VI. *Contributions to the Knowledge of Lower Carboniferous Plants.*—(contd.)*

III.—On the Fossil-Flora of the Black Limestones in Teilia Quarry, Gwaenysgor, near Prestatyn, Flintshire, with special reference to Diplopteridium teilianum KIDSTON sp. (gen. nov.) *and some other Fern-like Fronds.*

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[PLATES 23–26.]

CONTENTS.

(*a*) INTRODUCTION.

KIDSTON (1889) described a small collection of fossil-plants from the Black Limestones exposed in a quarry at Teilia Farm close to Gwaenysgor, a village lying about one mile South of Prestatyn in Flintshire. From the vertical distribution elsewhere of the species found at Teilia he concluded that the flora was of Lower Carboniferous Age and that it compared more closely with the flora of the Calciferous Sandstone Series than with that of the Carboniferous Limestone Series of the Lower Carboniferous Succession of the Scottish and Northumberland area.

In 1924 I found on visiting the quarry that the plant-bearing beds were still fairly accessible, although the quarry had not been worked for many years and was considerably

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overgrown with vegetation. With the grant kindly placed at my disposal by this Society, I had the beds opened up and obtained a fairly large collection of fossil-plants and animals. This collection enables me to add considerably to the list of species recorded by KIDSTON in 1889 and to extend our knowledge of the morphology of several plants of Lower Carboniferous Age. Several new species were found and descriptions of these will be given.

The Teilia Limestones which, according to MORTON (1886, p. 175) form the basal part of the Upper Black Limestone of the district (see stratigraphical table below), consist of beds of thin-bedded dark coloured limestone which dip 10° to N.N.E. The plant-bearing beds are exposed near to the entrance of the small quarry situated about 100 yards east of the farm buildings at Teilia. They lie about 25 feet below the topmost beds exposed in the quarry. The rock weathers easily and the joints in it have been widened by the action of the soil water. The water has also worked its way between some of the bedding planes, especially those containing plant fragments rendering the rock easily cleavable. When unweathered rock is cleft the smell of mineral oil is distinctly noticeable and, if treated with dilute mineral acids, the carbonates in the rock dissolve with effervescence, leaving a stiff oily paste containing a large proportion of organic debris. It is the vegetable contents which give the dark colour to the rock. The direction of the cleat was observed in one woody fragment to be 4° West of North.

MORTON suggests that the rock was formed by consolidation of a rapidly deposited calcareous mud. This deposit may have been formed in an inlet or lagoon, for one of the most interesting characteristics of the beds is the large number of marine shells, fish, and other animals which may be found bedded on the same surfaces as the plants. The deposition must have taken place under tranquil conditions, for almost entire fronds of fern-like plants, fish, and bivalve shells with both valves together, are found with no indication of their having been subjected to any considerable amount of wave-action.

One specimen of a Dictyonema-like organism similar to that described by HIND (1907), from Posidonomya beds in the Isle of Man was found in a block of limestone from the upper beds in the quarry. A similar organism has been recorded by RENIER (1926) from the Black Marble at Dinant in Belgium. All the other fossils to which reference is made in this memoir were found in a stratum of the Black Limestone of very uniform character about two metres in thickness which was exposed by a trench about four metres in length and two metres wide. Probably less than five cubic metres of the rock were split up and furnished examples of all the plant species which have been recorded from this locality.

The opportunity rarely occurs of studying an exactly contemporaneous fossil land-flora and marine fauna and of determining the age of the flora in terms of the faunal succession or *vice versa*. As regards composition this assemblage of fossil organisms (for fauna see WALTON, 1928) bears a close resemblance to that of the Posidonomya Shales in the valley of the Mohra in Western Upper Silesia (PATTEISKY, 1929).

Besides the plant-bearing beds in the Upper Black Limestone at Teilia, another important horizon with plants occurs near the base of the Limestone Series in North Wales and Flintshire. This horizon is separated from the overlying Teilia beds by about 700 metres of limestone. (See stratigraphical table p. 373.) The flora of these lower plant-bearing beds will be described in a future memoir, but attention may be called to the fact that *Archaeosigillaria vanuxemi* GÖPP. sp. has been recorded (HIND & STOBBS, 1906) from them and at one locality it occurs in great abundance.

(*b*) ON *Diplopteridium teilianum* KIDSTON SP. (GEN. NOV.)

(1889) *Sphenopteris teiliana,* KIDSTON, p. 424 ; Plate II, fig. 3.
(1923) *Sphenopteris teiliana,* KIDSTON, p. 96 ; Plate II, fig. 5 ; Plate XIX, figs. 6, 6a.
(1926) *Sphenopteris teiliana,* WALTON, p. 212 ; Plate 17, figs. 15–20.
(1928) *Sphenopteridium teilianum,* PATTEISKY, p. 501.
(1929) *Sphenopteridium teilianum,* PATTEISKY, p. 100, Plate V, fig. 2.

In 1926 I described some specimens of fronds of *Sphenopteris teiliana* KIDSTON, from the quarry at Teilia which furnished evidence that the frond of this plant is fundamentally pinnate in structure and that the apparent dichotomy of the main rachis is due to the absence of the apical part of the frond. The available evidence showed that in some fronds a forking rachis destitute of foliage pinnæ and constituting the apical part of the frond was present in the angle of the main fork. This peculiar terminal part of the frond, if found detached, would be distinguished only with difficulty from the fructification rachises referred by KIDSTON (1924) to *Telangium affine* L. & H. sp., in view of its mode of branching and similarly striated surface. In other examples of fronds from the same locality a short, unbranched strap-like appendage is present in the angle of the fork, while in still others there is nothing attached to the frond in this position. I concluded that in some fronds the apex was fertile, in others instead of a fertile apex nothing more than a small sterile continuation of the main rachis was developed, while in yet others the apex aborted after the two main vegetative arms of the frond were produced. Since writing the above account I found a more complete specimen in the collection of Lower Carboniferous plants in the Grosvenor Museum at Chester, and Mr. ALFRED NEWSTEAD, the Curator, kindly gave me permission to examine and describe it.*

The Grosvenor Museum specimen is in two fragments and consists of a piece of thin bedded Teilia Limestone which has been cleft into two pieces. One piece (Plate 23, fig. 1), exhibits the upper and middle part of a frond while the other, the counterpart, has the middle and lower part of the same frond. Photographs of the two pieces were taken and from one an ordinary enlargement was made, but in making the enlargement

* Grosvenor Museum, Chester. No. 7926. Collected by Mr. J. B. SHONE. Another specimen showing the connection between the fertile rachis and the rest of the frond is in the British Museum (V. 2847).

from the other the negative was reversed. The two enlargements were therefore photographs virtually taken from the same side or surface of the frond and, since the middle part of the frond was represented on both, the two could be accurately superposed and the construction of the almost complete frond demonstrated. The outline of the plant was then traced over with waterproof ink and the photograph bleached leaving the outline shown in Fig. 1. This outline drawing therefore summarises the evidence obtainable from the two parts of the specimen.

FIG. 1.—*Diplopteridium teilianum* KIDSTON sp. Outline drawing of specimen described on page 349 in the text. The sporangia are represented in black. Natural size. (Specimen in the Grosvenor Museum, Chester, No. 7926–7.)

The details of construction may be verified by reference to the photographs of the two parts of the specimen (Plate 23, figs. 1 and 2). The main rachis may be seen near the bottom of the figure and there are indications of some of the small pinnae (Plate 23, fig. 2, *f*) which are invariably found attached to it in this species. Where the main rachis forks the continuity of the two vegetative arms and the terminal naked rachis with the main rachis is manifest (Fig. 1 and Plate 23, fig. 2). The two vegetative arms have the same construction as those found on all the other specimens so far discovered. The terminal rachis, which is the distal continuation of the main rachis, forks to form two branches (Fig. 1), about two centimetres above its connection to the rest of the frond in a plane at right angles to the principal plane of the frond and to the bedding plane of the fossil, for one of the branches lies partly below the other and is directed obliquely downwards into the matrix. These two branches are of equal thickness at their junction and so it may be inferred that they were probably of similar construction and of equal size, one projecting on the adaxial and the other on the abaxial side of the frond. The existence of a branching in this plane was suspected from the evidence supplied by one of the specimens previously described (WALTON, 1926). These two divergent branches would not therefore be embedded in the same plane together with the two vegetative arms, and in all the specimens which have been discovered and which have a large part of the naked rachis preserved, only the base of the second of these two branches is ever shown. In all these specimens this branch then forks in a plane which must have been approximately parallel to the plane of the frond and the bedding plane of the fossil and both arms of this second forking are usually clearly represented. In subsequent forkings of these rachises the resulting branches appear to be of equal size, but it is impossible to determine the direction of the planes of the forkings because in some instances these fine branches appear to have twisted in the process of embedding. There is evidence of seven sets of equal forkings so that the number of ultimate branches of the naked rachis may have been as great as 128, and judging from the orientation of the forkings the extremities of the branches must have been situated on an approximately spherical envelope whose centre lay on the principal axis of the frond a short distance above the main fork. The bunch of naked rachises must have had the shape of a small bush.

Another interesting feature exhibited by this specimen is a group of synangia, possibly six in number, lying near the ends of some of the smaller branches of the naked rachis (Fig. 1, and Plate 23, fig. 1, 2, 3, and 4). The synangia are seen to consist of small bunches of elongated sporangia attached to small discs or knobs (Plate 23, fig. 4). The surface cells are seen to be elongated parallel to the long axis of the sporangium. It is not possible to determine with exactitude the number of sporangia in each synangium, but from the appearance of the synangium at the bottom of the group in Fig. 4, it is probable that the number was about eight. It was not possible to extract spores from any of these supposed sporangia.

Clear organic continuity between the synangia and the tips of the branches cannot be demonstrated, but there is no doubt that they belong to the frond among whose branches they lie for the following reasons :—

(*a*) The type of bare, forking rachis forming the apex of the frond may be matched almost exactly with the rachises which bear Telangium-like synangia and which were referred by KIDSTON (1924, p. 447) to *Sphenopteris affinis* L. & H. Moreover this type of slender, forking rachis is as far as the writer knows found only in the fructifications which KIDSTON has called *Telangium affine* L. & H. sp. and *Telangium bifidum* L. & H. sp. A somewhat similar type of rachis has been described by NATHORST (1894, Plate X, fig. 3) from Spitzbergen.

(*b*) These synangia are almost identical in size and form with those found attached to the peculiar rachises and referred by KIDSTON to *Telangium affine* L. & H. sp., as may be seen on comparing them with those figured by KIDSTON (*loc. cit.*). They also compare closely with *Telangium Scotti* as reconstructed by BENSON (1904).

(*c*) The close association of these synangia with the tips of the naked rachis of the frond, apart from these other considerations, would be of little significance in itself were it not that the plants in the Teilia beds are usually widely separate on the bedding surfaces, and rarely are two plant fragments found side by side on the surface of the same fragment.

Taking these pieces of evidence into consideration, there is ample justification for believing that the dichotomously forking rachis on the frond of *Sphenopteris teiliana* is the fertile part of the frond, and that with a very high degree of probability it bore the synangia which are found so closely associated with it.

Sphenopteris teiliana is at present therefore the most completely known frond, from the point of view of external morphology, of any Lower Carboniferous plant. It is highly probable from what is known that it is a Pteridosperm. It is possible that its seeds were borne in cupules on a separate frond, the cupules occupying corresponding positions to the synangia on the microsporangiate frond. In the specimen of *Telangium bifidum* L. & H. sp., which I figured in the previous memoir (1926), a roughly circular group of cupules surrounds the point of junction of the vegetative arms of the frond to the main rachis. I pointed out that the evidence is in favour of the view that these cupules were not attached, as KIDSTON stated, to the pinnæ of the frond. On the other hand, there is a clear suggestion that these cupules were attached to a naked forking rachis which formed the continuation of the main rachis beyond the point at which the two vegetative arms separated.

The peculiar morphological features of the frond of *Sphenopteris teiliana* necessitate the provision of another name of generic rank. As I have suggested, there seems little reason to doubt that this plant bore Telangium-like fructifications, but absolutely clear proof of continuity is lacking. KIDSTON does not appear to be justified in including the fronds of *Sphenopteris affinis* L. & H. in the genus *Telangium* as there is neither evidence of continuity between the sterile fronds and Telangium-like synangia on the one hand nor between any fertile rachis and the sterile fronds on the other. The same applies to *Sphenopteris bifida* L. & H., where nothing more definite than close association connects any fructifications with the sterile frond. Another reasonable objection lies in the fact that the genus *Telangium* was founded by BENSON (*loc. cit.*, p. 162) on petrified material of Upper Carboniferous Age and probably many different families of Pteridosperms had microsporangiate synangia of this type. In spite of this, several species, including those already mentioned of incrustations, have been referred to the genus *Telangium*. CARPENTIER (1928) includes *Sphenopteris striata* GOTHAN, in *Telangium* for, in addition to an almost constant association of the fertile and sterile parts which he considers belong to the same plant, the superficial markings on their rachises are the same. If, however, as CARPENTIER (1915) suspects may be the case, the synangia of *Sphenopteris striata* are bilocular, then a generic name other than *Telangium* must be given to this plant. The relative positions of sterile and fertile parts of the frond of *Sphenopteris striata* have not been determined. On the whole it seems best to avoid the use of the name *Telangium* for these fronds, and refer them to the genus *Sphenopteridium* since their vegetative characters are in agreement with what is found in that form-genus. For *Sphenopteris teiliana,* in which the position of the fertile rachis is known and presents distinctive morphological features, a new name *Diplopteridium* is proposed which may be defined as follows :—

Diplopteridium (gen. nov.). *Fronds, the apical part in fertile examples consisting of a* *dichotomously forking rachis destitute of foliage-pinnæ, or lamina. The main vegetative part of the frond (or the purely vegetative fronds) in two main segments attached to the main rachis at the same level on opposite sides of it just below the position of the fertile apical region. Each segment is tripinnatifid and pinnæ are borne on the main rachis below the level of attachment of the main segments.*

There is one species so far described, *Diplopteridium teilianum* KIDSTON sp. (nov. comb.). Characters those of the genus as defined above and in addition the specific characters enumerated in KIDSTON's diagnosis (1923) of the species.

Several form-genera of Palaeozoic plants which are known to be Pteridosperms have a fork near the base of the frond which divides the vegetative part of the frond into two main divisions. The fronds of the Pteridosperm genera *Neuropteris*, *Alethopteris*, and *Calymmatotheca* have this type of organisation, while *Sphenopteridium*, *Aneimites*, *Adiantites*, *Diplotmema*, *Palmatopteris*, *Mariopteris*, *Callipteris*, and *Eremopteris*, which are suspected of being Pteridosperms, also have it. In the Mesozoic it is found in *Thinnfeldia*, *Dicroidium*, and *Dichopteris*. Attention may be called to specimens of *Sphenopteris Schlehani* and *Sphenopteris Baumleri* figured by GOTHAN (1913) in which there is evidence, very marked in the former, of a scar in the angle of the main fork of the frond. This scar may well represent the position of attachment of a caducous fertile apical region. BUREAU (1914) gives illustrations of *Calymmatotheca tenuifolia* var. *Linkii* and *Diplotmema dissectum* which also furnish evidence of the presence of a bud or continuation of the main rachis beyond the main fork. It is possible that many Palaeozoic fern-like plants bore their fructifications in this position on the frond. It is clear, however, that many bore them otherwise. To take two instances, in *Alethopteris* (HALLE, 1929) and *Neuropteris* (KIDSTON & JONGMANS, 1911), the ultimate ramifications of the frond to which the seeds were attached also bore foliage pinnules, while in *Crossotheca* the microsporangiate fructifications were closely connected with foliage pinnules. ZEILLER (1897) has described an example of *Palmatopteris* in which a forked frond bore fructifications on the upper parts of the two main divisions of the frond and foliage pinnæ towards their bases. In *Calymmatotheca hoeninghausi* BGT. sp. (JONGMANS, 1930), the fertile rachises are very different from the vegetative parts of the frond, but vegetative pinnæ are found attached to rachises which on their higher branches bear cupules, so that the arrangement is different to that in Diplopteridium. There is, however, in *Calymmatotheca hoeninghausi* a clearer distinction between sterile and fertile regions than is exhibited by *Alethopteris* and *Neuropteris*.

