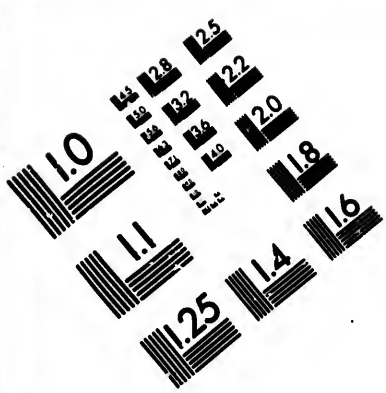


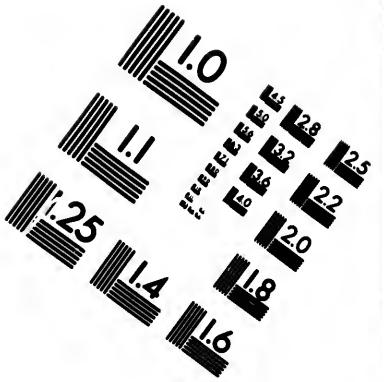
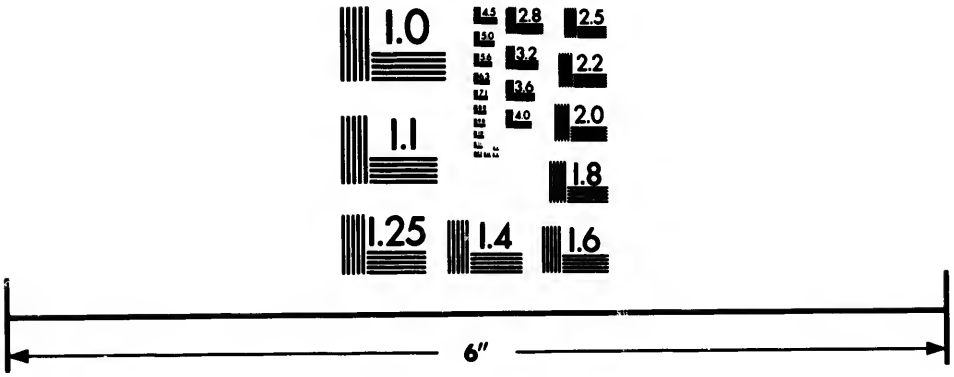
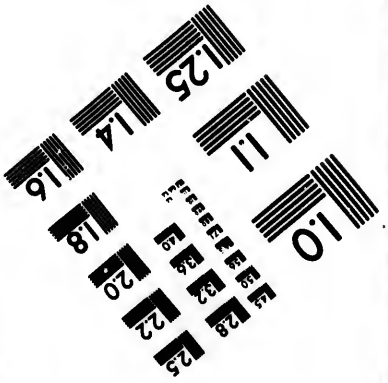


IMAGE EVALUATION TEST TARGET (MT-3)





Photographic Sciences Corporation

23 WEST MAIN STREET
WEBSTER, N.Y. 14580
(716) 872-4503

Technical and Bibliographic Notes/Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- [x] Coloured covers/ Couverture de couleur
- [ ] Covers damaged/ Couverture endommagée
- [ ] Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- [ ] Cover title missing/ Le titre de couverture manque
- [ ] Coloured maps/ Cartes géographiques en couleur
- [ ] Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- [ ] Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- [ ] Bound with other material/ Relié avec d'autres documents
- [x] Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distortion le long de la marge intérieure
- [ ] Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- [ ] Additional comments:/ Commentaires supplémentaires:

- [ ] Coloured pages/ Pages de couleur
- [ ] Pages damaged/ Pages endommagées
- [ ] Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- [ ] Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- [ ] Pages detached/ Pages détachées
- [ ] Showthrough/ Transparence
- [ ] Quality of print varies/ Qualité inégale de l'impression
- [ ] Includes supplementary material/ Comprend du matériel supplémentaire
- [ ] Only edition available/ Seule édition disponible
- [ ] Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image/ Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

10X	12X	14X	16X	18X	20X	22X	24X	26X	28X	30X	32X
						✓					

The copy filmed here has been reproduced thanks to the generosity of:

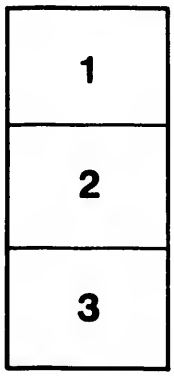
Metropolitan Toronto Library
Science & Technology Department

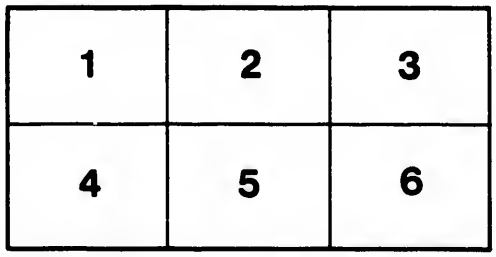
The images appearing here are the best quality possible considering the condition and legibility of the original copy and in keeping with the filming contract specifications.

Original copies in printed paper covers are filmed beginning with the front cover and ending on the last page with a printed or illustrated impression, or the back cover when appropriate. All other original copies are filmed beginning on the first page with a printed or illustrated impression, and ending on the last page with a printed or illustrated impression.

The last recorded frame on each microfiche shall contain the symbol ⟶ (meaning "CONTINUED"), or the symbol ▽ (meaning "END"), whichever applies.

Maps, plates, charts, etc., may be filmed at different reduction ratios. Those too large to be entirely included in one exposure are filmed beginning in the upper left hand corner, left to right and top to bottom, as many frames as required. The following diagrams illustrate the method:





L'exemplaire filmé fut reproduit grâce à la générosité de:

Metropolitan Toronto Library
Science & Technology Department

Les images suivantes ont été reproduites avec le plus grand soin, compte tenu de la condition et de la netteté de l'exemplaire filmé, et en conformité avec les conditions du contrat de filmage.

Les exemplaires originaux dont la couverture en papier est imprimée sont filmés en commençant par le premier plat et en terminant soit par la dernière page qui comporte une empreinte d'impression ou d'illustration, soit par le second plat, selon le cas. Tous les autres exemplaires originaux sont filmés en commençant par la première page qui comporte une empreinte d'impression ou d'illustration et en terminant par la dernière page qui comporte une telle empreinte.

Un des symboles suivants apparaîtra sur la dernière image de chaque microfiche, selon le cas: le symbole ⟶ signifie "A SUIVRE", le symbole ▽ signifie "FIN".

Les cartes, planches, tableaux, etc., peuvent être filmés à des taux de réduction différents. Lorsque le document est trop grand pour être reproduit en un seul cliché, il est filmé à partir de l'angle supérieur gauche, de gauche à droite, et de haut en bas, en prenant le nombre d'images nécessaire. Les diagrammes suivants illustrent la méthode.

32X

McGILL UNIVERSITY

PAPERS FROM THE DEPARTMENT

OF

GEOLOGY.

No. 9.—ON THE GENUS LEPIDOPHLOIOS AS ILLUSTRATED BY SPECIMENS FROM THE COAL FORMATION OF NOVA SCOTIA AND NEW BRUNSWICK.

BY

SIR J. WILLIAM DAWSON, C.M.G., LL.D.

[Reprinted from the Transactions of the Royal Society of Canada, Second Series, 1897-98, Vol. III, Section IV, pp. 57-78, with 13 Plates.]

MONTREAL, 1898.

II.—*On the Genus Lepidophloios as illustrated by specimens from the Coal Formation of Nova Scotia and New Brunswick.*

By SIR J. WILLIAM DAWSON, C.M.G., LL.D., F.R.S.

(Read June 24th, 1897.)

In the flora of the Carboniferous period, nothing is more remarkable than the abundance and wide distribution, as well as the magnitude and complex structure of trees allied to the humble Lycopods or Club Mosses of our modern woods. Trees of this type appear in the preceding Erian or Devonian period, but they attain their maximum development in the time of the deposition of the productive coal-measures, and rapidly diminish in the Permo-Carboniferous, disappearing altogether in the Permian. The great size and peculiar forms and structures of these trees, with the fragmentary state of most of the specimens obtained, have led to much confusion and controversy, and there are still important questions in dispute respecting some of the forms, and very specially in regard to the genus *Lepidophloios* and its allies.

