THE STANLEY CEMETERY FLORA (EARLY PENNSYLVANIAN) OF GREENE COUNTY, INDIANA

by

JOSEPH MILLER WOOD

Indiana Department of Conservation
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THE STANLEY CEMETERY FLORA (EARLY PENNSYLVANIAN) OF GREENE COUNTY, INDIANA

BY JOSEPH MILLER WOOD[1]

ABSTRACT

Plant macrofossils are found in shales, ironstone concretions, and sandstones that lie immediately above the Lower Block Coal near Stanley Cemetery in Greene County, Ind. The Lower Block Coal lies at the base of the Brazil Formation, which is the uppermost formation in the Pottsville Series (Pennsylvanian) of Indiana.

The majority of the 1,917 specimens (86 species) collected for this study were obtained from ironstone concretions in the shales. These concretions, which are similar to those found in the Mazon Creek area of Will and Grundy Counties, Ill., are probably the result of bacterial action centered around the plant fragment in clay.

The flora is similar to other Pennsylvanian floras of North America. Such species as *Annularia stellata, Sphenophyllum emarginatum, Neuropteris rarinervis, N. flexuosa, Alethopteris serli, Calamites suckowi,* and *Asterotheca oreopteridia* indicate that this flora bears a great resemblance to slightly younger floras, such as the Mazon Creek assemblage from the Carbondale Formation of Illinois. Such species as *Asterophyllites equisetiformis, Annularia radiata, Sphenophyllum cuneifolium, Lepidodendron dichotomum, L. wortheni, Palmatopteris furcata, Neuropteris obliqua, Megalopteris dawsoni,* and *Sigillariostrobus quadrangularis* indicate that the flora is not younger than early Allegheny and probably is Kanawha (late Pottsville) in age. Because this assemblange contains both Kanawha taxa and Allegheny entities it is only of general stratigraphic value.

This flora also is similar to European floras of Late Carboniferous age, and such species as *Sigillaria scutellata, Alethopteris davreuxi, A. decurrens,* and *Neuropteris obliqua* indicate an age equivalent to the floras of Westphalian B deposits.

INTRODUCTION

PRELIMINARY WORK

During the summer of 1953 I assisted Dr. James E. Canright, Department of Botany, Indiana University, in a study of the Pennsylvanian floras of Indiana that was conducted under the auspices of the Geological Survey, Indiana Department of Conservation. One of the sites visited was a small abandoned strip mine northwest of Worthington, Ind., that was especially rich in ironstone concretions similar to those of the Mazon Creek area in Illinois. The concretions were in a shale just above the Lower Block Coal

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in the lower part of the Brazil Formation. As examination of the literature revealed that no study of this flora of the Brazil Formatio,n had been made, I undertook such a study at Dr. Canright's suggestion and presented the results in a Ph. D. dissertation at Indiana University in 1960.

SCOPE OF PROBLEM AND METHODS USED

The purpose of this study was to collect and identify plant macrofossils associated with the Lower Block Coal in a restricted area near Worthington in southwestern Indiana. This flora was then compared with floras from other areas in an attempt to determine if there were any similarities between this flora and other American and European floras of the same age. In addition, any differences between this flora and floras not contemporaneous with it were noted. On the basis of this information the stratigraphic value of the collected flora was evaluated.

Nearly all the plant fossils were collected from four abandoned strip mines in northern Greene County, Ind., in the southeast corner of the Coal City Quadrangle near Stanley Cemetery (fig. 1). The locations of the mines that provided the flora are as follows:

Long and Price Mine ....SW¼NE¼ sec. 7, T. 8 N., R. 5 W.
Hannum Mine ....NE½SE¼ sec. 7, T. 8 N., R. 5 W.
Ray Mine ....NE¼SW¼ sec. 7, T. 8 N., R. 5 W.
Michaels Mine ....E½SW¼ sec. 12, T. 8 N., R. 6 W.

The Long and Price, Hannum, and Ray sites were strip mines in which the Lower Block Coal had been removed. The Michaels Mine, from which only a small amount of fossil material was obtained, was also a strip mine, but it yielded both Lower Block Coal and Upper Block Coal. Because the Lower Block Coal was the last coal obtained from the Michaels Mine, the spoil banks were topped by the overburden which had been above the Lower Block Coal, and it was from this material that the ironstone concretions were obtained.

Buckner Mine in the center of the NW¼ sec. 7, T. 8 N., R. 5 W., and the Girton Mine in the SE¼SE¼ sec. 1, T. 8 N., R. 6 W., were also carefully examined. Although both of these mines were within 1 mile of the others (fig. 1) and contained similar rocks, no plant fossils were found either in the Buckner or in the Girton Mine.

Between the time of discovery of the site in 1953 and the summer of 1956, I and other interested students from Indiana University collected plant fossils. This part-time collecting yielded 712

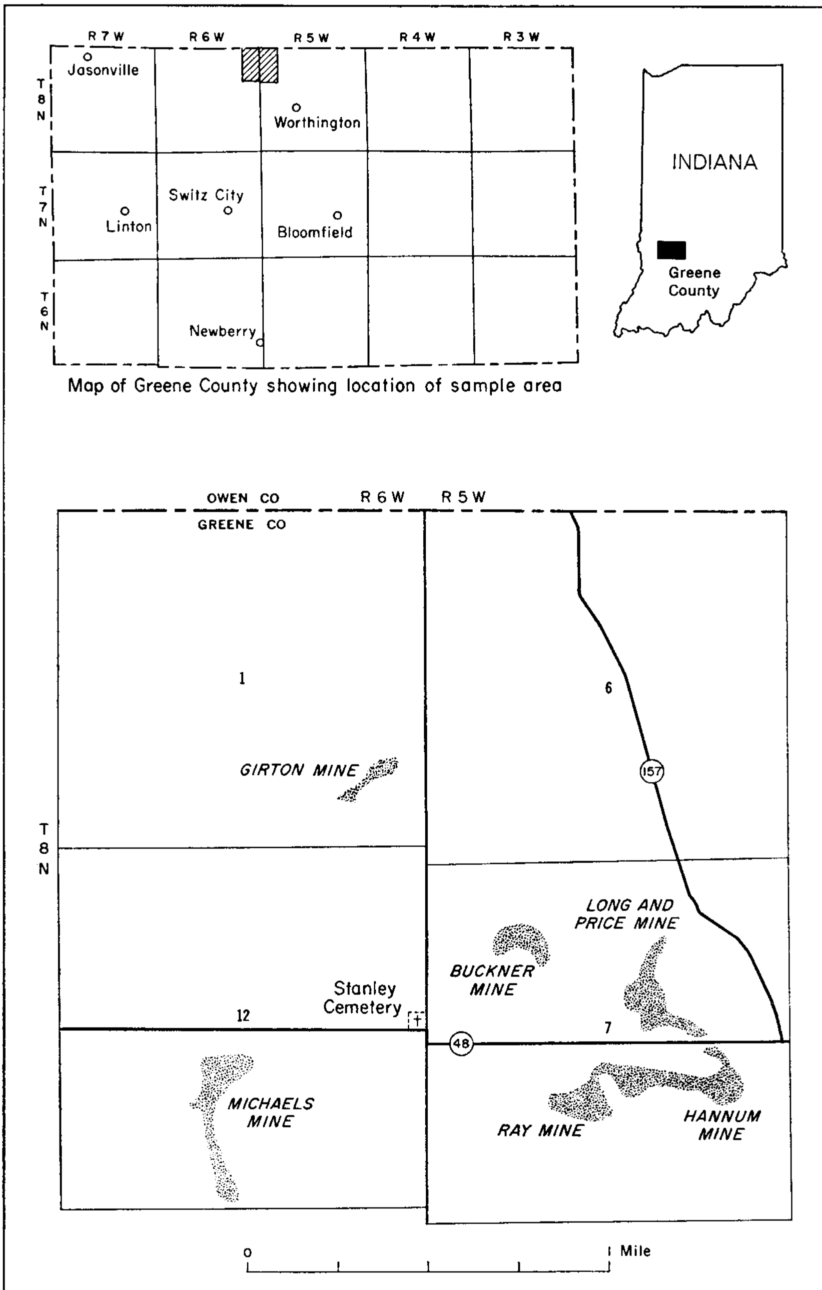

Figure 1.—Map showing collecting localities of the Stanley Cemetery flora and other mines mentioned in the text.

specimens that became part of the collection to be studied. These specimens came from the Long and Price, Hannum, and Ray sites, but as at that time it was thought that the whole area was called the Long and Price Mine, these fossils were identified by the symbol “L & P.” Extensive fieldwork in the summer of 1956 yielded 1,205 additional specimens, which were added to the 712 specimens that had been collected earlier. For convenience this collection of plant fossils from all four sites is called the Stanley Cemetery flora (fig. 1).

Most of the plant fossils collected were obtained from nodules in the shale above the Lower Block Coal. These nodules were broken open in the field, and only the ones containing well-preserved fossils were retained. Both halves of the nodules were brought back to the laboratory, cleaned, and numbered. All specimens were examined and sorted according to genus and species, regardless of collecting site; identifications were checked with the literature, and the specimens were cataloged.

Although considerable reference literature was available, some difficulty in making exact identifications was encountered. For instance, some species named by White were not figured, or only small fragments of them were illustrated. Some descriptions and illustrations in other old reports on North American floras are so poor that one is forced to rely on the reports of European floras. This makes it doubly difficult to interpret small differences between a specimen and the described and illustrated species.

ACKNOWLEDGMENTS

I wish to express my sincere appreciation for advice, encouragement, and invaluable criticism to Dr. James E. Canright, under whose direction this research was carried out and a dissertation was written. I also wish to express appreciation to my wife for her assistance and suggestions during the preparation of the thesis and to the National Science Foundation for granting me a Predoctoral Fellowship during the year 1956-57. Thanks also to Charles E. Wier, who aided greatly in revising the dissertation for publication, to Richard L. Powell, who helped revise the plates, and to other members of the Indiana Geological Survey who read the manuscript critically and offered many valuable suggestions.

GEOLOGIC SETTING

NOMENCLATURE OF ROCK UNITS

Some of the early geologists in Indiana worked on coal-bearing rocks and noted coals in the area west of Worthington in Greene

County. The earliest work was done by E. T. Cox (1896, p. 95), who noted that a coal 3 feet thick was mined in sec. 7, T. 8 N., R. 5 W. He called this Coal A and stated that Coal B was 20 to 30 feet above. He also remarked that there were impressions of Sigillaria and Calamites in the shale above Coal A. When G. H. Ashley reported on the coal deposits of Indiana 30 years later, he used roman numerals to designate coal seams and correlated these two coals with his Coal III and Coal IV in central Clay County about 25 miles northwest of Worthington (Ashley, 1899, p. 789). It soon became obvious that he had made some mistakes in correlation. He had also designated as Coals III and IV those coals that crop out just east of Jasonville and Linton and that are 150 feet higher than the two coals in sec. 7. The lower two coals were later correlated with the Lower Block Coal and the Upper Block Coal in Clay County (Ashley, 1909).

Cumings (1922, p. 527-528) proposed a classification of Pennsylvanian rocks in Indiana that included series and formation names. He included the Lower Block Coal and the Upper Block Coal in the Brazil Formation of the Pottsville Series. Kottlowski (1959) used this nomenclature, and the Indiana Geological Survey presently follows it.

DESCRIPTION OF ROCK UNITS

The geology of the Stanley Cemetery area was studied in detail by Kottlowski (1959) and was included in his report on the Coal City Quadrangle, from which much valuable information was obtained.

As all collecting was done from rocks in the Brazil Formation, the discussion of rock units will be restricted to this formation as it occurs in the collecting area. The Brazil Formation is underlain by the Mansfield Formation, and these two formations make up the Pottsville Series in Indiana (fig. 2). The Brazil Formation is overlain by the Staunton Formation, which is the basal formation of the Allegheny Series. The Brazil Formation consists of (in ascending order): (1) 2 to 3 feet of the Lower Block Coal; (2) 25 feet of shale that is soft, dark gray, sandy, and concretionary and that in some places includes thin-bedded sandstone beds; in places the upper part of the unit is sandstone; (3) 2 feet of underclay; (4) 2 to 3 feet of the Upper Block Coal; (5) 25 feet of shale and thick-bedded sandstone; (6) 2 feet of underclay; (7) 2 to 4 feet of the Minshall Coal; (8) 1 to 10 feet of black shale that grades upward into gray shale; (9) 1 to 9 feet of the Perth Limestone

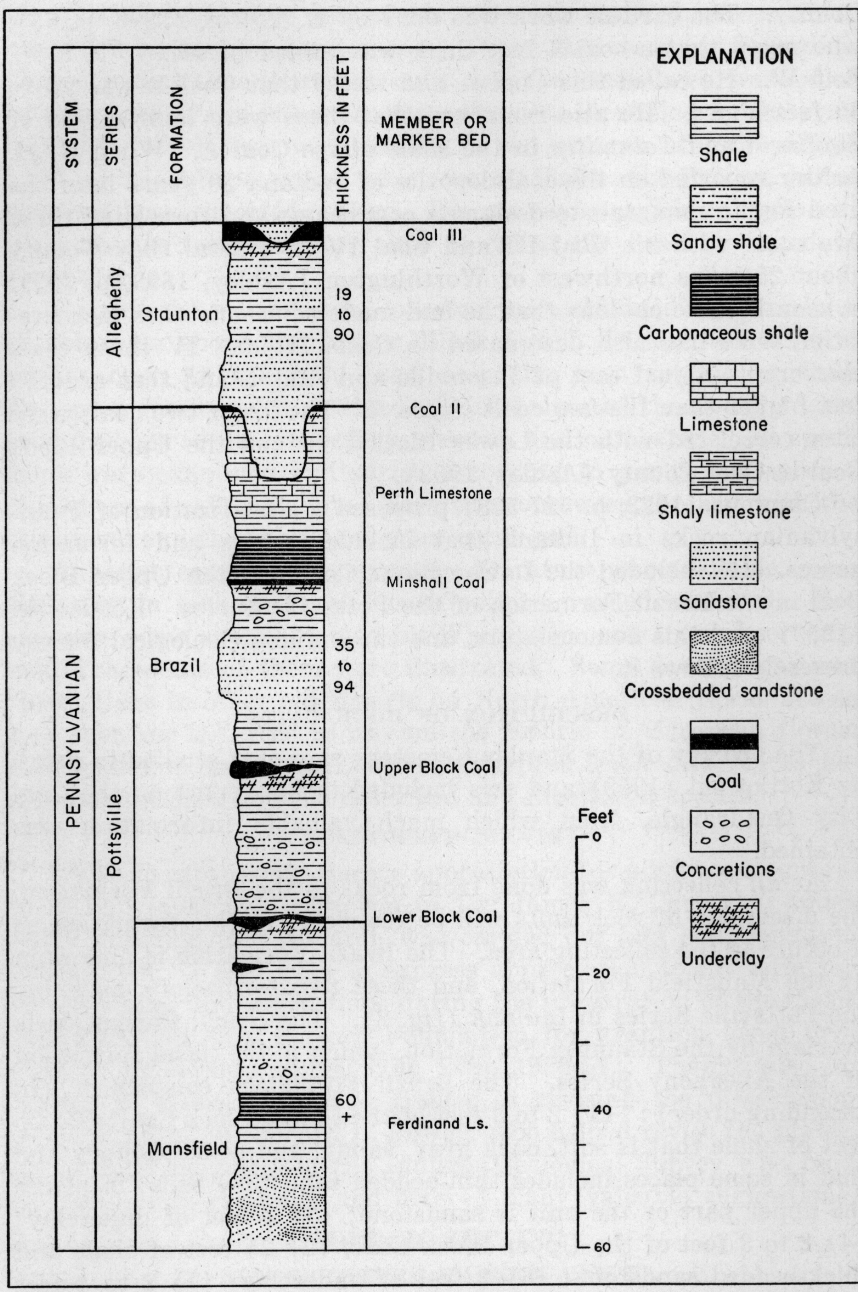

Figure 2.—Generalized columnar section of the collecting area of the Stanley Cemetery flora. Modified from Kottlowski, 1959.

Member that in places is shaly limestone or calcareous shale in the lower part; (10) 10 to 20 feet of sandy shale; and (11) 0.1 to 1.0 foot of Coal II. In some areas channel-filled sandstones replace parts of units 9 to 11. Because of local variations in thickness of the various units the Brazil Formation ranges from 35 to 94 feet in thickness in the Coal City area (Kottlowski, 1959).

Only units 1 to 5 were found at the collecting sites. Underclay beneath the Lower Block Coal was noted at the Hannum site, where numerous specimens of *Stigmaria ficoides* (Sternberg) were found in the natural position.

Carbonaceous plant impressions found in the shale (unit 2) immediately overlying the Lower Block Coal make up part of the flora discussed in this study. But as there were relatively few localities from which unweathered shales could be obtained, this component of the flora is smaller than that obtained from the ironstone concretions that weathered out of this shale.

Although most of the collection was obtained from concretions in the cast piles, some concretions were found in the high walls of both the Hannum and the Long and Price Mines. At both of these sites most of the concretions were obtained from shale 5 inches above the Lower Block Coal; a lesser number were found at higher levels but in the shale of unit 2. Nodules found in place differed from nodules found on the spoil banks in that the former were gray and relatively soft, so that when they were struck with a hammer, more of them were crushed than were cracked open. The weathered nodules were dark brown to reddish and were readily split along the plane of weakness caused by the flattened enclosed organic matter.

In addition to the plant impressions and the ironstone concretions in this shale, I found sections of calamitean pith casts which were in a horizontal or near horizontal position. Also, a few impressions of fossil plants were obtained from the thin sandstone beds immediately above the shale that contains the concretions.

ECOLOGIC CONDITIONS OF DEPOSITION

The plant fossils collected were deposited in what generally has been called the Eastern Interior Basin in shallow fresh water. Ironstone concretions, the source of most of these plant fossils, were included in a study by Feliciano (1924), who classified concretions under three subdivisions. The nodules of this study belong to his type one. They have an organic nucleus, and their shapes are strongly influenced by this organic inclusion.

Because of the absence of a limestone cap rock and of fossil marine invertebrates and the great abundance of plant fossils in the roof beds, Feliciano concluded that the nodules (of his type one) had been formed in fresh-water sediments. White (1911) had earlier suggested that the abundance of plant fossils alone was indicative of fresh-water deposition. I concur with this suggestion and believe that the Stanley Cemetery flora probably was deposited in fresh water.

Feliciano presented a series of chemical equations to substantiate his claim that the nodules that he described had been formed by the interaction of solutes in ground water and the surrounding clay and silt. He also suggested that anaerobic bacteria played a role in forming these nodules. I believe that the presence of micro-organisms is more important than was supposed by Feliciano. It has been noted that two mines in the immediate area from which concretions for this study were obtained yielded no nodules, in spite of the fact that the lithology of the area is relatively uniform. If one assumes that plant remains were distributed fairly uniformly throughout the area, the absence of nodules suggests to me that the formation of the nodules was dependent upon the presence of anaerobic bacteria, which acted in such a way as to bind the particles surrounding the plant fragments into the nodules in which they are now found. It seems more logical to assume that the bacteria either were not ubiquitous, or else were inhibited in the noduleless area, than to assume that the solutes in the ground water were not available, or that insufficient quantities of plants were present.

Feliciano stated a more important, but now new, fact, namely, that the flora of the nodules that occur above the coal is not the same type of flora that produed the coal, because ecologic conditions during the time of the deposition of the coal were different from those which existed at the time of the deposition of the roof shales.

The Stanley Cemetery flora is presumably a mixture of swamp and upland species. The calamite, lepidodendrid, and sigillarian remains characterize the swamp environment, whereas some of the fern species strongly suggest an upland environment. The ferns were probably washed from the upland areas when the swamp was inundated. The myriad seeds in the flora further indicate that this flora was enriched by upland species. This flora thus represents two ecologic zones, namely, the swamp zone in which hydrophytes abounded and the upland zone characterized by mesophytic plants which were carried into the depositional basin at times when the swamp was inundated.

The lithology of the strata from which the plant fossils were removed further suggests differences in depth or transporting power of the water. Thin beds of shale, siltstone, and sandstone make up the strata surrounding the nodules. A general increase in grain size in the area of collection seems to indicate a gradual subsidence of the area.

Stignmria in the underclays indicates that the coal was (at least in part) autochthonously produced. But the flora under study is not the flora of the Lower Block Coal but is the flora that was deposited after the coal swamp had been inundated, and it was probably extant on the surrounding uplands. The lack of an erosional zone above the coal suggests to me that there was only a very slight break in time, if any at all, between the flora of the swamp and that of the upland which was added to the coal flora.

Had the plants grown in this immediate area, large fronds and complete leaves would possibly have been preserved rather than the pieces of leaves and fronds that are commonly found. The presence of small plant parts and the sparseness of large specimens made up of organically attached parts indicate that the flora was transported some distance before its component parts were preserved.

PALEOBOTANICAL INTERPRETATION

PREVIOUS WORK ON FLORAS OF PENNSYLVANIAN AGE

Numerous papers on upper Paleozoic plant fossils were published in the United States between 1820 and 1870, but one of the most significant of the early contributions to American Pennsylvanian paleobotany, published in three parts a few years later, was written by Lesquereux (1880, 1884). He described the fossil flora of Pennsylvania, compared it with other American Carboniferous floras and with the known floras of Europe, and also listed the stratigraphic distribution of the Carboniferous plant fossils.

David White published work on the fossil flora of the Carboniferous rocks of Missouri (1893, 1899) and on the flora of similar age in the Appalachian area (1900a, 1900b).

The first detailed work dealing with a Pennsylvanian flora of Indiana was produced by T. F. Jackson (1917), who studied the lower Pennsylvanian flora of part of Monroe and Owen Counties.

A. C. Noé studied the fossil flora of the western Kentucky coalfield (1923) and the Pennsylvanian flora of northern Illinois (1925). Janssen (1939, 1940) also published information on Pennsylvanian flora of Illinois.

Read (1947) reviewed work done on Pennsylvanian floras and established nine floral zones for the United States. Two years later C. A. Arnold (1949) published a detailed account of the paleobotany of the Michigan coal basin. W. N. Stewart (1950) reported on the Carr and Daniels collections of fossil plants from Mazon Creek, Ill. Condit and Miller (1951) published a brief report on plant-bearing concretions from Iowa that resembled those of Mazon Creek, C. A. Arnold (1953) published a paper pertaining to early Pennsylvanian fossil plants from central Oregon, and Canright (1959) described fossil plants of Pennsylvanian age in Indiana.

This historical review of paleobotanical literature concerning the Pennsylvanian floras of the United States indicates that the study of fossil floral assemblages is not new in this country. Although such studies have appeared intermittently from 1820 to 1959, they do not present, however, a complete coverage of each geographic area. More specifically, the fossil floras of Michigan, Ohio, Pennsylvania, West Virginia, Virginia, Tennessee, Alabama, Arkansas, Oklahoma, Colorado, Kansas, Missouri, Illinois, and Kentucky have been studied more or less extensively, but only a small segment of the Pennsylvanian flora of Indiana has been examined in detail.

No specific mention is made here of the many fine publications based on American materials suitable for anatomical studies, for example, plant fossils preserved in calcareous concretions known as coalballs. But except for some coalballs from near Boonville, Ind., even this type of fossil material from Indiana has not been examined exhaustively.

The Europeans also have been studying plant fossils for more than a century. H. B. Geinitz (1955) studied floral variations in the coal measures of Saxony. He was the first to note that floral changes are evident from one horizon to another. Although the strata studied by Geinitz had a limited stratigraphic range, his observations concerning evolutionary changes became the theme upon which other researchers could present variations, refinements, and additions.

In 1877 Grand'Eury pointed out the specific modifications of the Carboniferous flora and listed the characteristics of each successive stage. At about the same time Weiss (1869-72), Stur (1875, 1877), and Zeiller (1886-88) published information on fossil plants. Their conclusions were similar to those of Lesquereux (1880, 1884) in the United States.

Kidston in his many publications (commencing in 1882) examined the Carboniferous floras of Great Britain and compared them with one another, as well as with the known European floras. Kidston (1894) published a complete list of known British Carboniferous plant fossils; however, subsequent research by Kidston (1923-25) and Arber (1902) soon rendered this list obsolete. Crookall (1931) continued the work of Kidston. Dix (1933) presented an attempt to divide the Upper Carboniferous f lora of Great Britain into nine floral zones. Read (1947) utilized this work in his f lora zones for the United States.

DIFFICULTIES IN COMPARING WITH OTHER FLORAS

To make a meaningful comparison of the flora collected from one locality with that collected elsewhere, the collection from each location must be representative of stratigraphic position and geographic area. When collecting was being done for this study, it was found that similar types of specimens were found in relatively restricted geographical areas. For example, an area that yielded mainly fern seeds with no foliage would be found on the spoil banks, and at another spot the seeds would be entirely lacking and the only specimens found would be those of perhaps only one, or at most two, species of a genus of fernlike foliage. A similar situation was experienced by Richardson (1956) while he was collecting specimens in Grundy and Will Counties, Ill. (oral communication). Thus a large area had to be examined before one could gain an idea of the range of species and genera represented within the flora.

Although carbonaceous impressions of neuropterid species were found in the shales immediately above the Lower Block Coal, they were singularly lacking from the floral elements preserved in the concretions. Thus both shales and concretions had to be examined thoroughly to obtain specimens of at least the majority of the genera and species which were contained within this flora.

Because the total number of specimens of any one species can be affected by the site of the collection and because a collection of shales or of concretions alone does not contain all elements of this flora, I believe that it is not wise to attempt to apply Bode's (1927, 1952) method to the materials of this flora or to those from the Mazon Creek area in Illinois.

