GEOLOGICAL SURVEY OF CANADA.
ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

THE

FOSSIL PLANTS

OF THE

ERIAN (DEVONIAN) AND UPPER SILURIAN FORMATIONS

OF CANADA,

BY J. W. DAWSON, C.M.G., LL.D., F.R.S.

PART II.

WITH FOUR PLATES.

Montreal:
GAZETTE PRINTING COMPANY.
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CONTENTS.

I.—Introduction.

In 1871, I had the honour to prepare, by request of the Director of the Geological Survey, a Report upon the state of our knowledge at that time of the Fossil Flora of the Upper Silurian and Erian Formations of Canada. In this Report, which extended to 92 pages, with 20 illustrative plates, 125 species of Land Plants were described or noticed, and the ages of the several sub-formations, their geographical distribution and equivalents, and the relations of the Erian Flora to that of the Carboniferous, and of the older Floras of Canada to those of Europe were fully discussed. These comparisons were further illustrated in a subsequent Report on the Fossil Plants of the Lower Carboniferous and Millstone Grit, published in 1873.*

Since the publication of these Reports, the explorations of the officers of the Geological Survey and my own researches, with those of other observers, have brought to light many new facts of sufficient importance to render necessary an additional publication on the subject, bringing up our knowledge to the present date, by descriptions of new species, new information respecting species formerly known, and farther discussion of the geological relations of the Flora. This I shall endeavour to do in the following pages, constituting part sccond of my Report of 1871.

It is the more important to give attention to this matter at the present time, that the pre-carboniferous Flora of Canada now takes the lead of that of all other countries, in the number and diversity of its specific forms. To such an extent is this the case, that doubts have been thrown on the actual age of the beds by geologists and palaeobotanists abroad, not accustomed to associate a Flora so rich and varied with rocks of so great antiquity. It will be seen in the following pages that the careful stratigraphical work of the officers of the Geological Survey and the evidence of animal fossils leave no room for doubt on this subject.

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* Geological Survey of Canada.

II.—Erian * and Upper Silurian Plants from the Restigouche River and the Bay des Chaleurs.

I. General Remarks.

Until recently it was supposed that the Upper Silurian rocks which appear at different places on the shores of the Bay des Chaleurs, were overlain unconformably by Lower Carboniferous beds, without the intervention of the Devonian or Erian group. The discovery in 1879 by Mr. R. W. Ells, M.A., of the Geological Survey, of remains of *Pterichthys* in the gray sandstones which underlie the Lower Carboniferous conglomerate of the cliffs on the north shore of the Restigouche River opposite Dalhousie, was the first palaeontological fact to indicate the existence of Erian beds, and the subsequent explorations of Mr. Ells, Mr. Foord and Mr. Weston have largely increased our knowledge of the rocks and their animal fossils, some of which have been examined and described by Mr. Whiteaves in the Reports of the Geological Survey. The writer of this Report has also twice visited some of the more important localities, and, with the aid of Mr. Richardson, late of the Geological Survey, has made additional collections of the fossil plants.

The importance of these discoveries relatively to Fossil Botany, depends largely on their showing the existence of a somewhat rich Upper and Lower Devonian Flora in beds clearly associated with the Upper Silurian below, and the Lower Carboniferous above; and that the Lower and Upper Erian plants, elsewhere recognized as characteristic of this formation at Gaspé, St. John in New Brunswick, and Perry in Maine, are here found associated with fossil fishes of unquestionably Devonian types, and in beds the relations of which are well exposed in the coast cliffs.

A short notice of the distribution and relations of the beds may not be out of place here.

At Cape Bon Ami, near Dalhousie, a fine section is exposed of bedded doleritic traps, alternating with bands of limestone and shale abounding in marine fossils. These, as determined by the late Mr. Billings, are characteristic of the Upper Silurian Period, and of the Lower Helderberg Group.† Some of the upper beds of this series include fragments

* In part first I have stated reasons for preferring the term *Erian* to Devonian, and shall use this term generally in this report, except when referring to European rocks.

† Acadian Geology, p. 579.

of fossil plants showing the structure of *Prototaxites*, and detached specimens of *Pachytheca* (*Aetheotesta*). At Cape Bon Ami these beds are succeeded, apparently conformably, by a great thickness of reddish porphyry and porphyritic breccia forming the light-house point at Dalhousie. This may belong either to the close of the Upper Silurian or the beginning of the Devonian Period, and at Dalhousie the section extends no farther. Farther up the Restigouche River, however, in the vicinity of Campbellton, where similar rocks occur, they are overlaid by calcareous and magnesian breccia or agglomerate, hard shales, conglomerates and sandstones of Lower Devonian age. The agglomerate and lower shales contain abundant remains of fishes of the genera *Cephalaspis*, *Coccosteus*, *Ctenacanthus* and *Homacanthus*, and also fragments of *Pterygotus*. The shales and sandstones abound in remains of *Psilophyton* with which are *Prototaxites*, *Arthrostigma* and *Leptophleum* of the same species found in the Lower Devonian of Gaspé Bay. These beds near Campbellton dip to the Northward, and the Restigouche river here occupies a synclinal, for on the opposite side, at Bordeaux Quarry, there are thick beds of gray sandstone dipping to the southward, and containing large silicified trunks of *Prototaxites*, in addition to *Psilophyton*. These beds are all undoubtedly Lower Erian, but further to the eastward, on the north side of the River, there are newer and overlying strata. These are best seen at Scaumenac Bay, opposite Dalhousie, between C. Florissant and Maguacha Point, where they consist of laminated and fine grained sandstone, with shales of gray colours, but holding some reddish beds at top, and overlaid unconformably by a great thickness of Lower Carboniferous red conglomerate and sandstone. In these beds numerous fossil fishes have been found, among which Mr. Whiteaves recognises species of *Pterichthys*, *Glyptolepis*, *Cheirolepis*, &c. With these are found somewhat plentifully four species of fossil ferns, all of Upper Erian types, of which one is peculiar to this locality; but the others are found in the Upper Erian of Perry in Maine, or in the Catskill Group of New York.

With reference to the precise relations of the Lower and Upper Erian beds of the Lower Restigouche and the Bay des Chaleurs, it would seem that the lower beds are associated with agglomerates and trap which appear to depend on a continuation of the volcanic action of the Upper Silurian Period. They are also much more disturbed than the beds of the Upper Series. These facts would seem to indicate that movements of the Erian beds may have been going on within that period, perhaps causing some local unconformability of the upper and lower parts of the series. This has not been proved by actual observation, but its probability is indicated by the facts above stated. It would also appear that, even in the Devonian age, the ridges of older Silurian

rocks had already given to this part of the coast of Canada, some rudiments of its present geographical features.

2. *Upper Erian or Pterichthys beds of Scaumenac bay, opposite Dalhousie.*

The following species were determined from specimens procured by Mr. A. H. Foord of the Geological Survey, by Mr. James Richardson and by myself. They are from the sandstones containing *Plerichthys Canadensis*, Whiteaves, and other fossil fishes; and which appear in a low anticlinal form, coming out from under the conglomerate and red Sandstone of the Lower Carboniferous.

Genus Archaeopteris.

This genus may be thus defined. Frond bipinnate, pinnules obovate, inequilateral, narrowing to the base and decurrent on the partial petioles; the main petiole often having accessory pinnules at the bases of the pinnæ. Veins spreading from the base, slightly curved or straight, dividing dichotomously into fine veinlets. Fertile pinnæ placed in the middle or at the base of the frond, bearing groups of club-shaped or oval spore-cases instead of pinnules.

These ferns, which are not, so far as known, found in the Carboniferous, are characteristic of the Upper Erian both in Europe and America. Included by most botanists in the old genus *Cyclopteris* or united with plants of other orders in the genus *Noëgerrathia*, the name *Adiantites* was given to them by Brongniart; but their fructification, so soon as known, was found to separate them altogether from that genus. For this reason I proposed for them the name *Archaeopteris*, while Schimper had called them *Palaeopteris;* but as this name was pre-occupied by a genus of Fossil Ferns, Schimper eventually adopted my name. I observe, however, that some English geologists still retain the names *Adiantites* or *Palaeopteris.*

Ferns of this genus, when the barren fronds are alone preserved, and when the venation is obscure, have the aspect of those of the genus *Adiantum*, or of the provisional fossil genus *Cyclopteris* and also resemble the leaves or fronds of uncertain affinity known as *Noeggerathia;* but the fructification is sufficiently distinctive, and even when this is absent, they can be recognised by an experienced eye. The species are distinguishable by the fructification, and also by the form and dimensions of the barren fronds, and having abundance of specimens both European and American, I think I can vouch for the distinctnes, at least as well-marked races or sub-species, of those referred to in the following pages.

(1) *Archæopteris Gaspiensis*, s. n.

Plate xxi. Pl. xxiii., Fig. 14.

Barren pinnæ densely leafy, with the pinnules broadly obovate and somewhat truncate at the apex, decurrent by a broadish base on the somewhat stout striated petiole, veins forked thrice and strongly curved toward the lower edge. In luxuriant fronds the pinnules are 2.5 centimetres long and 1.8 centimetre broad.

Fertile pinnæ with about twelve pinnules, each having a long midrib with about 7 pairs of crowded oblong spore-cases about 3 millimetres in length, pointed or somewhat obtuse at top, straight at the sides and apparently dehiscent at the apex. The midrib projects some distance beyond the sporecases.

This species difers from *A. Jacksoni*, Dn., in the arrangement of the spore-cases, which are also larger and more oblong, and the barren pinnules are broader, while the petiole is broader and has indications of flat scales or ramenta. It differs from *A. Hibernicus*, Brongt., in the arrangement and form of the spore-cases and in its shorter pinnæ, with fewer and less obtuse pinnules. It differs from *A. minor*, Lesquereux, in the arrangement of the spore-cases, which in the latter are in groups of three and of larger size, while the barren pinnules are much narrower. The present species resembles *A. Maccoyana*, Goeppert, in the form of the pinnules, but the fructification of the latter species is not known, and it may be merely a varietal form of *A. Hibernicus*. The present species is probably that referred to in my report on the Devonian plants of Canada as found in the Gaspé sandstone,* but the fragments known at that time did not enable me to separate it from *A. Jacksoni*. It is for this reason, as well as because the beds in which it occurs at Bay de Chaleur represent the upper part of Logan's Gaspé sandstones, that I have given it the name *Gaspiensis*, though I now think it likely that my supposed Gaspé specimen was really from the Scaumenac beds. The barren pinnæ are very near in form to those of *A. Rogersi* from Perry in Maine, but the petioles of the latter have transverse wrinkles and its fructificaton is unknown.

Ferns of this type are characteristic of the Upper Erian on both sides of the Atlantic, and do not occur in the Carboniferous proper; though forms resembling them occur in the lowest Carboniferous beds.

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* Page 487.

(2) *Archæopteris Jacksoni*, Dawson.

(Report on Devonian Plants, Part I., P. 45, Pl. XV. This Report, Plate xxiv., Figs. 15 to 18.)

In the large collections now obtained from Scaumenac Bay, it is evident that this species occurs as well as *A. Gaspiensis*, though more rarely. It may be distinguished by its shorter pinnae and broader pinnules, as well as by the smaller and more oval spore-cases, borne on forking veinlets instead of sessile on the midrib of the fertile pinnule. The two species are however so near to each other that it is not easy to distinguish them, except when the fructification is preserved.

A pinna of this species was mentioned by me in Report on Devonian Plants, Part I., as having been sent to the Geological Survey by a gentleman who had obtained it from the Gaspé sandstones. I have reason to believe however that it really came from Scaumenac Bay, and that it belongs to the previous species, though the specimen is not sufficiently perfect to render this certain. The beds at Scaumenac however are no doubt the equivalents and continuation of the upper part of the Gaspé sandstones.

(3.) *Cyclopteris obtusa*, Lesquereux.

