Floras of the Pocono Formation and Price Sandstone in Parts of Pennsylvania, Maryland West Virginia, and Virginia

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By CHARLES B. READ

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Including descriptions of 22 new species, 1 new genus, and 4 new combinations of Mississippian age

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FLORAS OF THE POCONO FORMATION AND PRICE SANDSTONE IN PARTS OF PENNSYLVANIA, MARYLAND, WEST VIRGINIA, AND VIRGINIA

By Charles B. Read

ABSTRACT

This report embodies the results of several years' investigations of the floras of the Pocono formation and Price sandstone. These formations contain floras of Mississippian age. The area in which they have been studied extends from the Lehigh River, northeastern Pennsylvania, to Pulaski County, southwestern Virginia. For the most part, work has been restricted to the landward facies of the formations, that is to say, the eastern and southeastern belts of outcrop. In addition, there are brief discussions of the higher Mississippian floras in the Mauch Chunk shale and correlative formations, and several species are described.

The Pocono from Lehigh to Susquehanna Rivers, Pennsylvania, is shown to range from approximately 1,100 to 1,600 feet in thickness, coarse clastics comprising the greater part of the unit. In the upper part there are numerous coaly partings by which an upper coal-bearing zone can be recognized. This zone is characterized by an abundance of species of *Triphyllopteris*. Another floral zone near the base of the section is characterized by species of *Adiantites*.

On the east side of Broad Top syncline, Pennsylvania, the formation appears similar to the sequence in the anthracite region and is 1,200 to 1,400 feet thick. Westward the formation becomes marine, and coal beds are no longer present. In Meadow Branch syncline, Maryland and West Virginia, the Pocono is 1,000 to 1,200 feet thick and includes only the Rockwell formation, Purslane sandstone, and Hedges shale of Stose and Swartz. The Myers shale and Pinkerton sandstone are believed to be equivalent to the Mauch Chunk shale and basal Pennsylvanian. The Hedges shale is shown to be the zone of *Triphyllopteris*. Along the Allegheny Front in the vicinity of Altoona, Pa., the Pocono carries only the *Adiantites* flora. The occurrence of strata that contain the *Triphyllopteris* flora has not been established.

In the Valley coal field of Virginia, valuable coal beds occur in the upper part of the Price sandstone, which is the equivalent of the Pocono in that region. These coal beds are in the upper part of the formation and are associated with the *Triphyllopteris* flora. Succeeding the Price sandstone are redbeds known as the Maccrady shale. This unit carries numerous coaly horizons, as indicated by coal streaks and beds of underclay or soil zones. The Maccrady is believed to interfinger with the Price to some extent, although the evidence is not conclusive.

It is apparent that the flora of the Upper Devonian Catskill formation characterized by *Archaeopteris* spp. is distinct from the floras of the lower Mississippian Pocono formation and Price sandstone. The meager available evidence suggests that the post-Pocono Mississippian floras may be equally distinct from those of the Pocono and Price.

New species or new combinations described and known species redescribed are as follows:

Lower part of Pocono and Price—zone of *Adiantites:*
Rhacopteris latifolia (Arnold), n. comb.; *Adiantites spectabilis*, n. sp.; *A. ungeri*, n. sp.; *A. cyclopteroides*, n. sp.; *A. cardiopteroides*, n. sp.; *Rhodea tionestana*, n. sp.; *R. alleghanensis*, n. sp.; *Alcicornopteris anthracitica*, n. sp.; *A. altoonensis*, n. sp.; *Lagenospermum* sp.; *Calathiops pottsvillensis*, n. sp.; *Girtya pennsylvanica*, n. sp.

Upper part of Pocono and Price—zone of *Triphyllopteris:*
Cardiopteris antecedens, n. sp.; *C. irregularis*, n. sp.; *Rhodea blacksburgensis*, n. sp.; *R. vespertina*, n. sp.; *R.* sp.; *Triphyllopteris alleghanensis* (Meek), n. comb.; *T. latilobata*, n. sp.; *T. lescuriana* (Meek) Lesquereux; *T. virginiana* (Meek), n. comb.; *T. rarinervis*, n. sp.; *T. biloba*, n. sp.; *Lagenospermum impariramеum* Arnold; *Lepidodendropsis scobiniformis* (Meek), n. comb.; *L. sigillarioides* Jongmans, Gothan, and Darrah; *L. vandergrachti* Jongmans, Gothan, and Darrah.

Mauch Chunk shale: *Sphenopteridium virginianum*, n. sp.; *S. brooksi*, n. sp.; *S. girtyi*, n. sp.; *Cardiopteris abbensis*, n. sp.; *Adiantites beechensis*, n. sp.; *Carpolithes virginianus*, n. sp.

INTRODUCTION

For short intervals during the period 1936–39, the writer had the opportunity to study in the field certain areas of outcrop of the Pocono formation and Price sandstone and to examine carefully both in field and laboratory the contained floras. Sections were studied and collections of plants made along the southern margin of outcrop of the Pocono from Mauch Chunk, Pa., to the Susquehanna River above Harrisburg, Pa.; in and around the Broad Top coal field, chiefly in Bedford County, Pa.; along the Allegheny Front from about Philipsburg, Pa., south into Maryland and West Virginia; at a few points where interesting collections required a field review of stratigraphic data in the plateau region of northwestern Pennsylvania; in Sleepy Creek Mountain, W. Va.; around Cheat Mountain in Randolph County, W. Va.; in the Pocono outlier near Rawley Springs, Va.; from the Price sandstone in the region around Lewisburg, W. Va., and White Sulphur Springs, W. Va.; and farther south in the Ridge and Valley province of the Appalachian Mountains into Pulaski County, Va. The writer's chief interest was in the fossil floras and their positions in the sections, affording an opportunity for application of the plants to problems of stratigraphic geology. Concentration was on the more landward phases of the sequences, and little attempt was made to examine regions where the section is marine.

During the course of field investigations of the Pocono and Price, the overlying Mauch Chunk shale, which is also of Mississippian age, was generally examined. Fossil plants that have been collected from several localities in this sequence of red beds were studied in the laboratory, and the results are incorporated in this report.

It is hoped that the recorded results of this work will provide a convenient starting point for future investigations of the floras of the Mississippian series. If this is the case the purpose of this account will be achieved. In any event, it should be understood that the following pages are a statement of progress and not a monograph of the Mississippian floras of the Appalachian region.

This paper is divided into two parts. The first summarizes the stratigraphic data and the writer's opinions regarding the floral zones of the formations. The second presents the descriptions and other facts pertinent to the floras from the viewpoint of the paleobotanist.

The writer wishes to acknowledge his indebtedness for help in the field to Mr. C. W. Unger, of Pottsville, Pa.; Mr. Bradford Willard, at the time attached to the Pennsylvania Geological Survey; Mr. D. B. Reger, of Morgantown, W. Va.; Mr. W. C. Holden, of Virginia Polytechnic Institute; and Mr. H. A. Swenson of the Geological Survey, U. S. Department of the Interior. All have supplied collections or information relative to collections or sections.

HISTORY OF PALEOBOTANICAL INVESTIGATIONS

When one considers the span of years during which there has been general knowledge of the presence of fossil plant material in the Pocono formation and Price sandstone and also the accessibility of many of the critical areas of outcrop, it is remarkable that so little has been done with these organic remains. The fact is that no serious attempt has ever been made to thoroughly study these floras and to determine the value of the assemblages for stratigraphic work.

As is indicated in another section of this report, the Pocono formation was first called the Vespertine series by the first Pennsylvania Survey (Rogers, 1844, p. 143–158), and in "The geology of Pennsylvania" (Rogers, 1858, p. 108, 141–146) there is found mention, for the first time, of the occurrence of fossil plants in this unit. Lesquereux (1858) figured and briefly described from the Vespertine the species *Noeggerathia bockschiana* [*Adiantites ungeri*, n. sp.] and *Lepidodendron* sp. [*Lepidodendropsis sp.*] The rather common occurrence of the former species was reported.

In 1880 a rather important, though brief, contribution by Meek was published posthumously. While visiting at White Sulphur Springs, W. Va., Meek became interested in the succession of strata in the vicinity, and visited the Devonian and Mississippian exposures in the cuts of the Chesapeake and Ohio Railroad at Lewis Tunnel. His paper (Meek, 1880, p. i–xix, pls. 1, 2) gives a general description of the rock sequence and describes a number of species of fossil plants from the upper part of the Price sandstone: *Lepidodendron scobiniforme* Meek, *Stigmaria?*, *Carpolithes?*, *Cyclopteris?* (*Archaeopteris*) *lescuriana* Meek, *Cyclopteris virginiana* Meek, and *Cyclopteris* (*Archaeopteris*) *alleghanensis*. The lycopod, as *Lepidodendropsis scobiniformis*, and the ferns, as *Triphyllopteris* spp., are now recognized to be marker fossils for the upper parts of the Price and Pocono.

In 1884, Lesquereux (1884, p. 850, 851) added considerably to the knowledge of Mississippian floras. He indicated the presence of *Triphyllopteris* in the flora, *T. lescuriana* (Meek) Lesquereux, although he failed to recognize the generic identity of Meek's other two species of ferns. He recorded the presence of a number of species of *Archaeopteris*, a matter which will be discussed below. Likewise, he listed a number of high-ranging (Pennsylvanian) types from the Price sandstone. The complete record of Pocono occurrences, as given in Lesquereux's summary of distribution, is as follows:

Pennsylvania:
- Mauch Chunk—*Archaeopteris bockschiana, A. obtusa, A. minor*
- Pottsville—*Archaeopteris bockschiana, A. obliqua*
- Sideling Hill, Huntingdon County—*Knorria acicularis, Lepidodendron* sp., *Rhachiopteris* fragments, *Sphenopteris flaccida, Stigmaria minuta, Stigmariocanna?, Ulodendron* sp.

West Virginia:
- New River—*Alethopteris helenae, Archaeopteris halliana, Megalopteris dawsoni, Pseudopecopteris obtusiloba, Sphenophyllum antiquum.*

Virginia:
- Lewis Tunnel—*Archaeopteris alleghanensis, A. rogersi, A. bockschiana, Lepidodendron corrugatum, Pseudopecopteris virginiana, Triphyllopteris lescuriana.*

In Lesquereux's records of plants from Mauch Chunk, Pa., Pottsville, Pa., and Lewis Tunnel, Va., species of

Archaeopteris are important elements. These occurrences, which are at variance with records given in this report, fall into two categories.

In the first category are the forms such as *Archaeopteris bockschiana* [*Adiantites ungeri*] and *Archaeopteris alleghanensis* [*Triphyllopteris*] that have been more recently assigned to other genera and which definitely are not referable to *Archaeopteris*. In the second are the species *Archaeopteris obliqua*, *A. minor*, and *A. rogersi*, which are correctly assigned to the genus. Some of these records are due to confusion in collecting. Thus, *A. obliqua* is recorded from the "Red shale of the Vespertine below Pottsville," *A. obtusa* from "Vespertine red shale below Mauch Chunk," and *A. minor* from red shale below Mauch Chunk. These are clearly from the Catskill rather than the Pocono. It will be recalled that the Vespertine as originally defined included strata between the Seral [Pottsville] and the Ponent [Catskill]. It is possible that at places red Ponent [Catskill] may have been wrongly interpreted by local collectors as Vespertine, or the basal boundary of the Vespertine may have been drawn lower than the base of the Pocono is now drawn. At any rate, collections of more recent date have not revealed these species in the Pocono. The record of *A. rogersi* at Lewis Tunnel is probably a misidentification of a species of *Triphyllopteris*. The plants listed from "New River" evidently came from Pottsville (lower Pennsylvanian) horizons, probably in the Sewell formation, which were incorrectly correlated with the Pocono.

David White (1913, p. 429), in cataloging the fossil flora of West Virginia, recorded the presence at Lewis Tunnel, Va., of *Archaeopteris alleghanensis* (Meek) Fontaine and I. C. White, *Archaeopteris bockschiana* Lesquereux, *Triphyllopteris lescuriana* (Meek) Lesquereux, *Triphyllopteris virginiana* (Meek) Read, *Lepidodendron scobiniforme* Meek, and *Lepidocystis siliqua* (Dawson) D. White. No mention of the occurrences or further data regarding the plants is given.

A number of short papers bearing on Pocono floras appeared in 1933 and 1934. Arnold (1933a, p. 114–117) recorded a lycopodiaceous strobilus from strata said to be Pocono in age in a quarry near Port Allegany, Pa. A little later that same year Arnold (1933b, p. 51–56) described from the Oswayo sandstone in the same quarry *Archaeopteris* cf. *A. roemeriana* Goeppert, *Rhacopteris?* sp., and *Trochophyllum breviinternodum* Arnold. He suggested that the presence of *Archaeopteris* and *Rhacopteris* in the same flora indicated an overlap in ranges such as one might expect in strata at the boundary between the Devonian and Mississippian. Apparently he favored the interpretation of the plant-bearing strata as Devonian. The writer has not examined Arnold's material and hesitates to offer an opinion based on the few photographs seen. It may be, however, that the *Archeopteris* cf. *A. roemeriana* is a *Rhacopteris*, or that the *Rhacopteris?* sp. is an *Archeopteris*. The preservation of the specimens is apparently rather poor.

David White (1934a, p. 34), at the meetings of the Geological Society of America in 1933, presented a paper entitled "Pocono orogeny, age, and climate" in which he stated his impressions regarding the problems of the formation. Likewise, he gave a brief analysis of the flora. He did not recognize, however, the two distinct assemblages present in the formation. Later, White published a criticism of Chadwick's conclusions regarding the age of the Pocono. It will be borne in mind that Chadwick, on the basis of stratigraphic work, had suggested that the Pocono and Mauch Chunk of eastern Pennsylvania might be Devonian in age and in fact had more or less challenged the Mississippian age of these units. White stated his opinion regarding the location of the type section, which he seems to have thought of as in the gap of Lehigh River at Mauch Chunk, Pa., on the flank of the Pocono Mountains. He made the very important point that nomenclatorial shuffling, which might result from the recognition that no Mississippian strata are present in the Pocono Mountains, has no bearing necessarily on the Mississippian age of strata of so-called Pocono elsewhere. Again, he discussed the general floral features of the Pocono and outlined the general features of the *Triphyllopteris* flora. He seems to have thought of *Adiantites* (*Aneimites*) as an upper Pocono rather than lower Pocono type and, in consequence, failed to realize the distinctness of the lower Pocono flora.

Jongmans and Gothan (1934, p. 17–44) published an account of the collections made from 13 localities in the Pocono and Price and indicated correlation with certain European strata. In that report they listed a number of forms as new and stated their intention of describing the plants.

In 1935, there was held at Heerlen, Netherlands, an important scientific meeting, the Second Congress for the Advancement of Studies of Carboniferous Stratigraphy. Arnold, Jongmans, Darrah, and Gothan presented papers which had a bearing either directly or indirectly on the Pocono floras. The final papers were published in 1937.

Arnold (1937, p. 47–62) gave a general account of the Mississippian floras in the light of recent work. His opinion regarding the Pocono is stated as follows:

> That there are no rocks of Mississippian age between the uppermost Upper Devonian and the Pottsville along the northern Appalachian region in localities where the "Pocono" was sup-

posed to occupy a prominent place now seems well established. On the other hand a distinct Mississippian flora is present in the Pocono at Pottsville, Pennsylvania, as well as in other places farther south. The exact relation between the Mississippian "Pocono" and Devonian "Pocono" and the extent of each horizon, it seems is not clear.

A good share of Arnold's comments on the features of the Pocono floras and the ranges of the plants is extracted from some of White's earlier work.

Jongmans (1937, p. 377, 378) gave a general account of his American work and discussed the features of the Pocono and Price floras as indicated by his collections. He held that the plant evidence supported the Carboniferous age of the formations and assigned a Viséan age to them.

Jongmans, Gothan, Walther, and Darrah (1937, p. 423–444), largely on the basis of Jongman's collections, presented a taxonomic paper on the Pocono flora. They listed and described from 13 localities in Pennsylvania and Virginia (Anthracite region and Valley coal field region) 19 specifically identified forms and several types which could be carried no farther than the genus. The specifically identified are *Sphenopteridium rhomboidale*, *Sphenopteris* (*Diplothmema?*) *remota*, *Rhodea* cf. *R. tenuis*, *R. tenuis*, *R.* cf. *R. geikei*, *Cardiopteridium holdeni*, *Neurocardiopteris antiqua*, *Triphyllopteris minor*, *T. compacta*, *T.* cf. *T. lescuriana*, *T.* cf. *T. collombiana*, *T. adiantiformis*, *T.* cf. *T. minor*, *Lepidodendropsis vandergrachti*, *L. hirmeri*, *L. cyclostigmatoides*, *L. sigillariodes*, *Cyclostigma* (*Pinakodendron?*) *ungeri*, *Lepidophyllum fimbriatum*.

Some of their descriptions and accompanying figures are good, but for the most part the writer, at least, has difficulty identifying his material from their work. The illustrations are in many cases too poor to give any idea of the fossil studied. In some cases this is, of course, due to the poor quality of the material. Little attempt is made to identify Meek's, Dawson's, or Lesquereux's species, other than *Triphyllopteris lescuriana*. Their conclusions regarding age were those previously expressed by Jongmans.

In the present work the writer has adopted a few of the names proposed. For the most part he has not recognized them. This is not through lack of knowledge of the existence of these named species but rather is for the above stated reasons.

C. A. Arnold (1939, p. 297–303, figs. 1–10) described, from the upper Pocono section at Fishing Creek Gap near Pine Grove, Pa., the species *Lagenospermum imparirameum*. In that account he suggested that the form might be of some stratigraphic value.

HISTORY OF STRATIGRAPHIC NOMENCLATURE OF THE POCONO FORMATION AND THE PRICE SANDSTONE

The term "Vespertine" was proposed by H. D. Rogers (1844, p. 156) for a stratigraphic unit comprising "the interesting formations above the horizon of the Ponent conglomerate, and that at the base of the great conglomerate under the coal measures. In Pennsylvania it is * * * the thick red shale deposit of the coal regions." In the same address it is stated that "The Ponent series includes all the rocks between the base of the Catskill red sandstone and the top of the overlying conglomerate. (Formation X, of the Pennsylvania and Virginia Annual Reports)."

Fourteen years later there appeared Rogers' (1858, p. 141–146) "Geology of Pennsylvania" in which these units were discussed at length. It is interesting to note that the Vespertine is defined as largely coarse-grained gray sandstone, conglomerate, and some coaly shale that carry plants. A new term, "Umbral series," is introduced for the red shale unit overlying the Vespertine and underlying the Seral. The Ponent is described as underlying the Vespertine and consists of red sandstone and shale with gray to olive beds in the upper part and at the top a red sandstone containing quartz pebbles.

A consideration of these early statements defining the map units of the Rogers surveys makes it apparent that Vespertine was orginally defined in 1844 as a red shale and later in 1858 as a hard, gray sandstone unit. Umbral was introduced to take the position in the column originally reserved for Vespertine, and the gray sandstone beds (apparently a part of Rogers' original Ponent conglomerate) were removed from the Ponent and placed in the Vespertine.

In 1876 Pocono was used as a substitute for Vespertine on a map of Bradford and Tioga Counties, Pa., prepared by Sherwood. In 1877 Ashburner and Platt more fully defined the unit. Ashley and Willard (1935, p. 615–617) have recently gone into this matter of the original definition of Pocono, and the writer has referred freely to their account in this connection. Ashburner (1877, p. 522–525) refers to the "Pocono (Vespertine) gray sandstone." Platt (1877, p. 23–30) indicates the same usage, namely substitution of Pocono for Vespertine. Ashburner's published section, unfortunately, was the one at Sideling Hill tunnel, the details of which apparently need revision. Platt, though conveying the same idea of substitution of Pocono for Vespertine, uses it primarily in a discussion of Allegheny Plateau sections. He does, however, state that it attains its maximum development in the Pocono Mountains.

According to Ashley and Willard (1935, p. 615–617), "It appears that Lesley, perhaps at a staff conference, certainly not later than 1876, proposed the term Pocono to replace Vespertine and intended it to be applied throughout the state wherever Vespertine had been used, whatever his type locality may have been." The usage of the term "Pocono" for the predominately gray sandstone unit between the Catskill formation and Mauch Chunk shale has been generally followed since then.

In the Summary Report (Lesley, 1895, p. 1629–1789) of the Second Pennsylvania Survey there is an excellent discussion of the features of the Pocono in Pennsylvania. It is perhaps noteworthy that the first detailed sections given are those along Lehigh River in the vicinity of Mauch Chunk. One is tempted to assume from this report that Lesley may have regarded the type section of the Pocono as being situated in that general area.

This final report of the Second Pennsylvania Survey included a general discussion of the features of the Pocono and reported the occurrence of minable coal in southwest Virginia. Numerous sections are given along Lehigh River; in Perry County; in Huntington County, including several around the Broadtop syncline and in Sideling Hill; in Blair County, Tipton Run coals, which have been shown to be Pennsylvanian; in the Allegheny Plateau; and in northern Pennsylvania. These data in northern Pennsylvania do not enter into the present discussion because they are outside the area of the report. It it interesting to note that at this early date the presence of a marine member (Riddlesburg shale member) in the Pocono on the west flank of the Broad Top basin had been noted (Lesley, 1895, p. 1659–1663).

In the meantime, the lower Carboniferous No. X of Virginia had been studied by several geologists. In W. B. Rogers' (1836, p. 183) reconnaissance of the Virginia area in 1835 he reports the general features of formation "No. 10" and mentions the occurrence of coal in Montgomery, Augusta, Botetourt, Rockingham, Berkeley, Frederick, and Shenandoah Counties. A number of other geologists, including J. P. Lesley (1862, p. 30–38), J. J. Stevenson (1887, p. 61–108), and McCreath and d'Invilliers (1887, p. 1–171), also reported the occurrence of coal in the Valley region of southwest Virginia.

The most important of these early reports on the No. X (Vespertine, Pocono) coals of Virginia was published by W. M. Fontaine (1877, p. 37–48). Fontaine outlined the areas of occurrence of Vespertine, indicating two belts of outcrop:

1. On the east flank of Alleghany Mountain, near White Sulphur Springs. * * * This belt extends an unknown distance north of the railroad, probably to the northern part of Bath County. To the south, it terminates near the northeastern border of Monroe County.

2. A much more extended and important belt, which lies about 30 miles east of the last. This commences in * * * Berkeley County and extends thence south through the State with some minor interruptions.

Fontaine (1877, p. 115–123) gave a detailed section measured near Greenbrier River at Lewis Tunnel in which he recognized the units seen in more recent work and discussed the correlation of the redbeds (Maccrady) above the Vespertine. He stated that the Vespertine here is divisible into three members: 1, a lower flagstone, sandstone, and conglomerate member some 560 feet thick; 2, a middle gray, coal-bearing sandstone member some 350 feet thick; and 3, an upper redbed member about 250 feet thick. He indicated the presence below the Vespertine of a thin Catskill sequence. The coal-bearing Vespertine in Augusta and Rockingham Counties was discussed, and a general section was given that shows some 400 feet of sandstone constituting the lower member and resting on Catskill, above which are 40 feet of gray flagstone succeeded by a shaly and coaly interval and capped by an undetermined thickness of shales and sandstones. The important Montgomery County, Va., area was likewise discussed. Along Poverty Creek a section was measured in which the following units were recognized: 1, Sandstone and flagstone, 930 feet; 2, sandstone, flagstone, and coal, 670 feet; 3, red shale, about 1,000 feet.

Campbell (1894, p. 171–190) named the No. X, or Vespertine, of earlier work in southwestern Virginia the Price sandstone and indicated his opinion regarding its correlation by placing "(Pocono)" after the name Price. He pointed out the rapid change in facies of the formation as it passes to the north and west in this region from a coal-bearing unit to one in which coals are rare and thin or absent. He also named the overlying red shale the "Pulaski," from exposures near the town of that name. He expressed the opinion that the relations between the Price and early Paleozoic limestone are due to overlap, though they are now known to be due to extensive thrust faulting. Campbell (1896, p. 3) again described these units in the Pocahontas quadrangle.

At the time Campbell was working in Montgomery County, Darton was mapping the Staunton, Virginia-West Virginia quadrangle. In 1894 the Staunton folio was published (Darton, 1894, p. 2, 3), and in it was described most of the coal-bearing lower Carboniferous area of Rockingham and Augusta Counties. Two units, a lower division of 300 feet of white to buff quartzite followed by an upper member of 450 feet of sandstones, shales, and coals, were recognized.

