A narrow frill marked by transverse costae occurs in free marginal border area and extends beyond contact margin, being broadest in the posterior-ventral area. Lateral surface of a valve, quadrilobate dorsally, with (a) a tubercle or short ridge close to anterior border, (b) two knob-like elevations in medial area, subequal or anterior one slightly larger, separated by a deep sulcus which extends about half-way to ventral margin of valve, (c) a slightly crescentic lobe-like swelling in posterior region, running almost to inner margin of frill, and separated from the posterior knob by a sulcus, and (d) a lobe-like swelling in antero-ventral region lying below knobs of (b) and separated from them and from (c) by narrow depressions. Length of valve 1 to 1.5 mm and height 0.75 to 1 mm.

Remarks. The quadrilobate surface of the dorsal half of a valve and the ventral swelling imparts to *H. novascotica* an appearance quite different from that of *H. dentata,* the genotype of *Hollinella.* Moreover, the median knobs are nearly subequal in size, and almost equidistant from the dorsal margin. In general distribution and number of elevated prominences the Nova Scotian species resembles more closely *Hollinella kolmodini* (Jones) Ulrich and Bassler from the Middle Devonian of New York and Ontario.

At some future time, if additional material be found that shows hinge-characters, it is probable that *novascotica,* which occurs in non-marine Mississippian strata will be assigned to another genus.

Occurrence. Horton Bluff formation, localities 35326, 35328, 35339, 35340.

Types. Hypotypes, GSC Nos. 14396 to 14399, inclusive.

Carbonita cf. *subula* (Jones and Kirkby)

Plate XXI, figures 2-4, 8, 9

Cythere sp. Jones *in* Dawson, Acadian Geology, 2nd ed., p. 256, fig. 78a (1868); Geol. Mag., n. ser., dec. 3, vol. 1, p. 361, Pl. 12, figs. 11a-c (1884); Can. Rec. Sci., vol. 7, p. 321, fig. 6 (1897).

Description. Valves up to 1 mm long by 0.4 mm high, the length being commonly two and a half to three times the height; outline, subelliptical, with dorsal margin flatly convex, ventral nearly straight or almost imperceptibly concave, anterior and posterior margins rounded, the posterior only slightly higher.

Shell surface smooth, and medial adductor scar not positively identified, although rarely a "colour spot" suggests such. Complete carapace unknown, but isolated valves very common as calcite casts and internal moulds.

Remarks. M. H. Latham (1933, p. 385) noted that the length of *Carbonita subula* from the Calciferous Sandstone and Carboniferous Limestone of Scotland was commonly nearly four times the height. Otherwise, the conformation of the valves of the Nova Scotia species approximates that of *subula.*

Occurrence. Horton Bluff formation, locality 35328.

Types. GSC Nos. 14400 to 14406, inclusive.

Euestheria dawsoni (Jones)

Plate XXIV, figure 1

Estheria sp. Jones, Acadian Geology, 2nd ed., p. 256, fig. 78d (1868).
Estheria dawsoni Jones, Geol. Mag., dec. 1, vol. 7, p. 220, Pl. 9, fig. 15 (1879); ibid., dec. 3, vol. 1, p. 361, Pl. 12, fig. 12 (1884); Can. Naturalist, vol. 7, p. 320, fig. 4 (1897).
Pseudestheria dawsoni Raymond, Bull. Mus. Compar. Zool., Harvard College, vol. 96, No. 3, p. 245 (1946).
Euestheria dawsoni Kobayashi, J. Faculty Sci., Univ. Tokyo, sec. 2, vol. 9, pt. 1, pp. 89, 156 (1954).

Remarks. In the original naming of this form, based on a not well preserved specimen from Horton, Nova Scotia, no description was given beyond the statements that concentric ridges were bold and distant, and that the specimen showed no other ornament. The better of the two original figures represents a five-fold enlargement of a carapace 4.6 mm long by 2.8 mm high, possessing a subterminal umbone, a straight hinge-line situated mostly behind the umbone, rounded anterior, ventral and postero-ventral margins and flatly curved or nearly straight posterior margin that meets the dorsal line at an obtuse angle. Eight lirae are shown, but these were probably increased by a few others originally extending over the umbo, but not preserved.

In material from the Cheverie formation, collected from near Cheverie, P. E. Raymond assigned five or six specimens to Jones' species, which he placed in a new genus *Pseudestheria.* Subsequently, however, Kobayashi considered this genus was pre-empted in part by *Euestheria,* characterized by reticulate or radial ornamentation in the interspaces between the lirae, and in part by *Lioestheria,* a genus with punctate ornamentation. Raymond on the basis of the Cheverie material gave the following description of the species: "Carapace elongate oval, with from 6 to 15 sharply elevated concentric lirae, separated by wide interspaces. The ratio of height to length is about 2:3. Only one of the five specimens is really well preserved. It is 3 mm long and 2 mm high and has 8 lirae. A specimen 4 mm long has 12, and a larger, but poorly preserved individual appears to have about fifteen."

In the opinion of the writer only the first mentioned carapace (GSC No. 14373, Pl. XXIV, fig. 1), which has nine lirae, belongs without doubt to

Euestheria dawsoni. The remainder he would refer partly to *Eoleaia leaiaformis* (Raymond) and partly to *Euestheria lirella* n. sp., elsewhere described in this report. Although *E. dawsoni* may resemble closely some variants of *Eoleaia leaiaformis* the latter show, if only indistinctly, a mesial depression, and generally from twelve to sixteen lirae, as compared with less than twelve in *dawsoni.* Under the microscope specimen 14373 of *E. dawsoni* shows an irregular polygonal sculpture between the lirae.

Occurrence. Cheverie formation, locality 2217.

Type. Hypotype, GSC No. 14373.

Euestheria lirella n. sp.

Plate XXII, figures 1-3, 5, 7

Description. Carapace, subelliptical to suboval to subquadrate; hinge-line, straight, about three-fifths to four-fifths length of shell; anterior and posterior margins sub-equally curved; umbo, subterminal, appearing to rise slightly above cardinal line in a lateral view. Lirae, numerous, close, over twenty in number, thread-like and extending over whole carapace.

	Length (mm)	Height (mm)
Holotype, GSC No. 14386	4.5	2.5
Paratype, GSC No. 14387	4.5	3
" " 14388	6	3
" " 14389	4.5	3.5
" " 14390	4	3

Remarks. The thread-like closely spaced lirae resemble those of *Euestheria raymondi* Copeland (1957, p. 38, Pl. V, figs. 1, 2), but *E. lirella* is a much smaller species and lacks an obliquely rising posterior margin.

Occurrence. Cheverie formation (rare), locality 2217; Horton group, Arichat Harbour and Port Royal, localities 5195 and 35356.

Types. Holotype, GSC No. 14386; paratypes, GSC Nos. 14387 to 14390, inclusive.

Euestheria belli (Raymond)

Plate XXII, figures 4, 8

Erisopsis belli Raymond, Bull. Mus. Compar. Zool., Harvard College, vol. 96, No. 3, p. 234, Pl. 1, fig. 6 (1946).

Asmussia (?) *belli* Kobayashi, J. Faculty Sci., Univ. Tokyo, sec. 2, vol. 9, pt. 1, pp. 89, 154 (1954).

Original description. "Carapace obliquely suboval, mytiliform, the greatest height back of the centre. Beak near the anterior end, hinge straight. Surface with 16 narrow raised lirae, with broad interspaces.

"The outline of this shell, with its axis directed from the beak to the ventral posterior end, strongly suggests reference to *Palaeolimnadiopsis*, but the lirae are not reflexed. Possibly it is an ancestor of the *Palaeolimnadiopsis* group.

"Measurements: Length about 5.00 mm., height, 3.75 mm."

Remarks. Kobayashi (op. cit., p. 24) noted that *Erisopsis* Raymond 1946 was preoccupied by *Erisopsis* Moehring 1858. In the type specimen, GSC No. 9450, the dorsal position of the umbo is uncertain, owing to loss of the anterio-dorsal area of the carapace. It is, however, clearly more subterminal than subcentral, and such a position favours the inclusion of the species in *Euestheria* rather than in *Asmussia* where it was doubtfully placed by Kobayashi.

Raymond's Plate I, figure 6, fails to show the straight dorsal margin and a flattened postero-dorsal triangular area, both of which occur posterior to the umbo. At least ten thread-like lirae meet this part of the dorsal margin at an obtuse angle. Traces of shell which occur on the flattened postero-dorsal area show a microscopic, irregular reticulum in the interspaces between the lirae.

A hypotype, believed by the writer to belong to the species, was gathered by him from the Horton of Petit de Grat Island, Richmond county. It has a dorsal line about 5 mm long and a postero-ventral length of about 6 mm in a direction about 15 degrees to the dorsal line; the greatest height falls in the posterior part of the carapace and is 3 mm. The lirae are poorly preserved on account of crushing to which this carapace had been subjected.

Occurrence. Cheverie formation, locality 2164; Horton group, Petit de Grat Island, Richmond county.

Types. Holotype, GSC No. 9450; hypotype, GSC No. 14407.

Asmussia alta (Raymond)

Plate XXIII, figures 1, 2

Pseudestheria alta Raymond, Bull. Mus. Compar. Zool., Harvard College, vol. 96, No. 3, p. 246, fig. 1 (1946).
Asmussia alta Kobayashi, J. Faculty Sci., Univ. Tokyo, sec. 2, vol. 9, pp. 89, 153 (1954).
Asmussia alta pars Copeland, Geol. Surv., Canada, Mem. 286, Pl. 5, fig. 3 (*non* Pl. 5, fig. 8) (1957).

Original description. "Carapace short, nearly as high as long. Beak anterior, almost at front, hinge line straight. The anterior outline is gently convex, the ventral one boldly rounded. There are about 14 narrow lirae, those at the beak obscured by pressure.

"The holotype is 4.00 mm long and 3.90 mm high. It differs from all other members of this genus in being so nearly equidimensional."

Remarks. The species was founded on a single specimen from the Cheverie formation, and the only other known specimen was collected by the writer from beds near the top of the Horton group on Arichat Harbour. The second specimen did not undergo the moderate compression that affected the type; it is subcircular in outline, 3.5 mm long by 2.75 mm high, and has umbo meeting the dorsal margin about two-fifths the total length of carapace from the anterior end. It possesses sixteen or seventeen lirae, about half of them lying in the ventral half of the carapace where they are narrow, prominently raised and separated by broad interspaces; the remaining half of the lirae are crowded over the umbo. In differentiation and number of lirae, as well as in outline of carapace and relative position of umbo, the Arichat specimen agrees remarkably with the holotype. In the last-mentioned character the species holds an intermediate position between *Asmussia* and *Euestheria.*

GSC specimen No. 12800 assigned by Copeland to the species, and derived from the Stellarton (Pictou) group, differs in its larger size and suboval outline, so that so far as presently known, *Asmussia alta* is restricted to the Horton group.

Occurrence. Cheverie formation, locality 2217; Horton group, Petit de Grat Island.

Types. Holotype, GSC No. 9451; hypotype, GSC No. 12799.

Eoleaia leaiaformis (Raymond)

Plate XXII, figure 6; Plate XXIII, figures 3-9; Plate XXIV, figures 7, 8

Pseudestheria leaiaformis Raymond, Bull. Mus. Compar. Zool., Harvard College, vol. 96, No. 3, p. 246, fig. 2 (1946).
Eoleaia leaiaformis Kobayashi, J. Faculty Sci., Univ. Tokyo, sec. 2, vol. 9, pp. 89, 140, 160 (1954).

Original description. "Carapace small, subrectangular, the ventral outline only slightly convex. The type has about 10 or 11 concentric lirae, whose course is almost straight on the median portion of the shell. The most striking features of this shell are the median depression and the course of the lirae. The median depression alone might be due to an accident of compression, but the lirae have a *leaiaform* appearance.

"The holotype is 4.25 mm long and 2.75 mm high. A larger specimen is 6 mm long, 4 mm high, and has 11 or 12 lirae."

Remarks. The dividing line between this species and *E. laevicostata* is more or less arbitrary, and difficulty arises in assigning certain variants to one or the other species. Normally *E. leaiaformis* has a larger number of lirae, up to sixteen, and lacks, or has scarcely perceptible, leaiaform-like carinae. In both species the ratio of height to total length of carapace is about 8:13, regardless of variable outline, which varies from subrectangular to subquadrate or even to suboval. Variation in both species occurs in the number of lirae within limits generally of ten to sixteen, but generally *leaiaformis* has the larger number. Nonetheless, although lacking presumably any evolutionary or age significance, there appear to be forms gradational from *Euestheria dawsoni* through *Eoleaia leaiaformis* to *Eoleaia laevicostata,* and possibly finally to *Leaia* sp. Raymond. For example, specimen GSC No. 14380 (Pl. XXIII, fig. 4), which was assigned to *leaiaformis* by Raymond, might equally well in the writer's view be assigned to *Euestheria dawsoni*; it has about twelve lirae, and a mesial depression scarcely exists. Specimen No. 14381 (Pl. XXIII, fig. 3) with about the same number of lirae, is more subrectangular in outline, and has a distinct broad, shallow, median depression bordered by rounded swellings without *Leaia*-like carinae; this is a mean form of *leaiaformis*. Specimen No. 14382 (Pl. XXIII, fig. 9), which has also about twelve lirae, in addition to a medial flattening or depression, has a perceptible narrowly rounded carina or anterior ridge about normal to the dorsal margin, but not reaching the ventral margin; an indistinct ridge occurs posteriorly. This specimen might be assigned as appropriately to *laevicostata* as to *leaiaformis*.

The straight cardinal line in *leaiaformis* is about seven-ninths total length of the carapace. All the forms of this species gathered by the writer from the vicinity of Arichat fail to show transitional forms to *laevicostata,* unlike specimens from the type Horton area, and this circumstance is the main reason that the writer provisionally at least accepts *laevicostata* as a separate species. Typical specimens from Arichat Harbour are Nos. 14383 (Pl. XXIII, fig. 7) and No. 14384 (Pl. XXIV, fig. 8).

Occurrence. Horton Bluff formation, locality 226; Cheverie formation, localities 679, 1482, 2164, 2217, 35335; Upper Horton, Arichat Harbour, localities 5195, 5196.

Types. Holotype, GSC No. 12398; paratype, GSC No. 14379; hypotypes, GSC Nos. 14380, 14381, 14382, 14383, 14384, 14405.

Eoleaia laevicostata (Raymond)

Plate XXIV, figures 3, 6

Leaia laevicostata Raymond, Bull. Mus. Comp. Zool., Harvard College, vol. 96, No. 3, p. 282, fig. 5 (1946).
Eoleaia laevicostata Kobayashi, J. Faculty Sci., Univ. Tokyo, sec. 2, vol. 9, pp. 89, 159 (1954).