As a contribution to the knowledge of these plants, and with the view of resolving some of the doubts entertained with respect to them, two species are here described, to which the attention of the writer has been directed for many years, and of which he has collected and studied many specimens in different states of preservation. They are those which he had named *Lepidophloios Acadianus* and *L. Cliftonensis*.

It will be instructive, in the first instance, to illustrate these by specimens from the coal-fields of Nova Scotia and New Brunswick, which have been placed with the rest of the author's collections of Carboniferous fossils in the Peter Redpath Museum of McGill University, and which more or less completely display their habit of growth, external parts, reproduction and internal structure.

The first of the species above-named, I met with about fifty years ago. In working at that time in the beds of sandstone containing erect *Calamites* at Dickson's Mills, near Pictou, Nova Scotia, I found lying prostrate among the Calamite stems a trunk, or large branch, with leaves and cones attached. It was mentioned, merely incidentally, in connection with the description of the mode of occurrence of the erect *Calamites*, in a paper in the Journal of the Geological Society of London,[1] and a cone and a portion of the bark, with the leaves attached, were presented to the collection of the society, along with the specimens of *Calamites*, rooted *in situ*, described in the paper. At that time, however, I supposed that the plant in question was referable to the genus *Lepidodendron*, and it was noticed merely as illustrative of the occurrence of other trees in the

[1] Vol. VII., 1851.

brakes of erect *Calamites*, then described with their roots and leaves complete for the first time. I may remark here that while much has been done more recently, by the late Dr. Williamson and others, in developing the internal structure and fructification of *Calamites*, Nova Scotia has taken the lead in the discovery of their habit of growth, external appearance and relations to the accumulation of coal. The species *Lepidophloios Acadianus* was not described by me till 1865, when the characters of other specimens from the Albion Coal Mines and the South Joggins were given in my paper, "On the Conditions of Accumulation of Coal," in the Journal of the Geological Society, vol. xxii. It was included in 1868, in the "Summary of the Coal Flora," in the second edition of "Acadian Geology."

The second species was discovered at a later date, and, for a reason to be explained in the sequel, was also first described as a *Lepidodendron*, under the name *L. Cliftonense*.[1]

In the following pages I shall discuss, with the aid of specimens in my collections representing more especially these two species, the following topics :—

I. The characters of the genus *Lepidophloios*.

II. The specific characters of *L. Acadianus* and *L. Cliftonensis*.

III. The relations of these species to others representing them elsewhere, and to the forms known as *Bothrodendron*, *Halonia*, *Lepidophloios*, etc.

IV. The relations of *Lepidophloios* to other genera of Carboniferous trees.

V. Its connection with the accumulation of coal.

I. The Genus Lepidophloios.

This genus was established by Sternberg in his great "Flora der Vorwelt," (1820) and its structure was illustrated by Corda (though under a new name, *Lomatophloios*, in 1845. Since that time it has attracted the attention of many palæobotanists, but owing to the fragmentary nature of their material much confusion and controversy have arisen, which culminated in the summary of the characters of the family *Lepidodendreæ*, attempted by Count Solms-Laubach in his "Introduction to Fossil Botany," (1891) and may be appreciated by a glance at the bibliography of the genus prepared by my friend, Mr. R. Kidston, to illustrate his paper on the Scottish species in the Transactions of the Royal Society of Edinburgh (1893). The last-mentioned paper is of great value in elucidating the difficulties attending the study of *Lepidophloios* in Europe, and especially in Great Britain, where good specimens seem to be very rare.

[1] Bulletin Geological Society of America, 1891.

(1) *Habit of Growth and External Parts.*

Trees, but by no means the largest in the coal forests; branching dichotomously but sometimes unequally, so as to produce branches apparently lateral. Branches usually stout, but, in some species at least, with slender branchlets bearing the strobiles. These may either be spiral or in two ranks, or irregularly disposed, often on thick branches. Fertile branchlets or pedunculs, when mature, dropping off and leaving rounded scars depressed in the centre and with a raised rim. Leaves very long, linear, with one rib forming a keel below. The leaves are articulated to the oblong leaf-bases by broadly rhombic surfaces pointed at the lateral ends, and with three dots, the central one of which marks the fracture of the bundle of vessels passing up the middle of the leaf.[1] The leaf-bases are strap-shaped, decurrent on the bark below, but so flat and so loosely attached above that, on the full development of the leaf, they separate at the upper ends from the bark and curve outward, so that the leaf-scar becomes pendant and the leaves seem to be borne on flattened petioles bending downward from their line of attachment. When the leaves have separated, the permanent leaf-bases remain, giving a rugged and scaly appearance to the stem. Finally, in dead or abraded stems, the leaf-bases are entirely stripped off, and a smooth surface of bark remains, on which are seen merely traces of the lines from which the leaf-bases have been torn off, and spirally arranged pits or elliptical spots marking the points of entrance of the bundles of vessels of the leaves into the stem. When in this condition the branches, especially those bearing the marks of the cones, assume forms to which the names *Halonia* and *Bothrodendron* have been applied. The latter term has, however, been used by Grand'Eury and Zeiller for trees which seem to be different from *Lepidophloios*, but which I have not seen, at least in well preserved specimens, in the Acadian coal-fields.

The above description will serve to explain the various views which have been held as to the leaf-bases and scars of *Lepidophloios*. In young and slender branches these are like those of *Lepidodendron*, but as the leaves become developed, the leaf-bases split off from the stem and bend downward, the leaves still remaining attached, but *not inverted*,[2] as some have supposed. Their lower parts, however, become horizontal, or even bend downward, and do not attain to an upward direction until they have spread out to an inch or more from the stem. When the old stem or branch in this condition is flattened, the leaf-scars appear at the lower instead of the upper sides of the leaf-bases. (Fig. A., p. 60.) A flat-

[1] The name "cushions," sometimes applied to the leaf-bases, is quite inaccurate. They are really flat, strap-like organs.

[2] Dr. Williamson, Proceedings Royal Society, Vol. lv., No. 334, 1894.

tened fragment of a stem or branch without the leaves, may thus be placed either with the scars on the upper or lower angle of the leaf-base, and they have been figured by authors in both positions. The former is the position when young, the latter when old. In the former condition the plant may be referred to *Lepidodendron*, or to *Lomatophloios* of Corda. In the latter it is the adult condition of *Lepidophloios*. This will appear more clearly in describing the species in detail. (See Plate IV.)

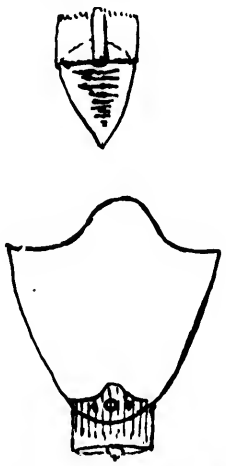


FIG. A.—YOUNG AND OLD LEAF-BASES OF LEPIDOPHLOIOS ENLARGED.

(2) *Internal Structure.*

Only one specimen of the species *L. Acadianus* has afforded to me fairly well preserved internal structure. It was figured and described in my paper of 1865, and some additional preparations have since been made, and have been micro-photographed through the kindness of Prof. Penhallow, of McGill University. (Plate VI.)

The specimen is a portion about two feet in length, apparently of a large branch, with two rows of cone-scars, and is slightly flattened, its longest diameter being about 4½ inches. It is mineralised with clay-ironstone, calcite and pyrite, and was obtained from the workings of the Albion Colliery in Pictou, Nova Scotia. The woody axis is scarcely an inch in diameter, and only its outer portion has the structure preserved, while outside of this a large portion of the stem, probably occupied by perishable parenchyma, has disappeared. External to the last is a ring of fine-grained quadrangular and imperfectly radiating tissue, about a quarter of an inch in thickness, and probably corresponding to what has

in similar stems been regarded as an equivalent of corky bark. This tissue is infiltrated with pyrite, so that it can be seen only as an opaque object, and is very imperfectly preserved. The outer bark and remains of the leaf-bases are in the state of dense shining coal. (Plate VI. and figures in the text.)

