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The First Documentation of a Lower Middle Pennsylvanian Upland Flora from the Eastern Margin of the Eastern Interior Basin (Illinois Basin)

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The first documentation of a lower Middle Pennsylvanian Upland flora from the eastern margin of the Eastern Interior Basin (Illinois Basin)

(TITLE)

BY

Vicki J. Comer

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

Master of Science in Botany

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

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YEAR

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Abstract

The primary objective of this study is to reconstruct the paleofloristics of an unnamed shale of lower Middle Pennsylvanian age. The shale is periodically exposed in the highwall of the Ashboro Pit, Log Cabin Coal Company, Clay County, Indiana. This will be the first upland fossil flora to be described from the eastern margin of the Eastern Interior Basin (Illinois Basin). The gray shale containing the upland flora lies directly above the Upper Block Coal (SW 1/4, SE 1/4, sec. 17, T. 11N., R. 6W.)

Two collections, collected on three different occasions were made available for analysis: Smithsonian Natural History Museum (1980, 1982) and Illinois State Museum (1978). The facies that contained this upland plant association could not be relocated. Numerous attempts were made between Fall 1989 through Spring 1991. It is believed that the facies was discontinuous and was not present in the exposed highwalls of the mine during the times examined.

A complete historical literature review on this particular paleoflora was conducted, particularly those citations of Megalopteris and Lesleya. Comparisons of upland associations in other parts of the Illinois Basin, for example Rock Island County, Illinois, as well as similarities and differences among other Pennsylvanian paleofloras are discussed. Significant fossils identified from the Smithsonian and Illinois State Museum Ashboro collections are: Lepidostrobophyllum, Sigillaria, Sphenophyllum cuneifolium, Alethopteris lonchitica, A. serli, Aulacotheca, Eusphenopteris morrowensis, Lesleya cheimarosa, Megalopteris southwellii, Neuropteris heterophylla, Pecopteris serrulata, P. plumosa, Cardiocarpus, Cordaianthus, Cordaites principalis and Samaropsis. Within the two collections there exists specimens that have never been associated with an upland floral association. These specimens are: Alethopteris missouriensis, Neuropteris obliqua, Neuropteris ovata, Callipteris flabellifera var.

moorei, *Asterophyllites charaeformis*, *Sphenophyllum majus*, *Carpolithus*, and *Calamites*. The environmental interpretations suggest the dark shale facies that contained the fossils represented a more organically rich, less oxygenated, low energy depositional environment. The light, fine grained shale is indicative of a high moving stream, less organically rich, more oxygenated. Preservation of the floral association did not appear to differ in respect to the different color or grain size. Upland floras were considered to be much more sensitive to environmental variations than swamp floras, therefore more likely to be the gene pool from which evolutionary advances were destined to occur.

Acknowledgements:

I would like to thank Elliott Spiker, Hal Gluskoter and all my friends and colleagues at the U. S. Geological Survey for their kind support and help with my thesis. This thesis work would not have been possible without the guidance of my Advisor, Dr. Raymond N. Pheifer in the Geology/Geography Department at Eastern Illinois University, as well as Richard Leary and the fossil collection at the Illinois State Museum. A very special thanks to William DiMichele, Sergius Mamay, and Debra Willard at the Smithsonian Natural History Museum for teaching me paleobotany and palynology. I am forever grateful to those who inspired me to become a Botanist; thank you Richard Phipps (The Giant Botanist), and the rest of the Tree Ringers, you helped me to grow taller by walking with the trees. Thank you Dr. Speer for all your stories, and Dr. Ebinger for giving me the confidence to teach. My Parents, Brothers, Grandmothers, and friends have always believed in me and without their love and affection nothing in my life would be possible. Lastly, I can not forget the unconditional love and companionship of Pumpkin and Heather.

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Introduction

The Ashboro Pit, Log Cabin Coal Company, in Clay County Indiana, has been known since approximately 1978 to contain a preserved upland fossil flora remnant in addition to common swamp fossils (Pheifer, DiMichele, Leary - personal communication). In 1978, a collection was made by Richard Leary at the Illinois State Museum, Springfield, Illinois, and Raymond Pheifer, at that time a graduate student at Indiana University, Bloomington, Indiana. In 1980 and 1982 two additional collections were made by William DiMichele at the Smithsonian Natural History Museum, Washington D.C. From 1989 to 1991, attempts were made to relocate the facies containing this unique flora but unfortunately the facies had been destroyed through normal strip mining practices. Identification of these collections of this upland paleoflora is the first from the lower Middle Pennsylvanian on the eastern margin of the Eastern Interior Basin, hereafter referred to as the Illinois Basin.

Most evolutionary and ecological concepts of Pennsylvanian age plants are based on fossils from wetland depositional environments of tropical Euramerica (Pfefferkorn, 1980; DiMichele et al. 1985). Paleotropical wetlands and lowlands included a variety of habitats from floodplains to coal swamps, the sharpest ecological distinction was between peat-accumulating coal-swamp environments and those with mineral-rich or clastic substrates. Factors that influence the composition of plant communities reveal climatic and depositional regimes, thus ecological and evolutionary relationships (DiMichele et al. 1985).

Fossil floras from upland niches are extremely rare, and therefore little known. It is believed that these floras have been the location of major advances in plant evolution. Evolution or adaptedness within the Kingdom Plantae is thought to have progressed more rapidly in variable upland environments than in swamps and lowlands. Functional morphology, a term that is synonymous with evolutionary morphology in paleobotany, is utilized to imply a potential function of that organ in relation to the preserved organ or organs and its environment. An extrapolation to a possible paleoenvironmental description and temporal patterns of floral composition within the environment are quite useful in the consolidation of stratigraphic plant distribution patterns. In addition, these data provide allowances for hypotheses about the forces that may have shaped the plant evolutionary record. It is believed that the seed-bearing plants (Cordaites and pteridosperms) evolved outside of the coal swamps in Middle and Late Pennsylvanian time (Mamay, 1976). This is a conclusion drawn from functional morphology data collected. Also, Lesleya, recently described as an upland plant, pushed the origin of the cycadales from the Early Permian (Leonardian) back to the Early Pennsylvanian (mid-Namurian), approximately 35 million years earlier (Leary, 1990). The presence of these ancestors in a mesophilous flora which grew on a well-drained, extra-basinal surface adds further evidence that major evolutionary events occurred outside the peat and alluvial depositional areas in which plants are often preserved (Leary, 1990). The purpose of the present study is to investigate the paleobotanical and stratigraphic significance of this upland flora from the lower Middle Pennsylvanian.

Literature Review

The Pennsylvanian Period (Late Carboniferous of Europe) lasted 290 to 330 mega-annum (Klein, 1990). The terrestrial floras of the Pennsylvanian Period are among the best known during the 400 million year history of vascular land plants primarily because of their economic and biostratigraphic significance and of course their aesthetic beauty. The majority of the fossil plants are derived from moist lowland or swamp environments where the depositional environment is most conducive for preservation. Our knowledge of drier-adapted plant associations: xerophilous (Pfefferkorn, 1980), upland (Chaloner, 1958; Leary, 1973), or extra-basinal (Pfefferkorn, 1980) floras, such as the Megalopteris - Cordaites floras in North America are restricted to certain stratigraphic intervals and geographic areas, namely in the early Middle Pennsylvanian west of the Appalachians (Winston, 1982). These paleofloras have been recently described by Leary (1973, 1975, 1977, 1979, 1981), Cross (1977), and Read and Mamay (1964). This rare flora is designated as Zone 7 (Read and Mamay, 1964), the widespread Megalopteris Zone.

Upland plants are believed to have existed during much, if not all, of the time of existence of land plants. Their remains are not likely to be preserved in the fossil record unless upland habitats occurred adjacent to basins of deposition (Read, 1947).

The literature before the turn of the century contains numerous descriptions of fossil plants by Leo Lesquereux (1866, 1870, 1879 - 1884, and 1884), the Swiss naturalist who arrived in the United States as the companion of Louis Agassiz. Volume 2 (1866) and volume 4 (1870) of the first Geological Survey of Illinois contain many of Lesquereux's descriptions.

David White published significant reports on the distribution of Pennsylvanian plants in Illinois. On the basis of his observations the subdivisions of the Pennsylvanian System in Illinois - Pottsville, Carbondale, and McLeansboro were created. White (1908) examined several localities in Western Illinois and published a list of 14 fossil plant genera observed. Leary (1975) reports that White (1931) describes these plants as representing an upland environment. The next period of study of Illinois Basin fossil plants was made by Noe (1925). A photograph and brief description of Megalopteris southwelli Lesquereux is included in this publication.

Read and Mamay (1964) provided the next important advancement in understanding the fossil floras by establishing floral zones to define their evolution through time correlated with stratigraphic occurrence. The zone of Megalopteris (Read and Mamay, 1964) can be recognized in the Appalachian region at or near the base of the Kanawha Formation and its equivalents, and in the midcontinent in the lower part of sequences that are believed to be equivalent to the Atoka Series. In New Brunswick it is represented in the Little River Group. In Illinois, it is prominently represented in the Tarter Member of the Abbott Formation of the McCormick Group and occurs in equivalent units in Eastern Iowa. In Texas the zone can be recognized in the base of the Lampasas Series. This zone has not been identified in the Ancestral Rocky Mountain and Cordillerran provinces but is probably represented by marine strata (Read and Mamay, 1964).

Although species of Megalopteris Schenk are especially characteristic of Zone 7, they are by no means present in all collections from this zone. The zone is also characterized by Neuropteris lanceolata Newberry and by large cardiocarpons of the Cardiocarpon phillipsi Read type. The species that occur in this zone in Illinois are listed in the Discussion section under "Comparison of Floras".

The various species of Megalopteris seem to be abundant where Pennsylvanian strata of early Atoka age occur immediately above pre-Pennsylvanian karst surfaces. This occurrence suggests the possibility that Megalopteris found habitats most favorable for growth in and adjacent to sinkholes and in calcareous soil. One best-known flora of this zone is from the "Fern Ledges" of the Little River Group (Lancaster Formation) near St. John, New Brunswick. The known species that characterize the flora at this locality are given by Stopes (1914).

The second and more extensive occurrence of upland floras occurred during the early Late

Pennsylvanian (Late Missourian). The Garnett Flora is one of at least four such "upland" floras from Kansas from the dry interval (Cridland and Morris 1963, Winston 1982). The kinds of plants appearing in the Garnett Flora are indicative of poorly known vegetative patterns which probably characterized extensive drier habitats during Pennsylvanian time. This flora, only preserved along with exceptional conifer -rich floras from the Late Missourian onwards, especially in the Permian, generally indicates a progressively drier environment on land in North America and Europe (Winston, 1982).

Winston (1982) restudied the depositional succession of the Lake Shale Member of the Stanton Limestone Formation as part of a broader biological and ecological study of the site at Garnett, Kansas. Twenty species of megafossils were found, including five ovules. The megaflora is dominated by Lebachia garnettensis with Cordaites being subdominant. Morphological and comparative evidence supports the conclusion that L. garnettensis abscised its ultimate branches. Callipteris flabellifera var. moorei is common but not abundant. The remaining vegetative species are rare. Nearly all the fossils collected were gymnosperms (Winston, 1982).

The terminology pertaining to this particular plant community has been misleading and unclear since the discovery and naming of the paleoflora. Pfefferkorn (1980) published a Short Communication on this subject.

