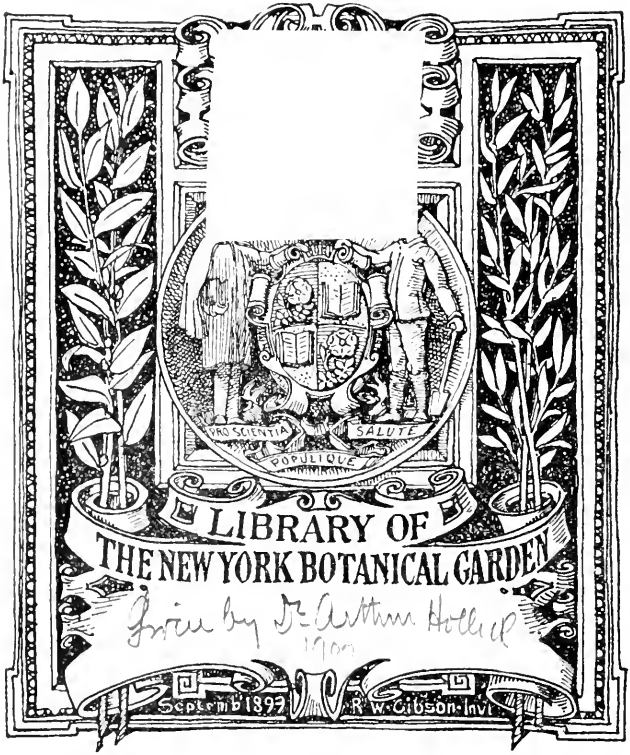
Kidston
Flora of the Carboniferous period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VOL. XIV.] [PART II.

PROCEEDINGS

OF THE

YORKSHIRE

GEOLOGICAL AND POLYTECHNIC SOCIETY.

EDITED BY W. LOWER CARTER, M.A., F.G.S.,
AND WILLIAM CASH, F.G.S.

1901.

LEEDS:
CHORLEY AND PICKERSGILL, THE ELECTRIC PRESS.

THE FLORA OF THE CARBONIFEROUS PERIOD.

BY ROBERT KIDSTON, F.R.S.E., F.G.S.

First Paper.

I have pleasure in complying with the request of your Council to read before your Society a short account of the Flora of the Carboniferous Formation, and in so doing shall, as far as possible, avoid technical language, as I address myself more specially to those who, though they have not previously given serious study to the subject, may have a wish to know more about the Fossil Plants which formed such a prominent feature in Carboniferous times, and who, one would fain hope, may be induced to give some attention to a branch of botany than which there is none that would more repay careful observation.

There has long been undoubted evidence of the occurrence of Algæ and Fungi in Carboniferous times in Britain, and recently I have met with a fossil in rocks of Calciferous Sandstone age so similar in appearance to *Fegatella*, that the Liverworts must now be added to our Carboniferous plants. I shall not, however, enter into a detailed description of these fossils, which are of rare occurrence, but pass to those groups which occupy a more prominent place and of which there is more certain knowledge. A fossil which has been referred to the mosses was described from the French Coal Measures by MM. Renault and Zeiller, but hitherto no representative of this class has been met with in Britain.

In the present paper we shall therefore reserve our remarks to the *Ferns*, *Equisetites*, and *Calamites*, leaving the *Lycopods*, *Sphenophylls*, *Cordaiteæ*, and *Coniferæ* for a future time.

Before proceeding further, it is necessary to point out that many fossil plant genera are quite provisional, for palæobotanists have seldom the *data* for the definition of a genus in the clear

and full manner which one demands in the case of genera founded on existing species. Notwithstanding the difficulties of the subject, by careful collecting and study much has been done in elucidating the structure and form of Carboniferous plants, and in some rare cases our knowledge is little less perfect than if we had been able to study the growing plant. Such results have only been attained by much study and careful observation, and are generally the result of the united labours of several workers—one laying the foundation and another building thereon. Thus the science of palæozoic botany has grown and, I doubt not, will grow.

I.—Ferns.

If we only consider the mere form of the frond and the arrangement of the veins, many fossil ferns have a considerable superficial resemblance to certain recent species; still this resemblance must not be regarded as affording any evidence on which to presume a generic relationship. The fact, however, remains that the same type of pinnule form and nervation which is found amongst Carboniferous ferns is seen amongst those existing at present, and also the same mode of circinate vernation (Plate XXVI., fig. 1).

In Carboniferous ferns the main rachis sometimes divided into two arms, as in *Calymmatotheca bifida* L. & H. sp. (Plate XXV., figs. 2, 3), and this dichotomous division even more frequently occurs in the pinnæ, which are once forked, or end in a pair of forks.

This character is rare in recent ferns in their native condition, but frequent in cultivated forms, resulting in the dichotomous or crested varieties of garden origin.

Among Carboniferous ferns the principal families are the *Sphenopteridæ*, *Neuropteridæ*, and *Pecopteridæ*. These will be briefly described.

Sphenopterideæ.

Considerable latitude of character is shown by the ferns included in this family. The pinnules may be more or less oval, entire or lobed, and contracted at the base into a short

stalk, or cuneate, and even almost filiform. Nervation radiating from the base of the pinnule and frequently dichotomising. The chief genus is *Sphenopteris* Brongt.

Sphenopteris Brongt. The general characters of one of the sections of the ferns commonly included in *Sphenopteris* is well represented by *Sphenopteris obtusiloba* Brongt. (Plate XXV., fig. 1). The pinnules are oval entire, lobed, or divided into 3-5 segments—their form varying according to their position on the pinna. The dichotomising veins radiate fan-like from the base of the pinnules (Plate XXV., fig. 1a).

Another section of *Sphenopteris* has pinnules with more or less cuneate segments, of which *Sphenopteris furcata* Brongt. may be taken as a typical representative (Plate XXVII., fig. 2). The segments of the pinnule are narrow, linear, with a veinlet running into each tooth (Plate XXVII., fig. 2a). In both of these sections there are some species with very small pinnules.

Although one must be very careful in generalising, still it seems as if the linear or cuneate pinnuled forms were more characteristic of Lower Carboniferous rocks, while those with rounded lobed pinnules were more typical of the Upper Carboniferous. Both types, however, occur together in all the divisions of the Carboniferous Formation.

Many species originally included in *Sphenopteris* have had special genera provided for their reception. In some cases the characters are derived from the mode of division of the pinnæ—characters dependent on the vegetative system. It appears to me very doubtful if any real advantage is derived from the creation of such genera, as they cannot be regarded as other than provisional, and personally I prefer retaining the ferns placed in these genera in *Sphenopteris*. As examples of the genera to which I refer, *Palmatopteris* Potonié (of which *Sphenopteris furcata* is the type), and *Diplothmema* Stur may be mentioned.

The other class of genera which have been taken from *Sphenopteris* Brongt. hold, however, a very different position, as they are founded on characters which are derived from their

fructification, but before referring to these more fully it is necessary very shortly to consider the fructification of existing ferns.

Recent ferns are divided into two great classes—the *Isosporous Ferns*, or those with one kind of spore, and the *Heterosporous Ferns*, or those with two kinds of spores—macrospores and microspores. With the latter class, however, we have nothing to do at present.

Returning to the Isosporous Ferns, these again form two great sections. First, those whose sporangia are provided with a prominent ring of cells, called an *Annulus* (Plate XXVIII., fig. 2), and those whose sporangia are destitute of this structure.

The first section contains the great majority of recent ferns, of which the common Polypody and Male fern may be mentioned as well-known representatives. The second group contains the *Marattiaceæ*, which comprises few genera and a small number of species, all of which are natives of more or less tropical areas.

In Carboniferous times both these groups are represented, though the exannulate ferns seem to have outnumbered those with annulate sporangia.

Let us now return to *Sphenopteris*. Many of the species originally included in that genus have in recent years been found showing their fructification, and for these new genera have been created. Among British Sphenopteroid forms a few are known to possess annulate sporangia, and of such are *Corynepteris* Baily and *Oligocarpia* Göppert. In the former the sporangia are placed in groups of five or six, united at the base around a common centre, and collectively form a globular mass or *sorus;* in the latter they form little circular heaps composed of a number of independent sporangia. Isolated annulate sporangia are frequent in the Yorkshire and Lancashire "Coal Balls," and also occur in the material from Pettycur, Fife, which is situated in the lowest division of the Carboniferous Formation (Calciferous Sandstone Series).

The exannulate form of fructification is illustrated by several genera, which are characterised by the form and arrangement of the sporangia. Among these may be mentioned *Renaultia* Zeiller, where the small oval sporangia are situated on the veins towards the margin of the pinnules (Plate XXVIII., fig. 4). They open by a longitudinal cleft. The fruiting pinnules are little modified from those of the barren frond.