The axis in cross-section shows a central space without structure, and with only obscure indications of transverse partitions of the Stern-

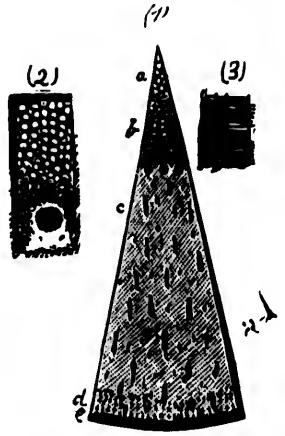


FIG. B.—ORIGINAL SECTIONS OF LEPIDOPHLOIOS ACADIANUS, 1865.

(1) Cross-section of *Lepidophloios*, showing (*a*) pith, (*b*) woody axis, (*c*) inner bark and leaf-bundles, (*d*) corky bark, (*e*) epidermis.

(2) Part of cross-section more magnified, showing double ring of scalariform fibres and leaf-bundles.

(3) Scalariform fibres still more enlarged.

bergian type. Surrounding this is a double cylinder of scalariform vessels or fibres,[1] coarser within and finer without, but not showing any radiating arrangement or medullary rays. The outer margin of the cylinder presents a series of loops or notches, each showing the section of one of the bundles of vessels proceeding to the leaves, each of which seems to have been enclosed in a sheath, which has perished. They appear to have run vertically, parallel to the surface of the stem for a space before diverging toward the surface. The cone-scars being placed at intervals of about 2½ inches vertically, are represented only occasionally on the slices by larger bundles. This structure may be considered as identical with that of *Halonia* as described by Williamson as *Halonia regularis*

[1] I do not use the term "tracheids," believing it to be altogether inappropriate to this kind of tissue, though used by many German authorities.

of Binney,[1] as illustrated by a slide, which I owe to his kindness, and also that of the simpler type of *Lepidodendra*, like *L. Harcourtii*, as described by Williamson, in which no secondary or exogenous woody system is developed. My specimen does not, however, show, except in spots, any traces of the inner bark, and the outer or corky layer is, as above stated, pyritized, so that its structure can be seen only imperfectly by reflected light. It is, however, traversed diagonally by the continuations of the leaf-bundles, which show the central bundle of scalariform vessels and two lateral bundles, apparently of hexagonal cells or fibres.

(3) *Fructification.*

The cones or strobiles of *Lepidophloios* are of the type included in the provisional genus *Lepidostrobus;* but are larger and more massive than the cones of ordinary Lepidodendra, and, so far as known, are attached to the sides of the trunk and branches by leafy peduncles or branchlets, either singly or in pairs. In two cases only have I found these cones actually in position. One of these is represented in Plate X. The other I cannot figure, owing, in the first place, to the position of the cone on a short peduncle imbedded in the long leaves of the stem or a large branch, and in the second place to the fact that the original specimen passed out of my hands many years ago and cannot now be recovered, so that I have only a rough sketch in my note-book of 1851 to represent it. The greater number of the cones which I attribute to my two Acadian species occur separately, and can be recognized only by comparison of their form and markings. (Plate IV.) None of them show the minute structures, but in one there are rounded bodies which are probably macrospores, scattered in the material occupying the basal portion, so that we may infer that, as in some other Carboniferous trees of Lepidodendroid type, there were macrospores below and microspores above. The fertile branchlets, very short in *L. Acadianus* and much longer in *L. Cliftonensis*, seem to have been deciduous or easily broken off when mature, leaving tubercles with a central depression, as observed in the fertile branches in the *Halonia* condition. In the more perfect condition of the branches they are concealed by the long and abundant foliage. In branches approaching to the erect position they may be in two ranks or alternate. When by unequal dichotomy there are side branches approaching to a horizontal position, the upper side of the branch may bear alternating cones, while there may be none on the lower side except at the edges, so that this side may appear to bear fruit in two ranks, while on the upper side the arrangement may be irregular or spiral. (Plates V., VII., VIII.) There is no evidence known to me

[1] Publications of Palæontographical Society, 1872.

of terminal cones, unless we regard the long peduncles of *L. Cliftonensis* as branches, and there is no doubt that as the leaf-bases of these are Lepidodendroid in form and the leaves short, they might, when detached, be easily mistaken for branches of *Lepidodendron* bearing terminal cones

II. Lepidophloios Acadianus, Dawson.

(Plates I. to VIII.)

Journal Geological Society of London, 1865, page 163, with figures of stem and branches in different states of leaf and cone, and of the structure of the axis of the stem. "Acadian Geology," second and following editions, 1868, etc., with similar figures and an attempt at restoration. Page 457.

This species, described in 1865, has recently been identified by Mr. R. Kidston in his Catalogue of Palæozoic Plants in the British Museum, and in his paper on *Lepidophloios* in the Transactions of the Royal Society of Edinburgh (1893), with the type species of the genus *L. laricinus* of

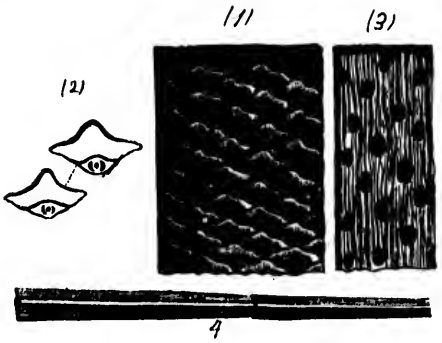


Fig. C.—Original Figure of Lepidophloios Acadianus, 1865.

(1) Impression of leaf-bases reduced.
(2) The same, natural size.
(3) Surface of middle bark.
(4) Portion of leaf.

Sternberg. While admitting, however, that portions of the bark of old specimens in a flattened state are scarcely distinguishable from that species, I am not prepared as yet to admit this identification, for the following reasons: First, the leaves, cones and internal structure of the European species cannot be said to be certainly known, and cannot therefore be compared with those of the Acadian form. Secondly, in well preserved specimens of *L. Acadianus* the leaf-bases are shorter in proportion to their width, and less completely reflexed than in Sternberg's species, while they do not show the central keel seen in the best figures

of *L. laricinus*. The fertile branchlets, as figured by Goldenburg, are also longer than in the Nova Scotia species. For these reasons I may still hold that my species is distinguishable, at least as a well-marked varietal form, and not improbably, when all the parts can be compared, as a distinct species.

Compared with its representative in Europe it may not have attained so large dimensions, as I have not found trunks of greater diameter than one foot. Fragments, however, of the bark show flattened leaf-bases, which, as we know that these were capable of enlargement in proportion to the growth of the trunk, may indicate larger trees than any found entire or nearly so. (Plate IV.)

The remarks already made respecting the internal structure of *Lepidophloios*, being based on a specimen of this species from the Albion Mines, Pictou, need not be repeated here.

Lepidophloios Cliftonensis, Dawson.

(Figs. IX. and X.)

Lepidodendron Cliftonense, "The Geological History of Plants," 1888, p. 452; Bulletin Geological Society of America, Vol. II., 1891, p. 533, and Plates 21, Figs. 3, 4 and 22, Figs. 5 to 7.

