January 1970

A comparison of the floras of the Colchester (No. 2) Coal and Francis Creek Shale

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Recommended Citation

Peppers, R. A., & Pfefferkorn, H. W. (1970). A comparison of the floras of the Colchester (No. 2) Coal and Francis Creek Shale. Retrieved from http://repository.upenn.edu/ees_papers/18

This material has been published in Smith, W.H., Nance, R.B., Hopkins, Johnson, R.G., and Shabica, C.W. *Depositional environments in parts of the Carbondale formation, western and northern Illinois: Francis Creek Shale and associated strata and Mazon Creek biota*, Illinois State Geological Survey Field Guidebook Series, No. 8, p. 61-74, 1970
NOTE: At the time of publication, author Hermann W. Pfefferkorn was affiliated with the Illinois State Geological Survey. Currently (September 2005) he is a faculty member in the Department of Earth and Environmental Science at the University of Pennsylvania.

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A COMPARISON OF THE FLORAS OF THE COLCHESTER (NO. 2) COAL AND FRANCIS CREEK SHALE

R. A. Peppers and H. W. Pfefferkorn
(Illinois State Geological Survey)

INTRODUCTION

Abundant data from spore studies of the Colchester (No. 2) Coal Member and from investigations of plant compressions in the Francis Creek Shale provide an opportunity to compare the flora of the coal with that of the overlying shale in the northeastern part of the Illinois Basin. As both floras were investigated by different methods and since different systems of form genera were used, it is first necessary to review the plant taxa found in the 2 facies and to arrange them according to major plant groups. Paleoenvironmental interpretations of Pennsylvanian floras are rare and widely scattered in the literature; therefore, some of the research on fossil spores and plant assemblages from other strata is discussed in this report. Finally, the report presents an interpretation of paleoecological conditions that existed during deposition of peat and mud, which eventually formed the No. 2 Coal and Francis Creek Shale.

SPORE FLORA OF THE COLCHESTER (NO. 2) COAL

The Colchester (No. 2) Coal Member of the Carbondale Formation and its equivalents have been the subject of more published palynological studies than any other coal in North America. Kosanke (1950) was the first to report on the miospores in the No. 2 Coal from several localities in Illinois and remarked on the diversified flora that is represented. Winslow's (1959) comprehensive work on the large spores and megaspores from most Illinois coals included a discussion of the No. 2 Coal. The small spore genera from 3 samples of Colchester Coal (IIIA) of Indiana (correlative to No. 2 Coal of Illinois) were recorded by Guennel (1952), and Wilson and Hoffmeister (1956) noted the presence of 48 species of spores from 9 localities of the Croweburg Coal in northeastern Oklahoma. Denton (1957), Habib (1966), and Gray (1967) carried out palynologic investigations of the Lower Kittanning Coal of Ohio and Pennsylvania (thought to be equivalent to the No. 2 Coal). Habib listed about 140 species from 15 sample sites. Meyers (1967) presented data on the distribution of the plant microfossils in 2-inch increment samples of the Henryetta Coal in the central part of eastern Oklahoma. Peppers (1970) differentiated 164 taxa from 50 samples taken from 23 localities in Illinois and showed some lateral variations in spore distribution.

Composition of Spore Assemblages in the No. 2 Coal

The spore assemblages in the No. 2 Coal are rich and varied. Although differences in the overall spore composition occur from place to place, the No. 2 Coal can generally be differentiated from other coals and correlated throughout the Basin.

Lycospora (54 to 66 percent) is the dominant small spore genus in the No. 2 Coal. The second and third most commonly encountered taxa are Laevigatosporites (mostly L. minutus and L. globosus) and Crassispora, which make up 15 to 25 percent and 6 to 11 percent respectively. Florinites (2 to 5 percent) is more abundant in the No. 2 Coal than in any other coal in the Carbondale Formation.

Calamospora, *Punctatisporites*, *Thymospora*, and *Triquitrites* make up most of the remaining spore population. *Triletes* is dominant (Winslow, 1959) in the large spore assemblage, and *Monoletes* is usually common in the No. 2 Coal of northern Illinois, except in one sample from Grundy County.