In *Urnatopteris* Kidston the barren (Plate XXIX., fig. 1) and fertile (Plate XXIX., figs. 2 and 3) fronds are dissimilar, that is, only some of the fronds bear sporangia, and on these the pinnules are entirely deprived of the limb—the sporangia being arranged in two rows, one on each side of the rachis. The sporangia are pointed-oval, and open at the summit by a small round pore (Plate XXIX., fig. 6). Each sporangium is free, but in their structure they have considerable resemblance to the sporangia of *Danæa* only in that genus the sporangia are united to each other to form a *synangium*. Though I only mention these two Sphenopteroid exannulate types, others are known.

NEUROPTERIDEÆ.

The most important genus of this family is *Neuropteris* Brongt. (Plate XXVIII., fig. 3. *Neuropteris gigantea* Sternb.). The pinnules are generally more or less oval or tongue-shaped, and articulated to the rachis, from which they are easily detached. Each pinnule had a central vein, from which are given off lateral divided veinlets (Plate XXIX., fig. 4). On some species of *Neuropteris*, possibly on the majority, between the points of insertion of the lateral pinnæ or towards the base of the frond, immediately below the pinnæ, the main rachis bore reniform or orbicular pinnules (Plate XXVIII., fig. 3, *a*, *a*), sometimes of large size; these, before their true origin was known, were supposed to belong to a distinct plant, and were named *Cyclopteris* by Brongniart. The fructification of *Neuropteris* is imperfectly known, but in the case of *Neuropteris heterophylla* Brongt. it was borne on long pedicels which terminate the pinnæ.

Linopteris Presl. (*Dictyopteris* Gutbier not Lamouroux) though rare in Britain, must not be omitted. In the form of the frond and pinnules it is similar to *Neuropteris*, and specimens not showing the nervation might easily be overlooked as belonging to that genus, but it is at once distinguished by the nervation, the veinlets of which unite among themselves to form a net-like reticulation (Plate XXX., fig. 2. *Linopteris obliqua* Bunbury sp. × $3\frac{1}{2}$).

Though this genus is certainly not common in Britain, it may be more common than supposed through being passed over for *Neuropteris*.

PECOPTERIDEÆ.

This family holds an important place among palæozoic ferns. *Pecopteris* Brongt. is the chief genus and contains many large and fine species. It is chiefly represented in the Upper Coal Measures, and *Pecopteris arborescens* may be regarded as the type (Plate XXVII., fig. 3).

The pinnules in *Pecopteris* are attached to the rachis by the whole of their base. They have straight sides and rounded apices. The pinnules are sometimes united among themselves at the base and possess a strong central mid-rib, from which—according to the species—are given off simple or dichotomously divided veins which extend to the margin.

The fructification of many of these ferns consists of four or five exannulate sporangia arranged in a stellate group, from which circumstance the genus *Asterotheca* has been proposed for them, though not generally adopted (Plate XXVII., fig. 4).

In the Middle Coal Measures, *Pecopteris* (*Asterotheca*) is represented by few species, but *Pecopteris* (*Asterotheca*) *Miltoni* is fairly plentiful. Though this species also occurs in the Upper Coal Measures, it is there associated with many other *Pecopterids* which are not found below that horizon.

The fronds of *Pecopteris* were of very large size and most probably some of the tree fern stems were the trunks of *Pecopteris*.

The *Pec. plumosa* Artis sp. (= *Pec. dentata* Brongt. Plate XXVII., fig. 1, Plate XXXI., figs. 1-4), so common in the Middle and Upper Coal Measures, forms the type of the genus

Dactylotheca Zeiller. This is characterised by the ovoid-pointed sporangia, which are placed singly on the veins and open by a longitudinal cleft (Plate XXXI., fig. 3). The barren pinnules vary greatly in form, being entire, lobed, or crenate, according to the position they hold on the frond. On the main rachis, at the point of insertion of the pinnæ, are curious, much-divided outgrowths, called aphlebia (Plate XXXI., fig. 2). These were originally supposed to be a climbing fern (*Schizopteris adnascens* L. & H.) which had used the frond of *Dactylotheca* as a support. These *aphlebia* are an integral part of the frond on which they occur, and are found on other species of ferns belonging to various genera.

Another *Pecopterid* genus, *Mariopteris* Zeiller, is extremely common in the Lower and Middle Coal Measures, but very rare in the Upper Coal Measures. The fructification is unknown, but the fern is distinguished by a double bifurcation of the rachis of the primary pinnæ. The leathery texture of the pinnules, difficult to describe but easily learnt from an examination of specimens, as well as the nervation, appears to me to add a character to the genus, which I would be inclined to restrict for *Mariopteris* (*Pecopteris*) *muricata* Schl. sp. (Plate XXXII., figs. 1 and 1a) and one or two close allies, but from which I would exclude such species as *Sphenopteris latifolia* Brongt.

The double bifurcation of the primary pinnæ, which occurs in this species, does not alone seem to me to be of much systematic importance.

ALETHOPTERIDEÆ.

The *Alethopterideæ* are closely related to the *Pecopterideæ*, but the pinnules are generally obliquely placed on the rachis, the prominent mid-rib joins the rachis near the upper margin of the pinnule, and thus gives a somewhat decurrent character to the mode of their insertion on the rachis. The lateral dichotomously divided veins are very numerous and run to the margin at almost right angles with the mid-rib. The common *Alethopteris lonchitica* Schl. sp. well illustrates these characters (Plate XXXII., figs. 2 and 3).

The fructification of *Alethopteris* is imperfectly known, but what is supposed to be a fruiting specimen of *Alethopteris Serlii* Brongt. has been described by Zeiller. This most interesting example appears to show that the sporangia were globular and arranged in rows along the veins. The fronds of *Alethopteris* attained to large size.

The genus *Lonchopteris* Brongt. (Plate XXVI., fig. 2) holds the same relationship to *Alethopteris* that *Linopteris* does to *Neuropteris*, having the same form of growth and pinnule cutting as *Alethopteris*, but is easily distinguished at first sight by the net-like reticulation of the veins (Plate XXVI., figs. 2a + 3).

Odontopterideæ.

The only genus of this family to which reference requires to be made is *Odontopteris* Brongt., which, however, is very rare in British Carboniferous rocks, and appears to be restricted to the Middle and Upper Coal Measures (Plate XXVIII., figs. 1 and 1a—*Odontopteris alpina* Presl. sp.).

The pinnules are more or less tongue-shaped and attached to the rachis by their broad base. They have no true mid-rib—several veins passing into the pinnules direct from the rachis, where they bifurcate once or twice.

Tree Fern Stems.

Some of the palæozoic ferns had stems like our modern Tree Ferns and must have attained to a considerable height. In Britain the two following genera of fern trunks occur:—

Caulopteris L. & H. (Plate XXXIII., fig. 1—*Caulopteris anglica* Kidston). The frond scars are arranged in vertical rows placed close to each other. They are oval and contain, a short distance within the margin, a closed oval or horse-shoe-shaped band, which corresponds to a tract of sclerenchymatous or much indurated tissue. Within this band and near its upper end is placed the vascular bundle scar. The outer surface of the stem is usually densely clothed with aerial rootlets.

Megaphyton Artis. (Plate XXXIII., fig. 2—*Megaphyton* sp. allied to *M. anomalum* Grand' Eury.). The fronds are attached

to these stems in two opposite rows, the frond on one side of the stem alternating with that on the other side.

The stem, except at the part to which the fronds are attached, was densely covered with aerial rootlets.

Caulopteris in its general aspect would much resemble one of the recent Tree Ferns, but *Megaphyton*, with its two opposite rows of fronds would have a very different aspect from any of the Tree Ferns at present existing.

Before passing from this brief consideration of the more important groups of palæozoic ferns, a few remarks must be made on their internal organisation, though this subject can only be touched on very slightly here.

The stems or rhizomes of recent ferns have no exogenous growth, that is, when the vascular bundle is once fully formed no new elements are subsequently added to it. Hence Tree Fern stems when once fully developed retain the same diameter of trunk for years.

Among fossil ferns whose structure is known, a few, generally of small size, possess the same structural peculiarities, but there is another type of palæozoic fern structure where, among other characters, an exogenous increase to the vascular system takes place. In these, after the formation of the primary vascular bundles, whose size is limited as in the first type, a cambium layer appears from which an outer circle of exogenously developed vascular tissue arises. This ring of secondary xylem or wood may increase indefinitely in size by additions from the cambium zone, the ultimate size of the stem being limited only by the life of the plant.

These Fern Stems with exogenous growth present certain anatomical characters intermediate between ferns and Cycads, and are now placed in a group to which Potonié has given the name of *Cycadofilices*. There is reason to believe, though little is known of their fructification, that they may be ferns, though in their anatomy they possess certain characters not found in existing members of this group. This discovery is one of the most interesting and important advances recently

made in the study of palæozoic botany, and to the *Cycadofilices* are known to belong certain *Sphenopteris*, *Alethopteris*, and *Neuropteris*.