Terrestrial environments are divided into two categories: depositional and erosional. Under uncommon occurrences erosional environments may preserve topographic features and fossils, but more commonly areas of deposition, fluvial and lacustrine, allow for preservation. These sites of preservations are often referred to as "basins". By definition: a basin is a depressed area with no surface outlet; an area in which sediment accumulated; or a low area in the Earth’s crust (Bates and Jackson, 1980). The scale may be as small as a local sinkhole that receives erosional sediment or as large as a graben (trough) that is regional in size. Since the vast majority of plants preserved in the fossil record reflect a specific depositional environment, the plant community preserved also reflects this. Therefore, a plant community that only under extraordinary circumstances is preserved should have a term that is not in any way misleading or confusing. Upland seems to suggest to many a plant association that grew at an elevated relief, possibly an erosional situation. Extra-basinal on the other hand does not render any particular topographic property. In addition, hygrophilous, mesophilous, and xerophilous refer to plant communities that prefer certain growing conditions, but do not reflect the type of deposition, even though hygrophilous/mesophilous floras have a better chance of being preserved in a depositional basin because of its growth habit as opposed to a extra-basin community. The plant assemblages that are in a lowland are distinctly different from the upland, but it appears that in the literature the distinction is not made clear (Pfefferkorn, 1980).

Leary (1973) first introduces the term "upland" to designate descriptive non-swamp floras, but the actual paleoecology of such floras was not known. It appears that this flora grew on soils derived from limestone bedrock in western Illinois, and many were near stream banks and ultimately were deposited in stream channels with minimal transport. Leary (1981) defines an upland flora as one that is dominated by the form genera Megalopteris and Lesleya, and containing Noeggerathiales and Cordaites. These uplands were considered well-drained and would have been less than 5 meters above the base level. Cridland and Morris (1963) suggest that elevations as little as 6 to 9 meters (20-30 feet) are sufficient to produce different types of floras. A carbonaceous shale is often located below these preserved floras therefore it is assumed that the plants grew on a surface that was well drained. An upland environment is one in which the land surface is sufficiently above the local water table for the soil to be well drained. A swamp or alluvial environment is where the root system of the plants are often inundated and are rarely exposed to drying or drought conditions. Upland floras are seldom preserved because erosion predominates, and only in isolated depressions have these plants been preserved in proximity to their site of growth (Leary and Pfefferkorn, 1977). The term xerophilous was used synonymously with upland in Leary (1975) to describe the topography of the Rock Island County, Illinois, site. The plants preserved here apparently grew along a water-filled channel and perhaps the presence of a permanent body of water permitted the growth of hydrophilous plants on an otherwise upland. Whether the vegetation was restricted to a narrow area

along the channel or whether it also covered the intervening plain is not known (Leary, 1975).

Plant fossils preserved in Rock Island County in basal Pennsylvanian rocks of western Illinois are significant because the composition of many of the paleofloras differs from those of more commonly preserved and better studied coal swamp floras. Differences are attributed to environmental influences (White, 1913, 1931), some floras were restricted to uplands, others grew on alluvial or delta plains (Leary, 1981). Paleobotanical evidence can be misleading without supporting geological evidence. Only recently have quantitative and lithofacies-paleoecological studies been undertaken (Leary, 1979, 1981).

Upland floras include a number of genera which are unknown in coal swamps. The Allied Stone Company quarry floras are distinct from commonly preserved floral associations in that they contain several genera uncommon in Pennsylvanian coal swamp floras (e.g. Lacoea, Megalopteris and Lesleya) (Leary, 1981). The distinct Megalopteris flora appears to contain greater percentages of pteridosperms and Cordaites and smaller percentages of ferns and lycopods than do Early Pennsylvanian floras associated with coal seams ("swamp flora") (Phillips et at., 1974). Arnold (1934) and Leary (1973) reported eleven localities where Megalopteris has been reported: (figure 1)

St. John, New Brunswick	**Dawson (1871), Stopes (1914)**
Rushville, Ohio	**Andrews (1875), Cross (1962)**
Port Byron, Illinois	**Lesquereux (1880)**
Wyoming Hill, Iowa	**Noe (1925)**
Grand Ledge, Michigan	**Arnold (1934)**
Putnam County, Indiana	**Arnold (1936), oral communication with Leary**
Pictou, Canada	**Bell (1940)**
West Virginia	**White (1913)**
Green County, Indiana	**Canright (1959), Wood (1963)**

Brown County, Illinois Leary and Pfefferkorn (1977)

Rock Island County, Illinois Leary (1974, 1981)

Figure 1.1 shows a map of the Illinois Basin with reported locations of Megalopteris.

Figure 1:

1. **Map of the Illinois Basin with reported locations of Megalopteris.**

A = Clay County, Indiana, Pheifer and Leary, 1978, DiMichele, 1980 or 1982

B = Putnum County, Indiana Arnold, 1936

C = Green County, Indiana Canright (1959), Wood (1963)

D = Brown County, Illinois Leary and Pfefferkorn (1977)

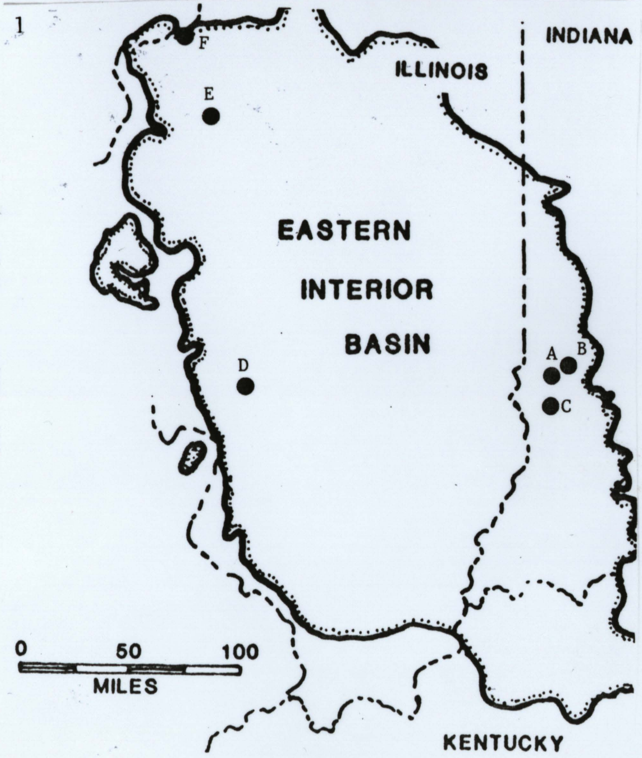
E = Rock Island County, Illinois Leary (1977, 1979, 1981)

F = Port Byron, Illinois Lesquereux (1880)

2. **The horizon in the Ashboro Pit, Clay County, Indiana, that contained the upland flora found by Leary and Pheifer in 1978. Specimens are stored at the Illinois State Museum, Springfield Illinois.**

2

1



INDIANA
ILLINOIS
F
E
EASTERN
INTERIOR
BASIN
A
B
C
D
0
50
100
MILES
KENTUCKY

Materials and Methods

Two upland impression / compression fossil collections from the Ashboro Pit, Log Cabin Coal Company, Clay County, Indiana, were examined, identified, and photographed. The first collection was made in 1978 by Richard Leary and Raymond Pheifer and is stored at the Illinois State Museum in Springfield, Illinois. Photographs of the mine were available but no field notes (figure 1.2, 2.1). The second collection was made by William DiMichele in 1980 and 1982 and stored at the Smithsonian Natural History Museum in Washington D.C. Field notes were included with the collection, but slides and photographs that were taken have been lost. Photographs of the Ashboro Pit were taken in 1991 (figure 2.2).

Figure 2:

1. **Photograph of the Ashboro Pit, Clay County, Indiana. Leary and Pheifer, 1978.**

2. **Photograph of the Ashboro Pit, Clay County, Indiana. Comer and Pheifer, 1991.**

1

2

Geology

The Late Paleozoic was a time of diverse sedimentation, progress in organic evolution, and diverse climatic conditions. The Carboniferous System of the Paleozoic is divided into two major Periods: the Mississippian and the Pennsylvanian. The Upper Carboniferous rocks of North America, known as the Pennsylvanian System, constitutes a very important segment of the geologic column of the North American continent.

Approximately 320 million years ago, the Mississippian sea withdrew from the midcontinent region which designated the close of the Mississippian. Erosion of pre-Pennsylvanian strata took place as a result of the regression of the sea in Early Pennsylvanian time. The Early Pennsylvanian Morrowan Sea stopped the erosion of the basin. Lithological variations in Pennsylvanian rocks were produced by subsidence of the Illinois Basin and world wide sea level changes. Changes from marine to non-marine deposits can be identified as cyclothems. Marine sandstones, limestones and shales were deposited as a result of changed shoreline positions, and Basin subsidence. Non-marine shales were deposited mainly on floodplains. Non-marine limestones and some shales were deposited locally in lakes and swamps. Coal seams are believed to have originated from peat deposits such as in swamps and wetlands. The following criteria have been agreed upon by geologist as required in the coal forming process: the evolutionary development of the flora, the climate and the geographical and structural position of the region (Stach et al. 1982). These parameters are critical in the formation of coal and represent the termination of the nonmarine portion of the depositional cycle.

Stratigraphy

The shale of interest is periodically exposed in the highwall of the Ashboro Pit of the Log Cabin Coal Company, Clay County Indiana. The gray shale containing the upland flora was directly above the coal referred to as the Upper Block Coal (Shaver et al., 1986). The mine is approximately 16 miles southeast of Terra Haute, Indiana, on Indiana Highway 46 (SW 1/4 SE 1/4 sec. 17, T. 11N., R. 6W), (figure 3).

The type locality of the Upper Block Coal is 2 to 3 miles (3 to 4.5 km) northeast of Brazil, Indiana, near the old mining town of Cardonia. Powell (1968) instituted the Upper Block to member status in the Brazil Formation primarily because of the commercial and geologic applications of the coal seam. Historically, this coal seam has been informally recognized by the same name since the turn of the century. In 1899 the coal was designated Coal IV in the sequence in northern Clay County and in Vigo County by Ashley (Shaver et al., 1986).

The Upper Block Member consists of moderately dull banded hard semisplint coal. The blocks measure 0.5 foot (0.15 m) to 3.0 feet (0.9 m) on a side. This results in two well-developed sets of vertical joints that trend about N. 20 degrees West and N. 70 degrees East. 1.5 feet (0.5 m) above the base of the coalbed is a zone of soft flaky coal (fusain). The coal is divided into two benches of unequal thickness. The lower bench tends to break up into small cubes, but the upper bench breaks into larger blocks. In places, the top few inches of the bed is a bone coal (Shaver et al., 1986).

Gray, hard, silty, thick bedded shale lines the roof of the coal. In a few places, there are several inches of gray, soft, flaky shale overlain by brown or gray, hard, medium grained, massive sandstone. Sandstone in some areas form a roof on the coal. The floor of the coal is gray underclay that is hard, slightly sandy and carbonaceous. (Shaver et al., 1986).

The Upper Block Coal Member has been correlated with the Pope Creek, Delwood, and Willis Coal Members in different parts of Illinois. Dry Wood Coal of Missouri, Ice House (No. 3)

and Elm Lick Coal of western Kentucky have also been correlated with the Upper Block Coal Member of Indiana (Shaver et al., 1986).