(*c*) ON THE FRONDS OF *Adiantites*, *Sphenopteridium*, ETC.

Only important synonymy and references to the more recent literature are given for each species described. The author's name and the year of publication of his work will enable the reader to find the full reference in the bibliography which is given at the end of this memoir.

Adiantites antiquus Ettingshausen sp. (Text-fig. 2.)

(1886) *Adiantum antiquum,* Ettingshausen, C., p. 98, text-fig. 7 ; Plate VII, fig. 1.
(1875) *Adiantides antiquus,* Stur, D., p. 66 ; Plate XVI, figs. 4–6 ; Plate XVII, figs. 3–4.
(1876) *Adiantites concinnus,* Heer, O., p. 9 ; Plate 2, fig. 21.
(1889) *Adiantites antiquus,* Kidston, R., p. 421, Plate 1, fig. 1.
(1914) *Adiantites tenuifolius,* var. antiquus Oberste-Brink, K., p. 90.
(1923) *Adiantites antiquus,* Kidston, R., p. 187, Plate XLV, figs. 1–2.
(1929) *Adiantites tenuifolius* var. *typica,* Patteisky, K., p. 86.

The frond of *Adiantites antiquus* has been described by Kidston and Oberste-Brink as quadripinnate. Two specimens from Teilia one of which is figured here (Fig. 2)

Fig. 2.—*Adiantites antiquus* Ett. sp. Outline drawing of a frond to show the main fork and the relation of the lateral pinnæ to it. The appearance of the rachis at the fork suggests that there might have been a terminal prolongation of the main rachis beyond the fork between the two main divisions of the frond. $\frac{2}{3}$ natural size. (From a specimen in the British Museum, No. V. 2757.)

provide evidence that the main rachis of the frond forks near the base and divides the frond into two, probably equal, parts each of which is quadripinnate. In both these specimens there is the appearance of a scar in the angle of the fork and it is possible that here, as in *Diplopteridium teilianum,* the apex of the frond was fertile and caducous.

Oberste-Brink unites *Adiantites antiquus* Ett. sp. with *Adiantites tenuifolius*

GÖPP. sp., but he figures no intermediate forms and they are distinct species. In *Adiantites antiquus* the ultimate divisions of the frond have very numerous straight veins radiating from the base while in *A. tenuifolius* (*cf.* Plate 26, fig. 31) the veins are more widely spaced and are curved.

Adiantites Machaneki STUR. (Plate 23, fig. 6; Plate 24, fig. 12 and text-fig. 3).

(1875) *Adiantites Machaneki*, STUR, D., p. 68; Plate XVII, figs. 5–6.
(1906) *Adiantites Machaneki*, RENIER, A., p. 154.
(1913) *Adiantites Machaneki*, SMITH, J., p. 141.
(1923) *Adiantites Machaneki*, KIDSTON, R., p. 189; Plate XLVII, figs. 5–6.
(1930) *Adiantites Machaneki*, PATTEISKY, K., p. 88, Plate 8, fig. 7.
cf. (1875) *Adiantites tenuifolius*, STUR, Plate XVI, fig. 3 (not fig. 2).

Fragments of this species are relatively common in the Teilia beds and two specimens have been found which throw additional light on the construction of the frond and show that it is essentially similar to that of *Adiantites antiquus*. One of these specimens (Plate 23, fig. 6) shows part of what is probably the main rachis or petiole. The main rachis bifurcates. Lateral pinnæ arise on the outer side of each of the arms close above the bifurcation and those placed higher alternate in position with them. The pinnæ branch successively to form finally branches of a fifth order which terminate in the characteristic cuneate segments with closely set straight veins.

FIG. 3.—*Adiantites Machaneki* STUR. Fragment of a frond to show the extremely narrow type of ultimate segment. $\frac{2}{3}$ natural size. (From a specimen in the Manchester Museum.)

In general construction the frond is very similar to *Sphenopteridium affine* L. & H. sp. as described and figured by HUGH MILLAR (1857) and later by KIDSTON, but, judging from the available specimens, it differs from the latter in having no pinnæ below the main fork. It also differs in the form of the ultimate foliage segments. In *Adiantites Machaneki* and *A. antiquus* there is a sharp distinction between foliage segment and rachis which bears it, whereas in *Sphenopteridium affine* the rachis gradually broadens out to form the foliage segment, and there are only two or three veins in the ultimate divisions.

There is considerable variation in the size of the segments in *Adiantites Machaneki*; in one specimen (Fig. 3) which resembles most nearly those figured by STUR the segments reach a length of over 20 mm. In another specimen (Plate 24, fig. 12) they are about 10 mm., while in the specimen (Plate 23, fig. 6) which has been already described they are about 5 mm. in length. In all these fronds, however, the segments are, as a rule, only slightly less than three times as long as wide, but sometimes this ratio is greater, as for example in the long narrow segments of the specimen shown in Text-fig. 3, and in the specimens figured by STUR (1875). In contrast to this the length of the segments in all the specimens of *Adiantites antiquus* the writer has examined or which are figured in the literature is less than twice the breadth. The distal margin of the segment in *Adiantites Machaneki* is straight while in *A. antiquus* it is almost always convex.

A specimen of *Adiantites* consisting of two pinnules which agree in detail with the pinnules of *A. Machaneki* is preserved in the KIDSTON collection (No. 2836). It was obtained from the Calciferous Sandstone Series at Ardross in Fife.

Adiantites tenuifolius GÖPP. sp. (Plate 26, fig. 31.)

(1846) *Cyclopteris tenuifolia*, GÖPPERT, Lief. V. and VI., p. 95 ; Plates IV and V, figs. 11 and 12.

(1875) *Adiantites tenuifolius*, STUR, D., p. 65, Plate XVI, fig. 2 (not fig. 3).

(1914) *Adiantites tenuifolius*, var. *tenuifolius*, OBERSTE-BRINK, K., p. 90, Plate IV, fig. 1.

(1923) *Adiantites tenuifolius*, KIDSTON, R., p. 193, Plate XLV, fig. 5, 5A, 6C.

(1929) *Adiantites tenuifolius*, var. *typica*, PATTEISKY K., p. 86.

The fragmentary specimen figured 1·9 × natural size in Plate 26, fig. 31, has several narrow obovate pinnules. Each pinnule is traversed by several slightly flexuous forking veins. OBERSTE-BRINK unites *A. antiquus* with *A. tenuifolius* as varieties of the same species, but the veins in the latter are wider apart and not so straight as in *A. antiquus*. *Adiantites tenuifolius* would seem to be closely related in form to *Adiantites oblongifolius* GÖPPERT (1836), judging from the figures given by GÖPPERT, but there is reason to believe, from stratigraphical as well as from other considerations, that *A. oblongifolius* is a distinct species, probably identical with *Adiantites sessilis* (ROEHL), POTONIÉ (1869). The specimen described here agrees very closely with that figured by STUR.

Adiantites sp. (Plate 23, fig. 5.)

(1889) "*Fructification of a Fern*," KIDSTON, R., p. 426, Plate 2, figs. 8–9.

The specimen figured in Plate 23, fig. 5, from the shape of the pinnules and the suggestion that there are several veins present in each pinnule, must be placed in the genus *Adiantites*. This specimen shows some resemblance to *Adiantites oblongifolius* GÖPP., for there is a trace of what appears to be a main vein near the base of some of the pinnules. In view of the poor preservation there is, however, considerable uncertainty about this important diagnostic feature. *Adiantites oblongifolius* has hitherto only been recorded from a much higher horizon than most of the species which are found in the Teilia Limestone. RENIER (1908) records *A. oblongifolius*, from the Charbonnage de l'Esperance at Badour in Belgium, associated with a mixture of Upper and Lower Carboniferous species. The specimens, which KIDSTON (1889) designates "Fructification of a Fern (?)" belong to the same species as that which is figured here (Plate 23, fig. 5). PATTEISKY (1929) figures a plant under the name *Neuropteris Gothani* which bears some points of resemblance to this specimen in the outline of the pinnules.

Diplotmema dissectum BRONGNIART sp. (Plate 24, fig. 18.)

For references and synonymy see KIDSTON, 1924, p. 248–249.

(1828) *Sphenopteris dissecta,* BRONGNIART, A., p. 183 ; Plate 49, figs. 2–3.
(1913) *Calymmatotheca lineariloba,* BUREAU, Plate XVII, fig. 5.
(1913) *Diplotmema dissectum,* BUREAU, Plate XXII, fig. 1.

It is difficult to separate specifically the specimen figured on Plate 24, fig. 18, from the plant identified by BUREAU as *Calymmatotheca lineariloba* and from *Sphenopteris dissecta* BGT. BUREAU'S plant is of slightly smaller stature than is usual for the species, but the segmentation of the frond and the form of the segments is similar.

Diplotmema bermudensiforme, forma *typica,* KIDSTON. (Plate 24, figs. 16–17.)

(1875) *Sphenopteris distans,* STUR, p. 23, Plate VI, figs. 2–5.
(1876) *Sphenopteris distans,* HEER, p. 8, Plate II, figs. 1–6.
(1877) *Diplotmema distans,* STUR, p. 243, Plate XV, 2, 3, 4, not 5. Plate XVII, fig. 1.
(1877) *Diplotmema Schonknechti,* STUR, p. 246, Plate XIV, figs. 7–8.
(1897) *Sphenopteris distans,* ZEILLER, p. 196.
(1913) *Diplotmema distans,* BUREAU, Plate XIX, figs. 1–3A.
(1913) *Diplotmema bermudensiforme,* GOTHAN, p. 73, Plate XV, fig. 5.
(1923) *Diplotmema bermudensiforme,* f. *typica,* KIDSTON, p. 250, Plate LXVII, figs. 3, 3A.
(1923) *Sphenopteris Schonknechti,* KIDSTON, p. 116.

Two small fragments which may be referred to this species are figured in Plate 24, fig. 16, 17. They can be matched most nearly with the plants described by STUR and BUREAU under the name *Sphenopteris* (*Diplotmema*) *distans* and by KIDSTON as *Diplotmema bermudensiforme* f. *typica.* The pinnules in this form are usually trilobed, a feature shown clearly on the smaller of the two fragments. The other specimen shows a bifurcation of the rachis. The two species *Diplotmema distans* STUR, and *D. Schonknechti* STUR, appear to be indistinguishable. STUR gives as the distinguishing characteristics the absence of hairs on the rachis of *D. Schonknechti,* which has also smaller fronds and small terminal obcordate segments. However, several of the specimens he figures of *D. distans* have no hairs, while one at least (his Fig. 4) has obcordate segments. The size of the frond could not be estimated from any of the specimens he figures.

ZEILLER described some large specimens of *Sphenopteris distans* from the Culm of Teflenli and Kilimli in Asia Minor. One of these consisted of a large axis 12–25 mm. wide bearing alternate laterals. These laterals forked at an angle of 35–40°. Their two branches curved towards one another farther up and bore the foliage pinnæ.

KIDSTON records the occurrence of *D. bermudensiforme* f. *typica* from the Lower Limestone Group of the Carboniferous Limestone Series and *D. Schonknechti* from the Calciferous Sandstone Series. It is suggested by KIDSTON that *D. bermudensiforme* f. *Geinitzii* may be a distinct species, and judging from the figures his suggestion seems to be justified.

Sphenopteridium capillare sp. nov. (Plate 24, figs. 9, 10, 11; text-fig. 4.)
(1886) *Sphenopteris moravica,* KIDSTON (non ETTINGSHAUSEN) p. 82.

This species is founded on two specimens from Teilia, one of which exhibits a considerable portion of a frond, mainly the upper parts, the other specimen showing the petiole. These two specimens taken together probably give a complete picture of the structure of a vegetative or sterile frond, or perhaps the vegetative part of a frond from which the fructification has fallen. There is no evidence besides the presence of a fork in the main rachis to suggest that any structure similar to the fertile rachis in *Diplopteridium teilianum* was ever attached to this frond.

In Plate 24, fig. 10, the organisation of part of one of the arms of the frond is seen in detail. It will be noticed that the divisions of the basal secondary pinnæ spread laterally and overlap the main rachis of the arms of the frond. The veins are not distinct from the lamina and it is probable from the narrowness of the segments that only one vein was present in each. The main rachis below the fork (Fig. 4, and Plate 24, fig. 11) shows faint transverse striations and is furnished at the base where it widens out near its point of attachment to the stem with several closely placed stipular pinnæ.

The species shows many points of resemblance to *Sphenopteridium rigidum* LUDWIG sp. It differs mainly in the closer setting of the pinnæ on the main rachis, the overlapping of the rachis, higher up the frond, by the basal secondary pinnæ, and in the more widely spaced ultimate segments. It resembles it in the striated rachis and in the general build and character of the frond. *Sphenopteridium Schimperi* GÖPP. sp. is also a fairly closely related form. In the narrow ultimate divisions *S. capillare* approaches in its characters some of the species which have been included in the genus *Rhodea* PRESL. *e.g., R. moravica,* STUR, and in *Sphenopteris, e.g., S. Jedlitschkai* PATTEISKY (1929). The ultimate divisions however, have blunt apices unlike the typical acute apices of *Rhodea,* and from other considerations to which reference has already been made it must be placed in the genus *Sphenopteridium.*

Another example of *Sphenopteridium capillare* (Plate 24, fig. 9) collected by C. PEACH from the Calciferous Sandstone Series at Burntisland in Scotland, and now in the collection at the British Museum (V. 9404), was identified by KIDSTON (1886) as *Sphenopteris moravica.*

Specific Diagnosis.

Sphenopteridium capillare WALTON. *Frond quadripinnate. Main rachis forks dividing the upper part of the frond into two equal divisions. Primary pinnæ alternate, attached to the main rachis and to the two divisions. The primary pinnæ, on the upper*

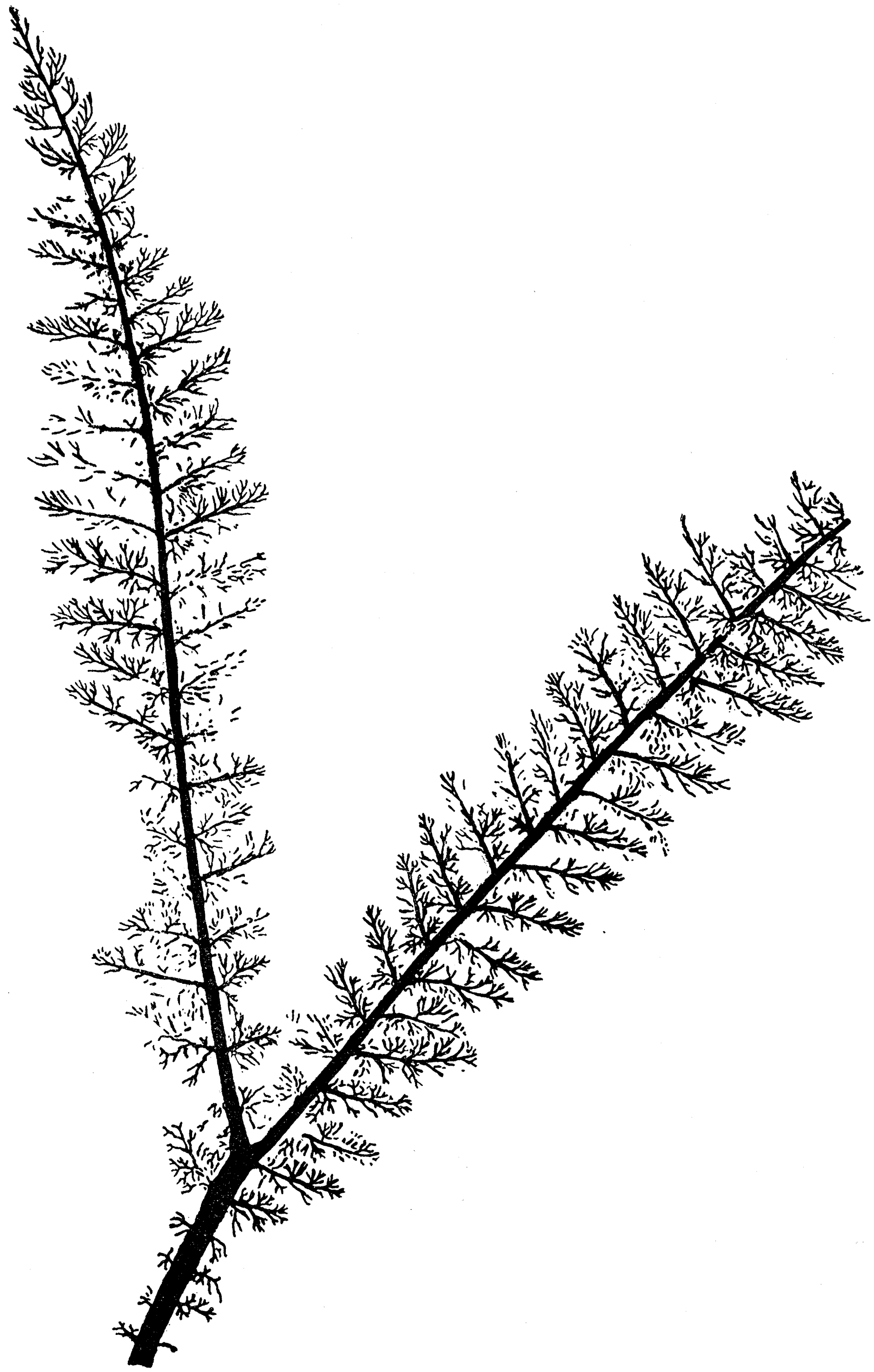


FIG. 4.—*Sphenopteridium capillare* sp. nov. Drawing of an almost complete frond, showing part of the main rachis with pinnæ. $\frac{2}{3}$ natural size. (From a specimen in the Manchester Museum.)

part of the frond, bear about ten secondary pinnæ. The secondary pinnæ have a sympodial organisation like the primary pinnæ and their lateral divisions are dissected into two or three narrow linear segments about 0·5 *mm. in width with blunt apices.*

Sphenopteridium pachyrrachis Göpp. sp. (Plate 25, figs. 21, 22 and 23.)