As an example of how step by step our knowledge of palæozoic botany is built up, it may be mentioned that the petioles described by Williamson as *Rachiopteris aspera* were subsequently found to belong to the stem named *Lyginodendron Oldhamium* by the same author, and further it has been discovered that *Lyginodendron Oldhamium* is the stem of the well-known *Sphenopteris Hoeninghausi* Brongt. (Plate XXIX., fig. 5). Could any better example be found of the result—or reward—of patient, plodding work, or of the provisional nature of genera founded on the vegetative organs?

Calamariæ.

Equisetites Sternberg.

A few fossils have been found in Carboniferous rocks which from their great external resemblance to the recent *Equisetum* or Horsetails, have been placed in a genus called *Equisetites* by Sternberg. These fossils are extremely rare, and as far as at present known do not go further back than the Coal Measures. One of the most interesting examples of the genus is the *Equisetites Hemingwayi* (Plate XXXIV., fig. 3), which was discovered by Mr. Hemingway, Barnsley.

The cones are oval, about one inch long and rather over half an inch broad. The outer surface of the cone is covered with hexagonal scales about one-fifth inch in diameter, with a small central point, indicating probably the place of attachment of the little pedicel by which the peltate shield was united to the axis of the cone. Nothing is known of the inner structure and arrangement of the sporangia, but the external appearance of *Equisetites Hemingwayi* is so like that of the cones of recent *Equisetum* (of which a figure is given for comparison, Plate XXXIV., fig. 4, *Equisetum hyemale*), that the affinities of *Equisetites Hemingwayi* Kidston with *Equisetum* is probably very close.

A specimen in the British Museum shows that the cones of *Equisetites Hemingwayi* were apparently sessile and borne at the nodes of a very Equisetum-like stem.

MM. Renault and Zeiller have described from the Comentry Coal Field an Equisetaceous stem, with distinct sheaths, under the name of *E. Mongi*. Some other small specimens from the Carboniferous have been ascribed to *Equisetites*, but their reference is in many cases doubtful.

Calamites Suckow.

The *Calamites* form one of the most prominent types of vegetation in Coal Measure times. True Calamites do occur in Lower Carboniferous rocks, that is, below the Millstone Grit, but there they take a very unimportant place and are of very rare occurrence. It is only when we reach the Upper Carboniferous that they attain their importance, both in numbers and diversity of form. Calamites reached to arborescent dimensions.

When dealing with the *Calamites*, we are under the necessity of placing the stems, foliage, and fructification of the plants comprised in this group in separate genera, as in few cases can the foliage and fruit be referred to the parent plant. In fact, even in the genus *Calamites* in which the stems are placed, there are almost certainly included plants which belong to different genera. One is led to infer this from the structure of Calamitic cones which show among themselves important structural differences. This fact must not be lost sight of, and the genus *Calamites* should be regarded more in the light of a group than of a true genus, but for practical purposes some system of classification, even if provisional, must be adopted.

The late Professor Weiss divided *Calamites* into three groups:—

I.—Calamitina. In *Calamitina* the branches are borne in verticils, but between each verticil there is one or more nodes from which no branches are developed.

II.—Eucalamites. The stems placed in this group bear branches from every node.

III.—Stylocalamites. Here the stems are either unbranched or, if lateral branches occur, they are developed very irregularly.

In all these divisions the ribs on the *pith-cast* alternate at the nodes.

There is a fourth division which, however, only occurs in the Lower Carboniferous:—

IV.—Asterocalamites Schimper. In these plants the ribs do not alternate at the nodes, and the branch scars are irregularly produced.

Before considering these groups more fully it is desirable to make a few general remarks on the Calamites as a whole.

The majority of the fossils referred to *Calamites* have ribbed exteriors, such as the figures of *Calamites (Stylocalamites) Suckowii* given by Brongniart and others (Plate XXXV., fig. 3). These do not represent the exterior of the plant as originally supposed, but are merely the casts of the pith cavity. This is well seen in the figure of *Calamites* (*Calamitina*) *approximatus* Brongt. given on Plate XXXV., fig. 2, where the cast of the pith cavity is seen at *a*, and the vascular portion of the stem at *b*. Plate XXXIV., fig. 2, also shows the same characters. The true outer surface of the stem of Calamites is rarely preserved, and though very young stems may show faint ribs the older stems have almost invariably smooth barks, though on rare occasions a ribbing of the outer surface seems to occur as in some examples of *Calamites (Calamitina) verticillatus* L. & H. (Plate XXXVI., fig. 4).

The stems of *Calamites* (except possibly in the very young condition) were hollow except at the nodes, where a more or less complete diaphragm of cellular tissue extended across the cavity. The pith cavity was surrounded by a zone of vascular wedges, in the inner angle of which is a carinal canal. This woody zone increased indefinitely in size by additions from a cambium ring. The vascular wedges are separated by broad medullary rays, and the whole is enclosed in a thick cortex. Modifications of this structure occur in different members of the group, but all conform in their outstanding features to this type

of stem. The aerial stems of *Calamites* spring from creeping rhizomes as seen in the figure of *Calamites Suckowii*, given on Plate XXX., fig. 1, as well as from the subterranean portion of the aerial stems (Plate XXXV., fig. 3).

Let us now return to the consideration of the three groups of stems, to which reference has just been made:—

I.—Calamitina.

Calamites varians Sternb. may be taken as typical of this group (Plate XXXIV., fig. 1. *Calamitina varians* var. *inconstans* Weiss).

The internodes vary in length, and the nodes bear closely-placed transversely oval leaf scars. The bark is smooth but frequently shows slight longitudinal clefts or cracks, which vary in their length and distance apart. These longitudinal cracks or lines probably arise through the splitting of the bark from the increase of the stem in girth. Between each branch-bearing node several branchless nodes intervene, their number varying, not only in the same species, but even on the same specimen. The foliage of some *Calamitinæ* consisted of acicular leaves, but whether all possessed such foliage is not known (Plate XXXVI., fig. 1).

II.—Eucalamites.

Calamites ramosus Artis. is representative of this section (Plate XXXVII., figs. 3 and 4). Each node gives rise to two branches, one on each side of the stem. The branches are superposed, and, though these again bear lateral branches, the plant would possess the form of a triangle. The surface of the stem is smooth. Plate XXXVII., fig. 4, shows the cast of the pith cavity; fig. 3 shows the outer surface of the species with smooth bark.

The foliage of *Calamites ramosus* consisted of lanceolate leaves, arranged in whorls and united by their bases to form a very narrow ring round the stem. This foliage was named *Annularia radiata* by Brongniart before it was discovered to be the foliage of *Calamites ramosus* (Plate XXXVII., fig. 1).

The fruit of *Calamites ramosus* is in the form of small cones which terminate the branchlets. Their structure is that of *Calamostachys*, which will be presently described.

In *Calamites* (*Eucalamites*) *cruciatus* Sternb. each node bore a verticil of somewhat distant branches.

III. Stylocalamites.

The *Calamites* in this group very rarely produced branches. *Calamites Suckowii* Brongt. is a good example (Plate XXXV., fig. 3). The outer surface of the stem was smooth, and if the nodes gave rise to branches they must have done so very rarely.

In *Calamites Cistii* Brongt., another member of this group, small scars occasionally are found on the nodes, but these probably are the scars, at least in part, of short stalked cones.

IV.—Asterocalamites Schimper.

This group is of generic value, and ranks in importance with the genus *Calamites*; it not only differs from *Calamites* in the ribs not alternating at the nodes, but also in the foliage being dichotomously divided. The fructification consisted of narrow cones, fully five inches long, which are periodically divided into sections by interposed barren whorls, so that the cone appears as if composed of a number of oblong segments resting on each other, and between which is a whorl of leaves. Each segment therefore consisted of a barren whorl, which is succeeded by 10 or 12 fertile whorls. Though specimens of the fruit and foliage are very rare in Britain, fragments of the stems are not uncommon. The genus is characteristic of the Lower Carboniferous.

Owing to our inability in the majority of cases of associating the isolated foliage branches of *Calamites* with the stems to which they belong, they are placed in the two following genera—*Calamocladus* and *Annularia*.

In *Calamocladus* Schimper (*Asterophyllites* Brongt.) the leaves are arranged in whorls. They are narrow linear or setaceous, single nerved and placed closely together. One of the commonest species is *Calamocladus equisetiformis* Schl. sp. (Plate XXX., fig. 3).

Annularia Sternberg contains those forms with whorled, single-nerved lanceolate leaves, widest near the centre like *Annularia radiata* Brongt. (Plate XXXVII., fig. 2), or with spathulate leaves like *Annularia sphenophylloides* Zenker. sp. (Plate XXXVII., fig. 1). The leaves unite at the base and form a very narrow collar round the stem.