Original description. "Carapace subrectangular, the height being to the length as about 8:13. Both radial ridges are rounded, slightly nodose. The anterior one is straight, α being about 90°; β is about 25°, which is unusually low. The holotype is 3.25 mm long, 2.00 mm high. There seem to be 7 or 8 lirae, with intervals slightly wider than themselves. Another specimen, 5 mm long, has 14 lirae. All data on this species are approximate, for the specimens are not well preserved, and the ridges are obscure. It differs from *L. leidyi* in its smoother ridges, more numerous lirae, and the greater value of α."

Remarks. The close relationship of this species to *Eoleaia leaiaformis* was discussed in remarks on that species. The writer believes that *laevicostata* is probably only a variant of *leaiaformis,* peculiar so far as known to the type area of the Horton group. However, until more, better preserved material of the *laevicostata* form is forthcoming, its generally fewer lirae and slightly more defined leaiaform-like carinae afford some justification for retaining a specific status. Even where the carinae are most leaiaform, they scarcely reach the ventral edge of the carapace.

Occurrence. Cheverie formation, localities 1754, 2164, 2217, 35335.

Types. Holotype, GSC No. 9449; hypotype, GSC No. 14385.

Leaia sp. Raymond

Plate XXIV, figures 4, 5

Leaia sp. Raymond, Bull. Mus. Compar. Zool., Harvard College, vol. 96, No. 3, p. 283 (1946).

Remarks. Several specimens of a species of *Leaia,* too poorly preserved for erection at this time of a new species, occur in collections from the Cheverie formation of the Horton group at locality 2217, where they are associated with *Eoleaia laevicostata* and *Eoleaia leaiaformis.* Although Raymond considered them to be conspecific with a species from Nova Scotia that Jones (*in* Dawson, 1868, p. 256, fig. 78e) assigned to *Leaia leidyi* (Lea) and subsequently to *L. leidyi* var. *salteriana* (Jones, 1884, p. 361, Pl. 12, fig. 13), they differ from that form in the much closer spacing of the lirae, and other differences may be found when better preserved material is available. The material forwarded to Jones by Dawson evidently was derived not from the Horton group, but from the younger Canso group (*see* Dawson, 1868, p. 394) and a like derivation applies to material from Parrsboro.

Occurrence. Cheverie formation, localities 2164, 2217.

Types. GSC Nos. 14408, 14409, 14409A.

INDEX TO LOCALITY NUMBERS

Nova Scotia

Horton Group

Horton Bluff Formation

226 Harding (Angus) Brook, Gaspereau valley, Kings county. Coll. H. M. Ami, 1898.
227 Duncanson Brook. Coll. W. A. Bell, 1914.
228 Curry (Trenholm) Brook, Kings county. Coll. H. M. Ami, 1897.
233 =227
234 Horton Bluffs, Avonport to Blue Beach. Coll. H. M. Ami, 1897.
360 =234
364 East of Wolfville. Coll. W. A. Bell, 1914.
423 Reed Brook (trib. Anderson Brook), about 5,000 ft. upstream in direct line from bridge on Avonport-Wallbrook road. Coll. W. A. Bell, 1914.
424 Reed Brook, about 500 ft. upstream from 423. Coll. W. A. Bell, 1914.
651 Harding (Angus) Brook, 1,600 ft. in direct line upstream from bridge at Melanson. Coll. W. A. Bell, 1914.
678 Blue Beach (Horton Bluffs) north of fault. Coll. W. A. Bell, 1913.
683 Curry Brook, about 480 ft. in direct line downstream from bridge on secondary road southwest of Wallbrook. Coll. W. A. Bell, 1914.
684 Curry Brook, about 300 ft. northeast and downstream from 683. Coll. W. A. Bell, 1914.
688 Curry Brook, about 970 ft. downstream in direct line from bridge on secondary road southwest of Wallbrook. Coll. W. A. Bell, 1914.
689 Harding (Angus) Brook, about 1,650 ft. in direct line upstream from bridge at Melanson. Coll. W. A. Bell, 1914.
690 Harding (Angus) Brook, about 4,300 ft. in direct line upstream from Melanson. Coll. W. A. Bell, 1914.
695 Tributary of Lebreau Creek, about 950 ft. in direct line south of bridge over Lebreau Creek, about 1 mile east of Martock. Coll. W. A. Bell, 1913.
698 Curry Brook, about 2,050 ft. in direct line upstream from bridge on Wallbrook road. Coll. W. A. Bell, 1914.
813 Horton Bluffs at Avonport. Coll. L. M. Lambe, 1908.
1170 =226
1173 Duncanson Brook, about 2,070 ft. in direct line upstream from bridge on Melanson-Gaspereau road. Coll. W. A. Bell, 1914.
1174 =1173
1195 Deep Hollow Brook about 2,300 ft. in direct line upstream from bridge on Avonport-Wallbrook road. Coll. W. A. Bell, 1914.
1226 Curry Brook, Gaspereau valley. Coll. H. M. Ami, 1898.
1480 Horton Bluffs, Kings county. Coll. W. A. Bell, 1913.
1483 Barkhouse Brook (tributary of West Avon River), about 4,700 ft. in direct line upstream from road bridge at Upper Falmouth. Coll. W. A. Bell, 1913.
1489 Halfway River, near mouth of tributary from Davidson Lake. Coll. W. A. Bell, 1914.
1490 French Mill Brook, about 1,400 ft. downstream from secondary road running from Upper Falmouth to Bishopville. Coll. W. A. Bell, 1914.
1564 Curry Brook, about 1,850 ft. upstream from mouth of tributary brook; the mouth of this tributary is about 9,000 ft. in direct line upstream from bridge of Curry Brook on Wallbrook road. Coll. W. A. Bell, 1914.
1654 Anderson Brook, about 4,550 ft. in direct line upstream from bridge on Wallbrook-Avonport road. Coll. W. A. Bell, 1914.

1674 Quarry, southeast of Wolfville. Coll. W. A. Bell, 1914.
1676 Curry Brook, 2,300 ft. in direct line upstream from bridge on Wallbrook road. Coll. W. A. Bell, 1914.
1679 Fall Brook, about 50 ft. stratigraphically above contact of Horton and granite, and below Windsor waterworks dam. Coll. W. A. Bell, 1913.
1680 =364
1681 Near Wolfville. Coll. W. A. Bell, 1914.
1682 Core of calyx drill-hole near West Gore.
1704 Cambridge shore, Walton area. Coll. W. A. Bell, 1914.
1750 Harding (Angus) Brook, about 2,100 ft. in direct line upstream from bridge on road at Melanson. Coll. W. A. Bell, 1914.
1753 =1480
1963 Curry Brook, Kings county. Coll. W. A. Bell, 1913.
1969 Halfway River, Hants county. Coll. W. A. Bell, 1913.
2161 Barkhouse Brook (tributary of West Avon River), about 4,200 ft. in direct line from bridge over West Branch Avon River on road at Upper Falmouth. Coll. W. A. Bell, 1913.
2163 =1480
2167 Curry Brook, about 1 mile upstream from bridge Wallbrook road. Coll. W. A. Bell, 1913.
2203 Halfway River, about 5,500 ft. in direct line downstream from Bishopville bridge. Coll. W. A. Bell, 1914.
2206 =1480
2209 George Bishop (Hollow) Brook, about 2,150 ft. in direct line upstream from bridge near Bishopville. Coll. W. A. Bell, 1914.
2210 Barkhouse Brook (tributary of West Avon River), about 3,450 ft. in direct line upstream from bridge near Upper Falmouth. Coll. W. A. Bell, 1914.
2215 Curry Brook, about 3,200 ft. in direct line upstream from bridge on Wallbrook road. Coll. W. A. Bell, 1914.
2224 Minas Basin shore, about 2,030 ft. northeast of Split Rock. Coll. W. A. Bell, 1914.
2227 Minas Basin, about 1,860 ft. southwest of bridge over Cambridge Creek. Coll. W. A. Bell, 1914.
2230 Rupert Brook at Hantsport. Coll. W. A. Bell, 1914.
2232 Halfway River, about 3,800 ft. in direct line downstream from bridge over Pencil Brook, southeast of Etna. Coll. W. A. Bell, 1914.
2502 =1489
2503 =1963
2507 Curry Brook, about 1,540 ft. in direct line downstream from bridge on road that runs southeast from main road between Wallbrook and Melanson. Coll. W. A. Bell, 1914.
2510 Curry Brook, at bridge on road that runs southeast from main road between Wallbrook and Melanson. Coll. W. A. Bell, 1914.
2511 Grand Pré, about 450 feet south of Grand Pré church. Coll. W. A. Bell, 1914.
2512 Grand Pré, about 530 ft. southwesterly from Grand Pré church. Coll. W. A. Bell, 1914.
2513 Curry Brook, 1,230 ft. downstream from mouth of tributary that lies about 9,000 ft. in direct line upstream from bridge on Wallbrook road. Coll. W. A. Bell, 1914.
2514 Curry Brook, about 3,800 ft. in direct line upstream from bridge on Avonport-Wallbrook road. Coll. W. A. Bell.
2515 Deep Hollow Brook, 1,390 ft. upstream from bridge on Avonport-Wallbrook road.
2519 Curry Brook, about 3,050 ft. in direct line upstream from bridge on Avonport-Wallbrook road. Coll. W. A. Bell, 1914.
2520 Curry Brook, 425 ft. upstream from 2519. Coll. W. A. Bell, 1914.
2521 Curry Brook, 600 ft. upstream from 2519. Coll. W. A. Bell, 1914.
2524 Grand Pré, 450 ft. northwest of Grand Pré church. Coll. W. A. Bell, 1914.
2526 Curry Brook, about 650 ft. downstream from tributary brook mouth of which lies about 9,000 ft. in direct line upstream from bridge on Wallbrook-Avonport road. Coll. W. A. Bell, 1914.

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2527 On road near Five Points (junction of roads, about 3,000 ft. southeast of Melanson) Gaspereau area, 1,030 ft. S10°W from road junction that lies ¾ mile east of Five Points. Coll. W. A. Bell, 1914.
2528 Harding Brook, about 1,400 ft. in direct line upstream from bridge at Melanson. Coll. W. A. Bell, 1914.
2529 Harding Brook, about 2,400 ft. in direct line upstream from bridge at Melanson. Coll. W. A. Bell, 1914.
2530 Harding Brook, about 1,800 ft. in direct line upstream from bridge at Melanson. Coll. W. A. Bell, 1914.
2531 Harding Brook, about 4,300 ft. in direct line upstream from bridge at Melanson. Coll. W. A. Bell, 1914.
2532 Kenney Brook, below school, south of Gaspereau. Coll. W. A. Bell, 1914.
2533 Crowell Creek, about 80 ft. upstream from CPR tracks. Coll. W. A. Bell, 1914.
2534 Crowell Creek, about 2,900 ft. upstream from CPR tracks. Coll. W. A. Bell, 1914.
2535 Curry Brook, about 1,030 ft. upstream in direct line from bridge on Melanson-Wallbrook road. Coll. W. A. Bell, 1914.
2536 Curry Brook, about 3,950 ft. upstream in direct line from bridge on Melanson-Wallbrook road. Coll. W. A. Bell, 1914.
2537 Curry Brook, about 3,050 ft. upstream in direct line from bridge on Melanson-Wallbrook road. Coll. W. A. Bell, 1914.
2538 Curry Brook at falls, about 4,700 ft. in direct line upstream from bridge on Melanson-Wallbrook road. Coll. W. A. Bell, 1914.
2539 Anderson Brook, about 3,700 ft. in direct line upstream from bridge on Wallbrook-Avonport road. Coll. W. A. Bell, 1914.
2540 =1480
35325 Reed Brook (tributary of Anderson Brook), about 2,200 ft. in direct line upstream from bridge on Wallbrook-Avonport road. Coll. W. A. Bell, 1914.
35326 Halfway River, 5,500 ft. downstream in straight line from bridge at Bishopville. Coll. W. A. Bell, 1914.
35328 Horton Bluffs, north of Blue Beach fault. Coll. W. A. Bell, 1913.
35329 Oakland Brook, about 2,530 ft. in direct line upstream from bridge on Wallbrook-Avonport road. Coll. W. A. Bell, 1914.
35330 Crowell Creek, about 1,100 ft. from mouth. Coll. W. A. Bell, 1914.
35331 Deep Hollow Brook, about 2,450 ft. in direct line from bridge on Wallbrook-Avonport road. Coll. W. A. Bell, 1914.
35332 Hurd (Earle) Creek, about 3,400 ft. in direct line upstream from culvert on shore road. Coll. W. A. Bell, 1914.
35333 Deep Hollow Brook, about 2,300 ft. in direct line upstream from bridge on Wallbrook-Avonport road. Coll. W. A. Bell, 1914.
35334 Hurd (Earle) Creek, about 3,500 ft. in direct line upstream from crossing highway 1. Coll. W. A. Bell, 1914.
35337 Barkhouse Brook (tributary of West Avon River), about 3,450 ft. in direct line upstream from bridge at Upper Falmouth. Coll. W. A. Bell, 1913.
35338 Walton shore, about 1,800 ft. west of Little Rainy Brook. Coll. W. A. Bell, 1914.
35339 Halfway River, about 3 m. in direct line upstream from bridge on shore road. Coll. W. A. Bell, 1914.
35340 Hollow Brook (tributary of Halfway River), about 1,900 ft. in direct line upstream from bridge southwest of Bishopville. Coll. W. A. Bell, 1914.

Cheverie Formation

678 South of Blue Beach, Horton Bluff, south of Blue Beach fault zone. Coll. W. A. Bell, 1913.
679 Crowell Creek, about 1,400 ft. in direct line downstream from bridge on shore road. Coll. W. A. Bell, 1914.
1482 Summerville wharf, Avon River. Coll. W. A. Bell, 1914.
1656 Tennycape River, east side, about ¼ mile above highway bridge at Tennycape. Coll. L. J. Weeks, 1940.
1754 =678

2070 On shore Avon River, about 5,040 ft. in direct line southwesterly from bridge over Cheverie Creek. Coll. W. A. Bell, 1914.
2164 =2070
2217 =2070
2533 Crowell Creek, 83 ft. upstream from CPR bridge. Coll. W. A. Bell, 1914.
35335 =2070

Horton Group (undifferentiated)

696 Bell's Brook, Goshen road, Guysboro county. Coll. T. C. Weston, 1886.
697 Monastery Brook at Giroirs, Guysboro county. Coll. T. C. Weston, 1885.
1472 South Maitland, Shubenacadie River, directly below contact with Windsor. Coll. W. A. Bell, 1914.
1479 South Maitland, from railway-cut west of Shubenacadie River bridge. Coll. W. A. Bell, 1914.
1752 Salma Brook, near Maitland. Coll. J. C. Sproule.
2212 Mill Creek, Brookville, at old mill site. Coll. W. A. Bell, 1914.
5032 MacPherson Lake east of Guysboro. Coll. I. M. Stevenson, 1957.
5195 Arichat Harbour, near head on south side. Coll. W. A. Bell, 1923.
5196 Arichat Harbour, south side, about 2,000 ft. west of head of harbour. Coll. W. A. Bell, 1923.
35356 Ruisseau Creek, Port Royal, Richmond county, near mouth of creek between bridges. Coll. W. A. Bell, 1923.
35357 Core from bore-hole at Port Royal, Madame Island, Richmond county. Coll. W. A. Bell, 1923.