Jongmans (1952, p. 8) stated:

> So it is wrong in my opinion to pay too much attention to what some paleobotanists call "detailed" or "small" stratigraphy. One of them came to the conclusion, for instance, that each of the seams of the Ruhr Basin (200 seams) could be distinguished by its flora and that the flora of each seam had its own character, but such a conclusion is only due to the fact that the collections examined were too small and most probably taken from too small a number of localities in the same seam.

When one compares a flora with published data, however, one usually must proceed without any knowledge of the completeness of the collection or bias used in collecting the published flora.

COMPARISON WITH OTHER FLORAS OF PENNSYLVANIAN AGE IN THE UNITED STATES

The Stanley Cemetery flora from Indiana bears an assemblage that unmistakably marks it as a middle Pennsylvanian flora, comparable to the floras of the Westphalian Stage of Europe and the floras of the upper part of the Yorkian Group and the Staffordian Group of Great Britain (table 1).

In comparison with the floral zones of Read (1947), the Stanley Cemetery flora contains elements of Read's Zone 3, as evidenced by *Alethopteris decurrens*, *Cordaites principalis,* and *Sphenophyllum cuneifolium.* But only the last two species are relatively common in this flora, and the presence of *A. decurrens* is interpreted as a reflection of an older flora. Read's Zone 4 is represented in the Stanley Cemetery flora by *Megalopteris (Cannophyllites)*, *Neuropteris tenuifolia,* and *Lepidodendron aculeatum,* and Read's Zone 5 is represented by *Neuropteris tenuifolia* and *N. scheuchzeri. N. rarinervis is* also present; it suggests a similarity to Read's Zone 6, which is further represented by *Alethopteris serli, Neuropteris schenchzeri, N. macrophylla,* (which Read lists as *N. clarksoni), Calamites suckowi, Annularia stellata*, and *Sphenophyllum emarginatum.* Zone 7 is represented by *Neuropteris flexuosa* and pecopterid species.

The Stanley Cemetery flora most closely compares with Read's Zone 6, which he considered to correspond with the lower parts of the Allegheny and Des Moines Series (table 1). Because the zones delimited by Read are difficult to recognize and because this flora also contains species of the genera *Lepidodendron, Lepidostrobus,*

Table 1.—*Stratigraphic position of names of formations, groups, and series used in this report*

Floral zones of Appalachian area of the United States	Eastern United States	Midcontinent	Indiana	Indiana	Illinois	Michigan	West Virginia	Western Pennsylvania	Eastern Pennsylvania	Nova Scotia	Nova Scotia	England	France	Netherlands	Europe	Europe
Zone 7	Allegheny Series	Des Moines Series	Allegheny Series		Carbondale Fm.		Allegheny Series	Freeport Group; Kittanning Group		Pictou Group	Stellarton Group; Morien Group	Radstockian Group	Assise de Bruay		Westphalian Stage	D
Zone 6				Staunton Fm.			Kanawha Group	Clarion Group				Staffordian Group				C
Zone 5	Kanawha Series	Lampasas Series	Pottsville Series	Brazil Fm.		Saginaw Group		Kanawha Series		Cumberland Group		Yorkian Group	Assise d'Anzin	Baarlo Group		B
Zone 4																
Zone 3	Lee Series	Morrow Series		Mansfield Fm.			New River Group		Upper Lykens Group	Riversdale Group						A
Zone 2																
Zone 1							Pocahontas Group		Lower Lykens Group	Canso Group				Epen Group		

and *Cardiocarpon,* which Read placed in his Zone 5, I believe that further investigation is necessary to define more clearly the floral zones before any definite statement concerning their stratigraphic range, at least in Indiana, can be made.

It is unfortunate that the “Correlation Chart of Pennsylvanian Formations of North America” (Moore and others, 1944) shows Read’s floral zones separated by solid rather than by broken lines. The implication that these zones represent the entire North American continent is also unfortunate. Actually Read established these floral zones on the basis of floral assemblages collected from the Appalachian and midcontinent regions only. Most of the flora came from the Appalachian region.

Jackson (1917) studied the flora of the Mansfield Formation in the Bloomington and Clay City Quadrangles in Monroe, Owen, Clay, and Putnam Counties, Ind. Although only 9 of the 40 species listed by Jackson for his flora are found in the Stanley Cemetery flora, there is, nevertheless, a striking similarity. Species listed in table 2 are found in both floras. The scarcity of *Neuropteris* species in Jackson’s flora is noteworthy because, according to Read’s zonation, the flora should contain *Neuropteris tenuifolia.* Possibly all the plants collected came from a position equivalent to Read’s Zones 3 and 4.

A comparison of the Stanley Cemetery flora with the list of species given by Lesquereux (1884) is practically impossible because one must first attempt to translate Lesquereux’s lettering system into the presently used system of naming coals. Thus the impressive distribution charts presented by Lesquereux (1884, p. 849-881) are almost completely useless at the present time.

A comparison of the species list of the Stanley Cemetery flora with the list of flora of Mazon Creek, Ill. (Stewart, 1950), indicates some similarity; 35 of 104 Mazon Creek species are found in the Stanley Cemetery flora. The Mazon Creek collection was obtained from the Francis Creek Shale, a member of the Carbondale Formation (table 1), which has also been the source of a large number of invertebrate fossil specimens (Richardson, 1956) and probably the best-known site for Pennsylvanian macrofossils in the United States. The fact that the Stanley Cemetery flora bears a similarity to the Mazon Creek material should be evaluated critically because museum collections are not normally truly representative of the locality.

Arnold (1949) showed that the Michigan coal flora collected from the Saginaw Group can be divided into three parts. His “lower” flora was correlated high in the Lee Series as compared with standard sections in the Eastern United States (table 1). His “intermediate” flora is late Kanawha in age. He believed that the “upper” flora also should be assigned a position high in the Kanawha Series, although he noted the possibility of an early Allegheny age for it.

Of the 80 species listed by Arnold (1949, p. 146-148) 23 are in the Stanley Cemetery flora. Of the 26 species listed by Arnold in his “lower” flora 9 of them are represented here (35 percent) ; of the 33 species from his “intermediate” flora 13 are in this flora (39 percent) ; and of the 21 species listed from the “upper” flora 8

Table 2--*Species common to Stanley Cemetery flora and to Jackson’s (1917) Indiana flora and Arnold’s (1949) Michigan flora*

Species	Jackson	Arnold lower flora	Arnold intermediate flora	Arnold upper flora
Alethopteris decurrens		x		x
S. serli	x			
Annularia sphenophylloides				x
Asterophyllites equisetiformis			x	
Calamites suckowi	x	x	x	x
Cardiocarpon annulatum	x		x	
C. late-alatum			x	
Cordaites crassinervis				x
C. principalis			x	
C. robbii	x			
Diplothmema obtusiloba	x			
Lepidodendron aculeatum	x			x
L. dichotomum		x		
L. lanceolatum				x
L. modulatum	x	x		
L. obovtum	x	x		
Megaloptris dawsoni			x	
Neuroptris obliqua		x	x	
N. rarinervs				x
N. scheuchzeri			x	
N. tenuifoli		x	x	
Rhabdocarpus mamtillatus		x	x	
R. cf. Mansfieldi			x	
R. multistriatus			x	
Sphenophyllum cunefolium	x	x	x	
S. entarginatum				x
Total number of common species	9	9	13	8
Number of species listed by the author (Jackson or Arnold)	40	26	33	21
Percentage of above author’s species	22.5	34.6	39.3	38.1

are found in this assemblage (38 percent). Some species occur in more than one flora.

There is a strong similarity between the Stanley Cemetery flora of Indiana and the Saginaw flora of Michigan (table 2). The Stanley Cemetery flora most closely resembles Arnold's "intermediate" flora. Arnold (1949, p. 153) correlated his "intermediate" flora with that of Read's Zone 5 but pointed out that there were similarities to the flora of Zone 4.

He (Arnold, 1949, p. 158) concluded that his "intermediate" flora is undoubtedly the same age as the flora from the Cumberland Group of Nova Scotia, which is considered to be equivalent to the Kanawha flora of the Eastern United States. But the Stanley Cemetery flora of Indiana also contains elements of both the "lower" and "upper" floras of Michigan, an indication of a time overlap with these floras in Michigan, and perhaps represents a transitional period during which younger elements of the flora were beginning to replace older species.

A comparison of the Stanley Cemetery flora with the flora of Missouri reported by White (1899) reveals that of the 85 species recorded in the Missouri flora 31 are in the Indiana assemblage (36 percent). White concluded that the Missouri coals are probably correlative with the coals of the Kittanning Group of middle Allegheny age and that possibly the flora from the upper coal might be as young as the upper Kittanning flora of Pennsylvania. Published results of subsequent research by White in Hinds and Greene (1915) included a brief study of the species cited by White in 1899. The results of this brief study indicated that the Missouri flora should be considered as earliest Allegheny or, more probably, late Pottsville in age.

Oligocarpia missouriensis, which is known to be present in younger rocks in Arkansas and Oklahoma (Hendricks and Read, 1934) and in rocks of the Morien Group of Nova Scotia (Abbott, 1954, p. 52), is found in both the Stanley Cemetery and Missouri floras, but this fact does not seem to be significant because of the long time range of this species. Its presence does not seem to tie the Indiana flora to the fossil flora of Missouri. The Indiana floral assemblage seems more closely similar to that of the Michigan coal basin than to the flora recorded by White (1899).

White (1913) studied the several floras of West Virginia. Only 11 (6.6 percent) of 167 West Virginian species of early Pottsville age are found in the Stanley Cemetery flora. His list of species from the Kanawha Group included 107 species, 21 (19.6 percent) of which are in common with the Indiana list. The list of Allegheny species is considerably shorter and contained 45 species, of which 11 (24.4 percent) are found in the Indiana assemblage. Thus the Indiana flora bears the greatest similarity to the group of Allegheny species. White did not illustrate the species, however, and thus there is some doubt whether identification is uniform for the West Virginia and Indiana assemblages.

Jongmans, Gothan, and Darrah (1937) also studied Carboniferous floras from West Virginia. Jongmans' list from the lower part of the Pocahontas Group totals 16 species, and 3 of them are in the Indiana (Stanley Cemetery) flora. None of the seven species listed for the upper part of the Pocahontas are found in the Indiana flora. The new River Group contains 19 species, and 7 of them are found in the Indiana flora. The list of species from the Kanawha Group contains 32 species, and 7 of them are found in Indiana. Jongmans' list of Allegheny species numbers 17, and only 3 species on this list are in the Stanley Cemetery flora.

The floras studied by Jongmans exceeded the time span of the assemblage given by White, evidence that this Indiana flora bears no significant resemblance to either the Pocahontas or the Allegheny floras of West Virginia. The similarity is greater between the Indiana flora and the Kanawha flora, even though a still larger percentage of species is common to the floras from the lower part of the Brazil Formation of Indiana and the New River Group of West Virginia.

White (1900b) listed the ranges of many plants collected from Pottsville rocks in the southern anthracite area of eastern Pennsylvania. He collected plants from the Lower Lykens and Upper Lykens Groups and divided the flora into the Lower Lykens, Lower Intermediate, Upper Intermediate, and Upper Lykens divisions. Comparison of the species found in these four categories with the species identified from the Stanley Cemetery flora reveals that only 3 of the 50 species listed from the Lower Lykens Coal group are found in the Stanley Cemetery flora. Seventeen species are listed as occurring in the Lower Intermediate flora, but none of these species is found in the Stanley Cemetery flora. The Upper Lykens list contains 122 species, but only 9 of these have been identified from the Indiana flora. The Upper Intermediate flora includes only 11 species, and 3 of these are found in the Stanley Cemetery flora.

The Indiana flora bears little resemblance to the Lower Lykens or Lower Intermediate floras of White. A similarity is found between the Stanley Cemetery flora and the Upper Lykens flora and between the Stanley Cemetery flora and the Upper Intermediate flora. Although the exact correlation of the Upper Lykens division of White is uncertain, the general aspect of the Upper Lykens flora seems to indicate a Kanawha age.

White (1900a) also studied floral assemblages in western Pennsylvania. His list from the Eagle Coal, which he stated is early Kanawha in age, contains 31 species. Eight of these species are also found in the Indiana flora (table 3). The Peerless Coal flora of middle Kanawha age comprises 65 species, and 10 of these are also found in the Indiana flora. The late Kanawha flora re-

Table 3--*Species common to Stanley Cemetery flora and to White's (1900a) Pennsylvania flora*

Species	Lower Kanawha	Middle Kanawha	Upper Kanawha	Clarion Group	Kittanning Group
Alethopteris decurrens	x				
A. serli	x	x	x	x	
Annularia radiata		x			
A. sphenophylloides			x	x	x
A. stellata			x	x	x
Asterophyllites equisetiformis			x		x
Calamites suckowi		x			x
Cordaianthus gemmifer					x
Cordaites borassifolius		x			x
Lepidodendron aculeatum					x
L. dichotomum	x			x	x
L. lanceolatum			x		
L. modulatum		x	x	x	x
L. obovatum	x	x			
Lepidostrobus variabilis	x	x			x
Mariopteris hymenophylloides			x		
Neuropteris clarksoni					x
N. flexuosa	x	x			
N. macrophylla					x
N. rarinervis			x	x	x
N. scheuchzeri			x	x	x
Palmatopteris furcata	x				
Renaultia chaerophylloides					x
Rhabdocarpus mamillatus					x
R. multistriatus		x		x	
Sigillria bradii				x	
Sphenophyllum cuneifolium	x	x	x		
S. emarginatum			x	x	x
Sphenopteris broadheadi			x		
Total number of common Species	8	10	12	10	17
Number of species listed by White	31	65	38	21	110
Percentage of White's species	25.8	15.3	31.5	47.6	15.5

ported by White is from the Stockton Coal. This assemblage, made up of 38 species, has 12 species in common with the Stanley Cemetery flora (table 3).

The flora from the Clarion Group is the oldest of three Allegheny floras presented by White. It is listed as containing 21 taxa identified to the species level, and 10 of these are also found in Indiana. The Kittanning reported by White is a rich flora containing 110 species, but only 17 species are found in both the Kittanning flora and in the Stanley Cemetery flora.

The flora of the Freeport Group also contains some longranging species that are found in the Stanley Cemetery flora. In fact, there are six species in all three of the Allegheny floras of White, and five of these six species are in the late Kanawha flora. The Stanley Cemetery flora is most nearly like White's late Kanawha and Clarion floras. This Indiana flora contains 48 percent of the species found in the Clarion Group and 32 percent of those found in the late Kanawha rocks (table 3). White records *Sphenophyllum cuneifolium* and *Annularia radiata* in rocks of Kanawha age and S. *emarginatum* and *A. stellata* in late Kanawha and younger rocks. *S. emarginatum* and *A. radiata* are listed as common and *S. cuneifolium* and *A. stellata* as not common in the Stanley Cemetery flora.

COMPARISON WITH CANADIAN FLORAS

The most recent and extensive comparative studies of American Mississippian and Pennsylvanian floras have been carried on by Bell (1938, 1940, 1944). The Canadian floras studied by Bell have yielded so many species that detailed comparisons are possible.

Bell's study of the Morien Group of the Sydney coalfield in Nova Scotia (1938) revealed three floras. The Indiana flora under study has the greatest similarity with the lowest zone in Nova Scotia. Bell (1938, p. 12) pointed out that this lowest zone shows an age relationship with Westphalian B or lower Westphalian C floras of Europe. As in the Indiana flora, such species as *Neuropteris scheuchzeri* and *Alethopteris serli* are present but are not abundant, an indication that the Nova Scotia flora is probably more nearly similar to Westphalian B than to Westphalian C assemblages.

Bell’s study of the Pictou coalfield (1940) presented species lists of floras from the Canso, Cumberland, Stellarton, and Pictou Groups. The Riversdale Group is not found in the Pictou area. The flora from the Canso is too small to be of value in this study because it contains only three species. The Cumberland flora is made up of 10 species, and 4 of them, *Neuropteris tenuifolia, N. obliqua, Cardiocarpon ingens,* and *Cordaites principalis,* are also found in the Stanley Cemetery flora (table 4).

Bell's list of species from the Stellarton is divided into two divisions. The lower portion, or Division 1, contains no fossils which Bell considered diagnostic of age, but its flora is made up of 10 species, and 7 of these are also found in the Stanley Cemetery flora. The flora of Division 11, which Bell stated contains fossils indicating a possible Westphalian B to C age, inludes 45 species; 16 of these species are found in the Indiana assemblage. Of the Pictou species listed by Bell only *Neuropteris tenuifolia* and *Cordaites principalis* are found in the Stanley Cemetery flora.

This Indiana flora bears a great resemblance to the flora of Division II of the Stellarton Group. As the assemblage from Division II is possibly late Westphalian B or Westphalian C in age, the correlation of the two assemblages is not greatly in conflict with purely geologic interpretations of the age of the rocks in this part of the Indiana geologic column.

Bell's last study (1944) of the Carboniferous flora of Nova Scotia listed species from the Riversdale, Cumberland, and Pictou Groups. Nine of the forty-eight species listed by Bell from the Riversdale and eighteen of eighty-two species from the Cumberland are found in the Stanley Cemetery flora (table 4). The upper Pictou assemblage differs from the Stanley Cemetery flora in a marked manner, but a few lower Pictou species are found in this Indiana flora.

Of the floral assemblages listed by Bell (1944), the Stanley Cemetery flora compares best with floras obtained from strata within the Cumberland of Nova Scotia. This fact is somewhat of an anachronism, because the Stanley Cemetery flora is similar to Bell's Stellarton II flora, which is presumably of Allegheny age (table 1), and to the Cumberland flora, which is Kanawha in age.

COMPARISON WITH EUROPEAN FLORAS

Zeiller (1886) discussed the flora of late Carboniferous age in France. His middle zone contains 113 species, and 28 of these are in the Stanley Cemetery flora of Indiana. His lower zone contains 44 species, and only 6 of them are found in this flora; his upper zone contains 113 species, and 26 of them are found in this flora. Zeiller defined his middle zone as Westphalian B in age.

Table 4--*Species common to Stanley Cemetery flora and to Bell's (1940, 1944) Nova Scotia flora*

Species	Riversdale (1944)	Cumberland (1940)	Cumberland (1944)	Stell-t I (1940)	Stellarton II (1940)	Pictou (1940)
Alethopteris decurrens	x		x			
A. grandini				x	x	
A. serli				x	x	
Annularia sphenophylloides.............					x	
Asterophyllites equisetiformis..........	x		x		x	
Calamites suckowi	x		x		x	
Calamostachys paniculata			x			
Cardiocarpon ingens		x				
Cordaites principalis	x	x	x	x	x	x
Diplothmema obtusiloba	x		x			
Lepidodendron aculeatum................			x			
L. dichotomum..................................			x	x	x	
L. lanceolatum..................................	x		x	x	x	
L. obovatum......................................			x			
L. ophiurus..					x	
L. wortheni..			x		x	
Lepidostrobus varibilis.....................	x		x	x	x	
Megalopteris dawsoni	x					
Neuropleris flexuosa					x	
N. obliqua		x	x			
N. scheuchzeri..................................				x	x	
N. tenuifolia......................................		x	x		x	x
Palaeostachya elongaza			x			
Palmatopteris furcata			x			
Sigillaria scutellata			x			
Sphenophyllum cuneifolium.............	x		x		x	
S. emarginatum.................................					x	
Total number of common species	9	4	18	7	16	2
Number of listed by Bell	48	10	82	10	45	9
Percentage of Bell's Species...........	18.8	40.0	21.9	70.0	35.5	22.2

Bertrand (1919) also listed species found in the Carboniferous of France. Compared with this assemblage, the Indiana flora is most similar to Zone B-1 of the Assise d'Anzin (Westphalian B) (table 1). The Stanley Cemetery flora is similar to the flora of the Charbon gras (Assise de Bruay or Westphalian C) as recorded by Bertrand (1922) from the Saar. None of the species listed by Bertrand from the younger floras are found in this Indiana assemblage. Bertrand's later paper (1928) discussed in general terms the floras of four regions in France. Of these, the floras of the Assise de Bruay contain an assemblage which most closely compares with the Stanley Cemetery flora from Indiana. This fact is interesting because according to Moore and others (1944), the Assise de Bruay is equivalent to lower Allegheny strata.

Compared with the species listed by Gothan (1923), the upper middle part of the Upper Carboniferous appears to have the great est number of species in common with the Stanley Cemetery flora. Of 31 species from the lower middle part of the Upper Carboniferous only 9 are represented in this Indiana flora; of 80 species from the middle of the middle part of the Upper Carboniferous 20 are present; and of 79 species from the upper middle part of the Upper Carboniferous 27 are in the Stanley Cemetery flora. Table 5 of Gothan and Remy's (1957) *Steinkohlenpflanzen* presents approximately the same picture, namely, that this Indiana flora equates with species assemblages from the Westphalian B and C rocks of Europe.

Jongmans' stratigraphic analysis of the Westphalian flora of part of the Netherlands (1928) is of interest in that his list of species found in the Epen Group shows an increase in the number of species common to the Stanley Cemetery flora as one goes higher in that group. The lower Epen assemblage of 26 species has only 1 species which is found in the Indiana flora, whereas 4 of the 19 species from the upper Epen flora are found in the Indiana flora. In the Baarlo Group the degree of similarity is even greater than in the Epen. From the lower Baarlo beds 5 of 30 species are also found in the Stanley Cemetery flora, from the middle Baarlo bed 8 of 26 species, and from the upper Baarlo beds 11 of 36 species. This is an indication that the floral assemblages of the upper parts of this short section of the geologic column are more nearly like the Stanley Cemetery flora.

The list of species from the Stanley Cemetery flora, as compared with the species from the British coal measures published by Crookall (1933), indicates that a higher percentage of species from Indiana is also found in the Staffordian Group than in the Yorkian or Radstockian Groups. Crookall listed 147 species from the Radstockian Group, and 24 of these species are also found in the Stanley Cemetery flora. He listed 202 species from the Staffordian Group and 407 species from the Yorkian flora; 38 of the Staffordian species and 32 of the Yorkian species are also found in the Stanley Cemetery flora.

Crookall (1933, p. 54) stated that *Alethopteris davreuxi,* which also appears in the Indiana flora, seems to be characteristic of the upper part of the Yorkian Group in Great Britain.

AGE OF THE STANLEY CEMETERY FLORA

Such species as *Asterophyllites equisetiformis, Lepidodendron dichotomum, L. wortheni, Palmatopteris furcata,* and *Neuropteris obliqua* strongly indicate a Kanawha age for the Stanley Cemetery flora. The genus *Megalopteris,* which is represented by *M. dawsoni,* further dates this flora as not younger than earliest Allegheny. Comparison of this flora with selected ones in Europe and such species as *Sigillaria scutellata, Alethopteris davreuxi, A. decurrens,* and *Neuropteris obliqua* suggest that this Indiana flora is similar to floras found in Westphalian B deposits.

But the Stanley Cemetery flora contains elements which suggest that it is a transitional type of flora containing species that are more typical of Allegheny age than of Kanawha. The large number of specimens of *Annularia* that intergrade between *Annularia radiata,* which is the older species, and *A. stellata* suggests that the shift from the older to the younger species of this genus has been recorded in this flora. The coexistence of *Sphenophyllum cuneifolium* and *S. emarginatum* in this flora also suggests a transition from a typically Kanawha flora, comparable to the Westphalian B floras in Europe, to an Allegheny flora, which finds its counterpart in the Westphalian C deposits of Europe. The Stanley Cemetery flora includes many species that were found in the younger Mazon Creek flora, such as *Annularia sphenophylloides, Neuropteris rarinervis, Alethopteris serli, Lepidodendron aculeatum, Lepidostrobus variabilis, Calamites suckowi,* and *Asterotheca oreopteridia.* The fact that this flora contains many species typical of the Mazon Creek flora, which is found in the basal part of the Carbondale Formation of Illinois, is further evidence that the assemblage found in the lower part of the Brazil Formation is transitional.

Sigillariostrobus quadrangularis is valuable as an index fossil. This species is relatively abundant in the Stanley Cemetery flora and also has been found at another site in Indiana, which I think is within the upper part of the Brazil Formation (Wood, 1947). White (1907) recorded this species from the Coal Hill and Spadra floras of Arkansas, which he interpreted to be earliest Allegheny in age. This species has not been recorded from beds older than those from which the Stanley Cemetery flora was obtained or from beds younger than earliest Allegheny.

Arnold (1949, p. 159) stated that more information about the stratigraphic range of *Neuropteris scheuchzeri is* needed. This species is present in the Stanley Cemetery flora, and its occurrence in Brazil strata substantiates Read's record (1947) for his Zone 5 *of Neuropteris tenuifolia* and adds to the known range of this taxon.

I believe that this flora can be used in a general way to date the strata from which it was obtained, at least to the series level, but that the age range indicated by the floral assemblage must be refined and narrowed.

FUTURE PALEOBOTANICAL WORK

As a beginner in paleobotany I became aware of the difficulties in making exact identification based on old reference works and in comparing the Stanley Cemetery flora with others reported in the literature. The following are suggested avenues of potential fruitful research in paleobotany:

1. More analyses of American floras of different ages are needed. Such studies will permit us to refine our knowledge about the time of appearance and disappearance of fossil plant species.
2. Detailed examinations of American floras of the same age are needed to determine when various taxa reached their zeniths in terms of numbers of specimens.
3. The drawings used in the old reference works to illustrate species should be supplemented with photographs that show diagnostic features.
4. A careful comparison of European types with American plant macrofossils needs to be undertaken. European and American literature indicate that at least some American types need to be separated from extant European types.

LIST OF FOSSIL PLANTS IN THE STANLEY CEMETERY FLORA

The fossil plants listed below were obtained from the ironstone concretions, shales, and sandstones above the Lower Block Coal in Greene County, Ind. Their relative abundance is indicated as follows: r-rare, 5 specimens or less; nc-not common, 5 to 20 specimens; c-common, more than 20 specimens.