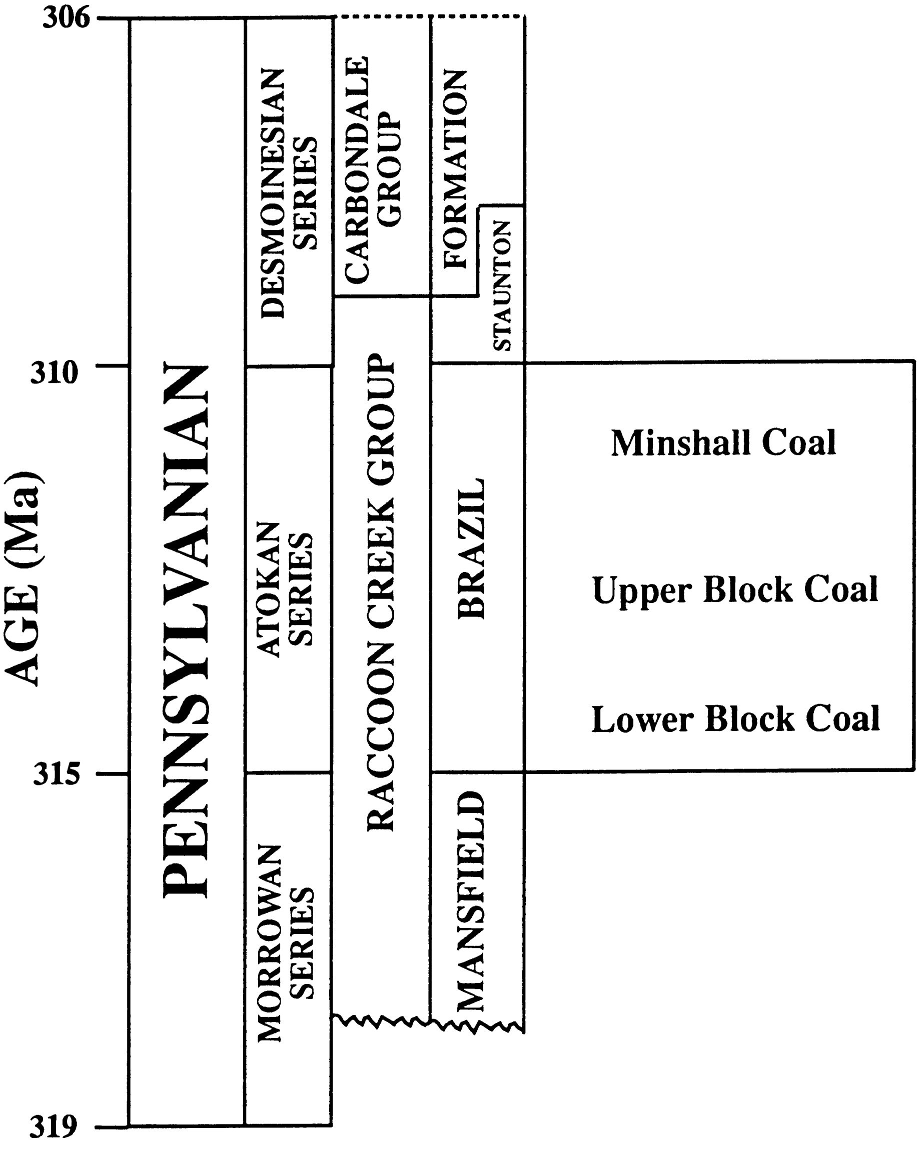


Figure 3. Stratigraphic relationships of Lower Block, Upper Block, and Minshall Coals, western Indiana. Dates on series boundaries are from Klein (1990). Stratigraphic column is modified from Shaver et al. (1986).

Systematic Paleontology - Plant Macrofossils

Descriptions

The two upland collections from the Ashboro Pit, upland flora have many of the same plant parts preserved. The most well preserved representative of each form genus was documented and photographed. The description and classification of these genera will be presented in the order considered to be the most significant components of an upland flora because of the rarity of the specimens.

PTERIDOSPERMS / CYCADOPHYTES

Genus : Megalopteris (Dawson) Andrews

Synonymy*

1828 Cannophyllites, Brongniart, Prodr., p. 130 (nomen rejiciendum; see Stafleu et al., 1972, p. 376)

1865 Neuropteris, Hartt in: Bailey, p. 550

1871 Neuropteris, (Megalopterris) Dawson, p. 51

1875 Megalopteris (Dawson) Andrews (nomen conservandum; see Stafleu et al., 1972, p. 376) p. 415.

*Leary and Pfefferkorn (1977)

Description:

A compound leaf or pinnae having three or more lobes or pinnules. The pinnules often attached at irregular distances and at irregular angles, giving the impression of a pedate/palmate frond, especially at the base, but more pinnate further away from attachment of the main stem. The pinnules are strap-shaped or lanceolate and generally large, but do vary greatly in size. The base of the pinnules are decurrent (attenuate) with unequal sides. The midvein is thick, with long striations; lateral veins dense and forking one to three times, curved or straight (Leary and Pfefferkorn, 1977).

Discussion

Noe (1925) places Megalopteris in the Filicales (Cycadofilicales), Megalopteridae. He describes it as a large-leafed fern with a simple pinnate frond and as probably herbaceous. The monograph revealed a palmately compound leaf or pinnae with three lanceolate, large pinnules (Noe, 1925, Plate XV).

More recently Megalopteris is placed in the Pteridosperms probably because of similar venation and leaf morphology to the Pteridosperms. Distinguishing characteristics between Lesleya and Megalopteris is difficult, especially with impression/compression fossils. Florin (1933) used stomata of the two genera to distinguish specimens when only fragments were preserved. Unfortunitely, generic determination was not possible with the Ashboro Pit collections since only impression fossils were available and no substantial carbon film of the compressions were preserved (plate 1).

Genus: Lesleya

species: cheimarosa or sp.

Description:

Simple leaf of considerable size, about 20 cm long and 4 cm wide, lanceolate with acute to attenuate tip. Base long and narrow (acuminate). Margin entire. Venation pinnate, midrib thick, 0.7 to 2 mm wide; lateral veins fork once or twice; lateral veins S-shaped with a 10 to 70 angle in center, and 40 to 70 angle on margin; 24 to 36 veins per cm on margin.

Holotype: ISM 416488

Paratypes: ISM 416508, 416526

*Leary and Pfefferkorn (1977)

Discussion:

The Illinois State Museum collection contains six specimens that appear to be Lesleya or a single pinna of Megalopteris; the venation more closely resembles Lesleya. One specimen of the apex of either Megalopteris or Lesleya was also included. The Smithsonian collection did not contain a Megalopteris specimen, but did include one positive identification of Lesleya cheimarosa (plate 2, 3).

The seed ferns and pteridosperms as a group is believed to be an extremely diverse group of organisms. Fossil remnants of vines, shrubs, small trees that are thought to have resembled fern foliage are in this group. The seed ferns reproduced not with spores, as do modern ferns, but with seeds. The leaves were frond-like ranging in size from 3 to 1.5 meters wide; leaf axes reached 8 cm in diameter. The form genera for the leaves vary greatly in their gross morphology and are categorized under the following names: Alethopteris, Callipteridum, Callipteris, Pecopteris, Megalopteris, Neuropteris, Linopteris, Odontopteris, Lescuropteris, Mariopteris, Pseudomariopteris, Sphenopteris, Eusphenopteris, Eremopteris, Lyginopteris, Palmatopteris, and Aneimites. These genera are commonly found in the Pennsylvanian coal swamp collections. Genera representing an upland flora are less understood and rarely documented. Preserved upland specimens from the Smithsonian collection includes: Alethopteris lonchitica, A. serli, A. missouriensis, Alethopteris sp., Pecopteris serrulata or P. plumosa (?), Neuropteris heterophylla, N. oblique, N. ovata, and Neuropteris sp. The upland collection at the Illinois State Museum contains poorly preserved specimens of Alethopteris sp., Callipteris flabellifera var. moorei (?), Megalopteris southwellii, Pecopteris sp., and Eusphenopteris morrowensis.

Noe (1925) describes Alethopteris as a Cycadofilicales, with pinnules broadly attached with decurrent bases. The midrib is very distinct with numerous secondary veins. Andrews (1961) elaborates and states that the fronds are several times pinnate, with pinnules that are attached by a flaring base and usually make an acute angle with the pinna midrib. Most, if not all of the Alethopteris form-genera are considered to have been borne on the medullosan pteridosperms. A clear definition of form-genera is a species that is similar in their gross morphological features but in which reproductive organs are lacking and consequently the natural affinities are unknown (Andrews, 1961).

Alethopteris lonchitica (Schlotheim) Sternberg

Description:

The most concise description of this species was found in Leary, (1977) and is restated here to assure accuracy in the identification. Pinnules linear-lanceolate or oblong, length to width ratio between 2.3:1 and 5:1 (average 3.2:1, based on 14 specimens from the Rock Island collection). The apex is obtuse to acute; base decurrent on the proximal side and deeply incised on the distal side, both features highly variable in shape. Pinnules not connected with each other in lower parts of pinna, but become confluent towards the apex. Pinnules attached obliquely 25 to 85 degrees (average approximately 60 degrees). The midvein is thick, nearly reaching the apex. Lateral veins varied in their form, normally forked once, rarely simple or forked twice; their angle at the midvein ranges from 30 - 70 degrees (average is 50); their angle with the margin ranges from 45 to 90 (av. 70). There are 32 to 50 veins per cm on margin (av. 40).

Discussion:

One specimen of this species in found in the Smithsonian upland collection (plate 4). None were identified from the Illinois State Museum collection. The Spencer Farm upland flora contained many well preserved and complete representatives of A. lonchitica. Alethopteris lonchitica is considered to be most common in the Westphalian A, B, and more scarce in D (Leary, 1977).

Alethopteris serlii (Brongniart) Goeppert, 1836

Synonymy

Pecopteris serlii Brongniart, 1828a, p. 292, pl. 85; 1828b, p. 57, 170

Alethopteris serlii (Brongniart). Goeppert, 1838, p. 301, pl. 21, figs. 6, 7.

Alethopteris serlii Brongniart. Lesquereux, 1879, pl. 29, figs. 1-5; 1880, p. 176.

Alethopteris serli (Brongniart). Bell, 1938, p. 67, figs. 6, 7; pl. 62, fig. 1.

Alethopteris serli Brongniart. Crookall, 1955, p. 17, pl.7, figs. 1, 2, 2a, 3; text-figs. 6, 14 B, 17C. (Contains a more complete synonymy.)

Alethopteris serlii (Brongniart) Goeppert. Oleksyshyn, 1976, p. 163, fig. 10A.

Description:

Alethopteris serlii is represented by a large frond. The secondary pinnae are elongate-lanceolate, and oppositely attached to a strong, longitudinally striated rachis about 5 mm thick; the pinnae differ in length. The pinnules are oblong, alternate or subopposite, and usually obliquely attached to a narrowly alate rachis; adjacent pinnules are separated from each other by a sharp sinus. The upper margin of the pinnules is slightly decurrent and unites adjacent pinnules; the pinnules are widest in the middle and taper rapidly to a blunt or slightly acuminate apex. Terminal pinnules usually are slightly undulate and are lanceolate, having bluntly pointed apices. The sizes of the pinnules vary, but the most common are 15-20 mm long by 6-8 mm broad at the widest part. The midvein is strong, broad, and slightly decurrent at the base; it usually extends to the apex of the pinnule or divides into veinlets near the apex. Numerous closely spaced lateral veinlets arise at a slightly oblique angle from the midvein, arch slightly, and usually divide once or twice. Some veinlets are simple; subsidiary veinlets enter the pinnules directly from the rachis (plate 5), (Oleksyshyn, 1982).