Windsor Group (undifferentiated)

1659 Frenchvale Brook, Cape Breton county. Colls. W. A. Bell and D. J. MacNeil, 1930.
1661 =1659
1662 =1659
1683 Red Point, Baddeck, Victoria county, beneath Windsor limestone. Coll. J. E. Hyde, 1912.
1684 Point Edward, Cape Breton county. Coll. J. E. Hyde, 1912.
5155 Coast near Warren Brook, 5 m. north of Ingonish Beach, Victoria county. Coll. A. S. McLaren, 1954.

New Brunswick

Horton Group

Memramcook Formation

1521 Creek near Calhoun, Albert county. Coll. W. A. Bell, 1928.
2516 Pollet River, Elgin county, about 800 ft. below first bridge below Gordon Falls. Collector unknown.

Albert Formation

416 Road between Moncton and Notre-Dame. Coll. W. J. Wright, 1913.
417 Downing Creek near Dover, West Moreland county. Coll. W. J. Wright, 1914.
418 Albert Mines, Albert county. Coll. W. J. Wilson, 1909.
426 Frederick Brook, below Albert Mines, about 500 ft. below old mill pond. Coll. W. J. Wright, 1913.
624 Moosehorn Brook, near mouth, Kings county. Coll. W. J. Wilson, 1908.
633 Moosehorn Brook, below dam, Kings county. Coll. W. J. Wilson, 1909.
652 Robertson Brook, Elgin, Albert county. Coll. W. J. Wilson, 1909.
659 Moosehorn Brook, ½ mile above railway, Kings county. Coll. W. J. Wilson, 1908.
675 Moosehorn Brook, 1½ m. above mouth, Kings county. Coll. W. J. Wilson, 1908.

814 Albert Mines, Albert county. Coll. L. M. Lambe, 1908.
815 Moosehorn Brook, at mouth, Kings county. Coll. W. J. Wilson, 1903.
905 Wards Creek road, 2½ m. south of Sussex. Coll. A. O. Hayes, 1925.
1500 Robertson Brook, Elgin, ½ mile above mouth, Albert county. Coll. W. J. Wilson, 1909.
1505 Robertson Brook, near falls, Albert county. Coll. W. J. Wilson, 1909.
1513 Robertson Brook, near village of Elgin, Albert county. Coll. W. J. Wilson, 1909.
1677 Petitcodiac River, north of Beliveau wharf. Coll. W. A. Bell, 1928.
1678 Petitcodiac River at Beliveau South. Coll. W. A. Bell, 1928.
2372 Albert Mines, Albert county. Coll. Robertson, 1891.
2500 =624
2517 Blue Cape, east side Petitcodiac River opposite Hillsboro, Albert county. Coll. W. A. Bell.

Kennebecasis Formation

82 Kennebecasis Island, Keith's Beach, St. John county. Coll. A. O. Hayes, 1914.
336 Kennebecasis Island, north shore, St. John county. Coll. A. O. Hayes, 1915.
653 Kennebecasis Island, Keith's Beach, St. John county. Coll. W. J. Wilson, 1908
674 Kennebecasis Island, bay south of Keith's Beach, St. John county. Coll. W. J. Wilson, 1908.
677 Kennebecasis Island, St. John county. Coll. W. J. Wilson, 1908.
687 =674
688 Kennebecasis Island, west shore, St. John county. Coll. W. J. Wilson, 1908.
1229 =674
2543 =82

Canso Group

1402 North of Cape Enragé, Albert county. Coll. W. A. Bell, 1936.

Newfoundland

Anguille Group (=Horton Group)

3579 Shore section Cape Anguille to Codroy. Coll. W. A. Bell, 1946.
5157 Cape Anguille section, south Cape Anguille. Coll. W. A. Bell, 1946.

Codroy Group (=Windsor plus Canso Groups)

3652 Codroy coast, section D, beds 71, Woody Cove beds (op. cit., p. 16). Coll. W. A. Bell, 1946.
3654 Crabbs Brook, from Searston beds (op. cit., fig. 3). Coll. W. A. Bell, 1946.
3657 Crabbs Brook, from Windsor group, about 1,200 ft. above railway bridge. Coll. W. A. Bell, 1946.
5156 Codroy coast, section D, beds 109, Woody Cove beds (Geol. Surv., Canada, Bull. 10, p. 15). Coll. W. A. Bell, 1946.
5160 Plaster Cove, section of Windsor group from Ship Cove to French Brook (op. cit., p. 22). Coll. W. A. Bell, 1946.

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PLATES I to XXIV

PLATE I

Figure 1. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 689. Horton Bluff formation, loc. 2167. (Page 24.)

Figure 2. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 691 × 2. Horton Bluff formation, loc. 1680. (Page 24.)

Figure 3. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 689 × 2. Horton Bluff formation, loc. 2167. (Page 24.)

Figure 4. Sporangium, possibly of *Lepidodendropsis corrugata*. GSC No. 790 × 2. Albert formation, loc. 624. (Page 24.)

Figure 5. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 700 × 2. Horton Bluff formation, loc. 1480. (Page 24.)

Figure 6. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 491 × 2. Albert formation, loc. Turtle Creek. (Page 24.)

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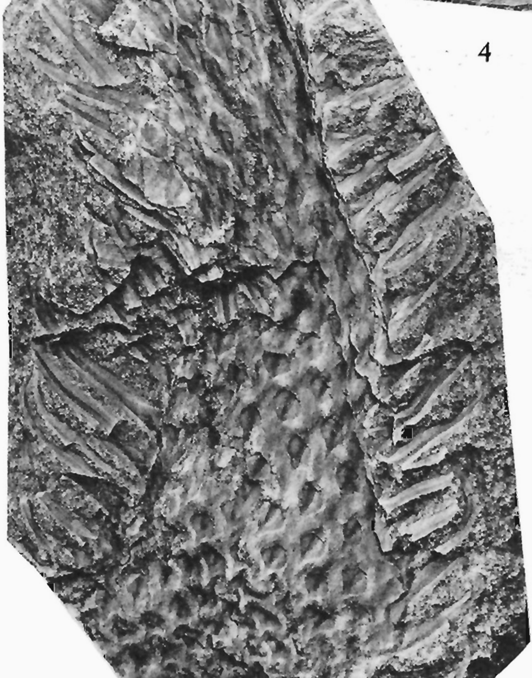

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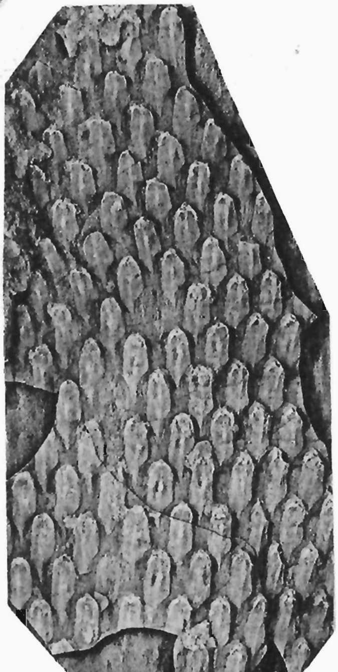

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Plate II

Figure 1. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 688 × 2. Cheverie formation, loc. 2164. (Page 24.)

Figure 2. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 688 (nat. size). (Page 24.)

Figure 3. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 701. Horton Bluff formation, loc. 2513. (Page 24.)

Figure 4. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 695. Horton Bluff formation, loc. 1170. (Page 24.)

Figure 5. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 697. Horton Bluff formation, loc. 226. (Page 24.)

Figure 6. Group of three sporangia, possibly of *Lepidodendropsis corrugata*. Horton Bluff formation, loc. 2161. (Page 24.)

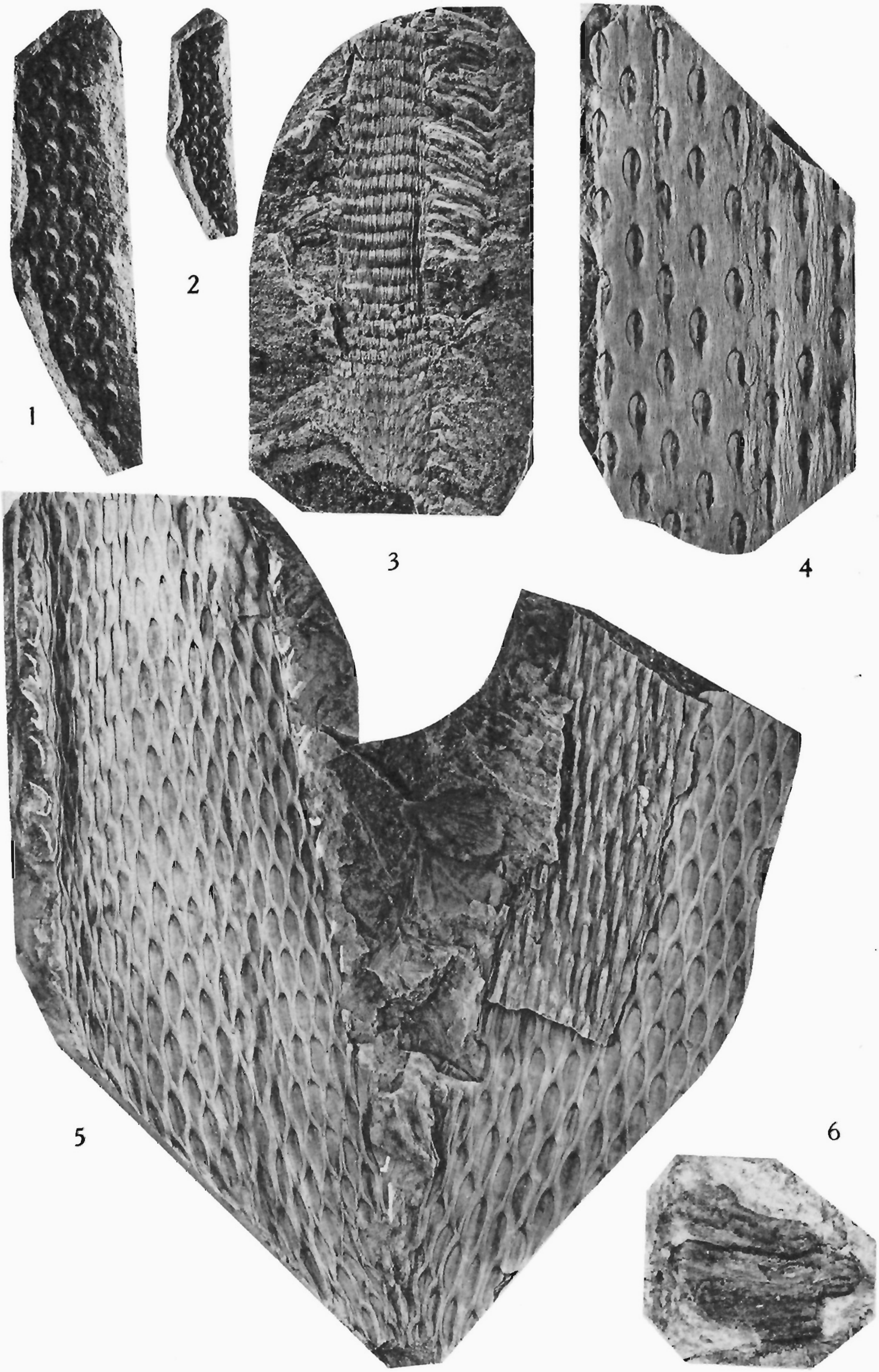

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Plate III

Figure 1. *Triletes glaber* (Dawson). Hypotype, GSC No. 712 × 8. Horton Bluff formation, loc. 2206. (Page 28.)

Figure 2. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 690, Horton Bluff formation, loc. 1963. (Page 24.)

Figure 3. *Triletes glaber* (Dawson). Hypotype, GSC No. 713 × 8. Horton Bluff formation, loc. 1969. (Page 28.)

Figure 4. *Triletes glaber* (Dawson). Hypotype, GSC No. 712A × 8. Horton Bluff formation, loc. 2206. (Page 28.)

Figure 5. *Triletes cheveriensis* n. sp. Paratype, GSC No. 716 × 8. Albert formation, loc. 2500. (Page 29.)

Figure 6. *Triletes cheveriensis* n. sp. Holotype, GSC No. 714 × 8. Cheverie formation, loc. 2164. (Page 29.)

Figure 7. *Triletes cheveriensis* n. sp. Paratype, GSC No. 705 × 8. Albert formation, loc. 624. (Page 29.)

Figure 8. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 702 × 2. Horton Bluff formation, loc. 2535. (Page 24.)

Figure 9. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 694 × 2. Horton Bluff formation, loc. 1963. (Page 24.)

Figure 10. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 698. Horton Bluff formation, loc. 1963. (Page 24.)

