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FOSSIL FLORA OF THE WEDINGTON SANDSTONE MEMBER OF THE FAYETTEVILLE SHALE

BY

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FOSSIL FLORA OF THE WEDINGTON SANDSTONE MEMBER OF THE FAYETTEVILLE SHALE

By DAVID WHITE [1]

ABSTRACT

The Wedington sandstone member of the Fayetteville shale has yielded fragmentary remains of fossil plants at several localities in the Winslow quadrangle, Arkansas. These forms, though many of them are indifferently preserved, are extremely significant in that they represent the first Mississippian land flora to be reported in the Midcontinent region. The age of the beds containing the flora is established by invertebrates, as well as by plants, to be early upper or middle Chester. The flora is related to that of the Chester group of the Eastern Interior basin and to beds of Chester age in the Appalachian trough through certain of its filicinean, calamarian, and lycopodiaceous forms. Likewise it is similar, in certain features, to standard lower Carboniferous floras of Europe. The Mississippian aspect of the flora is modified somewhat by the presence of a lower Pottsville or Namurian element, pointing to upper Chester age. This flora, however, contains no forms in common with the large assemblage of plants described by Lesquereux from the Bloyd shale (middle Pottsville) of the same region.

It is suggested that the plants grew in an environment not entirely favorable to the development of large size. The climate was probably marked by a seasonal deficiency of rainfall.

The flora, as it is now known, includes 35 species. It contains representatives of the Filicales, the Lycopodiales, the Equisetales, the Sphenophyllales, and the Pteridospermae.

STRATIGRAPHY AND DISTRIBUTION OF THE PLANT-BEARING BEDS

"Wedington sandstone" is the name given by Adams [2] to a sandstone in the upper part of the Fayetteville shale, a formation of upper Mississippian (Chester) age in northwestern Arkansas and eastern Oklahoma. It is classified as a member of the Fayetteville shale, though on account of frequency of repetition, it is often casually mentioned in this paper as the Wedington sandstone. The type locality of the sandstone is Wedington Mountain, in northern Washington County, Ark., in the southwest corner of the Fayetteville quadrangle.[3] The sequence of the beds in the Winslow quadrangle,[4] immediately adjacent on the south, from which the plant material has been obtained, is briefly summarized as follows:

Sequence of beds in Winslow quadrangle, Arkansas

	Feet
Pennsylvanian:	
Morrow group:	
Bloyd shale: Blue shale, gray and yellowish shale, and carbonaceous shale, including two marine limestones—the Kessler above and the Brentwood below—and a thin dark intervening shale—the coal-bearing shale—which includes the Washington County coal	100–220
Hale formation: Shale, sandstone, and thin limestone, marine	100–200
Unconformity.	
Mississippian:	
Pitkin limestone: Gray coarse-textured fossiliferous limestone	10–40
Fayetteville shale: Black thinly laminated carbonaceous shale containing calcareous concretions and limestone locally near base. (The Wedington sandstone member is a heavy light-gray to brown cross-bedded sandstone, normally capped by greenish to bluish shale, at the top of the Fayetteville shale)	150–300
Unconformity.	
Boone limestone: Light-gray limestone, containing chert in beds and lenses	100+

Normally the Wedington sandstone member is overlain by bluish shale that weathers yellowish and has a maximum thickness of 60 feet. In some places in northwestern Arkansas the shale is lacking and the Pitkin limestone, the youngest Mississippian formation of the region, rests directly on the Wedington sandstone or even on underlying beds of the Fayetteville shale.

The sandstone is lenticular and is 150 feet or less in thickness. It reaches nearly its maximum thickness in the vicinity of Prairie Grove and Lincoln, in the northwest corner of the Winslow quadrangle, where the fossil plants here described were found. It is a hard, resistant sandstone, varying from white to rusty dark gray and greenish gray, is usually rather coarse, and in places is ripple-marked and cross-bedded. Certain layers carry considerable mica, and the plant-bearing beds in the region contain numerous white to dark-blue clay pebbles of moderate size and generally well rounded, so that, locally at least, the Wedington sandstone member is conglomeratic.

[1] This report was essentially completed by Dr. White before his death, Feb. 7, 1935. The additions and corrections which have since been made are small editorial modifications.

[2] Adams, G. I., Zinc and lead deposits of northern Arkansas: U. S. Geol. Survey Prof. Paper 24, p. 27, 1904.

[3] Adams, G. I., and Ulrich, E. O., U. S. Geol. Survey Geol. Atlas, Fayetteville folio (no. 119), p. 4, 1905.

[4] Purdue, A. H., U. S. Geol. Survey Geol. Atlas, Winslow folio (no. 154), 1916.

The distribution of the Fayetteville shale is shown approximately on the geologic maps of Arkansas [5] and Oklahoma [6] and is described by Croneis,[7] who, on the basis of the marine invertebrates, correlates the Wedington sandstone member with the Chester group. Marine invertebrates are relatively rare in the sandstone, where the fossil plants are found in comparative abundance. Lists of invertebrate fossils are given by Purdue and Miser [8] and by Croneis.[9] The sandstone is likewise regarded by the paleontologists of the United States Geological Survey as of Chester age.

The plants buried in the Wedington sandstone bear evidence of destructive water wear. The identifiable debris consists mainly of fragments of the resistant outer cortex and roots of *Lepidodendron* and pieces of woody species belonging to the calamarian group. Large numbers of seeds having a hard outer shell were washed into the sand here and there, and a few broken and badly worn fragments of cones also are found. Fernlike plants, probably belonging to the pteridosperms, were present, but only very small fragments have yet been found in the sandstones and interbedded shales, though portions of large water-worn petioles of at least two genera have been collected.

The occurrence of rather abundant plant debris together with numerous shale pebbles points to the probable contemporaneous exposure of land not far from the fossiliferous localities, in spite of the fact that a few brachiopods also are mingled with the vegetable fragments. Such exposures not remote from the plant-bearing deposits accord with the description by Purdue and Miser of deformations taking place in the Harrison and Eureka quadrangles after the greater part of the Fayetteville shale had been deposited.[10] Apparently the Wedington sandstone marks a minor orogenic movement in this region near the end of Chester time.

PLANT LOCALITIES

Plants were first found in the Wedington by H. D. Miser in 1928 at localities near Lincoln, Ark. These and other places, some of them near Prairie Grove, Ark., he revisited in 1929 in company with C. L. Cooper and in 1930 in company with L. G. Henbest and me, when most of the present collection was gathered. The plant localities were revisited in 1931 by Mr. Miser, accompanied by Charles B. Read, and again in 1932 by Mr. Miser. The collected material consisted mostly of sandstone but included some plant-bearing shale interbedded in the sandstone.

Owing apparently to the destruction of the more fragile plant material before its final burial in the sand, the Wedington flora admits the recognition of but few species, yet it is of unusual interest, for it is the first indubitably Mississippian land flora to be discovered in the Midcontinent region. Therefore the species are described and illustrated in detail in the following pages, in order that the record may be of use to stratigraphers as well as paleontologists who may be concerned with comparing the Wedington flora with others, especially those of the Jackfork sandstone and the Stanley shale in the same region, concerning the age of which there is wide difference of opinion.

The precise localities from which Wedington plants were obtained are as follows:

1. Bob Kidd Hollow, south of United States Highway 62. 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lots 8075 and 8140), and by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264).
2. Cane Hill, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8144).
3. About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145), and by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8266).
4. Lincoln-Summers road, 4 miles west of Lincoln, Ark.; collected by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8267).
5. Six-tenths of a mile south of junction of State Highway 99 and United States Highway 62, 4 miles west of Lincoln, Ark.; collected by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8268).

GENERAL COMPOSITION OF THE WEDINGTON FLORA

The flora here described is the first land flora to be made known from beds of unquestioned Mississippian age in the entire southwestern portion of the United States. Accordingly, its correlative value and its importance as a paleobotanic datum plane with which to compare other fossil floras of the upper Mississippian and lower Pennsylvanian of the region exceed its meager worth as illustrating the plant life of the region in Wedington time.

Though some of the species in this flora are adequately represented in the collections, there is an unfortunately large percentage of forms of which only few and very small fragments—too meager, in fact, for satisfactory identification or description—have been obtained. Most of these are ferns or fernlike types. In treating them I have leaned toward describing as new species those that are not recognized as old ones, often basing specific differentiations on glaringly insufficient material, and have illustrated them very fully. This treatment should promote the discovery of additional and more ample illustrative material, which in turn should lead to the more definite and permanent identification and description of the genera and species. This procedure will assure greater completeness and clarity of the systematic as well as the distributional records.

[5] Branner, G. C., Geologic map of Arkansas, Arkansas Geol. Survey, 1929.
[6] Miser, H. D., Geologic map of Oklahoma, U. S. Geol. Survey, 1926.
[7] Croneis, Carey, Geology of the Arkansas Paleozoic area: Arkansas Geol. Survey Bull. 31, p. 69, 1930.
[8] Purdue, A. H., and Miser, H. D., U. S. Geol. Survey Geol. Atlas, Eureka Springs-Harrison folio (no. 202), p. 13, 1916.
[9] Croneis, Carey, op. cit., p. 71.
[10] Purdue, A. H., and Miser, H. D., op. cit., p. 16.

The genera and species in the present collections are listed below:

Adiantites minima White, n. sp.
Cardiopteris hirta White, n. sp.
Cardiopteris sp.
Neuropteris sp.
Rhacopteris sp.
Rhodea cf. R. subpetiolata (Potonié) Němejc.
Rhodea cf. R. moravica (Ettingshausen) Stur.
Sphenopteris cf. S. communis Lesquereux.
Sphenopteris (Palmatopteris) erectiloba White, n. sp.
Sphenopteris (Calymmatotheca) mississippiana White, n. sp.
Sphenopteris cf. S. obtusiloba Brongniart.
Sphenopteris cf. S. schimperiana Goeppert.
Telangium? sp.
Rhynchogonium fayettevillense White, n. sp.
Carpolithus inquirenda White, n. sp.
Lepidodendron henbesti White, n. sp.
Lepidodendron occidentale White, n. sp.
Lepidodendron purduei White, n. sp.
Lepidodendron cf. L. veltheimianum Sternberg.
Lepidodendron wedingtonense White, n. sp.
Lepidodendron sp. 1.
Lepidodendron sp. 2.
Stigmaria arkansana White, n. sp.
Stigmaria wedingtonensis White, n. sp.
Bothrodendron sp.
Lepidophyllum sagittatum White, n. sp.
Lepidostrobus occidentalis White, n. sp.
Lepidocystis chesterensis White, n. sp.
Archaeocalamites fayettevillensis White, n. sp.
Archaeocalamites gracilentus White, n. sp.
Archaeocalamites umbralis White, n. sp.
Archaeocalamites wedingtonensis White, n. sp.
Archaeocalamites? sp.
Chlamidostachys chesterianus White, n. gen. and sp.
Sphenophyllum? sp.

The Wedington flora is of mixed composition. It comprises ferns and fernlike plants, calamarian forms representing *Archaeocalamites*, and lepidophytes, of which *Lepidodendron* is the most abundant. No typical Pennsylvanian *Calamites* and no representatives of the genera *Asterophyllites*, *Annularia*, *Mariopteris*, *Alethopteris*, *Sigillaria*, or *Cordaites* have yet been found.

Though most of the species in the Wedington flora are here described for the first time, nearly all are closely related to species previously known, either in the upper Mississippian or in the lowest Pennsylvanian.

AGE OF THE FLORA OF THE WEDINGTON SANDSTONE MEMBER

The age of the beds containing the Wedington flora is not now subject to question, being approximately established by the sequence of marine faunas, with an associated flora, in the series of formations which compose type sections of the upper Mississippian and lower Pennsylvanian for this region.

The plant-bearing sandstones of the Wedington are normally intercalated in marine shales which, where not eroded, are in turn overlain by 15 to as much as 100 feet of Pitkin limestone, formerly known as the †*Archimedes* limestone.[11] The Pitkin formation, rich in marine life, embracing a few Pennsylvanian forms in a fauna overwhelmingly Mississippian in facies, comprises the beds of latest Mississippian age yet recognized in the Southwestern Interior basin. On the evidence of the marine invertebrates, examined by many paleontologists, it is referred to the upper Chester, whereas the Fayetteville shale, which in its upper part embraces the Wedington sandstone member, is regarded as of middle and upper Chester age. A slight unconformity at the base of the Pitkin permits the limestone locally to rest directly on the Wedington sandstone member, or even on underlying shale of the Fayetteville.

From the paleobotanist's point of view, so far as the criteria are yet in hand, the Wedington is evidently bound to the upper Mississippian by its large-pinnuled *Rhacopteris*, which has very close relatives in the beds of Chester age in the Appalachian trough as well as in western Europe; by its species of *Cardiopteris*, which differ but slightly from one widely spread in the upper Mississippian of the Appalachian trough and the Eastern Interior basin; by its *Archaeocalamites gracilentus* and the possibly associated *Chlamidostachys chesterianus*, which have European relatives in the upper Mississippian *Pothocites;* by its *Lepidodendron occidentale*, which differs only in the greater altitude of its leaf scar from the typical *Lepidodendron volkmannianum*, found both in Europe and in the American Chester, where it is characteristic of that stage in the Appalachian trough and the Eastern Interior basin; by its *Lepidophyllum sagittatum*, which represents a group of rather small, narrow, tapering, sword-pointed leaves of the Old World and Appalachian upper Mississippian; by its *Lepidocystis chesterensis*, present in the beds of Chester age in the Appalachian trough and possibly specifically identical with a form in the Mississippian limestone of Silesia; by its *Stigmaria wedingtonensis*, a form with radiately areolate leaf scars associated with the *Lepidodendron volkmannianum* group; and by its *Rhynchogonium fayettevillense*, which is most closely related specifically to European forms from the Mississippian limestone of Silesia, the Calciferous Sandstone of Scotland, and the Mississippian of the Arctic zone. All these forms are characteristically and exclusively Mississippian. Furthermore, the distribution of the forms specified above in beds of Chester age in the Appalachian and Eastern Interior basins leaves no room for doubt as to the correlation of the Wedington with the Chester group, the upper division of the Mississippian series in the Eastern Interior basin. These plant forms would proclaim the Chester

[11] A dagger (†) preceding a geologic name indicates that the name has been abandoned or rejected for use in classification in publications of the U. S. Geological Survey. Quotation marks, formerly used to indicate abandoned or rejected names, are now used only in the ordinary sense.

age of the deposits even if there were no associated invertebrate fossils to point out the position of the Wedington in the Mississippian column of the Southwest.

On the other hand, the flora is connected with the Pennsylvanian by a large element present in the Namurian or the next higher stages of the lower Pennsylvanian, included in the American Pottsville group. Among these mention may in particular be made of *Sphenopteris (Calymmatotheca) mississippiana*, which approaches extremely closely the earliest phase of the group of forms generally included under *Sphenopteris* or *Calymmatotheca hoeninghausii*. In the same category may be placed the *Adiantites*, the *Rhodea*, the *Neuropteris*, the group *Mesocalamites*, in which most of the forms of *Archaeocalamites* from the Wedington find their place; also *Lepidodendron wedingtonense*, which appears to have direct ancestral connection with *Lepidodendron wortheni* and *L. brittsii*, at the base of the Allegheny formation; *Lepidodendron* cf. *L. rimosum; Lepidostrobus occidentalis*, closely related to *Lepidostrobus variabilis* Lindley and Hutton; and several lepidodendroid forms, including that showing a cone scar and tentatively assigned to *Bothrodendron*, which fall within the comprehensive group generally referred by paleobotanists under the collective term *Lepidodendron veltheimianum*.

Several of the plants enumerated above appear to be present in the uppermost Mississippian of Europe as well as of America, though they range upward into the Namurian and some of them into the Westphalian, which is nearly equivalent to the middle and upper Pottsville of the Appalachian trough. On the whole, however, though the flora in hand exhibits ties connecting it with the basal Pennsylvanian, and especially the Namurian, its exclusively Mississippian representatives are sufficient in type and in number to demand its reference to the Chester Mississippian, though if considered only from the present knowledge of the fossil flora, the Wedington sandstone would be classed as upper Chester.

RELATIONS OF THE WEDINGTON FLORA TO THAT OF THE COAL-BEARING SHALE OF THE MORROW GROUP OF WASHINGTON COUNTY, ARKANSAS

The geographically nearest flora of Pennsylvanian age which has been described and with which the flora of the Wedington sandstone member may be compared is the well-known flora recorded from what was formerly known as the coal-bearing shale of Washington County, Ark., which occurs in the same region and in the same vertical section as the Wedington sandstone.

The Morrow group, in which the coal-bearing shale has its place, is in this region not over 400 feet thick. It rests usually upon the Pitkin limestone, or where the Pitkin has been removed by erosion it may lie upon the Wedington sandstone member or even on the lower part of the Fayetteville shale. At the base of the Morrow group is the Hale formation, consisting of shales, sandstones, and thin limestones, 80 to 300 feet in total thickness; above which lies the Bloyd shale, reaching a maximum thickness of 175 feet and containing near its base the Brentwood limestone member (whose maximum thickness in the Fayetteville quadrangle is 80 feet) and higher in the section the Kessler limestone member (in some places only 2 to 4 feet thick but reaching a maximum thickness of 70 feet in the Fayetteville quadrangle). Between these limestone members is an interval, usually 10 to 20 feet but in places 100 feet, occupied by shales that contain a thin coal formerly mined at several points in the Fayetteville quadrangle. This shale is known as the coal-bearing shale and the coal as the Washington County coal. More than 120 species, composing a well-balanced flora, were described or recorded by Lesquereux [12] as coming from this stage and vicinity. In his reports the plants are recorded as from a subconglomerate stage, then believed to be upper Mississippian, as the base of the Winslow formation, which lies upon the Morrow group, a short distance above the Kessler limestone, is marked by a quartz conglomerate regarded at that time as the †Millstone grit, the base of the Pennsylvanian or upper Carboniferous.

A review of the plants from the coal-bearing shale by me in 1893 resulted in the reference of that shale to a stage in the upper part of the middle Pottsville or possibly the extreme basal portion of the upper Pottsville and the consequent transfer of the Kessler limestone and overlying beds to the Pennsylvanian. Later, on account of the large Pennsylvanian element in the fauna, the lower portion of the Bloyd formation, embracing the Brentwood limestone, with its associated shales and sandstones, and the Hale sandstone, were placed in the Morrow group and likewise referred to the basal Pennsylvanian. All the formations carry abundant marine local faunas, which are listed by Miser.[13] The general faunas of the Morrow group and their stratigraphic distribution have been discussed somewhat fully by Mather.[14]

It is noteworthy that so far as the Wedington flora is known at the present moment, no species in it is found also in the large flora of the coal-bearing shale in the Morrow group. This fact accords with the length of the interval between the early upper or possibly the latest middle Chester and a stage lying probably in the upper part of the middle Pottsville. Certainly

[12] Lesquereux, Leo, Botanical and paleontological report on the Geological State Survey of Arkansas, in Owen, D. D., Second report of a geological reconnaissance of the middle and southern counties of Arkansas, pp. 295–399, Philadelphia, 1860; Description of the coal flora of the Carboniferous formation in Pennsylvania and throughout the United States: Pennsylvania 2d Geol. Survey Rept. P, 3 vols. and atlas, 1879–84.

[13] Purdue, A. H., and Miser, H. D., U. S. Geol. Survey Geol. Atlas, Eureka Springs-Harrison folio (no. 202), pp. 14–15, 1916. See also Croneis, Carey, Geology of the Arkansas Paleozoic area: Arkansas Geol. Survey Bull. 3, 1930.

[14] Mather, K. F., The fauna of the Morrow group of Arkansas and Oklahoma: Denison Univ., Sci. Lab., Bull. 18, pp. 59–284. 1915.

the equivalent at least of the entire Lee formation, over 1,200 feet thick, embracing the lower part of the Pottsville group of the Appalachian trough, was deposited in the Appalachian region in Pennsylvanian time before beds contemporaneous with the coal-bearing shale were there laid down.

Of the plant life of that portion of the Morrow lying below the coal-bearing shale very little is known. However, a small lot of specimens embracing *Lepidodendron* stems, for the most part in spongy sandstone with soft iron residues filling the cavities left by the macerated plants, was collected by H. D. Miser and now rests among the Geological Survey collections of fossil plants. No distinct leaf scars showing nerve traces and appendages remain. Even the outlines of the bolsters are obscure in some of the specimens. Their superficial features, however, associate these *Lepidodendron* stems with *L. aculeatum*, the comprehensive *L. veltheimianum*, the *L. obovatum* group, and possibly *L. jaraczewskii*. There is also present a single fragment apparently definitely referable to *Archaeocalamites scrobiculatus* as its characters are in close agreement with those of the form with sharply cut nodes and continuous ribs described as *Archaeocalamites transitionis*. The paleobotanic evidence is insufficient for a definite correlation, but it justifies the tentative assumption that the Hale formation is of basal Westphalian, if not, in fact, Namurian age.