(Plate XXII.)

I refer to this species a large and beautiful fern, which is obviously identical with that from the Catskill of Montrose, Pennsylvania, figured by Lesquereux in the "Coal Plants of North America" (Report of Pennsylvania Survey), pl. 49, fig. 7, and of which I have a specimen in my own collection from the same formation at Franklin, New York.

This species is characterised by very large obovate leaflets decurrent by a long narrow base upon the petiole. Whether it was a pinnate or bipinnate frond does not appear. The veins are fine, curved and several times forked. The terminal leaflet is cuneate and emarginate. Some of the large pinnules are 6 centimetres in length. This fern is referred by Lesquereux to my genus *Archæopteris*; but as its fructification is not known, and as this forms the most distinctive character of *Archæopteris*, I think it better to leave the species in the provisional genus *Cyclopteris*.

One of my plants from the Devonian of St. John is referred to Lesquereux's species *C. obtusa*. The identification was made on the evidence of the figure and description in Rogers' Report on Pennsylvania, which refer to a much smaller fern than the present species, with the pinnules somewhat different in form and attachment. As

Lesquereux, however, applies his name to the large species now under consideration, which is certainly distinct from the St. John fern, I must withdraw the name from the latter. In doing so, I may take advantage of a suggestion made by Schimper, who thinks that the St. John species might be placed in the genus *Aneimites*. It may accordingly be renamed *Aneimites obtusa*, which will at least prevent confusion.

(4) *Cyclopteris* (*Platyphyllum*) *Brownii*, Dawson.

(Report on Fossil Plants of Devonian and Upper Silurian, p. 46, Pl. xv., fig. 172, Journal of Geological Society of London, vols. xvii. and xix.—Figures and description. This Report, Plate xxiii., Figs. 11 to 13.

This beautiful fern was previously known only from Perry in Maine, where it occurs only rarely and in detached leaves. Mr. Foord's specimens shew its habit of growth in dense clusters of fronds attached to what appears to be a creeping rhizome with slender rootlets. It has evidently been a low-growing species, its flabellate leaves attached by somewhat broad bases to a root-stock probably prostrate. Unfortunately no fructification appears, so that the plant cannot be compared with modern species having the same habit of growth. I may state, however, that the veinlets widen and become more dense in approaching the outer margin of the frond, in a way which seems to indicate that the fructification was marginal, in the manner of the *Pterideæ*.

It seems probable that the fern from the Upper Devonian of Pennsylvania figured by Lesquereux in Fig. VII., p. 50 of the Coal Plants of N. America is identical with this species. He refers it to *Rhacophyllum* of Schimper, with the specific name *R. truncatum*, which will, in this case, be a synonym of *C. Brownii*. The genus *Rhacophyllum* is very loosely defined by Schimper, and is evidently provisional, including, according to him, young or basal fronds of ferns referred to other genera. As there is no evidence of this in the case of the present species, I see little advantage in removing it from the equally provisional genus *Cyclopteris*, until its fructification shall have been discovered. Should it, however, be considered desirable to remove it from *Cyclopteris*, I would propose for it the name of *Platyphyllum*, for which the characters of this plant as given in the paper cited above and in this note may suffice as generic characters.

(5) *Caulopteris* (*?*).

(Plate xxiv., Fig. 19.)

Among Mr. Foord's specimens is one that appears to represent the stem of a small tree fern. It is about one inch in diameter, flattened

and showing on the exposed side somewhat reniform scars quincunctially arranged. The best preserved leaf-scars show marks of vascular bundles which suggest the idea that it may have given origin to the petioles of ferns; but there is nothing to indicate whether this stem belongs to either of the species found with it.

(6) *Knorria*, sp.

(Plate xxiv., Fig. 20.)

A few stems, about half an inch in diameter, are marked with raised elongated leaf-scars in the manner of *Knorria*, and these may perhaps be connected with certain flattened obscure stems giving off long narrow leaves or branchlets found in the same beds. It is just possible that these stems may have belonged to such a plant as *Cordaites angustifolia* of the former part of this Report.

(7) *Lepidostrobus.*

Among the Scaumenac specimens there is a flattened cylindrical strobile resembling that of a *Lepidodendron* and much larger than that of *L. Gaspianum*. It indicates some plant of the genus *Lepidodendron*, but is too obscure to be described or figured.

(8) *Sternbergia.*

(Plate xxiv., Fig. 21.)

A few fragments of stems longitudinally striated, partly flattened and in a carbonised or pyritised state, show indications of a *Sternbergia* pith. They may be decayed branches of a *Dadoxylon* allied to *D. Ouangondianum* of S. John, which shows a well characterised pith of this nature.

3. *Lower Erian of the Vicinity of Campbellton.*

On the coast immediately west of Campbellton, over the *Cephalaspis* and *Coccoteus* beds already referred to, and associated with them, are shales holding abundant remains of plants. On the opposite side of the Restigouche River at Bordeaux quarry, are sandstones containing similar remains. The plants found in these beds are however different from those in the Scaumenac series, and belong to a much lower horizon, being perfectly identical with those in the lower part of the Gaspé sandstones

1. *Psilophyton Princeps*, Dawson.

(Report on Devonian and Silurian Plants, Pt. I., P. 37, P. ix., x., xi.)

This is perhaps the most common species at this locaity. It fills some beds of hard black shale indurated by trapean dyke, and occurs more sparingly in the lower breccia, associated with remans of *Cephalaspis*, &c. On the opposite side of the river, in the coarsesandstone of Bordeaux quarry, are layers and patches of a finer sandstore, abounding in slender branches of this plant, and sometimes showing ts fructification. The specimens found here show nothing furtherthan what I have already observed in Gaspé Bay, and have describe(in the first part of this report. They merely serve to confirm the conclusions arrived at from the study of the Gaspé specimens.

As it has been suggested by some botanists that *Psilophyon* may have been allied to the ferns of Stur's genus *Rhodea*, I may nention that after the study of hundreds of specimens, in every state of preservation, I have found no trace of any fronds on the branches, but on the barren branches minute acicular leaves, while the spore-cases, though in the form of sacks, having some resemblance to those of *Archaeopteris*, are entirely different in their habit of growth, and also very much larger.

In this connection I may state that in specimens from he Chemung shales of New York, recently obtained from Prof. Willams, I have found plants which may be referred to *Rhodea*. They arcslender delicately striated or smooth petioles, giving off pinnate divsions, which ultimately bifurcate frequently and appear to terminate in lat blade-like or cuneate leaves or fronds. They are the same objcts which I described from fragmentary specimens obtained from Prof. Hall as *Rhachiopteris pinnata*, in my paper on Devonian plants, in he Journal of the Geological Society of London, vol. xviii. In a note on Pof. Williams' plants, presented last year to the American Association for he Advancement of Science, I have described these specimens and have suggested the name *Rhodea pinnata* for them. They may be define to be stems bearing slender opposite branches in a decussate manner, the branches again dividing in a dichotomous or pinnate mode, and teminating in small cuneate or linear leaves. The fructification of tlese plants I have not seen, but they are in appearance and habit of growth altogether distinct from *Psilophyton*. I may also observe here that the stems of *Psilophyton* are much more woody, and in their ound central scalariform axis, present much more of structural affinityto Lycopods than to Ferns.

(2.) *Psilophyton robustius*, Dawson.

(Report on Devonian and Silurian Plants, Pt. I., P. 39, PL. x., xi., xii.)

This species abounds in the Campbellton shales along with the preceding, and is found in a more perfect condition than at Gaspé. Stems were seen two feet long and more than half an inch in diameter, branching dichotomously at top, and having their sides densely covered with short dichotomous branches. It is possible that some of these may have been prostrate stems bearing aerial roots; but it is quite as likely that the stems were erect, and possibly the lower portions of them may have been sub-aquatic.

(3.) *Arthrostigma gracile*, Dawson.

(Report Devonian, &c. Plants, Pt.I., P. 41, Pl. xiii. This Report, Pl. xxiv., Fig. 22.)

Stems and branches of this species are found at Campbellton, as at Gaspé, mixed with *Psilophyton*, though much more rare. The main stems show the rounded scars approaching to a verticillate arrangement, and bearing short thick conical spine-like leaves. The smaller branches are more densely covered with leaves, which seem to be spirally arranged, and when flattened, but for their more dense and longer leaves, might be mistaken for barren branches of *Psilophyton*.

The most interesting point in connection with this plant is the appearance of associated spikes or strobiles of fructification. These were noticed in a similar relation at Gaspé, and in may Report of 1871, I ventured to describe them as probably the fruit of this species. A similar association is observed at Campbellton, and strengthens this conclusion. At Campbellton also the cones are better preserved, and I have figured one of them in Plate xxiv, Fig. 22. They have apparently been cylindrical, but there seems reason to doubt whether they were strobiles bearing very thick and somewhat open scales, or spikes of sac-like spore-cases. The Campbellton specimens certainly favour the latter conclusion, and if this is correct, the fructification of this plant was of a very peculiar character, and in some respects more nearly allied to that of *Psilophyton* than to that of true Lycopods.

From these additional specimens, *Arthrostigma gracile* would seem to have been a small shrubby plant, with stems not exceeding an inch in diameter, and sparsely covered with conical spine-like leaves, which left, when detached, round scars like those of *Cyclostigma*. The branches, which were developed by bifurcation, were densely crowded with acicular leaves nearly at right angles to them, and were terminated by cylindrical spikes of fructification. We can thus restore this plant, and form some conception of its actual appearance.

(4) *Leptophleum Rhombicum*, Dawson.

(Report on Devonian, &c. Plants, Pt. I., P. 36, Pl. xiii, Figs. 88, 89.)

A branch or small stem of this plant, about an inch in diameter, was found in the sandstone near Campbellton. It shows nothing new, but is of interest from its horizon and association with *Psilophyton* in the same manner as at Gaspé.

Since the publication of my former Report, some confusion has been introduced into the position of this species by the identification with it on the part of Dr. Carruthers of a very different plant obtained in Queensland by Mr. Daintree.* This is perhaps not to be wondered at, since the Queensland plant beongs to a type of Lepidodendron characteristic in America of the Lower Carboniferous, and of which *L. tetragonum* of Sternberg is the representative. This plant had been discovered in the Carboniferous of Victoria by Dr. Selwyn, long before it was found in Queensland, in beds supposed to be Devonian. Specimens from Mr. Daintree's collection shown to me by Mr. Carruthers, and others in the collection of Dr. Selwyn, leave no doubt as to this. Now this type of *Lepidodendron* is certainly, when imperfectly preserved, not dissimilar in the form of its leaf-bases from *Leptophleum*, though quite different in the vascular scar and in other important respects. Still further to complicate matters, this Australian *Lepidodendron* was not only identified with *Leptophleum rhombicum*, but with the entirely distinct species *Lepidodendron Gaspianum*, and with *L. nothum* of Unger. The distinctness of the two former species may be easily seen from the figures and descriptions in the first part of this Report, and still more in detail in my papers in the Journal of the Geological Society, vols. xviii. and xix. Their more important distinctive characters may be stated thus—

	LEPIDODENDRON GASPIANUM.	LEPTOPHLŒUM RHOMBICUM.
Stems and branches	Long and slender; areoles elongate-lanceolate.	Short and stout, areoles regularly rhombic or transversely rhombic.
Vascular scars	In middle of areoles, or nearer upper end, according to surface exposed	Always in middle of areole.
Leaves.....	Short and much curved outward.	Long and somewhat straight and erect.
Fruit	Small, scaly.	Long, leafy.
Structure.....	Unknown, but probably allied to Carboniferous *Lepidodendron.*	Known to possess a large *Sternbergia*-pith and to have a very thin cortical layer.

* Journal of Geological Society, vol. 2.