Sculpture of main stems and large branches resembling that of the previous species, except that the leaf-bases are longer and more thoroughly reflexed, in this resembling those of *L. laricinus* of Europe. In consequence of this the leaves, which are apparently more persistent than those of *L. Acadianus*, are horizontal or droop at their proximal ends, as seen in the photograph (Plate IX.), and only rise upward toward the middle and extremities. This attitude shows that they were still living when the leaf-bases were quite bent downward. The stem forks into branches not more than an inch in diameter (Plate X.), and on these the leaf-bases are still adherent to the branch, and are transversely wrinkled in the manner of *Lepidodendron Wortheni* of Lesquereux. In this state a fragment of a branch might be described as a *Lepidodendron*, and the leaf-bases are not relatively broader than in my *L. decurtatum*, which might well be a leafless branch of this or an allied species. The leaves are in all respects similar to those of *L. Acadianus*, but a very little narrower. They extend on the trunk and thick branches to a length of ten inches without showing the point, and were sufficiently rigid easily to stand erect. The cones are longer and narrower than in *L. Acadianus*, though the scales are broad, as in other species of the genus, and are therefore large in proportion to the breadth of the cone. The cones are supported on long peduncles or fertile branchlets, springing from the sides of the branches and clothed with a few short leaves. The scars and leaf-bases

are similar to those on the smaller ordinary branches, and one of these peduncles found separately, might be taken for a branch of *Lepidodendron* with a terminal cone. The peduncles are seen to bend downward, owing to the weight of the cone.

The internal structure is as yet unknown.

I may have had fragments of the trunk and branches of this species in my collections for many years without being able to distinguish them, and indeed the smaller branches and peduncles would by most collectors be placed with *Lepidodendron*, while fragments of the old stems and branches in the Halonia condition, would scarcely be distinguishable from corresponding portions of *L. Acadianus*.

FIG. D. — ROUGH SKETCH OF PORTION OF L. CLIFTONENSIS, AS ORIGINALLY SEEN AT CLIFTON. (REDUCED.)

It first became known to me as a distinct species in the summer of 1876, when I made a short excursion along the northern part of New Brunswick, and spent a day in New Bandon at the Clifton sandstone quarries and the shore in that vicinity, to which I was attracted by the fact that Sir William Logan had several years previously collected, in a bed of shale under the sandstone quarried for grindstones, some well-preserved ferns, *Sphenophylla*, and other plants which I had described in "Acadian Geology" in 1868.[1] While collecting along the cliffs near the

[1] Pp. 241 *et seq.*, 473 *et seq.*

quarries, I was guided by Mr. Scott, the manager of the Clifton quarry, to a spot where a fall of rock had recently taken place and had thrown down a great slab of argillaceous sandstone or coarse shale, on which was laid out, as if prepared for an herbarium, the specimen represented in Fig. D.

As the mass of rock was too large to be removed entire, I made a rough sketch of the whole plant in my note-book, and cut out specimens as large as I could take away, showing the trunk, branches and cones. Other matters, however, were at the time occupying my attention, and the specimens were not described till 1888, when a short description was given in my "Geological History of Plants," at which time I regarded the plant as a *Lepidodendron*, nearly allied to *L. Wortheni* of Lesquereux. Two years later, a collection of plants from the coal formation of Newfoundland was placed in my hands by the late Mr. Murray, F.G.S., Director of the Geological Survey of Newfoundland, and his successor, Mr. Howley, F.G.S. Among these was a remarkable *Lepidodendron*, which I named *L. Murrayanum*, and which raised a number of questions as to the group to which *L. Wortheni* belongs, and some members of which had been described as Sigillariæ, because of the apparently vertical arrangement of the leaf-bases. The Newfoundland collection was described in the Bulletin of the Geological Society of America for 1891, and led to the re-examination of the Clifton specimen in the manner shown in the following extract:

III. The Relation of these Species to Others.

"In the coal formation of New Brunswick there is a species which I have described as *L. Cliftonense* from its locality,[1] and of which I have found very perfect specimens. It is in some respects so near to the above that I have doubted its specific distinctness, though on careful comparison there seem sufficient grounds for a difference of name. I therefore figure this species also, more especially as it has not been before figured and as it shows the fruit and habit of growth.

"It will be observed that this species agrees with the last in the forms of the leaf-bases and in the length of the leaves, which are, however, wider and sometimes as much as five inches in length, while the leaf-bases are transversely furrowed above as well as below the scars. The leaf-bases also are somewhat different in shape and more spirally arranged, and the leaves are longer in *L. Cliftonense*. Additional specimens might, however, show them to be varieties of one species. The foliage reminds one at first sight of that of *L. longifolium* of Sternberg, but both leaves and scars are altogether different in detail.

[1] Geological History of Plants, 1888, p. 164.

"I would remark here that the leafy branches in figure 8 (plate 22) are not a 'restoration,' but taken from a sketch in my note-book of a specimen exposed on a large slab of sandstone. It is the more necessary to remark this, as several European paleobotanists have borrowed similar figures from my papers without acknowledgment, and have printed them as 'restorations.' It may also be remarked that though the leaf-bases of *L. Cliftonense* are smaller in the older part of the stem than those of *L. Murrayanum*, this difference may be more apparent than real, since the specimen of the latter may be from the main trunk, and that of the former from one of the larger branches only.

"These plants raise several interesting points in regard to the Lepidodendra. As I have elsewhere pointed out,[1] the growth in diameter of stems of Lepidodendra took place in three different ways: In some, as in *L. Sternbergi*, the bark retains its vitality in such a manner that the leaf-bases increase in size and do not become separated from each other. In others, as in *L. Veltheimianum* and *L. Pictoense*, the leaf-bases remain small and the intervening bark becomes torn in strips, leaving wide gashes without any scars. An intermediate type is that which we have in *L. rimosum* and *L. corrugatum*, in which the scars increase only slightly in size and then become separated by rims of slightly wrinkled bark. It would appear, from the observations of Williamson and others, that the first condition appertains to those Lepidodendra that possess only a very slight development of the woody axis, while the second occurs in those species in which the woody zone becomes thick and strong.

"The two species above referred to evidently belong to the first category; and, as the stems found are not large, still older stems would probably show larger leaf-bases. Such species of Lepidodendra approach nearer than others to the genus *Lepidophloios* in the expansion of the old leaf-bases and the small development of the woody axis; and it is interesting to notice that they also resemble them in the great length of the leaves and the thickness of the branches. The Lepidodendra whose branches end in slender sprays are usually, if not always, those in which the woody axis is large and the bark of the old stems torn and wrinkled.

"I may add that these differences are most important in the discrimination of species of the genus *Lepidodendron* by the markings on the stems, though they have been too often overlooked.

"Another noteworthy point is the manner in which the fruit of *L. Cliftonense* is borne on slender branchlets with few and short leaves, extending from the thick branches. Such branchlets might, if alone, be readily mistaken for branches of other species. They also help to explain the scars of fructification often found on Lepidodendra, as well as on the so-called Ulodendra, some of which, however, are not generically distinct

[1] Ibid, p. 162; also Acadian Geology, 1878, p. 452.

from the Lepidodendra, and on *Lepidophloios*. In some species, especially of the latter genus, these scars are seen from their form to represent sessile cones, usually of large size; but in other cases they are merely round marks, as if indicating the insertion of branches or buds. The little fertile branchlets of *L. Ciftonense*, which would probably die after the maturity of the fruit, would leave such scars, and may probably account for some of the less intelligible of them.

"If now we compare our two species above described with others found in America and Europe, and most of which are characterized merely by the forms of the leaf-bases and scars, we may exclude from consideration all those in which the leaf-bases do not expand in growth, and confine ourselves to those having living and expanding leaf-bases. At first sight we might imagine that these would be the oldest, as being simpler than the others in structure; but though some of the Erian or Devonian species are probably of this type, in the lower Carboniferous, where the Lepidodendra first became important, the species with leaf-bases separated by wrinkled bark or by expansion of the cortical tissues between the leaf-bases are apparently predominant, though others also exist, and the type which we are now considering perhaps culminates in the Coal Formation.