Fructification of Calamites.

The fructification of *Calamites* consists of narrow linear cones, attaining in some species a few inches in length, though in most cases they are of smaller size. The arrangement of the sporangia in many of these cones is still unknown, but of some a very complete knowledge is possessed. For their reception several genera have been founded, as hitherto it has been generally impossible to refer them to their parent stems.

The more important of these genera may be briefly described.

Calamostachys Schimper. (Plate XXXVI., fig. 2).

The cone is composed of alternating whorls of barren leaves or bracts and sporangiferous scales. The basal portions of the bracts unite to form an almost horizontal collar which surrounds the axis, while the free parts of the bracts rise up almost at a right angle, the whole forming a saucer-like structure. Between each of these barren whorls is a fertile whorl. This consists of slender pedicels or *sporangiophores*, which spring from the axis at right angles and terminate in peltate shields, on the inner surface of which are borne four sporangia. Both homosporus and heterosporous cones occur in *Calamostachys*.

Palæostachya Weiss (Plate XXXIV., fig. 5; Plate XXXVI., fig. 3. *Palæostachya pedunculata* Williamson).

The cones placed in *Palæostachya* differ from those of *Calamostachys* in the sporangiophores springing from the axis immediately above the axils of the bracts and forming with the axis an angle of about 45 degrees.

For cones possessing the general appearance of *Calamostachys* and *Palæostachya*, but in which the arrangement and position of the fertile whorls are unknown, the genus *Volkmannia* Sternb. may be conveniently employed.

Macrostachya Schimper is another genus of Calamitic cones. These attained to considerable size, and are much larger and broader than those of the three preceding genera. The cones are composed of alternating closely placed verticils of many bracts, united to each other throughout the greater portion of their length; only the short upturned extremities of the bracts remain free. Each whorl of bracts thus forms a saucer-like collar which surrounds the thick axis of the cone. The arrangement of the sporangiophores has not been clearly made out.

Other types of Calamitic cones are known, but those mentioned are the principal forms which occur in British Carboniferous rocks.

Occasionally specimens of *Calamites* are found showing the remains of their rootlets. These are—in whole or in part—the fossils for which Lindley and Hutton founded the genus *Pinnularia* (Plate XXXV., fig. 1—*Pinnularia columnaris*). They consist of roots pinnately giving off lateral roots, which in turn bear the rootlets, apparently in the same plane.

That the *Calamariew* and *Equisetaceæ* are closely related is beyond all doubt, and there seems to be no satisfactory reason why they should not be united in one family under either of these names, preferably under that first mentioned.

The genus *Calamites* seems to have entirely disappeared without leaving any modern representative, while the less important palæozoic genus *Equisetites* is probably the ancestor of the recent *Equisetum*.

Explanation of Plates.

Plate XXV.

Fig. 1. *Sphenopteris obtusiloba* Brongt. Grange Colliery, Kilmarnock. Lower Coal Measures [1560]. Three-fifths natural size.

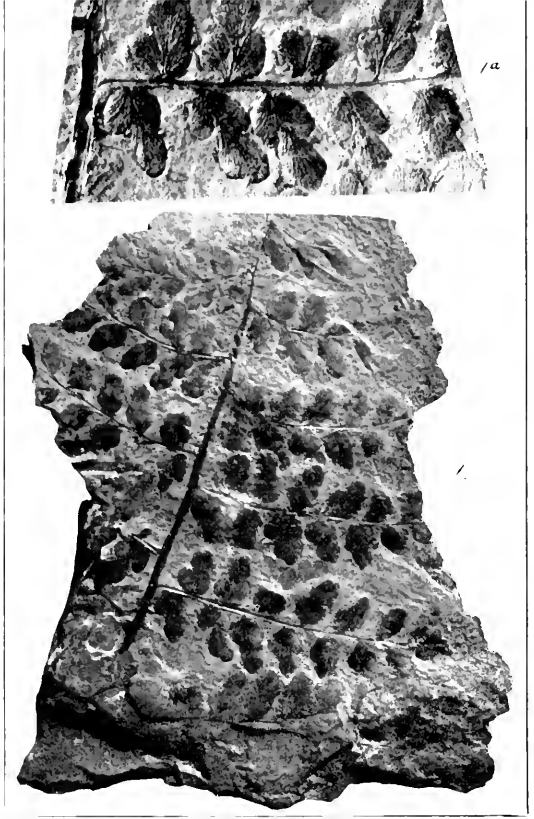
Fig. 1*a*. *Sphenopteris obtusiloba* Brongt. Portion of a pinna slightly enlarged to show the nervation of the pinnules. Specimen received from the Rev. D. Lundsborough, D.D.

[*Note.*—The figures enclosed in brackets give the registration numbers of the specimens in the Author's collection.]

Fig. 2. *Calymmatotheca bifida* L. & H. sp. Lewis Burn, about 200 yards below Lewis Burn Colliery, North Tynedale, Northumberland. Calciferous Sandstone Series (Lower Carboniferous) [728]. Three-fifths natural size. Basal portion of frond showing bifurcation of rachis.

Fig. 3. *Calymmatotheca bifida* L. & H. sp. Burdiehouse, Midlothian. Calciferous Sandstone Series [717]. Collected by the late Mr. C. W. Peach. Three-fifths natural size. Upper portion of frond showing bifurcation and pinnæ.

Fig. 3*a*. Pinnule enlarged.



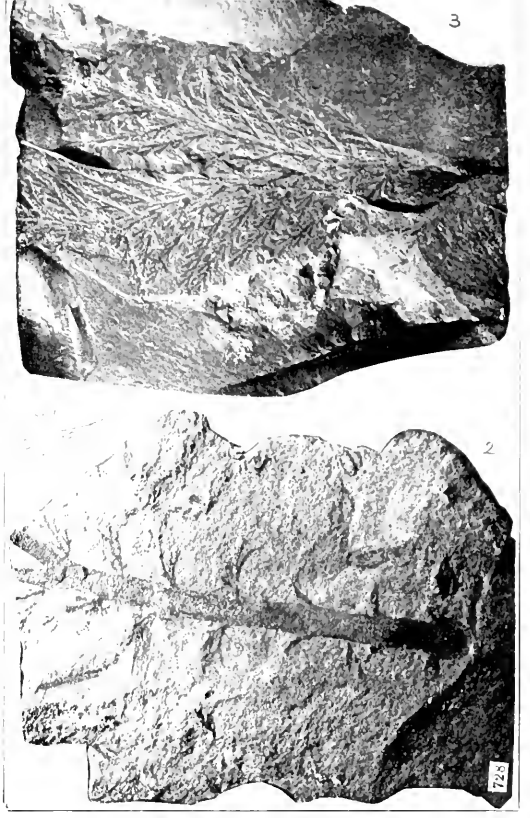


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Plate XXVI.

Fig. 1. *Spiropteris.* Braysdown, near Radstock, Somerset. Upper Coal Measures [510]. Young frond, probably of *Pecopteris* in circinate vernation. Rather less than half natural size.

Fig. 2. *Louchopteris rugosa.* Brongt. St. Eloi, Mariemont, Belgium. Coal Measures. Natural size [2634]. Specimen communicated by Rev. Father G. Schmitz, S.J., Louvain.

Fig. 2*a*. Portion of pinnule showing the reticulate nervation. Magnified about $2\frac{1}{2}$ times.

1

2a

2

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Plate XXVII.

Fig. 1. *Dactylotheca plumosa* Artis. sp. Monckton Main Colliery, near Barnsley. Middle Coal Measures [2107]. Natural size. Collected by Mr. W. Hemingway.

Fig. 1*a*. Pinnule enlarged four times.