J. J. Stevenson (1903, p. 16–45), in the first part of his memoir on the Carboniferous of the Appalachian basin, assembled the available information regarding the Pocono and Price in the region under discussion and considered the problem of their correlation with Mississippian units in other areas. In summarizing the general relationships of the Pocono, Stevenson came to the following conclusions:

1. The Pocono, when traced southwestward from Pennsylvania (Broad Top region), retains its general features into Virginia, although the upper portion becomes shalier and more notably coal-bearing. In extreme southwestern Virginia, some 60 to 70 miles from the Tennessee line, it becomes notably calcareous, the upper part becoming much like the overlying Mississippian limestone, while the lower passes into the Grainger shale.

2. When traced westward in the northern area (Pennsylvania), the formation thins, owing partly to disappearance of the lower beds. Notable changes in lithology are likewise apparent.

3. The Pocono, which in the past was regarded as entirely lower Carboniferous, probably in some areas contains units of Devonian age (northwestern Pennsylvania and Ohio particularly).

4. The coal-bearing shale and sandstone of Pennsylvania (upper 400 feet in Bedford and Huntingdon Counties) and of Virginia are probably equivalent to the Keokuk and Burlington limestones and the Kinderhook group of the Mississippi Valley. The rest of the Pocono of these areas is Devonian. The term "Logan" (an Ohio name) is suggested for the upper part of the Pocono.

Charles Butts (1905, p. 3, 4) published his survey of the Edensburg, Pa., quadrangle and gave a rather detailed section of the Pocono formation as it is exposed on the Allegheny Front west of Altoona on the right-of-way of the Pennsylvania Railroad (Horseshoe Curve). He named the prominent sandy unit at the top of the section the Burgoon sandstone member and correlated the red shale band directly below with the Patton shale member of adjacent areas. Butts pointed out the occurrence of fossil plants low in the section, which he assigned, on the authority of David White, to the Mississippian. He pointed out the difficulty of precisely fixing the base of the Pocono and drew the line on purely lithologic evidence. As regards the top of the formation, the Loyalhana limestone was given as the uppermost member. The thickness of the Pocono was given as 1,030 feet.

Stose and Swartz (1912, p. 1–25) made a notable contribution to the stratigraphy of the Pocono in the Paw-paw-Hancock folio, which they published in 1912. They divided the Pocono into five units, which are, from top to bottom, as follows:

Pinkerton sandstone
Myers shale
Hedges shale (coal-bearing)
Purslane sandstone
Rockwell formation

The total thickness of the units is 1,800–2,000 feet. Determination of the upper limit was based on evidence of a few plant fragments.

In the same year, Willis' (1912, p. 417–420) "Index to the stratigraphy of North America" appeared and carried a brief account of the Pocono and Price. Most of the statements related to the stratigraphy of the sequence in the Meadow Branch syncline.

Grimsley (1915, p. 136–166) in a survey of Jefferson, Berkeley, and Morgan Counties, W. Va., gave a detailed account of the stratigraphy and structure of the Meadow Branch or Sleepy Creek Mountain coal field. The stratigraphic divisions of Stose and Swartz were used, but much detailed information not published in the Paw-paw-Hancock folio was included.

M. R. Campbell (1925, p. 1–322) and his associates published an important account of the Valley coal fields of Virginia. In this report there are discussions of the geology of coal-bearing areas in the Price sandstone in Montgomery, Pulaski, Wythe, Bland, Smyth, Roanoke, Botetourt, Augusta, and Rockingham Counties, Va. A general account of the features of the Price in the Valley area is again based primarily on surveys in Montgomery County. At the base there is said to be at many localities a conspicuous conglomerate named the Ingles member. Above are 1,000 feet or more of sandstone and shale, followed by a coal-bearing unit and capped by 700 feet of sandstone and shale that grade into the Maccrady shale, a red shale above the Price (Stose, 1913, p. 232–255). The coal beds are shown to be several, although only two thick ones, the Merrimac and the Langhorne, are commonly mined.

In 1926, D. B. Reger (and others, 1926, p. 503–532) gave a general section and proposed a classification of the Pocono strata in Mercer, Monroe, and Summers Counties, W. Va., as follows:

	Feet
Sandstone, Logan (Burgoon) (Big Injun sand)	0–250
Shales	0–50
Sandstone (Squaw oil sand)	0–50
Shales	0–50
Coal, Merrimac	0–5
Shale	0–9
Sandstone, Lindside	0–40
Coal, Langhorne	0–1
Sandstone, Broad Ford (Weir oil sand) and associated marine beds	50–250
Shales	25–95
Shale, Sunbury (Coffee)	25–50
Sandstone, Berea	25–150

It is apparent that Reger followed the practice of the West Virginia Survey in breaking down formations into numerous small named units, presumably to facilitate mapping. It was felt that the tracing into the area under consideration of units from other regions was adequate to permit adoption of Ohio names. This general plan of classification has been followed by other West Virginia Survey reports of more recent date (Price, 1929, p. 189–200; Reger, 1931, p. 341–351).

Chadwick (1933, p. 91–107) brought up the possibility that the Pocono of certain areas in Pennsylvania might be Devonian rather than Mississippian. Concerning the so-called Pocono deposits in the Pocono plateau and in certain portions of the Allegheny Plateau, Chadwick expressed his opinion that they are contemporaneous with Catskill, Chemung, Portage, and Genesee "facies" of other areas. Furthermore, the opinion was stated that little, if any, Mississippian is present in the Pocono plateau. In consequence, the conclusion seems to have been reached that all of the eastern Pennsylvania Pocono strata were simply facies of Devonian beds of other areas. The Mauch Chunk shale was likewise suspected of being Devonian.

A number of geologists soon challenged Chadwick's conclusions. David White (1934b, p. 265–272) published a criticism of the idea and pointed out that the proving of the Devonian age of certain strata supposed to be type Pocono in the Pocono Mountains did not necessarily mean that certain other strata, particularly along the south side of the Anthracite region, were also Devonian and not Mississippian. In discussing this matter White went into some detail regarding paleontologic evidence that there is a Mississippian unit in the area under consideration. White pointed out the presence of a *Triphyllopteris* flora in the Pocono and suggested that *Adiantites* [*Aneimites*] was a Mauch Chunk form. Likewise, he cited the relationships between the Mauch Chunk and the Loyalhanna limestone as proof of the Mississippian age of the former.

In reply Chadwick (1935, p. 133–143) stated his belief that I. C. White was correct in his opinion that there was no Carboniferous in Pocono Knob or in the whole Pocono plateau, except in a few small outliers. He did, however, admit the occurrence of Carboniferous in the adjacent Moosic Mountains and suggested the term "Moosic" be used for these deposits. In the absence of specific evidence regarding the floras of the southern outcrops in the Anthracite region, Chadwick expressed skepticism regarding White's unqualified conclusion that they were Mississippian.

Ashley and Willard (1935, p. 615–617) likewise discussed Chadwick's views on the Pocono. Their view is that "Lesley's original thought * * * was to apply the name to sandstone between the 'Catskill' and Mauch Chunk * * *." They point out that the original use of the term "Pocono" by Sherwood was on a map of a region remote from the Pocono plateau. The concept of a type section in the case of the Pocono formation apparently cannot be used, but they urged that Pocono be continued as a name for the early Carboniferous formation it has come to designate in the literature.

Willard (1936, p. 565–607) published a long article on the continental Upper Devonian deposits of eastern Pennsylvania and went into some detail regarding the Pocono problem. He expressed the view that Lesley's type Pocono was in the Moosic Mountains, "an ill-defined, elevated area along the western portion of the Pocono Plateau." Apparently there can be little doubt regarding the Carboniferous age of the so-called Pocono in that area. Willard favored the view that "for the present, the Pocono should continue to be interpreted essentially as Lesley defined it and as observations indicate." Willard likewise concluded that there is a hiatus between the Pocono and the underlying Devonian over much of Pennsylvania. Furthermore, it is his view that the base of this unit is essentially synchronous over most of the area.

Willard and Cleaves (1938, p. 17, 18) published a composite section for south-central Pennsylvania. They recognized 1,600 feet of Pocono along the Susquehanna River above Harrisburg and proposed three member names: Second Mountain member, for massive gray sandstone and conglomerate resting on Catskill; Peters Mountain member, for platy gray sandstone and conglomerate; and Cove Mountain, for gray sandstone, conglomerate, and several coaly beds.

FLORAL DIFFERENTIATION IN THE POCONO FORMATION AND THE PRICE SANDSTONE

CATSKILL FORMATION

Underlying the Pocono in the sections studied in Pennsylvania, Maryland, and parts of West Virginia is the Catskill formation. The Catskill at many of the localities where the Pocono was examined is also plant bearing, but the remains are usually very fragmentary. At Tamaqua, Pa., *Archaeopteris* spp. was collected about 500 feet below the base of the Pocono. Fragments perhaps attributable to that genus were seen in Pottsville Gap and in Westwood Gap, Pa. In sections along the Allegheny Front in the vicinity of Altoona and Bellwood, Pa., *Archaeopteris* sp. was obtained within a few feet of the top of the Catskill, and in a similar position in the Broad Top coal field. In fact, in this latter region Reger has named the Saxton shale, which is some 330 feet below the base of the Pocono, and which is replete with plant fragments assigned to *Archaeopteris* sp. This unit is recognizable at least as far south as Randolph County, W. Va., where it carries numerous specimens of *Archaeopteris* and lies about 150 feet below the base of the Pocono.

LOWER POCONO FORMATION AND PRICE SANDSTONE

In the lower part of the Pocono, fossil plant material is rarely abundant or well preserved. At a number of localities, however, small collections have been obtained which indicate the existence of a distinct flora.

In the Southern Anthracite field the position of this flora is shown in the following section measured in Westwood Gap near Pottsville, Pa.:

Section of the lower part of the Pocono and part of upper Catskill in Westwood Gap, Pottsville, Pa.

	Feet
Pocono formation:	
1. Sandstone, gray, hard, with lenses of conglomerate, massive to medium-bedded	310
2. Sandstone, silty, and siltstone, olive; irregularly bedded; a few thin beds of conglomerate present	60
3. Sandstone, olive, medium-grained, massive	100
4. Siltstone, dark-gray, carbonaceous, irregularly bedded, carrying abundant plant remains	2±
5. Sandstone, gray to olive, medium-grained and medium-bedded	32
6. Shale, dark-gray, silty, carrying abundant roots in lower part and a few quartz pebbles	1
7. Sandstone, gray, massive, very conglomeratic	15
8. Conglomerate, massive, hard, containing pebbles up to 1½ inches in diameter, chiefly quartz	5
9. Sandstone, silty, olive, massive	12
10. Sandstone, olive to gray, medium-grained, massive	30
11. Sandstone and siltstone, interbedded, olive, some conglomerate lenses present. This unit is badly contorted so that there may be some repetition of beds. The thickness here given is therefore approximate	240
Total	807
Catskill formation:	
12. Siltstone, red, massive	12
13. Sandstone, olive, medium-bedded, conglomeratic	55
14. Red shale and sandstone not measured	----

In unit 4 of the preceding section, a florule was obtained in which the following species were identified:

Adiantites ungeri Read (abundant)
Alcicornopteris anthracitica Read

In Pottsville Gap at the same horizon additional plant material has been collected by C. W. Unger, of Pottsville, Pa., and the writer. Unger's collections, which were examined in the Reading Public Museum, contained the following species:

Adiantites ungeri Read (abundant)
Alcicornopteris anthracitica Read
Calathiops pottsvillensis Read

In the section below Millersburg, Pa., on the Susquehanna River, coal is present in the lower Pocono at the position of the *Adiantites* zone. Unfortunately, the plant material associated with it is very poorly preserved. However, numerous petiole fragments and a few pinnules attributable to *Adiantites* sp. were noted.

In the section of the Pocono exposed in Bell Gap west of Bellwood and along the abandoned branch line of the Pennsylvania Railroad, *Adiantites* and associated forms make their appearance almost immediately above the Catskill redbeds.

Section of the Pocono in Bell Gap west of Bellwood, Pa.

	Feet
Pocono formation:	
1. Sandstone, olive, fine-grained, massive	80
2. Covered, probably soft beds	22
3. Sandstone, olive, fine-grained, massive	8
4. Shale, gray, irregularly bedded, carrying occasional specimens of *Lingula* sp	6
5. Sandstone, medium-gray, massive, calcareous, carrying abundant specimens of marine invertebrates	3
6. Shale, gray, massive	2
7. Underclay, rather carbonaceous, dark-gray, massive	2
8. Shale and siltstone, gray to olive, carbonaceous partings occasional, carrying abundant plant fossils	14
9. Sandstone, gray, massive, root-bearing	2
10. Siltstone, olive, massive	1
11. Sandstone, olive, fine-grained, root-bearing	3
12. Shale, olive, irregularly bedded	1
13. Sandstone, olive, fine-grained, massive	2
Total	146
Catskill formation:	
14. Shale, red to olive, and sandstone, red to olive, thickness not measured	-----

From unit 8 in the above section a florule containing the following species was collected:

Adiantites spectabilis Read (abundant)
Lagenospermum sp.
Girtya pennsylvanica Read

Somewhat higher but still definitely in the lower part of the Pocono there has been collected in the exposures along the main line of the Pennsylvania Railroad on the Horseshoe Curve above Kittanning Point a flora containing the following forms:

Rhacopteris latifolia (Arnold) Read
Adiantites spectabilis Read (Abundant)
Rhodea sp.
Alcicornopteris altoonensis Read
Lepidodendropsis sp.

At Tionesta, in Forest County, Pa., collections have been made of a small but extremely interesting flora. The locality is a small, roadside exposure of silty olive shale and olive siltstone which, at that point, cannot be definitely tied to reference planes. It is, however, clear from the contained flora that the horizon is low in the Pocono. Elsewhere in the same region remains of very poorly preserved specimens of *Adiantites spectabilis* have been found in the lower part of the Pocono and presumably mark a lateral continuation of the plant bed explored at Tionesta. The list of plants collected is as follows:

Adiantites spectabilis Read (abundant)
cyclopteroides Read (abundant)
Rhodea tionestana Read
alleghanensis Read
Girtya pennsylvanica Read

At a horizon, the position of which is not definitely established but which is known to be low in the Price sandstone in the vicinity of Lewis Tunnel, Va., a few specimens referable to *Adiantites cardiopteroides* Read have been collected. These are apparently from the same general zone as the abundant *Adiantites* spp. known from the localities just discussed.

The complete flora of the lower Pocono is as follows:

Rhacopteris latifolia (Arnold) Read
Adiantites spectabilis Read
ungeri Read
cyclopteroides Read
cardiopteroides Read
Rhodea tionestana Read
alleghanensis Read
Alcicornopteris anthracitica Read
altoonensis Read
Lagenospermum sp.
Calathiops pottsvillensis Read
Girtya pennsylvanica Read
Lepidodendropsis? sp.

UPPER POCONO FORMATION AND PRICE SANDSTONE

The upper, coal-bearing, member of the Pocono usually contains some plants, and at a number of localities they are exceedingly abundant. Because the exposures below Pottsville in the gaps of the Schuylkill River and West Branch of Schuylkill River provide the best and most continuous sections seen in the Southern Anthracite region, the relationships of the plant-bearing strata there may be taken as a typical example. The sequence is as follows:

Section of the upper part of the Pocono formation in Pottsville Gap, Pottsville, Pa.

	Feet
Mauch Chunk shale:	
Shale, siltstone, and sandstone, red	35+
Pocono formation:	
1. Sandstone, fine-grained, silty, yellowish, rather massive	10
2. Covered, probably sandstone, quarried locally	37
3. Sandstone, light-gray, coarse, gritty, with occasional quartz pebbles	12
4. Shale, green to grayish-green and olive, irregularly bedded and fracturing irregularly, carrying some plants	5
5. Shale, thin-bedded, dark-gray, carrying plants	2
6. Rootsilt, gray, massive	2
7. Siltstone, massive, gray-green	3
8. Sandstone, medium-grained, gray, flaggy	3
9. Sandstone, massive, light-gray, medium-grained, with some grit lenses	7
10. Shale, gray to olive	½
11. Sandstone, olive, silty above, becoming medium-grained near base, thin-bedded, weathering massive	9
12. Siltstone, sandy, olive, massive	6
13. Claystone, olive to gray	½
14. Siltstone, olive to gray	2
15. Shale, somewhat silty, olive	4
16. Siltstone, olive to gray	14
17. Sandstone, gray, coarse, gritty, with numerous bands and lenses of quartz pebbles	199
18. Shale, black, micaceous, thin-bedded; carries plants	5
19. Sandstone, gray, fine-grained, flaggy	38
20. Sandstone, gray, medium-grained, massive	30
21. Shale, black, bony; pyrite nodules containing fragments of secondary wood observed	1
22. Sandstone, medium-grained, gray, massive	2
23. Shale, silty, gray, fracturing conchoidally, carrying fragments of plants	1
24. Coal, anthracite, with a thin gray claystone bed at base	½
25. Sandstone, gray, medium-grained, massive	18
26. Sandstone, medium to fine-grained, gray, flaggy	23
27. Claystone, gray	1
28. Shale, silty, carbonaceous, dark gray	1
29. Sandstone, conglomeratic, gray, massive	24
30. Shale, silty, even-bedded, gray; a few plant fragments observed	6
31. Sandstone, gray, gritty and pebbly, massive	25
32. Shale, gray, badly squeezed	½
33. Sandstone, gray, tending to be conglomeratic, massive	29
34. Shale, gray to olive, with a lenticular gray sandstone up to 3 feet thick in middle of unit, thin-bedded, carrying plants	9±
35. Sandsone, gray, medium-grained, massive, not well-exposed	15
36. Sandstone and siltstone to *Adiantites* beds	410
Total	990

From this section collections have been made as follows:

Units 4 and 5:

Rhodea vespertina Read
Triphyllopteris lescuriana (Meek)
Lagenospermum imparirameum Arnold
Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah
scobiniformis (Meek)

Unit 18:

Triphyllopteris lescuriana
Cardiopteris antecedans

Unit 21:

Carried only pyritized fragments of secondary xylem which have not been further studied.

Units 23 and 30:

Fragments are doubtfully identifiable as *Triphyllopteris* sp.

Unit 34:

Rhodea vespertina Read
Triphyllopteris lescuriana (Meek)
Lepidodendropsis scobiniformis (Meek)

In exposures at Mauch Chunk, Tamaqua, and at High Bridge, northwest of Pine Grove, Pa., similar plant remains were noted or collected. At Mauch Chunk very fragmentary material was identified in the field as *Triphyllopteris lescuriana* and *Rhodea vespertina.*

In the exposures in the gap of the West Branch of Schuylkill River the following florule was collected from strata about the equivalent of unit 34 in the Pottsville Gap exposures already discussed:

Rhodea vespertina Read
Triphyllopteris lescuriana (Meek)
Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah
scobiniformis (Meek)
sigillarioides Jongmans, Gothan and Darrah

The plant-bearing strata at Fishing Creek Gap or High Bridge, northwest of Pine Grove, Pa., have yielded the following remains:

Rhodea vespertina Read
Triphyllopteris lescuriana (Meek)
latilobata Read
biloba Read
Lagenospermum imparirameum Arnold
Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah
scobiniformis (Meek)
sigillarioides Jongmans, Gothan and Darrah

In all of the exposures of the Pocono along the Susquehanna River from the vicinity of Millersburg, Pa., south to a point below Dauphin, Pa., abundant remains of *Triphyllopteris lescuriana*, *Rhodea vespertina*, and *Lepidodendropsis scobiniformis* were found.

As regards plant remains in the upper part of the Pocono in the Allegheny Plateau region and Broad Top region of western Pensylvania the information is scant. In the section measured on the Horseshoe Curve above Altoona, Pa., a few fragments of *Lepidodendropsis scobiniformis* are reported from shale partings in the Burgoon sandstone (Butts, 1905). The writer has not seen these, but their reported position is at a horizon where the species might be expected.

In the exposures examined on the west side of the Broad Top coal field no plant remains have been seen in the upper part of the Pocono. However, in the section at the Broadtop railroad tunnel described by Ashburner, there appear to have been abundant plant remains in the coal-bearing shale in the upper part of the formation ("New River Coal Series") (Ashburner, 1895, p. 1663–1679). Unfortunately, the old collection made by the Pennsylvania Survey cannot be located, and additional material is not available. It appears, however, that these specimens included fragments of some of the representatives of the *Triphyllopteris* flora.

In the Meadow Branch syncline, West Virginia and Maryland, it has already been indicated that there is a question regarding the correlation of the units assigned in the past to the Pocono formation (Stose and Swartz, 1912). The rock sequence, as previously described, is as follows:

	Feet
Pinkerton sandstone	125
Myers shale (red)	800–900
Hedges shale (coal-bearing)	200
Purslane sandstone	320
Rockwell formation	500

The coal-bearing Hedges shale contains a flora, which was reported in the Paw-paw-Hancock folio (Stose and Swartz, 1912) and which the writer has examined more recently. It is as follows:

Rhodea vespertina Read
Triphyllopteris lescuriana (Meek)
Carpolithes sp.
Lepidodendropsis scobiniformis (Meek)

This flora is clearly that of the *Triphyllopteris* zone, widespread in the upper part of the Pocono. Its position, according to past classifications of the strata, is about in the middle of the so-called Pocono group.

Above the Hedges is the red Myers shale, and above the Myers is the light-gray Pinkerton sandstone containing rounded quartz pebbles. Coaly beds at the top of the Pinkerton are reported to yield material referable to *Lepidodendron* [*Lepidodendropsis*] cf. *L. corrugatum.* If this identification were positive, there could be no reasonable doubt regarding the Pocono age of the Pinkerton sandstone. However, the writer has examined the material and does not concur with the previously expressed opinion. Rather, he feels that the material is not identifiable, except in a general way as

Lepidodendron. It therefore seems only fair to reopen the question of the age of the post-Hedges formations. Lithologic evidence favors the correlation of Myers with Mauch Chunk, and Pinkerton with basal Pennsylvanian, and the flora of the Hedges indicates an upper Pocono age for that unit.

Lewis Tunnel, Alleghany County, Va., furnished some of the earliest collections of Pocono plants. These were obtained by Meek and reported posthumously in 1880 (Meek, 1880, p. i–xix, 26–44). In 1937, the writer visited the tunnel and measured a section there.

Section at and above west portal of Lewis Tunnel (Alleghany Station), Chesapeake and Ohio Railroad, Va.

	Feet
Maccrady formation:	
1. Siltstone and clay shale, variegated (red and olive), with occasional thin beds of olive sandstone and nodular, dark-gray, fresh-water limestone	40
2. Limestone, dark-gray, nodular, cherty (fresh water)	2±
3. Shale, silty, variegated	11
4. Siltstone, calcareous, yellowish to red	1±
5. Sandstone, olive, massive, fine-grained	6
6. Shale, variegated (olive to red), silty, with occasional olive sandstone layers	17
7. Sandstone, olive, fine-grained, and olive to gray siltstone and silty shale	14
8. Shale, dark, carbonaceous and coaly	6
9. Underclay, light-gray	3
10. Shale, silty, red to gray	4
11. Shale, carbonaceous, coaly	½
12. Underclay, light-gray	1½
13. Siltstone, olive, massive	4
14. Shale, silty, variegated (red, olive, gray)	11
15. Siltstone and sandstone, gray to olive, with plant fragments, including pyritized woody fragments and a few, erect trunk stumps of *Lepidodendropsis corrugatum*	12
16. Shale, coaly and bony	1
17. Underclay and root silt, light-gray	2
18. Shale, coaly	1
19. Underclay, light-gray	1
Total	133
Price formation:	
20. Sandstone, gray, massive, medium-grained	15±
21. Sandstone and siltstone, thin-bedded, carbonaceous	1±
22. Sandstone, gray, massive, medium-grained	12
23. Sandstone, shaly, lenticular, poorly exposed	½±
24. Sandstone, massive, gray, medium-grained	45
25. Sandstone, irregularly thin-bedded, medium-grained, light-gray, somewhat carbonaceous	5
26. Sandstone, medium-grained, gray, massive	50
27. Sandstone, thin-bedded, carbonaceous, dark-gray, fine-grained, silty	5
28. Sandstone, massive, gray, medium-grained	4
29. Sandstone, thin-bedded, silty, irregularly bedded, carbonaceous, with a few specimens of *Lepidodendropsis scobiniformis*	15
Price formation—Continued	
30. Siltstone, thin-bedded, dark-gray, carbonaceous	1½
31. Sandstone, massive, root-bearing, gray	6
32. Coal, impure	½
33. Rootsilt, dark-gray	1
34. Coal, impure	½
35. Sandstone, gray, silty, irregularly bedded, medium-grained, with abundant plant fragments	18
36. Rootsilt, dark-gray	2
37. Sandstone, massive, gray, root-bearing	3
38. Coal, impure	½
39. Rootsilt, dark-gray	5
40. Sandstone, medium- to coarse-grained, gray, massive	80
41. Siltstone, thin-bedded, carbonaceous	5
42. Sandstone to top of marine Riddlesburg shale member	50
Total	325½

The flora obtained by Meek came from somewhere in the interval of units 20–35. The precise horizon cannot be determined, because the old collections came from material removed during the excavation of the tunnel. Additional specimens cannot be obtained. The revised identifications are as follows:

Rhodea blacksburgensis Read
  vespertina Read
Triphyllopteris alleghanensis (Meek)
  lescuriana (Meek)
  virginiana (Meek)
Lepidodendropsis scobiniformis (Meek)

A short distance north of Vicker, Montgomery County, Va., in Price Mountain, the coals of the Price sandstone have been mined extensively. Along the secondary road leading from Vicker to the Merrimac mine, collections in shale and siltstone above the Merrimac coal bed yielded the following florule:

Rhodea blacksburgensis Read
  vespertina Read
Triphyllopteris lescuriana (Meek)
  latilobata Read
  virginiana (Meek)
  rarinervis Read
  biloba Read
Lepidodendropsis scobiniformis (Meek)

In fine-grained sandstone and siltstone beds that underlie the Merrimac coal bed and which are probably above the Langhorne coal bed, there were collected, a few hundred yards farther down this same road, a florule that included *Triphyllopteris lescuriana* and *Lepidodendropsis vandergrachti.*

Farther south, in the section north of Dublin, abundant, although badly weathered, specimens of *Triphyllopteris* spp. and *Lepidodendropsis* spp. mark the coal-bearing zone of the Price. Collections of well-preserved material were not obtained.