PLATE III

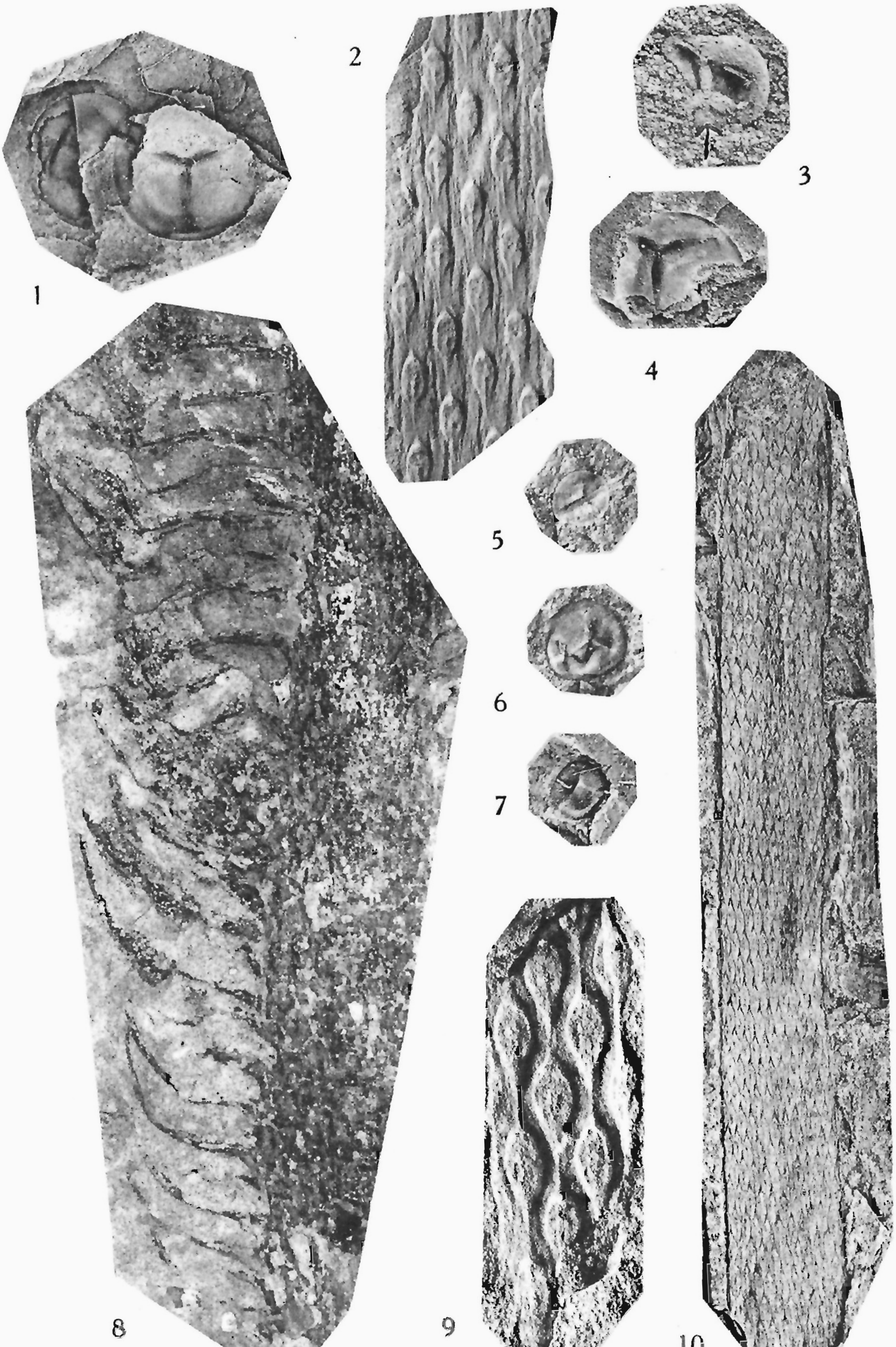


Plate IV

Figure 1. *Lepidostrobophyllum* sp. GSC No. 718 × 2. Albert formation, loc. 624. (Page 28.)

Figure 2. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 692. Kennebecasis formation, loc. 677. (Page 24.)

Figure 3. *Lepidophyllum* (*Lepidostrobophyllum*) *fimbriatum* Jongmans, Gothan and Darrah. Hypotype, GSC No. 710 × 2. Horton Bluff formation, loc. 2540. (Page 27.)

Figure 4. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 693. Horton Bluff formation, loc. 226. (Page 24.)

Figure 5. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 699. Horton Bluff formation, loc. 684. (Page 24.)

Figure 6. *Lepidodendropsis corrugata* (Dawson). Hypotype, GSC No. 696. Kennebecasis formation, loc. 653. (Page 24.)

PLATE IV

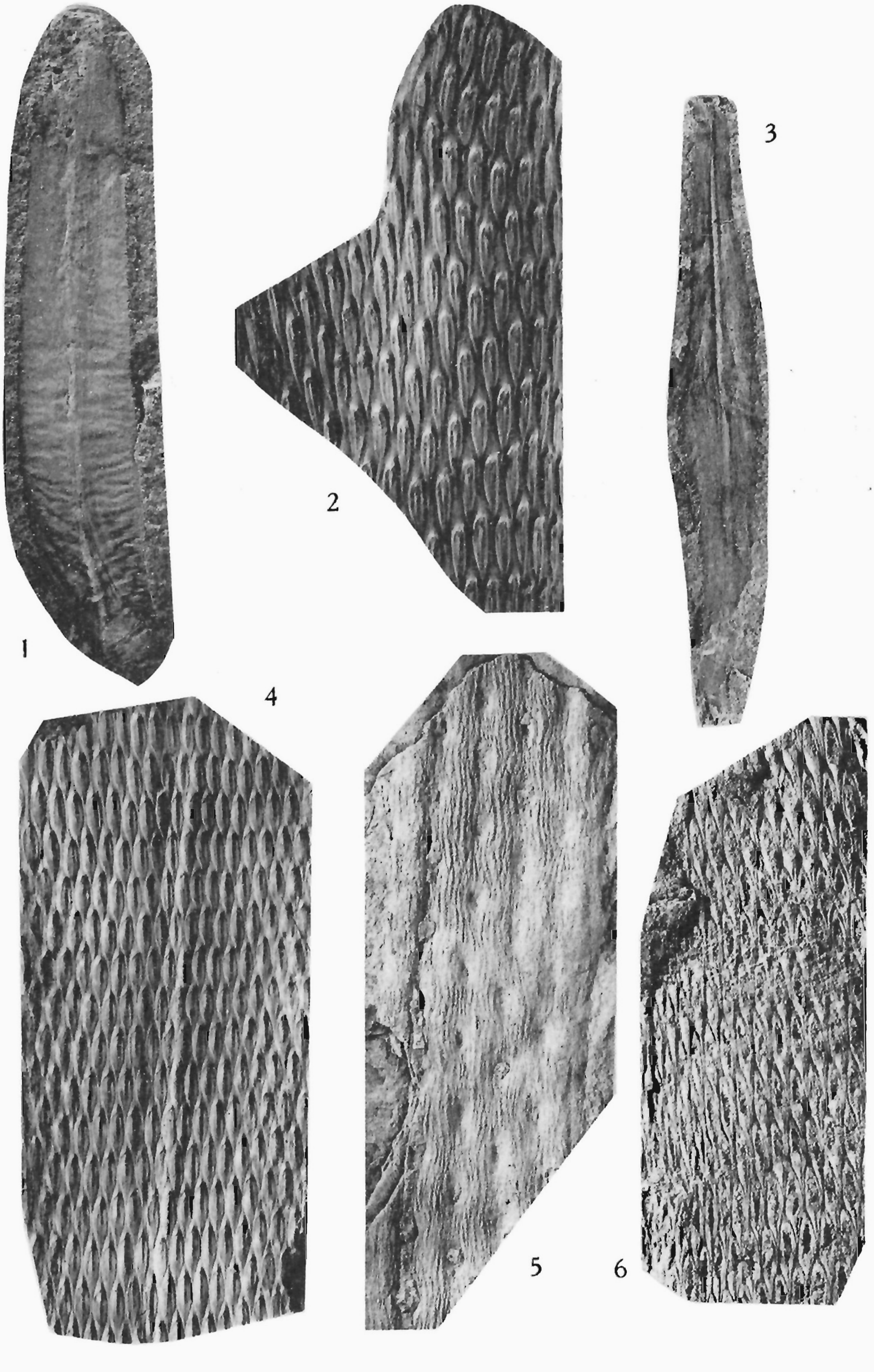
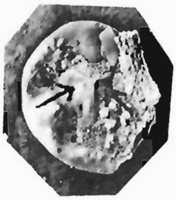


PLATE V

Figure 1. *Triletes glaber* (Dawson). Hypotype, GSC No. 711 × 8. Horton Bluff formation, loc. 1480. (Page 28.)

Figure 2. *Triletes glaber* (Dawson). Hypotype, GSC No. 717. Horton Bluff formation, loc. 813. (Page 28.)

Figure 3. *Triletes cheveriensis* n. sp. Paratype, GSC No. 715. Albert formation, loc. 2500. (Page 29.)



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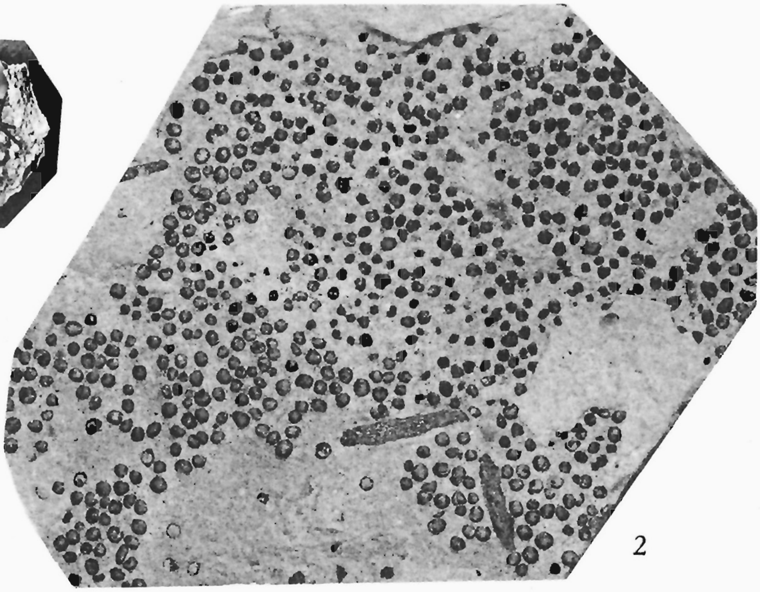

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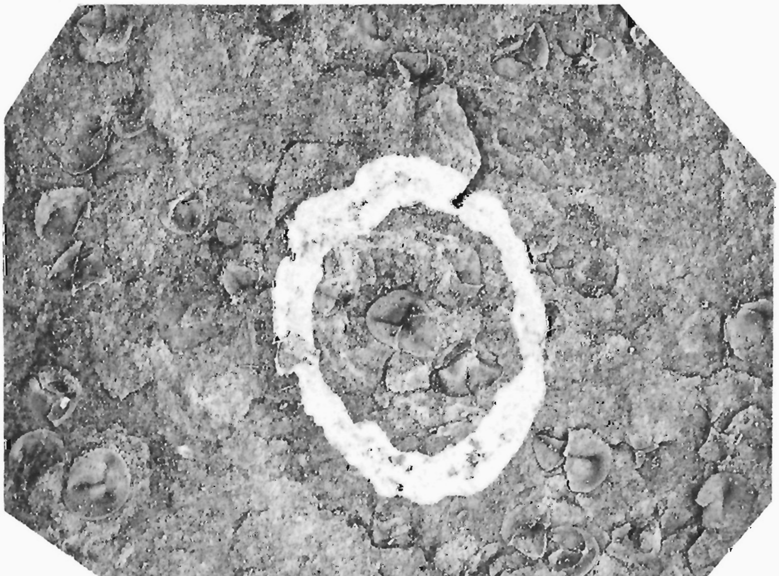

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Plate VI

Figure 1. *Lepidodendropsis* sp. A. GSC No. 706 × 2. Horton Bluff formation, loc. 813. (Page 26.)

Figure 2. *Lepidodendropsis* sp. B. GSC No. 709 × 2. Horton group, loc. 1752. (Page 27.)

Figure 3. *Lepidodendropsis* sp. A. GSC No. 707. Horton Bluff formation, loc. 813. (Page 26.)

Figure 4. *Nematophyllum* sp. GSC No. 789. Kennebecasis formation, loc. 653. (Page 30.)

Figure 5. *Lepidophyllum* (*Lepidostrobophyllum*) *fimbriatum* Jongmans, Gothan and Darrah. Hypotype, GSC No. 703 × 2. Horton Bluff formation, loc. 2534. (Page 27.)

PLATE VI

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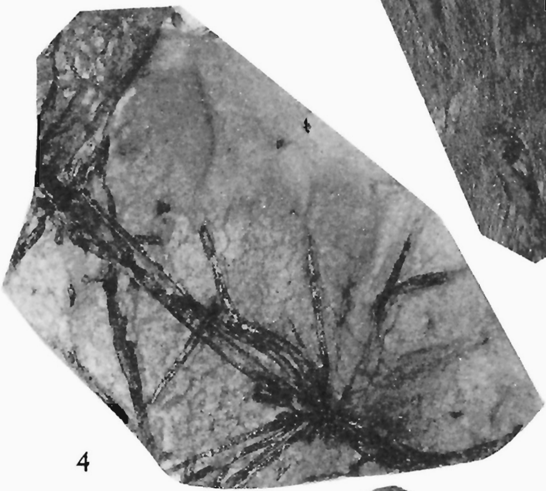

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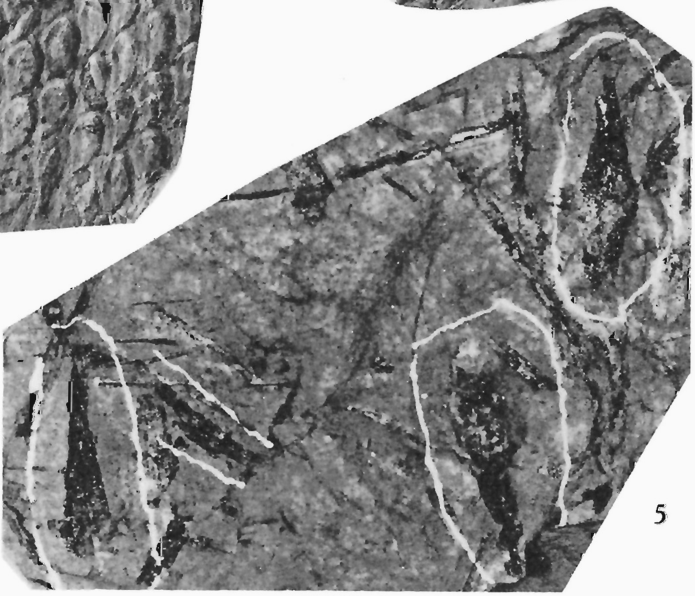

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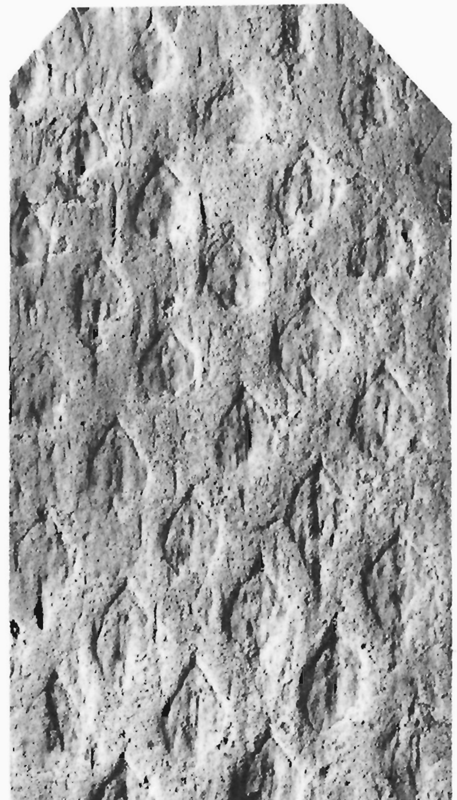
Plate VII

Figure 1. *Lepidodendron* sp. GSC No. 708. Horton Bluff formation, loc. 1963. (Page 28.)