"We may first refer to *L. costatum* of Lesquereux, with vertical rows of corrugated leaf-bases, but separated by distinct longitudinal spaces of wrinkled bark. This is a Lower Carboniferous species, and is compared by Lesquereux with his *L. Brittsi* and with *L. Volkmannianum*, Sternberg, of the European Carboniferous, both of which have strong points of resemblance in the characters of the leaf-bases, though differing in the scars and in the leaves, so far as known. The *L. Wortheni* of Lesquereux is based on fragments closely allied in general form to our species. So also is *L. diplostegioides*, a species found in the lower coals as far west as Arkansas. None of these species are, I think, sufficiently near to be identified with our Newfoundland and Nova Scotia species, though as most of them are known only by the bark of old stems, this may admit of doubt. In any case, Lepidodendra of this general type and aspect were widely distributed, both in Europe and America, in the Carboniferous, and especially in the lower portions of the Coal Formation, to which in all probability the Newfoundland specimens belong.

"I may add here that Zeiller [1] figures a species as *L. Veltheimianum*, which can scarcely be that species, and may be a branch of *L. Murrayanum*, with which it agrees very closely. The same plant is figured by Renault. [2] The leaf-bases of the Newfoundland species have also some resemblance to those of *L. aculeatum*, Sternberg, but differ in detail.

"Another interesting question rises here as to the limits of *Lepidodendron Sigillaria*, as determined by their surface markings. The markings of

[1] Végétaux fossiles du Terrain Houiller, 1880, pl. xxii.

[2] Cours de Botanique Fossile, 1881, pl. v, fig. 2.

the latter have usually been considered as characterized by the leaf-scars being placed in vertical rows and often on continuous prominent ribs, and also by the fact that the lateral vascular scars are much larger than the central one; but in such a case as Lesquereux's species, *L. costatum*, the confluent leaf-bases in vertical rows have the effect of ribs, and in a less degree the same remark applies to *L. Murrayanum*. I may add that when one happens to find young stems of *Sigillaria* not compressed, the leaf-bases are seen to project in the manner of those of *Lepidodendron*, and that in some non-ribbed Sigillarids, as in *S. elegans*, the very young branches have the scars arranged spirally.[1] In connection with this I may observe that Sauveur [2] has described two species of *Sigillaria*, *S. angustata* and *S. undulata*, which are scarcely distinguishable, so far as the old bark is concerned, from *L. Murrayanum;* and Goldenberg [3] has two similar species, *S. aspera* and *S. coarctata*. Goldenberg's two species are by the character of their scars unquestionably *Sigillaria*, but *S. angustata* and *S. undulata* of Sauveur, especially the former, might well have been lepidodendroid trees very near to *L. Murrayanum*. This, however, could be certainly ascertained only if more complete specimens could be found. On the whole one might infer that as the spiral and Lepidodendroid characters of *Sigillaria* appear most prominently on young branches, the more Lepidodendroid and spiral Sigillaria are the lowest in type and the ribbed Lepidodendra among the highest of that genus. But such a conclusion must be received as liable to many exceptions."

Subsequently to the appearance of this paper, in which I referred only to the branches and cones, I was led, in arranging the specimens in our museum, to strip off some of the long leaves from the largest slab in my possession, representing a portion of the trunk or a main branch, and was surprised to find that the leaves and leaf-bases were arranged on the plan of *Lepidophloios*. My Clifton specimen thus showed characters which combined those of *Lepidodendron* and *Lepidophloios*, and as the leaves and fruit were those of the latter genus, I have now no hesitation in referring it to this; though it furnishes a very interesting illustration of the close approximation of the two genera, as well as an example of the possibility of referring fragments of *Lepidophloios* to *Lepidodendron*. At the same time, a specimen from the Clifton quarries which is evidently a portion of the surface of a trunk or large branch, shows that in this species, which I think may be referred to *Lepidodendron Wortheni*, the character of the leaf-bases and leaf-scars, which are confined to slender branches in the associated *Lepidophloios*, may be persistent on the main trunk. Were it not for this specimen I would be induced to suggest that

[1] Acadian Geology, 1878, p. 434.
[2] Fossil Flora of Belgium, 1848, pl. lvi. and lviii.
[3] Brit. Mus. Catalogue, 1886, p. 151.

many branches of Lepidodendra figured by authors, and of this type might, if better known, be found to be branches of *Lepidophloios*. Yet, though this is possible, there is an equal possibility that they may really be *Lepidodendron*. These facts, however, lead to the discussion of what is known from structure, form and fructification, of the relationships of the Lepidodendreæ and Sigillariæ, in referring briefly to which subject I shall depend chiefly on Canadian examples in my own collections, as the current descriptions and figures of fragmentary specimens by authors abroad do not always furnish reliable data for comparison.

IV.— Relations to Lepidodendron, Ulodendron and Sigillaria.

We have already seen how easy it would be to refer fragments of *Lepidophloios* to the genus *Lepidodendron*, and in regard to internal structure it is probable that branches of *Lepidophloios* are scarcely distinguishable from those of the simpler styles of *Lepidodendron*, in which an outer cylinder of radiating wood is either absent or developed only on the larger stems. The difficulty is added to by the fact that some *Lepidodendra*, as for example, *L. ornatissimum* and *Veltheimianum* of Sternberg, bear sessile lateral cones on stems or large branches, and it seems certain that some plants of this group, bearing sessile cones in two rows, which have been referred to the genus *Ulodendron* of Lindley and Hutton, are really portions of Lepidodendra of this type. In my original description of *Lepidophloios Acadianus* in 1865, I was so far influenced by these apparent connections as to include under this genus not only the *Lomatophloios* of Corda, which is no doubt a synonym, but also the *Ulodendron* of Lindley and Hutton, of which two species or varieties are found in Nova Scotia, and some plants with leaf-scars, similar to those of *Lepidophloios*, but without the long pendant leaf-bases, and which are now usually classed by palæobotanists with the Sigillariæ. With regard to the *Ulodendron*, it may be stated that the Ulodendra and Ulodendroid *Lepidodendra* cannot be distinguished by the two-ranked cone-scars, because these occur also on *Lepidophloios*, but rather by the fact that the cones were not stalked but sessile by a broad base,[1] and that the leaf-bases and leaf-scars were of different form. I illustrate this by figures of two species or varieties of *Ulodendron*, corresponding to *U. majum* and *U. minus* L. and H., which are found, though rarely, in Nova Scotia. (Plates XI., XII.) In one of them (Plate XII.) the leaves are present, and are more like those of *Lepidophloios* than that of *Lepidodendron*, while the leaf-bases resemble in general form those of a *Sigillaria* of the *Clathraria* type. The plant is like *S. discophora* of Kœnig,

[1] It is quite likely that were the structures of these cones perfectly known, other differences would appear.

but cannot be a [redacted] *Sigillaria*. This was named *L. parvus*. In point of fact the Carboniferous forests contained many species of trees belonging to an advanced type of acrogenous structure, and so nearly allied that it is difficult, if not impossible, to distinguish them when in the state of imperfectly preserved fragments. The difficulties of the palæobotanist are increased by the presence of numerous species of *Sigillaria*, which, while for the most part distinguishable from all the Lepidodendreæ, yet in some of their genera approach them very nearly both in external markings of the stem and its internal structure. On the other hand, there are plants included among the Sigillariæ which there is at least reason to suspect belong to a higher type, akin in structure to the modern cycads. In a paper on the affinities of these plants, published in the Journal of the Geological Society in 1871, I suggested the following scheme of their affinities, placing the Sigillariæ as a group on the confines of the Acrogens and Gymnosperms. After the lapse of twenty-six years, and in view of the progress of discovery in the meantime, this scheme must require some modification; but we may well make its amendment a basis for discussing the present aspects of the question.

Cycadaceæ.	*Coniferæ.*
	Dadoxylon.
Favularia ?	Palæoxylon.
	Ormoxylon.
	Dictyoxylon.

SIGILLARIÆ.

Rhytidolepis.	Calamodendron.
Favularia ?	Calamopitus.
Clathraria.	Bornia.
Syringodendron.	Calamites.
Lepidophloios.	*Equisetaceæ.*
Lepidodendron.	
Lycopodiaceæ.	

In this the Sigillariæ are regarded as a central generalized group, from which, in regard to structure and affinities, various genera radiate towards Cycads and Conifers on the one hand, and Lycopods and Equisetums on the other.