In the area of the Ancona-Garfield structure, which lies along the axis of the La Salle Anticlinal Belt in southern La Salle County (fig. 1), the spore content of the No. 2 Coal differs from that of other parts of northeastern Illinois (table 1). There, the frequency of *Laevigatosporites* and *Crassispora* increases considerably so that they attain up to 47 and 25 percent respectively, at the expense of *Lycospora*. In the Cardiff area of northwestern Kankakee County, where an unusually thick channel-deposited coal occurs a few feet above, or is in contact with the No. 2 Coal, the proportion of *Lycospora* to *Laevigatosporites* is also reduced.

Paleobotanical affinities of the isolated spores are found in numerous papers that describe fossil fructifications with spores *in situ*. Potonié's (1962) monograph is a valuable reference for those studies published before 1962. The following is a list of the spore genera identified from the No. 2 Coal, arranged according to their paleobotanical affinities.

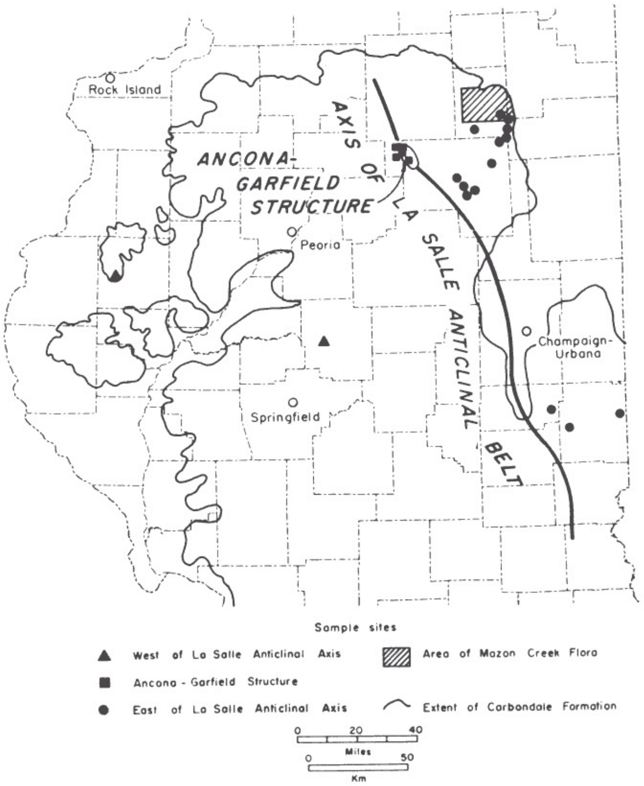

Fig. 1 - Area of Mazon Creek flora and sites from which the Colchester (No. 2) Coal has been sampled for spore analysis, adapted from Peppers (1970).

LYCOPSIDA
- *Crassispora*
- *Lycospora*
- *Densosporites*
- *Cristatisporites*
- *Vallatisporites*
- *Cirratriradites*
- *Endosporites*
- *Triletes*

SPHENOPSIDA
- *Elaterites*
- *Calamospora* (in part)
- *Vestispora* (in part)
- *Laevigatosporites* (only large species)

NOEGGERATHIALES*
- *Calamospora* (in part)
- *Cyclogranisporites* (in part)
- *Vestispora* (possibly)

FILICALES
- *Leiotriletes*
- *Granulatisporites*
- *Verrucosisporites*
- *Lophotriletes*
- *Raistrickia*
- *Convolutispora*
- *Camptotriletes*
- *Savitrisporites*
- *Thymospora*
- *Torispora*
- *Punctatisporites*
- *Cyclogranisporites* (in part)
- *Laevigatosporites* (only small species)
- *Microreticulatisporites* (possibly Filicales)
- *Triquitrites* (possibly Filicales)
- *Mooreisporites* (possibly Filicales)

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*Probably not significant in the coal-forming swamp because Noeggerathiales is thought to be in the upland flora.