ENVIRONMENT OF THE WEDINGTON FLORA

As to the environment in which the Wedington flora lived, little that is definite can be noted. The composition and distribution of the members of the Morrow group (Pennsylvanian), which succeeds the Pitkin limestone, suggest a nearly baseleveled Ozarkia, along the south flank of which were a series of shoal-water deposits that at times, at least, may have been barrier-lagoonal in nature. Scarcity of conglomeratic material negatives any considerable elevation of the northern land, which, as indicated by the relative freshness of the plant remains buried in the sandstone, must have been comparatively near.

Apparently most of the plants drifting into the shallow water of the Wedington sandstone environment were small; the calamarian stems were all small, the lepidophytes include very few impressions of large stems, no large stem referable to fern or pteriodosperm is present, and no *Cordaites* leaves have been detected.

As will be noted in the descriptions, the cuticles of most of the ferns and fernlike plants are rugose, and many of them are provided with spines or short bristle-like hairs, some scattered sparsely and some relatively closely on both pinnules and rachises, even of small and relatively delicate fronds. The leaf bases of most of the lepidophytes are very highly protuberant, in some specimens almost extraordinarily so. Furthermore, the outer covering of these plants was rather distinctly horny as well as rigid. The branches of *Lepidodendron henbesti* were slender and crooked, and near the ends the branchlets were so close (less than 2.5 centimeters apart) as to suggest a tangled or matted yet rather rigid growth. The seeds classed as *Rhynchogonium* are provided with an extension of the outer integument in a group of narrow acute teeth, suggesting a closed calyx, but the inner and thicker testa is cut in short blunt teeth, which appear to have rolled outward at the time of maturity of the seed, when also the calyx opened, presumably to permit fertilization, after which the calyx seems to have closed, as, very likely, also did the teeth guarding the opening to the pollen chamber of the seed. It is perhaps noteworthy that the cones described as *Chlamidostachys* bore broad winged bracts, along which the sporangiophores were distributed, and that by means of these wings and the hoodlike expansion of the terminal portion of the bract the fructifications seem to have been tightly wrapped and protected.

Though practically nothing is known of the internal structure of the plants, the inference may be drawn that the environment was not wholly favorable to the development of large size in growth of plants and trees and that the climate was probably marked by a seasonal deficiency of rainfall. Such a conclusion appears to harmonize with the occurrence of hardened and well-rounded pebbles of clay and fine-grained silt, mingled with the plants in the sandstone, and with the slightly gypseous content of the enveloping Fayetteville shale.

DESCRIPTIONS OF THE SPECIES

Genus ADIANTITES Schimper, emended, 1869

In connection with my description [15] of the seed *Wardia*, borne on certain fernlike fronds from the lower Pottsville of southern West Virginia, I applied the name *Aneimites* (Dawson) Schimper to these fronds as the generic name properly applicable, the name *Adiantites*, by which similar fronds had most frequently been designated, being then regarded as nomenclaturally untenable. For reasons that follow I discontinue this application of the name *Aneimites* in favor of *Adiantites*, the use of which, though on none too secure foundation, seems preferable to the coinage of a new generic name, otherwise necessary. Briefly, the essential points in the history of its use are as follows:

Adiantites was proposed by Goeppert [16] in 1836 to include 20 species, embracing chiefly ginkgoes, cyclopterids, and sphenopterids. Since that date all the species which in accordance with the accepted rules of nomenclature might be regarded as types of Goeppert's genus have been transferred to other genera. Mean-

[15] White, David, The seeds of *Aneimites:* Smithsonian Misc. Coll., vol. 47, pt. 3, no. 1550, p. 323, 1904.

[16] Goeppert, H. R., Systema filicum fossilium; Die fossilen Farrnkräuter: Acad. Caesarea Leopoldino-Carolina Nova Acta, vol. 17, Suppl., p. 216, Breslau, 1836.

while Schimper,[17] in 1869, proposed the genus *Adiantides* Schimper "(*Adiantites* auct.)", to which he referred either directly or as synonyms the species enumerated by Goeppert in Goeppert's final group.[18] Under the nomenclatural rules formerly followed by most paleobotanists the retention of Goeppert's term for this final residual, which included but four species, was permissible, without regard to generic type. Inasmuch as Schimper in his new genus gives type status to one of the species brought forward from Goeppert's list, his revision is here accepted. However, as the name *Adiantides* proposed as new by Schimper is evidently a mere modification of the spelling of the earlier name in a form that is not permissible under the rules followed by most paleontologists, the term *Adiantites* as spelled by Goeppert must be retained, though the restriction and definition of its conception and scope as emended by Schimper are recognized.

The subgeneric name *Aneimites*, proposed and long used by Dawson,[19] was made to embrace several species from the Upper Devonian, the Mississippian, and the Pottsville. However, *Cyclopteris* (*Aneimites*) *acadica* Dawson,[20] from the lower Mississippian of Nova Scotia, first published in 1860 and more fully described and illustrated in 1873,[21] is shown to have a bifurcated petiole, and the inferior ultimate pinnules, which are short petiolate, are remarkably recurved in a way that is characteristic of the subgenus. As *Cyclopteris* (*Aneimites*) *acadica* had, in connection with the description of other plants by Dawson, been designated as the type of the subgenus *Aneimites*,[22] and as the mode of division of the frond of this species seems to differ generically from that of the fronds under consideration, from the upper Mississippian and lower Pottsville, the use of *Aneimites* for the latter is precluded, in spite of the elevation of the term to generic rank by Schimper [23] in 1874, with priority given to Dawson's type species.

So far as known, *Aneimites*, restricted to accord with the generic characters of *Aneimites acadica*, is confined to the lower Mississippian, whereas *Adiantites* is apparently confined to the upper Mississippian, where it is represented by the plant here described as *Adiantites minima*, and to the Pottsville, where are found *Adiantites fertilis* and several other related species.

The genus *Adiantites* is typified in Goeppert's *Adiantites cuneatus*,[24] which Schimper made a synonym of Brongniart's *Sphenopteris nervosa*,[25] placing the latter at the head of the genus "*Adiantides.*" Characteristic of the genus is the species described by Ettingshausen [26] as *Adiantum antiquum*, which was more elaborately illustrated by Stur [27] under the name *Adiantides antiquus* (Ettingshausen). The essential generic characters are as follows:

Fronds tri- or quadripinnate with slender rachis; primary divisions alternate, often very open; pinnules cuneate to cuneate-obovate, truncate or rounded at the apex or divided into two to five cuneate lobes, usually slightly pedicellate with narrow, relatively terete, and sometimes very narrowly margined rachis; nerves numerous, flabellately divergent, or with imperfect development of a principal nerve strand in the lower portion of the pinnule or lobe, the nervilles being generally slender, several times dichotomous, and straight or slightly curved.

Adiantites minima White, n. sp.

Plate 4, figure 38

Major divisions not seen; penultimate rachis strong, rigid, dorsally low-rounded, and lineate with distinctly decurring nerve strands descending from the ultimate pinnae; ultimate pinnae alternate, oblique, at an angle of about 60°, close, slightly overlapping, small, linear-lanceolate, slightly acute, with relatively broad, rigid or slightly flexuose, very narrowly alate axis; pinnules small, alternate, slightly decurrent, broadly cuneate to obovate, cuneate when sublobate, slightly broad-pedicellate, oblique, slightly outward-curved, slightly obliquely round-truncate or broadly rounded at the apex, 3 or 4 millimeters long and 2 or 3 millimeters wide, the lobes, two or three in number, about 2.5 millimeters long and 1 to 2 millimeters wide, somewhat divaricate; lamina thick, very minutely rugose, nearly flat, and decurrent in a narrow border along the rachis; nervation partly flabellate without the development of a strong primary nerve, the secondary nerves being derived at a wide angle in the decurrent base of the pinnule or near the base of each lobe, the nervilles being nearly straight and forking low in the lobe to furnish generally two or three nearly straight nervilles to the lobe.

This species is remarkable for the small size of its pinnules and lobes. The lobes, though relatively broad and robust as compared with those of other species of *Adiantites*, are in their arrangement, mode of development, and nervation characteristic of the

[17] Schimper, W. P., Traité de paléontologie végétale, tome 1, p. 424, 1869.

[18] Goeppert, H. R., op. cit., p. 226; "c. Frons tripinnata."

[19] Dawson, J. W., On an undescribed fossil fern from the lower coal measures of Nova Scotia: Canadian Naturalist, vol. 5, p. 461, 1860.

[20] Dawson, J. W., On an undescribed fossil fern from the lower coal measures of Nova Scotia: Geol. Soc. London Quart. Jour., vol. 17, p. 5, 1860; On the conditions of the deposition of coal, more especially as illustrated by the coal formation of Nova Scotia and New Brunswick: Idem, vol. 22, p. 153, pl. 8, fig. 32, 1866.

[21] Dawson, J. W., Report on the fossil plants of the Lower Carboniferous and Millstone Grit formations of Canada, p. 26, pl. 7, figs. 52–63, Canada Geol. Survey, 1873.

[22] Dawson, J. W., The fossil plants of the Devonian and Upper Silurian formations of Canada, p. 48, Canada Geol. Survey, 1871.

[23] Schimper, W. P., op. cit., tome 3, p. 489, 1874. Schimper gives first place to *Aneimites acadica* (Dawson), which is followed by *Aneimites adiantoides*, of which Ettingshausen's *Adiantum antiquum* (Die fossile Flora des mährisch-schlesischen Dachschiefers, p. 98, pl. 7, fig. 1, 1865) is made a synonym.

[24] Goeppert, H. R., op. cit., p. 226.

[25] Brongniart, Adolphe, Histoire des végétaux fossiles, tome 1, p. 174, pl. 56, fig. 2, 1828.

[26] Ettingshausen, C. von, Die fossile Flora des mährisch-schlesischen Dachschiefers: K. Akad. Wiss. Wien, Math.-naturwiss. Kl., Denkschr., Band 25, p. 22, pl. 7, fig. 1, 1865.

[27] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Band 8, Heft 1, p. 66, pl. 16, figs. 4–6, pl. 17, figs. 3–4, 1875.

genus. On account of their very small size, the plant is suggestive of portions of *Sphenopteris divaricata* or some of the relatively large and cuneately lobed pinnules referred by some authors to the *Sphenopteris hoeninghausii* group.

The general aspect of the narrowly alate rachis is shown in figure 38, plate 4, as are some of the aspects of the pinnules. Although the pinnules approximate in size some of those characteristic of *Sphenopteris hoeninghausii*, they are readily distinguished by the flat lamina and the more distinctly cuneate lobes.

Among the known species of *Adiantites*, *A. minima* appears most closely related to *Adiantites fertilis*,[28] to the smallest pinnae and pinnules of which the fragments in hand are strikingly similar. The Arkansas plant differs, however, in its shorter and relatively broader pinnules, which are thicker and in general rather more open. In the Pottsville plant, *Adiantites fertilis*, the leaf is thin and the nervation slender and relatively distant.

The fruit *Wardia*, found attached to *Adiantites fertilis* and generically in association with other species of the genus at other localities in the Pottsville group, has not yet been found in the Wedington. It will probably be discovered on further search. The genus is characteristic of and mainly confined to the Pottsville (Westphalian).

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8075).

Type: U. S. Nat. Mus. 39477.

Genus CARDIOPTERIS Schimper, 1869 [29]

Cardiopteris hirta White, n. sp.

Plate 4, figures 29, 31, 32, 33, 34, 35, 37

Pinnules relatively small, mostly about 11 millimeters in length, rounded, somewhat polymorphous, ranging from ovate or broadly oval to very broadly ovate or even slightly reniform, the younger ones generally longer than broad, the older frequently as broad or even broader than long, occasionally very faintly sublobate in one or two rounded and hardly differentiated lobes; lamina usually overlapping or clasping at the base, nearly flat, slightly arched at the border, rather thick, minutely rugose and provided with numerous stiff, relatively coarse hairs generally about 2 millimeters in length, for the most part oriented parallel to the nervation, which they partly obscure; nervation flabellate from the narrow point of attachment; nerves rather coarse, frequently striate, forking three to five times, according to the size of the pinnule, at a very narrow angle, while passing nearly straight or but slightly arching to the margin and approximately equidistant in all parts of the pinnule.

Most common among the small fragments and detached pinnules of ferns in the collection are relatively small isolated pinnules of a species of *Cardiopteris*, obviously related to *Cardiopteris polymorpha* (Goeppert) Schimper. The pinnules, which are generally rounded, rarely exceed 12 millimeters in length, and the smallest are less than 6 millimeters and scarcely more than 5 millimeters in breadth. All are characterized by the presence of short, stiff hairs, generally parallel to and even obscuring the nervation.

The most common and characteristic form of this species is seen in figure 35, plate 4, in which two clasping pinnules are probably not far from their original position. Another specimen, viewed dorsad and exhibiting the characteristic overlapping of the lobes, is shown in figure 32, plate 4, and the details of venation of a relatively large pinnule, slightly sublobate at the distal margin, are seen in figure 37.

Some relatively broad specimens of *Cardiopteris hirta* show slight sublobation, and two of the smallest pinnules are illustrated in figures 29, 33, and 34, plate 4. No fragments of rachis to which pinnules are attached have been noted in the collection.

The rugosity and hairs characteristic of the species are shown in the enlargements, figures 31 and 37, plate 4, as is the nervation.

Cardiopteris hirta is closely related to *Cardiopteris polymorpha* (Goeppert) Schimper, though its pinnules are generally much smaller than those of *C. polymorpha* and are, in particular, distinguished by the broad striate nerves on which are superposed the short, stiff hairs.

The average pinnule of this species rather closely resembles the smallest of the pinnules figured by Stur [30] from the Waldenburg series as *Cardiopteris* sp. It is, however, much smaller than the larger Waldenburg pinnules, which are much more broadly reniform and much larger.

The ordinary pinnules of *Cardiopteris hirta* are rather strikingly similar in size, form, and even in nervation to some of the pinnules described as *Cardiopteridium spetsbergense* by Nathorst,[31] though there is no evidence that the more distinctly cordate or cyclopterid pinnules from the Wedington were associated with much larger heteromorphous pinnules, rather broadly attached or even petiolate and provided in some specimens with midribs, as was the case with the plant made by Nathorst the basis for his genus *Cardiopteridium*, which is found in the Mississippian of Spitsbergen.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8075), and by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264).

Types: U. S. Nat. Mus. 39478–39482.

[28] White, David, The seeds of *Aneimites:* Smithsonian Misc. Coll., vol. 47, pt. 3, p. 323, pls. 47, 48, 1904.

[29] Schimper, W. P., Traité de paléontologie végétale, tome 1, p. 451, 1869.

[30] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Band 8 Heft 2, p. 182, pl. 11, fig. 6, 1877.

[31] Nathorst, A. G., Nachträge zur paläozoischen Flora Spitzbergens: Zur fossilen Flora der Polarländer, Teil 1, Lief. 4, p. 16, pl. 9 (see especially figs. 14 and 15),1914.

Cardiopteris sp.

Plate 4, figures 40, 41

The small fragment shown in plate 4, figures 40 and 41, is one of two specimens comprising portions of torn leaves that apparently represent a species of *Cardiopteris* in which the leaves are much larger than in *Cardiopteris hirta*, already described. In this form the pinnule, which is apparently slightly thinner than in the other species, has, as will be noted on comparing the figures, somewhat more distant nervation, which is less equidistant in the interior of the pinnule as compared to the marginal region. In this specimen leaf hairs do not seem to be present.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264).

Types: U. S. Nat. Mus. 39483.

Genus NEUROPTERIS (Brongniart) Sternberg, 1825 [32]

Neuropteris sp.

Plate 4, figures 26, 27, 28

Among the small fragments of pinnae and the detached pinnules found in the collections are several that are apparently referable to the genus *Neuropteris*, though they are inadequate for satisfactory identification or specific description. Like the pinnules of the earlier representatives of this genus, they are broadly attached, and near the apex of the pinna or in the very young pinnules they are more or less confluent. A sublobate terminal pinnule is illustrated in figure 28, plate 4. Young pinnules broadly attached and probably decurrent have likewise been observed. The nervation of these pinnules is distinctly neuropterid, with generally well-developed median nerves, even where some of the nervilles, especially in the decurrent parts of the lamina, are derived from the rachis. The nerves are coarse and slightly irregular. They fork once or twice at rather wide angles while bending outward toward the margin, which they generally meet at an oblique angle. As is shown in the enlargement, figure 26, plate 4, the nervation is partially obscured by the presence of numerous short bristlelike hairs scattered over both the dorsal and ventral surfaces of the pinnule. These hairs are relatively large at the base, are stiff, and taper rather rapidly upward to a sharp point. They are about 1 or 1.25 millimeters in length, and they generally lie parallel to the nervation, but occasionally their disposition is irregular.

The form represented by these specimens appears rather more rounded at the apex, and the pinnules are generally smaller than those in the material from the Mississippian of Europe figured as *Neuropteris antecedens*, though the larger of the fragments from the Wedington sandstone is in many respects comparable to one of the specimens figured by Stur in plate 15, figure 4, of "Die Culm-Flora." Neuropterid forms of the type illustrated by Ettingshausen [33] as *Neuropteris heterophylla* Brongniart and by Stur [34] as *Neuropteris antecedens* date far back in Mississippian time. Assuredly, however, not all the fronds illustrated by Stur as *Neuropteris antecedens* Stur can have belonged to a single species.

The Wedington plant is further characterized by the rigid bristlelike hairs borne on both surfaces of the lamina, which itself is coriaceous.

Though the pinnules agree in form with some of those of the *Neuropteris pocahontas* group in the lower Pottsville of the Appalachian trough, all differ from that group, which is not provided with hairs, by the much more distant, more broadly forking, and less strongly arched nervation.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8075), and by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264).

Types: U. S. Nat. Mus. 39484, 39485.

Genus RHACOPTERIS Schimper, 1869 [35]

Rhacopteris sp.

Plate 4, figures 1, 6

A single specimen in the collection embracing portions only of three consecutive pinnules, shown in figure 1, plate 4, rather clearly represents a large-pinnuled species of *Rhacopteris*. As seen in the illustration and enlarged photograph, figure 6, plate 4, the leaf is thick, even leathery, and granular-rugose. It is shallowly dissected in very oblique or nearly vertical lobes which turn slightly outward. The overlapping pinnules represented in this specimen were probably 2 centimeters or more in length and 1.25 to 1.5 centimeters or more in width. The coarse, gently arching, and rather evenly curved nerves are in relief on both the dorsal and ventral surfaces. They are rather distant, nearly equidistant one from another, and they appear to fork three to five times at a narrow angle in passing from the midrib, which is not well developed in the upper part of the pinnule, to the apex of the lobe.

In the size and indicated shape of the pinnules and both the texture and the nervation, this plant approaches very closely an undescribed species in the Mississippian of the Appalachian trough.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264).

Type: U. S. Nat. Mus. 39486.

[32] Brongniart, Adolphe, Mus. histoire nat. Paris Mém., tome 8, p. 233, 1822. Sternberg, Kaspar, Versuch einer geognostisch-botanischen Darstellung der Flora der Vorwelt, Tentamen, p. xvii, 1825.

[33] Ettingshausen, C. von, Die fossile Flora des mährisch-schlesischen Dachschiefers: K. Akad. Wiss. Wien, Math.-naturwiss. Kl., Denkschr., Band 25, p. 20, text fig. 4, pl. 6, fig. 1, 1865.

[34] Stur, Dionysius, op. cit., Heft 1, pl. 15.

[35] Schimper, W. P., Traité de paléontologie végétale, tome 1, p. 481, 1869.

Genus RHODEA Presl, 1838 [36]

Rhodea cf. R. subpetiolata (Potonié) Němejc

Plate 4, figures 2, 3

A few small fragments, one of which is photographically illustrated in plate 4, figures 2 and 3, are, on account of the asymmetry of the pinnules, in which the inner basal lobes are longer and larger, referred with some doubt to the genus *Rhodea*. Though the pinnules are small and the lobes fewer, less truncate, and less unequal, they are slightly suggestive of *Rhacopteris subpetiolata* Potonié,[37] transferred by Němejc[38] to *Rhodea*.

In some of the specimens the pinnules have a generally rhomboidal outline. The lobes are rather deeply dissected, narrowly wedge-shaped, and more or less obliquely rounded, with slight indication of truncation at the apex. The distal basal lobe appears broader, a little larger, and less oblique than the proximate lobe. The lamina is slightly arched ventrad and very narrowly decurrent along the upper portion of the outer rachis. The larger lobes are provided with median nerves, from which nearly straight nervilles pass at relatively oblique angles, forking once, whereas the narrow upper lobes appear to be provided with but a single nerve.