As to the difference of *Lepidodendron Gaspianum* and *L. nothum*, the following remarks from my paper on Scottish Devonian Plants may serve to indicate it. At the time when I described *Lepidodendron Gaspianum* I had not access to Scottish specimens of *Lepidodendron* from the Devonian, but these had been well figured and described by Salter, and had been identified with *L. nothum* of Unger, a species evidently distinct from mine, as was also that figured and described by Salter, whether identical or not with Unger's species. In 1870 I had for the first time an opportunity to study Scottish specimens in the collection of Mr. Peach; and on the evidence thus afforded I stated confidently in my Report of 1871, that these specimens represented a species distinct from *L. Gaspianum*, perhaps even generically so. It differs from *L. Gaspianum* in its habit of growth by developing small lateral branches instead of bifurcating, and in its foliage by the absence or obsolete character of the leaf-bases and the closely placed and somewhat appressed leaves. If an appearance of swelling at the end of a lateral branch in one specimen indicates a strobile of fructification, then its fruit was not dissimilar from that of the Canadian species in its position and general form, though it may have differed in details. On these grounds I declined to identify the Scottish species with *L. Gaspianum*. The Lepidodendron from the Devonian of Belgium described and figured by Crepin, in his "Observations sur quelques plantes fossiles des dépôts Devoniens," has a better claim to such identification, and would seem to prove that this species existed in Europe as well as in America. I also saw in Mr. Peach's collection in 1870, some fragments which seemed to me distinct from Salter's species, and possibly belonging to *L. Gaspianum*.

(5) *Cordaites angustifolia*, Dawson.

(Report on Devonian, &c. Plants, Pt. I., Page 44, Pl. xiv.)

Leaves referable to this species are common at Campbellton, and clearly distinct from any of the other plants there. They must have been very long and parallel-sided, as I have never seen a distinct termination of one of them. They can scarcely be said to have any venation, but present merely a delicate longitudinal striation, and when well preserved their surfaces are smooth and polished. Whether they really have any affinity with the true *Cordaites* it is impossible certainly to decide, as they have not been found attached to a stem or connected with any organs of fructification. They may have been aquatic, and certainly have more resemblance to fossilised leaves of *Zostera* than to anything else.

(6) *Prototaxites Logani*, Dawson.

(Report on Devonian, &c. Plants, P. 16, Plate ii.)

In the Bordeaux quarry, opposite Campbellton, I found in the summer of 1881 several silicified trunks of trees of this species, some of them in the debris of the quarry, but one of very large size still *in situ*. It was black in colour, with a distinct bark of coaly matter, and showed evident lines of growth on the weathered end. It was imbedded in stems and branches of *Psilophyton*, which must have drifted with it from the shore; but as the sandstone of this quarry is evidently a littoral deposit, and at no great distance from the old Silurian land, neither kind of plant need have come from any very remote locality. The tree in question was prostrate and slightly flattened, its horizontal diameter being 2 feet 6 inches, and its vertical diameter about 1 foot 4 inches. The bark on this and other large trunks showed a longitudinally ribbed or wrinkled appearance.

A number of slices were made of the wood of these trees from different parts of the stems; but the structure seemed uniform throughout, from centre to circumference, and similar to that already described and figured from Gaspé specimens. Some of the specimens show, especially under polarised light, a curious and beautiful peculiarity of preservation, in the occurence of rows of crystals of quartz in the interior of the fibres, and which in some specimens are so regular that they might be mistaken for a hexagonal areolation of the walls.

Fragments of fossil wood in a carbonised state found in the shaly beds at the top of the Upper Silurian section at Cape Bon Ami also show the structure of *Prototaxites*, and prove that plants of this kind existed, along with *Psilophyton*, before the close of the Upper Silurian age. I have already in the first part of this Report (1871), noticed the occurrence of similar fragments in the Ludlow of England, and have stated certain reasons rendering it probable that they may be found in still older rocks, and Dr. Hicks has recently described* specimens from the Denbighshire grits of Corwen, N. Wales, in the base of the Upper Silurian. Dr. Hicks's specimens, which he has kindly permitted me to study, are broken angular fragments of drift wood, like those that may be found at the mouths of creeks in any wooded country. They are silicified, but in some of the specimens the thick woody walls of the fibres still exist in a carbonised state, and while the wood is evidently that of *Prototaxites*, the smaller diameter of the fibres and some difference in

* Journal of Geol. Society, 1881, vol. xxxvii.

their markings would seem to indicate that it is a distinct species, which has been named *P. Hicksii*, in honour of its discoverer.

FIG. 1.—*Ætheotesta.* (*a*) Natural size. (*b*) Section. (*c*) Section enlarged.

Besides the great age of Dr. Hicks's specimens, they are also interesting as being associated with well preserved specimens of the globular bodies found with the wood of *Prototaxites* in the Ludlow of England, and named by Hooker *Pachytheca*. These bodies have been supposed to be spore-cases of Lycopodiaceous plants, and remains of algae, &c.; but the specimens obtained by Dr. Hicks show a dense outer wall of radiating fibres similar to those of *Prototaxites*, with an internal granular nucleus. They thus resemble the Carboniferous fruits of the genus *Aetheotesta* of Brongniart, a genus which I had previously recognised among specimens from the Devonian of Scotland, sent to me by Dr. Brown of Einburgh. Similar bodies with similar structure occur with fragments of *Prototaxites* at Cape Bon Ami, (Wood cut, Fig. I.) and round carbonaceous spots, possibly remains of similar bodies, are found in the sandstone of Bordeaux quarry. This constant association of *Pachytheca* with *Prototaxites*, along with its similarity of structure, certainly lends some probability to the view that they belong to the same plant. In this case the resemblance of *Pachytheca* to *Ætheotesta*, an acknowledged gymnospermous fruit, certainly adds confirmation to the view which I have maintained ever since I first studied the structure of *Prototaxites* in 1856, that it is a prototypal gymnosperm, and not as some British botanists have supposed, contrary to the whole of the possibilities of its mode of occurrence and preservation, as well as to its structure, a gigantic alga to be relegated to a new genus "*Nematophycus*". Of all the algic fancies which have loaded the nomenclature of geology with imaginary fucoids, founded on all sorts of trails and impressions of animals, and on badly preserved specimens of land plants, this is one of the most baseless.

Since however, so late as last year, this extravagant view has been sustained by men of so high reputation as Etheridge, Carruthers and Thistleton Dyer, in the discussion of Dr. Hicks's specimens, I think it desirable in the interest of scientific truth to reproduce here the sub-

stance of the reasons which I gave in 1873, and again in 1881, in favour of my original conclusion. In support of this I have referred to: (1.) The mode of occurrence of Prototaxites. (2.) Its microscopic structure. (3) Its probable affinities.

Mode of Occurrence.—This alone should suffice to convince any practical palæontologist that the plant cannot be a sea-weed. Its large dimensions, one specimen found at Gaspé being three feet in diameter; its sending forth strong lateral branches, and gnarled roots; its occurence with land plants in beds where there are no marine organisms, and which must have been deposited in water too shallow to render possible the existence of the large oceanic Algæ to which Mr. Carruthers likens the plant, are all conditions requiring us to suppose that the plant grew on the land. Further, the trunks are preserved in sandstone, retaining their rotundity of form even when prostrate; and are thoroughly penetrated with silica except the thin coaly bark. Not only are Algæ incapable of occurring in this way, but even the less dense and durable land plants, as Sigillariæ and Lepidodendra are never found thus preserved. Only the extremely durable trunks of coniferous trees are capable of preservation under such circumstances. In the very beds in which these occur, *Lepidodendra*, tree ferns and *Psilophyton*, are flattened into mere coaly films. This absolutely proves, to any one having experience in the mode of occurrence of fossil plants, that here we have to deal with a strong and durable woody plant.

These considerations were dwelt on in my published descriptions of Prototaxites, but they naturally have more weight in the judgment of practical geologists that in that of botanists.

Microscopic Structure.—I may say in general that we have in this case to deal not with a recent but a fossil wood, that this wood belongs to a time when very generalized and humble types of gymnosperms existed, and that the affinities of the plant are to be sought with Taxineæ, and especially with fossil Taxineæ, rather than with ordinary pines. If we refer to the beautiful memoir on the Devonian of Thuringia, by Richter and Unger,* and study the figures and descriptions of *Aporoxylon primigenium*,† *Stigmaria annularis*, *Calamopteris debilis*, and *Calamosyrinx Devonicus*, we shall find that there are Devonian plants referred by those eminent palæontologists to Gymnosperms and higher Cryptogams, which fall as far short of modern standards of comparison as *Prototaxites* itself. Nothing can be more fallacious in fossil botany than comparisons which overlook the structures of those primitive palæ-

* Trans., Vienna Academy, 1856.

† I have elsewhere compared *Aporoxylon* with *Prototaxites*, 'Jour. Geol. Soc.' 1862, p. 306. Report on Devonian plants.

ozoic trees which in so many interesting ways connect our modern gymnosperms with the cryptogams.

It is scarcely necessary to reply to such a statement as that the fibres of Prototaxites have no visible terminations. They are very long, no doubt, and both in this and their lax coherence they conform to the type of the yews. In Mesozoic specimens of *Taxoxylon* which I have now before me, the fibres are nearly as loosely attached and as round in cross section as in *Prototaxites*. In these, as in *Prototaxites*, water-soakage has contributed to make the naturally lax and tough yew-structure less compact, and to produce that appearance of thickness of the walls of the fibres which is so common in fossil woods.

The spiral fibres lining the cells of *Prototaxites* have been supposed to be tubes connecting the cells. This is a question of fact and vision, and I can only say that to me they appear to be solid, highly refracting fibres; and under high powers, precisely similar to those of fossil specimens of *Taxoxylon* from British Columbia, and to those seen in charred slices of modern yews.

But what of the arrangement of these fibres. It is true that, as I have stated, they appear in some cases to pass from cell to cell, and I hesitated to account for this appearance. The possibilities of such an appearance may be explained however by the following considerations: (1.) In more or less crushed fossil plants, it is not unusual to see what are really internal structures appearing to pass beyond the limits of the cell-wall, from the mere overlapping of cells. I have good examples in the Mesozoic *Taxoxylon* already mentioned. (2.) In fossil woods the original cell-wall is often entirely destroyed, and only the ligneous lining remains, perhaps thickened by incrustation of mineral matter within. In this case the internal lining of the cell may seem to be an external structure. I have examples both in Mesozoic conifers and in Carboniferous plants. Long soaking in water and decay have thus often made what may have been a lining of wood-cells appear as an intercellular matter, or an external thickening of the walls. (3.) In decayed woods the mycelium of fungi often wanders through the tissues in a manner very perplexing; and I suspect, though I cannot be certain of this, that some fossil woods have been disorganized in this way. At the time when my description was published, I felt uncertain to which of these causes to attribute the peculiar appearance of *Prototaxites*. I have now, from subsequent study of the cretaceous Taxineæ of British Columbia, little hesitation in adopting the first and second explanations, or one of them, as probable.

Medullary rays appear to have existed in *Ptototaxites*. The evidence of these is the occurrence of regular lenticular spaces in the tangential section, which appear as radiating lines in the transverse section. The

tissues have perished; but some tissues must have occupied these spaces; and in fossil woods the medullary rays have often been removed by decay, as one sometimes sees to be the case with modern woods in a partially decayed state. Mr. Carruthers should have been more cautious in this matter, after his denial, on similar grounds, of medullary rays in *Sigillaria* and *Stigmaria*, contrary to the testimony of Brongniart, Goeppert, and the writer, and the recent exposure of his error by Professor Williamson. That the wood-cells have been in part crushed into the spaces left by the medullary rays is only a natural consequence of decay. The fact that the medullary rays have decayed, leaving the wood so well preserved, is a strong evidence for the durability of the latter. The approval with which Mr. C. quotes from Mr. Archer, of Dublin, the naïve statement that "the appearance of medullary rays was probably produced by accidental cracks or fissures," would almost seem to imply that neither gentleman is aware that radiating fissures in decaying exogenous woods are a consequence of the existence of medullary rays, and that water-soaked wood cannot be cracked in this way.