PTERIDOSPEMALES
- *Vesicaspora*
- *Florinites* (in part)
- *Monoletes* (in part)

CORDAITES
- *Florinites* (in part)

UNKNOWN
- *Converrucosisporites*
- *Schopfites*
- *Kewaneesporites*
- *Anapiculatisporites*
- *Pustulatisporites*
- *Apiculatisporis*
- *Acanthotriletes*
- *Spackmanites*
- *Maculatasporites*
- *Dictyotriletes*
- *Reticulatisporites*
- *Knoxisporites*
- *Indospora*
- *Grumosisporites*
- *Cadiospora*
- *Reinschospora*
- *Tuberculatosporites*
- *Wilsonites*
- *Perotriletes*
- *Hymenospora*
- *Paleospora*
- *Alatisporites*

TABLE 1 - AVERAGE ABUNDANCE OF SMALL SPORE TAXA IN THE COLCHESTER (NO. 2) COAL

Plant groups	Spores	West and east of Ancona-Garfield structure (%)	On Ancona-Garfield structure (%)
Lycopods	*Lycospora*	54-66	34
	Crassispora	5-11	12
Ferns	*Laevigatosporites*	12-22	35
	Punctatisporites	2-4	2
	Thymospora	1	5
Sphenopsids	*Laevigatosporites*	3	2
	Calamospora	2	2
Pteridosperms	*Florinites* *Monoletes*	2-3	2-3
Cordaites	*Florinites*	2-5	2-5
Other spores		1	3

In the No. 2 Coal, spores having their affinity with arborescent lycopods account for 59 to 77 percent of the assemblage. The second and third most commonly encountered spores are those derived from the Filicales (15 to 25 percent) and sphenopsids (about 3 to 8 percent), which are represented by *Calamospora* and the larger species of *Laevigatosporites*. Five percent or less of the coal flora consists of the gymnospermic Cordaitales and pteridosperms, most of which are probably *Cordaites*. It is difficult to assess the proportion of the pteridospermic *Monoletes* pollen present because the small and large spore assemblages, including megaspores, are separated and treated differently during preparation for spore studies. Pteridosperms might have been more common than indicated in table 1. However, evidence from the coal ball flora (Pfefferkorn, unpublished data) also points to their rare occurrence in the peat flora.

Spore Succession in Coals

Since correlation of coals has been the principal objective of most of the palynologic studies in Illinois, sampling of coals in relatively large increments, such as lower, middle, and upper benches, has been made. However, trends in spore succession in the No. 2 Coal have been observed from these studies. Kosanke (1950) mentioned that *Schopfites* is more abundant in the lower portion of the coal, while *Alatisporites* and *Calamospora* are more common in the upper portions, but numerically these genera are not very significant. Generally there is a decrease of *Lycospora* and an increase in *Laevigatosporites*, especially *L. globosus*, from the bottom or middle of the coal to the top.

Paleoecologic interpretations of coal deposition based on spore studies have been suggested by several workers (Neves, 1958; Peppers, 1964, 1970; Marshall and Smith, 1965; Habib, 1966; Habib, Reigel, and Spackman, 1966; Habib and Groth, 1967; and Clapham, 1970), who have traced the succession of spore assemblages within Carboniferous coals or in coals and associated strata. Other investigations (A. H. V. Smith, 1957, 1964, and 1964; Butterworth, 1964; Alpern, Liabeuf, and Navale, 1964; Hacquebard, Cameron, and Donaldson, 1964; and Habib, 1968) have shown the relation between petrographic and palynologic constituents in coal, but studies of this kind have not yet been made on any coals in the Illinois Basin. A comparison of the floral succession of the No. 2 Coal and Francis Creek Shale with similar investigations in other areas is also hindered by the fact that the No. 2 Coal lies above the range of significant numbers of *Densosporites*. Most other studies have been made on older strata where *Densosporites* (from lycopods) plays a significant part in the ecology of the peat swamp.

A decrease in abundance of *Lycospora* and an increase in small species of *Laevigatosporites*, (including *L. globosus*) from the bottom toward the top of the coal, as occurs in the No. 2 Coal, has also been noted by A. H. V. Smith (1957, 1964, and 1964) in some Carboniferous coals in England; by Hacquebard, Cameron, and Donaldson (1964) in the Sydney Coal in Nova Scotia; and by Habib (1966) and Habib and others (1966) in the Lower Kittanning Coal of Pennsylvania. The coals investigated by Smith and Habib, however, are characterized by a significant increase of *Densosporites* towards the top of the coal. Smith (1957) found that if peat development had not been interrupted, there was another *Lycospora* phase above the *Densosporites* phase. Habib (1966) observed the *Densosporites* zone only beneath marine shale in western Pennsylvania, but as in the No. 2 Coal of northeastern Illinois, he reported (1968) that *Laevigatosporites globosus* and *Punctatisporites obliquus* were the dominant species in the upper part of the Upper Freeport Coal where it is overlain by fresh water deposits.