Similarly in Draper Mountain near Pulaski, Va., poorly preserved specimens of *Triphyllopteris lescuriana* and *Rhodea vespertina* were noted.

FLORAS OF THE LOWER PART OF THE MAUCH CHUNK SHALE AND EQUIVALENT FORMATIONS

The nature of the present report makes it desirable to summarize the present status of knowledge concerning the post-Pocono and post-Price Mississippian floras as a basis for the separation of the lower from the upper units on the basis of their contained plants. Therefore, a portion of the systematic chapter is devoted to these higher floras, and in the following paragraphs an attempt is made to outline their general features as now known.

At the beginning, it must be emphasized that the lithology of the Mauch Chunk is not a type well suited for the preservation of plant material in an identifiable form. Similarly, its correlatives in the northern and central Appalachian regions rarely show many well-preserved plant fossils. On the other hand, the bedding planes are not infrequently covered with what probably are the oxidized remains of plants, and roots running across the bedding planes give evidence that plant life existed in moderate abundance on the Mauch Chunk delta surfaces.

In Pennsylvania along the belt of Mauch Chunk outcrop south of the Southern Anthracite coal field, root remains are very common in the Mauch Chunk. In addition, the writer has seen in the cabinets of local collectors a few isolated pinnules of *Aneimites* sp. that are not sufficiently well preserved to be described. It is at once apparent that the material does not present a sufficient number of species to provide any basis for floral characterization.

In Fork Lick district, Webster County, W. Va., along Elk River a short distance below Whitaker Falls, White and Girty collected in 1895 a very interesting florule which is described in this report. The stratigraphic position of this assemblage has been determined as near and probably below the horizon of the Big Spruce Knob coal of Reger (1920, p. 221–225). The following tabulation is a general section of the succession of Mauch Chunk along upper Elk River.

General Section of Mauch Chunk shale on upper Elk River, Webster County, W. Va., Mauch Chunk shale (in part Reger, 1920):

	Feet
1. Shale and thin sandstone, chiefly red with some olive beds, the unit predominantly soft and forming a long slope in which exposures are poor	725
2. Sandstone, olive, thin-bedded, fine-grained, probably the Big Spruce Knob sandstone member of Reger	25
3. Shale, dark-gray, carrying plant fragments	2
4. Coal, bituminous, reported very impure	---
5. Shale and thin sandstone, red to olive	300
6. Sandstone, massive, olive to gray, micaceous, the Webster Springs sandstone member of Reger	75
Total	1,127
Greenbrier limestone:	
Thickness not measured—stream level of Elk River	51

The florule is apparently from unit 5 in the section. Its composition is as follows:

Sphenopteridium virginianum Read
Rhodea? sp.
Carpolithes virginianus Read

A related florule has been obtained from outcrops apparently higher in the section, in adjacent Upshur County on Beech Fork, about half a mile southeast of Left Fork of Beech Fork at the level of the now abandoned Alexander Lumber Company Railroad grade. This florule is as follows:

Sphenopteridium brooksi Read
girtyi Read
Adiantites beechensis Read
Sphenopteris? sp.

From the lower part of the Bluefield shale, just above the Greenbrier limestone in the vicinity of Abbs Valley, Va., a collection made by White and Campbell many years ago has yielded abundant material of the species here described as *Cardiopteris abbensis*, together with numerous stems, and petioles that cannot be identified. According to invertebrates from the underlying marine limestone as well as from the Bluefield, the rocks are believed to be Chester and at least correlative in part with the Glen Dean limestone (Butts, 1933, p. 42, 43).

SUMMARY OF FLORAL SUCCESSION

In the preceding discussion an attempt has been made to present the evidence regarding the occurrences of fossil plants in the sections which have been studied. It now seems appropriate to examine the data and to arrive at conclusions, if possible, regarding the stratigraphic ranges of floras or definite assemblages of plants.

It has been indicated that the very characteristic rocks of the Pocono are set off in many of the sections by equally distinct floras. Underneath, the red shales and sandstones of the Catskill carry at numerous localities the remains of *Archaeopteris* spp. These occur high in the formation and only a short distance stratigraphically below the base of the Pocono. Thus there appears to be some basis in fact for the prevalent idea that *Archaeopteris* is characteristic of the Catskill and its equivalents. Likewise, it seems to be restricted, if one may judge from the present work, to these Devonian rocks. Not a single well-substantiated occurrence of *Archaeopteris* in the Mississippian is known to the writer.

The lower part of the Pocono appears to be rather well characterized by a flora, the most conspicuous element of which is the genus *Adiantites*. Collectively this flora is as follows:

Rhacopteris latifolia (Arnold)
Adiantites spectabilis Read
ungeri Read
cyclopteroides Read
cardiopteroides Read
Rhodea tionestana Read
alleghanensis Read
Alcicornopteris anthracitica Read
altoonensis Read
Lagenospermum sp.
Calathiops pottsvillensis Read
Girtya pennsylvanica Read
Lepidodendropsis? sp.

This flora, numbering only 13 forms, is extremely interesting because of the association with remains of *Adiantites*, a representative of the genus *Rhacopteris*, two species of *Alcicornopteris*, and some interesting fructifications and polleniferous synangia (*Girtya*, *Calathiops*, *Lagenospermum*). In the anthracite region it seems to be characteristic of the lower, flaggy, olive sandstone and shale beds that in some sections (Susquehanna River) carry thin coals. Any single locality is poor in species, and usually *Adiantites* is the most conspicuous element.

Along the Allegheny Front in Pennsylvania this flora has been seen at a number of localities where, as in the anthracite fields, remains of species of *Adiantites* are very abundant. In fact, it is in this area of outcrop that the *Adiantites* zone can be seen to best advantage.

Farther south the *Adiantites* zone can be recognized by its contained fossils only in the vicinity of Lewis Tunnel, Va. There, a few specimens of *Adiantites cardiopteroides* occur in the lower part of the Price sandstone at a horizon, the exact position of which is unknown. The absence of this floral zone in most sections in Virginia is due in all probability to the marine facies of much of the lower part of the Price sandstone.

Separated from the *Adiantites* zone by a variable but always considerable thickness of sandstone and shale is an upper coal-bearing member of the Pocono and Price. This member carries abundant material, in almost all sections, of a flora very distinct from the lower or *Adiantites* assemblage. Because of the almost invariable presence in great abundance of material referable to *Triphyllopteris* this has been called the *Triphyllopteris* zone and the plant assemblage the *Triphyllopteris* flora. It is a very conspicuous unit in the anthracite region, where evidences of its presence can be found in every section.

On the Allegheny Front the *Triphyllopteris* zone appears to be in the position of the Burgoon sandstone member of the Pocono, if one may judge from the occurrence of *Lepidodendropsis scobiniformis*. There is some question in the writer's mind regarding this, however, and it may be that the Burgoon represents sandstone beds only at the base of the *Triphyllopteris* zone. If this is true, a hiatus may exist between the Burgoon and the overlying Loyalhanna limestone, since the bulk of the upper coal-bearing member of the anthracite region is then missing. The evidence is not conclusive.

The *Triphyllopteris* zone on the east side of the Broad Top coal field is apparently the upper coal-bearing member, although this correlation is based to a considerable extent on lithology and on early reports about fossil occurrences.

In Meadow Branch syncline the coal-bearing Hedges shale is very definitely the *Triphyllopteris* zone. Available collections show the presence of the characteristic species in abundance.

At Lewis Tunnel, Va., the *Triphyllopteris* flora again is seen to be associated with coal in the upper part of the Price sandstone (Pocono equivalent). Apparently, it carries upward into the Maccrady shale, as do the coal-forming conditions.

Farther southwest in the Valley coal fields, the coal-bearing member of the Price sandstone is identical with the *Triphyllopteris* zone. Species referable to this flora are found everywhere associated with the coals.

A list of the species in the *Triphyllopteris* flora is as follows:

Cardiopteris irregularis Read
antecedens Read
Rhodea blacksburgensis Read
vespertina Read
sp.
Triphyllopteris alleghanensis (Meek)
lescuriana (Meek)
latilobata Read
virginiana (Meek)
rarinervis Read
biloba Read
Lagenospermum imparirameum Arnold
Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah
scobiniformis (Meek)
sigillarioides Jongmans, Gothan, and Darrah

The overlying Mauch Chunk and its equivalents contain little plant material of importance. From various localities fairly low in the formation there have been obtained the following species:

Sphenopteridium virginianum Read
brooksi Read
girtyi Read
Cardiopteris abbensis Read
Adiantites beechensis Read
Aneimites sp.
Carpolithes virginianus Read

In a general way it appears that this higher Mississippian must be characterized by the presence of *Sphenopteridium* and *Cardiopteris* along with *Aneimites*-like species of *Adiantites*. The data are insufficient to provide an adequate characterization, and they are here published simply to emphasize the distinctness of the Pocono floras.

COLLECTION LOCALITIES

The following list assigns numbers to the points (shown in fig. 1) at which collections of specimens were made and gives the species found at each collection station. The collection points are arranged according to fossil zones. The locality numbers are referred to in the systematic descriptions and plate explanations.

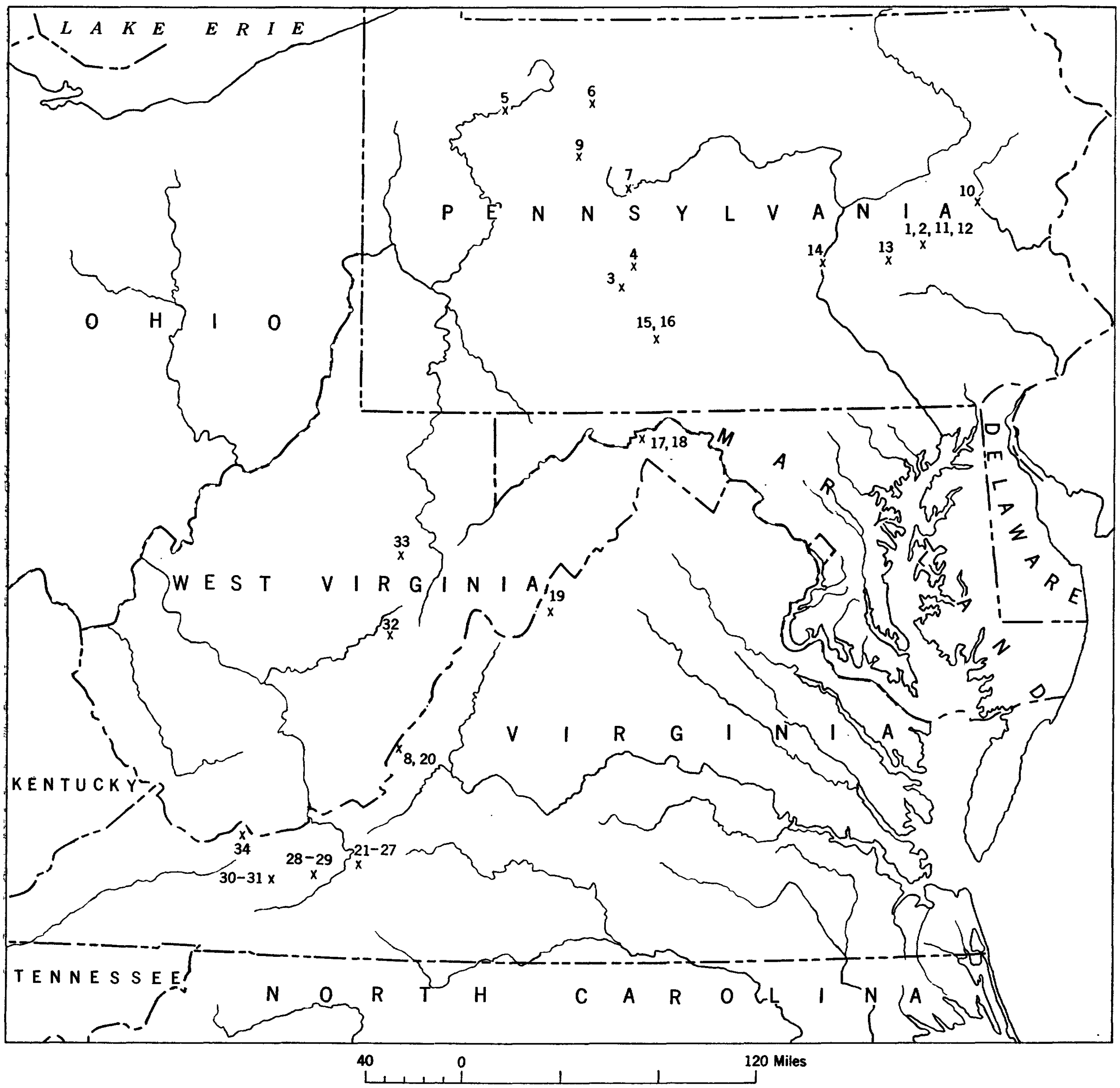

FIGURE 1.—Map showing geographic positions of sections examined and localities where collections were obtained. Localities are marked by X, and number refers to list on pages 15–16.

ADIANTITES FLORA

1. Shale in lower part of Pocono formation along Pennsylvania Railroad right-of-way in gap south of Pottsville, Schuylkill County, Pa.
   Adiantites ungeri Read
   Alcicornopteris anthracitica Read
   Calathiops pottsvillensis Read
2. Shale in lower part of Pocono formation in Westwood Gap on east side of West Branch of Schuylkill River, near Pottsville, Schuylkill County, Pa.
   Adiantites ungeri Read
   Alcicornopteris anthracitica Read
3. Shale in lower part of Pocono on Horseshoe Curve just above Kittanning Point on main line of Pennsylvania Railroad near Altoona, Blair County, Pa.
   Rhacopteris latifolia (Arnold)
   Adiantites spectabilis Read
   Rhodea sp.
   Alcicornopteris altoonensis Read
   Lepidodendropsis sp.
4. Shale in lower part of Pocono on now abandoned branch line of Pennsylvania Railroad at Collier Station near Bellwood, Blair County, Pa.
   Adiantites spectabilis Read
   Lagenospermum sp.
   Girtya pennsylvanica Read
5. Shale in lower part of Pocono formation on hill along road about 2 miles south of Tionesta, Forest County, Pa.
   Adiantites spectabilis Read
   cyclopteroides Read
   Rhodea tionestana Read
   alleghanensis Read
   Girtya pennsylvanica Read
6. Sandy shale in lower part of Pocono south of Gray Gables, Elk County, Pa.
   Adiantites spectabilis Read
7. Shales in lower part of Pocono at east end of railroad tunnel near Caledona, Clearfield County, Pa.
   Adiantites spectabilis Read
8. Alleghany Station, Va.: Outcrop of lower Price sandstone along road near west portal of Lewis Tunnel on Chesapeake and Ohio Railroad.
   Adiantites cardiopteroides Read
9. Patton, Jefferson County, Pa., in lower part of Pocono formation.
   Lagenospermum sp.

TRIPHYLLOPTERIS FLORA

10. Coaly beds in upper part of Pocono formation on east side of Lehigh River, Mauch Chunk, Carbon County, Pa. Material noted but too poor to be collected.
    Rhodea vespertina Read
    Triphyllopteris lescuriana (Meek)
11. Coaly and shaly beds in upper part of Pocono formation along Pennsylvania Railroad right-of-way south of Pottsville, Schuylkill County, Pa.
    Cardiopteris antecedens Read
    Rhodea vespertina Read
    Triphyllopteris lescuriana (Meek)
    Lagenospermum imparirameum Arnold
    Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah
    scobiniformis (Meek)
12. Coaly and shaly beds in upper part of Pocono formation along West Branch of Schuylkill River in Westwood Gap near Pottsville, Schuylkill County, Pa.
    Rhodea vespertina Read
    Triphyllopteris lescuriana (Meek)
    Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah
    scobiniformis (Meek)
    sigillarioides Jongmans, Gothan, and Darrah
13. Shale in upper part of Pocono formation at High Bridge Park near Pine Grove, Schuylkill County, Pa.
    Rhodea vespertina Read
    Triphyllopteris lescuriana (Meek)
    latilobata Read
    biloba Read
    Lagenospermum imparirameum Arnold
    Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah
    scobiniformis (Meek)
    sigillaroides Jongmans, Gothan, and Darrah
14. Dark coaly shale in upper part of Pocono formation near Millersburg, Dauphin County, Pa.
    Rhodea vespertina Read
    Triphyllopteris lescuriana (Meek)
    Lepidodendropsis scobiniformis (Meek)
15. Shale in upper part of Pocono, one fourth of a mile north of Riddlesburg, Bedford County, Pa., and on west side of Raystown Branch of Juniata River. Reported in notes by D. White.
    Triphyllopteris latilobata Read
16. Shale in upper part of Pocono in gap in Tussy Mountain, 2 miles north of Riddlesburg, Bedford County, Pa.
    Triphyllopteris latilobata Read
17. Hedges shale in coal prospects on Short Mountain southeast of Devils Nose and at foot of hills, Morgan County, W. Va.
    Triphyllopteris lescuriana (Meek)
    Rhodea vespertina Read
    Carpolithes sp.
    Lepidodendropsis scobiniformis (Meek)
18. Hedges shale in Chapelle shaft, Short Mountain, Morgan County, W. Va.
    Rhodea vespertina Read
    Triphyllopteris lescuriana (Meek)
    latilobata Read
    Lepidodendropsis scobiniformis (Meek)
19. Shale in Pocono formation, 4 miles southwest of Rawley Springs, Rockingham County, Va.
    Rhodea vespertina Read
    Triphyllopteris lescuriana (Meek)
    latilobata Read
    rarinervis Read
20. Shale and fine-grained sandstone in upper part of Price sandstone at and in Lewis Tunnel on Chesapeake and Ohio Railroad near Alleghany Station, Alleghany County, Va.
    Rhodea blacksburgensis Read
    vespertina Read
    Triphyllopteris alleghanensis (Meek)
    lescuriana (Meek)
    virginiana (Meek)
    Lepidodendropsis scobiniformis (Meek)

21. One and a half miles north of Vicker, Montgomery County, Va., on road to Price Forks in an outcrop of upper part of Price sandstone above Merrimac coal.
    Rhodea blacksburgensis Read
    vespertina Read
    Triphyllopteris lescuriana (Meek)
    latilobata Read
    virginiana (Meek)
    rarinervis Read
    biloba Read
    Lepidodendropsis scobiniformis (Meek)
22. One and a half miles north of Vicker, Montgomery County, Va., on road to Price Forks in an outcrop of upper part of Price sandstone below Merrimac coal.
    Triphyllopteris lescuriana (Meek)
    Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah
23. Keifer's mine in Merrimac coal, upper part of Price sandstone, Price Mountain near Vicker, Montgomery County, Va.
    Triphyllopteris latilobata Read
24. Keifer's and Shaeffer's mines in Merrimac coal, upper part of Price sandstone, Price Mountain near Vicker, Montgomery County, Va.
    Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah
    scobiniformis (Meek)
25. Crockett-Price's mine in Merrimac coal, upper part of Price sandstone, Price Mountain near Vicker, Montgomery County, Va.
    Lepidodendropsis scobiniformis (Meek)
    sigillarioides Jongmans, Gothan, and Darrah
26. Meyers Brothers' mine in Merrimac coal, upper part of Price sandstone, Price Mountain near Vicker, Montgomery County, Va.
    Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah
27. Upper part of Price sandstone near Long's Shop Post Office, Montgomery County, Va.: Cowin's mine, Husier Hollow Creek, 2½ miles from post office in a 22-inch coal, 15 feet below Merrimac coal.
    Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah
    scobiniformis (Meek)
    sigillarioides Jongmans, Gothan, and Darrah
28. Upper part of Price sandstone at Altoona mines near Pulaski, Pulaski County, Va.
    Rhodea blacksburgensis Read
    Triphyllopteris lescuriana (Meek)
29. Shale in upper part of Price sandstone and above Merrimac coal at prospect of N. H. Herd, 2 miles northwest of Pulaski, Pulaski County, Va.
    Rhodea sp.
    Triphyllopteris lescuriana (Meek)
30. Stony Creek mines in the Merrimac coal, upper part of Price sandstone, 6 miles northwest of Wytheville, Wythe County, Va.
    Rhodea blacksburgensis Read
    Triphyllopteris lescuriana (Meek)
31. Roof shale of coal bed in upper part of Price sandstone on Stony Creek, 6 miles northwest of Wytheville, Wythe County, Va.
    Cardiopteris irregularis

FLORAS OF THE MAUCH CHUNK AND OTHER HIGHER MISSISSIPPIAN FORMATIONS

32. Near or below the horizon of the Big Spruce Knob coal along Elk River near Whitaker Falls, Fork Lick district, Webster County, Virginia.
    Sphenopteridium virginianum Read
    Rhodea? sp.
    Carpolithes virginianus Read
33. Mauch Chunk formation on Beech Fork about half a mile southeast of Left Fork of Beech Fork at the level of the abandoned Alexander Lumber Company Railroad grade, Upshur County, W. Va.
    Sphenopteridium brooksi Read
    girtyi Read
    Adiantites beechensis Read
    Sphenopteris? sp.
34. Lower part of Bluefield shale just above Greenbrier limestone in Abbs Valley, Tazewell County, Va.
    Cardiopteris abbensis Read

DESCRIPTION OF SPECIES

LOWER POCONO FORMATION AND PRICE SANDSTONE

Genus RHACOPTERIS Schimper, 1869

1869. *Rhacopteris* Schimper, Traité de paléontologie végétale v. 1, p. 481, 482.

Genotype.—*Rhacopteris elegans* (Ettingshausen) Schimper.

Fronds generally once pinnate, linear; the pinnules opposite to alternate, asymmetrical, basally contracted, and attached by a short stalk or sessile; pinnules often lobed and variously incised. Venation dichotomous, fanlike, without midrib. Texture of lamina coriaceous. Fructifications borne on otherwise naked segments which are at least once dichotomous, the resultant arms bearing pinnate branches upon which are borne exannulate sporangia.

Rhacopteris latifolia (Arnold) Read, n. comb.

Plate 16, figure 5; plate 18, figures 2, 3

1939. *Archaeopteris latifolia* Arnold, Mich. Univ., Mus. Paleontology, Contr., v. 5, no. 11, p. 307; pl. 7, fig. 3; pl. 9, figs. 1–16; pl. 10, fig. 1.

Frond pinnate, possibly bipinnate. Species known from fronds or pinnae up to 12 centimeters in length, narrow, linear, apparently lax. Pinnules crowded, overlapping, subopposite, obovate, asymmetrical, sessile to subsessile on the rachis. Proximal margins of pinnules entire, slightly concave. Distal margins crenate or dentate; venation apparently originating from a plexus of strands at base, dichotomizing frequently to fill the laminae, with veins closely spaced as they pass chiefly to the distal margins. Texture apparently coriaceous.

The aspect of two specimens referable to this species is seen in plate 16, figure 5, and plate 18, figure 3. It appears from the available material that this species is perhaps bipinnate. If so, this is one of the few bipinnate forms known. However, it is possible that the structure which appears to be a primary rachis is in reality a stem bearing small pinnate fronds.