Alethopteris missouriensis D. White

Description and Discussion:

This seed fern has leaflets which are slender (3-6 mm x 10-30 mm), somewhat acutely-pointed, are inserted nearly perpendicularly, and have definitely confluent bases. A moderate midvein enters the leaflet and follows a straight path to the tip. Lateral veins usually divide once (although occasionally twice) and meet the margin at nearly right angle with a count of 45-50 per centimeter. This species is a upper Middle and lower Upper Pennsylvanian form (Gillespie et al., 1978), (Plate identification Wagner, 1968), (plate 6).

Callipteris Brongniart 1849 (Pteridospermatae)

Callipteris is a variable genus with alethopterid-like pinnae. The classification and evolutionary significance is unclear in the literature. It is used as an index fossil to mark the boundary between the Pennsylvanian and the overlying Permian. Unfortunately, more recent findings of this plant in much older rocks has caused problems in biostratigraphic analysis.

Callipteris flabellifera var. moorei

Description: Callipteris flabellifera var. moorei has one dichotomy in its main rachis; the rest of the frond is once or twice pinnately compound. Intercalary pinnules are attached to pinnae and to the main rachis. The common basal expansion of the rachis is probably the point of attachment of the leaf to the stem (Winston, 1982).

Discussion: Callipteris flabellifera var. moorei (= Dichophyllum moorei) includes different morphological interpretations: such as palmate compounding, a combination of dichotomies, pinnate compounding with apparently palmate branching actually being subopposite branching in the pinnate system (Winston, 1982). Mamay expressed uncertainty when asked to identify (verbal communication, 12/91), yet agreed it resembled Dichophyllum moorei (Read and Mamay, 1964). Comparison of this specimen to Winston (1982), Read and Mamay (1964), Remy and Remy (1977) appears to confirm closest resemblance to Callipteris flabellifera var. moorei (plate 6). The only representative sample was photographed from the Illinois State Museum collection.

Eusphenopteris (Weiss 1869) Simon-Scharold 1934 (non Kidston 1882)

The most concise description of this genus was taken from Remy and Remy (1977). The German was translated to English by J. Pontolillo in 1992, and was originally from Novik (1947). The fronds of this pteridosperm are forked once and have multiple, pinnate, divergently forked branches. The catadromous leaflets are often enlarged but not aphleboidally (without veins, veinless) altered. The leaflets are rounded to obovate; entirely margined to crenate. The leaflets (pinnae) sit along the axis on a narrow base or petiole / stalk. The venation is feathery (pinnate to palmate and is sometimes covered with striations of bast (phloem). The plants have the appearance of an arborescent growth form. Catadromous refers to Milde's classification of ferns into catadromous and anadromous series according as to whether their lowest secondary branches originate on the posterior or anterior side of the pinnae.

Eusphenopteris morrowensis (D. White) van Amerom

Basionym:

Diplothmema morrowensis 1943 David White, Lower Pennsylvanian species of Marioteris, Eremopteris, Diplothmema, and Aneimites from the Appalachian region: U.S. Geological Survey Professional Paper 197-C, p. 99-100, pl. 34, fig. 1; pl. 35, fig. 1. (Leary and Pfefferkorn, 1977)

Description:

A large amount of variability exists as to the size and shape of the pinnules. Lobing can be dramatic or slight ranging from diamond to ovoid shape. Generally three to seven lobes per pinnule. The base of the pinnules are decurrent on the proximal side and incised on the distal side. Base attachment of the pinnules closer to the tip of the pinnae becomes entire. Pinnule tips are obtuse to acute. Venation is dichotomous and pinnate. Midveins are straight to undulate in the lower two-thirds of the larger pinnules and is not different from lateral veins in smaller (younger) pinnules. One vein per larger pinnule. Glands may be seen on well preserved compressions, but not in this collection. A suggested frond reconstruction showed at least three times pinnate. (Leary and Pfefferkorn, 1977).

Discussion:

One specimen was identified from the Illinois State Museum collection (plate 7). The species has been documented from the Rock Island Illinois site, and Spenser Farm, Illinois site. The foliage of Eusphenopteris morrowensis has been found associated, but with no organic connections to the seed Lagenospermum (= Nudospermum). Also, the male fructification Telangiopsis has been noted to occur on the same bedding plane (Leary and Pfefferkorn, 1977).

Pecopteris sp.

The magnificent marattiaceous tree fern Psaronius produced croziers at the apex of the stem. The expansion of these fronds produced planated, bilaterally symmetrical leaves of the Pecopteris types. The length of the fronds have been estimated at 1.5 to 3 meters. The fronds are once to quadripinnate with pinnae and pinnules borne alternately on each side of a pinnae and pinnules borne alternately on each side of a pinna rachis. The pinnules become pinnatified toward the tip. The venation of the pinnules is open-type, often dichotomous. On the abaxial side of the pinnules, below the vein, sporangia are often borne (Stewart, 1983). Several poorly preserved pinnules were in both the Smithsonian and Illinois upland collections. Unfortunately, the Illinois sample could not be identified, but the Smithsonian sample appeared to be Pecopteris serrulata or P. plumosa. It appears that depending on the source of the identification that these two species are synonymous, for example Read and Mamay (1964) refer to this species as Pecopteris serrulata.

Pecopteris (Senftenbergia) plumosa (Artis) Radforth

Synonomy

Neuropteris serrulata Dawson; Geol. Soc. Lond., Quart. Journ., vol 18, p. 320, Pl XV,figs. 35a, b (1862); Foss. Pl. Devon. and Up. Silur. Canada, Geol. Surv., Canada, p. 49, Pl. xviii, fig, 213 (1871).

Pecopteris (Alethopteris) serrulata Hartt; in Dawson, Acad. Geol., 2nd ed., p. 553, Fig. 192K (1868).

Pecopteris (Aspidites ?) serrulata Hartt; in Dawson, Fossil Pl. Devon. and Up. Silur. Canada, Geol. Surv., Canada, p. 55, Pl. XVIII, figs. 207-209 (1871).

Pecopteris plumosa Stopes; Geol. Surv., Canada, Mem. 41, p.44, Pl. XII, figs. 7-28, text Fig. 7 (1914).

Description:

The fronds are once to tripinnate with considerable variation in pinnule cutting. Secondary pinnae, from 3 to 15 cm in length, and attached at open angles, and often touch or overlap at their borders. Tertiary pinnae are linear-lanceolate, attached obliquely or nearly at right angles with acute apex. The midvein is minutely flexuous, the laterals simple or once divided, or in crenate pinnules a branch entering a lobe divides once and again higher up (Bell, 1944). (plate 7)

Neuropteris (Brongniart 1822) Sternberg 1825 (al. Imparipteris Gothan 1941)

Several different form species identified in the Smithsonian collection are included: Neuropteris heterophylla, N. oblique, N. ovata, and Neuropteris sp. A translation from German to English was made to assure written descriptions coincided with the visual / plate identifications (translation by J. Pontolillo, 1992).

The Neuropteris frond is 3 to 4 fold pinnate. The frond axes exhibit a distinct longitudinal striation. The frond bases are bordered with Cyclopteris-style leaflets. All axes aside from the last and next to last are bordered with intermediate leaflets. The leaflets of the frond tip and frond lateral section sometimes end with a leaflet. The leaflets are slightly parallel, sturdy to oblong tongue-shaped; bases are typically heart shaped. The leaflets are almost fixed along the axis in sheets. The leaflet-tips are rounded and varied (in appearance) in relation to leaflet length. The lateral veins are forked and pinnate in pattern. Type section: Neuropteris heterophylla (BRGT.) STERNBG. 1825.

Synonomy:

Neuropteris heterophylla Brongniart, 1822

Filicities (Sect. Nevropteris) heterophylla Brongniart, 1822, p. 33, 239, pl. 2, fig 6.

Neuropteris heterophylla Brongniart, 1828a, p. 243, pl. 71; pl. 72, fig. 2; 1828b, p. 53, 169.

Imparipteris (Neuropteris) heterophylla Brongniart. Gothan and Remy, 1957, p. 124, 133, 189, 218, figs. 118, 119, 218; chart 5.

Neuropteris heterophylla Brongniart. Crookall,1959, p. 92, 96, pl. 25, figs 1-3 and many more.

Neuropteris heterophylla Brongniart. Darrah, 1970, p. 98.

Neuropteris heterophylla Brongniart. Oleksyshyn, 1976, p. 164, fig. 10B.

Description:

Neuropteris heterophylla has leaflets that are set densely together, touching one another, but not overlapping. They are oblong, and irregularly obtuse to short tongue-shaped in form. The base is distinctly heart shaped, slightly retracted but never emarginated / pouched or auricled. The leaflet tips are rounded. Since the leaflets are fixed in a stitched manner, they cover the heart-shaped base of the supporting axis or - when viewed from the underside - cover the axis of the leaf base. The median vein is easy to follow for two - thirds of the leaflet length, but it is not especially marked (plate 8).

Neuropteris obliqua (Brongniart) Goeppert, 1841

Synonomy

Pecopteris obliqua Brongniart, 1828a, p. 320, pl. 96, figs. 1-4; 1828b, p. 57, 107.

Neuropteris obliqua Brongniart. Goeppert, 1841, p. 3, 6, pl. 11, fig. 1.

Neuropteris obliqua (Brongniart). Zeiller, 1886, pl. 48, figs. 1, 2, 4-7; 1888, p. 284.

Imparipteris (Neuropteris) obliqua (Brongniart) Zeiller. Gothan and Remy, 1957, p. 129, 133, 189, 216, figs. 125-127; chart 5.

Neuropteris obliqua Brongniart. Crookall, 1959, p. 165, pl. 42, fig. 2; pl. 45, figs. 1,2; contains a more complete synonymy.

Neuropteris obliqua Brongniart. Lyons and others, 1976, figs. 4A-H, 5A-C.

Description:

Neuropteris obliqua has leaflets that are rounded to elongate deltoids with rounded, sometimes sharpened, tips. The leaflet bases cover only the axes, since the leaflet attachments are more odontopteridian and not dot - shaped or petiolate as in the case with most Neuropteris species. A median vein region is only weakly indicated at the leaflet base. In the case of the apical leaflets, the advance of previously separated vein groups from the leaf base form a multi-bifurcated, slightly flexuoses vein pattern that is suggestive of Odontopteridian venation. Occurrence: Upper Namurian to Westphalian B (plate 8).

Neuropteris ovata Hoffmann, 1826

Synonomy:

Neuropteris ovata Hoffmann, 1826, p. 158, pl. 16, figs. 5-8.

Neuropteris ovata Hoffmann. Noe, 1925, p. 58, 60, pl. 20, fig. 3; pl. 21, fig. 4.

Neuropteris ovata Bell, 1938, p. 60, pl. 52, fig. 4; pl. 53, fig. 3; pl. 54, fig. 1-3.