Hacquebard, Cameron, and Donaldson (1964) traced the lateral development of the Sydney Coal through fluviatile, forested peat bog, open moor, and lacustrine environments. In 1957, Smith maintained that the position of the water table during vegetal growth was the controlling factor in the spore succession in coals of Yorkshire, England, and that in the early stages the arborescent lycopods were growing in shallow water where decomposition was anaerobic. As the water became shallower, plants bearing *Laevigatosporites* (Filicales and Sphenophyllales) were more common, and when the surface of the peat was no longer submerged, but still wet, the *Densosporites* phase developed. In 1964, however, Smith considered that changes in climate interfered with the normal succession and were responsible for widespread lateral changes in composition of spore assemblages.

According to Habib (1966); Habib, Riegel, and Spackman (1966); and Habib and Groth (1967), arborescent lycopods grew along the margin of the coal swamp at the beginning of peat accumulation of the Lower Kittanning Coal. They were replaced by the *Densosporites* and *Laevigatosporites globosus* - *Punctatisporites obliquus* assemblages toward the center of the basin where the water table was higher and the water more brackish or marine, as indicated by the overlying shales. Although Chaloner and Muir (1968) pointed out the effect of different source areas, movement of shoreline, and changes in sea level on the spore population in coal, they emphasized the importance of climate, supporting Smith's interpretation. Chaloner (1968) compared studies on Pennsylvanian rocks with unpublished data of Muir on spores from British cyclic Jurasic and Cretaceous rocks. Conifer pollen, which responds to fluctuations in climate, was found most frequently in marine shales and in sandstone; whereas, they decrease in abundance in nonmarine rocks and coal.

Clapham (1970) investigated a marine section in the Flowerpot Formation (Permian) of Oklahoma. He found spores of a typical upland flora (mainly conifers) in most of the beds. Only one layer contained spores of a marsh or swamp flora (ferns, cycadophytes, and conifers). According to sedimentological features, this layer indicates a regressive facies.

COMPRESSION FLORA OF THE FRANCIS CREEK SHALE

The well preserved and diverse Mazon Creek compression flora found in concretions of the overlying Francis Creek Shale Member has also been the source of numerous publications. Many of these concretions are found in private collections and museums throughout the world. The flora of the Francis Creek Shale is often called the "Mazon Creek Flora" even though most specimens found today are derived some distance from Mazon Creek. Langford (1958 and 1963), for instance, applied the expression "Wilmington Coal Flora" and Noé (1925) applied the local names Braidwood, Morris, and Coal City to the fauna. For purposes of communication, the term "Mazon Creek Flora" can be applied to all floras collected from the Francis Creek Shale in northeastern Illinois as the general character is the same at all locations. There are, however, minor differences in the floras from different locations which are important for paleogeographical interpretations.

The plant fossils at Mazon Creek were discovered in the middle of the last century. They received special attention because they were attractive and could be collected in large numbers. The nodules normally split along the plane of the fossil, and the shape of the nodule roughly corresponds to that of the fossil. The fossils are not always in one plane but are naturally curved due to the early and rapid formation of the nodules (Johnson and Richardson, this Guidebook, p. 55), resulting in exceptional preservation.

The specimens found in the last century were described in part by Lesquereux (1866, 1870, 1880, 1884) and later by Sellards (1902, 1903). At least one report was published in Italy (Peola, 1907). While underground and strip mining were active in the 1930's, several large collections were made from the large number of fossils exposed. The most outstanding is the Langford collection, which is now housed in the Field Museum of Natural History (which has the largest part of the collection), the Illinois State Museum, and the U. S. National Museum. Noé (1925) discussed part of the flora in a well illustrated report, and one of his students, Janssen (1940, 1946), published several papers on the flora. Several paleobotanists found new forms, mainly fructifications, from museum specimens (Darrah, 1936, 1938; Arnold, 1938; Andrews and Mamay, 1948; Kosanke, 1955; Chaloner, 1956; Delevoryas, 1964; Taylor, 1967). A short report on a special collection made by 2 amateur collectors, Carrs and Daniels, was given by Stewart (1950).