Figure 2. *Asterocalamites scrobiculatus* (Schlotheim). Hypotype, GSC No. 783. Cheverie formation, loc. 2217. (Page 29.)

Figure 3. *Asterocalamites scrobiculatus* (Schlotheim). Hypotype, GSC No. 782. Horton Bluff formation, loc. 1704. (Page 29.)



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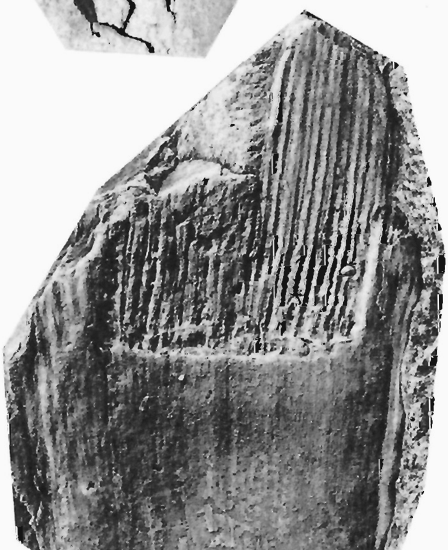

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PLATE VIII

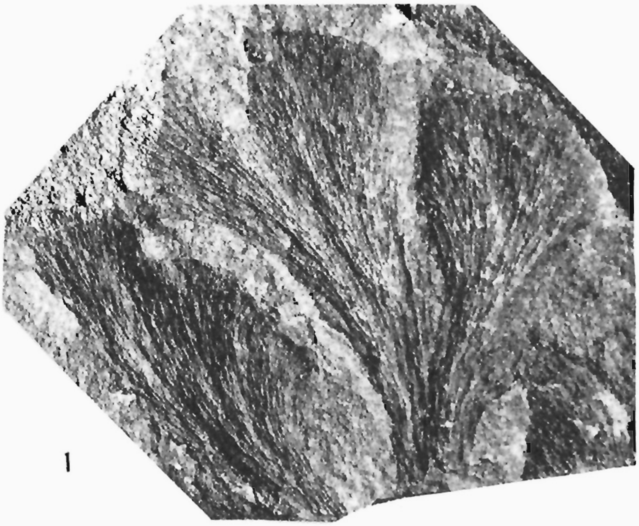
Figure 1. *Aneimites acadica* Dawson. Hypotype, GSC No. 310. Horton Bluff formation, loc. 226. (Page 30.)

PLATE IX

Figure 1. *Aneimites acadica* Dawson. Hypotype, GSC No. 725 × 4. Albert formation, loc. 417. (Page 30.)

Figure 2. *Aneimites acadica* Dawson. Hypotype, GSC No. 720. Horton Bluff formation, loc. 1170. (Page 30.)

Figure 3. *Aneimites acadica* Dawson. Hypotype, GSC No. 729. Albert formation, loc. 417. (Page 30.)



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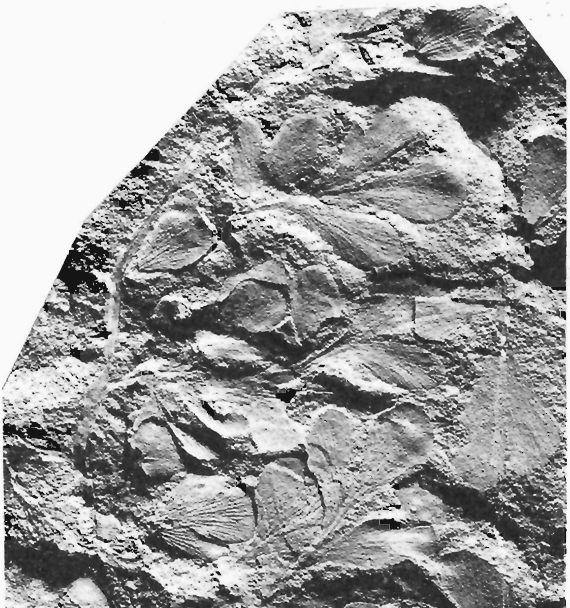

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Plate X

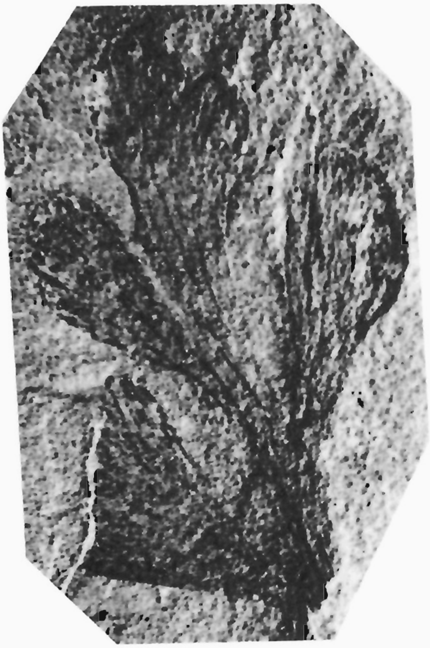
Figure 1. *Aneimites acadica* Dawson. Hypotype, GSC No. 728 × 4. Kennebecasis formation, loc. 336. (Page 30.)

Figure 2. *Aneimites acadica* Dawson. Hypotype, GSC No. 723. Horton Bluff formation, loc. 2532. (Page 30.)

Figure 3. *Aneimites acadica* Dawson. Hypotype, GSC No. 730. Horton Bluff formation, loc. 228. (Page 30.)

Figure 4. *Aneimites acadica* Dawson. Hypotype, GSC No. 732. Horton Bluff formation, loc. 2530. (Page 30.)

PLATE X



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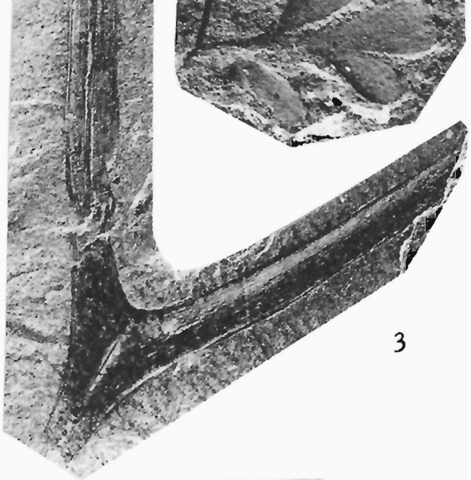

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PLATE XI

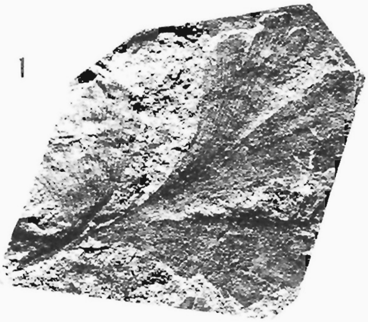
Figure 1. *Aneimites acadica* Dawson. Hypotype, GSC No. 788. Horton Bluff formation, loc. 2532. (Page 30.)

Figure 2. *Aneimites acadica* Dawson. Hypotype, GSC No. 726 × 4. Albert formation, loc. 624. (Page 30.)

Figure 3. *Aneimites acadica* Dawson. Hypotype, GSC No. 727 × 5 approx. Albert formation, loc. 624. (Page 30.)

Figure 4. *Aneimites acadica* Dawson. Hypotype, GSC No. 731. Horton Bluff formation, loc. 684. (Page 30.)

PLATE XI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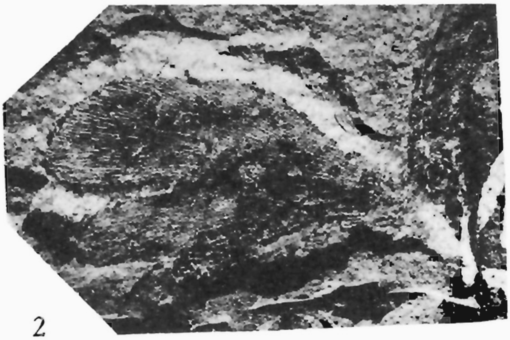
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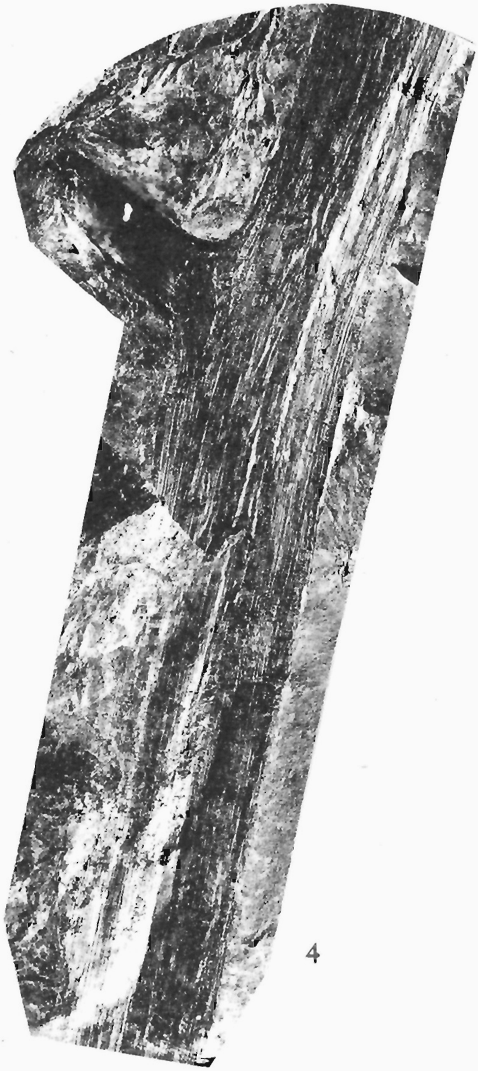
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Plate XII

Figure 1. *Sphenopteridium macconochiei* ? Kidston. Hypotype (?) GSC No. 765 × 2. Cheverie formation, loc. 2164. (Page 35.)

Figure 2. *Sphenopteridium macconochiei* ? Kidston. Hypotype (?) GSC No. 764 × 2. Cheverie formation, loc. 2164. (Page 35.)

Figure 3. *Sphenopteris strigosa* n. sp. Paratype, GSC No. 734 × 4. Kennebecasis formation, loc. 336. (Page 32.)

Figure 4. *Sphenopteridium macconochiei* ? Kidston. Hypotype (?) GSC No. 762 × 2. Cheverie formation, loc. 2164. (Page 35.)

Figure 5. *Sphenopteris strigosa* n. sp. Paratype, GSC No. 738 × 2. Kennebecasis formation, loc. 674. (Page 32.)

Figure 6. *Sphenopteris strigosa* n. sp. Holotype, GSC No. 733 (reverse surface) × 2. Albert formation, loc. 2517. (Page 32.)

Figure 7. *Sphenopteris strigosa* n. sp. Paratype, GSC No. 780 × 2. Anguille group, Newfoundland, loc. 5157. (Page 32.)

Figure 8. *Sphenopteris strigosa* n. sp. Holotype, GSC No. 733 × 4. Albert formation, loc. 2517. (Page 32.)

Figure 9. *Sphenopteris strigosa* n. sp. Paratype, GSC No. 736 × 4. Albert formation, loc. 652. (Page 32.)

Plate XII

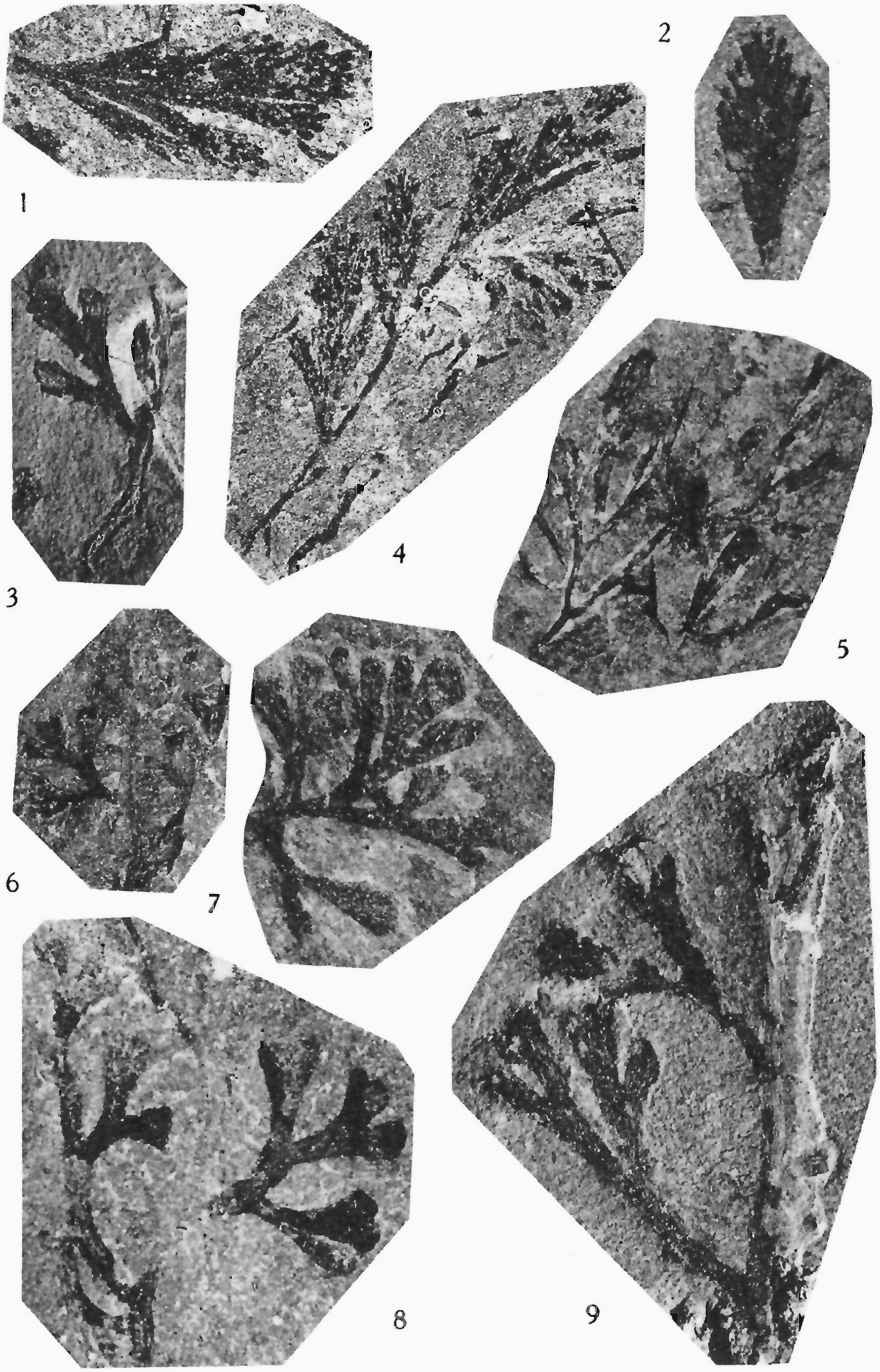

Plate XIII

Figure 1. *Sphenopteridium macconochiei* ? Kidston. Hypotype (?) GSC No. 766. Cheverie formation, loc. 2164. (Page 35.)