For references and synonymy, see Kidston, R., 1923, p. 164.

(1929) *Sphenopteridium pachyrrachis*, Patteisky, K., p. 93, Plate 4, fig. 5.

Kidston records *S. pachyrrachis* var. *stenophylla* Göpp. sp. from Teilia, and I have been able to confirm this record. The specimen figured in Plate 25, fig. 23, represents part of a primary pinna which in its narrow, deeply dissected segments agrees closely with some of the specimens figured by Kidston (1923). This variety *stenophylla* is, however, uncommon in the Teilia beds ; the commonest form is illustrated in Plate 25, figs. 21 and 22, and is characterised by the extreme narrowness of the pinnæ near the apex of the frond, and by the rounded extremities of their ultimate segments. The ultimate segments in var. *stenophylla* are angular or pointed.

The specimen figured in Plate 25, fig. 21, shows the upper regions of a frond. The counterpart of this specimen showed about three centimetres more of the main rachis. There is no indication of pinnæ on the main rachis below the fork and the frond differs in this respect from all other known examples of *Sphenopteridium* fronds. The pinna attached on the right-hand side of the base of the right-hand division of the frond agrees in form with the pinnæ of the var. *stenophylla*. The segments at the top of this specimen show the extremely narrow form.

Sphenopteridium crassum Lindley and Hutton sp. (Plate 25, fig. 24.)

For references and synonymy see Kidston, R., 1923, p. 168.

(1929) *Sphenopteridium crassum*, Patteisky, R., p. 96, Plate 10, fig. 2.

The small fragment figured in Plate 25, fig. 24, is referred to this species, with which it agrees in venation and form of pinnules.

The two species *Sphenopteridium pachyrrachis* and *S. crassum* are very closely related and may even represent extreme forms of the same species. Kidston in his account of the Teilia flora in 1889 writes, " the whole matter of the affinities of these ferns to each other requires to be carefully gone into." If the diagnoses of the two species given in the memoirs in 1923 be compared it is clear that he finds considerable difficulty in formulating the differences. The pinnules of *S. crassum* are smaller and broader than those of the other and those on the higher part of the frond are more elongate and rhomboidal.

Sphenopteridium has hitherto only been recorded from the Oil Shale Group of the Calciferous Sandstone Series.

Rhodea tenuis Gothan. (Plate 24, figs. 13, 14 and 15.)

(1876) *Sphenopteris frigida*, Heer, O., p. 6, Plate I, fig. 2 ; *cf.* figs. 1, 3, 4, 5, and 6.

(1894) *Calymmatotheca bifida*, Nathorst, G., p. 19, Plate 3, figs. 1, 2, and 3.

(1913) *Rhodea tenuis*, Gothan, W., p. 15, Plate 2, fig. 2 ; Plate 3, figs. 1, 2, and 3.

(1923) *Rhodea tenuis*, Kidston, R., p. 229, Plate LIX, fig. 7 ; Plate LXI, fig. 2.

(1928) *Diplotmema subgeniculatum*, Walton, J., p. 744.

Rhodea tenuis is one of the commonest plant-fossils encountered in the Teilia Limestones. Small detached pinnæ are abundant on some surfaces, where they are mixed up with detrital remains of other plants and animals. Such surfaces covered with numerous very small fragments undoubtedly represent periods of slower sedimentation during which relatively larger quantities of vegetable fragments had time to accumulate and settle down.

Considerable variation in form is shown by the specimens grouped in this species ; in some the ultimate segments are exceedingly long and narrow (Plate 24, fig. 14), while in others the segments are shorter and broader and show a tendency to be webbed (Plate 24, fig. 13). Both these types are illustrated in the figures accompanying GOTHAN's description of the species (1913) and are found in the Teilia beds.

KIDSTON records the species from the Burdiehouse Limestone Oil Shale Group. Calciferous Sandstone Series.

Spathulopteris Ettingshauseni FEISTMANTEL sp. (Plate 24, figs. 7–8.)

(1873) *Sphenopteris Ettingshauseni*, FEISTMANTEL, O., p. 505, Plate XIV, fig. 8, 8A, Plate XV, figs. 9, 9A.

(1875) *Sphenopteris Ettingshauseni*, STUR, D., p. 29, Plate VI, fig. 9; Plate VII, figs. 1–2.

(1914) *Sphenopteridium Ettingshauseni*, OBERSTE-BRINK, K., p. 88.

(1923) *Spathulopteris Ettingshauseni*, KIDSTON, R., p. 177, Plate XLIII, fig. 2.

(1929) *Spathulopteris Ettingshauseni*, PATTEISKY, K., p. 107, Plate 7, fig. 1 ; Plate 11, fig. 1.

The specimen figured on Plate 24, fig. 7, suggests that there were no pinnæ on the rachis below the fork. In another specimen about 9 cms. of a similar rachis are preserved and show no pinnæ. There are, therefore, grounds for believing that the frond of this species was organised in much the same way as the fronds of *Adiantites antiquus* and *A. Machaneki*. Several fragments have been found at Teilia, but the specimen shown in Plate 24, fig. 7, a form not hitherto found in Britain, illustrates best the characteristically closely set, rhomboidal pinnæ. Another specimen (Plate 24, fig. 8) is remarkable for the extremely slender form of the ultimate segments.

OBERSTE-BRINK places the species in *Sphenopteridium*, but there is no evidence of the presence of sclerotic bars in the cortex of the rachis and there seem to be no pinnæ below the fork. For these reasons it is best to separate it from the forms grouped in *Sphenopteridium*. KIDSTON places it in *Spathulopteris* on account of its resemblance to *Spathulopteris obovata*, in which the ultimate segments have much the same form. In *Spathulopteris* there are no pinnæ below the fork.

Spathulopteris clavigera KIDSTON sp. (Plate 24, fig. 19 and Fig. 5.)

(1894) *Sphenopteris Gersdorfi*, KIDSTON, R., p. 241.

(1923) *Sphenopteris clavigera*, KIDSTON, p. 142.

(1928) *Spathulopteris clavigera*, WALTON, p. 744.

The small fragment of a frond figured twice natural size in Plate 24, fig. 19, corresponds exactly with KIDSTON's description of *Sphenopteris clavigera*. He describes the secondary pinnæ as follows:—"Alternate, narrow deltoid, rachis stout, straight, with 2–4 pairs of pinnules. Pinnules alternate, clavate, very small and of firm texture, basal 1–3 lobed, lobes deeply separated, segments clavate; upper pinnules simple. Nervation is obscure."

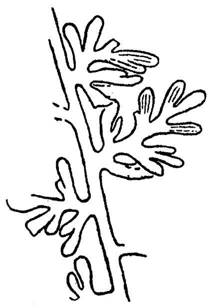


FIG. 5.—*Spathulopteris clavigera* KIDSTON. Small fragment to show the form and venation of the ultimate segments. × 2 natural size. (From a specimen in the Manchester Museum.)

In the Teilia specimen there is very definite indication of from 1–3 veins in each ultimate segment or pinnule which tend to run parallel to the sides of the pinnule as in other species of *Spathulopteris* (Fig. 5).

I have also identified this species in a small collection of fossil plants sent to me by Mr. W. S. BISAT from Keasden Beck, Clapham, Yorkshire. The horizon from which this specimen was obtained is characterised by the goniatite *Anthracoceras glabrum* and is, according to Mr. BISAT, equivalent to a horizon low down in the Upper Limestone Series in Scotland.

Rhacopteris Machaneki STUR. (Plate 25, fig. 20.)

(1875) *Rhacopteris Machaneki*, STUR, D., p. 75; Plate VIII, fig. 4.

The specimen on which the record of the occurrence of this species at Teilia is based is figured on Plate 25, fig. 20. The specimen shows that the veins in the pinnules all tend to pass from the base of the pinnule in an anadromic direction towards the forward margin. The pinnules are more elongated than in *R. inaequilatera* GÖPP., and *R. Lindeaeformis* BUNB., and, unlike these two species, the terminal pinnules are very different from those attached lower down on the frond. In this variation in form of the pinnules on the same frond it compares with some other species in the genus especially with such a form as that described by me in an earlier memoir under the name *Rhacopteris cf. petiolata* GÖPP. sp. (1926). The specimen probably represents an almost complete frond, for the lowest pinnules represented are in their narrow form very similar to those near the apex.

Rhacopteris circularis WALTON.

(1926) *Rhacopteris circularis*, WALTON, J., p. 208, Plate 16, figs. 5, 6, 7 and 8; Plate 17, figs. 13 and 14.

This species has been recorded only from Teilia. It is very closely allied to *R. inaequilatera*, GÖPP. and *R. lindseaeformis*, BUN.

Rhacopteris fertilis WALTON.

(1926) *Rhacopteris fertilis*, WALTON, J., p. 205, Plate 16, figs. 2, 3 and 4.

Only one example of this species is known; it probably represents the fertile frond of one of the other species, perhaps *R. circularis*. This specimen was found in the quarry at Teilia.

Rhacopteris petiolata GÖPP. sp.

For synonymy and description of specimens found at Teilia see WALTON, J., 1926, p. 209.

Rhacopteris robusta KIDSTON.

(1923) *Rhacopteris robusta,* KIDSTON, p. 216, Plate 51, figs. 5, 6 and 7.

(1926) *Rhacopteris cf. petiolata,* WALTON, J., p. 210, Text-fig. 1, Plate 16, fig. 10 and Fig. 12.

(1929) *Rhacopteris robusta,* PATTEISKY, K., p. 112, Plate 6, fig. 1.

From a comparison between the examples of this species figured by KIDSTON and PATTEISKY and those of the specimens from Teilia which I have already described and figured under the name of *Rhacopteris cf. petiolata,* I now consider that they all belong to one species, *R. robusta,* KIDSTON.

R. circularis, R. inaequilatera, R. lindseaeformis, those specimens described by me as R. *cf. petiolata, R. robusta,* and *R. petiolata* GÖPP., form an almost continuous series and it is sometimes difficult to draw a sharp line between the species. There is no doubt about the specific identity of the specimens described by PATTEISKY from Silesia with those from Teilia.

Sphenopteris obfalcata sp. nov. (Plate 25, fig. 27 and Text-fig. 6.)

Numerous specimens have been found at Teilia of the plant on which this new species is established. There is very considerable range in form in the ultimate segments of the frond. The frond is at least tripinnate, some of the fronds having a petiole with a slightly expanded base bearing pinnæ similar to those figured in Plate 25, fig. 27, where four almost complete examples are to be seen. In Text-fig. 6, a single secondary pinna from another specimen is drawn in outline. The ultimate segments, as is shown in the photograph and the Text-figure, are curved in the plane of the frond towards the apex of the pinna or secondary pinna which bears them. The apex of each segment is rounded and the broadest part of the segment is just behind the apex. No examples of rachises forking into equal or approximately equal arms have been observed among the numerous examples of this species which have been examined. The fronds, all of which appear to be sterile, are constructed on a pinnate system. In some respects, for example in the form of the ultimate segments and the somewhat lax habit of the frond, this species approaches the forms grouped in the genus *Spathulopteris*. But the curvature of the pinnule segments seems to be a constant character and, in view of the fact that in *Spathulopteris* the frond forked near the base, it seems advisable to retain this

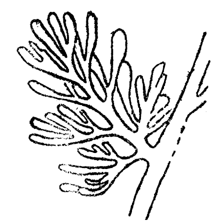


FIG. 6.—*Sphenopteris obfalcata* sp. nov. Single pinna to show the form and arrangement of the ultimate segments. Natural size. (From a specimen in the Manchester Museum.)

species provisionally in the form genus *Sphenopteris*. In some examples found at Teilia the ultimate segments are even smaller and narrower than those figured here.

Specific diagnosis.

Sphenopteris obfalcata sp. nov. *Frond tripinnate. Petiole straight or with a uniform curvature in one direction. Primary pinnæ narrow deltoid, obtuse. Secondary pinnæ deltoid. The ultimate segments are falcate and widest just behind the apex, which is rounded. Venation obscure.*

Sphenopteris cf. filiformis KIDSTON.

The specimen (The Manchester Museum, No. L.12094) which I am inclined to refer to this species is in general appearance very similar to the plant described by KIDSTON under this name (1923). The rachis is longitudinally striated as well as the rachises of the next order. The fragment is at least tripinnatifid. The ultimate divisions of the frond have rounded extremities and measure from 0·5–1·0 mm. in width. Most of the segments appear to be uninerved. The branches and segments of the frond are all curved over in the same direction as in the specimen described by KIDSTON, who attributed this to some mechanical cause such as a water current. I am inclined to think that *Sphenopteris filiformis* KIDSTON represents nothing more than an immature frond of some other better defined genus such as *Adiantites* or forms such as *Sphenopteris affinis* L. & H. Soft immature segments of a fallen and wilted frond would be easily deflected by current action before being completely buried in the mud.

KIDSTON records the species from the Cementstone Group, Calciferous Sandstone Series, Scotland.

Neuropteris antecedens STUR. (Plate 25, figs. 25 and 26.)

(1866) *Neuropteris Loshii,* ETTINGSHAUSEN (non BRONGNIART), p. 5, Plate VI, fig. 2.

(1866) *Neuropteris heterophylla,* ETTINGSHAUSEN (non BGT.), p. 96, Plate VI, fig. 1 and Text-fig. 4.

(1875) *Neuropteris antecedens,* STUR, D., p. 53–56, Plate XV, figs. 1–6.

(1884) *Neuropteris antecedens,* STERZEL, T., p. 207, Plate figs. 2A–2H.

(1913) *Neuropteris antecedens,* GOTHAN, W., p. 198, Plate XLVI, fig. 6.

(1914) *Neuropteris antecedens,* OBERSTE-BRINK, K., p. 125, Plate VI, fig. 1.

(1924) *Neuropteris antecedens,* GOTHAN and SCHLOSSER, p. 7, Plate VI, fig. 3.