Though much smaller, the pinnules in the specimen illustrated are most suggestive of *Rhodea subpetiolata* (Potonié), from the Waldenburg series and the coal basins of central Bohemia,[38] with which the Arkansas plant may be associated pending the discovery of specimens adequate for its definite identification and description.

Superficially the Wedington specimens resemble the specimen illustrated by Feistmantel[39] in plate 15, figure 14, of his paper on the plants from the Carboniferous limestone at Rothwaltersdorf under the name *Hymenophyllites furcatus* Brongniart. The resemblance is, however, remote, if dependence is put on the enlarged figure 14a of the same plate as illustrating the detailed lobation and nerves.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8075).

Types: Figured specimens, U. S. Nat. Mus. 39487

Rhodea cf. R. moravica (Ettingshausen) Stur

Plate 4, figures 19, 24, 25

The collection from the Wedington contains several very small fragments of a sphenopterid with small pinnules cut as if skeletonized in very narrow, delicate, rather broadly divergent but somewhat irregular lobes, which may fork widely in linear, slightly flexuose subdivisions very nearly equaling in width the mother lobes. The very small specimen seen in figure 19, plate 4, illustrates these features. The material is insufficient for definite specific determination.

It is, however, perhaps specifically identical with some of the specimens figured by Ettingshausen[40] as *Trichomanes moravicum* Ettingshausen, which was transferred by Stur[41] to the genus *Rhodea*.

The fragment with the more open lobes is very closely comparable to one of the specimens from the Moravian-Silesian roofing slates illustrated by Stur[42] as *Rhodea goepperti* (Ettingshausen) sp. There is, however, nothing else in the collection which closely resembles other specimens described by Stur under the same name.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264).

Types: Figured specimens, U. S. Nat. Mus. 39488, 39489.

Genus SPHENOPTERIS (Brongniart) Sternberg, 1825 [43]

Sphenopteris cf. S. communis Lesquereux

Plate 4, figure 9

A single fragment of *Sphenopteris*, which in its mode of ultimate subdivision and, to some extent, in the form and aspect of its connate, oblique, and but slightly dissected pinnules, which are ovately rounded at the top and slightly cuneate, rather closely resembles the plant from the Morrow group described by Lesquereux under the name *Sphenopteris communis*. The fragment is shown in figure 9, plate 4. Like the Morrow species, this one is somewhat rugose-villous, with partly masked, oblique, somewhat diffused, and relatively close nervation.

Further specimens are needed for the proper characterization and identification of this plant.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8075).

Type: Figured specimen, U. S. Nat Mus. 39490.

Sphenopteris (Palmatopteris) erectiloba White, n. sp.

Plate 4, figures 10, 16

Ultimate divisions alternate, linear, very oblique, parallel, rigid, with dorsally terete, ventrally shallowly depressed, narrow, straight rachis; pinnules very oblique, nearly erect, lineate to very narrowly cuneate obovate, dissected in two to five narrow cuneate lobes,

[36] Presl, Karl, in Sternberg, Kaspar, op. cit., Hefte 7, 8, p. 109, 1838.

[37] Potonié, H., Ueber einige Carbonfarne: K. preuss. geol. Landesanstalt Jahrb., 1899, p. 26, 1892; Die floristische Gliederung des deutschen Carbon und Perm: K. preuss. geol. Landesanstalt Abh., neue Folge, Heft 21, p. 21, fig. 6, 1896.

[38] Němejc, F., *Rhodea subpetiolata* Pot. sp., a new leaf type in the coal basins of central Bohemia: Acad. tchèque sci. Bull. internat., année 28, pp. 56–61, pl. 1, text figs. 1, 2, 1927.

[39] Feistmantel, Ottokar, Das Kohlenkalkvorkommen bei Rothwaltersdorf in der Grafschaft Glatz und dessen organische Einschlüsse: Deutsche geol. Gesell. Zeitschr., Band 25, pp. 463–551, 1873.

[40] Ettingshausen, C. von, Die fossile Flora des mährisch-schlesischen Dach, schiefers: K. Akad. Wiss. Wien, Math.-naturwiss. Kl., Denkschr., Band 25, p. 100-pl. 6, fig. 4, 1865.

[41] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Band 8, Heft 1, p. 42, pl. 11, fig. 7, 1875.

[42] Idem, pl. 11, figs. 3–7.

[43] Brongniart, Adolphe, Mus. histoire nat. Paris Mém., tome 8, p. 233, 1822. Sternberg, Kaspar, op. cit., Tentamen, p. xv, 1825.

which in turn are very deeply dissected in the larger units, which are slightly arched ventrad, round obtuse at the apex, with lateral margins nearly parallel; lamina rather dense, minutely rugose, sparsely provided with rather slender short bristlelike hairs on the dorsal surface, and decurrent to form a very narrow bordering wing along the rachis.

Owing to the small size of the fragments here described, the mode of division of the frond and the satisfactory generic reference of the species are not at present determinable. The very oblique position, the close spacing, and the rigidity of the narrow pinnae are shown in figure 16, plate 4, which includes portions of two ultimate pinnae, extremely oblique and parallel, attached to a penultimate axis. The lobes are apparently rapidly dissected in the course of their development into narrowly cuneate lineate divisions, in which the lateral borders converge very slowly in passing downward. Bidentate lobes, in which the division is incipient, are relatively rare in the specimens.

The fragment here described deserves comparison with the forms referred by authors to *Palmatopteris*, including *P. furcata*. It is also comparable to the plant from the Westphalian series in the Durham coal field of England described by Kidston [44] as *Rhodea eltringhami*. Similar erectness of the lobes of the skeletonized sphenopterid is found in the Mississippian as well as the Pennsylvanian both in the Old World and in America.

Among the lower Pennsylvanian species to which the plant in hand may be compared, mention should be made of *Sphenopteris ettingshauseni* Stur?, some of whose pinnules are small, fasciculate, and erect, though generally less compact and broader.[45]

In general form and mode of development of the very oblique ultimate pinnae and the pinnules, the species in hand agrees with the older Mississippian sphenopterids. It is particularly comparable to *Sphenopteris schimperiana* Goeppert as illustrated by Vaffier,[46] and it suggests comparison with some of the figures of forms from the upper Culm referred by Bureau [47] to *Diplotmema furcatum*.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264).

Types: U. S. Nat. Mus. 39491.

Sphenopteris (Calymmatotheca) mississippiana White, n. sp.

Plate 4, figures 4, 5, 11, 13, 14, 15, 17, 18, 20, 21, 22, 23, 30, 36, 39

Mode of primary division unobserved; main axis rigid and having a width of 1 centimeter or more, with rather thick carbonaceous residue, in which *Dictyoxylon* structure is apparent; petioles lineate, with rather thick carbonaceous residue, the surface of which is provided with rather distant fairly strong though moderately slender spines; ultimate pinnae small, mostly rather short, generally with rather broad rachis, which is ventrally shallowly and broadly sulcate and lineate, dorsally rounded, and slightly flexuose in the upper portions; pinnules small, ovate-deltoid to oval-ovate and oval-deltoid, very open, slightly pedicellate, generally close, alternate, nearly touching or slightly overlapping, shallowly cut in three to five or six divaricate lobes, which become broadly cuneate or slightly squarrose, truncated, or very shallowly sinused at the apices, some of which are creased or slightly reflexed, and slightly acute at the distal angle; lamina thick, faintly rugose, frequently depressed ventrally just within the border of the lobes, as if fertile, slightly inflated ventrad, very narrowly decurrent along the rachis in the ultimate divisions, and sparsely provided with short bristlelike spines situated on low round protuberances; nervation rather coarse and forking at a wide angle to provide a nerville for each lobe or tooth.

The thin deposits of shale interbedded with the Wedington sandstone contain rather numerous very small fragments of a *Sphenopteris* whose close relationship to the *Sphenopteris* (*Calymmatotheca*) *hoeninghausii* group is shown not only by the form and arrangement of the ultimate pinnae and the pinnules but by the associated impressions of *Dictyoxylon* stems and the carbonized remains or the impressions of fragments of petiole sparsely clothed with small slender thornlike spicules of the type found on *S. hoeninghausii*. All the frond fragments are very small, and none of them show the mode of primary division of the frond; but nevertheless their number and characters are such as to admit not only specific description but the confident consideration of the species as representing an early form of the *Lyginopteris* type of frond in this very late Mississippian deposit. The *Lyginopteris* (*Dictyoxylon*) type is found also in a species from the Carboniferous limestone (upper Mississippian) from Rothwaltersdorf, in Glatz, referred in 1873 to *Sphenopteris hoeninghausii* by Feistmantel.[48]

Fragments illustrating the ordinary size of the ultimate pinnae and the relations and lobation of the pinnules in the middle or lower portions of the frond are shown in figures 13 and 17, plate 4. The photographic enlargement of the former, figure 14, plate 4, shows both the pits left at the bases of the spicules on the ventral surface of the specimen, from which the epidermal residue has in part been scaled, and the depressions that have the appearance of sporangia, located immediately within the margin of the sharply depressed or creased ventral surface of the lamina. The

[44] Kidston, Robert, Fossil plants of the Carboniferous rocks of Great Britain: Great Britain Geol. Survey Mem., Paleontology, vol. 2, pt. 3, p. 236, pl. 58, figs. 4, 4a, 4b, 1923.

[45] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Band 8, Heft 1, p. 29, pl. 7, fig. 1, 1875.

[46] Vaffier, A., Étude géologique et paléontologique du Carbonifère inférieur du Mâconnais: Univ. Lyon Annales, nouv. sér. 1, Sci. méd., fasc. 7, pl. 4, figs. 1, 1a, 1b, 1c; pl. 5, figs. 1, 1a, 1b, 1c, 1901.

[47] Bureau, Édouard, Bassin houiller de la basse Loire, fasc. 2, Description des flores fossiles, atlas, pl. 24 bis, figs. 1, 2, 3, 1913. (In the series "Études des gîtes minéraux de la France.")

[48] Feistmantel, Ottokar, Das Kohlenkalkvorkommen bei Rothwaltersdorf in der, Grafschaft Glatz und dessen organische Einschlüsse: Deutsche geol. Gesell. Zeitschr. Band 25, p. 504, pl. 14, figs. 7, 7a, 1873.

small fragment, figure 22, plate 4, which apparently was borne in the lower part of a pinna, probably in the middle or basal portion of the frond, exhibits the largest pinnules observed in the collection. In this as in other specimens the locations of the bases of the short spines that occur also on the midrib and on the rachis, as well as the decurrent lamina, are visible.

The fragment seen in figure 30, plate 4, in which the pinnules are more elongated, is probably derived from the upper part of the frond. On account of the less truncate lobation, which is not so distinctly divaricate and distant in this specimen, there is some room for question as to its specific identity with the others figured. The rachis is, however, distinctly spinose. The lamina is marked by the bases of the minute spicules or spines, and indications of developing squarrose lobation may be seen. The fragment shown in figure 20, plate 4, representing a small apical portion of an ultimate pinna from the lower part of the frond, in dorsal view, illustrates the relatively minute size of the pinnules and their lobation, which will at once be recognized as characteristic of the early *Sphenopteris hoeninghausii* group. The midrib, somewhat flexuose, is seen in dorsal relief.

A rather elongated form of pinnule, agreeing with that in figure 30, plate 4, though very much smaller, is shown in figure 17, plate 4. These figures indicate the generally relatively small form and the comparatively delicate detail of lobation in this Mississippian form. The spicular bases and the impressions of several of the flattened spicules, which in comparison with the very small pinnule are relatively large, may be observed in the photographic enlargement, four times natural size, figure 21, plate 4.

A rather indistinct cluster of what appear to be sporangia, apparently of the *Calymmatotheca* type, is shown magnified four times in figure 15, plate 4. It has the aspect of rather compactly though irregularly arranged sporangia grouped in a roundish glomerule that may be pedicellate. The reference of this specimen as possibly representing the polleniferous capsules of the species is tentative. Yet the frond described is unquestionably referable to *Calymmatotheca*.

Figure 4, plate 4, shows a part of an axis in which the dictyoxylon cortex is seen both in the impression and in the carbonized residue. The anastomosing strands shown in the enlargement, figure 5, plate 4, are strong, and the areas enclosed by the mesh vary in size, some of them being relatively large. Traces of the probably glandular and spicule-bearing protuberances are plainly visible near the centers of some of these areas.

In form and general aspect the fragments in hand carrying the small pinnules are similar to some of the ultimate pinnae described by Gothan [49] as *Lyginopteris hoeninghausii*, but the pinnae in the Wedington form are more compactly placed and more fully lobate, notwithstanding their small size.

The average pinna of this species somewhat resembles in size and even in shape one of the fragments from the Waldenburg beds originally figured by Stur as *Calymmatotheca stangeri* Stur.[50]

Localities: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8075), and by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264). About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145).

Types: U. S. Nat. Mus. 39492–39500.

Sphenopteris cf. S. obtusiloba Brongniart, 1829 [51]

Plate 4, figure 12

Among the forms of *Sphenopteris* represented by small fragments, too incomplete for identification and description, are two small sections of ultimate pinnae, one of which is illustrated in figure 12, plate 4.

The nervation of the pinnules is mainly derived from a primary nerve that is relatively strong, especially toward the base of the pinnule. The nervilles fork two or three times, while arching more or less, in passing from the midrib or the base of the pinnule to the border.

As to the inclusion of this form in the group represented by *Sphenopteris obtusiloba* or *Sphenopteris trifoliata*, there is little room for doubt. The largest pinnule is rather distinctly subtrilobate. The fragment shown in figure 12, plate 4, accords with the more distal pinnules or those in the upper part of the ultimate pinnae of the above-mentioned group. Obviously, however, the fragments are not definitely referable to either of the above-named species.

In some respects the figured specimens are somewhat comparable with the specimens from the Moravian-Silesian slates described by Stur [52] as *Sphenopteris foliolata*, which is, however, rather more like an extremely lax phase of *Sphenopteris obtusiloba*, though it clearly is not referable to that species. In the Silesian material the pinnules are more nearly reniform and are more crowded and less decurrent.

The fragment illustrated is superficially comparable also to that figured by Bureau from the upper Culm of the basin of the lower Loire [53] as *Sphenopteridium dissectum* Schimper.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8075).

Type: Figured specimen, U. S. Nat. Mus. 39501.

[49] Gothan, Walther, Die Steinkohlenflora der westlichen paralischen Carbonreviere Deutschlands: Inst. Paläobotanik u. Petrographie der Brennsteine Arbeiten, Band 1, Heft 2, p. 72, pl. 21, fig. 1, Preuss. geol. Landesanstalt, 1931; Die oberschlesische Steinkohlenflora, Teil 1, Farne und farnähnliche Gewächse: K. preuss. geol. Landesanstalt Abh., neue Folge, Heft 75, pl. 13, fig. 1, 1913.

[50] Stur, Dionysius, op. cit., Heft 2, p. 155, pl. 9, fig. 4, 1877.

[51] Brongniart, Adolphe, Histoire des végétaux fossiles, tome 1, p. 204, 1829.

[52] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Band 8, Heft 1, p. 22, pl. 5, figs. 3–5, 1875.

[53] Bureau, Édouard, Bassin houiller de la basse Loire, fasc. 2, atlas, pl. 7, fig. 3, 1913.

Sphenopteris cf. S. schimperiana Goeppert [54]

Plate 4, figures 7, 8

A few small fragments, one of which is illustrated in figures 7 and 8, plate 4, though insufficient for reliable determination, offer such distinctive characters as to deserve illustration, in the hope that publication may lead to the discovery of more complete specimens. As shown in figure 7, one fragment shows a detached pinnule or possibly merely a lobe of a pinnule, fasciculate in type, in which the lobes, whose collective profile is rounded, are rather deeply cut, closely placed, cuneate in position, relatively rounded at the apex, and almost equally wide in all parts. The carbonaceous residue, a portion of which remains, is thick and slightly rugose, and the nerves fork at a rather narrow angle.

On account of the very close resemblance of the fragments described above to the details of the plant figured by Feistmantel [55] as *Hymenophyllites schimperianus* from the Carboniferous limestone at Rothwaltersdorf, in Silesia, I tentatively place them under that specific name, though the agreement with the descriptions and figures published by Goeppert [54] and Schimper [56] is more remote.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264).

Type: Figured specimen, U. S. Nat. Mus. 39502.

Genus TELANGIUM Benson, 1904 [57]

Telangium? sp.

Plate 5, figure 2

Under the reference cited above is photographically illustrated what appears to have been a loose glomerule of fusiform, acutely tapering sacs. The single specimen in hand was evidently macerated, and the resulting hollows in the sand are filled with sand grains and loose limonitic powder. At the bottom and toward the upper border of the mold are seen the impressions of portions of clawlike appendages, which I interpret as probably sporangial. The inner surfaces of these sporangia (?) are relatively smooth. There is no trace of a median nerve or other vascular tissue in the sporangial impressions.

The small fragment in hand is probably referable to the genus *Telangium*, though it is rather closely comparable to some of the specimens described as *Calymmatotheca*. The example illustrated deserves comparison especially with *Telangium affine* (Lindley and Hutton) Benson as illustrated by Kidston [58] from the oil shale group of the Calciferous Sandstone series of Scotland.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White in 1930 (U. S. Geological Survey lot 8075).

Type: Figured specimen, U. S. Nat. Mus. 39503.

Genus RHYNCHOGONIUM Heer, 1876 [59]

The seeds described below as *Rhynchogonium fayettevillense* are apparently indistinguishable generically both from those illustrated and described by Heer from the Mississippian of Spitsbergen as *Rhynchogonium* and specifically as *R. crassirostre* and *R. costatum*, on the one hand, and that described by Zalessky [60] from the Mississippian Msta stage of northern Russia under the name *Boroviczia*, on the other. Though admitting the very close similarity in characters and the obvious relationship of his genus to that much earlier described by Heer, Zalessky concluded, though not without doubt, that the Russian form was probably of true generic rank, by virtue of the apparently more elaborate integuments. Subsequently, however, Nathorst,[61] after reexamination and redescription of *Rhynchogonium* and close comparison of the Spitsbergen seed with *Boroviczia*, rejected the structural distinction and concluded that the genera were extremely closely related, but that they might, however, be usefully separated by reason of the prolonged beak, which is more sharply differentiated in *Rhynchogonium* than in *Boroviczia*. He also uses the name *Boroviczia* for two species of seeds from Spitsbergen.

As will be seen in the description of *Rhychogonium fayettevillense*, its form, though comparable to that of *Rhynchogonium costatum* Heer, is intermediate between *R. costatum* and the ovate *Boroviczia karpinskii*. In the Wedington seed the lobes or segments marked by longitudinal costae prevailingly number 10 instead of 8, as in the Arctic seed. The free lobes forming what Zalessky described as the "calyx" appear to be an extension of the outer vascular integument, which below the point of union of the teeth or lobes may be coherent with the very thick inner testa.

Boroviczia is represented by a species found in the upper Pottsville at Campbells Ledge, near Pittston, Pa., and in my judgment it is also distinctly congeneric with the fruits described by Lindley and Hutton [62] as *Carpolithus sulcatus*, which was referred by Kidston to

[54] Goeppert, H. R., Ueber die fossile Flora der Silurischen, der Devonischen und unteren Kohlenformation oder des sogenannten Uebergangsgebirges: Acad. Caesarea Leopoldino-Carolina Nova Acta, vol. 27, p. 66, pl. 37, figs. 2a, 2b, 1859.

[55] Feistmantel, Ottokar, Das Kohlenkalkvorkommen bei Rothwaltersdorf in der Grafschaft Glatz und dessen organische Einschlüsse: Deutsche geol. Gesell. Zeitschr., Band 25, p. 513, pl. 15, figs. 13, 13a, 1873.

[56] Schimper, W. P., Les végétaux fossiles, in Koechlin-Schlumberger, J., and Schimper, W. P., Le terrain de transition des Vosges, p. 341, pl. 29, 1862.

[57] Benson, Margaret, *Telangium scotti*, a new species of *Telangium* (*Calymmatotheca*) showing structure: Annals of Botany, vol. 18, p. 162, 1904.

[58] Kidston, Robert, Memoir on the fossil plants of the Carboniferous rocks: Great Britain Geol. Survey Mem., Paleontology, vol. 2, pt. 5, p. 446, pl. 101, figs. 1, 5, 1924.

[59] Heer, Oswald, Flora fossilis arctica, vol. 4, Abt. 1, p. 19, 1876.

[60] Zalessky, M. D., Über Früchte aus den Untercarbon-Ablagerungen des Msta, beckens in Nord-Russland: Acad. imp. sci. St.-Pétersbourg Bull., tome 22, no. 3-p. 115, 1905. (See *Boroviczia karpinskii*, p. 114, figs. 1–9.)