The statement has been made that some specimens of *Prototaxites* appear to be "made up of spherical cells". In point of fact, in all well preserved specimens the distinct fibrous structure of *Prototaxites* occurs, but in parts of the larger trunks, as is usual with fossil woods, it has been replaced by concretionary structure, or by that pseudo-cellular structure which proceeds from the formation of granular crystals of silica in the midst of the tissues.

Affinities.—In discussing these I must repeat that we must bear in mind with what we have to deal. It is not a modern plant, but a contemporary of that "prototype of gymnosperms" *Aporoxylon*, and similar plants of the Devonian. Further, the comparison should be not with exogens in general, nor conifers in general, but with Taxineæ, and especially with the more ancient types of these. Still further, it must be made with such wood partly altered by water-soakage and decay and fossilized.

My original determination of the probable affinities of *Prototaxites*, as a very elementary type of taxine tree, was based on the habit of growth of the plant—its fibrous structure, its spirally-lined fibres, its medullary rays, its rings of growth, and its coaly bark, along with the durable character of its wood, and its mode of occurrence; and I made reference for comparison to other Devonian woods and to fossil taxine trees.

On the contrary, it has been attempted to compare the plant as to *structure* with certain chlorospermous Algæ, and as to *size* with certain

gigantic Melanosperms, not pretented to show similar structure. This is obviously a not very scientific way of establishing affinities. But let us take these grounds separately. The little jointed calcareous sea-weed *Halimeda opuntia*, has been viewed as an allied structure, and reference has been made to Kutzing's figure of the tissue of the plant as seen after the removal of its calcareous matter.* Harvey's description of this structure, which I verified several years ago, in an extensive series of examinations of these calcareous Algæ, undertaken in consequence of a suggestion that *Eozoön* might have been an organism of this nature, is as follows:—"After the calcareous matter of the frond has been removed by acid, a spongy vegetable structure remains, made up of a plexus of slender longitudinal unicellular filaments constricted at intervals, and at the constrictions emitting a pair of opposite decompound, dichotomous, corymboso-fastigiate horizontal ramelli, whose apices cohere and form a thin epidermal or peripheric stratum of cells." It will be seen at once that this structure has no resemblance whatever to anything existing in *Prototaxites*, and without taking into account the fact that *Halimeda opuntia* is a small calcareous sea-weed, divided into flat reniform articulations, to which this structure is obviously suited, as it would be equally obviously unsuited to the requirements of a thick cylindrical trunk, not coated with calcareous matter.

In point of size, on the other hand, it has been compared with the great *Lessonia* of the Antarctic seas, whose structure, however, is not pretended to resemble that of *Prototaxites* except in the vague statement of a pseudo-exogenous growth. *Leesonia* I have not examined, but the horny *Laminariæ* of our North American seas have no resemblance in structure to *Prototaxites*.

Nothing further, I think, need be said in reply to these objections: and *Nematophycus* may be allowed to take its place along with a multitude of obsolete fucoids which strew the path of palæntology. As to *Prototaxites*, it is confessedly an obscure and mysterious form, whose affinities are to be discussed with caution, and with a due consideration of its venerable age and state of preservation, and probably great divergence from any of our modern plants; and it is to be hoped that ere long other parts than its trunk may be discovered to throw light on its nature. Indications of this desirable consummation are afforded by the association of *Prototaxites* with *Aetheotesta*, and I am not without hopes of discovering the foliage and fruit of the plant attached to its trunk; though when it is considered how rarely the drift trunks of *Dadoxylon* in the Carboniferous sandstones are associated with other

* A more characteristic figure is given in Harvey's "North American Algæ."

parts of these plants, we need not be surprised that the trunk of this older tree is the only portion certainly known.

It is satisfactory to find the evidence of the Scaumenac and Campbelton beds confirming the conclusions deduced in my Report of 1871 from the consideration of the Erian floras of Gaspé, New Brunswick, and Maine. It is evident that here, as in Gaspé, *Prototaxites* and *Psilophyton* with *Arthrostigma* are characteristic of the Lower Erian, while ferns of the genus *Archaeopteris* are equally so of the Upper Erian immediately underlying the Carboniferous.

It will be observed also that two of the species of the beds of Perry in Maine re-appear in the Upper Erian of Scaumenac, an evidence of the true Erian age of the former beds, though they are so closely associated with the Lower Carboniferous of Southern New Brunswick. At Scaumenac, indeed, but for the occurrence of the characteristic Erian fishes and the slight unconformability, the beds holding *Archaeopteris* might be regarded as a lower member of the Lower Carboniferous. The occurrence of *Archaeopteris* also connects these Scaumenac beds with the Kiltorcan series of Ireland, whose flora is undoubtedly Upper Erian. Again, the appearance of *Cyclopteris obtusa*, as well as the other plants and the fishes, connects the Scaumenac beds with the Catskill series of New York.

We thus have in the Restigouche region very distinct representatives of the Lower Erian and Upper Erian floras, though without as yet any representative of the rich Middle Erian flora of St. John, New Brunswick, or of that of the Hamilton and Chemung of New York. It will be observed, however, that the St. John flora combines the characters of both the Lower and Upper Erian, in the association, for example, of *Psilophyton* with *Archaeopteris*, though with the addition of many other forms, especially of ferns.

Farther, a comparison of the facts stated in this Report with those in my Report of 1873 on the Floras of the Lower Carboniferous and Millstone grit, will show the entire distinctness of either of these latter sub-floras from those of the preceding Erian, and their closer relation with that of the Coal-formation. This I propose to discuss more in detail under a subsequent head.

III.—New Ferns from the Middle Erian of St. John, New Brunswick.

Since the publication of my Report of 1871, I have obtained the portion of the collections of the late Professor Hartt remaining in the hands of his widow, and have been enabled to detect the following new species, the characters of which were published in the Journal of the Geological Society of London, May, 1881:—

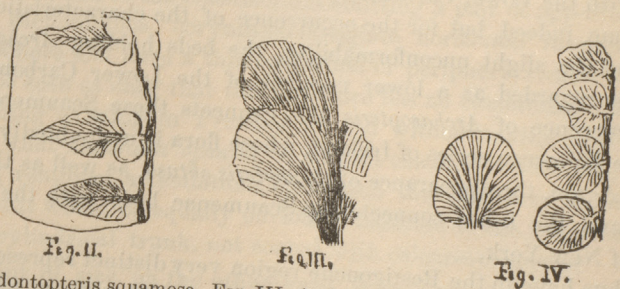

Fig. II. Odontopteris squamosa. Fig. III. Archæopteris. Fig. IV. Cardiopteris Eriana.

Odontopteris squamosa, sp. n. (Woodcut Fig. II.)

Petiole slender, bearing short pinnules placed at right angles to it, and each consisting of two rounded decurrent pinnulæ and a terminal pinnule of triangular form. Toward the end only the terminal pinnule appears. Veins obscure, diverging from a midrib, broad at base. Frond apparently of a thick or coriaceous texture.

This would seem to have been a creeping or parasitic fern. In its general habit its bears some resemblance to *Cyclopteris dissecta* of Unger, from the Devonian of Thuringia, but appears to have more affinity with the genus *Odontopteris* than with *Cyclopteris*.

Cardiopteris eriana, sp. n. (Woodcut Fig. IV.)

Pinnules nearly round or slightly oblong, nearly equally cordate at base, somewhat crowded on a slender petiole. Length from 8 to 14 millim. Veins regularly spreading from the centre of the base, curving toward the margin, and forking twice or thrice.

This is the first appearance of this Lower Carboniferous genus in the Devonian. The species closely resembles *Cyclopteris polymorpha* of Göppert, though every way smaller and more delicate.

ARCHÆOPTERIS ?, sp. n. (Woodcut Fig. III.)

Petiole apparently woody, bearing broadly obovate decurrent pinnules, with strong flabellate, straightish nerves. Pinnules overlapping each other.

This plant bears a general resemblance to *Archaeopteris* of the type of *A.* (*Cyclopteris*) *Maccoyana* of Göppert; but the woody petiole or branchlet, and the coarse texture of the pinnules, raise the suspicion that the specimen may not be a fern, but may have belonged to a coniferous tree of the type of *Voltzia* or *Salisburya*.

CYCLOPTERIS, sp.

Fragments of a very large cyclopterid leaf, with flabellate veins, and which, when entire, must have three inches in diameter. It is too imperfect for description, but indicates a frond of the same general character with *Cyclopteris Brownii* from Perry, in Maine.

Other specimens indicate a small species of *Archaeopteris*, more delicate than *A. Jacksoni;* and there are some fragments which seem to show, though not indisputably, that the submerged leaves of *Asterophyllites latifolia* were long and linear, approaching in form to those previously described as *A. lenta*. A fragment of *Hymenophyllites*, about the size and form of *H. Gersdorffi*, shows minute rounded spore-cases comparable with those of the modern genus *Todea*, which the fern itself also closely resembles.

The species above described add to the number of small and delicate ferns by which the St.-John beds are so especially characterized.

Doubts having been expressed by Dr. Hagen of Cambridge* respecting the geological age of the Erian shales of St. John, New Brunswick, and more especially with reference to the fern *Pecopteris serrulata*, described in my Report of 1871, I think it necessary to add the following statements :—

The oldest remains of insects known to geologists, those of the Erian (Devonian) shales of St. John, New Brunswick, occur in beds rich in plant remains. It was indeed solely by means of the extensive quarrying operations carried on by Messrs. Hartt and Matthew in these beds in search of fossil plants, that the insect remains were discovered. In less thoroughly explored beds, fossils so rare and so obscure could not have been found. It is natural therefore that fossil plants should occur on the same slabs with the insects. On one of these, holding a fragment of the wing of *Platephemera antiqua*, there appears a considerable portion of a frond of *Pecopteris* (*Aspidites*) *serrulata*, Hartt, a common spe-

* Bulletin of Harvard Museum, March, 1881.

cies in these beds, and also a small fragment of a leaf of the still more common *Cordaites Robbii*. It appears that Dr. Geinitz of Dresden saw this specimen in 1866, and not being at that time familiar with the ferns of the Devonian of New Brunswick, very naturally supposed that the frond was that of the closely allied *P. plumosa* of Brongniart, and on this ground he was induced to hint a suspicion that the specimen was of Carboniferous age. Dr. Scudder referred to this opinion of Geinitz in his paper on Devonian insects in the Geological Magazine, Vol. V.; and gave reasons sustaining the Devonian age of both fern and insect. I did not think it necessary to refer publicly to the matter, but took occasion to explain the true state of the case in a private letter to Geinitz; and in my Report on the Devonian plants of Canada I quoted Hartt's description in full, and noticed the distinctness of his species from *P. plumosa*.

I find, however, that this doubt has been revived by Dr. Hagen in a paper on Devonian insects in the Bulletin of the Museum of Comparative Zoology for the present year (Vol. viii. No. 14). Dr. Hagen does not profess to be an authority in fossil plants, but fortifies his statements by a letter from Mr. Lesquereux, which does not, however, touch the question at issue, as he does not appear to have compared the specimen of Hartt's species with *P. plumosa*; and though he insinuates a doubt as to the validity of some of my Devonian species, even this does not apply, since the species in question was carefully described by the late Prof. Hartt, and accepted by me after study of his material, which included several very considerable portions of well preserved fronds.

Though doubts and suspicions thus cast on work carefully and exhaustively done, in so far as material exists, should not seriously affect the minds of naturalists, I have thought it desirable to set the matter at rest, as far as possible; and have therefore, through the kindness of Dr. Scudder and the Curator of the Boston Society of Natural History, obtained access to the original specimen, and would now state the actual facts.