(1930) *Neuropteris antecedens,* PATTEISKY, K., p. 158, Plate 6, fig. 2, Plate 7, fig. 2.

Only two fragments of this interesting species were found. They are both figured in Plate 25 (figs. 25–26). Owing to imperfections in the preservation the outlines of the pinnules are not distinct. Apparently only the lignified tissues in the veins are represented by carbonaceous residues. The details of the venation are, however, sufficiently clear to afford a means of comparison with the figures which accompany the original description. The venation is open and there is a main vein in each pinnule. This is clearly shown in the pinnules at the base of Fig. 25. In the pinnules at the top of the figure, however, there is not quite such a sharp distinction between main and lateral veins.

There are specimens of this species in the Kidston Collection at the Geological Museum, London, from Limekilns, East Kilbride, Lanarkshire, Carboniferous Limestone Series (No. 709); from the "River Noe, between the Viaduct and Back Tor Bridge, Edale, Derbyshire" (No. 3310); and a third from "beach below promenade and west of barricades, North Sands, Tenby, Wales" (No. 4836)

(*d*) Fructifications.

Calathiops Göppert.

(1865) *Calathiops*, Göppert, H. R., p. 268.
(1873) *Psilophyton*, Feistmantel, O. (non Dawson), p. 541.
(1914) *Pterispermostrobus*, Stopes, M. C., p. 74.
(1915) *Telangium*, Arber, E. A. N. and Goode, R. H., p. 99.
(1924) *Pterispermostrobus*, Kidston, R., p. 473.
(1924) *Calathiops*, Gothan, W., and Schlosser, P., p. 5.
(1927) *Calathiops*, Gothan, W., p. 4.
(1929) *Calathiops*, Carpentier, A., p. 47.
(1929) *Calathiops*, Patteisky, p. 165.

cf. Calathiops Göppert.

(1915) *Xenotheca*, Arber, E. A. N., and Goode, R. H., p. 96.

The genus was instituted by Göppert in 1864 for some fructifications of Lower Carboniferous Age from the Culm of Rothwaltersdorf in Lower Silesia. In a recent memoir on some fructifications of the same age from Vogtland, Gothan (1927) discusses the relation of *Calathiops* to *Schuetzia* Geinitz and *Alcicornopteris* Kidston, and gives accurate descriptions of these interesting fructifications about whose affinities so little is known. The name *Calathiops* was given originally to specimens which were described as consisting of small bunches of linear scale-like appendages borne on the ends of rachises which fork, usually dichotomously, and are destitute of foliage pinnules. It has not been demonstrated whether these structures are microsporangia or sporophylls or whether they merely represent some form of investment which originally surrounded a seed or microsporangia. Göppert did not demonstrate clearly that these structures are in a whorl, surrounding a central space, as was implied in the original description of the genus. Stopes (1914) employed the name *Pterispermostrobus* for fructifications, closely similar to *Calathiops* as figured and described by Göppert, which she concluded were either seeds or male organs and which were borne on naked forking rachises. There is no essential difference between these two form genera, and, since *Calathiops* has undoubted priority, it should be used for this type of fructification. The plant fragment referred by KIDSTON (1924) to *Pterispermostrobus* is included more conveniently in *Calathiops*.

Calathiops is merely a provisional form-genus for a certain type of fructification of indeterminable nature. It is quite possible that better preserved examples of some of the plants at present included in *Calathiops* may give information which will make it possible to transfer them to some such genus as *Alcicornopteris* KIDSTON (1924). In *Alcicornopteris* there is evidence that the linear appendages are microsporangia so that the bunches of appendages constitute synangia. KIDSTON uses the name *Schuetzia* GEINITZ (1863) for fructifications of Lower Carboniferous Age closely similar to those of *Alcicornopteris*. The genus *Schuetzia* was originally instituted for some fructifications of Permian Age consisting of racemose bunches of microsporangiate cones which SCHUSTER (1911) considers to be the fructifications of a plant with foliage of a coniferous type, and very similar to *Walchia*. It is clear that the plant *Schuetzia Bennieana* KIDSTON (*loc. cit.*, p. 425) bears no relation to these Permian fossils and should be placed in the genus *Alcicornopteris* with which it is clearly closely related.

Calathiops acicularis GÖPPERT. (Plate 26, fig. 35.)

(1865) *Calathiops acicularis*, GÖPPERT, H. R., p. 269 ; Plate LXIV, fig. 7.

cf. Calathiops acicularis GÖPP.

(1915) *Xenotheca devonica* (pars) ARBER, E. A. N. and GOODE, R. H., p. 97 ; Plate IV, fig. 5.

The specimen shown in Plate 26, fig. 35, compares with GÖPPERT's illustration of *Calathiops acicularis* in possessing bunches of pointed, linear appendages borne terminally on bare, forking rachises. The shape and size of these appendages is also in close agreement with those shown by GÖPPERT. In his Fig. 7 there is a very clearly defined group of three bunches, a central one, and a shortly stalked one on each side of it. A similar group is seen on the right-hand side of the specimen found at Teilia (Plate 26, fig. 35), but here the stalks of the two lateral bunches are not quite so distinct.

I have no hesitation, therefore, in assigning this specimen to GÖPPERT's species. It is much smaller in dimensions than the plant from Vogtland which GOTHAN and SCHLOSSER (1924) referred tentatively to *Calathiops acicularis*, but which was later identified by GOTHAN (1927) as *Calathiops* (*Alcicornopteris*) *Zeilleri* VAFFIER sp. It is considerably larger than the specimen which KIDSTON refers to *Pterispermostrobus* (1924) from the Calciferous Sandstone Series at Dumbartonshire in Scotland ; the latter in dimensions according more closely with a *Telangium*.

The nature of the appendages on the Teilia specimen cannot be determined, for no spores or membranes are preserved. They might be microsporangia, for microsporangia of this size and shape are found in *Alcicornopteris* ; on the other hand, CARPENTIER (1929) has shown that certain fructifications, which he refers to *Sphenopteris striata* GOTHAN, consist of seed cupules with long, sharp-pointed segments which without the presence of a seed, for some have been found with a seed in them, would probably be taken for bunches of microsporangia.

One of the fructifications described by ARBER and GOODE (1915) from rocks of supposed Devonian Age in North Devon, and named by them *Xenotheca devonica*, consists of a single bunch of linear appendages apparently joined together at the base but otherwise resembling in form and dimensions the specimens here referred to *Calathiops acicularis*.

Calathiops glomerata sp. nov. (Plate 26, figs. 32, 33, and 34.)

This species is of larger dimensions than *C. acicularis* GÖPP., but is not nearly so large as *C. beinertiana* GÖPP., or any other species hitherto described. No information is given by any of the specimens which are grouped under this specific name as to the nature of these fructifications or of the plants to which they belonged. In Plate 26, fig. 34, at *a* some of the appendages are separate from one another and may be seen to be about 1 mm. broad.

Specific diagnosis.

Calathiops glomerata sp. nov. Fructifications consisting of bunches (about 10 mm. long by 4 mm. wide) of linear appendages which are usually closely pressed together or united. The appendages are at least 5 mm. long and 1 mm. wide. The bunches are attached to smooth, occasionally forked rachises which may attain a diameter of 2·5 mm.

Calathiops renieri sp. nov. (Plate 26, fig. 36.)

The remarkable fructification figured in Plate 26, fig. 36 is one of two similar specimens found at Teilia, that figured being the largest and most completely preserved. In both specimens the large tulip-like structure appears to consist of flattened scales or of a cup-shaped structure which has been split into separate parts. There is evidence of two layers of carbonaceous matter which supports this interpretation of the fossil. The surface is coarsely striated and the striations appear to be due to the presence of strands or fibres of more resistant tissue which have been isolated by partial maceration before fossilisation was effected. The obliquity of the pedicel to the axis of the other part of the fossil would appear to be an original feature, for it occurs in the other specimen as well. Professor RENIER interpreted this fossil as a cup-shaped fructification, for he suggested a comparison between it and the Pteridosperm fructifications *Potoniea* and *Whittleseya*; however, in view of the absence of any evidence to show whether it represents a microsporangiate fructification of the *Whittleseya* type or a large seed cupule, I have placed it provisionally in the genus *Calathiops*.

Specific diagnosis.

Calathiops renieri sp. nov. *Fructification consisting of a bunch or cup-shaped group of broad scales attached to a short stalk. The axis of the bunch inclined at an angle of about* 45° *to the stalk. Fructification about* 4·5 *cm. long and* 2·7 *wide; stalk* 4·0 *cm. long and* 0·3 *wide.*

Fructification A. (Plate 26, fig. 37.)

This small fragment probably represents two groups of microsporangia attached to a slender rachis. A peculiar feature is that the supposed sporangia are attached at right angles to the axis of the short pedicels which bear them. This peculiarity suggests a comparison with those Upper Carboniferous microsporangiate fructifications which are grouped in the genus *Crossotheca.*

Fructification B. (Plate 26, fig. 38.)

The fossils shown in Plate 26, fig. 38, may be bilobed scales or possibly winged seeds. Since there is nothing but a thin film of carbonaceous material it is impossible to be sure which of these possibilities is right. Another specimen was found at Teilia consisting of irregular groups of these structures surrounding parts of a smooth rachis which showed evidence of branching. A third specimen, also consisting of groups of these structures, is preserved in the Sedgwick Museum at Cambridge with a label stating that the specimen came from Denbighshire. The matrix in which the Cambridge specimen is embedded is a very hard black limestone.

Holcospermum ellipsoideum GÖPP. sp. (Plate 26, figs. 40, 40A.)

(1852) *Trigonocarpum ellipsoideum,* GÖPPERT, H. R., p. 250, Plate XLIV, fig. 7.
(1860) *Trigonocarpum ellipsoideum,* GÖPPERT, H. R., p. 567.
(1901) *Semina* (pars) POTONIÉ, H., p. 150, fig. 99A.

cf. Holcospermum ellipsoideum GÖPP. sp.

(1876) *Rhyncogonium globosum,* HEER, O., Plate V, figs. 1–2.
(1876) *Rhyncogonium crassirostre,* HEER, O., Plate V, fig. 4.
(1876) *Rhyncogonium costatum,* HEER, O., Plate V, figs. 6–11.

Several seeds of the type figured in Plate 26, fig. 40, have been found at Teilia. They are oval in shape and have five apparently equal ribs extending from the base to the apex. It seems most likely that these ribs belong to one side of a compressed seed and that there were as many on the other side of the seed. The two edges of the fossil would also represent ridges so that the seed in its uncompressed state had probably about twelve ribs. The five best preserved examples vary slightly in size, the largest is 9·5 mm. by 16·0 mm., and the smallest 7 mm. by 11 mm. In the specimen on Plate 26, fig. 40, some of the ribs are seen to terminate in small teeth which form the beak of the seed. Seeds attributed to the genus *Rhyncogonium* HEER (1876) and *Boroviczia* ZALESSKY (1905) show some general features of similarity to this type of seed, but in these genera the ribs when visible are in line with the sinuses between the teeth, which are longer than those of the Teilia seeds. These seeds appear to be identical with the seed described and figured by GÖPPERT under the name *Trigonocarpum ellipsoideum,* and it is noteworthy that his seed was found associated with *Asterocalamites scrobiculatus, Sphenopteridium pachyrrachis,* and *Rhacopteris petiolata* in *Posidonomya* beds. Similar seeds have been described by POTONIÉ from the Harz and Magdeburg Culm, and others of much the same type by BUREAU (1914) from the " Culm Superieur " in the Lower Loire. It is possible that this species merely represents a state of preservation of a seed which, if better preserved, might have been placed in either *Rhyncogonium* or *Boroviczia,* but which in view of its poor preservation must be classed in the genus *Holcospermum,* NATHORST (1914).

Carpolithes sp.

The seed figured in Plate 26, fig. 41, shows a differentiation into a sheath-like integument (or perhaps cupule) and a basal region occupied by a concretionary mass. The former is finely striated longitudinally (Plate 26, fig. 41A). The concretionary mass probably represents material which has filled the space originally occupied by the nucellus or prothallus of the seed.

This seed bears some points of resemblance to *Rhyncogonium crassirostre* HEER.

(*e*) PTERIDOPHYTA.

Equisetineæ.

Asterocalamites scrobiculatus SCHLOTH. sp. (Plate 26, fig. 39.)

For references and synonymy see :—

(1886) KIDSTON, R., p. 35, 36, and 37.
(1927) HIRMER, M., p. 377.
(1929) PATTEISKY, K., p. 169.

Several specimens belonging to this species were found at Teilia. The most interesting of these (Plate 26, fig. 39) consists of a branch bearing the characteristic forked leaves. There are five leaf-bearing nodes shown. There were probably about twelve leaves borne at each node. Each leaf is forked about 15 mm. above its base into two equal parts, each of which is again forked further up so that there are four equal terminal segments in each leaf. The pointed ends of some of the segments may be seen at the top of the figure on the left. This specimen is closely similar to some of those figured by STUR (1875).

Another specimen (Manchester Museum, No. L.12093), consisting of a relatively stout stem, exhibits a branch scar above each of the three nodes. The stem (? pith cast) is about 5 cm. wide and 19 cm. long. The branch scars are arranged spirally on the stem. This specimen compares very closely with that figured by POTONIÉ (1901) from the Culm of Magdeburg. One example of a detached leaf shows the presence of a median ridge down the centre of each division of the leaf.

Distribution.—A. scrobiculatus is recorded by KIDSTON (M.S. Geol. Surv. and Museum, London) from all the divisions of the Lower Carboniferous in Scotland. More than 60 per cent. of the localities from which it is recorded are in the Oil Shale Group, Calciferous Sandstone Series.

Lepidodendraceæ.

Lepidodendron cf. calamitoides NATHORST. (Plate 26, fig. 30.)

The leaves on this fragment of a *Lepidodendron* are exceedingly narrow and are less than 1 mm. broad. They stand out at right angles to the axis. Some of the leaves appear to have a wider region just at the base where they are attached to the stem. The leaf cushions on the stem are very small, they are diamond shaped and measure approximately 3–4 mm. in length and about 1 mm. in width. The leaf scar is not distinguishable. This leafy shoot bears a close resemblance in habit and dimensions to *Lepidodendron calamitoides* NATHORST, and the very similar species L. *Nordenskioldi* NATHORST (1920). It bears some points of resemblance, especially in the narrow form of the leaves, to *L. corrugatum,* DAWSON (1873). Unfortunately the leaf-cushions are not sufficiently well preserved for one to be quite certain about the identity of this specimen.

Lepidodendron cf. obovatum, STERNBERG.

The plants in the Teilia Limestones are preserved in the form of very low relief incrustations and so there is considerable difficulty in identifying species of a genus such as *Lepidodendron* where features of surface relief may be important diagnostic characters. The specimen shown on Plate 25, fig. 28, might belong to one of several species, but, according to Dr. W. J. JONGMANS, it most closely resembles *L. obovatum* STGB.

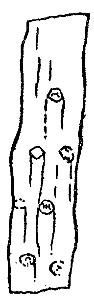


FIG. 7.—*Sigillaria* sp. Drawing of a small fragment to show the form and arrangement of the leaf-scars. Natural size. (From a specimen in the Manchester Museum.)

Sigillaria sp. (Fig. 7.)

Fig. 7 illustrates the main features of a small specimen of an axis on which there are visible some small leaf scars of the Sigillaria type. Each scar has below it a decurrent cushion. The form and arrangement of the scars is very like that found in *Sigillaria euxina* ZEILLER, and there is close resemblance to the figure of the specimen from the Mines d'Aniche given by CARPENTIER (1913) under the name *Sigillaria f. euxina* ZEILLER.

(*f*) THE FLORA OF THE TEILIA LIMESTONES COMPARED WITH SOME OTHER LOWER CARBONIFEROUS FLORAS.

In 1889 KIDSTON had already recognised the relationship between the flora found in the Teilia Limestones, from the few specimens that he had at his disposal, and the flora of the Calciferous Sandstone Series in Scotland. The species recorded since then both of animal and vegetable fossils have fully justified this comparison and have at the same time made clear the close relationship which exists between this fauna and flora and those of certain parts of the Lower Carboniferous Succession in Silesia.