The Sigillarian structure is based on that of a remarkable axis showing structure which I had at that time found in an erect trunk at the South Joggins, and of which the details are figured in the paper above referred to. Though I have since found a still better preserved axis of different type, to be referred to in the sequel, I still hold that my original specimen represents one, and that the more advanced, Sigill-

arian type, and approaches very near to tissues of *Cordaites* on the one hand and to that of Cycads on the other.

Other doubtful species mentioned in the original account of *Lepidophloios Acadianus* (1865) above referred to, were those which I named *L. platystigma*, *L. tetragonus* and *L. prominulus*. The first of these has large rhombic leaf-scars like those of *Lepidophloios* placed on confluent uneven leaf-bases, and with a central vascular scar which is double. These characters do not correspond exactly with those of *Lepidophloios*, nor with Sigillariæ like *S. Menardii*, Brongniart. The second has perfectly rhombic leaf-bases with a central leaf-scar strictly of Lepidodendroid type, though sometimes appearing as a rounded spot without any distinct vascular marks. The third is very near to this, but with more elevated and rugose leaf-bases of smaller size; but this difference may be an accident of condition of growth and state of preservation. Some of my botanical friends are inclined to refer all these to *Sigillaria*, but to this I must demur, unless indeed that genus be regarded as place of refuge for any Carboniferous tree which cannot be conveniently provided for elsewhere, and indeed that has been to a large extent its use.

This being the case, it may be appropriate here to inquire briefly as to the normal characters of Sigillariæ, properly so-called.

In regard to external form and markings, the typical Sigillariæ are trees often of great size, with the trunks covered with hexagonal or shield-shaped leaf-scars, in each of which is seen a central vascular mark with two elongated and often curved marks at either side. This indicates a leaf with a very broad insertion, and usually long and rigid, and with a midrib containing a vascular bundle and two lateral structures, cellular or vascular, and of uncertain significance. These leaf-scars are placed in vertical rows on the middle of raised ribs which traverse the trunks vertically and become narrower and more numerous toward the upper part of the stem, and disappear by expansion of the bark toward the base.

Sigillariæ of this type have been classed with others having narrow ribs no wider than the scars, to which the name *Rhytidolepis* has been given, and these again pass into others in which the ribs disappear or consist merely of rows of contiguous leaf-scars. To these the name of *Favularia* has been given.

It is obvious that these appearances present some resemblance to those of *Lepidophloios*, but yet in the typical forms there are marked and essential points of difference in the vertical arrangement of the leaf-bases and in the character of the vascular impressions, which imply differences in internal structure and foliage. To these have to be added the fact that the stems of Sigillariæ seem to have been either simple or with few branches, and that, so far as known, their fructification was borne in bands placed transversely on the stems and showing numerous small

rounded marks of the insertion of the organs of reproduction, indicating that they were different from those of *Lepidophloios* and *Lepidodendron*. It is to be observed, however, that when one has the opportunity to see stems and branches of Sigillariæ of different ages, the superficial markings present very diverse appearances in different portions of the same tree, and that in the younger branches and the basal portions, the peculiar ribbed appearance to a great extent disappears, and though a great number of species have been described, it seems certain that many of them may be founded on different portions of one and the same tree. In my paper on the Coal Flora already referred to, and in Acadian Geology, I have given several examples of this.

It is also to be observed that the fruit-scars seen on the stems of Sigillariæ could not have given attachment to large cones like those of *Lepidophloios* and *Ulodendron*, but only to comparatively slender organs, homologous with leaves rather than with branches, and this accords with the appearance of the slender and long-stalked organs attributed by Goldenberg and Zeiller to *Sigillaria*, and variously interpreted as producing macrospores or pollen sacs. It seems very probable that there are various arrangements of reproductive organs in different types of *Sigillaria*.[1]

In addition, however, to the typical Sigillariæ above referred to, there are others included in the group *Clathraria* of palæobotanists which are destitute of ribs and have the leaf-bases arranged spirally, and more of the type of *Lepidophloios*, in which group, as already stated, I had placed them in my paper of 1865, and though I am not now disposed to insist on this, at the same time I am convinced that they present essential generic differences from true Sigillariæ.

As concerns the present subject, I may content myself with pointing out the marked structural difference between the true Sigillariæ and such plants of the *Lepidophloios* type, and also the fact, which I have

[1] One of these is shown by a specimen from Sidney, Cape Breton, now in my collection, and figured on a reduced scale in my paper of 1865 in the Journal of the Geological Society and in Acadian Geology, p. 432. It is a good impression of part of a stem or branch of a *Favularia* near to *F. elegans*, Brongt. At one side is a short, but distinct branch, slightly ascending, and about two inches long, with an obtuse termination. Near the end it has ovoid leaf-scars, differing in form from those on the main stem, and resembling those of *Clathraria*, but near the base this branch shows clusters of round scars, apparently fruit scars. Another branch at the same level, but at right angles to the first, springs from the main stem, and passes through the slab, being flattened on the opposite side, where it shows similar markings. There would thus seem to have been at least four verticillate branches proceeding from the stem at one level and bearing the fruit, not on cones, but on their sides. This is evidently a special modification of the ordinary mode of rings of fruit scars on the main stem. Whether it imports a specific or generic difference I do not presume to decide. I hope that this and other instructive specimens in our collections will eventually be properly figured, since though they do not show the actual fruit, they illustrate its character and mode of attachment.

already insisted on in my Geological History of Plants, that even in the Sigillariæ proper we have probably two types of organization, one approaching to that of Cycads and Cordaitæ and the other allied to Sigillariæ. In other words, that the dividing line between *Gymnosperms* and *Acrogens* or *Archegoniatæ* falls within the great genus *Sigillaria*, as now held by palæobotanists.[1]

In proof of this I may refer to the structure of an axis described by me in 1871, and taken from an erect ribbed *Sigillaria*, undoubtedly of that genus, and probably allied to, if not identical with, my *S. Brounii*. I have described the details of this structure in the paper referred to, and may here merely refer to the figures of the more important tissues and invite attention to their resemblance to those of Cordaitæ, as figured by Renault and other French botanists, and to those of modern Cycads.

It may, however, be doubted whether this axis may not have been introduced accidentally into the trunk in which it was found. This would be in the last degree improbable in the case of a trunk not filled with foreign debris, but containing along with sand apparently only fragments of its own interior tissues. Farther, in many erect trunks at South Joggins there are masses of mineral charcoal on the bottom, which have fallen in before any foreign matter entered, and which, when prepared by nitric acid and examined microscopically, show similar structures, as I have shown in my paper of 1860 on Vegetable Structures in Coal.[2] These observations confirm the impression that this structure, much more advanced than that of any Cryptogams, recent or fossil, was that of many at least of the Sigillarian trees.

But another and less advanced structure comparable with that of Lepidodendra is also found. Of this an excellent example was discovered by Mr. Albert J. Hill in the coal measures of the Cumberland basin in Nova Scotia, and was described by me in 1877. It was an erect ribbed *Sigillaria*, with broad ribs like *S. reniformis*, and twelve feet in height, filled with sandstone, but having its axis perfectly firm in calcite, and standing, like a pole or the core of a casting, erect in the stem, nearly from the base to the summit, though fallen a little to one side. It will be seen that its structure corresponds with *Diploxylon* of Corda, and with those more advanced Lepidodendroid stems which have thick development of radiating tissue.[3]

---

[1] Journal Geological Society of London, Vol. XXVII.
[2] Quart. Journ. Geol. Soc., Vol. XV.
[3] Note on a specimen of *Diploxylon*, Quart. Journ. Geol. Soc., Vol. XXXIII.

V. Relations of Lepidophloios to the Accumulation of Coal.

On this subject it is not necessary to say much, as what is noted of the Lepidodendra in my papers on the Accumulation of Coal, in the Journal of the Geological Society (1865), and in the chapter on that subject in Acadian Geology covers nearly all that can be said of *Lepidophloios*.