In plate 18, figure 2, is seen a fertile specimen referred by Arnold to the same species as the sterile frond just discussed. They were found in the same beds and at the same locality, but their organic connection has not been demonstrated. It is apparent that such specimens have slightly sinuous axes bearing short lateral branches crowded with sporangia. Details of the sporangia are not discernible. This specimen is similar to the fertile fragment described by Walton (1926, p. 205–208) under the name *Rhacopteris fertilis*.

This species was referred by Arnold to *Archaeopteris* but appears more correctly assignable to *Rhacopteris*. The very close agreement of the pinnule form with *Rhacopteris inaequilatera* Goeppert and *Rhacopteris circularis* Walton is at once apparent. The fertile fragment, supposedly referable to the species, is likewise in agreement with the fertile segments of the genus already known.

Locality 3.

Genus ADIANTITES Goeppert, amend.

1836. *Adiantites* Goeppert, Die fossilen Farrnkrauter: p. 216, 217.

Genotype.—*Adiantites antiquus* Ettingshausen.

Fronds several times pinnate, rather lax, the fronds often angular, probably owing to a climbing habit. Pinnae alternate. Pinnules alternate, usually cuneate, apically truncate, attached at the base by a footstalk or sessile, the base constricted. Venation derived from a single strand or plexus of strands at the base and radiating to supply the lamina by repeated dichotomy. Texture usually coriaceous.

Adiantites spectabilis Read, n. sp.

Plate 7, figure 3; plate 10, figure 6; plate 11, figures 4, 5; plate 14, figures 1–4

Fronds of large size, lax, flexuose, probably tripinnate with a flexuose rachis. The primary pinnae set at close to right angles on the rachis, also flexuose, the same features being true of the secondary pinnae, which are oblong-lanceolate, lax, rachis slender, pinnae nearly touching or slightly overlapping.

Pinnules broadly ovate or deltoid to obcuneate ovate, short pedicellate, entire or cut slightly or nearly to the base into two, three, or sometimes more, varyingly obcuneate and flabellate, erect divisions which may themselves be sublobate. Lamina apparently thick. Nervation palmate from the single basal nerve, the veins arching slightly.

This is a particularly large representative of the genus *Adiantites*. Judging from the lax habit and markedly sinuose rachides, a climbing or clambering habit was likely.

It has been shown by Walton that in the related *Adiantites antiquus* (Ettingshausen) Stur (1875, p. 66–68, pl. 16, figs. 4–6; pl. 17, figs. 3, 4) the main rachis is basally dichotomous, the two divisions being quadripinnate. This may, however, be a false dichotomy, since a scar exists at the base of this fork suggesting a prolongation of the main axis into a fertile division.

From *Adiantites antiquus* the American *A. spectabilis* differs in the somewhat larger pinnules with more rounded apices and in the more marked tendency toward lobation of the lamina.

Localities 3–7.

Adiantites ungeri Read, n. sp.

Plate 2, figures 4–6

Specimens consisting of numerous detached pinnae that are mostly cut into from 2 to 5 lobes, though some are very slightly incised or simple. The general shape is oblong-cuneate, with the apices of the pinnules or pinnule segments broadly rounded or truncate. The bases of the pinnules show evidence of a distinct stalk. Venation indistinct but apparently consisting of a number of equally strong, closely spaced veins radiating from the bases and dichotomously forking as they pass toward the distal margin.

Specimens of this species occur in considerable abundance in the basal portion of the Pocono in Pottsville Gap and Westwood Gap, where they are associated with *Alcicornopteris anthracitica*. Only the detached pinnules are definitely known, although associated with them are numerous fragments of smooth axes of pinnae and larger rachides that are almost certainly the remains of the phyllopodial framework upon which the pinnules were borne. These pinnules are very common in some of the thin arenaceous shale beds that occur in the lower part of the Pocono.

The species appears to be closely related to *Adiantites antiquus* (Ettinghousen) Stur (1875, p. 66–68, pl. 16, figs. 4–6; pl. 17, figs. 3, 4), from which it may be distinguished by the somewhat larger pinnules. However, there is so much variation in the form and size of the pinnules in both species that positive distinction in some cases may not be possible. In fact, the two species might be regarded as identical; but, considering the dominantly European distribution of *A. antiquus*, it seems best for the time being to set up the American form as distinct.

Similarly, *Adiantites ungeri* is related to, but distinct from, *A. bassleri* Read from the Lower Carboniferous from the Paracas Peninsula, Peru (Read, 1938, p. 396–404, fig. 6). It has been pointed out that this species is also very closely related to *A. antiquus.*

This form from the Pocono has been named for C. W. Unger, of Pottsville, Pa., who has cooperated with the writer in obtaining the material and first showed specimens to the writer while in the field.

Localities 1 and 2.

Adiantites cyclopteroides Read, n. sp.

Plate 11, figures 1, 2; plate 12, figures 1, 2

Nature of frond and of larger divisions unknown. Pinnules short-stalked, obliquely placed on the slender, flexuose rachis; reniform to oval, markedly asymmetrical, tending to be sublobate. Venation partially concealed, apparently owing to thickness of lamina, sparsely distributed short hairs on the surface. Nervation rather distant, palmate, curving slightly in passing to the margin.

Locality 5.

Adiantites cardiopteroides Read, n. sp.

Plate 3, figure 5; plate 13, figures 1, 2, 4, 5

Pinnae linear, rachis slightly flexuose. Pinnules large, open, sessile with relatively broad attachments, sometimes auriculate, broad, heteromorphous, rounded, ovate or orbicular, often cut deeply into 2 or 3 lobes. Nerves slender, distinct midrib absent, the basal nerves forking 4 to 5 times while arching to the border.

Locality 8.

Genus RHODEA Presl

1838. *Rhodea* Presl, *in* G. K. Sternberg, Versuch einer geognostischbotanischen Darstellung der Flora der Vorwelt, Heft 7, 8, p. 109.

Genotype.—*Rhodea furcata* Presl.

The genus *Rhodea* Presl includes sterile, fernlike fronds and frond fragments, the pinnules of which are sphenopteroid in their general aspect but dissected deeply into numerous segments, each of which is traversed by a single vein. The lamina is at the same time markedly reduced so that the frond divisions appear to be little more than the vascular strands with but a feeble suggestion of the leaf segment adjacent.

Rhodea is a form genus, and material referable to it is very common in the Mississippian of this continent as well as the Lower Carboniferous of Europe.

Rhodea tionestana Read, n. sp.

Plate 18, figure 1

Larger divisions of frond at present unknown. Ultimate divisions linear-lanceolate, rigid, carrying crowded, alternate pinnules; pinnules deeply cut into 4 to 6 lobes that are directed upward all the way from base of pinnae. Lobes narrow, forming only a slight wing on either side of the single vein or vascular bundle that traverses each division of the pinnule, the lobes thus being deeply incised and dissected; apices of the lobes rounded.

The reference of this fernlike plant to *Rhodea* is provisional. As has been shown at another point in this report, *Rhodea* is a form genus for pinnule types that in the past have been placed in the genus *Sphenopteris* but which are now segregated as *Rhodea* because of the high degree of dissection. This dissection and partial elimination of lamina is in fact so marked in *Rhodea*, as defined, that only a single vein traverses each lobe of the pinnule, and the lamina forms but a narrow wing on each side of the vein. It is possible that *Rhodea tionestana* should be referred to *Sphenopteridium*, though this genus is marked by a dichotomous rachis, and no evidence of such a feature was seen in the specimen from Pennsylvania. However, the pinnule type approaches to some extent that of the known species of *Sphenopteridium.*

This species is quite distinct among now known American representatives of *Rhodea.* The linear-lanceolate aspect of the pinnae, the crowded pinnules, and the rather rigid, erect aspect of the pinnae all serve to set the form apart from others described in this paper. In addition, it is quite large for a representative of the genus.

Rhodea tionestana recalls somewhat the European species of *Sphenopteris*, such as *S. pachyrachis.* It is, however, a smaller form than most of the species known from abroad.

Locality 5.

Rhodea alleghanensis Read, n. sp.

Plate 16, figure 4

Frond small, dichotomous at the apex, bipinnate or tripinnate, the pinnae crowded, lax, broadly lanceolate, with rounded apices. The pinnules alternate, crowded, frequently overlapping, deeply cut into several lobes, each of which carries a single vein, the lamina on either side of the vein being very narrow, lobed, erect, and in general tapering toward the apices of the pinnae.

This species occurs in the lower part of the Pocono formation of northwestern Pennsylvania and is rather common, but usually in a rather fragmentary state. An examination of the figure indicates that the specimen is of the same general type of *Rhodea blacksburgensis* and *R. vespertina*, from which it differs in the more marked, erect attitude of the pinnule lobes as well as in the apical dichotomy of the frond. This feature is not known in either of the two comparable types, although abundant specimens are available of both. It is possible that the generic references of the species here described should be changed in view of this difference in frond architecture.

No attempt is here made to compare this form with European species. There are perhaps several similar types from the Lower Carboniferous of Europe, but since the writer has seen material of none of these, it is obviously impossible to make very close comparisons.

Locality no. 5.

Genus ALCICORNOPTERIS Kidston

1887. *Alcicornopteris* Kidston, Royal Soc. Edinburg Trans., v. 33, p. 152.

Genotype.—*Alcicornopteris convoluta* Kidston.

Under this generic name there have been described several examples of naked petioles that are dichotomous near the apex and then repeatedly branch dichotomously to form a markedly convoluted system of flattened segments which usually show evidences of much reduced laminae. There have also been described under this name several fertile structures, namely large, campanulate synangia of the *Calathiops* type which are presumably microsporangial. The relationships of the fertile and sterile organs are not entirely clear.

Alcicornopteris anthracitica Read, n. sp.

Plate 17, figure 9

Larger divisions of the frond unknown, the specimens consisting of fragments of the apices of very small pinnae that show one to two dichotomies and that are highly convolute. The laminae, if present, are very slightly developed, but the axes of the pinnae are markedly flattened.

There is very little to distinguish this form, and question may be raised concerning the desirability of reporting the fragment under a new specific name. However, it does seem desirable to distinguish this type of structure from other known forms, and its small size does appear to be a distinction of possible value. In *Alcicornopteris zeilleri* Vaffier (1901, p. 124–126, pl. 6, fig. 5; pl. 7, fig. 1) which is a larger form, there is a fairly well developed lamina. The present species differs in the lack of any lamina and in the smaller size. No fertile fragments have been observed in the material at hand so that it is impossible to compare *A. anthracitica* with the fructifications referred to the genus. It is to be hoped that better and less fragmentary material of this form may be obtained in the future so that a more satisfactory characterization may be given.

This species is associated with *Adiantites ungeri* in the lower portion of the Pocono formation in both the Pottsville and Westwood Gaps in the southern edge of the Southern Anthracite Coal Field of Pennsylvania. It has not been noted elsewhere.

Localities 1 and 2.

Alcicornopteris altoonensis Read, n. sp.

Plate 16, figures 1, 2

Larger divisions unknown, the fragments consisting of fairly large pinnae that are apparently fleshy and flabellate, and near flabellate, irregularly lobed, lax, convoluted pinnules that also appear fleshy. No venation is present, although the surface is irregularly longitudinally striate and furrowed.

This species is very closely related to *Alcicornopteris convoluta* Kidston (1924, p. 418–421) and, in fact, may be identical. The American species does not, however, show such marked convolutions of the pinnules as does Kidston's form.

It is probable that this structure is related in some way to *Adiantites spectabilis* from the same locality. Dawson (1873, p. 26, 27, pl. 7, figs. 61–63) has noted a similar association in the case of *Adiantites acadica*, and Schimper (Schimper and Schenk, 1891, p. 110, 111, fig. 87) reports structures of the same type as the fertile pinnae of *Triphyllopteris collombiana*.

Locality no. 3.

Genus LAGENOSPERMUM Nathorst

1914. *Lagenospermum* Nathorst, A. G., Zur fossilen Flora der Polarländer, teil 1, p. 29.

Genotype.—*Lagenospermum sinclairi* (Kidston MS.) Arber.

Lagenospermum is a name proposed by Nathorst for small seeds and seedlike bodies preserved as impressions, radiospermic in their general aspect and agreeing in external features with *Lagenostoma* Williamson, *Physostoma* Williamson, *Conostoma* Williamson, and *Radiospermum* Arber. This genus is, to the writer's knowledge, known only from Mississippian and Lower Carboniferous strata.

Lagenospermum sp.

Seed bearing organ, small, varying from 6 to 9.5 millimeters in length and about 2 millimeters broad at the widest point, spindle shaped, with the chalazal end bluntly rounded. Sheath apparently 6-lobed and possibly finely striate, although this is not clear; the apical teeth or lobes of the sheath acuminately pointed. Seed about 5 millimeters long and 1.2 millimeters broad, spindle shaped, rounded both at the chalazal and micropylar ends, the vascular strand at the chalazal end being small but distinct.

The features which distinguish *Lagenospermum* sp. are its extremely small size, its marked spindle shape, and the acuminate teeth of the cupule lobes. Unfortunately the matrix is not favorable to the preservation of details of small specimens so that many of the characters which might serve to set apart these interesting seeds cannot well be recognized.

Lagenospermum sp. is of particular interest because of its association with *Adiantites spectabilis*. It will be recalled that Nathorst, in his discussion of the Culm Flora of Spitzbergen, pointed out the association of *L. arberi* and *A. bellidulus* and suggested that they might be seed and frond of the same plant. While he could not demonstrate actual organic connection, he apparently regarded the association as fairly convincing. In consequence, it is extremely interesting to discover again sheathed, spindle-shaped radiospermic seeds associated with the abundant remains of a species of *Adiantites* that is closely related to *A. bellidulus*.

Locality 9.

Genus CALATHIOPS Goeppert

1865. Calathiops Goeppert, Paleontographica, Band 12, p. 268–270, pl. 64, figs. 4–10.

Genotype.—*Calathiops beinertiana* Goeppert.

Calathiops pottsvillensis Read, n. sp.

Plate 17, figure 5

Organs superficially suggesting seeds, elongate, oval, with somewhat truncate apices and bases; length about 19 millimeters, width 9.5 millimeters; marked on the exterior of the exposed side by 12 to 15 longitudinal ribs that are slightly irregular and that are raised above the rest of the fossil. To some extent these ribs appear fused at the base and apices of the specimen, and their interpretation is somewhat problematical.

Determination of the true nature of the single specimen of this species is difficult, although the fossil itself is very well preserved. From examination of the illustration, it will be seen that the fructification is elongate, oval, and of fair size, suggesting, in fact, a *Rhabdocarpus* from the Pennsylvanian. It is longitudinally ribbed as described above and at first glance impresses one as being a seed. However, upon further consideration it appears more likely that it is a synangium of microsporangia. This opinion is founded upon the interpretation of the riblike structures exposed on the surface as tubular microsporangia which are free or slightly adnate. It is quite possible that the whole structure may be a mass of such sporangia so crowded as to form the compact headlike organ resembling a seed. However, it is only fair to point out that this is simply an interpretation of structure, and the specimen may be an early seed type.

The single specimen is associated with *Adiantites ungeri* and *Alcicornopteris anthracitica* in the lower part of the Pocono in the Pottsville Gap, Schuylkill River.

In referring this species to the genus *Calathiops* the writer adopts the usage of several recent authors who have listed the genus as a provisional one, the microsporangial or megasporangial nature of which is not finally determinable.

Locality 1.

Genus GIRTYA Read, n. gen.

Under the new generic name *Girtya* are included specimens of campanulate synangia similar in some respects to *Whittleseya* but differing in several important respects. The four critical features are as follows:

1. The synangium massive, somewhat cup-shaped, at least externally.

2. The microsporangia elongate, tubular, presumably dehiscing distally, free except at the base.

3. The microsporangia in a compact head arranged irregularly owing to their terminal positions on short, crowded branches, the internodes very short. The apex of the master branch system is marked by a dichotomy, the successive anadromic helicoid branches bearing terminally the sporangia which are given off close together just above the dichotomy, so that a sort of pseudoreceptacle is formed by the dichotomy.

4. Synangia borne on a "scorpioid" or markedly dichotomously branched and probably flattened axis that may be identical with *Alcicornopteris*.

It is probable that in this genus may be included the synangia figured by Kidston (1924, pl. 108, figs. 7–9a; text figs. 39, 40) under the name of *Alcicornopteris* as specimens of the *Schuetzia bennieana* type. As has been indicated by Halle (1933, p. 54), it is improper to include in *Alcicornopteris* such synangia as were figured by Kidston, this genus being a form genus and restricted to a scorpioid frond. Likewise, *Schuetzia bennieana*, which is from the Calciferous sandstone of Great Britain, is probably not generically identical with the genotype, *Schuetzia anomala* Geinitz, from the Permian. Halle has suggested that these forms might possibly be placed in *Calathiops*, or a new genus might be set up. Apparently he had no material and took no steps to institute such a change.

The details of morphology of the material at hand will be discussed in connection with the description of species. However, it is perhaps appropriate here to speculate briefly on the probable relationship of *Girtya* to certain of the sterile fronds that are described here.

Material of *Girtya* is known from two localities, one in Blair County, Pa., and the other in Forest County, Pa. At both localities the material is associated with *Adiantites* so abundantly as to form *Adiantites* beds. In Blair County the species is *A. spectabilis* and in Forest County, *A. cyclopteroides*. With the exception of specimens of *Rhodea*, the beds are otherwise barren of fern or pteridosperm material. In consequence, the natural inference from the association is that the synangia placed in the form genus *Girtya* may be the microsporangia of *Adiantites*.

From the point of view of morphology, this opinion also finds support to the extent that the axes upon which the synangia are borne are superficially similar to the rachides of *Adiantites*, and, furthermore, these two species are angular-branching fronds suggesting a clambering or climbing habit, the angularity of branching being frequently almost scorpioid. Of course, it is impossible to demonstrate any actual organic continuity, but the occurrence is suggestive, and it appears not unlikely that further search will reveal specimens supporting or proving this view.

This genus is named for the late Mr. G. H. Girty, of the U. S. Geological Survey, who collected the material in 1903.

Girtya pennsylvanica Read, n. sp.

Plate 15, figures 1–3; plate 16, figure 3

Synangium cup-shaped, slightly constricted distally, about 11 millimeters long and 9 millimeters wide. The "receptacle," formed by the apical dichotomy of the master branch system, bearing an indefinite number of elongated, narrowly cylindrical microsporangia that are free except at their bases, where they may be united into pairs. The sporangia are not sessile on the master branch system but are on short pedicels that are given off in crowded succession by the master branch system in the cup of the dichotomy so that the arrangement of the sporangia is irregular but crowded.

Synangia borne on short branches of a scorpioid ramification, these branches flattened.

The material at hand consists of numerous specimens that are quite similar in their general features, although it is possible that it may eventually be necessary to separate them specifically. As is indicated in the illustrations, the principal type of the species is an isolated synangium exposed along an imperfect parting of a buff, fine-grained, silty sandstone. The specimen is partly compressed and in consequence shows considerable relief. Unfortunately, the counterpart of the specimen is missing. The specimen is obviously cup-shaped but slightly constricted distally. An examination of the illustrations definitely demonstrates that the sporangia are long, tubular bodies mounted on short pedicels that are dichotomous.

The synangia that have been described above are comparable both with those described as *Alcicornopteris zeilleri* Vaffier and *Schuetzia bennieana* Kidston. The chief difference between the two types is one of habit rather than morphology of the synangium. Thus *A. zeilleri* is borne terminally on some of the lobes of a scorpioid branch of frond, while *S. bennieana* is borne spirally on rather rigid branches. It would thus appear that the material under discussion should be referred to *Alcicornopteris*, but when it is recalled that this genus was established by Kidston to include peculiar sterile pinnae it then becomes questionable whether the modification of this genus is justifiable. Therefore, based on the American material, the new name *Girtya* has been proposed.

Localities 4 and 5.

UPPER POCONO FORMATION AND PRICE SANDSTONE

FERNS AND FERNLIKE PLANTS

Genus CARDIOPTERIS W. P. Schimper

1869. *Cardiopteris* W. P. Schimper, Traité de paléontologie végétale, tome 1, p. 451

Genotype: *Cardiopteris polymorpha* (Goeppert) W. P. Schimper.

Fronds pinnate; rachis striate. Pinnae inserted at approximately right angles, opposite to subopposite, often crowded. Pinnules opposite to subopposite, attached by the central portion of the base, sessile or subsessile, round-cordate to elongate-cordate, usually symmetrical. The venation with a primary or several primaries at the base, forking equally and fanlike to supply the whole pinnule. Texture apparently coriaceous.

This genus is fairly common in the Lower Carboniferous of Europe. In North America it appears to be a rare genus and is known only from a few stations in the Mississippian.

Cardiopteris irregularis Read, n. sp.

Plate 10, figures 1, 2

Complete fronds unknown; fragments of pinnae the only parts preserved; pinnules large, alternate, close, oblique, attached by a broad and slightly oblique base to the distinctly lineate rachis, slightly asymmetrically ovate to inaequilaterally triangular, rounded to acute at the apex, with irregularly undulate borders and the rachis in many specimens distinctly sublobately cut on the proximal side. Lamina rather thin, slightly concave ventrally, in many pinnules rolled back at the borders. Nervation distinct, of moderate strength, the exact nature indicated by the figures.

This plant, which at present is known only from fragments collected in a single locality, is unquestionably related to *Cardiopteris polymorpha* (Goeppert) Schimper (1869, p. 452). *Cardiopteris polymorpha* is, of course, a younger form, being more generally characteristic of the Chester group and its equivalents. From *C. polymorpha*, *C. irregularis* is to be distinguished by its elongated, conspicuously asymmetrical, and acute pinnules, which are sometimes irregularly parted into one or two broad lobes on the lower side.

Locality 31.

Cardiopteris antecedens Read, n. sp.

Plate 9, figures 1, 2

Frond divisions unknown. Pinnules nearly flat, narrowly and obliquely ovate or ovate deltoid to rhombic, strikingly asymmetrical, entire or slightly lobate, rounded at the apex, basally cordate. Nervation neuropteroid, with an indistinct median nerve, the nerves curving outward and forking two or three times in passing to the border.

This species has a rather striking neuropteroid aspect and is quite distinct in the Pocono flora. Both in nervation and in outline the fragments are so similar to *Neuropteris* that one is strongly tempted to place it in that genus.

Cardiopteris antecedens is apparently related to *Neuropteris antecedens* Stur (1875, p. 53–56, Taf. 15, figs. 1–6).

Locality 11.

Genus RHODEA Presl

Rhodea blacksburgensis Read, n. sp.

Plate 3, figures 1, 2

Frond unknown, the material consisting of fragments of pinnae bearing pinnules. The pinnae tending to be angularly flexuose, very slender, and smooth or slightly striate longitudinally. Ultimate pinnae alternate, distant, set at an acute angle on the rachis of the larger order, the rachides of these also slender and angularly flexuose, short, the pinna outline short ovate. Pinnules narrow, highly divided, each lobe coursed by a single vein, the lobes rounded at the apices, the whole pinnule tending to be somewhat more compact and less slender than in *Rhodea vespertina.*

The separation of this species from *Rhodea vespertina* is based on the relatively more compact and somewhat smaller pinnules that appear to characterize this species, and also on the nature of the lobes of the pinnule which are much shorter and slightly broader in this than in *R. vespertina.*

Rhodea blacksburgensis is to be compared also with *R. smithi* Kidston (1923b, p. 226, 227, pl. 56, figs. 1, 2; pl. 57, figs. 2, 3), from the Calciferous sandstone of England. Unfortunately, no material of that species has been on hand, so that firsthand comparison is impossible. From the published illustrations it appears that *R. smithi* is a slightly larger type.

This is a fairly common species in the Mississippian Price sandstone and correlative formations in the Appalachian trough.

Localities 20, 21, 28, and 30.

Rhodea vespertina Read, n. sp.

Plate 3, figures 3, 4; plate 4, figures 1–4; plate 16, figure 6

Frond rather delicate, the rachis slender, apparently rigid, slightly flexuose, finely striate. Ultimate pinnae alternate or subopposite, distant, set at an angle of about 45°, linear lanceolate, the axis very slender. Pinnules of the *Rhodea* type, finely divided, alternate, well-separated, linear and very narrow, with a single nerve; apex of the pinnule rounded. The pinnules are set at acute angles and branch into numerous lobes.

The details of frond division of this fern are at present unknown. As will be seen, this species finds its closest relationships in *Rhodea tenuis* Gothan (1913, p. 15, pl. 2, fig. 2) and *Rhodea smithi* Kidston (1923b, p. 226, 227, pl. 56, figs. 1, 2; pl. 57, figs. 2, 3). It may, in fact, be identical with *Rhodea tenuis*, but as little material of that species is available and in view of the distribution difficulties involved it seems best tentatively to separate the two.