TABLE I.—List of Plant Species found at Teilia with Records of their Occurrence in Some other Localities.

—	Scotland.				Isle of Man.	Silesia.					Chemnitz-Hainchen.	Notes.
	1	2	3	4	5	6	7	8	9	10	11	
Archæocalamites scrobiculatus	×	×	×	×	×	×	×	—	×	×	×	
Lepidodendron, cf. *calamitoides*	—	—	—	—	—	—	—	—	—	—	—	Culm, Spitzbergen (NATH.).
,, cf. *obovatum*	—	—	—	—	—	—	—	—	—	×	—	
Adiantites antiquus	×	×	—	—	×	×	—	—	—	—	—	
,, *machaneki*	—	—	×	—	×	×	—	×	—	—	—	
,, *tenuifolius*	—	×	—	×	—	×	—	—	—	—	—	
Calathiops acicularis	—	—	—	—	—	—	—	—	—	—	—	Rothwaltersdorf, Kohlenkalke (GÖPP.).
,, *glomerata*	—	—	—	—	—	—	—	—	—	—	—	
,, *renieri*	—	—	—	—	—	—	—	—	—	—	—	
Diplopteridium teilianum	—	—	—	—	—	—	×	—	—	—	—	
Diplotmema bermudensiforme (including *D. Schonknechti*)	—	×	×	—	—	*cf.*	—	×	×	×	×	
Diplotmema dissectum	—	—	×	—	—	—	—	—	—	—	—	
Holcospermum ellipsoideum	—	—	—	—	—	×	—	—	—	—	×	"Cum Posidonomyis ad Eimelrod Hassiæ" (GÖPP.).
Neuropteris antecedens	—	—	×	—	—	×	×	—	×	*cf.*	×	
Rhacopteris circularis	—	—	—	—	—	—	—	—	—	—	—	
,, *fertilis*	—	—	—	—	—	—	—	—	—	—	—	
,, *lindseæformis*	—	×	×	—	—	×	—	—	—	—	—	
,, *machaneki*	—	—	—	—	—	—	—	—	—	—	—	Altendorf (STUR).
,, *petiolata*	—	×	×	—	—	×	—	—	—	—	*cf.*	
,, *robusta*	—	×	—	—	—	×	×	—	—	—	—	
Rhodea tenuis	—	×	—	—	—	—	—	—	—	—	—	
Spathulopteris clavigera	—	—	×	—	—	—	—	—	—	—	—	
,, *ettingshauseni*	—	×	—	—	—	×	—	—	—	—	—	
Sphenopteridium capillare	—	×	—	—	—	—	—	—	—	—	—	
,, *crassum*	—	×	—	—	—	*cf.*	—	—	—	—	—	
,, *pachyrrachis*	×	×	—	—	×	×	—	—	—	—	—	
Sphenopteris obfalcata	—	—	—	—	—	—	—	—	—	—	—	
,, cf. *filiformis*	*cf.*	—	—	—	—	—	—	—	—	—	—	

Explanation of Table 1.

Scotland . . .	1—Cementstone Group, Calciferous Sandstone Series.
	2—Oilshale Group, Calciferous Sandstone Series.
	3—Lower Limestone Group, Carb. Limestone Series.
	4—Upper Limestone Group, Carb. Limestone Series.
Isle of Man . .	5—Posidonomya Shales at Gaw Ghortha.
Silesia	6—Sumpfenwalde Horizon in Posidonomya Shales.
	7—Hanselmühle Horizon in Posidonomya Shales.
	8—Lower Wagstädter Beds.
	9—Upper Wagstädter Beds.
	10—Lower Ostrauer Beds.
Germany . . .	11—Culm of Chemnitz-Hainchen.

The recent important work by PATTEISKY (1929) on the Upper Silesian Lower Carboniferous has greatly facilitated the recognition of a fairly close correlation between the Teilia Limestones and part of the Silesian Succession by carrying further the work recorded in the classical researches of STUR (1875–1877). In Table I a list is given of the species that have been found at Teilia with records of their occurrence in some other parts of Europe. It is clear that there is a close connection botanically between this flora and the flora of the Oil Shale Group of the Calciferous Sandstone Series in Scotland, while the occurrence of *Neuropteris antecedens* and *Spathulopteris clavigera* are suggestive of a certain element in common with the Carboniferous Limestone Series. It appears to have little in common with the Cementstone Group. There are reasons therefore for regarding the Teilia flora equivalent to the flora of a zone very high up in the Calciferous Sandstone Series. There are at least nine species of fern-like plants from Teilia which are also found in beds of the Sumpfenwald Horizon in the Mohra Valley in Upper Silesia. The marine fauna found associated with the plant remains in the Teilia beds help to strengthen the comparison. It will be noticed in Table II that *Posidonomya becheri*, which is an abundant fossil in the Teilia beds, is not recorded from higher beds in Flintshire and North Wales or from above the Blackbyre Limestone in Scotland (MACGREGOR, 1929).

It persists in Silesia up as far as the Glockersdorf Horizon. In each of these areas *Posidonomya corrugata* appears in beds almost immediately higher in the series.

These facts afford substantial evidence for regarding the Teilia Beds as equivalent to the upper part of the Oil Shale Group on the one hand, and on the other hand to the upper part of the *Posidonomya becheri* Beds in the Mohra Valley. Unfortunately no identifiable plants have been found in the Holywell Shales in Flintshire, but one would expect to find a Lower Carboniferous Flora extending upwards into them at least as far as the horizon characterised by the Goniatite genus *Eumorphoceras*.

No flora corresponding to the *Archaeosigillaria-flora* of the Lower Brown Limestone in the Prestatyn and Denbigh area has been identified in Scotland. *Archaeosigillaria vanuxemi* GÖPP. has, however, been found in several places near the base of the

TABLE II.—The Relation of the Teilia Beds to the Carboniferous Succession in Flintshire, North Wales, Central Scotland, and Upper Silesia. (Adapted from SARGENT, MACGREGOR, PATTEISKY.)

FLINTSHIRE AND NORTH WALES.		CENTRAL SCOTLAND.		UPPER SILESIA.	
HOLYWELL AREA—					
Holywell Shales .	*Gastrioceras cancellatum.* *Reticuloceras* spp. *Homoceras proteum* and *diadema.*		*Millstone Grit.*		
	Eumorphoceras.	Calmy Limestone (*Eumorphoceras*, HOR.).	Upper Limestone Group.	Untere Ostrauer .	*Posidonomya corrugata.* *Rhacopteris* not recorded.
				Hultschiner . . .	*Pos. corrugata.*
				Obere Wagstädter .	*Pos. corrugata.* *Rhac. transitionis.*
			Limestone Coal Group.	Untere Wagstädter	*Pos. corrugata.* *Rhacopteris* not recorded.
	Posidonomya corrugata.	Hosie Limestone (*Pos. corrugata*).	Lower Limestone Group.	Grätzer Grauwacke	*Pos. corrugata.* *Rhacopteris* not recorded. *Glyphioceras*, sp.
PRESTATYN AREA—					
		Hurlet Limestone.	Oil Shale Group.	Glockersdorf Hor. .	*Posidonomya Becheri.* *Glyph. striatum striatum.*
Teilia Beds at the top of the Upper Black Limestones.	TEILIA FLORA with *Posidonomya Becheri, Goniatites sphærico striatus.*	Blackbyre Limestone (*Posidonomya Becheri*).		Hanselmühle Hor. .	*Rhacopteris*, 2 spp.
Upper Grey Limestones.				Sumpfenwalde Hor.	*Pos. Becheri* (max. develop.). *Glyph. crenistria.* *Rhacopteris* abundant.
Middle White Limestones.			Cementstone Group.	Freihermersdorf Unterstufe.	
Lower Brown Limestones.	*Archæosigillaria vanuxemii, Rhacopteris Weissii*, etc.				
Basement Conglomerate.					

Carboniferous Limestones in the North of England. Judging from the photograph given by GILKINET (1922) of a plant, which he erroneously attributes to a dichotomous branch bearing fructifications of *Asterocalamites*, from the Upper Devonian of Belgium, it is evident that the specimen is not *Asterocalamites* but *Archaeosigillaria vanuxemi* GÖPP. The dichotomous forking branches show three out of presumably four orthostichies of short scale-like leaves and can be matched almost exactly with some of the numerous examples of such twigs that have been collected at the Grange Quarry at Denbigh in the Lower Brown Limestone. The *Archaeosigillaria-horizon* would appear to indicate a position very near the base of the Lower Carboniferous in Britain. Outside Britain it has only been recorded from the base of the Viséen, the Lower Carboniferous of Spitzbergen (NATHORST, 1914) and the Upper Devonian.

In conclusion, my best thanks are due to Dr. J. W. JACKSON, of the Manchester Museum, for valuable assistance with geological difficulties, and to Mr. and Miss PRICE, of Teilia Farm, for much kindly help and hospitality. I also acknowledge gratefully the financial assistance which the Royal Society granted to me towards the cost of the excavations carried out in connection with this work.

REFERENCES.

ARBER, E. A. N., and GOODE, R. H. (1915). ' Proc. Camb. Phil. Soc.,' vol. **18**, p. 97.
BENSON, M. (1904). ' Ann. Bot.,' vol. **18**, p. 161.
BUREAU, E. (1914). " Bassin de la Basse Loire," Ministère des Travaux publics, Paris.
CARPENTIER, A. (1913). ' Mem. Soc. Geol.' (Lille), vol. **7**, pp. 93, 133, 357, and 372.
Idem (1915). ' Rev. Gén. Bot.,' vol. **27**, p. 321.
Idem (1928). ' Rev. Gén. Bot.,' vol. **40**, p. 392.
Idem (1929). ' Bull. Soc. Sci. Nat. Ouest,' vol. **9**, p. 3.
DAWSON, J. W. (1873). Rep. Geol. Surv. Canada, Montreal, p. 19.
ETTINGSHAUSEN, C. (1866). ' Denkschr. Akad. Wiss.,' Wien, vol. **25**.
FEISTMANTEL, O. (1873). ' Z. Deut. Geol. Ges.,' vol. **25**, p. 463.
GEINITZ, H. B. (1863). " N. Jahrb. Min.," Stuttgart, p. 525.
GILKINET, A. (1922). " Mem. Soc. Geol. Belgique,' pp. 12, 227.
GÖPPERT, H. R. (1836). ' Nova Acta Leop. Carol,' vol. **7**. Suppl.
Idem (1846). " Gattungen der Fossilen Pflanzen." Bonn.
Idem (1852). ' Verh. Kais. Leop. Carol. Akad. Naturf.,' vol. **22**, Suppl.
Idem (1860). " Ueber die Fossile Flora der Silurischen der Devonischen und Unteren Kohlenformation oder des Sogennanten Uebergangsgebirges." Breslau.
Idem (1865). ' Palaeontographica,' vol. **12**. Cassel.
GOTHAN, W. (1913). ' Abh. Preuss. Geol. LdAnst.,' vol. **75**, pp. 15, 57, 61.
Idem (1927). ' Abh. Sachs. Geol. LdAmts.,' vol. **5**, pp. 4, 10.

GOTHAN, W., and SCHLOSSER, P. (1924). "Neue Funde von Pflanzen der Alteren Steinkohlenzeit (Kulm) dem Kossberge bei Plauen im Vogtland." Leipzig.

HALLE, T. G. (1929). 'K. Svenska. Vetensk. Handl.,' vol. **6**, p. 7.

HEER, O. (1876). 'K. Svenska. Vetensk. Handl.,' vol. **14**.

HIND, W. (1907). 'Proc. Yorks. Geol. Soc.' vol. **16**, p. 141.

HIND, W., and STOBBS, J. (1906). 'Geol. Mag.,' vol. **3**, p. 391.

HIRMER, M. (1927). 'Handbuch der Paläobotanik.' Munich and Berlin.

JONGMANS, W. J. (1928). "Compte Rendu du Congrès pour l'Avancement des Études de Stratigraphie Carbonifère, Heerlen 1927." Liége.

Idem (1930). 'Jaarversl. 1929 Geol. Bur.,' Heerlen, p. 77.

KIDSTON, R. (1886). "Catalogue of the Palaeozoic Plants," Brit. Mus. London.

Idem (1889). 'Trans. Roy. Soc. Edin.,' vol. **35**.

Idem (1894). 'Proc. Roy. Phys. Soc. Edin.,' vol. **12**, p. 183.

Idem (1923–1925). Memoirs of the Geol. Surv. of Great Britain, Palæontology, vol. **2**.

KIDSTON, R. and JONGMANS, W. J. (1911). 'Arch. Néerland Sci.' B, vol. **1**.

LINDLEY, J., and HUTTON, W. (1835). "The Fossil Flora of Great Britain," vol. **2**, London.

MACGREGOR, M. (1929). 'Trans. Geol. Soc. Glas.,' vol. **18**, p. 478.

MILLER, H. (1857). "The Testimony of the Rocks," Frontispiece. Edinburgh.

MORTON, G. H. (1886). 'Proc. Liv. Geol. Soc.,' vol. **5**, p. 175.

NATHORST, A. G. (1894). 'K. Svenska. VetenskAkad. Handl.,' vol. **26**, No. 4.

Idem (1914). "Zur Fossilien Flora der Polarlander," vol. **1**, pt. 4.

Idem (1920). "Zur Kulmflora Spitzbergens." Stockholm.

OBERSTE-BRINK, K. (1914). 'Jahr. K. Preuss. Geol. LdAnst.,' vol. **35**, Pt. 1.

PATTEISKY, K. (1928). "Die Begrenzung der sudetischen Stufe des Steinkohlengebirges." (See under JONGMANS, W. J., 1928, p. 493).

Idem (1929). "Die Geologie und Fossilfuhrung der Mahrischschlesischen Dachschiefer- und Grauwackenformation." Naturw. Verein, Troppau.

POTONIÉ, H. (1901). 'Abhandl. K. Preuss Geol. LdAnst.,' vol. **36**.

RENIER, A. (1906). 'Ann. Soc. Geol. Belge.,' vol. **33**.

Idem (1908). 'Rev. Univ. Min.,' vol. **21**, p. 66.

Idem (1926). 'Ann. Soc. Geol. Belge,' Bulletin, vol. **48**, p. 312.

ROEHL, E. VON (1869). "Fossile Flora der Steinkohlen Formation Westphalens," Cassel, p. 45.

SCHUSTER, J. (1911). 'SitzBer. Akad. Wiss.,' Wien, vol. **120**, p. 1125.

SMITH, J. (1913). 'Trans. Geol. Soc. Glas.,' vol. **14**.

STERZEL, T. (1884). 'Ber. Naturw. Ges. Chemnitz' (Festschrift) 1883–4.

STOPES, M. C. (1914). 'Dept. of Mines, Geol. Surv. Canada,' memoir 41, p. 74.

STRAHAN, A. (1890). "Geology of the Neighbourhoods of Flint, Mold and Ruthin," Geol. Surv. Memoir.

STUR, D. (1875). 'Abhandl. K. Geol. RchsAnst.,' Wien, vol. 8, pt. 1.

Idem (1877). 'Abhandl. K. Geol. RchsAnst.,' Wien, vol. **8**, pt. 2.

WALTON, J. (1926). 'Phil. Trans.,' B, vol. **215**, pp. 210–219.

Idem (1928). "A preliminary Account of the Lower Carboniferous Flora of North Wales and its Relation to the Floras of some other Parts of Europe" (See under JONGMANS, 1928, p. 743).

ZALESSKY, M. D. (1905). 'Bull. Acad. Imp. Sci.,' Petrograd, vol. **22**.

ZEILLER, R. (1897). 'Bull. Soc. Bot.,' France, vol. **44**, p. 202.

DESCRIPTION OF THE PLATES.

All specimens figured here are from Teilia, with the exception of that shown in fig. 9.