Langford (1958, 1963) was the first to undertake a monographic treatment of the flora. Even though his 2 well illustrated books were mainly written for private collectors, they have been cited in recent scientific monographs. If the limitations of Langford's books in nomenclature and taxonomy are kept in mind, they are the best guides to the flora that exist. A more recent monograph that includes the Mazon Creek Flora has been published by Darrah (1970), in which many special aspects of the flora were described for the first time. The Mazon Creek Flora has been mentioned in numerous other papers, especially those that consider biostratigraphic correlations and floral reconstruction.

Composition of the Mazon Creek Flora

The Mazon Creek Flora is the richest known flora of Paleozoic age in North America, both in the number of species and specimens. The list of generic names provided below shows which genera are found and how they are systematically grouped. Form genera and organ genera are indicated, as well as the correlation of sterile foliage with organ genus of fertile foliage. This should eliminate the confusion produced by Langford (1958, 1963) who applied organ genera names of fructifications to sterile foliage.

LYCOPSIDS (Lycopodophyta, Club mosses)

Lepidodendron
Lepidophloios
Sigillaria
Asolanus
Omphalophloios
(bark of trees; these names are generally applied to the entire plant)

Lepidophylloides (formerly Lepidophyllum) (leaf)
Lepidostrobophyllum (leaf on cone)
Lepidostrobus (cone with microspores)
Lepidocarpon (cone with megaspores)
Sigillariostrobus (cone)
Sporangiostrobus (cone)
Stigmaria (root)
Ulodendron (branch scars)

SPHENOPSIDS (Arthrophyta, Articulata, Equisetinae, Calamitacea, horsetails)

Calamites (pith-cast of the stem)
Annularia (whorl of leaves)
Asterophyllites (whorl of leaves)
Calamostachys (cone)
Palaeostachya (cone)
Macrostachya (cone)

Sphenophyllum (leaf whorls on stem)
Sphenophyllostachys (cone)
Bowmannites (cone)

FILICINAE (Pterophyta, ferns)

Marattiales (tree ferns)

Pecopteris (sterile foliage, form genus)

Asterotheca (pecopterid)
Acitheca (pecopterid)
Ptychocarpus (pecopterid)
Radstockia
(fertile foliage, organ genera)

Psaronius (stem, if found, petrified in coal balls)

Megaphyton
Caulopteris
(stem, if found, as compression)

Aphlebia (part of the genus, irregular basal pinnules)

Other ferns

Alloiopteris
Sphenopteris (part of the genus)
Rhodea (?)
Aphlebia (part of the genus)
(sterile foliage, form genera)

Dactylotheca (pecopterid)
Senftenbergia (pecopterid)
Oligocarpia (sphenopterid)
Renaultia (sphenopterid)
Hymenotheca (sphenopterid)
Corynepteris (alloiopterid)
(fertile foliage, organ genera)

Crossotheca (pecopterid to sphenopterid)
Myriotheca (sphenopterid)
Zeilleria (sphenopterid)
fertile foliage genera which might be ferns but have been attributed to the seed-ferns by some authors

PTERIDOSPERMS (Cycadofilicales, seed-ferns)

Neuropteris
Linopteris
Cyclopteris
Odontopteris
Alethopteris
Desmopteris
Mariopteris
Sphenopteris (part of the genus)
Diplothmema
(foliage, form genera, often being equivalent to natural groups)

Codonotheca
Whittleseya
Schopfitheca
Dictyothalamus (so called *Mariopteris* buds)
Dolerotheca (?) (called *Plinthiotheca* by Langford)
(male fructifications)

Trigonocarpus
Holcospermum
Samaropsis
Codonospermum
Carpolithus
Neuropterocarpus
Perispermum
(seeds)

CORDAITES

Cordaites (leaves and whole plant)
Artisia (pith cast of the stem)
Cordaicladus (leaf scar)
Cordaianthus (male fructification)
Cordaicarpus (seed)

INCERTAE SEDIS (natural affinity not known)

Schopfia

The assignment of form-genera to natural groups usually can be made without difficulty. The only genera which occur in different natural groups, *Sphenopteris*, *Aphlebia*, *Crossotheca*, *Myriotheca*, and *Zeilleria* are relatively rare and do not drastically alter the statistical analysis of an assemblage.