Rhodea vespertina is the species referred by Lesquereux to *Sphenopteris flaccida* Crepin (1874, p. 7, 8, pl. 2, figs. 1–5), an identification which has been quoted by several American authors. This identification is obviously incorrect, *S. flaccida* having no resemblance to *R. vespertina* as the species is now understood.

Rhodea vespertina is the most widely distributed and most abundant plant species in the lower Mississippian of the Appalachian trough, being present at least in fragments and usually very profusely distributed at most plant-bearing localities.

Localities 10–14, 17–21.

Rhodea sp.

A number of small specimens of a large *Rhodea*-like form from High Bridge, near Pine Grove, Pa., have previously been referred to *Rhodea*. Specimens were observed at many places in the Lehigh River section of the Pocono near Mauch Chunk, Pa. Other than the relatively large, compact, broad lobes of the pinnules, there is little to identify this form, and were it not for its possible stratigraphic significance, it would have been considered too poorly preserved to mention in this report.

Locality 13.

Genus TRIPHYLLOPTERIS W. P. Schimper

1869. *Triphyllopteris* W. P. Schimper, Traité de paléontologie végétale, tome 1, p. 478.

Genotype.—*Triphyllopteris collombi* W. P. Schimper.

Fronds bipinnate or perhaps tripinnate in some species. Rachis heavy, transversely marked by short, broad rugosities, the base somewhat enlarged and showing evidence of a clean-cut abcission layer. Pinnae alternate to subopposite, set at acute angles, usually close and not infrequently overlapping. Ultimate pinnae similar. Pinnules sphenopteroid to modified archaeopteroid in form, that is, sessile or very short-stalked, the base tapering to the point of attachment; form rhombic to obovate, entire or more frequently trilobed or bilobed, the divisions obovate to linear and acute. Venation derived from one or more basal strands, forking palmately several times to supply the whole pinnule. Texture apparently coriaceous in many instances.

The representatives of this genus are very characteristic of the upper parts of the Pocono formation and Price sandstone. They appear to be very important contributors to the associated coals, if one may judge from their abundance in close association with such deposits.

Key to the known American species of Triphyllopteris

Fronds bipinnate or tripinnate, the rachides marked by transverse rugosities. Pinnae tending to be rigid and frequently set at a rather acute angle to the rachis. Pinnules bilobate, trilobate, or multilobate, cuneate, the nervation palmate.

1. Pinnules and pinnule lobes broad-cuneate, distally rounded or rhombic, the general aspect of the frond somewhat lax.

a. Pinnules small, frequently oval, and rarely showing much angularity, not uncommonly broader than long . . . . *T. alleghanensis* (Meek)

b. Pinnules larger, rounded, oval, the basal pinnules broader than long . . . . . . *T. latilobata* Read, n. sp.

c. Pinnules large, rhomboidal, the basal pinnules markedly heteromorphous, nervation distant . . . . . . *T. rarinervis* Read, n. sp.

d. Pinnules but slightly incised into lobes, these lobes compressed, the general aspect of the pinnules compact, the lobes distally pointed but rather broad . . . . . *T. virginiana* (Meek)

2. Pinnules and pinnule lobes narrow, rounded, or pointed, the general aspect of the frond rigid.

a. Pinnules quite small, lobes separate, narrow, chiefly pointed, pinnules frequently bilobed, aspect fasciculate . . . . . *T. biloba* Read, n. sp.

b. Pinnules large, narrow, lobate, the lobes well separated, narrow, the apices rounded or pointed . . . . . . *T. lescuriana* (Meek)

Triphyllopteris alleghanensis (Meek) Read, n. comb.

Plate 5, figures 1, 2

1880. *Cyclopteris (Archaeopteris) alleghanensis* Meek, Philos. Soc. Washington, Bull. v. 2, app. 8, p. xviii, 44, pl. 1, figs. 2a, 2b.

1880. *Adiantites (Asplenites) alleghanensis* Meek, Philos. Soc. Washington Bull. v. 2, app. 8, p. xix, 44.

1880. *Palaeopteris alleghanensis* Meek, Philos. Soc. Washington Bull., v. 2, app. 8, p. xix, 44.

1879. *Archaeopteris alleghanense* (Meek) Lesquereux, Pennsylvania 2d Geol. Survey Rept. P, atlas, p. 9, pl. 49, figs. 9, 9a; text (1880), p. 307.

1913. *Archaeopteris alleghaniensis* David White, West Virginia Geol. Survey, v. 5 (A), pt. 2, p. 392, 429.

Frond narrow, bipinnate; pinnae linear, slightly arcuate, rachis transversely corrugated; ultimate pinnae small, alternate to subopposite, open, often nearly at a right angle to the rachis, closely and markedly overlapping, ovate or deltoid and short below to ovate triangular above, ultimate rachis sometimes flexuose, ventrally sulcate, narrowly alate.

Pinnules variable in form, alternate, the lower being very broadly and asymmetrically obovate to obcuneate, truncately rounded at the apex, and short to round obcuneate and ovate-obcuneate, obtuse; those higher being more narrowly obovate-cuneate and sublobate. The lowest pinnule on the primary rachis shortest, somewhat polymorphous, broadly ovate to round and cut into 3 to 5 broadly cuneate, asymmetrical lobes. Lamina broadly inflated, coriaceous, nerves often concealed, the single primary nerve forking twice in the larger lobes or pinnules.

This species differs decidely from the other species of the genus by its much smaller size and the relatively broader pinnules and lobes. The extremely broadly cuneate, short lateral or basal pinnule which appears pedicellate, together with the small size, is the most distinctive characteristic. As in other species, the pinnules vary greatly both in form and size.

An interesting feature of this species is the occasional occurrence in the lower parts of the frond or pinna of small heteromorphous or reduced pinnules that are broader and more rounded than those which are normal to this type. It is difficult to refer, with confidence, these pinnules to the species with which they are found, though in size they are in accord with the associated type.

It is interesting to note, particularly in some of the basal pinnae, a sort of foreshadowing in form of the later *Sphenopteris trifoliolata* Artis.

Locality 20.

Triphyllopteris lescuriana (Meek) Lesquereux

Plate 5, figures 3, 4; plate 6, figures 1–3

1880. *Cyclopteris (Archaeopteris) lescuriana* Meek, Philos. Soc. Washington Bull., v. 2, app. 8, p. xvi.
1880. *Sphenopteris lescuriana* Meek, Philos. Soc. Washington Bull. v. 2, app. 8, p. xvii.
1880. *Adiantites (Asplenites) lescurianus* Meek, Philos. Soc. Washington Bull., v. 2, app. 8, p. xvii.
1880. *Palaeopteris lescuriana* Meek, Philos. Soc. Washington Bull., v. 2, app. 8, p. xvii.
1879. *Triphyllopteris lescuriana* (Meek) Lesquereux, Pennsylvania 2d Geol. Survey, Rept. P, atlas, pl. 50, figs. 6–6c; text (1880), p. 297, 298.
1913. *Triphyllopteris lescuriana* (Meek) Lesquereux. David White, West Virginia Geol. Survey, v. 5 (A), pt. 2, p. 392, 429.

Fronds probably bipinnate, ovate-lanceolate, markedly dissected, very graceful in general aspect, with a slender, ventrally sulcate rachis. Lateral pinnae alternate, open nearly at a right angle at the base of the frond and becoming more acute apically, close, slightly overlapping, lanceolate; rather rigid in general aspect, tending to be decurrent. Pinnules obcuneate or oblanceolate, the upper ones distant, very oblique to nearly erect at the top of the pinna, asymmetrical, bluntly narrowed at the apex and bluntly bidenticulate or tridenticulate at the top, slightly decurrent.

Nervation rather coarse. Primary nerve diverging gradually from the rachis and forking 4 to 5 times at a narrow angle; the lateral nerve forking once or twice while passing straight or slightly arched and nearly parallel to the apex.

This species is characterized by its narrowly obcuneate or oblanceolate pinnules with deeply dissected lobes that are bluntly rounded or bluntly dentate at the apex, the erect venation, the narrowly lanceolate pinnae that appear stiff and rigid, and finally by the generally fragile yet graceful aspect.

Although large collections numbering hundreds of specimens of *Triphyllopteris* have been examined, this beautiful species is apparently rare. The forms here described as *T. rarinervis* and *T. bilobata* are apparently similar but must be regarded as distinct. The points of distinction will be indicated in connection with the descriptions of those species.

From *Triphyllopteris alleghanensis* Meek this species differs in the much narrower pinnules or pinnule lobes, in its somewhat more rigid aspect, in the generally larger pinnule size, and in the venation.

Localities 10–14, 17–22, and 28–30.

Triphyllopteris latilobata Read, n. sp.

Plate 8, figures 1–3; plate 10, figure 5

Fronds bipinnate, linear lanceolate, inclined to be slightly lax. Rachis petiolate, of medium width, rugose.

Pinnae fairly close, not uncommonly overlapping slightly, alternate to subopposite; broadly ovate to narrowly ovate in outline; set at an open angle on the rachis.

Pinnules obliquely placed on the pinnae rachides; the basal pinnules very broad, often squarrose, sessile, tending to be heteromorphous; the other pinnules narrower although markedly ovate, sessile and tending to be broadly attached; the pinnules chiefly simple, becoming bilobed or trilobed only in the upper portion of the frond and in the apical and subapical portions of the pinnae; the lobes usually shallowly incised.

Venation palmate.

Triphyllopteris latilobata is distinguished from *T. lescuriana* by the broader, less rhomboidal pinnules that are more broadly attached, by the rarity of lobate or sublobate pinnules, and by the tendency towards laxity. The distinction is at times rather difficult, suggesting a transitional series. However, the common forms of the two species are recognized readily, and in consequence separation is attempted.

Localities 13, 15, 16, 18, 19, 21, and 23.

Triphyllopteris virginiana (Meek) Read, n. comb.

1880. *Cyclopteris virginiana* Meek, Philos. Soc. Washington Bull., v. 2, app. 8, p. xviii 43, pl. 1, fig. 3.

Although a large number of specimens from Lewis Tunnel, Greenbrier County, W. Va., near Alleghany Station, Va., have been examined, no fragments seem referable to the species described by Meek as *Cyclopteris virginiana*. It thus appears probable that there was a paucity of the material in the first place, that is, the plant is a rare one; and also it is to be borne in mind that in all probability many plant-bearing horizons were penetrated in the cutting of the tunnel and that these are no longer exposed.

Meek's description, which may not be available to many paleontologists, is as follows:

> Frond apparently attaining a large size, and probably tripinnate. Primary pinnae with a rather stout, rigid, smooth, or slightly striated rachis. Secondary pinnae long lanceolate, regularly alternating, nearly straight, rather closely arranged, and standing nearly or quite at right angles to the rachis. Pinnules more oblique, rather approximate and regularly alternating; lower or inner ones shorter and broader than the

others, abruptly narrowed, or apparently sometimes subcordate at the base, and attached to the rachis by an extremely short petiole, more or less distinctly trilobate, the lobes being obtuse, and broad ovate in form; succeeding pinnules gradually becoming five-lobed, more elongated, or obtusely sublanceolate, more oblique, and less abruptly tapering at the base; beyond these, the others are less and less strongly lobed, or merely undulated on the margins, while a few near the extremities of the pinnae are quite simple, still more oblique, and very gradually tapering to, and more or less decurrent upon, the rachis. Nervation distinct, nerves slender, palmately spreading, and bifurcating several times.

Localities 20 and 21.

Triphyllopteris rarinervis Read, n. sp.

Plate 7, figures 1, 2; plate 12, figures 3, 4; plate 13, figure 3

Fronds at least bipinnate, inclined to be broadly lanceolate, rather rigid, the pinnae set at a slightly acute angle in the lower portion of the frond and becoming more acute distally.

Rachis rugose, heavy. Secondary pinnae slightly overlapping, dense, alternate, or subopposite, linear to oblong ovate, slightly decurrent on the main axis.

Pinnules large, decurrent, attached by a broad and short stalk, chiefly broad ovate but ranging to narrower forms, wedge-shaped basally, the basal pinnules on the pinnae, particularly in the lower parts of the frond, tending to be very broad and slightly heteromorphous. Lobation varying from entire forms to bilobate or trilobate, the entire or unlobed forms commonest, and the lobation, when it occurs, not deep cut. Terminal pinnules bilobate or trilobate are rounded apically.

Venation obscure, a single nerve apparently entering the base of the pinnule and by repeated dichotomy giving rise to a series of distant bundles that pass subparallel to the margin.

This is a very distinct species and includes the largest forms of this genus yet known. Its typical form with the broad pinnules is readily recognized.

Localities 19 and 21.

Triphyllopteris biloba Read, n. sp.

Plate 9, figures 3–5; plate 11, figure 3

Pinnae close, overlapping, the pinnules and lobes smaller than in *Triphyllopteris lescuriana*, sessile, and pinnules open; lobes erect and oblique, presenting a fasciculate aspect and usually very narrow. Nerves indistinct, fine, close, running nearly parallel to the apex of the pinnule or lobe.

This species is a smaller, much more compact type than *T. lescuriana*, to which it is unquestionably closely related. As is suggested by the name, the bilobate condition of the pinnules is very common, the two lobes usually being of the same length. The pinnules are usually bluntly rounded at the apex.

The type specimens of *Triphyllopteris biloba* are chosen from a long series indicated by Meek as *T. lescuriana.*

Localities 13 and 21.

Genus LAGENOSPERMUM Nathorst

Lagenospermum imparirameum Arnold

1939. *Lagenospermum imparirameum* Arnold, Torrey Bot. Club Bull., v. 66, no. 5, p. 297–303, figs. 1–10.

Seeds borne in cupules or sheaths on slightly unequally dichotomous branches; the cupules paired or in fours. Cupules approximately 3 millimeters broad and 10 millimeters long, formed by 5 bracts that are fused below, are free above, and are acutely pointed apically. Seeds single in each cupule, apparently borne on very short pedicels, enclosed almost completely by the sheath and scarcely visible. Seeds, oval, about 2 millimeters in diameter and about 5 millimeters in length, radiospermic. Details unknown.

The general aspect of the material that is referred by Arnold to this species is seen in the figures. In fact, plate 17, figure 8, reproduces a photograph of one of Arnold's type specimens. The cupular nature of these fossils, as they appear ordinarily, is quite apparent. They are readily mistaken for polliniferous organs, and were it not for Arnold's careful work in demonstrating the presence of seeds it is probable that they would be at this time placed in that category.

Arnold records this species from Fishing Creek Gap (High Bridge), near Pine Grove, Pa., and from Merrimac mine in Price Mountain, Montgomery County, Va. In addition, he states that a few specimens were seen in a collection from the lower part of the Pocono formation on Horeshoe Curve of the Pesnnsylvania Railroad, Blair County, Pa. The writer has not been able to specifically confirm this latter identification.

Localities 11 and 13.

LEPIDODENDRALES

Genus LEPIDODENDROPSIS Lutz

1933. *Lepidodendropsis* Lutz, Palaeontographica, Band 78, Abt. B, p. 118–130.

Genotype.—*Lepidodendropsis hirmeri* Lutz.

Lepidodendron-like plant remains with small, elongate, longitudinally directed, closely appressed, generally spindle-shaped, leaf bolsters of the general type of *Sublepidodendron* Nathorst; leaf scars indistinct, without accompanying ligule and without parichnos scar; vascular strand single; margins of the bolsters distinctly raised into narrow ridges or lines.

Lepidodendropsis has long been known in America, the literature usually referring to it as "*Lepidodendron scobiniforme*" Meek (1880, p. xii–xv, 38–40, pl. 1, fig. 1), or "the group of *Lepidodendron scobiniforme* Meek," or "*L. corrugatum* Dawson (1859, p. 68, figs. 2a, 2b)." Such material is, in fact, relatively common in the lower Mississippian coal-bearing clastic formations such as the Pocono formation, the Price sandstone, and the Horton series, all of which lie in the central and northern portions of the Appalachian trough. The genus is a very distinct one and deserves to be separated from *Lepidodendron.* It is not readily confused with other American types. *Lepidodendropsis* is known in Europe from abundant material of the genotype, *Lepidodendropsis hirmeri* Lutz, from the Lower Carboniferous strata in Bavaria, Germany. In America it was identified by Jongmans, Gothan, and Darrah (1937, p. 429–441) prior to the present paper. These writers listed as new species, *Lepidodendropsis cyclostigmatoides*, *L. vandergrachtii*, and *L. sigillarioides.* Neither *Lepidodendropsis corrugatus* (Dawson) nor *L. scobiniformis* (Meek) were included among the described species as new combinations, although, according to the authors, they may be referable to the genus *Lepidodendropsis.* These writers seemed to prefer to use new names rather than the older names which they apparently did not regard very highly, although these older species are based on adequate material and the illustrations are as well executed in the older as in the more recent contributions.

According to Jongmans, Gothan, and Darrah, *Lepidodendron corrugatum* Dawson may be identified with *Lepidodendropsis hirmeri* Lutz (1933, p. 118–130). If this is correct, and it can be determined only after very careful comparison of actual specimens, then it follows that *Lepidodendropsis hirmeri* Lutz becomes a synonym of *Lepidodendron corrugatum* Dawson, and the latter becomes the genotype. This is, of course, purely speculative and as has been remarked above, cannot be stated as a fact until close comparison of the specimens has been made.

Lepidodendropsis vandergrachti Jongmans, Gothan, and Darrah

Plate 18, figure 4; plate 20, figures 4, 5

1937. *Lepidodendropsis vandergrachti* Jongmans, Gothan, and Darrah, 2ème congrès pour l'avancement des études de stratigraphie carbonifère, Compte rendu, tome 1, p. 436–439, pl. 52, figs. 33, 34; pl. 53, fig. 35; pl. 54, figs. 36–38; pl. 58, fig. 49.

Leaf bolsters arranged in nearly perfect horizontal and vertical rows, very broadly rhomboidal; the basal portion of the bolsters more attenuate than the apical portion; leaf scars situated in the upper portion of the bolsters; large, oval, somewhat broader than long, carrying a centrally located, small vascular scar and below it an indistinct marking which has been interpreted as the parichnos scar; bolsters closely rather than widely spaced, bordered by broadly rounded raised areas.

The writer has had only the rather poor halftones of Jongmans, Gothan, and Darrah, made from inferior specimens, as a basis for his identifications. However, there can be little doubt as to the specific reference, the critical features of leaf bolsters being quite apparent in the illustrations referred to above.

A comparison of the illustrations of the type lot with the specimens illustrated in this paper indicates the very close similarity. The very broad bolsters, rounded rather than angular; the large, oval, transversely elongate leaf scar; the centrally located vascular strand as well as the scar below the vascular strand that has been doubtfully interpreted as a parichnos scar, are all features that set this species apart from material now known and referable to other species of the genus *Lepidodendropsis* Lutz.

The parichnoslike scar perhaps merits some discussion. The precise identification of these markings is very difficult. The bolsters are not distinct on the leaf bases, but judging from the position of the small scars there can be very little doubt concerning the parichnoian nature.

This species is fairly common, being known from a number of localities in the anthracite region of northeastern Pennsylvania as well as in the Virginia region.

Localities 11–13, 22, 24, 26, and 27.

Lepidodendropsis scobiniformis (Meek) Read, n. comb.

Plate 19, figures 3–5; plate 20, figures 1–3

1880. *Lepidodendron scobiniforme* Meek, Philos. Soc. Washington, Bull., v. 2, app. 8, p. xiii–xv, 38–40, pl. 1, fig. 1.

Bolsters elongate, rhomboidal, about three-eights of an inch long and about one-eighth of an inch wide, slightly angular, arranged in a very close spiral so that the adjacent bolsters appear to be in nearly horizontal as well as vertical rows. Bolster margins clearly marked by narrow, raised areas; lower portion of the bolsters devoid of any markings; the leaf scars indistinct, situated in the upper portion of the bolsters, somewhat quadrangular, the angles somewhat rounded; vascular strands centrally located, but the details not apparent.

The original specimen of this species came from Lewis Tunnel on the Chesapeake and Ohio Railroad in Alleghany County, Va., near White Sulphur Springs, W. Va. Associated with *Lepidodendropsis scobiniformis* are *Triphyllopteris lescuriana*, *T. virginiana*, and *T. alleghanensis*.

Lepidodendropsis scobiniformis has long been recognized by various geologists as a rather good index fossil of the Pocono formation and its equivalent, the Price sandstone in Virginia. In a number of localities where the coal-bearing shale facies of this formation is developed, the species, or one closely related, occurs in profusion.

There can be no doubt that *Lepidodendron scobiniforme* Meek is more correctly referable to *Lepidodendropsis*. The rather angular bolsters, the very indistinct leaf scars, the absence of parichnos and ligules, and the generally smooth bolster surface set off by raised margins point to its affinity with Lutz' genus. *Lepidodendropsis scobiniformis* is evidently identical with Jongman, Gothan, and Darrah's (1937, p. 431–434) *Lepidodendropsis hirmeri* Lutz, if one may judge accurately from the figures of those authors. Thus, there comes up the question of treatment of a named American species which may be synonomous with an European form. For the time being, the writer is following the rather questionable procedure of ignoring the assignment of the European name to the species, owing to the lack of material of *L. hirmeri* for comparison. Furthermore, if it does develop that *L. hirmeri* and *L. scobiniformis* are identical, then *L. scobiniformis* will stand and *L. hirmeri* will become the synonym. The continued use of both names will serve a useful purpose, however, if each is restricted to the continent from which it was originally described.

It has not been possible to examine type material, or even specimens identified by Dawson, of *Lepidodendron corrugatum*, but that species is probably identical with *Lepidodendropsis scobiniformis;* and if further investigation demonstrates that fact, then *L. scobiniformis* will in turn become a synonym of the earlier *L. corrugatum*.

As has been stated above, *Lepidodendropsis scobiniformis* is a very common species in the Pocono, occurring at most localities where a considerable amount of plant material is obtainable.

Localities 11–14, 17, 18, 21, 24, 25, and 27.

Lepidodendropsis sigillarioides Jongmans, Gothan, and Darrah

Plate 19, figures 1, 2

1937. *Lepidodendropsis sigillarioides* Jongmans, Gothan, and and Darrah, 2ème Congrès pour l'avancement des études de stratigraphie carbonifère, Compte rendu, tome 1, p. 438–441, pl. 55, figs. 39–41; pl. 56, figs. 42–44.

A number of fragments of this species are set apart because of the very apparent vertical and horizontal alignment of the bolsters and leaf scars as well as the vertical ribbing. One of these specimens is here illustrated. In no example seen by the writer has preservation been sufficiently good to warrant comment.

Localities 12, 13, 25, and 27.

MAUCH CHUNK SHALE AND EQUIVALENT FORMATIONS

Genus SPHENOPTERIDIUM W. P. Schimper 1874

1874. *Sphenopteridium* W. P. Schimper, Traité de paléontologie végétale, tome 3, p. 487.

Genotype.—*Sphenopteridium dissectum* (Goeppert) W. P. Schimper.

Frond bipinnate, rachis heavy, characteristically transversely rugose, owing to apparently heavy sclerotic bands in the cortex; dichotomous usually below leafy portion of frond; the dichotomy usually an acute angle. Pinnules obliquely set, sphenopteroid, wedge- to rhomboid-shaped and usually somewhat dissected; contracted at the base, and seated on the axis of the ultimate pinna by a short footstalk. Venation sphenopteroid, veins numerous.

This genus is generally characteristic of the Lower Carboniferous in Europe. It has not been previously recorded in America.

Sphenopteridium virginianum Read, n. sp.

Plate 1, figures 7, 8, 9

Fronds bipinnate and probably tripinnate. Ultimate pinnae alternate to subalternate, set at an angle of about 45°, lanceolate and not very long. The rachis of the ultimate and subultimate pinnae longitudinally coarsely striate, the striate widely spaced. Pinnules crowded, slightly overlapping, deltoid, cuneate at the broad, short-stalked base, obtuse apically, and deeply cut into 2 to 5 narrow, linear, obliquely set lobes.

Nervation partly obscured, originating in one or possibly more strands at the base, running upward, and dichotomizing to supply the several lobes with one or more veins.

The assignment of this species to the genus *Sphenopteridium* is perhaps questionable. In the general form of the pinnules and in the nervation, the agreement with *Sphenopteridium dissectum* (Kidston, 1923a, p. 160–163), for example, is rather close. However, the specimens seen fail to show the transverse rugosities so characteristic of the genus. In fact, were it not for the longitudinal markings, the specimen would be assigned to *Spathulopteris* Kidston (1923a, p. 172, 173).

Sphenopteridium virginianum differs from *S. girtyi* in its more erect and elongated pinnules, which are more deeply dissected; the latter also has rugose axes which distinguish it. From *S. brooksi*, *S. virginianum* is separated by the absence of transverse rugosites and by the marked dissection of the pinnules.

Locality 32.

Sphenopteridium brooksi Read, n. sp.