Phylum Tracheophyta
Subphylum Lycopsida.
Order Lepidodendrales

Aspidiaria sp. Presl (c)
Lepidodendron aculeatum Sternberg (c)
L. dichotomum Sternberg (c)
L. lanceolatum? Lesquereux (nc)
L. latifolium Lesquereux (r)
L. modulatum Lesquereux (nc)

L. obovatum Sternberg (nc)
L. ophiurus Brongniart (nc)
L. vestitum Lesquereux (nc)
L. wortheni Lesquereux (c)
Lepidophyllum sp. Brongniart (c)
Lepidostrobus cf. L. incertus Lesquereux (nc)
L. variabilis, Lindley and Hutton (nc)
Lepidostrobophyllum ovatifolius (Lesquereux) (c)
Sigillaria brardi Brongniart (r)
S. davreuxi Brongniart (r)
S. kidstoni? Crookall (r)
S. scutellata Brongniart (nc)
Sigillariostrobus quadrangularis (Lesquereux) (c)

Subphylum Sphenopsida
Order Equisetales

Annularia mucronata Schenck (c)
A. radiata (Brongniart) (c)
A. sphenophylloides (Zenker) (c)
A. stellata, (Schlotheim) (nc)
Asterophyllites equisetiformis (Schlotheim) (c)
Calamites cruciatus Sternberg (nc)
C. suckowi Brongniart (c)
Calamostachys sp. Schimper (c)
C. paniculata? Weiss (nc)
C. superba Weiss (r)
C. tuberculata (Sternberg) (c)
Cingularia sp. Weiss (nc)
Macrostachya infundibuliformis (Bronn) (r)
Palaeostachya elongata (Presl) (c)

Order Sphenophyllales

Sphenophyllum cuneifolium (Sternberg) (nc)
S. emarginatum Brongniart (c)
S. hauchecornei (Weiss) (nc)

Subphylum Pteropsida
Orders Filicales, and Cycadofilicales
Alethopterids

Alethopteris davreuxi (Brongniart) (nc)
A. decurrens (Artis) (nc)

A. grandini (Brongniart) (nc)
A. serlii (Brongniart) (nc)
Callipteridium sullivanti (Lesquereux) (nc)

Sphenopterids

Diplothmema obtusiloba (Brongniart) (nc)
Oligocarpia, missouriensis D. White (c)
Palmatopteris furcata (Brongniart) (nc)
Renaultia chaerophylloides (Brongniart) (nc)
Sphenopteris (Hymenotheca) broadheadi D. White (c)

Precopterids

Asterotheca crenulata (Brongniart) (nc)
A. cyathea (Schlotheim) (c)
A. oreopteridia (Schlotheim) (c)
Mariopteris hymenophylloides? (Lesquereux) (r)
M. mazoniana (Lesquereux) (c)
Pecopteris clintoni Lesquereux (nc)
P. pseudovestita? D. White (c)
P. serpillifolia? Lesquereux (c)

Neuropterids

Cyclopteris sp. Brongniart (r)
C. orbicularis Brongniart (r)
Megalopteris dawsoni (Hartt) (nc)
Neuropteris flexuosa Sternberg (nc)
N. heterophylla? Brongniart (nc)
N. macrophylla (Brongniart) (r)
N. obliqua? (Brongniart) (nc)
N. rarinervis Bunbury (ne)
N. scheuchzeri Hoffman (c)
N. tenuifolia, (Schlotheim) (nc)
Odontopteris subcuneata Bunbury (nc)

Miscellaneous pteridophyll organs

Aphlebia crispa (Gutbier) (nc)
Aulacotheca sp. Halle (nc)
Spiropteris sp. Schimper (nc)
Whittleseya sp. Newberry (nc)

Cycadofilicalean seeds

Holcospermum sp. Nathorst (r)
Pachytesta cf. P. vera Hoskins & Cross (r)

Rhabdocarpus cf. R. mansfieldi Lesquereux (nc)
R. mamillatus Lesquereux (nc)
R. multistriatus (Presl) (r)
Trigonocarpus sp. Brongniart (c)

Order Cordaitales

Artisia sp. Sternberg (c)
Cardiocarpon sp. Brongniart (c)
C. annulatum Newberry (c)
C. dilatatus Lesquereux (r)
C. ingens? Lesquereux (nc)
C. late-alatum Lesquereux (c)
Cordaianthus gemmifer Grand'Eury (nc)
Cordaicarpon sp. Geinitz (c)
Cordaites borassifolius (Sternberg) (r)
C. crassinervis Heer (nc)
C. principalis (Germar) (c)

SYSTEMATIC PALEOBOTANY

Subphylum LYCOPSIDA

Order LEPIDODENDRALES

Aspidiaria sp. Presl

Plate 1, figure 1

Aspidiaria seldotheimiana Presl, in Sternberg, 1838, Versuch einer Geognostischen Botanischen Darstellung der Flora der Vorwelt, pts. 7 and 8, p. 131, pl. 68, fig. 10.

Remarks.--Specimens representing lepidodendrid trunks are fairly abundant in this flora and represent partially decayed materials. Their stratigraphic value is zero; however, as Arnold (1947, p. 98) pointed out with a quotation from Scott, these specimens are of value in pointing out the difficulties of the subject.

Lepidodendron aculeaturn Sternberg

Plate 1, figure 2

Lepidodendron aculeatum Sternberg, 1820, Versuch einer Geognostischen Botanischen Darstellung der Flora der Vorwelt, pt. 1, p. 20, 23, pl. 6, fig. 2; pl. 8, figs. 1Ba, b.

Remarks.--One of the specimens figured was found in the sandstone overlying the nodule-bearing shales above the coal and shows evidence of lateral deformation. But the leaf cushions still bear the tips curved in opposite directions characteristic for this species. The major features of the leaf sear proper are lacking, but the position of the scar on the cushion, together with the transverse markings of the keel, permits identification. The lines forming the upper faces of the leaf cushion extend below the leaf sear and join the margins of the leaf cushion. The specimen pictured is an ironstone concretion in which the leaf sear, keel, and markings are visible.

Renier and Stockmans (1938, p. 60) and Janssen (1939, p. 39) commented on the difficulty of separating *Lepidodendron aculeatum* from *L. obovatum.* Zeiller (1888, p. 439) stated that the two may be separated by means of a leaf cushion in *L. obovatum* which is in most specimens wider than it is high. Hirmer (1927, p. 203) listed the two species *L. aculeatum* and *L. obovatum,* as contemporaneous species but did not suggest any similarity of the two taxa. I believe that specimens of these two species from this flora are particularly difficult to separate.

Lepidodendron dichotomum Sternberg
Plate 1, figure 3

Lepidodendron dichotomum Sternberg, 1820, Essai d'un exposé géognosticobotanique de la flore du monde primitif, v. 1, pt. 1, p. 20, 25, pl. 1, pl. 2, (and pl. 3?); v. 2, pts. 7-8, p. 177, pl. 68, fig. 1.

Remarks.--As noted by White (1899, p. 200) and Arnold (1949, p. 170), literature on this species has led to much confusion. This specimen is comparable to the leaf cushion of type I as discussed by Lesquereux (1880, p. 384) because of its square-rhomboidal shape. The specimen pictured shows a dichotomously branched limb which bears leaf cushions on which the leaf scar is above the widest part of the cushion; the lower keel is visible on the leaf cushion and lacks any transverse markings. The lower part of the specimen bears leaf cushions which are more elongate, but the features of the cushion are not discernible because of sphalerite.

Zeiller (1888, p. 442) placed Lesquereux's material identified as *Lepidodendron dichotomum* Sternberg (Lesquereux, 1880, p. 384, pl. 64, fig. 1.) under *L. obovatum* Sternberg, a position which seems justifiable to me because Lesquereux's illustrations show a leaf cushion which is not square-rhomboidal as described in his discussion. There is some question about Lesquereux's identification because he used the name *L. dichotomum* in the text and referred to, figure 3 of plate 64, but on page 12 of the Atlas he listed figure 3 of plate 64 as *L. obovatum.*

Hirmer (1927, p. 203) placed Arber's species *L. loricatum* in parentheses and also equated *L. dichotomum* to *L. fuliginosum* Williamson, further emphasizing the existing confusion.

I think it is advisable to identify the few specimens in this flora as *L. dichotomum* on the basis of the leaf cushion shape and the position of the leaf sear on the cushion.

Lepidodendron lanceolatum? Lesquereux
Plate 1, figure 4

Lepidodendron lanceolatum Lesquereux, 1880, Pennsylvania Geol. Survey Rept. Prog. P, v. 2, p. 369, pl. 63, figs. 3-5a.

Remarks.--This specimen, preserved as a sandstone impression, shows the general character of the leaf cushions, but the exact shape of the leaf sear is not discernible from this material. A marking in the widest region of most of the cushions is strongly suggestive of a leaf scar from which a prominent keel passing through the length of the cushion is visible. Nevertheless, this specimen is referred to Lesquereux's species because of the long, slender leaf cushion and the supposed position of the leaf sear on the leaf cushion.

The history of the confusion regarding the status of this species was given by Arnold (1949, p. 167), who, in agreement with Bell (1944, p. 88), preferred to retain Lesquereux’s species until it could be satisfactorily separated from *Lepidodendron lycopodioides* Zeiller (not Sternberg) or from L. simile Kidston. I agree with Bell and Arnold about retaining this species.

Lepidodendron latifolium Lesquereux

Plate 1, figure 5

Lepidodendron latifolium Lesquereux, 1880, Pennsylvania Geol. Survey Rept. Prog. P, v. 2, p. 370, pl. 63, figs. 7-8.

Remarks.--This unusual species has not been reported from any other flora since it was first described by Lesquereux, who did not know the exact horizon of his type specimen. The specimen pictured was recovered from the sandstone which lies immediately above the ironstone concretion-bearing shale over the coal. The species is rare.

Lepidodendron modulatum Lesquereux

Plate 1, figure 6

Lepidodendron modulatum Lesquereux, 1854, Boston Jour. Nat. History, v. 6, p. 428.

Remarks.--The specimen pictured is believed to be a portion of a small twig on which commensurately small leaf cushions are borne. Although the round-topped rim which separates the leaf cushions is clearly visible in this specimen, it lacks the ropy appearance mentioned by Arnold (1949, p. 170). The case for the separation of *Lepidodendron modulatum* from *L. aculeatum*, contrary to the opinion of most authors, was presented by Arnold (1949) and is accepted by me because this separation may enhance the stratigraphic value of both species.

Lepidodendron obovatum Sternberg

Plate 1, figure 7

Lepidodendron obovatum Sternberg, 1820, Essai d’un exposé géognostico botanique de la flore du monde primitif, v. 1, pt. 1, p. 21, 25, pl. 6, fig. 1; pl. 8, fig. lAa, b; pt. 4, p. x.

Remarks.--This species is not common, but it has been found in ironstone concretions near the Stanley Cemetery.

Zeiller (1888, p. 442) pointed out that size variations of the leaf cushions reflect the age of the branch on which the leaf cushions are found but that the rounded lateral angles and the faint curvature of the upper and the lower tips are distinguishing features.

Renier and Stockmans (1938, p. 60) recorded both *Lepidodendron aculeatum* and *L. obovatum* from Belgium and noted that although both species are present in their specimens, they are difficult to separate from one another.

L. obovatum is distinguishable from *L. aculeatum*, which possesses a more elongate cushion. *L. dichotomum can* be separated from *L. obovatum* by means of the more regularly rhomboidal leaf scar which is situated higher on the cushion in *L. dichotomum.*

Lepidodendron ophiurus Brongniart
Plate 1, figure 8

Lepidodendron ophiurus Brongniart, 1828, Prodrome d'une histoire des végétaux fossiles: Dictionnaire sci. nat., v. 57, p. 85, 173.

Remarks.--Arnold (1949, p. 163) discussed the opinions of some previous authors regarding this and similar species. He stated that Zeiller (1888, p. 458) probably had the oldest figure of *L. ophiurus* which could be considered authentic. The material from this flora compares with Zeiller's figures. Arber (1922, P. 197) discussed *L. ophiurus* and concluded that it is a distinct species which is separable from *L. lycopodioides* on the basis of leaf scar shape, presence or absence of the leaf scar print, and keel ornamentation. Jongmans (1929), however, lumped *L. simile*, *L. lycopodioides, and L. ophiurus.* I believe that the material from this Indiana flora is best referred to *L. ophiurus* (sensu Jongmans) because no specimens from this flora can be referred to Arnold's species L. *ophiurioides,* which he stated resembles *L. ophiurus* Brongniart. In addition, the criteria for the separation of *L. ophiurus* from *L. lycopodioides* and *L. loricatum* set forth by Arber (1922, p. 205) do not permit the inclusion of my specimens under the latter two species.

Lepidodendron vestitum Lesquereux
Plate 1, figure 9

Lepidodendron vestitum Lesquereux, 1854, Boston Jour. Nat. History, v. 6, p. 428.

Remarks.--The specimen figured can be assigned to *Lepidodendron vestitum* because of the leaf scar position on the cushion. I agree with Arnold (1949, p. 169), who stated that this species seemed to be distinctive enough to be separated from *L. aculeatum* and *L. obovatum*. The figured specimen has undergone slumping, so that the upper and lower angles have been displaced and the vertical alignment of the tips has been lost. I believe, however, that the leaf scar position is the significant feature. The species is not common in the Stanley Cemetery flora.

Lepidodendron wortheni Lesquereux
Plate 2, figure 1

Lepidodendron wortheni Lesquereux, 1866, Illinois Geol. Survey, v. 2, p. 452, pl. 44, figs. 4, 5.

Remarks.--Specimens of this species are relatively common in the Stanley Cemetery flora and bear elongate cushions which are asymmetrical, lack parichnoi and ligule scars, and are characterized by heavy transverse markings on the lower half of the cushions as far as the leaf scar. These striations instead of a keel are characteristic of this species.

White (1899, p. 192)) noted that *Lepidodendron wortheni* is not easily separated from *L. brittsii* and *L. volkmannianum.* Bell (1938, p. 94) stated that his specimens from Nova Scotia agreed with White's description and illustration of *L. brittsii*. He further stated that the two species are essentially the same and identified his material as *L. wortheni.* Arnold (1949, p. 167), however, recognized *L. brittsii* in his Michigan materals.

I believe that the two species are distinct and that the separation of the two, as stated by White, on the basis of the height to which the transverse bars rise on the leaf cushion, permit the separation of *L. wortheni* from *L. brittsii*; the former has transverse bars reaching up to the leaf sear, whereas the latter has transverse bars restricted to the lower half of the cushion. Furthermore, the leaf cushions of *L. brittsii* are broader and more rounded than are those of *L. wortheni.* This species is common in the Stanley Cemetery flora.

Lepidophyllum sp. Brongniart
Plate 2, figure 2

Lepidophyllum Brongniart, 1828, Prodrome d'une histoire des végétaux fossiles, p. 87.

Remarks.—Arnold's (1947, p. 116 ff.) discussion concerning the use of the two form genera *Lepidophyllum* and *Sigillariophyllum* for leaf compressions of lycopods called attention to Graham's proposition (1935) that vascular strand number in the leaves is of diagnostic value at generic level. Arnold criticized this mode of distinguishing detached lycopod leaves by emphasizing that this criterion might put leaves known to be attached to lepidodendrid axes in the form genus *Sigillariophyllum.* It seems more logical to restrict the use of this vascular strand number to those detached leaves which have not been previously found attached to either a lepidodendrid or sigillarian axis. In this latter sense this specimen is referred to Brongniart's species rather than to the genus *Sigillariophyllum*, which was proposed by Grand'Eury for those leaves which have been found attached to sigillarian stems.

Additional confusion regarding the validity of the genus *Lepidophyllum* was pointed out by Andrews (1955, p. 179), who stated that this generic epithet had been preempted by Cassini for a living member of the Compositae.

Lepidostrobus cf. L. incertus Lesquereux
Plate 2, figure 3

Lepidostrobus incertus Lesquereux, 1880, Pennsylvania Geol. Survey Rept. Prog. P, v. 2, p. 442, pl. 69, figs. 25, 25a.

Remarks.--This species is tentatively referred to Lesquereux's species because it bears a closer resemblance to Lesquereux's description and illustration than to any other.

Lepidostrobus variabilis Lindley and Hutton
Plate 2, figures 4, 5, and 6

Lepidostrobus variabilis Lindley and Hutton, 1831, The fossil flora of Great Britain, v. 1, p1s. 10 and 11.

Remarks.--Zeiller *(1888,* p. 499) stated that this species varies in size and disposition of the sporophylls. It can be distinguished from *Lepidostrobus ornatus* by the nonreflexed laminae. It is larger and more compact than *L. ophiurus.*

Arber (1922, p. 176) discussed the relationship between *L. variabilis* and *L. geinitzi* Schimper and concluded that when the two are preserved as impresssions, no distinctly visible characters permit their separation. Further, Arber, in discussing *L. squarrosus* Kidston, which is separated from *L. variabilis* Lindley and Hutton on the basis of larger size and disposition of the bracts, concluded that the two “do not appeal” to him as worthy of specific rank. Because of the evident confusion regarding *L. variabilis* Lindley and Hutton, these specimens from the Indiana flora are referred to this species sensu Arber.

Hirmer (1927, p. 230) noted that *Lepidostrobus variabilis* may be the cone of *Lepidodendron oldhamius* Williamson.

Lepidostrobophyllum ovatifolious (Lesquereux)
Plate 2, figures 7 and 8

Lepidostrobus ovatifolius Lesquereux, 1870, Illinois Geol. Survey, v. 4, p. 441, pl. 30, figs. 2, 2c.
Remarks.--The specimens pictured are compressions in the concretion-bearing shales immediately above the coal. The basal halves of the laminae exhibit only a slight taper. This species is separated from similar material used by White to typify his new species *Lepidophyllum jenneyi* (1899, p. 214), which exhibits an acuminate apex, a wider sporanglum, and a pronounced dilation of the lamina at the point of junction with the sporangium.
Hirmer (1927, p. 231) proposed the new genus *Lepidostrobophyllum* to encompass detached sporophylls. This species is referred to Hirmer’s genus.

Sigillaria brardii Brongniart
Plate 2, figures 9 and 10

Sigillaria brardii Brongniart, 1828, Prodrome d’une histoire des végétaux fossiles, p. 65, 172.
Remarks.--Two specimens from the Stanley Cemetery flora are referred to *S. brardii.* The specimen preserved as a coalified layer represents the subsurface layer and displays the prominent parichnos scars and the fine, vertically oriented striae. The other specimen, which is a cast of the surface, displays the leaf cushions. Hirmer (1927, figs. 313-318) reproduced the illustrations from Weiss and Sterzel (1893), which show the several forms of this species that compare with these specimens. The specimens pictured were found in the sandstone and sandy shale overlying the concretion-bearing shales and are the only specimens of this species which I found near Stanley Cemetery.

Sigillaria davreuxi Brougniart
Plate 3, figure 1

Sigillaria davreuxi Brongniart, 1836, Histoire des végétaux fossiles, v. 1, p. 464, pl. 148.
Rema*rks*.--The elongate leaf cushions of this species permit ready separation of this form from other species. The specimen figured, the only specimen of this species found in the Stanley Cemetery flora, is a cast from the sandstone immediately overlying the ironstone concretion-bearing shales. So far as I know, this species has not been previously identified in American floras. But it has been recorded from France by Zeiller (1888, p. 569), from Belgium by Renier and Stockmans (1938, p. 66), and from Germany by Gothan and Remy (1957, p. 80) and by Hirmer (1927, p. 262).

Zeiller (1888, p. 571) stated that *Sigillaria davreauxi* is easily distinguished from *S. tessellata* by the elongate leaf cushion and the prominent foliar Sears. It can be separated from *S. boblayi* because the foliar scars in *S. davreauxi* are wider in comparison to their height than are those of *S. boblayi.* It differs from *S. mamillaris* in that in *S. davreuxi* the papillae project less and the scars are much more elongate.

Lesquereux (1880, pl. 72, fig. 5) pictured a specimen of *S. mamillaris* which is very similar to the specimen from this Indiana flora. Lesquereux (1880, p. 483) does Dot mention *S. davreuxi,* a fact which may indicate that he was not familiar with that species and that his specimen may indeed be *S. davreuxi.* The material figured by Lesquereux must be examined, however, before his identification can be judged. The species is not common in the Stanley Cemetery flora.

Sigillaria kidstoni? Crookall
Plate 3, figure 2

Sigillaria kidstoni Crookall, 1925, Geol. Mag., v. 62, no. 4, p. 165, pl. 6, fig. 1.

Remarks.--This single specimen compares most closely to Crookall's species, although the measurements of the specimen are slightly larger than those given in the original description (1925, p. 165). No other species described to date so nearly approximates this specimen. The rugose nature of the surface is reminiscent of the character of *Sigillaria brardii* Brongniart, but the leaf cushions of that species (which are nearly as high as wide) differ from the leaf cushions of this specimen, in which the cushions are much wider than they are high. The presence of ribs further sets this specimen apart from *S. brardii.* Crookall stated that S. *kidstoni* resembles *S. reniformis* Brongniart in its rugose and ribbed nature, but that it differs from the latter by lacking both prominent horizontal bars above the leaf cushions and markings which descend from the upper sides of the leaf cushions out into the ribs. Crookall further noted that the middle of the rib of *S. kidstoni* is not smooth as it is in *S. reniformis.*

Sigillaria scuttellata Brongniart
Plate 3, figure 3

Sigillaria scutellata Brongniart, 1822, Sur la classification et la distribution des végétaux fossiles: Mus. histoire nat. Paris Mém., p. 22, 89, pl. 1, fig. 4.

Remarks.--Sigillaria elongata resembles *S. scutellata,* but the former possesses more elongated cushions on which the lateral angles are more rounded. The specimen figured is a sandstone cast found in the sandstone cap which overlies the concretion-bearing shale above the coal. It is not common in the Stanley Cemetery flora.

Sigillarlostrobus quadrangularis (Lesquereux)
Plate 3, figures 4 and 5

Lepidocystis quadrangularis Lesquereux, 1880, Pennsylvania Geol. Survey Rept. Prog. P, v. 2, p, 455, pl. 69, fig. 5.

Sigillariostrobus quadrangularis White, 1903, U.S. Geol. Survey Bull. 211, p. 106.

Remarks.--Cones of this species are common in the Stanley Cemetery flora and have also been found in Warren County, Ind., in a restricted horizon believed to be in the lower part of the Brazil Formation of the Pottsville Series. I have already discussed (1957) the material from Warren County. In these specimens the cone fragments were found to contain megaspores of the species *Triletes glabratus* Zerndt. I discussed the discovery at that time of objects strongly resembling microspores and concluded that these cones were probably heterosporous. Details of the morphology of the cone, along with comments relative to the taxonomy of this species, are described in the above-dated publication.

Subphylum SPHENOPSIDA

Order EQUISETALES

Annularia mucronata Schenk

Plate 3, figure 6

Annularia -mucronata Schenk, 1883, Pflanzen aus der Steinkholen Formation, in Richthofen, China, v. 5, no. 2, p. 226, pl. 30, fig. 10, text-fig. 10.

Remarks.--Abbott (1958, p. 315-317) noted that this species is relatively common in American floras of Pennsylvanian age. She placed material identified by Lesquereux as *Annularia sphenophylloides* var. *intermedia* and specimens listed by Bell as *A. stellata* forma *mucronata* under Schenk's species. The material from the Stanley Cemetery flora, which is identified as *A. macronata*, is easily separable from *A. sphenophylloides* (pl. 3, fig. 7), so that I believe that there is no need to use categories below specific level for identifying this material.

Abbott listed occurrences of *A. mucronata* in States adjoining Indiana from rocks ranging from the Allegheny Series to the middle part of the Dunkard Group (Permian), but she did not note the occurrence of the species in Indiana. Thus this record of *A. mucronata* is a contribution to the distribution list for this species within Indiana and also extends the stratigraphic range of this species into rocks of Kanawha age. The species is relatively common in the Stanley Cemetery flora.

Annularia radiata (Brongniart)

Plate 3, figure 8

Asterophyllites radiatus Brongniart, 1822, Sur la classification et la distribution des végétaux fossiles, p. 35, pl. 2, figs. 7a, b.

Annularia radiata Sternberg, 1826, Essai d'un exposé géognostico-botanique de la flore due monde primitif, v. 1, pt. 4, pl. 31,

Remarks.--Although these specimens from the Stanley Cemetery flora do not exhibit the sharply tapering tips ascribed to *Annularia radiata*, they can be separated from *A. stellata* because the widest part of the leaf falls near the middle and the number of leaves per whorl is less than in *A. stellata*. Well-preserved specimens of *A. radiata* and *A. stellata* can be separated by leaf length because all leaves of a whorl in *A. radiata* are very nearly the same length, whereas the lateral leaves in *A. stellata* are noticeably longer than the other leaves of the whorl.

White (1899, p. 158) referred *A. stellata* Brongniart to *A. ramosa* Weiss because Weiss and Stur had shown that *A. stellata* was the leaf species for

Calamites ramosus Artis. Kidston and Jongmans (1917, p. 141) later placed *C. ramosus* Artis under *C. carinatus* Sternberg, however, and thus Artis' specific epithet is no longer valid. Canright (oral communication) found *C. carinatus* Sternberg in the Stanley Cemetery flora. Abbott (1958, p. 318) stated that materials identified by White as *Annularia ramosus* and those identified as *A. radiata* by both Lesquereux and White are all specimens of *A. radiata* Brongniart.