The fern on the specimen in question (No. 8496 of the Boston Society's collection) is undoubtedly *Pecopteris serrulata* of Hartt, and exhibits in a tolerable state of preservation six secondary pinnae of one side of a primary pinna of the species. To a hasty observer, supposing the specimen to be a piece of Carboniferous shale, it would be natural to refer the fern to *P. plumosa* of Brongniart or to *Aspidites silesiacus* of Goeppert, which it perhaps more closely resembles; and since its fructification is still unknown, it may quite as likely belong to the group or sub-genus *Aspidites* in which Goeppert and Schimper place *P. silesiaca*, as to that of *Cyathites* in which Schimper places *P. plumosa*.

The distinctive characters indicated by Hartt are principally the form and insertion of the pinnæ, the slender crenulate, revolute, lanceolate pinnules, and the simple veinlets. Perhaps the most obvious characteristic is the peculiarly elongated acuminate points of the primary and secondary pinnæ, in which this species seems to differ from all its near allies. In the specimen in question, though only a portion of one side of a primary pinna is seen, and its characteristic elongate termination is absent, yet one of the secondary pinnæ shows this character very well, and the simple veins and crenate revolute margins may be made out with a lens in a good light. I do not think that any palæobotanist, in view of these characters, would decide to identify this fern with *P. plumosa*, unless indeed he were of opinion that the whole group to which that species belongs could constitute one broad specific type extending from the Devonian to the Permian, a view to which I should have no objection, provided sufficient connecting links can be found.

It is farther to be observed that this fern occurs with a group of species which I have shown to be distinct not only from those of the Coal formation, but from those of the Millstone Grit and those of the Lower Carboniferous Coal-measures or Horton series (sub-Carboniferous of some American geologists), which sub-floras are well developed in the Acadian provinces, and overlie stratigraphically the beds holding the fern which is the subject of this note and its associated fossils.

I may add here Hartt's description of the plant and my note on it, from my Report of 1871:—

"PECOPTERIS (ASPIDITES?) SERRULATA, Hartt.—(Pl. XVIII., Figs. 207 to 209.)—Acad. Geol. p. 553, Fig. 92.—M.D., St. John, New Brunswick."

Tripinnate; pinnæ short, alternate, close or open, lanceolate, very oblique, situated on a rather slender, rounded, subflexuose rachis; pinnules small, linear lanceolate, crenulate, revolute, moderately acute, oblique, sessile, decurrent, widest at the base, open, separated from one another by a space equal to the width of a pinnule, slightly arched towards the point of pinna; longest at base of pinna, decreasing thence gradually to the apex; terminal pinnule elongated. Median nerve entering the pinnule very obliquely, flexuous, running to the apex. Nervules very few, oblique, simple, and somewhat rarely forking at the margin."

"Numerous additional specimens of this species confirm Prof. Hartt's determination of its distinctness from *P. plumosa*, Brongt. It perhaps more strongly resembles Goeppert's *P. silesiaca:* but this last has

broader and more closely arranged pinnules decurrent on the petiole. It may be taken as a Devonian representative of the delicate Pecopterids of which the species above named are Carboniferous types. Mr. Hartt's specimens enable me to represent its habit of growth. Schimper quotes under this name a Carboniferous species of Lesquereux. But Lesquereux's species is *Alethopteris serrula.*" This was subsequently corrected by Schimper in the Supplement to his Palæontologie Vegetale.

IV.—The Nature and Affinities of Ptilophyton.

(*Lycopodites Vanuxemii* of Report on Devonian and Upper Silurian Plants, Pt. I., P. 35.—*L. plumula* of Report on Lower Carboniferous Plants, P. 24, Pl. I., Figs. 7, 8, 9.)

In the Reports above referred to, these remarkable pinnate frond-like objects were referred to the genus *Lycopodites*, as had been done by Goeppert in his description of the European species *Lycopodites pennaeformis*, which is very near to the American Erian form. Since 1871, however, there have been many new specimens obtained, and very various opinions expressed as to their affinities. While Hall has named some of them *Plumalina* and has regarded them as animal structures, allied to hydroids, Lesquereux has described some of the Carboniferous forms under the generic name *Trochophyllum*, which is however more appropriate to plants with verticillate leaves which are included in this genus. Before I had seen the publications of Hall and Lesquereux on the subject, I had in a paper on Scottish Devonian Plants,* separated this group from the genus *Lycopodites* and formed for it the genus *Psilophyton*, in allusion to the feather-like aspect of the species. My reasons for this, and my present information as to their nature, may be stated as follows :—

Schimper, in his "Palæontologie Vegetale," (possibly from inattention to the descriptions or want of access to specimens) doubts the Lycopodiaceous character of species of *Lycopodites* described in my published papers on plants of the Devonian of America and in my Report of 1871. Of these *L. Richardsoni* and *L. Matthewi* are undoubtedly very near to the modern genus *Lycopodium*. *L. Vanuxemii* is, I admit, more problematical; but Schimper could scarcely have supposed it to be a fern or a fucoid allied to *Caulerpa* had he noticed that both in my species and the allied L. *pennæformis* of Goeppert, which he does not appear to notice, the pinnules are articulated upon the stem, and leave scars where they have fallen off. When in Belfast in 1870, my attention was again directed to the affinities of these plants by finding in Prof. Thomson's collection a specimen from Caithness, which shows a plant apparently of this kind, with the same long narrow pinnæ or leaflets, attached, however, to thicker stems, and rolled up in a circinate manner. It seems to be a plant in vernation, and the parts are

* Canadian Naturalist, 1878.

too much crowded and pressed together to admit of being accurately figured or described; but I think I can scarcely be deceived as to its true nature. The circinate arrangement in this case would favour a relationship to ferns; but some Lycopodiaceous plants also roll themselves in this way, and so do the branches of the plants of the genus *Psilophyton*.

The specimen consists of a short erect stem, on which are placed somewhat stout alternate branches, extending obliquely outward and then curving inward in a circinate manner. The lower ones appear to produce on their inner sides short lateral branchlets, and upon these and also upon the curved extremities of the branches, are long narrow linear leaves placed in a crowded manner. The specimen is thus not a spike of fructification, but a young stem or branch in vernation, and which when unrolled would be of the form of those peculiar pinnate *Lycopodites* of which *L. Vanuxemii* of the American Devonian and *L. pennæformis* of the European Lower Carboniferous are the types, and it shows, what might have been anticipated from other specimens, that they were low tufted plants, circinate in vernation. The short stem of this plant is simply furrowed, and bears no resemblance to a detached branch of *Lycopodites Milleri* which lies at right angles to it on the same slab. As to the affinities of the singular type of plants to which this specimen belongs, I may quote from my Report on the Lower Carboniferous plants of Canada, in which I have described an allied species, *L. plumula*:—

"The botanical relations of these plants must remain subject to doubt, until either their internal structure or their fructification can be discovered. In the meantime I follow Goeppert in placing them in what we must regard as the provisional genus *Lycopodites*. On the one hand they are not unlike the slender twigs of *Taxodium* and similar Conifers, and the highly carbonaceous character of the stems gives some colour to the supposition that they may have been woody plants. On the other hand, they might, so far as form is concerned, be placed with algae of the type of Brongniart's *Chondrites obtusus*, or the modern *Caulerpa plumaria*. Again, in a plant of this type from the Devonian of Caithness to which I have referred in a former memoir, the vernation seems to have been circinate, and Schimper has conjectured that these plants may be ferns, which seems also to have been the view of Shumard."

On the whole, these plants are allied to Lycopods rather than to ferns; and as they constitute a small but distinct group, known only so far as I am aware in the Lower Carboniferous and Erian or Devonian, they deserve a generic name, and I proposed for them in my Paper on Scottish Devonian Plants, 1878, that of *Ptilophyton*, a name sufficiently

distinct in sound from Psilophyton, and expressing very well their peculiar feather-like habit of growth. The genus was defined as follows;—

"Branching plants, the branches bearing long slender leaves in two or more ranks, giving them a feathered appearance; vernation circinate. Fruit unknown, but analogy would indicate that it was borne on the bases of the leaves or on modified branches with shorter leaves."

The Scottish specimen above referred to was named *Pt. Thomsoni*, and was characterized by its densely tufted form and thick branches. The other species known are:—

Pt. pennæformis, Goeppert, L. Carboniferous.

Pt. Vanuxemii, Dawson, Devonian.

Pt. plumula, Dawson, L. Carboniferons.

Shumard's *Filicites gracilis*, from the Devonian of Ohio, and Stur's *Pinites antecedens*, from the Lower Carboniferous of Silesia, may possibly belong to the same genus. The Scottish specimen referred to is apparently the first appearance of this form in the Devonian of Europe.

I have at a still later date had opportunities of studying considerable series of these plants collected by Prof. Williams of Cornell University, and prepared a note in reference to them for the American Association, of which, however, only an abstract has been published. I have also been favoured by Prof. Lesquereux and Mr. Lacoe of Pittston, with the opportunity of studying the specimens referred to *Trochophyllum*.

Prof. Williams's specimens occur in a dark shale associated with remains of land plants of the genera *Psilophyton*, *Rhodea*, &c., and also marine shells, of which a small species of *Rhynchonella* is often attached to the stems of the *Ptilophyton*. Thus these organisms have evidently been deposited in marine beds, but in association with land plants.

The study of the specimens collected by Prof. Williams developes the following facts:—(1.) The plants are not continuous fronds, but slender stems or petioles with narrow linear leaflets attached in a pinnate manner. (2.) The pinnules are so articulated that they break off leaving delicate transverse scars, and the lower parts of the stems are often thus denuded of pinnæ for the length of one or more inches. (3.) The stems curve in such a manner as to indicate a circinate vernation. (4.) In a few instances the fronds were observed to divide dichotomously toward the top; but this is rare. (5.) There are no indications of cells in the pinnules; but, on the other hand, there is no appearance of fructification unless the minute granules which roughen some

of the stems are of this nature. (6.) The stems seem to have been lax and flexuous, and in some instances they seem to have grown on the petioles of ferns preserved with them in the same beds. (7.) The frequency of the attachment of small brachiopods to the specimens of *Ptilophyton* would seem to indicate that the plant stood erect in the water. (8.) Some of the specimens show so much carbonaceous matter as to indicate that the pinnules were of considerable consistency. All these characters are those rather of an aquatic plant than of an animal organism or of a land plant.

The specimens communicated by Prof. Lesquereux and Mr. Lacoe are from the Lower Carboniferous, and evidently represent a different species with similar slender pitted stems, often partially denuded of pinnules below; but the pinnules are much broader and more distant. They are attached by very narrow bases, and apparently tend to lie on a plane, though they may possibly have been spirally arranged. On the same slabs are rounded sporangia or macrospores like those of *Lepidodendron*, but there is no evidence that these belonged to *Trochophyllum*. On the stems of this plant, however, there are small rounded bodies apparently taking the places of some of the pinnules. These may possibly be spore-cases; but they may be merely imperfectly developed pinnules. Still the fact that similar small granules appear on the stems of the Devonian species, favours the idea that they may be organs of fructification.

The most interesting discovery, however, which results from the study of Mr. Lacoe's specimens, is that the pinnules were cylindrical and hollow, and probably served to float the plant. This would account for many of the peculiarities in the appearance and mode of occurrence of the Devonian *Ptilophyton*, which are readily explained if it is supposed to be an aquatic plant, attaching itself to the stems of submerged vegetable remains and standing erect in the water by virtue of its hollow leaves. It may well, however, have been a plant of higher organization than the algae, though no doubt Cryptogamous.

The species of *Ptilophyton* will thus constitute a peculiar group of aquatic plants, belonging to the Devonian and Lower Carboniferous periods, and perhaps allied to Lycopods and Pillworts in their organization and fruit, but specially distinguished by their linear leaves serving as floats and arranged pinnately on slender stems. The only species yet found within the limits of Canada is *Pt. plumula* found by Dr. Honeyman in the Lower Carboniferous of Nova Scotia; but as *Pt. Vanuxemii* abounds in the Erian of New York, it will no doubt be found in Canada also.