Plate 1, figures 10, 11, 14

Frond small, slender, bipinnate, dichotomous below, the angle about 30°. Rachis longitudinally striate and transversely rather sparingly rugose. The rachis below the dichotomy carrying subopposite short pinnae which are clothed with distant to crowded, lobed pinnules and pinnatifid pinnules; the pinnae in this portion of the frond never crowded and giving a rather loose appearance. The divisions above the dichotomy bipinnate, the pinnae forming an angle of 30° to 60° with the main rachis, the pinnae rather crowded, tending to overlap. Pinnae lanceolate, rigid; axis slender, carrying multilobate pinnules below and 2- to 5-lobate pinnules distally. Pinnules ovate-cuneate in outline, but this modified by lobation, the lobes frequently slender, although more rounded than in *Sphenopteridium virginianum*. Venation obscure, apparently similar to *S. virginianum*.

From *Sphenopteridium girtyi* this species is to be distinguished by its more robust habit, its thicker corrugated rachis, the more erect position of the generally closer pinnules, and the less distinctly cuneate form of the latter. At the same time it is separated from *S. virginianum* by the narrower, laciniate pinnules as well as by the narrower, more delicate rachis of the latter.

Locality 33.

Sphenopteridium girtyi Read, n. sp.

Plate 1, figures 1–6

Fronds imperfectly known, probably not very large.

Pinnae lanceolate or linear, slender; the axes narrow, and densely clothed with markedly decurrent pinnules which tend to overlap slightly. Pinnules pointed and cut into 3 to 5 narrow and often outwardly curved lobes, which in turn may be incised slightly into 2 to 3 lobes. Lamina rather thick. Nervation springing from the median zone of the rachis at a very oblique angle and passing outward, apparently as 2 to 3 nerves into the pinnule, where there is palmate division as a result of successive dichotomies, the nerves being fairly widely spaced.

Occurring on slabs of shale with the pinnae just described are occasional fragments of larger axes marked by the longitudinal striations and short, irregular, transverse ridges which are recognized as so characteristic of *Sphenopteridium*. This associated material suggests that the generic reference should be *Sphenopteridium* rather than *Spathulopteris* (Kidston, 1923a, p. 170–172).

Sphenopteridium girtyi recalls to some extent the European *S. speciosum* Kidston (1923, p. 170–172) in the general aspect of the pinnae and in pinnule form. However, *S. girtyi* is somewhat larger and the pinnule lobes hardly so slender.

Locality 33.

Genus CARDIOPTERIS W. P. Schimper 1869

Cardiopteris abbensis Read, n. sp.

Plate 2, figures 1–3

Known only from abundant isolated pinnules that range in size from 1–3 centimeters in width and 1–4 centimeters in length; the general aspect of the pinnules round-cordate, symmetrical, the apex either very gently rounded or slightly elongate with sharper rounding. Venation radiates from the point of attachment of the pinnule to the rachis, no midrib evident. Texture probably coriaceous.

This species is known from abundant specimens from the basal Bluefield shales in the vicinity of Abbs Valley, Va. Numerous isolated petiole fragments and stems are likewise present but cannot be related with certainty to this species.

In the rotundity of the cordate pinnules and in their small size this species stands well apart from other forms here described and cannot be confused with Pocono types.

Locality 34.

Genus ADIANTITES Goeppert, emend.

Adiantites beechensis Read, n. sp.

Plate 10, figures 3, 4

Ultimate pinnae close, alternate, narrowly oblong, with rather slender, flexuose rachis. Pinnules alternate, ranging from deltoid-ovate, trilobate, and short-stalked to oblong, obtusely rounded, 4- to 6-lobed, the lobes deeply parted, obovate, with a rhomboidal and sublobate terminal. Nervation distinct, with a primary nerve continuing apically for about one-third to one-fourth of the distance and giving off decurrent and arching secondaries. The primary nerve gradually diffuses into similar secondaries, all of which fork once or twice in passing to the margins of the pinnules.

This species, so named because of its occurrence at Beach Fork, Randolph County, W. Va., is readily distinguished by its obovate-cuneate and lobate pinnules and by its small size. In its general aspect this form is suggestive more of the Pottsville types than of the Mississippian types.

Locality 33.

Genus CARPOLITHES Schlotheim

1820. *Carpolithes* Schlotheim, Petrefactenkunde, p. 418.

Genotype.—*Carpolithes abietinus* Schlotheim.

Carpolithes virginianus Read, n. sp.

Plate 1, figures 12, 13

Associated with the fragments of *Sphenopteridium virginianum* and attached to an axis that is marked by the same distant longitudinal markings as is the axis of *S. virginianum* is a small seed rather similar to that described as characteristic of *Aneimites fertilis* White but differing in the more rounded outline and narrower border as well as in the larger size. The seed coat is traversed by slender, subparallel ribs which form an annular border at the apex. The seed is slightly decurrent on the stem, but there can be little room for doubt concerning its attachment or the association with *S. virginianum*, although the exact morphological relationships are unknown.

Locality 32.

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INDEX

[Italic numbers indicate description]

PLATES 1–20

PLATE 1

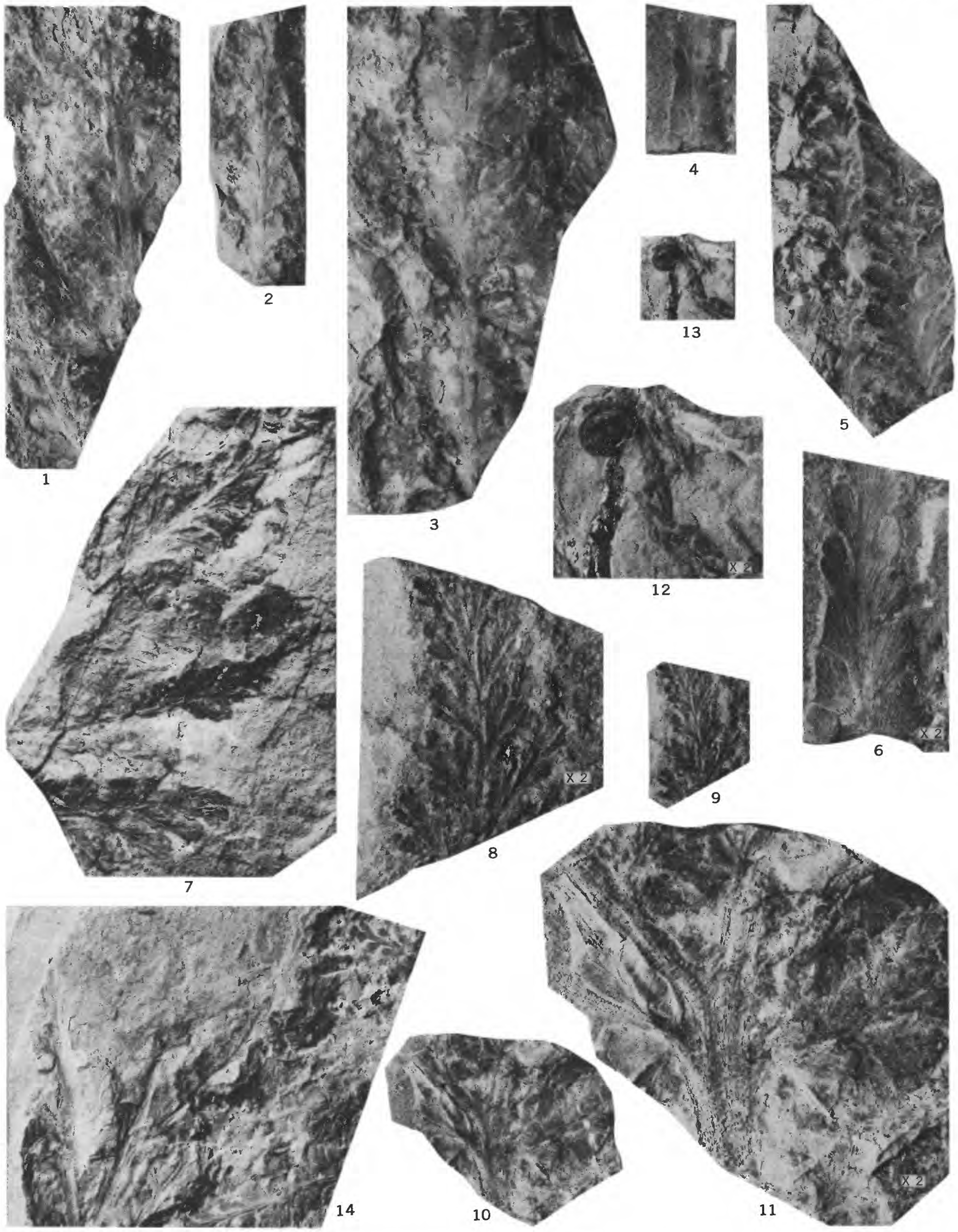
[All figures natural size unless otherwise indicated on plate]

FIGURES 1–6. *Sphenopteridium girtyi* Read, n. sp. (p. 28).
1–5. General features of organization of frond. Loc. 33. 1, USNM 40675. 2, USNM 40676. 3, USNM 40677. 4, USNM 40678. 5, USNM 40679.
6. The details of venation. Loc. 33. USNM 40678.

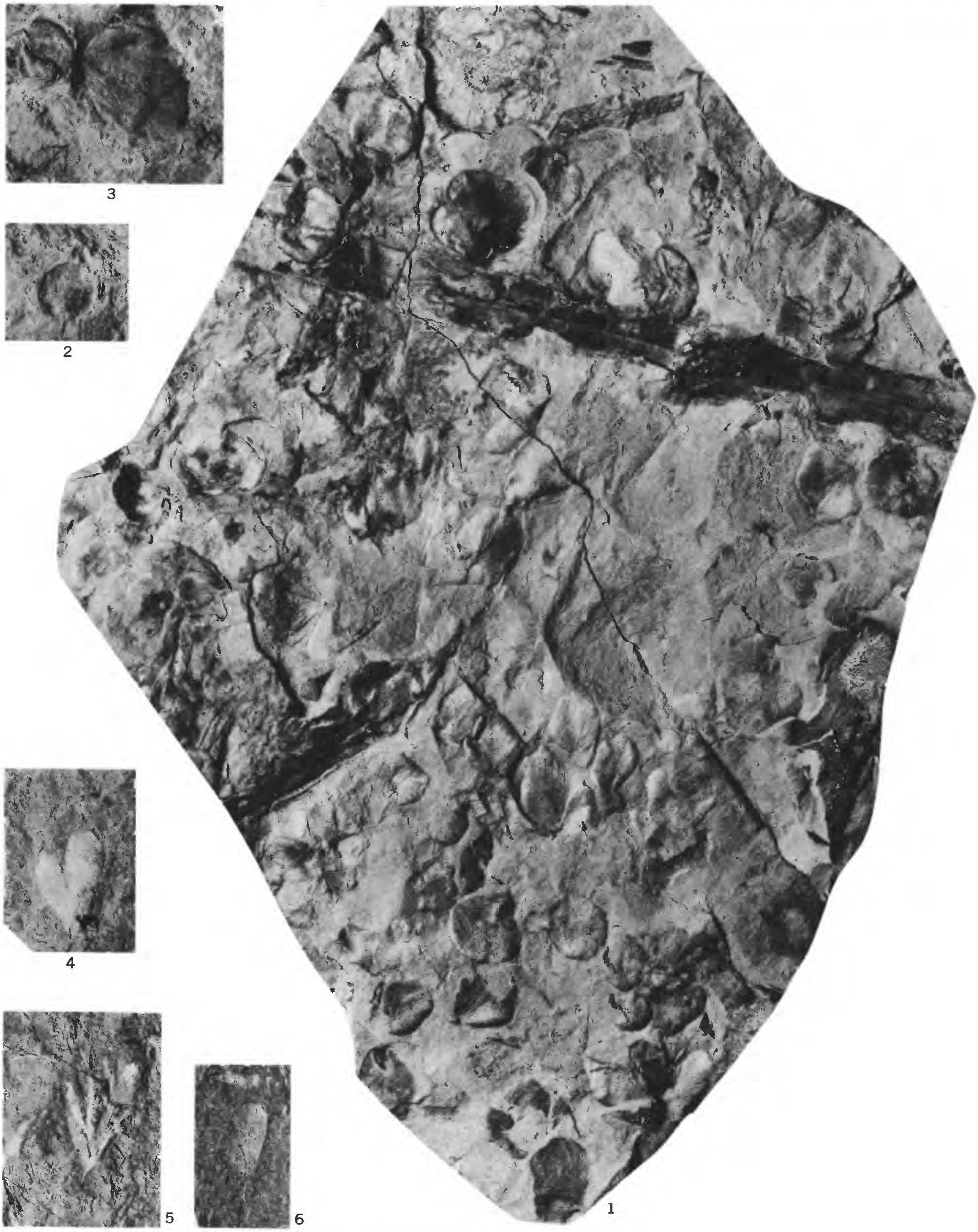
7–9. *Sphenopteridium virginianum* Read, n. sp. (p. 27).
7, 9. Form of pinnule and pinna. Loc. 32. 7, USNM 40636. 9, USNM 40637.
8. The venation. Loc. 32. USNM 40637.

10, 11, 14. *Sphenopteridium brooksi* Read, n. sp. (p. 28).
Features of frond. Note the dichotomy of the rachis. Loc. 33. 10, 11, USNM 40654. 14, USNM 40655.

12, 13. *Carpolithes virginianus* Read, n. sp. (p. 29)
Form of the seed. Loc. 32. USNM 40698.



SPHENOPTERIDIUM AND *CARPOLITHES*



3 2 4 5 6 1

CARDIOPTERIS AND *ADIANTITES*

PLATE 2

[All figures natural size]

FIGURES 1–3. *Cardiopteris abbensis* Read, n. sp. (p. 28)
Isolated pinnules, showing form and venation. This species is known only from such material. Loc. 34. 1, USNM 40680. 2, USNM 40681. 3, USNM 40682.

4–6. *Adiantites ungeri* Read, n. sp. (p. 17)
Isolated pinnules referred to this species, showing variation in size and form. Loc. 1 and 2. 4, USNM 40660. 5, USNM 40661. 6, USNM 40662.

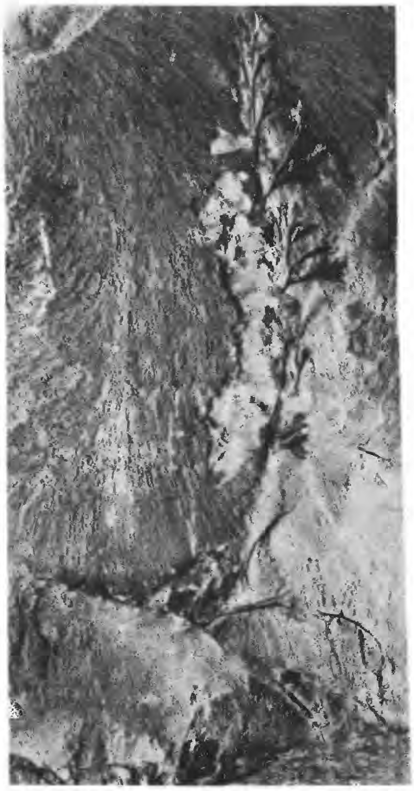
PLATE 3

[All figures natural size unless otherwise indicated on plate]

FIGURES 1, 2. *Rhodea blacksburgensis* Read, n. sp. (p. 22)
Fragment of a pinna showing the slender, angular, flexuose nature, and the relatively compact, highly divided pinnules. Loc. 20, 21, 28, 30. USNM 40656.

3, 4. *Rhodea vespertina* Read, n. sp. (p. 22)
Several fragmentary pinnae, the pinnules of which are somewhat larger and with broader lobes than in *R. blacksburgensis* Read, n. sp. Loc. 10–14, 17–21. USNM 40639.

5. *Adiantites cardiopteroides* Read, n. sp. (p. 18)
Fragment of a pinna. Loc. 8. USNM 40683.



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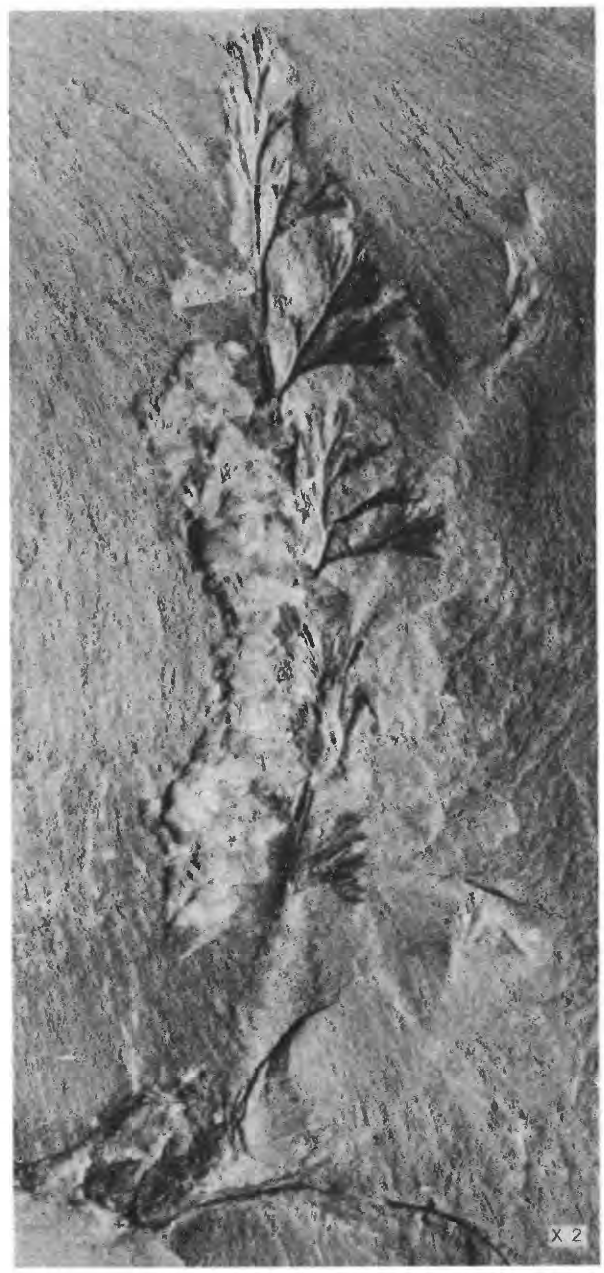

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RHODEA AND *ADIANTITES*

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RHODEA

PLATE 4

[All figures natural size unless otherwise indicated on plate]

FIGURES 1–4. *Rhodea vespertina* Read, n. sp. (p. 22)

General aspect and details of pinnae of this species. The form in figures 1 and 2 is typical of the species, whereas that seen in figures 3 and 4 is more nearly like *Rhodea blacksburgensis*. Loc. 10–14, 17–21. 1, 2, USNM 40638. 3, 4, USNM 19923.

PLATE 5

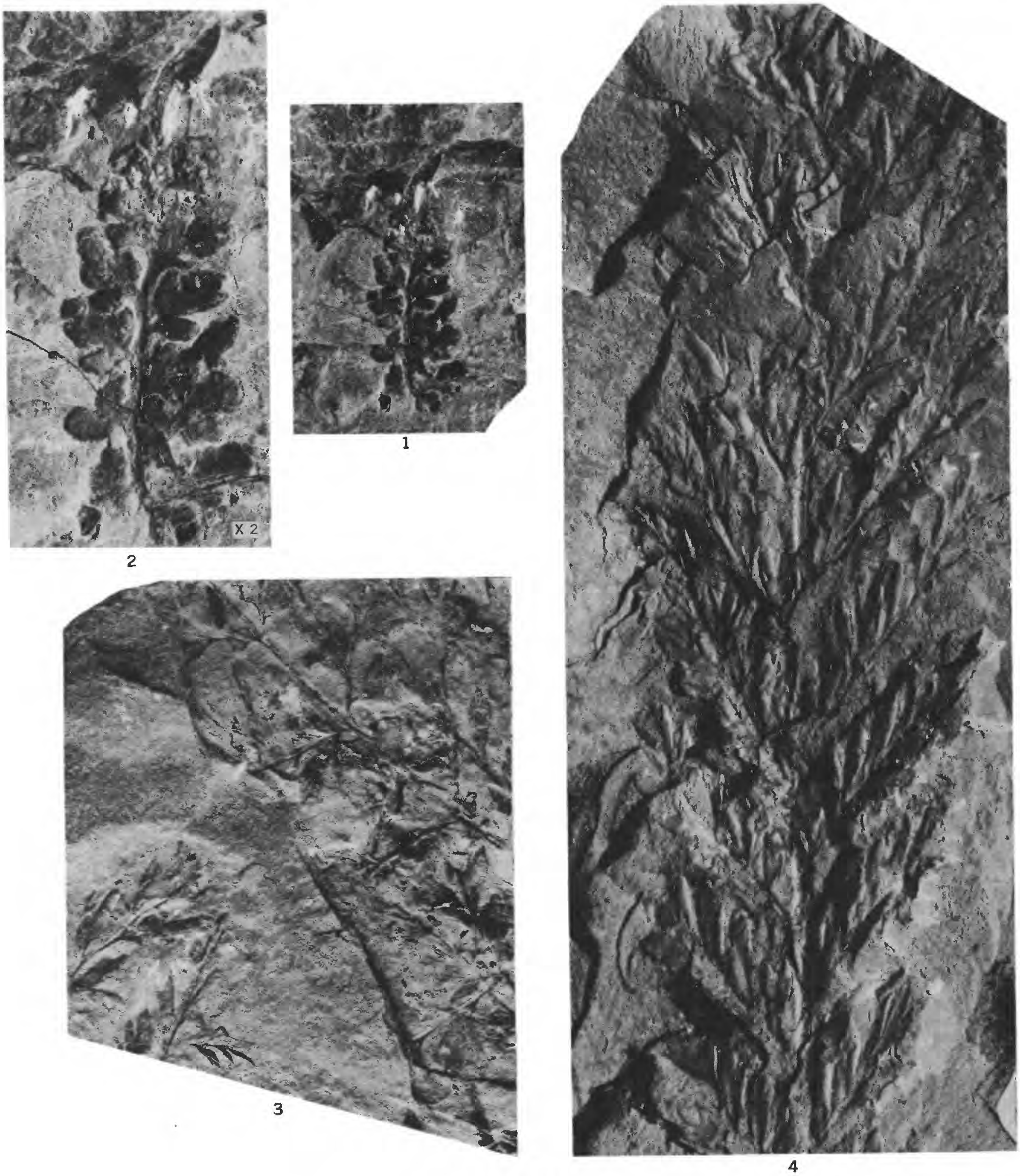
[All figures natural size unless otherwise indicated on plate]

FIGURES 1, 2. *Triphyllopteris alleghanensis* (Meek) Read, n. comb. (p. 23)

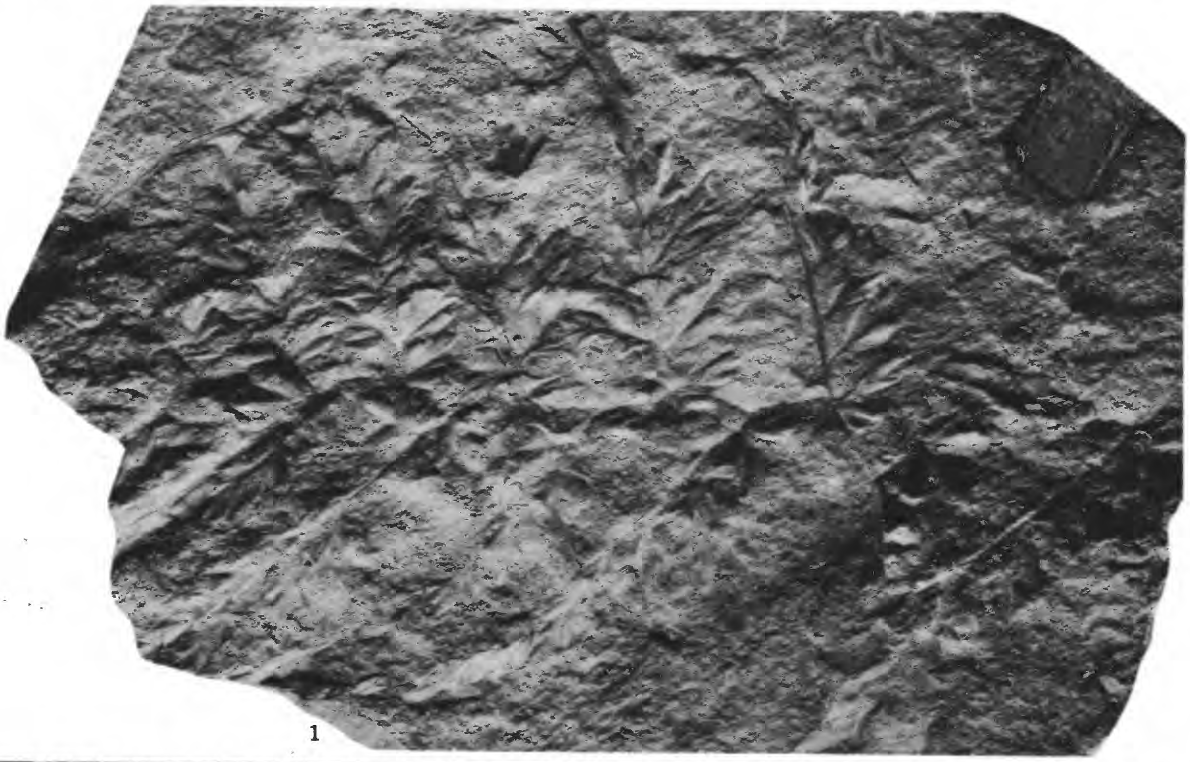
Fragment of a pinna showing the small oval pinnules. The general aspect suggests some of the Diplothmemas of the Pennsylvanian. Loc. 20. USNM 40689.