The specimens from the Stanley Cemetery flora strikingly resemble the Mazon Creek specimens shown by Langford (1958, p. 40, fig. 40) and identified by him as *A. pseudostellata* Potonié. Although the latter name was mentioned by Gothan and Weyland (1954, p. 196) and by Gothan and Remy (1957, 1). 183, table 5), Abbott (1958) did not treat this species in her monograph of this genus. Gothan and Remy noted that *A. pseudostellata* has a stratigraphic range from mid-Westphalian B to mid-D, a shorter span than that attributed to *A. radiata.* Gothan and Weyland, as well as Langford, noted that the whorls of *A. pseudostellata* are smaller than those of *A. stellata,* and Gothan and Weyland also noted that there are fewer leaves per whorl in Potoniés species than in *A. stellata.*

Although I have not seen the original description and illustrations for *A. pseudostellata,* I believe that using this name for the material figured by Langford is not in keeping with Langford's statement that Potoniés species is smaller than *A. stellata.* Furthermore, Langford, so far as I have been able to determine, is the only American paleobotanist who has recognized tile species among American materials. I believe that this fact further substantiates my opinion that Langford's specimens have not been correctly identified. Although few of the materials studied by Abbott (1958) are from Indiana, it seems reasonable to assume that Abbott would have included *A. pseudostellata* if this species had occurred in American floras.

Arnold (1949, p. 183), in discussing paleobotanical materials of Michigan, retained *A. radiata* as other authors do. I therefore believe that tile specific epithet as proposed by Brongniart should be retained. This species is relatively common in the Stanley Cemetery flora.

Annularia sphenophylloides (Zenker)
Plate 3, figures 7 and 9

Galium sphenophylloides Zenker, 1833, Neues Jahrb., p. 398, pl. 5, figs. 6-9.
Annularia sphenophylloides Gutbier, 1837, Naturwiss. Gesell. Isis Dresden Sitzungsber., p. 436.

Remarks.--Specimens of this species are fairly common in the Stanley Cemetery flora and exhibit rather wide size variations. The broadly terminating, spatulate leaves permit ready identification. Specimens were preserved in concretions and in the roof shales of the coal.

Annularia sphenophylloides is separated from *A. galioides* (Lindley and Hutton) Kidston, which resembles it in size, because *A. sphenophylloides* has spatulate-shaped leaves rather than the lanceolate leaves of *A. galioides.*

Annularia stellata (Schlotheim) Wood
Plate 4, figure 1

Casuarinites stellatus Schlotheim, 1820, Die Petrefactenkunde auf ihrem jetzig Standpunkte durch die Beschreibung seiner SammIung versteinerter und-

fossiler Uberreste des Thier und Pflanzenreichs der Vorwelt erläuter, p. 397.
Annularia stellata Wood, 1860, Acad. Nat. Sci. Philadelphia Proc., p. 236.

Remarks.--The leaves of many specimens of this species from the Stanley Cemetery flora show the depressed midrib and the inflated lamina upon which Lesquereux (1870, p. 423) based his species *Annularia inflata*. White (1899, p. 162) discussed the occurrence of the "inflated" characteristic in his specimens from southwestern Missouri but did not unite Lesquereux's species with that of *A. stellata*. Janssen (1940, p. 12), on the other hand, concluded that Lesquereux's species was founded on erroneous characteristics and that it should be referred to the species *A. stellata*. Abbott (1958, p. 323) also concluded that Lesquereux's specimens labeled *A. inflata* are specimens of *A. stellata.* I agree that because of the variations within this species Lesquereux's specimens are more correctly identified as *A. stellata*. Janssen, however, attributed *A. stellata* to Martin, a practice which subsequent authors have not followed.

White (1893, p. 30) called attention to Zeiller's treatment of *A. stellata* in which he had given Schlotheim's species priority over *A. longifolius* Brongniart. He further pointed out that if Martin's specimens of *Phytolithus stellatus* are the same as Schlotheim's specimens, then the former would have priority; however, this change should be decided after Martin's type has been reexamined. Abbott (1958, p. 323-324) did not discuss White's statement, nor did she mention Martin's material, although she discussed the other species which had been placed in synonymy with *A. stellata*.

Variations in leaf length among the specimens obtained from the Stanley Cemetery flora are rather pronounced, but the leaves roughly retain a spatulate rather than a lanceolate outline. This species is not as common in this flora as *A. radiata* (Brongniart) Sternberg is.

Asterophyllites equisetiformis (Schlotheim)

Plate 4, figure 2

Casuarinites equisetiformis Schlotheim, 1820, Die Petrefactenkunde, p. 397.
Asterophyllites equisetiformis Brongniart, 1828, Prodrome d'une histoire des végétaux fossiles, p. 159.

Remarks.--Specimens of this species are found in ironstone concretions and in the roof shales of the coal and, although relatively common in the Stanley Cemetery flora, have been recovered only as fragmentary remains. White (1899, p. 153) pointed out that his specimens referred to this species, because of the large stems, may be main axes of the plant, a characteristic which has permitted other authors to refer the robust specimens to *Asterophyllites longifolius* or *A. rigidus*. White's specimens show leaves which are not over 1.5 cm in length, a leaf length that agrees with that of the material from the Stanley Cemetery flora.

As White pointed out, specific delimitation within the genus *Asterophyllites* possibly has not been fully established for many species. Arnold (1949, p. 183) stated that this species probably represents materials which are alike in form and that this group may not represent a single biologic species. Because of variation in the specimens from Mazon Creek described by Lesquereux and from southwestern Missouri described by White, I believe that the size variation permissible within the species is greater than that recognized by many authors. This is particularly true because varied environmental conditions, together with branching, may result in either reduced or more robust parts of the same species. Abbott (1958, p. 299-302) discussed the species and charted (p. 297) the criteria by which *A. equisetiformis* may be separated from the three other American species which she recognized (*A. chaeraeformis* Goeppert, *A. grandis* Sternberg, and *A. longifolius* Sternberg). It is interesting to note that Abbott interpreted *A. equisetifolius* as having a wider size variation than the other species of the genus.

A. equisetiformis is relatively common in the Stanley Cemetery flora.

Calamites cruciatus Sternberg
Plate 4, figures 3 and 4

Calamites cruciatus Sternberg, 1825, Versuch einer Geognostischen Botanischen Darstellung der Flora der Vorwelt, v. 1, pt. 4, p. 46, Tentamen, p. 27, pl. 49, fig. 5; v. 2, 1833, pts. 5, 6, p. 48.

Remarks.--Specimens referable to this species have been found in ironstone concretions and as pith casts in the shales above the coal. They are identifiable by short nodes in the pith cast and by numerous branch scars. In these specimens the alternation of the ribs at the nodes and the bluntly rounded tips of the pith-cast ribs are specially clear.

Zeiller (1888, p. 357) pointed out that this species is differentiated from *Calamites ramosus* by short Internodes. Kidston and Jongmans (1917, p. 167) pointed out the branch scars, which are cuplike, and which contain a central raised part toward which the ribs converge-a condition seen in the specimens of the Stanley Cemetery flora. This species is not common in this flora.

Calamites suckowi Brongniart
Plate 4, figure 5

Calamites suckowi Brongniart, 1828, Histoire des végétaux fossiles, v. 1, p. 124, pl. 15, figs. 5, 6; pl. 16, fig. 2 (not pl. 14, fig. 6; pl. 15, fig. 1; pl. 16, fig. 1).

Remarks.--The figured specimen of this species is a pith cast of an internodal area that is longer than it is wide. The ribs, which appear slightly undulate in part of the cast, are mainly parallel and straight and have broadly rounded termini. Branch scars are very rare among the specimens recovered from the Stanley Cemetery flora.

Zeiller (1888, p. 337) and Arnold (1949, p. 180) stated that this species is one of the most widely distributed Pennsylvanian plant fossils. It is well represented in the Stanley Cemetery flora.

Calamostachys sp. Schimper
Plate 4, figure 6

Calamostachys typica Schimper, 1869, Traité de paléontologie végétale on la flore du monde primitif, v. 2, p. 328, pl. 23.

Remarks.--Materials referable to this genus have been found only in the ironstone concretions above the coal in the area under study. The cone pictured appears to be an immature specimen. Although the specimen is strongly similar to *Calamostachys germanica* Weiss, which has been reported from other

North American floras of Pennsylvanian age, I believe that these specimens can be identified only to the generic level.

Calamostachys paniculata? Weiss
Plate 4, figure 7

Calamostachys paniculata Weiss, 1876, Beitrdge zur fossilen Flora, Pt. 1, Steinkohlen-Calamarien: Abh. geol. Specialkarte Preussen, v. 2, p. 59, pl. 13, fig. 1; Steinkohlen-Calamarien, Pt. 2, p. 173, pl. 19, fig. 3; pl. 21, fig. 6.

Remarks.--This species has not been found in many American floras. Bell (1944, P. 105) reported it in his materials from the Cumberland Group of Nova Scotia. Hirmer (1927, p. 452) listed the species as the cone of *Calamites cruciatus* Sternberg. Jongmans (1911, p. 303) reviewed the literature pertaining to this species and pointed out the similarity of *C. paniculata* Weiss to *C. polystachya* Sternberg, which has a longer cone and is less branched.

The specimens figured are questionably identified as *C. paniculata* Weiss on the basis of cone size, bract shape, and position.

Calamostachys superba Weiss
Plate 4, figure 8

Calamostachys superba Weiss, 1876, Beitrdge zur fossilen Flora, Pt. 1, Steinkohlen-Calamarien, p. 46, pl. 4, figs. 2, 2a.

Remarks.--The cones in the specimen pictured are borne on opposite sides of an axis which is not well enough preserved to permit identification. The specimen appears to be a small or young cone, and the lower parts of the cone seem to have reached maturity before the sporangia in the upper part of the cone were mature.

This species is not common in the floras of the United States or Canada. I have not been able to find any other report of its discovery in materials from the United States. Bell's (1938, p. 87) report of it in the base of the Morien Group (lower Allegheny) in Nova Scotia is the only other record of its discovery on this continent.

Calamostachys tuberculata (Sternberg)
Plate 5, figures 1 and 2

Bruckmannia tuberculata Sternberg, 1826, Essai d’un exposé géognostico-botanique de la flore du monde primitif, v. 1, pt. 4, p. 45, pl. 29; pl. 45, f ig. 2.
Calamostachys tuberculata Weiss, 1884, Beitrdge zur fossilen Flora, Pt. 3, Steinkohlen-Calamarien: Abh. Geol. Specialkarte Preussen, v. 5, D. 178.

Remarks.--This is the most common species of *Calamostachys* in the Stanley Cemetery flora. Although the cone substance has been replaced by kaolinite in most specimens, the characters of the fructification are easily discernible. The only specimen attached to an axis bearing foliage is pictured here, but this one specimen presents a problem. Zeiller (1888, p. 400) and Hirmer (1927, p. 404), among others, pointed out that *Calamostachys tuberculata* is the fructification of *Annularia stellata* (Schlotheim) Wood and that both of these entities are borne on stems of *Calamites multiramis* Weiss. The photograph showing the cones attached to a branch bearing leaves suggests that the leaves would be identified as specimens of *Annularia radiata* Brongniart or *A. pseudostellata* Potonié; the leaves of the specimen are not complete on either halt of the concretion, however, but are broken off. Although I believe that the foliage attached to these two cones is *A. stellata,* similar to other specimens of that species from this flora, the problem of the stem is not resolved because *Calamites multiramis* has not been found in the Stanley Cemetery flora. Even though the cone agrees with the description for *Calamostachys tuberculata,* the identity of the attached foliage is not definitely established here,

Cingularia sp. Weiss

Plate 5, figure 3

Cingularia Weiss, 1871, Fossile der jungsten Steinkohlenformation und des Rothliegenden im Saar-Rhein-Gebiete, pt. 2, no. 2, p. 137.

Remarks.--The specimens collected from the Stanley Cemetery flora do not completely reveal the exact mode of attachment of the sporangiophores to the cone axis, but the disposition of the sporangia strongly suggests a reflexed attachment immediately beneath the sterile bracts. The sporangiophore which is attached directly beneath and next to the sterile bracts can be seen in the upper parts of the pictured cone.

Only a few cones showing this mode of sporangiophore attachment have been collected from this Indiana locality. Only two species of this genus have been described, and both are found in rocks of Westphalian (Yorkian?) age in Great Britain. Gothan and Remy (1957, p. 183) listed *Cingularia typica* Weiss from Westphalian B or C deposits of Germany.

C. typica Weiss has basally united, stiff, sterile bracts which depart from the axis and pass out in a straight line. The sporangiophores, which are also united at the base, become separated and divide once again before terminating in a truncated tip. Each sporangiophore bears four sporangia. The sporangia of *C. cantrilli* Kidston are not known, but Kidston (1917, p. 1046) described four concentric scars on each sporangiophore which he concluded were the attachment points for the sporangia. *C. cantrilli* Kidston differs from *C. typica* in lacking the sterile bracts of the latter species.

The sterile bracts on these specimens from the Stanley Cemetery flora appear to differ from the two named species. On these specimens the sterile bracts in the lower part of the cone are depressed just beyond the point of attachment to the axis but within a short distance arch upward along the bract away from the axis.

Except for Jongmans' (1937, p. 374) and Jongmans, Gothan, and Darrah's (1937, p. 410) mention of a specimen of *C. typica* Weiss from Allegheny rocks of West Virginia, this is the first reported discovery of *Cingularia* in North America.

Macrostachya infundibuliformis (Bronn)

Plate 5, figure 4

Equisetum infundibuliforme Bronn, in Bischoff, 1828, Die kryptogamischen gewächse mit besonderer berücksichtigung der flora Deutschlands v. 1, p. 52, pl. 6, figs. 4, 9, 10.

Macrostachya infundibutiformis Schimper, 1869, Traité de paléontologie végétale, v. 1, p. 333, pl. 23, figs. 5-17.

Remarks.--This specimen is a partial mold of the cone. The whorl of bracts are 4 to 6 mm apart and alternate regularly at each node. The flattened nature of the bracts is clearly visible, but the uninervate condition is not clearly shown in any of them. The preserved part of the cone shows only 10 bracts per whorl; it is assumed, however, that there were slightly more than this number of bracts on half of this fructification.

This specimen is assigned to this species on the basis of the number of visible bracts, the size of the cone as revealed by this fragment, and the flattened bracts.

Arnold (1947, p. 150) listed *Macrostachya thompsoni* Darrah as the bestknown American species of the genus *Macrostachya; M. infundibuliformis* differs from Darrah's species in having fewer bracts per whorl. Bell (1938, p. 88) described *M. infundibuliformis* among his Sydney coalfield materials and noted that it is a rare species. The species is likewise rare in the Stanley Cemetery flora.

Palaeostachya elongata (Presl)
Plate 5, figure 5

Volkmannia elongata Presl, 1838, Gesell. vaterl. Mus. Bohmen Verb., p. 27, pl. 1.
Palaeostachya elongata Weiss, 1876, Beiträge zur fossilen Flora, Pt. 1, Steinkohlen-Calamarien, p. 108, pl. 15; Pt. 2, p. 181, pl. 22, fig. 15.

Remarks.--This species is relatively common in the Stanley Cemetery flora. The specimens exhibit a high degree of replacement by kaolinite, but the attachment of the sporangiophores immediately above the attachment points of the sterile bracts is quite apparent.

Order SPHENOPHYLLALES

Sphenophyllum cuneifollum (Sternberg)
Plate 5, figure 6

Rotularia cunefolia Sternberg, 1823, Essai d'un exposé géognostico-botanique de in flore du monde primitif, v. 1, pt. 2, p. 37, pl. 26, figs. 42a and b.
Sphenophyllum cuneifolium Zeiller, 1880, Explication de la carte géologique de la France, Second Partie, Végétaux fossiles du terrain houiller de la France, p. 30, pl. 161, figs. 1, 2.

Remarks.--Specimens referable to this species are not common in the Stanley Cemetery flora and have been recovered only from the roof shales of the coal. The specimens, like those of *Sphenophyllum emarginatum,* are small. None was found with dissected leaves. I believe that this species, like *S. emarginatum,* started as a diminutive plant, enlarged during the course of time, and developed cleft leaves in late Pennsylvanian time.

This species is distinguishable from *S. majus* because *S. cuneifolium* is smaller and has shorter teeth and less divided venation. S. *cuneifolium is* distinguishable from *S. verticillatum* Schlotheim and *S. oblongifolium* Germar and Kaulfuss, as pointed out by Zeiller (1888, p. 419), by having leaves which are concave and not convex along the margins. Abbott (1958, p. 337) studied the Problem of leaf dissection in this species and concluded that such species as *S. erosum, S. gemma, S. trifoliatum, S. tatum, S. myriophyllum, S. costulatum, S. dichotomum,* and *S. saxifragaefolium* belong to *S. cuneifolium.* Although

Abbott stated that this species ranges from the Pottsville through the Monongahela Series, she did not note the occurrence of *S. cuneifolium* in Indiana.

Sphenophyllum emarginatum Brongniart
Plate 5, figure 7

Sphenophyllum emarginatum Brongniart, 1828, Prodrome d'une histoire des végétaux fossiles, p. 68.

Remarks.--Zeiller (1888, p. 411) stated that this species is easily confused with that of *Sphenophyllum cuneifolium* because of the similarity of leaf size and shape; the specimens of *S. emarginatum* may be recognized, however, by the rounded teeth rather than the sharply pointed serrations seen in *S. cuneifolium.*

White (1899, p. 180) said that this species had persisted through a long span of time and that during this period the species had undergone an enlargement of leaves and a modification of leaf shape. The specimens from Indiana are within the lower limits of size as defined for the species and correspond closely to those found by White in southern Missouri. I believe that the small-leafed specimens from the lower Pennsylvanian of Indiana supports White's contention that the leaves of the species increased in size with progression of time.

This species is relatively common in the Stanley Cemetery flora and occurs mainly in the roof shales of the coal.

Sphenophyllum hauchecornei (Weiss)
Plate 5, figure 8

Macrostachya hauchecornei Weiss, 1884, Beiträge zur fossilen Flora, Pt. 3, Steinkohlen-Calamarien, p. 196, pl. 16, fig. 4.

Sphenophyllum hauchecornei Remy, 1955, Deutsche Akad. Wiss. Berlin Abh., K1. Chemie, Geologie u. Biologie, v. 1955, no. 1, p. 8, pls. 1-3; pl. 4, fig. 1.

Remarks.--The specimen figured is one of two cones of the same type found in one concretion. The fragment of the cone pictured is 6 cm long. The disposition of the lower part of this fragment suggests that the complete cone was much longer than the preserved fragment. The closely set nodes and the long bracts are distinguishing characteristics of this species. Cones of this species are not rare in the Stanley Cemetery flora.

W. Remy (1955, p. 8) discussed the history of *Macrostachya hauchecornei* and the confusion regarding the relationship of this cone to leaf and stem taxa. Remy united *M. hauchecornei* Weiss, *Calamites sachsei* Stur, and *Sphenophyllum cuneifolium* Sternberg.

I believe that the argument presented by Remy, based upon a study of available type specimens and specimens figured by previous authors, is sound. The fact that these three species have been recorded separately from deposits of the same age further supports Remy's thesis that they are parts of the same plant.

Orders FILICALES and CYCADOFILICALES

ALETHOPTERIDS

Alethopteris davreuxi (Brongniart)

Plate 6, figures 1 and 2

Pecopteris darreuxii Brongniart, 1828, Prodrome d'une histoire des végétaux fossiles, p. 57.

Alethopteris davreuxi Goeppert, 1836, Die fossilen Farrenkräuter (Systema filicum fossilium): Nova Acta Leopoldina, v. 17, p. 295.

Remarks.--Crookall (1955, p. 10) pointed out that this species is a highly variable taxon. The specimens which he examined show variations in the lateral veins from straight to highly flexuous.

The rounded nature of the tip of those pinnules which are fully extended is clearly seen, but the margins of those pinnules which are not fully spread out are depressed into the matrix, so that the pinnules appear to have a pointed tip. The subsidiary veins which enter the decurrent part of the pinnule are clearly seen in the figured specimens.

The species has been reported from American floras by Noé (1925, p. 15) and from the Pennsylvanian flora of Will County, Ill., by Janssen (1939, p. 145). This species was not recognized by Lesquereux, however; he (1880, p. 168) described *Callpteridium inaequale.* White (1899, p. 123) identified specimens of this species from the flora collected in Henry County, Mo. He (1899, p. 294296) listed *C. inaequale* Lesquereux [= *Alethopteris davreuxi* (Brongniart)] and stated in a footnote: "Names of foreign related species, whose distribution is given, are in parentheses immediately following the names of the American species to which they bear relation." He did not enumerate the reasons for this juxtaposition, and so we do not know why he considered these two entities to be "related or similar." I have found no other reference to any similarity of the two above-mentioned species. *C. inaequale* is not present in this flora from the Lowcr Block Coal, but *A. davreuxi* is represented by several specimens.

Crookall (1955, p. 10) pointed out that *A. davreuxi* has much finer lateral veins than *A. valida* has. *A. davreuxi* differs from *A. grandini* by having a more pointed pinnule apex and lateral veins which are more widely spaced than are those of *A. grandini*.

Crookall noted that *A. davreuxi* ranges in age from Westphalian B to D in the British fossil floras. Gothan and Remy (1957, table 5) showed that the species appears in Westphalian A deposits and persists into Westphalian C. Their discussion of this taxon (1957, p. 120) stated that it is a very rare species which is found mainly in the Westphalian B rocks of Germany. This species is not common in the Stanley Cemetery flora.

Alethopteris decurrens (Artis)

Plate 5, figure 9

Filicites decurrens Artis, 1825, Antediluvian phytology illustrated by a collection of the fossil remains of plants, peculiar to the coal formations of Great Britain, pl. 21.

Alethopteris decurrens Zeiller, 1888, Études des gites minéraux de la France Bassin houiller de Valenciennes, description de la flore fossile, p. 221, Atlas, pl. 34, figs. 2, 3; pl. 35, fig. 1; pl. 36, figs. 3, 4.

Remarks.--This species differs from *Alethopteris lonchitica* Zeiller, which possesses pinnules that are somewhat wider in their middle regions than at the base, whereas the pinnules of *A. decurrens* have parallel margins. *A. decurrens* differs from *A. serli* Brongniart by having pinnules that are narrower in proportion to their length and that terminate in a more acute apex.

This species is not common in the Stanley Cemetery flora. I have found that it has been previously reported from only two other American floras: the Michigan coal basin flora described by Arnold (one specimen is pictured without the benefit of any discussion) and the Wilmington flora described by Langford (1958). Crookall (1932, p. 739) listed it as a chief species of the Yorkian of England, and Gothan and Remy (1957, p. 120) listed it as found in Westphalian A to C deposits of West Germany.

Alethopteris grandini (Brongniart)
Plate 6, figure 3

Pecopteris grandini Brongniart, 1832 or 1833, Histoire des végétaux fossiles, v. 1, p. 286, pl. 91, figs. 1-4.
Alethopteris grandini Goeppert, 1836, Die fossilen Farrenkräuter, p. 299.

Remarks.--*Alethopteris grandini is* distinguishable from *A. serli* by having pinnules which are roundly terminated. Bell (1940, p. 119) pointed out that the pinnules on the upper side of the rachis in *A. grandini* are obliquely inserted but that those on the lower side are normal to the rachis. Crookall (1955) also reported this condition for the species. The specimens figured show a tendency toward this orientation.

Gothan and Remy (1957, table 5) showed that this species ranges only from the top part of Westphalian C through Permian deposits. Crookall (1955, p. 33) stated that the earliest record of this species is specimens from the lower part of Westphalian C deposits. The occurrence of this species in the Stanley Cemetery flora is noteworthy because it extends the known stratigraphic range of the species.

Alethopteris serli (Brongniart)
Plate 6, figures 4 and 5

Pecopteris serli Brongniart, 1828, Prodrome d'une histoire des végévtaux fossiles, p. 57.
Alethopteris serli Goeppert, 1836, Die fossilen Farrenkräuter, p. 301, pl. 21, figs. 6, 7.

Remarks.--*Alethopteris serli* can be distinguished from *A. grandini* by its less rounded pinnule termination and the more pronounced sinus produced by the decurrence of the lower edge of the pinnule, which is reflected in the upper edge of the pinnule immediately below. Further, the pinnules of *A. serli* are more closely set than are those of *A. grandini.* White pointed out that some specimens identified as *A. lonchitica,* after they have been more carefully cleared from the matrix, reveal a less sharply terminated pinnule, an indication that these specimens are more correctly identified as *A. serli.*

White (1899, p. 118) recognized a variety *missouriensis,* which was subsequently placed by Crookall (1955, p. 18) under *Alethopteris serli.*

Callipteridiurn sullivanti (Lesquereux)
Plate 6, figure 6

Callipteris sullivanti Lesquereux, 1854, Boston Jour. Nat. History, v. 6, p. 423.
Callipteridium sullivanti Weiss, 1870, Deutsche geol. Gesell. Zeitschr., v. 22, p. 876, pl. 21, figs. 1-3.

Remarks.--The specimen figured shows the venation and the pinnule shape, although the specimen is folded at the rachis and is partially doubled in this ironstone concretion. This species is not common in the Stanley Cemetery flora, but the reports of its discovery by Lesquereux (1880, p. 164) in Pennsylvania and Illinois and by White (1899, p. 123) in Missouri indicate that it is not rare. Langford (1958, p. 241) recorded this species as very common in the flora of Wilmington, Ill.

SPHENOPTEIRIDS

Diplothmerna obtusiloba (Brongniart)

Sphenopteris obtusiloba Brongniart, 1829, Histoire des végétaux fossiles, v. 1, p. 204, pl. 53, figs. 2, 2a.
*Diplothmema obtusiloba S*tur, 1877, K.-k. geol. Relchanst. Abh., v. 8, p. 230.

Remarks.--This fragmentary specimen representing a species not common in the Stanley Cemetery flora is identified as *Diplothmema obtusiloba* (Brongniart) because of the pinnule shape and venation pattern.