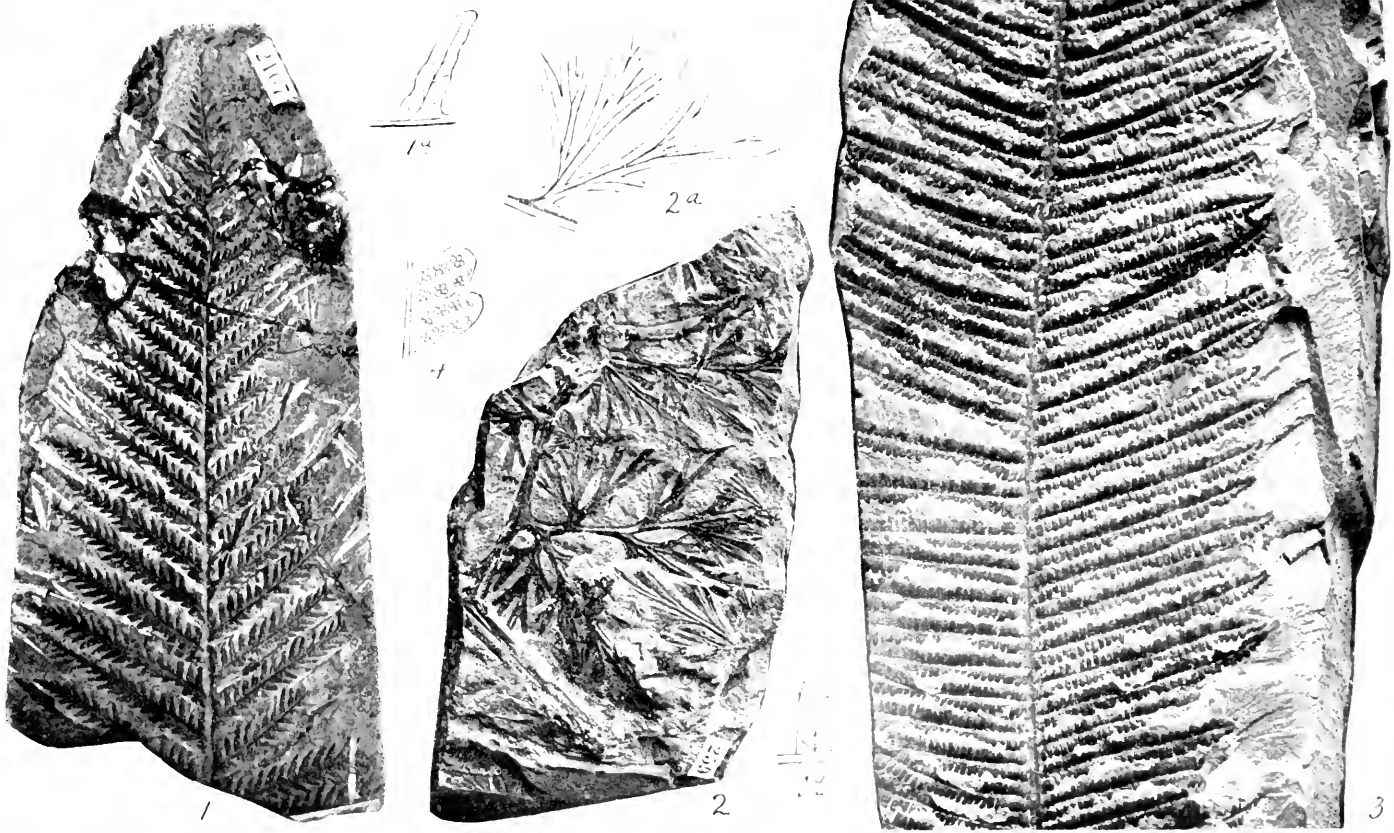
Fig. 2. *Sphenopteris furcata* Brongt. Cramlington, Northumberland. Lower Coal Measures [259]. Natural size. Collected by Mr. J. Sim.

Fig. 2*a*. Pinnule enlarged to show nervation.

Fig. 3. *Pecopteris arborescens* Schloth. sp. Radstock, Somerset. Natural size. Upper Coal Measures [452].

Fig. 3*a*. Pinnule enlarged to show nervation.

Fig. 4. *Pecopteris* (*Asterotheca*) *Miltoni* Artis. sp. (after Zeiller). Enlarged twice.



Photographed by R. Kidston

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Plate XXVIII.

Fig. 1. *Odontopteris alpina* Presl sp. Monckton Main Colliery, near Barnsley. Middle Coal Measures [1962]. Three-fifths natural size. Collected by Mr. W. Hemingway.

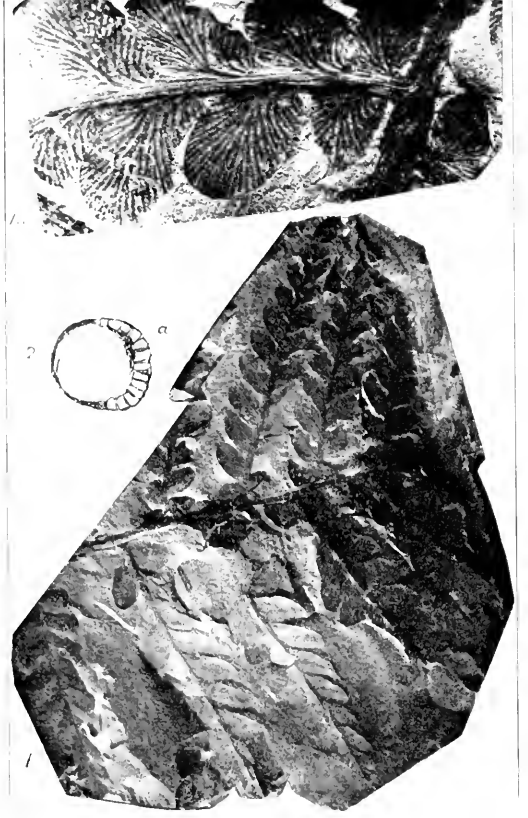
Fig. 1*a*. Portion of pinna enlarged to show the nervation.

Fig. 2. Annulate fern sporangia, in section, Pettycur, Fife [Slide No. 550]. Magnified 50 times. *a*. Annulus.

Fig. 3. *Neuropteris gigantea* Sternb. Hill Top Colliery, Skegby, near Hiechnael-under-Huthwaite, Notts. [206]. Three-fifths natural size. Middle Coal Measures. Collected by Mr. E. Wilson. On the main rachis, as at *a*, are seen the small cyclopteroid pinnules.

Fig. 4. *Renaultia microcarpa* Lesqx. Blairpoint, near Dysart, Fife. Lower Coal Measures [773]. Collected by Mr. James Bennie. Pinnule showing the fructification enlarged.

Fig. 4*a*. Sporangium more highly enlarged to show the structure.



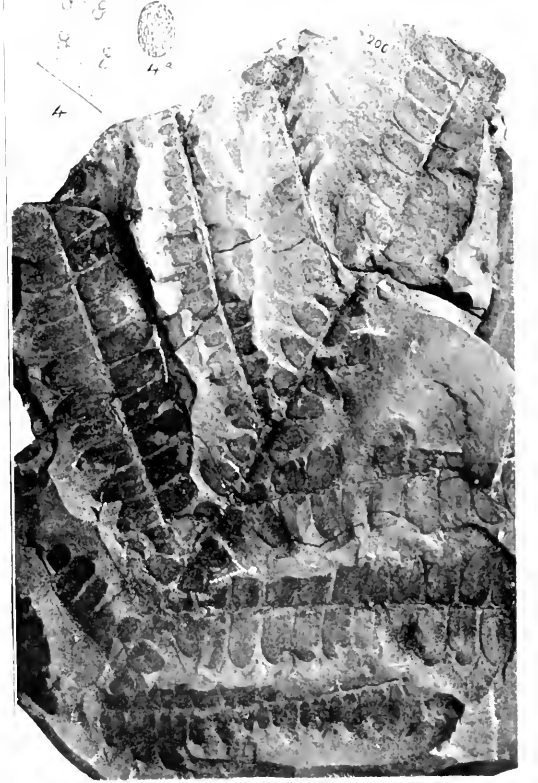


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Plate XXIX.

Fig. 1. *Urnatopteris tenella* Brongt. sp. Furnace Bank, Sauchie, near Alloa, Clackmannanshire. Lower Coal Measures [1983]. Natural size. Portion of barren frond.

Fig. 2. *Urnatopteris tenella* Brongt. sp. Furnace Bank, Sauchie, near Alloa, Clackmannanshire. Lower Coal Measures [1988]. Natural size. Fruiting frond.

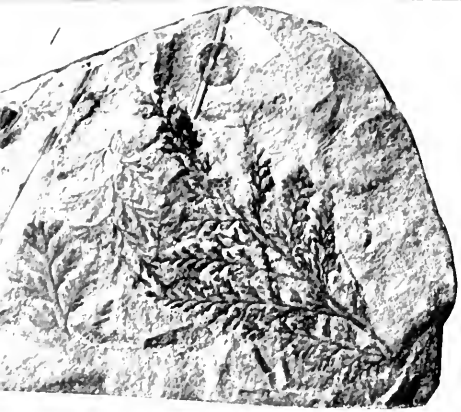
Fig. 3. *Urnatopteris tenella* Brongt. sp. Ellismuir, Baillieston, Lanarkshire. Lower Coal Measures [2450]. Enlarged about twice. Collected by Mr. P. Jack.