[61] Nathorst, A. G., Nachträge zur paläozoischen Flora Spitzbergens: Zur fossilen Flora der Polarländer, Teil 1, Lief 4, p. 22, 1914.

[62] Lindley, John, and Hutton, William, Fossil flora of Great Britain, vol. 3, pl. 220, 1837.

the genus *Rhynchogonium*.[63] To the same genus, further, is to be referred a specimen in the Lacoe collection, in the United States National Museum, representing *Trigonocarpum ellipticum* Goeppert, from the Carboniferous limestone of Rothwaltersdorf, in Silesia.

From the examination of the specimens in hand, there appears to be no adequate basis for the generic distinction between *Boroviczia* and the earlier established genus *Rhynchogonium*, to which in the following pages I have given precedence.

Rhynchogonium fayettevillense White, n. sp.

Plate 8, figures 1–8, 12–14, 22

Seeds ovate-oval to ovate-triangular in longitudinal profile, 11 to 18 millimeters in length, 4 to 11 millimeters in width, round at the bottom, apiculate to tapering-acute at the top, with broad chalaza, above which originate 6 to 12 nearly equal ribs, which become sharper and crested or narrowly alate in passing upward, the intervening areas or segments being slightly concave, especially near the ribs, parted near the top in tapering narrow lobes, which may converge, though distinct, to a sharp point or which may be slightly reflexed or flared in a short funicular neck; outer surface rather finely and somewhat irregularly striate; inner surface of outer testa very finely striate with the rows of minute punctations, which are slightly elongated in the longitudinal direction.

The seeds here described occur in great numbers in portions of the plant-bearing Wedington sandstone, where they appear to have accumulated in pockets in the rapidly deposited sand. They differ greatly in size, as may be seen by a glance at the photographs, but in spite of these considerable differences I am disposed to regard most of them as belonging to a single species, in which many of the specimens are presumably very young. The small specimens seem to have been more easily compressed than the large ones, but I observe no specific character other than size in accordance with which they may be differentiated, and in the matter of size the gradational sequence appears to be complete.

Several seeds of average dimension are shown in a group in figure 2, plate 8. The larger specimens in this group are of the average dimension. Figure 7, plate 8, illustrates the comparatively large chalaza. Figure 3, plate 8, shows a large and apparently mature specimen in which the overlobes of the segments of the outer testa are converged to a point and prolonged with considerable delicacy. This specimen represents the extreme length of the tapering lobes. The free ends of the lobes of the outer integument, some of which appear short and blunt, as if shriveled or possibly rolled backward somewhat, are seen in figures 1 and 13, plate 8.

In several of the specimens, especially those of smaller size, the fruit is rather indistinctly, or rarely distinctly, triangular. However, the dominance of three primary ribs is nearly always lost in passing upward, so that the angles, usually 7 to 10 in number, are nearly equal in prominence. The crest simulates a wing but thickens rapidly backward from the edge. None of the seeds are attached to any fragment of stem or rachis. The relations of the seed to any one of the pteridospermatic types present in the flora is a matter of speculation. All but a small number of the specimens are in sandstone, and of these none are flattened, though many of them are somewhat deformed under pressure. Evidence as to the internal structure is lacking. However, from the aspect of the free upper portions of the segments of the outer test, it appears rather probable that the pollenic chamber was large, that the micropylar neck was relatively soft and nonresistant, and that the apices of the lobes, which flare outward in most of the specimens, may have turned upward and inward, covering, if not closing, the micropylar canal in the mature specimens after fructification. In fact, I am slightly inclined to believe that the free upper portions of the outer envelope may have opened and flared distinctly outward only at maturity of the ovule.

The seeds, though representing the old form genus *Rhabdocarpos* Goeppert and Berger, are possibly related to *Hexapterospermum* Brongniart or possibly even to *Lagenostoma* Williamson.

The seed from the Wedington is very closely related in its characters to that described by Goeppert as *Trigonocarpum ellipticum*, especially as that species is exemplified in the Lacoe collection of the United States National Museum by a specimen (no. 26795) from Rothwaltersdorf, in Silesia. The European form is, however, almost exactly oval and is less distinctly ribbed.

Congeneric with the plant described above and rather closely related to it, though considerably larger, is the fruit from the upper Pottsville at Campbells Ledge, near Pittston, Pa., described by Lesquereux[64] as *Carpolithus cistula*. The Wedington form agrees in size as well as other characters rather more closely with specimens collected near Colinton, near Edinburgh, Scotland, and presumably from the Calciferous Sandstone series, identified by Kidston, who transmitted the specimens to the Lacoe collection, now in the United States National Museum (nos. 26465, 26466, 26467, and 26469) as *Carpolithus sulcatus* Lindley and Hutton. The Wedington seed should also be compared with that from the lower Carboniferous of Scot-

[63] Zalessky, M. D., op. cit., p. 120.

[64] Lesquereux, Leo, Description of the coal flora of the Carboniferous formation in Pennsylvania and throughout the United States: Pennsylvania 2d Geol. Survey Rept. P, vol. 2, p. 595, 1880.

land described by John Walton as *Holcospermum ellipsoideum*, whose generic identity with *Rhynchogonium*, as suggested by Walton,[65] is hardly to be doubted. To the genus *Rhynchogonium* should also be referred the fruit described by Bureau [66] as a sporangium of *Lepidophloios laricinus* Sternberg. The cleft calyxlike beak of the plant from the upper Culm of the basin of the lower Loire is plainly shown in Bureau's figure, which in form resembles Zalessky's *Boroviczia*, though in size the fruit closely resembles *Rhynchogonium cistula* (Lesquereux).

Localities: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lots 8075, 8140), and by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264). About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145).

Types: U. S. Nat. Mus. 39504–39513.

Genus CARPOLITHUS Linnaeus, 1768

Carpolithus inquirenda White, n. sp.

Plate 8, figures 9, 10, 15

Seeds very small, ovate-round, 3 to 3.5 millimeters long and 2.5 to 3 millimeters wide, rounded at the base, slightly apiculate with rather thick envelope, which is sclerotic with radiating nerves at the base.

The fruit illustrated in figures 9, 10, and 15, plate 8, is represented by only two specimens in the collection. It might readily be mistaken for a small sporangium except for the fact that, as indicated in the photograph, plate 8, figure 9, the integumental residue is relatively thick and apparently thickest at the base, which is marked by rather strong, though not very distinct, longitudinal radial nervation. Further, the apex of the fruit is slightly apiculate. The specimen shown in figure 9, plate 8, is partly split longitudinally at the apex. That seen in figure 15, plate 8, is similarly beaked at the top and flattened at the base. There is, therefore, little room for doubt that the fruit is a seed.

The fruit here described is extremely close to those described by Lesquereux under the name *Carpolithes perpusillus*, from Campbells Ledge, Pa., and by Lindley and Hutton as *Carpolithes ovoideus* as identified by Lesquereux in English material. The specimens from Pennsylvania are generally somewhat smaller than the Wedington form, but the British specimens are distinctly larger, though strikingly similar.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264).

Types: U. S. Nat. Mus. 39515, 39516.

[65] Walton, John, Contributions to the knowledge of lower Carboniferous plants, pt. 3: Royal Soc. London Philos. Trans., ser. B, vol. 219, p. 368, pl. 26, figs. 40, 40a, Sept. 9, 1931.

[66] Bureau, Édouard, Bassin houiller de la basse Loire, fasc. 2, Description des flores fossiles, atlas, pl. 74, fig. 6, 1913. (In the series "Études des gites minéraux de la France.")

Genus LEPIDODENDRON Sternberg, 1820 [67]

Lepidodendron henbesti White, n. sp.

Plate 6, figures 1, 4–9

Stems and branches of rather small size, very ramose, branches irregular, often unequal, at angles of about 60°, the branchlets sometimes but 2.5 or 3 centimeters apart in the small twigs and not in the same plane; leaf cushions broadly diamond-shaped, rhombic in the small twigs, with rather strongly protruding leaf scar, which is situated considerably below the transverse axis of the bolster and which is very narrowly separated from those on either side; leaf scar relatively high on leaf cushion, generally facing slightly distad in the smaller branches and usually appearing at the extreme upper apex in the flattened specimens, very broad, the lower border nearly straight or slightly round dentate at the medial line; lateral angles acute and but faintly decurrent, the lateral borders convex above the lateral angles and passing nearly straight, with very slight inward curvature, to the slight obtuse upper angle, which appears slightly notched around the ligular pit; nerve trace and lateral cicatricules small, close to the lower margin of the leaf scar, or placed one-third of the altitude of the leaf scar; leaf cushions broadly rounded below the leaf trace and generally rather faintly round carinate, the lateral fields being relatively flat or gently arched; lateral appendages generally rather faint, though sometimes well marked in the impressions, narrow, relatively long, and slightly convergent downward; ligular pit generally distinct and marked in the impressions by a protruding point inclined slightly downward close to the apex of the scar.

The general aspect of the bolsters and leaf scars of this species is shown in figure 5, plate 6, which represents the partial width of a branch that appears to be of moderate size. Not all of the fragment is shown in the photograph. As is shown in the change in the direction of the bolsters, this fragment is branching at the top. Another branch is indicated at the extreme left about 4 centimeters below the top, and the base of yet another branch appears on the opposite side nearly 10 centimeters above the top of the fragment shown in the photograph. The stem is slightly zigzag, to correspond to the ramification. The frequency of division of the small branches of the species is well illustrated in figure 6, plate 6, and the counterpart, figure 9 of the same plate, which exhibits certain features not shown in the other specimen. In one of the smaller branches seen in the collection, divisions appear to have been at intervals of 2 to 3 centimeters.

The leaf trace, usually partially concealed in the somewhat compressed bolsters, is shown in figures 4 and 5, plate 6. In portions of both these specimens the parichnoian appendages are indistinctly seen. In

[67] Sternberg, Kaspar, Versuch einer geognostisch-botanischen Darstellung de Flora der Vorwelt, Heft 1, p. 23, 1820.

some of the partly flattened bolsters the impressions of the appendages are not only made to overlap a little on the lower border of the leaf scar, but some of them are continuous with the internal mold of the lateral cicatricules.

As shown in figure 5, plate 6, the leaf cushion is ordinarily nearly flat or slightly convex, with a very poorly defined, slightly rounded keel, which, where more distinct, owes its prominence to the impression of the vascular sheath as much as to any actual keel on the outer surface of the bolster. In the specimen shown in figure 5 the lower border of the leaf scar is nearly horizontal or but slightly round-dentate on the medial line. The impression of the orifice of the ligular pit seen in many of the bolsters overlaps behind the tip of the leaf scar, so as to produce the effect of notching the leaf scar. It is probable, however, that the uncompressed leaf scar is but slightly round-notched at the apex.

The impressions of the cortical neural tracts dilate broadly downward, so that the leaf cushions appear to be divided into a downward-broadening median and two relatively short lateral fields, which adjoin the border of the leaf scars. This appearance is probably incidental to the condition of preservation and the collapse of the neural sheath. Some of the parichnoian appendages seem to coalesce with the border portions of the neural sheath.

The very broad or nearly square outline of the bolster impressions of the smaller branches is illustrated in figures 1, 6, 7, 8, and 9, plate 6. The aspect of the leaf scar and its relative proportions are shown in figure 1, which illustrates a small fragment of branch impression. This represents nearly the smallest of the branches of this species yet found in the collection.

The species described above is characterized by the rather distinctly diamond-shaped outline of the bolster, by the very broad deltoid leaf scars, the lower borders of which are nearly straight, by the relatively flat or but slightly round-carinate configuration of the area below the leaf scar, and by the rather elongated and faint appendages, which are not visible in all specimens. The irregular closely spaced branching, which lies in different planes, also appears characteristic.

At the type locality, about 2 miles southwest of Prairie Grove, only fragments of the impressions of stems or branches of relatively small diameter appear to represent this species. Pieces of several larger stems that might at first be referred to this form are on close inspection found to be faintly transversely corrugated across the broadly rounded lower portion of the bolster. I have therefore placed them with *Lepidodendron wedingtonense*, notwithstanding close similarities between the leaf scars, which in these forms are very strongly protuberant and suggest those of *Lepidodendron henbesti*. On the other hand, the typical *Lepidodendron wedingtonense* is very distinctly corrugated both above and below the leaf scar. The collection of additional material may point the way to a different taxonomic association of these fragments with much larger, more strongly protruding, and in some specimens faintly corrugated leaf cushions.

In its frequency of branching and the very broadly rhombic or nearly squarrose impressions of the bolsters, *Lepidodendron henbesti* is comparable superficially with some of the impressions of small branches from the Allegheny formation of the Pennsylvanian, referred by Lesquereux to *Lepidodendron dichotomum*. That species differs saliently, however, by its distinctly carinate bolsters and by the more rhomboidal form of leaf scar.

Localities: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8140). About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145).

Types: U. S. Nat. Mus. 39514, 39517–39522.

Lepidodendron occidentale White, n. sp.

Plate 5, figures 5, 8

Bolsters in rows, alined nearly vertical and transverse; leaf cushions contiguous, broadly ovate, with rather clearly marked sinuate lateral boundary lines, distally, rather obliquely, and broadly round-truncate a very short distance above the leaf scar, nearly flat or in the lower part slightly higher along a rather broad medial zone, which is transversely corrugated but not carinate; leaf scar rather prominent, facing slightly upward with both distal and proximate borders arched, relatively straight on the sides and forming acute lateral angles, which bend slightly downward to define a roughly obovate area that includes the leaf scar and the lower fields; vertical diameter of leaf scar approximately two-thirds that of the transverse; medial scar large, a little above the middle of the leaf scar; lateral traces at the same level and a little distant; lateral appendages slightly elongated vertically and relatively broad; ligular pit large, a little above the obscurely and shallowly sinused upper angle of the leaf scar.

Several fragments in the collection (lot 8145) from the locality about 2 miles southwest of Prairie Grove, two of which are illustrated in figures 5 and 8, plate 5, represent this form, which evidently falls within the somewhat comprehensive group generally identified as *Lepidodendron volkmannianum*. The larger fragment (fig. 5) is not sufficient to prove that the alinement of the bolsters is at once vertical and transverse, though assuredly it approaches close to those directions. The traces in the leaf scar are nearly midway of its height and are alined slightly above the lateral angles. In other words, the upper and lower halves of the leaf scar are hardly symmetrical, though they at first suggest

symmetry. The generally round, sometimes even slightly indented upper border that appears to be characteristic of *Lepidodendron volkmannianum* Sternberg is not seen in the two specimens in this collection. On the impressions of several of the bolsters slightly elongated shallow depressions extending downward short distances from the upper borders of the field offset the lateral cicatricules and offer slightly questionable evidence of the presence of the lateral parichnoian appendages. On all the fragments in hand the transverse corrugation is mainly confined to the broad medial zone of the leaf cushion.

On account of the obviously close relationship of the Wedington tree to the Old World type of *Lepidodendron volkmannianum* Sternberg, I was at first disposed to refer it tentatively to that species. However, inspection of the original figure given by Volkmann,[68] together with the descriptions and illustrations of the European type as given by Sternberg,[69] the founder of the species, Presl,[70] Stur,[71] and others, shows that the tree from the Wedington sandstone differs from the European type in such significant respects as to prohibit its inclusion under the same name. As figured both by Volkmann and by Sternberg, the European plant is much shorter in the vertical diameter of its leaf scar, and the upper angle of the leaf scar is very much more rounded, so as to produce a curved profile, in alinement with which the lateral angles are somewhat extended. In the Wedington trunk, on the contrary, the distal angle is well developed, the vertical diameter is much longer in proportion, and the lateral angles not so prolonged. However, the European type as shown by Volkmann and Sternberg is transversely corrugated along a relatively narrow median zone, almost exactly as in the specimens here described.

The Old World species as generally described and figured appears to be present in the Chester group of the Eastern Interior basin and in the beds of Chester age in the Appalachian trough. Specimens with vertically short leaf scars apparently conforming to the European type are figured by Noé [72] from the Chester group near Princeton, in western Kentucky.

The material from Kentucky deserves comparison with the fragments figured by Stur [73] as *Lepidodendron volkmannianum* from the Waldenburg series. The lateral appendages seem to be lacking in the European material representing the *L. volkmannianum* as generally illustrated, but points which are possibly construable as lateral appendages may be observed in Stur's plate 40, figure 2.

[68] Volkmann, G. A., Silesia subterranea, pl. 15, fig. 4, Leipzig, 1720.

[69] Sternberg, Kaspar, Versuch einer geognostisch-botanischen Darstellung der Flora der Vorwelt, Tentamen, p. x, pl. 53, figs. 3a, 3d, 1825.

[70] Presl, Karl, in Sternberg, Kaspar, op. cit., Hefte 7, 8, p. 179, pl. 68, fig. 8, 1838.

[71] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Band 8, Heft 2, p. 286, pl. 18, fig. 4; pl. 23, figs. 2–5, 1877.

[72] Noé, Adolf, The flora of the western Kentucky coal field, in Weller, Stuart, Geology of the Princeton quadrangle: Kentucky Geol. Survey, ser. 6, vol. 10, p. 129, fig. 2, p. 130, fig. 4, Frankfort, 1923.

[73] Stur, Dionysius, op. cit. (Die Culm-Flora), Heft 2, p. 288, pl. 18. (See fig. 4.)

The species from Arkansas differs but little from that figured by Bureau [74] as *Lepidodendron volkmannianum* from the basin of the lower Loire, except that the latter has rather wider bolsters as well as somewhat shorter leaf scars.

A closely related species is that figured under the name *Lepidodendron turbinatum* Lesquereux.[75]

On account of the relatively large size of the leaf scar, the generally obovate configuration of the truncated bolster, and the relief of the leaf scar, the form in hand presents some superficial resemblance to the foreshortened bolsters of *Lepidodendron clypeatum*. That species differs, however, by the distinct keel, which is transversely notched, by the phyllotaxy, and by other features that are equally distinct though less conspicuous.

Locality: About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145), and by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8266).

Types: U. S. Nat. Mus. 39523, 39524.

Lepidodendron purduei White, n. sp.

Plate 5, figure 9

Bolsters foliaceous, fusiform or narrowly acute, contiguous, very obliquely protruding, slightly overlapping, noncarinate, dorsally strongly and evenly rounded, slightly beaked at the summit at the point of emission of the nerve; leaves attached at the lateral margins around the upper third of the protruding cushion, slightly wider at the base than the bolster at the widest part, very oblique or nearly erect, about 5 millimeters wide and 2.5 centimeters long, tapering gently from a point abreast of the apex of the bolster to the acute tip, with wide medial nerve and apparently broadly and roundly sulcate ventrally toward the base; ligular pit distinct; appendages not observed.

A single fragment, shown in figure 9, plate 5, is the sole representative of what is apparently a very interesting species. The erosion of the specimen permits the observation of the impressions of the appressed and nearly erect leaves, both along the upper border of the fragment and near its base. The cortices of the cushions are apparently hard and rounded, except near the apex, which is slightly carinate; leaf scars are not clearly indicated, for the reason that the leaves are still attached to the extremely obliquely directed overlapping apical portions of the bolsters.

As shown in the figure, the leaves are attached along the upper third or more of the length of the bolster. Where the underlying bolsters are broken away, the leaves are seen to continue from the upper borders of the bolster with a slight dilation in width near the

[74] Bureau, Édouard, op. cit. (Bassin houiller de la basse Loire), pl. 77, figs. 1–3, 1913.

[75] Lesquereux, Leo, Report on the fossil plants of Illinois: Illinois Geol. Survey, Paleontology, vol. 2, p. 453, pl. 44, fig. 6, 1866; Description of the coal flora of the Carboniferous formation in Pennsylvania and throughout the United States: Pennsylvania 2d Geol. Survey Rept. P, vol. 2, p. 382, pl. 64, fig. 5, 1880.

base, after which they taper gradually and evenly to the rather slender, acute apices. The leaf is ventrally round-sulcate over the midrib in the lower portion, and the lateral grooves, presumably holding the stomata and connecting with parichnoian developments, are rather narrow and faintly defined. The ligular pit is represented by a short needlelike protruding cast, seen on one or two of the bolster impressions. In a few places vague oval or rounded patterns, suggestive of the illustrations of leaf scars published in some of the earlier literature, are faintly indicated, but nothing which I can regard with confidence as outlining the vertical width of the foliar attachment or the parichnoian features is present.

Among other American species of *Lepidodendron*, this fragment appears to represent a form more closely related to *Lepidodendron lanceolatum* Lesquereux than to any other representative of the genus. Among the Old World types it is strikingly comparable to that described by Ettingshausen [76] as *Lepidodendron haidingeri*.