The leaflets of Neuropteris ovata are set densely together, but do not overlap. They are sturdy and nearly parallel. The leaflet bases, especially in the apical region, display a more or less broad, odontopteridian form. The base upper-edge is incised; the base lower-edge draws the axis downward or is auricled. The leaflet-tips are well rounded. The venation is delicate. The median vein region is indicated by a weak indentation and the median vein is not developed in any pronounced way. Rather, many parallel veins form a thick vascular bundle which then grades into flat, wandering lateral veins. The lateral veins then curve down and strike, in the basal leaf section, perpendicular or nearly perpendicular to the edge. Each is forked from one to three times. Occurrence: Westphalian D (stratigraphic index species). (plate 9)

Sphenopsida

Subphylum Equisetophyta

Class Sphenopsida (Articulatae)

Order Calamitiales

Genus Calamites Suckow, 1784

The arborescent Calamites or herbaceous-like Sphenophyllum (categorized as the articulates) were poorly represented in the upland collections. One specimen of Calamites sp. is in the Illinois collection. It could not be identified beyond genus because most of the species identifications are based on the length between the nodes (internodal space). Unfortunately one node compression was preserved with two internodes. The radially aligned ribs between the nodes found on the jointed stem can be clearly detected. (plate 9)

Specimens of calamite foliage preserved in the Illinois collection were identified as Asterophyllites charaeformis Brongniart, 1822. The 1 cm in length leaves are upward bending with only 4 to 5 leaves per whorl. The leaves tend to be strongly incurved with smaller branches branching into numerous tiny branchlets. The range of this species is throughout the Lower and Middle Pennslyvanian. (plate 10)

Order Sphenophyllales

Family Sphenophyllaeae

Genus Sphenophyllum Brongniart, 1822

Sphenophyllum is a small herbaceous articulate that possesses jointed ribbed stems with whorls of leaves. Two different species were in the Smithsonian upland collection: Sphenophyllum cuneifolium and S. majus.

Sphenophyllum cuneifolium (Sternberg) Zeiller, 1880

Synonomy

Rotularia cuneifolia Sternberg, 1823, p. 23, pl. 26, fig. 4a, b.

Sphenophyllum cuneifolium (Sternberg) Zeiller, 1879, pl. 161, figs. 1, 2; 1880, p. 30.

Sphenophyllum cuneifolium Sternberg. Gothan and Remy, 1957, p. 59, 60, fig. 49; chart 5.

Sphenophyllum cuneifolium Sternberg) Zeiller. Abbott, 1958, p. 336, pl. 37, fig. 22; pl. 38, fig. 36; chart 3.

Sphenophyllum cuneifolium Sternberg. Crookall, 1969, p. 579, pl. 107, fig. 5; pl. 109, figs. 3, 4, 13, 14; text-figs. 160-162, 163a, 171a. (Contains a more complete synonymy).

Sphenophyllum cuneifolium Sternberg. Lyons and Chase, 1976, fig. 4E.

Description:

Sphenophyllum cuneifolium has narrow, laterally branching stem with whorls of heterophyllous leaves at each node. The leaves near the tip are wedge shaped and average 12 mm in length and 5 mm in width. Six to twelve leaves are commonly found per whorl. Lateral margins are straight and slightly convex; distal margins are straight and slightly arching. The distal margin of the leaves may be entire or may have a median notch, 1.5 to 2.5 mm deep and bearing from 6 to 14 sharp, mucronate teeth. Older leaves are more dissected with deeper clefts (Oleksyshyn, 1982). In North America, the distribution ranges from Westphalian A through D. More detailed information about this genus can be found in Oleksyshyn (1982). Identification of this specimen was made with Bell, 1940; Gillespie et al., 1978; Oleksyshyn, 1982. (plate 10)

Sphenophyllum majus (Bronn) Bronn, 1835

Synonomy

Rotularia major Bronn, in Bischoff, 1828, p. 89, 131, pl. 13, fig. 2a, b.

Sphenophyllum majus (Bronn) Bronn, 1835, p. 32, pl. 8, fig. 9a, b.

Sphenophyllum majus Bronn. White, 1899, p. 180, pl. 50, figs. 5, 6a; pl. 51, fig. 9; pl. 73, fig. 3.

Sphenophyllum majus (Bronn) Bronn. Abbott, 1958, p. 349, pl. 37, fig. 23; pl. 46, fig,. 75; chart 4.

Sphenophyllum majus Bronn. Crookall, 1969, p. 594, pl. 107, fig. 1; pl. 108, fig. 1; text-figs. 163B, 166, 171D. (Contains a more complete synonymy)

Description:

The leaves are wedge shaped, 10 - 13 mm long and 6 - 8 mm broad at the distal margin; there are usually 6 leaves per whorl radiating out from the node. The lateral leaf margins are straight to convex, parallel to the veinlets. The distal margin is straight to slightly arching and crenate or irregularly toothed and cut into acuminate laminae. The central notch of the distal margin is variable. The distribution range is Westphalian B to Lower Permian in North America (Oleksyshyn, 1982). Identification of this specimen was made from Noe (1925), Bell (1940) and Oleksyshyn (1982). (plate 11)

Lycopsida

Class Lycopsida

Order Lepidodendrales

Family Sigillariaceae

Genus Stigmaria Brongniart, 1822

The Lycopods of the Pennsylvanian were primarily large trees reaching a magnificent height of 34.5 meters (134 feet). Trunks of these arborescent-sized plants had a dbh (diameter at breast height) of 1-2 mm to two meters. The "scale tree" or Lepidodendron can be distinguished from Sigillaria "seal tree" by the arrangement of the leaf cushions. Lepidodendron has diamond shaped, spirally arranged leaf cushions, as opposed to Sigillaria with its vertically arranged scars (Gillespie et al., 1978).

Stigmaria is a form-generic name for the fragments of underground root or rhizoid material of the arborescent lycopods that is often preserved. Stigmaria occurs in all kinds of fossiliferous strata, but is more common directly beneath the coal beds in siltstones or mudstones, which represents the original topsoil in which the plant was rooted (Oleksyshyn, 1976). The specimen that was identified, with a certain amount of uncertainty because of the degree of degradation of the plant organ, was classified as Stigmaria sp. There was one sample in the Illinois State Museum collection, but the sample was not adequately photographed.

Cordaites

Order Cordaitales

Family Cordaitaceae

Genus Cordaites Unger, 1850

The conifer-like Cordaites are believed to be the precursor to the modern day gymnosperms, and existed from the Upper Mississippian into the Triassic. The preservation of these plants is primarily the trunk, made of secondary wood, and the large strap shaped parallel veined leaves. The height of the tree has been reconstructed to reach 30 feet (9.1 meters) with leaves up to 3 feet long (0.9 meters) (Jennings, 1990). The growth habit of this plant includes a mesophytic / hydrophytic (swamp) environments, as well as xerophytic / upland terrains. A common leaf species of Cordaites principalis was in the Illinois State Museum collection (plate 11). Read and Mamay (1964) included it in the list of Zone Megalopteris species one might expect to find.

Cordaites principalis (Germar) Geinitz, 1855

Synonomy

Flabellaria principalis Germar, 1848, p. 55, pl. 23.

Cordaites principalis (Germar). Geinitz, 1855, p. 41, pl. 21, figs. 1, 2, 2a, 2b.

Cordaites principalis (Germar). Bell, 1938, p. 103, pl. 105, fig. 1; pl. 106, fig. 1.

Cordaites principalis Germar. Oleksyshyn, 1976, p. 171, 173; text-fig. 15A.

Description:

The leaf specimens consist of 4 to 6 cm broad leaves with parallel venation. The long, narrow, lanceolate leaves can reach 50 cm in length. 20-30 major veins exist per cm/width with 1-6 false vein between each actual. The apex of the leaf often splits. This is a common species in the upper Lower and Middle Pennsylvaninan. (plate 11)

Fructifications:

Several different reproductive organs have been identified in the Illinois and Smithsonian upland collections. The preservation of these structures is more rare than vegetative, and even fewer have organic connections to the leaves. No organic connections were found in either collection. The Illinois megafossil compression-impressions contained many seed specimens preserved in dark, silt to fine sand-sized sediment (plate 12). These coalified seeds ranged from less than 1.0 cm up to 1.5 cm in diameter. A permineralized specimen (1.1 cm in diameter) was classified as Carpolithus (plate 12). This is a name used for seeds with radial symmetry, but not having enough morphological characteristics preserved to give a more precise determination in the pteridosperms (Gillespie et al., 1978).

Synangia produced by the medullosan seed ferns are referred to Aulacotheca Halle. It is believed to be one of the earliest pollen-producing organs preserved in the fossil record. One specimen is preserved and found in the Smithsonian collection. The specimen is approximately 2.5 x 2.0 cm long (plate 13). The structure is thought to be composed of a radial, hollow ring of laterally fused elongate sporangia with dehiscence presumably occurring to the inside of the ring. Distal ends of individual sporangia are separated from each other to form free sporangial tips (Mickle and Leary, 1984). Remains of numerous synangia have been found in sediments interpreted as "upland" by Leary (1981).

The Cordaites reproductive structure morphlogically resembles a cone with bracts and scales and are often referred to as strobili or inflorescences. These compound structures contain both pollen and ovulate fructifications. Cordaianthus is the form-genus these reproductive structures have been assigned. One such cone appeared in the Illinois collection with a length of 1.1 cm and a diameter of .6 cm; it is very poorly preserved (plate 13). Samaropsis and Cordaicarpus are the two platyspermic seed form genera designated to this group of organisms. Seeds resembling these form genera are placed in the Cordaites because of their resemblance of the seeds produced by Cordaites, not to say that all the seeds that look like Samaropsis and Cordaicarpus came from a Cordaites, but out of convenience are grouped together.

Samaropsis Goeppert is a large, ovate to heart-shaped structure with a wide wing. They are impressions of flat, and more or less circular seeds. Two specimens were fairly well preserved in the Illinois State Museum Ashboro Pit collection, and are believed to represent two different species. Samaropsis sp. #1 is approximately 2.2 cm wide and 2.6 cm long and appears round. The actual seed appears to be oval is shape with strongly pointed apices, 1.0 x 1.2 cm (plate 13). Samaropsis sp. #2 is more heart shaped, 1.5 cm in width and 2.2 cm long. This seed is better preserved than specimen #1. The seed appears more circular with dimensions of .6 x .9 cm (plate 14). Several poorly preserved specimens in the Illinois State Museum Ashboro Pit collection, were identified as Cordaicarpus. The dimensions of the samples averaged .4 x .8 cm with very small points at each apex, on the wing and the seed. The wings (sarcotesta) appear quite small, not extending only millimeters from the actual seed (plate 14).

One specimen in the Smithsonian Ashboro Pit collection, was described as Lepidostrobophyllum. Cones of Lepidodendron are referred to as Lepidostrobus and when an individual fertile bract is found separate from the rest of the cone, it is included in Lepidostrobophyllum (plate 14). The length of the bract was 1.8 cm.

Problematica

One specimen from the Smithsonian collection could not be identified (verbal communication with DiMichele, Mamay, Leary, 1991). It is a broad leaved, pinnately compound, parallel veined specimen (plate 15). It was preserved in the darker, silt to fine sand-sized sediment. The leaflets appeared to be approximately 4 cm wide, but it was difficult to determine exactly because of the overlapping of the leaflets, and the condition of the specimen. The midrib was quite thick approaching 5 cm in width at its thickest point. Very little carbon material was preserved, therefore no cuticle analysis was possible. This is obviously a specimen that needs to be examined in greater detail, especially if another specimen resembling it could be located. With only this sample, it was not reasonable to speculate further.