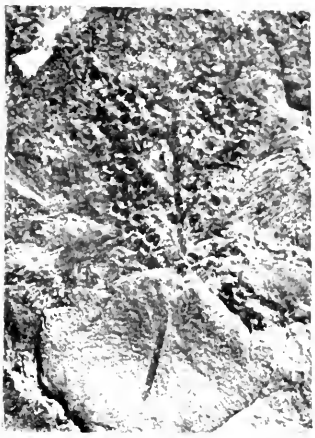
Fig. 4. *Neuropteris gigantea* Sternb. Coseley, near Dudley. Middle Coal Measures [212]. Pinnule enlarged to show nervation.

Fig. 5. *Sphenopteris Honinghausi* Brongt. Tullygarth, near Clackmannan. Lower Coal Measures [938]. Natural size.

Fig. 5*a*. Pinnule enlarged [936].

Fig. 6. *Urnatopteris tenella* Brongt. sp. Furnace Bank, Sauchie, near Alloa, Clackmannanshire. A few sporangia enlarged and showing terminal pore [1970].





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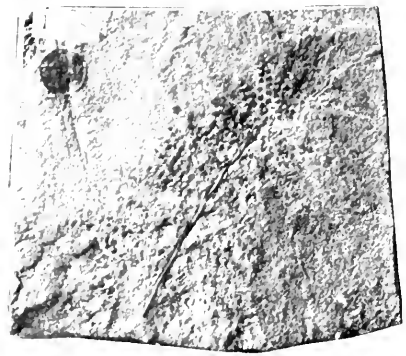

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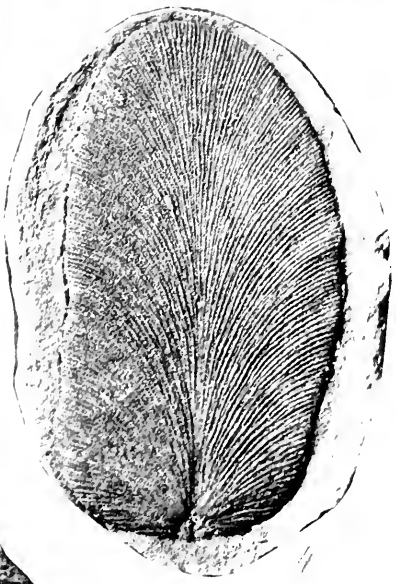

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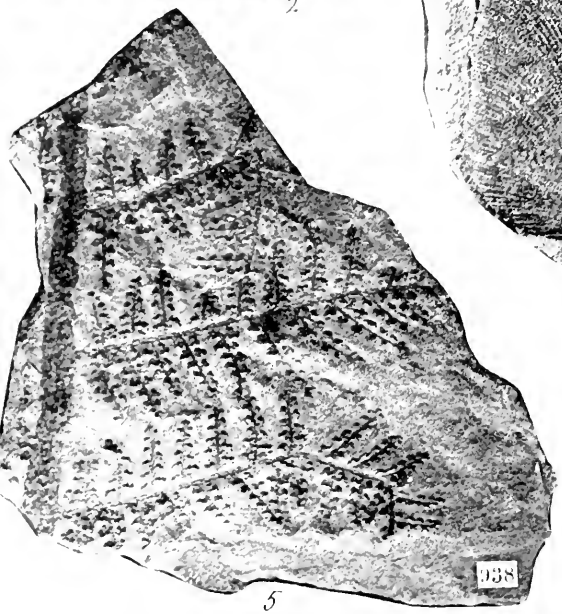

938

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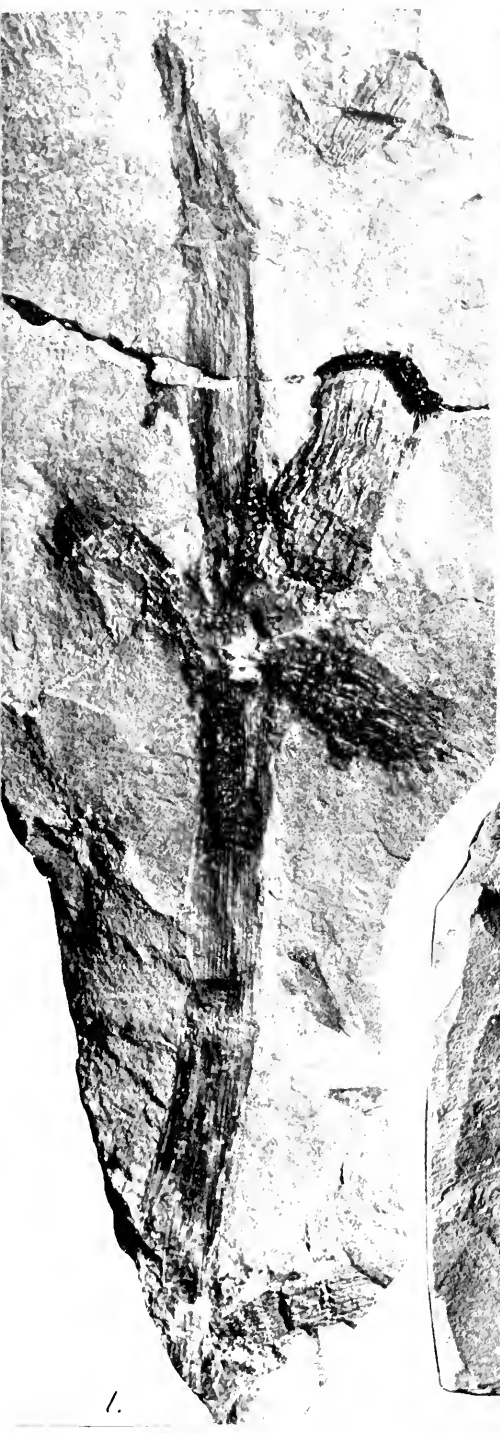
5a

Plate XXX.

Fig. 1. *Calamites Suckowii* Brongt. Ellismuir, Ballieston, Lanarkshire. Lower Coal Measures. Four-fifths natural size. Towards the centre of the specimen the rhizome gives rise to three aerial stems. At the lower end of the specimen another stem is given off. From the direction in which the stems bend, it is apparently the under surface of the rhizome which is exhibited. Collected by Mr. P. Jack.

Fig. 2. *Linopteris obliqua* Bunbury sp. Pittston, Pa., U.S.A. Specimen received from the late Mr. R. D. Lacoe [1348]. Pinnule enlarged about $3\frac{1}{2}$ times to show the nervation.

Fig. 3. *Calamodendron equisetiformis* Schl. sp. Cadeby Colliery, Conisborough, Yorkshire. Middle Coal Measures [1536]. Collected by Mr. W. Hemingway.



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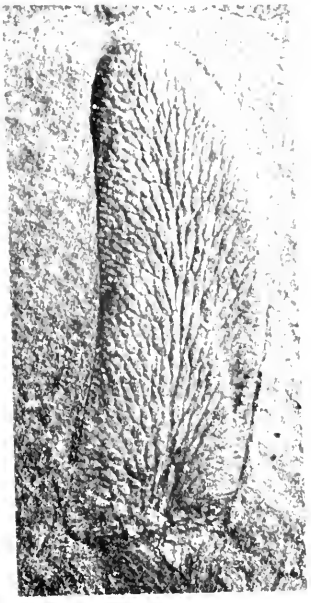

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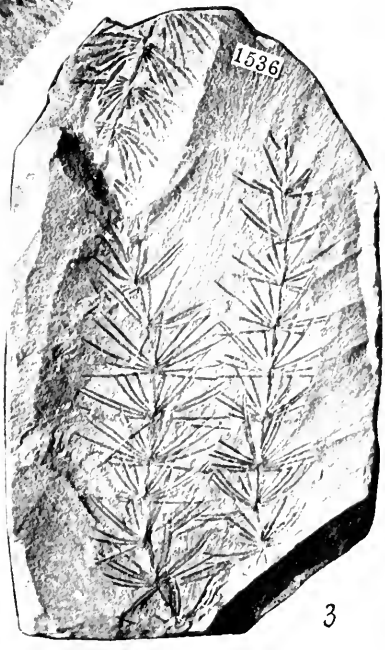

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Plate XXXI.

Fig. 1. *Dactylotheca plumosa* Artis, sp. Monckton Main Colliery, near Barnsley. Middle Coal Measures [2105]. Natural size. Collected by Mr. W. Hemingway.

Fig. 2. *Dactylotheca plumosa* Artis, sp. forma *crenata* L. & H. sp. Fruiting specimen. Monckton Main Colliery, near Barnsley. Middle Coal Measures [1210]. Portion of frond showing *Apiculata* the *Schizopteris adnascens* L. & H. Natural size. Collected by Mr. W. Hemingway.

Fig. 3. *Dactylotheca plumosa* Artis, sp. Monckton Main Colliery, near Barnsley. Middle Coal Measures [2008]. Pinnule showing sporangia × 8. Collected by Mr. W. Hemingway.

Fig. 3*a*. Sporangium × 25.