The fragment from the Wedington sandstone is very similar both in the form of its bolsters and in the persistent broad, sharp-tapering upward-growing leaves to the specimen from the upper Culm figured by Bureau [77] as *Lepidodendron lycopodioides* from the lower Loire. It deserves comparison also with the leafy branches figured by the same author as *Lepidodendron veltheimianum*.[78]

Though represented by but a single fragment, the characters exhibited in the bolster and leaf of this stem appear to define a species hitherto undescribed. It is named in honor of the late Prof. A. H. Purdue, who for many years was engaged in the study of the geology of the region embracing the Wedington sandstone in northwestern Arkansas and who was author of the Winslow folio.

Locality: About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8266).

Type: U. S. Nat. Mus. 39525.

Lepidodendron cf. L. veltheimianum Sternberg [79]

Plate 5, figure 4

A slightly oval discoid impression of the attachment scar and border zone marking the position of a sessile lepidophytic cone is shown in figure 4, plate 5. The details of the scar are not well revealed by the sandy matrix.

The fragment is closely comparable to some of the cone scars left on the trunks of *Lepidodendron* of types referred by various authors to *Lepidodendron veltheimianum*, and in default of information showing to which if any of the forms from the Wedington sandstone this is specifically referable, I tentatively list it under the collective name. Comparisons may be made with the strobiliferous stems from the Waldenburg beds illustrated under *L. veltheimianum* by Stur.[80] Similar cone scars have been described under *Bothrodendron* and *Sigillaria*, but without portions of the surrounding cortex bearing leaf scars characteristic of their respective genera the generic as well as the specific reference is questionable. Superficially the impression in hand is suggestive of the cone scars occurring on the rather large trunks described by Lesquereux from the Carbondale formation of Illinois under the name *Ulodendron*.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8140).

Types: Figured specimen, U. S. Nat. Mus. 39526.

Lepidodendron wedingtonense White, n. sp.

Plate 7, figures 1–4, 6, 7, 9, 10; plate 9, figure 6

Trunks attaining moderately large size, branching rather frequently, often unequally, at a moderately wide angle; leaf cushions so arranged that those in the alternate rows are alined nearly transversely to the axis, fusiform in plan, slightly wider above the middle, very strongly and very obliquely protuberant, generally low-rounded dorsally, rarely slightly round-carinate along the medial line, irregularly and rather closely corrugated transversely both in the lower fields and above the leaf scar, and becoming separated at an early age by narrow marginal zones or borders which in the older parts of the trunk are clearly twisted at a low angle, each cushion being bounded by a separate strand; cushions appearing narrowly ovate with generally complete concealment of the leaf scar in the compressed specimen, by reason of the foreshortening of the upper part of the bolster; leaf scar borne at the summit of the protruding cushion and usually facing slightly upward, though sometimes inclined downward at a low angle, relatively broad, nearly straight across the base, laterally acute, and passing with very slight outward curvature of the margin to the high upper angle, which is rather narrowly rounded; vertical axis about two-thirds the transverse; nerve and parichnoian traces distinct and generally placed considerably below the medial line of the leaf trace, the nerve trace generally larger and slightly higher than the parichnoian traces, the distance between which is generally less than one-third of the width of the leaf scar; nerve sheaths ascending very obliquely in the cushions, appressed and acute in the *Knorria* stage; parichnoian appendages hardly visible in the impressions, invariably faint, rather narrowly elongated and convergent downward.

[76] Ettingshausen, C. von, Die Steinkohlenflora von Radnitz in Böhmen: K.-k. geol. Reichsanstalt Abh., Band 2, Abt. 3, p. 55, pls. 22, 23, 1854.

[77] Bureau, Édouard, op. cit., pl. 31, fig. 1; pl. 32; pl. 34, fig. 1.

[78] Idem, pl. 30 bis, fig. 1b, 1913.

[79] Sternberg, Kaspar, op. cit. (Flora der Vorwelt), Tentamen, p. xii, pl. 52, fig. 3, 1825.

[80] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Band 8, Heft 2, p. 278, pl. 22, figs. 1a, 1b, 2, 3a, 3b, 1877.

The aspect of the fragments of this species is shown in figure 6, plate 7, in which the bolsters are slightly larger than the average, and figure 1, plate 7, in which they are smaller. Figure 1 illustrates the marked protrusion of the cushions in an obliquely ascending direction. Both of the figured specimens, which are impressions made by the bolsters as buried in the sand, show the corrugation of the cushions and the readiness with which the leaf scars may be totally concealed in compressed specimens. Only where the mold is slightly broken away is any portion of the leaf scar itself visible. A branch much smaller than the main axis or lower branched division is seen to emerge in the example shown in figure 1. The presence of elongated leaf cushions in the lower portion of the branch that is visible indicates probably a twig rather than the attachment of a cone. Both specimens show the characteristic diminution of the transverse corrugation as the leaf scar is approached from below. In fact, the cushion is in some specimens so nearly smooth below the leaf scar that in fragments completely compressed the upper part of the field might erroneously be taken for a part of the leaf scar which, owing to the rounded upper outline of the impression, might present a rather close similarity to the scars of *Lepidodendron wortheni* Lesquereux or some of the phases referred to *Lepidodendron volkmannianum* Sternberg.

In figure 4, plate 7, is seen the sandstone cast of the inner cortex of the specimen illustrated in figure 1. This shows the *Knorria* aspect, in which the neural tracts with surrounding transpiration tissue are seen to ascend very obliquely through the mesocortex. The end view of this cast of the partly compressed stem indicates approximately the very small size of the woody cylinder of the stem.

Leaf cushions of relatively large size are shown in figure 9, plate 7, and illustrate the ropy marginal zones bordering the bolsters as they become slightly distant in the older portions of the trunk. These marginal bands anastomose, but the strands can generally be traced from cushion to cushion. Some of the bordered cushions of the old bark are somewhat elongated.

The form of leaf scar characteristic of *Lepidodendron wedingtonense* is shown uncovered in figure 9, plate 7. This specimen illustrates the relatively larger size of the nerve trace as compared with the lateral cicatricules. The traces appear to be relatively close to the lower border of the leaf scar on account of the slight deformation of the bolster under compression. The very broadly pyramidal profile of the upper border of the leaf scar as here shown is characteristic of the species.

The aspect of the smaller branches of the tree when they are partly compressed is illustrated in figures 2 and 7, plate 7. As shown in figure 7, the transverse corrugation of the bolsters is evident, even in the relatively small branches. The phase in which the tissue underlying the outer cortex overlies the leaf scar and in *Bergeria* forms the outline of the leaf-cushion tract is illustrated by the specimen seen in figure 6, plate 9.

In the few specimens in which the cushions are but slightly compressed the leaf scars face nearly at right angles to the axis and protrude abruptly, some of them nearly 5 millimeters, from the general level of the leaf cushion. In fact, the protrusion of some of the leaf cushions is greater than their width.

Certain specimens have been observed which are interesting on account of the obscurity of the transverse corrugations in the lower portion of the cushions. The fields, which are but faintly carinate, appear to have been stretched slightly longitudinally.

This species, apparently the most common lepidophyte in the Wedington sandstone, is rather clearly a descendant of the *Lepidodendron volkmannianum* Sternberg stock, which is generally present in the upper and middle Chester wherever fossil plants have been found in beds of that age in the Midcontinent and Appalachian troughs. Many of the flattened impressions are strongly similar to the Old World species, though they are generally narrower, tapering more slenderly at the base. In the compressed stems the lower part of the bolster is rarely indented sufficiently to bring even a portion of the leaf scar into view. Besides the relative narrowness of the bolster and the much greater altitude and more pyramidal form of the leaf scar, the ropy marginal zones in the well-developed portions of the bark help readily to distinguish the species from *Lepidodendron volkmannianum* Sternberg. The faintly round-carinate form seen occasionally in the rounded leaf cushion also is distinctive.

On the other hand, though the angle of the leaf spiral is lower, it appears rather evident that the Wedington plant is closely related—perhaps lineally—to the Pennsylvanian species from the Midcontinent region described as *Lepidodendron wortheni* Lesquereux [81] and *Lepidodendron brittsii* Lesquereux.[82] Both these forms appear to have shorter leaf scars that are of lower altitude and more rounded. The ropy marginal borders seen even in relatively young branches have not, I believe, been observed in either of the two Pennsylvanian species just mentioned. It is probable that neither of these species has so strongly protruding leaf cushions as those of *Lepidodendron wedingtonense*.

Another form of *Lepidodendron* with transversely corrugated bolsters is that from Mâcon erroneously illustrated by Vaffier [83] under the name *L. acuminatum*.

[81] Lesquereux, Leo, Report on the fossil plants of Illinois: Illinois Geol. Survey, Paleontology, vol. 2, pl. 49, figs. 4, 5, 1866; Description of the coal flora of the Carboniferous formation in Pennsylvania and throughout the United States: Pennsylvania 2d Geol. Survey Rept. P, vol. 2, pl. 64, figs. 8, 9, 1880.

[82] Lesquereux, Leo, op. cit. (Coal flora), vol. 2, pl. 63, figs. 1, 2, 1880. White, David, Fossil flora of the Lower Coal Measures of Missouri: U. S. Geol. Survey Mon. 37, p. 188, pl. 52, figs. 1, 2; pl. 53, fig. 1; pl. 54, figs. 1, 2, 1899.

[83] Vaffier, A., Étude géologique et paléontologique du Carbonifère inférieur du Mâconnais: Lyon Univ. Annales, nouv. sér., 1, Sci. méd., fasc. 7, p. 133, pl. 9, 1901.

The characters of the leaf scars of Vaffier's specimens are not distinctly shown.

Lepidodendron henbesti is distinguished from *Lepidodendron wedingtonense* by its generally more distinctly diamond-shaped leaf cushions, by its closer crowding of the leaf cushions, apparently without intervening border zones even in the older stems, by the small traces placed very low in the leaf scar, by the more numerous though generally not well-developed keels on the relatively flat cushions, and by the very slightly and irregularly zigzag branches, which divide much more frequently, at generally wider angles. In *Lepidodendron henbesti* the branches become very slender, hardly more than 3 millimeters in diameter, and branches 5 millimeters in diameter may give off subdivisions not more than 2.5 centimeters distant from one another. In this species, too, the leaf scar is relatively large, and the very young cushions, which may be nearly rhombic, are not transversely corrugated.

Locality: About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145).

Types: U. S. Nat. Mus. 39527–39535.

Lepidodendron sp. 1

Plate 8, figure 23

A single fragment in the collection offers characters such as apparently prohibit its reference to any of the forms described in the preceding pages. It is characterized by cushions that are not only slender but protrude so far and so obliquely as to give the fragment the aspect of a *Halonia*. The details are shown clearly in the squeeze of the sandstone impression or mold photographed in plate 8, figure 23. The details of the leaf scar are indistinct, the leaves being still attached to the bolsters. The leaves, as indicated by the impression, are oblique and stand at an angle of less than 45° to the axis; they are relatively narrow and probably 8 or 10 centimeters in length, tapering gradually from the base to the slightly obtuse point. It may be assumed that the scars left by the detached leaves on the older stems will be relatively narrow in proportion to their height.

The plant in hand is easily distinguished from *Lepidodendron purduei* by the rigid, linear, elongated leaves. Apparently the cushions are relatively much narrower than in that species.

Locality: Cane Hill, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8144).

Type: Figured specimen, U. S. Nat. Mus. 39536.

Lepidodendron sp. 2

Plate 7, figure 8

Represented only by the carbonized residue of a portion of a small branch; bolsters distant from one another nearly one-third of their width, broadly diamond-shaped, acute at the base, slightly raised above the intervening cortex, with somewhat protruded leaf scar above the middle or, in the compressed and foreshortened cushions, near the upper end, in which case the leaf trace and lower fields form a broadly ovate pattern, angular or obliquely truncated at the base; bolsters narrowly carinate a short distance below the leaf scar but some of them flatly arched as they approach the proximal angle; leaf scar relatively small, roughly rhomboidal in outline, right-angled or slightly obtuse-angled at the base, acute laterally, with drooping lateral crests, the upper borders slightly arched to form a rounded upper angle, the vertical diameter being about half the lateral; nerve trace near the center of the scar, punctiform; lateral cicatricules punctiform, nearly on the level of the nerve trace and distant from one another nearly half the longer diameter of the scar; lateral appendages faintly developed; ligular pit small, close to the upper angle of the leaf scar.

The single fragment of a small stem in which the cortical residue is preserved, as shown in figure 8, plate 7, is remarkable for the notable distance between the bolsters in contrast to the size of the stem. It is interesting as illustrating within the limits of a small fragment the foreshortening of the bolsters in its lower portion, those higher on the axis being broadly diamond-shaped, with the exposure of the fields above the leaf scar. The form of the foreshortened bolsters, the relative size, and, to an extent, the shape of the leaf scar are comparable to those of the bolsters and leaf scars seen in some fragments referred by authors to *Lepidodendron volkmannianum*. There is, however, no trace of transverse corrugation in this specimen, even where the lower fields form a nearly flat area and the keels, some of which are seen below the leaf scars, are very nearly flat.

The small size and vertical shortness of the leaf scars preclude all reference of this fragment to *Lepidodendron henbesti*, and, on the other hand, there is no trace of the fusiform pattern or the transverse corrugation of *Lepidodendron wedingtonense*. Although no specimens showing the mature phases of the species represented by this fragment are at hand, and the fragment itself is none too well preserved, it is hoped that the illustration may aid in the recognition in some later collection of specimens that will more fully characterize the species and permit its satisfactory description or its identification with one already established.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8140).

Type: Figured specimen, U. S. Nat. Mus. 39537.

Genus STIGMARIA Brongniart, 1822 [84]

Two species of *Stigmaria* have been found in the Wedington sandstone. In both, the root scars are relatively distant, though not so conspicuously remote as in the forms of *Stigmaria* in the lower zones of the Mississippian. In both the Wedington forms the umbilical scars are slightly smaller than in the typical Pennsylvanian species.

Stigmaria wedingtonensis is at once seen, by its coarse reticulation and the narrow zone of radiate areolation about the root scars, to be referable to the *stellata* group of *Stigmaria*, which is in general characteristic of the upper Mississippian. The other species, which for convenience is here called *S. arkansana*, is relatively smooth except where maceration and collapse have caused some irregular longitudinal wrinkling of the cuticle.

On the basis of the structure, which plainly was adapted to serve the purposes of transpiration as well as for maintaining the trunk in upright position, the application of the term "roots" to the upper subterranean divisions radiating from the base of the trunk, forking repeatedly and bearing the so-called "appendages" or true roots, has been questioned by some paleobotanists.

On account of its resemblance to the "roots" of *Lepidodendron volkmannianum*, which belong to the *stellata* group, and on account of the obviously close relation of *Lepidodendron occidentale* to *Lepidodendron volkmannianum*, it is believed that *Stigmaria wedingtonensis* is probably referable to *L. occidentale*, though it belonged possibly to *Lepidodendron wedingtonense*, with which also it is associated. On the other hand, *Stigmaria arkansana* was perhaps attached to the tree here described as *Lepidodendron henbesti*.

Stigmaria arkansana White, n. sp.

Plate 5, figure 6; plate 9, figure 8

Surface relatively smooth with little indentation of the rootlet scars; surface of the parent "root" slightly rugose; umbilical scars relatively small, rather distant, with very narrow border rings.

The outer impression of the root of the species is shown in the small fragment illustrated in plate 9, figure 8, and a larger fragment, representing the subepidermal cast and embracing in its area the counterpart of the original of plate 9, figure 8, is shown in plate 5, figure 6.

The umbilical scars are slightly smaller in proportion to the size of the divisions of the "root" than in most of the later forms characteristic of the Pennsylvanian. The species is possibly to be associated with *Lepidodendron henbesti*, which is present at the same locality.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8140).

Types: U. S. Nat. Mus. 39538, 39539.

Stigmaria wedingtonensis White, n. sp.

Plate 5, figure 7; plate 9, figure 3

Root surface very coarsely pustulate-shagreened in short, broad areas which are close, irregular in arrangement, though in places roughly alined, and which vary but little in diameter with reference to distance from the root scar. Root scars relatively small and distant from one another, the umbilical cicatrix bordered by a narrow, rather sharply defined zone of small, radially slightly elongated tubercles.

This form of *Stigmaria*, which clearly is of Mississippian lineage, being related to the *stellata* group, is represented by but few fragments in the collection. The rather coarse meshing is shown on the mold, figure 7, plate 5, more distinctly than on the impression illustrated in figure 3, plate 9. The root scars, as shown in figure 7, plate 5, are apparently nearly in the plane of the intervening surface. The zone of small, radially arranged and pustulate-appearing areas is narrower than in most species of the *stellata* group. A notable feature, shown in figure 7, plate 5, is the smaller size and closer spacing of the root traces toward what is apparently the lower end of the parent "root", which, it may be inferred, is tapering in the same direction.

This species, which is believed to have been attached to *Lepidodendron occidentale*, is distinguished from the Pennsylvanian species of *Stigmaria* and from the one here described as *Stigmaria arkansana* by the coarsely pustulate-areolate surface of the parent root and by the narrow rings of radiate tubercles about the umbilical cicatrices. The species differs also from Pennsylvanian forms of *Stigmaria* by the slightly smaller and more distant umbilical scars, though this characteristic is not so marked as in the stellate forms from the earlier stages of the Mississippian.

Locality: About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145).

Types: U. S. Nat. Mus. 39540, 39541.

Genus BOTHRODENDRON Lindley and Hutton, 1933 [85]

Bothrodendron sp.

Plate 7, figure 5

Leaf scars slightly raised on obliquely ascending, narrow, more or less faintly developed cushions, in relatively oblique alinement; leaf cushions oval, round at the base, deeply notched in V-shaped pattern at the top, apparently with distally radiating lines about the ligular pit; leaf scar situated in the upper part of the cushion, small; lateral cicatricules long, very

[84] Brongniart, Adolphe, Mus. histoire nat. Paris Mém., tome 8, p. 228, 1822.

[85] Lindley, John, and Hutton, William, The fossil flora of Great Britain, vol. 2 pls. 80, 81 (description); pl. 117, p. 97, 1833.

narrow, rather distant, arching slightly outward, converging slightly at the lower ends, which are not far above the base of the leaf scar; cuticle apparently rugose.

Two fragments in the collections are rather clearly referable to the genus *Bothrodendron*. A cortical mold (pl. 7, fig. 5) shows very obliquely ascending vaseular tracts terminating in none too well defined leaf scars. Though the details of the scar are by no means so well preserved as is desirable, the lateral cicatricules are fairly distinct, and there appears to be no doubt as to the presence of a ligular pit in the deep, acutely V-shaped notch at the upper end.

Another fragment, representing only a part of the width of an old stem, in which the cuticle had become irregularly torn longitudinally, probably in the natural process of growth, represents a welted or irregularly seamed impression broadly encrusted with carbonaceous residue. This phase of stretched cortex is of the type sometimes referred by Lesquereux to the genus *Ulodendron*. Here and there a few faint traces of leaf scars agree with the cortical impression shown in figure 5, plate 7.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8140).

Type: Figured specimen, U. S. Nat. Mus. 39542.

Genus LEPIDOPHYLLUM Brongniart, 1828 [86]

Lepidophyllum sagittatum White, n. sp.

Plate 6, figure 3; plate 9, figure 2

Bract very narrowly triangular, acuminate, 4 millimeters wide at base, 3.5 centimeters long, tapering upward, with nearly straight or faintly concave margins, from the widest point, which is slightly above the base, and dorsally slightly round-convex, with distinct round midrib tapering upward and bordered by shallow and rather broad grooves; also marked dorsally by faint depressions slightly within the border; sporangiophore and sporangium uncorrelated.

The specimen illustrated in figure 3, plate 6, which is enlarged twice in order to show some detail, belongs to the Mississippian group of forms of *Lepidophyllum*, in which the bract, of moderate size, is narrowed more strongly and tapers gradually and more acutely than in the Pennsylvanian forms. In general size the bract in hand is comparable to the smaller representatives of the *Lepidophyllum lanceolatum* group of the Pennsylvanian. It is distinguished, however, by the narrowly triangular outline in which the margins pass nearly straight, with uniform convergence, from a point just above the base to the slender acute apex.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lots 8075 and 8140).

Types: U. S. Nat. Mus. 39543, 39544.

[86] Brongniart, Adolphe, Prodrome d'une histoire des végétaux fossiles, p. 87, 1828.

Genus LEPIDOSTROBUS Brongniart, 1828 [86]

Lepidostrobus occidentalis White, n. sp.

Plate 5, figures 1, 3; plate 8, figure 20

Cones linear, narrow, dense, rigid, round at the apex; bracts very delicate, about 11 millimeters long, 1 millimeter wide, linear-lanceolate, narrowed toward a relatively elongated distally protruding base or heel; sporangiophores in oblique spirals, apparently nine, nearly at right angles to the slender axis, very narrow just above the point of attachment, broadening gently in very narrowly obcuneate form, with relatively straight borders, to the base of the bract; sporangia narrow, elongated, slightly cordate at the distal end when compressed; spores not identified.