PLATE 23. *All Figures are from untouched Photographs.*

FIG. 1.—*Diplopteridium teilianum* KIDSTON, sp. Central region of a frond showing on each side a vegetative arm (*a* and *b*), and between them the repeatedly forking fertile rachis (*c*). A group of synangia, which were probably attached to the frond, are seen at *d*. 0·94 × natural size. (J. B. SHONE.)
The Grosvenor Museum, Chester. No. 7926.

FIG. 2.—Counterpart of the fossil shown in fig. 1. The fertile rachis is shown connected to the frond at *e*. The top of the main rachis or petiole is shown at *f*. The other lettering is the same as for fig. 1. 0·94 × natural size. (J. B. SHONE.)
The Grosvenor Museum, Chester. No. 7927.

FIG. 3.—The central part of the frond shown in fig. 1 at greater magnification. *d*, *d*, synangia. *c*, *c*, fertile rachis. Enlarged 1·9 diameters.

FIG. 4.—The group of synangia shown at *d* in fig. 1. Enlarged 3·76 diameters.

FIG. 5.—*Adiantites* sp. Primary pinna of a frond. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12069.

FIG. 6.—*Adiantites machaneki* STUR. Specimen showing most of the rachis system of a frond. The characteristic form and arrangement of the pinnules is shown in the right-hand top corner. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12070.

PLATE 24. *All figures are from untouched Photographs.*

FIG. 7.—*Spathulopteris ettingshauseni* FEISTMANTEL, sp. Part of a frond exhibiting a fork in a principal rachis. 0·94 × natural size. (J. W., 1924.)
The Manchester Museum. No. L.12059 and L.12060.

FIG. 8.—*Spathulopteris ettingshauseni* FEISTMANTEL, sp. Pinna of a frond with pinnules of a more slender form than is usual in this species. 0·94 × natural size.
The British Museum, London. No. V.2848.

FIG. 9.—*Sphenopteridium capillare* sp. nov. Fragment of one of the two main arms of a frond.
Locality :—Burntisland, Scotland.
Horizon :—Calciferous Sandstone Series, Lower Carboniferous.
The British Museum, London. No. V.9404. (C. PEACH.)

FIG. 10.—*Sphenopteridium capillare* sp. nov. Part of one of the main arms of a frond (*see* Text-fig. 4). The segments of some of the pinnules are seen to overlap the main rachis near the top of the figure. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.11934/A.

FIG. 11.—*Sphenopteridium capillare* sp. nov. Petiole of a frond showing the transition from the ordinary type of pinna near the top to the small, closely-set stipular pinnæ at the base. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12075.

FIG. 12.—*Adiantites machaneki* STUR. Fragment of a frond illustrating the typical form of the ultimate segments. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12087.

FIG. 13.—*Rhodea tenuis* GOTHAN. A form of the species with slightly webbed segments. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12055/A.

FIG. 14.—*Rhodea tenuis* GOTHAN. Form with deeply separated and exceedingly narrow segments. 0·94 × natural size. (J. W., 1924.)
The Manchester Museum. No. L.12054.

FIG. 15.—*Rhodea tenuis* GOTHAN. Typical form of the species with pointed linear segments. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12079.

FIG. 16.—*Diplotmema bermudensiforme* forma *typica,* KIDSTON. Small fragment of a frond exhibiting an equal forking of the rachis. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12053.

FIG. 17.—*Diplotmema bermudensiforme* forma *typica,* KIDSTON. A small fragment of a pinna with the characteristic three-lobed pinnules at the apex. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12092.

FIG. 18.—*Diplotmema dissectum* BRONGNIART, sp. One of the two arms of a frond with the characteristic linear segments. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12052.

FIG. 19.—*Spathulopteris clavigera* KIDSTON, sp. Small fragment of a frond enlarged. Enlarged × 1·9 diameters. (J. W., 1926.)
The Manchester Museum. No. L.12061.

PLATE 25. *All figures are from untouched Photographs.*

FIG. 20.—*Rhacopteris machaneki* STUR. Specimen with apex preserved. The venation is visible in some of the pinnules. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12058.

FIG. 21.—*Sphenopteridium pachyrrachis* GÖPP., sp. Part of a frond showing a forking in the main (?) rachis. The fine ultimate segments are seen in the upper right-hand corner of the photograph. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12074.

FIG. 22.—*Sphenopteridium pachyrrachis* GÖPP., sp. Specimen with stouter ultimate segments than those shown in fig. 21. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12072.

FIG. 23.—*Sphenopteridium pachyrrachis* GÖPP., sp. An example showing the typical form of the segments. This type is rare in the Teilia beds. 0·94 × natural size. (J. W., 1924.)
The Manchester Museum. No. L.12073.

FIG. 24.—*Sphenopteridium crassum* LINDLEY and HUTTON, sp. Fragment of a pinna showing the characteristic striations on the segments. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12080.

FIG. 25.—*Neuropteris antecedens* STUR. Portions of four pinnæ bearing the ovate pinnules, those near the bottom of the figure showing a pronounced main vein. Enlarged 1·9 diameters. (J. W., 1926.)
The Manchester Museum. No. L.12067.

FIG. 26.—*Neuropteris antecedens* STUR. Small fragment from a higher position on a frond to show the venation. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12068.

FIG. 27.—*Sphenopteris obfalcata* sp. nov. Part of the main rachis of a frond bearing four complete pinnæ. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12083.

FIG. 28.—*Lepidodendron* cf. *obovatum.* The transversely elongated elliptical leaf-scars are shown on some of the lower leaf cushion represented in the photograph. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L. 12076.

FIG. 29.—*Calathiops* sp. Group of four bunches of scales, sporangia or cupules. The bunch on the left shows the form of the free parts of the appendages. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12066.

PLATE 26. *All figures are from untouched Photographs.*

FIG. 30.—*Lepidodendron* sp. The lower part of the axis bears no leaves. The fine hair-like leaves may be seen attached to the upper part. 0·94 × natural size. (J .W., 1924.)
The Manchester Museum. No. L.12077.

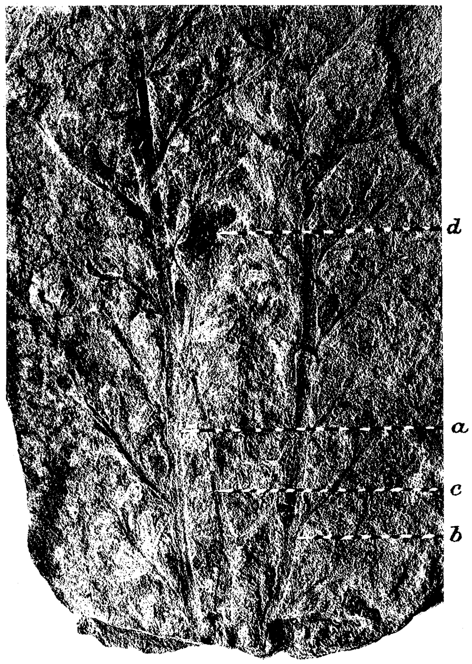
FIG. 31.—*Adiantites tenuifolius* GÖPP., sp. Parts of two pinnæ enlarged to show the venation. The narrow outline of the pinnules on the right is probably due to maceration. Enlarged 1·9 diameters. (J. W., 1925.)
The Manchester Museum. No. L.12089.

FIG. 32.—*Calathiops glomerata* sp. nov. Specimen showing the smooth forking rachis and the groups of cupule-like structures, of which those at the base on the right show indication of longitudinal striations indicating their composite structure. 0·94 × natural size. (J. W., 1924.)
The Manchester Museum. No. L.12064.

FIG. 33.—*Calathiops glomerata* sp. nov. A fragmentary specimen showing the mode of attachment of the bunches to the rachis. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12088.

FIG. 34.—*Calathiops glomerata* sp. nov. Group of bunches in which some of the appendages are separated from one another. A fragment of a Pterinopecten is seen at the bottom of the figure on the left. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12090.

FIG. 35.—*Calathiops acicularis* GÖPP. Fructification consisting of about eight bunches of pointed, linear appendages. The separate appendages are seen most clearly on the top bunch on the left. 0·94 × natural size. (J. W., 1924.)
The Manchester Museum. No. L.12063.



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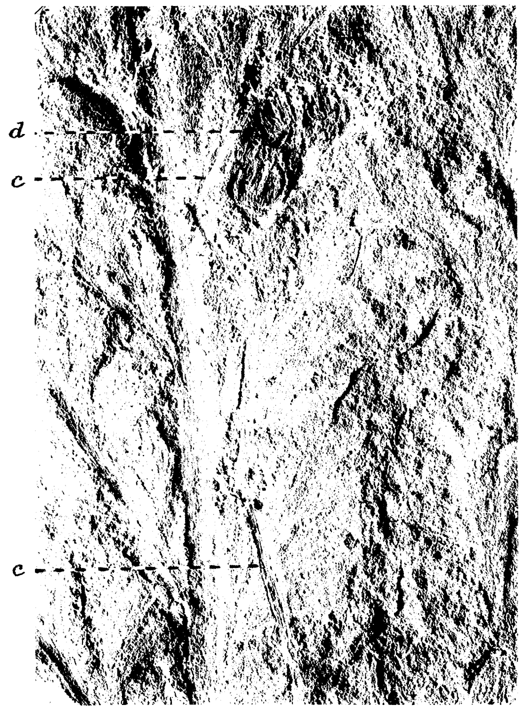

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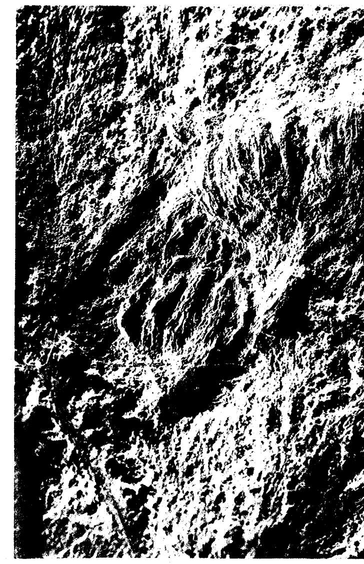

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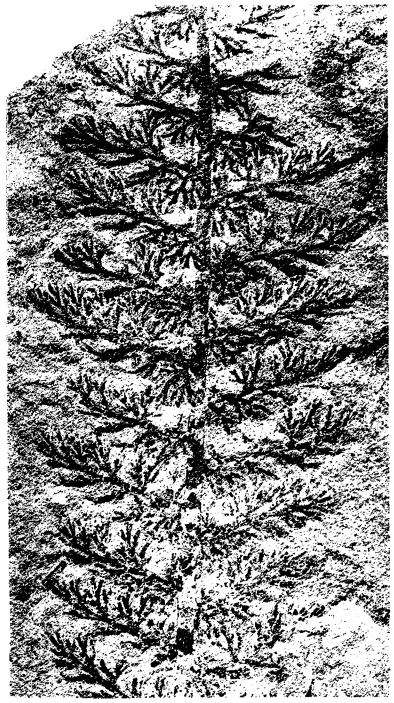
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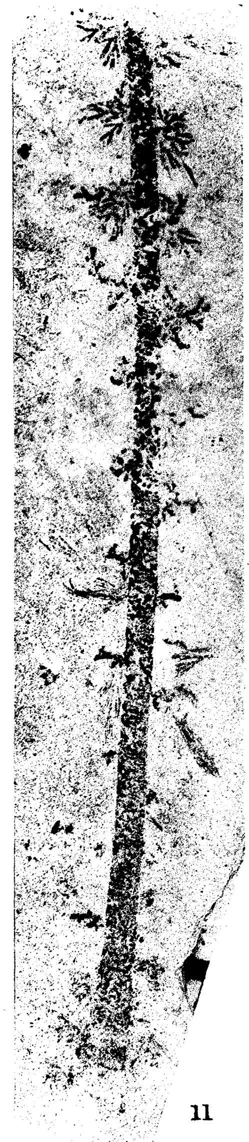
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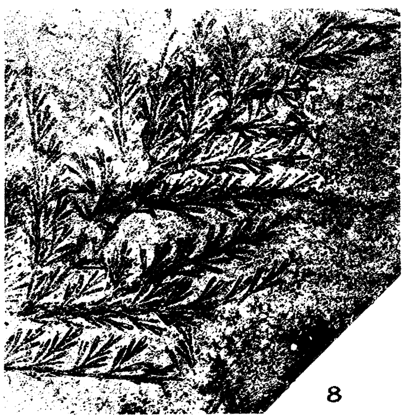
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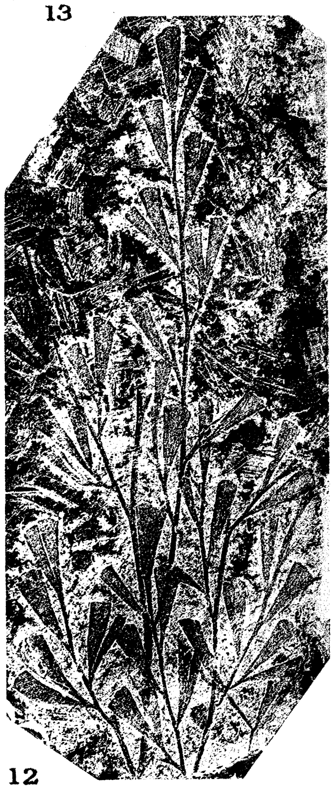
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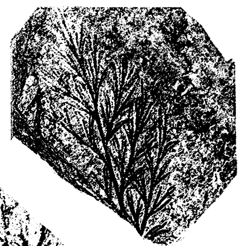
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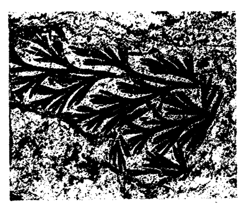
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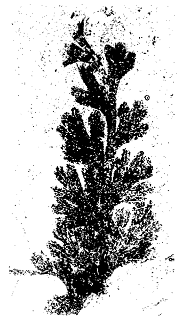
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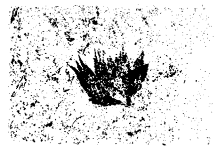
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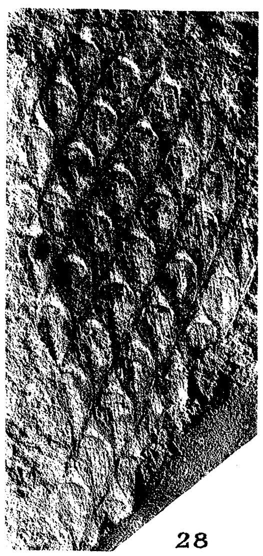
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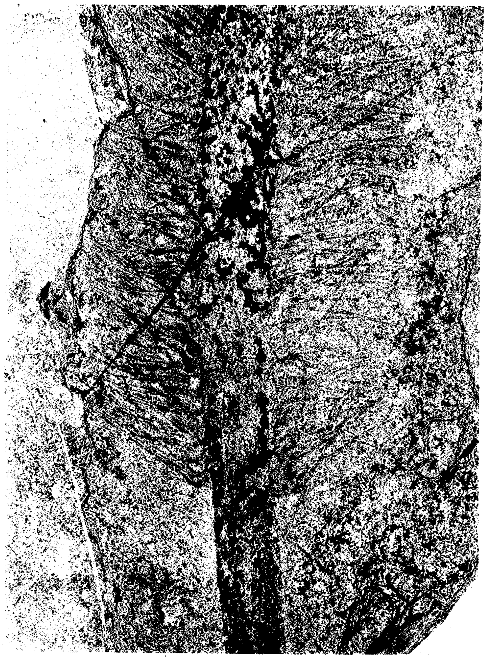

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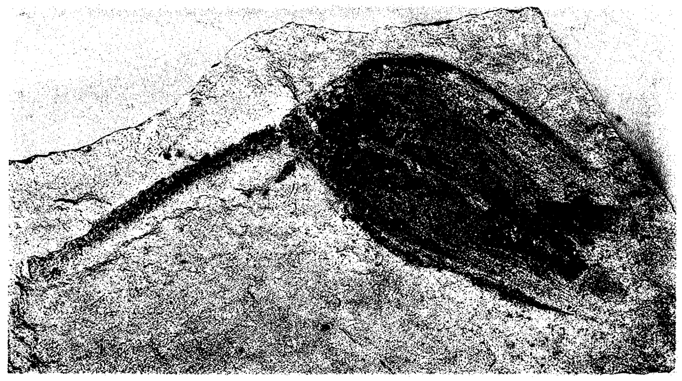

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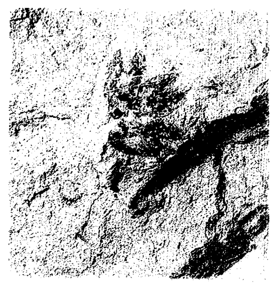

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FIG. 36.—*Calathiops renieri* sp. nov. Example of the large cupule-like fructification. 0·94 × natural size. (J. W., 1925.)