I may merely state that such specimens as I possess, in a flattened and carbonized state, show that in ordinary circumstances the outer bark and leaf-bases have yielded a film of compact coal, perhaps $\frac{1}{100}$th of the thickness of the recent stem, and that the woody axis will appear usually as mineral charcoal of the same character as that of the Lepidodendra The large cones and their contained sporangia and macrospores must have contributed to the mass of such material which enters into the coarser layers of coal, but can, until the microscopic structure of these organs is better known, scarcely be distinguished from the similar parts of other Lepidodendroid trees. The trees of the genus *Lepidophloios* were associated in the Carboniferous swamps with *Sigillaria*, *Lepidodendron*, *Calamites*, etc., and were most plentiful in the Middle and Upper Coal Formations, but do not seem to have been so abundant as either of these genera in any locality in which I have studied them.

DESCRIPTION OF THE PLATES.

PLATE I, or Plate II, Lower figure.

Lepidophloios Acadianus—Impression of the leaf-bases on sandstone.

PLATE II.

Part of the same trunk, and surface of bark immediately below the leaf-bases, and epidermis showing punctiform marks like *Bothrodendron* of Lindley and Hutton.

PLATE III.

The same—Portion of bark with leaves attached.

PLATE IV.

The same—Leaf-bases of a large and old stem, above; below, cones or strobiles seen transversely and longitudinally, also a detached scale or *Lepidophyllum*.

PLATE V.

The same—Horizontal branch showing arrangement of cone-scars above and below.

PLATE VI.

The same—Transverse section of axis, magnified, showing outer and inner ring of scalariform fibres (upper figure × 20, lower figure × 48), with leaf-bundles at outer margin of axis and spaces representing their sheaths.

PLATE VII.

with Plate II

The same, or possibly the upper figure a true *Bothrodendron*. The lower figure a branch in the *Halonia* state, but at one spot near the right hand showing a few perfect leaf-bases.

PLATE VIII.

The same—*Halonia* state of a branch or small stem, showing very distinct cone-scars.

PLATE IX.

Lepidophloios Cliftonensis.—Portion of stem showing reflexed leaf-bases and the drooping position of the basal portion of the long leaves.

PLATE X.

The same—Upper figure a fertile branchlet with cone. Lower figure an ordinary branch.

PLATE XI.

Ulodendron of the type of *U. majus*, L. and H. Half natural size. South Joggins. 8/

PLATE XII.

Ulodendron allied to *U. minus*, L. and H. Upper figure showing cone-scars and leaf-bases. Lower figure, reverse of same specimen, showing leaf-bases and leaves.

PLATE XIII.

Lepidophloios Acadianus.—Rough restorations showing general habit.

PLATE XIV.

Lepidophloios Cliftonensis.—Rough restoration showing general habit. On same plate a fragment of bark with short leaves, perhaps of a *Sigillaria* of the *Clathraria* type.

FIGURES IN THE TEXT.

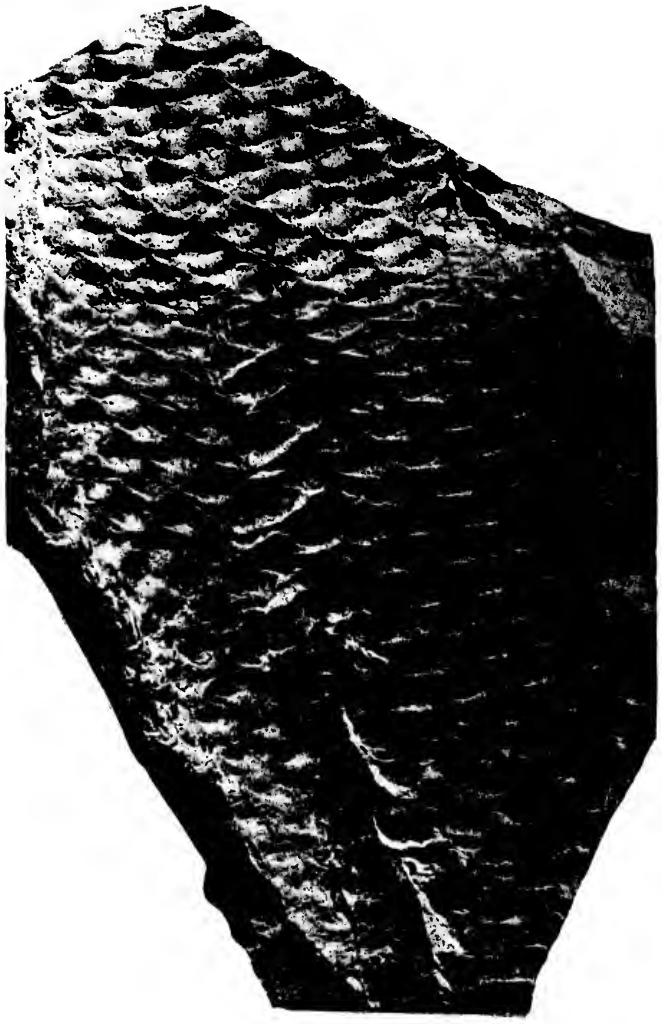
Fig. A.—Young and old leaf-bases of *Lepidophloios Cliftonensis.*

Fig. B.—Original sections (1865) of *Lepidophloios Acadianus.*

Fig. C.—Original figures of markings, etc. (1865), of *Lepidophloios Acadianus*, with impressions and outlines of leaf-bases, surface of inner bark and leaf.

Fig. D.—Rough sketch of *Lepidophloios Cliftonensis* in situ on a surface of sandstone.