The species here described is represented by a few fragments only, which apparently fall within the comprehensive group generally rather loosely described under the term *Lepidostrobus variabilis* Lindley and Hutton.

The specimens have been badly water-worn, the bracts being nearly all abraded and generally even frayed. A fragment of stripped axis about 15 centimeters in length is incomplete. It indicates a linear, much elongated, rather rigid type of cone. As shown twice the natural size in figure 20, plate 8, which illustrates the detail of the impression of the axis, the ventral angle at the base of the sporangiophore is marked by a protruding narrow wedge or spine, which may be interpreted as ligular. The bases are relatively prominent. As seen in figure 3, plate 5, the sporangiophores stand nearly at right angles to the axis in all the fragments observed. Notwithstanding the advanced erosion, faint indications of the bracts, including the rather prolonged heels, are visible. At several points collapsed sporangial sacs appear to be present. These are narrow, smooth, and matte and, in the flattened state, have a rounded collar that does not appear to be closely adherent to the base of the sporangiophore. Unfortunately additional material illustrating the bracts, sporangia, and spores is lacking. The dark discoid object in the lower part of the cone seen in figure 3, plate 5, is a detached scar of *Stigmaria* lodged in the midst of the *Lepidostrobus*, as is shown also in the photograph of the counterpart, figure 1, plate 5.

Localities: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8140). About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145). Six-tenths of a mile south of junction of State Highway 99 and United States Highway 62, 4 miles west of Lincoln, Ark.; collected by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8268).

Types: U. S. Nat. Mus. 39545–39547.

Genus LEPIDOCYSTIS Lesquereux, 1880 [87]

Lepidocystis chesterensis White, n. sp.

Plate 6, figure 2

Sporangia small, rather narrowly obovate triangular, about 4.5 millimeters long and 3 millimeters wide, slightly rigid, with thin wall faintly rounded along the dorsal axis, which is longitudinal, shallowly and narrowly sulcate up nearly to the distal end, which is marked by a transverse oval depression just within the margin.

The aspect of the interesting and widespread form of sporangium here described is suggestive of a detached bolster related to *Lepidodendron* or *Bothrodendron*. The carinate dorsal axis rises to its highest point just beneath the transverse oval depression. This feature is illustrated in the impression of the specimen in figure 2, plate 6. In spite of the fact that the sporangial impression appears to be thin, it is nevertheless relatively rigid. Only occasionally is this fossil, which is common in the upper Mississippian of the Appalachian trough, deformed or folded. It is invariably isolated. The dimplelike depression at the upper end of the narrow dorsal crease may represent the ligular pit. The crease itself probably corresponds to the axis of the sporangiophore, and the transverse depression, present in all specimens and invariably characteristic of the type, may conform to the head of the sporangiophore or the heel of the bract. I have, however, never found *Lepidocystis chesterensis* in contact with the axis or sporangiophore; yet there can be little doubt as to its function as a spore holder. No megaspores are, however, in contact with the specimens in hand.

The American species just described is obviously of the same nature as the fossil from the Carboniferous limestone of Rothwaltersdorf described by Feistmantel [88] as *Cardiocarpum rostratum*.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8075).

Type: U. S. Nat. Mus. 39548.

Genus ARCHAEOCALAMITES Stur, 1875 [89]

Calamarian remains, as might be expected from the arenaceous environment, are relatively common in the Wedington sandstone. Four types of stem fragments are found, all having rather clearly marked though not very thick woody zones, all essentially smooth or but faintly lineate or striate on the outer surface, and all marked by pith casts more or less distinctly of the *Bornia* type, in which the nodes are relatively indistinct and foreshortened in some specimens to a mere transverse crease, whereas most of the pith ribs when exposed are seen to be continuous from internode to internode except as, in the enlarging stem, costae corresponding to the introduction of new vascular wedges are introduced in the internodes of increasing diameter.

Costae are seldom even faintly distinguishable in the impression of the exterior of the stem.

The larger stems from the Wedington seem all to fall within the range of variations to be found in the illustrations given by different authors under the name *Bornia radiata* (Brongniart) Schimper or *Archaeocalamites scrobiculatus* (Schlotheim) Seward. None of them agree, however, with the original illustration of *Calamites scrobiculatus* published by Schlotheim.[90] In the Old World type the pith ribs are much fewer and flatter, and the nodes are scarcely creased transversely, the cicatricules being punctiform, longitudinally elongated, and situated between the ribs. Schlotheim's type represents an earlier form and correspondingly lower stage.

In the type illustration of *Bornia radiata*, as published by Brongniart [91] under the name *Calamites*, the pith cast is sharply and deeply constricted at the nodes, and though the ribs are numerous and similar in aspect to those of *Archaeocalamites wedingtonensis*, the admission of the Wedington species under the same name is prohibited by its lack of the widely flaring, stellate, leafy nodal sheath illustrated and described very distinctly by the French author. It may be added that Brongniart's plant cannot, without violence to modern refinement in classification, be included under the same specific name with Schlotheim's *Calamites scrobiculatus*, which is further illustrated by Zeiller [92] in typical material.

In his great work on the Culm flora Stur [93] has described and figured a somewhat comprehensive series of stems representing several species, as I view them, under the name *Archaeocalamites radiatus*, the generic name being established for the group. Also he figures a large number of leafy stems with elongated dichotomously dissected *Sphenophyllum*-like leaves, including those described by Ettingshausen [94] as *Schizaea transitionis*. None of the stems from the Wedington sandstone are very close to those figured by Stur, though a leaf, possibly related to one of the stems and here

[87] Lesquereux, Leo, op. cit. (Coal flora), p. 54, 1880.

[88] Feistmantel, Ottokar, Das Kohlenkalkvorkommen bei Rothwaltersdorf in der Grafschaft Glatz und dessen organische Einschlüsse: Deutsche geol. Gesell. Zeitschr., Band 25, p. 540, pl. 17, fig. 38, 1873.

[89] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Band 8, Heft 1, p. 9, 1875.

[90] Schlotheim, E. F., Die Petrefactenkunde auf ihren jetztigen Standpunkt, p. 402, pl. 20, fig. 4, 1820.

[91] Brongniart, Adolphe, Histoire des végétaux fossiles, p. 122, pl. 26, fig. 4, Paris, 1828.

[92] Zeiller, René, Végétaux fossiles du terrain houiller: Explication Carte géol. France, tome 4, pt. 2, p. 17, 1879; atlas, pl. 159, fig. 2, 1878.

[93] Stur, Dionysius, op. cit., Heft 1, p. 2, pl. 1, figs. 3-8; pls. 2, 3, 4; pl. 5, figs. 1, 2, 1875; Heft 2, p. 74, pl. 2, figs. 1-6; pl. 3, figs. 1, 2; pl. 4, figs. 1, 1b; pl. 5, fig. 1, 1877.

[94] Ettingshausen, C. von, Die fossile Flora des mährisch-schlesischen Dachschiefers: K. Akad. Wiss. Wien, Math.-naturwiss. Kl., Denkschr., Band 25, pl. 17, fig. 5, 1865.

described as *Archaeocalamites?* sp., closely approaches Ettingshausen's *Schizaea.*

Associated with the *Archaeocalamites* stems are strobili bearing bifurcated sporangiferous bracts of sphenophylloid aspect, here described as a new genus, *Chlamidostachys.* They have much the general superficial aspect of those first described as *Pothocites* Paterson and later assigned as fertile strobili to *Archaeocalamites* and are almost certainly related to them, notwithstanding some apparently important differences. The structure of these strobili is somewhat complicated, and on account of the partial maceration of the material and the gritty matrix, information as to the distal portions of bracts and the structure is still inadequate.

Though all the calamarian stems in the Wedington are referable to *Archaeocalamites,* the aspect of *Archaeocalamites wedingtonensis* and in particular of *Archaeocalamites umbralis* is suggestive of the developing typical calamitean stem, in which not only are the nodes distinct and the costae mainly alternate but the internodes are not so crowded one against the other and the interlacing of the lax vascular strands is usually easily observable. Evidence of leaf scars at the upper ends of the costae of the pith casts is distinctly observed only in *Archaeocalamites umbralis.* In *Archaeocalamites wedingtonensis* and *Archaeocalamites fayettevillensis* the presence of leaves is indicated only by neutral pits of pin-point size connecting with the trace of the vascular system between the costae. In the rather remarkable little stem described as *Archaeocalamites gracilentus.* however, some, at least, of the nodes are distinguished externally by protrusions of the outer woody zone that have the aspect of rapidly tapering blunt spines. These protrusions, which may be merely the bases of abraded appendages, are borne, few in number, in verticils at the conspicuously dilated nodes. In view of the thick wood of the plant it is possible that these are the remains of branches provided with thick wood at their very bases.

One only of the stem fragments, tentatively referred to *Archaeocalamites wedingtonensis,* is provided with distinct verticils of small oval nodal scars. None of the calamarian stems of the Wedington exhibit so frequent alternation of costae at the node as is seen in *Calamites ramifer* Stur and other forms, including most of those referred to *Archaeocalamites* in the basal Pennsylvanian of the Appalachian trough.

Archaeocalamites fayettevillensis White, n. sp.

Plate 9, figure 10

Stems of rather small size, smooth or finely striate externally, with moderately distant internodes, which are faintly indicated externallp and are marked with a very narrow, sharp, shallow depression in the pith cast, across which the very narrow, rather closely placed costae pass with relatively rare alternation.

This species, represented by but few specimens in the collection, one of which is shown in figure 10, plate 9, is rather easily differentiated from the associated forms by the narrow and slightly crowded ribs. As seen in the illustration, the external impression of the stem is nearly smooth, with extremely faint indication of costation and, as in associated species, with faint expression of articulation. Articulation is, however, plainly seen in the pith cast, which is slightly constricted at the immediate node, which is very narrow. The costae are nearly as narrow as those in the larger fragments of the very slender species described below under the name *A. gracilentus.* No evidence of branching or appendages is seen. Details as to leaf scars and appendages await the discovery of additional material.

The specimen illustrated invites comparison with one of the fragments figured by Stur [95] as *Calamites ramifer,* though that specimen is much more finely costate than the other pith casts described under the same name, besides which the nodes in the Arkansas specimen are much less distinctly calamarian in aspect.

Localities: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8075). About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145).

Type: U. S. Nat. Mus. 39549.

Archaeocalamites gracilentus White, n. sp.

Plate 9, figures 1, 5, 9

Stems very slender, tapering downward extremely gently to a slender pointed base; rather distantly articulate, finely lineate on the outer surface of a thin woody outer cylinder, and dilated rather abruptly at the nodes, some of which are marked by verticils of several small rounded tubercular protrusions corresponding to short, extremely open, rapidly tapering bases of appendages or branches; pith cast slightlv constricted at the nodes, which become increasingly closer in the tapering base and distinctly costate, with very narrow, slender, straight, rather prominently rounded costae, some of which appear slightly crowded.

This very graceful and interesting species is rather rare at the localities at which collections of plants were made from the Wedington sandstone. It is, however, easily recognized by the very slender stems, the narrow costae of the pith cast, the closely and distinctly lineate impression of the outer cortex, and the dilation of the cortex at the nodes, many of which are marked, as shown in figures 1, 5, and 9, plate 9, by short, blunt, rapidly tapering processes that apparently represent the bases of appendages or bracts, and which are marked internally by small oval impressions suggesting tubercles in small numbers, forming verticils at some of the

[95] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Heft 2, pl. 21, fig. 4, 1877.

nodes. Such verticils are imperfectly shown in the upper part of figure 9. In this fragment, which is one of the largest seen among the specimens of this species, the rather typical sharply indented archaeocalamitian node is seen in the lower part.

The fragment illustrated in figure 5, plate 9, is so smooth on the outer surface that it might readily be passed as the slender petiole of a fern or some other plant. Careful examination reveals indications of the pith costae. The dilated node near the upper end of the fragment, from which the pith cast has been removed, shows a semispinous appendage or appendicular base on each side and pits marking the neural tract of two others in the slightly compressed mold. In the specimen photographed in figure 1, plate 9, is seen the rounded edge of a slightly flattened stem. Here the thickness of the carbonized outer cylinder is shown and the dilation of the cylinder at the node in the upper part of the fragment. In this example, as in that shown in figure 9, plate 9, the pith cast itself is constricted at the node, but the costae are continuous, the stem being nearly uniform in size. From the uniformity in size of the stem and the apparent absence of introduced costae at the node, as well as from the fact that the woody residue is in this form developed as in others, it is concluded that the stem is mature and of full size. The costae of the pith cast are faintly seen to be very finely lineate.

One unfigured specimen is unusually interesting in that it shows the long, tapering, slender bases of several stems which converge and which possibly were attached at a single node of a rhizome or parent stem. As with other specimens, the impression of the stem, in which the cuticle was in contact with the matrix, reveals no trace of costae. However, both the costation and the constricted nodes of the pith are well shown at the left. It should be noted that this impression extends, with very slight diminution in the extreme lower portion, very nearly to the lower edge of the rock fragment, and the dilations at the nodes are apparent nearly as far as the cast can be traced in place, though they are not so prominent at the lower end of the mold.

Archaeocalamites gracilentus differs so markedly from all other calamarian material in the collection that its differentiation is exceedingly evident. No other species has such marked nodal dilation as this, and none bears spinelike processes arranged in verticils at the nodes.

The similarity between the stems here described as *Archaeocalamites gracilentus* and those from the Moravian-Silesian roof slates described by Ettingshausen [96] as *Calamites tenuissimus* Goeppert is remarkably close. Information is lacking, however, as to the pith casts of the plant from the roofing slates, but, on the other hand, no leaves such as those figured by Ettingshausen are observable on the American material, which superficially resembles even more closely the stems described by Paterson [97] and Kidston [98] as belonging to *Pothocites grantonii*.

The slender stems here described invite comparison with the axes of the cones from the Wedington, to which the name *Chlamidostachys* is given, for both on account of the characters of those axes and the analogies between *Chlamidostachys* and *Pothocites*, which is borne by a stem very similar to *Archaeocalamites gracilentus*, it seems not improbable that *A. gracilentus* may have supported the strobili mentioned above. No trace of bifurcation, such as is reported in the stem of *Pothocites*, is observed in the Wedington specimens, but in both forms the stem is very slender, being comparable in size, with rather long internodes, which are striate externally, with costate piths, and which may be provided at the nodes with protuberant processes or short blunt spines, marking the origin of probable branches. Between the two types of cones also there are notable similarities, which are pointed out in the description of *Chlamidostachys* (p. 39). Therefore, the discovery of additional material may show union between *Archaeocalamites gracilentus* and *Chlamidostachys chesterianus*. *Pothocites* is regarded as the fruit of *Archaeocalamites scrobiculatus* (Schlotheim) Seward, its leaves being indentified by Kidston with *Sphenophyllum tenerrimum* Ettingshausen. However, the variation in the types of fruit and in the leaves referred to *Archaeocalamites scrobiculatus* or its synonym *Bornia radiata* only emphasizes the view already stated that this name covers an aggregate of species that should be susceptible of differentiation.

Locality: About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145). Fragments apparently referable to the species are included also in U. S. Geological Survey lot 8075, collected at Bob Kidd Hollow, 3.2 miles southwest of Prairie Grove, Ark.

Types: U. S. Nat. Mus. 39550–39552.

Archaeocalamites umbralis White, n. sp.

Plate 9, figure 4

Stems comparatively small, slender, tapering rather gently downward in the lower part, with relatively short segments two to three times as long as thick, dilated slightly at the nodes, with distinct outer vascular zone of moderate thickness, and nearly smooth externally between the nodes; articulations distinct in the pith cast, marked with thickening and slight dilation of the vascular cylinder; internodal pith cast slightly enlarged just above and just below the articulation and marked by about 20 comparatively broad, prominently rounded ribs that are rather obtusely rounded distally, though

[96] Ettingshausen, C. von, op. cit., p. 16, text fig. 2, pl. 1, figs. 1, 2, 1865.

[97] Paterson, Robert, Description of *Pothocites grantonii*, a new fossil vegetable from the coal formation: Bot. Soc. Edinburgh Trans., vol. 1, p. 45, pl. 3, 1841.

[98] Kidston, Robert, On the affinities of the genus *Pothocites* Paterson, with the description of a specimen from Glencartholm, Eskdale: Annals and Mag. Nat. History, 5th ser., vol. 11, p. 304, 1883.

generally alined across the node and marked a little below the node by rather large but generally faint leaf scars; intercostal or canilicular furrows narrow and rather deep; surface of ribs of pith cast very finely and apparently irregularly striate; outer cortex very finely lineate.

The type of stem illustrated in figure 4, plate 9, appears to be not rare in the upper part of the Mississippian of eastern America, though in the collection from the Wedington sandstone it is represented by only a few fragments that are clearly referable to this species. The nodes are slightly dilated and marked by thickening of the vascular cylinder, in which the articulations are relatively distinct. The thickness of the outer cylinder is especially notable toward the base of this specimen.

The species is further characterized by the short nodes and the relatively broad costae of the pith cast, which are rather distinctly rounded at the upper ends. The ribs are dorsally high-rounded, with relatively narrow intervening sulci. The articulation in this stem is more clearly shown in the pith casts than in any of the other species from the Wedington sandstone, though the internodes of the pith are closely set and the ribs generally in continuous alinement. The aspect of the pith cast is more distinctly calamarian than that of the associated species, yet the node itself lacks the prevalent intertwining of the neural strands seen in the later types found in the Pennsylvanian. The compactness of the articulations and the general continuity of the costae of the pith, combined with the rather thick vascular cylinder, associate the plant with the later forms of *Archaeocalamites*. The impression of the outer cortex, a portion of which is shown in figure 4, plate 9, shows little trace of costation and but faint evidence of articulation.

Archaeocalamites umbralis resembles in general form and size the lower portion of a stem figured by Stur [99] as *Calamites haueri*. In Stur's species, however, from the Waldenburg series, the ribs are partly alternate, with distinct leaf traces and well-marked nodes of the calamarian type.

Localities: About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145). A portion of a pith cast nearly twice the size of that figured but presenting the same costal characters and tentatively referred to the species, although exhibiting undulation of the ribs, probably the result of mechanical deformation, is present in U. S. Geological Survey lot 8140 from Bob Kidd Hollow, 3.2 miles southwest of Prairie Grove, Ark.

Type: U. S. Nat. Mus. 29553.

Archaeocalamites wedingtonensis White, n. sp.

Plate 9, figures 7, 12, 13

Stems of moderate size, tapering rather gently toward the base and divided into internodes varying from three times to twice the diameter of the stem, the nodes being hardly visible in the external impression and marked by faint narrow transverse depressions on the pith cast; outer surface generally smooth, rather distinctly and distantly lineate, with minutely striate interspaces; pith cast distinctly costate where free from remains of external tissue, with straight and regular, generally low-rounded costae, dorsally rather distinctly lineate, nearly all in continuous alinement in the larger stems, and separated by rather broad sulci in which the casts of the canals are generally distinct and rather large; leaf scars apparently small and obscure.

This species is one of the commonest in the Wedington sandstone. The general aspect of the cast is shown in figure 12, plate 9. The distinctness of specific characters varies with the state of preservation and, in particular, according to the maceration of the outer cylinder with consequent masking of the characters. In some of the specimens, such as that shown in figure 7, plate 9, both costation and nodes are completely concealed beneath the residue of the outer tissue and cuticles. This feature is shown also in portions of the reverse of the specimen, seen in figure 12, plate 9, where the partly macerated woody cylinder shows little but the impression of the finely lineate cuticle, which is finely striate between the rather distinct lines. All expression of costation is lost, and the nodes are hardly discernible with certainty in the specimen shown in figure 13, plate 9, though some specimens clearly reveal the costation on a portion of the somewhat macerated pith. The external impressions of such examples may easily be mistaken for the impressions of petiolar fragments of ferns.

Evidence of the presence of leaves or branches is generally obscure. Minute pustular scars are visible at the upper ends of the ribs in some of the fragments, and small scars, hardly larger than pin points, mark corresponding connections with the pith cast. Several of the specimens show very faint and rather small depressions, apparently corresponding to branches or the attachment of fructifications at the joints. That illustrated in figure 7, plate 9, though somewhat macerated and deformed, shows the depressions more clearly than any other in the collection. In this example we see a row of very small, closely placed, slightly discoid impressions elongated somewhat in the longitudinal direction and marked by punctate neural scars somewhat above the middle. It is possible that the fertile strobili described on page 38 as *Chlamidostachys chesterianus* were borne by the type of stems here distinguished as *Archaeocalamites wedingtonensis*, though it is probable that they were connected with *Archaeocalamites gracilentus*, for reasons stated under the heading of that species.