Arnold (1949, p. 202) noted that Lesquereux had placed this species in his genus Pseudopecopteris. Kidston (1923, p. 27) regarded the species as a member of the genus Sphenopteris. Arnold also stated that such species as *Sphenopteris striata, S. irregularis, S. latifolia,* and *Diplothmema schumannii* had been placed under *D. obtusiloba by* various authors.

Bell (1938, p. 20) described a new species from his Canadian material, named it *Sphenopteris whitii*, and placed White's (1899, p. 24) material, identified as Pseudopecopteris *obtusiloba (Brongniart).* in synonymy with his new species. Arnold concluded that the differences between *S. whitii* Bell and *P. obtusiloba* (Brongniart) might be the result of differences in preservation. I agree with Arnold's conclusion.

I believe that the justification for retaining *Sphenopteris striata* Gothan as a separate species is weakened by the fact that *S. striata* and *Diplothmema obtusiloba* are very similar. Furthermore, *D. obtusiloba* has been recorded mainly from lower Pennsylvanian deposits, whereas *S. striata* has been found in greater abundance in middle and upper Pennsylvanian strata. The location of these two species suggests that they are variations of the same taxon-variations which are not always sufficiently distinct enough to permit their separation. (See Gothan and Remy, 1957, table 5.)

Oligocarpia missouriensis D. White
Plate 6, figure 7

Oligocarpia missouriensis D. White, 1899, U.S. Geol. Survey Mon. 37, p. 66, pl. 20, figs. 1, 2; pl. 21, figs. 1?, 2?, 3, 4.

Remarks.--Specimens referable to this species are relatively common in the Stanley Cemetery flora. As In those specimens described by White, the fructifications are obscure, but they appear to be made up of several sporangia which are closely grouped.

Bell (1938, p. 44) discovered specimens of this species in the flora of the Sydney coalfield of Canada. These, he noted, bear some resemblance to *Oligocarpia gutbieri* Goeppert, but they can be separated from that species because the lobes of the pinnules bear fewer veins. White, in his original description, had already noted the similarity of these two species, but he had stated that the fructifications of his species did not appear to be situated as near to the margin as were those in some of the illustrations of Goeppert's species. White also noted that specimens which he had figured from the Lacoe collections from Mazon Creek, Ill., might also be specimens of *Oligocarpia missouriensis*.

In her monograph of the genus *Oligocarpia*, Abbott (1954, p. 52) emended the description of this species and listed it as occurring in uppermost Pottsville and Allegheny rocks in Canada, Missouri, and Ohio.

Palmatopteris furcata (Brongniart)

Plate 6, figures 9 and 10

Sphenopteris furcata Brongniart, 1828, Prodrome d'une histoire des végétaux fossiles, p. 50.

Palmatopteris furcata Potonié, 1892, Preuss. geol, Landesanst, Jahrb., 1891, p. 1, pl. 1, text-fig. 1, P. 3.

Remarks.--Arnold (1949, p. 205) noted that the generic position of plants of this type had been shifted by various authors. He concluded that White's (1943, P. 93) discussion in favor of using *Palmatopteris* Potonié for plants having dissected pinnules of the sphenopterid type precluded the use of *Diplothmema* Stur. Bell, however, in two of his papers (1938, p. 33; 1944, p. 70) followed Kidston and referred the species to the genus *Diplothmema*. Gothan and Weyland (1954, p. 135) and Gothan and Remy (1957, p. 100) followed the line of thinking proposed by White and Arnold.

The distribution of this species in the United States, as Arnold pointed out, is little known. The discovery of this species among the materials from the Stanley Cemetery flora contributes to still sparse geographic and geologic knowledge.

Berry had reported this species from the Paracas deposits (Lower Carboniferous) in Peru, but Jongmans (1954, p. 194), in commenting on this find, stated that Gothan (1928, p. 293) had renamed the species *Sphenopteris paracasica*.

Palmatopteris furcata (Brougniart) can be distinguished from *Sphenopteris spinosa* Goeppert because the latter species has leaf segments terminating in spines and a more compact appearance. The leaves of *Sphenopteris alata* are also much less deeply cleft than are those of *P. furcata*, and in the former species the wing of the rachis is much wider than that seen in *P. furcata*.

Renaultia chaerophylloides (Bronguiart)

Plate 7, figure 1

Pecopteris chaerophylloides Brongniart, 1834, Histoire des végétaux fossiles, v. 1, p. 357, pl. 125, figs. 1, 2.

Renaultia chaerophyIloides Zeiller, 1883, Annaes sci. nat., Botanique, ser. 6, v. 16, p. 208, 185; pl. 9, figs. 16, 17.

Remarks.--White (1899, p. 49) discussed specimens from southwestern Missouri which had been identified by Lesquereux and retained this species in the genus *Sphenopteris.* White's list of synonymous species includes specimens later cited by Kidston (1923, p. 315) under *Renaultia chaerophylloides* (Brongniart), and this treatment of the species is accepted by me.

This species has not been frequently reported from American floras and, insofar as I know, has not been reported from any Canadian sites. This specimen is not common in the Stanley Cemetery flora.

Sphenopteris (Hymenotheca) broadheadi White
Plate 7, figures 2, 3, and 4

Sphenopteris (Hymenotheca) broadheadi White, 1899, U.S. Geol. Survey Mon. 37, p. 41, pl. 13, figs. 1, 2.

Remarks.--Specimens of this species are rather common in the Stanley Cemetery flora and are of especial interest because of the few reported occurrences of this species.

White (1899, p. 43) described specimens from Pitcher's coal mine, 3½ miles southeast of Clinton, Henry County, Mo. Hinds and Greene (1915, p. 260) considered the Henry County coals to correlate with the upper part of the Pottsville Series. I know of no other report of this species.

White pointed out that the species described was fertile material. The figured specimens show clearly the general outline of the fruiting structure, which appears as a single unit, but, unfortunately, the material from this collection reveals no more about the structure of the fructification.

The larger of the two specimens pictured is identical to that shown by White (1899, pl. 13, figs. 2, 2a) ; the smaller specimen is also a fertile specimen, on which the fructifications were not detected until xylol was used on the specimen. This second specimen is interesting because it resembles the specimens identified by White as a new species, *Sphenopteris missouriensis.*

In his discussion of the fertile material identified as *Sphenopteris (Hymenotheca) broadheadi* (1899, p. 42), White stated that the sterile parts of this plant might be the fronds which he described on the following pages as *S. missouriensis.* The smaller of the two specimens pictured here, although larger than the sterile material figured by White, is identical to it except that this specimen is fertile. Clarification and reduction of terms should be accomplished, if possible, because of the difficulty brought about by Bell's (1938, p. 27) transfer of material identified by White (1899, p. 16) as *Eremopteris missouriensis* Lesquereux to the genus *Sphenopteris* and the setting up of his version of *S. missouriensis?* (Lesquereux). Kidston (1923, p. 90) had previously removed part of White's *E. missouriensis* Lesquereux material mentioned above and referred it to *S. alata* Brongniart. To add to the complication, Janssen (1940, p. 56) transferred White's *E. missouriensis* Lesquereux to *Diplothmema zobeli* Goeppert.

Kidston (1923, p. 154) described a new species of Westphalian age which he named *S. vernoni* and stated that it was similar to, but not the same as, *S. missouriensis* White because the latter species "differs in having oblong penultimate pinnae suddenly contracted into a point, and the pinnules in having more prominent lobes."

I believe that the material identified as *S. missouriensis* White is the sterile condition of *S. broadheadi* White and that the latter species has page priority and should therefore be retained as the valid species to include *S. missouriensis* White.

PECOPTERIDS

Asterotheca, crenulata, (Brongniart)
Plate 7, figure 5

Pecopteris crenulata Brongniart, 1828, Prodrome d'une histoire des végétaux fossiles, p. 57.

Asterotheca crenulata Kidston, 1924, Great Britain Geol. Survey Mem., Paleontology, v. 2, pt. 5, p. 516.

Remarks.--Lesquereux evaluated materials from Mazon Creek (1880, p. 193) and concluded that his material was sufficiently different from the European material to warrant introducing the new species *Pecopteris subcrenulata*. Lesquereux was also influenced by the fact that his specimens came from a different geologic horizon than the European specimens did.

White (1899, p. 64) considered Lesquereux's material to be *Sphenopteris subcrenulati (*Lesquereux). Kidston referred Lesquereux's species back to Bronpniart's species. I agree with Kidston's conclusion because Kidston had a specimen identified by Zeiller with which he could compare his materials.

Bell (1938, p. 72) introduced a new species *Asterotheca herdi*, which resembles *A. crenulata* by having some pinnules which are crenulated. The longer pinnules. of *A. crenulata* separate it from the smaller specimens of *A. miltoni* (Artis), to which it bears some resemblance. *A. crenulata* is not common in the Stanley Cemetery flora.

Asterotheca cyathea (Schlotheim)
Plate 7, figures 6 and 7

Filicites cyatheus Schlotheim, 1820, Die Petrifactenkunde, p. 403. *Asterotheca cyathea* Stur, 1877, K.-k. geol. Reichanst. Abh.. v. 8, p. 187.

Remarks.--*Asterotheca cyathea* (Schlothheim) and *A. arborescens* (Schlothheim) have been united by some authors, although most specimens of the latter species are smaller than those of the former species. Kidston discerned the two species (1923, p. 483, 488) in materials from Great Britain. The materials from the Stanley Cemetery flora are not easily separated because of the intergradations among the specimens. For this reason the two species are treated as one because the collected specimens are more predominately characteristic of *A. cyathea.*

Bell (1938, p. 74) described *A. robbi,* collected from a Canadian flora, and separated it from *A. cyathea* on the basis of simple lateral veins in the majority of his specimens. He further delimited his species by the fine hairs on both the upper and lower surfaces of the pinnules in *A. robbi*. He pointed out that White (1899, p. 78) had reported that these hairs had been seen on a specimen identified as *Pecopteris* cf. *P. arborescens*. Kidston (1923, p. 489) stated that White's specimen was really *A. cyathea* (Schlotheim).

The group composed of *A. cyathea, A. arborescens, A. robbi,* and perhaps *A. hemitelioides* apparently is an intergrading group and may represent only differences in preservation or ecologic variations. That they represent parts of an evolving group made up of varieties of forms of one taxon is a possibility.

The presence of *A. cyathea* in the Stanley Cemetery flora extends the known stratigraphic range of this species because it and *A. arborescens* have been recorded as occurring first in middle Pennsylvanian floras.

Asterotheca oreopteridia (Scholtheim)
Plate 7, figure 8; plate 8, figures 1 and 2

Filicites oreopteridus Schlotheim, 1820, Die Petrefactenkunde, p. 407.
Asterotheca oreopteridia Kidston, 1924, Great Britain Geol. Survey Mem., Paleontology, v. 2, pt. 5, p. 495, pl. 118, figs. 1, la, 2, 2a; pl. 119, figs. 1-4; text figs. 51-53.

Remarks.--This species, which is common in the Stanley Cemetery flora, is, as pointed out by previous authors, easily confused with *Asterotheca miltoni,* which is recognized by the several divisions of the lateral veins.

White (1899, p. 80), in describing *Pecopteris jenneyi* from southwestern Missouri, noted the fact that his species is a part of the "complex of Pecopteris species, among which *Pecopteris oreopteridia* (Schloth.) Brgt. and *P. lepidorachis* are the most familiar." Kidston (1923, p. 499), in discussing *A. oreopteridia,* did not mention the species *Pecopteris jenneyi* White or White's idea that *A. lepidorachis* (Brongniart) is related or similar to *A. oreopteridia* (Schlotheim).

The fact that difficulties are encountered in separating specimens of *A. oreopteridia* from those of *A. miltoni* and that Gothan and Remy (1957, table 5) reported *A. oreopteridia* as first appearing in Westphalian D deposits of mid-Europe and showed *A. miltoni* as being found in rocks ranging in age from Westphalian A to middle Westphalian D, after which it decreases sharply, suggests to me that *A. miltoni* may be a form of *A. oreopteridia,* a species more frequently found in earlier floras than in later floras.

Mariopteris hymenophylloides? (Lesquereux)
Plate 8, figure 3

Alethopteris hymenophylloides Lesquereux, 1870, Illinois Geol. Survey, v. 4, p. 393, pl. 10, figs. 1-4.
Mariopteris hymenophylloides Kidston, 1925, Great Britain Geol. Survey Mem., Paleontology, v. 2, pt. 5, p. 588.

Remarks.--Materials rarely found in the Stanley Cemetery flora are doubtfully referred to Lesquereux's species. This species has not been reported earlier from any American flora other than that from the Mazon Creek area, where Lesquereux obtained his type specimens.

Although Lesquereux described the venation pattern as being composed of lateral veins that fork but once, the artist has presented at least one example in figure 2 of plate 56 in which the division is twofold. This second division of one of the two lateral veins is more common in my figured specimen than in the specimens described by the author of the species; however, as I know of no other species that so nearly approximates this species, I have assigned my specimen to Lesquereux's taxon.

Lesquereux placed this species in the genus *Pseudopecopteris* (1880, p. 196). Kidston (1925, p. 588) placed this species under *Mariopteris.*

Mariopteris mazoniana (Lesquereux)
Plate 8, figures 4 and 5

Alethopteris mazoniana Lesquereux, 1870, Illinois Geol. Survey, v. 4, p. 391, pl. 9, figs. 1-8; pl. 13, figs. 5-6.
Mariopteris (Pseudopecopteris) mazoniana D. White, 1893, U.S. Geol. Survey Bull. 98, p. 46.

Remarks.--This polymorphic species is rather common in the Stanley Cemetery flora. The history of the species was presented by Janssen (1940, p. 58), who concluded that *Mariopteris mazoniana* (Lesquereux) represents a distinct species, I agree with Janssen's conclusion.

Pecopteris clintoni Lesquereux
Plate 8, figure 6

Pecopteris clintoni Lesquereux, 1880, Pennsylvania Geol. Survey Rept. Prog. P, v. 2, p. 251, pl. 42, figs. 1-5b; pl. 27, figs. 5-5a.

Remarks.--White (1899, p. 94) united *Pecopteris clintoni and* some specimens figured and described by Lesquereux as *Callipteridium membranaceum*. I believe that White’s discussion substantiates his inclusion of parts of the latter species within the taxon *P. clintoni L*esquereux.

Corsin (1951, p. 281) preferred to retain *P. clintoni* in the sense set forth by Lesquereux and accepted White’s description. Corsin did not accept White’s list of synonymous species but did not state his reasons for restricting this species. This species is not commonly found in the Stanley Cemetery area.

Pecopteris pseudovestita? D. White
Plate 8, figure 7

Pecopteris pseudovestita D. White, 1899, U.S. Geol. Survey Mon. 37, p. 85, pl. 28, figs. 1, 2, 2a; pl. 29; pl. 31, figs. 1, 2, 3?; pl. 32, figs. 1, 2.

Remarks.--The status of this species is questionable because White placed parts of both *Alethopteris ambigua* Lesquereux and *Pecopteris clintoni* Lesquereux in synonymy with his new species. Both *A. ambigua* and *P. clintoni* are recognized by other authors, but White’s *P. pseudovestita* is recognized by only a few paleobotanists.

Some specimens from this flora can be placed under *P. clintoni* Lesquereux, but other specimens more closely resemble *P. pseudovestita*. Thus the materials identified from the Stanley Cemetery flora as *P. pseudovestita* are tentatively referred to White’s species, but I still do not believe that the species is clearly defined.

Pecopteris serpillifolia? Lesquereux
Plate 8, figures 8 and 9

Pecopteris serpillifolia Lesquereux, 1880, Pennsylvania Geol. Survey Rept. Prog. P, v. 2, p. 237, pl. 46, figs. 1-3d.

Remarks.--Specimens from the Stanley Cemetery flora are questionably referred to Lesquereux’s species on the basis of pinnule shape and venation pattern. Lesquereux recorded the species (1880, p. 238) as not rare in the

Mazon Creek flora. Materials which are identified as *Pecopteris serpillifolia?* are likewise not rare in this Indiana flora.

Except for Janssen's (1939, p. 126) reference, this species has not been reported from any American or European floras. White (1899, p. 97), however, stated that two of his unfigured specimens having delicate, translucent pinnules were suggestive of Lesquerenx's species. Lesquereux said that his fern was coriaceous.

NEUROPTERIDS

Cyclopteris sp. Brougniart
Plate 9, figure 1

Cyclopteris Brongniart, 1828, Prodrome d'une histoire des végétaux fossiles, p. 51; 1830, Histoire des végétaux fossiles, v. 1, p. 215.

Remarks.--The single specimen referable only to Brongniart's genus shows the coarse venation and the off-centered appearance caused by an auricle or lobe on one side of the attachment point. The extended nature of the lamina on the side opposite to the lobe is also well shown. Nothing comparable to this specimen was noted by Lesquereux or White from their collections from Pennsylvania, and no specimens of this genus have been reported from any American or Canadian flora so far as I know. Only one specimen has been found in the Stanley Cemetery flora.

Cyclopteris orbicularis Brongniart
Plate 9, figure 2

Cyclopteris orbicularis Brongniart, 1830, Histoire des végétaux fossiles, v. 1, p. 220, pl. 61, figs. 1-2.

Remarks.--This is the only specimen of this species found in the Stanley Cemetery flora. The venation and apparent texture of the specimen are only grossly similar to those described by Lesquereux (1880, p. 78) for *Neuropteris dilata* Lindley and Hutton from his materials. White (1899, pl. 44, fig. 2) illustrated *N. dilata*, which he identified also from Missouri materials. This specimen differs from *N. dilata* Lindley and Hutton, however, in that the branches of the veins of the specimen figured by White (1899) depart from one another at a wide angle, whereas in the present specimen the branch veins separate at an acute angle. Furthermore, Lesquereux described his specimen as having veins 15 mm apart, but in this specimen from Indiana the veins are not more than 1 mm apart. The specimens figured by White appear to be somewhat leathery in texture; this Indiana specimen appears to be membranaceous. The fact that the shape of this specimen and that of *N. dilata* are quite dissimilar is of no consequence. Crookall (1929, p. 62) noted that the shapes of Cyclopteris pinnules vary with their position on the frond.

Gothan and Remy (1957, p. 124, fig. 118) showed the aphlebia of *N. heterophylla*, which, although they are of various shapes, resemble the aphlebia of the species described here. I believe that the presence of this specimen suggests that *N. heterophylla* Brongniart was a part of the Stanley Cemetery flora, although the parts of foliage from this flora which are questionably referred to that species are fragmentary. Bolton (1926, p. 324) and Stockmans (1933), however, referred to members of the genus in assoiation with *Neuropteris* foliage but cited the occurrence of these structures as isolated parts, and thus they made it almost impossible to assign members of this form genus to a known species of *Neuropteris.*

Megalopteris dawsoni (Hartt)
Plate 9, figures 3 and 4

Neuropteris dawsoni Hartt, in Dawson, 1868, Acadian geology, p. 551, fig. 193.
Megalopteris dawsoni E. B. Andrews, 1875, Ohio Geol. Survey Rept., v. 2, pt. 2, p. 412.

Remarks.--Although the specimen is fragmentary and shows nothing of the branching character of the fronds, it is identified as *Megalopteris dawsoni* and is differentiated from *M. kelleyi* and *M. southwellii* by the nature of the venation pattern as described by Arnold (1949, p. 212). The significance of this genus as a stratigraphic tool has been discussed by Stopes (1914, p. 54), who referred to White's statement (1900b, p. 887) that this rare genus appeared to be characteristic of Pottsville rocks. Arnold (1947, p. 162) stated that "Megalopteris has been found only in North America where it occurs most abundantly in the Connoquenessing stage of the upper Pottsville."

Neuropteris flexuosa Sternberg
Plate 9, figure 5

Neuropteris flexuosa Sternberg, 1826, Essai d'un exposé géognostico-botanique de la flore du monde primitif, v. 1, pt. 3, p. 44, pl. 32, fig. 2.

Remarks.--Although they are fragmentary, the specimens from the Stanley Cemetery flora identified as *Neuropteris flexuosa* are so designated on the basis of pinnule shape and venation.

White (1893, p. 91) noted that the variations among his southwestern Missouri specimens made specific separation difficult and that the intergradations between his, specimens made the specific boundary difficult to set. Although he followed Lesquereux in assigning his specimens to European species, he further noted that his materials did not fit into the old descriptions in all points. In his later work (1899, p. 131), White noted that *N. missouriensis* Lesquereux is very nearly related to *N. flexuosa.*

Bolton (1926) reiterated Brongniart's remarks about the resemblance between *N. loshii* (Brongniart), *N. tenuifolia* (Schlotheim) sp., *N. flexuosa* Stur, and *N. rotundifolia* Bunbury. She further pointed out the fact that unless pinnules of the same age are compared, the use of vein number at the edge of a pinnule as a diagnostic feature, as used by Zeiller and Kidston, leads to erroneous conclusions.

N. flexuosa can be distinguished from *N. heterophylla* by its broader pinnules, which have a cordate base, and by the closer venation pattern of its figured specimens.

Neuropteris heterophylla? Brongniart
Plate 9, figures 6, 7, and 8

Neuropteris heterophylla Brongniart, 1828, Prodrome d'une histoire des végétaux fossiles, p. 53.

Remarks.--Bolton (1926, p. 310), after examining many specimens identified as *Neuropteris heterophylla* Brongniart, was doubtful whether this species could be considered a valid one and stated that subsequent work would reveal that the materials previously referred to this species were juvenile or varietal forms of other species. Stockmans (1933, p. 10) recognized the species as a valid taxon, as did Arnold (1949, p. 197), who (p. 195) stated that *N. heterophylla* and Zeiller's *N. tenuifolia* (Schlotheim) are inseparable when only small parts have been preserved.

Stopes (1914, p. 58) united *N. polymorpha* Dawson with *N. heterophylla* and further emphasized the difficulties in identifying this species.

Janssen (1940, p. 46) concluded that the specimens described by Lesquereux as *N. capitata* are also members of the *N. heterophylla* complex. Arnold (1949, p. 197) stated that his specimens of *Neuropteris* cf. *N. heterophylla* Brongniart more closely resembled the specimens from Mazon Creek, Ill., which Lesquereux had identified and described as *N. capitata*.

Although the identification of this material as *N. heterophylla?* Brongniart is tentative because of the fragmentary nature of the present specimens, I believe that questionable identification is permissible on the basis of leaf shape, size, and venation which are like those of specimens of this species figured by the authors cited in this discussion.

Neuropteris macrophylla (Brongniart)
Plate 9, figure 9

Neuropteris macrophylla Brongniart, 1830, Histoire des végétaux fossiles, v. 1, p. 235, pl. 65, fig. 1.
Neuropteris macrophylla Kidston, 1888, Royal Soc. Edinburgh Trans., v. 33, p. 354.

Remarks.--Confusion about the limits of this species described by Brongniart and *Neuropteris clarksoni* Lesquereux led Kidston (1887, p. 354) and Bell (1938, p. 60) to include the latter species under *N. macrophylla.* White (1893, P. 79), however, recognized *N. macrophylla* and *N. clarksoni* as distinct entities.

Assigning the figured fragment to this species is justifiable because of the unusual venation pattern which is characteristic for the species and not easily confused with that of other species. The venation is much coarser than that seen in *N. scheuchzeri Hoffmann*. Furthermore, as Arnold (1949, p. 192) pointed out, *N. scheuchzeri* has a weaker midvein than that seen in *N. macrophylla*.

Crookall (1929, p. 60) and Kidston (1887, p. 355) stated that *N. macrophylla* does not possess hairs. Bell (1938, p. 60), however, noted punctae on his specimens, an indcation to him that "these punctae are evidently the bases of hairs, though hairs of quite different type and pattern from those present on *scheuchzeri.*" White (1893), p. 79) stated that *N. clarksoni* is hirsute.

I believe Kidston's case for the union of specimens identified as *N. clarksoni* Lesquereux under *N. macrophylla* Brongniart is well documented and justifiable. I believe, however, that punctae (hairs?) in his specimen (also noted in Bell's Canadian material) should be taken into account as a character which, although it has not been clearly expressed in all specimens, is nevertheless diagnostic for the species.

Neuropteris obliqua? (Brougniart)
Plate 9, figure 10

Pecopteris obliqua Brongniart, 1832 or 1833, Histoire des végétaux fossiles, v. 1, pl. 96, figs. 1-4, p. 320.
Neuropteris obliqua Zeiller, 1888,Études des gites minéraux de la France--Bassin houiller de Valenciennes, p. 284, Atlas pl. 48, figs. 1, 2 (also fig. 3?), figs. 4-7.

Remarks.--Arber (1922, p. 207) has presented the most comprehensive study of this species. Bolton (1926, p. 316) also considered the species, but she added only her approval to the previous author's work. Arber discussed *Neuropteris callosa* Lesquereux and concluded that, although these two species have been confused, they stand as valid and separable species. Bolton, however, thought that some species which could not be easily placed would prove to be intermediate between *N. obliqua* and *N. callosa*. Materials referable to the latter species have not been found in the Stanley Cemetery flora, and thus I cannot give any conclusion about the relationship or resemblance of these two species.

As Arnold and other authors have pointed out, *N. heterophylla* and *N. tenuifolia* are similar to *N. obliqua. in* that they show a mixoneurid condition in the upper pinnules. But the mixoneurid character of the pinnules persists for a shorter distance from the apex of the pinnae in *N. heterophylla* and *N. tenuifolia* than in *N. obliqua.* Specimens from the Stanley Cemetery flora are preserved only in short segments, so that persistence of the mixoneurid condition cannot be determined by the collected specimens. None of the specimens show the characteristics better than the figured specimen.

I conclude that because of confusion in identifying fragmentary specimens, this material should be referred only questionably to *N. obliqua* (Brongniart) on the basis of the nature of the venation pattern, which is more compact near the margins of the pinnules than near the middle parts, and the shape of the pinnules and the manner of their attachment.