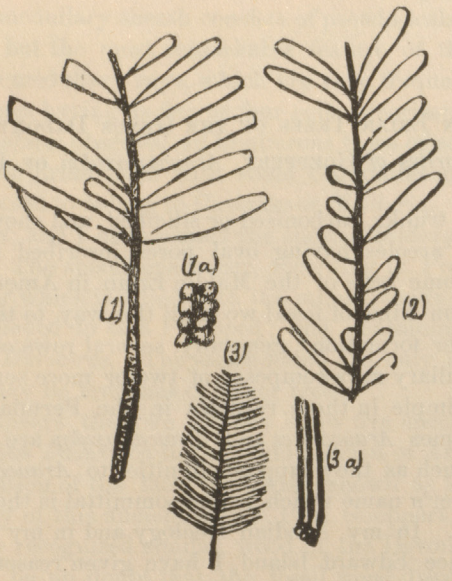

FIG. V.—(1) (2) *Ptilophyton lineare*, natural size. (1 *a*) Portion of stem magnified. (3) Portion of *Pt. Vanuxemii*, natural size. (3 *a*) Portion enlarged.

I figure here in the accompanying woodcut (Fig. V.) two of Mr. Lacoe's specimens of *Ptilophyton* (*Trochophyllum*) *lineare* (Figs. 1 & 2), and for comparison a fragment of *Pt. Vanuxemii* (Fig. 3.) I may refer also to the figure of *Pt. plumula* given in my Report on the Lower Carboniferous Plants.

V.—Note on Erian Trees of the Genus Dadoxyion, Unger, (*Araucarites of* Goeppert, *Araucarioxylon* of Kraus.)

Large woody trunks, carbonised or silicified, and showng wood-cells with hexagonal areoles having oval pores inscribed in them, occur abundantly in some beds of the Middle Erian in America, and constitute the most common kind of fossil wood all the way to the Trias. They have in the older formations, generally, several rows of pores on each fibre, and medullary rays composed of two or more series of cells, but become more simple in these respects in the Permian and Triassic series. The names *Araucarites* and *Araucarioxylon* are perhaps objectionable, inasmuch as they suppose affinities to *Araucaria* which may not exist. Unger's name which is non-committal is therefore, I think, to be preferred. In my Acadian Geology and in my Report on the Geology of Prince Edward Island, I have given reasons for believing that the foliage of some at least of these trees was that known as *Walchia*, and that they may have borne nutlets in the manner of Taxine trees (*Trigonocarpum*, &c.) Grand d'Eury has recently suggested that some of them may have belonged to *Cordaites*, or to plants included in that somewhat varied and probably artificial group.

The earliest discovery of trees of this kind in the Erian of America, was that of Matthew and Hartt, who found large trunks, which I afterwards described as *Dadoxylon Ouangondianum*, in the Erian Sandstone of St. John, New Brunswick, hence named by those geologists the "Dadoxylon sandstone". A little later, similar wood was found by Prof. Hall and Prof. Newberry in the Hamilton group of New York and Ohio, and the allied wood of the genus *Ormoxylon* was obtained by Prof. Hall in the Portage group of the former State. These woods proved to be specifically distinct from that of St. John, and were named by me *D. Halli*, *D. Newberryi*, and *Ormoxylon Erianum*. The three species of *Dadoxylon* agreed in having composite medullary rays, and would thus belong to the group *Palaeoxylon* of Brongniart. In the case of *Ormoxylon* this character could not be very distinctly ascertained, but the medullary rays appeared to be simple.

I am indebted to Prof. J. M. Clarke of Amherst College, Massachusetts, for some well preserved specimens of another species from the Genesee shale of Canandaigua, New York. They show smal stems or branches, with a cellular pith surrounded with wood of Coniferous type,

showing two to three rows of slit-formed bordered pores in hexagonal borders. The medullary sheath consists of pseudo-scalariform and reticulated fibres; but the most remarkable feature of this wood is the structure of the medullary rays, which are very frequent, but short and simple sometimes having as few as four cells superimposed. This is a character not before observed in Coniferous trees of so great age, and allies this Middle Erian form with some Carboniferous woods which have been supposed to belong to *Cordaites* or *Sigillaria*. In any case this structure is new, and I have named the species *Dadoxylon Clarkii*, after its discoverer. The specimens occur, according to Prof. Clarke, in a calcareous layer which is filled with the minute shells of *Styliola fissurella* of Hall, believed to be a Pteropod; and containing also shells of *Goniatites* and *Gyroceras*. The stems found are only a few inches in diameter, but may be branches of larger trees.

It thus appears that we already know five species of Coniferous trees of the genus *Dadoxylon* in the Middle Erian of America, an interesting confirmation of the facts otherwise known as to the great richness and variety of this ancient flora. Prof. Goeppert informs me that he has recently recognised similar wood in the Devonian of Germany, and there can be no doubt that the fossil wood discovered by Hugh Miller in the Old Red Sandstone of Scotland, and described by Salter and McNab, is of similar character, and probably belongs to the genus *Dadoxylon*. Thus this type of Coniferous tree seems to have been as well established and differentiated into species in the Middle Devonian as in the succeeding Carboniferous.

VI.—The Genus Cladoxylon in America.

In the Report on the Fossils of the Devonian rocks of Thuringia, by Unger and Richter,* the former has described and figured certain fossil stems showing structure, to which he gives the name *Cladoxylon*, and makes them the types of a Family *Cladoxyleae*, which he regards as allied to Lycopods. He describes the stem of *C. mirabile* as having a slender cellular pith surrounded by a series of vertical plates of scalariform tissue, adhering internally, and separating and sometimes forking toward the exterior, the whole surrounded by a thick cellular investment.

Prof. Clarke has been so fortunate as to find in the *Styliola* limestone, which contains the branches of *Dadoxylon*, a specimen showing the structure of *Cladoxylon*, and so similar to Unger's species *C. mirabile*, that I think it may safely be referred to it. The stem is 1.5 centimetre in diameter, and marked with about fifteen longitudinal ribs; which are the edges of the radiating plates of scalariform vessels. In the cross section, the axis consists of vertical but wavy radiating bands of pseudo-scalariform tissue, with intervening cellular matter. Enclosing the axis is a cylinder of thin-walled cellular tissue traversed by a few bundles of fibres. The outer surface has a dense cortical structure, but unfortunately shows no external markings. This discovery affords another interesting link of connection between the Erian flora of Eastern America and that of Europe.

We know from the rocks and fossils of Gaspé and St. John, that in the Middle Devonian period there was much land on the Eastern side of the North American Continent. But at this period the regions of Western New York and Ohio and of Western Canada, were covered by the sea. It thus happens that the land flora of the Hamilton and associated rocks of the interior portion of the Continent, consists merely of drifted and macerated remains carried out to sea. The number and variety of these remains, however, testify in a remarkable manner to the richness of the flora, representing as it does, though in an imperfect manner, many species of Conifers, Tree-ferns, and Arborescent Lycopods, all of which probably grew on limited insular areas.

To Prof. Clarke we are also indebted for the discovery of a fossil tree allied the to *Prototaxites* in the Hamilton Group of New York (*Cellu-loxylon primævum*, Dn.) Mr. B. H. Wright, of Penn Yan, N.Y., has discovered in the Portage and Chemung Groups the remarkable tree fern, *Asteropteris Noveboracensis*, Dn., *Equisetites Wrightiana*, Dn., and *Cyclostigma affine*, Dn. These species have been described in the Journal of the Geological Society of London, May, 1881.

* Vienna; 1856.

VII.—Comparative View of the successive Palæozoic Floras of Canada.

1. Carboniferous Flora.

(1.) *Permo-Carboniferous Sub-flora:*—

This occurs in the upper member of the Carboniferous system of Nova Scotia and Prince Edward Island, originally named by the writer the Newer Coal Formation, and more recently the Permo-Carboniferous, and the Upper beds of which may not improbably be contemporaneous with the Lower Permian or Lower Dyas of Europe. In this formation there is a predominance of red sandstones and shales, and it contains no productive beds of coal. Its fossil plants are for the most part of species found in the Middle or Productive Coal-formation, but are less numerous and there are a few new forms akin to those of the European Permian. The most characteristic species of the upper portion of the formation, which has the most decidedly Permian aspect, are the following:—

Dadoxylon materiarium, Dawson.
* *Walchia* (*Araucarites*) *robusta*, Dn.
* *W.* (*A.*) *gracilis*, Dn.
Calamites Suckovii, Brongt.
C. Cistii, Brongt.
* *C. gigas*, Brongt.
Neuropteris rarinervis, Bunbury.
Alethopteris nervosa, Brongt.
Pecopteris arborescens, Brongt.
* *P. rigida*, Dn.
P. oreopteroides, Brongt.
* *Cordaites simplex*, Dn.

Of these species those marked with an asterisk have not yet been found in the Middle or Lower members of the Carboniferous system. They will be found described and several of them figured in my Report on the Geology of Prince Edward Island. The others are common and widely diffused Carboniferous species, some of which have extended to the Permian period in Europe as well. From the Upper beds characterised by these and a few other species, there is a gradual passage downward into the productive-Coal measures, and a gradually increasing number of true Coal-formation species.

It is worthy of remark here that the association in the Permo-Carboniferous of numerous trunks of *Dadoxylon* with the branches of *Walchia* and with fruits of the character of *Trigonocarpa*, seems to show that these were parts of one and the same plant.

(2.) *Coal-Formation Sub-flora* :—

The Middle or Productive Coal-formation, containing all the beds of coal which are mined in Nova Scotia and Cape Breton, is the headquarters of the Carboniferous flora. From this formation I have catalogued* 135 species of plants; but as several of these are founded on imperfect specimens, the number of actual species may be estimated at 120. Of these more than one half are species common to Europe and America. No less than nineteen species are *Sigillariæ* and about the same number are *Lepidodendra*. About fifty are Ferns and thirteen are *Calamites*, *Asterophyllites* and *Sphenophylla*. The great abundance and number of species of *Sigillariæ*, *Lepidodendra* and ferns are characteristic of this sub-flora; and among the ferns certain species of *Neuropteris*, *Pecopteris*, *Alethopteris* and *Sphenopteris*, greatly preponderate.

(3.) *The Millstone Grit Sub-flora* :—

In this formation the abundance of plants and the number of species are greatly diminished. Trunks of Coniferous trees of the species *Dadoxylon Acadianum*, having wide wood-cells with three or more series of discs and complex medullary rays, become characteristic. *Calamites undulatum* is abundant and seems to replace *C. Suckovii*, though *C. cannaeformis* and *C. cistii* continue. *Sigillariæ* become very rare, and the species of *Lepidodendron* are few, and mostly those with large leaf-bases. *Lepidofloyos* still continues and *Cordaites* abounds in some beds. The ferns are greatly reduced, though a few characteristic Coal-formation species occur, and the genus *Cardiopteris* appears. Beds of Coal are rare in this formation; but where they occur there is in connection with them a remarkable anticipation of the rich Coal-formation flora, which would thus seem to have existed locally in the Millstone Grit period, but to have found itself limited by generally unfavourable conditions. In America, as in Europe, it is in the North that this earlier development of the Coal Flora occurs, while in the South there is a lingering of old forms in the newer beds.

(4.) *The Lower Carboniferous Sub-flora* :—

This group of plants is best seen in the shales of the Horton series,

* Acadian Geology, and Report on Flora of Lower Carboniferous, 1873.

under the Lower Carboniferous marine limestones. It is small and peculiar. The most characteristic species are the following :—

Dadoxylon (*Palæoxylon*), *antiquius*, Dn.—A species with large medullary rays of three or more series of cells.