The Manchester Museum. No. L.12062.

FIG. 37.—*Fructification A*. This specimen appears to consist of two Crossotheca-like synangia. 0·94 × natural size. (J. W., 1924.)

The Manchester Museum. No. L.12065.

FIG. 38.—*Fructification B*. Three bilobed scales or seeds (?). 0·94 × natural size. (J. W., 1925.)

The Manchester Museum. No. L.12091.

FIG. 39.—*Asterocalamites scrobiculatus* SCHLOTH., sp. Leafy twig with five nodes and numerous leaves. The leaves are each forked twice. The pointed tips of some of the segments of the leaves may be seen in the top left-hand corner. 0·94 × natural size. (J. W., 1925.)

The Manchester Museum. No. L.12078.

FIG. 40.—*Holcospermum ellipsoideum* GÖPP., sp. Example of one of the several specimens found at Teilia. 0·94 × natural size. (J. W., 1925.)

The Manchester Museum. No. L.12057.

FIG. 40A.—The same seed as that in fig. 40. Enlarged 1·9 diameters.

FIG. 41.—*Carpolithes* sp. Seed with longitudinally striated testa or husk (?). 0·94 × natural size. (J. W., 1925.)

The Manchester Museum. No. L.12056.

FIG. 41A.—The same seed showing the longitudinal striations and a concretionary mass representing, in all probability, the prothallial cavity. Enlarged 1·9 diameters.

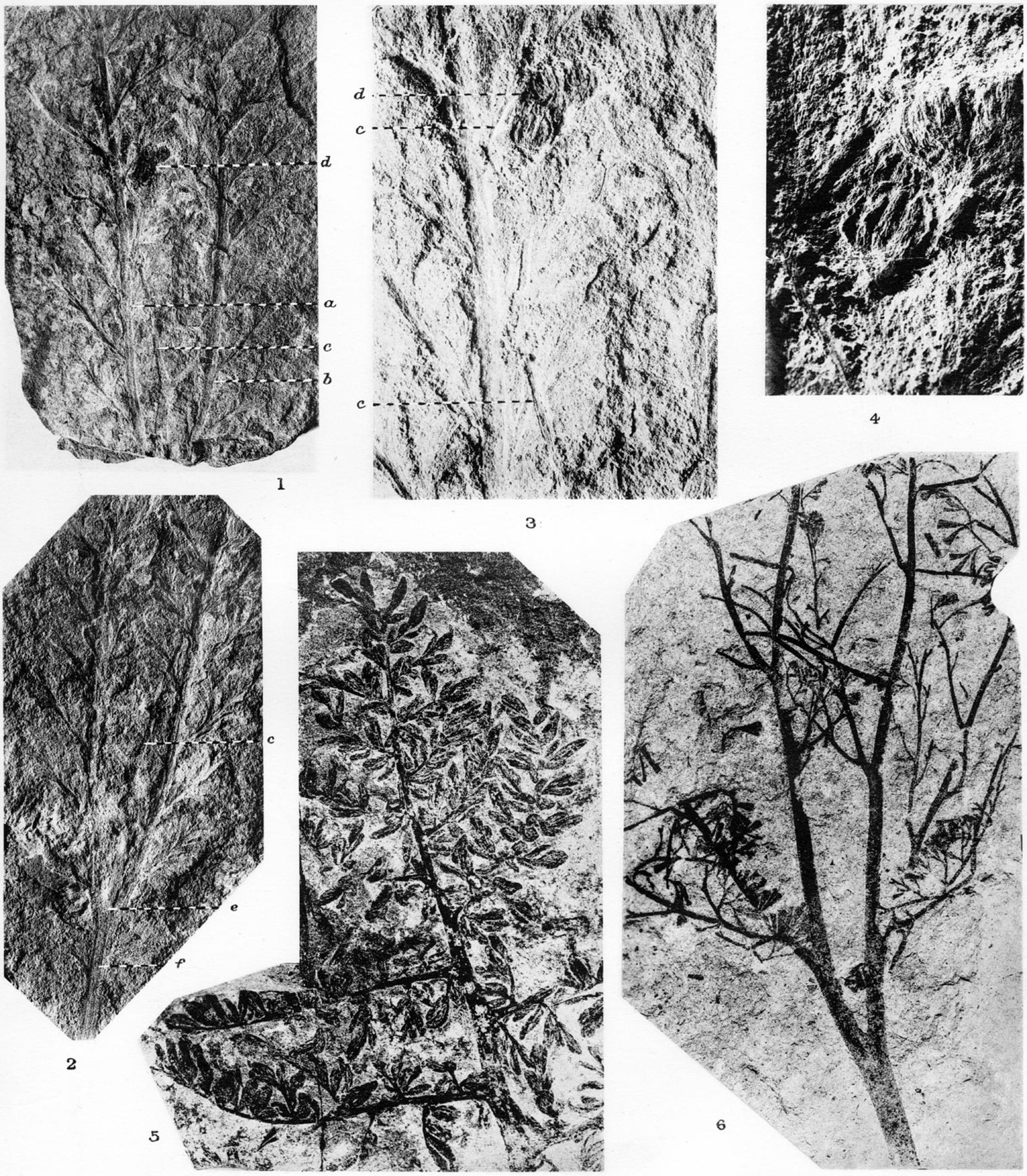

Plate 23. *All Figures are from untouched Photographs.*

Fig. 1.—*Diplopteridium teilianum* Kidston, sp. Central region of a frond showing on each side a vegetative arm (*a* and *b*), and between them the repeatedly forking fertile rachis (*c*). A group of synangia, which were probably attached to the frond, are seen at *d*. 0·94 × natural size. (J. B. Shone.)
The Grosvenor Museum, Chester. No. 7926.

Fig. 2.—Counterpart of the fossil shown in fig. 1. The fertile rachis is shown connected to the frond at *e*. The top of the main rachis or petiole is shown at *f*. The other lettering is the same as for fig. 1. 0·94 × natural size. (J. B. Shone.)
The Grosvenor Museum, Chester. No. 7927.

Fig. 3.—The central part of the frond shown in fig. 1 at greater magnification. *d*, *d*, synangia. *c*, *c*, fertile rachis. Enlarged 1·9 diameters.

Fig. 4.—The group of synangia shown at *d* in fig. 1. Enlarged 3·76 diameters.

Fig. 5.—*Adiantites* sp. Primary pinna of a frond. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12069.

Fig. 6.—*Adiantites machaneki* Stur. Specimen showing most of the rachis system of a frond. The characteristic form and arrangement of the pinnules is shown in the right-hand top corner. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12070.

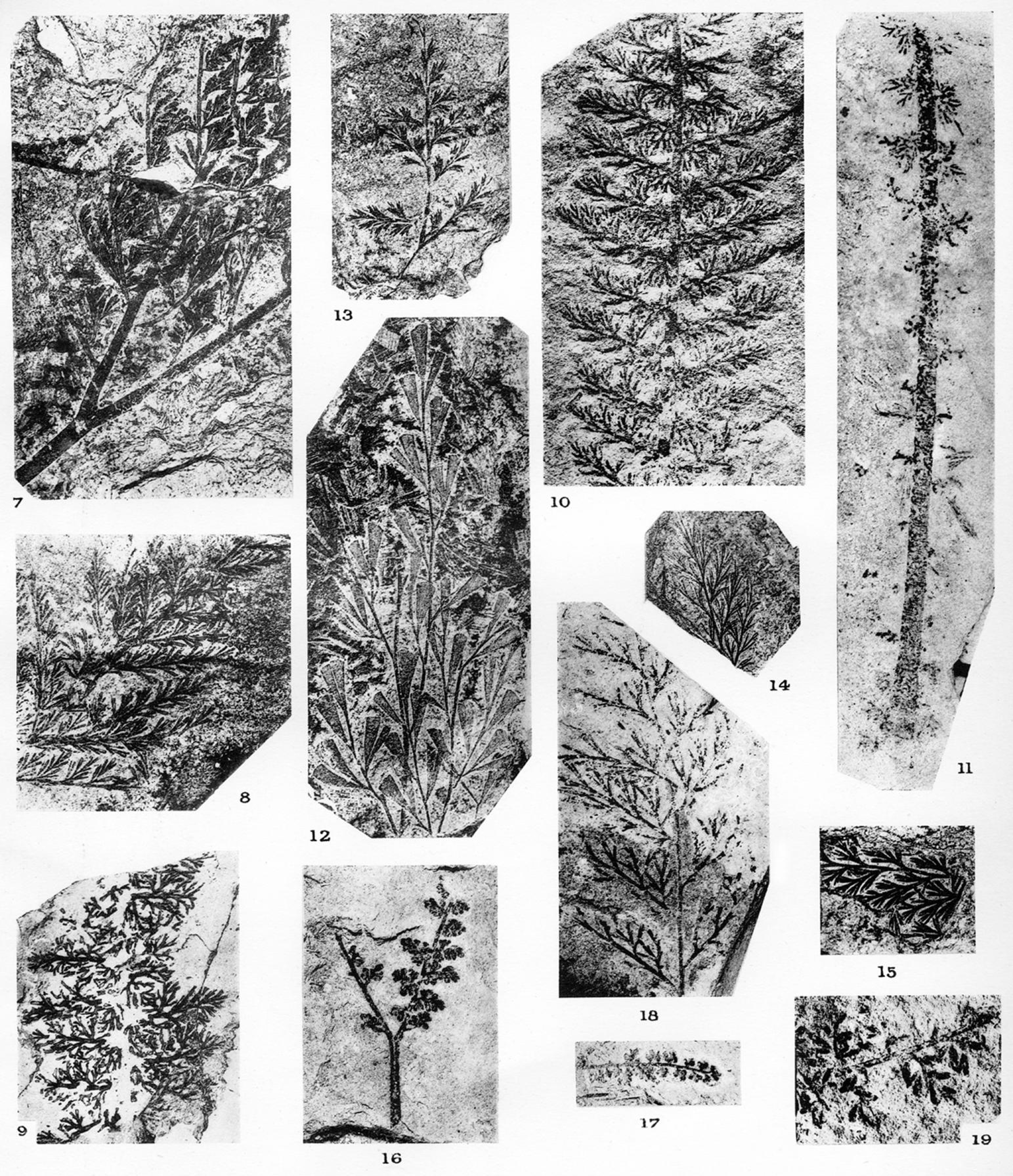

PLATE 24. *All figures are from untouched Photographs.*

FIG. 7.—*Spathulopteris ettingshauseni* FEISTMANTEL, sp. Part of a frond exhibiting a fork in a principal rachis. 0·94 × natural size. (J. W., 1924.)
The Manchester Museum. No. L.12059 and L.12060.

FIG. 8.—*Spathulopteris ettingshauseni* FEISTMANTEL, sp. Pinna of a frond with pinnules of a more slender form than is usual in this species. 0·94 × natural size.
The British Museum, London. No. V.2848.

FIG. 9.—*Sphenopteridium capillare* sp. nov. Fragment of one of the two main arms of a frond.
Locality :—Burntisland, Scotland.
Horizon :—Calciferous Sandstone Series, Lower Carboniferous.
The British Museum, London. No. V.9404. (C. PEACH.)

FIG. 10.—*Sphenopteridium capillare* sp. nov. Part of one of the main arms of a frond (*see* Text-fig. 4). The segments of some of the pinnules are seen to overlap the main rachis near the top of the figure. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.11934/A.

FIG. 11.—*Sphenopteridium capillare* sp. nov. Petiole of a frond showing the transition from the ordinary type of pinna near the top to the small, closely-set stipular pinnæ at the base. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12075.

FIG. 12.—*Adiantites machaneki* STUR. Fragment of a frond illustrating the typical form of the ultimate segments. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12087.

FIG. 13.—*Rhodea tenuis* GOTHAN. A form of the species with slightly webbed segments. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12055/A.

FIG. 14.—*Rhodea tenuis* GOTHAN. Form with deeply separated and exceedingly narrow segments. 0·94 × natural size. (J. W., 1924.)
The Manchester Museum. No. L.12054.

FIG. 15.—*Rhodea tenuis* GOTHAN. Typical form of the species with pointed linear segments. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12079.

FIG. 16.—*Diplotmema bermudensiforme* forma *typica*, KIDSTON. Small fragment of a frond exhibiting an equal forking of the rachis. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12053.

FIG. 17.—*Diplotmema bermudensiforme* forma *typica*, KIDSTON. A small fragment of a pinna with the characteristic three-lobed pinnules at the apex. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12092.

FIG. 18.—*Diplotmema dissectum* BRONGNIART, sp. One of the two arms of a frond with the characteristic linear segments. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12052.

FIG. 19.—*Spathulopteris clavigera* KIDSTON, sp. Small fragment of a frond enlarged. Enlarged × 1·9 diameters. (J. W., 1926.)
The Manchester Museum. No. L.12061.

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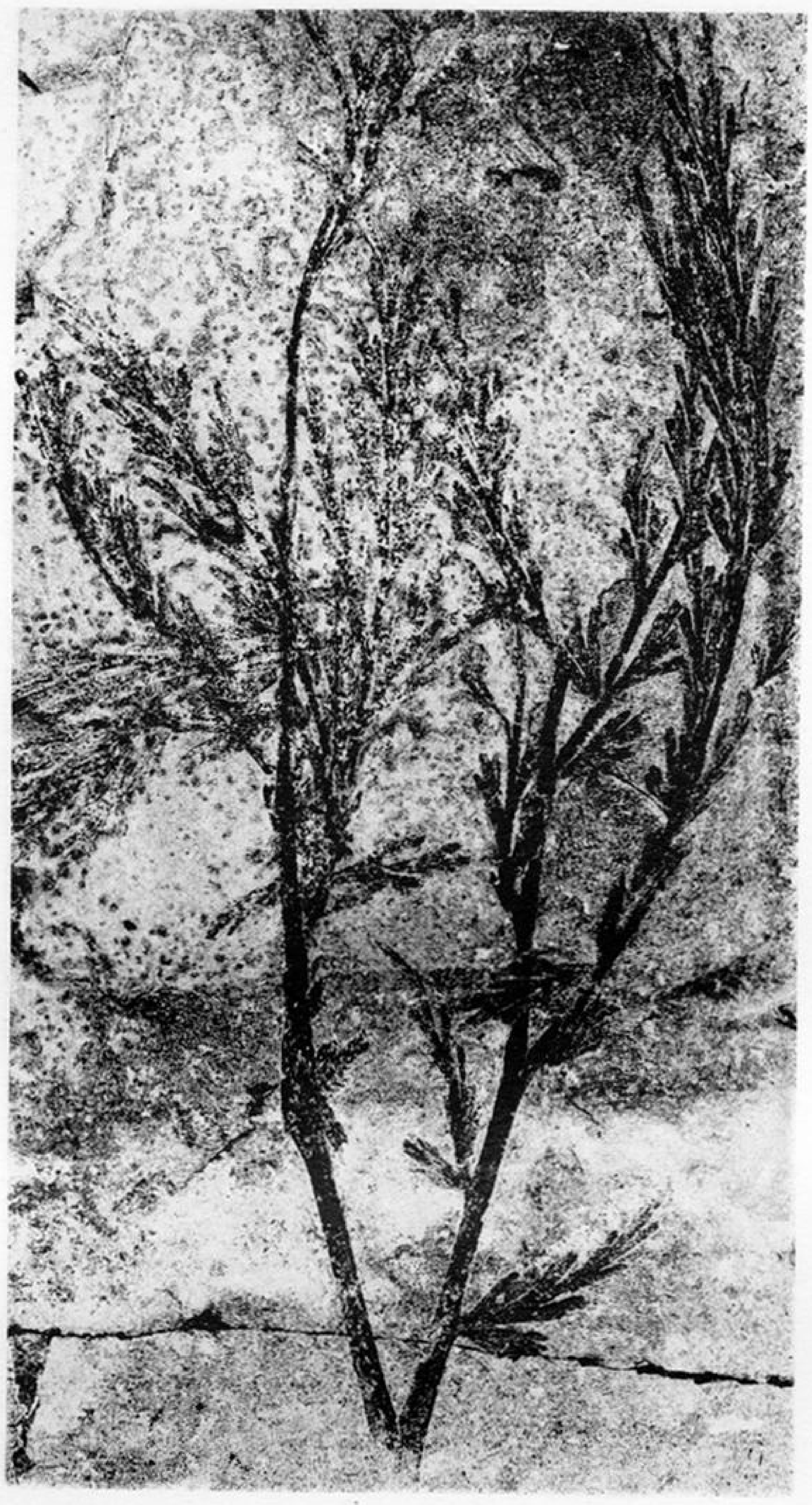