Neuropteris rarinervis Bunbury
Plate 10, figure 2

Neuropteris rarinervis Bunbury, 1847, Geol. Soc. London Quart. Jour., v. 3, p.425, 438, pl. 22.

Remarks.--White (1899, p. 130) pointed out the similarity between *Neuropteris coriacea* Lesquereux and *Neuropteris rarinervis*. Bolton (1926, p. 312) placed Lesquereux's species under *N. rarinervis* Bunbury. As pointed out by Arnold (1949, p. 194), Bertrand (1930) and Stockmans (1933) suggested that the specific epithet *rarinervis* be abandoned. Bell (1938, p. 59) did not agree with Stockmans, who discarded Bunbury's species in favor of *N. attenuata* Lindley and Hutton. Bell contended that the representation of *N. attenuata* was erroneous and misleading. Arnold stated that Bell's specimens from the Sidney coalfield are the same as the European specimens of *N. rarinervis* Bunbury. I believe that Bell and Arnold have substantiated Bunbury's species.

In differentiating species, Zeiller and Kidston used the number of veins per centimeter of leaf margin as a diagnostic feature. Bolton (1926, p. 297) discussed this technique and stated that the age of the leaf is a factor in determining the number of veins in a unit length of leaf margin. In her discussion (1926, p. 312) of the species *N. rarinervis* Bunbury, however, she stated that the number of veins per centimeter is a reliable diagnostic feature.

This species, which is readily identified by the nature of the venation pattern, is not common in the Stanley Cemetery flora.

Neuropterls scheuchzeri Hoffmann

Plate 10, figure 1

Neuropteris scheuchzeri Hoffmann, in Keferstein, 1826, Teutschl. Geognosie-geologie dargestellt, v. 4, p. 157, pl. 1b, figs. 1-4.

Remarks.--Zeiller (1888, p. 251) placed *Neuropteris angustifolia* Brongniart, *Neuropteris cordata* Lindley and Hutton (not Brongniart), *N. cordata* var. *angustifolia* Bunbury, and *N. hirsuta* Lesquereux in synonymy with *N. scheuchzeri.* White (1899, p. 132) agreed with Zeiller in his treatment of the species. Janssen (1940, p. 45) added *N. fasciculata* Lesquereux and *N. decipiens* Lesquereux to the list, further emphasizing the apparent variability of this species. In her description of *N. scheuchzeri*, Bolton (1926, p. 313) pointed out that this is the only known species of *Neuropteris* which possesses hairs.

The materials from the Stanley Cemetery flora support Arnold's statement (1949, p. 190), contrary to White's, that the early forms of the species were as large as those shown from deposits of later age. I believe that the species placed in synonymy by the authors cited above are forms of the variable species *N. scheuchzeri* Hoffmann. Canright, on the other hand, found an abundance of the *angustifolia* variety in a mine east of those included in this study, but within the Brazil formation, and on the basis of this discovery he agrees with White (oral communication).

Neuropteris tenuifolia (Schlotheim)

Plate 10, figures 3 and 4

Filicites tenuifolius Schlotheim, 1820, Die Petrefactenkunde, p. 405, pl. 22, fig. 1.
Neuropteris tenuifolia Zeiller, 1888, Éftudes des gites. minéraux de la France Bassin houiller de Valenciennes, p. 273, pl. 46, fig. 1.

Remarks.--This species belongs to the *Neuropteris heterophylla* group sensu Bertrand (1930). Stockmans (1933) described both *N. tenuifolia* and *N. heterophylla* and regarded them as distinct species; however, he and Arnold (1949, p. 195) stated that large numbers of these specimens must be available to identify and separate the two species definitely. Bell (1940, p. 117) listed *N. tenuifolia* from the Pictou coalfield but did not give an illustration of his materials. His illustrations for this species from the Sydney coalfield, Nova Scotia, are relatively fragmentary.

Although previous authors have pointed out the difficulties of separating fragmentary specimens of *N. heterophylla* from those of *N. tenuifolia,* I believe that identification of fragmentary specimens from the same stratum is justifiable when both species appear to be present, such as in the Stanley Cemetery flora. The specimens are identified as *N. tenuifolia* on the basis of the taper of the pinnules. Specimens of this species were recovered from ironstone concretions and from roof shales of the coal.

Odontopteris subcuneata Bunbury
Plate 10, figure 5

Odontopteris subcuneata Bunbury, 1847, Geol. Soc. London Quart. Jour., v. 3, p. 427, pl. 23, figs. la-lb.

Remarks.--In the specimen collected from the Stanley Cemetery flora the pinnules are creased along the midrib, so that the specimen illustrated appears at first to lack the essential odontopterid characteristics; on close examination, however, the absence of a midvein in the pinnule permits identification of these specimens.

Bell (1938, p. 62) called attention to the polymorphic nature of this species, stating that the number of veins entering the base of the smaller pinnules is of greater importance than is the auriculate character or the arrangement of the pinnules. Bell placed *Odontopteris wortheni* Lesquereux in synonymy with *O. subcuneata* Bunbury. I believe that Bell attempted to simplify identification of this species and thus used vein number in much the same manner that Zeiller and Kidston used it in the genus *Neuropteris.* Bolton (1926, p. 297) criticized this practice and showed that vein number varies with the age of the specimen.

Janssen (1940, p. 50) showed that the description for *O. subeuneata* Bunbury and *O. heterophylla* Lesquereux are essentially the same. Bell (1938) found hairs on specimens of *O. subcuneata* Bunbury, a characteristic used by Lesquereux (1880, p. 130) to identify *O. wortheni.* I therefore believe that the inclusion by Bell and Janssen of *O. wortheni* and *O. heterophylla* under *O. subcuneata* Bunbury is justified.

MISCELLANEOUS PTERIDOPHYLL ORGANS

Aphlebia crispa, (Gutbier)
Plate 10, figure 6

Fucoides crispus Gutbier, 1835, Abdrücke and Versteinerungen des Zwickauer Schwarzkohlengebirges, p. 13, pl. 1, fig. 11.

Aphlebia crispa Presl, in Sternberg, 1838, Essai d'un exposé géognostico-botanique de la flore du monde primitif, v. 2, pts. 7-8, p. 112.

Remarks.--This specimen, which is one of few from the Stanley Cemetery flora, is a fragment of a complete structure. Although the terminal parts are lacking, the wide wing of the blade on either side of the midvein is visible, as is the venation pattern, which is made up of prominent bands that divide with the division of the lamina.

So far as I know, this species has not been reported from any other American floras. Furthermore, it does not appear to be a common species among European materials.

This species differs from *Aphlebia spinosa* Lesquereux, which bears more narrow subdivisions of the lamina. Langford (1958, p. 287-289) attempted to outline the species of this genus which are found in his Illinois flora. Although four species were figured, Langford commented on only two of these and omitted references or citations for all of them. Thus a comparison of Langford's material with that illustrated by other authors is not easily made.

Aulacotheca sp. Halle

Plate 10, figure 8

Aulacotheca Halle, 1933, K. Svenska vetensk. akad. Handl., ser. 3, v. 12, no. 6, p. 30.

Remarks.--This specimen is a poorly preserved example of a spore-bearing structure. Structures that strongly resemble spores are preserved in a part of the specimen in grooves which are mainly filled with kaolinite. The putative spores could not be removed intact for further examination, however, without destroying the macrofossil in which they are imbedded. Although the structure strongly resembles a pteridospermous seed, sporelike objects arranged in longitudinally oriented groups favor the placement of the specimen in an organgenus for spore-producing structures. The shape of the structure differs sharply from the specimens of *Whittleseya* which have been recovered from the Stanley Cemetery flora, and for this reason this specimen is placed in the genus *Aulacotheca* Halle, which covers those male fructifications that are elongate and that have roundly tipped, closed ends.

Another specimen from the Stanley Cemetery flora is morphologically similar to the pictured specimen, but it does not contain any sporelike structures. This genus is not common in the Stanley Cemetery flora.

Spiropterls sp. Schimper

Plate 10, figure 9

Spiropteris Schimper, 1869, Traité de paléontologie végétale, v. 1, p. 688.

Remarks.--The specimen pictured shows the circinate vernation of an undetermined species of fernlike foliage. The pinna is fertile, but the details of the fructification are so obscure that it is not possible to place the species in any fructification organ-genus. Such a species probably has no stratigraphic value.

Whittleseya. sp. Newberry

Plate 10, figure 7

Whittleseya Newberry, 1853, Annals Sci., Cleveland, v. 1, p. 106.

Remarks.--The specimen figured is one of two discovered in the Stanley Cemetery flora. Neither specimen presents an external surface large enough to permit specific identification. The collected specimens are much smaller than those figured by Lesquereux (1880, p. 523-525, pl. 4, figs. 1, la, 2, 3). They approach, however, the dimensions (13 ram by 17 mm) listed by Matthew (1910, D. 98) for *Whittleseya dawsoniana*, which White described in 1901, but which Matthew erroneously listed as his new species. Stopes (1914, p. 78) placed Matthew's species in synonymy with White's species. Although the dimensions approach those given for *W. dawsoniana*, the shape of the specimen more closely resembles *W. concinna* Matthew. The specimen is larger than *W. desiderata* D. White (White, 1901, p. 102, pl. 8, figs. 1, la, 2), which measures 9 to 14 mm long by 6 to 10 mm wide at the truncate apex. The distal ends of the specimens from the Stanley Cemetery flora are not discernible, so that the nature of the teeth, if present, cannot be determined.

None of the descriptions of the species of *Whittleseya* include any mention of the punctae or short glandular hairs which are clearly visible on specimens from this flora when the compressions are wetted with xylol.

The spores recovered from this specimen are identical to the spores pictured by Halle (1933) for *Whittleseya.*

CYCADOFILICALEAN SEEDS

Holcospermum sp. Nathorst

Plate 11, figure 1

Holcospermum Nathorst, 1914, Nachträge zur Paläozoischen Flora Spitzbergens -Zur Fossilen Flora der Polarländer, P. 28.

Remarks.--This specimen, the only one of its kind found in the Stanley Cemetery flora, is the impression of a seed 4.6 cm long and 3.3 cm, wide. The impression is nearly flat except for a circular depression near the middle of the specimen and is longitudinally striated by coarse ribs running the entire length of the seed and converging at both ends. The specimen is referred to Nathorst's genus *Holcospermum* on the basis of its general shape and its striations.

In size and shape this specimen resembles *Pachytesta vera* Hoskins and Cross and *P. shorensis* (Salisbury) Hoskins and Cross (1946, p. 352-353). The lack of structural detail, however, militates against placing this specimen in either of the two species mentioned above.

Pachytesta cf. P. vera Hoskins and Cross

Plate 11, figure 7

Pachytesta vera Hoskins and Cross, 1946, Am. Midland Naturalist, v. 36, no. 1, P. 248.

Remarks.--This seed is very similar in size and form to that figured by Arnold (1949, p. 214, pl. 29, fig. 3) as *"Trigonocarpus" noeggerathi.* This figured specimen does not appear to have a projecting nucellus, but it has a short nucellar beak as described by Hoskins and Cross (1946, p. 248-249, 352) for their new species. This specimen is markedly smaller than the material described by Hoskins and Cross and is nearer the dimensions of *Trigonocarpus noeggerathi* Sternberg. A definite outer layer, which gives no hint of ribbing in this specimen, but which is contracted in the upper regions of the seed, together with the apparently short nucellar beak, is considered sufficient evidence for me to place this specimen under *Pachytesta vera* Hoskins and Cross. Even though the tissues of this specimen are not preserved, the specimen can be ascribed to the species emended by Hoskins and Cross (1946, p. 342).

Rhabdocarpus cf. R. mansfieldi Lesquereux

Plate 11, figure 3

Rhabdocarpus mansfieldi Lesquereux, 1880, Pennsylvania Geol. Survey Rept. Progress P, Atlas, pl. 85, fig. 21, p. 18.

Cordaicarpus mansfieldi Lesquereux, 1880, Pennsylvania Geol. Survey Rept. Progress P, v. 1, p. 539.

Remarks.--The size, shape, and longitudinal ribs of this specimen closely resemble the characteristics of the specimen first described and figured by

Lesquereux (1880, D. 18) as *Rhabdocarpus mansfieldi* and later (p. 539) referred to by him as *Cordaicarpus mansfieldi.* Arnold (1949, p. 213-214) discussed the difficulties associated with Lesquereux's treatment of the material and its supposed attachment to cordaitean twigs. I accept Arnold's position that this seed is more probably a pteridospermous seed than a cordaitean seed.

Rhabdocarpus mamiflatus Lesquereux
Plate 11, figure 2

Rhabdocarpus mamillatus Lesquereux, 1884, Pennsylvania Geol. Survey Rept. Progress P, v. 3, p. 816, pl. 110, figs. 39-42.

Remarks.--This seed is referred to Lesquereux's species on the basis if size, shape, and longitudinal striae. This species has not been frequently reported from American floras and is not common in the Stanley Cemetery flora.

Rhabdocarpus multistriatus (Presl)
Plate 11, figure 6

Carpolithes multistriatus Presl, in Sternberg, 1822, Versuch einer Geognostischen Botanischen Darstellung der Flora der Vorwelt, pt. 2, p. 208, pl. 39, figs. 1, 2.
Rhabdocarpus multistriatus Lesquereux, 1880, Pennsylvania Geol. Survey Rept. Progress P, v. 2, p. 578, Pl. 85, figs. 22, 23.

Remarks.--The specimen pictured is the only one of its kind in the Stanley Cemetery flora. It is referred to Presl's species on the basis of similarity in size, shape, and ornamentation as presented by Lesquereux (1880, p. 578, pl. 85, figs. 22, 23). Nothing comparable to this seed has been found in American floras other than *Rhabdocarpus apiculatus* Newberry (1873, p. 377, pl. 44, fig. 6), *R. carinatus* Newberry (1873, p. 386, pl. 44, fig. 3), and *R. costatus* Newberry (1873, p. 378, pl. 44, fig. 8), all illustrations of which appear to me to differ from one another slightly. But all of Newberry's species differ from this specimen in shape.

Trigonocarpus sp. Brongniart
Plate 11, figure 4

Trigonocarpus Brongniart, 1828, Prodrome d'une histoire des végétaux fossiles, p. 137.

Remarks.--This part of a seed shows the oval central area surrounded by a thick layer of carbonaceous material, which I interpret as a layer rather than a thin or narrow wing. Striations on the seed itself are longitudinally oriented, although faint. This specimen probably represents the internal part of a seed, such as some species of *Trigonocarpus*.

Order CORDAITALES

Artisia sp. Sternberg
Plate 11, figure 8

Artisia Sternberg, 1838, Essai d'un exposé géognostico-botanique de la flore du monde primitif, v. 2, pts. 7-8, p. 192.

Remarks.--Cordaitean pith casts of the type pictured are frequently found in the Stanley Cemetery flora. The septations of these specimens are shallow, round-bottomed depressions which encircle part or all of the more or less cylindrical casts.

Although the specimens seem to resemble *Artisia transversa (= Artis)* Sternberg in the height of the rings or collars, in their rough regularity, and in the prominent convex base, a specific epithet is not assigned to these fossils. The stratigraphic value of this species is probably slight.

Cardiocarpon sp.
Brongniart
Plate 11, figure 5

Cardiocarpon Brongniart, 1828, Prodrome d'une histoire des végétaux fossiles, p. 87.

Remarks--This seed is not common in the Stanley Cemetery flora and so far as I can determine is not comparable to other American species of seeds. Lesquereux described *Rhabdocarpus jacksonianus* (1880, p. 576, pl. 85, figs. 1719), which from his figures would include seeds of the size of these specimens; however, the specimen from the Stanley Cemetery flora, except for minute longitudinal striae, does not have the coarse markings shown by Lesquereux.

Cardlocarpon annulatum
Newberry
Plate 11, figures 9, 10, and 11

Cardiocarpon annulatum Newberry, 1853, Annals Sci., Cleveland, v. 1, p. 152, fig. 2.

Remarks.--These specimens are larger than those shown by Lesquereux (1880, p. 564, pl. 85, figs. 36, 37) or by Arnold (1949, p. 230, pl. 34, figs. 1, 3), but they are approximately the same size as those figured by Newberry (1873, p. 374, pl. 43, figs. 8, 8a). In the micropylar area these seeds bear a slight resemblance to *Cardiocarpon ingens* Lesquereux, but the specimens lack the peaked micropylar wing and the pronounced micropylar indentation characteristic of *C. ingens.*

Arnold (1949, p. 230), in his discussion of specimens of this species from the Michigan coal basin, noted the occurrence of *Ginkgophyllum grandifolium* with these seeds. This association was not noted in the Stanley Cemetery flora. Arnold pointed out that this seed appears to range from the roof of the Sharon coal, which according to Moore and others (1944) is equivalent to the lower part of the Mansfield Formation of Indiana, to near the top of the Pottsville Series. This species is very common in the Stanley Cemetery flora.

Cardiocarpon dilatatus
Lesquereux
Plate 12, figure 1

Cardiocarpus ditatatus Lesquereux, 1884, Pennsylvania Geol. Survey Rept. Prog. P, v. 3, p. 806, pl. 110, fig. 2.

Remarks.--The wrinkling of the cover over the nucellus suggests a modification in the wing shape from the normal position, so that the micropylar indentation is accentuated. Lesquereux, in describing this new species (1884, p. 806), stated that this seed is similar to *Cardiocarpon baileyi* Dawson. Stopes, figured the latter species from her Canadian materials (1914, p. 92, pl. 19, fig. 48) and showed the laterally extended wing covering an elongate nucellus, which differs sharply from that described by Lesquereux. This species is rare in the Stanley Cemetery flora.

Cardiocarpon ingens? Lesquereux
Plate 12, figure 2

Cardiocarpus ingens Lesquereux, 1860, Botanical and paleontological report on the geological state survey of Arkansas, *in* Owen, Second report of a geological reconnaissance of the middle and southern counties of Arkansas, p. 311, pl. 4, figs. 4-4a.

Remarks.--Seeds of this type are questionably referred to Lesquereux's species because of the micropylar sinus in the rim. One of the two Seeds illustrated by Lesquereux has only a slight indentation at the point of attachment of the seed, a condition which might have been quite variable and could even have been lacking. This specimen resembles *Cardiocarpus drupaceous* Brongniart as figured by Langford (1958, p. 327, fig. 624), but it differs from Langford's illustration in its shape. The Indiana specimen tends to be heart shaped, whereas Langford's specimen is circular.

This species is less common in the Stanley Cemetery flora than is *C. annulatum* Newberry.

Cardiocarpon late-alatum Lesquereux
Plate 12, figure 3

Cardiocarpon late-alatum Lesquereux, 1880, Pennsylvania Geol. Survey Rept. Prog. P, v. 2, p. 568, pl. 85, figs. 46, 47.

Remarks.--Although larger in all proportions than seeds of this species described by Lesquereux (1880, p. 568, pl. 85, figs. 46, 47) and Arnold (1949, p. 229, pl. 34, fig. 2), this seed is referred to Lesquereux's species. Because the range of variation for this species is not known, as stated by Arnold, I believe that this seed can be assigned to this species.

Cordaianthus gernmifer Grand'Eury
Plate 12, figure 4

Cordaianthus gemmifer Grand'Eury, 1877, Acad. sci. inst. France M6m. 24, p. 228, pl. 36, figs. 4-7.

Remarks.--Lesquereux (1880, p. 545-546) divided Grand'Eury's species into two new species: *Cordaianthus ovatus* and *C. dichotomus*. *C. ovatus* was distinguished by characters of the "gemmuIes" and *C. dichotomus* by its mode of branching. This subdivision by Lesquereux has not been acknowledged by any subsequent author.

C. gemmifer Grand'Eury differs from Stope's *C. devonicus* (Dawson) by having spikelets borne on a short stalk. It differs from *C. pitcairniae* Lindley and Hutton by having a narrower main axis, which bears fewer spikelets than are shown for *C. pitcairniae.* This specimen differs from Bell's *C. spinosus* (Dawson) by having smaller spikelets and a longer pedicel than *C. spinosus* has.

Cordaicarpon sp. ? Geinitz
Plate 12, figure 7

Cordaicarpon Geinitz, 1862, Dyas oder die Zechsteinformation und das Rothliegende, v. 2, Die Pflanzen der Dyas und Geologisches, p. 150.

Remarks.--This seed is questionably referred to Geinitz's genus on the basis of shape, although the seed is not flat. The part preserved represents the inner part of the seed from which any wing or lateral extension has been removed. The seed appears to have been smooth on the halves separated by the longitudinal ridge. Seeds of this type are rare in the Stanley Cemetery flora.

Lesquereux showed a species called *Cardiocarpus ingens*, but his species did not have an inflated nucellus as this specimen has. Furthermore, his specimens showed a prominent wing, which, although not present in this specimen, could have been removed before the rest of the seed was preserved. Langford (1958, p. 326, fig. 622) reported a specimen similar to this one from the Wilmington flora of Illinois; he designated it *Samaropsis* Goeppert. Arnold (1938, p. 226) pointed out that the name *Samaropsis* is often applied to seeds having a wing broader than, equal to, or in excess of the diameter of the nucule, but this does not appear to be true for the specimen figured by Langford.

Cordaites borassifolius (Sternberg)
Plate 12, figure 6

Flabellaria borassifolia Sternberg, 1823, Essai d'un exposé géognostico-botanique de la flore du monde primitif, v. 1, pt. 2, p. 31, 36, pl. 18; pt. 4, pl. 34.

Cordaites borassifolius Unger, 1850, Genera et species plantarum fossilium, p. 277.

Remarks.--Complete specimens of this species have not been found in the Stanley Cemetery flora, but fragmentary remains are relatively common. Although the nature of the apical parts of these fragmentary specimens cannot be determined, they are identified as *Cordaites borassifolius* because the specimens show a thick coriaceous epidermis, in which the venation pattern made up of the regular alternation of a narrow vein with a thick one is visible. This venation pattern permits the separation of this species from the other species of cordaitean foliage which are known.

Cordaites crassinervis Heer
Plate 12, figure 5

Cordaites crassinervis Heer, 1877, Flora Fossile Helvetiae, p. 150, pl. 30, fig. 4.

Remarks.--Material from Michigan similar to this specimen was pictured by Arnold (1949, p. 224, pl. 30, fig. 4), who ascribed his fragmentary species to *Cordaites crassinervis* Heer. Fontaine and White (1880, p. 97, pl. 37, fig. 10) described a new species which they also called *Cordaites crassinervis.* The illustrations of these specimens from West Virginia are also similar to Indiana material except that the basal parts of the West Virginia specimens show a branching vascular system. But in the area in which the leaf is widest, the veins remain undivided in this Indiana specimen and in Arnold's specimen. I believe that all three can be included in Heer's species.

Cordaites principalls (Germar)

Plate 12, figure 8

Flabellaria principalis Germar, 1848, Die Versteinerungen des Steinkohlengebirges von Weltin und Lbbeitin im Saalkreise, p. 55, pl. 23.

Cordaites principalis Geinitz, 1855, Die Versteinerungen der Stein kohlenformation in Sachsen, p. 41, pl. 21, figs. 1, 2, 2a, 2b.

Remarks.--The surfaces of the specimens of *Cordaites principalis* from the Stanley Cemetery flora have an epidermal layer which is less coarse than that seen in specimens of *Cordaites borassifolius* Sternberg from the same site. Examination of the venation reveals the diagnostic pattern consisting of one to five fine veins more or less equally spaced between the heavy veins. The nearly parallel edges of the specimen suggest that the leaf was long and that the taper of these leaves was either slight or was accentuated only in the terminal parts as shown in the specimen figured by Arnold (1949, pl. 30, fig. 2).

Arnold (1949, p. 222) pointed out that the species of this genus had been neglected and ignored in most floristic studies. He also noted White's subdivision of the genus (1899, p. 258), and I agree with Arnold's comment that this subdivision is not widely applicable to specimens of the genus.

Although specific diagnoses of the species of this genus should be based on complete specimens, I believe that specific determination of the species in the Stanley Cemetery flora is permissible on the basis of venation.

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PLATES 1-12

Numbers preceded by L & P refer to accession numbers of specimens in the original collection from the Long and Price, Hannum, and Ray Mines. Numbers preceded by W refer to accession numbers of specimens in the author's personal collection from the same sites, These two collections are in the Paleobotanical Collections at the University of Missouri. The number preceded by I.U. refers to the accession number of the specimen in the Indiana University Paleobotanical Collections.