Statistical counts of the Mazon Creek Flora that have been made by Janssen (1946), Stewart (1950), and Darrah (1970) are shown in tables 2 and 3. Janssen (1946) used about 440 nodules all smaller than 4.5 centimeters, so he excluded many forms which had not been broken apart before deposition. Stewart (1950) counted 2 collections (Carrs and Daniels, both now at the University of Illinois) and based his count on approximately 3600 specimens. Darrah (1970) included only the most common species and gave percentages only for groups of 4 or 5 species. The last column (this report) lists the major plant groups of about 360 specimens in the Illinois State Geological Survey collection.

TABLE 2 - COMPARISON IN DECREASING ABUNDANCE OF DIFFERENT GROUPS OF PLANTS FROM THE FRANCIS CREEK SHALE IN DIFFERENT COLLECTIONS

Janssen (1946)	Stewart (1950)	Darrah (1970)	ISGS (this report, 1970)
Pteridosperms	Ferns	Pteridosperms	Pteridosperms
Ferns	Pteridosperms	Ferns	Ferns
Sphenopsids	Sphenopsids	Sphenopsids	Sphenopsids
Lycopods	Lycopods	(?)	Lycopods
Cordaites	Cordaites	(?)	Cordaites

The order of decreasing abundance of the groups is the same in all the counts except for the reversal in proportions of ferns and pteridosperms in Stewart's tabulation. As this collection was brought together by 2 local collectors (Carrs and Daniels) near Morris, the difference may reflect a regional difference.

Darrah (1970) noted gigantism, especially in the pteridosperms. In the Carrs and Daniels collection this is apparent in Neuropteris scheuchzeri (or, as Darrah terms the large form, N. decipiens). Besides extremely large specimens, both normal and small sized specimens occur. Ideal growing conditions and a minimum of selection during transportation could account for this size range.

Paleoecological Interpretations of Compression Floras

Paleoecological differences in floras of the same age have been studied by Gothan and Gimm, 1930; D. White, 1931; Daber, 1959; Havlena, 1960 and 1961; Cridland and Morris, 1963, and others. Studies were focused on Permian and upper or lowermost Pennsylvanian plant fossils. No attempt has been made, as far as we know, to use data from both spores and compression fossils. Gothan and Gimm (1930) found 2 distinct floras in the lower Permian of Thuringia: one, immediately overlying the coal seam, is characterized by pecopterids (ferns), Calamites (sphenopsids), and pteridosperms; the other flora, representing a dryer habitat, is the Callipteris - Walchia - association (pteridosperms, sphenopsids and conifers, including Cordaites). A mixing of the 2 floras was also reported from some localities. Cridland and Morris (1963) found upper Pennsylvanian floras in Kansas and concluded that the upland vegetation was represented by Dichophyllum, Taeniopteris, and Walchia. The swamp flora consisted of Cordaites, Calamites, Sigillaria, ferns, and pteridosperms.

Cordaites has been defined both as a swamp plant and as an upland plant. Wartmann (1969) offered a solution to this problem by interpreting Cordaites as a physiologic "xerophyte," which is able to live in dry areas as well as in swamps, under brackish or saline conditions, and where there is a nitrogen deficiency.

Daber (1959) found 2 floras of similar age in the Dinantian, and Havlena (1961) also found two in the Namurian. The floras have been designated seam-forming ("flozformend" or "floznah") and those distant from the seam ("flözfern" or "flözfremd"). The seam-forming flora occurs only in the immediately overlying shale and consists of large specimens. At some vertical distance from the seam, plant fragments occur in the shale and sandy shale that are either from the seam flora or from an entirely different flora brought in from some distance. David White (1931) discussed the environmental aspects of the lowermost Pennsylvanian (Caseyville) flora of the Illinois Basin. He differentiated the swamp flora from an "upland" flora of the plains (underlain by limestone) between St. Louis and Rock Island.

The Carboniferous flora of the northern hemisphere had long been considered to be very uniform in lateral extent of stratigraphic units. This uniformity was, however, the effect of the search for a general rule and the grouping together of all the floras found in at least one cyclothem. Even the distinction between only 2 floras is an oversimplification, because many microenvironments within each major environment were present. Fisk (1960), for instance, illustrated 6 plant microenvironments in the recent Mississippi Delta: mudflat, natural levee, forest swamp, fresh marsh, brackish marsh, and salt marsh.