Discussion

Comparison of Upland Floras

The Ashboro Pit in Clay County, Indiana, contains specimens that are supurbly characteristic of a unique upland flora of Middle Pennsylvanian age. This flora from the eastern margin of the Illinois Basin has not previously been described and is rarely documented in the botanical literature. A compilation of the identified specimens found in the Ashboro Pit can be found in Table 1. Other noteworthy research findings of upland floras from the Pennsylvanian are compared to the Ashboro Pit flora in Table 1.

The Lycopods are only sparsely represented in the Smithsonian and Illinois Museum Ashboro Pit collections. A bract of a cone, Lepidostrobophyllum, was observed in the Smithsonian collection (plate 14). Leary (1981) documented a similar finding. Stigmaria, underground root or rhizoid material from arborescent lycopods, were found in the Illinois Museum Ashboro Pit collection. Lycopods are abundant in swamp floras but unable to survive in drier habitats. Others (Stopes, 1914; Read and Mamay, 1964; Leary, 1977, 1981) have also recognized remains of these Lycopods.

The Sphenopsids are only a minor part of the Ashboro Pit collection. Specimens of Sphenophyllum cuneifolium are in both collections (plate 10, 11). This species was identified by Stopes (1914) and Bell (1938); while Leary (1977, 1981) only classified to genus. Other Sphenopsida have been cited to occur along with upland floras such as Annularia (Leary, 1977, 1981), A. latifolia, A. radiata, A. stellata (Stopes, 1914), A. radiata, A. sphenophylloides (Bell, 1938), A. cuspidata (Read and Mamay, 1964), A. asteris (Leary, 1977) and A. vernensis (Leary, 1981). Asterophyllites charaeformis is part of the Illinois Ashboro Pit collection (plate 10). White (1908) and Leary (1977, 1981) have identified Asterophyllites along with the following species: A. erectifolius (White, 1908; Leary, 1981), A. equisetiformis (Bell, 1938, Leary, 1977), A. longifolius (Leary, 1981). Calamites suckowi was identified by Stopes (1914) and Bell (1938) and C. waldenburgensis by Bell (1938).

Calamostachys andanensis along with C. germanica and Mesocalamites cistiiformis have been identified by Leary (1977, 1981).

The Filicopsids are not part of the upland flora of the Ashboro Pit even though species have been identified by others. For example, Alloiopteris quercifolia (Leary, 1977, 1981) and A. gracillima (White, 1908) have been cited, also Dactylotheca aspera (Leary, 1977, 1981).

White (1908) identified Lacoea and Leary (1977, 1981) identified L. seriata, Palaeopteridium reussii, and Gulpenia limburgensis, Noeggerathiales, that are considered part of an upland flora, but no representitives were detected in the Ashboro Pit collecions.

The Pteridosperms appear to make up a significant portion of the upland flora in the Ashboro Collections as well as other documented upland floras. Adiantites obtusus was identified by Stopes (1914). Alethopteris (plate 4; Read and Mamay, 1964) as a genus was represented. In addition, other species recognized are: A. lonchitica (plate 4; White, 1908; Stope, 1914; Bell, 1938; Leary, 1977, 1981); A. serli (plate 5; Bell, 1938). Asterotheca miltoni was identified by Bell (1938). Aulacotheca was identified in the Smithsonian Ashboro Pit collection (plate 13). White (1908) noted Cheilanthites cheathami and Danaeites and Dipplotmema furcatum was identified by Stopes (1914) and Bell (1938). Bell (1938) also identified Eupecopteris dentata. Euspenopteris morrowensis was identified (Plate 7; Leary 1977, 1981). Read and Mamay (1964) documented Eremopteris as part of an upland flora. Hymenotheca bronni, and H. dathei were part of Bell's collection (1938). Leary (1977, 1981) documented Holcospermum sp. and Lagenospermum sp. as a part of an upland flora.

The rarity in the preservation of Lesleya and Megalopteris can be attributed to the erosional surface these plants presumably grew on. Any occurence of these fossils is of great significance both taxonomically and evolutionarily. Lesleya cheimarosa was identified in the Smithsonian and Illinois Ashboro Pit collections (plate 2, 3). Leary (1977, 1981) also identified this fossil. White (1908) identified L. grandis. Megalopteris was identified by White (1908), Stopes (1914), Read and Mamay (1964), and Leary (1977, 1981). Megalopteris southwellii (plate 1,2; White, 1908; Read and Mamay, 1964) has been recorded. Additional species of Megalopteris that are described are: M. abbreviata (Read and Mamay, 1964), M. dawsoni (Stopes, 1914; Read and Mamay, 1964; Leary 1977, 1981),

M. fasciculata, M. hartii, M. marginata (Read and Mamay, 1964), M. ovata (Leary, 1977, 1981).

There are numerous Pteridosperm genera that have been documented in the literature to be elements of an upland floral association that were not found in neither Ashboro Pit collections: Linopteris muensteri (Bell, 1938), Lonchopteris eschweileriana (Bell, 1938), Mariopteris (Leary, 1977, 1981), M. inflata (White, 1908), Oligocarpia splendens (Stopes, 1914), Pterispermostrobus bifurcatus (Stopes, 1914), Rhacopteris busseana (Stopes, 1914), Rhodea (Leary, 1977, 1981), Rhodeopteridium phillipsii (Leary, 1977, 1981), Sporangites acuminata (Stopes, 1914), Telangium (Leary, 1981), Whittlesya (Leary, 1981) W. elegans (White, 1908, Leary, 1977), and Zeilleria avoldensis (Bell, 1938).

The Pteridosperm form genus Neuropteris had nine different species documented as upland species. One species, Neuropteris heterophylla, was found in the Smithsonian Ashboro Pit collection (plate 8; Stopes, 1914). Additional species include: N. aculeata (Bell, 1938), N. eriana (Stopes, 1914), N. gigantea (Stopes, 1914), N. missouriensis (Read and Mamay, 1964), N. neuropteroides (White, 1908), N. scheuchzeri (Bell, 1938), and N. selwyni (Stopes, 1914).

Several different Pecopteris species were found in the Ashboro Pit collections. Pecopteris serrulata and P. plumosa (plate 7) were specimens in the Illinois and Smithsonian collections. Pecopteris serrulata was documented by Read and Mamay (1964) and P. plumosa by Stopes (1914). No Sphenopteris specimens were in the Ashboro collection but the literature citations included the following: Sphenopteris communis (White, 1908), S. marginata, S. valida (Stopes, 1914), S. missouriensis (Bell, 1938), S. palmatiloba (Read and Mamay, 1964), and S. preslesensis (Leary, 1977, 1981).

The Ashboro Pit collections included Cordaites and the following associated reproductive structures: Cordaites principalis, Cordiocarpus, Cordaianthus, and Samaropsis (plate 13 and 4). White (1908) only included Archaeopteris stricta and Cardiocarpon. Stopes (1914) documented the following species from the Lancaster Formation, near St. John, New Brunswick: Cardiocarpon baileyi, C. cornutum, C. crampii, C. obliquum, Cordaianthus devonicus, Cordaites principalis, C. robbii, Dadoxylon ouangondianum, Dicranophyllum glabrum, Poacordaites, Sternbergia, Whittleseya concinna, W. dawsoniana. Bell (1938) studied the Morien Series, Nova Scotia, and listed fewer upland species: Cordaites principalis, and Samaropsis cornuta. Read and Mamay (1964) included the following species: Cardiocarpon, Cordaianthus, Cordaites principalis, Psygmophyllum, and Trigonocarpon. Leary (1977, 1981) found only the following genera in the Cordaitales on the western edge of the Illinois Basin: Artisia, Cardiocarpus, Cordaianthus, Cordaites principalis, and Samaropsis.

The Ashboro Pit collection contains species that are exclusive to the Illinois Basin during the lower Middle Pennsylvanian. These specimens are valuable to the understanding of this floral association: Alethopteris missouriensis (plate 6), Neuropteris obliqua (plate 8), Neuropteris ovata (plate 9), Callipteris flabellifera var. moorei (plate 6), Asterophyllites charaeformis (plate 10), Sphenophyllum majus (plate 11), Carpolithus (plate 12), and Calamites (plate 9).

Table 1. Comparison of Upland Floras

	This study	White (1908)	Stopes (1914)	Bell (1938)	Read Mamay (1964)	Leary (1977, 81)
LYCOPSIDA						
Lepidodendron sp.						●
crenatum			●		●	●
volkmannianum					●	
wortheni						●
Lepidophloios						●
Lepidophylloides						●
Lepidostrobus						●
Lepidostrobophyllum	●					●
Lepidocarpon						
Sigillaria sp.			●			
rugosa					●	●
Stigmaria	●					
ficoides			●			
SPHENOPSIDA						
Annularia						
asteris						●
cuspidata					●	
latifolia			●			
radiata			●	●		
stellata			●			
sphenophylloides				●		
vernensis						●
Asterophyllites						
charaeformis	●					
erectifolius		●				●
equisetiformis				●		●
longifolius						●
Calamites suckowi			●	●		
waldenburgensis				●		
Calamostachys						●
andanensis						●
germanica				●		
Mesocalamites						●
cistiiformis						●
Sphenophyllum						●
cuneifolium	●		●	●		
FILICOPSIDA						
Alloiopteris						●
gracillima		●				
quercifolia						●
Dactylotheca aspera						●
NOEGGERATHIALES						
Lacoea sp.		●				

Table 1. Continued

	This study	White (1908)	Stopes (1914)	Bell (1938)	Read Mamay (1964)	Leary (1977, 81)
seriata						●
Palaeopteridium reussii						●
Gulpenia limburgensis						●
PTERIDOSPERMS						
Adiantites obtusus			●			
Alethopteris sp.	●				●	
lonchitica	●	●	●	●		●
serli	●			●		
Asterotheca miltoni				●		
Aulacotheca	●					
Cheilanthites cheathami		●				
Danaeites sp.		●				
Dipplotmema furcatum			●	●		
Eupecopteris dentata				●		
Euspenopteris						
morrowensis	●					●
Eremopteris					●	
Hymenotheca sp.						●
bronni				●		
dathei				●		
Holcospermum sp.						●
Lagenospermum sp.						●
Lesleya						●
cheimarosa	●					●
grandis		●				
Linopteris muensteri				●		
Lonchopteris eschweileriana				●		
Mariopteris						●
inflata		●				
Megalopteris						●
abbreviata					●	
dawsoni			●		●	●
fasciculata					●	
hartii					●	
marginata					●	
southwellii	●	●			●	
ovata						●
Neuropteris	●					●
aculeata				●		
eriana			●			
heterophylla	●		●			
gigantea			●			
missouriensis					●	
neuropteroides		●				
scheuchzeri				●		
selwyni			●			
tenuifolia				●	●	
Oligocarpia splendens			●			
Pecopteris	●					

Table 1. Continued

	This study	White (1908)	Stopes (1914)	Bell (1938)	Read Mamay (1964)	Leary (1977, 81)
serrulata	●				●	
plumosa	●		●			
Pterispermostrobus bifurcatus			●			
Rhacopteris busseana			●			
Rhodea						●
Rhodeopteridium phillipsii						●
Sphenopteris					●	
communis		●				
marginata			●			
missouriensis				●		
palmatiloba					●	
preslesensis						●
valida			●			
Sporangites acuminata			●			
Telangium sp.						●
Whittlesya						●
elegans		●				
Zeilleria avoldensis				●		
CORDAITALES						
Archaeopteris stricta		●				
Artisia						●
Cardiocarpon sp.		●			●	
baileyi			●			
cornutum			●			
crampii			●			
obliquum			●			
Cardiocarpus sp.	●					●
Cordaianthus sp.	●				●	●
devonicus			●			
Cordaites principalis	●		●	●	●	●
robbii			●			
Dadoxylon ouangondianum			●			
Dicranophyllum glabrum			●			
Psygmophyllum					●	
Poacordaites sp.			●			
Samaropsis sp.	●					●
Samaropsis cornuta				●		
Sternbergia sp.			●			
Trigonocarpon					●	
Whittleseya concinna			●			
dawsoniana			●			

The Ashboro Mine site included additional species which did not occur in any of the other locations or by the author as indicated above. These unique specimens are as follows:

Alethopteris missouriensis
Neuropteris obliqua
Neuropteris ovata
Callipteris flabellifera var. moorei
Asterophyllites charaeformis
Sphenophyllum majus
Carpolithus
Calamites sp.