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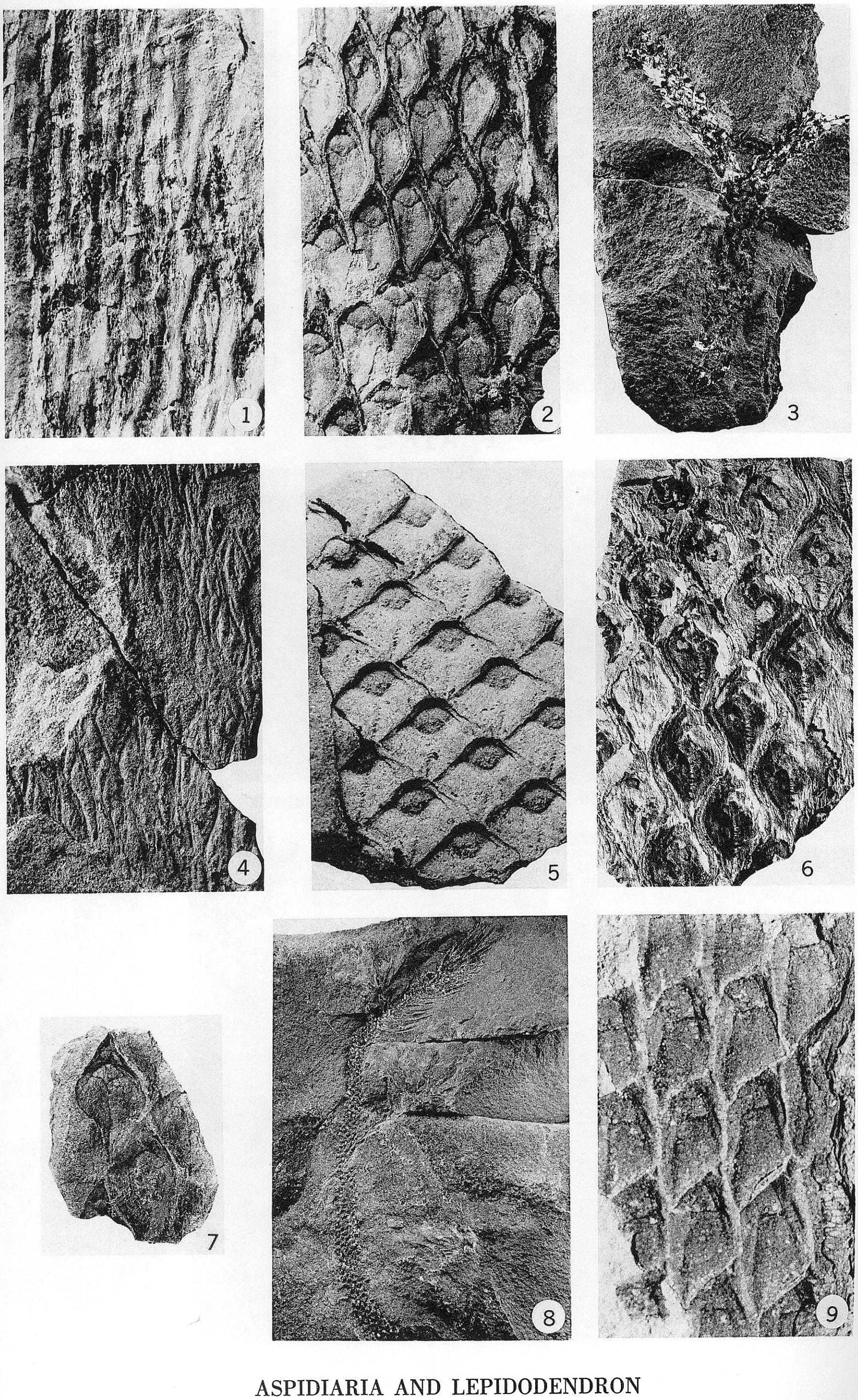
PLATE 1

Figure 1. *Aspidiaria sp.* Presl; L & P 648; X 1½
2. *Lepidodendron aculeatum* Sternberg; L & P 289; X 4/5
3. Lepidodendron dichotomum Sternberg; L & P 13; X ½
4. *Lepidodendron lanceolatum?* Lesquereux; L & P 651; X 4/5
5. *Lepidodendron latifolium* Lesquereux; W 965; X 1
6. *Lepidodendron modulatum* Lesquereux; (Canright, 1959, pl. 1, fig. 3); I.U. 210; X ½
7. *Lepidodendron obovatum* Sternberg; W 484; X 4/5
8. *Lepidodendron ophiurus* Brongniart; W 857; X ½)
9. *Lepidodendron vestitum* Lesquereux; W 1200; X 2



ASPIDIARIA AND LEPIDODENDRON

PLATE 2

Figure 1. *Lepidodendron wortheni* Lesquereux; W 242; X 2/5

2. *Lepidophyllum* sp. Brongniart; L & P 346; X 2/5

3. *Lepidostrobus cf. L. incertus* Lesquereux; W 1041; X 4/5

4. *Lepidostrobus variabilis* Lindley and Hutton; W 617; X 4/5

5. *Lepidostrobits variabilis* Lindley and Hutton; W 377; X 4/5

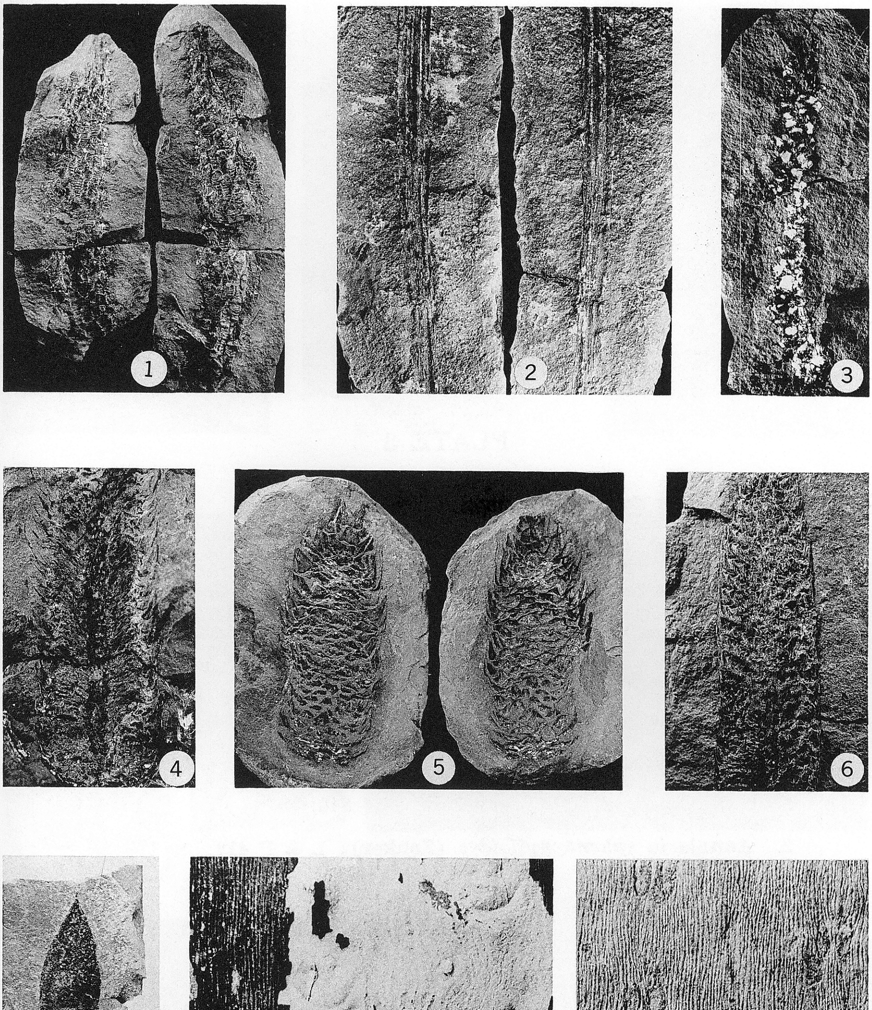
6. *Lepidostrobus variabilis* Lindley and Hutton; L & P 11; X 4/5

7. *Lepidostrobophyllum ovatifolius* (Lesquereux); W 1143; X 1

8. *Lepidostrobophyllum ovatifolfits* (Lesquereux); W. 1180; X 1

9. *Sigillaria brardii* Brongniart; W 1170; X 1

10. *Sigillaria brardii* Brongniart; L & P 420; X 1



LEPIDODENDRON, LEPIDOPHYLLUM, LEPIDOSTROBUS, LEPIDOSTROBOPHYLLUM, AND SIGILLARIA

PLATE 3

Figure 1. *Sigillaria davreuxi* Brongniart; W 1167; X 4/5

2. *Sigillaria kidstoni?* Crookall; W 414; X 1

3. *Sigillaria scutellata* Brongniart; W 1172; X 1

4. *Sigillariostrobus quadrangularis* (Lesquereux); W 418; X 1

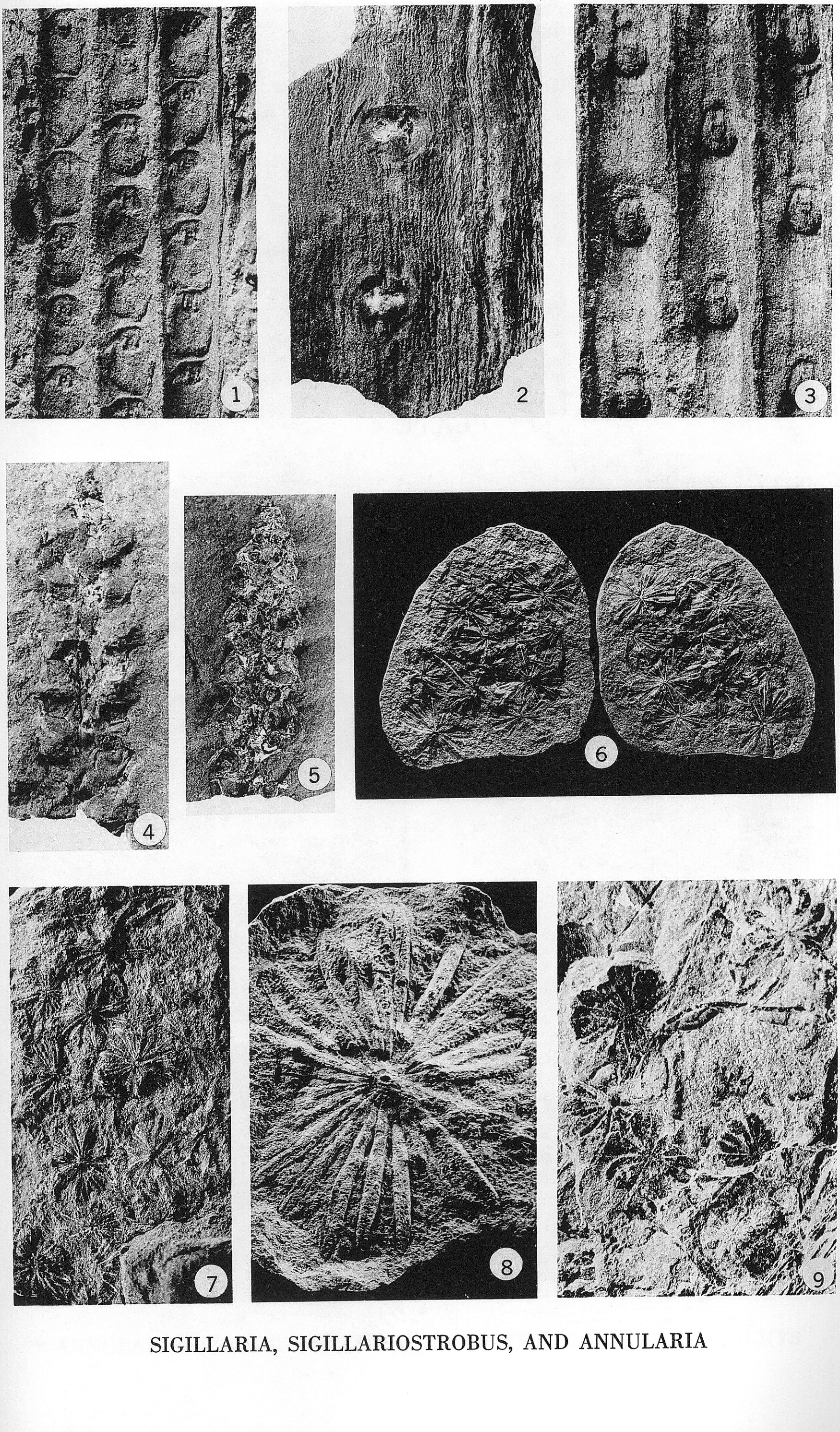
5. *Sigillariostrobus quadrangularis* (Lesquereux); W 795; X 4/5

6. *Annularia mucronata* Schenk; W 821; X 3/5

7. *Annularia sphenophylloides* (Zenker); W 1088; X 4/5

8. *Annularia radiata* (Brongniart); W 840; X 1

9. *Annularia sphenophylloides* (Zenker); L & P 417; 1½



SIGILLARIA, SIGILLARIOSTROBUS, AND ANNULARIA

PLATE 4

Figure 1. *Annularia stellata* (Schlothelm) Wood; W 842; X ½

2. *Asterophyllites equisetiformis* (Schlotheim) ; W 1140; X 1½

3. *Calamites cruciatus* Sternberg; W 367; X ½

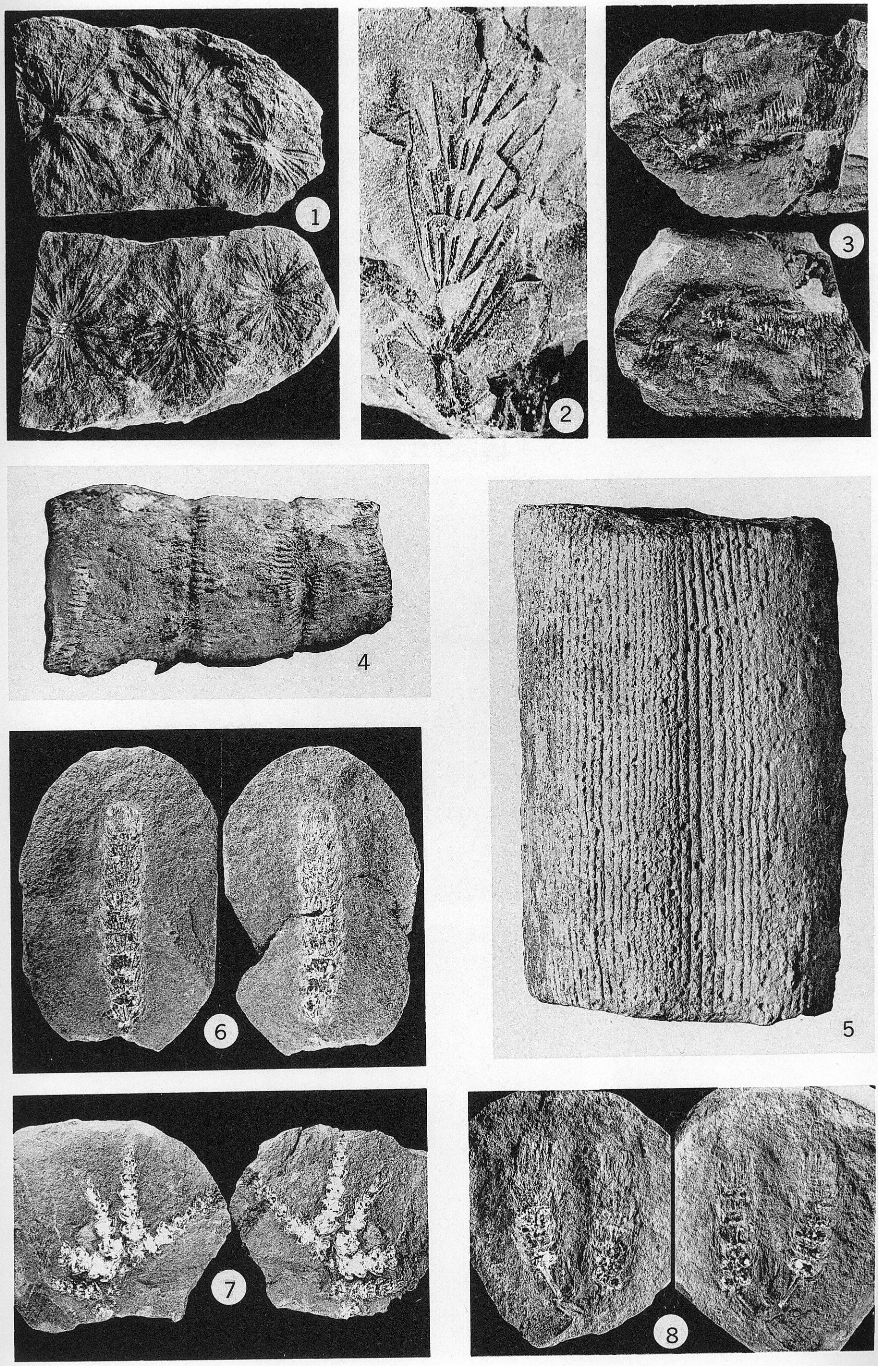
4. *Calamites cruciatus* Sternberg; L & P 263; X 2/3

5. *Calamites suckowi* Brongniart; L & P 271; X 2/3

6. *Calamostachys* sp. Schimper; L & P 381; X 2/3

7. *Calamostachys paniculata?* Weiss; L & P 404; X ½

S. *Calamostachys superba* Weiss; L & P 123; X ½



ANNULARIA, ASTEROPHYLLITES, CALAMITES, AND CALAMOSTACHYS

PLATE 5

Figure 1. *Calamostacitys tuberculata* (Sternberg); W 996; X ½

2. *Calamostachys tuberculata* (Sternberg) ; L & P 302; X 4/5

3. *Cingularia sp.* -Weiss; L & P 42; X 4/5

4. *Macrostachya infundibuliformis* (Bronn); W 1025; X 1

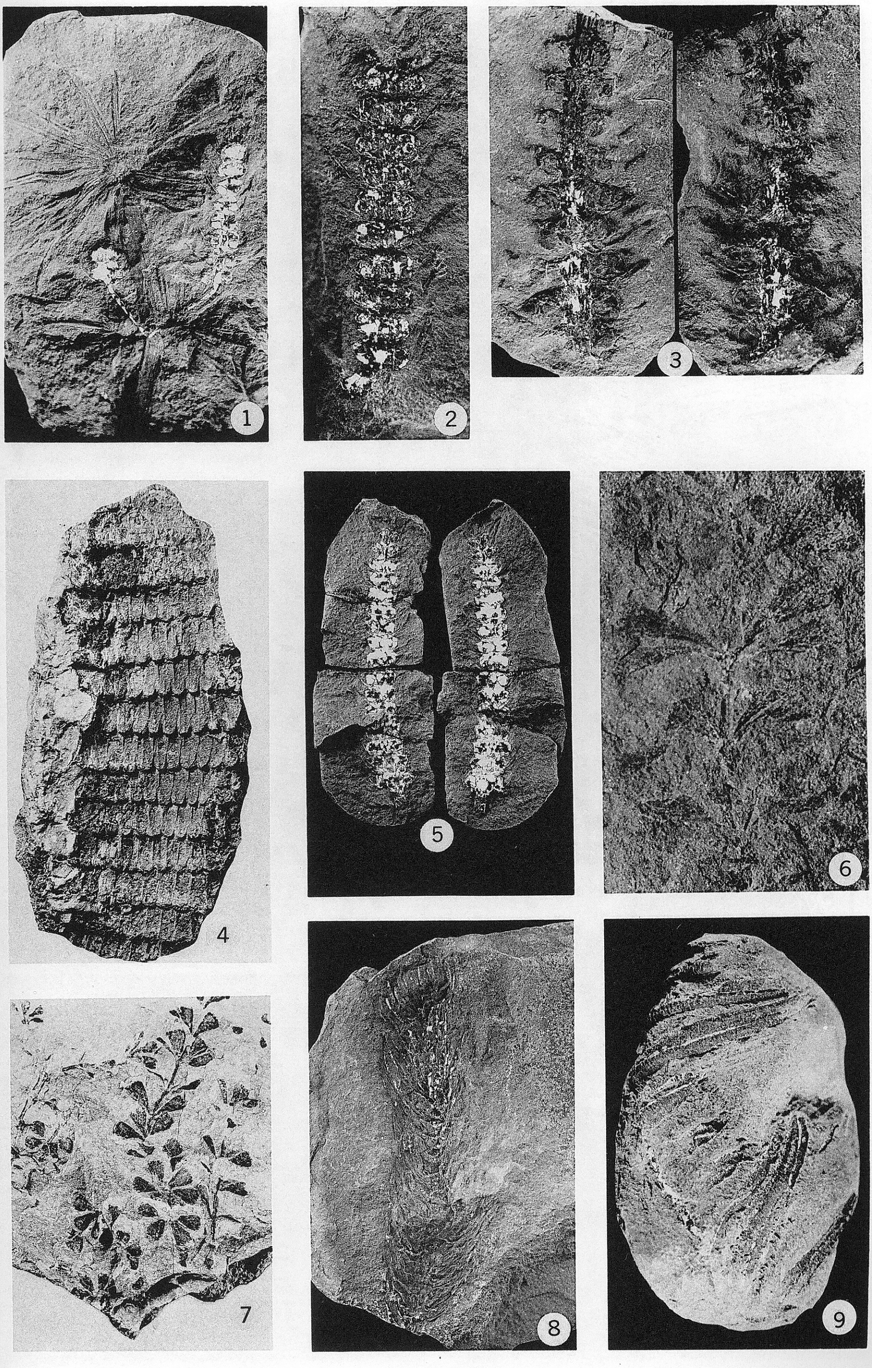
5. *Palaeostachya elongata* (Presl); L & P 59; X ½

6. *Sphenophyllum cuneifolium* (Sternberg); W 609; X 2

7. *Sphenophyllum emarginatum* Brongniart; L & P 419; X 4/5

8. Sphenophyllum hauchecornei (Weiss); W 332; X 4/5

9. *Alethopteris decurrens* (Artis); W 531; X 1



CALAMOSTACHYS, CINGULARIA, MACROSTACHYA, PALAEOSTACHYA, SPHENOPHYLLUM, AND ALETHOPTERIS

PLATE 6

Figure 1. *Alethopteris davreuxi* (Brongniart) ; W 392; X 4/5

2. *Alethopteris davreuxi* (Brongniart); W 424; X ½

3. *Alethopteris grandini* (Brougniart); L & P 23; X 1

4. *Alethopteris serli* (Brongniart) ; W 632; X 4/5

5. *Alethopteris serli* (Brongniart); W 631; X 1

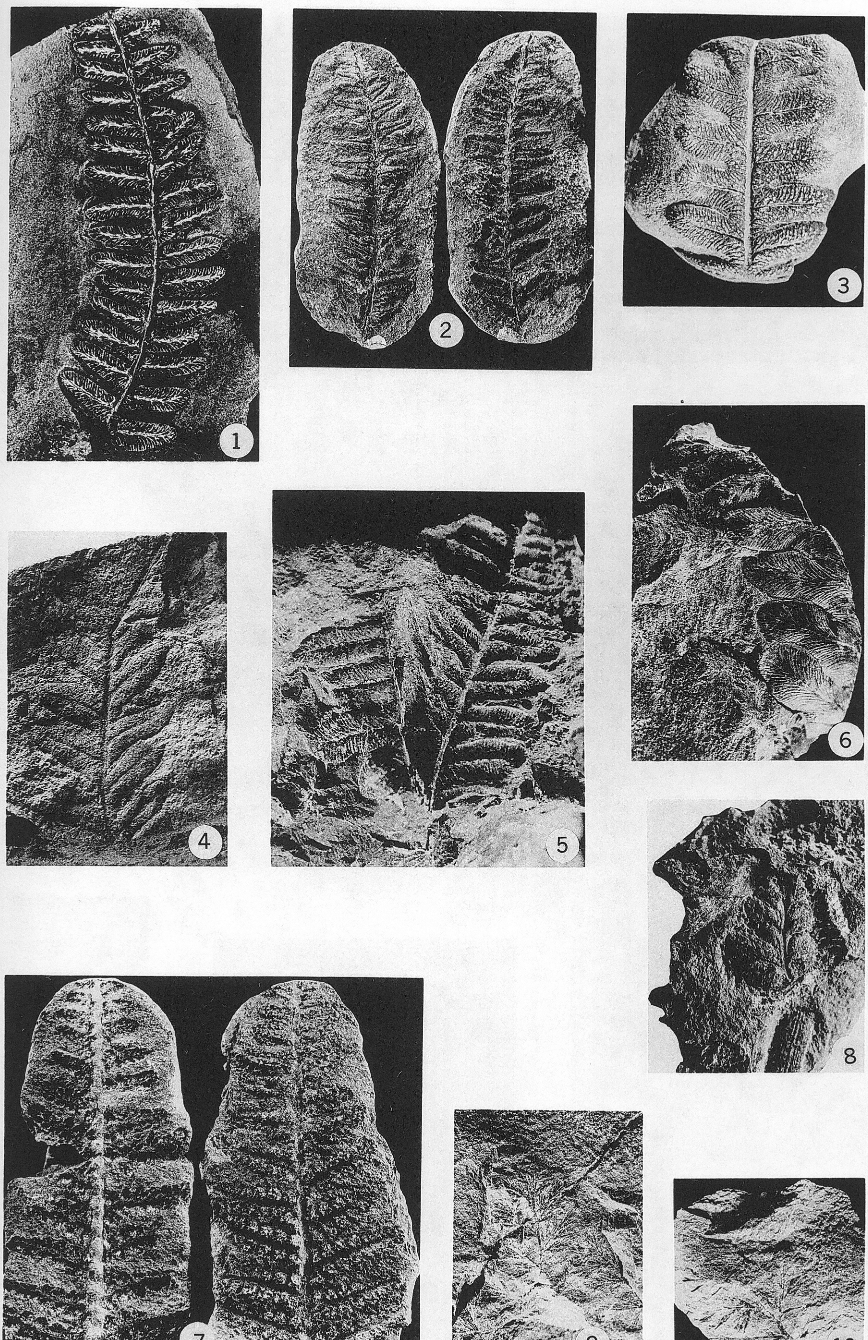
6. *Callipteridium sullivanti* (Lesquereux); L & P 472; X 4/5