COMPARISON OF FLORAS OF NO. 2 COAL AND FRANCIS CREEK SHALE

Several factors influence the validity of the comparisons (table 3) of the No. 2 Coal Flora, interpreted from spore data, and the Mazon Creek Flora, reconstructed from plant compressions:

1. Plants that produce the largest number of spores or fructifications and other organs tend to be disproportionally represented in spore assemblages and compressions. This distorted picture of the actual flora does not affect the comparison of floras in the same facies, but may cause apparent differences between floras of different environments.
2. Spores with certain kinds of ornamentation and structures such as bladders are widely disseminated by wind and water.
3. Prevailing wind and water current direction distributes spores and other parts of plants unequally and mixes plants from different environments.
4. Spore exines that are resistant to decay are more frequently preserved than weakly resistant exines. Plants with thick cuticles and large amounts of suberin and lignin in their tissues are more likely to be fossilized. Some lower plant groups, such as fungi, bryophytes, and certain algae, are infrequently preserved in the fossil record.
5. Different maceration techniques provide different proportions of spore taxa as illustrated by Hughes, Jekhowsky, and Smith (1964).

TABLE 3 — COMPARISON IN PERCENT OF THE FLORAS OF THE COLCHESTER (NO. 2) COAL, THE FRANCIS CREEK SHALE, AND THE LOWER KITTANNING COAL ROOF SHALE OF WEST VIRGINIA

Plant group	Spores (No. 2 Coal)		Plant megafossils (Francis Creek Shale)			Megafossils (Lower Kittanning Coal roof shale)
	East and west of La Salle Anticlinal Belt (%)	Ancona-Garfield Structure (%)	Janssen 1946 (%)	Stewart 1950 (%)	ISGS Collection (%)	Gillespie and Clendening 1962 (%)
Lycopsids	60–78	46	6	7	14	9
Sphenopsids	3–8	4	20	11	17	22
Ferns	15–27	42	26	48	24	19
Pteridosperms	2–3	2–3	44	34	44	49
Cordaites	2–5	2–5	2	0.3	0.5	—
Others	1	3	2	—	.5	1

6. Comparison of the statistical analysis of small and large spore assemblages is difficult because analysis of the 2 assemblages is usually done separately. The count of the pteridospermic Monoletes in the spore population is especially affected by this procedure.
7. Plant compressions obtained from one or a few localities over a short time interval, especially in strip mining operations, do not provide as good a representation of the entire flora as compressions collected at a large number of locations over a long time interval. Other collecting factors that affect plant representation include the areas accessible to collectors, method of building spoil piles in strip mines, erosion of spoil piles, and the number of fossils discarded or overlooked by amateur collectors.
8. During periods of rapid sedimentation, more plants are buried than in periods of slow sedimentation.
9. Errors in taxonomic interpretations are possible.

Although many of these factors may present an erroneous picture of a single fossil flora, 2 or more floras in the same facies tend to be altered in approximately the same extent and direction. However, more serious problems, such as not knowing the number of spores and leaves produced by fossil plants, are encountered when comparing spore floras with compression floras.

A comparison of percentages of major plant groups in the 3 collections of Mazon Creek plant compressions and the compressions from above the Lower Kittanning Coal shows a rather close correlation (table 3). Gillespie and Clendening (1962) found a flora from the roof shale of the Lower Kittanning Coal containing many of the same species as the Mazon Creek Flora, but the number of species was much smaller. This might be due to farther transport or to very special growing conditions. Of the 1000 specimens counted, the pteridosperms account for nearly 50 percent, the sphenopsids, which are more common than in the Mazon Creek Flora are second (22 percent), closely followed by ferns (19 percent). Lycopods are the rarest plants, and Cordaites has not been reported.

The most striking differences between the No. 2 Coal Flora and the Mazon Creek Flora is the very small proportion of lycopods and the large proportion of pteridosperms and sphenopids in the latter. Caution is necessary in comparing the percentages because of the difficulty in assessing the proportion of pollen to pteridosperms in the coal. In the vicinity of the Ancona-Garfield structure, lycopod spores decrease in proportion and fern spores increase in importance. Cordaites is of minor importance in all the floras. Other evidence of the difference in the No. 2 Coal and Mazon Creek Floras is the presence of spores in some fructifications of the Mazon Creek Flora that have not been found in the No. 2 Coal (unpublished data).