Environmental Interpretation:

The shale and coal horizons throughout the Illinois Basin are well described only if of important economic value. Unfortunately the unnamed shale periodically exposed in the highwall of the Ashboro Pit has not been described and documented. Therefore, stratigraphic, lithological, sedimentological, topographic, paleotopography, and floristics examination is necessary to thoroughly document this horizon. This study provides at least an initial analysis of the paleoecological / paleoenironmental setting. Peppers (1979) offers six criteria for examining and interpreting the paleoecology of Pennsylvanian floras. These include: 1) sedimentological observations; 2) investigation of morphology and anatomy of the plants; 3) examination of coal petrology; 4) study of physiological features and geography; 5) comparison with modern sedimentary environments; 6) chemical analysis of coal. In this study: the analysis of the plant association (see Megafossil Description and Comparison of the Upland Flora sections); description of the stratigraphy; sediment analysis; suggestions on the comparison of modern sedimentary environments, are examined.

Apparently, the shale facies that contained the upland flora meandered in such a way that only at various times was this facies exposed by strip mining. The shale containing the fossils was either of a dark, silt to fine sand-sized texture or a lighter, clay to silt sized texture. The more coarse shale may represent a more organically rich, less oxygenated, low energy depositional environment. A typical situation for this would be a fast moving stream or alluvial system. The light, fine grain texture would represent a lacustrine system, or slow moving stream or river where there is adequate time for decomposition to occur causing a less organically rich, more oxygenated, high energy environment. The amount and type of organics preserved in the shale is influenced by the original source material. Preservation of the floral association did not appear to differ in respect to the different color or grain size. Since it has been hypothesized that

these plants grew away from a direct water source, in well-drained soil, preservation of these specimens could only occur if the plant part made its way into a conducive depositional environment. It has been suggested that these detached plant parts were washed or blown into either a stream or lake that occasionally either flooded (high water flow) or dried out (low water flow). This scenario would account for the variability in color and grain size, but not floral differences. This scenario would also justify the observation that the shale horizon of interest does not always appear along the stratigraphic section. If the body of water is a stream, the meandering nature of moving water would prevent it from always appearing when outcrop exposure is perpendicular to the horizon. It seems plausible that if the margin of the lake dried out, the same could happen.

Evolutionary Interpretation

The Pennsylvanian period in North America and Europe was a time in which extensive swamps developed in coastal and deltaic settings. These swamp habitats were a dominant part of the terrestrial landscape. The basic physical settings of swamps are believed to be the same as that of modern swamp environments (Phillips and DiMichele, 1981). The plants that occupied them were completely different from those occupying post-Paleozoic swamps. These differences were not only taxonomic, the reproductive biologies and architectures of the dominant trees differed greatly from those that came later. Due to the nature of the plant diversity with both physical similarity and biological distinctiveness, the Pennsylvanian-age swamps provide excellent opportunities to look for general patterns of community structure and dynamics that are independent of the particular species mix involved and allows ecological principles applied to modern plant associations to be tested in these ancient environments (DiMichele and DeMaris, 1987). The physical conditions of these swamps are extremely stressful to the plants, and as a result only a small group of the total terrestrial flora can tolerate these conditions. Therefore, a sharp ecotone exists (vegetational boundary) between swamps and the surrounding communities in "dry-land" habitats (DiMichele, 1979).

The distinctive boundaries between wetland and upland floral associations creates completely different evolutionary paths taken by each of the vegetative associations. Upland floras are considered much more sensitive to environmental variations and more likely to be the gene pool from which evolutionary advances are destined to occur. An example such as Lesleya (Leary, 1990), a cycad, occurring earlier in the fossil record than previously believed is perhaps the rule as opposed to the exception. Documentation of the upland paleofloras are infrequent not only because of the rarity in preservation, but also the bazaar specimens are overlooked when it comes to identification. There exists in the Smithsonian collection an unidentified specimen from the Ashboro Pit (verbal communication with Mamay, DiMichele, Leary 1991) and inevitably placed in the Problematica section of this study. The large, lanceolate, pinnately compound leaflets, with parallel venation, thick midrib, resembles the modern day Bowenia, a cycad, except for the parallel venation. This might be an example of a characteristic within a family that was unsuccessful. The Cordiates represent the only group of plants at that period of time with parallel venation and yet no fossil nor modern representative resembles this specimen. It again becomes apparent that a major portion of the flora was evolving, advancing evolutionarily, existing at the same time as the coal swamps of the Pennsylvanian, but representatives from these upland communities are not present in the swamp, just as we see today in modern plant associations.

Environmental adaptations to xerophytic environments such as: high ratio to volume surface area, sclerenchymous (rigid) leaves, thick cuticle, sunken stomata, epidermal hairs or trichomes, and succulent growth habit would be expected in upland vegetation. Even thought the plant families that existed during the Pennsylvanian are different than modern day plant families, the mechanisms of adaption to the environment appear to remain unchanged. Adaptation must be considered in the context of the environment. Adaptation used here refers to a state, not as a process as in natural selection. A state of adaptation has to be understood within the parameters of the physical and biological environment. Temporal changes in adaptive morphology can not be evaluated independent of the environmental changes. Adaptative mechanisms of neo-swamp plant communities to their environment have been studied by many over the past century and offer a wealth of knowledge. These plants growing in a hydrophytic environment, basically plants with their root systems inundated, are in many respects comparable to Pennsylvanian hydrophytic plants.

The North American continent, on the equator during the Pennsylvanian, resulted with the Illinois Basin probably not experiencing seasonality, therefore standing water was prevalent year around. Unfortunately, standing water allows nutrients to be readily available, removing the sensitivity the plant has to other environmental factors, and removing all climatic signals. Therefore, over time it appears that evolution would be delayed in swamp communities. Reproductive mechanisms that involve the medium water are considered more primitive, especially since it is believed plants first evolved in water. Swamp plants are believed to have used either water or wind as their means of pollen, spore or seed dispersal. Whereas the upland plants, also wind dispersers, not only had to adapt to variable environmental conditions, reproductive strategies varied in response to available resources ie. insects. The seed from the Cordiates, Samaropsis are obviously morphologically structured for wind with the expanded tissue of the sarcotesta. The Cordiates and Callipteris both appear in the upland plants identified, also appeared in the Permain where drier conditions are known to have existed.

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Plate 1:

1. Megalopteris southwellii Lesquereux. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (1/4x)

2. Megalopteris southwellii Lesquereux. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photo)

1

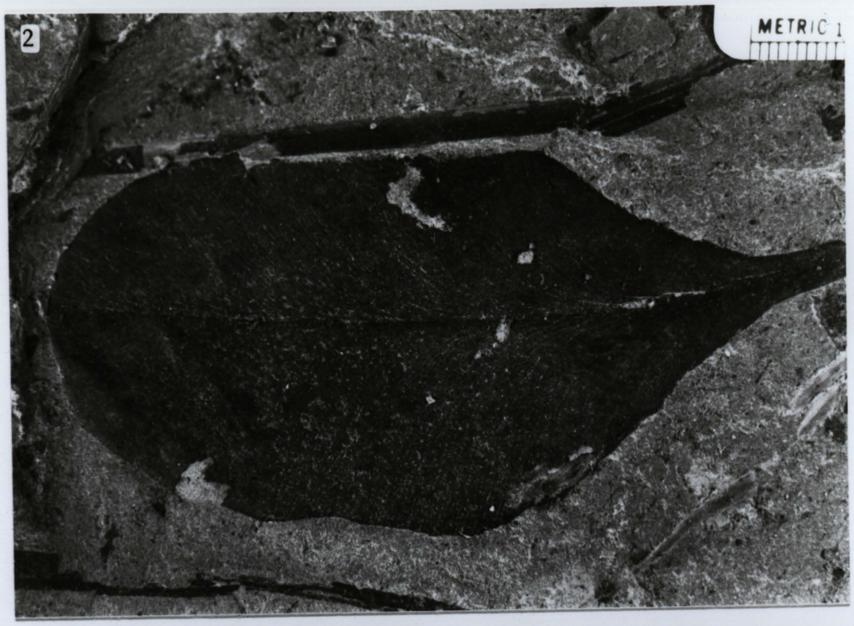
2

Plate 2:

1. Megalopteris southwellii Lesquereux. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (1/4 x)

2. Lesleya cheimarosa Leary. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)

3. Lesleya cheimarosa Leary. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)


2

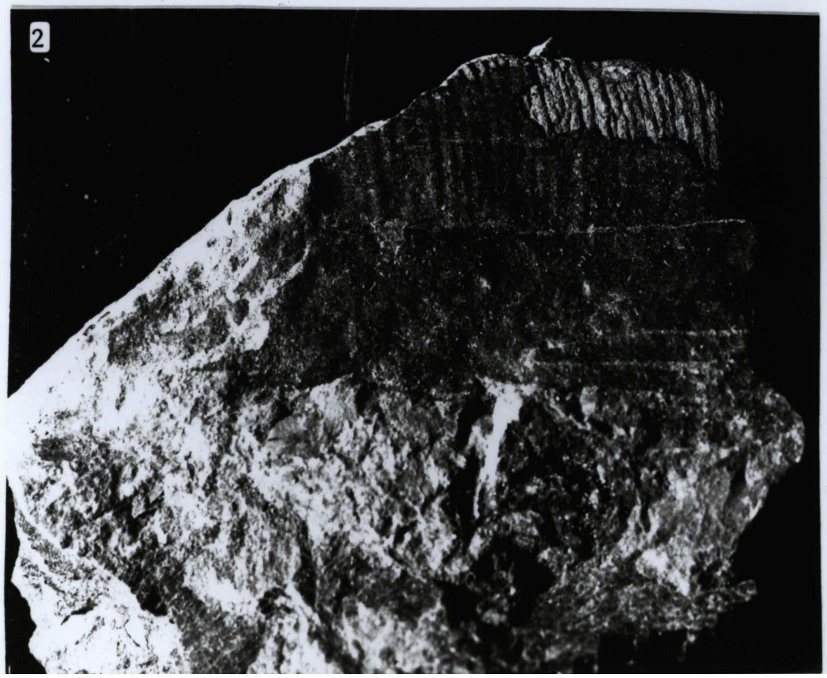

1


3

Plate 3:

1. and 2. Lesleya cheimarosa Leary. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (1x)

1



2

Plate 4:

1. Alethopteris lonchitica (Schlotheim) Sternberg. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (2x)

2. Alethopteris sp. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (1/4x)

1

2

Illinois State Museum
Springfield

Acc. No. ____________ Temp. No. 14

[illegible]

Ashboro Pit, Log Cabin Mine,
Clay Co., Indiana 1976

Plate 5:

A. and B. Alethopteris serlii (Brongniart) Goeppert. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (1x)


A

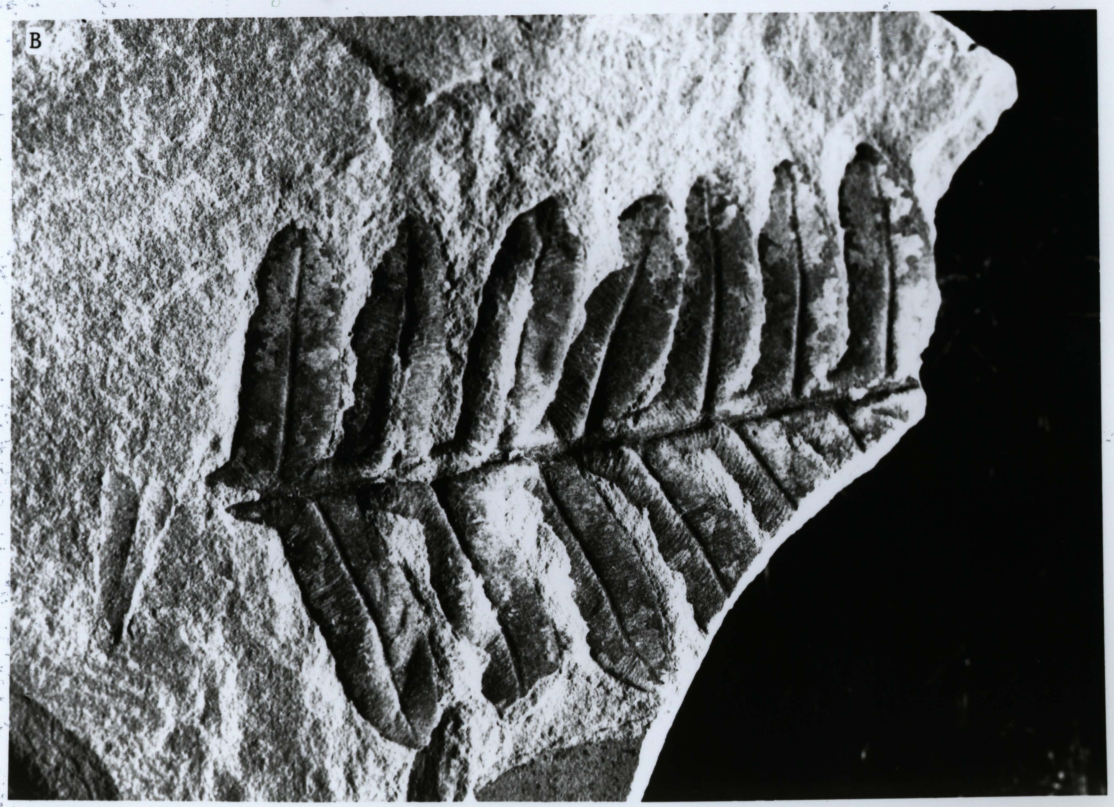

B

Plate 6:

1. Alethopteris missouriensis D. White. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (1x)

2. Callipteris flabellifera var. moorei. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)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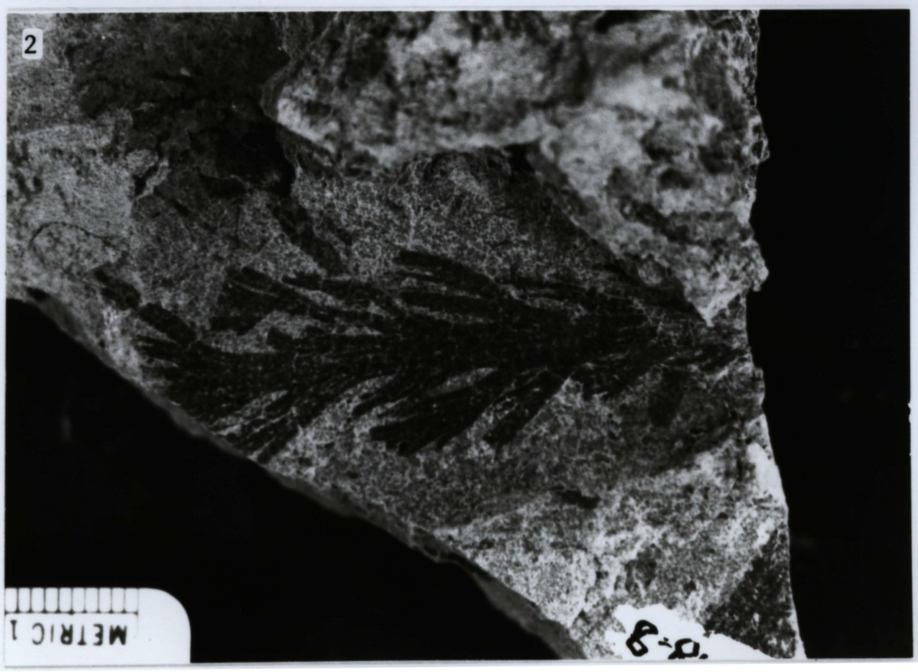
2
METRIC 1

Plate 7:

1. Pecopteris (Senftenbergia) plumosa (Artis) Radforth. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (1.5x)

2. and 3. Eusphenopteris morrowensis (D. White) van Amerom. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)

1

2

3

Plate 8:

1. Neuropteris heterophylla Brongniart. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (2x)

2. Neuropteris obliqua Brongniart. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (1/4x)

1

2

Plate 9:

1. Neuropteris ovata Hoffmann. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (2x)

2. Calamites sp. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)

1

2

Plate 10:

1. Sphenophyllum cuneifolium (Sternberg) Zeiller. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (1.5x)

2. Asterophyllites charaeformis Brongniart. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)


1
LC2.14


METRIC
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2

Plate 11:

1. **Sphenophyllum majus (Bronn) Bronn. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (2.5x)**

2. **Cordaites principalis (Germar) Geinitz, 1855. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)**


1
LC2J8
USNM loc
38354

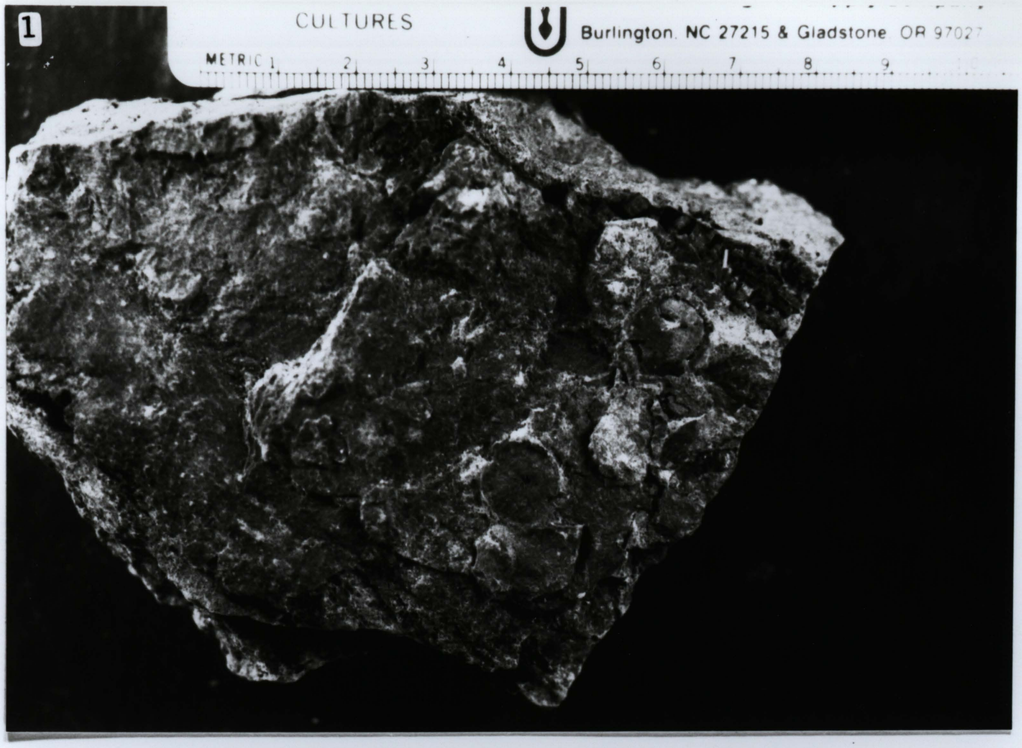

2
METRIC 1

Plate 12:

1. **Coalified seeds.** Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)

2. Carpolithus. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)

1


CULTURES
Burlington, NC 27215 & Gladstone OR 97027
METRIC 1 2 3 4 5 6 7 8 9

2

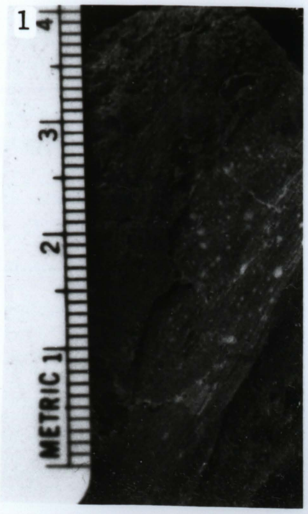

1 2 3 4
CENTIMETERS

Plate 13:

1. Cordaianthus. **Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)**

2. Samaropsis **#1. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)**

3. Aulacotheca **Halle. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (2x)**



1

2

3

Plate 14:

1. Lepidostrobophyllum. Smithsonian Natural History Museum, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (3x)

2. Cordaicarpus. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)

3. Samaropsis #2. Illinois State Museum, Leary and Pheifer, 1978, Ashboro Pit, Clay County Indiana, (scale on photograph)

1

2

3

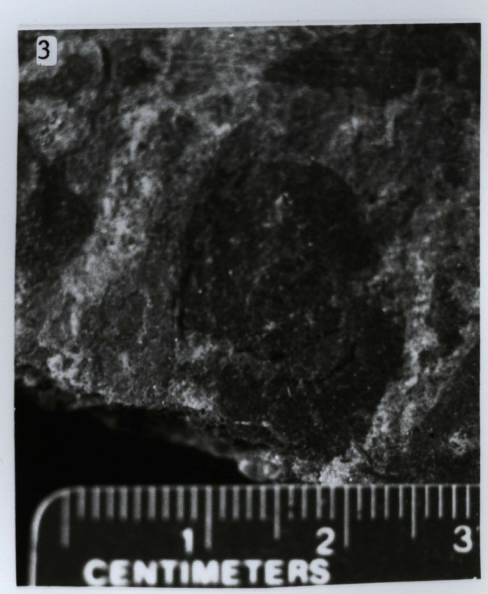


Plate 15:

1. and 2. Problematica. Smithsonian Natural History, DiMichele, 1980 or 1982, Ashboro Pit, Clay County Indiana, (1/2x)

1

2