7. *Oligocarpia missouriensis* D. White; L & P 44; X 3/4

8. *Diplothmema obtusiloba* (Brongniart); W 436; X 1

9. *Palmatopteris furcata* (Brongniart); W 635; X 4/5

10. *Palmatopteris furcata* (Brongniart); W 114; X 3/4



ALETHOPTERIS, CALLIPTERIDIUM, OLIGOCARPIA, DIPLOTHMEMA, AND PALMATOPTERIS

PLATE 7

Figure 1. *Renaultia chaerophylloides* (Brongniart) ; L & P 91; X 2/3

2. *Sphenopteris (Hymenotheca) broadheadi* White; W 423; X 3/4

3. *Sphenopteris (Hymenotheca) broadheadi* White; W 1091; X 3/4

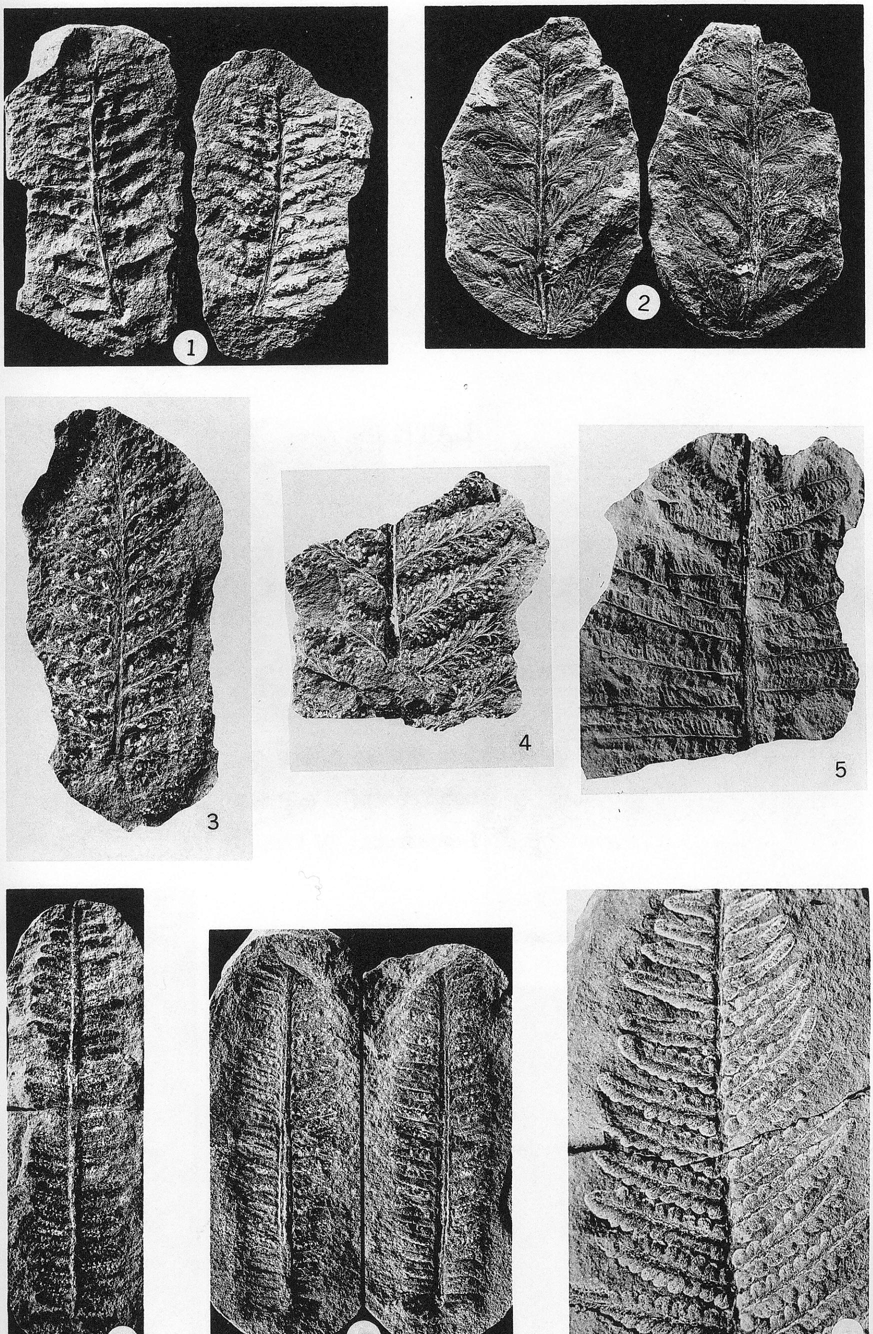
4. *Sphenopteris (Hymenotheca) broadheadi* White; W 557; X 2/3

5. Asterotheca crenulata (Brongniart); L & P 511; X 4/5

6. *Asterotheca cyathea* (Schlotheim); W 422; X 4/5

7. *Asterotheca cyathea* (Schlotheim); W 366; X 4/5

S. Asterotheca oreopteridia (Schlotheim); W 960; X 4/5



RENAULTIA, SPHENOPTERIS, AND ASTEROTHECA

PLATE 8

Figure 1. *Asterotheca oreopteridia* (Schlotheim); L & P 36; X 2/3

2. Asterotheca oreopteridia (Schlotheim) ; W 1050; X 2/3

3. *Mariopteris hymenophylloides?* (Lesquereux); W 175; X 4/5

4. *Mariopteris mazoniana* (Lesquereux); L & P 342; X 4/5

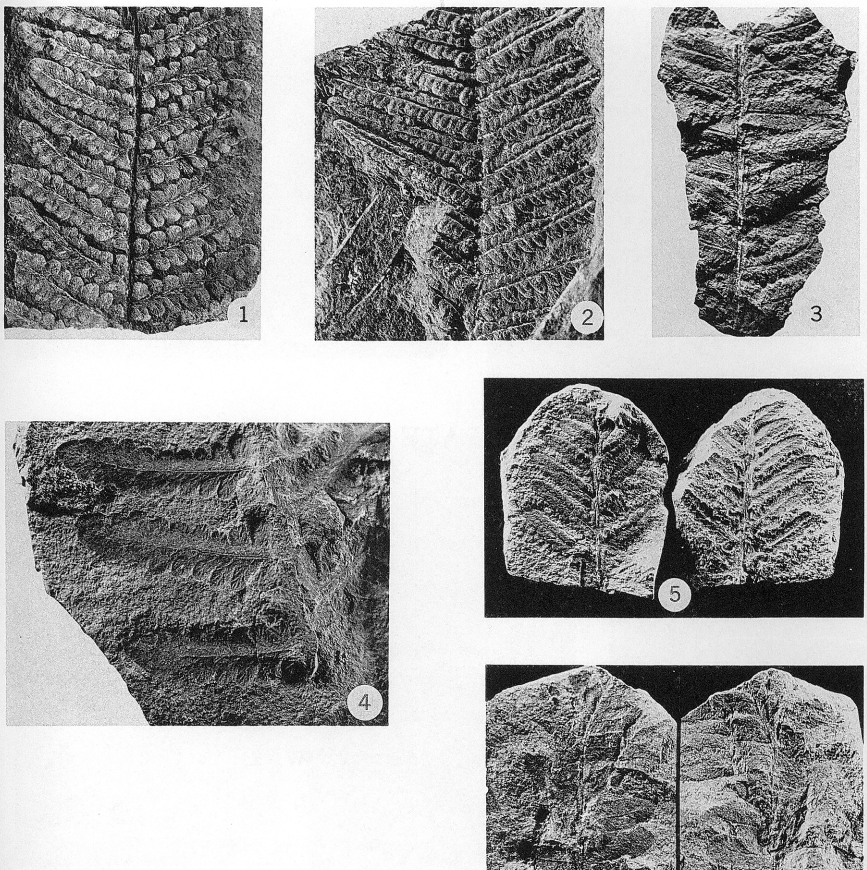
5. *Mariopteris mazoniana* (Lesquereux); W 952; X ½

6. *Pecopteris clintoni* Lesquereux; W 164; X 2/3

7. *Pecopteris pseudovestita?* D. White; L & P 490; X ½

8. *Pecopteris serpillifolia?* Lesquereux; L & P 512; X 1

9. *Pecopteris serpillifolia?* Lesquereux; W 595; X 2/3



ASTEROTHECA, MARIOPTERIS, AND PECOPTERIS

PLATE 9

Figure 1. *Cyclopteris* sp. Brongniart; W 634; X 2/3

2. *Cyclopteris orbicularis* Brongniart; W 583; X ½

3. *Megalopteris dawsoni* (Hartt) L & P 314; X ½

4. *Megalopteris dawsoni* (Hartt) L & P 315; X 4/5

5. *Neuropteris flexuosa* Sternberg; W 11; X 1

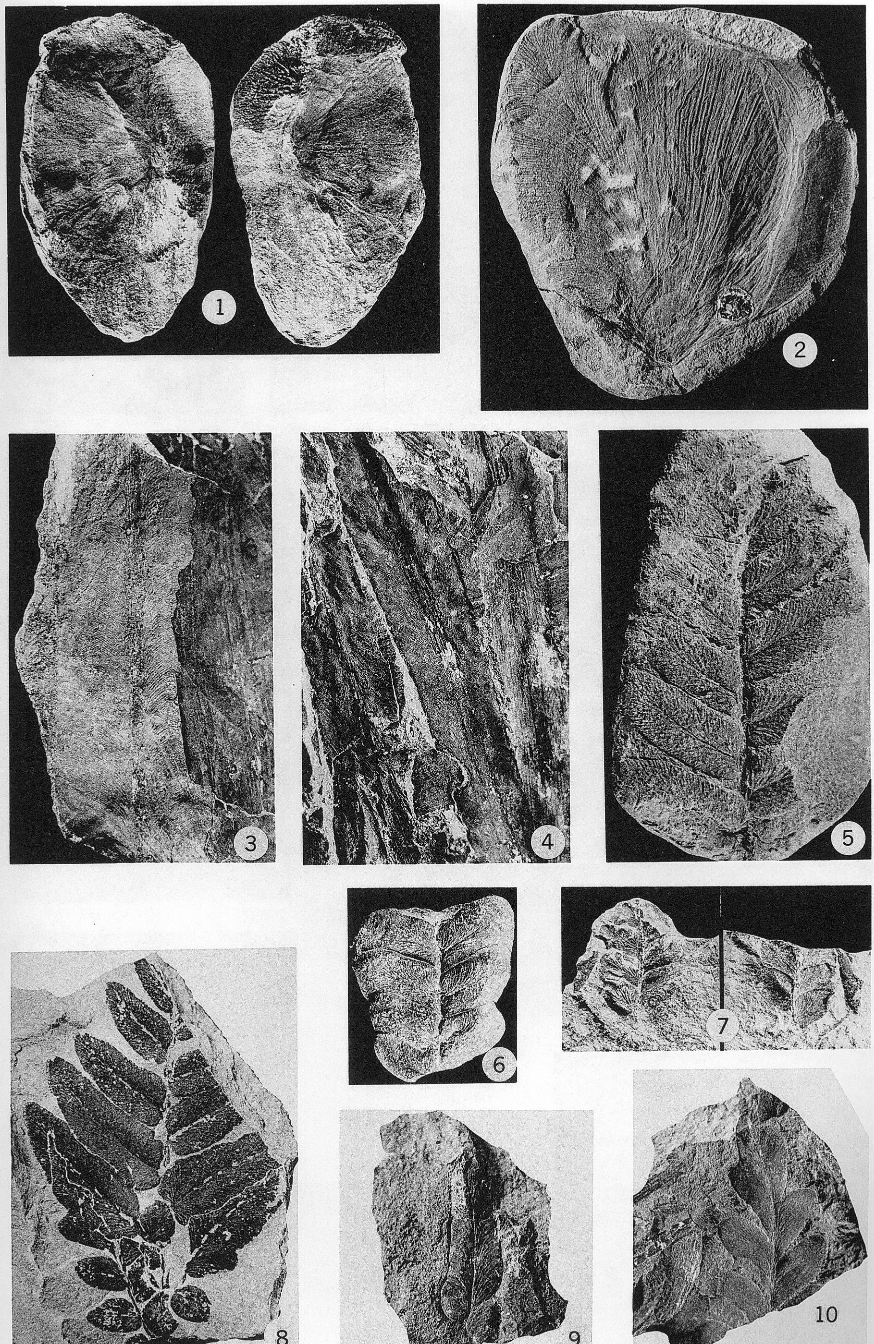
6. *Neuropteris heterophylla?* Brongniart;; W 15; X 3/4

7. *Neuropteris heterophylla?* Brongniart; W 119; X 1

8. *Neuropteris heterophylla?* Brongniart; L & P 415; X 3/4

9. *Neuropteris macrophylla* (Brongniart); W 44; X 1

10. *Neuropteris obliqua?* (Brongniart); W 106; X 4/5



CYCLOPTERIS, MEGALOPTERIS, AND NEUROPTERIS

PLATE 10

Figure 1. *Neuropteris scheuchzeri* Hoffmann; L & P 321; X 1 1/5

2. *Neuropteris rarinervis* Bunbury; L & P 440; X 1

3. *Neuropteris tenuifolia* (Schlotheim); W 556; X 3/4

4. *Neuropteris tenuifolia* (Schlotheim) ; L & P 422; X 1 1/5

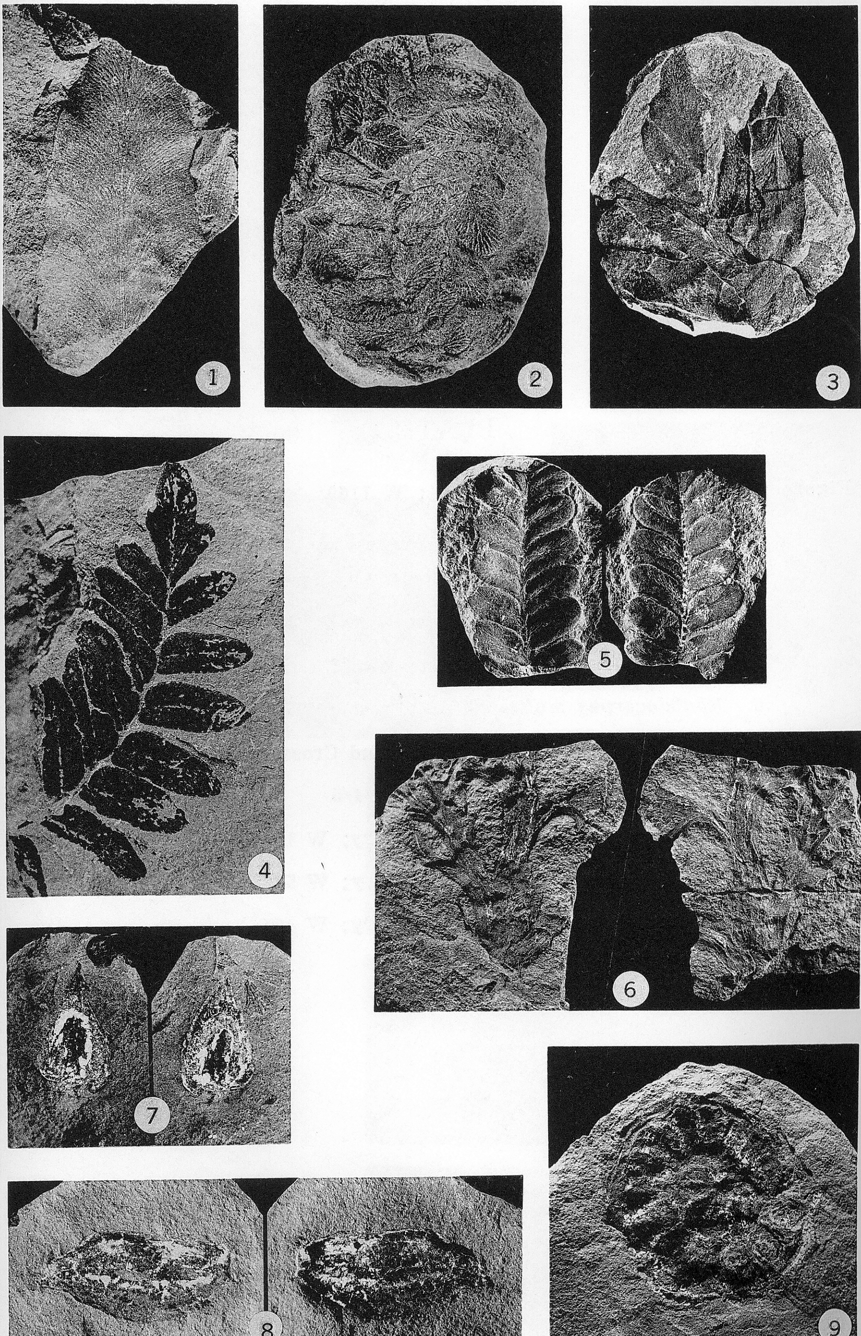
5. *Odontopteris subeuneata* Bunbury; W 118; X 2/3

6. *Aphlebia crispa* (Gutbier); W 1089; X 2/3

7. *Whittleseya* sp. Newberry; L & P 297; X 4/5

8. *Aulacotheca* sp. Halle; W 494; X 4/5

9. *Spiropteris* **sp.** Schimper; L & P 60; X 3/4



NEUROPTERIS, ODONTOPTERIS, APHLEBIA, WHITTLESEYA,
AULACOTHECA, AND SPIROPTERIS

PLATE 11

Figure 1. *Holcospermum* sp. Nathorst; W 1169; X 1

2. *Rhabdocarpus mamillatus* Lesquereux; W 504; X 2

3. *Rhabdocarpus* cf. *R. mansfieldi* Lesquereux; W 887; X 4/5

4. *Trigonocarpus* sp. Brongniart; L & P 243; X 3/4

5. *Cardiocarpon* sp. Brongniart; W 1182; X 1 1/5

6. *Rhabdocarpus multistriatus* (Presl); W 62; X 4/5

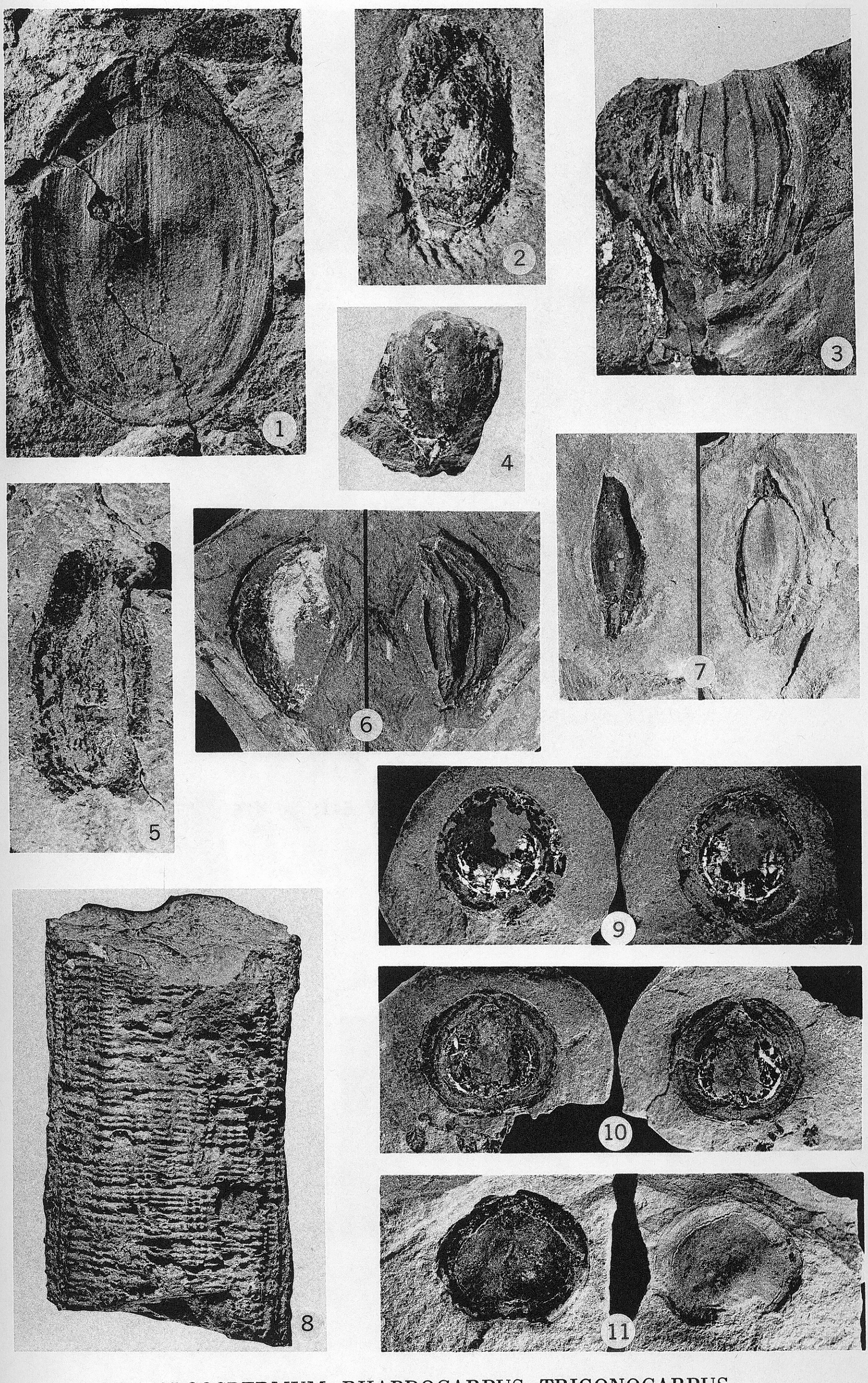
7. *Pachytesta* cf. *P. vera* Hoskins and Cross; W 615; X 4/5

8. *Artisia* sp. Sternberg; W 867; X 4/5

9. *Cardiocarpon annulatum* Newberry; W 157; X 3/4

10. *Cardiocarpon annulatum* Newberry; W 579; X 3/4

11. *Cardiocarpon annulatum* Newberry; W 496; X 3/4



HOLCOSPERMUM, RHABDOCARPUS, TRIGONOCARPUS, CARDIOCARPON, PACHYTESTA, AND ARTISIA

PLATE 12

Figure 1. *Cardiocarpon dilatatus* Lesquereux; W 194; X 3/4

2. *Cardiocarpon ingens?* Lesquereux; L & P 403; X 4/5

3. *Cardiocarpon late-alatum* Lesquereux; L & P 144; X 1 1/5

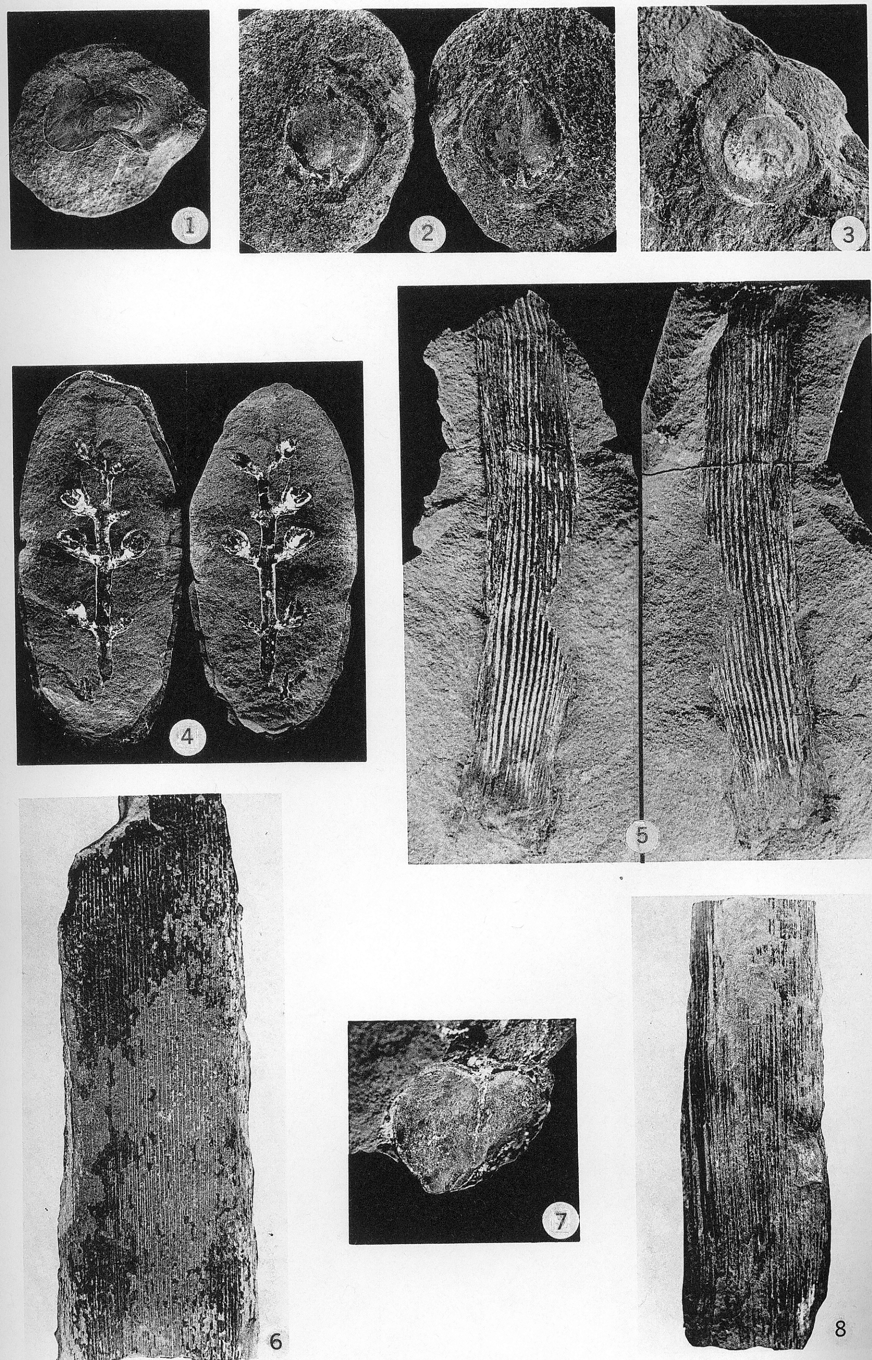
4. *Cordaianthus g*emmifer Grand'Eury; W 1095; X 3/4

5. *Cordaites crassinervis* Heer; L & P 517; X 4/5

6. *Cordaites borassifolitis* (Sternberg) ; L & P 332; X 3/4

7. *Cordaicarpon* sp.? Geinitz; W 43; X ¼

8. *Cordaites principalis* (Germar); W 641; X 4/5



CARDIOCARPON, CORDAIANTHUS, AND CORDAITES