[99] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Band 8, Heft 2, p. 90, pl. 5, figs. 3a, 3b, 1877.

Archaeocalamites wedingtonensis is distinguished by the relatively large size of the stem as compared with the associated species; by the typical *Bornia* type of nodal demarcation, the node being, however, very slightly constricted; and by the low-rounded costae of the pith cast, which are distinctly lineate, whereas the intercostal sulci are moderately broad and the neural casts usually distinct and relatively large. Furthermore, the residues of the outer zone, including the woody cylinder and the external envelopes, usually completely mask the costation of the pith cast, frequently concealing also the presence of the nodes themselves. The stems are very much larger and the ribs narrower, less closely placed, and less distinctly marked at the nodes than in *Archaeocalamites umbralis*, in which the nodes are somewhat dilated. On the other hand, the costae of the pith cast are much broader and more distantly spaced than in *Archaeocalamites fayettevillensis*.

The ribs of the pith casts of the species from the Wedington are proportionately considerably narrower than in the Old World specimens figured as *Asterocalamites scrobiculatus* (Schlotheim) Seward or its supposed synonyms. An exceptionally near approach to the stem in hand is found in one of the specimens figured by Schimper [1] as *Calamites radiatus*.

Localities: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lots 8075 and 8140), and by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264). Cane Hill, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8144). About 2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8145).

Types: U. S. Nat. Mus. 39554–39556.

Archaeocalamites? sp.

Plate 9, figure 11

On account of its very close similarity to some of the foliage referred by various authors to *Archaeocalamites scrobiculatus*, the leaf fragment shown in figure 11, plate 9, is tentatively referred to the genus *Archaeocalamites*, with the recognition of the consequent implication that one species in the Wedington flora may be identical or very close to a European form gathered by authors into the group species *Archaeocalamites scrobiculatus* (Schlotheim) Seward. That not all the forms under this collective name are specifically identical is proved by the differences in their leaf characters and in their fruits. The figured specimen is the sole representative *Archaeocalamites* leaf in the collections from the Wedington. There is no stem of *Sphenophyllum* or fern similar in leaf. The bracts and the sporangia of the associated cones, *Chlamidostachys*, are distinctly sphenophylloid.

[1] Schimper, W. P., Les végétaux fossiles, in Koechlin-Schlumberger, J., and Schimper, W. P., Le terrain de transition des Vosges, pl. 1 (see fig. *a* only), 1862.

Except that the Arkansas leaf is very much smaller, it agrees closely with the plant described by Ettingshausen [2] as *Schizaea transitionis*. It is three times dichotomously divided, but the greater part of the left lobe of the first subdivision is broken away. The divisions are relatively rigid, nearly equal in width, slightly flexuose, bifurcating at a narrow angle, and slightly divaricate. The terminal divisions taper and are acute, with slightly thickened margins. The lamina is not very thick and is nearly flat. The primary nerve bifurcates at a very narrow angle not far below the points of division of the leaf. The nerves passing into the tertiary divisions originate by bifurcation in the upper part of the secondary division and pass nearly parallel through the tertiary.

Both as to size and form the fragment illustrated may be compared especially with the illustrations given by Stur to show the foliate stems from the Moravian-Silesian roofing slates.[3]

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8075).

Type: Figured specimen, U. S. Nat. Mus. 39557.

Genus CHLAMIDOSTACHYS White, n. gen.

Chlamidostachys chesterianus White, n. sp.

Plate 8, figures 11, 17, 18, 19, 21

Strobili large, reaching a length of 10 centimeters or more and varying in width from 2.5 to 3 centimeters or more; hardly rigid, cylindrical, rounded at the apex, with fluted axis 2.5 to 3 millimeters wide, articulated transversely at distances of 2.5 to 2 millimeters, the costae being continuous in alinement on each side of the articulation; nodes provided with verticils of approximately nine sporangiophores; sporangiophores open nearly at right angles to the axis, some slightly reflexed, some inclined slightly distad, thick, narrowest very near the base, broadening upward, slightly concave ventrally, low round-arched dorsad, forking or giving off narrow linear lateral branches, those in the lower portion very oblique, those at a distance of about 7 millimeters from the axis very open and dividing in four or five subdivisions, apparently arranged in peltate form and splitting parallel to the main axis of the cone or at nearly a right angle to the basal portion of the sporangiophore; form of peltate subdivisions apparently variable, obcuneate-ovate to round-ovate and ovate-elliptical, some of them 5 millimeters or more in length, and invariably appressed so as to define the outer surface of the strobilus; lower portions of the sporangiophore provided with a broad, thin wing, which curves upward and slightly inward to form a cylindrical or semicylindrical chamber in which oval

[2] Ettingshausen, C. von, Die fossile Flora des mährisch-schlesischen Dachschiefers: K. Akad. Wiss. Wien, Math.-naturwiss. Kl., Denkschr., Band 25, p. 27, pl. 7, fig. 5, 1865.

[3] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Band 8, Heft 2, pl. 3, p. 8, 1877.

or oblong-lanceolate sporangia, in groups of four or five, are borne in asteriform arrangement about short pedicels springing obliquely from point to point along the ventral side of the basal portion of the sporangiophore; sporangia, whose groups are sparsely scattered on the surface of the sporangiophore, dehiscent by a ventral slot or elongated opening, reaching from the base halfway or quite to the apex and varying in width, those on the upper divisions of the sporangiophore, including the lower portions of the broad peltate ultimate subdivisions, being generally smaller than those nearer the axis of the cone, though much elongated groups simulating sori appear to be borne on the ventral surface of some of the appressed outer lobes, so as to form low rounded prominences on the outer surface of the cone.

The fertile strobili here described present certain features strongly resembling the strobili of *Pothocites* as originally described by Paterson [4] and as later critically revised by Kidston.[5] In fact, noticing rounded protuberances and obscure resemblances to scattered "stellate bodies" on the surface of the strobilus, I was at first disposed to place the Arkansas specimens in the Scotch genus. Further examination, however, showed clearly that the American material belonged to a distinct undescribed genus. In both genera we have slender cylindrical cones with closely appressed bracts, arching in low rounded prominences, arranged in longitudinal series. As originally described some of these rounded protuberances, each corresponding to a bract, are capped by structures resembling quadripartite sporangia, in which the sporangia, lanceolate or linear-oblong in shape, are spread out flat about the central point of attachment and are open longitudinally for their entire length. Kidston, who reviewed the species, all from the Calciferous Sandstone series and mostly from Glencartholm, near Eskdale, near Edinburgh, described the sporangia as generally four in number, borne on the concave under surface of the quadrangularly peltate dilation of a sporangiophore that originates in the axis of the cone. The cone itself is borne by a slender rigid smooth stem, which is described as branching. *Pothocites grantonii* Paterson,[4] *Pothocites patersoni* Etheridge,[6] and *Pothocites calamitoides* Kidston,[7] together with an unnamed species of *Pothocites* described by Etheridge,[6] were finally referred by Kidston to the single species *Pothocites grantonii*, which he ascribed to the single species *Bornia radiata*, more generally known as *Asterocalamites scrobiculatus*.

Much remains to be learned regarding the structure of the cone from the Wedington sandstone. The features exhibited, however, show that it differs generically from *Pothocites*, though it was, I suspect, similarly borne on a slender pipestemlike stalk, which in this paper is described as *Archaeocalamites gracilentus*. In *Pothocites* the axis of the cone is described as cylindrical, the sporangiophores being in 10 (?) vertical rows. Further, the sporangiophores are interrupted at regular intervals of about 2 centimeters (?), where a verticil of normal sterile filiform dichotomous bracts marks the abrupt constriction of the cone, the axis of which may be exposed for a very short interval. However, the most important generic distinction lies in the broad, slightly fleshy, and thinly alate sporangiophore of *Chlamidostachys*, which widens cuneately upward with branching nervation in sphenophylloid fashion and which becomes laciniately cut in sphenophylloid lobation at the dilated and generally closely appressed upper portion. The sporangia, oval or round-oval, are borne in groups of four or five on short pedicils springing from the nerves on the ventral surface of the lower fertile portion of the bract. I have seen no evidence of any peltate enlargement at the top of the pedicil. In fact, in the flattened specimens the sporangia, which apparently open longitudinally, present an aspect suggestive of *Asterotheca*. In a few specimens the abruptly appressed upper portion of the bract presents a low-rounded surface comparable to the protuberances on *Pothocites*, and in a few specimens, owing possibly to the displacement of the tips of the lobes of the bract, the impression presents a roughly stellate configuration in which three or four lobes suggest the external patterns drawn by Paterson and Kidston from the Scotch specimens. It is not too much to say that these resemble canoe-shaped sporangia lying flat on the surface of the cone and opening longitudinally along their ventral axes, as in *Pothocites*. This aspect may be accidental and mechanical. The explanation awaits the collection and detailed examination of additional material. On the other hand, it does not appear to the writer that a satisfactory explanation has yet been given of the stellate structures on the outer surface of *Pothocites*, which are arranged in four or five vertical rows and also in distantly spaced verticils, while the groups of sporangia, several times as numerous, are crowded. Certainly they do not appear to accord with the quadrisporangiate group borne on short sporangiophores springing from the axis of the cone, as described by Kidston.

So far as the general structure of *Chlamidostachys* is revealed by the specimens in hand, it defines a type of fructification more nearly comparable to that of *Sphenophyllum* than to any of the equisetalean or calamarian genera. Certain features of the cone suggest *Bowmannites* or even *Cheirostrobus*. It will be noted that the axis of the cone of *Chlamidostachys* appears to be articulated, that the bracts springing

[4] Paterson, Robert, Description of *Pothocites grantonii*, a new fossil vegetable from the coal formation: Bot. Soc. Edinburgh Trans., vol. 1, p. 45, pl. 3, 1841.

[5] Kidston, Robert, On the affinities of the genus *Pothocites* Paterson: Annals and Mag. Nat. History, 5th ser., vol. 10, pp. 404–405, 1882; On the affinities of the genus *Pothocites* Paterson, with the description of a specimen from Glencartholm, Eskdale: Idem, vol. 11, pp. 297–314, pls. 9–12, 1883; Bot. Soc. Edinburgh Trans. and Proc., vol. 16, pp. 28–38, pls. 1–4, 1885.

[6] Etheridge, Robert, Note on the further discovery of a species of *Pothocites* (Paterson) in the lower Carboniferous rocks near West Calder: Bot. Soc. Edinburgh Trans., vol. 12, p. 151, 1874.

[7] Kidston, Robert, On the affinities of the genus *Pothocites* Paterson: Annals and Mag. Nat. History, 5th ser., vol. 10, p. 404, 1882.

from the nodes are verticillate, and that the internodes are distinctly fluted, as in the calamarian cone. In view of the sphenophylloid type of leaf, such as that described as *Archaeocalamites* sp. (pl. 9, fig. 11), associated with the branches of *Asterocalamites*, and in view of the structure, so far as at present known, of *Chlamidostachys*, the question arises whether there are not now classed under the term *Bornia* or its synonymns *Archaeocalamites* and *Asterocalamites*, plants which cannot properly be included among the Equisetales or Calamariales and which are more nearly related, though perhaps intermediate, to the Sphenophyllales. On the assumption that *Chlamidostachys* is really associated with the archaeocalamitean type of forked leaf and that the Wedington cone is borne on an archaeocalamitean stem, consideration should, according to my view, be given to the revision of the classification of the sphenophylloid group of *Archaeocalamites* and its possible systematic differentiation.

Asterophyllites spaniophyllus Feistmantel,[8] from the Carboniferous limestone at Rothwaltersdorf, which was referred by Stur[9] as the fruit of *Archaeocalamites radiatus*, has a verticil of spiral leaves filling five verticils of fertile bracts but without constriction of the cone, as in the Scotch *Pothocites*.

Bureau argues that *Archaeocalamites scrobiculatus* is a comprehensive type which, like the genus *Cordaites*, produces a diversity of fruits representing species far more numerous than is indicated by the stems and foliage. To a fruit from the upper Culm of the basin of the lower Loire Bureau[10] gives the name *Bornia pachystachys* and regards it as associated with *Bornia transitionis*, under which he places *Archaeocalamites scrobiculatus*. However, in Bureau's *Bornia pachystachys*, as in *Bornia grand'euryi* Renault[11] and *Bornia esnostensis* Renault,[12] the cones are without bracts, the sporangia being borne in groups of four to six on more or less distinctly peltate sporangiophores springing directly from the axis.

The diversity of fructification referred to the *Archaeocalamites* stock is further illustrated by Nathorst's *Pothocitopsis*, another type of cone, apparently without bracts, from the lower Carboniferous of Spitsbergen,[13] regarded by its author as closely related to *Pothocites*.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser, L. G. Henbest, and David White, 1930 (U. S. Geological Survey lot 8140).

Types: U. S. Nat. Mus. 39558–39562.

Genus SPHENOPHYLLUM Koenig, 1825[14]

Sphenophyllum? sp.

Plate 8, figure 16

A plant fragment photographically illustrated in figure 16, plate 5, though problematic and solitary, is of such unusual interest that attention should be drawn to it, if only for the purpose of encouraging the search for additional specimens. A single slender curved stalk or petiole broadens rapidly about 3 millimeters from the base into a lamina that is apparently cut nearly to the base in two lobes, one of which is broken away but which were probably equal or nearly equal. The left lobe appears to present the characters of *Sphenophyllum*. It is cuneate, narrowing, with convex borders, rather rapidly at the base, the margins diverging but slightly in the upper part, and truncate and cut in four or five blunt sphenophylloid teeth at the apex. A single nerve forks at the base of the lobe and again at a very narrow angle somewhat higher, to furnish a nerve that passes upward into the marginal teeth. The lamina is thick and granular-rugose. It is of course possible that the fragment may belong to a dichotomous pinnule of a fern or pteridospermic leaf.

Locality: Bob Kidd Hollow, south of United States Highway 62, 3.2 miles southwest of Prairie Grove, Ark.; collected by H. D. Miser and C. B. Read, 1931 (U. S. Geological Survey lot 8264).

Type: Figured specimen, U. S. Nat. Mus. 39476.

[8] Feistmantel, Ottokar, Das Kohlenkalkvorkommen bei Rothwaltersdorf in der Grafschaft Glatz und dessen organische Einschlüsse: Deutsche geol. Gesell. Zeitschr., Band 25, p. 498, pl. 14, fig. 5, 1873.

[9] Stur, Dionysius, Die Culm-Flora: K.-k. geol. Reichsanstalt Abh., Band 8, Heft 2, p. 74, 1877.

[10] Bureau, Édouard, Bassin houiller de la basse Loire, fasc. 2, Description des flores fossiles, p. 240; atlas, pl. 65, figs. 1, 2; pl. 66, figs. 1–5; pl. 67, figs. 1–5a, 1914. (In the series "Études des gites minéraux de la France.")

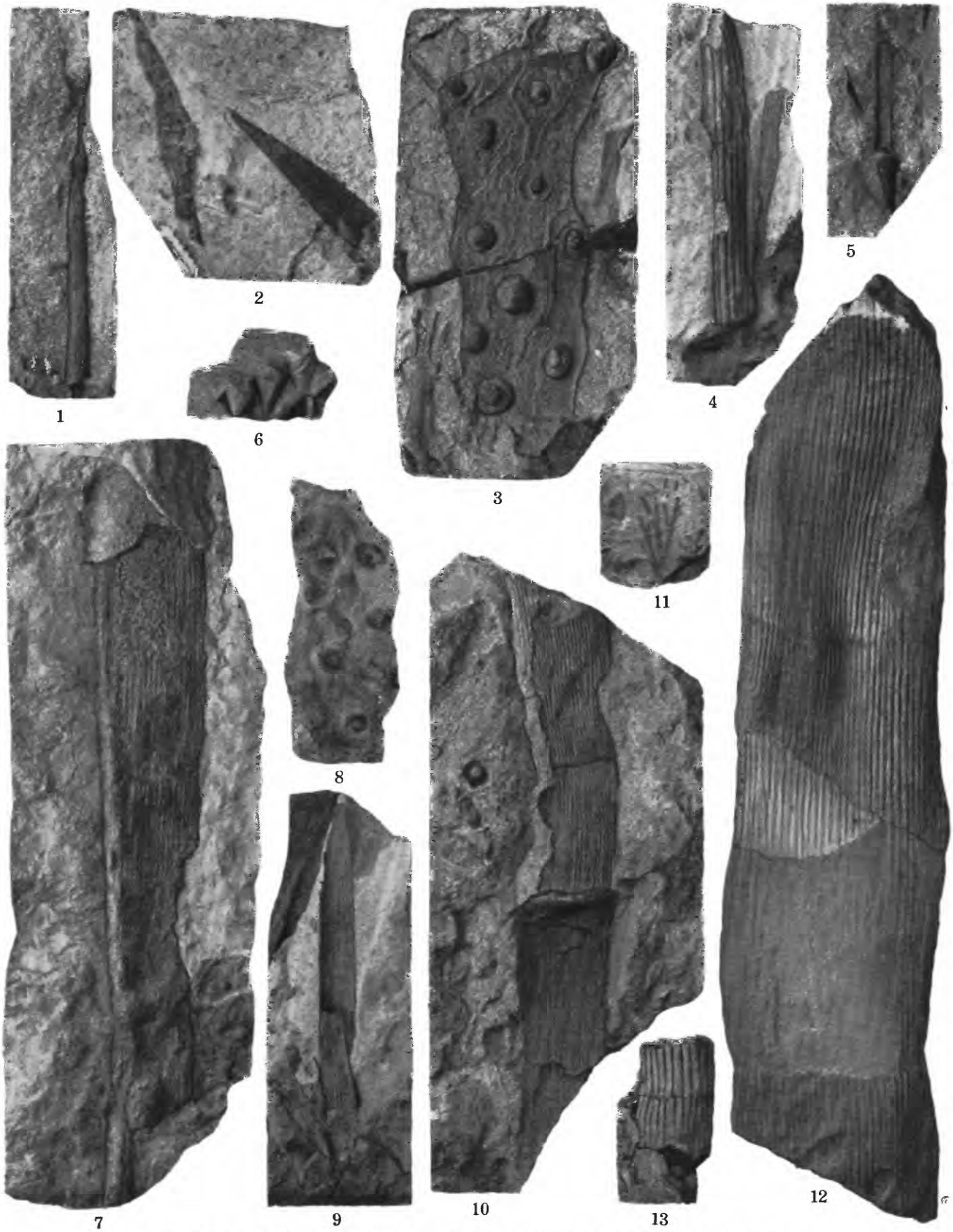
[11] Bureau, Édouard, Les fructifications du genre *Bornia:* Soc. sci. nat. ouest France Bull., 3e sér., tome 3, p. 122, pl. 5, fig. 6, 1913.

[12] Renault, B., Bassin houiller et permien d'Autun et d'Épinac, fasc. 4, pt. 2, Flore fossile, p. 82, 1896; atlas, pl. 43, figs. 1–10, 1893. (In the series "Études des gites minéraux de la France.")