Fig. 4. *Dactylotheca plumosa* Artis, sp. forma *dentata* sp. Brongt. Monckton Main Colliery, near Barnsley. Middle Coal Measures [2112]. Pinnules enlarged. Collected by Mr. W. Hemingway.

Photographed by R. Kidston

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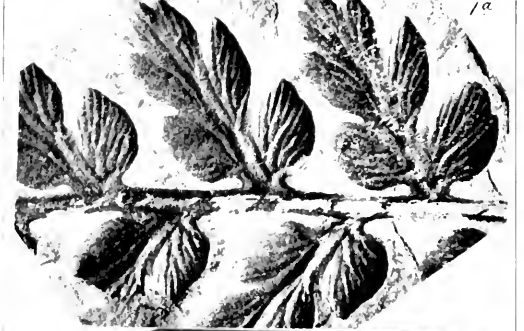
Plate XXXII.

Fig. 1. *Mariopteris muricata* Schl. sp. Monckton Main Colliery, near Barnsley. Middle Coal Measures [2393]. Three fifths natural size. Collected by Mr. W. Hemingway.

Fig. 1*a*. Portion of pinna with pinnules to show the nervation. Magnified twice.

Fig. 2. *Alethopteris lonchitica* Schl. sp. Monckton Main Colliery, near Barnsley. Middle Coal Measures [1959]. One quarter natural size. Collected by Mr. W. Hemingway.

Fig. 3. *Alethopteris lonchitica* Schl. sp. Blairpoint, Dysart, Fife. Lower Coal Measures [2816]. Portion of a pinna enlarged twice to show the nervation.



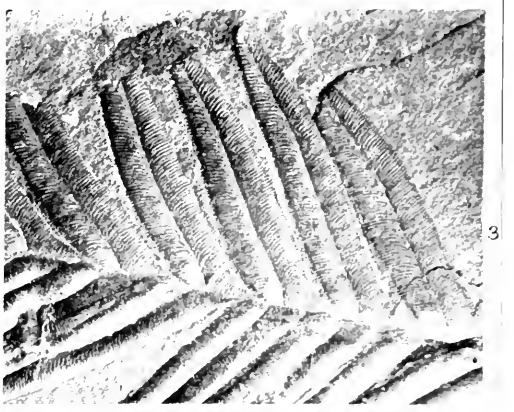


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Plate XXXIII.

Fig. 1. *Caulopteris cyclostigma* Lesqx. Braysdown Colliery, Radstock, Somerset. Upper Coal Measures [972]. Three-fifths natural size. *a*. Vascular scar contained within the sclerenchymatous band *b* of the frond scar.

Fig. 2. *Megaphyton* sp. allied to *Megaphyton anomalum* Grand'Eury. Woolley Colliery, Darton, near Barnsley. Middle Coal Measures [2159]. Three-fifths natural size. Collected by Mr. W. Hemingway. Portion of stem showing one of the rows of frond scars.

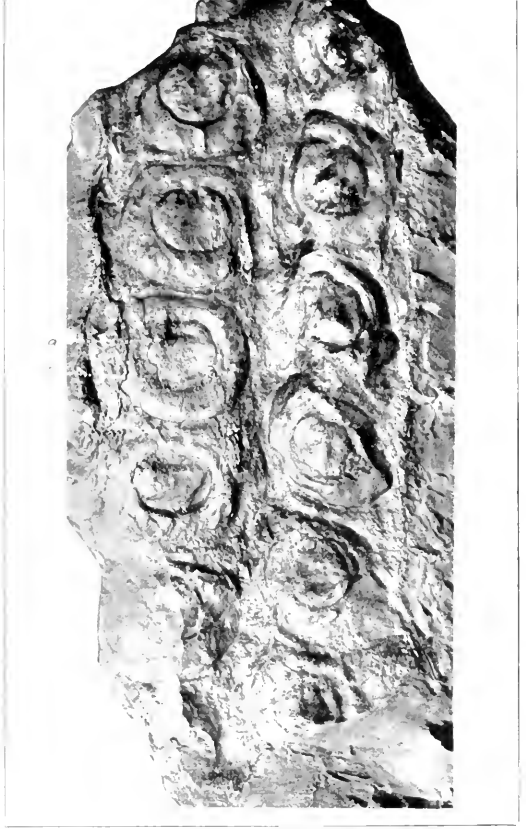

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Plate XXXIV.

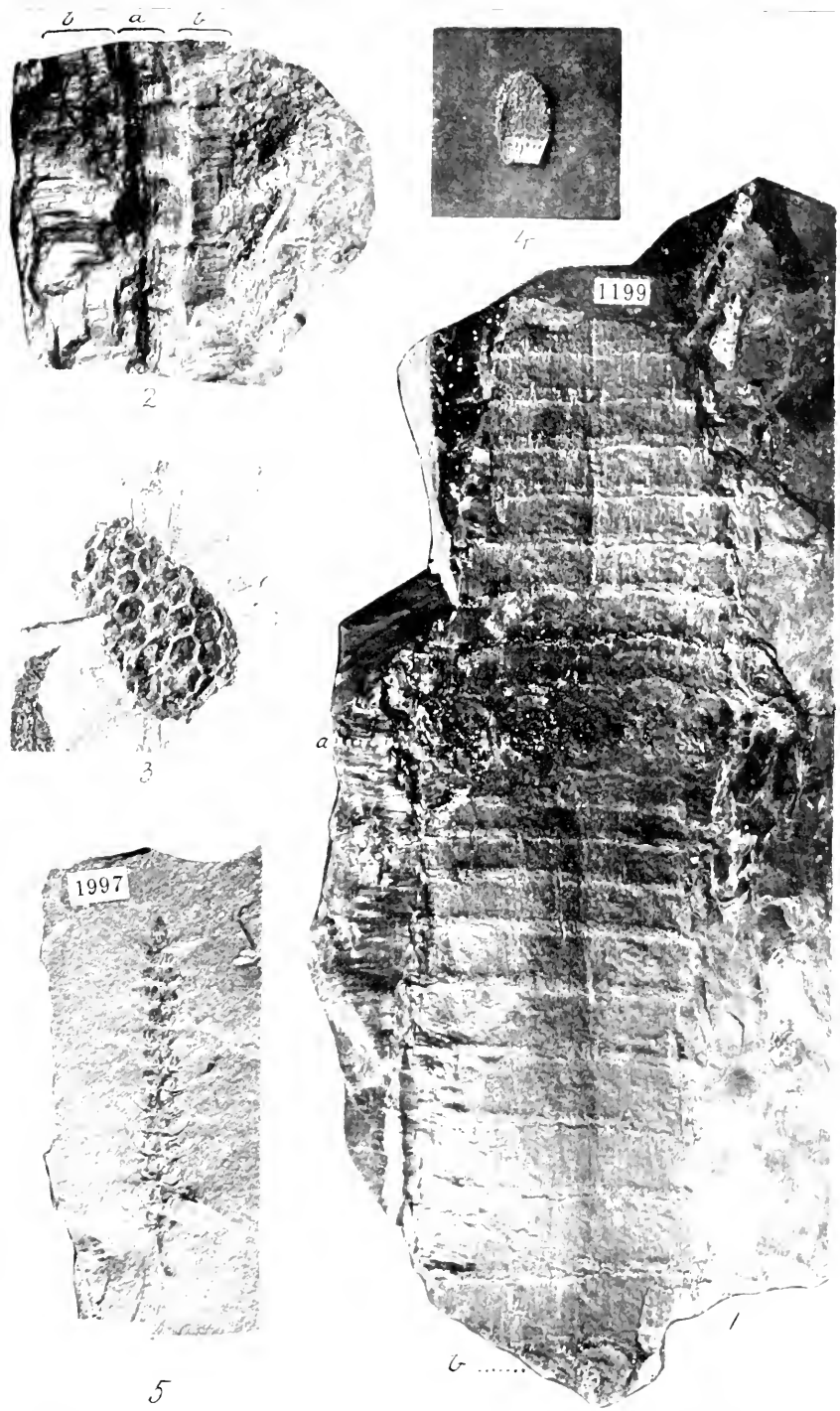
Fig. 1. *Calamitina Goepperti* Ett. sp. Woolley Colliery, Darton, near Barnsley. Middle Coal Measures [1199]. Natural size. Collected by Mr. W. Hemingway. At *a* and *b* are seen two whorls of branch scars.

Fig. 2. *Calamite* from "Coal Ball," Hard Bed, Halifax. Lower Coal Measures. Specimen in the collection of the late Mr. Spencer, Halifax. *a*. Cast of pith cavity. *b b*. Vascular axis with structure preserved. Natural size.

Fig. 3. *Equisetites Hemingwayi* Kidston. Monckton Main Colliery, near Barnsley. Middle Coal Measures [1678]. Natural size. Collected by Mr. W. Hemingway.