3, 4. *Triphyllopteris lescuriana* (Meek) Lesquereux (p. 24)

Large pinnae showing general rigidity of the ultimate pinnae and pinnules and the form of the pinnules. Loc. 10–14, 17–22, 28–30. 3, USNM 40644. 4, USNM 1467.



TRIPHYLLOPTERIS



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TRIPHYLLOPTERIS

PLATE 6

All figures natural size]

FIGURES 1–3. *Triphyllopteris lescuriana* (Meek) Lesquereux (p. 24)

Considerable portions of fronds, showing the rigid aspect of the markedly lobed, narrow, apically pointed pinnules. Note the generally erect nature of the pinnae. Loc. 10–14, 17–22, 28–30. 1, USNM 2190. 2, USNM 40704. 3, USNM 19956.

PLATE 7

[All figures natural size]

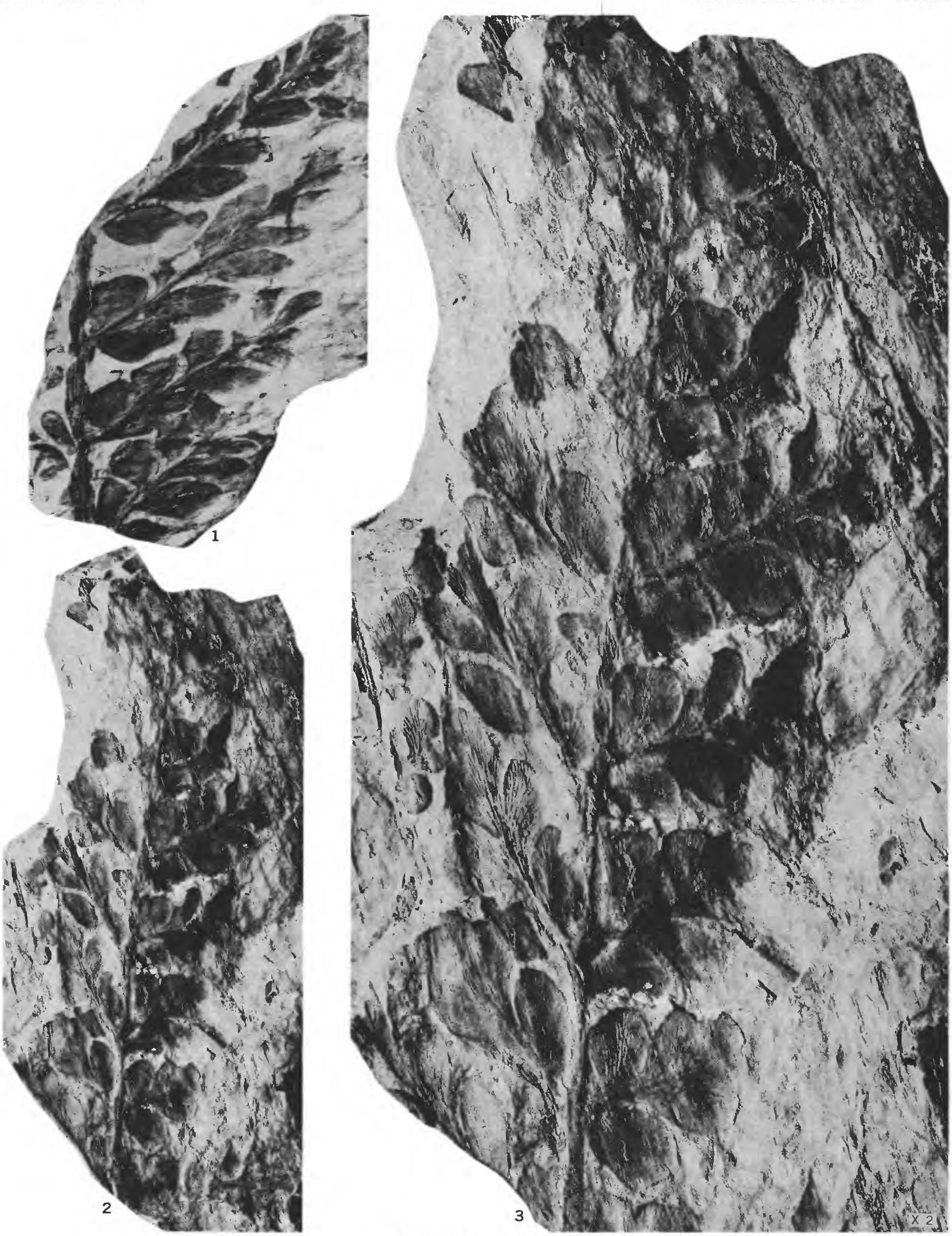
FIGURES 1, 2. *Triphyllopteris rarinervis* Read, n. sp. (p. 25)

Specimens showing the large rhomboidal pinnules, the general aspect of the frond, and the distant venation in specimens of considerable portions of fronds. Loc. 19 and 21. 1, USNM 19934. 2, USNM 40641.

3. *Adiantites spectabilis* Read, n. sp. (p. 17)

Fragment of the rather angular rachis with pinnae departing at a right angle. Fragments of pinnae are seen to the right. Loc. 3–7. USNM 40634.

TRIPHYLLOPTERIS AND *ADIANTITES*



TRIPHYLLOPTERIS

PLATE 8

[All figures natural size unless otherwise indicated on plate]

FIGURES 1, 2, 3. *Triphyllopteris latilobata* Read, n. sp. (p. 24)

Frond fragments, natural size and enlarged, showing the relatively large oval pinnules and the extremely broad basal pinnules. Note the close venation indicated in the enlargement, figure 3. It is possible that the specimen shown in figure 1 is slightly distorted by the intense pressure to which the shale has been subjected. Loc. 13, 15, 16, 18, 19, 21, 23. 1, USNM 40693. 2, 3, USNM 40694.

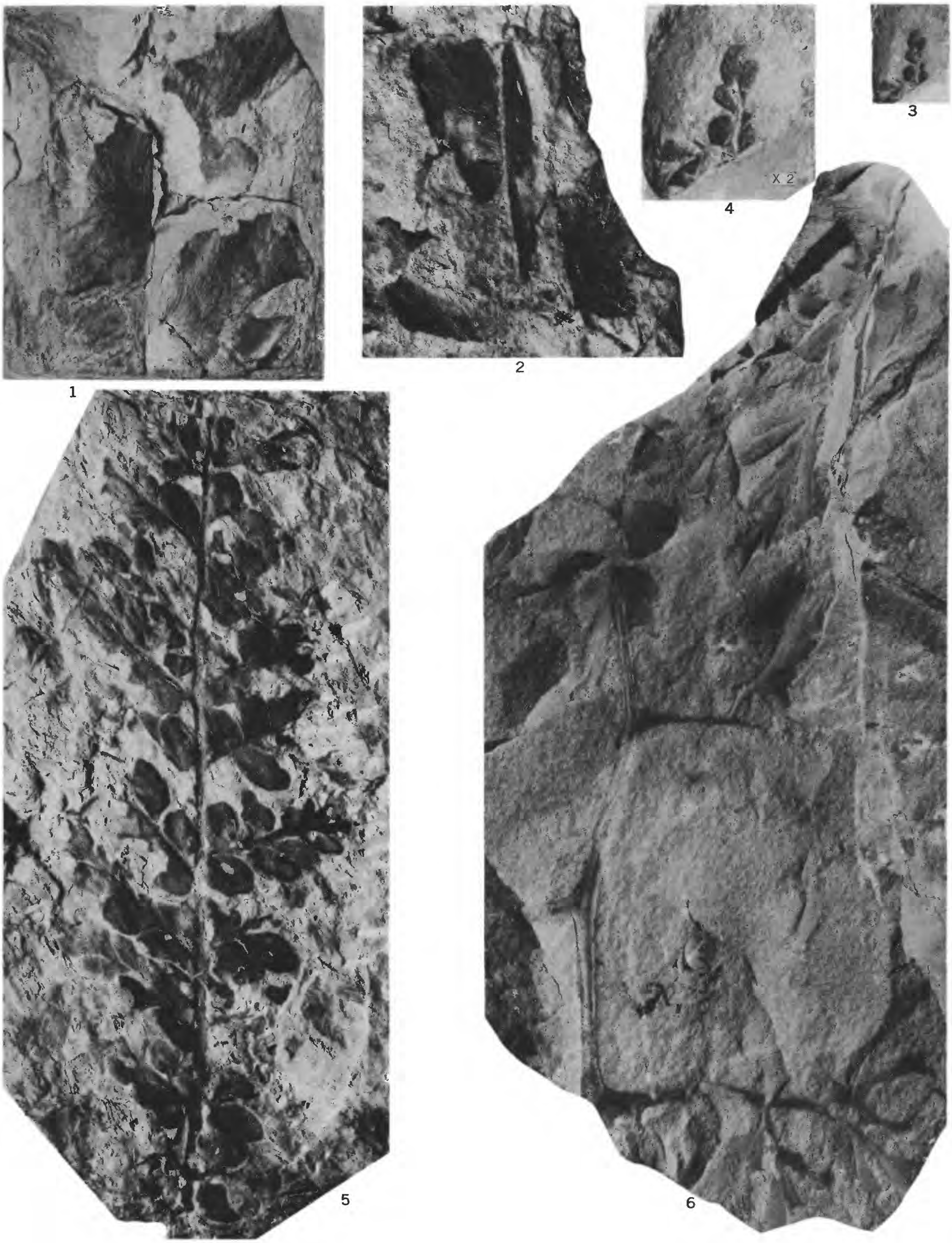
PLATE 9

[All figures natural size unless otherwise indicated on plate]

FIGURES 1, 2. *Cardiopteris antecedens* Read, n. sp. (p. 22)
Distal portion of a pinna showing the rhombic terminal (fig. 1) and a fragment (fig. 2) with more rounded pinnules. Loc. 11. 1, USNM 40645. 2, USNM 40690.

3–5. *Triphyllopteris biloba* Read, n. sp. (p. 25)
Specimens showing the rigid-appearing pinnae and pinnules, and the small, separate, narrow, and pointed lobes. Loc. 13 and 21. 3, USNM 40703. 4, 5, USNM 40635.

CARDIOPTERIS AND *TRIPHYLLOPTERIS*



CARDIOPTERIS, *ADIANTITES*, AND *TRIPHYLLOPTERIS*

PLATE 10

[All figures natural size unless otherwise indicated on plate]

FIGURES 1, 2. *Cardiopteris irregularis* Read, n. sp. (p. 21)
Opposite sides of the same specimen, showing the pinnule form and venation. Loc. 31. 1, USNM 40663. 2, USNM 40664.

3, 4. *Adiantites beechensis* Read, n. sp. (p. 28)
Apical fragment showing the *Aneimites*-like form of the pinnules. Loc. 33. USNM 40699.

5. *Triphyllopteris latilobata* Read, n. sp. (p. 24)
Large pinna showing ultimate pinnae and the oval pinnules. Loc. 13, 15, 16, 18, 21, 23. USNM 40695.

6. *Adiantites spectabilis* Read, n. sp. (p. 17)
A slab showing a sinuous rachis to which is attached several pinnae carrying pinnules dissected into rather linear lobes. Loc. 3–7. USNM 40665.

PLATE 11

[All figures natural size unless otherwise indicated on plate]

FIGURES 1, 2. *Adiantites cyclopteroides* Read, n. sp. (p. 18)

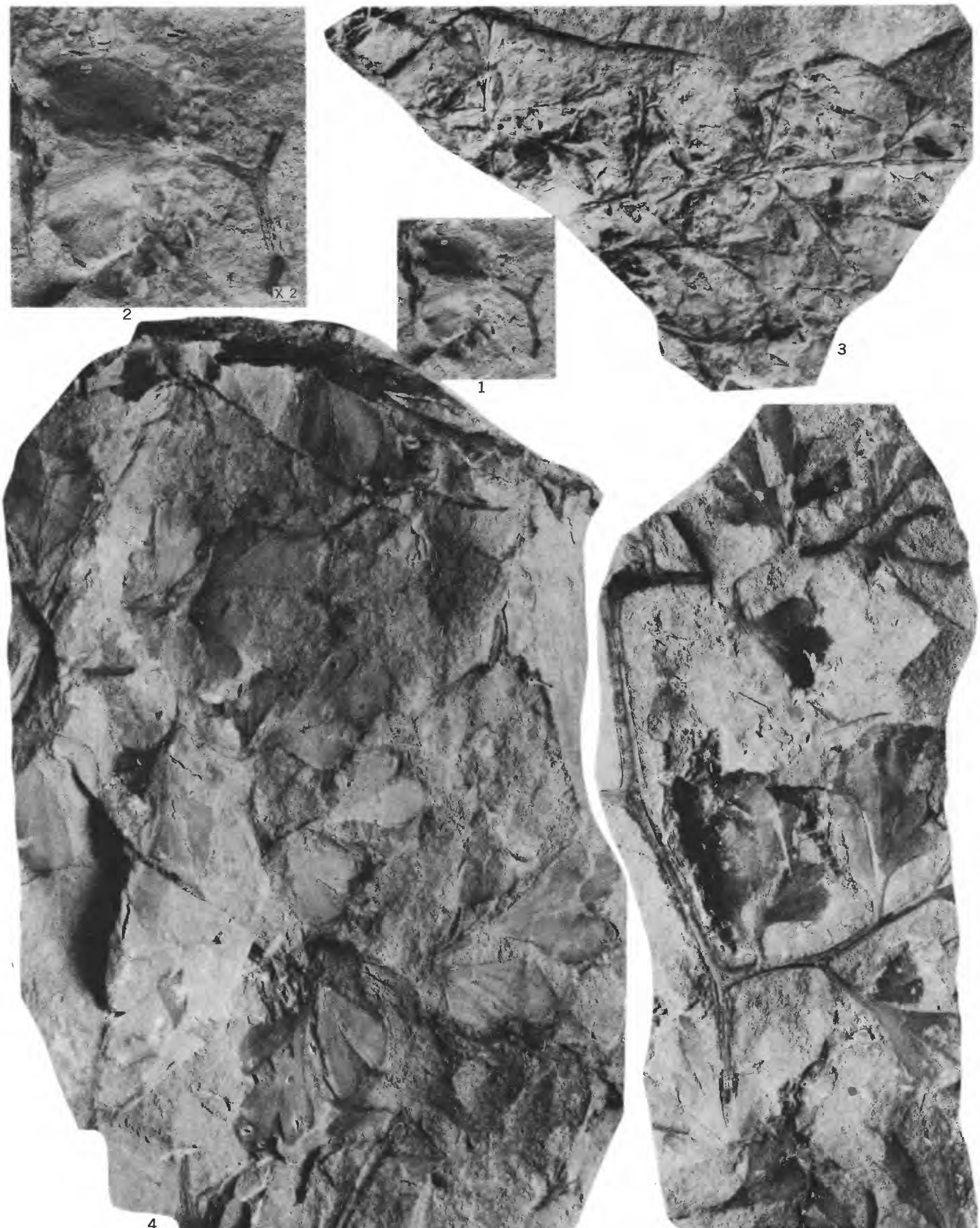
Pinnule and fragment of the axis of the pinna to which it was attached. Note the obcordate form, owing to dissection, of the pinnule, its venation, and the irregularity of the rachis. Loc. 5. USNM 40684.

3. *Triphyllopteris biloba* Read, n. sp. (p. 25)

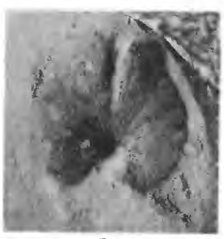
Fragment of a pinna showing the general rigid aspect and the narrow pinnules. Loc. 13, 21. USNM 40644.

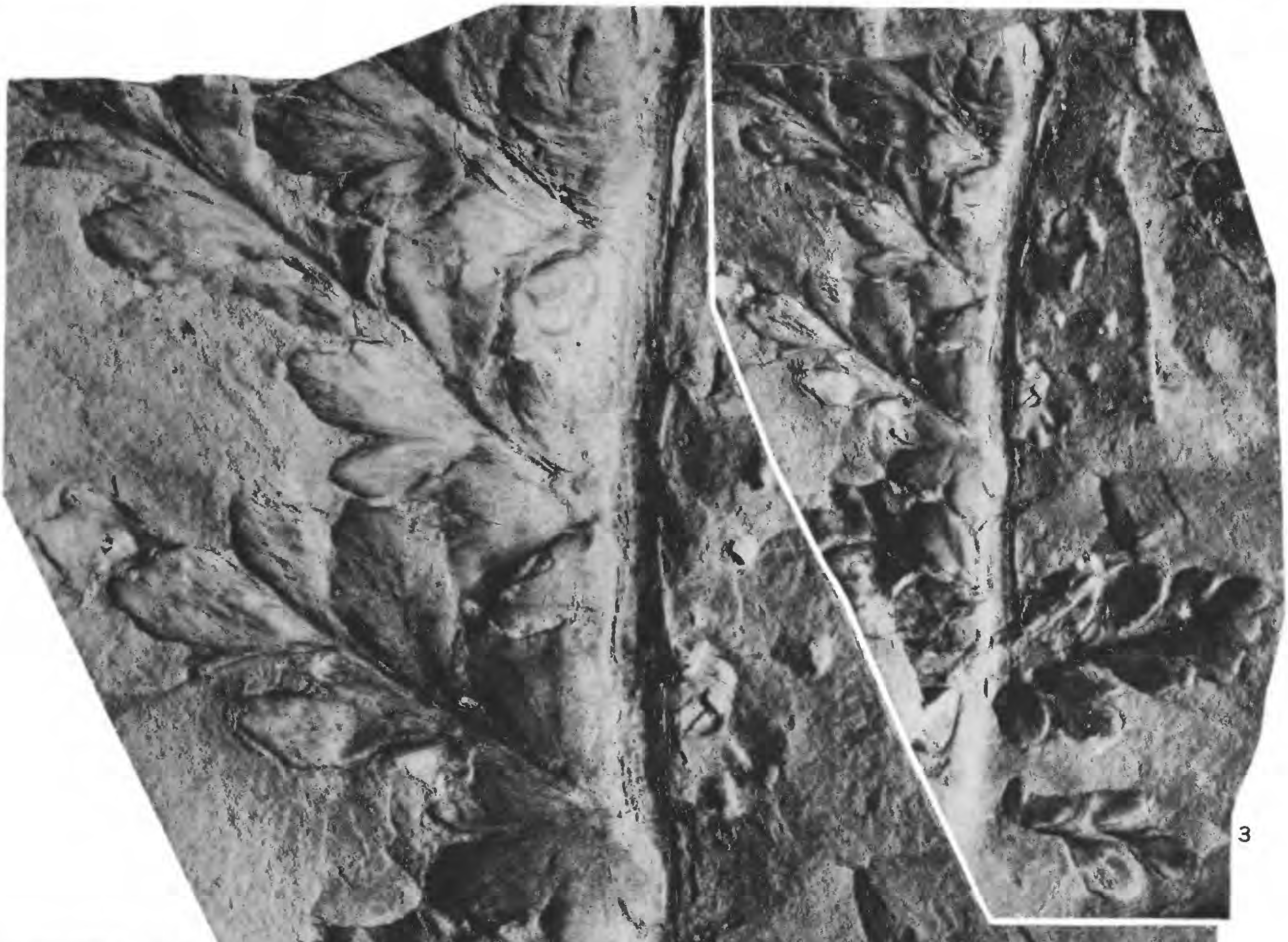
4, 5. *Adiantites spectabilis* Read, n. sp. (p. 17)

Slabs carrying fragments of pinnae. Note, in figure 4, the great variation in pinnule form. In figure 5 may be seen a fragment of an angularly sinuose rachis with attached pinnae bearing pinnules. Loc. 3–7. 4, USNM 40687. 5, USNM 40688.



ADIANTITES AND *TRIPHYLLOPTERIS*





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ADIANTITES AND *TRIPHYLLOPTERIS*

PLATE 12

[All figures natural size unless otherwise indicated on plate]

FIGURES 1, 2. *Adiantites cyclopteroides* Read, n. sp. (p. 18)

Typical pinnule referable to this species showing the reniform asymmetrical form and the details of venation. Loc. 5. USNM 40652.

3, 4. *Triphyllopteris rarinervis* Read, n. sp. (p. 25)

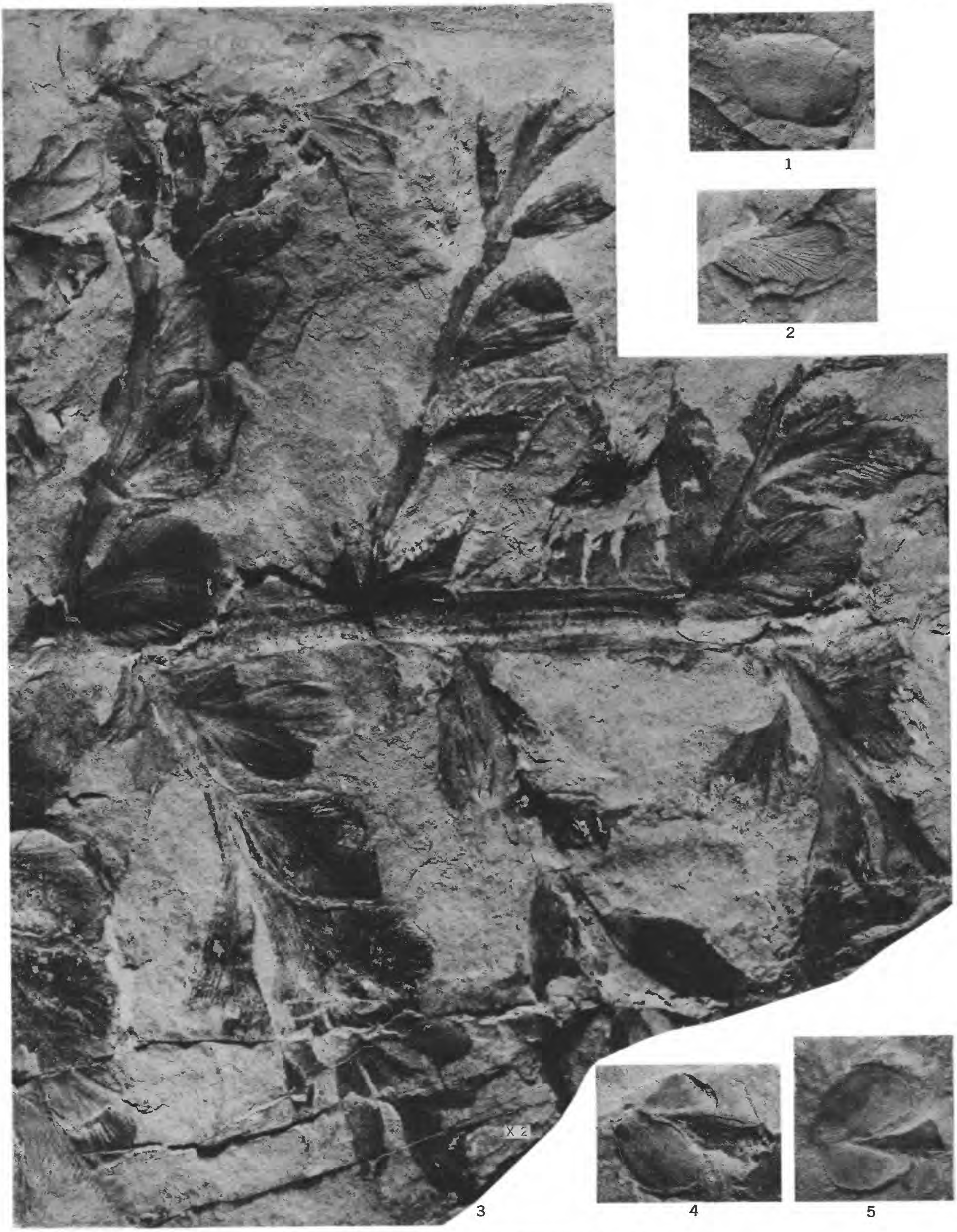
Portion of a frond showing the transverse rugosity of the rachis, the form of the pinnae, and the general variation in form and venation of the pinnules. Loc. 19, 21. USNM 19974.