Lepidodendron corrugatum, Dn.—A species closely allied to *L. Veltheimianum* of Europe, and which is its American representative. This is perhaps the most characteristic plant of the formation, and presents very protean appearances, in its old stems, branches, twigs, and *Knorria* forms. It had well characterised stigmaria roots, and constitutes the oldest erect forest known in Nova Scotia.

Lepidodendron tetragonum, Sternberg.

L. obovatum, Sternb.

L. aculeatum, Sternb.

L. dichotomum, Sternb.

These species are comparatively rare, and the specimens are too imperfect to render their identification certain.

Cyclopteris (*Aneimites*) *Acadica*, Dn.:—A very characteristic fern, allied in the form of its fronds to *C. tenuifolia* of Goeppert, to *C. nana* of Eichwald, and to *Adiantites antiquus* of Stur. Its fructification, however, is nearer to that of *Aneimia* than to that of *Adiantum*.

Ferns of the genera *Cardiopteris* and *Hymenophyllites* also occur, though rarely.

Ptilophyton plumula, Dn. :—This is the latest appearance of this Erian genus, which also occurs in the Lower Carboniferous of Europe and of the United States.

Cordaites borassifolia, Brongt.

On the whole, this small flora is markedly distinct from that of the Millstone Grit and true Coal formation, from which it is separated by the great length of time required for the deposition of the marine lime- and their associated beds, in which no land plants have been found; nor is this gap filled up by the conglomerates and coarse arenaceous beds which, as I have explained in Acadian Geology, in some localities take the place of the limestones.

In my Report on the Plants of the Millstone Grit and Lower Carboniferous, I have referred at length to their relation to the foreign beds of similar age, and which are known to geologists by a number of local names.

(2.) Erian Flora.

(1.) *Upper Erian Sub-flora:—*

This corresponds to the Catskill and Chemung of the New York series, and to the Upper Devonian of Europe.

The flora of this formation, which consits mostly of sandstones, is not rich. Its most distinctive species on both sides of the Atlantic seem to be the ferns of the genus *Archeopteris*, along with species referred to the genus *Cyclopteris*, but which, in so far as their barren fronds are concerned, for the most part resemble *Archaeopteris*.

The representative species *Archaeopteris Jacksoni*, *A. Rogersi*, and *A. Gaspiensis* have already been referred to in this Report, as well as *Cyclopteris obtusa* and *C. Brownii*, both very characteristic species.

Leptophleum rhombicum and fragments of *Psilophyton* are also found in the Upper Erian. There is evidence of he existence of extensive forests probably of Lycopodiaceous trees in his period, in the deposits of spore-cases (*Sporangites Huronensis*) in the shales of Kettle Point, Lake Huron; and Prof. Orton of Columbus, Ohio, informs me that extensive deposits of similar character exist in that State, though with accompaniments which suggest doubt as to he origin above stated.

The Upper Erian Flora is thus very distinct from that of the Lower Carboniferous, and the unconformable relation of the beds may perhaps indicate a considerable lapse of time. Still, even in countries where there appears to be a transition from the Carboniferous into the Devonian, the characteristic flora of each formation may be distinguished.

(3.) *Middle Erian Sub-flora:—*

Both in Canada and the United States that part of the Great Erian System which may be regarded as its middle division, the Hamilton and Marcellus Shales of New York, the Cordaite Shales of St. John, New Brunswick, and the Middle Shales and Sandstones of the Gaspé series, presents conditions more favourable to the abundant growth of land plants than either the Upper or Lower member. In the St. John beds in particular, there is a rich fern flora, comparable with that of the Coal formation. It is, however, distinguished by a prevalence of small and delicate species, and by such forms as *Hymenophyllites* and the smaller Sphenopterids, and also by some peculiar ferns, as *Archaeopteris* and *Megalopteris*. In addition to ferns, it has small *Lepidodendra*, of which *L. Gaspianum* is the chief. *Calamites* occur, *C. radiatus* being the dominant species. This plant, which in Europe appears to reach up into the Lower Carboniferous, is so far strictly Erian in America. *Sigillariæ* scarcely appear, but *Cordaites* is abundant, and the earliest

known species of *Dadoxylon* appear, while the *Psilophyton* so characteristic of the Lower Erian, still continues, and the remarkable aquatic plants of the genus *Ptilophyton* are locally abundant. A tabular view of this flora will be found in Part I. of this Report.

(3.) *Lower Erian Sub-flora :—*

This belongs to the Lower Devonian Sandstones and Shales, and is best seen in that formation at Gaspé and the Bay de Chaleur. It is characterised by the absence of true ferns *Calamites* and *Sigillariæ*, and by the presence of such forms as *Psilophyton*, *Arthrostigma*, *Leptophleum* and *Prototaxites*. *Lepidodendron Gaspianum* and *Leptophleum* already occur, though not nearly so abundant as *Psilophyton*. The plants described above from the Campbellton beds are those most characteristic of the Lower Eran.

The Lower Erian plants have an antique and generalised aspect which would lead us to infer that they are near the beginning of the land flora, and practically few indications of land plants have been found earlier within the limits of Canada.

(3.) The Silurian Flora and Still Earlier Indications of Plants.

In the Upper beds of the Silurian, those of the Helderberg series, we still find *Psilophyton* and *Prototaxites ;* but below these we have no land plants. In the United States, Lesquereux and Claypole have described remains which may indicate the existence of Lycopodiaceous and Annularian types as far back as the beginning of the Upper Silurian, and Hicks has found *Prototaxites* and *Psilophyton* in beds as old in Wales, along with some uncertain stems named *Berwynia*. In the Lower Silurian the *Protannularia* of the Skiddaw series in England, may represent a land plant, but this is uncertain, and no similar species has been found in Canada.

Specimens of the so-called *Eopteris* found in rocks equivalent to the Hudson River series in France, convince me that this is nothing but an aggregation of tabular crystals of pyrite, which would seem, however, to have formed around thread-like stems perhaps belonging to algae, or perhaps of the nature of scolithoid burrows.

The Cambrian rocks are so far barren of land plants; the so-called *Eophyton* being evidently nothing but markings, probably produced by crustaceans and other aquatic animals. In the still older Laurentian, the abundant beds of graphite probably indicate the existence of plants, but whether aquatic or terrestrial it is impossible to decide at present. I have discussed this subject in a paper on the Laurentian Graphite in the Journal of the Geological Society of London (1870).

It would thus appear that in so far as Canada is concerned, our certain knowledge of Land Vegetation begins with the Upper Silurian, and that its earliest forms were Acrogens allied to Lycopods and prototypal gymnosperms, forerunners of the Conifers. In the Lower Devonian little advance is made. In the Middle Devonian this meagre flora had been replaced by one rivalling that of the Carboniferous, and including Pines, Tree-ferns, and arboreal forms of Lycopods and of Equisetaceous plants, as well as numerous herbaceous plants. At the close of the Erian the flora again became meagre, and continued so in the Lower Carboniferous. It again became rich and varied in the Middle Carboniferous, to decay in the succeeding Permian.

In the Mesozoic a new flora appears; and in Western Canada we have, in the Middle Cretaceous, forests of Angiospermous Exogens comparable with those of modern times and including many modern genera. In Eastern Canada we have no known representative of the floras which intervened between the Permian and the Pleistocene.

VIII.—On the Bearing of Canadian Palæozoic Botany on Questions as to the Origin and Extinction of Species.

Fossil plants are almost invariably uncertain with reference to their accurate determination, and have been regarded as of comparatively little utility in the decision of general questions of palæontology. This results principally from the fragmentary condition in which they have been studied, and from the fact that fragments of animal structures are more definite and instructive than corresponding portions of plants.

It is to be observed, however, that our knowledge of fossil plants becomes accurate in proportion to the extent to which we can carry on the study of specimens in the beds in which they are preserved, so as to examine more perfect examples than those usually to be found in museums. When structures are taken into the account, as well as external forms, we can also depend more confidently on our results. Further, the abundance of specimens to be obtained in particular beds often goes far to make up for their individual imperfection. The writer of these pages has been enabled to avail himself very fully of these advantages; and on this account, if on no other, feels entitled to speak with some authority on theoretical questions.

It is an additional encouragement to pursue the subject, that, when we can obtain definite information as to the successive floras of any region, we thereby learn much as to climate and vicissitudes in regard to the extent of land and water; and that, with reference to such points, the evidence of fossil plants, when properly studied, is, from the close relation of plants to their stations and climates, even more valuable than that of animal fossils.

It is necessary, however, that in pursuing such enquiries we should have some definite views as to the nature and permanence of specific forms, whether with reference to a single geological period, or to successive periods; and I may be excused for stating here some general principles, which I think important for our guidance, with special reference to the palæozoic floras which form the subject of this Report.

(1.) Botanists proceed on the assumption, vindicated by experience, that, within the period of human observation, species have not materially varied or passed into each other. We may make, for practical purposes, the same assumption with regard to any given geological period, and may hold that for each such period there are specific types, which, for the time at least, are invariable.

(2.) When we inquire what constitutes a good species for any given period, we have reason to believe that many names in our lists represent merely varietal forms or erroneous determinations. This is the case even in the modern flora; and in fossil floras, through the poverty of specimens, their fragmentary condition and various states of preservation, it is still more likely to occur. Every revision of any group of fossils detects numerous synonyms, and of these many are incapable of detection without the comparison of large suites of specimens.

(3.) We may select from the flora of any geological period certain forms, which I shall call *specific types*, which may for such period be regarded as unchanging. Having settled such types, we may compare them with similar forms in other periods, and such comparisons will not be vitiated by the uncertainty which arises from the comparison of so-called species which may, in many cases, be mere varietal forms, as distinguished from specific types. Our types may be founded on mere fragments, provided that these are of such a nature as to prove that they belong to distinct forms which cannot pass into each other, at least within the limits of one geological period.

(4.) When we compare the specific types of one period with those of another immediately precedent or subsequent, we shall find that some continue unchanged through long intervals of geological time, that others are represented by allied forms regarded either as varietal or specific, and as derived or otherwise, according to the view which we may entertain as to the permanence of species. On the other hand, we also find new types not rationally deducible on any theory of derivation from those known in other periods. Farther, in comparing the types of a poor period with those of one rich in species, we may account for the appearance of new types in the latter by the deficiency of information as to the former. Where many new types appear in the poorer period this conclusion seems less probable. For example, new types appearing in poor formations, like the Lower Erian and Lower Carboniferous, have greater significance than if they appeared in the Middle Erian or in the Coal Measures.

(5.) When specific types disappear without any known successors, under circumstances in which it seems unlikely that we should have failed to discover their continuance, we may fairly assume that they have become extinct, at least locally; and where the field of observation is very extensive, as in the great coal fields of Europe and America, we may esteem such extinction as practically general, at least for the northern hemisphere. When many specific types become extinct together, or in close succession, we may suppose that such extinction resulted from physical changes; but where single types disappear,

under circumstances in which others of similar habit continue, we may not unreasonably conjecture that, as Pictet has argued in the case of animals, such types may have been in their own nature limited in duration, and may have died without any external cause.

(6.) With regard to the *introduction* of specific types we have not as yet a sufficient amount of information. Even if we freely admit that ordinary specific forms, as well as mere varieties, may result from derivation, this by no means excludes the idea of primitive specific types originating in some other way. Just as the chemist, after analyzing all compounds and ascertaining all allotropic forms, arrives at length at certain elements not mutually transmutable or derivable, so the botanist or zoologist must expect sooner or later to arrive at elementary specific types, which, if to be accounted for at all, must be explained on some principle distinct from that of derivation. The position of many modern biologists, in presence of this question, may be logically the same with that of the ancient alchemists with reference to the chemical elements, though the fallacy in the case of fossils may be of more difficult detection. Our business at present, in the prosecution of palæobotany, is to discover, if possible, what are elementary or original types, and, having found these, to enquire as to the law of their creation.