Figure 2. *Sphenopteridium macconochiei* ? Kidston. Hypotype (?) GSC No. 763 × 2. Cheverie formation, loc. 2164. (Page 35.)

Figure 3. *Diplotmema patentissimum* (Ettingshausen). Hypotype, GSC No. 757 × 2. Albert formation, loc. 675. (Page 36.)

Figure 4. *Diplotmema patentissimum* (Ettingshausen). Hypotype, GSC No. 758 × 2. Albert formation, loc. 633. (Page 36.)

Figure 5. *Adiantites tenuifolius* (Goeppert). Hypotype, GSC No. 769. Cheverie formation, loc. 2164. (Page 33.)

PLATE XIII

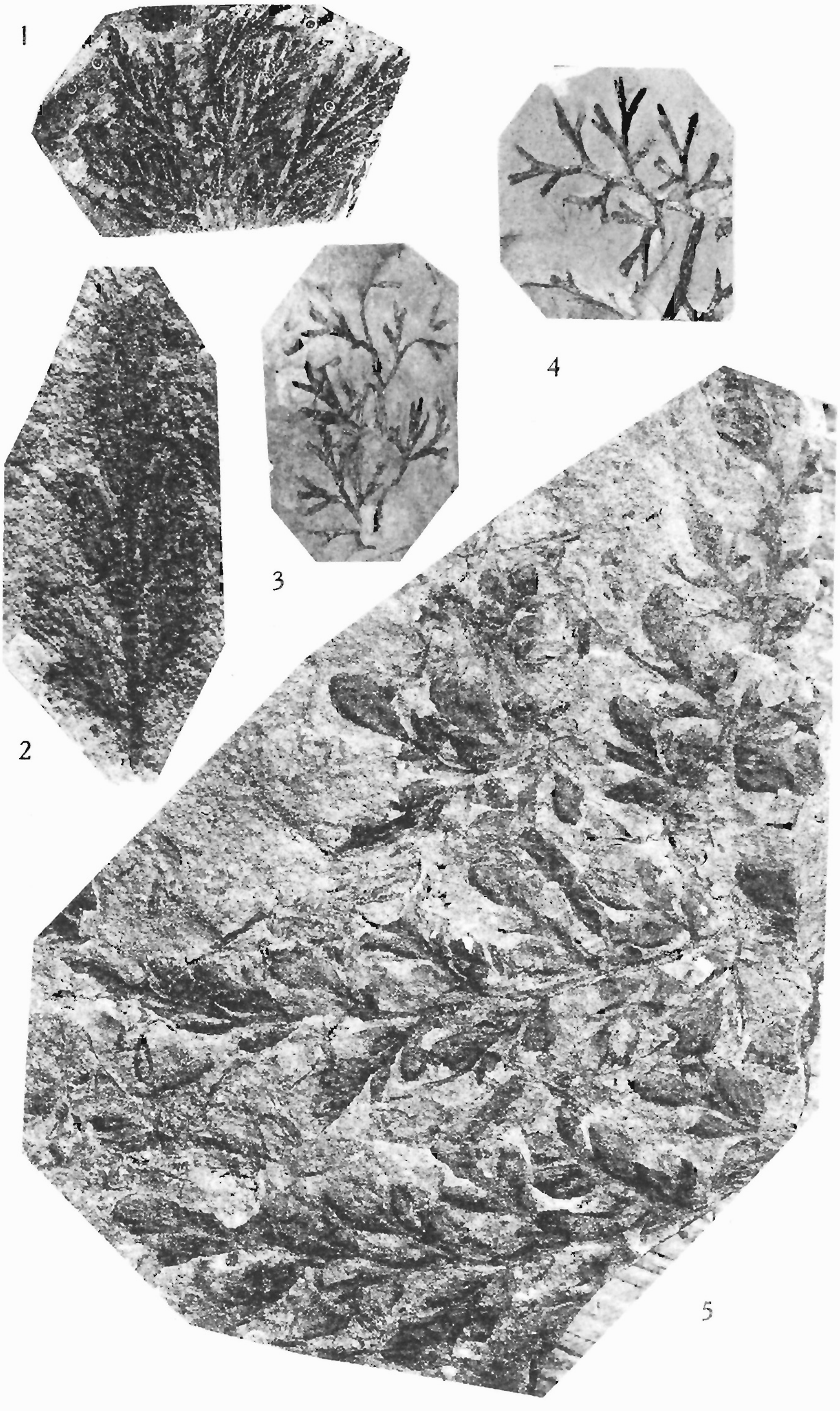

Plate XIV

Figure 1. *Sphenopteridium* sp. GSC No. 845 × 2. Cheverie formation, loc. 2164. (Page 35.)

Figure 2. *Sphenopteridium* sp. GSC No. 767. Cheverie formation, loc. 2164. (Page 35.)

Figure 3. *Sphenopteridium* sp. GSC No. 768. Cheverie formation, loc. 2164. (Page 35.)

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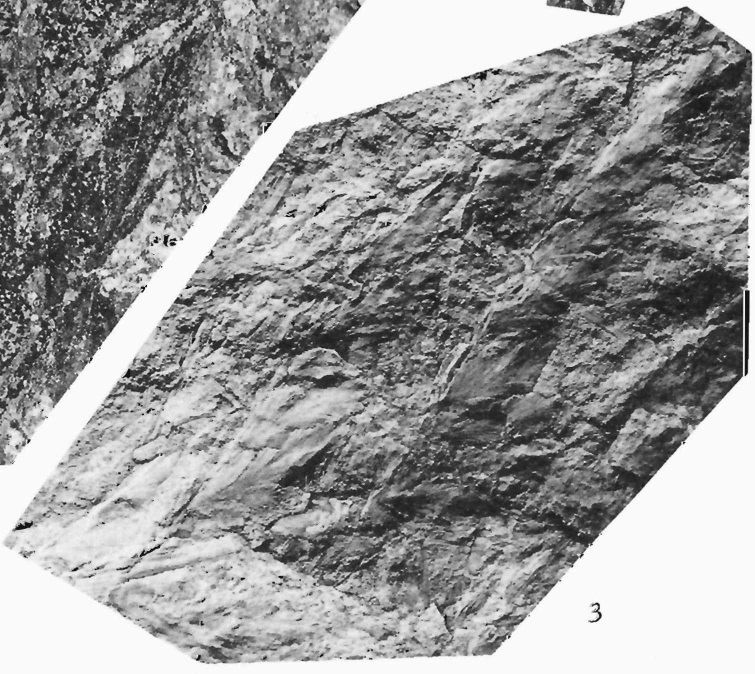

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PLATE XV

Figure 1. *Diplotmema patentissimum* (Ettingshausen). Hypotype, GSC No. 753. Albert formation, loc. 675. (Page 36.)

Figure 2. *Diplotmema patentissimum* (Ettingshausen). Hypotype, GSC No. 759 × 2. Horton Bluff formation, loc. 228. (Page 36.)

Figure 3. *Adiantites tenuifolius* (Goeppert). Hypotype, GSC No. 770. Cheverie formation, loc. 2164. (Page 33.)

Figure 4. *Telangium bretonensis* n. sp. Paratype, GSC No. 743 × 2. Windsor group, loc. 1661. (Page 39.)

Figure 5. *Telangium bretonensis* n. sp. Paratype, GSC No. 778 × 2. Codroy group, loc. 5156. (Page 39.)

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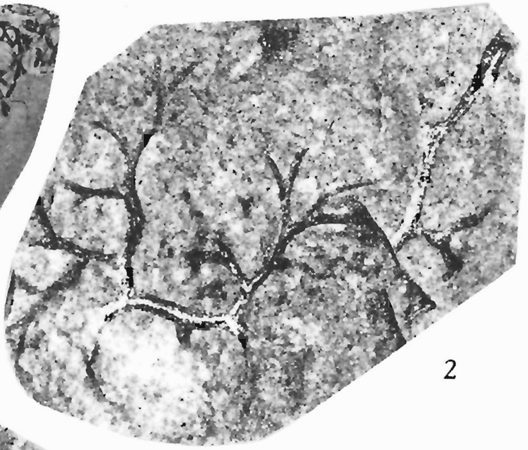

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PLATE XVI

Figure 1. *Telangium bretonensis* n. sp. Paratype, GSC No. 740 × 2. Windsor group, loc. 1661. (Page 39.)

Figure 2. *Telangium bretonensis* n. sp. Holotype, GSC No. 739. Windsor group, loc. 1661. (Page 39.)

Figure 3. *Telangium bretonensis* n. sp. A synangium × 4, in close association with holotype No. 739 as shown in rectangle Figure 2.

Figure 4. *Telangium bretonensis* n. sp. Paratype, GSC No. 744 × 4; an unattached synangium. Windsor group, loc. 1661. (Page 39.)

Figure 5. *Telangium bretonensis* n. sp. Paratype, GSC No. 741 × 2. Windsor group, loc. 1661. (Page 39.)

Figure 6. *Diplotmema* ? sp. GSC No. 775 × 2. Codroy group, Nfld., loc. 3652. (Page 40.)

Figure 7. *Diplotmema patentissimum* (Ettingshausen). Hypotype, GSC No. 752 × 2. Albert formation, loc. 675. (Page 36.)

Figure 8. *Telangium bretonensis* n. sp. Paratype, GSC No. 746 × 2. Windsor group, loc. 1661. (Page 39.)

Figure 9. *Diplotmema patentissimum* (Ettingshausen). Hypotype, GSC No. 755 × 4; seed at S. Albert formation, loc. 675. (Page 36.)

PLATE XVI

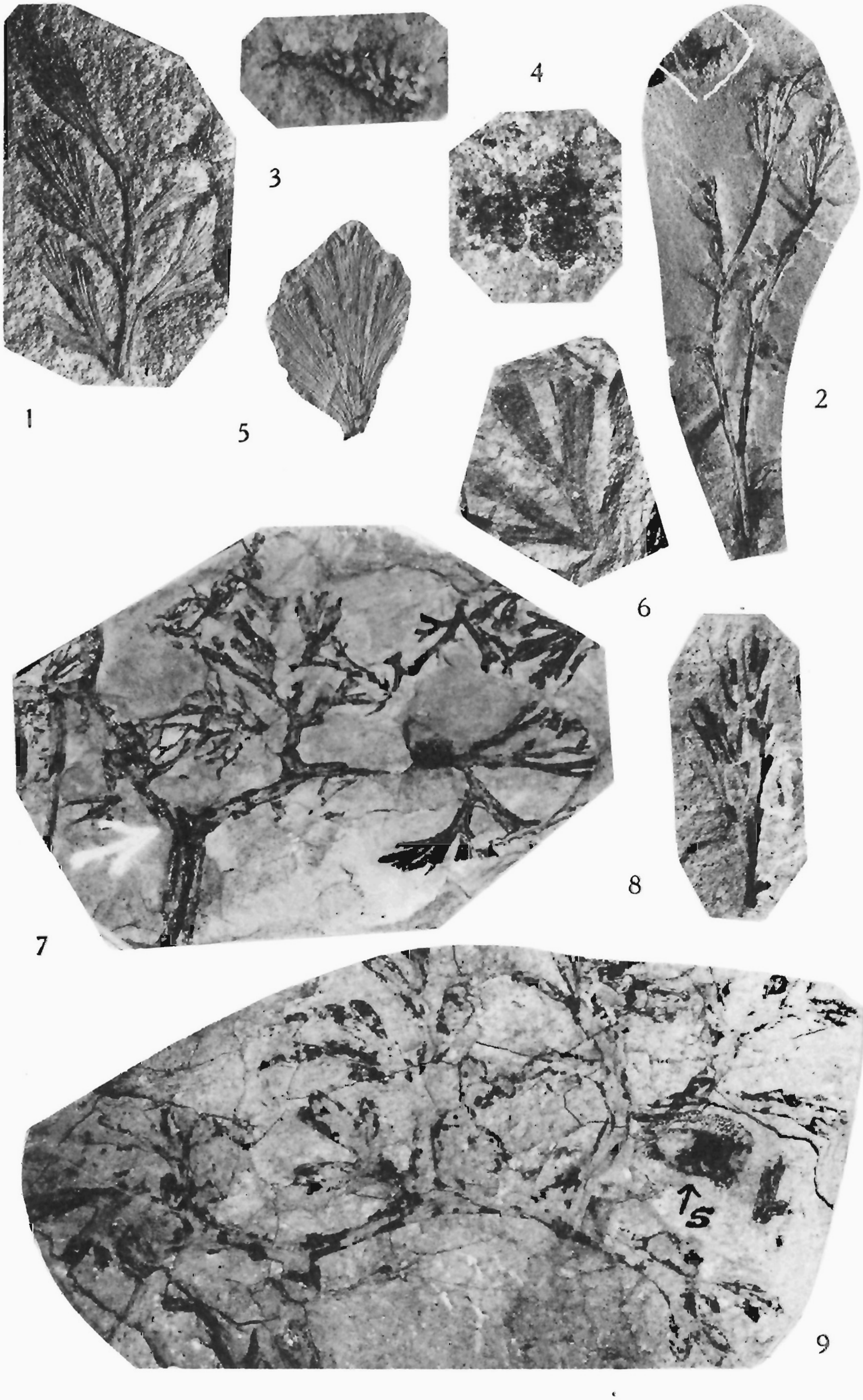

Plate XVII

Figure 1. *Telangium bretonensis* n. sp. Paratype, GSC No. 745 × 4; seed capsule. Windsor group, loc. 1661. (Page 39.)