CONCLUSIONS

The correlation of major plant groups with various environments that existed during peat accumulation of the No. 2 Coal is listed below and schematically illustrated in figure 2.

Swamp, wet - lycopod (Lepidodendrales), fern, Cordaites (rare) - association
Swamp, dry - fern, lycopod (Lepidodendrales and Sigillarian), sphenopsid - association
Levees and floodplain - pteridosperm, fern, sphenopsid - association
Upland - pteridosperm, Cordaites, Noeggerathiales (rare) - association

Significant upland forms have not been observed in spore assemblages of the No. 2 Coal or from compression fossils from the Francis Creek Shale. Pfefferkorn has observed (unpublished data) an upland

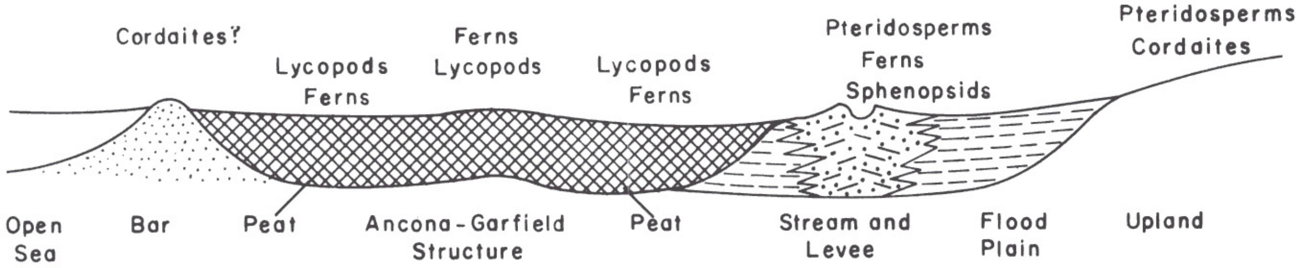

Fig. 2 - Schematic interpretation of floral distribution in sedimentary facies in the Illinois Basin during time of deposition of Colchester (No. 2) Coal.

compression flora in western Illinois and Peppers (1964) has recorded an upland spore flora from younger Pennsylvanian marine shales in Illinois.

The floral succession during peat accumulation of the No. 2 Coal in northern Illinois apparently began with primarily an arborescent lycopod assemblage that was growing in quiet, shallow water. As the water table lowered, ferns and sphenopsids became more abundant, but lycopods were still the most important group.

A second flora, a fern-lycopod association, is indicated by local variations in the spore assemblage in the No. 2 Coal in the region of the Ancona-Garfield structure and the Cardiff area. This may indicate a slightly higher elevation during the life of the No. 2 Coal swamp flora. Sigillarian lycopods, Filicales, and Sphenophyllales were better represented throughout deposition of the peat, in the Ancona-Garfield and Cardiff areas. In fact, at times the latter 2 groups may have existed in greater numbers than even the arborescent lycopods. The water table was probably lower and the water less brackish than in the remaining area of peat accumulation. The spore population represents a flora intermediate between the flora near the base of the No. 2 Coal, in which arborescent lycopods are prevalent, and the Mazon Creek Flora of the overlying Francis Creek Shale, in which pteridosperms and ferns are most common.

The Mazon Creek Flora was probably derived from a plant community that populated slightly higher elevations where the water table was lower than in a coal-forming swamp. A flora even farther upland and more distant from peat swamps was probably dominated by gymnosperms, including Cordaites, which was probably the source of large numbers of Florinites. Chaloner (1958 and 1959), Chaloner and Muir (1968), and Cross (1968) pointed out that a disproportionate number of wind-borne saccate pollen grains, such as Florinites, would be found far offshore in marine sediments as described by Neves (1958) and Peppers (1964). However, since cordaitalean plants make up only about 1 percent of the Mazon Creek Flora, it seems unlikely that this flora could be considered an upland flora. Rather, the Mazon Creek Flora probably inhabited a nearshore deltaic environment along the floodplains, mudflats, and levees.

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