Fig. 4. Cone of *Equisetum hyemale*, natural size, for comparison with *Equisetites Hemingwayi*.

Fig. 5. *Palaeostachya pedunculata* Williamson. Blairpoint, Dysart, Fife. Lower Coal Measures [1997]. Natural size.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a
b
2
4
1199
a
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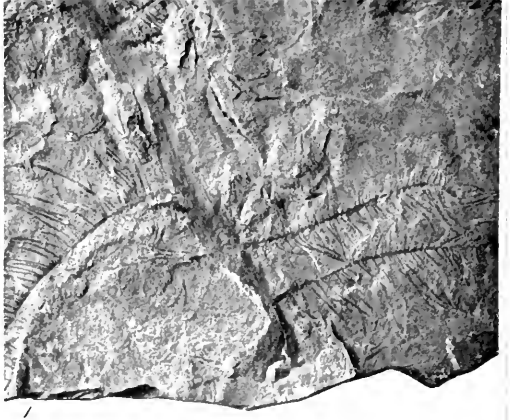
1997
5
1
c

Plate XXXV.

Fig. 1. *Pinnularia columnaris* Artis, sp. Crophead Pit, Sauchie, near Alloa, Clackmannanshire. Lower Coal Measures [2815]. Three-fifths natural size. Probably the rootlets of a *Calamite*.

Fig. 2. *Calamitina approximata* Brongt. sp. Woodhill Quarry, Kilmaurs, Ayrshire. Lower Coal Measures [1551]. Three-fifths natural size. At *a* is seen the cast of the pith cavity, and at *b* the impression of the vascular cylinder.

Fig. 3. *Calamites Suckowii* Brongt. Oaks Colliery, near Barnsley. Middle Coal Measures [2218]. Three-fifths natural size. Collected by Mr. W. Hemingway. Pith cast of stem *a*, giving off another stem *b*, also only represented by the pith cast. At *c* are seen some rootlets.



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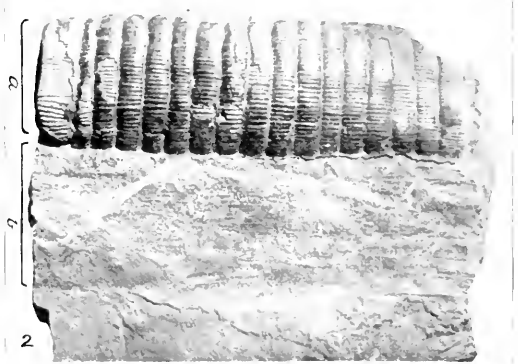

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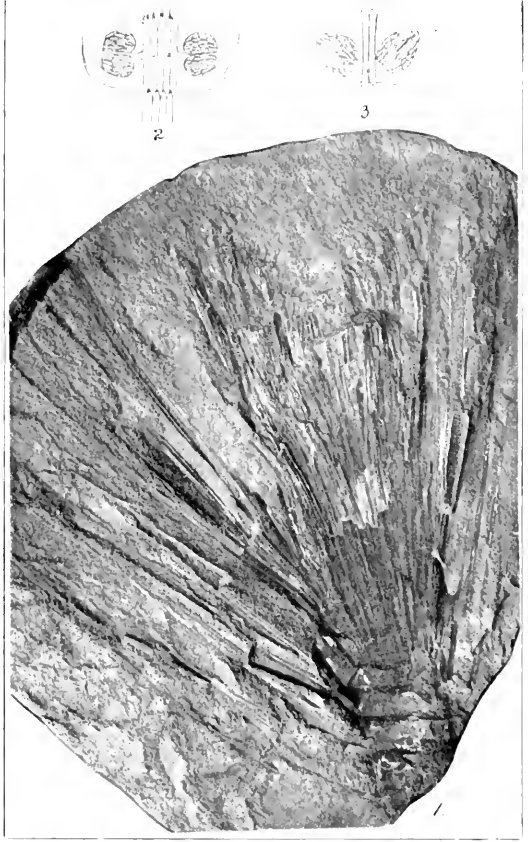
Plate XXXVI.

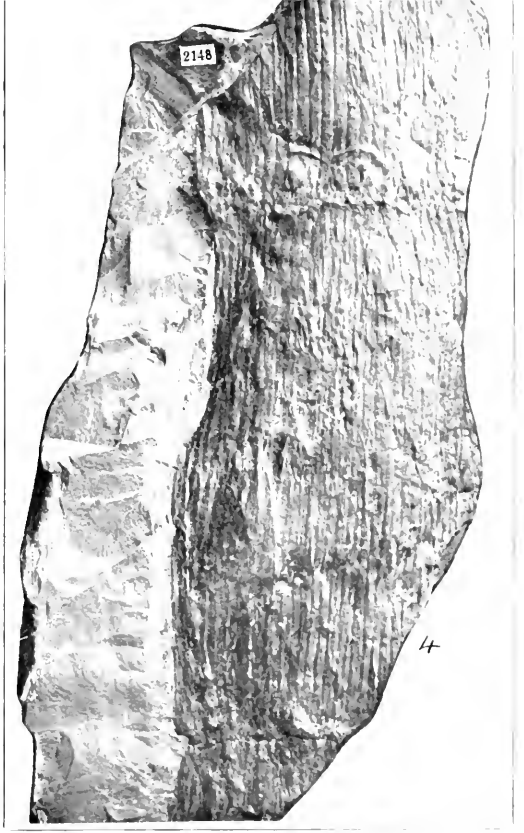
Fig. 1. Termination of a Calamite belonging to the section *Calamitina*, showing the long narrow foliage. Three fifths natural size. Dolly Lane, Leeds. Middle Coal Measures. Collected by Mr. J. W. Bond.

Fig. 2. Diagrammatic representation of *Calamostachys*, showing barren and fertile whorl.

Fig. 3. Diagrammatic representation of *Palaeostachya*, showing barren and fertile whorl.

Fig. 4. *Calamitina verticillata* L. & H. sp. Oaks Colliery, near Barnsley, Yorkshire. Middle Coal Measures [2148]. Three-fifths natural size. Collected by Mr. W. Hemingway. At the upper end of the specimen is seen a verticil of branch scars. The fossil shows a ribbed exterior which in this species appears to represent the outer surface of the plant.





Photographed by R. Kidston

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Plate XXXVII.

Fig. 1. *Annularia sphenophylloides* Zenker sp. Small branch showing leaf-whorls. Camerton, Somerset. Upper Coal Measures [2304]. Collected by Mr. G. West. Three-fifths natural size.

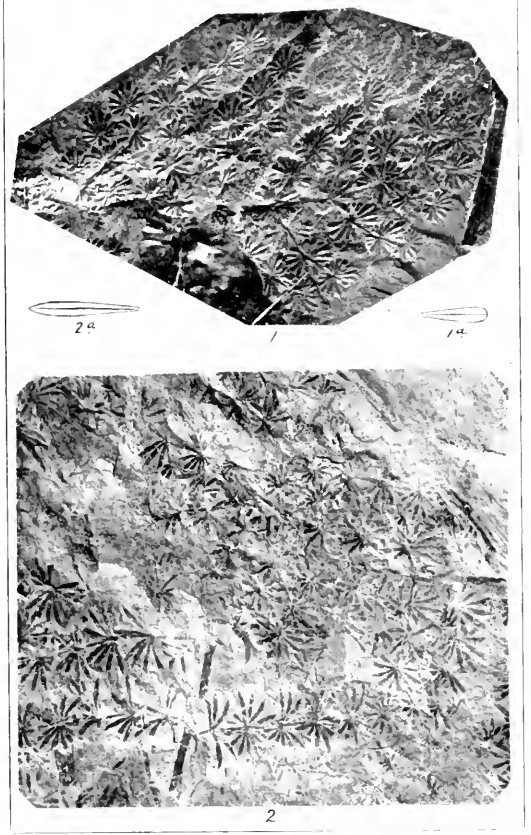
Fig. 1*a*. Leaf enlarged.

Fig. 2. *Annularia radiata* Brongt. This is the foliage of *Calamites ramosus* Artis. Three-fifths natural size. Lochwood Colliery, Easterhouse, Lanarkshire. Lower Coal Measures [2426]. Collected by Mr. P. Jack.

Fig. 2*a*. Leaf enlarged.

Fig. 3. *Calamites ramosus* Artis. Dolly Lane, Leeds. Middle Coal Measures [2699]. Three-fifths natural size. Collected by Mr. J. W. Bond. This example shows the outer surface of the stem, which is smooth.

Fig. 4. *Calamites ramosus* Artis. Devonside, near Alloa, Clackmannanshire. Lower Coal Measures [2817]. Three-fifths natural size. Collected by Mr. J. F. Lyon. This specimen is the cast of the pith cavity.



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