Figure 2. *Telangium* sp. GSC No. 781 × 4. Codroy group, Nfld., loc. 5160. (Page 40.)

Figure 3. *Diplotmema patentissimum* (Ettingshausen). Hypotype, GSC No. 756 × 4. Albert formation, loc. 675. (Page 36.)

Figure 4. Seed associated with *Telangium bretonensis* n. sp. and possibly belonging to that species. GSC No. 747 × 4. Windsor group, loc. 1661. (Page 39.)

Figure 5. *Rhacopteris robusta* Kidston. Hypotype, GSC No. 748 × 2. Windsor group, loc. 1662. (Page 38.)

Figure 6. *Carpolithus tenellus* (Dawson). Hypotype GSC No. 786 × 4. Horton Bluff formation, loc. 683. (Page 37.)

Figure 7. *Carpolithus tenellus* (Dawson). Hypotype, GSC No. 787 × 4. Anguille group, Nfld., loc. 3579. (Page 37.)

Figure 8. *Rhacopteris robusta* Kidston. Hypotype, GSC No. 749 × 2. Windsor group, loc. 1662. (Page 38.)

Figure 9. *Diplotmema* ? sp. GSC No. 773 × 2. Codroy group, Nfld., loc. 3652. (Page 40.)

Figure 10. *Diplotmema* ? sp. GSC No. 773, nat. size.

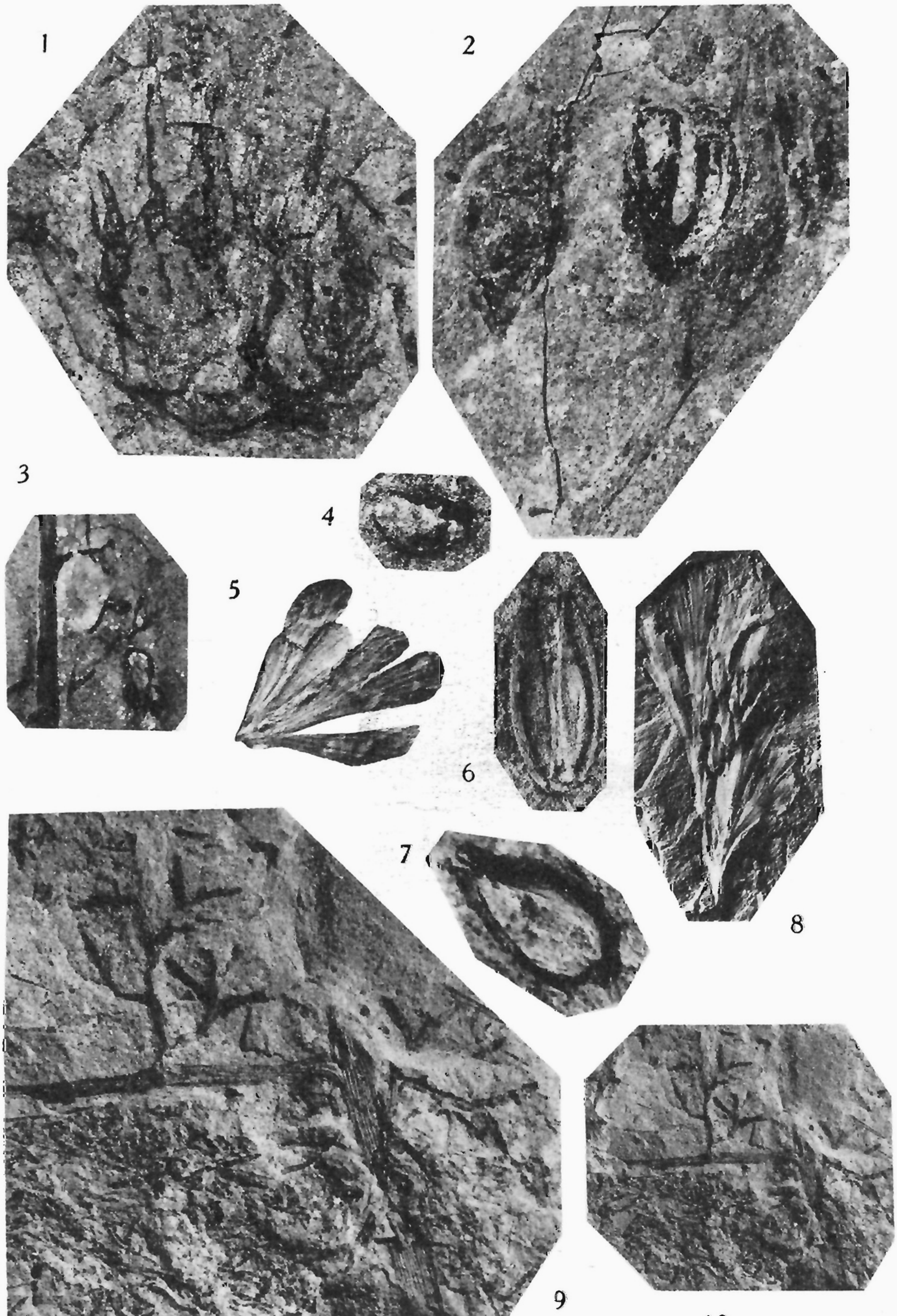
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Plate XVIII

Figure 1. *Diplotmema* ? sp. GSC No. 776 × 2. Codroy group, Nfld., loc. 3652. (Page 40.)

Figure 2. *Rhacopteris robusta* Kidston. Hypotype, GSC No. 751 × 2. Windsor group, loc. 1662. (Page 38.)

Figure 3. *Rhacopteris robusta* Kidston. Hypotype, GSC No. 750 × 2. Windsor group, loc. 1662. (Page 38.)

Figure 4. *Diplotmema* ? sp. GSC No. 774 × 2. Codroy group, Nfld., loc. 3652. (Page 40.)

Figure 5. *Diplotmema* ? sp. GSC No. 772 × 2. Codroy group, Nfld., loc. 3652. (Page 40.)

Figure 6. *Rhacopteris petiolata* (Goeppert). Hypotype, GSC No. 779 × 2. Codroy group, Nfld., loc. 3654. (Page 38.)

PLATE XVIII

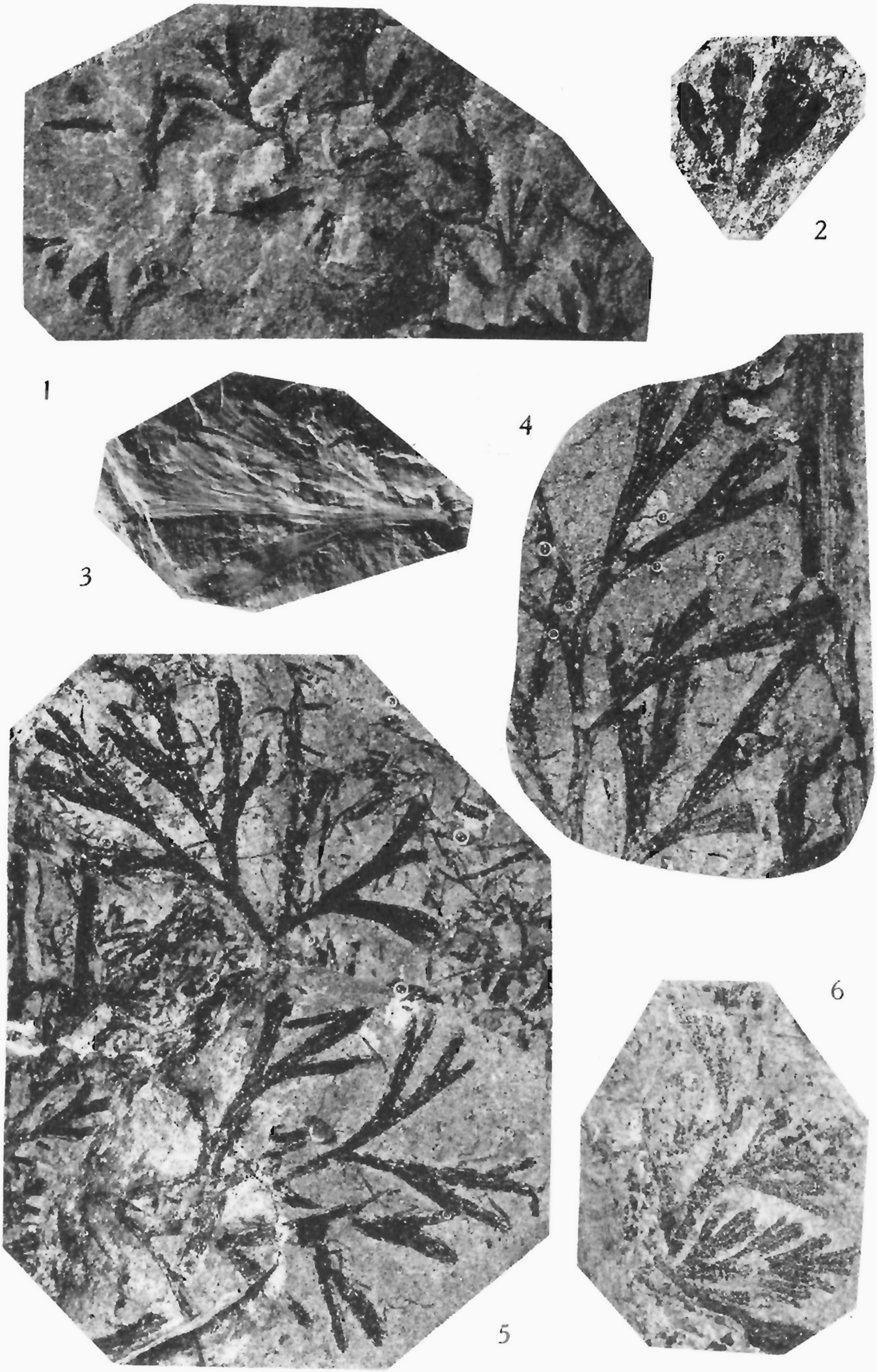

PLATE XIX

Figure 1. *Limnoprimitia ? hortonensis* n. sp. Holotype, left valve, GSC No. 14391 × 8. Horton Bluff formation, loc. 35328. (Page 41.)

Figure 2. *Limnoprimitia ? hortonensis* n. sp. Holotype, right valve, GSC No. 14391 × 8. (Page 41.)

Figure 3. *Limnoprimitia ? hortonensis* n. sp. Holotype, dorsal view, GSC No. 14391 × 8. (Page 41.)

Figure 4. *Limnoprimitia ? hortonensis* n. sp. Holotype, ventral view, GSC No. 14391 × 8. (Page 41.)

Figure 5. *Limnoprimitia ? hortonensis* n. sp. Paratype, right valve, GSC No. 14392 × 8. Horton Bluff formation, loc. 35328. (Page 41.)

Figure 6. *Limnoprimitia ? hortonensis* n. sp. Paratype, right valve, GSC No. 14393A × 8; paratypes—B, a left valve × 8; C, a right valve × 8; D, a left valve × 8. Horton Bluff formation, loc. 35328. (Page 41.)

Figure 7. *Limnoprimitia ? hortonensis* n. sp. Paratype, right valve, GSC No. 14394 × 8. Horton Bluff formation, loc. 35328. (Page 41.)

Figure 8. *Limnoprimitia ? hortonensis* n. sp. Paratype, inside view of left valve, GSC No. 14395 × 8. Horton Bluff formation, loc. 35328. (Page 41.)

Figure 9. *Triphyllopteris minor* Jongmans, Gothan and Darrah. Hypotype, GSC No. 760. Cheveric formation, loc. 1656. (Page 33.)

Figure 10. *Spirorbis avonensis* n. sp. Holotype, GSC No. 14414 × 8. Horton Bluff formation, loc. 35326. (Page 41.)

Figure 11. *Spirorbis avonensis* n. sp. Paratype ,GSC 14410 × 8. Horton Bluff formation, loc. 35326. (Page 41.)

Figure 12. *Spirorbis avonensis* n. sp. Paratype, GSC No. 14413 × 8. Horton Bluff formation, loc. 35328. (Page 41.)

PLATE XIX

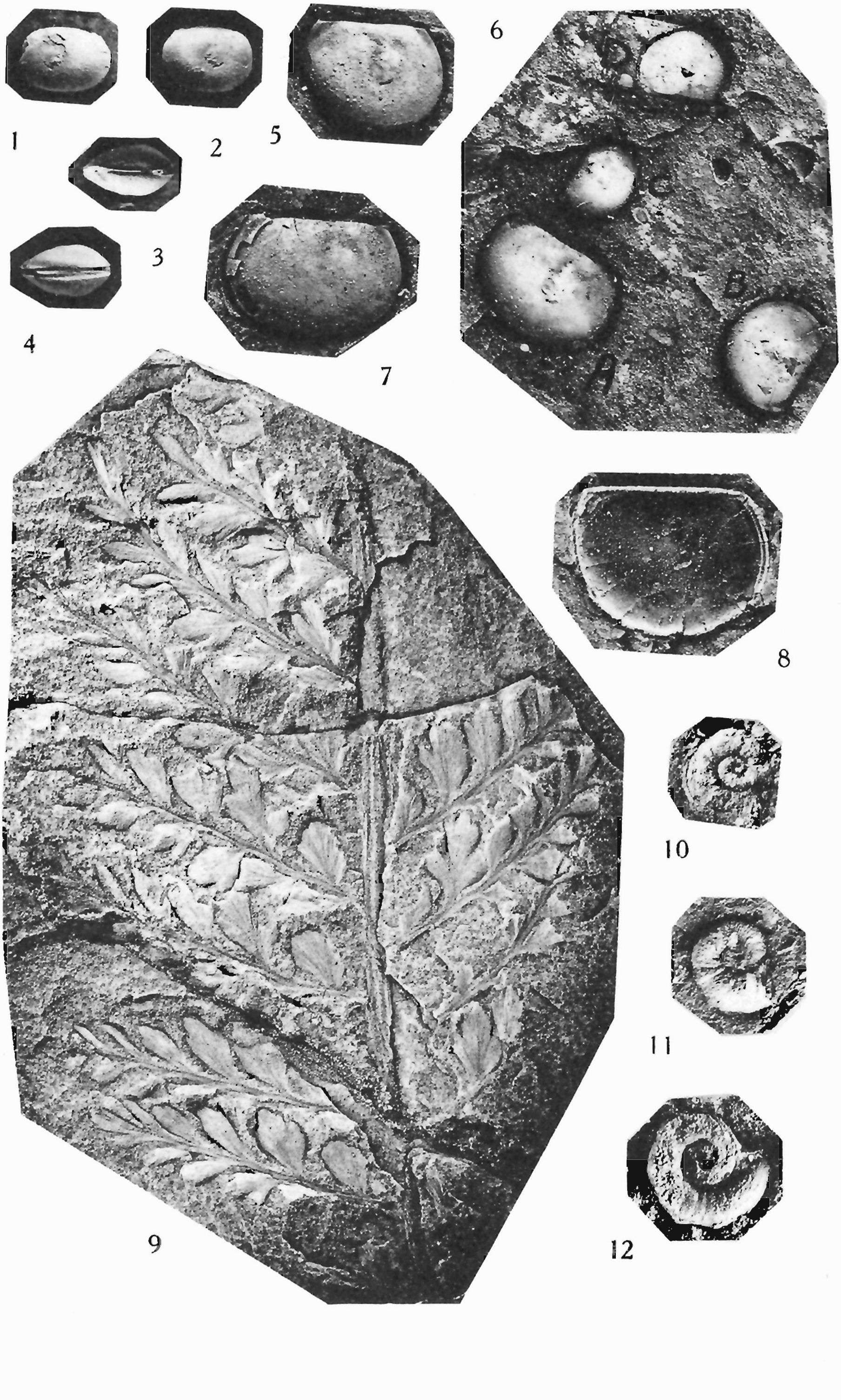

Plate XX

Figure 1. *Spirorbis avonensis* n. sp. Paratype, GSC No. 14412 × 8. Horton Bluff formation, loc. 35328. (Page 41.)