[13] Nathorst, A. G., Nachträge zur paläozoischen Flora Spitzbergens: Zur fossilen Flora der Polarländer, Teil 1, Lief. 4, p. 78, pl. 3, figs. 5 and 6, 1914. (See *Pothocitopsis tertillii.*)

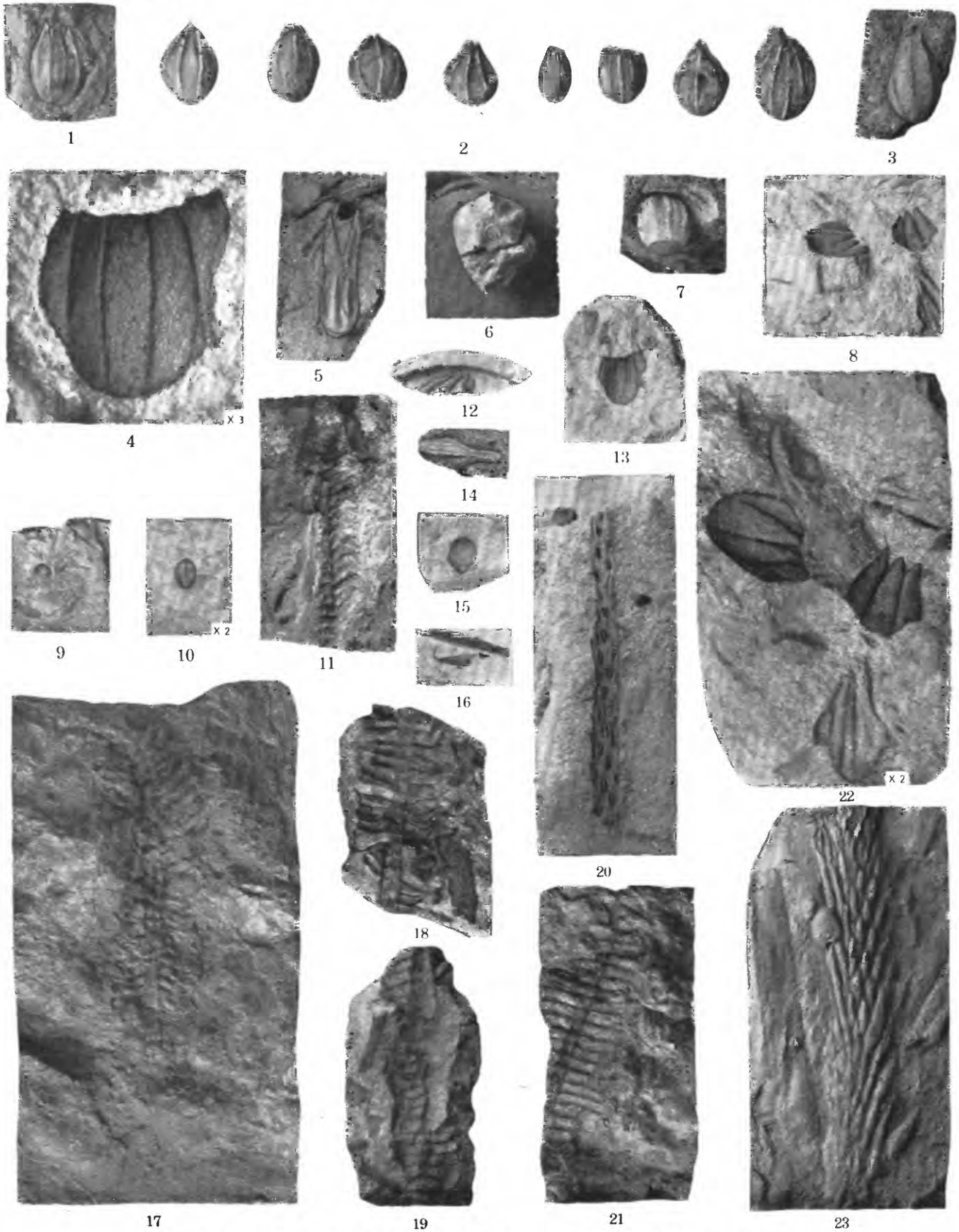
[14] Koenig, C., Icones fossilium sectiles, p. 42, 1825.

PLATES 4–9



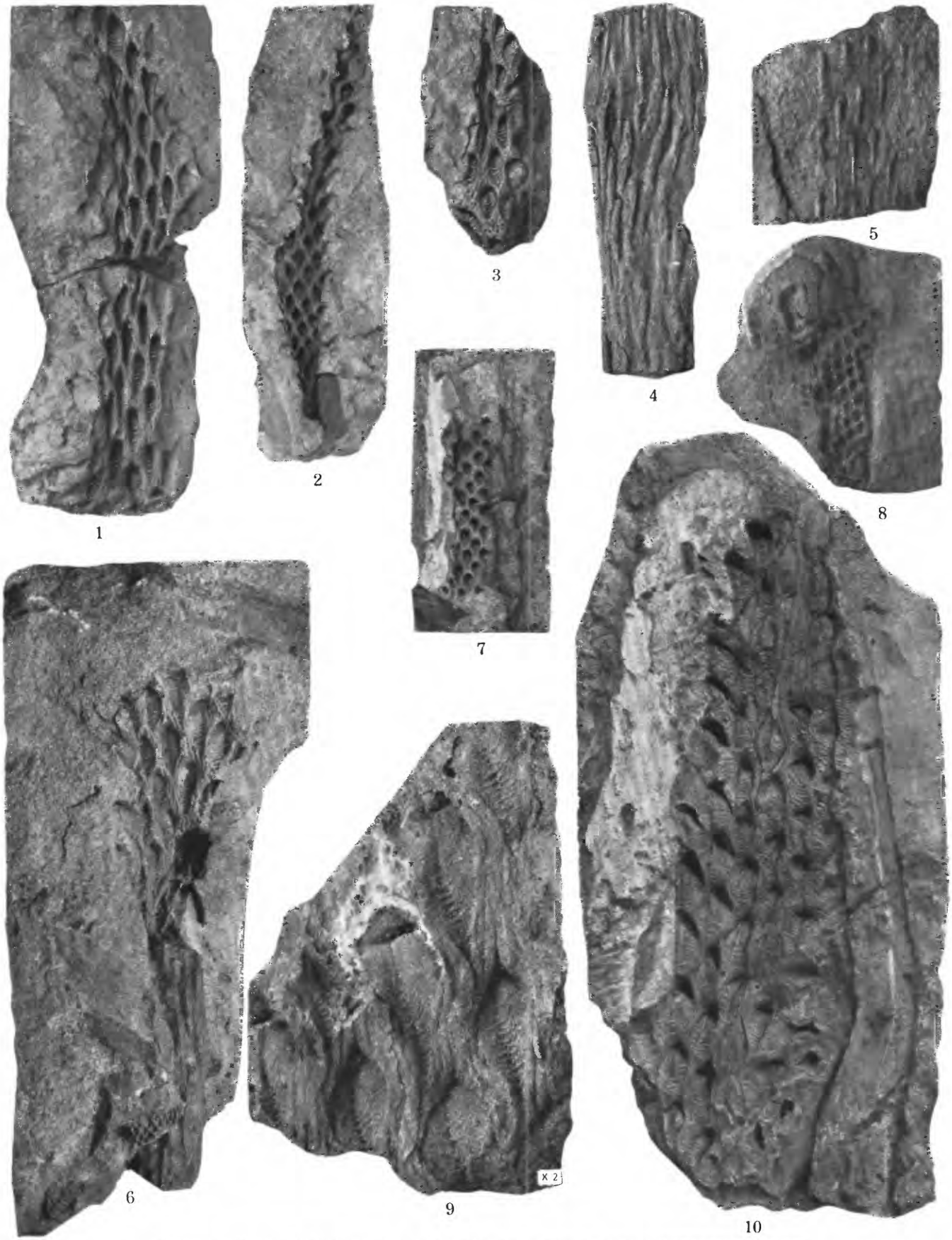
FOSSIL FLORA OF THE WEDINGTON SANDSTONE MEMBER OF THE FAYETTEVILLE SHALE.

1; 5; 9. *Archaeocalamites gracilentus* White, n. sp.
2. *Lepidophyllum sagittatum* White, n. sp.
3. *Stigmaria wedingtonensis* White, n. sp.
4. *Archaeocalamites umbralis* White, n. sp.
6. *Lepidodendron wedingtonense* White, n. sp.
7; 12; 13. *Archaeocalamites wedingtonensis* White, n. sp.
8. *Stigmaria arkansana* White, n. sp.
10. *Archaeocalamites fayetterillensis* White, n. sp.
11. *Archaeocalamites* sp.



FOSSIL FLORA OF THE WEDINGTON SANDSTONE MEMBER OF THE FAYETTEVILLE SHALE.

1; 2; 3; 4; 5; 6; 7; 8, 22; 12; 13; 14. *Rhynchogonium fayettevillense* White, n. sp.
9, 10; 15. *Carpolithus inquirenda* White, n. sp.
11; 17; 18; 19; 21. *Chlamidostachys chesterianus* White, n. gen. et sp.
16. *Sphenophyllum?* sp.
20. *Lepidostrobus occidentalis* White, n. sp.
23. *Lepidodendron* sp.

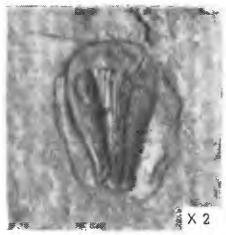


FOSSIL FLORA OF THE WEDINGTON SANDSTONE MEMBER OF THE FAYETTEVILLE SHALE.

1; 2; 3; 4; 6; 7; 9; 10. *Lepidodendron wedingtonense* White, n. sp. **5.** *Bothrodendron* sp. **8.** *Lepidodendron* sp.

1

2



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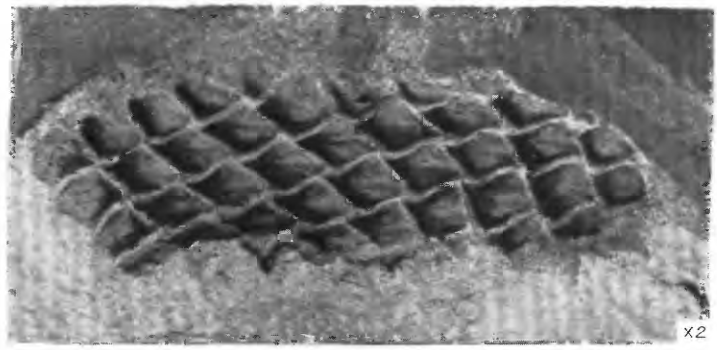

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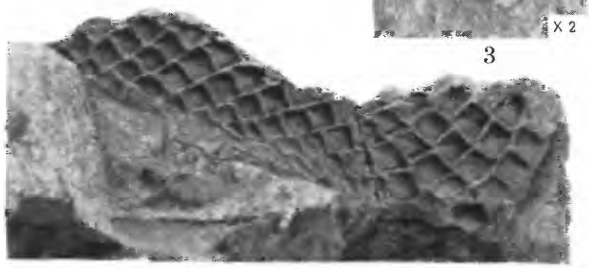

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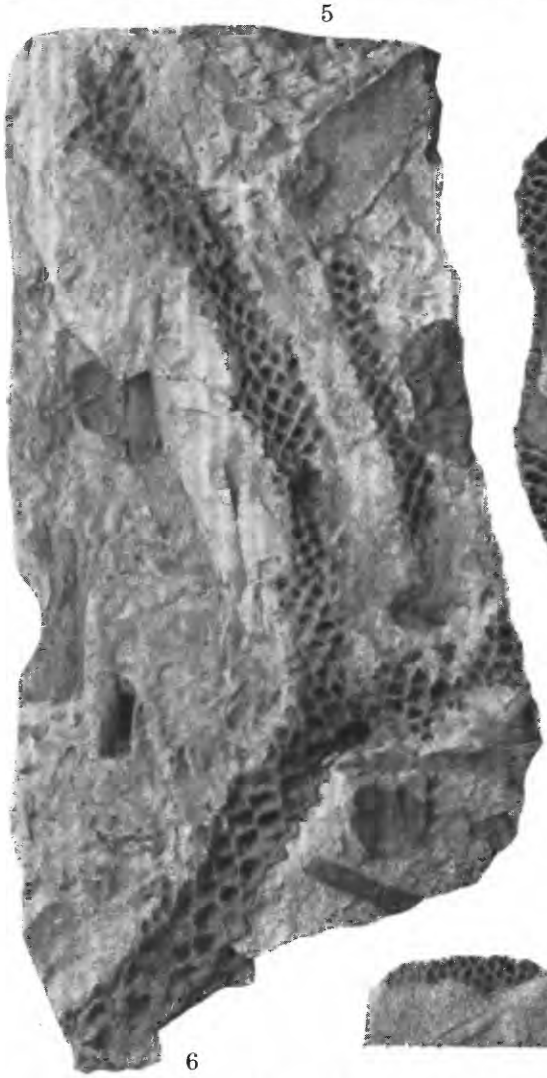

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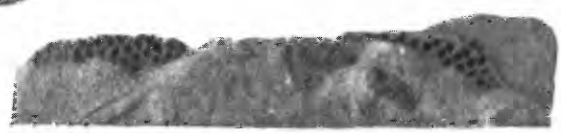
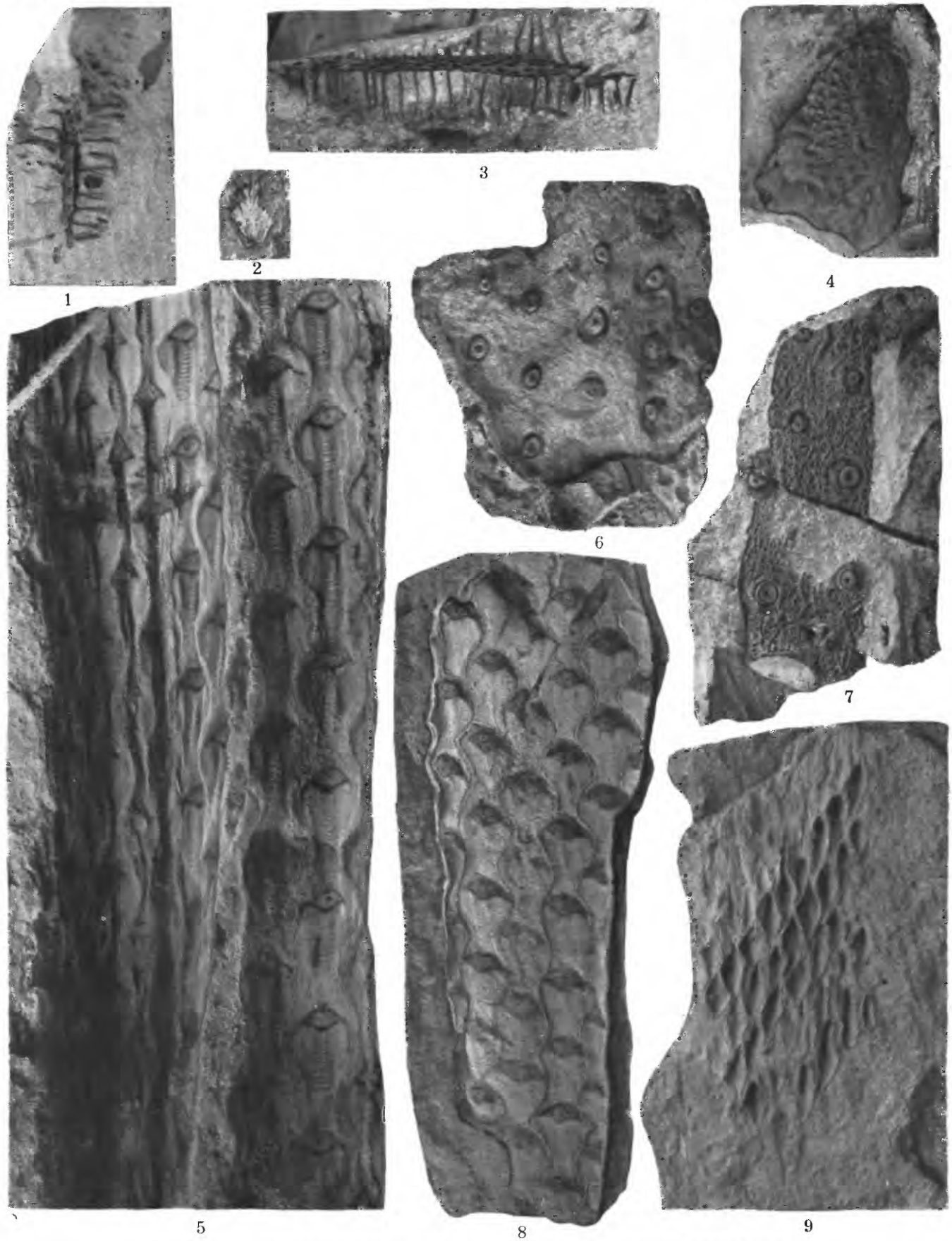


8

9

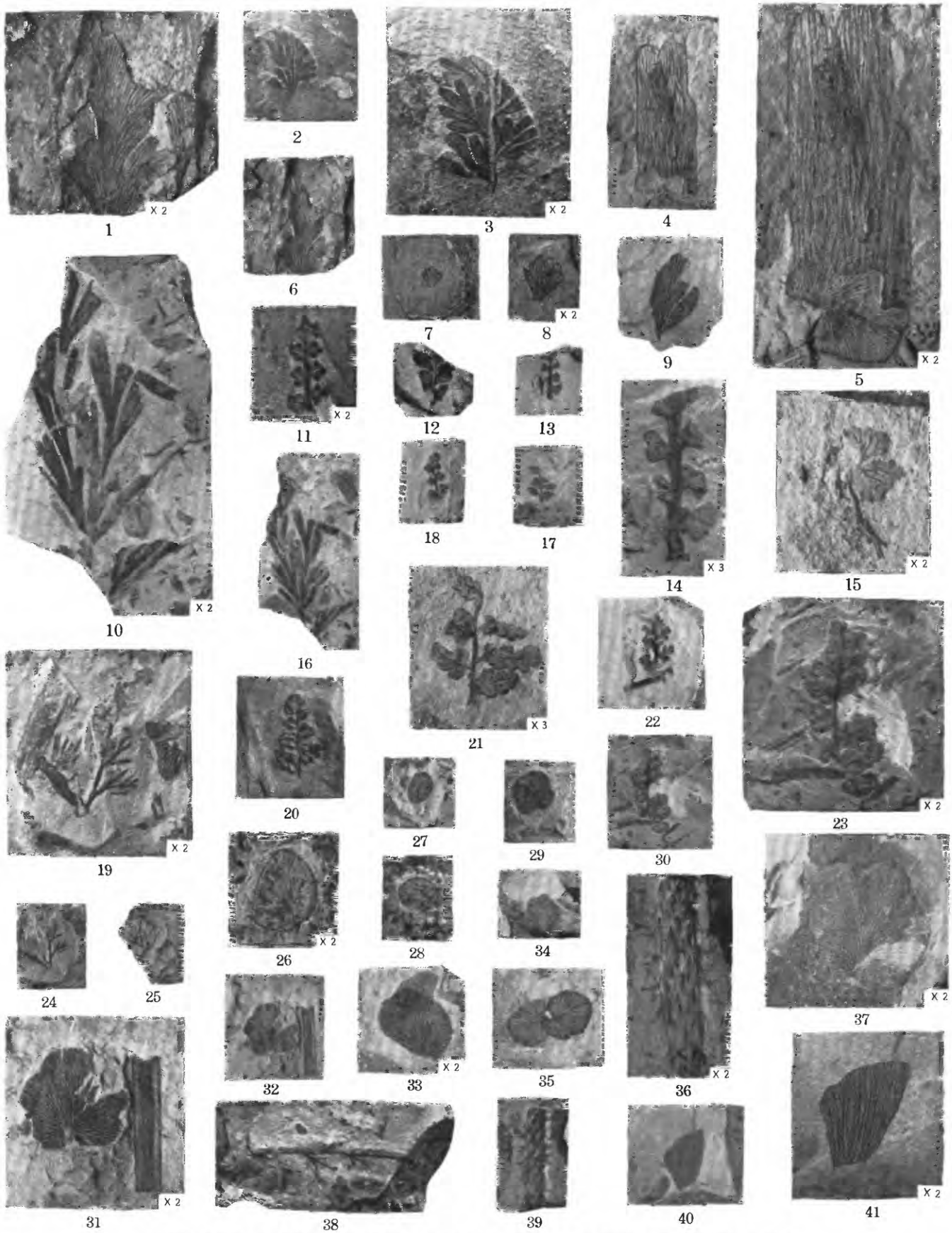
FOSSIL FLORA OF THE WEDINGTON SANDSTONE MEMBER OF THE FAYETTEVILLE SHALE.

1; 4; 5; 6, 9; 7, 8. *Lepidodendron henbesti* White, n. sp. **2.** *Lepidocystis chesterensis* White, n. sp **3.** *Lepidophyllum sagittatum* White, n. sp.



FOSSIL FLORA OF THE WEDINGTON SANDSTONE MEMBER OF THE FAYETTEVILLE SHALE.

1; 3. *Lepidostrobus occidentalis* White, n. sp.
2. *Telangium(?)* sp.
4. *Lepidodendron* cf. *L. veltheimianum* Sternberg.
5; 8. *Lepidodendron occidentale* White, n. sp.
6. *Stigmaria arkansana* White, n. sp.
7. *Stigmaria wedingtonense* White, n. sp.
9. *Lepidodendron purduei* White, n. sp.



FOSSIL FLORA OF THE WEDINGTON SANDSTONE MEMBER OF THE FAYETTEVILLE SHALE.

1, 6. *Rhacopteris* sp.
2, 3. *Rhodea* cf. *R. subpetiolata* (Potonié) Němejc.
4, 5; 11, 18; 13, 14; 15; 17, 21; 20; 22; 23, 30; 36, 39. *Sphenopteris mississippiana* White, n. sp.
7, 8. *Sphenopteris* cf. *S. schimperiana* Goeppert.
9. *Sphenopteris* cf. *S. communis* Lesquereux.
10, 16. *Sphenopteris* (*Palmatopteris*) *erectiloba* White, n. sp.
12. *Sphenopteris* cf. *S. obtusiloba* Brongniart.
19, 24; 25. *Rhodea* cf. *R. moravica* (Ettingshausen) Stur.
26, 28; 27. *Neuropteris* sp.
29; 31, 32; 33, 34; 35; 37. *Cardiopteris hirta* White, n. sp.
38. *Adiantites minima* White, n. sp.
40, 41. *Cardiopteris* sp.