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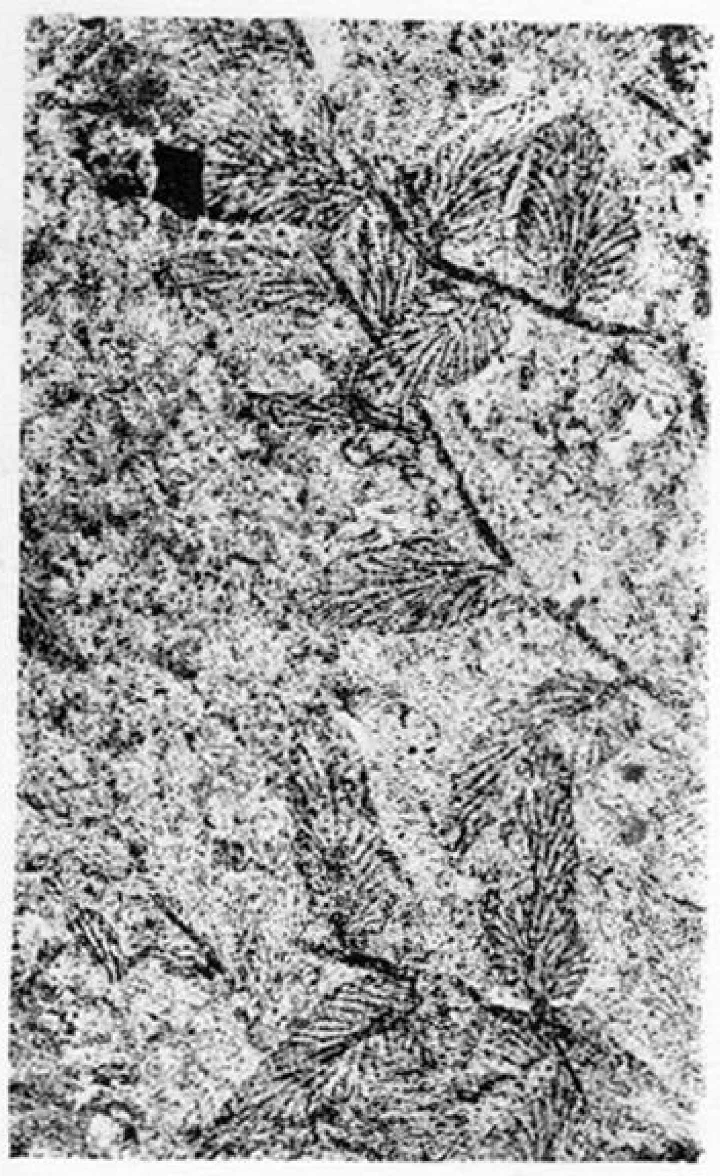

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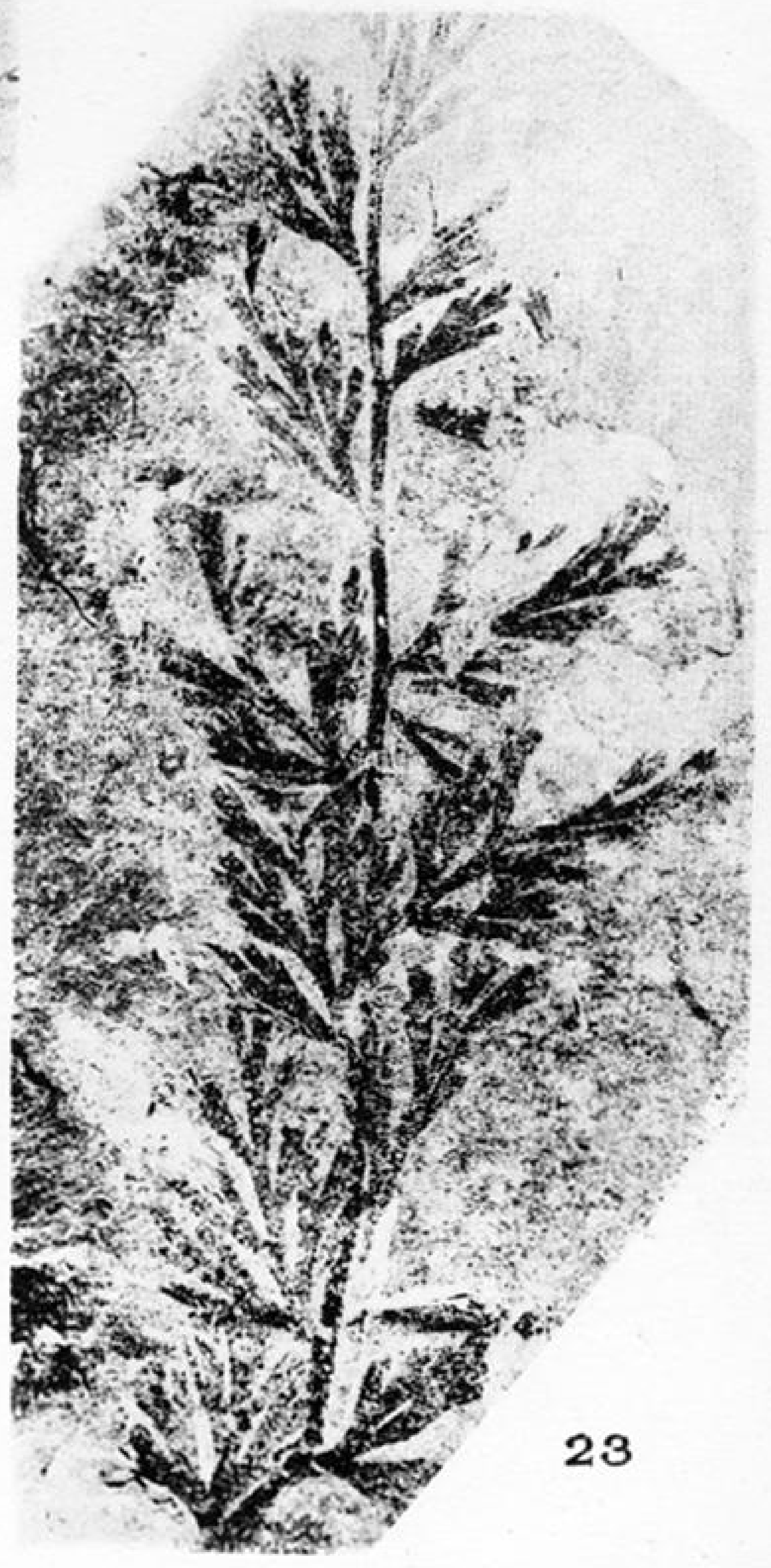

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PLATE 25. *All figures are from untouched Photographs.*

FIG. 20.—*Rhacopteris machaneki* STUR. Specimen with apex preserved. The venation is visible in some of the pinnules. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12058.

FIG. 21.—*Sphenopteridium pachyrrachis* GÖPP., sp. Part of a frond showing a forking in the main (?) rachis. The fine ultimate segments are seen in the upper right-hand corner of the photograph. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12074.

FIG. 22.—*Sphenopteridium pachyrrachis* GÖPP., sp. Specimen with stouter ultimate segments than those shown in fig. 21. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12072.

FIG. 23.—*Sphenopteridium pachyrrachis* GÖPP., sp. An example showing the typical form of the segments. This type is rare in the Teilia beds. 0·94 × natural size. (J. W., 1924.)
The Manchester Museum. No. L.12073.

FIG. 24.—*Sphenopteridium crassum* LINDLEY and HUTTON, sp. Fragment of a pinna showing the characteristic striations on the segments. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12080.

FIG. 25.—*Neuropteris antecedens* STUR. Portions of four pinnæ bearing the ovate pinnules, those near the bottom of the figure showing a pronounced main vein. Enlarged 1·9 diameters. (J. W., 1926.)
The Manchester Museum. No. L.12067.

FIG. 26.—*Neuropteris antecedens* STUR. Small fragment from a higher position on a frond to show the venation. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L.12068.

FIG. 27.—*Sphenopteris obfalcata* sp. nov. Part of the main rachis of a frond bearing four complete pinnæ. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12083.

FIG. 28.—*Lepidodendron* cf. *obovatum*. The transversely elongated elliptical leaf-scars are shown on some of the lower leaf cushion represented in the photograph. 0·94 × natural size. (J. W., 1926.)
The Manchester Museum. No. L. 12076.

FIG. 29.—*Calathiops* sp. Group of four bunches of scales, sporangia or cupules. The bunch on the left shows the form of the free parts of the appendages. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12066.

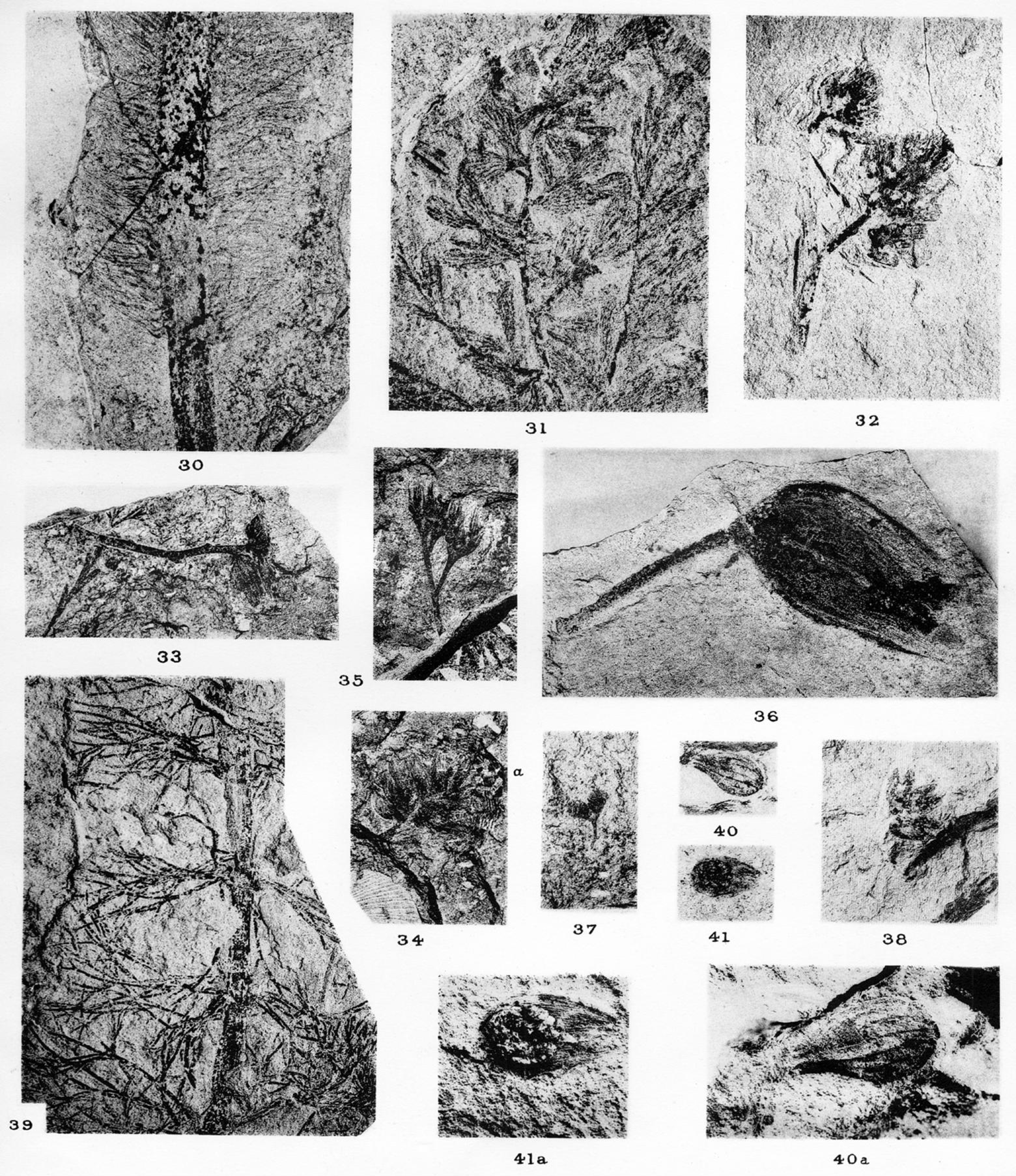

Plate 26. *All figures are from untouched Photographs.*

Fig. 30.—*Lepidodendron* sp. The lower part of the axis bears no leaves. The fine hair-like leaves may be seen attached to the upper part. 0·94 × natural size. (J .W., 1924.)
The Manchester Museum. No. L.12077.

Fig. 31.—*Adiantites tenuifolius* Göpp., sp. Parts of two pinnæ enlarged to show the venation. The narrow outline of the pinnules on the right is probably due to maceration. Enlarged 1·9 diameters. (J. W., 1925.)
The Manchester Museum. No. L.12089.

Fig. 32.—*Calathiops glomerata* sp. nov. Specimen showing the smooth forking rachis and the groups of cupule-like structures, of which those at the base on the right show indication of longitudinal striations indicating their composite structure. 0·94 × natural size. (J. W., 1924.)
The Manchester Museum. No. L.12064.

Fig. 33.—*Calathiops glomerata* sp. nov. A fragmentary specimen showing the mode of attachment of the bunches to the rachis. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12088.

Fig. 34.—*Calathiops glomerata* sp. nov. Group of bunches in which some of the appendages are separated from one another. A fragment of a Pterinopecten is seen at the bottom of the figure on the left. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12090.

Fig. 35.—*Calathiops acicularis* Göpp. Fructification consisting of about eight bunches of pointed, linear appendages. The separate appendages are seen most clearly on the top bunch on the left. 0·94 × natural size. (J. W., 1924.)
The Manchester Museum. No. L.12063.

Fig. 36.—*Calathiops renieri* sp. nov. Example of the large cupule-like fructification. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12062.

Fig. 37.—*Fructification A.* This specimen appears to consist of two Crossotheca-like synangia. 0·94 × natural size. (J. W., 1924.)
The Manchester Museum. No. L.12065.

Fig. 38.—*Fructification B.* Three bilobed scales or seeds (?). 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12091.

Fig. 39.—*Asterocalamites scrobiculatus* Schloth., sp. Leafy twig with five nodes and numerous leaves. The leaves are each forked twice. The pointed tips of some of the segments of the leaves may be seen in the top left-hand corner. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12078.

Fig. 40.—*Holcospermum ellipsoideum* Göpp., sp. Example of one of the several specimens found at Teilia. 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12057.

Fig. 40a.—The same seed as that in fig. 40. Enlarged 1·9 diameters.

Fig. 41.—*Carpolithes* sp. Seed with longitudinally striated testa or husk (?). 0·94 × natural size. (J. W., 1925.)
The Manchester Museum. No. L.12056.

Fig. 41a.—The same seed showing the longitudinal striations and a concretionary mass representing, in all probability, the prothallial cavity. Enlarged 1·9 diameters.