ON THE GENUS LEPIDOPHLOIOS



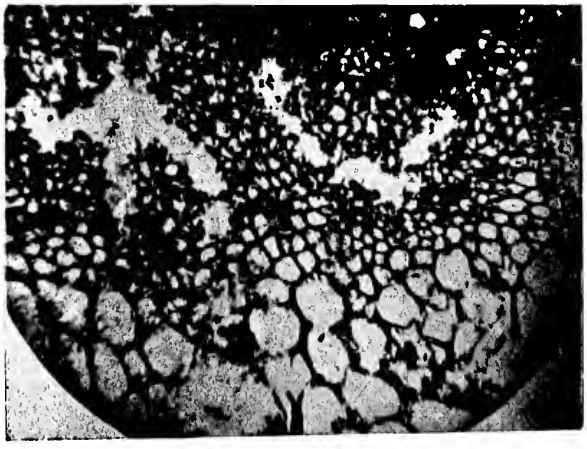
ON THE GENUS LEPIDOPHLOIOS

ON THE GENUS LEPIDOPHLOIOS

ON THE GENUS LEPIDOPHLOIOS

ON THE GENUS LEPIDOPHLOIOS

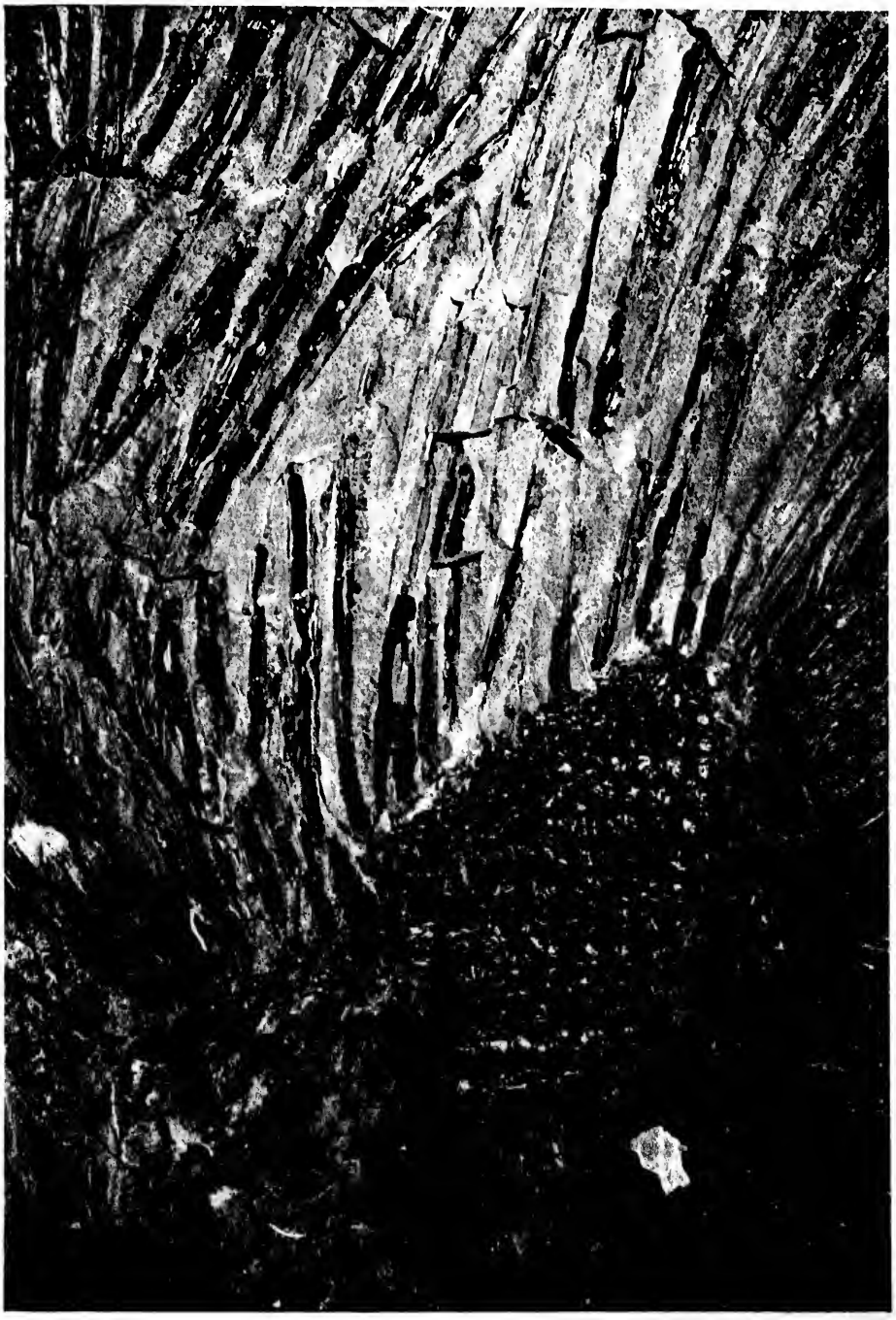
ON THE GENUS LEPIDOPHLOIOS



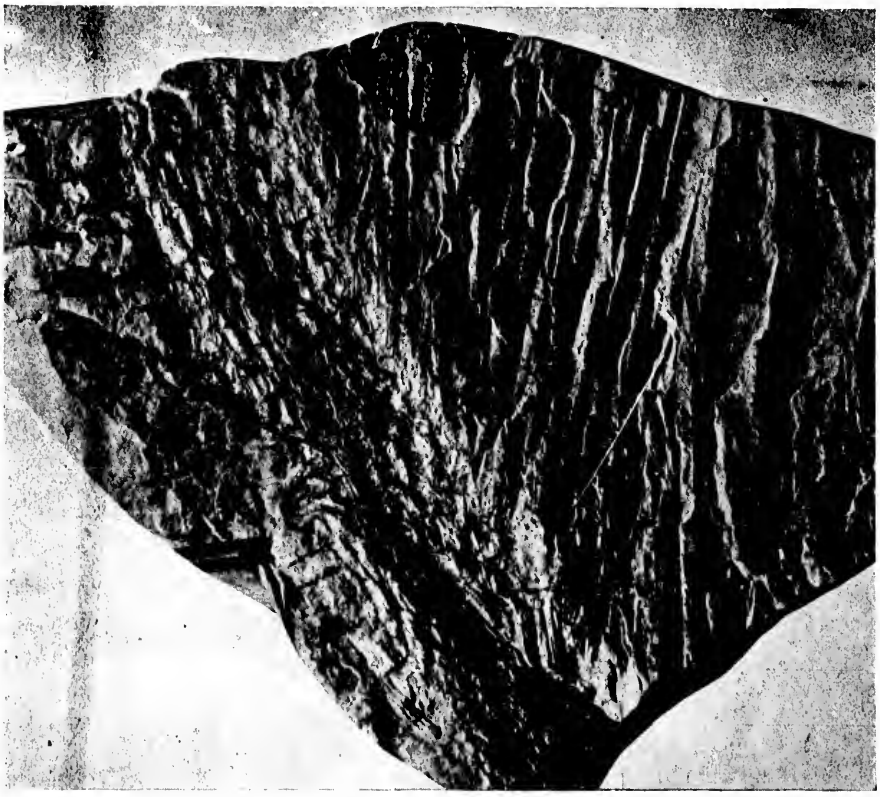
ON THE GENUS LEPIDOPHLOIOS

ON THE GENUS LEPIDOPHLOIOS

ON THE GENUS LEPIDOPHLOIOS

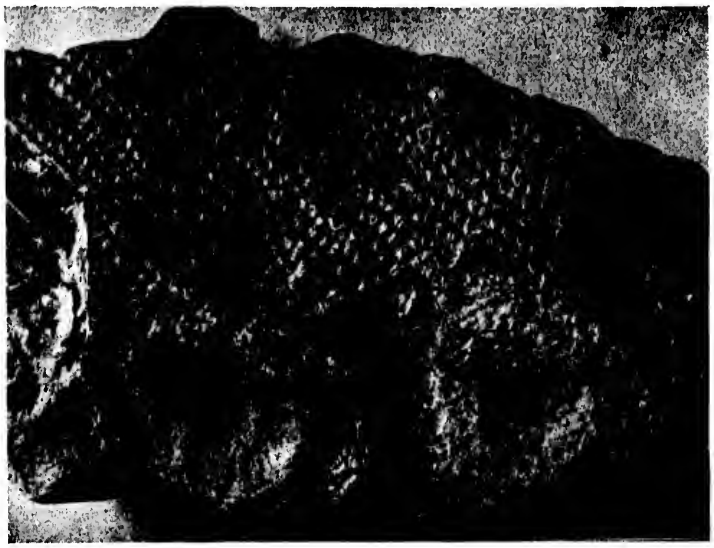


ON THE GENUS LEPIDOPHLOIOS

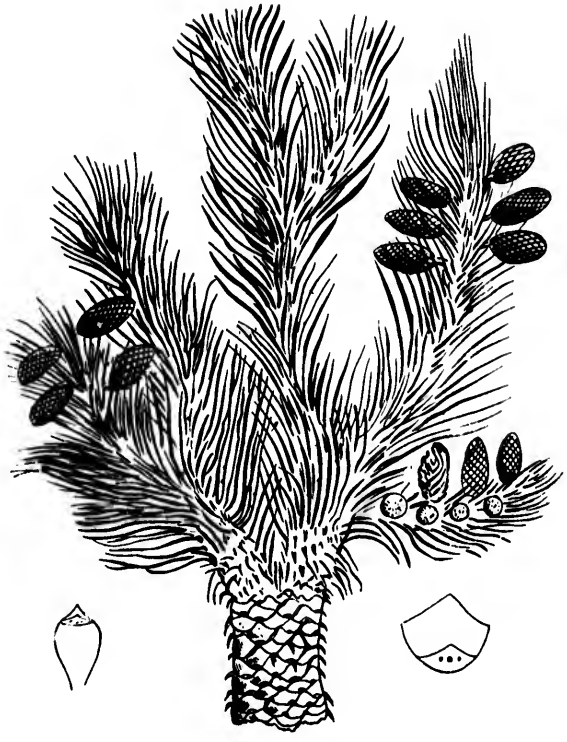


ON THE GENUS LEPIDOPHLOIOS

ON THE GENUS LEPIDOPHLOIOS



ON THE GENUS LEPIDOPHLOIOS



ON THE GENUS LEPIDOPHLOIOS