(7.) In prosecuting such questions geographical relations must be carefully considered. When the floras of two successive periods have existed in the same region, and under circumstances that render it probable that plants have continued to grow on the same or adjoining areas throughout these periods, the comparison becomes direct, and this is the case with the Erian and Carboniferous floras in North-Eastern America. But when the areas of the two formations are widely separated in space, as well as in time, any resemblance of facies that we may observe may have no connection whatever with an unbroken continuity of specific types.

I desire, however, under this head, to affirm my conviction that, with reference to the Erian and Carboniferous floras of North America and of Europe, the doctrine of "homotaxis," as distinct from actual contemporaneity, has no place. The succession of formations in the Palæozoic period evidences a similar series of physical phenomena on the grandest scale throughout the northern hemisphere. The succession of marine animals implies the continuity of the sea-bottoms on which they lived. The head-quarters of the Erian floras of America and Europe must have been in connected or adjoining areas in the North Atlantic. The similarity of the Carboniferous flora on the two sides of the Atlantic, and the great number of identical species, proves a still

closer connection in that period. These coincidences are too extensive and too frequently repeated to be the result of any accident of similar sequence at different times, and this more especially as they extend to the more minute differences in the features of each period, as, for instance, the floras of the Lower and Upper Devonian, and of the Lower, Middle, and Upper Carboniferous.

Another geographical question is that which relates to centres of dispersion. In times of slow subsidence of extensive areas, the plants inhabiting such areas must be narrowed in their range and often separated from each other in detached spots, while, at the same time, important climatal changes must also occur. On the re-emergence of the land such of these species as remained would again extend themselves over their former areas of distribution, in so far as the new climatal and other conditions would permit. We would naturally suppose that the first of the above processes would tend to the elimination of varieties, the second, to their increase; but, on the other hand, the breaking up of a continental flora into that of distinct islets, and the crowding together of many forms, might be a process fertile in the production of some varieties if fatal to others.

Farther, it is possible that these changes of subsidence may have some connection with the introduction, as well as with the extinction, even of specific types. It is certain, at least, in the case of land plants, that such types come in most abundantly immediately after elevation, though they are most abundantly preserved in periods of slow subsidence. I do not mean, however, that this connection is one of cause and effect; there are, indeed, indications that it is not so. One of these is, that in some cases the enlargement of the area of the land may be as injurious to terrestrial species as its diminution, by producing a more extreme climate and greater dryness.

Another point on which I have elsewhere insisted, and which has been found to apply to the Tertiary as well as to the Palæozoic Floras, is the appearance of new types within the Arctic and Boreal areas, and their migration southward. Periods in which the existence of northern land coincided with a general warm temperature of the northern hemisphere, seem to have been those most favourable to the introduction of new forms of land plants. Hence there has been throughout geological time a general movement of new floras from the Palaearctic and Nearctic regions to the southward.

Applying the above considerations to the Erian and Carboniferous floras of North America, we obtain some data which may guide us in arriving at general conclusions. The Erian flora is comparatively poor, and its types are in the main similar to those of the Carboniferous. Of

these types a few only re-appear in the Middle Coal formation under identical forms; a great number appear under allied forms; some altogether disappear. The Erian floras of New Brunswick, Maine, and the Bay des Chaleurs occur side by side with the Carboniferous of the same region; so does the Erian of New York and Pennsylvania with the Carboniferous of those states. Thus we have data for the comparison of successive floras in the same region. In the Canadian region we have, indeed, in direct sequence, the floras of the Upper Silurian, the Lower, Middle, and Upper Erian, and the Lower, Middle, and Upper Carboniferous, all more or less distinct from each other, and affording an admirable series for comparison in a region whose geographical features are very broadly marked. All these floras are composed in great part of similar types, and probably do not indicate very dissimilar general physical conditions, but they are separated from each other by the great subsidences of the Corniferous limestone and the Lower Carboniferous limestone, and by the local but intense subterranean action which has altered and disturbed the Lower Erian beds and associated them towards the close of that period with igneous products. Still, none of these changes was universal. The Corniferous limestone is absent in Gaspé, and probably in New Brunswick, where, consequently, the Erian flora could continue undisturbed during that long period. The Carboniferous limestone is absent from the slopes of the Appalachians in Pennsylvania, and even from the borders of some portions of the Coal Areas of Nova Scotia and New Brunswick, where a retreat may have been afforded to the Upper Erian and Lower Carboniferous floras. The disturbances at the close of the Erian were limited to those eastern regions where the great limestone-producing subsidences were unfelt, and, on the other hand, are absent in Ohio, where the subsidences and marine conditions were almost at a maximum.

Bearing in mind these peculiarities of the area in question, we may now group in a tabular form the distinct specific types recognized in the Erian system, indicating, at the same time, those which are represented by identical species in the Carboniferous, those represented by similar species of the same general type, and those not represented at all. For example, *Calamites cannæformis* extends as a species into the Carboniferous; *Asterophyllites latifolia* does not so extend, but is represented by closely allied species of the same type; *Prototaxites* disappears altogether before we reach the Carboniferous.

Table of Erian and Carboniferous Specific Types.

Erian Types.	Represented in Carboniferous— by identical types.	Represented in Carboniferous— by related forms.
1. Syringoxylon mirabile		
2. Nematoxylon		
3. Prototaxites		
4. Aporoxylon		
5. Ormoxylon		
6. Dadoxylon		*
7. Sigillaria Vanuxemii		*
8. S. palpebra		*
9. Didymophyllum		
10. Calamodendron		*
11. Calamites transitionis	*	
12. C. cannæformis	*	
13. Asterophyllites scutigera		
14. A. latifolia		*
15. Annularia laxa		
16. Sphenophyllum antiquum		*
17. Cyclostigma		
18. Anthrostigma		
19. Lepidodendron Gaspianum		*
20. L. Veltheimianum	*	
21. Lycopodites Matthewi		*
22. L. Richardsoni		
23. L. Vanuxemii		*
24. Lepidophloios antiquus		*
25. Psilophyton princeps		
26. P. robustius		
27. Cordaites Robbii		*
28. C. augustifolia		
29. Archæopteris Jacksoni		
30. A. Gaspiensis		
31. Aneimites obtusa		*
32. Cyclopteris obtusa		
33. C. Brownii		
34. C. varia		*
35. Neuropteris polymorpha		*
36. N. serrulata		*
37. N. retorquata		*
38. N. resecta		
39. Megalopteris Dawsoni		
40. Sphenopteris Hœninghausi	*	
41. S. Hartii		*
42. Hymenophyllites curtilobus		
43. H. obtusilobus		*
44. Alethopteris discrepans		*
45. Pecopteris serrulata		*
46. P. preciosa		
47. Trichomanites		*
48. Callipteris		*
49. Psaronius		*
50. Cardiocarpum		*
51. C. Crampii		
52. Antholithes		*
53. Trigonocarpum		*

Of the above fifty-three forms in all, found in the Erian of Eastern America, all, except the four last, are certainly distinct specific types. Of these only four re-appear in the Carboniferous under identical species, but no less than twenty-six re-appear under representative or allied forms, some at least of which a derivationist might claim as modified descendants. On the other hand, nearly one half of the Devonian types are unknown in the Carboniferous, while there remain a very large number of Carboniferous types not accounted for by anything known in the Devonian. Farther, a very poor flora, including only two or three types, is the predecessor of the Erian flora in the Upper Silurian, and the flora again becomes poor in the Upper Devonian and Lower Carboniferous. Every new species discovered must more or less modify

the above statements, and the whole Erian flora of America, as well as the Carboniferous, requires a thorough comparison with that of Europe, before general conclusions can be safely drawn. In the meantime I may indicate the direction in which the facts seem to point, by the following general statements:—

1. Some of the forms reckoned as specific in the Devonian and Carboniferous may be really derivative races. There are indications that such races may have originated in one or more of the following ways:— (1) By a natural tendency in synthetic types to become specialized in the direction of one or other of their constituent elements. In this way such plants as *Arthrostigma* and *Psilophyton* may have assumed new varietal forms. (2) By embryonic retardation or acceleration,* whereby certain species may have had their maturity advanced or postponed, thus giving them various grades of perfection in reproduction and complexity of structure. The fact that so many Erian and Carboniferous plants seem to be on the confines of the groups of Acrogens and Gymnosperms may be supposed favourable to such exchanges. (3) The contraction and breaking up of floras, as occurred in the Middle Erian and Lower Carboniferous, may have been eminently favourable to the production of such varietal forms as would result from what has been called "the struggle for existence." (4) The elevation of a great expanse of new land at the close of the older Erian and the beginning of the Coal period, would, by permitting the extension of species over wide areas and fertile soils, and by removing the pressure previously existing, be eminently favourable to the production of new, and especially of improved, varieties.

2. Whatever importance we may attach to the above supposed causes of change, we still require to account for the origin of our specific types. This may forever elude our observation, but we may at least hope to ascertain the external conditions favourable to their production. In order to attain even to this it will be necessary to inquire critically, with reference to every acknowledged species, what its claims to distinctness are, so that we may be enabled to distinguish specific types from mere varieties. Having attained to some certainty in this, we may be prepared to inquire whether the conditions favourable to the appearance of new varieties were also those favourable to the creation of new types, or the reverse—whether these conditions were those of compression or expansion, or to what extent the appearance of new types may be independent of any external conditions, other than those absolutely necessary for their existence. I am not without hope that

* In the manner illustrated by Hyatt and Cope.

the further study of fossil plants may enable us thus to approach to a comprehension of the laws of creation, as distinguished from those of the continued existence of species.

In the present state of our knowledge we have no good ground either to limit the number of specific types beyond what a fair study of our material may warrant, or to infer that such primitive types must necessrily have been of low grade, or that progress in varietal forms has always been upward. The occurrence of such an advanced and specialized type as that of *Syringoxylon*,* in the Middle Devonian, should guard us against these errors. The creative process may have been applicable to the highest as well as to the lowest forms, and subsequent deviations must have included degradation as well as elevation. I can conceive nothing more unreasonable than the statement sometimes made that it is illogical or even absurd to suppose that highly organized beings could have been produced except by derivation from previously existing organisms. This is begging the whole question at issue, depriving science of a noble department of inquiry on which it has as yet barely entered, and anticipating by unwarranted assertions conclusions which may perhaps suddenly dawn upon us through the inspiration of some great intellect, or may for generations to come baffle the united exerions of all the earnest promoters of natural science.

* As this genus depends so far on the structure of only a single specimen, it may perhaps be regarded as not fully established.

EXPLANATION OF PLATES.

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PLATE XXI. —*Archæopteris Gaspiensis.* Barren and fertile pinnæ. Upper Erian, Scaumenac.

PLATE XXII.—*Cyclopteris obtusa.* Pinna and examples of lateral and terminal pinnules, Upper Erian, Scaumenac.

PLATE XXIII.—*Cyclopteris* (*Platyphyllum*) *Brownii*, Figs. 11 to 13, groups of fronds showing habit of growth, Upper Erian, Scaumenac.

Archæopteris Gaspiensis, Fig. 14, Upper Erian, Scaumenac.

PLATE XXIV.—*Archæopteris Jacksoni*, Figs. 11 to 18, Upper Erian, Scaumenac.

Caulopteris, sp., Fig. 19, same form. and loc.

Knorria, sp., Fig. 20. " " "

Sternbergia, sp., Fig. 21. " " "

Fruit of *Arthrostigma*, Fig. 22, Lower Erian, Campbellton.

INDEX TO GENERA OF PRE-CARBONIFEROUS PLANTS.

Described or noticed in Parts I. and II.

* A few generic terms, rejected or not used in the text, are introduced here to facilitate reference.

A.Grignard del et lith. A.Mortimer,Lith.Ottawa.

A.Grignard del et lith. A.Mortimer,Lith.Ottawa.

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