PLATE 13

[All figures natural size unless otherwise indicated on plate]

FIGURES 1, 2, 4, 5. *Adiantites cardiopteroides* Read, n. sp. (p. 18)
Specimens showing the relatively large, heteromorphous, ovate to orbicular pinnules and the features of venation. Loc. 8. 1, USNM 40700. 2, USNM 40685. 4, USNM 40701. 5, USNM 40686.

3. *Triphyllopteris rarinervis* Read, n. sp. (p. 25)
Portion of the specimen shown in plate 7, figure 2, to show the details of pinnule-form and variation, and venation. Loc. 19, 21. USNM 40641.



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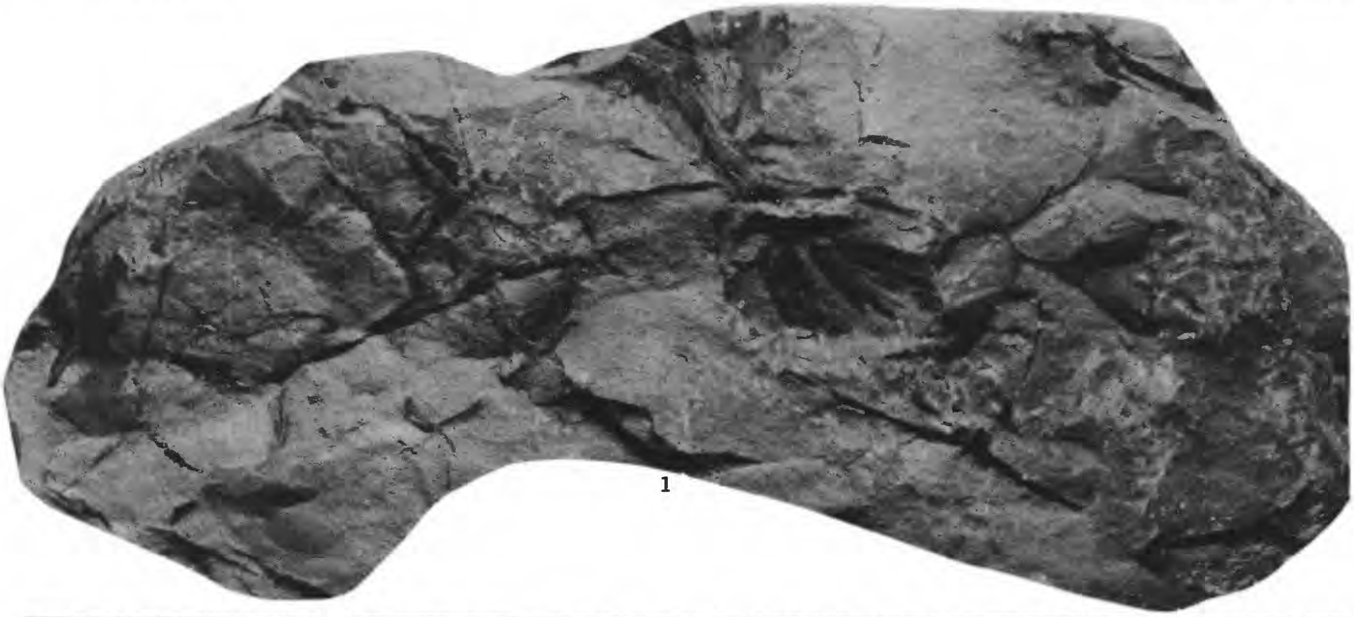
ADIANTITES AND *TRIPHYLLOPTERIS*



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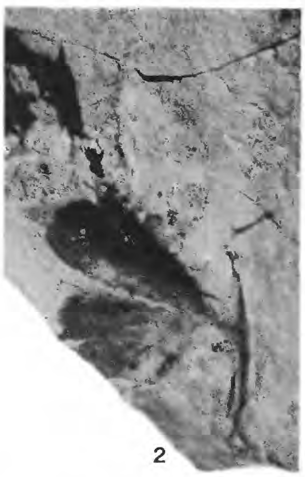

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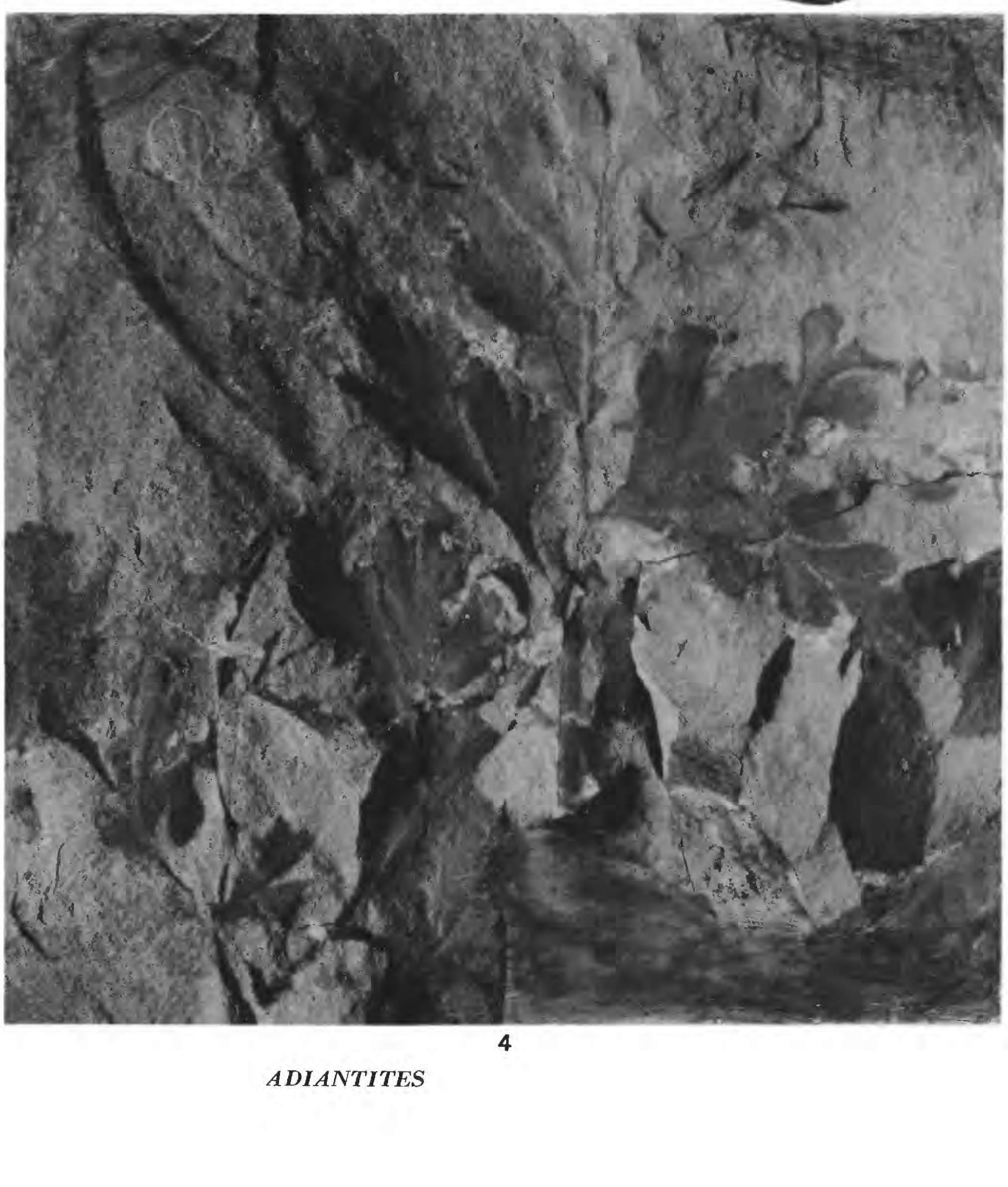

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ADIANTITES

PLATE 14

[All figures natural size unless otherwise indicated on plate]

FIGURES 1–4. *Adiantites spectabilis* Read, n. sp. (p. 17)

1. A fragment of a rachis with numerous subaverage-sized pinnules attached; note the angularity of the insertions of the pinnae. Loc. 3–7. USNM 40646.
2, 3. Typical isolated pinnules, the varying degrees of dissection being at once apparent. Loc. 3–7. USNM 40647, USNM 40648.
4. A fragment near the apex of a large frond or frond segment is seen; note the variation in size and form of the pinnules. Loc. 3–7. USNM 40640.

PLATE 15

[All figures natural size unless otherwise indicated on plate]

FIGURES 1–3. *Girtya pennsylvanica* Read, n. gen. and sp. (p. 21)

Morphology of the synangium. Note the tubular nature of the sporangia, their position on the branch system, and their free arrangement. Loc. 4, 5. 1, 3, USNM 40696. 2, USNM 40697.

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GIRTYA


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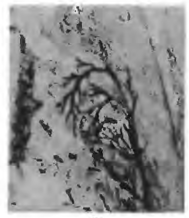
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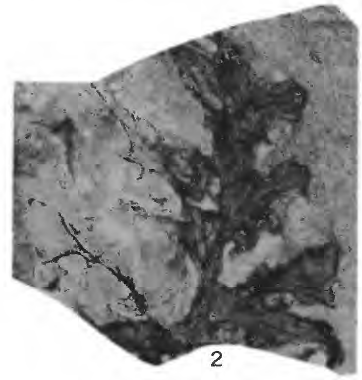
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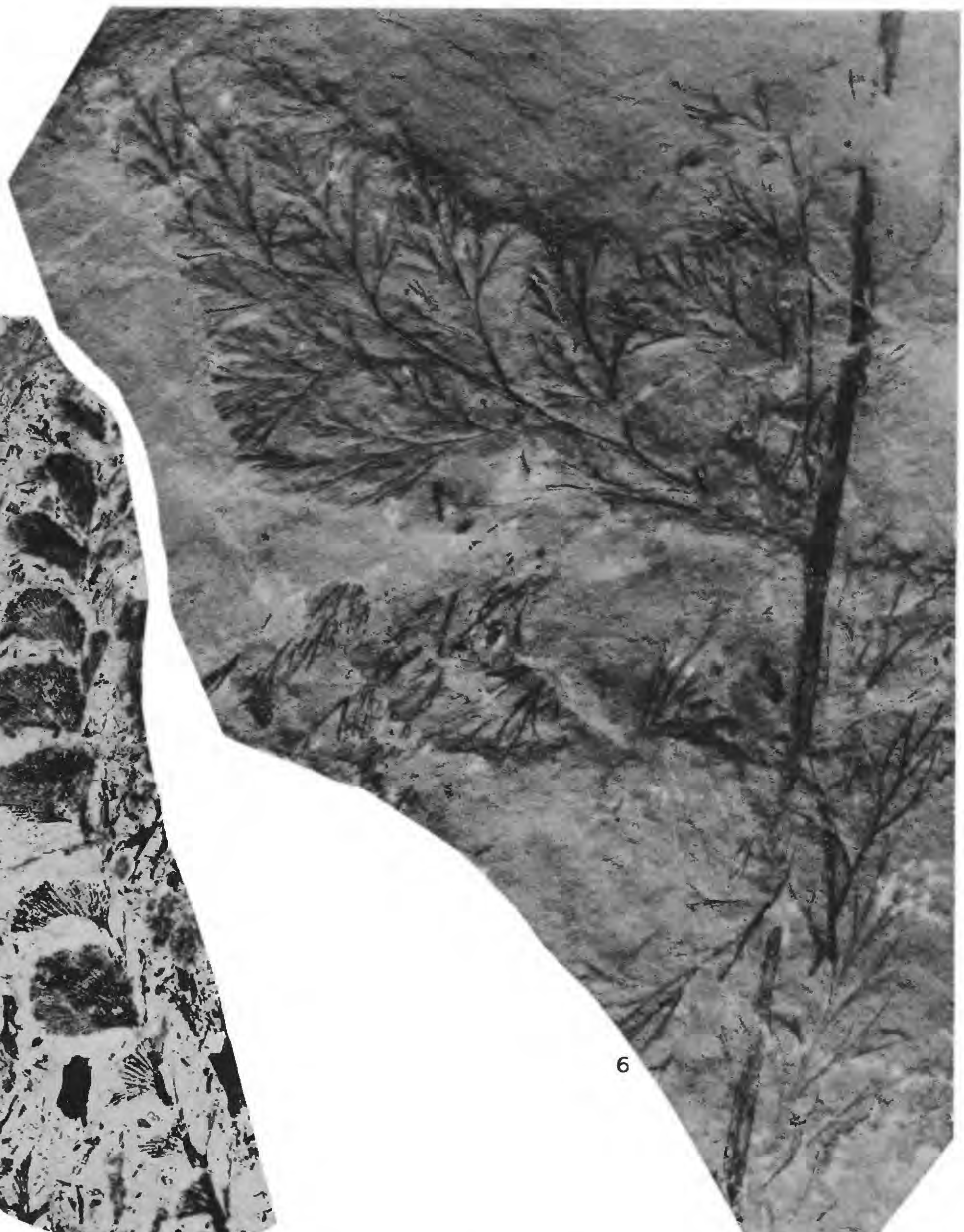
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ALCICORNOPTERIS, *GIRTYA*, *RHODEA*, AND *RHACOPTERIS*

PLATE 16

[All figures natural size unless otherwise indicated on plate]

FIGURES 1, 2. *Alcicornopteris altoonensis* Read, n. sp. (p. 19)
Specimens showing the flabellate nature of the structures. Loc. 3. 1, USNM 40649. 2, USNM 40650.

3. *Girtya pennsylvanica* Read, n. gen. and n. sp. (p. 21)
A synangium showing general features. Loc. 4, 5. USNM 40651.

4. *Rhodea alleghanensis* Read, n. sp. (p. 18)
A well-preserved fragment showing general form. Loc. 5. USNM 40691.

5. *Rhacopteris latifolia* (Arnold) Read, n. comb. (p. 16)
A fragment showing form and venation of the pinnules. Loc. 3. USNM 40666.

6. *Rhodea vespertina* Read, n. sp. (p. 22)
A large frond fragment showing form of the pinnae and pinnules. Loc. 10–14, 17–21. USNM 40657.

PLATE 17

[All figures natural size unless otherwise indicated on plate]

FIGURES 1–4, 6–8. *Lagenospermum imparirameum* Arnold (p. 25)

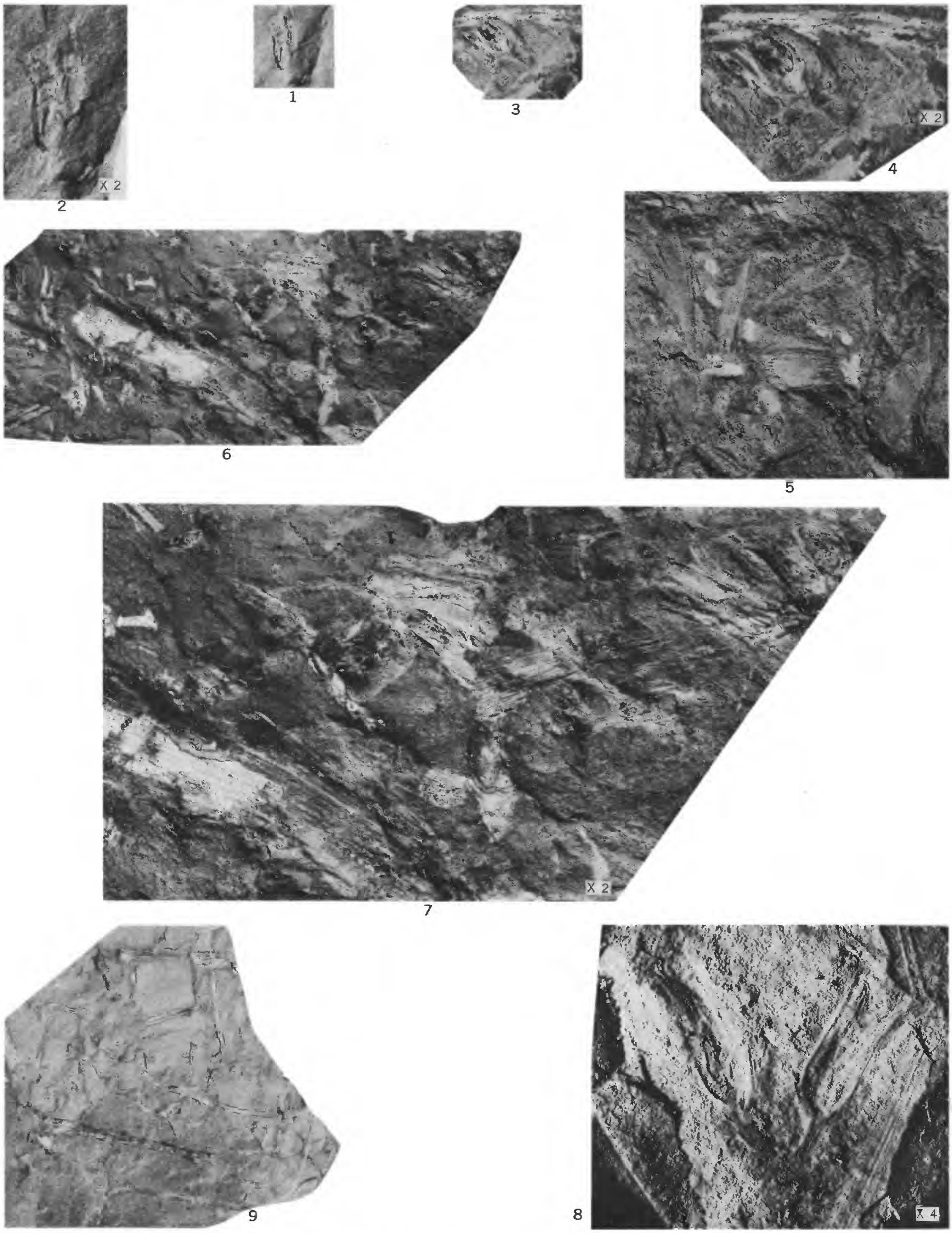
Features of the fructifications. Note their cupular and slightly unevenly paired structure. Loc. 11, 13. 1–4, 6, 7, Reading Museum, Reading Pa.; 8, University of Michigan paleobotanical collection.

5. *Calathiops pottsvillensis* Read, n. sp. (p. 20)

Specimen showing its seedlike nature and the association with *Adiantites ungeri*, n. sp. Loc. 1. Reading Museum, Reading, Pa.

9. *Alcicornopteris anthracitica* Read, n. sp. (p. 19)

Specimen showing the angular helicoid branching. Loc. 1, 2. Reading Museum, Reading, Pa.



LAGENOSPERMUM, *CALATHIOPS*, AND *ALCICORNOPTERIS*

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RHODEA, *RHACOPTERIS*, AND *LEPIDODENDROPSIS*

PLATE 18

[All figures natural size unless otherwise indicated on plate]

FIGURE 1. *Rhodea tionestana* Read, n. sp. (p. 18)
Several pinnae showing form. Loc. 5. USNM 40658.

2, 3. *Rhacopteris latifolia* (Arnold) Read, n. comb. (p. 16)
2. Associated fructification. Loc. 3. USNM 40667.
3. A pinna. USNM 40668.

4. *Lepidodendropsis vandergrachti* Jongmans, Gothan, and Darrah (p. 26)
A large forking branch. Loc. 11–13, 22, 24, 26, 27. USNM 40702.

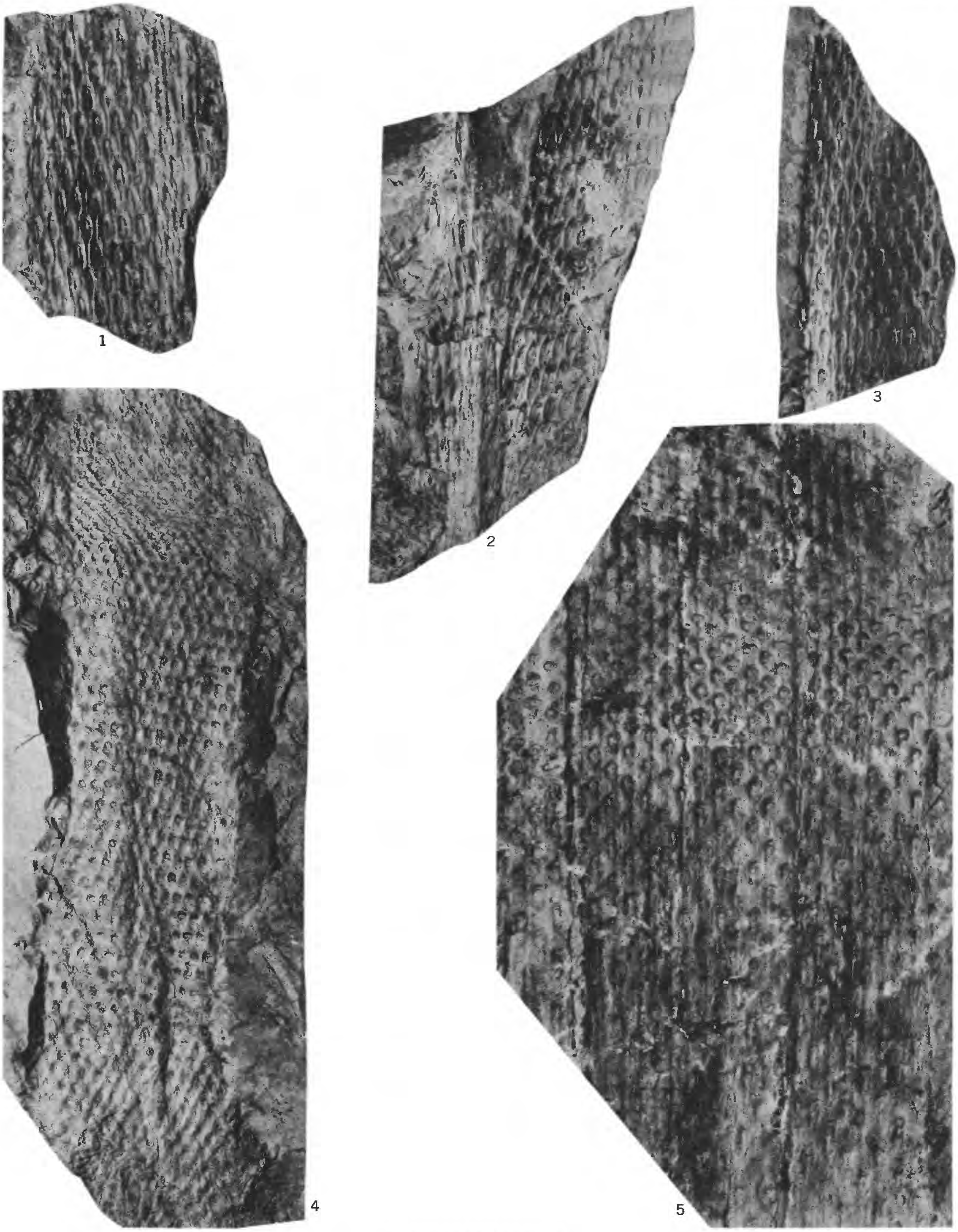
PLATE 19

[All figures natural size]

FIGURES 1, 2. *Lepidodendropsis sigillarioides* Jongmans, Gothan, and Darrah (p. 27) Loc. 12, 13, 25, 27. 1, USNM 40669. 2, USNM 40670.

3–5. *Lepidodendropsis scobiniformis* (Meek) Read, n. comb. (p. 26)
Several stem fragments showing the very characteristic bolsters. Loc. 11–14, 17, 18, 21, 24, 25, 27. 3, USNM 40671. 4, USNM 40672. 5, USNM 40659.

LEPIDODENDROPSIS



LEPIDODENDROPSIS

PLATE 20

[All figures natural size]

FIGURES 1–3. *Lepidodendropsis scobiniformis* (Meek) Read, n. comb. (p. 26)
Fragments of stems showing the characteristic leaf bolsters. Loc. 11–14, 17, 18, 21, 24, 25, 27. 1, USNM 40692. 2, USNM 40673. 3, USNM 40674.

4, 5. *Lepidodendropsis vandergrachti* Jongmans, Gothan, and Darrah (p. 26)
Illustrations showing the relatively broad, short leaf bolsters. Loc. 11–13, 22, 24, 26, 27. 4, USNM 40642. 5, USNM 40643.