Figure 2. *Triphyllopteris virginiana* (Meek). Hypotype, GSC No. 761B × 2. Horton group (upper part equivalent to Cheverie formation), loc. 1656. (Page 34.)

Figure 3. *Triphyllopteris virginiana* (Meek). Hypotype, GSC No. 761. Horton group (upper part equivalent to Cheverie formation), loc. 1656. (Page 34.)

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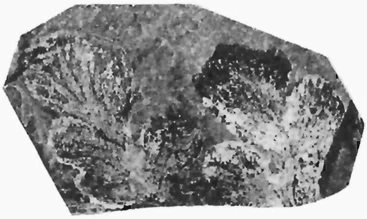

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Plate XXI

Figure 1. *Hollinella ? novascotica* (Jones and Kirkby). Hypotype, GSC No. 14396 × 8. Horton Bluff formation, loc. 35328. (Page 42.)

Figure 2. *Carbonita* cf. *subula* (Jones and Kirkby). GSC No. 14404 × 8, right valve. Horton Bluff formation, loc. 35328. (Page 43.)

Figure 3. *Carbonita* cf. *subula* (Jones and Kirkby). GSC No. 14406 × 8, right valve. Horton Bluff formation, loc. 35328. (Page 43.)

Figure 4. *Carbonita* cf. *subula* (Jones and Kirkby). GSC No. 14401 × 8, left valve. Horton Bluff formation, loc. 35328. (Page 43.)

Figure 5. *Hollinella ? novascotica* (Jones and Kirkby). Hypotype, right valve GSC No. 14399 × 8. Horton Bluff formation, loc. 35328. (Page 42.)

Figure 6. *Hollinella ? novascotica* (Jones and Kirkby). Hypotype, left valve, GSC No. 14397 × 8; specimen at top is exterior mould of another left valve. Horton Bluff formation, loc. 35328. (Page 42.)

Figure 7. *Hollinella ? novascotica* (Jones and Kirkby). Hypotype, exterior mould of right valve, GSC No. 14398 × 8. Horton Bluff formation, loc. 35328. (Page 42.)

Figure 8. *Carbonita* cf. *subula* (Jones and Kirkby). GSC No. 14402 × 8, left valve of larger specimen. Horton Bluff formation, loc. 35328. (Page 43.)

Figure 9. *Carbonita* cf. *subula* (Jones and Kirkby). GSC No. 14400, right valve at bottom left; left valve at top right. Horton Bluff formation, loc. 35328. (Page 43.)

Figure 10. Probably cast of rootlets, resembling worm trails. GSC No. 791. Horton Bluff formation, loc. 2206. (Page 13.)

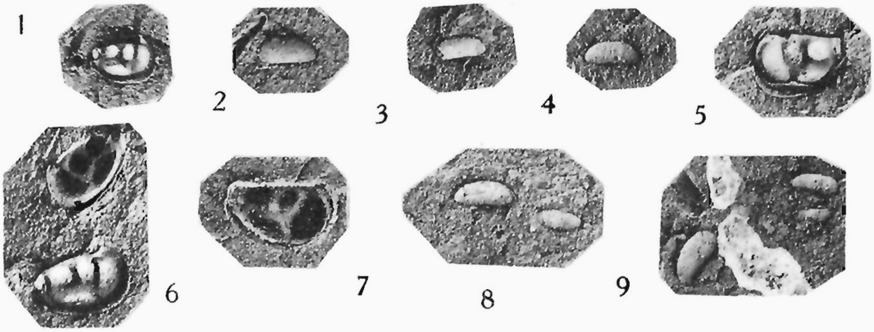

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Plate XXII

Figure 1. *Euestheria lirella* n. sp. Holotype, right valve, GSC No 14386 × 8. Horton group, loc. 5195. (Page 45.)

Figure 2. *Euestheria lirella* n. sp. Paratype, right valve, GSC No. 14390 × 8. Horton group, loc. 5195. (Page 45.)

Figure 3. *Euestheria lirella* n. sp. Paratype, left valve, GSC No. 14387 × 8. Horton group, loc. 5195. (Page 45.)

Figure 4. *Euestheria belli* (Raymond). Hypotype, left valve, GSC No. 14407 × 8. Horton group, Arichat Harbour, Petit de Grat Island. (Page 45.)

Figure 5. *Euestheria lirella* n. sp. Paratype, right valve, GSC No. 14388 × 8. Horton group, loc. 5195. (Page 45.)

Figure 6. *Eoleaia leaiaformis* (Raymond). Hypotype, left valve, GSC No. 14405 × 8. Cheverie formation, loc. 2164. (Page 47.)

Figure 7. *Euestheria lirella* n. sp. Paratype, right valve, GSC No. 14389. Horton group, loc. 5195. (Page 45.)

Figure 8. *Euestheria belli* (Raymond). Holotype, left valve, GSC No. 9450 × 8. Cheverie formation, loc. 2164. (Page 45.)

PLATE XXII

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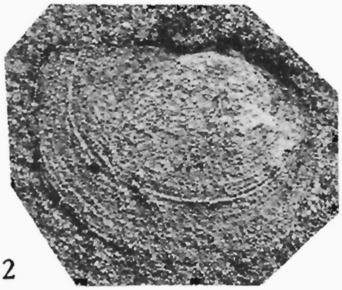

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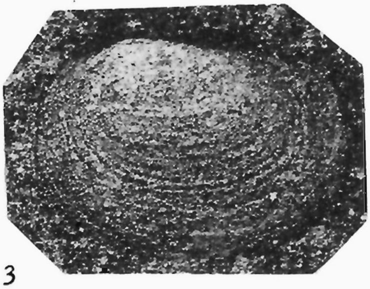

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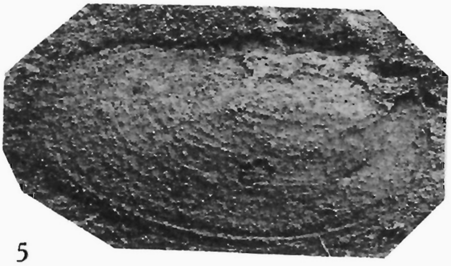

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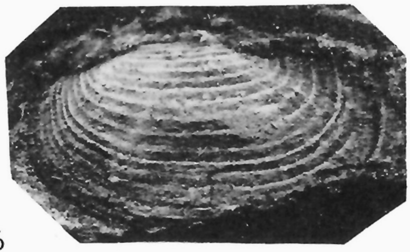

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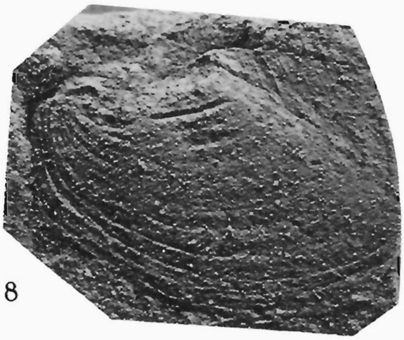

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Plate XXIII

Figure 1. *Asmussia alta* (Raymond). Hypotype, right valve, GSC No. 12799 × 8. Horton group, Petit de Grat, Richmond co. (Page 46.)

Figure 2. *Asmussia alta* (Raymond). Holotype, right valve, GSC No. 9451 × 8. Cheverie formation, loc. 2217. (Page 46.)

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Figure 5. *Eoleaia leaiaformis* (Raymond). Hypotype, right valve, GSC No. 14382A × 8. Horton Bluff formation, loc. 226. (Page 47.)

Figure 6. *Eoleaia leaiaformis* (Raymond). Holotype, right valve, GSC No. 12398 × 8. Cheverie formation, loc. 2164. (Page 47.)

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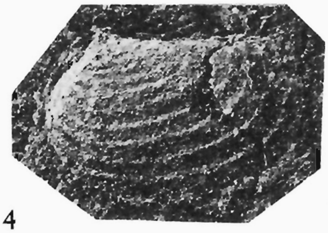

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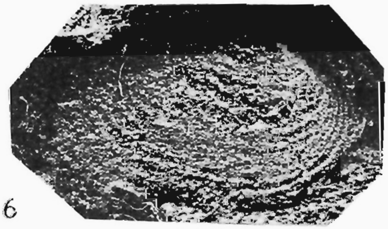

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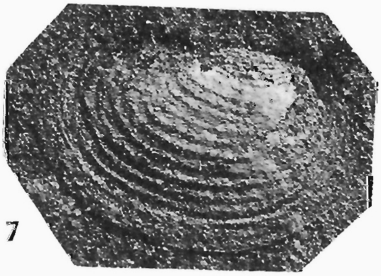

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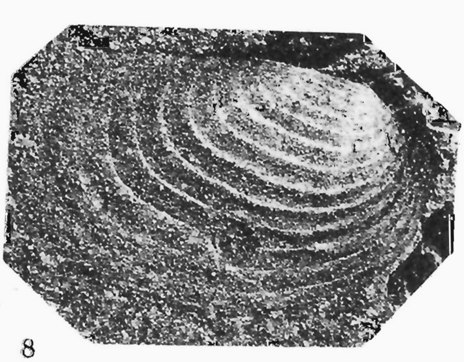

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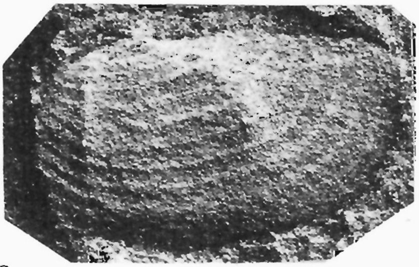

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Plate XXIV

Figure 1. *Euestheria dawsoni* (Jones). Hypotype, left valve, GSC No. 14373 × 8. Cheverie formation, loc. 2217. (Page 44.)

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Figure 3. *Eoleaia laevicostata* (Raymond). Hypotype, external mould of left valve, GSC No. 14385 × 8. Cheverie formation, loc. 1754. (Page 48.)

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Figure 5. *Leaia* sp. Raymond. GSC No. 14408 × 8, left valve. Cheverie formation, loc. 2217. (Page 49.)

Figure 6. *Eoleaia laevicostata* (Raymond). Holotype, right valve, GSC No. 9449 × 8. Cheverie formation, loc. 2164. (Page 48.)

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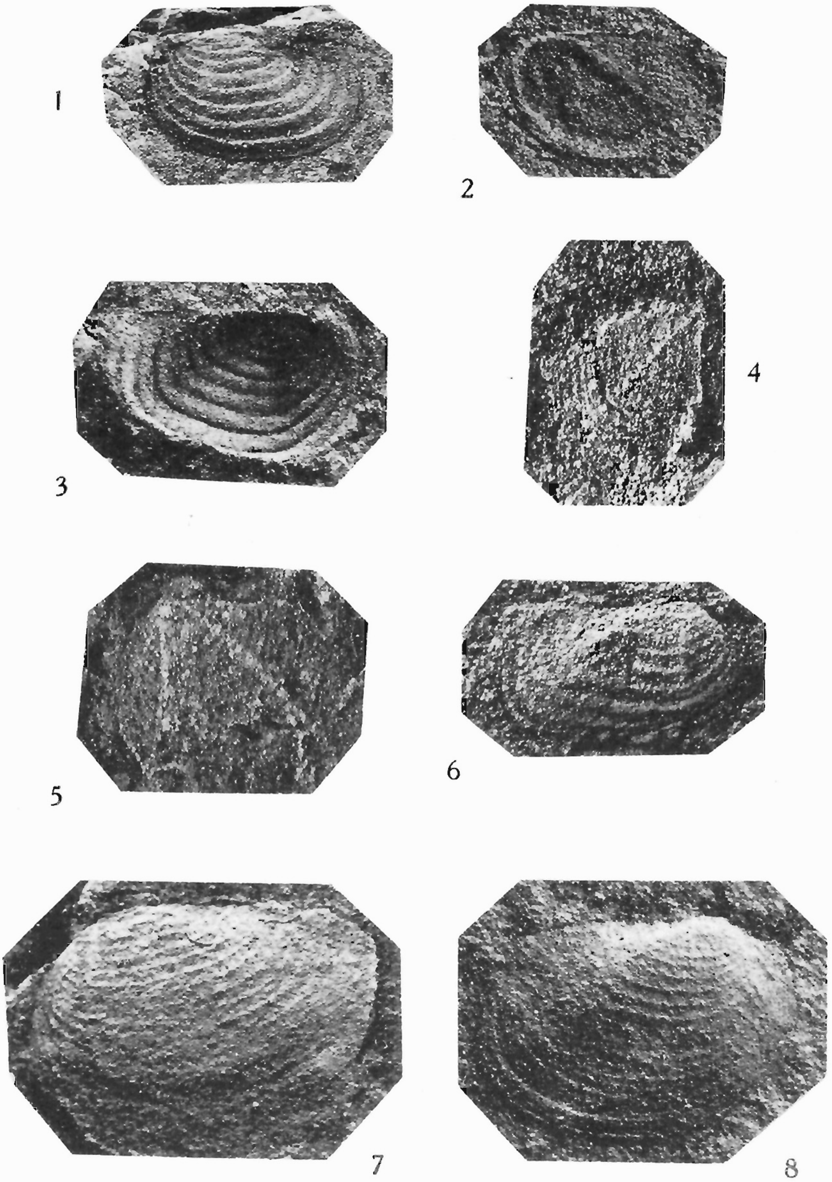
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INDEX TO FOSSILS

Numbers in **bold-face** type indicate where species are described.